INTRODUCTION

Think; of a cell as a Tiny, bustling city yewr body. Sach cell is like a

werkier. buy deg riod tl bo ric ells have walls called

wewbranes. which are likie cily borders. deciding what gees iw and oul.

Jil there are lille factories called

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As an MBBS student. this is secret code

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Biomolecules and cell

Introduction

- Life is composed of lifeless chemical molecule

- living matter 1s mainly composed of carbon, hydrogen,

oxygen, nitrogen, phosphorus and sulfur.

- Several other functionally important elements are Ca, K,

Na, CI, Mg, Fe, Cu, Co, I, Zn, F, Mo and Se.

- Carbon, it possesses a unique property to form an infinite

number of compounds.

- It 1s estimated that about 90% of compounds found in

living system invariably contain carbon.

What are Complex biomolecules??

- this complex molecule is formed by lot of single

molecules (i.e monomeric units)

- example of monomeric units which forms the complex

molecule are aminoacids, nucleotides & monosaccharide

- This monomeric unit Serve building blocks of complex

biomolecules Like proteins, nucleicacids(DNA and RNA)

and polysaccharides, respectively.

- The important complex biomolecules their respective

building blocks and functions are given below

Tasie 1.1 The major complex biomolecules of cells

Biomolecule Building block Major functions

(repeating unit)

1. Protein Amino acids Fundamental basis of structure and

function of cell (static and dynamic functions).

2. Deoxyribonucleic acid (DNA) ~~ Deoxyribonucleotides Repository of hereditary information.

3. Ribonucleic acid (RNA) Ribonucleotides Essentially required for protein biosynthesis.

4. Polysaccharide (glycogen) Monosaccharides (glucose) Storage form of energy to meet short term

5. Lip Fatty acids, glycerol Storage form of energy to meet long term

demands; structural components of membranes.

- The macromolecules (protein, lipids ,nuclei acids and

polysaccharides )form supramolecular eg. membranes

- which in turn organize into organelles, cells, tissues,organs

and finally the whole organism

\* Cell

\* : Cellis defined as the structural and functional unit of the living body.

- it has two major parts:

Nucleus

Cytoplasm

\* Tissue is defined as the group of cells having similar Function.

e.g. muscle tissue, nervous tissue, epithelial tissue.

\* organ is defined as the structure that is made up of two or more primary

types of tissues.

\* organ system is defined as group of organs that work together to carry out

specific Functions.

e.g. : Digestive system, respiratory system, Circulatory system

Ee)

specialised wp tissue w==p organ (IN system ===) organism

cell

muscle cell mm muscle w=) heart w= circulatory wep circulatory

tissue system system makes

up part of the

human body

Example of general organization of circulatory system.

7 What is a cell membrane?

Cell membrane / plasma membrane

- It is a protective sheath.

- Its an elastic structure

- It envelops the cell body.

- This membrane separates extracellular Fluid from intracellular Fluid.

- It is semi-perméable membrane.

- So, there is free exchange of certain substances between €CF and ICF.

- It is composed of proteins; lipids; carbohydrates.

What are the functions of cell membrane?

Ansinctions

protection: Cell membrane protects the cytoplasm; organelles present in the

cytoplasm.

Selective permeability: Cell membrane allows only some specific substances to

pass through it.

Nutrients are absorbed into the cell through the cell membrane

excretory Function: waste products & metabolites are excreted out from cell

through the cell membrane.

Exchange of gases like Oxygen and carbon dioxide occurs through the cell

membrane.

cell membrane Maintains shape and size of the cell.

What are the functions of cell membrane?

ANS - cytoplasm

- cytoplasm is a gelatinous material bound by the cell membrane

- It contains many organelles

- Simportant organelles present in cytoplasm are

- endoplasmic reticu—lum

- Golgi apparatus

- mitochondria

- lysosomes

- peroxisome.

0. Whe is encloplasmic élicubuum, (ER)? Wha are the Giypes of

encloplagmic reliculum?

The endoplasmic reticulum (ER) is a system of channels that is continuous with

the nuclear membrane (or “envelope” covering the nucleus and composed of

the same lipid bilayer material.

- It is made up of network of tubular and Flat vesicular structures

- It processes and transport molecules that are made by the cell.

- It's of two types I) rough endoplasmic reticulum

ii) smooth endoplasmic reticulum

ic. Reficull

- it appears rough due to the attachment of granular ribosomes.

- it helps in protein synthesis

- It helps in removing worn-out organelles

Smooth endoplasmic reficulum

- It appears smooth and is called agranular endoplasmic reticulum.

- It helps in synthesis of lipid substances

A) — Smooth Nuclear envelope

UCIeOS endoplasmic reticulum

Nucleus

Nuclear pore

Rough

endoplasmic

reticulum Nuclear

Pore

Cisternal space

Cisternae

Q.What is Golgi apparatus ? What are the Functions of it?

Golgi apparatus is responsible for sorting, modifying, and shipping off the

products that come from the rough €R

Golgi apparatus / Golgi complex is a membrane-bound organelle.

- They process the proteins

- They are absent in red blood cells.

- It has S to 8 fattened membranous sacs called the cisternae.

Functions

The Golgi apparatus has two distinct sides, each with a different role.

One side of the apparatus receives products in vesicles.

[processing of material: vesicles containing lipids and glycoproteins are

transported to Golgi apparatus from €R ; here they are modified and proce

ii) Packaging of materials: The processed material is packed in the Form of

secretory vesicles and lysosome

iii) Then delivers the packed material from the opposite side

Golgi Apparatus cis face

Golgi Body ina Cell

e.g i

©

or

eum,

ssed

Incoming

tronspxt

~esicies-

.What is lysosome?

A lysosome is an organelle that contains enzymes that break down and digest

unneeded cellular components, such as a damaged organelle.

\* Lysosymes are formed by breaking of from Golgi apparatus

\* Lysosomes act as intracellular digestive system.

\* it digests:

- damaged cellular structures.

- products of protein digestion intracellularly.

- bacteria.

\* Hydrolytic enzymes are present in the lysosomes.

\* these hydrolytic enzymes can split an organic compound into many parts

\* important lysosomal enzymes are

- Proteases : it hydrolyzes the proteins into amino acids

- Lipases: it hydrolyzes the lipids into Fatty acids and glycerides

- Amylases: it hydrolyzes the polysaccharides into glucose

- Nucleases: it hydrolyses the nucleic acids into mononucleotides.

Specific Functions of lysosome

- It degrades macromolecules

- It degrades worn-out molecules

- It Removes excess secretory products in the cells.

LYSOSOME

Membrane — Hydrolytic enzymes

Cg

Transport proteins

Q. What is mitochondria?

- Mitochondrial is the “powerhouses” of the cell.

- Its rod shaped.

- It is a bilayered organelle containing an outer membrane and inner

membrane.

- The inner membrane is Folded in the Form of shelf-like inward projections

called cristae

- Cristae contains many enzymes which are involved in respiratory chain and

synthesis of ATP

- Enzymes and other proteins of respiratory chain

i. Succinic dehydrogenase

ii. Dihydronicotinamide adenine dinucleotide dehydrogenase

ii. Cytochrome oxidase

iv. Cytochrome C

v. ATP synthase.

Functions of mitochondria

i) Production of energy

- It produces the energy required for cellular functions.

- energy is produced by oxidation of digested Food particles like proteins, lipids

etc.

- Released energy is stored in mitochondria and used later for synthesis of

ATP.

ii) Synthesis of ATP

- components of respiratory chain in mitochondria are responsible for the

synthesis of ATP

iii) Apoptosis

- Cytochrome C and second mitochondria-derived activator of caspases are

secreted in mitochondria

- They are involved in apoptosis.

Mitochondria

Inner Intermembrane Matrix Outer

membrane » membrane

what are peroxisomes? What are the functions of

peroxisomes?

- Peroxisomes are the membrane limited vesicles like the lysosomes.

- They are pinched off from endoplasmic reticulum.

- Peroxisomes contain some oxidative enzymes such as catalase, urate oxidase

and D-amino acid oxidase

- they are also called as microbodies

Functions of peroxisomes

Peroxisomes:

i. Breakdown the Fatty acids by beta-oxidation

ii. Degrades the toxic substances such as hydrogen peroxide and other

metabolic products by detoxification.

Example:

Whenever hydrogen peroxide is produced in the cell, the peroxisomes are

ruptured, and the oxidative enzymes are released; These oxidases destroy

hydrogen peroxide

jii.Accelerate gluconeogenesis from fats

iv. Degrades purine to uric acid

vParticipate in the Formation of myelin

viPlay a role in the Formation of bile acids.

LIPID

BILAYER

PLASMA

MEMBRANE

Zellweger syndrome

+ a condition characterized by the absence of functional

peroxisome due to defect in peroxisome biogenesis

+ Peroxisome biogenesis disorders (PBDs), are a Group of

rare diseases involving the defective enzyme activities of

peroxisomes

+ zellweger syndrome is one of it and it is severe form

+ The victims of this disease may die within one year after

birth

+ The biochemical abnormalities associated with PBDs

include increased levels of very long chain Fatty acids and decreased

concentrations of plasmalogens

Mcq

1. What is the enzyme present in peroxisome?

a Enolase

v) Catalase

Zymase

Granzyme

©)

d)

2 what 1s the function of lysosome?

E. degradation

r. Blood supply

a. Helps in migration

H. Kills whe

3.protein is a macromolecule it is made up of?

I1.carbon

J. magnesium

k.aminoacids

L.sucrose

4 polysaccharides is made up of ?

m) monosaccharides

ny Aminoacid

o) Nitrogen

p) Potassium

S.example of prokaryote cell

a. bacteria

r.Rat cell

s. Human cell

7. Plant cell

Answers

1.b

2a

3.¢

4a

Sa

MEMBRANE TRANSPORT

Explain the structure of the plasma membrane.

Fluid mosaic model of Membrane

Passive Transport Mechanisms

Classify membrane transport mechanisms.

Add a note on active transport.

. Classify transport mechanisms across the

cell membrane. Define uniport, symport,

antiport with examples.

Explain the structure of the plasma membrane.

Fluid mosaic model of Membrane

Plasma Membrane :- It is a protective sheath.

- It is an elastic structure

- It envelops the cell body.

- This membrane separates extracellular fluid from

intracellular FAuid.

The plasma membrane consists of:

1) lipid layer

lipid bilayer is composed of three main types of

lipids:

- phospholipids

- sphingolipids

- cholesterol.

3. Membrane Proteins

The protein substances present in protein layer is

classified into two categories:

1. Integral proteins.

2. Peripheral Proteins.

4. Carbohydrate Groups

These are present only on outer side and attached to lipids ( glycolipids )

or protiens ( glycoprotiens ), aiding in cell recognition and

communication.

Cell Membrane Structure

Carbohydrate Sugar Hydrophilic Heads

Glycoprotein

ycop poy

Globular Proteins

: WS

Nie | STO AChalls

pes QOS Integral Membrane

Protei

Cell Membrane rorens

Receptor Proteins

Thought:

Peripheral Membrane

Proteins

Hydrophobic Tail

The fluid mosaic model, proposed by Singer and Nicolson, provides a

comprehensive understanding of the structure of biological membranes. This

model is widely accepted due to its accuracy in describing the complex

composition and behavior of cell membranes.

Membrane Thickness and Composition

Biological membranes are remarkably thin, typically ranging from 5 to 8

nanometers in thickness.

These membranes are primarily composed of a lipid bilayer, which is a double

layer of lipid molecules.

This bilayer serves as the fundamental structural component of the membrane.

Lipid Bilayer Arrangement

The hydrophobic (nonpolar) regions of the lipid molecules face each other at the

core of the bilayer, creating a hydrophobic interior.

the hydrophilic (polar) regions face outward, interacting with the aqueous

environment both inside and outside of the cell.

extrinsic (Peripheral) Membrane Proteins

- These proteins are loosely associated with the surface of the

membrane.

- They can be easily separated from the membrane.

- An example of an extrinsic protein is cytochrome c found in

mitochondria.

Intrinsic (Integral) Membrane Proteins

- Intrinsic proteins are tightly integrated into the lipid bilayer.

- They can only be separated from the membrane through the use of

detergents or organic solvents.

- Examples of intrinsic proteins include hormone receptors and

cytochrome P450.

Asymmetry and Mosaic Appearance

One of the critical observations of the fluid mosaic model is that

membranes exhibit asymmetry. This is due to the irregular distribution of

proteins across the membrane's surface, resulting in a mosaic-like

appearance. The combination of lipid and protein subunits in the

membrane creates a mosaic.

cholesterol

integral (intrinsic) proteins peripheral (extrinsic) protein

inner face

peripheral protein

(gtycoprotein)

Extracellular fluid

p==epaeeess\peaINe Tres

== Ui OLBALEN JAIN A0B AY

pergherat protein. Cyloplasm intergral protein transport protein shelersterol

Classify membrane transport mechanisms. Add a

note on passive and active transport

Transport mechanism across the cell membrane helps in

transport of essential substances like nutrients, water,

electrolytes to the cell

- It also helps the Cells to get rid of unwanted substances

like waste materials, C02 .

Classification :-

Simple

Diffusion [ Pump Vesicle

Osmosis

| Facilitated

Diffusion

ul

PASSIVE TRANSPORT

Simple diffusion :

«simple process depends on concentration gradient of a particular

substance across the membrane.

+ Passage of water and gases through membrane occurs by passive

diffusion.

«This process does not require energy.

2. Facilitated diffusion :

+ Solute moves along the concentration gradient (from higher to lower

concentration) and no energy is needed.

« distinguishing Feature is facilitated diffusion occurs through mediation

of carrier or transport proteins.

«Specific carrier proteins for the transport of

1glucose

2.galactose

3 leucine

4 phenylalanine have been isolated

Passive transport

Mechanism of Facilitated diffusion :

«transport carrier)protein exists in two conformations.

+ pong conformation-exposed to side with high solute concentration

+ This allows binding of solute to specific sites on carrier protein.

+ Protein undergoes a conformational change (ping state) to expose to the

side with low solute concentration

+ solute molecule is released.

« Hormones regulate Facilitated diffusion.

EXAMPLE:

linsulin- increases glucose transport in muscle and adipose tissue

2.amino acid -transport in liver and other tissues.

Active transport

Active transport is the movement of substances against the

chemical or electrical or electrochemical gradient.

- It is also called uphill transport.

- IE requires energy

- Energy is obtained by breaking down adenosine

triphosphate (ATP).

Carrier proteins involved in active transport are of two

types:

1. Uniport : carries a substance only in single direction

2. Symport/antiport: this type of carrier protein can

transports two substances at a time.

Active transport is of two types

i) primary active transport

ii)Secondary active transport

Primary active transport

It is the type of transport mechanism in which the energy

is

liberated directly from the breakdown of ATP.

sodium, potassium, calcium, hydrogen and chloride are

transported by this method.

Example :- sodium potassium ( Na+-K+) pump

This pump transports sodium from inside to outside the

cell and potassium is transported from outside to inside the cell

This pump is responsible for the distribution of sodium

and potori im inar anrare tha nall mamhrana

Active Transport

High concentration : Low concentration

gradient : gradient

CNN ee

© 4

Extracellular

fluid 1

Intracellular

fluid

|

Low concentration : High concentration

gradient gradient

Secondary active transport

It is the transport of a substance with sodium ion, by means

of a common carrier protein. i.e. When sodium is

transported by a carrier protein, another substance is also

transported by the same protein simultaneously.

- IE may be in the same direction of sodium movement or in

the opposite direction.

It may be in the same direction of sodium movement or in

the opposite direction.

Secondary active transport is of two types:

1. Cotransport ( same direction)

2. Counter transport. opposite direction )

Examples of Secondary Active Transporters

Co-transporters

(symporters)

Antiporters

Dopamine,

LO

ca?

Na\*/

neurotransmitter co-

transporter

Na‘/Ca\* Na'/H\*

exchanger exchanger

Na'/K\*/CI" co- K\*/CI" co-

transporter transporter

. Classify transport mechanisms across the cell

membrane. Define uniport, symport, antiport

with examples.

\*\*Classification discussed in another answer \*\*

Uniport system : This involves the movement of a single molecule through the membrane

e.g. transport of glucose to the erythrocytes.

2. Symport system : The simultaneous transport of two different molecules in the same

direction

e.g. transport of Na+ and glucose to the intestinal mucosal cells from the gut.

3. Antiport system : The simultaneous trans- port of two different molecules in the

opposite direction

e.g exchange of Cl— and HCO3— in the erythrocytes. Uniport, symport and antiport

systems are considered as secondary active transport systems.

Uniport Symport Antiport

1

1

Cotransport

Uniporter Synporter Antiporter

A A B A

Extra edge

Na+-K+ pump :

+ cells have a high intracellular K+ concentration and a low Na+ concentration.

« Na+-k+ pump Consists of two alpha and two beta subunits

+ Na+-K+ ATPase pumps 3Na+ ions from inside cell to outside and brings 2K+ ions

from the outside to inside with a concomitant hvdrolvsis of intracellular ATP.

3 Na+ (in) + 2K+ (out) + ATP ----- + 3Na\* (out)+ 2K\* (in) + ADP + Pi

+ major portion of cellular ATP utilized by Na+-K+ pump to maintain requisite

cytosolic Na+ and K+ levels.

« Quabain inhibits Na+-K+ ATPase.

Na+-cotransport system :

+ amino acids and sugars are transported into cells by Na+-cotransport system

+ consists of passage of glucose( or amino acid)into cell with a simultaneous

movement of Na+.

+ ATP is required to pump out intracellular Na+ through mediation of Na+-K+

ATPase.

Sodium-Potassium Pump

Extracellular fluid

TRANSPORT OF MACROMOLECULES:

- transport of macromolecules such as proteins, polysaccharides and

polynucleotides across the membranes is equally important.

- two independent mechanisms namely

1. endocytosis-intake of macromolecules by the cells

2.exocytosis -release of macromolecules from cells to outside

Endocytosis

Endocytosis :

- estimated approximately of exterior

surface of plasma membrane possesses

characteristic coated pifs.

- pits can be internalized to form

coated vesicles which contain an

unusual protein called clathrin.

+ Uptake of low density lipoprotein

(LDL) molecules by cells is a good

example of endocytosis.

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Exocytosis

Exocytosis:

+ Release of macromolecules to outside

of the cells mostly occurs via Golgi

apparatus.

- macromolecules are transported to

the plasma membrane in vesicles

- secretion of hormones (e.g) insulin,

parathyroid hormone) usually occurs by

exocytosis.

5

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Zh ES

MCQ’S

QT)WHICH OF THE FOLLOWING IS NOT AN PRIMARY ACTIVE

TRANSPORT?

a) Na-k atpase

b)h-k atpase

c)h atpase

d)cl-hc03 exchange

ANS:D)CL-HCO03 EXHANGE

Q2)WHICH OF THE FOLLOWING IS NOT AN TRANSPORT

SYSTEM?

