

Macromolecules

in the Biological System



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I. Macromolecules in The Biological System

by Elias Narciso Matos, Ph.D.

II. Prerequisite Courses or Knowledge

The student must possess knowledge of the basic contents covered in chemistry curriculum and, in particular topics concerning modules 5, 6, 7, mainly.

Notion of isomerism and of stoichiometry
Structure and reactivity of Aldehydes and Ketones
Structure and reactivity of Amino acids
Concept of Aromatics and heterocyclic

III. Time

120 hours

Unit	Hours
GLUCIDS	40
PROTEINS	40
LIPIDS	30
Practical Activity	10
Total	120

IV. Material

Module 8 (macromolecules in the biological system) is based on the following learning material: chemistry school books, chemistry educational software, virtual computerised experiments, simple experiments, textbooks and manuals.

V. Module Rationale

This module introduces the study of some representative compounds of macromolecular nature which are vital for the balance, development, maintenance, and supplement of living organisms.

The module solidifies and extends knowledge obtained from previous modules mainly on Aldehydes, Ketones and amino acids, linking them to the organism's vital functions. The study on the contents of this module will give knowledge about properties and the activity of some of the main macromolecules for the survival of organisms.



VI. Content

6.1 Overview

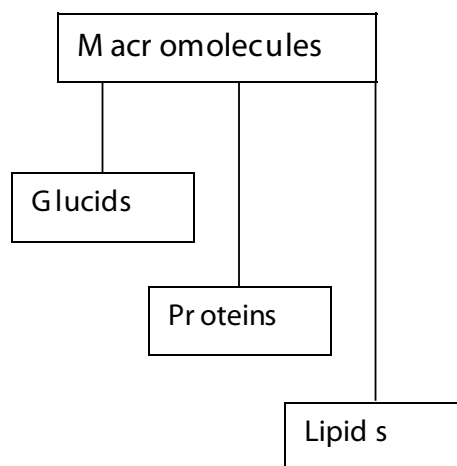
The present module 8 (macromolecules in the biological system) is made up of four units they are: Carbohydrates, Proteins, Lipids, and finally practical activities.

Each unit states and analyses the basic knowledge about the structure, nomenclature and synthesis, as well as the chemical and physical macromolecular properties with biological significance.

In the practical components, the module offers training on how to handle basic laboratory equipment and/or computer simulated exercises about techniques for synthesizing, separating, purifying and determination of physical constants of the compound.

The module has the duration of a total of 120 hours.

6.2 Graphic Organizer



Unit #	Name	Duration
Unit I :	Glucids	40
Unit II :	Proteins	40
Unit III :	Lipids	30
Unit IV :	Experimental activity	10
Total		120



VII. General Objective(s)

Module 8 (macromolecules in the biological system) offers the basic fundamentals about the main theoretical and practical aspects of macromolecule chemistry.

This module systematically discusses some of the main classes of organic macromolecular compounds of vital importance for the living organisms, they are: Carbohydrates (Glucids), Proteins and Lipids.

This module also analyzes the relation between the structures, properties, reactivity, and the physical-chemical behavior of the organic compounds of great molecular weight.

Studying the module will deepen the knowledge about organic compounds and help establish a correlation between structure of matter and its properties.

Develops the ability to make critical observation, and reasoning permitting thus the best application and/or usage of these compounds.

VIII. Specific Learning Objectives (Instructional Objectives)

Provide the student with theoretical knowledge about Carbon compounds of great molecular weight with biological importance, revealing its coherence, obtain its physical properties and its reactivity, mainly of the Glucids, the proteins and the lipids.

Be able to handle basic laboratory equipment for a laboratorial research, and know the techniques to synthesize, separate, purify and determine physical constants of organic compounds.

Offer macromolecular compounds simulations.



Unit	Learning objective(s)
1. Glucids (Carbohydrates)	<p>At the end of the unit the student should be able to:</p> <ul style="list-style-type: none">- Describe the structure of Carbohydrates- Classify the carbohydrates- Attribute names to carbohydrates using the nomenclature of IUPAC- Know the chemical and physical properties of carbohydrates and its correlations- Know the method of production and identification- Know the stereochemistry in Glucids, as well as phenomenon involved in the spatial disposition of these molecules- Discuss the relation between structure and properties based on simple examples
2. Proteins	<p>At the end of the unit the student should be able to:</p> <ul style="list-style-type: none">- Know the structure and properties of the essential amino acids- Know the structure of the peptides- Describe the peptide bond- Know the structure of proteins- Differentiate the protein structures and their functions (primary, secondary, tertiary)- Describe the structure and function of some Proteins e Nucleotides (DNA, RNA)- Know the methods of production
3. Lipids	<p>At the end of the unit the student should be able to:</p> <ul style="list-style-type: none">- Know the general structure of lipids- Classify lipids (saturated and non- saturated)- Interrelate the structure and properties of the fatty acids- Know the physical and chemical structure of lipids- Know the sources of production and identification
4. Practical Activity	<p>At the end of the unit the student should be able to:</p> <ul style="list-style-type: none">- Identify the carbons in the carbohydrates- Exercise carbohydrates' properties- Identify the Proteins- Identify the Properties of Lipids



IX. Teaching And Learning Activities

Pre-assessment

Title of pre-assessment **Macromolecules in the biological system**

Rationale: The work sheet evaluates the basic knowledge on organic chemistry, as well as solid knowledge of the contents of modules 5, 6, 7 indispensable to the success of the work in the present module.

Questions

1. Glucids or Carbohydrates are:
 - a) Compounds made up of only carbon and hydrogen
 - b) Compounds that contain water
 - c) Aldehydes and Ketones containing Polyhydroxyl group
 - d) Compounds of the family of fats
2. Chemically fats are:
 - a) Esters of glycerol with fatty acids
 - b) Esters of superior alcohols with fatty acids
 - c) Aldehydes of great molecular weight
 - d) Acids of great molecular weight
3. Proteins are compounds made up of:
 - a) Units of glucose linked by glycosidic linkage
 - b) Units of amino acids linked by peptide bond
 - c) Units of monosaccharide linked by glycosidic linkage
 - d) Products of the decomposition of polysaccharides
4. Fatty acids are:
 - a) Acids with many ramifications
 - b) Acids of fat people
 - c) Acids of great molecular weight
 - d) Carboxylic acids
5. Glycosidic linkage occurs between
 - a) Fats
 - b) Units of Amino acids
 - c) Units of monosaccharide
 - d) Proteins



6. The bonds between organic compounds are mainly:
 - a) Ionic
 - b) Covalent
 - c) Metallic
 - d) Dipole-dipole
7. Peptide bond occurs between:
 - a) Fats
 - b) Units of amino acids
 - c) Units of monosaccharide
 - d) Proteins
8. Polysaccharides are made up of:
 - a) Thousands of units of acids linked by Glycosidic linkage
 - b) Thousands of units of amino acids linked by peptide bonds
 - c) Thousands of units of monosaccharide linked by Glycosidic linkage
 - d) Thousands on units of amino acids linked by peptide bonds
9. Isomerism is the phenomenon of:
 - a) Existence of molecules with the same molecular mass
 - b) Molecules absorbing all light
 - c) Molecules with the same composition but different structures
 - d) Molecules differing in one segment constituted by one atom of carbon and two atoms of hydrogen.
10. Asymmetrical carbon is:
 - a) Central Carbon
 - b) Carbon with four different bonds
 - c) Carbon with two double bonds
 - d) Carbon in heterocyclics
11. Glucose is:
 - a) Aldose
 - b) Ketose
 - c) Pentose
 - d) Hexoketose
12. Fructose is:
 - a) Aldose
 - b) Ketose
 - c) Pentose
 - d) Hexoaldose



13. In sugars the carbon atom that determines the series is:
- The closest to the main functional group
 - The farthest from the main functional group
 - The central atom
 - None of the above
14. Reducing sugars are:
- The easily soluble
 - The ones with a free functional group
 - The sweetest
 - The ones that do not have a free functional group
15. Oils are:
- Esters of glycerol and saturated fat acids
 - Esters de glycerol and unsaturated fat acids
 - Esters de superior alcohols and saturated fat acids
 - Esters de superior alcohols and saturated fat acids
16. Waxes are:
- Esters of glycerol and saturated fat acids
 - Esters of glycerol and unsaturated fat acids
 - Esters of superior alcohols and saturated fat acids
 - Esters of superior alcohols and saturated fat acids
17. Enantiomers are isomers:
- Which differ on the position of the central atom
 - Which rotates the light in the same magnitude but in opposite direction
 - Which differ on the position of one hydrogen central atom
 - Which rotates the light in different magnitude but the same direction
18. Glycosidic linkage:
- Bond between Amino and carboxyl groups
 - Between two Amino groups
 - Between carboxyl and hydroxyl groups
 - Between two monosaccharides
19. A typical bond in proteins is:
- Glycoside
 - Peptide
 - Acetalic
 - None of the above



20. Cellulose is:

- a) Monosaccharide
- b) Disaccharide
- c) Polysaccharide
- d) None of the above

Answer key

1. Glucids or carbohydrates are:

- c) – Polyhydroxyl Ketones and Aldehydes

2. Fats chemically are:

- a) – Esters of glycerol and fat acids

3. Proteins are compounds made up of:

- b) – Units of Amino acids bonded by peptide bond

4. Fatty acids are:

- c) – Acids of great molecular weight

5. Glycosidic linkage occurs between:

- c) – Units of monosaccharide

6. Bonds in organic compounds are mainly:

- b) – Covalent

7. Peptide bonds happen between:

- b) – Units of amino acids

8. Polysaccharides are made up of :

- c) – Thousands of monosaccharide units bonded by glycosidic linkage.

9. Isomerism is the occurrence of:

- c) – Existence of molecules with the same composition but different structures

10. Asymmetrical carbon is:

- b) – Carbon with four different bonds

11. Glucose is:

- a) – Aldose

12. Fructose is:

- b) – Ketose



13. In sugars the carbon atom that determines the series is:
b) – The farthest from the main functional group
14. Reducing sugars are:
b) – The ones that have a free functional group
15. Oils are:
b)- Esters of glycerol and unsaturated fat acids
16. Waxes are:
c) – Esters of superior alcohols and saturated fat acids
17. Enantiomers are isomers:
b)- Which rotates the light in the same magnitude but in opposite directions
18. Glycosidic linkage in Proteins is:
d) – Between two monosaccharide
19. The typical bond in a protein is:
b) – Peptide
20. Cellubiose is:
b) – Disaccharide

Pedagogical Comment For Learners

The above exercise is constructed in order to; allow the student to grade his levels of basic knowledge and pre requisites he possesses for the comprehension of this module.

Scores between 30% and 60% show the existence of fundamentals, although with gaps in the basic knowledge required to successfully undertake this module. Such gaps can be filled through the study of pre-university books of modules 5, 6, and 7.

Scores below 30% show the need of some thorough work for preparation, which should be done through the study of secondary school books.

Results above 90% show the existence of basic principals required to successfully undertake the course.



X. Learning activities

Learning Activity 1

Title of learning activity: **Glucids (carbohydrates)**

Summary of the learning activity

Learning activity 1 allows gathering of basic knowledge about Glucids (carbohydrates), its classifications and its derivatives, main physical and chemical properties, stereo symmetry, as well as phenomenon involved in the molecules space disposition.

To this group of substances belong the sugars, vital compounds for life on earth. They are found in a large spectrum of natural substances and serve above all as the main source of energy for the organisms.

They are generally classified by their size and main functional group.

The study of theme 1 (Glucids) requires around 40 hours of work. During which the references should be closely studied, take notes and make small resumes and answer orientation quizzes found along the course.

List of Required Readings

Carbohydrates origin: Wikipedia, free encyclopedia

- <http://pt.wikipedia.org/wiki/Carboidrato>
- <http://www.uac.pt/~cgomes/TE/Estagio/03-04/WQs/WQS/wq/outros/Carboi.htm>
- Reducing character of sugars
http://www.notapositiva.com/trab_estudantes/trab_estudantes/biologia/biologia_trabalhos/hidrolenzimsac.htm

List of Relevant Useful Links

- Carbohydrate's metabolism
<http://www.probiotica.com.br/artigos.asp?id=110&tabela=saudeInformativ>
- <http://www.google.co.ke/search?hl=en&q=a%C3%A7ucar+reductor&btn=Seas>
(Properties of sugars /discussion on inverted sugar)



- www.esalq.usp.br/departamentos/lan/pdf/Mono%20e%20Dissacarideos%20-%20Propriedades%20dos%20Acucares.pdf
- <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>
(Carbon Hydrates/nucleic acids/lipids /functions)
- <http://campus.fct.unl.pt/gdeh/mestrado/Teoricas/An%20E1lise%20de%20carboidratos.pdf>
(Carbohydrate's analysis) practical activities
- Sweet like sugar
<http://www.qmc.ufsc.br/qmcweb/artigos/sugar.html>
(Concept/Functions/basic needs of organism)

Detailed description of the activity

Carefully read the references and take notes about the following topic:

- Definition of carbohydrates and the historical development of the concept
- Classification and nomenclature of carbohydrates
- Characterization of carbohydrates (monosaccharide, disaccharides, and the most common polysaccharides)
- Structure, properties, and reactivity of the monosaccharide
- Structure and properties of disaccharides
- Structure, properties and reactivity of polysaccharides

The acquirement of the capacity and abilities offered by this module is aided by carrying out the following tasks:

Task 1: Carbohydrates introduction

- 1.1-Carbohydrate's concept
- 1.2-Occurrence, composition and importance
- 1.3-Classification and nomenclature of the carbohydrates
- 1.4-Physical properties

Task 2: Monosaccharide

- 2.1- Structure of monosaccharide
- 2.2- Formation of rings (lactone)
- 2.3- Stereoisomerism
- 2.4- oxocyclotautomerism
- 2.5- Monosaccharide reactions



Task 3: Oligosaccharides

- 3.1- Disaccharides
- 3.2- Reducing disaccharides (type 1)
- 3.3- non reductor disaccharides (type 2)

Task 4: Polysaccharides

- 4.1- Polysaccharides composition
- 4.2- Properties
- 4.3- Starch
- 4.4- Glycogen
- 4.5- Cellulose

Formative evaluation

Along with the contents there are questions that help in the orientation of your studies.

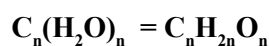
Learning activities

Task 1: Carbohydrates

This task consists on the reading and resume of the compulsory references above listed, in which are found and deepened the knowledge on the historic concept of CARBOHYDRATES and its occurrence, classification, most common carbohydrate's nomenclature, offers information about the relation, structure of physical and chemical properties.

1.1 Concept carbohydrates

The concept of carbohydrates of carbon hydrates is generally used to appoint natural compounds that other than carbon have a hydrogen structure and oxygen in a 2:1 ratio just like water.



It is worth pointing out that there are compounds with this composition that do not belong in the group of carbon hydrates, the same way that there are compounds classified as carbohydrates without strictly obeying with this composition.

Ex. Acetic acid Lactic acid
 $C_2H_4O_2$ $C_3H_6O_3$

Apart from that the hydrogen and oxygen present in this natural compound are not found in the form of a molecule in water. These facts make some group of actors to prefer to refer to them as Glucids.

Carbohydrates or Glucids are chemically Aldehydes or Ketones containing polyhydroxyl group or compounds which by hydrolysis can be transformed into Aldehydes or Ketones



Formative Assessment 1

- a) Why is it preferred to use the name Glucids instead of carbohydrates?
- b) Chemically define carbohydrates or Glucids!

1.2 Occurrence, composition and importance.

Most of these substances are found in nature in its vegetal form where they are synthesized from the Carbon Dioxide (CO_2) and water (H_2O) present in the atmosphere from the process of photosynthesis.

Belonging to this group are the sugars, which we already know about its vital importance for life on earth.

One of the most important Glucids formed that way is glucose (+) $\text{C}_6\text{H}_{12}\text{O}_6$ which by condensation forms substances of great molecular weight like cellulose ($\text{C}_6\text{H}_{10}\text{O}_5$)_n, which constitute the supporting structure of plants (forms the walls of vegetal cells), or the amino acid that by storing mainly seeds serves as the plant's food reserve during its growth.

Ingested by animals, starch and in the case of herbivores animals Cellulose, are broken down in its original units of Glucose. These are taken to the liver by the blood stream and there they are recombined with the formation of glycogen or animal starch (substance of animal reserve).

Starts from glucose, transforms into amino acids, which also combine to form proteins that make up most of the animal's body.

The nucleic acids (DNA, RNA) carriers of the hereditary genetic characters in the living cells partially contain in their structures Glucids.

Practical applications of Glucids are found in the paper of textile industries, natural (cotton), or artificial (rayon, viscose), cellophane, plastic materials (celluloid), explosives, adhesives, etc.



Formative Assessment 2

Give three examples of practical applications of Glucids!

1.3 Classification and nomenclature of carbohydrates.

The carbohydrates are classified under different points of views.

The most usual ways of classifying are:

a) By size (number of basic units)

Taking into account the make up and enormous size of molecules as well as its properties they are divided in three groups:

Monosaccharide

Simple sugars formed by basic non hydrolysable with generally 5-6 carbon atoms.

Examples: Glucose, fructose, mannose.

Oligosaccharides

Sugars made up of 2 to 10 basic units of monosaccharide. The oligosaccharides are hydrolysable into simpler compounds (monosaccharide)

Examples: Sucrose, lactose, maltose.

The carbohydrates that can be hydrolyzed in two monosaccharide molecules are called disaccharides.

Polysaccharides

The carbon hydrates that can be hydrolyzed in many units of monosaccharide (they can reach 10000 approximately units).

