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FACULTY OF ENGINEERING & TECHNOLOGY

Dr. NIHARIKA SINGH
Assistant Professor
Dept. of Biotechnology

Course: B. Sc Biotechnology

Sub Code: CBBS-303

Semester: 3rd

Sub Name: Biochemistry and Metabolism

LECTURE 1

Dr. NIHARIKA SINGH
Assistant Professor
Dept. of Biotechnology

INTRODUCTION

- Amino acids are a group of organic compounds containing **two functional groups-amino and carboxyl.** The **amino group (-NH)** is basic while the **carboxyl group – (-COOH)** is acidic in nature.
- General structure of amino acids: The amino acids are termed as α-amino acids, if both the carboxyl and amino groups are attached to the same carbon atom. The **α-carbon atom binds to a side chain represented by R which is different for each of the 20 amino acids found in proteins**.
- The amino acids mostly exist in the ionized form in the biological system.

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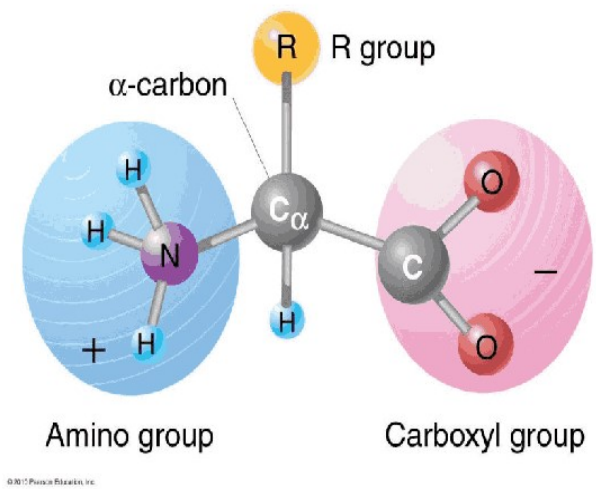
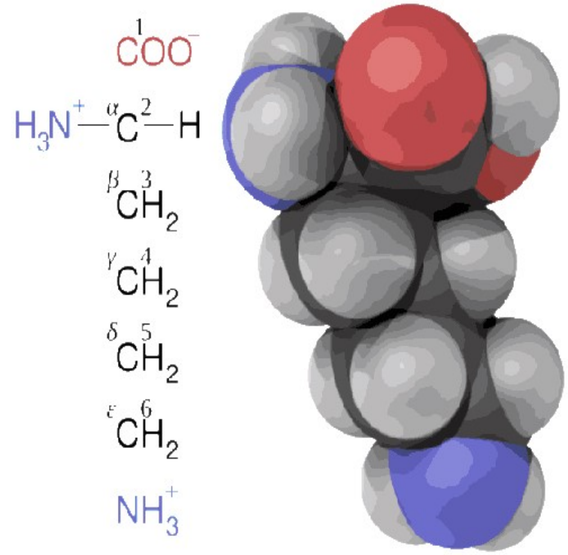
GENERAL STRUCTURE



Each Amino acid:	Phenylalanine
Three letter abbreviation	Phe
One-letter symbol	F



Greek lettering and numbering systems help to define specific carbon atoms.

https://www.docsity.com/es/amimoacidos/3979454/

HISTORY

- The first amino acid which was discovered is Asparagine in 1806. Threonine was the last amino acid to be found in the year 1938.
- All the amino acids have trivial or common name from which they were first isolated.
- Asparagine was found in asparagus and glutamine was found in wheat gluten: tyrosine was first isolated from cheese and glycine (greek glykos means sweet) was so named because of the sweet taste.

CLASSIFICATION OF AMINO ACID

A. Nutritional classification of amino acid

B. Classification of amino acid based on polarity

C. Amino acid classification based on their metabolic fate

D. Amino acid classification based on the structure

E. Two main groups of amino acids

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A. Nutritional classification of amino acid

1. Essential or indispensable amino acid

2. Non-essential or dispensable amino acid

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1. **Essential amino acids**

- The amino acid which cannot be synthesized by the body and, therefore need to be supplied through the diet is called essential amino acids.
- Ten amino acids comes under this group. Arginine ,Valine , Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan

2. Non-Essential amino acids

- The body can synthesize about 10 essential amino acids to meet the biological needs hence they need not be consumed in the diet.
- Glycine, Alanine, Serine, Cysteine, Aspartate, Asparagine, Glutamate, Glutamine, Tyrosine, and Proline.

Essential Amino acids	Non-Essential Amino acids
Arginine	Glycine
Histidine	Alanine
Isoleucine	Asparagine
Leucine	Aspartate
Lysine	Glutamate
Methionine	Serine
Phenylalanine	Cysteine
Threonine	Glutamine
Tryptophan	Tyrosine
Valine	Proline

B. Classification of amino acids based On polarity

1. Non-polar amino acids with aliphatic 'R' group
2. Non-polar amino acids with aromatic 'R' group
3. Polar amino acids with no charge on 'R' group
4. Polar amino acids with negative 'R' group
5. Polar amino acid with positive 'R' group

1. **Non polar amino acids with aliphatic 'R' group**

- These amino acids are non polar and also referred to as hydrophobic (water hating).
- They have no charge on the 'R' group.
- The amino acids included in this group are Glycine, Alanine, Leucine, Isoleucine, Valine and Methionine

2. **Non polar amino acids with aromatic 'R' group**

- Their aromatic side chains are relatively nonpolar (hydrophobic).
- All can participate in hydrophobic interactions.
- The amino acids included in these groups are Phenylalanine, Tryptophan and tyrosine

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3. Polar amino acids with no charge on 'R' group

- These amino acids carry no charge on 'R' group and are soluble in water or more hydrophilic.
- They possess group such as hydroxyl, sulfhydryl and amide groups.
- They participate in hydrogen bonding of protein structure.
- The amino acids in this group are- Proline, Serine, Threonine, Cysteine, Glutamine and Asparagine

4. Polar amino acid with negative 'R' group

- The dicarboxylic monoacid.
- Aspartic acid and Glutamic acid are included in this group.

5. Polar amino acid with positive 'R' group

- These amino acids carry positive charge on the 'R' group
- They are dibasic monocarboxylic acid.
- They are highly basic in nature.
- The three amino acid Lysine, Arginine and Histidine are included in this group

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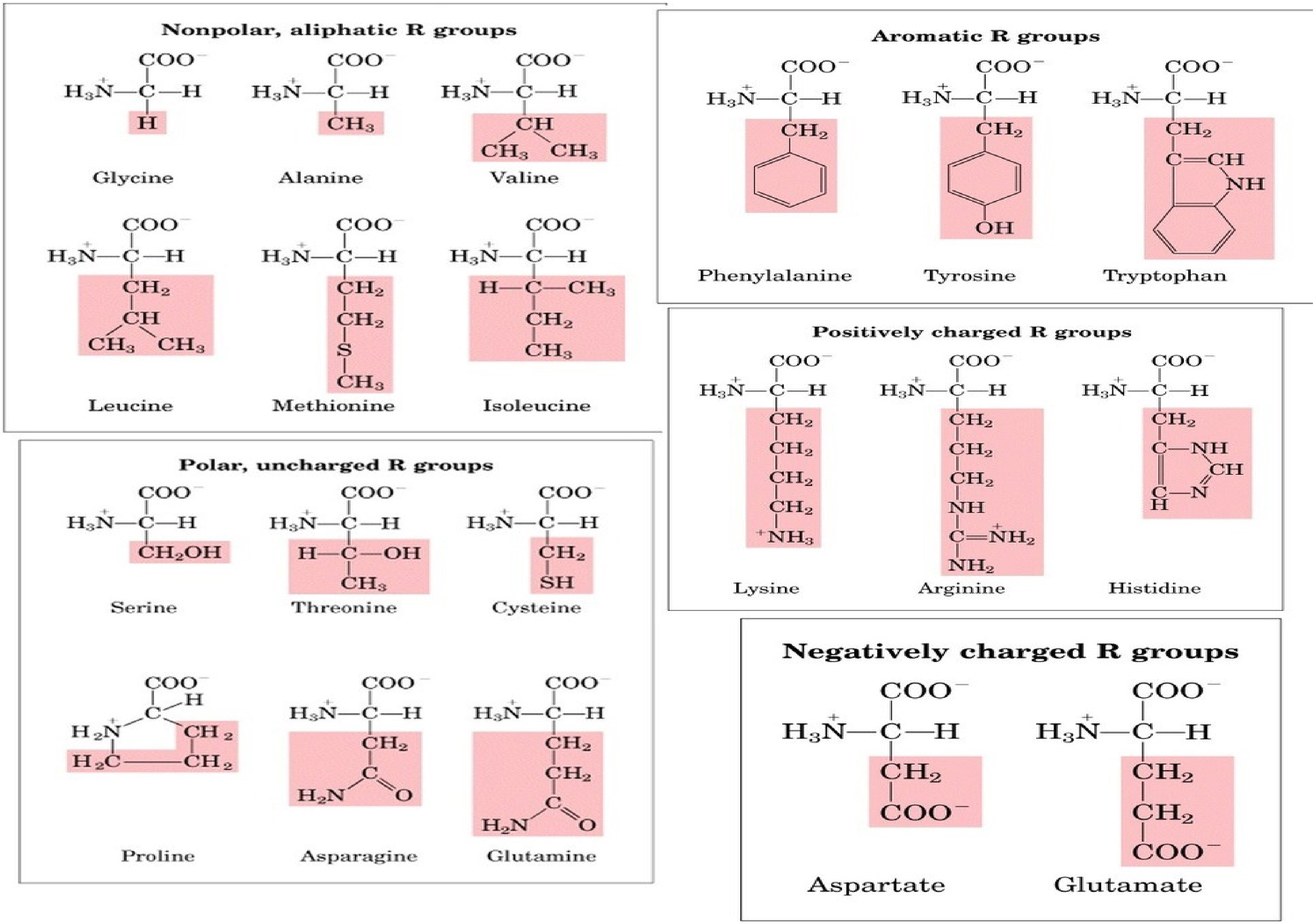
Nonpolar, aliphatic R groups
Glycine
Alanine
Valine
Leucine
Methionine
Isoleucine
Aromatic R groups
Phenylalanine
Tyrosine
Tryptophan
Polar, uncharged R groups
Serine
Threonine
Cysteine
Proline
Asparagine
Glutamine
Positively charged R groups
Lysine
Arginine
Histidine
Negatively charged R groups
Aspartate
Glutamate

C. Amino acid classification based on their metabolic fate

1. Glucogenic amino acids

2. Ketogenic amino acids

3. Glucogenic and Ketogenic amino acids

1. **Glucogenic amino acids**

- These amino acids serve as precursors for the formation of glucose and glycogen. The amino acids included in this group are Glycine, Alanine, Serine, Aspartic Acid, Asparagine, Glutamic Acid, Glutamine, Proline, Valine, Methionine, Cysteine, Histidine, And Arginine.