A)uniport

B)symport

c)antiport

d)biport

ANS:D)BIPORT

Q3)MOVEMENT OF IONS IN NA-K ATPASE?

A)3na and 2k

b)2na and 3 k

c)3naand1k

d)2na and 2 k

ANS:A)3NA AND 2K

» Classification of carbohydrates with suitable examples.

+ Monosaccharides.

+ What are Mucopolysaccharides? Mention Describe their

biomedical importance with suitable examples.

«+ Compare and contrast the structural differences between

starch and glycogen.

€pimerism and anomerism.

utarotation.

Why is sucrose a non-reducing sugar?

Composition of sucrose, maltose and lactose.

Describe polysaccharides.

Describe disaccharides.

mucopolysaccharides, location, and its Function.

INTRODUCTION OF CARBOHYDRATES

They are the major source of energy from our diet.

They composed of the elements C, H and 0.

. They are also called saccharides, which means “sugars.” are produced by

photosynthesis in plants .

: Such as glucose which are synthesised in plants from C0zHO0, and energy from

he sun.

. (CH.0)n : Molecular/Chemical formula

n-> no. of total carbons

Isomers - 2N

n -> no. of asymmetrical/chimeric carbons

. Carbohydrates are compounds of biological importance , includes :

. provide energy through oxidation

. supply carbon for the synthesis of cell components

. serve as a form of stored chemical energy

. form part of the structures of some cells and tissues

major carbohydrates include

. D-Glucose

«+. Blood sugar. Main source of energy in body.

.D-Fructose

Constituent of sucrose, the common sugar.

. D-Galactose

Constituent of lactose, glycolipids and glycoproteins.

(J) . D-Mannose

Constituent of globulins, mucoproteins and glycoproteins.

BASICS OF CARBOHYDRATE CHEMISTRY

Carbohydrates defined as Poly hydroxy group with Aldehyde or

Ketones

«~ . POLYHYDROXY means many OH groups

«~. OH GROUP group makes the carbohydrate H i

. Polar Ad HoH

. Has tendency to bind phosphate ND SPC

. Suffix - ‘ol' ( €g. Glycerol ) H i

J). No.oFOHgroupsarelessthant Fa —

the no. of carbon atoms

«+. CHOLESTEROL - Amphipathic (polar & non-polar components)

«~ . ALDEHYDE OR KETONE - Functional Groups

«~ . Aldehyde group is always present at C1

«Keto group is always present at C2

«Functional carbon is symmetric but only in linear configuration «< .

SYMMETRIC CARBON - Any 2/3/4 valencies are occupied by same group-of

atoms

«~. ASYMMETRIC CARBON

GJ . Bn asymmetric carbon atom (chiral carbon) is a carbon atom that is attached to four

different types of atoms or groups of atoms

J . Whenever a compound has asymmetric carbon, that compound will show both structural

& optical isomerism

J . Central carbon is asymmetric & shows both Structural & Optical isomerism

GJ . Knowing the number of asymmetric carbon atoms, one can calculate the maximum

possible number of stereoisomers for any given molecule as follows:

&J . IF nis the number of asymmetric carbon atoms then the maximum number of isomers =

2n (Le Bel-van't Hoff rule).

J . An aldopentose with 3 asymmetric carbon atoms has 23 = 8 stereoisomers:

OH OH O

OH OH

CLASSIFICATION OF CARBOHYDRATES

Question: what is the classification of carbohydrates 2

CLASSIFICATION OF CARBOHYDRATES

Carbohydrates

Oligosaccharide Polysaccharide

Functional Ruma of || Di- Tr Tetra- Homopoly- Hetropoly-

gop || Soon saccharide | saccharide | saccharide | saccharide saccharide

atoms [

Tri Starch 4 ie

Aldoses rioses Maltose Raffinose Stachyose

e.g Glucose Dextrin Heparin

Tetroses Lactose

Chondroitin

Glycogen

Ketoses Pentoses Sucrose lycog sulfate

e.g Fructose Dermatan

Hexoses Cellulose Sulfate

Keratan

Inulin Sulfate

Heptoses

Question : what are different types of monosaccharides

and their biological importance

monosaccharides contain 2-9 carbon molecule

- Monosaccharides, often called simple sugars, are the simplest group of

carbohydrates.

- They have the general formula Cn(H20)n and cannot be Further

hydrolyzed.

- Monosaccharides are categorized based on the functional group and the

number of carbon atoms.

- Aldoses are monosaccharides with an aldehyde functional group (eg.

glyceraldehyde, glucose).

- Ketoses are monosaccharides with a keto functional group (eg.

dihydroxyacetone, fructose).

- Monosaccharides are further classified as trioses (3C), tetroses (4C),

pentoses (SC), hexoses (6C). and heptoses (7C) based on the number of

carbon atoms.

- These classifications, along with functional groups, are used in the

naming of monosaccharides. For example, glucose is an aldohexose, while

fructose is a ketohexose.

Monosaccharides

Trioses

Glyceraldehyde

Dihydroxyacetone

Tetroses

D-Enythrose

Pentoses

D-Ribose

D-Deoxyribose

D-Ribulose

D-Xylose

L-Xylulose

D-Lyxose

Hexoses

D-Glucose

D-Galactose

D-Mannose

D-Fructose

Heptoses

D-Sedoheptulose

Occurrence

Found in cells as phosphate

Found in cells as phosphate

Widespread

Widespread as a constituent of

RNA and nucleotides

As a constituent of DNA

Produced during metabolism

As a constituent of glycoproteins

and gums

As an intermediate in uronic acid pathway

Heart muscle

As a constituent of polysaccharides

(starch, glycogen, cellulose) and

disaccharides (maltose, lactose,

sucrose). Also found in fruits

As a constituent of lactose

(milk sugar)

Found in plant polysaccharides

and animal glycoproteins

Fruits and honey, as a constituent

of sucrose and inulin

Found in plants

Biochemical importance

Glyceraldehyde 3-phosphate is an intermediate

in glycolysis

Its 1-phosphate is an intermediate in glycolysis

Its 4-phosphate is an intermediate in

carbohydrate metabolism

For the structure of RNA and nucleotide

coenzymes (ATP, NAD\*, NADP?)

For the structure of DNA

It is an important metabolite in hexose

monophosphate shunt

Involved in the function of glycoproteins

Excreted in urine in essential pentosuria

As a constituent of lyxoflavin of heart muscle

The ‘sugar fuel’ of life; excreted in urine in

diabetes. Structural unit of cellulose in plants

Converted to glucose, failure leads to

galactosemia

For the structure of polysaccharides

Its phosphates are intermediates of glycolysis

Its 7-phosphate is an intermediate in hexose

monophosphate shunt, and in photosynthesis

Describe disaccharides.

Composition of sucrose, maltose and lactose.

DISACCHARIDES - 2 monosaccharides bound by glycosidic bond

Maltose Glu + Glu alpha (1-4) | Reducing sugar

Isomaltose Glu + Glu alpha (1-6) | Reducing sugar

Non - Reducing

Trehalose Glu + Glu alpha (1-1) sugar

Non - Reducing

Sucrose Glu+Fruc | alpha. (1.-2) sugar

Lactose Gal+ Glu B(1-4) Reducing sugar

< . When two monosaccharide are combined by glycosidic linkage, a disaccharide is

formed.

«~ . Therefore they yield two molecules of same or different monosaccharide on

hydrolysis.

«~ . General formula of Disaccharides : Cn(H20)n-1

«~ . They are formed when two monosaccharides combine in a

dehydration reaction

«<~ . Monosaccharides - Disaccharide

glucose + glucose - maltose + H20

glucose + galactose- lactose

glucose + fructose - sucrose

Sucrose

- Sucrose (cane sugar) is a common commercial sugar produced

primarily from sugar cane and sugar beets.

- Sucrose consists of two monosaccharides: a-D-glucose and 3-

D-fructose.

- These two monosaccharides are connected by a glycosidic bond

(a-12 linkage), specifically between C1 of a-glucose and C2 of 3-

fructose.

- Because the reducing groups of glucose and fructose are

involved in the glycosidic bond, sucrose is a non-reducing sugar

and cannot Form osazones.

- Sucrose is a significant source of dietary carbohydrates and is

employed as a sweetening agent in the food industry.

- It is sweeter than most common sugars, such as glucose,

lactose, and maltose (except for fructose).

- In the intestine, the enzyme sucrase hydrolyzes sucrose into

glucose and fructose, which are then absorbed into the body.

MALTOSE

«~ Maltose, is a disaccharide Formed from two units of glucose.

«~ . Maltose is commonly called Malt Sugar.

«It is produced commercially and used as an energy

«source for growing embryo in seed

«~ Used in alcohol production.

LACTOSE

«lactose is a disaccharide derived from the condensation of Galactose and

glucose

«Lactose is commonly called Milk Salt

«It is Dextrorotatory

«Lactose requires you have an enzyme called lactase to digest FUNCTIONS

«Widely used in food industry.

«Also used as filler in tablets.

EXTRA EDGE

What is inversion of sucrose ?.?

- Sucrose is naturally dextrorotatory (+66.5°).

- When sucrose is hydrolyzed, it becomes levorotatory (—28.2%), and this change

in optical rotation is called inversion.

- The hydrolyzed mixture of sucrose, containing glucose and fructose, is known

as invert sugar.

- The process of inversion occurs during the hydrolysis of sucrose, which can be

catalyzed by the enzyme sucrase (invertase) or dilute acid.

- During this process, sucrose is first split into a-D-glucopyranose (+52.5°) and

[3-D-fructofuranose, both of which are dextrorotatory.

- However, 3-D-fructofuranose is less stable and quickly converts to 3-D-

fructopyranose, which is strongly levorotatory (92°).

- As a result, the overall effect is that dextrorotatory sucrose (+66.5°) is

converted to the levorotatory form (—28.2°) after inversion.

[tS revision time

Carbohydrates

Monosaccharide Oligosaccharide Polysaccharide

Number of : 22 H o Hetropol

Functional Di- Tri- Tetra- omopoly poly-

| group Shen | saccharide LE saccharide | saccharide || saccharide

Starch Hyaluronic

Aldoses | Trioses Maltose | Raffinose | Stachyose { J | add

{ § 4

e.g Glucose | Dextrin Heparin

Tetroses Lactose J | J § J

- ~ Chondroitin

Glycogen

Ketoses || Pentoses Sucrose J ( ycog sulfate

e.g Fructose - Lconidosa Dermatan

Hexoses \ | \_\_\_ Sulfate

imilin Keratan

Heptoses | | \_\_ Sulfate

—

POLYSACCHARIDES

Question: what are different types of polysaccharides 2

POLYSACCHARIDES are two types

1. HOMO POLYSACCHARIDES

«Made up of same carbohydrate units

«Mostly Branched

2. HETERO POLYSACCHARIDES

«Made up of different carbohydrates units

«+ Mostly unbranched

HOMOPOLYSACCHRIDES

«different types of HOMO POLYSACCHARIDES

1. STARCH

2. GLYCOGEN

3. DEXTRAN

4. CelLULOSE

S. INULIN

6.DEXTRIN

7.CHITIN

-y &,

Starch Glycogen Cellulose

LA iaded 0 VRPT

Amylose

Question : what are different and similarities Btw starch and glycogen?

Similarities

1. Both starch and glycogen are polysaccharides, composed of multiple sugar

(glucose) units linked together.

2. Glucose is the basic repeating unit in both starch and glycogen, connected by

glycosidic bonds.

3. They serve as storage forms of carbohydrates in their respective organisms,

providing a readily available energy source.

4. Both starch and glycogen contain a-glycosidic bonds in their structures, which

contribute to their branching patterns.

Differences between Starch and Glycogen:

Starch:

1. Starch is primarily found in plants and serves as their carbohydrate reserve.

2. It consists of two main components, amylose (water-soluble) and amylopectin

(water-insoluble), each with distinct structural characteristics.

3. Amylopectin is branched with a(1—6) glycosidic bonds at the branching points,

creating a more complex structure.

4. Starch is an essential dietary component for humans and plays a significant role in

nutrition.

Glycogen:

1. Glycogen is the primary carbohydrate storage molecule in animals, including

humans.

2. It is highly concentrated in the liver, muscles, and other tissues of animals.

3. Glycogen has more numerous branches than starch, with a(1—#6) glycosidic

bonds at branching points.

4. Glycogen primarily Functions as a short-term energy reserve in the human body,

particularly in muscles and the liver.

Starch grains

in chloroplast

a 3

Glycogen

granules

in liver cell

microfibril

in cell wall

Glycogen Cellulose Starch

Question:what is dextran and use of it 2

DEXTRAN

«~ Made up of apha - glucose

«+ Hasa(1>4),a(1>6),a(1>2),a(1»3)bonds

«+ High molecular weight structure

«Highly branched structure

« i/v (intravenously) Dextran is used as Plasma volume expander in hypovolemic shock

«In Gel Filtration chromatography, Gel is dextran

CELLULOSE

- Cellulose is exclusively Found in plants and is the most abundant organic substance in the plant

kingdom.

- It is @ major component of plant cell walls, providing structural support.

- Cellulose is completely absent in the bodies of animals.

- Cellulose is composed of (3-D-glucose units linked by 3(1—4) glycosidic bonds.

- Mammals, including humans, lack the enzyme needed to break (3-glycosidic bonds, so they

cannot digest cellulose (a-amylase breaks a-bonds only).

- Some ruminants and herbivorous animals have gut microorganisms that produce enzymes

capable of cleaving 3-glycosidic bonds.

- Hydrolysis of cellulose results in the formation of the disaccharide cellobiose, followed by [3-

D-glucose.

Donot get confused

“Dextrins result from starch

breakdown, while dextrans are

glucose polymers in microbes \*

DextRAN - runs in blood ‘(plasma

volume expander )

Extra edge

Question:what are different types of Fibers 2

FIBRES - TYPES

1. INSOLUBLE

- Cellulose

- Hemicellulose

«~ Excreted unchanged

2. SOLUBLE

.- Pectins

« Absorbs water & converted to Gel form, which is excreted

«<~ Better in preventing Constipation

Question:what is inulin and use of it 2

INULIN

Made up of B Fructose

USES

«~ Ideal for measuring GFR

«~ PREBIOTIC (Food for Bacteria)

HETEROPOLYSACCHRIDES

Question: What are heteropolysacchrides and features 2

Mucopolysaccharides are heteroglycans made up of repeating units of

sugar derivatives, namely amino sugars and uronic acids. These are more

commonly known as glycosaminoglycans (GAG).

«. Defined as Tandem Repeat AS- UA

«Present in mucus secretions (lubricant)

«All GAGS combine with proteins to form PROTEOGLYCANS

«Highly SULFATED

«Contains more negative charge

«+. Slimy & Slippery

EXAMPLES

Mucopolysaccharides or glycosamino glycans (GAG) are heteropolysaccharides,

containing uronic acid and amino sugars.

Acetylated amino groups, sulfate and carboxyl groups are also generally present.

They attract water molecules and so they produce viscous solutions.

Mucopolysaccharides in combination with proteins Form mucoproteins. Examples of

mucopolysaccharides are.

1. Hyaluronic Acid

It is present in connective tissues, tendons, synovial fluid and vitreous humor.

lt serves as a lubricant in joint cavities.

It is composed of repeating units of N-Acetyl-glucosamine — Glucuronic acid

2. Heparin

It is - anticoagulant widely used when taking blood in vitro for clinical studies.

It is also used in vivo to prevent intravascular coagulation.

|t activates antithrombin lll, which in turn inactivates thrombin, factor X and Factor IX.

Heparin is present in liver, lungs, spleen and monocytes.

3. Chondroitin Sulphate

It is present in ground substance of connective tissues

Widely distributed in cartilage, bone, tendons, cornea-and skin.

4. Keratan Sulphate

It is the only GAG which does not contain any uronicacid.

The repeating units are galactose and N-acetyl glucosamine in beta linkage.

It is Found in cornea and tendons.

JS. Dermatan Sulphate:

It is Found in skin, blood vessels and heart valves.

It is helpful in maintaining shape and structure of tissue.

Question: what are differences btw proteoglycans and glycoproteins 2

PROTEO GLYCANS GLYCO PROTEIN

Carbohydrate >>> Protein Protein >>> Carbohydrate

Ex: GAGS Ex: Collagen

Carbohydrate is always ALL plasma proteins

Heteropolysaccharide > EXCEPT ALBUMIN (only protein)

Proteoglycan

A corepmoten OA¢

~ >

Proteoglycans are

> heavily glycosylated

proteins. It consists of a

core protein and one or

more harris lycan

chains GAGS].

T SAMPLE STRUCTURE OF A

PROTEOGLYCAN

ISOMERISM

Question : What are isomerism for carbohydrate 2

Isomerism

«<~ The existence of two or more molecules having the same molecular

formula, but with different bonding arrangements of atoms, or different

orientation of their atoms in space

(1) STRUCTURAL / STERIO ISOMERISM

Functional

Enantiomerism

Epimerism

Anomerism

2)OPTICAL ISOMERISM

Question : What are types of structural isomersim 2

STRUCTURAL / STERIO ISOMERS - compounds with the same molecular

formula, but which differ in the spatial arrangement of their atoms.

(1)FUNCTIONAL ISOMERS

«<~ . Two or mare compounds having the same molecular formula but different functional

groups are functional group isomerism.

2 . ENANTIOMERISM | D/ L ISOMERISM / mirror images

«~ . Different H & OH orientation around the penultimate carbon Reference 2nd

last carbon

<~ ABUNDANT FORMS IN Carbohydrates are D forms , Amino Acids are L

forms

OM On

H——OH HO—1—H

HO—t—H H=—-1+—0OH

H=—1+—0OH HO=—t—H

H—+—OH HO——H

CH,0OH CH,OH

D-Glucose L-Glucose

3. EPIMERISM

« . Always Exogenous

« . Different H & OH orientation around only one carbon other than

penultimate carbon

«<~ . Mannose is epimer of glucose at C2

«<~ . Galactose is epimer of glucose at C4

<~ . Mannose & Galactose are not epimers of each other

Question : What are different anomersims for carbohydrate 2

4. ANOMERISM

«~ . Linear Structures To Cyclic Structure’s

«<~ . The combining carbons are Functional carbons; Always combine with 2nd last

carbon

CYCLIC STRUCTURE

1) PYRANOSE

« . 6 Membered Ring

<~ . No. of carbons -5

2) FURANOSE

< . 5 Membered Ring

<~ . No. of carbons -4

CH,OH

HOH ( 0 CH,OH|

H OH OH H

Haworth projection of Haworth projection of

A} PYTanosc 1 furanosc

«< . Glucose includes 99% Pyranose, 1% Furanose mainly Pyranose

«< . Fructose includes 1.99% Furanose g% pyranose mainly Furanose

«~ . In Hexoses (6C) Both Pyranose & Furanose exists

« . In Pentoses (5C) Only Furanose exits

Question : What are types of optical isomersim 2

OPTICAL ISOMERISM

. Same molecular formula but different optical properties

. right - dextro rotatory (d) (+)

. Left - levo rotatory CI) (-)

. Glucose is always d (+)

. Fructose is always | (-)

. Levo rotatory power of Fructose more than Dextro rotatory power

of Glucose

«~ RACEMIC MIXTURE - Equal d + |, Optically inactive

«~ RACEMASE - Interconvert 2 isomers

5% 4 &§ 4

CHO CHO

Ho—f—n 1—f—on

CH,OH CH,OH

L-Glyceraldehyde D-Glyceraldehyde

Question : What are test for carbohydrate 2

TESTS

1. MOLISCH TEST

«~ . General test given by all

«<~ . No. of carbons > = 5

2. BENEDICT'S TEST

«<~ . Given by reducing sugars to detect the presence of glucose

in urine (gluco- suria).