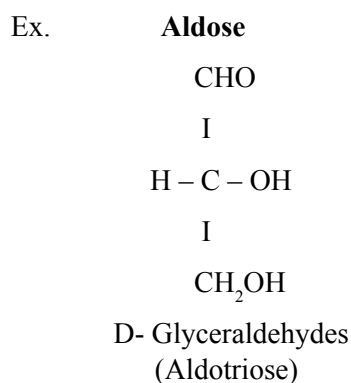
Examples: Cellulose, amylose, glycogen, starch.

b) By main function (functional group)

In carbohydrates we mainly find hydroxyl and carbonyl with the main function taken up by the carbonyl group. So, in the particular case of monosaccharide we have:

Aldoses

Sugars that have the Aldehydes group as the main group

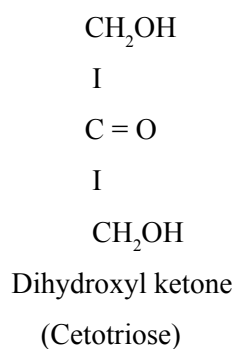




Ketoses

Sugars that have the Ketones group as the main group

Ex. **Ketose**



Ex.	Aldose	Aldose	Ketose
	CHO	CHO	CH ₂ OH
	H - C - OH	H - C - OH	C = O
	H - C - OH	HO - C - H	HO - C - H
	H - C - OH	H - C - OH	H - C - OH
	CH ₂ OH	H - C - OH	H - C - OH
	D- Ribose	CH ₂ OH	CH ₂ OH
	(Aldopentose)		
		D - Glucose	D- Fructose
		(Aldo hexose)	(Ceto hexose)

c) **By the number of carbon atoms**

Triose (contain 3 carbon atoms)

Tetrose (contain 4 carbon atoms)

Pentose (contain 5 carbon atoms)

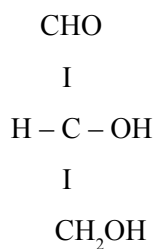
Hexose (contain 6 carbon atoms)

Heptose (contain 7 carbon atoms)



d) By the absolute configuration of the molecule

This system has as its compound of reference the Glyceric aldehydes

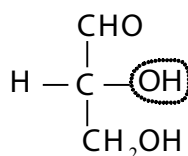


D- Glyceraldehyde

D configuration (destro)

When the similarity of the Glyceric aldehyde of the hydroxyl group of the asymmetric carbon atom farthest from the functional group is to the right.

(lat: Dexter=right)

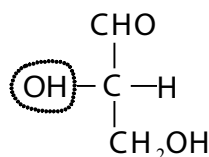


This shows that OH is the determinant of D or L configuration

L configuration

When the hydroxyl group of the asymmetric carbon atom farthest from the functional group is found at the left.

(lat: Laevus=left)



e) By specific rotation of light

- (+) Rotation: Clockwise

When the compound rotates light in the direction of clock pointers.

Ex. (+)-D - Glucose ($< +52,7^{\circ}$)

- (-) Rotation: Anticlockwise

When the compound rotates light in the reverse direction of clock pointers.

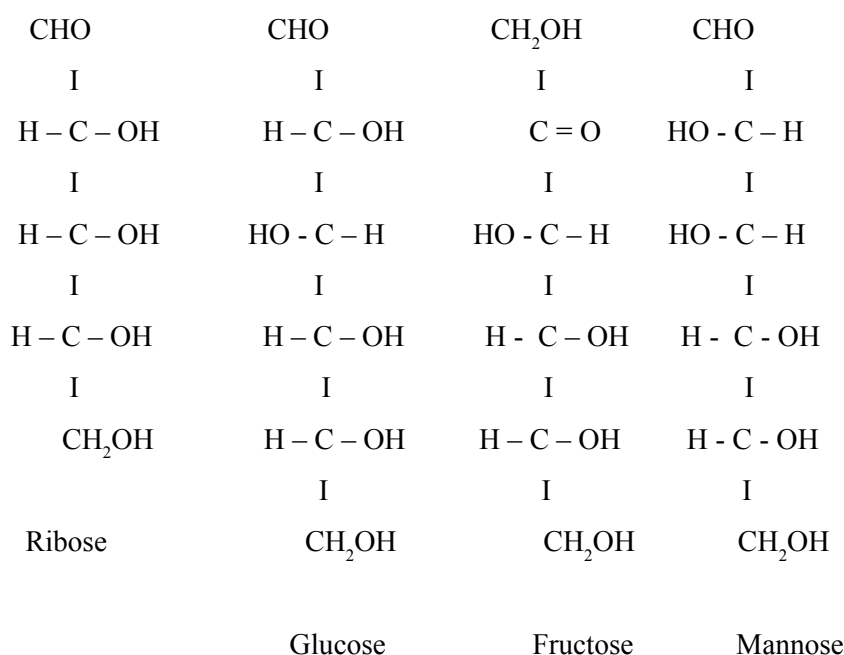


Ex: (-) (D)- Fructose (α -D-92,4⁰)

Nomenclature

The majority of carbohydrates have trivial names originated from the substances from which they were firstly isolated and added with the terminations **-ose** or **-uloses** for the Aldoses and Ketoses respectively.

Ex. Ribose, Glucose, Fructose, Mannose.



Formative Assessment 3

- a) Illustrate the structure of fructose!
- b) Make a complete classification of fructose!
- c) Define the concepts of monosaccharide, disaccharides, and polysaccharides

1.4 Physical properties

The mono- and disaccharides are crystalline, colorless, tasteless, and sweet.

Carbohydrates are substances easily soluble in water (this is because of the presence of many hydroxyl groups) and in some solvent organics.

They are not very soluble in nonpolar solvents. (Ex. Benzene, ether, etc.)

In water they form oversaturated solutions (melasses).



Under heat, they are stable until reaching around 150c. Decompose at temperatures up to 200c and form caramel. Form charcoal at temperatures above 200c.

In general they deviate the plan of polarized light.

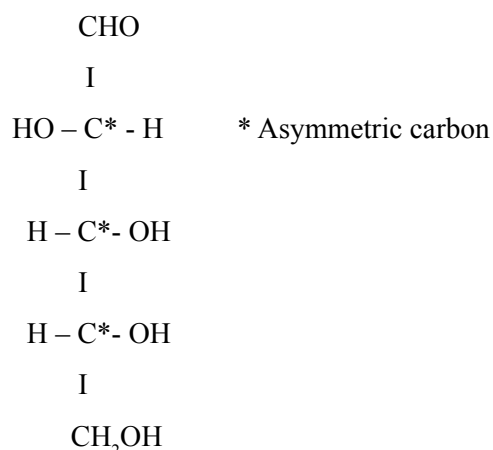
Task 2 : monosaccharide

The aim of this task is to familiarize with the basic structures of Glucids as well as the properties resulting from the structure. These compounds being Aldehydes and Ketones containing polyhydroxyl group present in its reactivity the properties of common compounds.

2.1 Structure of monosaccharide

- Monosaccharide are compounds of carbon containing polyhydroxyl group
- Are part of chiral compounds i.e., molecules not congruent with their reflex on a mirror.
- Present optic activity (optic isomers rotate polarized light plan)
- Are stereoisomers (isomers that differ on spatial orientation of the substituents).
- Have at least one asymmetric carbon atom.

Ex:



For a molecule with N asymmetric atoms there can be formed 2^n stereoisomers.

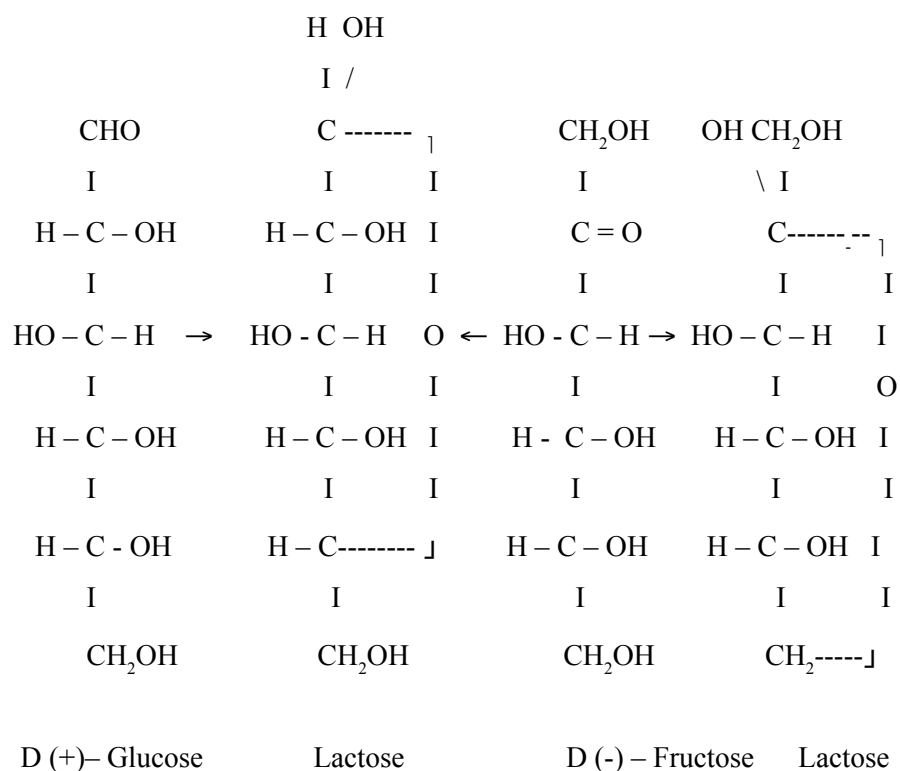
For example, a D- glucose with 4 asymmetric centers form 2^4 , so sixteen (16) stereoisomers which makes eight (8) pairs of Enantiomers (antipodes optics).

The constituents of a pair of Enantiomers have the same physical and chemical properties and have the same magnitude of deviation of plane polarized light, but in opposite directions.

Of the sixteen (16) isomers only one (1) is (+) Glucose, and the most abundant monosaccharide. The second isomer corresponds to a (-) Glucose which is enantiomer found in nature. The other fourteen (14) isomers are diastereomers of (+) Glucose.

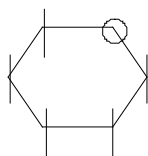


These structural elements in monosaccharide react between them forming intermolecular semiacetals named Lactone.

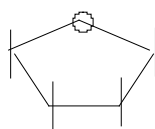


It is worth emphasizing that due to the steric conditions mainly occurs the formation of rings with six (6) atoms (without internal tensions) in some rings with five (5) atoms relative to the less stable.

The cyclic forms can be derived from the tetrahydropirane and tetrahydrofuran, so they are also called piranose and furanose respectively.



Tetrahidropirano



Tetrahidrofuran

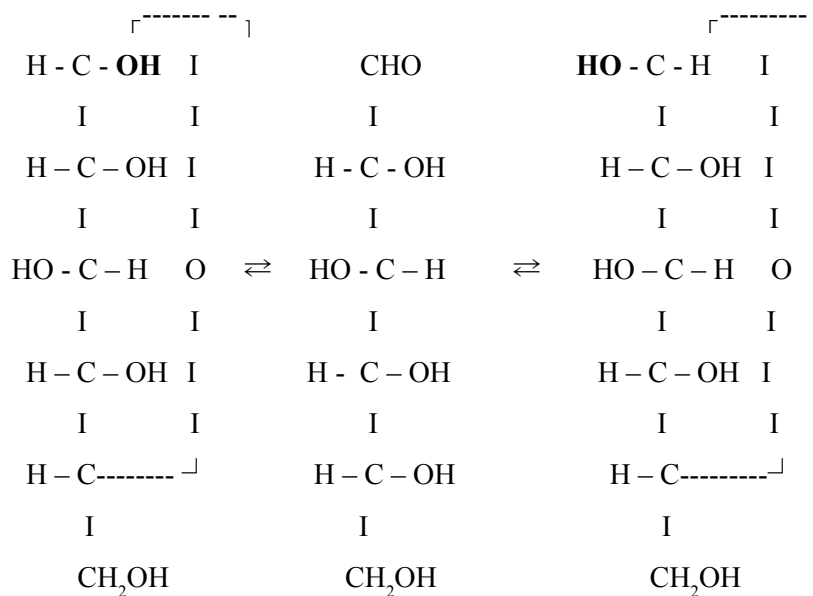


Formative Assessment 5

- Explain the major stability of the piranose and furanose in relation to other rings!

2.3 Stereoisomerism

With the cyclization there is always one more asymmetric center formed. This conditions the existence of two more diastereomers lactones called **Monomers** α and β .



α - D -(+)- Glucopiranosose
(Lactol)

D-(+)-Glucose
(Aldehyde)

β - D -(+)- Glucopiranosose
(Lactol)

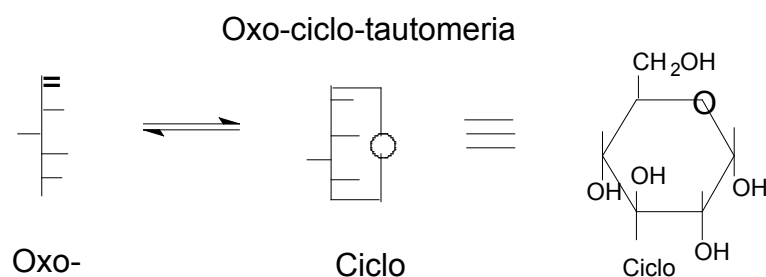
In Fisher's projection of series D sugars, the new hydroxyl group is written on the right when related to monomer (α) and on the left to represent the monomer in the form of (β). For the L series we use the naturally opposite process.



2.4 Oxocyclotautomerism

In solution there are formed a balance of three tautomeric forms. This balance is known as oxo-cyclo-tautomerism is generally moved to the cyclic form.

Let us use glucose as an example:



Through the changing conditions of crystallization (mainly the temperature and solvent variations) is possible to isolate from glucose solution a series of monomers α - or β - piranoses.

The glucopiranoses of the pure α - series rotates polarized light at a specific angle of 112° . The β rotates polarized light at a specific angle of 19° .

However dissolving one of these in pure water we observe a gradual change in the polarized light rotation caused by the conformation at a rotation angle equal to 52.7° .

A fresh aqueous solution (that has just been made) of α - Glucopiranoses rotates polarized light at a specific angle of 112° . However with time these angles decrease until 52.7° . Meanwhile dissolving a β - glucopiranoses with a specific angle of deviation of 19° it is observed that with time the angle increases to the same size of 52.7° .

Pure B-D-glucose has an optical relation of $[\alpha]_D = +18.7^\circ$, the α - anomer has

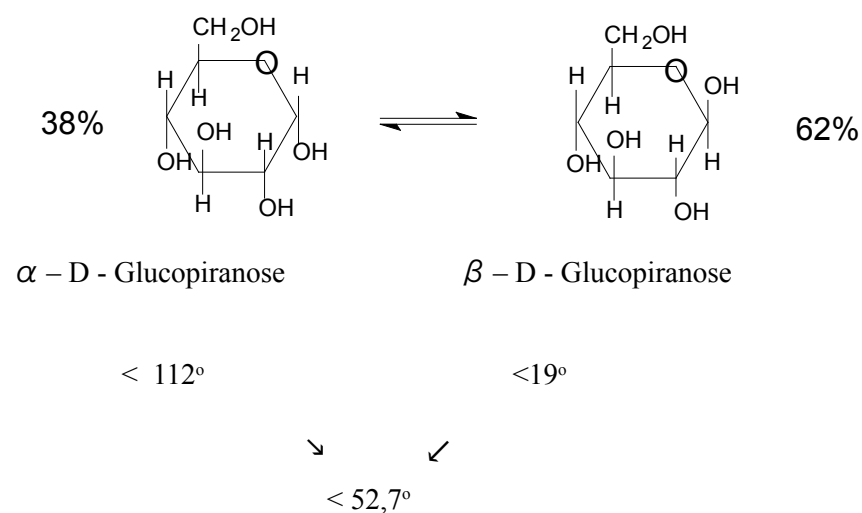
$[\alpha]_D = +112^\circ$. If either pure anomer is dissolved in water, the optical rotation of the solution gradually changes until it reaches an equilibrium value of $+52.7^\circ$. This phenomenon results from interconversion of the two anomers in solution. At equilibrium the solution contains 63.6% of β - (more stable) and 36.4% of α - anomer.



This phenomenon of change in the rotation of monomers α or β to reach the value of balance is known as mutarotation

Example. Mutarotation of glucose

Hawort projection



Formative Assessment 6

- a) What are monomers?
- b) What do is mutarotation?

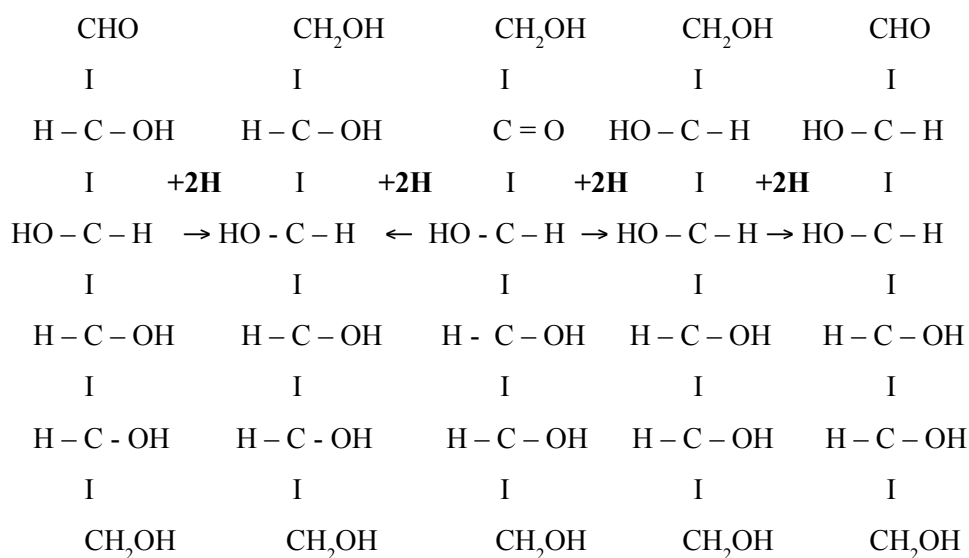
2.5 Monosaccharide reactions

In the presence of halides of Lithium and Aluminum or amalgams (NaBH_4) the carbohydrates let themselves reduce to alcohols sugars (alditol) whose name is characterized by the termination -itol.