2. **Ketogenic amino acids**

- These amino acids breakdown to form ketone or fat bodies. Two amino acids Leucine and Lysine are exclusively ketogenic.

3. **Glucogenic and ketogenic amino acids**

- These amino acids breakdown to form precursors for both ketone bodies and glucose.The four amino acids Isoleucine, Phenylalanine, Tryptophan and Tyrosine are precursor for synthesis of glucose as well as fat.

Gluconeogenic Amino acids	Ketogenic Amino acids	Gluconeogenic and Ketogenic amino acids
Glycine	Threonine	Leucine
Alanine	Isoleucine	Lysine
Serine	Phenylalanine	
Aspartic Acid	Tryptophan	
Asparagine	Tyrosine	
Glutamine		
Glutamic Acid		
Proline		
Valine		
Methionine		
Cysteine		
Histidine		
Arginine		

D. Amino acid classification based on the structure

1. Amino acids with aliphatic side chains
2. Hydroxyl group containing amino acids
3. Sulfur containing amino acids
4. Acidic amino acids and their amides
5. Basic amino acids
6. Aromatic amino acids
7. Imino acids

E. Two main groups of amino acids

1. Standard amino acids

2. Non standard amino acids

1. Standard amino acids

Amino acids are building blocks of protein. The 20 standard amino acids also takes part in formation of protein structure. Arginine ,Valine , Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, Glycine, Alanine, Serine, Cysteine, Aspartate, Asparagine, Glutamate, Glutamine, Tyrosine, and Proline

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2. Non-standard amino acids

In addition to 20 standard amino acids, proteins may contain non-standard residues created by modification of standard residues already incorporated into a polypeptide. 4-Hydroxyproline- derivative of Proline 5-Hydroxylysine- derivative of Lysine 6-N-Methyllysine Ý-Carboxyglutamae Desmosine Selenocysteine

PROPERTIES OF AMINO ACIDS

The amino acids differ in their physiochemical properties which determine the characteristic of protein.

A. **Physical properties**

B. **Chemical properties**

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A. PHYSICAL PROPERTIES

1. **Solubility :** Most of the amino acids are usually soluble in water and insoluble in organic solvents.
2. **Melting point :** Amino acids generally melt at higher temperatures, often above 200°C.
3. **Taste :** Amino acids may be sweet (Gly, Ala, Val), tasteless (Leu) or bitter (Arg, Ile), Monosodium glutamate (MSG; ajinomotto) is used as a flavouring agent in food industry.
4. **Optical properties**: All amino acids except glycine possess optical isomers due to the presence of asymmentric carbon atom. Some amino acids have a second as symmentric carbon e.g. isoleucine, threonine.

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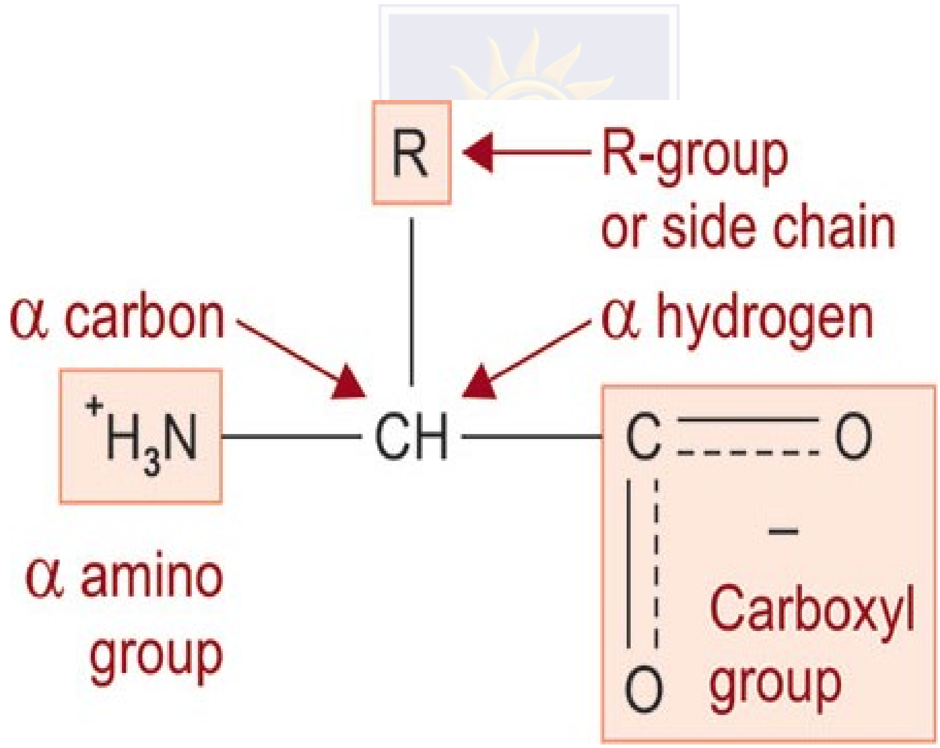
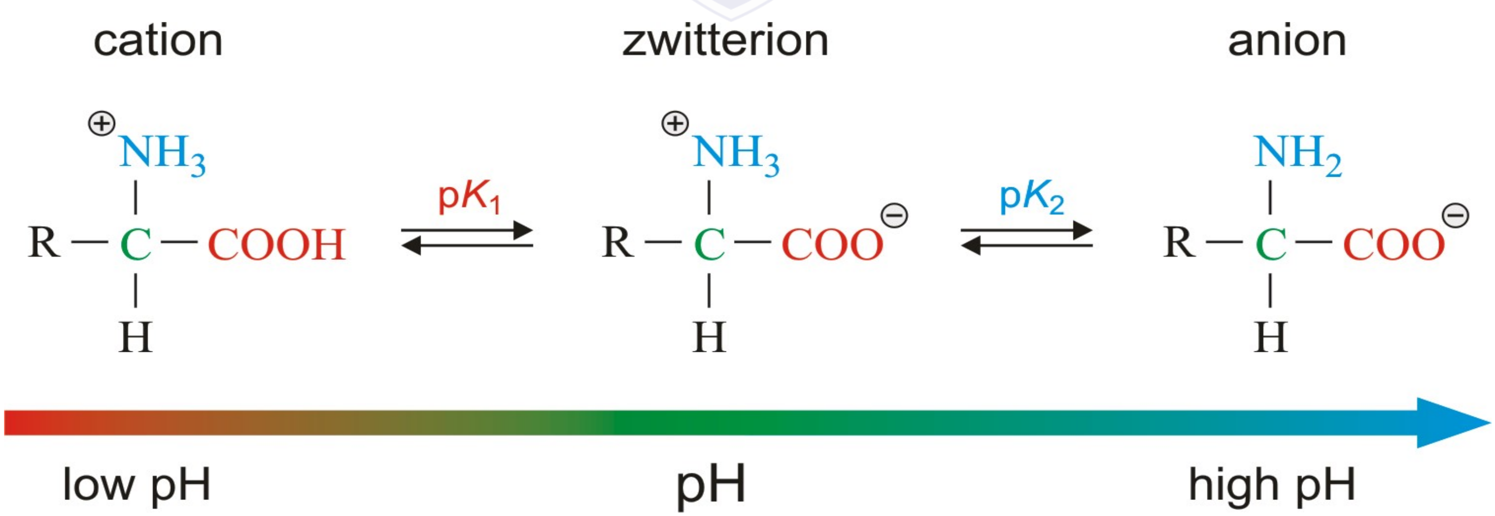
5. Amino acids as ampholytes : amino acid contains both acidic(-COOH) and basic (-NH2) groups. They can donate a proton or accept a proton , hence amino acids are regarded as ampholytes.



6. Zwitterion or dipolar ion: It is a hybrid molecule containing positive and negative groups. The amino acids rarely exist in a neutral form with free carboxylic (-COOH) and free amino (-NH) groups. In strongly acidic pH(low pH), the amino acid is positively charged (cation) while in strongly alkaline pH (high pH), it is negatively charged (anion). Each amino acid has a characteristic pH (e.g. leucine, pH 6.0) at which it carries both positive and negative charge and exist as a zwitter ion.



7. Isoelectric pH (symbol pI): the pH at which a molecule exists as a zwitter ion and carries no net charge making the molecule electrically neutral.

8. Titration of amino acids: The existence of different ionic forms of amino acids can be more easily understood by the titration curves. Example at low pH leucine exists as a fully protonated form as cation. As the titration proceeds with NaOH, leucine loses its protons and at isoelectric pH, it becomes a zwitterion. Further titration results in the formation of anionic form of leucine.

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B. CHEMICAL PROPERTIES

1. **Reaction with ammonia:** The carboxyl group of dicarboxylic amino acids reacts with NH3 to form amide

Aspartic acid + NH_3^+ ------> Aspargine

Glutamic acid + NH_3^+ -----> Glutamine

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2. The amino acid behave as bases and combines with acids (e.g. HCL) to form salts.

3. Reaction with ninhydrin : The α- amino acids react with ninhydrin to form a purple, blue or pink colour complex (Ruhemann's purple).

Amino acid + Ninhydrin ------> Keto acid + NH3 + CO2 + Hydrindantin

Hydrindantin + NH3 + Ninhydrin ------> Ruhemann's purple

Ninhydrin's reaction is effectively used for the quantitative deamination of amino acids and proteins. (Proline gives yellow colour with ninhydrin).

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4. Colour reactions of amino acids : Amino acids can be identified by specific colour reactions.