« . Itis a standard laboratory test employed to diagnose

diabetes mellitus.

«~ . Benedict's reagent contains sodium carbonate, copper sulphate and

sodium citrate.

«~ . Any sugar with free aldehyde/ keto group will reduce the Benedict's

reagent

« . Therefore, this is not specific for glucose

None Traces of Moderate Large

reducing sugar amount of

reducing

3. SELIWANOFF TEST

« . Distinguish b w keto & Aldehyde sugar

« . Positive in keto sugar

4. BARFOED'S TEST

« . Positive in monosaccharides

«~ . Distinguishes b w mono & Disaccharides

5. GOD - POD TEST ( Glucose Peroxidase Oxidase Enzymatic test)

«~ Measures blood glucose

GLUCOSE under action of GOD form Gluconic Acid + H202 under action

POD coloured Compound formed

«~ . Accurate

6. Osazone Formation

«< . All reducing sugars will form osazones with excess of phenylhydrazine when kept

at boiling temperature

«~ Osazones are insoluble.

«~ Each sugar will have characteristic crystal form of osazones

Introduction

This chapter uncovers the central role of proteins in our lives. Enzymes drive chemical

reactions, hormones regulate our bodies, and immunoglobulins protect us from

infections, all hinging on proteins. Understanding denaturation, where proteins unravel

due to factors like heat, sheds light on why some injections require refrigeration.

But this journey isn't confined to textbooks; it's practical. In today's fitness-conscious

world, proteins are key to sculpting the body you desire. You'll grasp the significance of

amino acids, the building blocks of life, and their essential role in nutrition. You'll

differentiate between proteins that align with your fitness goals and those to avoid.

These insights will guide your daily dietary choices and fitness routines.

Through this exploration, you'll realize that proteins are the foundation of life, shaping

not only your health but also your understanding of the world within and around you.

Amino acids and proteins

Amino Acids:

- Compounds with both amino group (NH2) and carboxyl (COOH) groups.

- Building blocks (monomeric units) of peptides and proteins bonded by peptide bonds.

Peptides and Proteins:

- Polymers of amino acids bonded by peptide bonds.

Peptide Bonds:

- Formed between two amino acids.

- Created between a carboxyl group of the first amino acid and an amino group of the

next.

- Number of peptide bonds is one less than the amino acid residues in the chain (eg.

dipeptides have 2 amino acids and 1 peptide bond).

Amino Acids / Amino Acid Residues:

- Once included in a peptide or protein chain, they are called amino acid residues or amino

acid moieties.

Difference between Peptides and

Proteins:

- Peptides: 2-50 amino acids in the

chain.

- Oligopeptide: 2-10 amino acids.

- Polypeptide: 11-50 amino acids.

- Proteins: More than S50 amino acids.

- Note: Some authors consider chains

with over 100 amino acids as proteins.

- Example: Insulin (S1 amino acids) can be

labeled as a protein or polypeptide.

Proteins are organic compounds with a high molecular weight formed of carbon, oxygen,

hydrogen and nitrogen and may also contain sulphur, phosphorus and non-protein

organic groups and metal ions.

They are polymers formed of subunits called amino acids linked

Together by peptide linkage.

INTRODUCTION

«Functional groups of Amino Acids

1. Amino group is always on left side

2. Acid group is always on right side

«Central carbon atom is Asymmetric

«&. Can show both Optical & Structural Isomerism

«. ALL AA HAVE 1 ASYMMETRIC CARBON , EXCEPTIONS

No asymmetrical carbon - Glycine

2 asymmetrical carbons - Isoleucine, Threonine

Classification of amino acids based on nutritional requirement with suitable

examples.

Classification of amino acids based on chemical structure with suitable

examples.

Classification of amino acids

The 20 primary protein amino acids can be classified on several basis. These are,

|. Based on the Chemical structure:

Amino acids are classified into 7 structural groups.

1) Aliphatic amino acids:

a) Non-branched chain amino acids: Glycine, Alanine.

b) Branched chain amino acids: Valine, Leucine and

Isoleucine.

2) Aromatic amino acids: Tryptophan, Phenylalanine,

Tyrosine, Histidine

3) Sulphur containing amino acids: Cysteine and

Methionine.

4) Hydroxy amino acids:Serine, Threonine and Tyrosine

5) Amino acids with amide group (CON8i): Asparagine,

Glutamine

6) Charged amino acids: Include Acidic amino acids,

basic amino acids.

a) Acidic amino acids: Aspartic acid, Glutamic acid

b) Basic amino acids: Lysine, Arginine, Histidine.

7) Imino acids (contain an imino group): Proline (Pro)

Il. Based on the Charge:

Amino acids are classified into 3 groups based on the

charge on their R - group.

a) Acidic Amino Acids (Monoamino dicarboxylic acids):

These have acidic R groups. €.g.: Glutamic Acid,

Aspartic Acid

b) Basic Amino Acids (Diamino monocarboxylic acids):

These have basic R groups. €g. Lysine, Arginine, and

Histidine

c) Neutral Amino Acids (Monoamino monocarboxylic

acids):

They have neutral R groups. €.g: Glycine, Alanine etc

lll. Based on the polarity

1. Polar amino acids: They are

hydrophilic in nature

€g.Glycine, serine, cysteine,

threonine, glutamine, lysine, arginine,

glutamic acid etc.

2. Non-polar amino acids: They arc

hydrophobic in nature.

€g.Alanine, Phenylanine, tryptophan,

valine, leucine, isoleucine. methionine

etc.

IV. Based on the Nutritional

requirement:

Based on the nutritional requirement,

the amino acids can be classified into

Ewo groups-

Essential amino acids - examples given

in essential amino acid question

(MATT VIL PHLY)

Non-essential amino acids.(Glycine,

alanine, serine, cysteine, tyrosine,

aspartic acid, glutamic acid,

asparagine, glutamine, proline)

Classification based on metabolic status:

Glucogenic :- Can be converted to glucose in the body after the removal of the amino

group.

Ex:-Glycine, Alanine, Serine, Threonine, Glutamic acid, Glutamine,

Ketogenic :- Can be converted to ketone bodies, acetyl CoA, or fat after the removal of

the amino group.

- Example: Leucine.

Both glucogenic and ketogenic :- Can split into two parts after the removal of the amino

group; one part can be converted to glucose, and the other can be converted to ketone

bodies or fat. ~~ Examples: Lysine, Isoleucine, Tyrosine, Phenylalanine, Tryptophan.

Essential amino acids.

Essential amino acids (Indispensable amino acids):

Amino acids, which are not synthesized in the body and therefore have to be

supplied throughthediet,arecalledessentialaminoacids. Theseare;

1. Methionine

2. Arginine\*

3. Threonine

4. Tryptophan

3. Valine

6. Isoleucine

7. Leucine

8. Phenylalanine

9. Histidine

10.Lysin

Importance of essential amino acids:

Twenty amino acids needed for protein synthesis, with the body capable of

producing non-essential amino acids.

- Essential amino acids must come from dietary proteins as the body cannot

synthesize them.

- Dietary proteins are the sole source of essential amino acids for the body.

- Lack of essential amino acids in the diet hinders protein synthesis and results in

negative nitrogen balance.

- Proteins lacking one or more essential amino acids fail to support proper growth

and body tissue maintenance.

Matt vil phly

Semi-essential amino acids: Among the essential amino acids, arginine and

histidine are called semi-essential amino acids as they are essential in the d iet

of children, pregnant & lactating women (Semi-essential amino acids are not

synthesized in sufficient quantities in these physiological groups) & are not

essential in the diet of normal adults.

Extra edge

Amphoteric nature of amino acids (Ampholytes):

Amino acids are ampholytes, because they behave both as an Acid and as a Base.

a) behavior as an Acid: In the presence of a base, amino acids can donate a proton and thus

acts as an acid.

b) Behavior as a Base: In the presence of an acid, amino acid can accept a proton

thus acts as base

Since amino acids can act both as an acid (i.e. proton donor) and a base (i.e. proton

acceptor), they are said to have amphoteric nature (ampholytes).

Isoelectric pH (pl) of amino acids

What is zwitter ion and their properties ?

Isoelectric pH (pl) of an amino acid is defined as the pH at which amino acids

exist as neutral zwitterions (dipojar ion).

€.g: pl of aspartic acid is 2.9; pl of glycine is 6.1; pl of histidine is 7.6

At Isoelectric pH, amino acids possess equal number of positive and negative

charges, hence bear no net charge, do not move in an electric field.

A zwitter ion is an ion that contains two functional groups. In simple

terms,

it is an ion possessing both positive and negative electrical charges.

Therefore, zwitterions are mostly electrically neutral (the net

formal charge

is usually zero).

H HE

| |

HoN—C=COOH === \*HisN — C— coo"

L R

Amino acid Zwitterion

EXTRA EDGE

Define limiting amino acids.

The term “limiting amino acid" is used to describe the essential amino acid present in the lowest

quantity in a food protein relative to a reference food protein like egg whites. The term “limiting

amino acid" may also refer to an essential amino acid that does not meet the minimal requirements

for humans

Examples :- lysine, threonine,

methionine, and tryptophan

Explain disorders of sulfur-containing amino acids.

1. Cystinuria:

- Cystinuria is a genetic disorder where the renal tubules fail to reabsorb

cystine efficiently. This results in the accumulation of cystine in the urine,

leading to the Formation of cystine stones in the kidneys and urinary tract.

2. Homocystinuria:

- Homocystinuria is an inherited metabolic disorder characterized by the

accumulation of homocysteine in the blood and urine. It can result from

deficiencies in enzymes involved in homocysteine metabolism. This condition

can lead to various health problems, including eye, skeletal, and

cardiovascular issues.

3. Methionine Malabsorption:

- In methionine malabsorption disorders, the body has difficulty absorbing

and utilizing methionine. This can lead to various symptoms and issues

related to methionine deficiency.

4. Cystathioninuria:

- Cystathioninuria is a metabolic disorder in which there is an elevated

excretion of cystathionine in the urine due to an enzyme deficiency. It is

typically considered a benign condition with no associated clinical symptoms.

Peptide bonds

Definition :

Peptide bonds are anhydride, covalent bonds formed between a carboxyl group of an

amino acid and an amino group of succeeding amino acid.

H H 0

H rt 4° H I

\ #2 AN 74 Fra

N—C—C # N—=C—¢C a

HL Son WoL Son

R, R.

Amino acid 1 Amino acid 2

Gh 10] Gag

Ha 23 a Le ik

HO + N=C=C=N=C=C —

hoo | “oH

R: Peptide R:

bond

Water Dipeptide

Salient features of peptide bonds:

1) Peptide bond is a strong covalent bond.

2) Peptide bond is an anhydride bond (j.e. formed by the loss ofa water

molecule).

3) Peptide bonds are amide linkages.

4) Peptide bond generally exists in -trans configuration (exception is

peptide bond formed by proline, a imino acid, which has -cis

configuration).

JS) Peptide bonds are partial double bond in nature.

6) Peptide bonds are semi-rigid in nature.

7) All atoms - C, N, 0 and Hare coplanar.

8) During denaturation, peptide bonds are not affected, because peptide

bonds are strong covalent bonds.

Importance of peptide bonds:

Peptide bonds are responsible for the polymerization of amino acids to

form peptides (oligopeptides and polypeptides) and proteins.

Biologically important peptides (biological

importance of peptides).

Physiologically (Biologically) important peptides:

Bodycontainsmanyimportantpeptides(containing2-50aminoacids) thathavediverse

physiological functions.

These are,

1) Camosine and Anserine: Both are dipeptides. Carnosine is made up of ~-alanine &

histidine; anserine is a derivative of carnosine. These peptides are present in

muscles.

2) Glutathione (-y- glutamyl cysteinyl glycine): It is a tripeptide made up ofy-

glutamic acid, cysteine and glycine.

Present in erythrocytes in large amounts. It is a powerful reducing agent and

involved in various reduction reactions in the body. ( \*\*futher information given in

glutathione question\*\*')

Glutathione functions are discussed in detail in next page.

3) Thyrotropin releasing hormone (TRH): A tripeptide secreted by hypothalamus,

stimulates the pituitary gland to release thyrotropin stimulating hormone (TSH).

4) Enkephalins: Pentapeptide neurotransmitters. Enkephalins inhibit pain sensation.

3) Oxytocin:Anonapeptidehormonesecretedbyposteriorpituitary.ltcausesuterine

contraction.

6) Vasopressin (ADH): A nonapeptide hormone secreted by posterior pituitary. It is

required for smooth muscle contraction and water reabsorption.

7) Bradykinin: Nonapeptide. It is a vasodilator.

8) Kallidin: Decapeptide. It is a vasodilator.

9) Angiotensins: Angiotensin Il (octapeptide) is derived from Angiotensin |

(decapeptide). Angiotensin Il is a hypertensive peptides, stimulates the release of

aldosterone from adrenal glands.

10) Glucagon :It is a hyperglycemic hormone.

11) Gramicidin, Actinomycin (Antibiotics) are peptides in nature.

12) Gastrin, Secretin (Gastrointestinal hormones) are also peptides.

13) Insulin (51 amino acids): Secreted from ~-cells of islet of langerhans. It is a

hypoglycemic hormone, lowers blood glucose level.

Glutathione

Glutathione (Abbreviated as GSH):

Glutathione (or y- glutamyl cysteinyl glycine) is tripeptide made up of y-glutamic acid,

cysteine and glycine. Glutathione is abbreviated as GSH, because sulfhydryl group (SH) of

cysteine is the active group of glutathione.

Structure of GSH : y Glutamic acid - Cystein - Glycine

It exists in 2 forms, reduced glutathione (GSH) and oxidized glutathione (GS-56).

H202 HO

GSH peroxidase

GSH ————— SSG

A — o ge

(Reduced) GSSG reductase (oxidised)

NADP\* NADPH, H\*

Reduced form of glutathione is biologically active and it is a powerful reducing agent,

required for many reduction reactions.

Functions:

1. GSH is involved in the anti-oxidation of toxic oxidants like hydrogen peroxide, and

superoxides by its peroxidase activity. This reaction is catalyzed by glutathione

peroxidase, a selenium containing enzyme. In this reaction, reduced glutathione (GSH) will

e converted to oxidized glutathione (GS-SG).

Glutathione's

antioxidant

properties are

utilized in skin

whitening

treatments

2. GSH required for the intestinal absorption of iron by convering Fe<3 to Fes2

3. GSH required for the recoversion of methemoglobin (Fe+3) to Hemoglobin (Fe+2).

4. Glutathione also has a coenzyme role (€.g. Maleyl acetoacetate isomerase etc)

3S. GSH protects the sulfhydryl (SH) group of several enzymes | proteins.

6. Meister cycle: Glutathione is also involved in the transport of amino acids in the

kidney tubules via Meister cycle or y- glutamyl cycle.

7. GSH is involved in the detoxification of bromobenzene to mercapturic acid.

Proteins

Structure of protein

The structure of proteins is rather complex which can be divided into 4 levels of

organisation

1.Primary structure: The linear sequence of amino acids forming the backbone of proteins

(polypeptides).

2secondary structure:The spatial arrangement of protein by twisting of the polypeptide

chain.

3 Tertiary structure: The three dimensional structure of a functional protein.

4. Quaternary structure: Some of the proteins are composed of two or more polypeptide

chains referred to as subunits.

The spatial arrangement of these subunits is known as quaternary structure.

For your understanding

Amino Acids

A S

~\*° ° °° ALN

uU 0 e® ® .

. °° H 0? >

Alphabets — uu— Primary Structure . °

Vv T %ee® 2

02° %%%, .

R P o’ %ee’

\\_ y [PR SE

Pleated Sheet Alpha Helix

Antibodies Science

Useful Routine

Words ml) Secondary Structure

Vital Tool

Rely Practices

J

v

i Sy

Antibodies are a useful tool Pleated Sheet

Routine practices rely Cpe >

on at ibodion Sentences Tertiary Structure Alpha Helix

Science is vital.

Antibodies are a useful

tool in the advancement

of research. Routine practices

h as West: Blot

sioslin schanisitn Paragraphs «ue Quanternary Structure

Immunofluorescence,

Immunoprecipitation and Flow

Cytometry, rely on antibodies

Structural organisation of proteins (primary,

secondary, tertiary and quaternary structure).

PRIMARY STRUCTURE OF PROTEIN

1. €ach protein has a unique sequence of amino acids which is

determined by the genes contained in DNA.

2. The primary structure of a protein is largely responsible for its

function Lead to many genetic diseases.

3. The amino acids are held together in a protein by covalent

peptide bonds or linkages.

4. These bonds are rather strong.

3. Formation of a peptide bond: When the amino group of an amino

acid combines with the carboxyl group of another amino acid, a

peptide bond

6. dipeptide will have two amino acids and one peptide bond

7 Ine eptide bond is rigid and planar with partial double bond in

character.

N-terminus

C-terminus

Secondary structure of proteins

SECONDARY STRUCTURE OF PROTEIN

1. The conformation of polypeptide chain by twisting or folding is

referred to as secondary structure.

2. The amino acids are located close to each other in their

sequence.

3. Two types of secondary structures,

a-helix and

B-sheet

alpha - Helix

it is most common spiral structure of protein.

. It has a rigid arrangement of polypeptide chain.

. The a-helix is a tightly packed coiled structure with amino acid

side chains extending outward from the central axis.

. The a-helix is stabilised by extensive hydrogen bonding. It is

formed between H atom attached to peptide N, and 0 atom attached

to peptide C.

. The hydrogen bonds are individually weak but collectively, they are

strong enough to stabilise the helix.

. All the peptide bonds, except the first and last in a polypeptide

chain, participate in hydrogen bonding.

. €ach turn of a-helix contains 3.6 amino acids and travels a

distance of 0.54 nm.

. The spacing of each amino acid is 0.15 nm.

.a-Helix is a stable conformation formed spontaneously with the

lowest energy.

Secondary structure

Hydrogen bond

B-Pleated sheet

. This is the second type of structure . B-sheetsare composed

of two

or more segments of fully extended peptide chains.

. In the B-sheets, the hydrogen bonds are formed between

the neighbouring segments

Parallel and anti-parallel -sheets

RD B pleated sheet &.-

219 Tn 5... 98." B strand, shown as a flat

we % arrow pointing toward

BH dF the carboxyl end \

3% oN ; +a 1 Pleats

i AL TH Hydrogen bond

ig. J X 1]

BE I a a | PRS 9 Pi 3

ar Wl?

