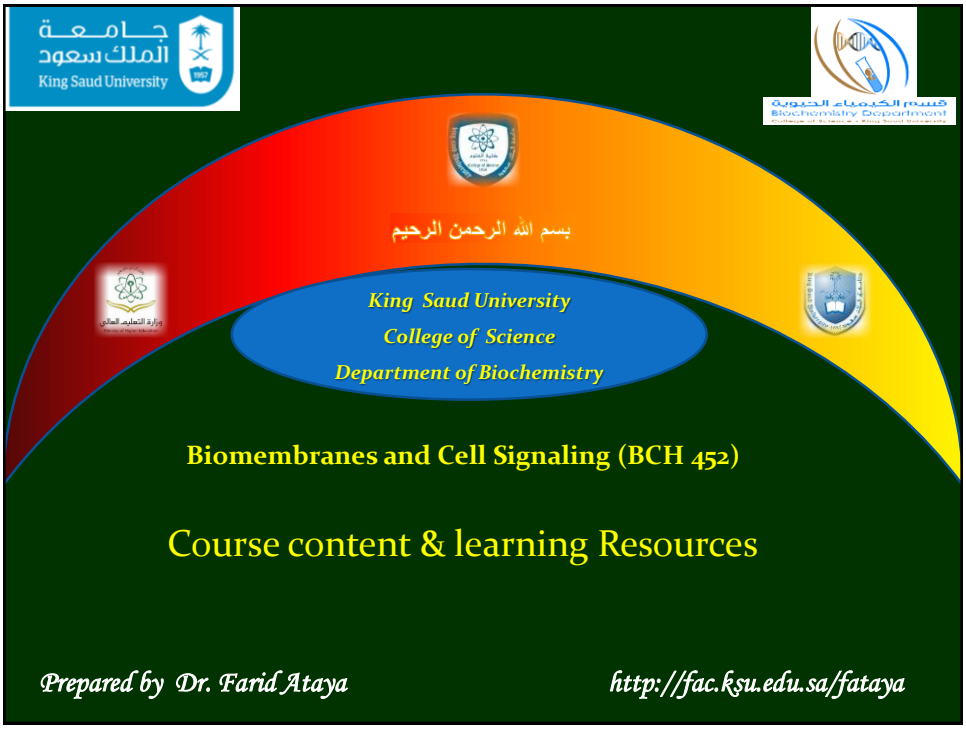


BCH 452
Biomembranes and Cell Signaling

- Course Symbol & No. : BCH 452
- Credit Hours : 2 (2+0)
- Prerequisite : BCH 302
- Class schedule : Sunday and Tuesday 11:00 am to 11:50 am.
- Class location : AA35 building No. 5
- Examinations : Continuous Assessment Tests (CAT)
  - First (30 Marks) Sun, 20/06/1438h – 19/03/2017
  - Second (30 Marks) Tues, 11/08/1438h – 07/05/2017
  - Final (40 Marks)

Course description

- General structural and functional properties of natural and synthetic membranes.
- Function and properties of proteins, lipids and carbohydrates of biomembranes.
- Solubilization and fractionation of biomembranes.
- Fluid mosaic model.
- Types of transport across biomembranes.
- Calculation of energy change in each case.
- Composition and function of the different types of cellular membranes: Membranes of erythrocytes, intestinal mucosa, renal tubules, muscle cells, mitochondria, nerve cells, retinal cells and bacterial cells.
- Types and properties of signal and signal transduction.
- Biosynthesis and assembly of membranes.

Course Objectives

- To understand the properties, composition and functions of Biomembrane
- To be able to differentiate the basic constituents of the cell membrane with respect to their function.
- To be able to critically evaluate the use of various scientific techniques in understanding of the basic membrane structure.
- To learn about the various types of transport mechanisms such as energy dependent and energy independent phenomena operating across the membrane.
- To be able to understand the basic function of cell membrane of nervous tissues in nerve impulse propagation.
- To understand the role of membrane receptors in signal transduction.
- To relate the basic structure of mitochondrial membrane, endoplasmic reticulum membrane and bacterial membrane to their respective functions.
- To understand the structure of cell membranes of rod and cone cells and know how does it help in propagation of vision?