Name of Reaction	Colour developed	Aminoacid involved
Xanthoproteic reaction	Yellow to orange	Phenylalanine, tyrosine,tryptophan
Millon's test	Pink red	tyrosine
Sakaguchi test	Red colour	Arginine
Hopkins Cole reaction		Tryptophan
Nitroprusside reaction	Reddish colour	Cysteine
Sullivan reaction	Red colour	Cysteine, cystine
Lead acetate test	Black colour	Sulphur containing AA
Biuret reaction	Purple violet	Histidine & 2 or more peptide linkage
Ninhydrin reaction	Blue colour	α -Amino acid

https://www.slideshare.net/lordsrk/protein-chemistry-bsc-nursing-amp-bpt

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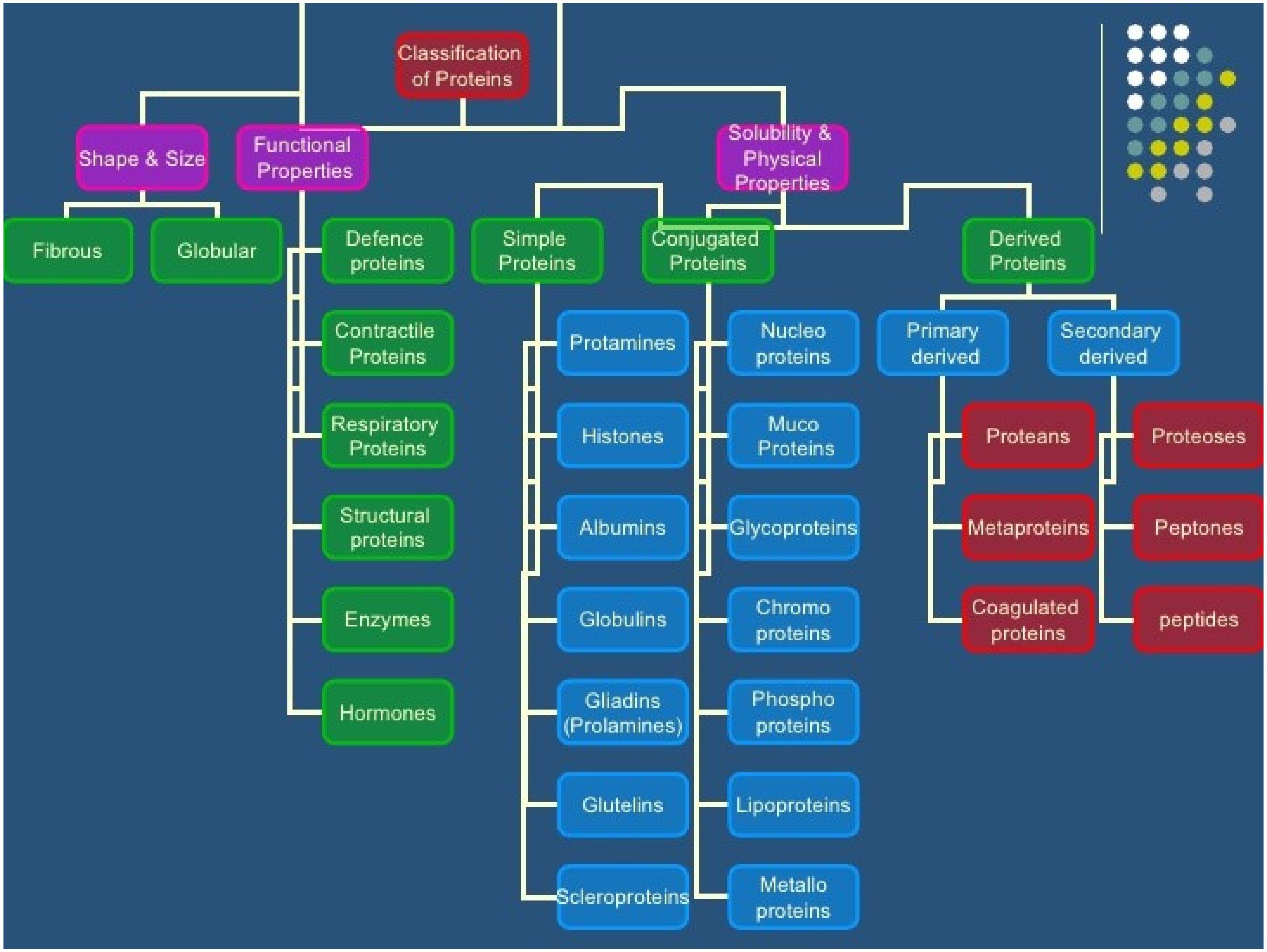

https://www.slideshare.net/lordsrk/protein-chemistry-bsc-nursing-amp-bpt

PROTEIN

Introduction

- Protein name is derived form a Greek word PROTOS which means “the first or the supreme.
- Protein are extremely complicated and nitrogenous molecule made up of variable number of amino acid residue joined to each other by a specific covalent bond called peptide bond.
- 20 amino acid which have been found to occur in all proteins, known as standard amino acid.

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IMPORTANCE OF PROTEINS

- ✓ Proteins make up about 15% of the mass of the average person.
- ✓ Enzyme act as a biological catalyst
- ✓ Storage and transporte – Haemoglobin
- ✓ Defenece -Antibodies
- ✓ Hormones – Insulin
- ✓ Ligaments and arteries (mainly formes by elastin Protein)
- ✓ Muscle – Proteins in the muscle respond to nerve impulses by changing the packing of their molecules (Actin and myosin)
- ✓ Hair, nails and skin: Protein keratin as main component Why are proteins important to us:

CLASSIFICATION BASED ON STRUCTURE

Primary structure

- The **primary structure** of proteins is defined as a linear sequence of amino acids joined together by peptide bonds.
- **Peptide bonds** and **disulfide bonds** are responsible for maintaining the primary structure.

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Secondary structure

- The **secondary structure** of a protein is defined as a **local spatial structure** of a certain **peptide segment**, that is, the relative positions of **backbone atoms** of this peptide segment.
- **H-bonds** are responsible for stabilizing the secondary structure.
- Repeating units of **Ca-C(=O)-N(-H)-Ca** constitute the **backbone of peptide chain.**
- Six atoms, **Ca-C(=O)-N(-H)-Ca**, constitute a **planer peptide unit**.

Tertiary structure

The **tertiary structure** is defined as the **three-dimensional arrangement of all atoms** of a protein.

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Quaternary structure

- The quaternary structure is defined as the spatial arrangement of multiple subunits of a protein.
- These subunits are associated through H-bonds, ionic interactions, and hydrophobic interactions

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CLASSIFICATION BASED ON BIOLOGICAL FUNCTION

1. Catalytic Protein

- These are enzyme which may be simple or conjugated.
- Examples: Alkaline phosphatase, Alanine transaminase

2. Regulatory or Hormonal protein

- Many protein and peptide acts as Hormone.
- Examples: Insulin, Growth Hormone

3. Structural Protein

- Contribute to the structure of the tissue.
- Examples: Collagen, Elastin

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4. Transport Protein

- Serve to carry substances.
- Examples: Transferrin carry Iron, Haemoglobin carry Oxygen

5. Immune Protein

- Serve in defense mechanism
- Examples: Immunoglobulin, IgG, IgA, IgM, IgD, IgE

6. Contractile Protein

- Takes part in the muscle contraction.
- Examples: Actin, Myosin

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7. Genetic Protein

- Protein present in combination with nucleic acid.
- Example: Histone Protein.

8. Storage Protein

- To store protein for nutritional purposes.
- Examples: Casein in Milk, Gliadin in Wheat.

CLASSIFICATION BASED ON SHAPE

Depend upon the axial ratio the protein are classify into two type of protein.

1. **Globular protein**

2. **Fibrous protein**

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Fibrous Protein

- Axial ratio more than 10.
- Long thread like molecule.
- Their helical strands mainly form fibers.
- These protein are insoluble in water.
- Form structure of the tissue
- Present where support is required.
- Example
  - ✓ Collagen
  - ✓ Elastin
  - ✓ Keratin

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Globular Protein

- Axial ratio less than 10.
- Spheroid or ovoid in shape.
- Enzyme are mostly globular in shape.
- Subdivided into two type of protein:
  - ✓ Albumins: Water soluble.
  - ✓ Globulin: Soluble in dilute salt solution.

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PROTEIN PURIFICATION

1. **Chromatography:** the method of separating amino acids on the basis of differences in absorption, ionic charges, size and solubility of molecules
2. **Electrophoresis:** effects separation in an electric field on the basis of differences in charges carried by amino acids and proteins under specific condition
3. **Ultracentrifugation:** effects separation on the basis of molecular weight when large gravitational forces are applied in the ultracentrifuge.
4. **Precipitation Methods:** salts as sodium sulfate, ammonium sulfate, cadmium nitrate, silver nitrate and mercuric chloride at specific conc. precipitate some proteins while others remain in solution
5. **Dialysis:** is for the removal of small, crystalloidal molecules from protein solution.

CHROMATOGRAPHY

- Much of modern biochemistry depends on the use of column chromatographic methods to separate molecules.
- Chromatographic methods involve passing a solution (the mobile phase) through a medium (the immobile phase) that shows selective solute components.
- The important methods of chromatography are:
  - ✓ Ion-Exchange Chromatography
  - ✓ Antibody Affinity Chromatography
  - ✓ Gel Filtration Chromatography
  - ✓ HPLC (High Performance Liquid Chromatography)

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Denaturation of Proteins

Denaturation is a process in which proteins or nucleic acids lose the quaternary structure, tertiary structure and secondary structure which is present in their native state, by application of some external stress or compound such as a strong acid or base, a concentrated inorganic salt, an organic solvent (e.g., alcohol or chloroform), radiation or heat.

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- Denaturation occurs because the bonding interactions responsible for the secondary structure (hydrogen bonds to amides) and tertiary structure are disrupted.
- In tertiary structure there are four types of bonding interactions between "side chains" including: hydrogen bonding, salt bridges, disulfide bonds, and non-polar hydrophobic interactions. which may be disrupted.
- Therefore, a variety of reagents and conditions can cause denaturation. The most common observation in the denaturation process is the precipitation or coagulation of the protein.

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Heat can be used to disrupt hydrogen bonds and non-polar hydrophobic interactions. This occurs because heat increases the kinetic energy and causes the molecules to vibrate so rapidly and violently that the bonds are disrupted. The proteins in eggs denature and coagulate during cooking. Other foods are cooked to denature the proteins to make it easier for enzymes to digest them. Medical supplies and instruments are sterilized by heating to denature proteins in bacteria and thus destroy the bacteria.