TERTIARY STRUCTURE OF PROTEIN

1. The three-dimensional arrangement of protein structure is

referred to as tertiary structure.

2.1t is a compact structure with hydrophobic side chains held

interior while the hydrophilic groups are on the surface of the

protein molecule.

3. This type of arrangement. ensures stability of the molecule.

4. Bonds of tertiary structure: Besides the hydrogen bonds,

disulfide bonds (-s -S), ionic

interactions (electrostatic bonds) and hydrophobic interactions also

contribute to the tertiary structure of proteins.

Beta sheet

Tertiary structure

Alpha helix

QUATERNARY STRUCTURE OF PROTEIN

1. Some of the proteins, however, consist of two or more

polypeptides which may be identical or unrelated.

2. Such proteins are termed as oligomers and possess quaternary

structure.

3.. A dimer consits of two polypeptides while a tetramer has four

Bonds in quaternary structure

4. The monomeric subunits are held together by non-covalent bonds

namely hydrogen bonds, hydrophobic interactions and ionic bonds.

3. These proteins play a significant role in the regulation of

metabolism and cellular function.

6. Examples of oligomeric proteins: Hemo-globin, aspartate

Eranscarbomylase, lactate

HEMOGLOBIN

Iron Heme

Polypeptide ~ Oxygen

chain molecules

Summary

Amino acids

Primary protein structure

sequence of a chain of

animo acids

AN

Vv

Alpha helix Secondary protein structure

hydrogen bonding of the

peptide backbone causes

the amino acids to fold into

a repeating pattern

Pleated sheet

Tertiary protein structure

three-dimensional folding

pattern of a protein due to

side chain interactions

Quaternary protein structure

protein consisting of more

than one amino acid chain

Extra edge

Chaperones (Heat shock proteins):

Some proteins can spontaneously undergo folding to attain the active

conformation. But, some proteins require a specialized group of proteins

known as chaperones (or heat shock proteins) that assist in protein folding.

Chaperones reversibly bind with unfolded proteins to cause the proteins to

fold and attain the compact and biologically active conformations.

Bonds responsible for protein structure

Protein structure

-Covalent Bonds: These are strong bonds in protein structure.

- Peptide Bonds:Formed between amino acids, creating the

protein's backbone.

- Disulfide Bonds:Created by the sulfur groups (SH) of cysteine

residues, contributing to structural stability. They can form within

a single polypeptide chain or between different chains.

- Non-Covalent Bonds: These are weaker, but collectively crucial for

protein structure.

- Hydrogen Bonds:Formed by sharing hydrogen atoms between

the nitrogen and carbonyl oxygen of different peptide bonds.

- Hydrophobic Bonds:Non-polar amino acid side chains tend to

associate with each other.

- Electrostatic Bonds:0ccur between negatively charged (C00)

and positively charged (NH3+) groups in amino acids.

- Van der Waals Forces:Non-covalent associations between

electrically neutral molecules, resulting from electrostatic

interactions due to dipoles.

Extra edge

Protein Characteristics:

1. Solubility. :Proteins Form colloidal solutions in water due to their large size.

2. Molecular Weight - Protein molecular weights vary based on the number of

amino acid residues. They range from 4,000 to 440,000.

- Examples: Insulin (5,700), Myoglobin (17,000), Hemoglobin (64.450), Serum

albumin (69,000).

3. Shape:- Proteins exhibit a wide variety of shapes, including globular (insulin), oval

(albumin), and fibrous (fibrinogen).

4. Isoelectric pH (pl):- The isoelectric pH (pl) is determined by the nature of amino

acids. At pl, proteins are electrically neutral.

- Examples: Pepsin (1.1), Casein (4.6), Human albumin (4.7), Urease (3.0), Hemoglobin

(6.7), Lysozyme (11.0)

S. Acidic and Basic Proteins:- Basic proteins have a higher ratio of (Lys + Arg) to (Glu

+ Asp), while acidic proteins have a lower ratio.

6. Precipitation of Proteins:-

- Precipitation at pl: Proteins are least soluble at their isoelectric pH and can be

precipitated.

- Precipitation by Salting Out:- Neutral salts like ammonium sulfate cause protein

precipitation, with the amount required depending on molecular weight.

- Salting In: Small salt quantities increase protein solubility.

- Precipitation by Heavy Metal Salts:- Heavy metal ions like Pb2+ cause protein

precipitation.

~ Precipitation by Anionic Reagents:- Anionic acids like tannic acid can precipitate

proteins.

- Precipitation by Organic Solvents:- Organic solvents like alcohol dehydrate

proteins, causing precipitation.

7. Color Reactions:- Proteins give various color reactions useful for identifying amino

acids present in them.

Denaturation of proteins and agents causing denaturation.

Definition: The process of disorganization of native protein structure is called

Denaturation. Denaturation involves the loss of secondary, tertiary and

quaternary structures without breaking the primary structure.

Denaturation causes the unfolding of native 3-dimensional form of proteins.

Reason: Higher structures of proteins (3-D conformation) are maintained by weak

non-covalent bonds, which can be easily disrupted by a variety of physical and

chemical agents, whereas the primary structure of proteins are not easily broken

because they are maintained by strong covalent peptide bonds.

Heat, acid,

base, heavy

metal salts,

agitation

>»

Active protein Denatured protein

Agents causing denaturation:

Denaturation can be caused by various physical and chemical agents.

i) Physical agents: Pressure, heat, X-ray, UV radiation, ultrasound etc.

if) Chemical agents: Acids, alkali, organic solvents (ether, alcohol etc.), high

concentration of urea, salicylates and heavy metals (lead, mercury, silver etc).

Characterstics of Protein Denaturation:

1. Native helical structure of the protein is lost.

2. The primary structure remains intact; peptide bonds are not hydrolyzed.

3. Denatured protein loses its biological activity.

4. It becomes insoluble in the solvent where it was originally soluble.

0 Denatured protein's solution becomes more viscous with reduced surface

ension.

6. Denaturation increases the presence of ionizable and sulfhydryl groups due

Eo the loss of hydrogen and disulfide bonds.

7. Denatured protein is more easily digested due to increased exposure of

peptide bonds to enzymes.

8. Denaturation is typically irreversible.

9. Some careful denaturation can be reversible, known as renaturation (eg.

hemoglobin in the presence of salicylate).

10. Denatured protein cannot be crystallized.

Denaturation vs Coagulation

Denaturation

Coagulation

Coagulation is the process

of clumping small

Denaturation is the

process of changing

properties of a molecule

from its native state

Important in sterilization

and killing of

microorganisms.

Denaturation abolishes

the properties of a

molecule

Denaturants such as

strong acids, bases, heat,

radiation, etc

molecules together and

form aggregates.

Important in blood

coagulation and water

treatment

Coagulation changes the

liquid state of the

molecules

Coagulants such as alum

sulfate, clotting factors,

etc.

Classification of proteins based on the biological function:

Proteins have diverse biological functions, based on which they can be classified as,

2) Defence proteins:

€.g. Immunoglobulins

as antibodies

1) Catalytic proteins:

All enzymes are protein in

nature (exception is

ribozymes, which are RNA in

3) Structural proteins:

€g. Keratin present in hair

and nail; Collagen is present

in muscles.

nature). €.g: Hexokinase, <& 2

Amylase etc.

10) Haemostatic 12) Respiratory proteins: J) Ho mona] pro reins

Co. i gen €.g. Hemoglobin, Myoglobin protein in nature. Cg:

Prothrombin etc. Growth hormone, Insulin

HEMOGLOBIN etc.

a - 5) Contractile proteins:

9) Membrane proteins €.g: Actin, Myosin and

€g: Sodium potassium Tropomyosin present in

pump or Sodium muscle

potassium ATPase. \_— - ane

MYOFIBRIL OE ——

7) Storage proteins: 6) Transport proteins:

€g. Ferritin storage of iron

in liver and bone marrow.

€.g. Serum albumin carries

bilirubin, fatty acids etc.

Transferrin transports Iron.

8) Visual proteins:

€g. Rhodopsin and Ce

Titan eis in 13) Receptor proteins: m Suter proteins

the retina of eye. Cg: Insulin receptors, ne ra proteins.

Glucagon receptor, steroid emogiobin

hormone receptors etc.

14) Genetic proteins:

€g. Histones, various

Factors.

transcription and translation

Extra edge

Classification of proteins based on their chemical composition

(SESE

(EE

1

> Albumins +> Collagens =>Nucleoproteins | Coagulated > Proteoses

proteins

+ Globulins > Elastins > Chromoproteinf> Proteans [> Peptones

> Prolamins MN => Glycoprotein Metaproteing® Polypeptides

Le» Glutelins => Phosphoprotein > Simple

peptides

p> Histones > Lipoprotein

Lp» Amino acids

=> Protamins N Metalloprotein

>. Globins

Classification of proteins based on shape (conformation)

: Based on shape. proteins are classified into 2 groups.

1) Globular pro

Enzymes.

2) Fibrous proteins: These are elongated and fiber- like structures. €g. Keratin, collagen,

elastin etc.

Isoelectric pH and isoelectric precipitation of

proteins.

Isoelectric pH (pl) of Proteins:

- Definition: The pH at which proteins exist as zwitterions, with an equal number of

positive and negative charges.

- Examples: Pepsin (pl 1.1), Casein (pl 4.6), Albumin (pl 4.7), Human Hemoglobin (pl 6.7), etc.

- Properties:

1. At pl, the net charge is zero; the protein doesn't move in an electric field.

2. Proteins have minimal buffering capacity and viscosity at their isoelectric pH.

3. Proteins are least soluble and most precipitable at their isoelectric pH, as they tend

to aggregate and precipitate.

Isoelectric Point (pl):

- Definition: The pH at which a molecule carries no net electrical charge, especially for

amino acids.

- Proteins have their own isoelectric pH (pl) values based on their amino acid composition.

- pl is important in various biological and chemical processes, such as electrophoresis and

isoelectric precipitation.

Zwitterion

H J H .

TL Fuk iS gr H,N—

: d

pH < pl pH = pl pH > pl

Isoelectric Precipitation of Proteins:

- Definition: Precipitation of proteins at their isoelectric pH.

- Some proteins, like casein, precipitate immediately when adjusted to their

isoelectric pH.

- Explanation: Proteins are least soluble at their isoelectric pH, where they exist

as zwitterions with minimal electrostatic repulsion. This leads to easy

aggregation and precipitation.

- Example: Casein precipitates readily when pH is adjusted to 4.6 (the isoelectric

pH of casein).

Which of the following is not an aromatic amino acid?

A. Phenylalanine

B. Tyrosine

C. Tryptophan

D. Arginine

Which of the following amino acids has an imino ring

A Proline

B. Tyrosine

C. Tryptophan

D. Histidine

Which of the following is not a basic amino acid?

A Histidine

B. Arginine

C. Lysine

5. Glycine

Which of the following amino acids is polar in nature?

A Aspartic acid

B Alanine

C Proline

D Methionine

Which of the following contain a phenol group?

A. Arginine

B. Phenylalanine

C. Tyrosine

D. Proline

Answers

a. Deaminationis \_\_\_\_\_\_ of amino group.

(R) Removal

(B) Addition

(C) Supplementation

(D) None of these

Answer:

The removal of amino group from the amino acids as ammonia is deamination. It may be

oxidative or non-oxidative in nature. The NH3 so liberated is used for synthesis or urea.

. The amino acids required for creatine formation:

(B) Glycine

(C) Methionine

(B) Arginine

(D) All of these

Answer:

The three amino acids glycine, arginine and methionine are required for creatine formation.

Glycine combines

Biuret test is specific for

(8) Two peptide linkage

(B) Phenolic group

(C) Imidazole ring

(D) None of these

Answer:

Biuret test is answered by compounds containing two or more CO—NH groups i.e, peptide

bonds. All protein and peptides possessing at least two peptide linkages i.e. tripeptide (with 3

amino acids) give positive biuret test. The principle of biuret test is conveniently used to

detect the presence of proteins in biological fluids. The mechanism of biuret test is not

clearly known. It is believed that the colour is due to the formation of a copper co-ordianated

complex.

1 The basic amino acids are

(A) Lysine

(B) Bile acids

(C) Glycine

(D) Alanine

Answer:

Lysine, arginine, histidine. These are dibasic monocarboxylic acids.

Non-Protein amino acids are

(A) Ornithine

(B) B-alanine

(C) y-amino butyric acid

(D) All of these

Answer:

The amino acids which are never found in protein structure are collectively referred

to as non-protein amino acids. However, the non- protein amino acids perform several

biological functions. e.g. ornithine, citrulline, thyroxine.

In metabolic point of view, amino acids are classified as

(A) Glycogenic

(B) Ketogenic

(C) Glycogenic or Ketogenic

(D) All of these

Answer:

Amino acids are divided into 3 groups based on their metabolic fats.

a. Glycogenic: These amino acids can serve as precursors for the synthesis of

glucose (or glycogen) e.g, alanine, aspartate, glycine.

b. Ketogenic: Fat can be synthesized from these amino acids e.g. leucine, lysine.

¢. Glycogenic or ketogenic: The amino acids that can form glucose as well as fat

eg. isoleucine, phenylalanine, lysine.

A Zwitterion is

(B) Positive ion

(B) Negative ion

(C) Both (R) and (C)

(D) None of these

Answer:

Zwitterion (dipolar ion) is a hybrid molecule containing positive and negative ionic

groups. €ach amino acid has a characteristic pH (eg. leucine pH 6.0), at which it

exists as zwitterions.

What are Essential Fattyacids? Name them.

Enumerate the functions of essential fatty acids.

Name three essential fatty acids

What are the advantages and disadvantages of the intake of

polyunsaturated fatty acids?

Classification of lipids with suitable examples.

Essential fatty acids — definition, examples and important functions.

Phospholipids — definition, types and functions.

Rancidity and lipid peroxidation.

Lung surfactant and Respiratory Distress Syndrome.

Cholesterol - structure and biological importance.

Name four functions of phospholipids in the body.

Name any Two Phospholipids. Write their Significance.

INTRODUCTION

Understanding lipid biochemistry is crucial not only for

biochemists but also for everyone, as it unravels the

intricate mechanisms of how lipids, in our body, function.

From a day-to-day perspective, this knowledge empowers

individuals to make informed dietary choices and grasp

the significance of essential and non-essential fatty acids.

Knowing this can lead to healthier eating habits and better

nutrition, which are fundamental for overall health and

well-being. It sheds light on the role of lipids in energy

storage, cellular structure, and their impact on various

health aspects, promoting a more holistic approach to

personal health management and nutrition.

Long Carbon Chains

Solid at Room Temperature

®

Lipids

Introduction to lipid biochemistry

Any compound that is insoluble in water & soluble in non polar organic

solvent

Soluble in organic solvents (alcohol, ether etc) actually potentially

related to fatty acids .

Lipids

Phospholipid Triglyceride Cholesterol

Phospholipid bilayer

Cell (Cell membrane)

V8

FATTY ACID / Acyl group Vig lal

. Polar compounds ola

. FA + alcohol = Non polar fat wou

R:C00( H + HO) R = RCOOR: (non-polar fat) ( €ster bond )

4

Functions of Lipids 103g

. Storage form of energy (triglycerides) cle

. formation of membranes ( phospholipids and cholesterol)

. Metabolic regulators (steroid hormones and prostaglandins)

. Act as surfactants o Cotouy

Act as detergents Chdesls

. Act as emulsifying agents (amphipathic lipids)

. Act as electric insulators in neuron’s

. Provide insulation against changes in external temperature

(subcutaneous fat)

.Give shape and contour to the body

. Protect internal organs by providing a cushioning effect (pads of fat)

. Help in absorption of fat soluble vitamins (A, D, € and KD

. Improve taste and palatability of food

Q: What are the clinical applications of lipids

Clinical Applications

. Excessive fat deposits cause obesity.

. Truncal obesity is a risk factor for heart attack

. Abnormality in cholesterol and lipoprotein

metabolism leads to atherosclerosis and cardiovascular diseases

. In diabetes mellitus, the metabolisms of fatty acids and lipoproteins

are deranged, leading to ketosis

What is Classification of lipids ?

Classification of lipids

1. Simple lipids

2 . Compound lipids

. They are fatty acids esterified with alcohol; but in addition they

contain other groups.

. Phospholipids, containing phosphoric acid. Non-phosphorylated

lipids

3 . Derived lipids

. They are compounds which are derived fro

Ids or precursors of lipids, fatty acids, steroids. 4 . Lipids

complexed to other compounds.

Lipids: Definition & Classification

1

=,

[ 1 | 1} 1 (A)

Simple Lipids| Compound Lipids Derived Lipids Miscellaneous lipids

FA + Alcohol FA+ Alcohol+ addl. grp Hydrolysis of simple/ |Posses characteristics

compound lipids of lipids

Phospholipid: ;

F TAG Pk REE ERAS I~ Fatty acids ht Squalene.

Glycolipids ;

F Waxes F cinsin k Steroids EF Carotenoids

= Lipoproteins 2 Eicosanoids

Ketone bodies

. Simple lipids. They are esters of fatty acids with

glycerol

rer TT F—

Glycerol iIAcyl Glycerol | Triacyglycero

Ester bond.

One FA + 3FA+

Glycerol. 2FA + Glycerol. | glycerol +TG

Amphipathic Amphipathic Neutral Fats

(Non polar)

Triglyceride

Glycerol 3 fatty acid chains ®

I | | Ul

4 H \ (6) N

Example of i - cu, —CHz ++ CH; —CHz — CH;

Structure of simple | = :

Lipids I

H=C=0 —(C—CH; — CHz + CH — CH; —CHj)

f

H=—C=— [o] —(C—CH; — CH; +=«CH\_ — CH; — CH3)

we

QUESTION : what are the PROPERTIES OF TRIACYLGLYCEROLS ?

Randcidity and lipid peroxidation

PROPERTIES OF TRIACYLGLYCEROLS

A few important properties of triacylglycerols, which have biochemical

relevance, discussed below

1. Hydrolysis:

. Triaculglycerols undergo stepwise enzymatic hydrolysis to finally liberate

free fatty acids and glycerol .

. The process of hydrolysis, catalysed by lipases

2. Saponification:

. The hydrolysis of triacyl-glycerols by alkali to produce glycerol and

soaps is known as saponification

Triacylglycerol + 3 NaOH = Glycerol + 3 R-COONa (soaps)

3. Rancidity:

. Rancidity is the term used to represent the deterioration of fats and

oils resulting in an unpleasant taste.

. Fats containing unsaturated are more susceptible to rancidity.

. Hudrolytic rancidity occurs due to partial hydrolysis of triacylglycerols

by bacterial enzymes.

. Oxidative rancidity is due to oxidation of unsaturated tatty acids.

4. Antioxidants:

. The substances which can prevent the occurrence of oxidative rancidity

are known antioxidants.