Topics to be covered	No. Lect
Definition of Membranology. Composition of biomembranes: Lipids, proteins and carbohydrates. General functions of biomembranes	1-2
Micelles, liposomes and vesicles, their preparation and applications in drug delivery. Membrane solubilisation with detergents. Visualization of membrane proteins with SDS-PAGE	3
Visualization of membrane proteins with freeze fracture and freeze-etching electron microscopy. Structural and functional asymmetry of membranes with respect to carbohydrates, lipids and proteins. Factors affecting fluidity of membranes. Diffusion coefficient. Fluid mosaic model.	4-5
Role of cell surface carbohydrates in recognise ion, as receptor of antigens, hormones, toxins, viruses and bacteria. Their role in histocompatability and cell-cell adhesion. Visualization of membrane carbohydrates	6
Diffusion across biomembranes. Ficks law. Structural types of channels (pores): a-type, B-barrel, pore forming toxins, ionophores. Functional types of channels (pores): • voltage-gated channels e.g. sodium channels, • ligand-gated channels e.g. acetylcholine receptor (nicotinic-acetylcholine channel), • c-AMP regulated.	7
Gap junctions and nuclear pores. Transport systems: • Energetics of transport systems, G calculation in each type. • Passive Transport (facilitated diffusion).	8

Topics to be covered	No. Lect
Kinetic properties. Passive transport: • Glucose transporters (GLUT 1 to5), • $C1^-$, HCO_3 exchanger (anion exchanger protein) in erythrocyte membrane	9
Kinetic properties. Active transport: Types of active transport: Primary ATPases (Primary active transporters): P transporters (e.g. Na^+, K^+, ATPase)	10
First assessment Exam	
ATP binding cassettes (ABC transports) • (e.g. cystic fibrosis transmembrane conductance regulator-chloride transport). Multidrug resistance protein transporter. V transporters, F transporters. • Secondary active transporters (e.g. Na^+ -dependent transport of glucose and amino acids). To be covered under intestinal brush border	11
Transport of large molecules (Macromolecules) Types: Exocytosis, Endocytosis-pinocytosis and phagocytosis Types of pinocytosis: • Absorptive pinocytosis, characteristics and examples. • Fluid phase pinocytosis, characteristics and examples	12

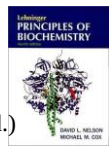
Topics to be covered	No. Lect
SPECIALIZED MEMBRANES: Erythrocyte membrane. Isolation. Types and functions of membrane proteins. Cytoskeletal system of the erythrocyte membrane. Microfilaments of the membrane. Transport of glucose, anions, cations.	13
Intestinal brush border membrane. Types and functions of membrane proteins. Transport of glucose with sodium as an example on secondary active transport. Transport of amino acid, transport of bile acids Na^+/ K^+ antiport	14
Renal Tubular membrane: Membrane s of proximal and distal renal tubules and the functions of each. Reabsorption processes NaCl, H_2O, glucose, HCO_3^- and amino acids. Secretion of H^+. Transport of amino acid by γ- glutamyl cycle.	15
Membrane of muscle cells: Sarcolemma and sarcoplasmic reticulum and the function of each Ca^{2+} -ATPase in each.	16
Second Assessment Exam	

Topics to be covered	No. Lect
Mitochondrial membranes: Outer and inner membranes. • The interrelationship among; phosphate transporter (Pi/H^+), adenine nucleotide transporter (ADP/ATP), dicarboxylate transporter (Pi/malate) and OH^-/ Pi antiporter. • The interrelationship among: Ca^{2+}/Na^+ antiporter. • The interrelationship among: Tricaboxylate transporter (Malate/Citrate); Dicarboxylate transporter (Pi/ malate), malate α-ketoglutarate transporter. • The interrelationship among: Monocaboxylate transporter (pyruvate/ OH^-) and OH^-/Pi antiporter.	17
Membranes of nerve tissue: A brief review of CNS anatomy and types, functions of nerve cells. Myelin membrane-structure and function and composition-multiple sclerosis.	18
The structure of retina in brief. Red and cone cells. Detailed formation of 11-cis-retinal and rhodopsin from β-carotene. Conformational changes that rhodopsin undergoes after photoactivation that leads metarhodopsin II (active rhodopsin). Detailed cascade of biochemical reactions involved in the visual cycle.	19-20
Nerve impulse generation (Action potential generation along an exon) Neurotransmitters, neurotransmitter-gated ion channel receptors as major signal transduction elements at neural synapses.	21
Model of the mechanism of regulation of synaptic vesicles function by calcium ions and calmodulin kinase II. Myasthenia gravis. Nerve gases	22