Alcohol disrupts Hydrogen bonding

- Hydrogen bonding occurs between amide groups in the secondary protein structure. Hydrogen bonding between "side chains" occurs in tertiary protein structure in a variety of amino acid combinations. All of these are disrupted by the addition of another alcohol.
- A 70% alcohol solution is used as a disinfectant on the skin. This concentration of alcohol is able to penetrate the bacterial cell wall and denature the proteins and enzymes inside of the cell. A 95% alcohol solution merely coagulates the protein on the outside of the cell wall and prevents any alcohol from entering the cell. Alcohol denatures proteins by disrupting the side chain intramolecular hydrogen bonding. New hydrogen bonds are formed instead between the new alcohol molecule and the protein side chains.

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Acids and Bases disrupt Salt Bridges

- Salt bridges result from the neutralization of an acid and amine on side chains. The final interaction is ionic between the positive ammonium group and the negative acid group. Any combination of the various acidic or amine amino acid side chains will have this effect.
- The denaturation reaction on the salt bridge by the addition of an acid results in a further straightening effect on the protein chain as shown in the graphic on the left.

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Heavy metal salts

- Heavy metal salts act to denature proteins in much the same manner as acids and bases. Heavy metal salts usually contain Hg+2, Pb+2, Ag+1 Tl+1, Cd+2 and other metals with high atomic weights. Since salts are ionic they disrupt salt bridges in proteins.
- The reaction of a heavy metal salt with a protein usually leads to an insoluble metal protein salt.

Example of denaturation that occurs in our living:

1. Denaturation of human hair
    - ✓ The extent to which fatty acid oxygenases are activated in the normal epidermis is not known
2. In cooking eggs
    - ✓ cooking eggs turns them from runny to solid
    - ✓ cooking food makes it more digestible.
3. Milk forms a solid curd on standing
    - ✓ bacteria in milk grows
    - ✓ forms lactic acid
    - ✓ coagulates into a solid curd

CARBOHYDRATES

INTRODUCTION

- Carbohydrates are the **most abundant of all the organic compounds in nature.**
- Carbohydrates are defined as polyhydroxy aldehydes or ketones and their derivatives or as substances that yields one of these compounds
- **Hydrates of carbon.**
- Composed of **carbon, hydrogen, and oxygen**
- Functional groups present include hydroxyl groups
- **-ose** indicates sugar.
- General empirical formula is $\mathbf{C_n(H_2O)_n}$

- In plants, energy from the Sun is used to convert carbon dioxide and water into the carbohydrate glucose.
- Many of the glucose molecules are made into long-chain polymers of starch that store energy.
- About 65% of the foods in our diet consist of carbohydrates.
- Other carbohydrates called disaccharides include sucrose (table sugar) and lactose in milk.

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- During digestion and cellular metabolism, carbohydrates are converted into glucose, which is oxidized further in our cells to provide our bodies with energy and to provide the cells with carbon atoms for building molecules of protein, lipids, and nucleic acids.
- In plants, a polymer of glucose called cellulose builds the structural framework. Cellulose has other important uses, too.
- The wood in our furniture, the pages in your notebook, and the cotton in our clothing are made of cellulose.

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PHYSICAL PROPERTIES OF CARBOHYDRATES

- **Stereoisomerism:** Compound shaving the same structural formula but they differ in spatial configuration. Example: Glucose has two isomers with respect to the penultimate carbon atom. They are D-glucose and L-glucose.
- **Optical Activity:** It is the rotation of plane-polarized light forming (+) glucose and (-) glucose.
- **Diastereoisomers:** It the configurational changes with regard to C2, C3, or C4 in glucose. Example: Mannose, galactose.
- **Annomerism:** It is the spatial configuration with respect to the first carbon atom in aldoses and second carbon atom in ketoses.

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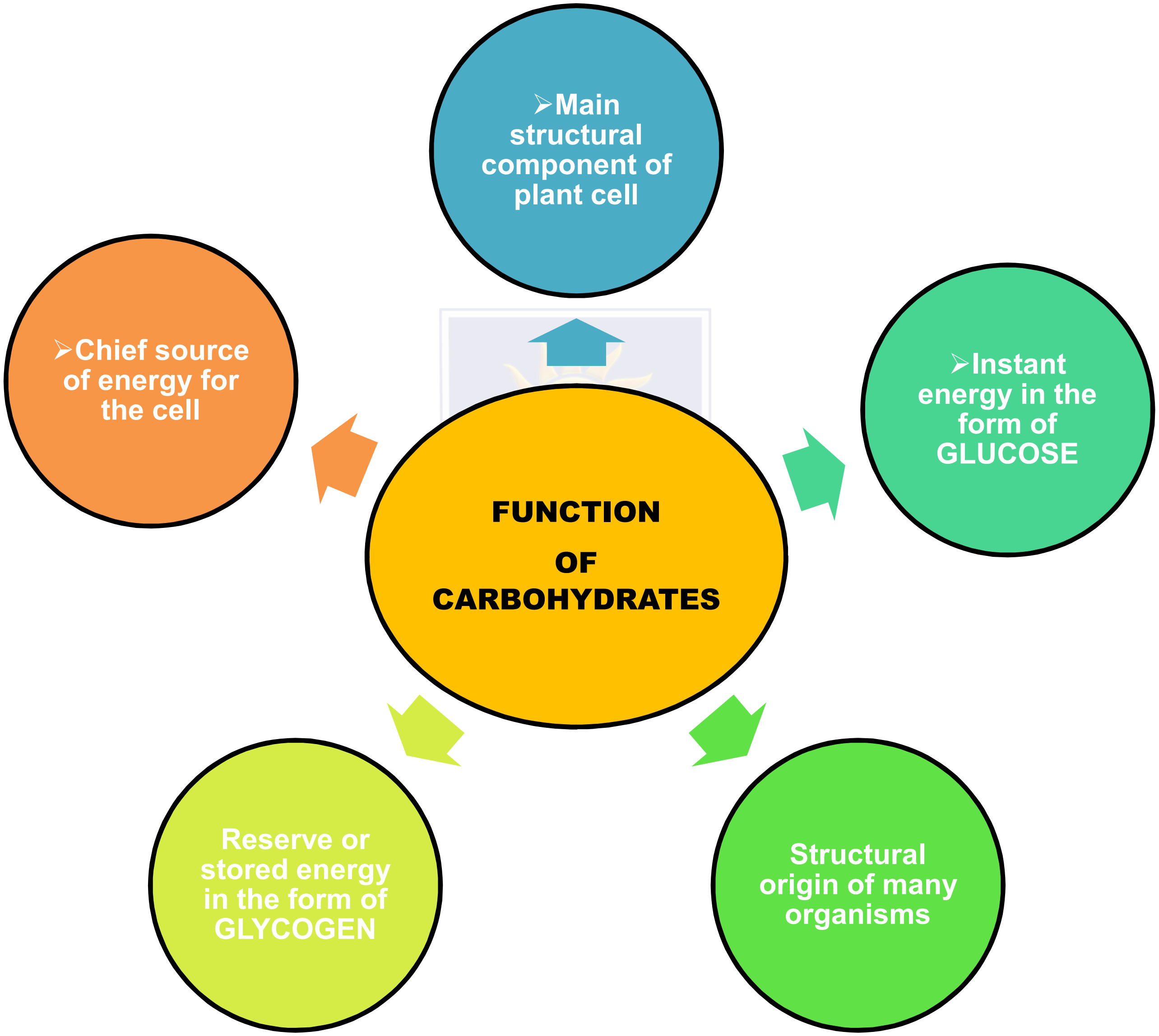
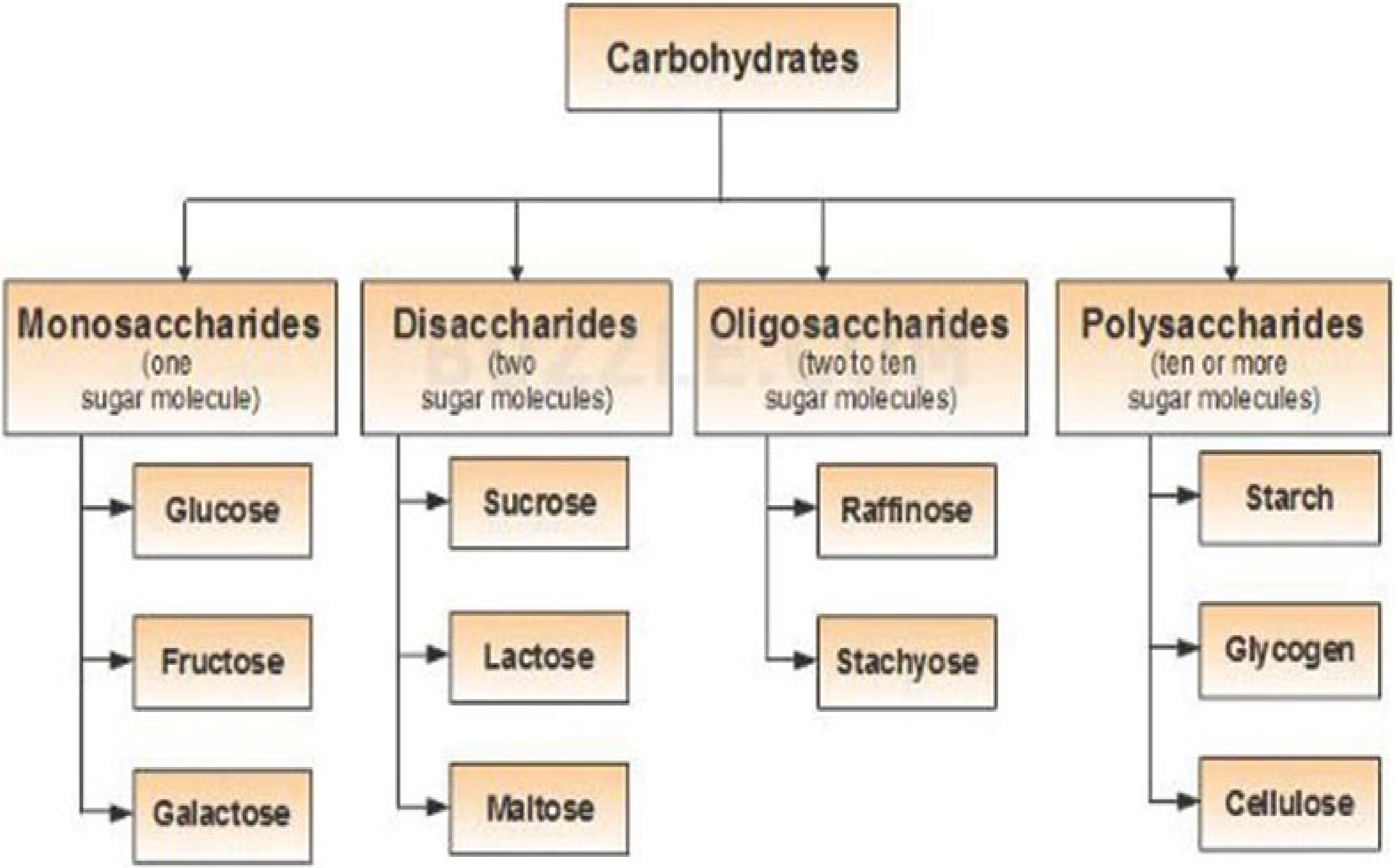
CHEMICAL PROPERTIES OF CARBOHYDRATES