. antioxidants such as tocopherols (vitamin €, hydroquinone, gallic acid

and a-naphthol)

Forensic correlation :- " hr BY

Saponification ( adipocere) SET)

“late-stage postmortem , ,

decomposition product consisting of How is low calcium levels

a mixture of free fatty acids in blood in pancreatitis

(FFAS) formed under favorable related to process of

conditions due to the hydrolysis of saponification ??

triglycerides in adipose tissue.

5. Lipid peroxidation/ oxidative rancidity is the chain of reactions

of oxidative degradation of lipids. Tt is the process in Which free radicals

"steal" electrons from the lipids

in cell membranes, resulting in cell damage. This process proceeds by a

free radical chain reactionmechanism. It most often

affects polyunsaturated fatty acids, because they contain multiple double

bonds in between which

lie methylene bridges (-CH2-) that possess especially reactive hydrogen

atoms.

Pathology correlation:-

Lipid peroxidation,

© driven by oxidative

stress, is linked to cell

damage,

atherosclerosis, cancer,

and inflammation

Topic : COMPLEX lipids

Complex lipids has

FA + ALCOHOL + OTHER COMPONENTS

If the other compound is Phosphate Then Phospholipids form

which has

Polar phosphate NP lipid forms

. If the other compound is Carbohydrate Then Glycolipids

form which has Polar carbohydrate NP lipid forms

Phospholipids

Name four functions of phospholipids in the body.

Structure of phospholipid

~ A phospholipid is characterized by its amphipathic nature,

signifying the presence of both hydrophobic and hydrophilic

components.

~ At the molecular level, a phospholipid consists of a phosphate

group, known as the "head," on one end and two parallel fatty acid

chains, often referred to as the "tails."

~ The phosphate group's negative charge imparts polarity to the

head, rendering it hydrophilic, or "water-loving."

~ In contrast, the lipid tails are nonpolar, uncharged, and

hydrophobic, indicating their "water-fearing” nature, as they repel

and are repelled by water.

~ The tails may consist of both saturated and unsaturated fatty

acids, and this combination significantly influences the fluidity of

these tails.

~ The dynamic interplay between the polar head and hydrophobic

tails plays a fundamental role in the structure and function of

phospholipids.

Phospholipid

Pp

6. I

Phosphate

group

Glycerol

Hydrophilic head

Head

Tail

Hydrophilic

head

Hydrophobic tails

Hydrophobic

tails

(a) Structural formula (b) Space-flling model (¢) Phospholipid symbol

Name any Two Phospholipids. Write their Significance.

Phospholipids are structural componenets of biological membrane

and helps in selective permeability of membrane

There are two classes of phospholipids

1Glycerophospholipids (or hosphoglyce-rides)

. that contain glycerol as the alcohol.

2Sphingophospholipids (or sphingomyelins)

that contain sphinogogen as the alcohol .

Glycerol phospholipids are the major lipids that occur in biological

membranes.

Phosphatidic acid

This is the simplest phospholipid

It is an intermediate in the synthesis of triacylglycerols and

phospholipids.

The other glycerol phospholipids containing different nitrogenous

bases or other groups maybe regarded as their derivatives.

Point to remember ~

In sphingophospholipid

Alcohol glycerol is

never present

Phosphate & base is

never present

Lecithins (phosphatidulcholine )

These are the most abundant group of phospholipids

Chemically, lecithin is a phosphatidic acid with

choline as the base.

\*\*see lung surfactant answer to know more about lecithin\*\*

Cardiolipin :-

It is so named as it was first isolated from heart muscle.

Structurally, a cardiolipin consists of two molecules of phosphatidic

acid held by an additional glycerol through phosphate groups.

It is an important component of inner mitochondrial membrane and

essential for mitrochondrial function.

Decreased cardiolipin levels may result in mitochondrial dysfunction,

aging, hypo- thyroidism, cardioskeletal myopathy (Barth syndrome).

Cardiolipin is the only phospho~- gluyceride that possesses antigenic

properties.

Others :- Cephalins , Phosphatidylinositol, Phosphatidylserine,

Plasmalogens.

Correlation :~

You encounter this

\\_, cardiolipin

9 In microbiology as anti

: cardiolipin antibody

in detection of syphilis

And in medicine in anti

phospholipid antibody

syndrome

Sphingophospholipids

. Glucosyl ceramide / Glucocerebroside

1

. Always found in extra neural tissues

. Never found in CNS

. Galactosy| Ceramide Galacto cerebroside

1

Always found in CNS

Funtions of phospolipids

Phospholipids constitute an important group of compound lipids that

perform a wide variety of functions

1. In association with proteins, phospholipids form the structural

components of membranes and regulate membrane permeability.

2. Phospholipids (lecithin, cephalin and cardiolipin) in the mitochondria

maintain the conformation of electron transport chain components, and

thus cellular respiration.

3. Phospholipids participate in the absorption of fat from the intestine.

4. Phospholipids are essential for the synthesis of different

lipoproteins, and thus participate in the transport of lipids.

5. Accumulation of fat in liver (fatty liver) can be prevented by

phospholipids, hence they are regarded as lipotropic factors.

6. Arachidonic acid, an unsaturated fatty acid liberated from

phospholipids, serves as a precursor for the synthesis of eicosanoids

(prosta~- glandins, prostacyclins, thromboxanes etc).

7. Phospholipids participate in the reverse cholesterol transport and

thus help in the removal of cholesterol from the body.

for Antiphospholipid

Antibody Syndrome :-

An autoimmune disorder

where the immune

system produces

antibodies against

phospholipids

8. Phospholipids act as surfactants (agents lowering surface

tension). For instance, dipalmitoyl phosphatidylcholine is an

important lung surfactant. Respiratory distress syndrome in

infants is associated with insufficient production of this

surfactant.

9. Cephalins, an important group of phospho lipids participate in

blood clotting.

10. Phosphatidylinositol is the source of second messengers—

inositol triphosphate and diaculgiyceol, that are involved in the

action of some horomones.

Lung surfactant and Respiratory Distress

Syndrome.

Dipalmitoul lecithin is an important phosphatidyicholine found in

lungs.

It is a surface active agent and prevents the adherence of

inner surface of the lungs due to surface tension.

Respiratory distress syndrome in infants is a disorder

characterized by the absence of dipalmitoyl lecithin.

Respiratory Distress Syndrome (RDS) in children, also known as

infant respiratory distress sundrome (IRDS), is a condition

primarily affecting premature infants. It's caused by a

deficiency of surfactant in the lungs, leading to breathing

difficulties.

~ Rapid and labored breathing

~ Grunting during exhalation

~ Visible retractions (chest wall

Symptoms :- pulling in)

~ Gyanosis (bluish skin and mucous

membranes)

~ Flaring of the nostrils

~ Difficulty feeding

L/S RATIO ~

Lecithin- Sphingomyelin ratio (L/ Sratio) in amniotic fluid is an indicator

frequently used to evaluate fetal lung maturity.

Prior to 34 weeks of gestation, the concentrations of lecithin and

sphingomyelin in amniotic fluid are almost equal.

Later, the concentration of lecithin rises markedly and the L Sratio

becomes 5 at term.

In preterm infants, the L/ Sratio is 1 or < 1, resulting in respiratory

distress.

Infant Respiratory Distress Syndrome

Newborn After A)

Healthy Delivery YY

Aiveon

Respiratory Distress

Following Premature

Delivery

Extra edge

\*\*Glycolipids (Glycosphingolipids):\*\*

- Important components of cell membranes and nervous tissues, especially in the brain.

- Simplest form is cerebrosides, containing a ceramide (sphingosine attached to a fatty

acid) and one or more sugars.

- Rey glycolipids include galactocerebroside and glucocerebroside.

- Galactocerebroside contains cerebronic acid as its fatty acid component.

- SulFagalactosylceramide is the sulfatide derived from galactosylceramide.

\*\*Gangliosides:\*\*

- Predominantly Found in ganglia and are the most complex glycosphingoli ids.

- Derivatives of cerebrosides and contain one or more molecules of N-acetylneuraminic

acid (NANA), an important sialic acid.

- Key brain gangliosides: GM1, GM2, GD, and GT (G represents ganglioside, M/D/T

indicate sialic acid residues, and the number denotes the carbohydrate sequence).

- 6M2 accumulates in Tay-Sachs disease.

- Lipoproteins:

Complexes of lipids and proteins, transport lipids in circulation.

- Types: Chylomicrons, VLDL, LDL, HDL, and free Fatty acid-albumin complexes.

- Structure: Lipid core (cholesterol esters, triglycerides) surrounded by a phospholipid

monolayer with apolipoproteins.

- Separation: Done by density (ultracentrifugation, electrophoresis, immunoassays).

- Metabolism: Includes synthesis, transport, utilization; key sites are liver and intestines.

- Diseases: Imbalances linked to atherosclerosis, cardiovascular disease, hyperlipidemia,

Familial hypercholesterolemia.

Steroids

Steroids are the compounds containing a cyclic steroid nucleus (or ring) namely

cyclopentanoperhydrophenanthrene (CPPP). It consists of a phenanthrene nucleus

(rings A, B and C) to which a cyclopentane ring (D) is attached.

There are several steroids in the biological system. These include cholesterol, bile acids,

vitamin D, sex hormones, adrenocortical hormones, sitosterols, cardiac glycosides and

alkaloids. IF the steroid contains one or more hydroxyl groups it is commonly known as

sterol (means solid alcohol).

CHOLESTEROL STRUCTURE AND BIOLOGICAL

IMPORTANCE

cholesterol

steroid nucleus

OH

hydroxyl

group

Functions

1. Cholesterol is an integral component of cell

membranes and hence influences membrane

permeability.

2. A number of biologically important substances are

synthesised from cholesterol (e.g. vitamin D, bile

acids, mineralocorticoids, glucocorticoids and

sex hormones).

3. Cholesterol acts as an electrical insulator and

helps in the propagation of nerve impulses.

Fatty acids are transported to liver as cholesteryl

esters for oxidation

It is an essential ingredient in the structure

of lipoproteins

It help in Membrane Fluidity

Topic : FATTY ACIDS

Question : what are the uses of fatty acids ?

+ Fatty acids can exist both free and as part of complex lipids

+» They play a number of key roles in metabolism

« Functions of fatty acids are

1. major metabolic fuel

2. storage and transport of energy

3. as essential components of all membranes 4. gene regulators

Question: what is the classification of fatty acids ?

On the basis of various characteristics, fatty acids are classified

into different categories, ie.

According to the chain length

According to the body requirement

« According to the degree of unsaturation

+ According to the position of H-atoms

CLASSIFICATION BASED ON THEIR CHAIN LENGTH

Short chain FA = 2-4C

Medium chain FA = 6-126

Long chain FA = 14-20C

Very long chain (VLCFA) = >20C (usually required in brain)

classification based on the body requirement

Man can not synthesis some fatty acids in his body and these

must be included in diet is called as essential fatty acis.

The examples are linoleic acid, linolenic acid and arachidonic acid.

Certain fatty acids can be synthesized in the tissue from other

fatty acids. These fatty acids are need not be included in diet and

called as nonessential fatty acids.

The examples are Palmitoleic acid and Oleic acid.

CLASSIFICATION DEPENDING ON THE DEGREE OF SATURATION

1Saturated fatty acids

. Saturated fatty acids are 'filled” (saturated) with

hydrogen no double bonds

. Most saturated fatty acids are straight

hydrocarbon chains with an even number of carbon atoms.

. The most common fatty acids contain 12-22 carbon atoms.

2 Unsaturated fatty acids are the fatty acids that

contain one or more double bond in their aliphatic chain.

. These may either be Monounsaturated fatty acids (MUFA) or Poly

unsaturated fatty acids (PUFA.

. They are liquid at room temperature.

Abundant in fish and reduce the risk of coronary

near diseases.

(Fats and fatty acids )

X;

Saturated fats ) ( Unsaturated fats )

Animal fats,butter,lard

l

(polyunsaturated fats ) (“monounsaturated fats )

3

Omega-3 fatty acids Omega-6 fatty acids | [Omega-9 fatty acids

ElcosatEnole REE Corn oil QE Olly

ish, shellfis i V]

Docosahexaenoic acid(DHA) ees 5 el] peanuts

fish, shellfish almonds

a-linolenic acid(ALA)

flaxsed,soybean, walnut,

rapeseed oil

Classification of fats based on fatty acids

QUESTION :- Essential fatty acids - definition, examples

and important functions.

PUFA

The fatty acids that cannot be synthesized by the body and,

therefore, should be supplied in the diet are known as essential

fatty acids (EFA.

Chemically, they are polyunsaturated fatty acids, namely linoleic

acid and linolenic acid .

Arachidonic acid becomes essential, if its precursor linoleic acid is

not provided in the diet in sufficient amounts.

Biochemical basis for essentiality :

Linoleic acid and linolenic acid are essential since humans lack the

enzymes that can introduce double bonds beyond carbons 9 to 10.

Functions of EFA :

Essential fatty acids are required for the membrane structure and

function, transport of cholesterol, formation of lipoproteins,

prevention of fatty liver etc.

They are also needed for the synthesis of another important group

of compounds, namely eicosanoids .

Deficiency of EFA :

The deficiency of EFA results in phrynoderma or toad skin,

characterized by the presence of horny eruptions

Question: What are the omega 3 fatty acids ?

OMEGA 3 CATEGORY

1

22 carbons & 6 double bonds present

Health drinks are fortified with DHA

Requires for brain development of first 2-3 urs of

Life

Breast milk contains DHA

218 carbons & 3 double bonds Essential FA

Precursor of omega 3 category 3

. 20 carbons & 5 double bonds

Question: What are the omega 6 fatty acids ?

OMEGA 6 CATEGORY

1. GAMMA - LINOLENIC

2LINOLEIC ACID

. 18 carbons & 2 double bonds

. Most essential FA

. Precursor of Omega - 6 category

3. ARACHIDONIC ACID

. 20 carbons & 4 double bonds

. Important for the Synthesis of PGs &

Leukotrienes

Question : what are difference btw omega 3 and omega

6 fatty acids ?

\* Anti-inflammatory \* Pro-inflammatory

\* Polyunsaturated fatty acids \* Polyunsaturated fatty acids

\* Role in the body: control blood \* Role in the body: brain function,

clotting, build cell membranes in the normal growth and development

brain, normal growth and

development

\* Research indicates roles in blood

pressure, rheumatoid arthritis, and

depression

PROSTAGLANDINS

TOPIC:PROSTAGLANDINS AND RELATED COMPOUNDS

prostaglandins and their related compounds

1. prostacyclins (PGD

2. thromboxanes (TXA)

3. leukotrienes (LT)

4. ipoxins are collectively known as eicosanoids

+ they all contain 20 carbons

- Eicosanoids are locally acting hormones with a wide range of

biochemical functions.

STRUCTURE OF PROSTAGLANDIN:

+ Prostaglandins are derivatives of 20-carbon fatty acid namely

prostanoic acid hence known as prostanoids.

+ a cyclopentane ring (formed by carbon atoms 8 to 12) and two side

chain with carboxylg roup on one side.

+ Differ in structure due to substituent group and double bond on

cyclopentane ring.

= = =

HO OH

PROSTAGLANDINS

+ Arachidonic acid (5,811 14 —eicosatetraencic acid) is the precursor

for prostaglandinins .

+ occurs in endoplasmic reticulum as:

1. Release of arachidonic acid from membrane bound phospholipids by

phospholipaseA

2-occurs due to hormones such as epinephrine or bradukinin.

2. Oxidation and cyclization of arachidonic acid to PGG2 converted to

PCH2 by a reduced glutathione dependent peroxidase.

3. PGH2 serves as the immediate precursor for synthesis of a numbero f

prostaglandins, including prostacycling and thromboxanes.

+ known as cyclic pathway of arachidonic acid.

+ In the linear pathway of arachidonic acid, leukotrienes and lipoxins are

synthesize

Cyclooxygenase:

+ prostaglandin synthesis partly controlied by enzyme cyclooxygenase.

+ Capable of undergoing self-catalysed destruction to switch off PG

synthesis.

P450 petiaway Lipoxygenase pathway A)

{Ay

NSAIDs mee ~~ COX |

PG and Tx

synthases

|

Anti-inflammation Loss of

(2) Tumour growth parturition

Thrombotic (1) Protection of (1) Inflammation

tendency gastric mucosa

(2) Resistance

to thromboembolism

+ Prostaglandins act as local hormones

+ produced in tissues in contrast to hormonal synthesis which occurs in

specialized glands.

+ not stored and degraded to inactive products at site of production.

actions of PGs differ in different tissues.

+ Sometimes PGS bring about opposing actions in the same tissue,

They mediate :

1. Regulation of blood pressure :

prostaglandins (PGE, PGA and PGI2) are vasodilator

+ results in increased blood flow and decreased peripheral resistarrce to

lower blood pressure.

+ PGs serve as agents in treatment of hypertension

2. Inflammation :

+ prostaglandins PGE! and PCGE2 induce the symptoms of inflammation

(redness swelling, edema etc)

+ natural mediators of inflammatory reactions of

1rheumatoid arthritis (involving joints)

2. psoriasis (skin)

3.conjunctivitis (eyes)

+ Corticosteroids are used to treat inflammatory reactions asthey inhibit

prostaglandin synthesis.

3. Reproduction:

+ PGE2 and PGF2 are used for medical termination of pregnancy and

induction of Tabor.

4 Pain and fever :

+ pyrogens (fever producing agents) promote prostaglandin biosynthesis

leading to the formation of PGE2 in hypothalamus

+ PGE2 along with histamine and bradykinin cause pain.

+ Migraine is also due to PGE2.

+ Aspirin and other non-steroidal Drugs inhibit PG synthesis and thus

control fever and relieve pain.

PAIN MNEUMONIC ~ BEE ( B ~- bradykinin ; €E - PGE). Py

FEVER

Ld reg

5.Regulation of gastric secretion :

+ prostaglandins( PGE) inhibit gastric secretion used for treatment of

gastric ulcers.

+ Stimulate pancreatic secretion and increase motility of intestine

causes diarrhea.

6. Influence on immune system :

+ Macrophages secrete PGE which decreases immunological functions of

B-andT ~lymphocytes.

7. Effects on respiratory function :

PGE — bronchodilator

PGF- constrictor of bronchial smooth muscles.

PGET and PCGE2 are used in the treatment of asthma.

Correlation with physiology :-

& Prostaglandins constrict the

efferent arteriole in the kidney,

helping to maintain glomerular

filtration rate (GFR) and

regulate renal blood flow.

10. Platelet aggregation and thrombosis :

+ prostacyclins (PGI2) inhihit platelet aggregation.

+ thromboxanes (TXA2) and prostaglandin €2 promote platelet

aggregation and blood clotting lead to thrombosis.

+ PGlI2-endothelial cells lining the blood vessels prevents adherence of

platelets to blood vessels.

+ TXA2 -released by platelets and spontaneous aggregation when the

platelets contact with collagen or thrombin.