Topics to be covered	No. Lect
Signal transduction: Types (modes) of intercellular signal transduction. Basic elements of signal transduction pathway at the cellular level. Basic properties of intercellular receptors versus cell surface receptors	23-24
Major classes of cell surface receptors for secreted signalling molecules. Receptor tyrosine kinase in detail. Types and structures of second messenger molecules	25-26
Bacterial plasma membrane: Phosphoenol pyruvate-dependent phosphotransferase system (PTS). Lactose permease (galactoside permease). The interrelationship between the two systems	27
Biosynthesis and assembly of membrane: The synthesis and assembly of lipid components. The ribosomal synthesis membrane insertion, and initial glycosylation of integral membrane proteins via the secretory pathway. Post-translation processing of proteins (insertion into the plasma membrane, transport to lysozomes or secretion).	28
Final exam	

Books

1. Delvin T.M. (ed.) Text book of Biochemistry with Clinical Correlations. Wiley-Liss, (6th edition), USA
2. Harrison, R. & Lunt G.G.. Biological Membranes; their structure and function. Halasted, New York, (Latest edition).
3. Gomperts, B.D. The plasma membrane: Models for structure and function. Academic Press, London (latest Edition).
4. Weissman, G. and Claiborne (eds.) Cell membranes: Biochemistry, Cell Biology and Pathology. H.P. Publishing Co., New York, (Latest edition).



- Molecular Biology of the Cell, Fourth Edition by Alberts. Et al.,
- Principles of Biochemistry by Lehninger. by DL. Nelson and MI. Cox (latest ed.)
- Biochemistry by Lubert Stryer (latest Edition).
- Molecular Cell Biology , Lodish et al.,
- Harper's Biochemistry

Outline of cell structure

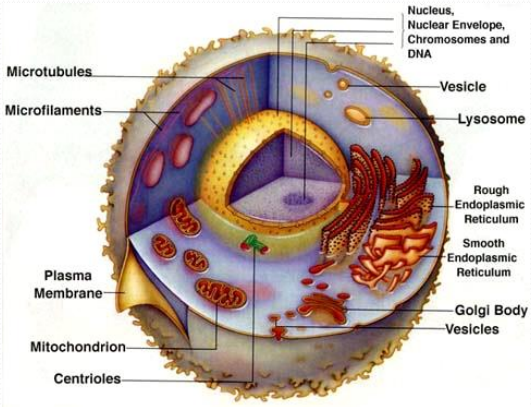
- Cells from different organisms have different shapes, structures, and sizes.
- All cells have protoplasm.

- They are usually divided into two broad groups: Eukaryotes and Prokaryotes.
  - Eukaryotic cells (Eu = true; kary = nucleus): have a membrane-bound nucleus and a variety of organelles and internal membranes.
  - Prokaryotic cells (Pro = before) are smaller (a general rule) and lack much of the internal compartmentalization and complexity of eukaryotic cells; No membrane-bound nucleus or other organelles.
  - Viruses do not always conform to cell theory:
    - one or more of the basic cell components is missing.
    - Inside the host cell, viruses are living matters.

- **Prokaryotes cells; all in one!!**
  - It shows a limited range of morphologies but very diverse metabolic capabilities.
  - Prokaryotes are single-celled organisms.
    - Do NOT have true nucleus or organelles.
    - Most have circular or "looped" DNA
    - lack much of the internal membranous compartmentalization
    - Mainly unicellular organisms
- **Eukaryotic Cells**
  - Eukaryotic cells are complex cells (different sizes, shapes, and structures) and specialized but they all have:
    - Membrane-bound nucleus which contains the cell's genetic material; DNA
    - Organelles, each is *surrounded by a membrane or two* like lysosome, Golgi bodies, endoplasmic reticulum, mitochondria, etc
    - Eukaryotic DNA is organized in linear structures (chromosomes), associated with proteins (histones)

Generic Animal Cell (cont.)

- Animals have a variety of cells that differ in shapes, structures, and sizes.
- A model structure is shown as follow:



Generic Animal Cell (cont.)