- **Osazone formation**: Osazone are carbohydrate derivatives when sugars are reacted with an excess of phenylhydrazine. eg. Glucosazone
- **Benedict's test**: Reducing sugars when heated in the presence of an alkali gets converted to powerful reducing species known as enediols. When Benedict's reagent solution and reducing sugars are heated together, the solution changes its color to orange-red/ brick red.
- **Oxidation**: Monosaccharides are reducing sugars if their carbonyl groups oxidize to give carboxylic acids. In Benedict's test, D-glucose is oxidized to D-gluconic acid thus, glucose is considered a reducing sugar.
- **Reduction to alcohols**: The C=O groups in open-chain forms of carbohydrates can be reduced to alcohols by sodium borohydride, NaBH4, or catalytic hydrogenation (H2, Ni, EtOH/H2O). The products are known as "alditols".

FUNCTION OF CARBOHYDRATES



CLASSIFICATION OF CARBOHYDRATES



https://microbenotes.com/carbohydrates-structure-properties-classification-and-functions/

MONOSCCARIDES

- Simplest group of carbohydrates and often called simple sugars since they cannot be further hydrolyzed.
- Colorless, crystalline solid which are soluble in water and insoluble in a non-polar solvent.
- These are compound which possesses a free aldehyde or ketone group.
- The general formula is $C_n(H_2O)_n$ or $C_nH_{2n}O_n$.
- They are classified according to the number of carbon atoms they contain and also on the basis of the functional group present.
- The monosaccharides thus with 3,4,5,6,7… carbons are called trioses, tetroses, pentoses, hexoses, heptoses, etc., and also as aldoses or ketoses depending upon whether they contain aldehyde or ketone group.
- Examples: Glucose, Fructose, Erythrulose, Ribulose.

Classification of Monosaccarides

SUGAR	STRUCTURAL FORMULA	ALDOSES	KETOSES
Triose	$C_3H_6O_3$	Glyceraldehydes	Dihydroxy acetone
Tetroses	$C_4H_8O_5$	Erythrose, Threose	Erythrulose
Pentoses	$C_5H_{10}O_5$	Xylose, Ribose, Arabinosee	Ribulose
Hexoses	$C_6H_{12}O_6$	Glucose, Galactose, Mannose	Fructose

Monosaccarides

Glucose:

- ✓ The essential energy source for all body functions.
- ✓ Other names: Dextrose and Blood Sugar.
- ✓ A component of each disaccharide.

Galactose:

- ✓ Seldom occurs freely in nature
- ✓ Binds with glucose to form sugar in milk: lactose.
- ✓ Once absorbed by the body, galactose is converted to glucose to provide energy.

Fructose:

- ✓ The sweetest of all sugars (1.5 X sweeter than sucroe)
- ✓ Occurs naturally in fruits and honey “the fruit sugar”

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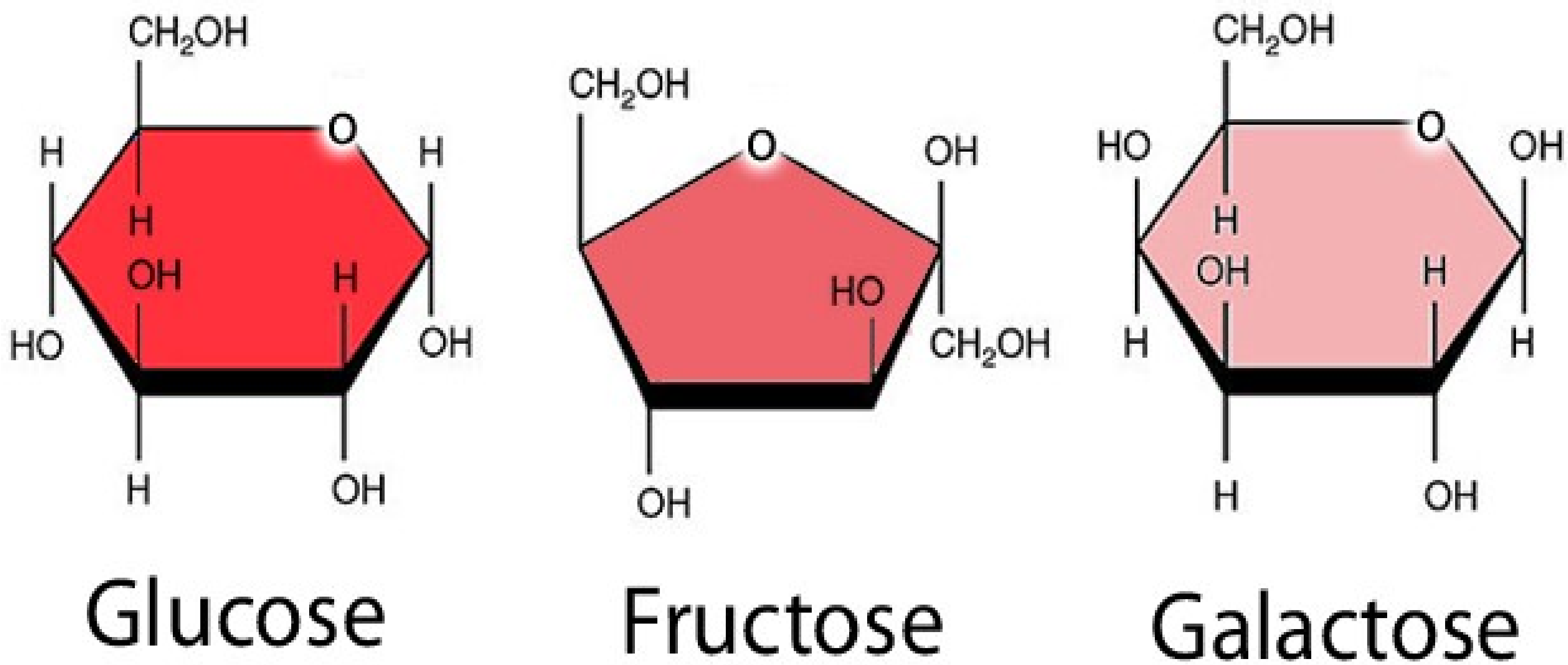
Monosaccharides



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PROPERTIES OF MONOSACCHARIDES

1. **Mutarotation :**

When a monosaccharide is dissolved in water, the optical rotatory power of the solution gradually changes until it reaches a constant value. For ex : when D-glucose is dissolved in water, a specific rotation of +112.2 degree is obtained, but this slowly changes , so that at 24h the value has become +52.7 degree. This gradual change in specific rotation is known as mutarotation. This phenomenon is shown by number of pentoses, hexoses and reducing disaccharides.

2. **Glucoside formation :**

When D-glucose solution is treated with methanol and HCl, two compounds are formed, these are α – and β-D- glucosides. Thus, formed glucosides are not reducing sugar and also does not show phenomenon of mutarotation

3. Reducing power :

Sugars having free or potentially free aldehyde or ketone group have an ability to reduce the cupric copper to cuprous.

4. Oxidation / Reduction:

The alcoholic OH, aldehyde (COH) or keto (C=O) group are oxidized to carboxyl group with certain oxidizing agents. The oxidation may be brought under mild or with vigorous oxidizing condition.

Disaccharides

- Composed of 2 monosaccharides
- Cells can make disaccharides by joining two monosaccharides by biosynthesis.

Glucose + fructose = Sucrose

- ✓ Table sugar
- ✓ Found naturally in plants: sugar cane, sugar beets, honey, maple syrup
- ✓ Sucrose may be purified from plant sources into Brown, White and Powdered Sugars.

Glucose + galactose = Lactose

- ✓ The primary sugar in milk and milk products.
- ✓ Many people have problems digesting large amounts of lactose (lactose intolerance)

Glucose + glucose = Maltose

- ✓ Produced when starch breaks down.
- ✓ Used naturally in fermentation reactions of alcohol and beer manufacturing.

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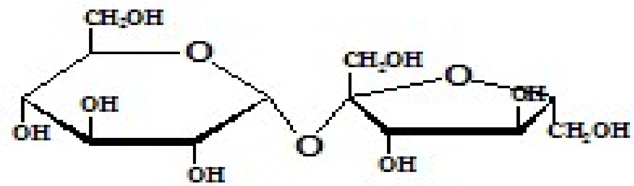
Digestible Disaccharides in Food

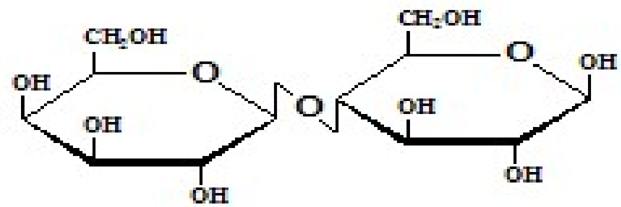
Sucrose

(Glucose-fructose)



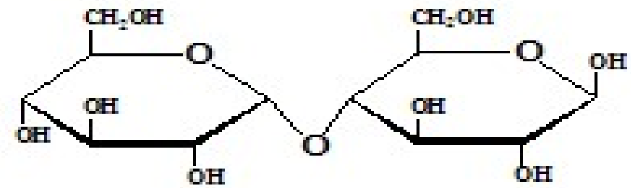
Lactose

(Galactose-glucose)



Maltose

(Glucose-glucose)



https://byjus.com/chemistry/disaccharides/

Polysaccharides

- They are also called as “glycans”.
- Polysaccharides contain more than 10 monosaccharide units and can be hundreds of sugar units in length.
- They yield more than 10 molecules of monosaccharides on hydrolysis.
- Polysaccharides differ from each other in the identity of their recurring monosaccharide units, in the length of their chains, in the types of bond linking units and in the degree of branching.
- They are primarily concerned with two important functions ie. Structural functions and the storage of energy.
- They re further classified depending on the type of molecules produced as a result of hydrolysis.