+ PGlI2-vasodilator

TXA2-vasoconstrictor,

8. Influence on renal functions :

+ PGE increases glomerular filtration rate (GFR) and promotes urine

output.

+ Excretion of Na+ and K+ is also increased by PGE.

9. Effects on metabolism :

+ Prostaglandins influence certain metabolic reactionsby mediation of

CAMP.

+ PCE decreases lipolysis, increases gly cogen formation and promotes

calcium mobilization from bone.

Correlation to

pharmacology :-

(Nonsteroidal Anti-

/ £ .

USES OF PROSTAGLANDINS: @ aameny ove

- used in treatment of 8 inhibiting prostaglandin

1. gastric uloers production, reducing

2. hypertension inflammation, pain, and

3. Thrombosis fever, decreases renal

4. asthma blood flow

5. medical termination of pregnancy,

6. prevention of conception

7. induction of labor

Inhibitors of prostaglandin synthesis in controlling fever, pain,

migraine, inflammation etc.

WHAT IS LEUKOTRINES?

+ Leukotrienes are synthesized by

1.leucocytes

2.mast cells

3.lung

4 hearts. spleen by lipoxygenase pathway of arachidonic acid.

+ synthesis of different leukotrienes (A4, 84, C4, D4 and €4)

through intermediate, 5-hydroperoxyeicosatetraencic acid (5-HPETE)

+ Anaphylaxis is a violent and fatal allergic reaction.

+ leukotrienes( C4, D4 and €4) are slow-reactinG substances of

anaphylaxis (SRS-A), released after immunological challenge.

+ Leukotrienes are implicated in asthma, inflammatory reactions,

hypersensitivity (allergy) and heart attacks.

«cause contraction of smooth muscles, bronchoconstriction,

vasoconstriction, adhesion of white blood cells and release of lysosomal

enzymes.

+ lipoxins act as counter regulatory compounds of immune response.

5-lipoxygenase

+FLAP

Leukotriene A,

Leukotriene C4 Leukotriene A4

synthase hydrolase

4-series E

& 3 Leukotriene B,

cysteinyl leukotrienes

(LTCa, LTDa4, and LTEs)

5-lipoxygenase

+FLAP

Leukotriene As

Leukotriene Ca

synthase

Leukotriene As

hydrolase

5-series

cysteinyl leukotrienes

(LTCs, LTDs, and LTEs)

Leukotriene Bs

DIETRY AND OTHER RELATIONS OF PGS:

+ high intake of marine lipids containing unsaturatedf atty acids

(UFA).

+ most predominant UFA in the fish foods consumed by Eskimos is 5,

8, 1, 14, ' | T-eicosapentaenocicacid (EPA).

+ EPA is the precursor for leukotrienes

+ eicosapentaencic acid inhibits the Formation thromboxanes

(TXAdpromotes platelet aggregation and thrombosis.

+ diet rich in marine lipids (with EPA) decreases plasma cholesterol

and triacylglycerols.

+ Reduced synthesis of TXA2 responsible for low incidence of heart

attacks in Eskimos.

QDWHICH OF THE FOLLOWING IS A SUCIDE ENZYME?

a)cyclooxygenase

blipooxygenase

cJhistamine

dleukotrines

ANS:A)CYCLOOXYGENASE

Q2)DIET OF FISH FOOD CONTAINS?

aunsaturated fatty acid

b)saturated fatty acid

c)sodim

doglucose

ANS:ADUNSATURATED FATTY ACID

Q3NJHICH OF THE FOLLOWING IS NOT EICOSANOIDS?

Adprostaglandins

b)leukotrines

c)thromboxanes

dhistamine

ANS: DIHISTAMINE

gicesaneids (Including

pressasglandinds):

g1Cesaneids are Gempounds derived

f1om eiCosa (20 -Garben) poL¥eneic

fatty acids (C20 pelyunsaturased

favty acids). There are three

different eicosanoids,

- Progtaneids: (Includes

Prostaglandins, pressacycling and

Thromboxanes). - Leucetriens

+ LIPOXINS

Definition:

Nucleotides are building blocks of nucleic acids (DNA and RNA).

Components:

Each nucleotide is made up of 3 components

i) Nitrogenous base ii) Pentose sugar iii) Phosphate group

i) Nitrogenous base:

May be either purine bases or pyrimidine bases.

a) Purine bases:

Adenine and guanine are major purine bases

e Adenine (6-aminopurine)

e Guanine (2-amino 6-oxopurine)

“NH, o°

2 N

A 4

N ih Ha

b) Pyrimidine bases: Adenine (4) Guanine (G)

Cytosine, Thymine and Uracil are pyrimidine bases.

e Cytosine (2-oxy 4-aminopyrimidine)

® Thymine (2,4-dioxy 5-methylpyrimidine)

e Uracil (2,4-dioxypyrimidine)

ii) Pentose sugar:

Pentose sugar can be either ribose or deoxyribose sugar. DNA has deoxyribose

sugar and RNA has ribose sugar.

iii) Phosphate molecules:

Nucleotides can have one, two or three phosphate molecules: consequently

Nucleotides are called mono, di and tri nucleotide phosphates.

E.9.: AMP, ADP, ATP have one, two and three phosphate molecules respectively.

0 [@]

3C \_H \_H

IOUS

So N Oo

H

cytosine thymine uracil

Nucleoside: Nitrogenous base+ Pentose sugar

\* Nucleotide: Nitrogenous base+ Pentose sugar+ Phosphate(s)

[i.e. Nucleotide = Nucleoside + Phosphate(s)]

Similarly, Deoxy nucleotide: Nitrogenous base+ deoxy pentose sugar+ Phosphate(s)

Functions of free nucleotides:

Nucleotides are the building blocks ofnucleic acid. In addition to this, free

nucleotides in the body perform various functions like energy metabolism, protein

synthesis, regulation of enzyme activities, signal transduction and variety of

metabolic activities.

I) Functions of adenosine nucleotides:

1) ATP:

e ATP is the energy currency of the cell. It is the universal carrier of energy within

the body. ATP is required for the provision of energy for muscle contraction,

transmission of nerve impulses and transport of nutrients across the membrane.

e ATP is required for the ligase type of enzymatic reactions. Energy is released

when

ATP is hydrolyzed to ADP and Pi. E.g. Pyruvate carboxylase.

e ATP is also required for energy transfer when ATP is hydrolyzed to AMP and

PPi.

E.g. Acyl CoA synthase

\* ATP is involved in phosphate transfer reactions. E.g. Glucokinase reaction.

\* ATP is involved in pyrophosphate transfer reactions. E.g. PRPP synthetase.

e ATP is involved in adenosyl transfer reactions. E.g. SAM synthesis.

e Cyclic AMP a secondary messenger is formed from ATP (by adenylate cyclase).

Adenine

Ribose

2) Coenzymes:

Few coenzymes have adenosine nucleotides. E.g. NAO, NADP, FMN, FAD

3) PAPS (Phosphoadenosine phosphosulphate) orActive sulfate:

PAPS act as a sulfate donor for many sulfation reactions.

E.g.: PAPS is required for the synthesis of sulfated glycosaminoglycans. PAPS is

also required for certain detoxification process.

4) SAM (S-Adenosylmethionine):

SAM functions as a methyl donor in methylation reaction.

E.9.: SAM is required for the synthesis of epinephrine from nor-epinephrine.

II) Functions of guanosine nucleotides:

1) GTP is required for provision of energy during protein synthesis.

2) Cyclic GMP is a secondary messenger formed from GTP by guanylate cyclase.

III) Functions of cytidine nucleotides :

1) CDP choline is required for the synthesis of lecithin (Phosphatidyl choline).

2) CDP ethanolamine is required for synthesis of cephalin (Phosphatidyi

ethanolamine).

IV) Functions of uridine nucleotides:

1) UDP glucose:(Uracil-ribose-(P)-(P)-Glucose)

UDPG is carrier of glucose in the synthesis of glycogen, glycoproteins and

proteoglycans.

2) UDP-glucuronic acid: (Uracil-ribose-(P) - (P) - glucuronic acid) UDP glucuronic

acid is required for detoxification ofbilirubin.

Nucleic acid Chemistry

Definition: Nucleic acids are polynucleotides.

There are 2 types of nucleic acid:

1) Deoxyribonucleic acid (DNA):

2) Ribonucleic acid (RNA)

L| Adenine | | Adenine [J

HN, A H HN A H

o® o

H Ll H N

| Guanine | Guanine |

0 & a A

ne, MN Nu, MN

BY Ctosine\_ [Cytosine JN

H. NH, H. NH,

Ya Ras

N o N 0

BX Thymine | uracii |

HC 0 H 0

Tp RNA Lp

H=N N

Structure and function of DNA.

Watson and Crick model of DNA.

Name 2 differences of B form and A form DNA

Structure of DNA:

DNA is a polymer of deoxy-ribonucleotides. Bases present are adenine, guanine,

cytosine & thymine. Sugar present in. DNA is deoxy ribose. The monomeric

deoxyribonucleotides are held together by 3'-5' phosphodiesterase linkage .

There are many different forms of DNA. Among these, B, A and Z forms are

important.

\* Bform: Right handed double helix, has 10 base pairs per turn.

\* A form: Right handed double helix, has 11 base pairs per turn.

® Z form: Left handed double helix, has 12 base pairs per tum.

In physiological conditions, B-form of

DNA is predominant.

Watson & Crick proposed the double

helix model to explain the structure of

B-DNA.

1. DNA is a right-handed double helix consisting of two twisted

polydeoxyribonucleotide strands.

2. These strands are antiparallel, like two roads with opposite traffic directions.

3. The double helix has a width of 20 A® and a turn (pitch) of 34 A° with 10 pairs of

nucleotides.

4. Hydrophilic deoxyribose phosphate backbones are on the outside, and

hydrophobic bases are on the inside.

5. Complementary base pairing holds the two strands together, with A-T having 2

hydrogen bonds and G-C having 3.

6. Chargaff's rule is proven as A equals T and G equals C.

7. Genetic information is on the template (sense) strand, while the other is the

antisense strand.

8. The double helix features major and minor grooves for protein interactions

without disrupting base pairs.

This concise summary should help you memorize the key points for your

examination.

Sugar-Phosphate

Backbones

/

!

Nucleotide ——

I

N

\

\,

Key:

[@ Adenine

[J Thymine

ll Guanine

[@ Cytosine

Hydrogen Bonds

Antiparallel DNA Strands DNA Ladder Double Helix

Base pairing rule: The base adenine of one chain is always paired with thymine

of another chain with two hydrogen bonds. Similarly cytosine of one chain is

bonded with guanine of another chain with three hydrogen bonds. This is called

base pairing rule. Thus 2 strands are complementary to each other.

This is explained by

chargaff's rule. Chargaff's Rule: If states that the sum of purine nucleotides

(A+G) is equal to sum of pyrimidine nucleotides (C+T). [A+ G = C + T]. This is

because of base pairing rule.

Functions of DNA

DNA is the fundamental unit of genetic information. The genetic information stored

in the DNA serves two functions:

1. DNA is the chemical basis of expression of characters: DNA contains the

information for the synthesis of all the protein molecules of the body. The

information contained in the DNA is first copied into RNA molecules (by

transcription), which then directs the synthesis of proteins (by translation).

2. DNA is the chemical basis of heredity: It provides the template for the

transferring the genetic information from the parent cell to daughter cell (by

replication). This maintains the genotype in offspring.

Sugar Phosphate

Backbone

Base Pair

Guanine

Nitrogenous|~ CYtosine

Bases Thymine

Adenine

Extra edge

Other types of DNA

- DNA is not limited to the double helical structure and can adopt unusual

forms.

- These unique DNA structures play a crucial role in molecular recognition by

proteins and enzymes, essential for DNA to function correctly.

\*Bent DNA:\*

- DNA typically follows a straight path with adenine-containing tracts.

- Bent DNA arises when A-tracts are substituted with other bases or when the

helix collapses into the minor groove of an A-tract.

- Bending can also result from factors like photochemical damage or

mispairing of bases.

\*G-Quartets and G-Tetraplexes:\*

- G-quartets are planar structures connected by Hoogsteen hydrogen bonds.

- G-tetraplexes, antiparallel four-stranded DNA structures, have been

observed.

- Telomeres at the ends of eukaryotic chromosomes, rich in guanine, form G-

tetraplexes.

- G-tetraplexes are targeted for anticancer treatments.

- They play roles in processes such as immunoglobulin gene recombination and

HIV double-stranded RNA dimerization.

These unusual DNA structures have far-reaching implications for the

functioning of DNA and its interactions with proteins and enzymes.

Different types of RNA and their functions.

RNA (Ribonucleic acid):

RNA is the polymer of ribonucleotides. Sugar is ribose. Bases present are Adenine,

Guanine, Cytosine, Uracil. RNA is generally single stranded. There are 3 major types

of RNA

1) Transfer RNA (tRNA)

2) Messenger RNA (mRNA)

3) Ribosomal RNA (rRNA)

Besides these, two minor forms of RNA

1) Heterogeneous nuclear RNA (hnRNA): These are precursors of mRNA

2) Small nuclear RNA (snRNA): These aid in the conversion of hnRNA to mRNA.

TYPES OF RNA

{tRNA o

—mRNA — housekeeping ncRNA 1 PR

(messenger RNA)

rRNA

(ribosomal RNA)

RNA duulut LncRNA (2

Messenger RNA - a”

— 2 200 nucleotides xpd

— IncRNA

—n cR N A ed (long non-coding RNA) r-

{ mem

(non-coding RNA)

-— MicroRNA pre-miRNAs

- regulatory ncRNA=— (19 10 22 nucleotides)

— snoRNA Om Vout

< 200 nucleotides (small nucleolar RNA) A Ju

— small NcRNA\_ <iRNA snoRNAs

(small interfering RNA) +I

— SNRNA g

(small nuclear RNA) b 2 pr

mms L pina

(PIWkinteracting RNA) snRNAs

Structure and function of tRNA.

Transfer RNA Structure

- Transfer RNA (tRNA) typically contains 71-80 nucleotides, often around 75, with a

molecular weight of approximately 25,000.

- There are at least 20 types of tRNAs, corresponding to the 20 amino acids found in

proteins.

- The first elucidation of t1RNA's structure was performed for alanine by Holley.

Cloverleaf Structure:

- The overall structure of tRNA resembles a clover leaf with four arms, each

featuring a base-paired stem.

The Arms:

1. Acceptor Arm (CCA Arm):It has a CCA sequence (5' to 3") at its end where the

amino acid binds.

2. Anticodon Arm: This arm holds a three-base sequence (anticodon) crucial for

recognizing mRNA's triplet codon. The codon and anticodon are complementary.

3. D Arm:Named due to dihydrouridine presence.

4. TWC Arm:Contains a sequence of T, pseudouridine (1), and C.

5. Variable Arm:The most variable part of tRNA. This variability leads to two tRNA

categories:

- Class I tRNAs: The most common form, with 3-5 base pairs in length (about 75%

of tRNAS).

- Class II tRNAs:Contain longer arms with 13-20 base pairs.

Base Pairs:

- The structure of tRNA is maintained by complementary base pairing in its arms.

- Base pairs in the arms: Accepter arm (7 bp), TWC arm (5 bp), Anticodon arm (5 bp),

D arm (4 bp).

Functions of tRNA:

tRNA carries amino acids to the ribosomes during protein synthesis. Each tRNA is

specific for an amino acid, but some amino acids are carried by more than one tRNA.

tRNA

— Amino Acid

attachment site

D loop

cuc

GUC CAG Ii CCAUAG

mRNA

Codon

rRNA (Ribosomal RNA):

\* rRNA constitutes 60 to 70% of total RNA's of the cell.

\* Most of the rRNA combines with protein and exist as ribosomes. Thus ribosome

is nucleoprotein particle.

® Ribosomes have 2 sub unit a large subunit and small subunit. The prokaryotic

ribosomes are 70 S ribosomes, made up of larger 50 S and smaller 30 S subunits.

The eukaryotic ribosomes are 80 S ribosomes, made up of larger 60 S and

smaller 40 S subunits. Each subunit (larger and smaller) exists in dissociated

form. Association of these subunits takes place during protein synthesis. The

complete ribosome has 2 sites. (A site is amino acyl site and P site is peptidyl

site).

FunctionofrRNA: Ribosomesarefactoryofproteinsynthesis.Onribosomes mRNA,

tRNA interacts to translate the codons present in mRNA to the specific sequence

of amino acids in the polypeptide chain.

rRNA

Large subunit

Small subunit

Ribosome

Structure and function of mRNA

MRNA (Messenger RNA):

\* mRNA is synthesized from the template strand of DNA. Thus mRNA

synthesized will be complementary to the template strand (or similar to the non-

template strand).

® The genetic message encoded in DNA is transcribed to mRNA. But the site of

synthesis of protein is ribosomes present in the cytosol. So mRNA from the

nucleus is transported to the cytoplasm. Since mRNA carries the message from

DNA present in the nucleus to ribosomes present in the cytosol for protein

synthesis, it is called the messenger RNA. mRNA acts as template for protein

synthesis.

Structure:

e 5'end of MRNA start with 7 methyl GTP (hence called 7 methyl GTP cap),

which protects mRNA from 5' exonuclease action.

3' end of MRNA has a polyadenylate tail of 22 - 250 AMP residues (hence

called Poly A tail), which provides stability and protects from 3' exonuclease

action.

e Between the 51 and 31 ends, there are number of codons.

Functions

- MRNA (messenger RNA)serves as a critical intermediary in protein synthesis.

- The genetic code, in MRNA, is comprised of codons, which are sequences of 3

bases (triplet codons).

- Using four types of nucleotides (A, G, C, and U), there are 64 possible triplet

codons.

- Out of these 64 codons, 61 are responsible for coding amino acids.

- The remaining 3 codons are referred to as "nonsense codons" or "chain termination

codons."

- Since these codons code for amino acids, there are instances where some amino

acids are coded by more than one codon.

- The codon \*\*AUG\*\* acts as the "chain initiation codon," and it codes for methionine,

Signaling the start of protein synthesis.

- On the other hand, the codons \*\*UAA, UGA, and UAG\*\* are the "nonsense codons”

or "chain termination codons." When any of these codons occurs in the mRNA

sequence, the protein synthesis process stops or reaches its end point.

| Transcription

LULU VUE] ra

| Translation

o— 0-0-0000 Amino acid sequence

Extra edge

Genetic code:

Definition:

The genetic code is defined as the specific nucleotides sequence present in mRNA.

Genetic code directs the synthesis of proteins with specific amino acid sequences.

Characteristic of genetic code:

a) Triplet codon:

The genetic code is present as codons. Each codon consists of three bases (Triplets)

on rnRNA. Using 4 bases (A, G, C, and U), 64 codons are possible. Out of these 64

codons, 3 codons (UAA, UAG, UGA) are called nonsense codons or chain termination

codons because they do not code for any amino acids and the protein synthesis

stops or ends whenever these codons occurs on mRNA. Other 61 codons code for 20

different amino acids. In these, AUG (present in 5' end of mRNA), which codes for

amino acid methionine is called Initiator codon. (Some of examples of codons are

UCU = Serine, UUU =Phenylalanine, AGU =Serine, GUU =Valine, GGU :=Glycine etc.).

b) Unambiguous (Specific):

A codon always codes for a single specific amino acid.

c) Degenerative:

Most amino acids are coded by more than one codon.