While in aldose's hydrogenation we always get one alcohol in Ketone's hydrogenation there are two diastereomers, since the reduction happens while a new asymmetric center is formed.



Ex.



D-(+)-Glucose D-(+)-glucitol D-(-)-Fructose D-(+)-Manitol D-(+)-Mannose

Alcoholic sugars are colorless substances that crystallize well and have a sweet flavor.

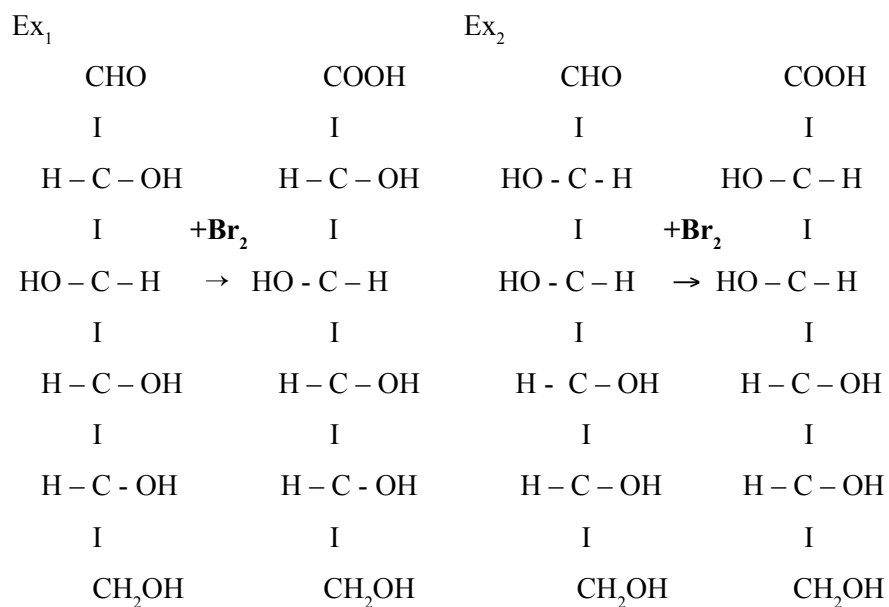
The D-glucitol or D-sorbitol (sorbite) is used in place of sugars for diabetics.

Many hexitol are usual components of plants. For example red algae, fruit like pears, apples, strawberry and peaches. Manitol is found in algae, grass, fruit and fungus.

2.5.2 Monosaccharide oxidation

Aldoic acid

Using mild oxidants like bromine water (Br_2, aq) or diluted nitric acid (HNO_3, dil) is possible to oxidise the Aldehyde group of Aldoses, there is a carboxylic group that is only stable in an alkaline environment. In an acidic environment we have condensation between the carboxylic group and the hydroxyl group of α or β forming lactones.

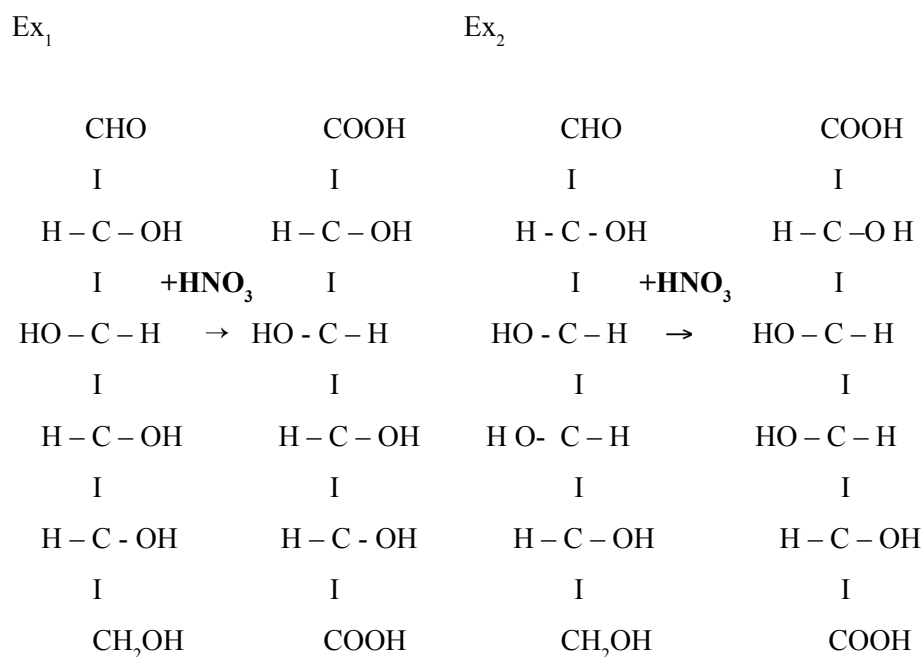


D-(+)-Glucose Ác.-D-(+)-glucónic D-(+)Mannose Ác. D-(+)-Manonic

Aldaric acids

Strong oxidizing environments attack not only the Aldehyde group, but also the hydroxyl group primary of the Aldoses forming dicarboxyl acids (aldaric acids) known as acid sugars.

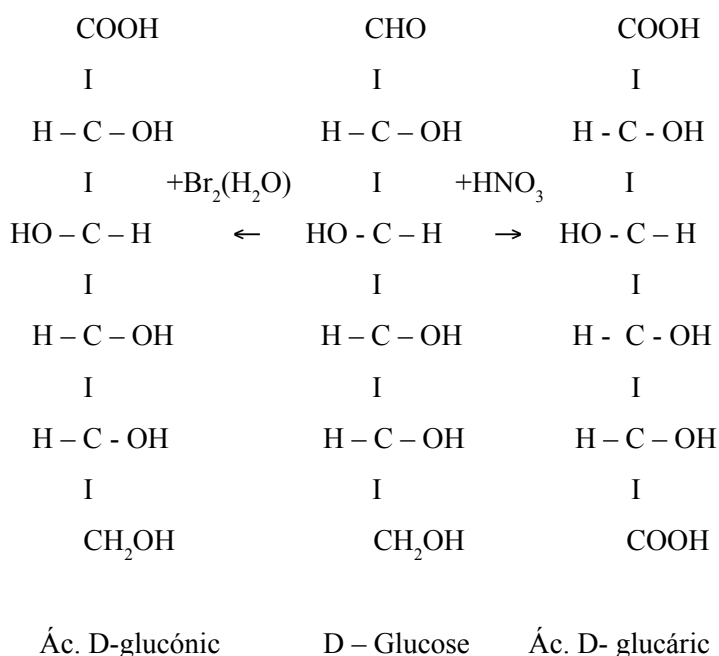
Aldaric acids can also easily form lactones.





D-(+)-Glucose Ác.-D-(+)-glucáric D-(+)-galactose Ác.-D-(+)-galactáric
 (Ác. mucic)

Ex.₃ Resume

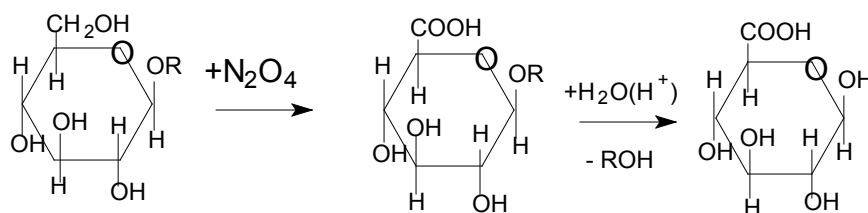


Acidos urínicos (glycoside oxidation)

Medium oxidizing agent (Ex .Dinitrogen peroxide in water solution) oxide the hydroxyl group primary to glycosides up to the carboxylic group. The compounds formed are called Uronides.

Uronides can be transformed into Uronic acid through hydrolysis of the acetal bond.

Ex.



 β -D-Glucopiranoside β -D-glucorónideÁc.- β -D- glucorónic

Uronic acids are important to the organism, because with their help substances that contain hydroxyl groups are linked like glycosides and eliminated from the body in the form of urine (disentoxication).

Free sugars represent low gain in this process.

O Ascorbic and glucuronic acids are products of the oxidization of monosaccharide and have particular importance. Ascorbic acid makes up Vitamin C, widely found in nature especially in green plants. They have as function, reactant of oxidation-reduction transporting hydrogen in biochemical reactions.

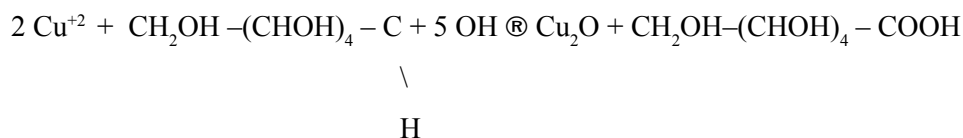
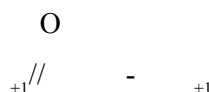
As for glucorónic acid, in which the primary glucose hydroxyl was oxidized to carboxylic group, while the aldehyde group remains intact have special importance in the biosynthesis of natural polysaccharides.

2.5.3 Reaction of identification

Sugars being Aldehydes/Ketones containing polyhydroxyl group, present similarities in reactivity with Aldehyde, Ketones semiacetals, having the same reducing properties as these in which they base their main methods of identification.

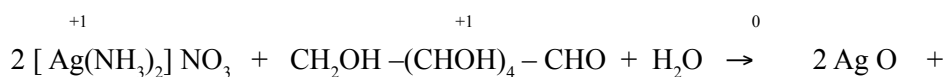
Thus, sugars can reduce solutions of Fehling, Haine, Tollens, Nyland, Trommer oxidizing to acids.

Fehling's solution : Cu^{2+} , KNa-Tartrate (OH)



Color: Blue \rightarrow Red stone komplex

Tollen's solution : Ag^+ , OH⁻ in ammoniacal solution.





Production of silver mirror

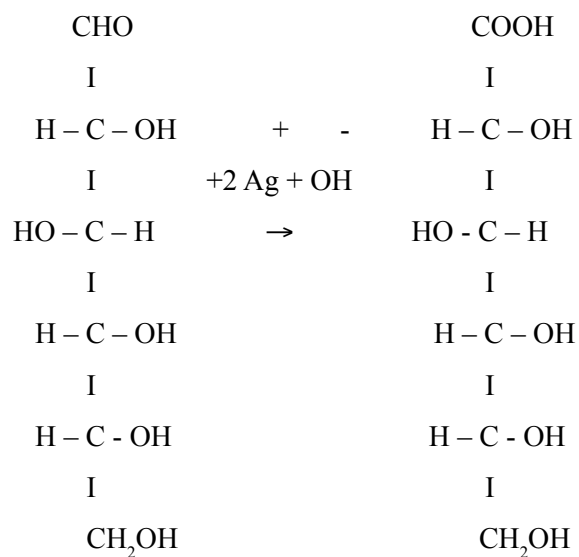
Haine's solution : Cu^{+1} , OH^{-} , Glycerol

→ Production of Cu_2O (Red)

Nyland's solution : Bi^{3+} , K, tartrate

→ Reduction of Bismuth ion to element bismuth (oxidation state zero)

Tollen's solution : Ag^{+} , OH^{-}



D-(+)-Glucose

Ác.-D-(+)-glucónic



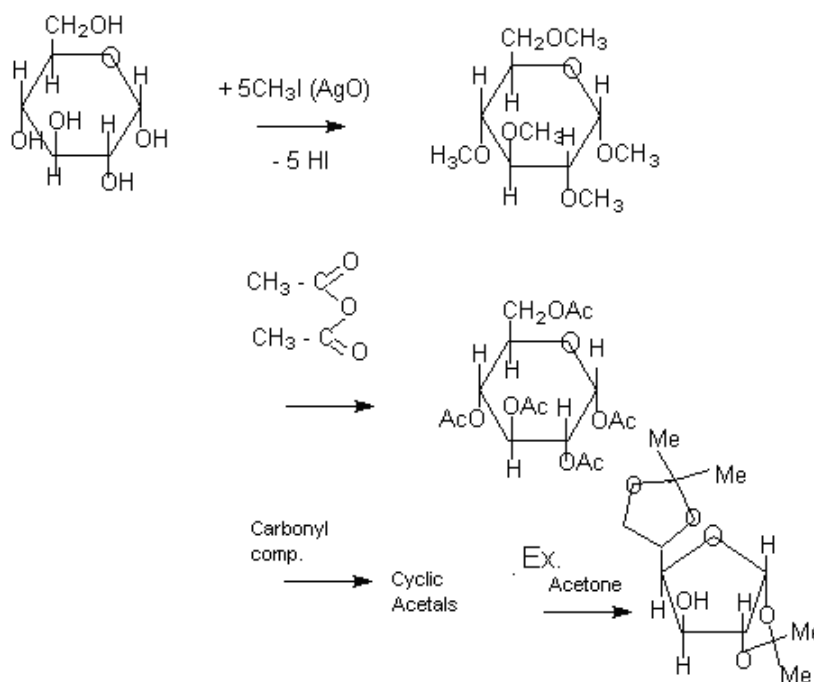
2.5.4 Hydroxyl groups reactions.

Monosaccharide being compounds containing polyhydroxyl group behave like polyalcohol.

Like with nucleophilic substitution reactions (S_n) with halides of alkyl, they esterify with anhydride and form cyclic acetals with Carbonyl compounds.

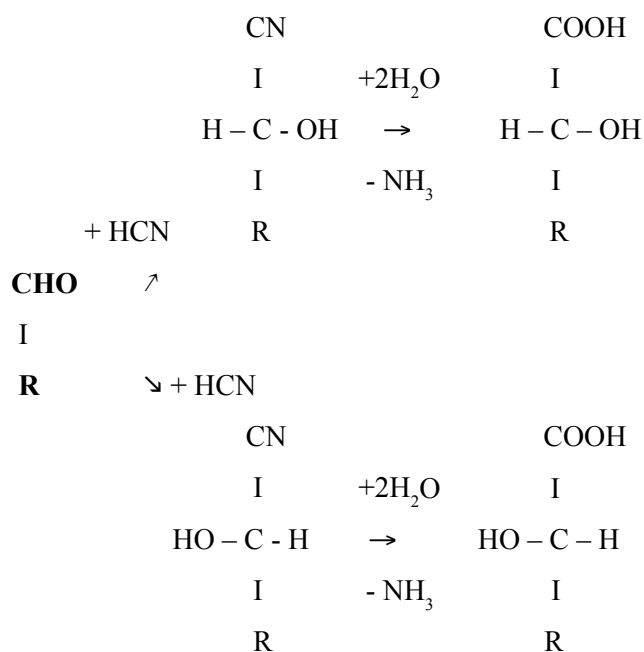
Ex. D-Glucose reacts with methyl iodide in the presence of silver oxide forming Penta-O-metilderivates. With acetic anhydride in pyridine forms Penta-O-acetilderivates.

With carbonyl compounds in the presence of $ZnCl_2$ form cyclic acetals.

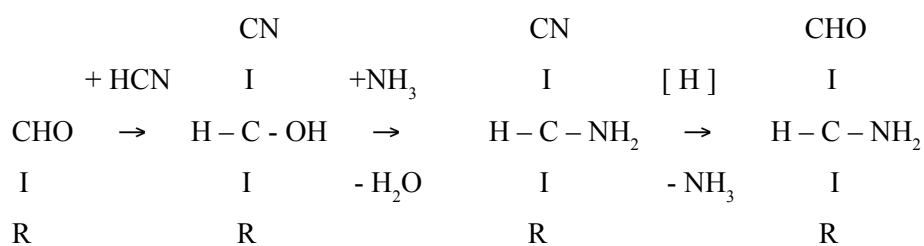


In most cases we can obtain typical products of carbonyl compounds in nucleophilic agents.

For example, the reaction with cyanidric acid forms a mixture of epimers cyanonides whose hydrolysis produce Aldoolic acids. These naturally can be reduced with amalgam of sodium until the monomers aldoses whose chain was increased by one carbon atom in relation to the agents.



On the other side the cyanohydrin in the presence of Ammoniac turns into aminonitriles that hydrogenates through acids catalytically to produce Amino sugars.

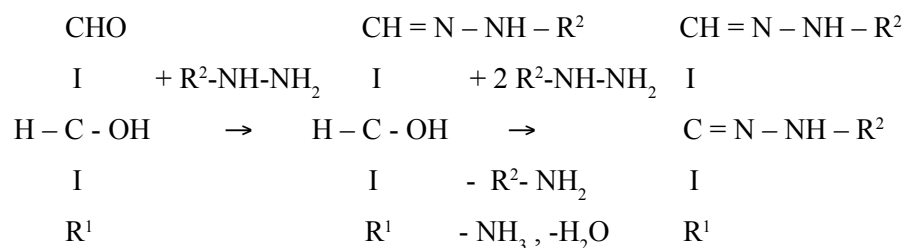


2.5.6 Formation of Osazones

Exposing Monosaccharide to heat in acetic acid with Phenylhydrazine forms osazones, which are yellow crystals not very soluble in water.

First the carbonyl group reacts with a mole of Phenylhydrazin forming Phenylhydrazon.

Next the adjacent carbonyl group is oxidized forming an osazone eliminating aniline and ammonia.