- The animal cell is surrounded by lipid bilayer plasma membrane.
- The content inside the plasma membrane is called protoplasm. It contains many organelles and subcellular structures as:
  - **Nucleus:** contain the genetic materials and surrounded by porous nuclear membrane. It contains liquid called neucleoplasm.
  - **Ribosome:** the site of protein synthesis. It is a group of protein subunits and ribosomal RNA.
  - **Mitochondria:** the site of energy production. It is a double –walled organelle having many enzymes for energy production (The Power House). The inner membrane is highly folded to increase the area of energy production. The number of mitochondria increases as the energy needs increases.
  - **Lysosome:** the site of removal of cell degraded waste substances. It contains many digestive enzymes and it is known as suicide bag as it burst and its contents release to lyse the cell when the cell die.
  - **Golgi Bodies,** a membranous structure. It packages proteins into membrane-bound vesicles inside the cell before the vesicles are sent to their destination.
  - **Endoplasmic reticulum (ER);** a network of membranes that may carry ribosomes or not. It share in the synthesis and export of proteins and membrane lipids.

Lipids

Lipids are esters of fatty acids and alcohol.

The lipids are a heterogeneous group of compounds, including:

- fats, - oils, -waxes, -steroids, and
- related compounds which are related more by their physical than by their chemical properties.
- Although the term *lipid* is sometimes used as a synonym for fats, fats are a subgroup of lipids called triglycerides.

Lipids have the common property of being:

(1) relatively insoluble in water and

(2) soluble in nonpolar solvents such as ether and chloroform.

Lipids are hydrophobic small molecules; this character allows them to form structures such as vesicles or membranes.

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Lipids of Physiologic Significance

1. They are important dietary constituents as they are high *source of energy (9.3 cal/g)*
2. Animal lipids are *more energetic and more saturated* than plant lipids
3. They are source of the *fat-soluble vitamins*
4. They provide body with the *essential fatty acids* contained in the fat of natural foods.
5. Fat is stored in adipose tissue, where it also serves as a *thermal insulator* in the subcutaneous tissues and around certain organs.
6. Nonpolar lipids act as *electrical insulators*, allowing rapid propagation of depolarization waves along myelinated nerves.
7. Phospholipids and sterols are major structural elements of biological membranes.
8. Other lipids, although present in relatively small quantities, play crucial roles as:
   - enzyme cofactors,
   - electron carriers,
   - Light absorbing
   - Some pigments,
   - hydrophobic anchors for proteins,
   - "chaperones" to help membrane proteins fold,
   - Emulsifying agents in the digestive tract,
   - Some hormones are derived lipids, and
   - intracellular messengers.

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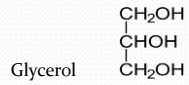
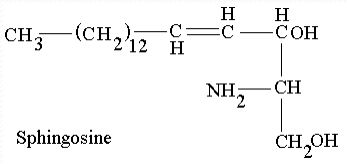
The alcohol forming lipids

- There are many alcohols
- The most important in lipids are glycerol and sphingosine
  - Glycerol is hydroxylic alcohol (contains 3-OH groups)



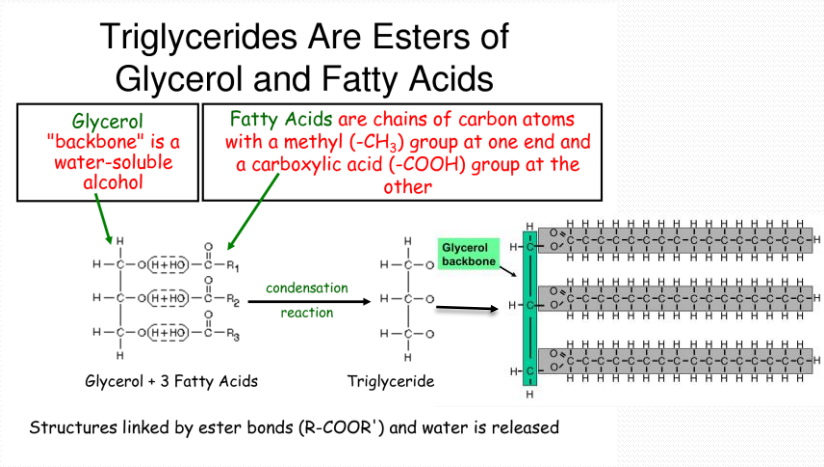
Glycerol

  - Sphingosine is amino alcohol



Sphingosine

Triglycerides



Fatty acids are aliphatic carboxylic acids

Fatty acids are long hydrocarbon chain preceded by carboxyl group.

- i.e. They are carboxylic acids with hydrocarbon chains.

i.e. it has small polar, hydrophilic end (the carboxy end) and long nonpolar, hydrophobic end (the 4-36 hydrocarbon tail).