E.g.: Serine has 6 codons, Glycine has 4 codons.

(Only methionine and tryptophan are coded by single codon)

d) Universal:

Same codon codes for same amino acids in all the organisms.

e) Non overlapping and comma less:

The codons are read from 5' to 3' direction continuously from AUG without any

punctuation.

Base pairing rule and Wobble hypothesis.

- Wobbling refers to the loose pairing between the base at the 3' end of the codon

and the complementary base at the 5' end of the anticodon.

- In the genetic code, the first two bases of the codon on mRNA always have a

strong complementary base pairing with the anticodon on tRNA.

- However, the complementary pairing of codon and anticodon can wobble at the

third base (3' base).

- The third base (3' base) in the codon sometimes fails to recognize its

complementary base in the anticodon (Sf base).

- This phenomenon allows some tRNAs to recognize more than one codon.

- For example, the two codons for arginine, AGA and AGG, can bind to the same

anticodon UCU.

- The Wobble hypothesis explains the degeneracy of the genetic code, where

multiple codons can code for the same amino acid.

- The degeneracy and wobbling phenomenon together reduce the occurrence of

mutations in the genetic code.

\*\*\*Base pair rule given in DNA STRUCTURE answer \*\*

Difference dna vs rna

Fe sae sa sa se s+ a» a se + a » a » x a sa sae + a » a se s+ a » x eo x as

CTP (¥8Yg) Poy dwnaqeumwy, YQ.

le. oC |400-F00

RE EE F.1d)

: + |t00-to00

ess

«see

+ |" eocTV |-

.

ess

.

«sxe

Fe sa se + a» a eo + a » a se + a » a » x a » a » a se + a » a se + a » x eo x a sa

EE Em a

EE EE Ea a

\ifamin D

EE

CPE RE SE SE SUC SY TE TE

EEE RR EE EE TE

LE TE

Miomin K.

PE EE Er TE EE SE

EE TE SY

Outee :

Tolidhing samoves 20° BL

od we a

q . H . .

CETTE

ET TE

DI TE

100-300

biglday

© | 300-400"

uglday

Fe sa se + a» a eo + a » a se + a » a » x a » a » a se + a » a se + a » x eo x a sa

FT TE Tr

Fe sae + a» a se s+ a x» a se + a» & » x a» a » a se s+ ae x» x eo x a sxe

iow 83 (Rivaffowin)

— NAD + ound. NADP dhapondasd WZipanss amd. seaspedine smachion

Enzyme

NAD\* dependent

I. Carbohydrate metabolism

(a) Glyceraldehyde 3-phosphate dehydrogenase

(b) Lactate dehydrogenase

(¢) Pyruvate dehydrogenase complex

(d) u-Ketoglutarale dehydrogenase complex

Il. Lipid metabolism

(e) [Hydroxy acyl CoA dehydrogenase

(1) P-Hydroxybutyrate dehydrogenase

(9) Alcohol dehydrogenase

W. Protein metabolism

(h) Branched chain u-keto acid dehydrogenase

(i) Tyramine dehydrogenase

NAD\* or NADP\* dependent

(a) Glutamate dehydrogenase

{b) Isccitrate dehydrogenase

NADP dependent

(a) Glucose 6-phosphate dehydrogenase

(b) Malic enzyme

NADPH dependent

(a) 3-Keloacyl reductase

(b) HMG CoA reductase

(c) Squalene epoxidase

(d) Cholesterol 7ce-hydroxylase

(e) Phenylalanine hydroxylase

i Dihwdrfolate reductase

a-Keto acids of branched chain amino acids

(Leu, lle, Val) ——+ Corresponding acyl CoA thicesters

Tyramine ——» p-Hydroxyphenyl acetate

Glutamate + a-Ketoghutarale + NH,

Isocitrale —— Oualosuccinate

Glucose G-phosphate —— 6-Phosphogluconolacione

Malate » Pyrnate

3-Ketoacyl enzyme ——» 3-Hydroxy acyl enzyme

HMG CoA ——» Mevalonale

Squalene —— Squalene oxide

Cholesterol —— Ta-Hydroxy cholesterol

Phenylalanine — Tyrosine

Folic acid ——s Tatrahudrofolic acid

Q) Whot ose. uli - witonwng 7

A) Addivdosnics. ove Quiagomdiie to Hu. Qction of vitamin,

© Mivitdiak; a podomins” ouies \itmin’ deficioios

Exasples 9 Avis widormisu - oses. —

Antivitamin/vitamin antgonists Vitamin

Dicumarol Vitamin K

Warfarin

Thiaminase

Pyrithiamine

Oxythiamine

Galactoflavin

Isoniazid

Deoxypyridoxine

Avidin

Desthiobiotin

Aminopterin

Methotrexate

Trimethoprim

Sulfonilamide Para-aminobenzoic

LR

Jilnoduclisn,

€nzymes are biocatalyst that speeds up digestion and metabolism. They are located in the cells, cytoplasm,

mitochondria, tissues and body fluids.

2 types:

£ndoenzymes-

€nzymes that Function within the cells. Most of the enzymes are these types. €g. metabolic enzymes

(cytochrome oxidase)

£xoenzymes-

Enzymes that are liberated by cells and catalyse reactions outside the cell. €g. digestive enzymes (amylase,

lipase, protease)

PROPERTIES OF ENZYMES

.it doesn't involve in the reaction

.it is used for rate of reaction

. Decrease the time of reaction

. Provide activation energy

. Do not change the equilibrium of reaction

. Do not change the free energy of Substrate / product

. Heat liable

TOPIC : ENZYME CLASSIFICATION

Question: . Write in detail about the

classification of enzymes and give suitable

examples.( IUBNB CLASSIFICATION)

No. eNzMe

1 Oxidoreductase

2 Transferase

3 Hydrolase

4 Lyase

3S Isomerase

6 Ligase

— They are defined as a enzyme that is used to transfer's electrons or hydrogen atoms

Reaction

fo} o NADH+H B

NN NAD 0 0]

HO ——C —H a |

Lactate C

L dehydrogenase 4 Nom

(LDH)

Dehydrogenase Use 02 as an electron acceptor

Use molecules other than 02 as electron

Oxidases acceptor (NAD, FAD, NADP) - Oxidative

decarboxylases

Peroxidases Use H202 as an electron acceptor

Oxygenases Incorporate 02 into the substrate

— Transferases are defined as enzymes that used to transfer any molecules so that the

molecular formula is changed

Example:

-

0

|

- <

I J

Oe Oe Oe OO) eee OO

\

[o}

Oo

f- -

[ele]e)

I

[e]

Alanine

alpha ketoglutarat

Alanine

transaminase

(ALT)

—— C=0 Hy!

C00 H

Pyruvate

Glutamate

FEATURES

Methyl transferase

Transfer 1 carbon units

Kinases

Transfer phosphate from ATP

Phosphorylase

Transfer phosphate from pi

Amino transferase

Transfer amino groups

HYDROLASES:

+ They are defined as enzymes that used to break the chemical structure with Use of H20.

Examples:

+ Phosphatase - Remove phosphate from a substrate

+ All digestive enzymes

Ra a + H,0

Pyrophosphate

(0)

Pyrophosphatase II o

—— D3 HO i —0

o®

Phosphate

+ They are defined as enzymes that can make/ break [do not require H20 / ATP]

COO coo

HN—C—H Sei HN—C—H

+ ATP + NHS ’ + ADP + P,

(CH), (CH,),

C C

0 0 0 NH,

L-Glutamate L-Glutamine

Synthetases Link 2 molecules without using ATP

Aldolase Produce aldehydes via elimination reactions

Decarboxylase Produce 02 by eliminating reactions

(simple only)

Hudrat Add or remove water

ydratase (do not break bond)

ISOMERASES:

+ They are defined as enzymes that used to make different compounds but the molecular

formula do not change .

maleate fumarate

HO 0) 0 maleate isomerase HO

OH

Oo

EXAMPLES FEATURES

Racemase Interconvert L&D stereoisomers

Transfer groups between atoms

Mutase it

within a molecule

€pimerase Interconvert epimers

LIGASES:

+ They are defined as enzymes that used to make different compound use of ATP to make them

Synthetase Link 2 molecules via an ATP-

dependent reaction.

Carboxylase Use C02 as a substrate

CoO CoO

HN—C—F N—C—H

ATP NH, AD P

(CH,) CH

C C

TOPIC: CO ENZYMES

Question: what are CO ENZYMES and their examples 2

DEFINITION:

+ Coenzyme is a substance that enhances the action of an enzyme .

+ The catalytic activity of enzymes mostly depends on the presence of non-protein

compounds called coenzymes.

1. Lipoic acids

Lipoic acid is a coenzyme but not a vitamin

2. Vitamins

All water -soluble vitamins act as coenzymes (B-complex & VIT C)

Only Fat soluble vitamin acting as coenzyme - VIT K (carboxylation)

3. Nucleotides

NAD

NADP

FAD FMN

4. Mg requires as a coenzyme for

Kinases

Phosphorylases

Carboxylases

S. Cu REQUIRED FOR

+ Oxidases

Cyt c Oxidase

Tyrosinase

Ascorbic Acid Oxidase

Amino Acid Oxidase

Lysyl Oxidase

Cytoplasmic SOD [Super Oxide dismutase]

+ Mitochondrial SOD requires Manganese

6. Molybdenum

Xanthine Oxidase

Sulfite Oxidase

Question: what are types of enzymes inhibitors 2

There are 6 types of enzymes inhibitors:

1. Competitive

2. Non-competitive

3. Uncompetitive

4. Allosteric

3. Feedback inhibition 6. Suicidal inhibition

COMPETITIVE INHIBITION -

Inhibitor resembles substrate in structure. Inhibitor binds at active site.

Features:

. Km (Michaelis constant) does not depend upon change in enzyme and substrate concentration.

. Km defines affinity between a particular enzyme substrate pair.

. But in competitive inhibition the affinity b/w enzyme and substrate decreases because now enzyme has affinity

for both substrate and inhibitor.

. Affinity decreases so Km increases

. Inhibitor resembles substrate

.V max remains same but Km increases.

Competitive Inhibitors examples

1. Arsenate = Glyceraldehyde-3 -PDH

2. Oxamate ->Lactate DH

3. Malonate (3C) -> Succinate DH

4 Fluorocitrate -> Aconitase

NON - COMPETITIVE INHIBITION -

Substrate do not resemble inhibitor in structure. Inhibitor binds at regulatory or

allosteric site. When inhibitor binds at regulatory site, it changes the shape of active site, so

that substrate cannot bind .

Features

.V max is lowered

. Km is same

. Affinity is same

. Inhibitor can bind with €S complex, and does not change the

substrate affinity For the enzyme.

. This inhibition is mostly irreversible.

Examples

1lodoacetate -> Glyceraldehyde - 3 - POH

2 NaF -> €nolase

3. Fluoroacetate -> Aconitase

| UN-COMPETITIVE INHIBITION enT-corpervo

+ Substrate binding exposes the inhibitor binding site away from the catalytic/substrate binding

site.

+ Increasing substrate concentration does not reverse the inhibition. The inhibited reaction rate

parallel the normal one as reflected on decreased both v max and Km-

- Acetylcholine inhibits Placental ALP (Alkaline Phosphatase)

Fee BACK INHIBITION / END PRODUCT nHemoN|

- €nd product itself inhibits the reaction

~ Example

+ Feed back Inhibition is a natural phenomenon occurring in body.

+ It is normally observed in regulation of enzymes and pathways.

SUICIDAL INHIBITION / MECHANISM BASED, REY |

Example - Allopurinol Inhibits Xanthine oxidase by a proper mechanism

Suicidal Inhibition is unnaturally occurring phenomenon e.g Drugs

competitive non-competitive uncompetitive

inhibitors inhibitors inhibitors

Describe suicide inhibition of enzymes.

Name one suitable example for suicidal inhibition of enzymes.

- Suicide inhibition, also called suicide inactivation or mechanism-based

inhibition, is an irreversible type of enzyme inhibition.

- It occurs when an enzyme binds a substrate analog.

- During the normal catalysis reaction, this binding leads to the formation

of an irreversible complex through a covalent bond.

- This complex renders the enzyme permanently inactive.

EXAMPLES.

- 3-fAuorouracil acts as a suicide inhibitor of thymidylate synthase during thymine synthesis

from uridine.

- This inhibition is crucial for halting the proliferation of rapidly dividing cells, including fast-

growing cancer tumors.

- Cells die from a "thymineless death" because they lack thymine necessary for DNA

synthesis.

- Often used in combination with methotrexate, a potent inhibitor of dihydrofolate reductase

enzyme.

- Aspirin, which inhibits cyclooxygenase 1and 2 enzymes.

- Nerve agents and pesticides like parathion irreversibly inhibit acetylcholinesterase .

TOPIC : ENZYMES REGULATION

Question. What are the Various ways of Enzyme Regulation 2

(DEFINITION\*process by which cells can turn on turn off or modulate the activities which are the activities

of various metabolic pathways by regulating the activity of enzyme.

Enzyme Regulation

1) Induction and Repression of Enzyme Synthesis:

- Regulation of enzyme synthesis at the gene level.

- Induction increases enzyme synthesis, while repression decreases it.

- Examples:

1. Insulin induces glycolytic enzymes and represses gluconeogenic enzymes.

2. Glucagon induces pyruvate carboxylase and represses PFK.

Il) Allosteric Regulation:

Repression

1 E D c B A

XX i; IE I I MEX

rranseriptior] |

Repressor mmm

mRNA Active

repressor

Translation protein

Wp votophan

(corepressor)

- Allosteric enzymes have allosteric sites different from the active site.

- Allosteric modifiers bind to these sites, either activating (allosteric activators) or inhibiting (allosteric

inhibitors) enzyme activity.

- Classification based on effect on Km and Vmax:

a) K-Class allosteric enzymes: Change Km but not Vmax (substrate saturation kinetics like competitive

inhibition).

b) V-Class allosteric enzymes: Change Vmax but not Km (substrate saturation kinetics like non-competitive

inhibition).

- Allosteric enzymes show cooperativity, with positive and negative modifiers affecting active site activity.

(a) Reaction

substrate BR 2

Ill) Covalent Modification:

f) Irreversible Covalent Modification (Proenzymes or Zymogens):

- Some enzymes are synthesized as inactive proenzymes.

- Converted to active Form by irreversible breakage of specific covalent peptide bonds.

- Example: Proteases in the Gl tract (e.g. trypsinogen to Lrypsin.

- Significance: Protects tissue from auto-digestion and facilitates rapid activity.

B) Reversible Covalent Modification:

- Regulation by reversible phosphorylation and dephosphorylation.

- Phosphate groups control enzyme activity.

- Examples: Glycogen phosphorylase (phosphorylated form active, dephosphorylated form

inactive) and glycogen synthase (phosphorylated form inactive, dephosphorylated form active).

IV) Feedback Regulation:

1) Feedback Allosteric Inhibition:

- €nd product inhibits the key enzyme in a pathway.

- Regulation at the enzyme level.

- Example: ALA synthase in heme synthesis inhibited by excess heme.

2) Feedback Repression:

- €nd product represses the synthesis of the key enzyme at the gene level.

- Example: HMG CoA reductase in cholesterol synthesis repressed by excess cholesterol.

- Prevents excess synthesis of end products by regulating key enzymes in metabolic pathways.

A Enzyme 1 B Enzyme 2 C| Enzyme 3 D

@ Negative feedback

EXTRA EDGE

Multienzyme Complexes:

- Definition:Multienzyme complexes refer to the localization of several enzymes

catalyzing a sequence of consecutive reactions of a metabolic pathway into a

macromolecular complex.

- Examples: Fatty acid synthase complex, alpha-ketoglutarate dehydrogenase

complex, Pyruvate dehydrogenase complex, etc.

-Complex Activity:Multienzyme complexes are active only in their complex form.

Individual enzyme activities within the complex cannot be separated through

fractionation.

Significances of Multienzyme Complexes:

1. Efficiency:Multienzyme complexes increase the efficiency and speed of

metabolic pathways by directly transferring intermediates from one enzyme to the

next, preventing their dilution in the surrounding medium. This ensures an

uninterrupted sequence of reactions until the pathway is completed.

2. Protection of Intermediates:Intermediates bound to multienzyme complexes are

shielded from diversion into other metabolic pathways, thus enhancing the

specificity of the pathway.

A

Sibstate mmmp sm proc

intermediate intermediate

B substrate tunnel

substrate EE) mmm) product

LARIVATNY en3yme compen

EXTRA EDGE

Enzyme Compartmentalization:

Definition: Enzyme compartmentalization refers to the organization of

enzymes within distinct cellular locations, allowing for precise regulation of

metabolic pathways.

Examples:

1. Fatty Acid Metabolism: Enzymes involved in fatty acid synthesis are

primarily located in the cytosol, while those responsible for fatty acid

degradation are found in mitochondria, ensuring these processes do not

occur simultaneously.

2. Heme Synthesis: Heme, an important component for hemoglobin, is

synthesized in one cellular compartment and then transported across

membranes for further processing, preventing unwanted reactions.

Regulation: Enzyme compartmentalization enables the regulation of

metabolic pathways by keeping specific enzymes in separate compartments,

ensuring that each reaction occurs where and when needed, thus preventing

unwanted or futile cycles.

Question: what are the DIAGNOSTIC and THERAPEUTICS USES

of enzymes?

DIAGNOSTIC USES

1. SGOT, SGPT For Liver diseases

THERAPEUTICS USES

1. Lactase -> Lactose Intolerance

2. Lactamase -> Penicillin Allergy

3. Urokinase / Streptokinase - Converts Plasminogen - Plasmin

-> Used for lysis of Intravascular clots.

4. Trypsin / chymotrypsin used for pain + inflammation in chronic back pain

and sprain.

S. Collagenase

-> Skin ulcers (reduces the format of scar tissue)

6. Pepsin - Pancreatic insufficiency & chronic indigestion

7. Asparaginase/ Glutaminase -> All (Acute Lymphoblastic Leukemia)

8. Uricase -> Gout

9. Alpha - 1- Anti trypsin -> Emphysema

- IN ALL (Acute Lymphoblastic Leukemia), the cancer cell has high demand for

Asparagine & Glutamine

- These enzymes break down these AA & ALL cell will die

+ Coenzymes provide additional chemically reactive functional groups

besides those present in the amino acids of the apoenzymes

— Are either small organic molecules or inorganic ions

+ Metal ions often act as additional cofactors (Zn2+, Mg2+, Mn2+ & Fe2+)

— A metal ion cofactor can be bound directly to the enzyme or to a coenzyme

+ COENZYME

— A small organic molecule, acting as a cofactor in a conjugated enzyme

+ Coenzymes are derived from vitamins or vitamin derivatives

— Many vitamins act as coenzymes, esp. B-vitamins.