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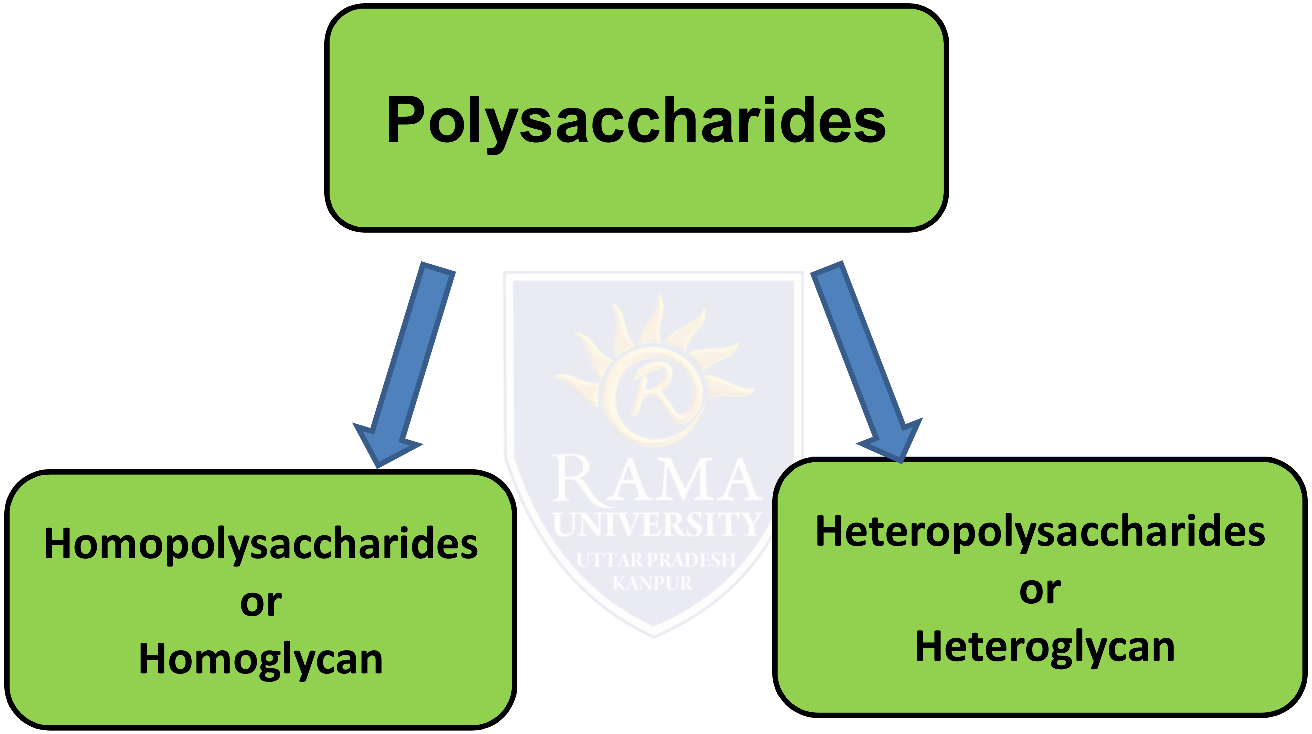
CLASSIFICATION OF POLYSACCARIDES



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HOMOPOLYSACCARIDES

1. Starch
2. Glycogen
3. Cellulose
4. Inulin
5. Dextrans
6. Chitin

STARCH

- Carbohydrates of the plant kingdom
- Major digestible polysaccharides in our diet.
- Sources: Potatoes, tapioca, cereals (rice, wheat) and other food grains
- Two types of plant starch:
  - ✓ Amylose
  - ✓ Amylopectin

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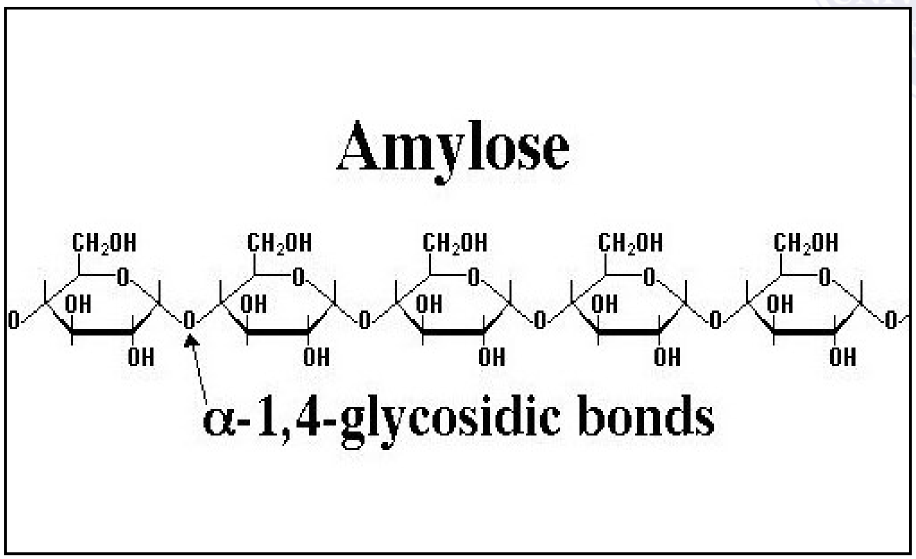
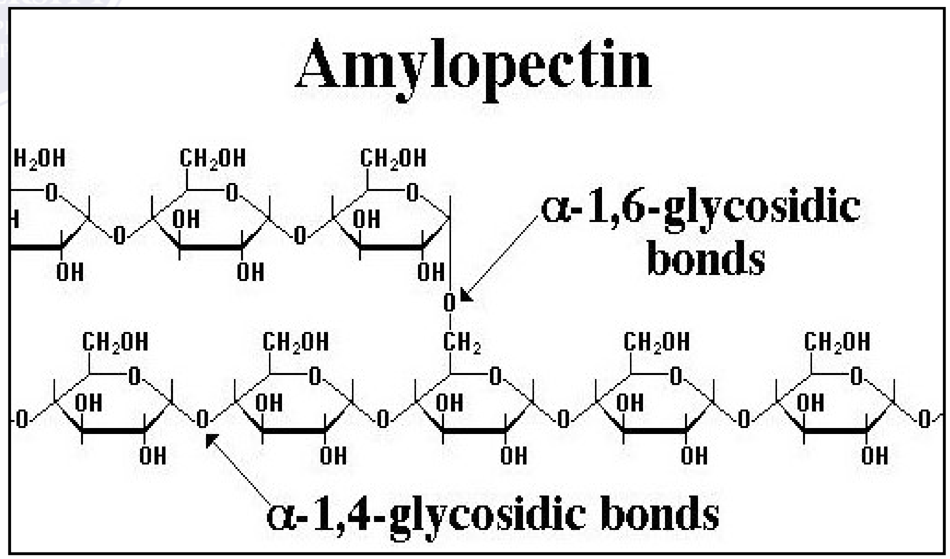
Amylose: is in the form of **straight chain linked together with α- 1-4, linkages** indicating **300 – 5,500 glucose units per molecules**, **molecular wt range from 105 to 106**. Generally it is water soluble and gives blue colour with iodine.

Amylopectins: It contain beside **straight chain several branched chains**, which are arranged in **α—1-4 and β-1-6 linkage units**, one molecule of amylopectin contains **50,000 to 5,00,000 glucose molecules**, **molecular wt. range from 107 to 108**, it is insoluble in water and gives purple colour with iodine .