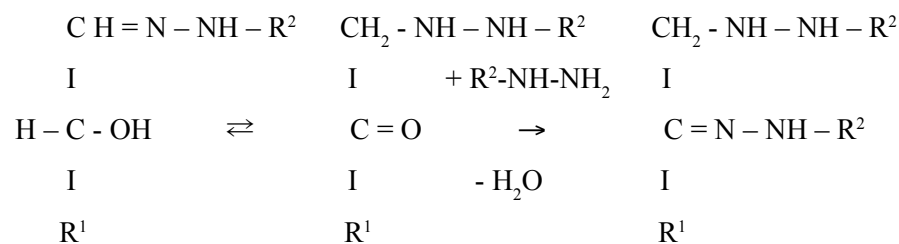


Aldose

Phenilhydrazon

Osazone

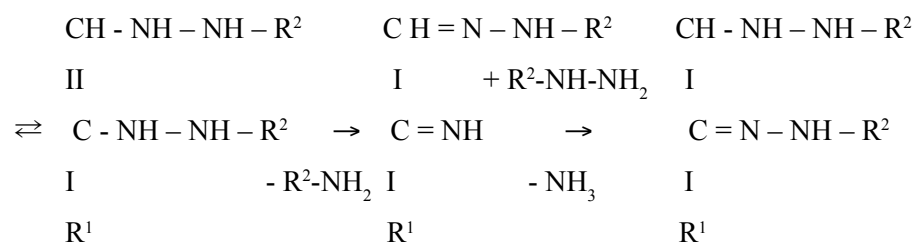
Mechanism:



Phenylhydrason

Osonhydrazin

Osazone



Osazones are Bis(phenylhydrazines) of compounds 1, 2- dicarbonyls.

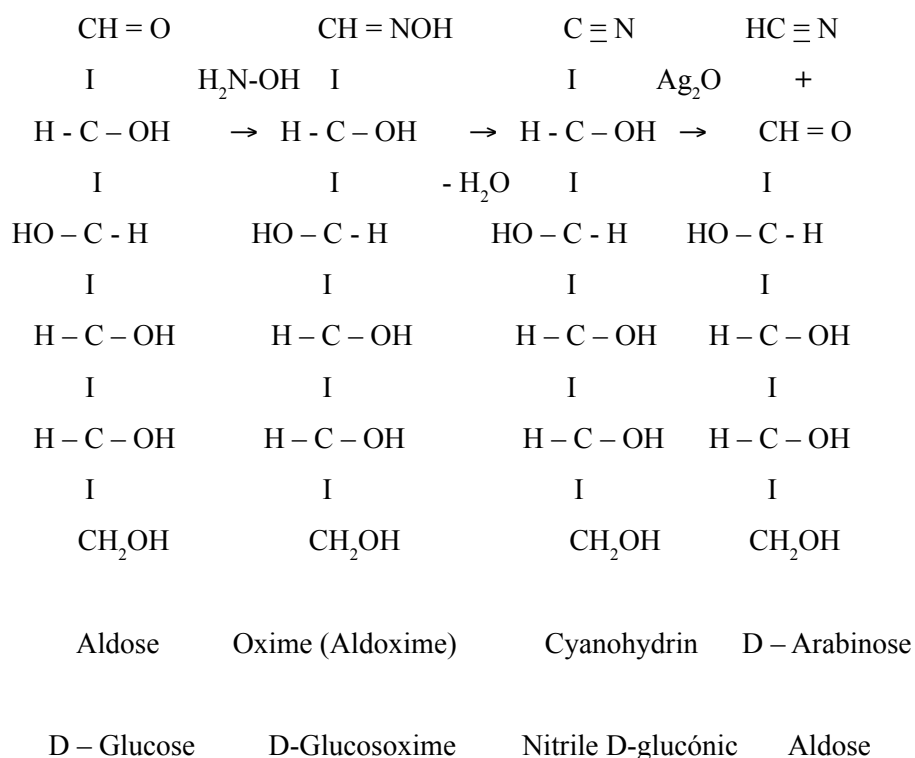
The epimer sugars D-Glucose and D-Mannose as well as D-Fructose form identical osazones.



2.5.7 Formation of Oximes

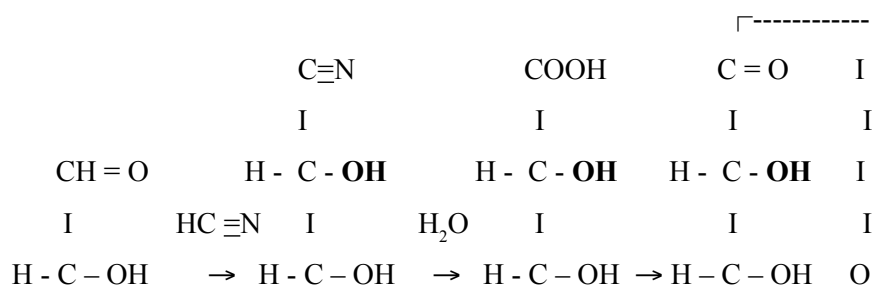
Reactions of Aldoses (ex. Glucose) with hydroxylamina form an Oxime of Aldehyde function, whose dehydration forms a cyanohydrin.

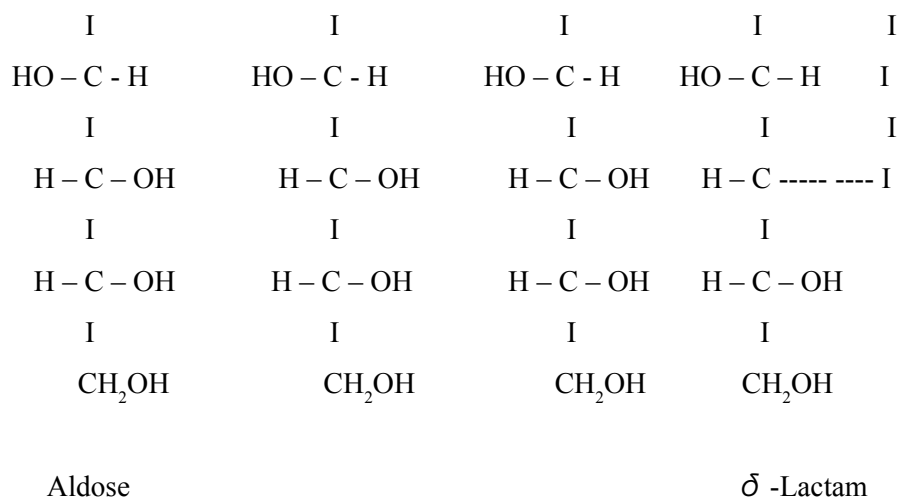
In the presence of silver oxide, it decomposes in Hydrocyanic acid and an Aldose (Arabinose). This sequence of reaction constitutes Wohl's method of degradation.



2.5.7 Hydrocyanic acid action

Aldoses react with hydrocyanic acid forming cyanohydrins. These can be hydrolyzed to acids and these can also be reduced to Aldoses of the homolog superior series in carbon atoms. (Fischer Kaliani's method of construction)





Formative assessment 7

- a) Write an equation of the reaction of the identification of glucose with Fehling's reagent!
- b) Explain why it is possible to identify the glucose with Fehling's reagent!

Task 3 : Oligosaccharides

In this activity you will get familiar with the theoretic and practical precepts of some compounds we deal with on a daily basis.

Oligosaccharides are compounds formed in two (2) to ten (10) units of monosaccharide bonded by glycosidic linkage.

Within the oligosaccharides the disaccharides are the ones that have the most importance.

In nature there are only found a few free disaccharides like sugar cane, milk and malt.

3.1 Disaccharides

Disaccharides are carbon hydrates made up of two units of monosaccharide. A molecule of a disaccharide produces two molecules of monosaccharide by hydrolysis.

From the analysis of the structure of disaccharide molecules it can be concluded that they are the result of condensation, with the elimination of water, of two monosaccharide molecules that can be identical or different in order for the disaccharides to be differentiated by:



- By nature of monosaccharide that constitute it
- By size of rings (Piranoose or Furanose)
- By the configuration (α ou β) of the glycosidic linkage
- By the position of the glycosidic linkage (whether it happens between the hydroxyl monomers of the two rings or not).

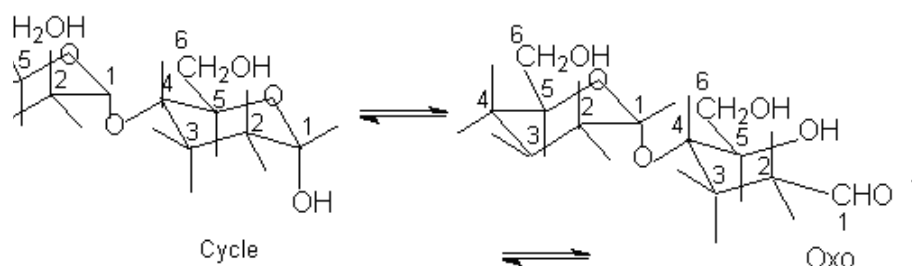
In general two monosaccharide molecules link each other in the form glycoside.

In the glycoside union between two monosaccharide molecules can originate a disaccharide, a water molecule can separate itself from the hydroxyl glycoside groups (also known as hemiacetal), or between one hydroxyl group hemiacetal (glycosidic) and another alcoholic. In the act of formation of the link we find two variables:

- a) The condensation happens between two (2) hydroxyl glycoside. In this case we are talking about a decarburization of a disaccharide (type 1).
- b) On the other hand the transformation may happen between a hydroxyl glycoside of one of the units of monosaccharide and a hydroxyl non glycoside (alcoholic) of another monosaccharide unit. In this case we are talking about a monocarbonization (type 2)

In the first case (type 1) the two types of monosaccharide contain a acetyl group, on the second case (type 2) stays only a hemiacetal (semi-acetyl).

As consequence the type 2 disaccharides with the monocarbonilization show redacting properties and show maturation because as consequence of oxo-cyclo-tautomerism it is possible to have a transition of the cyclic semi-acetyl to the form of oxo (open) with one free aldehyde group.



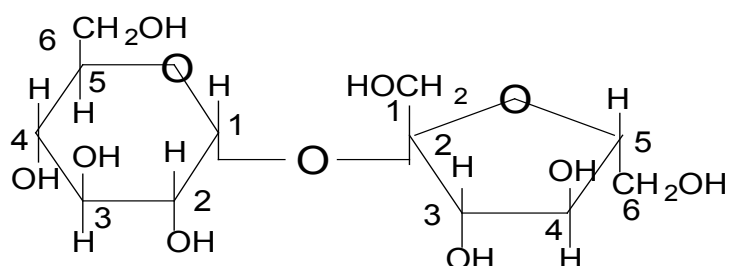
In contrary, type 1 disaccharides do not show these properties because of the blockage of the two hydroxyl glycoside by the formation of the acetyl.

3.2 Reductor Disaccharides (type 1)

As an example of non-reductor disaccharides we have Saccharose (sugar from sugar cane) that we abundantly find in the vegetal kingdom and are technically obtained from sugar cane or beetroot.



Saccharose is structurally made up of one unit of α -D-glucose and one unit of β -D-fructose. The two units of hexose link, each other, by a glycosidic linkage between Glucose's C-1 and Fructose's C-2, this causes the blockage of carbonyl functions (glycosidic linkage - 1, 2)



α -D-Fructofuranosil- β -D-Glucopiranoside or α -D-Glucopiranosil- β -D-Fructofuranoside

α -D- Glucose(+)	β -D-Frutose (-)
< + 52,7°	< -92,4°
Saccharose < 66,5°	

Saccharose's systematic name is α -D-Fructofuranosil- β -D-Glucopiranoside or α -D-Glucopiranosil- β -D-Fructofuranoside .

Saccharose rotates polarized light to the right (+66.5°). Off its hydrolysis in an acidic environment we can get a mixture of Glucose and Fructose called inverted sugar because in it we can observe a strong light deviation to the left caused by the strong influence of fructose.

Saccharose's molecular formula is: $C_{12}H_{22}O_{11}$

Saccharose does not have Osazones forms, there are not monomers and does not have mutarotation when dissolved, because they don't make up the free Aldehyde and Ketone group.

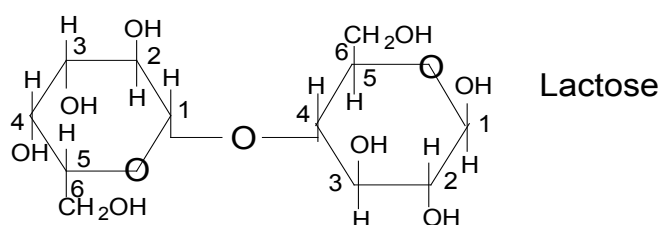
3.3 Non-reductor Disaccharides (Type 2)

As an example of a reductor sugar we have Lactose and Maltose.

Lactose is mainly found in mammal's milk. It is made up of a β -D-Galactose molecule that links glycosidically with a hydroxyl in the position 4 (alcoholic) of a β -D-Glucose molecule. It is a 4-O- β -D-Galactopiranosil- β -D-glucopiranoside.



Lactose



Glycosidic linkage -1,4

β -D-Galactose

β -D-glucose

4-O- β -D-Galactopiranosil- β -D-glucopiranoside

Lactose is a reductor sugar, it exists in the forms α and β , which have mutarotation and forms Osazones because of the fact that it has a free hemiacetal hydroxyl in the glucose molecule.

It can be obtained commercially as a sub product in cheese making.

General formula: $C_{12}H_{22}O_{11}$

Maltose

Maltose is formed by two (2) glucose molecules. These molecules are linked glycosidically by the hemiacetal hydroxyl group of a α -glucose (position 1) and a alcoholic hydroxyl group in position 4 of another glucose molecule.

By consequence it contains a free carbonyl group that fits in the reductor properties, mutarotation and other typical properties of Aldehydes.

Reduces solutions by Fehling, Tollens, Haine, and others.

When joined with Phenylhydrazin it forms an Osazone $C_{12}H_{20}O_9$.

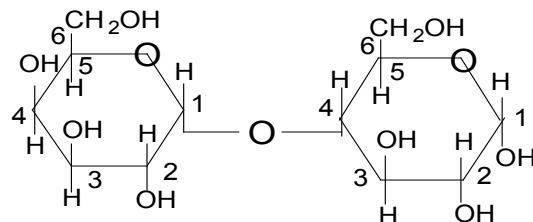
It is oxidized by bromine water forming a monocarbolyxic acid ($C_{11}H_{21}COOH$) the malt biotic acid.

Maltose can be produced along with other substances through amide hydrolyze with acidic solutions. Exist in the form α and β where $\alpha = +112^\circ$ and $\beta = +168^\circ$ which have mutarotation, and when dissolved at an angle $< +136^\circ$. These facts show that Maltose has a free Carbonyl group.

By acidic hydrolyze or by Maltase enzyme action, turns totally into a D- Glucose (β -Glycoside).



Maltose



Maltose

α -D- Glucose

α -D- Glucose

4-O-(α - Glucopiranosil)- α -D-Glucopiranoside

Formative Assessment 8

- Characterize Oligosaccharides
- Glucids are part of the composition of milk. Illustrate this compound's structure and explain what type of sugars it belongs to.

Task 4: Polysaccharides

Exercise 4 deepens the fundamental knowledge about vital compounds for the existence and survival of Humanity.

In the study will be found information about the structures of natural macromolecules with biological importance and will discuss the correlation between the structures and properties.

They serve for protection, support and reserve for living organisms.

4.1 Polysaccharides composition

Polysaccharides are compounds made up of hundreds or even thousands of monosaccharide units per molecule. These units link each other by glycosidic links that can break by hydrolysis.

Polysaccharides are natural polymers considered derived off Aldoses and Ketoses by polymerization by condensation.

4.2 Physical properties

Most of the polysaccharides are not soluble in water, or form a colloidal solution. The colloidal state reflects a relatively high molecular mass that changes from ca. 1700 to couple of millions.

In nature the main polysaccharides are Cellulose, starch and glycogen.

All of them are made up of D-glucose units.



Starch and cellulose are produced in plants from carbon dioxide (CO₂) and water (H₂O) by the process of photosynthesis.

Cellulose makes up the basic supporting structure for plants giving them their shape and rigidity. It is the most abundant organic material on earth.

Starch forms the nutritive reserve of plants, while glycogen represents the carbohydrates reserve in animals.

4.3 Starch

Starch, being the energetic reserve of plants is found in great quantities in seeds and in the foods like potatoes, cassava, corn etc.

Starch is always in the form of granules. These are insoluble in cold water and partially soluble in hot water.

In general starch is made up of a fraction of 20%, soluble in water, amylose and about 80% of a fraction insoluble in water the Amylopectin.

Starch degenerates until D-glucose by heating with diluted mineral acids. If the hydrolysis is partial we get a mixture that is hard to separate the fragments of polysaccharides called dextrans.

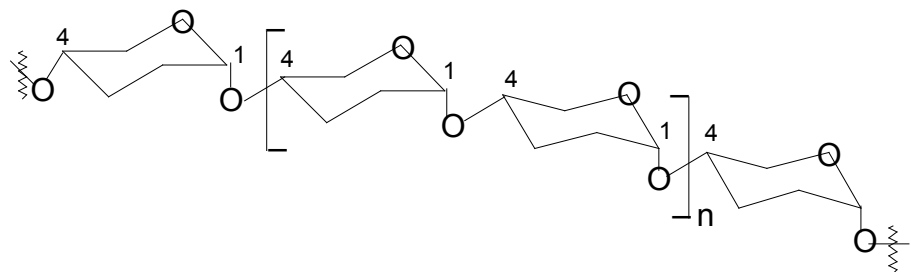
In the presence of Iodine starch incorporates Iodine's molecules turning blue.

Amylose as well as amylopectin are made up of D-Glucose units; the difference between them is the size and form of the molecule.

Amylose form linear chains, of Glucose molecules that are joined in the form α -(1,4)-glycosidic.

Presents a mass that varies between 150 000 and 600 000 that corresponds to between 1000 and 4000 units of glucose.