Enzyme definitions

Enzyme Protein only enzyme that facilitates a chemical reaction

(simple)

Coenzyme Compound derived from a vitamin (e.g. NAD") that assists an

enzyme in facilitating a chemical reaction

Cofactor Metal ion (e.g. Mg?\*) that that assists an enzyme in facilitating a

chemical reaction

Apoenzyme Protein only part of an enzyme (e.g. isocitrate dehydrogenase)

that requires an additional coenzyme to facilitate a chemical

reaction (not functional alone)

Holoenzyme Combination of the apoenzyme and coenzyme which together

facilitating a chemical reaction (functional)

Define the active site of enzymes.

— The specific portion of an enzyme (location) where the substrate binds while it undergoes

a chemical reaction

— The active site is a 3-D ‘crevice-like’ cavity Formed by secondary & tertiary structures of

the protein part of the enzyme

— Crevice formed from the Folding of the protein Also called as binding cleft

— An enzyme can have more than only one active site

— The amino acids R-groups (side chain) in the active site are important for determining the

specificity of the substrate

Question: What is Enzyme Specificity?

Explain the concept of absolutely specific enzymes.

— An enzyme will catalyze a particular reaction for only one substrate

— Most restrictive of all specificities

+ Not common

— Catalase has absolute specificity for hydrogen peroxide (H202)

— Urease catalyzes only the hydrolysis of urea

— The enzyme will act only on similar substrates that have a specific functional group

» Carboxypeptidase cleaves amino acids one at a time from the carboxyl end of the peptide chain

+ Hexokinase adds a phosphate group to hexoses

— The enzyme will act on a particular type of chemical bond, irrespective of the rest of the molecular

structure

— The most general of the enzyme specificities

+ Phosphatases hydrolyze phosphate—ester bonds in all types of phosphate esters

+ Chymotrypsin catalyzes the hydrolysis of peptide bonds

STEREOCHEMICAL SPECIFICITY:

— The enzyme can distinguish between stereoisomers

— Chirality is inherent in an active site (as amino acids are chiral compounds)

+ L-Amino-acid oxidase catalyzes reactions of L-amino acids but not of D-amino acids

Explain the influence of various factors on enzyme activity. Explain the

effect of temperature on enzyme activity.

Define metalloenzymes and provide two examples.

Factors affecting enzymatic activity - enzyme concentration, pH,

temperature and substrate concentration.

Effect of pH and temperature on enzyme activity.

ENZYME ACTIVITY:

\* Measure of the rate at which an enzyme converts substrate to products in a biochemical reaction.

4 factors affect enzyme activity:

» Temperature

. pH

+ Substrate concentration: [substrate]

» Enzyme concentration: [enzyme]

TEMPERATURE (b):

+ With increased t the €KIN increases More collisions Increased

reaction rate

+ Optimum temperature (EOPT) is the temperature at which the

enzyme exhibits maximum activity

— The tOPT For human enzymes = 37degree Celsius

+ When the t increases beyond tOPT Changes in the enzyme's tertiary

structure occur, inactivating & denaturing it (e.g. fever)

+ Little activity is observed at low t

pH:

+ Optimum pH (pHOPT) is the pH, at which the enzyme exhibits

maximum activity

\* Most enzymes are active over a very narrow pH range

-Protein & amino acids are properly maintained

— Small changes in pH (low or high) can result in enzyme denaturation

& loss of Function

+ Each enzyme has its characteristic pHOPT, which usually Falls within

physiological pH range 7.0 - 7.5

+ Digestive enzymes are exceptions:

— Pepsin (in stomach) — pHOPT = 2.0

— Trypsin (in SI) — pHOPT = 8.0

=

S

=

I>]

<

5

Increased number

of enzyme—

substrate

collisions

Optimum

temperature

i

Denaturation

due to excess

heat

|

Maximum rate

'

|

| Optimum pH

|

+ IF [enzyme] is kept constant & the [substrate] is

increased.

— The reaction rate increases until a saturation

point is met

+ At saturation the reaction rate stays the same

even if the [substrate] is increased

— At saturation point substrate molecules are

bound to all available active sites of the enzyme

molecules

+ Reaction takes place at the active site

— IF they are all active sites are occupied the

reaction is going at its maximum rate

+ Cach enzyme molecule is working at its maximum Substrate concentration >

capacity

— The incoming substrate molecules must “wait

their turn”

Maximum reaction rate

/

Rate approaches

maximum

Reaction rate (ve

+ IF the [substrate] is kept constant & the [enzyme] is increased

— The reaction rate increases

— The greater the [enzyme], the greater the

reaction rate

«RULE:

— The rate of an enzyme-catalyzed reaction is

always directly proportional to the amount

of the enzyme present

+ In a living cell:

— The substrate is much higher than the enzyme

\* Enzymes are not consumed in the reaction

» Enzymes can be reused many times Enzyme con

Effect of product concentration

The accumulation of reaction products generally decreases the enzyme velocity.

Enzyme Activation by Metals:

- Some enzymes require specific metallic cations (Mg2+, Mn2+, Zn2+, etc.) or anions (CI) for

optimal activity.

- Metals act as activators by interacting with substrates, forming complexes, participating in

reactions, or inducing enzyme conformational changes.

- Two categories:

- Metal-activated enzymes (e.g. ATPase with Mg2\* and Ca2\*, Enolase with Mg2+): Metals can

be easily exchanged with other ions.

—Metalloenzymes : These enzymes hold the metals rather tightly which are not

readily exchanged. e.g. alcohol dehydro- genase, carbonic anhydrase, alkaline phos- phatase,

carboxypeptidase and aldolase contain zinc.

Phenol oxidase (copper);

Pyruvate oxidase (manganese); Xanthine oxidase (molybdenum); Cytochrome oxidase (iron

and copper).

Km (Michaelis -Menton constant) with significance.

Definition:

Km is defined as the substrate concentration at half maximum velocity (1/2 Vmax). Km is

expressed in moles/ L.

Significance of Km:

1) Km is the characteristic feature of an enzyme for its substrate: It is a constant for an

enzyme for its substrate. Km is termed as the signature of the enzymes.

2) Km is the measure of affinity of enzyme for its substrate:

Lower the Km value higher w ill be the substrate affinity of enzymes and vice versa. €g:

Glucose is phosphorylated by glucokinase (liver enzyme) & hexokinase (present in all

tissues). Both have different Km value for glucose.

Km of glucokinase is 10 mmol/L & Km of hexokinnse is 0.05 11111101/L

This indicates hexokinase has more affinity thnn glucokinase For glucose.

3) Enzymes have 50 % efficiency at Km:At Km, enzymes have half the maximum velocity i.e.

only 50% of enzymes are active (other 50% are free).

ea Te

Michaelis - Menten Reaction

equation rate

0.5V Va

\ =

Vo = Vmax [S] Km +4

+ ot

Kn [S] 0 Km Substrate concentration 4

4) Km value is helpful in understanding the natural substrate of enzymes that act on more than one

substrates. For instance, hexokinase can phosphorylateglucose, fructose, galactose, mannose etc. But

this enzyme has the lowest Km (maximum affinity) For glucose than other substrate. So, it can be

concluded that the glucose is the natural substrate of hexokinase enzyme.

5) pH.temperature and inhibitors affect Kmvalues.

6) Isoenzymes have different Km values For the same substrates.

Isoenzymes

Isoenzymes - definition, characteristics and clinical

significance.

- Definition: Isoenzymes are distinct molecular forms of an enzyme that

catalyze the same reactions within a single species.

- Characteristics:

1) Isoenzymes possess different structures and physical/chemical

properties.

2) Despite these differences, all isoenzyme forms of an enzyme perform the

same reaction, acting on the same substrate to produce identical products.

3) Isoenzymes exhibit variations in amino acid compositions, electrophoretic

mobility, and immunological properties. They can be separated via

electrophoresis.

4) Isoenzymes may have distinct Km values (and Vmax) for the same

substrates.

5) Isoenzymes frequently consist of multiple polypeptide chains, forming

oligomeric units. For example, LDH has 4 polypeptide chains, and CK has 2

polypeptide chains.

Clinical Significance of Isoenzymes:

- Isoenzymes are valuable diagnostic markers for various diseases, as their

tissue-specific distribution and regulation make them indicative of tissue

damage or dysfunction.

- Measuring the levels of specific isoenzymes in the blood can aid in the

diagnosis and monitoring of diseases.

- Examples of clinical significance include:

- LDH isoenzymes: Elevated LDHI levels in the blood can be indicative of

myocardial infarctions, while increased LDHS levels may suggest muscle

dystrophies.

- CK isoenzymes: Elevated CK-MM levels are associated with skeletal

muscle disorders, like muscle dystrophies. Elevated CK-MB levels can

indicate myocardial infarctions.

Extra edge

- Regulatory Role of Isoenzymes:

- Isoenzymes are typically found in different tissues and are regulated

by distinct inducers, repressors, and allosteric modifiers based on the

specific needs of those tissues. This tissue-specific regulation provides a

point for the fine-tuning of enzyme activity in various parts of the body.

Describe the clinical significance of following enzymes: LDH,

alkaline phosphatase, creatinine kinase, amylase, alanine

transaminase.

LDH

Isoenzyme | Composition | Electrophore | Presentin Elevated in

name tic migration

LDH 1 (Hy) Fastest Myocardium, myocardial

Heat moving RBC, kidney infarction

resistant

LDH2 (H;M,) Myocardium, Kidney

Heat RBC, kidney disease,megalo

resistant blastic anemia

LDH3 (H,M,) brain Leukemia,malig

nancy

LDH4 (H M3) Lung,spleen Pulmonary

Heat labile infarction

LDH5 (My) Slowest Skeletal Skeletal muscle

Heat labile moving muscle, Liver | and liver

Inhibited by diseases

urea

Creatine kinase

Isoenzy

Compo . .

me OMPO | present in Elevated in

sition

name

CK-1 Brain,prostate,Gl

Fast BB tract,lung,bladder,uteru | CNS diseases

moving s,placenta

a Acut dial

. cute myocardia

2% of MB Myocardium/ Heart my

infarction

total

CK-3

S| MM Skeletal muscle,

pi Myocardium

moving

ALP

Orthophosphoric monoester phosphohydrolase

\* produced In mucosa of small intestine, proximal convoluted tubule,

bone, liver, placenta

+ Catalyses alkaline hydrolysis of naturally occuring and synthetic

substrates

Alpha 1 ALP-epithelial cells of biliary canaliculi

+ Alpha 2 heat labile ALP- hepatic cells

+ Alpha 2 heat stable ALP-not destroyed at 65°C

inhibited by phenylalanine placental

Pre beta ALP - bone, heat labile

+ Gamma ALP - intestinal cells inhibited by phenylalanine

\* Leukocyte alkaline phosphatase -decreased in CML

increase in lymphoma

Clinical significance

Hepatobiliary disease

\* Hepatic carcinoma

\* Hepatic metastases

- Pagets disease (10 - 25 times)

\* Bone cancer

+ Healing of bone fracture

+ Osteomalacia and rickets

\* Hyperparathyroidism

+ Ca of ovary,uterus-regan isoenzyme

+ Metastatic Ca of pleural surfaces -Nagao isoenzyme

ALT (Alanine transaminase) is rich in liver.

Normal serum level is 3 - 35 IU/L.

During liver diseases,

ALT is released into the blood and their level increases in the blood, which

reflects a possible liver damage

AMYLASE

Amylase is produced in the salivary glands and pancreas. Elevated levels of

amylase can be observed in the following conditions:

1. Acute Pancreatitis: This is a major cause of increased amylase levels.

Inflammation of the pancreas leads to the release of amylase into the

bloodstream.

2. Mumps (Acute Parotitis): Mumps is a viral infection that primarily affects the

salivary glands, particularly the parotid glands. Inflammation of these glands can

result in elevated amylase levels.

3. Obstruction in Pancreatic Duct: Any obstruction or blockage in the pancreatic

duct can lead to increased amylase levels because the enzyme cannot flow into

the intestines as it normally would.

4. Severe Diabetic Ketoacidosis: In rare cases, severe diabetic ketoacidosis, a

complication of uncontrolled diabetes, can lead to increased amylase levels.

Diagnostic enzymes — examples and clinical significance.

- Diagnostic enzymes, also known as clinical enzymes, are intracellular

enzymes.

- They lack a specific role in the bloodstream and are primarily located in

specific tissues.

- When these corresponding tissues undergo normal wear and tear or are

damaged, these enzymes are released into the bloodstream.

- In healthy individuals, the concentration of diagnostic enzymes in the blood is

typically low and within normal levels.

- Elevated levels of diagnostic enzymes in the blood reflect possible damage to

the specific tissue where these enzymes are abundant.

- Measurement of increased blood enzyme levels is essential for diagnosing

diseases and conditions related to the affected tissues.

- The degree of enzyme elevation often correlates with the extent of tissue

damage.

- Diagnostic enzymes also play a role in prognosis by helping assess disease

severity and progression.

\*\* examples and clinical significance you can write from the prior answer \*\*

Cardiac markers for myocardial infarction.

1. Creatine Phosphokinase (CPK):

- CPK is the first enzyme to be released into circulation, appearing within 6-18

hours after an MI.

- It reaches its peak value within 24-30 hours and returns to normal levels by

the 2nd or 3rd day.

2. Aspartate Transaminase (AST or SGOT):

- AST rises after CPK and reaches its peak within 48 hours of the MI.

- It takes 4-5 days to return to normal levels.

3. Lactate Dehydrogenase (LDH1):

- LDH1 typically rises from the second day after infarction.

- It reaches its peak by the 3rd or 4th day and takes about 10-15 days to

return to normal levels.

- LDH is the last enzyme to rise and the last to return to normal levels in MI.

4. Cardiac Troponins (CT):

- Cardiac troponins, although not enzymes, are highly useful for early MI

diagnosis.

- Troponin I and Troponin T are significant markers.

- Cardiac Troponin I (CTI) is released into circulation within four hours after

the onset of MI, peaks within 12-24 hours, and remains elevated for about a

week.

5. Myoglobin:

- Myoglobin is an early marker for MI diagnosis.

- However, it is not specific to cardiac diseases.

6. Brain Natriuretic Peptide (BNP):

- High serum concentrations of BNP are a marker for congestive cardiac

failure.

Taste 6.12 Summary of diagnostic markers used for the evaluation of acute myocardial infarction

Diagnostic marker Time of peak Time of return Diagnostic importance

elevation to normal level

Myoglobin 4-6 hrs 20-25 hrs Earliest marker, however not cardiac specific.

Cardiac troponin | 12-24 hrs 5-9 days Early marker and cardiac specific.

Cardiac troponin T 18-36 hrs 5-14 days Relatively early marker and cardiac specific.

However, elevated in other degenerative diseases.

Creatine phosphokinase (MB) ~~ 20-30 hrs 24-48 hrs Cardiac specific and early marker.

Lactate dehydrogenase (LDH I) ~~ 48-72 hrs 10-15 days Relatively late marker and cardiac specific.

Aspartate transaminase 30-48 hrs 4-6 days Not cardiac specific.

Cardiac Biomarkers

Multiples of Upper Reference Limit

dL

1

1

+ Hepato-biliary markers.

Enzymes Indicating Liver Damage (Hepatic Jaundice):

\* ALT (SGPT): Normal level is 3 - 35 U/liter of serum.

+ AST (SCOT): Normal level is 4 - 40 U/liter of serum.

+ LDH (Particularly LDH isoenzyme 4): Normal level is 60 - 200 U/L.

- These enzyme levels increase in cases of liver damage, such as hepatic

jaundice.

Enzymes Indicating Biliary Diseases (Obstructive Jaundice):

\* Alkaline Phosphatase (ALP): Normal serum level is 3 - 13 KA units/dL.

+ GGT (y-glutamyl transferase): Normal serum level is 7 - 50 U/L.

+ 5'-Nucleotidase: Normal serum level is 2 - 17 U/L.

- These enzyme levels increase during posthepatic jaundice or obstructive

jaundice.

- 5'-Nucleotidase is a better indicator of biliary diseases, as it is biliary-

specific, while ALP may also increase in bone diseases and GGT may increase

in alcoholic liver diseases.

Name two enzymes of pancreatic injury.

SERUM LIPASE

SERUM AMYLASE

Therapeutic enzymes:

Enzymes that are used in the treatment of certain diseases are called

therapeutic enzymes

+ Streptokinase obtained from streptococcus and urokinase obtained

from urine of human beings are used in the lysis of the intravascular

clots as they convert plasminogen to plasmin which lyses the clot.

+ Asparginase is used in the treatment of leukemia. Tumour cells have a

high requirement for asparagine. Administration of intravenous

asparginase enzyme decreases the plasma level of asparagine and

availability of asparagine to the tumor cells is decreased. This

depresses the feasibility of tumor cells.

+ Papain is used in the treatment of inflamation.

+ Antitrypsin is used in the treatment of emphysema.

+ Collagenase is used in the treatment of burns and ulcers.

1 Asparginase Acute Lymphatic Leukemia (cells need Asparagine for its

growth)

2 Streptokinase LYSE INTRACELLULAR CLOT

3 Uro kinase Lyse Intracellular Clot

a Plasminogen PLASMIN /CLOT LYSIS

5 Streptokinase DNA ase applied locally

6 Hyaluronidase Enhance local anesthesia

7 Pancreatic (Lipase & Trypsin) Pancreatic insufficiency = oral administration

Papain Anti-inflammatory

Alpha Anti Trypsin Emphysema

Multiple choice questions

Which of the following is a lyase?

A) Aldolase B

=) Acelbyl-CoA Carboxylase

<) Fatty Acyl- CoA Dehydrogenase

D) Acetyl-CoA Synthetase

Which of the following enzyme is not volved in oxidation

reduction reactions?

A) Dehydrogenase

B) Hydrolase

C ) Peroxidase

D ) Oxygenase

Which of the following is not a coenzyme?

A) Lipoic acid

B) AT?

C) Vitamin K

TY S—adenosyl methionine

Which of the following is not a copper-conlaining enzyme?

A) Mitochondrial superoxide dismutase

B) Cytosolic superoxide dismutase

C) Tyrosinase

D) Lysyl oxidase

Which of the following is the coenzyme group present in the enzvme

xantine oxidases ?

A) Molybdenum

3) Zine

C) Manganese

TY Copper

Answer

la

2b

34

4.0

5.

Essay Questions

1. Define enzymes. Describe the classification and mechanism of

action of enzymes.

2. Classify enzymes with examples. Enumerate the factors affecting

the rate of enzymatic actions. Competitive inhibition of enzymes,

Short Guestions

1. What are the Types of enzymes inhibition.

2. Distinguish between competitive and non-competitive inhibition of

enzyme action with example.

3What is a co—enzyme? How is it different from activator,

4 Creatine phosphor kinase

§. What is non competitive inhibition