So, the overall of fatty acids is insoluble in water.

They occur mainly as esters in natural fats and oils.

They are transported in the blood as free fatty acids (unesterified form).

Fatty acids that occur in natural fats are usually *straight-chain* derivatives (unbranched) containing an *even number* of carbon atoms.

A few branched-chain fatty acids have also been isolated from both plant and animal sources.

The chain may be saturated (*containing no double bonds*) or unsaturated (*containing one or more double bonds*).

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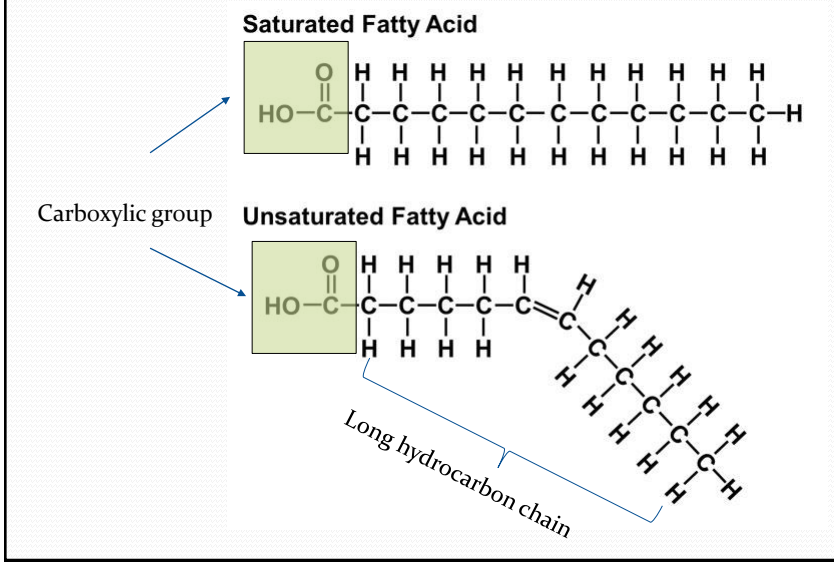

Fatty Acids Are Named After Corresponding Hydrocarbons

The most frequently used systematic nomenclature names the fatty acid after the hydrocarbon with the same number and arrangement of carbon atoms, with -oic being substituted for the final -e (Genevan system).

Saturated fatty acids are those containing single covalent bonds between carbon atoms [CH_3-$(CH_2)_n$-COOH]

Their name is composed from the latin number of the carbons end in -anoic, eg, octanoic acid,

Unsaturated acids are those containing at least one double bond between carbon atoms

Their name end in -enoic, eg, octadecenoic acid (oleic acid).

Carbon atoms are numbered from the carboxyl carbon (carbon No. 1). The carbon atoms adjacent to the carboxyl carbon (Nos. 2, 3, and 4) are also known as the α, β, and γ carbons, respectively, and the terminal methyl carbon is known as the ω or n-carbon.

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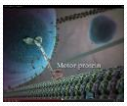
videos

Cell, tissue, organ
https://www.youtube.com/watch?v=HBvfBB_oSTc

https://www.youtube.com/watch?v=FzcTgrxMzZk

https://www.youtube.com/watch?v=g4L_QO4WKtM



https://www.youtube.com/watch?v=g159zCnvpBs

- https://quizlet.com/106516227/principles-of-biochemistry-lehninger-6th-edition-chapter-11-biological-membranes-and-transport-flash-cards/
- https://quizlet.com/142016359/chapter-11-biological-membranes-and-transport-flash-cards/
- https://quizlet.com/123617448/chapter-11-biological-membranes-and-transport-flash-cards/
- https://quizlet.com/104726299/chapter-11-biological-membranes-and-transport-flash-cards/ (MCQ)
- https://quizlet.com/169548375/chapter-11-biological-membranes-and-transport-flash-cards/ (fill in the space)
- http://wenku.baidu.com/view/e4a071c65fbfc77da269b155.html###
- https://quizlet.com/85889411/chapter-11-biological-membranes-and-transport-flash-cards/ (MCQ)
- https://quizlet.com/109358583/chem-4551-chapter-11-biological-membranes-and-transport-flash-cards/ (written questions)
- https://quizlet.com/104000803/biochem-ch-11-biological-membranes-and-transport-flash-cards/ (Fill in the space)