Amylose



(1-4)- α -D -Glucopiranoside

Amylose is the fraction of starch that forms that intense blue color with Iodine.

The Amylose chain in solution adopts the elliptical form, because of the α configuration of all glycosidic links. Because these chains are whirled up in a helix (like a



whirlwind staircase) create spaces (interstices) big enough to hold the molecules of Iodine allowing that way the appearance of the color.

Amylopectin is a highly branched molecule. The links through the chain in the form α -(1-4)-glycosidic, and in the form α -(1-6) glycosidic in the branching points.

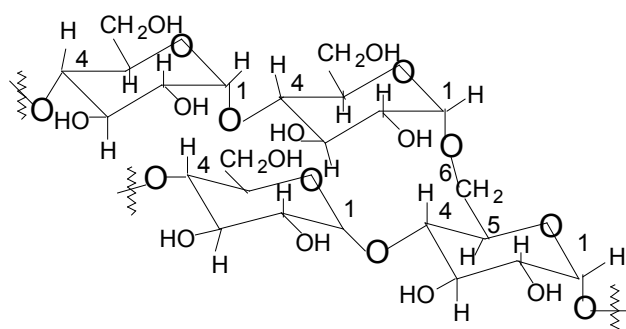
The short chains (branches) have about 20 to 25 units of glucose.

In structure Glycogen is similar to Amylopectin. Even though its chains are more branched, with 3 to 18 units of D-Glucose in each branch, and has a relatively higher molecular mass that goes from 10^5 to 10^7 .

While starch is produced exclusively in plants, Glycogen represents “the reserve of Carbon hydrates” of animals’ organisms.

After the partial conversion of Carbon hydrates of food, Glycogen is stored in the liver and muscles.

With Iodine it becomes of dark red color.



4.5 Cellulose

Cellulose is the main supporting substance in plants. As a supporting substance it is the main component of plant’s cellular walls and is the most common Carbon hydrates on earth.

The vegetal fibers, such as cotton, linen, hemp are made up of pure Cellulose.

Cellulose is soluble in water, is insipid and is non reductor.

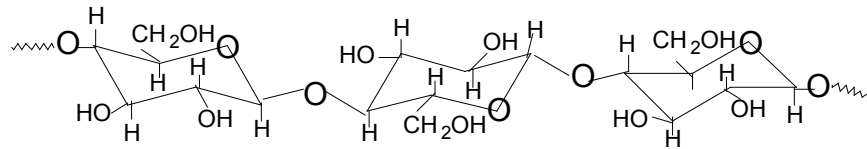
Cellulose is different to starch, this is due to the fact that the units of D-Glucose that makes them up are joined by β (1, 4)-glycosidic links, off which derives the different properties of these natural products.

Cellulose’s molecular mass is relative to its origin, it varies from 200 000 to millions. This equates to over 1 500 glucose units per molecule.

The long cellulose chains are placed next to each other forming bundles, are kept in position by Hydrogen links between the numerous adjacent Hydroxyl groups.



Cellulose



Formative Assessment 9

- Compare the structure and properties of Amylose and of Amylopectin!
- What is the importance of Cellulose in the biological system?



Formative Assessments

Formative Assessment 1

- a) Why is the designation Glucids proffered over the name Carbohydrates?
 - That is because in nature there are carbon compounds like acetic acid and lactic acid that have the exact same proportions of Oxygen and Hydrogen as water, even though they are not classified as Carbohydrates.
- b) Chemically define Carbohydrates or Glucids!
 - Carbohydrates or Glucids are chemically Aldehydes and Ketones containing polyhydroxyl group or compounds by hydrolysis, can transform them.

Formative Assessment 2

Give three examples of biological importance of Glucids!

- Substance of animal reserve. Ex. Glycogen
- Plant support substance. Ex. Cellulose
- Energy source. Ex. Saccharose

Formative Assessment 3

- a) Write down the structure of Fructose!
 - See text
- b) Make a complete classification of Fructose!
 - Fructose is a monosaccharide, a ketose, hexose, series D, levorotatory (counterclockwise).
- c) Define the following concepts, disaccharide and polysaccharide.
 - Monosaccharide

Simple sugars formed by one basic non hydrolysable unit with generally five to six carbon atoms.

Ex. Glucose, Fructose, Mannose.

Disaccharide

Sugars made up of two basic units of monosaccharide. Disaccharides are hydrolosable in simpler compounds (monosaccharide).

Ex. Saccharose, Lactose, Maltose.

Polysaccharides

Carbon hydrates that can hydrolyze in many monosaccharide units (can reach about 10 000 units).



Formative Assessment 4

- a) Explain Glucose's solubility!
Glucose is an easily soluble compound because it is an Aldehyde containing polyhydroxyl group and polar.
- b) Explain why Ribose has an optic activity!
Ribose has three asymmetric carbon atoms.

Formative Assessment 5

- Explain why piranoses and furanoses are relatively more stable when compared to other chains!

Piranoses and furanoses have relatively less tension when compared to other chains resulting in the deformation of the linking angles (Bayer's tension).

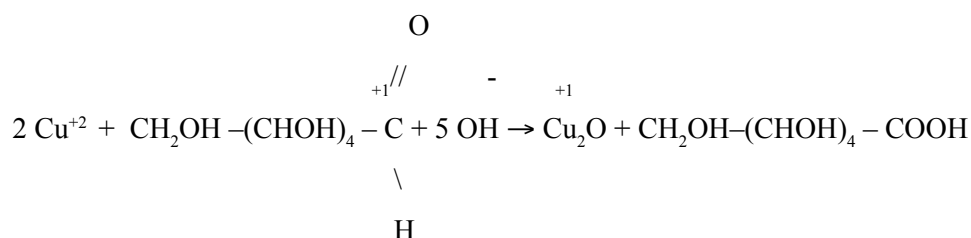
Formative Assessment 6

- a) What are monomers?
Monomers are Diastereomers Lactones resultant of the cyclisation and formation of a new asymmetric centre designed by monomers α and β .
- b) What do you understand by mutarotation?
Mutarotation is the phenomenon of change in the angle of deviation of monomers α or β until the value of equilibrium.

Formative Assessment 7

- a) Write the equation of the reaction of identification of Glucose with Fehling's reagent!

Fehlings: Cu^{2+} , KNa-Tartrate (OH)



Color before the reaction (**Blue**) \rightarrow After (Red stone komplex)

- b) Explain why it is possible to identify glucose using Fehling's reagent!
Glucose is an Aldehyde containing polyhydroxyl group. The free Aldehyde group of sugar is oxidized by copper ions of an acid group, causing simultaneously the reduction of these forming Cu_2O that has a red color.



Formative Assessment 8

- a) Characterize Oligosaccharides!

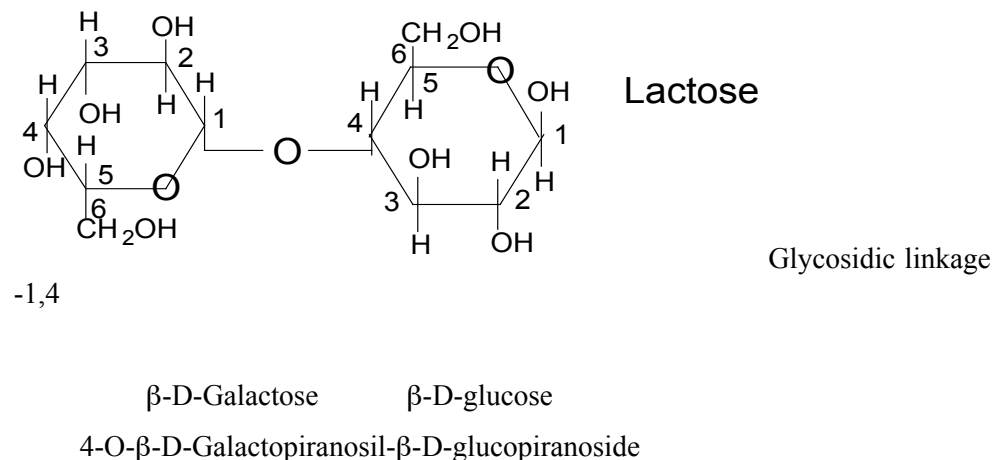
Oligosaccharides are sugars formed between two (2) to ten (10) units of monosaccharide linked by glycosidic linkage.

- b) Glucids are part of milk's composition. Illustrate the structure of this compound and explain to what type of sugar it belongs to!

The Glucid mainly found in mammal's milk is Lactose.

It is made up of a β -D-Galactose molecule that links by glycosidic linkage to a hydroxyl in position 4 (alcoholic) of a β -D-Glucose. This means that it is in fact a 4-O- β -D-Galactopyranosyl- β -D-Glucopyranose.

Lactose



Lactose is a reductor sugar, exists in the forms α and β , presents mutarotation and forms Osazon due to the fact that it has free hemiacetalic hydroxyl in the Glucose molecule.

Formative Assessment 9

- a) Compare the structure and properties of Amylose and Amylopectin!

Both Amylose and Amylopectin are made up of D-Glucose units, differing from each other by size and shape of the molecule.

Amylose form linear chains, of Glucose molecules that are linked in the form α - (1, 4) - glycosidic.

Has a mass that varies from 150 000 to 600 000 and corresponds to between 1000 and 4000 glucose units. It is easily soluble in water.



The Amylose link in solution adopts an elliptical form, because of the α configuration of all glycosidic links. Because these chains are wrapped around they create spaces (interstices).

Amylopectyn is a highly branched molecule. The links throughout the chain are made in the form of α - (1-4)-Glycoside, and in the form α - (1-6)-Glycoside on the branching points.

The short chains (branches) have around 20 to 25 units of Glucose. Its relative mass varies from 200 000 to 1000 000.

Amylopectin makes up the main component in starch (ca. 80%).

Due to the degree of branching it is not very soluble in water.

b) What is the importance of Cellulose in the biological system?

Cellulose serves as the material for plant support.

It can also be in taken by herbivores for the production of essential units for their metabolism.

Glossary (Key terms)

1. Carbohydrates or Glucids
2. Monosaccharide
3. Oligosaccharide
4. Polysaccharide
5. Aldose
6. Ketose
7. Oxocyclo-tautomerism
8. Mutarotation
9. Reductor sugar
10. Asymmetric Carbon



1. Carbohydrates or Glucids

Chemically Carbohydrates and Glucids are Aldehydes or Ketones containing polyhydroxyl group or compounds that through hydrolysis, can be transformed in these.

2. Monosaccharide

Simple sugars formed by a basic non hydrolysable unit generally with five to six Carbon atoms.

3. Oligosaccharide

Sugars made up of two to ten basic units of monosaccharide. Oligosaccharides are hydrolysable in simpler compounds (monosaccharide).

4. Polysaccharide

The carbohydrates which can hydrolyze in many units of monosaccharides (may reach about 100000 units).

5. Aldose

Sugar which main functional group is aldehyde.

6. Ketose

Sugar which main functional group is aldehyde.

7. Oxocyclo-tautomerism

Equilibrium of three tautomeric forms, of monomers α , β and the cyclic form of sucrose denominated oxo-cyclo-tautomerism .

8. Mutarotation

The occurrence of changes in the angle of deviation of monomers α and β up to the value of equilibrium is denominated mutarotation.

9. Reducing Sugar

Sugar with at least one free functional group capable of oxidation reduction reactions.

10. Asymmetric carbon

Carbon with four different substituents. Chiral Carbon (?)



Learning Activity 2

The learning activity 2 (two) offers essential knowledge about Proteins, its composition, structure, main physical and chemical properties, its biological activity, as well as issues correlated with stereoisomerism of these compounds.

Proteins are vital bio compounds for the life on Earth.

They are found in all organisms and as essential part of their structure and functioning.

The study of Unit 2 (Proteins) takes approximately 45 studying hours. Here attention should be paid to references, taking notes, making summaries and answering to formative questionnaires for orientation which can be found along the sheet work.

List of Required Readings

- <http://www.fsa.br/quimica/Biomol%Eqculaskaren.pdf>
(Aminoacids/Peptide bond/Aminoacids structure)
- Origem : Wikipédia, a enciclopédia livre
<http://Pt.Wikipédia.org/wiki/Prote%C3%ADnos>
- http://pt.wikipedia.org/wiki/Liga%C3%A7%C3%A3o_pept%C3%ADdica
(Peptide bond)
- QMCWEB://o mundo das proteínas
<http://www.qmc.ufsc.br/qmcweb/artigos/proteinas.html>
(struture/protein functions / essential aminoacidos/ simple and conjugated proteins)
<http://Pt.Wikipédia.org/wiki/Prote%C3%ADnos>

List of Relevant Useful Links

- <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>
(Carbon hydrates/nucleic acids/lipids)
- <http://www.amtechs.com/folding/education/prstruc.html>
- <http://verjo2.iq.usp.br/aula-2-aminoac-estrut-primaria-prot.pdf>
- <http://www.google.com/search?hl=en&q=Estrutura+das+proteinas>
(protein structures)
- <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>
(Carbon hydrates/nucleic acids/lipids /functions)



List of relevant MULTIMEDIA resources

(The Molecules of life) == Screem capture

http://biop.ox.ac.uk/www/mol_of_life/index.html

Read with attention the reference and take notes in regard the following matters:

- Proteins
- Composition of Proteins
- Essentials Amino acid
- Peptide linkage
- Importance and structure of proteins
- Proteide (DNA and RNA)

The process of acquiring skills and abilities offered in this module are facilitated by solving the following tasks:

Task 1: Introduction to Proteins

- 1.1 – Concept of Proteins
- 1.2 – Occurrence, composition and importance

Task 2: Amino acids

- 2.1 - Structure of Amino acids
- 2.2 – Properties of Amino acids
- 2.3 – Reactions of Amino acids
- 2.4 – Essentials Amino acids

Task 3: Peptides

- 3.1 – Structure of peptide linkage
- 3.2 – Formation of peptide linkage

Task 4: Proteins

- 4.1 – Primary structure
- 4.2 – Secondary structure
- 4.3 – Tertiary structure
- 4.4 – Quaternary structure



Task 5: Proteins

- 5.1 – Proteide structure
- 5.2 – Nucleoproteins
- 5.3 – Ribonucleic acid (RNA)
- 5.4 – Deoxyribonucleic acid

Formative evaluation

Along the text you will find questions for orientation which you should answer.



Learning activities

Task 1 : Introduction to Proteins

The readings on Proteins will familiarize you with important biomolecules for organisms. The Chapter offers an overview of Proteins and its functions and basic structure.

Proteins are considered biopolymers of life.

1.1 Concept Protein

Proteins (or albuminous substances) are especially important among natural products that constitute living cells. The name protein originated from Greek **proteos**, meaning 'first'. This name was certainly chosen because among all chemicals, they are indeed the substance of life. Together with the Hydrates of carbon and fat, they are essential components of animal food.

Proteins are natural polymers constituted by Amino acids units.

Judging by its functions Proteins are classified as fibroses (p.e. Keratin, collagen), contractile (ex. myosin, actin) and globular (hormones and enzymes, p.e. insulin).

However all Proteins are natural polymers constituted by high number of basic units of Amino acids bonded by peptide linkage.

1.2 Occurrence, composition and importance

Proteins are macromolecules which constitute about $\frac{3}{4}$ of dried weight of the majority of animals, and are involved in the structure and function of any living organism.

Some Proteins have pure structural function (as example Keratin which is the important component of skin, hair and nails or Collagen which is component of fibres and tendons and forming bones, myosin and actin as components of muscles). Many other Proteins have catalytic functions (enzymes), allowing the occurrence of chemical reactions in living systems. Other Proteins have regulation functions acting as hormones in many physiological processes (growth, metabolism, reproduction and functioning of many organs). For example, insulin controls the metabolism of carbohydrates and lipids. Yet other Proteins participate in the immunologic system protecting the organism (antibody).

It is calculated that in human body exist around 5.000.000 of different Proteins, each of them doing specific and necessary functions for the good development and life or organisms.

The amount of Proteins differs from specie to specie and among individuals from the same specie.



Formative assessment 1:

- a) – Define and classify proteins!
- b) – What is the function of proteins in the organism?

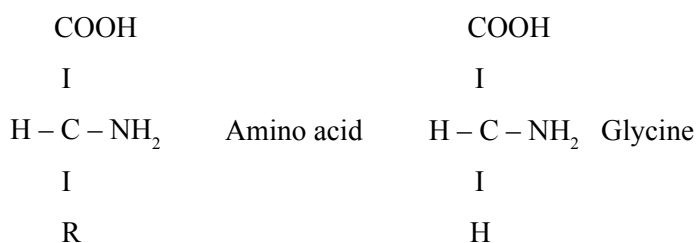
Task 2: Amino acids

Task two, offers an overview on basic units of proteins (Amino acids) as well as the historic development of it's discovering.

In 1820, was found out that when heated gelatin protein with diluted acids, they would break down in its basic components.

It was seen that one of the main components was the molecule of Glycine $\text{NH}_2\text{CH}_2\text{COOH}$, which is the simplest of the compounds known as Amino acids.

Structurally, Glycine can be considered as derivate from Acetic acid, CH_3COOH replacing one Hydrogen atom (H) by amino group ($-\text{NH}_2$).



2.1 – Structure of Amino acids

Amino acids (AA) are bifunctional compounds that contain one acid function due to the presence of carboxyl group and, one basic function originated from the presence of Amino group.

Amino acids, in general, can be differentiated according to group Amino position in acids α , α , χ δ etc. amino carboxylic.

From 1820 to 1935, various experiments were made to identify all the amino acids that make up a Protein. Although in this process there were found many amino acids in nature, it was observed that only 20 of them occur regularly in Protein.

The α - amino acids are the most important ones, given that they make up the structural units of Proteins, which can be produced by hydrolysis.