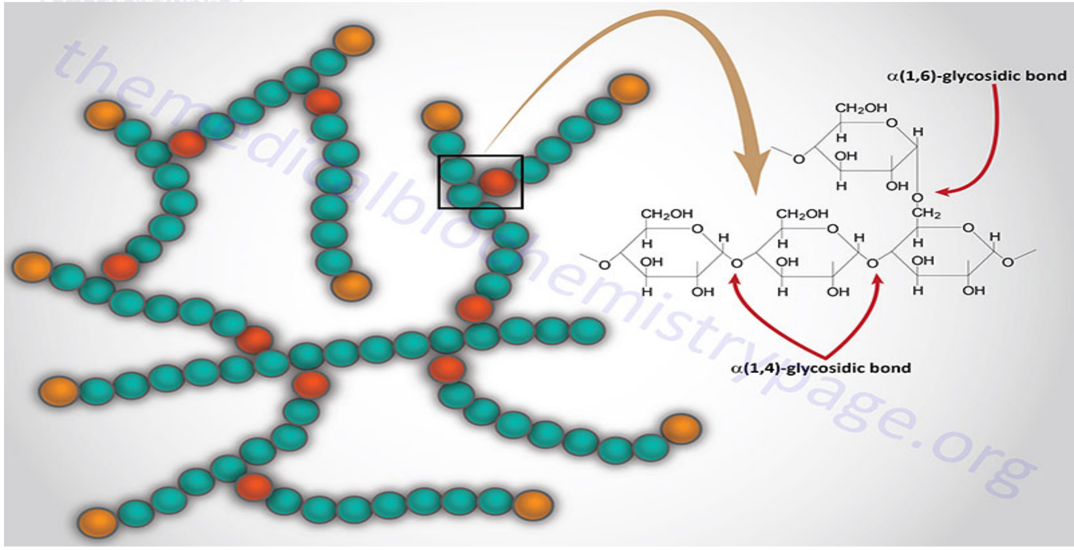




https://vivadifferences.com/difference-between-amylose-and-amylopectin/

GLYCOGEN

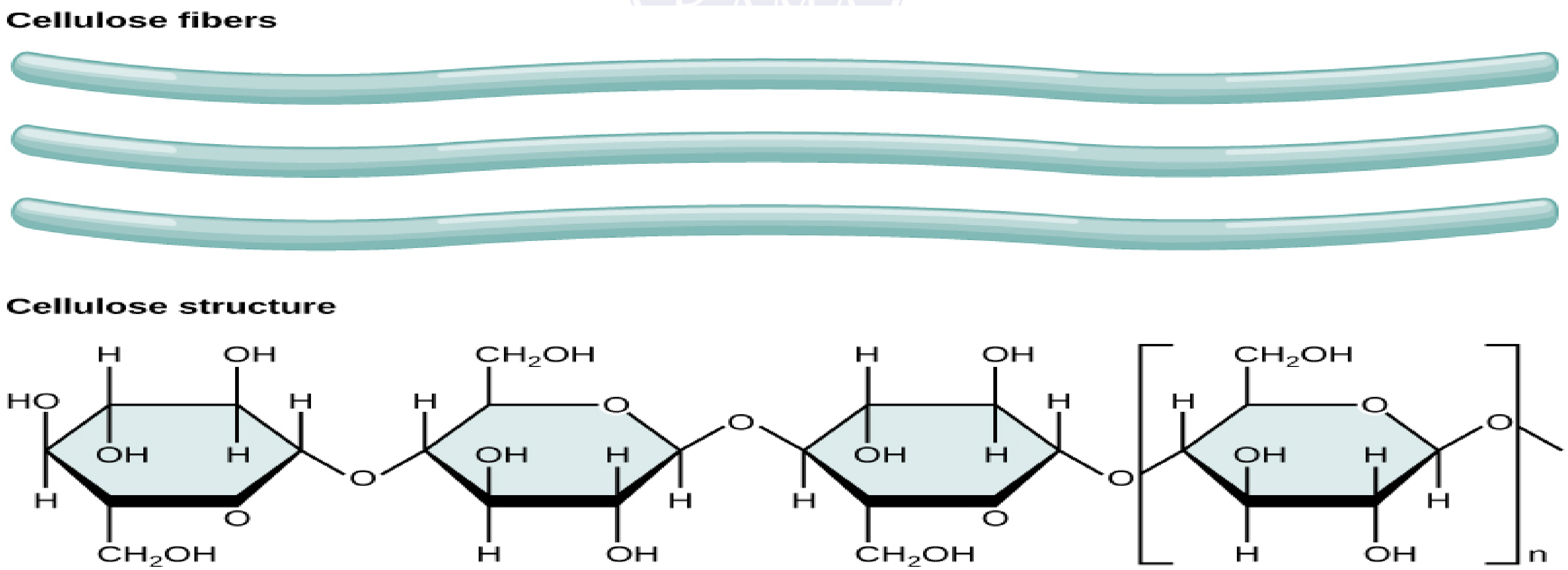
- A homopolysaccharide: linear chain of **α- (1→4) linked** glucosyl residues with branches joined by **α- (1→6)** linkages
- **Storage form of energy in the body**.
- Stores more glucose residues per gram than starch.
- **More branched and compact** than starch.
- Glycogen in liver (6-8%) is higher than that in the muscles (1-2%).
- Liver glycogen - first line of defense against declining blood glucose levels especially between meals.
- Not found in plants.



https://themedicalbiochemistrypage.org/glycogen-metabolism/

Cellulose

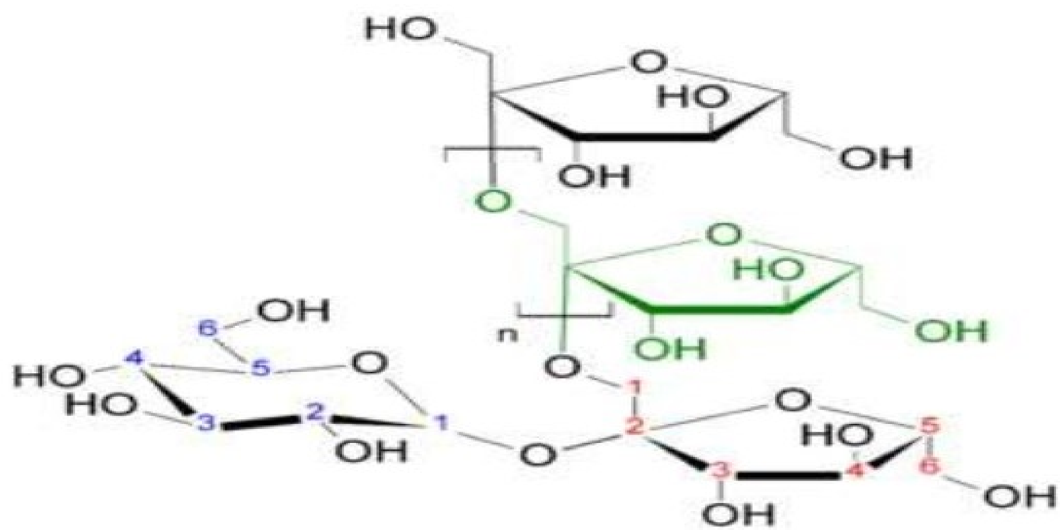
- Glucose units combined by **β-1,4 linkages.**
- **Straight line structure with no branches.**
- Mol weight- 2-5 million.
- Form cell walls in plant cells
- Also called fiber or ruffage
- **Indigestible by humans**
- **Herbivores animals have large caecum which harbour bacteria which break cellulose.**



https://alevelbiology.co.uk/notes/cellulose/

Inulin

- D -fructose in **β-1,2 linkages.**
- Source: • Bulbs and tubers chicory, dahlia, dandelion, onions, garlic.
- Not metabolized.
- Not absorbed nor secreted by kidneys.