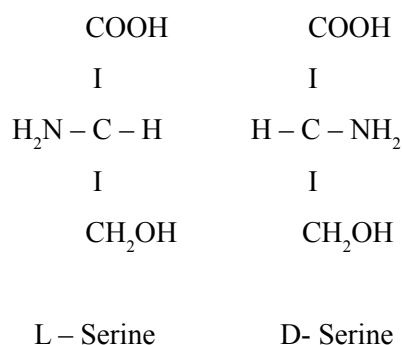


All known amino acids, form isomers except Glycine which doesn't have an Asymmetric carbon.

Most natural amino acids that form intracellular Proteins have an **L configuration**, but in some natural substances there were found substances of the **series D**, mainly in microorganisms. For example, in Streptococcus Faccalis there is a D-Alanine content of 39-50%, this value can reach 67 % in Staphylococcus Aureus.

D-amino acids were also identified as substances that are products of the biological activity of these microorganisms.

Amongst all amino acids Serine was conventionally established as the referent amino acid for the series D and L having as standard the position of α -amino group.



However, most natural amino acids differ only in the structure of the organic residue linked to Carbon α .

Of the AA that is found in nature, only about 20 are components of Proteins in the living organisms. The others are either intermediary products or final products of metabolism.

2.2 Properties of Amino acids

Contrary to Amines and carboxylic acid amino acids are crystalline solid, non volatile, and melt in decomposition, at very high temperatures.

They are soluble in water and insoluble in organic non polar solvents, just like petroleum ether, o benzene, diethyl ether, etc.

The respective aqueous solutions behave like solutions of high dipole moment.

Its acidic and basic constants are excessively small, compared with the carboxylic acid's constants (-COOH) and of animals' (-NH₂).

A Glycine, for example, has $K_a = 1,6 \cdot 10^{-10}$ and $K_b = 2,5 \cdot 10^{-12}$, while the majority of the carboxylic acids have K_a values of about 10^{-5} and the majority of aliphatic amines have K_b values of about 10^{-4} .



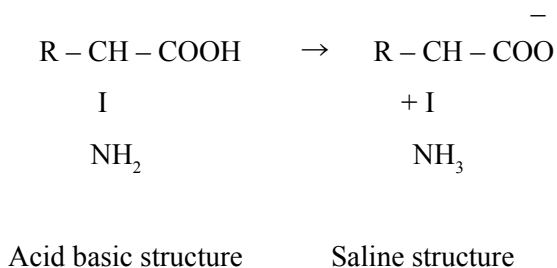
The R-CH(NH₂)COOH molecule contains an acidic group and a basic group, but in fact this species does not exist in the solid state nor does it exist as a solution, but forms an internal corresponding salt.

+

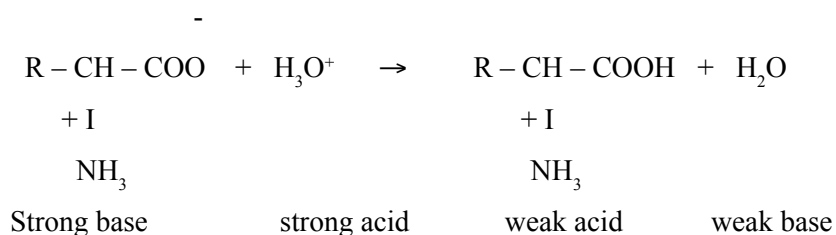


2.3 Amino acids reactions

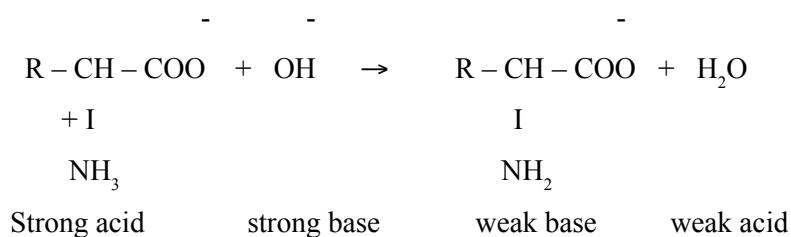
Although the AA have two functions, one basic and one acid, because of the presence of the carboxylic and amino groups in their structure, in fact these compounds are found in the form of bipolar ions, and not in the ionized form. These way, the AA have a saline structure (of an internal salt) dipolar.



Because of the bipolar structure the AA can take protons or give them away, this meaning, they behave like acids and bases: they are amphoteric. In the presence of a strong acid (H₃O⁺) the AA react like bases, accepting protons.

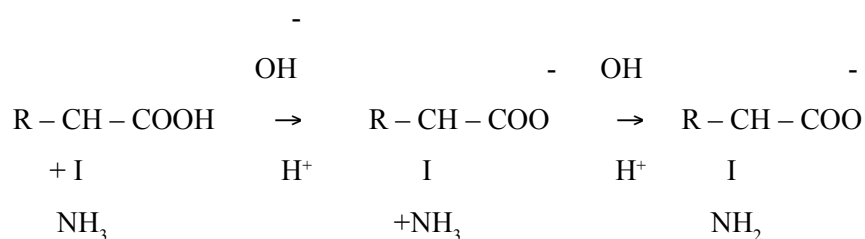


In the presence of a strong base AA gives away one proton.





Resumed:



2.4 Essential amino acids

In the human species there are eight (8) “essential amino acids” that cannot be synthesized by the organism (Leucine, Isoleucine, Methionine, Tryptophan, Valine, Tyrosine and Phenylalanine) these are compulsory in taken through our diet, already as complete structures. These are called essential amino acids not because they are the only indispensable for our organisms normal functioning but because they are essential in our diet.

The other 12 amino acids can be synthesized in the cells from simpler products that have C, H, O and N.

Although, AA's and Protein's production from inorganic compounds are only possible in plants.

Formative Assessment 2

- What do you understand by amino acid?
- What are the properties of amino acids?
- What are essential amino acids?

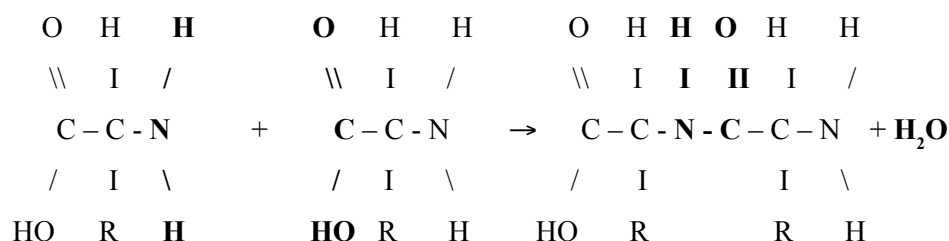
Task 3: Peptides

In this task you will get familiar with the formation of Proteins basic structures.

Peptides result from the fusion of amino acids through the Amine groups of one amino acid with the carboxylic group of another amino acid.

Proteins are characterized by the amide group (-NH-CO-) called Peptide bond.

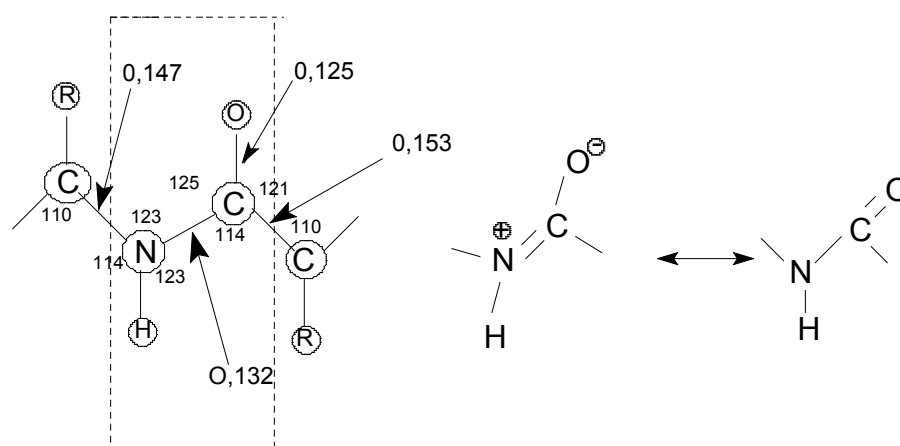
Formally the peptide bond is formed by the “fusion” of the amino and carboxylic groups of two amino acids with the release of water.



Subsequent polymerizations are possible, this because the presence of a free amino group (NH_2) and of a carboxylic group (COOH) in the peptide which can be bonded with the other amino acid molecules. The resulting molecule of two amino acids, containing, only one peptide bond, is called dipeptide, derived of three amino acids and a tripeptide. It is common to call the molecule class resulting from the relatively small peptides of amino acids, and the class of molecules with a high number of amino acids (with more than 70 units) of Peptides or Proteins.

3.1 Structure of the Peptide bond

The peptide bond – COHN -, that unites the acidic and basic residues in the proteins have a specifically plane constitution. All four atoms of the bond are found on the same plane. The link N-C is shorter comparing to aliphatic amines (R-NH_2) where their length is 0,147nm. These reduction of length and the disposition of the bonds is because of the existence of conjugation N-C and C=O and of the dislocation of the electronic density, this means, the bond N-C is partially double and the C=O is partially simple.

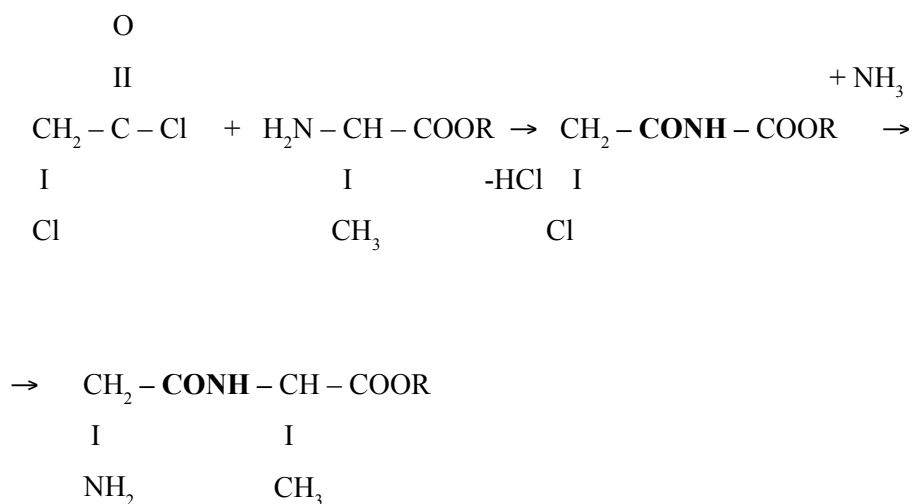




The existence of a double partial double bond N-C stops the rotation of the molecule around this bond. Although the most important is the possibility of rotation through the links with the carbons α of the amino acids residues, allowing that way the formation of various conformations.

3.2 Formation of the Peptide bond

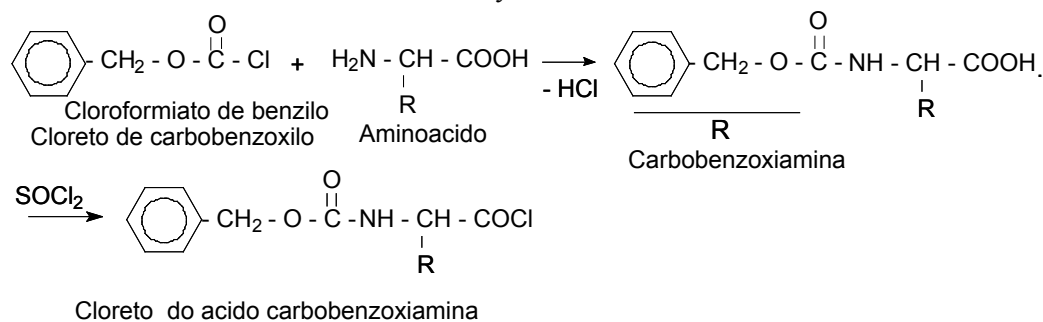
The formation of the peptide bond isn't a process as linear as it was presented above. This process is very energetic, for that it is resorted to derivatives with a lot of energy.



The modern synthesizing methods have three phases

1. Introduction of the protector group.

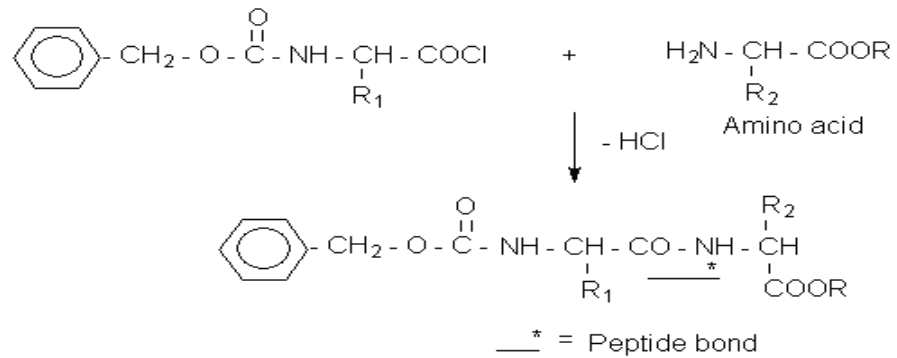
- Use of catalysts that increase gain of the peptide link.
- Decrease on the minimum tendency of amino acids' racemic modification.





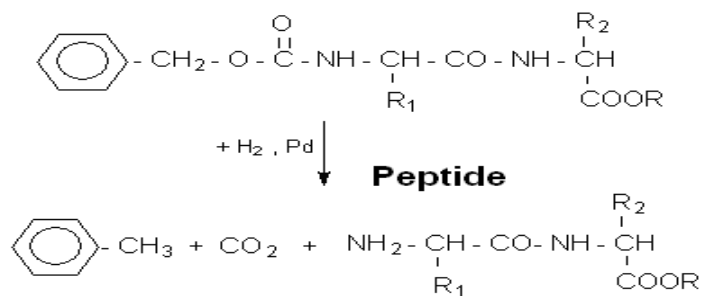
2. Formation of the peptide bond

- It is used to derive amino acids N-terminus rich in energy, mainly halides, azides etc.



3. Separation of the protector group

- Catalytic hydrogenation
- Introduction of bromide water/ glacial acetic acid or acid trifluoroacetic anhydrous

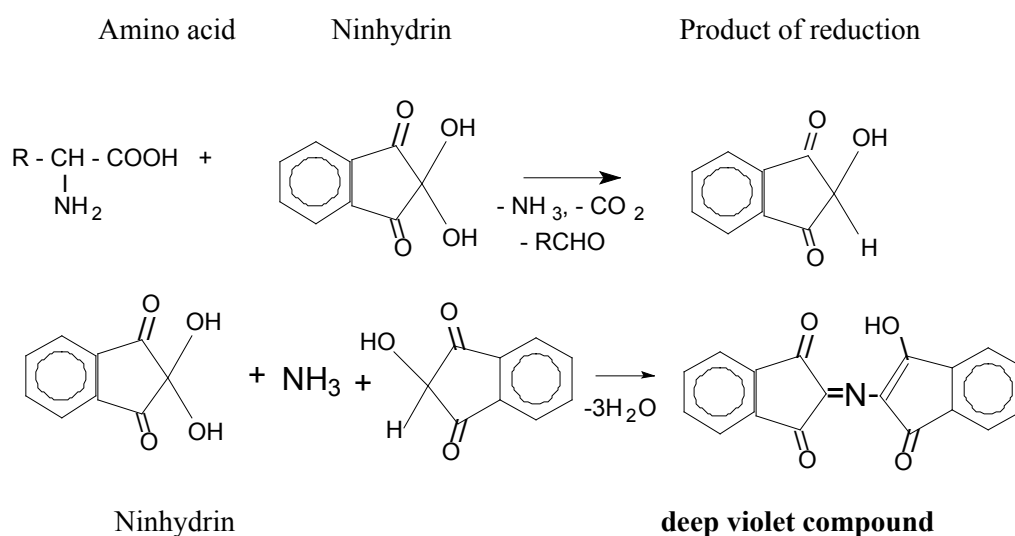




3.3 Recognition of a Peptide link

The Peptide bond can be amongst others recognized by the reaction of the amino acids.

Reaction with Ninhydrin



Formative assessment 3

- a) What are Peptides?
- b) Characterize the peptide linkage!

Task 4: Proteins

This task refers to an important class of bimolecular compounds, which do not only provide the body with Carbon and Hydrogen but also with Nitrogen and Sulphur

As a side functions protein molecules protect the body against infection, mechanical support and catalysis of metabolic reactions.

Proteins are biological molecule important for animal and vegetal life.

Structurally they are polymer molecules formed by a large number of fundamental units, amino acids, bounded by peptide linkage. Proteins are multifunctional units, serving as much as structural material of plants and animals, as well as biological catalysts (Enzymes), and even as protectors (antibodies).

Generally proteins are mixes, made up of polypeptide chains with a molar mass that varies from 10 000 to various millions.



Proteins have an acidic side and a basic side representing by that amphoteric substances.

Proteins are divided in two classes: Fibrous proteins, insoluble in water, and globular proteins soluble in water or aqueous acids, bases or salts.

In water they form colloidal solutions.

The resulting solutions are colloidal, due to the great dimensions of the protein's molecules. These colloids precipitate and form flakes when they are added to a salty solution. This precipitation (only physical change) is reversible because it doesn't result in a physical change of the chemical properties.

Protein's solubility depends on the PH and the salt contents present in the solution. The difference, between the two classes as to what regards solubility, is related with the respective form of molecules which is coarsely shown by their respective names.

The fibrous molecules are long and filamentous and tend to be placed side by side, with the formation of fibers; in some cases the molecules keep this disposition due to numerous intermolecular hydrogen bonds. For this reason the intermolecular forces that a possible solvent has to win are very strong. The globular protein molecules are found folded on themselves in compacted units, with which frequently has spheroid shape. The folds are produced in a way that the lipophilic parts will turn inside out and towards each other tight in, for example- bristle to the exterior surface when drenched in water. The existing Hydrogen bonds are mainly intermolecular. The contact areas are comparatively weak.