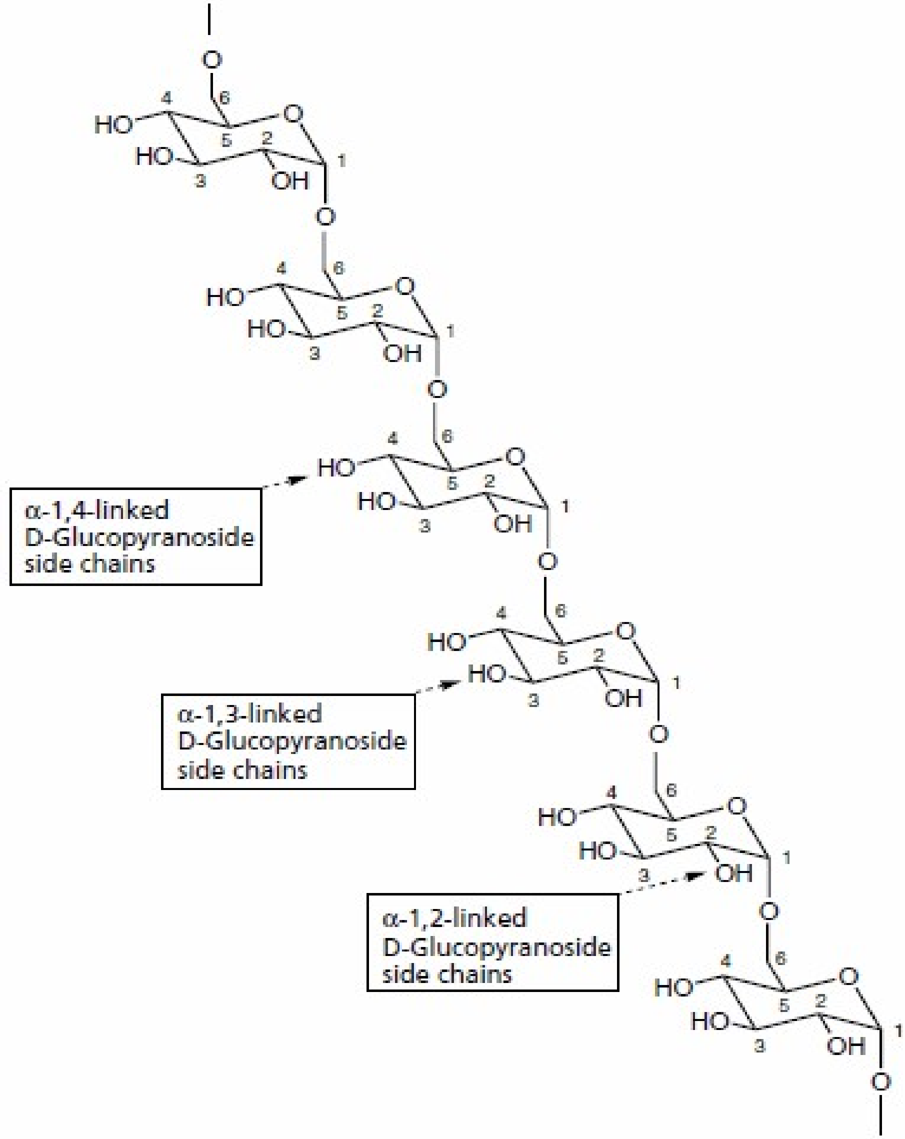


Chemical structure of Inulin

https://www.slideshare.net/AbdulRehman944/inulin-significance-in-food

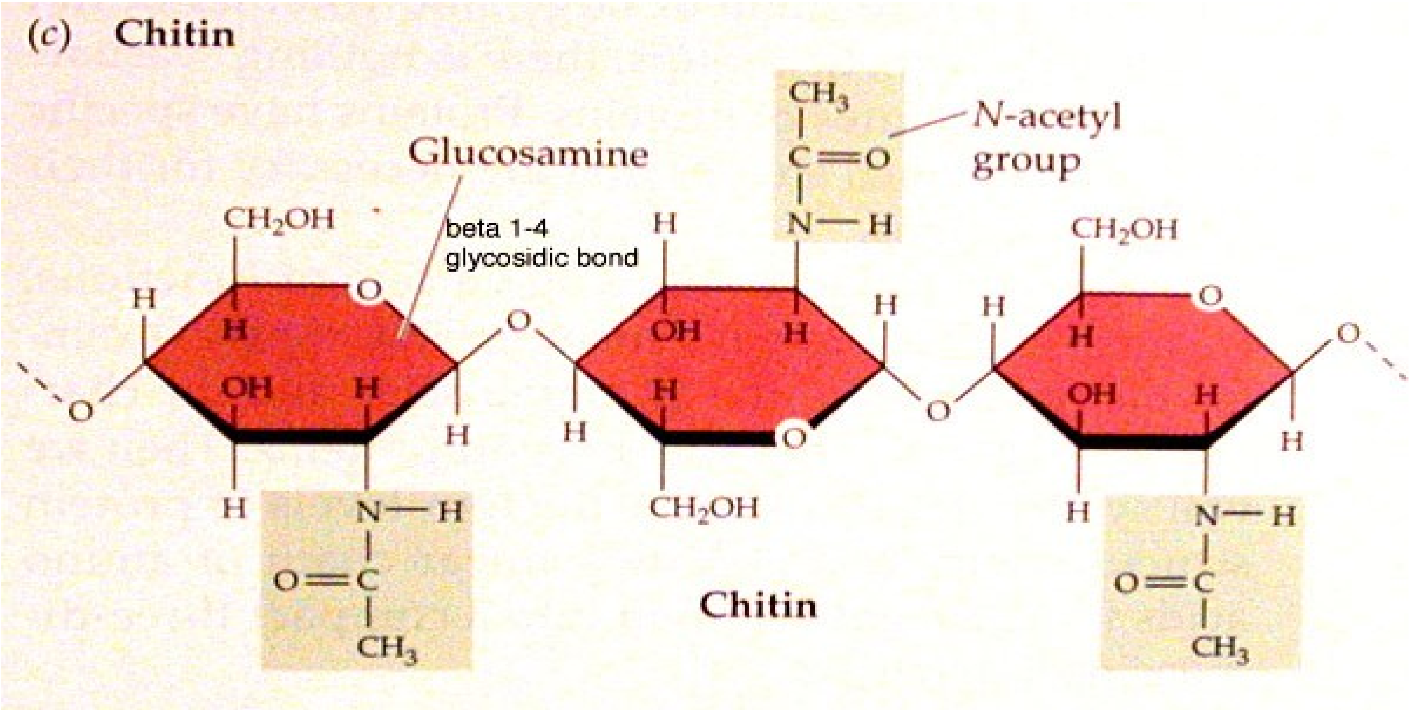
DEXTRANS

- **Highly branched homoglycan** containing Glu residues in 1-4 and 1-3 and 1-2 linkages.
- **Produced by microbes**.
- Molecular weight:- 1-4 million.
- As large sized, they will not move out of vascular compartment so used as plasma expanders.



CHITIN

- N-acetyl glucosamine with beta 1,4 glycosidic linkage
- **Exoskeleton of crustacea and insects.**



https://girlmeetsbiochemistry.wordpress.com/2013/04/06/chitin-is-exctin/

MUCOPOLYSACCHARIDES

- Mucopolysaccharides are glycosaminoglycans, i.e., hetero-polysaccharides composed of hexosamines and non-nitrogenous sugars linked by glycosidic bonds; some also contain various substituent groups.
- The mucopolysaccharides of mammalian tissues may be classified as-

1. Polycarboxylates (hyaluronic acid, chondroitin)
2. Polysulfates (keratan sulfates)
3. Polycarboxy-sulfates (chondroitin 4- and 6-sulfates, previously designated chondroitin sulfate A and C, respectively; dermatan sulfates; and heparitin sulfates).

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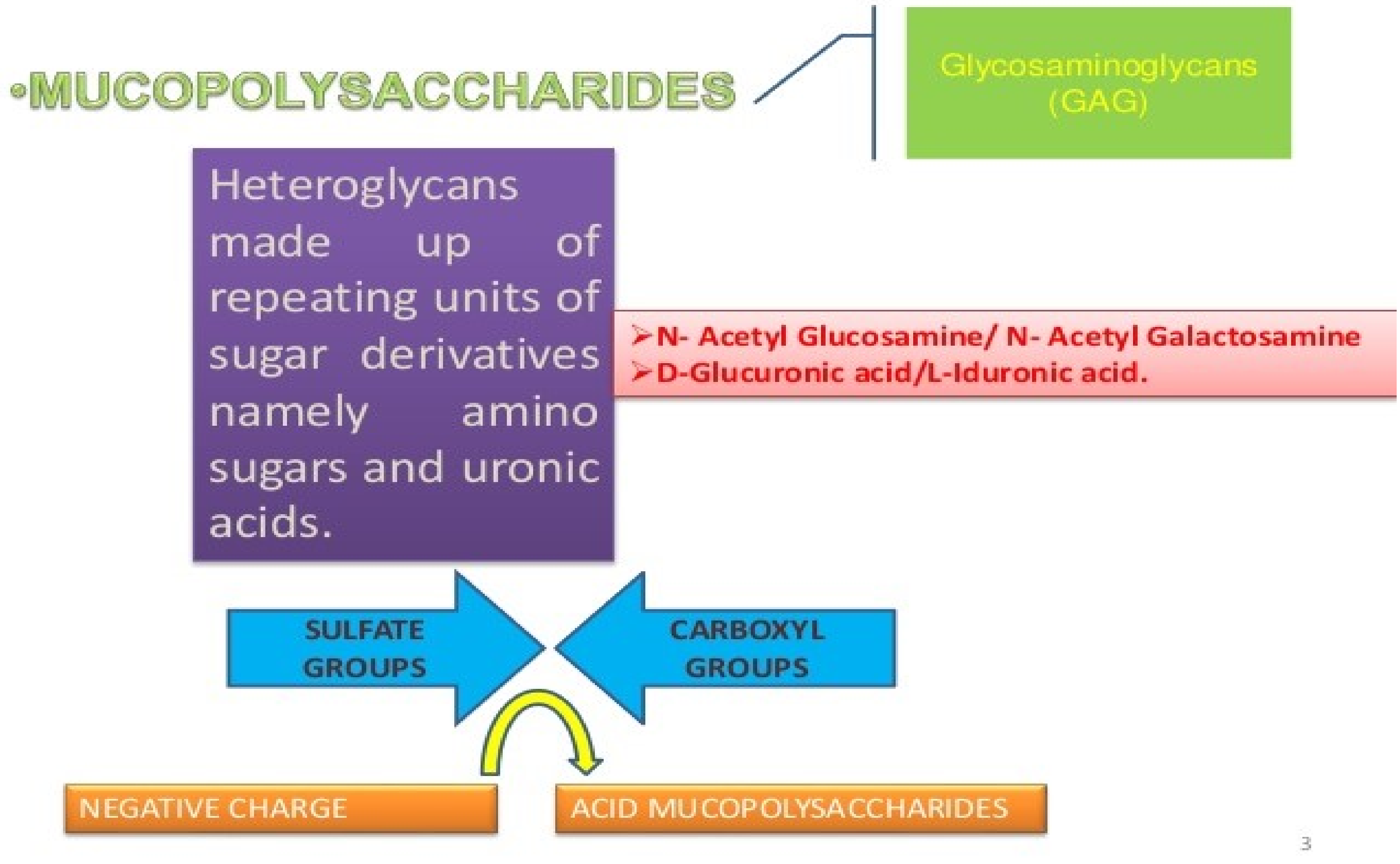

https://www.slideshare.net/anjuvs7/metabolism-of-mucopolysaccharides

BACTERIAL POLYSACCARIDES

Extracellular polysaccharides (EPSs)

- Excreted heteropolysaccharides
- Most often acidic
- Frequently form solutions of high viscosity
- Gram -positive and Gram -negative products

Capsular Polysaccharides (CPSs)

- Cell -associated heteropolysaccharides
- Most often acidic, but some are neutral
- Solutions can be highly viscous
- Gram -positive and Gram -negative pro ducts

Lipopolysaccharides (LPSs)

- Component of the outer membrane
- Amphiphilic
- Gram -negative bacterial component

Teichoic acid

- Gram -Positive

Mycobacterium cell wall components

- Mycolyl arabinogalactan
- Lipoligosaccharides (LOSs)
- Glycopeptidolipids (GPLs)
- Phenolic glycolipids (PGLs)

GLYCOPROTEIN

- Glycoproteins are proteins that contain oligosaccharide chains (glycans) covalently attached to polypeptide side-chains.
- This process is known as glycosylation.
- The carbohydrate is attached to the protein during the following modifications: Co- translational modification & Post-translational modification.
- In proteins that have segments extending extracellularly, the extracellular segments are often glycosylated.

CLASSIFICATION OF GLYCOPROTEINS

There are **3 major classes** of glycoproteins:-

1. **N-linkage (N -acetylglucosamine to asparagine)**

2. O-linkage (N -acetylgalactosamine to serine)

3. Glycosyl-phosphatidyl-inositol (GPI) linkage

- **N-glycosidic linkage** (i.e, N-linked), involving the amide nitrogen of asparagine and N -acetylglucosamine (GlcNAc-Asn)
- **O-glycosidic linkage** (i.e, O-linked), involving the hydroxyl side chain of serine or threonine and a sugar such as N - acetylgalactosamine (GalNAc-Ser[Thr])
- linked to the carboxyl terminal amino acid of a protein via a phosphoryl-ethanolamine moiety joined to an oligosaccharide (glycan), linked via glucosamine to phosphatidylinositol (PI).

N-LINKED GLYCANS

Importance of N-linked Glycans

- ✓ are found in ovalbumin and the immunoglobulins.
- ✓ Part of the recognition of immunoglobulins is due to the sequence of the oligosaccharide chains of the glycans.
- ✓ A very important further use of N-linked oligosaccharides is in intracellular targeting in eukaryotic organisms.
- ✓ Proteins destined for certain organelles or for excretion from the cell are marked specifically by oligosaccharides during posttranslational processing to ensure they arrive at their proper destinations.

O-LINKED GLYCANS

Importance of N-linked Glycans

- ✓ Mucins, which are found extensively in salivary secretions, contain many short O-linked glycans.
- ✓ Increase the viscosity of the fluids in which they are dissolved.
- ✓ Function is intracellular targeting and molecular and cellular identification.
- ✓ Example: blood group antigens.
- ✓ Antarctic fish contain a glycoprotein that serves as an "antifreeze", preventing the freezing of body fluids, even in extremely cold water.

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BIOLOGICAL FUNCTION OF GLYCOPROTEINS

Glycoproteins	Functions
Collagens	Structural molecule
Mucin	Lubricant and protective agent
Transferrin, Ceruloplasmin	Transport molecule
Immunoglobins Histocompatibility antigens	Immunologic molecule
Chorionic gonadotropin, Thyroid stimulating hormone (TSH)	Hormone
Various, e.g. alkaline phosphates	Enzyme
Various proteins involved in cell-cell (e.g. sperm-oocyte), virus-ll, bacterium-cell, and hormone-cell interactions	Cell attachment-recognition site

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