In the presence of acids or bases the Protein suffers denaturation (a chemical reaction occurs).

The Proteins are also denaturated by heat (high temperature), by urea and guanidine salts.

The Proteins are generally identified by the chromatic reactions. (Reaction with Nyhidrine, Biuret etc.)

4.1 Primary structure

The structure of a Protein is determined by the number, type and by the sequence of amino acids in the protein chain, linked by amidic bonds (peptide).

Protein's macromolecules are made up of one or various peptide chains.

In the chain we call the side where we find the extreme Amid group **N- terminus** and the side with the extreme Carboxylic group **C- terminus**.

The molecular masses that characterize the polypeptide chain in the Proteins are about 20 000 what corresponds to 150 to 180 amino acids residue (the average molecular mass of a AA residue is ca. 120)

Although the primary structure, doesn't explain the physiological properties nor the spatial configuration of the Proteins.



4.2 Secondary structure

The secondary structure represents a spatial configuration of the amino acid chain. It concerns the spatial relation between the close residues, due to way in which the polypeptide chains are arranged in space because of the ionic attractions or formation of Hydrogen bonds.

Of the primary structure (long sequences of amino acids) it would be expected shapeless and badly defined structures for the Proteins. But in fact practical observations show that many Proteins were isolated in crystalline form, which means that the polymer presents a well defined distribution. This structure is characterized by the formation of conformations, which result in the interaction between the amidic groups of the same molecule or different molecules forming Hydrogen bridges.

Given that amidic bonds (peptides)- CONH- have a planar shape, the Hydrogen bonds can be intracellular originating α helical structures (characteristic of the elastic proteins. For example, in keratin α in wool, hair and other body hair on animals) or can be intercellular originating a β structure, pleated sheet (pleated sheet - β). For example, fibroin in silk sheets, which are flexible but not much elastic.

4.3 Tertiary structure

The not well defined border with the previous structure, concerns more with the interactions between distant residues in the polypeptide chain because of the fold of this chain determined by the different types of bond previously referred to: nonpolar, ionics, of Hydrogen and even disulfide bonds.

The tertiary structure results from the interaction of the functional groups of the chain.

Describes as the spiral is bent and curved. When taking this spiral shape, what originates the appearance of a special configuration, the tertiary structure of Proteins, this meaning, the three-dimensional spiral shape that the protein molecule.

This structure is kept by the interaction between the functional groups of the chain. By a carboxylic group and a hydroxyl group, an Ester forms, the sulphur atoms form disulfide linkage (-S-S-).

This way we can get two types of Proteins: As fibrous, of regular shape in helical α or pleated sheet- β , and the globular, generally of a mixed structure, with various shape, these being the ones that most properly is applied the designation of tertiary structure. It is important to note that Enzymes always belong to this last category.

4.4 Quaternary structure

This designation is reserved in the case the Protein is made up of various sub units, equal or different, referring at how they are associated.

This is the most complex and less clarified.

It influences the chemical and biological activities of the Protein.



An example of this is Hemoglobin, which is made up of four sub units, two of each type, disposed alternately like quarters of a sphere.

Formative assessment 4

- a) Classify Proteins by their type?
- b) What are the principal structures of Proteins?

Task 5: Proteide

Task 5 introduces a family of compounds proteids linked to components of different nature. These compounds have very specific functions in the organism.

In some cases, to determine the functions, the globular proteins combine with other non protean compounds, their designation coming from their nature.

The most important types are:

- a) Lipoproteins- Proteins linked to a lipid-, principal components of the plasmatic membranes;
- b) Mucoproteins- when Proteins link to Carbon hydrates-, components of intracellular fluids and blood plasma;
- c) Nucleoproteins- association of special Proteins and nucleic acids-, frequent state of nucleic acids;
- d) Metal proteins- Proteins combined with metallic elements or prosthetic group containing metallic elements- normally enzymes or pigments transporting small molecules, like Hemoglobin.

This type of Proteins is called Proteide or conjugated proteins.

5.1 Proteide's structure

In some Proteins, the molecule has a non peptide portion, called prosthetic group; these Proteins are called conjugated proteins of Proteide.

The Prosthetic group is closely related with the biological specificity of the Protein.

For example, Lipoproteins

The Protein is linked to a lipid.

5.2 Nucleoproteins

Are found in the nucleus of living cells. The prosthetic group are nucleic acids. Ex. DNA, RNA.

These macromolecules are called semantics because they transport information.

The Nucleoproteins can be isolated by the extraction of living cells with water, alkalis, sodium chloride or tampon solution (4-7).



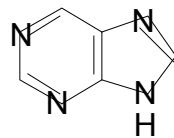
After the extraction follows the precipitation of Proteins by acids, ammonia sulphate or calcium chloride.

Next follows a Hydrolysis that can be acidic or enzymatic.

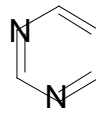
A Hydrolyzed Protein is fractioned in various components namely:

- a) Organic Nitrogen bases (purine and pyrimidine);
- b) Monosaccharide (pentose: ribose and desoxiribose);
- c) Phosphate group

The nitrogen bases derived off purin and pyrimidin



Purina

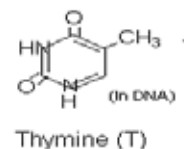
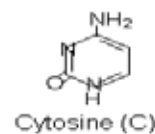
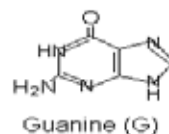
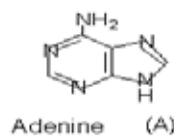


Pirimidina

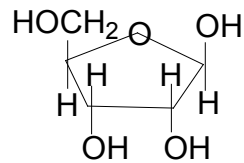
Only five of them are used they are: Adenine and Guanidine (purin), cytosine, timin and uracil (pirimidinas).

purine bases

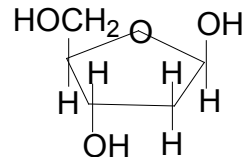
pyrimidine bases



There are two pentoses found in Nucleoproteins they are: β -D-ribose and β -D-2-desoxiribose. These carbohydrates differ only in the existence of one more oxygen atom in Ribose.



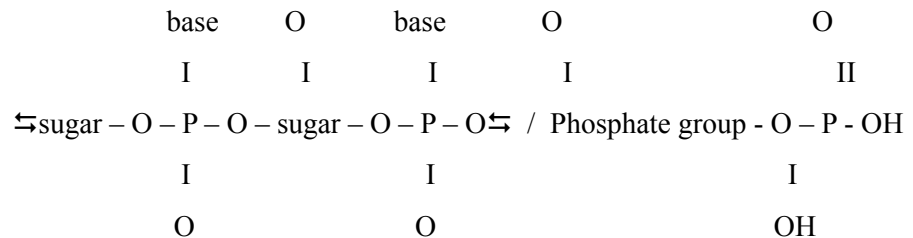
β -D-ribose



β -D-2-desoxiribose

The β -D-ribose sugar is found in Ribonucleic acids (RNA) while β -D-2-desoxiribose are found in Desoxi-Ribonucleic acids (DNA).

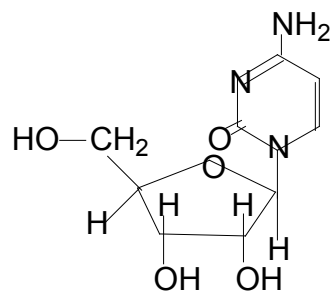
While in the dorsal spine the Protein molecule is a polyamidic chain (one polypeptide chain), the nucleic acid's molecule's is a polyester chain (called polynucleotide chain). The ester derives from phosphoric acid (the acidic part) and from a sugar (the alcoholic part):



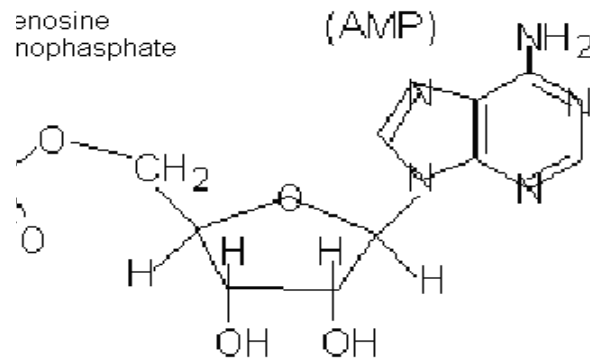
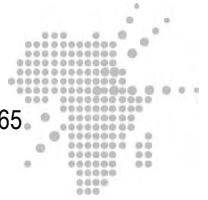
The Phosphate group functions like a linking bridge between the monosaccharide molecules; the basic skeleton of nucleic acids is in fact a long chain of alternate Pentoses with a Phosphate group.

The units of sugar have a furanose shape and are linked to the Phosphates by the C-3 and C-5 Hydroxyl groups.

The organic bases are linked to the pentoses by glycosidic linkage. The set is called **Nucleoside**.



When the Nucleoside is esterified by Phosphoric acid, in the Hydroxyl group in position 5 transform into **Nucleotide**.



The Nucleotides like AMP can attain more Phosphate groups, that confer reactivity. The successive bonds (2nd and 3rd) have higher energy content and the resulting compounds (ADP and ATP) are used as some sort of energy reserve for the metabolic reactions that are needed by them.

Ribonucleic acid (RNA) consists of ribonucleosides bonded together in to a polymer. The ribonucleoside subunits are linked by phosphate esters. The 5'hydroxyl group of each nucleoside riboforanoside is esterified to phosphoric acid. Ribonucleoside that is phosphorylated at its 5'carbon is called a ribonucleotide.

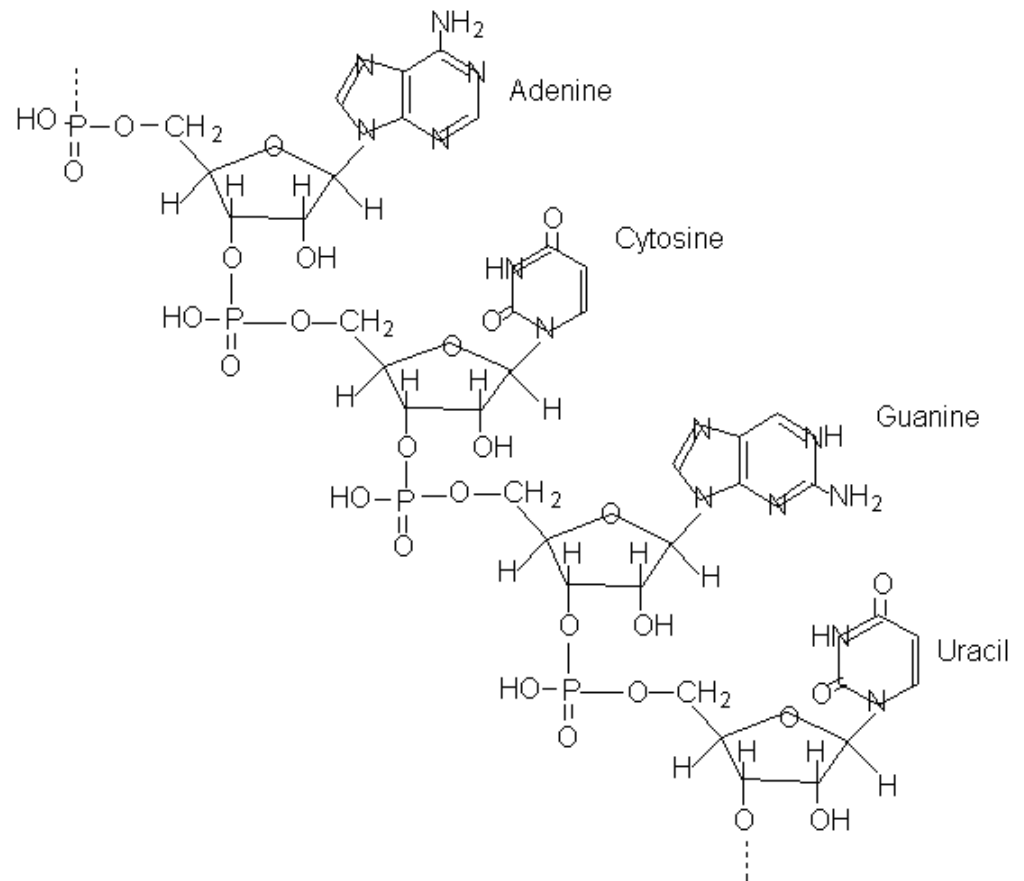
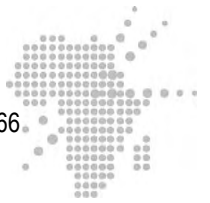
5.3 Ribonucleic acid (RNA)

Ribonucleic acid (RNA) is a simple polymer of Nucleotides containing four to five before mentioned nitrogen containing bases (Adenine, Guanine, Cytosine, Uracil) and only one of the two monosaccharide - β -D-ribose; normally occurs in two linear chains, but there are also cyclic shapes known.

RNA: Ribonucleic Acid

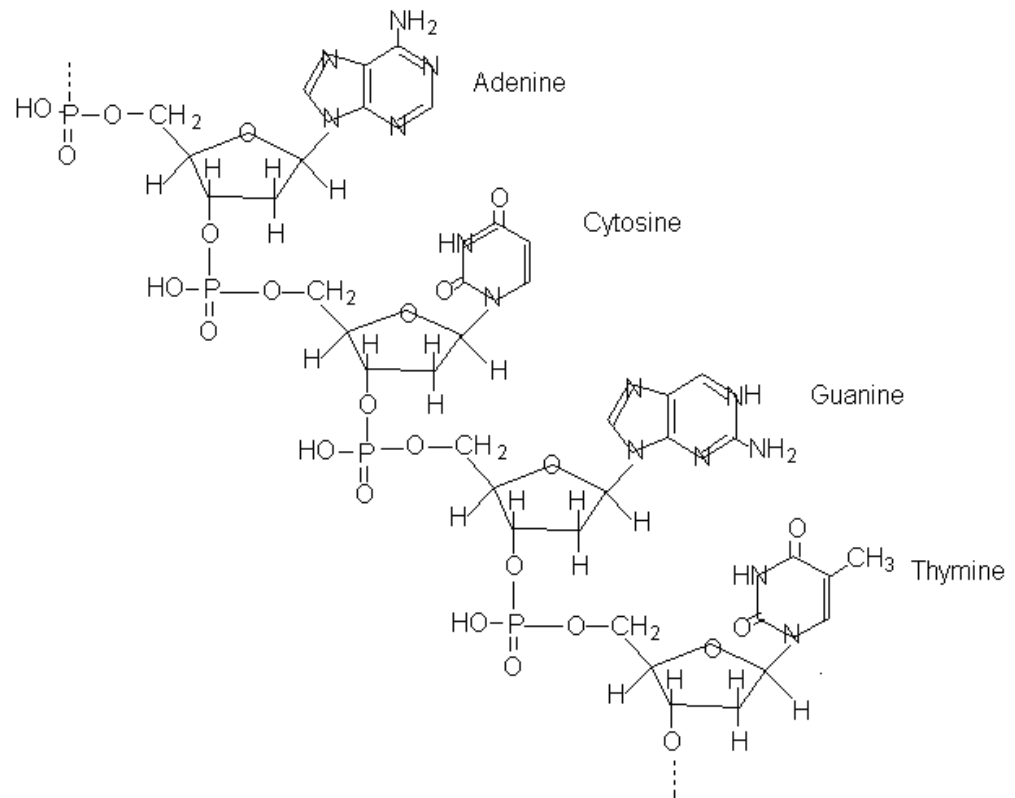
5.4 Deoxyribonucleic acid (DNA)

Deoxyribonucleic (DNA) is much more complex and has molecular weight much higher than RNA. It is also a linear or cyclic polymer of Nucleotides with four nitrogen containing bases, but Uracil is now substituted by thymine.





DNA: Deoxyribonucleic Acid



On the other side, DNA does occur in simple chains, but in double chains twisted in helix (double helix), this structure is kept by Hydrogen bonds formed by the organic bases two by two: Adenine-Thymine and Guanine-Cytosine. The set resembles a rope ladder, strand made up of alternative residues of Deoxyribose and Phosphate and the degrees plan of the organic bases linked by the pairs.

DNA is an “instructional manual” for Protein synthesis; the instructions are coded and the code is simple arranged from the different organic bases throughout the chain—each group of three successive bases (named “codon”) specifies an amino acid, this way, the series of amino acids that makes up each Protein can be read in the DNA chain using proper techniques.

Generally, the instructions are “transcribed” to the ribonucleic acid found in the Ribosomes and there occurs the synthesis of the different Proteins. The agent of this transcription and transporter of the message is also a fragment of ribonucleic acid known as “messenger” (m-RNA).

DNA can also replicate itself, to pass on its information content when a cellular division happens, and the process involves the progressive untangle of a double helix (just like closing a zipper) and the concomitant formation of two new complementary helices from individual filaments and off neighboring swimming nucleotides, which



will link once more in the order given by the ordering code of the organic bases. As always, the reactions are catalyzed by the appropriate enzymes.

The nucleic acids normally occur associated with Proteins, therefore being called Nucleoproteins. This is the material that makes up Chromosomes and, curiously, also the majority of viruses.

In fact viruses are primary form of protection of a particular set of information, but lacking techniques for reading the information and materials that allows its auto reproduction; this is only possible through the “infection” of a host, for example a bacteria, which provides these requisites.

Formative assessment 5

- a) Define Proteide!
- b) What is the composition of Nucleic acids
- c) Define the following concepts: Nucleotide, and Nucleoside!

Glossary (Key terms)

- 1- Amino acid
- 2- Protein
- 3- Peptide
- 4- Peptide bond
- 5- Nucleoside
- 6- Nucleotide
- 7- Nucleoproteins
- 8- prosthetic group
- 9- RNA
- 10- DNA

**1. Amino acids**

Amino acids (AA) are bi functional compounds that have an acidic function, due to the presence of a Carboxylic group, and a basic function, originated by the Amino group. It constitutes the basic units of Proteins.

2. Protein

Proteins are natural polymers made up of Amino acid units linked by a Peptide bond

3. Peptide

Molecule formed by some Amino acids linked by Peptide bonds.

4. Peptide bond

Amid group (-NH-CO-) that makes the link between Amino acids in the Peptides and Proteins, named Peptide bond.

5. Nucleoside

Group made up of organic bases linked to Pentose by glycosidic bonds.

6. Nucleotide

Group made up of organic bases linked to Pentose by glycosidic bonds and esterified by Phosphoric acid, in the Hydroxyl group position 5.

7. Nucleoproteins

The association between special Proteins and Nucleic acids.

8. Prostetic group

Non proteic group linked to a protein

9. RNA

Ribonucleic acid

10- DNA

Deoxyribonucleic acid



Formative assessment

Formative assessment 1

- a) Describe and classify Proteins!

Proteins are natural polymers made up of Amino acid units linked by a Peptide bond.

Depending on the function they are classified as fiber proteins (ex. Queratina Colagens), contracte Proteine (ex. Miosine, Actin) and globule Proteine (hormones and enzymes; ex. Insulin).

- b) What is the function of Proteins in the organism?

Some Proteins have purely structural functions (ex. keratin or Collagen) others have catalyzing functions (enzymes), other Proteins have a regulating function acting as hormones in many physiological processes (growth, metabolism, reproduction and the functioning of many organs). Others participate in the immune system that defends the organism (antibodies).

Formative assessment 2

- a) What do you understand by Amino acids?

Amino acids (AA) are bi functional compounds that have an acidic function, due to the presence of a Carboxylic group, and a basic function, originated by the Amino group. It constitutes the basic units of Proteins.

- b) What are the properties of Amino acids?

Amino acids are crystalline solids, non volatile, that melt in decomposition, at very high temperatures.

Are soluble in water. Its respective aqueous solutions behave like solution of high dipole moment.

Its acidic and basic constants are excessively small, when compared to Carboxylic acid's (-COOH) constants and of the Amines (-NH₂).

The R-CH(NH₂)COOH molecule has an acidic and a basic group, but in fact this species does not exist neither in its solid state nor as a solution, but forms a correspondent internal salt.



- c) What are essential Amino acids?

In the human species there are eight (8) "essential amino acids" that cannot be synthesized by the organism (Leucin, Isoleucin, Methyonine, Tryptophan, Valine, Tyrosine and Phenylalanine) these are compulsory in taken through our diet, already as complete structures.



Formative assessment 3

- a) What are Peptides?

It is common to label the class of molecules resulting from a number relatively small of Peptide's Amino acids.

Peptides are characterized by a Amid group (**NH-CO-**) named Peptide bond.

- b) Characterize a Peptide bond

The Peptide bond **-CONH-**, which unites the acidic and basic residues in the Proteins have specifically plane structure. All four atoms of the bond are on the same plane. The link **N-C** is shorter in relation to aliphatic amines ($R-NH_2$) with a length of 0. 147nm. this decrease in length and the disposition of the bonds on a plane is caused by the existence of **N – C and C = O** conjugation and of the delocalization of the electronic density, this is, the bond **N – C** is partially double and **C = O** is partially simple.

Formative assessment 4

- a) Classify Proteins by their type?

Proteins are divided in two big classes: fibrous proteins, not soluble in water, and globular proteins, soluble in water or aqueous solutions whether they are acidic, basic, or salts.

In water they form colloidal solutions.

- b) What are the principal structures of Proteins?

The principal structures of Proteins are four:

- Primary structure (Number, type and sequence of Amino acids)
- Secondary structure (α -Helix and β -pleated sheet)
- Tertiary structure (three dimensional structure, spiral or folded)
- Quaternary structure (Complex association of structures)

Formative assessment 5

- a) Define Proteide

They are Proteins, with a molecule that has a non peptide portion, known as prosthetic group: such Proteins are called conjugated proteins or Proteide.

- b) What is the composition of Nucleic acids?

Nucleic acids are made up of:

- Organic nitrogenous bases (purine and pirimidine)
- Monosaccharide (pentoses: ribose and deoxiribose)
- Phosphate group



The Nucleic acid's molecule's spinal is a Polyester chain (known as Polynucleotide chain). The ester derives from the Phosphoric acid (the acidic part) and from a sugar (the alcoholic part).

c) Define the following concepts: Nucleotide, and Nucleoside

Nucleoside is a set made up of organic bases linked to pentoses by glycosidic linkage.

When a nucleoside is esterified by Phosphoric acid, in the Hydroxyl group position 5 it turns into a **Nucleotide**.



Learning Activity 3

Title of learning activity: **Lipids**

Summary of the learning activity

Learning activity 3 focuses on an important group of biomolecules with structural functions, the protection of reserves mainly energy reserves.

The concept of a Lipid covers a group of biomolecular compounds with varying composition with a common factor its solubility in non polar solvents.

In this activity we will examine the structures, reactivity and functions of Lipids.

The activity requires around 30 working hours.

List of Required Readings

- <http://pt.wikipedia.org/wiki/L%C3%ADpido>
(Definition and composition) /Structure /Classification
- <http://naeg.prg.usp.br/puni/modulos/quimica6.pdf>
(Oils and fats Pg 38 – 40 /Soaps and detergents)

List of relevant useful links

- <http://pt.wikipedia.org/wiki/Gordura>
(Composition/Structure and functions)
- <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>
(Carbon hydrates/nucleic acids /lipids)
- <http://pt.wikipedia.org/wiki/Fosfol%C3%ADpido>
(Phospholipids)
- <http://www.dbio.uevora.pt/jaraujo/biocel/lipidos.htm>
Definition/ structure/classification/Glycerides/conjugated lipids

List of relevant MULTIMEDIA resources

<http://www.scite.pro.br/tudo/pdf.php?-quimicamodulo>



Detailed description of the activity

Carefully read the references and take notes about the following points and answer the formative assessments:

- Concept of Lipids
- Composition of Lipids
- Types of Lipids (Fats, oils, waxes)
- Fatty acids
- Glycerides
- Functions of Lipids

In order to help get the capabilities and abilities offered by this module the following task should be solved:

Task 1: Lipids introduction

- 1.1 Concept of Lipids
- 1.2 Function of Lipids

Task 2: Fatty Acids

- 2.1 Structure and properties of fatty acids
- 2.2 Identification of the properties of fats and fatty acids

Task 3: Glycerides

- 3.1 Structure of Glycerides
- 3.2 Classification of Glycerides
- 3.3 Properties of Glycerides
- 3.4 Phosphatides

Task 4: Fats and oil fats

- 4.1 Chemical properties of fats
- 4.2 Characterization of fats

Task 5: Waxes

Formative evaluation

Find included in the text formative activity for auto evaluation.



Learning activities

Task 1: Lipids introduction

Task one (1) of learning activity three introduces a heterogeneous class of bio compounds the organism cannot function without.

This group of compounds as well as having functions of support, protection, and energy, present the solubility of non polar solvents.

1.1 Concept of a Lipid

The animal and vegetal fats like lard, butter, olive oil, oil fats, natural waxes and Phosphatides are all known as Lipids. They are natural compounds with little or no solubility in water. In this group are also included mineral oils (Hydrocarbons) and etheric oils (terpens and steroids). In general they are esters of carboxylic acids with high molecular weight (fatty acids).

This is an interesting group of natural organic substances because other than having a great importance in our diet, they also make up the base for the manufacturing of other industrial products.

The majority of the use of fatty substances is found in the food industry, because fats are the most concentrated source of energy for humans, supplying more than double the amount of energy supplied by an equal amount of carbohydrates; but a diet with high levels of animal fat causes heart diseases; being as a substitution for them vegetal oil (peanut oil, sunflower oil, etc.).

The main varieties of fats and oils are soya oil, sunflower, palm, peanut, cotton, colza (a variety of spring greens used as fodder for cattle, a type of oil used in lighting is extracted from its seeds), olive oil, and fish oils.

These substances are also used in other industries, like the pharmaceutical industry (Ex. ricin oil is laxative, cod fish oil is reconstituent), polishes industry (linen oil, wood oil); industrial chemistry (production of fatty acids, soaps, glycerin, and tensioactive, etc.).

Even though fats are mainly Lipids they do not have any non lipid organic substances, so we will find essential components the Glycerides (mono-, di-, and triglycerides) and secondary components (saturated and non-saturated Hydrocarbons, Phosphoglycerides, vitamins, chorants and terpenic acids).

1.2 Function of Lipids

Fats are essential substances for the nutrition of organisms. They constitute the reserve substance of the organism and are the richest source of energy in the body.

Fats with around 40Kj/g have more than double the heat of physiological combustion of carbohydrates which offer (ca. 16.7Kj/g).



Linolic acid and linolenic Acidos linolic and linolenic “essential fatty acids” are indispensable for the human’s diet, that’s why they have to be added as solidified fats. Fat solidification (Norman 1909) has great economical importance. Low cost animal and vegetal oils are that way turned into valuable fat used in the technique.

Synthetic fats are used in soap production.

Formative assessment 1

- a) Define lipids
- b) Give some functions and applications of lipids

Task2 : Fatty acids

This task identifies and differentiates carboxylic acids of great molecular weight most frequent in Lipids. In this chapter there will also be practical tasks that can be done in a simple laboratory or even at home with objects used on a daily routine.

2.1 Structure and properties of fatty acids

Carboxylic acids with high molecular weight (ca. 12 to 20 carbon atoms) are called, Fatty acids. Fatty acids are subdivided into saturated and unsaturated.

The fatty acid that is the most important and of greatest molecular weight is Oleic acid ($C_{17}H_{33}COOH$), is an unsaturated acid with a double bond.

Oleic acid is found in practically every natural fat in varying amounts.

Vegetal fats (of coconuts, of palm) have amongst others lauric acid ($C_{11}H_{23}COOH$) and miristic ($C_{13}H_{27}COOH$).

Animal fats (butter, tallow, pig lard) have preferably Glycerides of palmitic ($C_{15}H_{31}COOH$) and stearic acid ($C_{17}H_{35}COOH$).

Natural fats are almost without exception made up of non branched fatty acids with an even number of carbon atoms (synthesized Glycerides for diet can also have odd number of carbon atoms).

Unsaturated fatty acids always show a cis (Z) configuration on the double bond.

Many compounds with the cis configuration hardly fit in the crystalline net and that’s why generally they melt at much lower temperatures its trans isomers (E).

The most frequent acids in that constitute Glycerides are:



Name of the acid	Formula	Number of Carbons
Palmitic Ac	$\text{CH}_3 (\text{CH}_2)_{14} \text{COOH}$	16
Stearic Ac.	$\text{CH}_3 (\text{CH}_2)_{16} \text{COOH}$	18
Oleic Ac.	$\text{CH}_3 (\text{CH}_2)_7 \text{CH} = \text{CH}(\text{CH}_2) \text{COOH}$ (cis)	18
Lauric Ac.	$\text{CH}_3 (\text{CH}_2)_{10} \text{COOH}$	12
Miristico Ac.	$\text{CH}_3 (\text{CH}_2)_{12} \text{COOH}$	14
Linoleic Ac.	$\text{CH}_3 (\text{CH}_2)_4 \text{CH} = \text{CH}-\text{CH}_2-\text{CH}=\text{CH}(\text{CH}_2)_7 \text{COOH}$	18
Ricinoleic Ac.	$\text{CH}_3 (\text{CH}_2)_5 \text{CH}(\text{OH})\text{CH}_2-\text{CH}=\text{CH}(\text{CH}_2)_7 \text{COOH}$	18

Formative assessment 2

- Define and classify fatty acids!
- Give examples about the occurrence of fatty acids!

Task 3: Glycerides

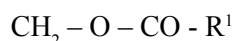
The activity in this task evolves around the basic structures of fats and oils

The solid or semi-solid fats as well as fatty oils (liquid fats) are Glycerol esters and carboxylic acids with great molecular weight (ca. 12 to 20 carbon atoms) known as fatty acids. Due to the fact that they are Glycerol esters they are also called Glycerides. Natural fats also have different compositions given that Glycerol can be esterified with only one type of acid molecules (simple Glyceride) or simultaneously by various different fatty acid molecules (mixed Glyceride).

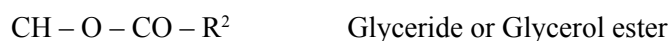
3.1 Glyceride's structure

Natural fats can also have different compositions given that Glycerol can be esterified with only one type of acid molecules (Simple Glyceride) or simultaneously by various different fatty acids' molecules (mixed Glyceride).

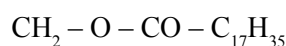
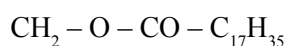
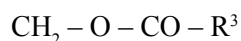
General structure of Glycerides

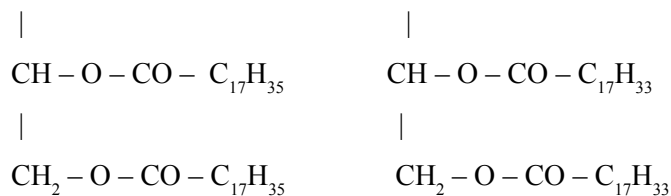


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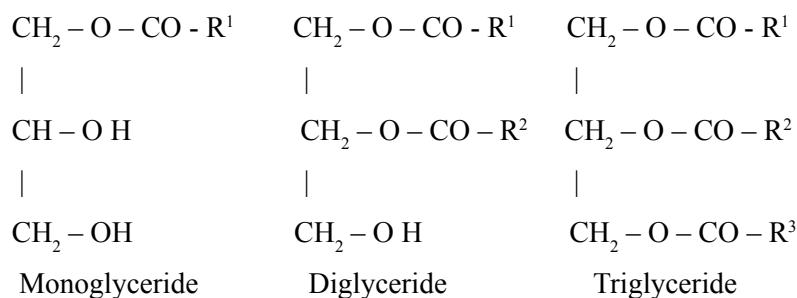


Glyceride containing 3 molecules
Stearic acid
(Simple Glyceride)

Glyceride containing 1 molecule of
stearic acid and 2 of oleic acid
(Combined Glyceride)

3.2 Classification of Glycerides

Because Glycerol is an trivalent alcohol, Glycerides based on the degree of Esterification can be classified in mono, di or triglyceride.



3.3 Properties of Glycerides

There is a close link between the structure and aggregative state of fats.

Fats that have mainly the remains of unsaturated carboxylic acids are generally liquids.

In fats are predominant Glycerides of saturated acids, while in oils the acids are unsaturated.

As a rule Glycerides of saturated acids have relatively superior fusion points when compared to the ones related to non saturated acids.

Ex.

Glyceride :

esteáric	oléic	linoléic	palmitic	palmitoleic
P.F. = 73,1°C	P.F. = 5,5 °c	P.F. = -13,1°C	P.F. = 66,4°C	P.F= 2,3°C



With the increase of temperature the fats turn from a solid state to a liquid. They are not soluble in cold water, are not very soluble in hot water and well soluble in organic solvents (Ethanol, Ether, Tetrachloromethane etc.) In general their density is inferior to water's (0.90 – 0.94). The level of refraction increases as the level of insaturation increases. Its viscosity is bigger than water's being higher in oils that have many Hydroxyl groups (Ex. Resin oil). They are greasy. Stain paper and fabrics.

Formative assessment 3

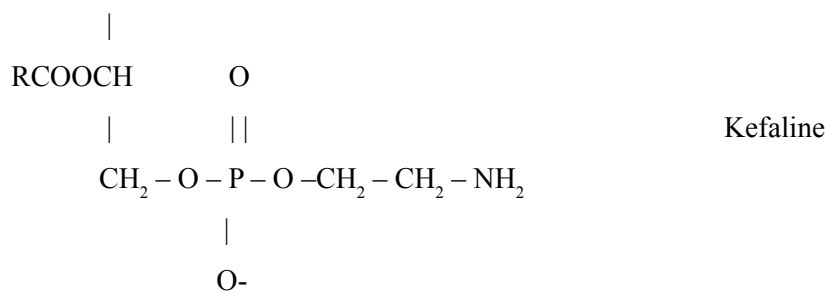
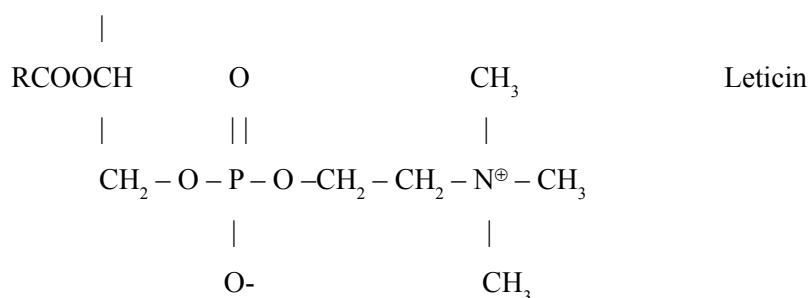
- What are Glycerides!
- How are Glycerides classified!

3.4 Phosphatides

Phosphotides or Phospholipoydes exist in every cell, particularly in the nervous cells, egg yolks, liver and kidneys.

They are Diesters of Phosphoric acid.

Phosphatides have importance in the formation of biological membranes. For examples of Phosphatides we have Lecitin and Kefaline. In these cases Glycerol is esterified with two moles fat acids and by Phosphoric acid.





Task 4: Fats and fatty oils

The task offers a vision about Lipids with structural and energy supply functions

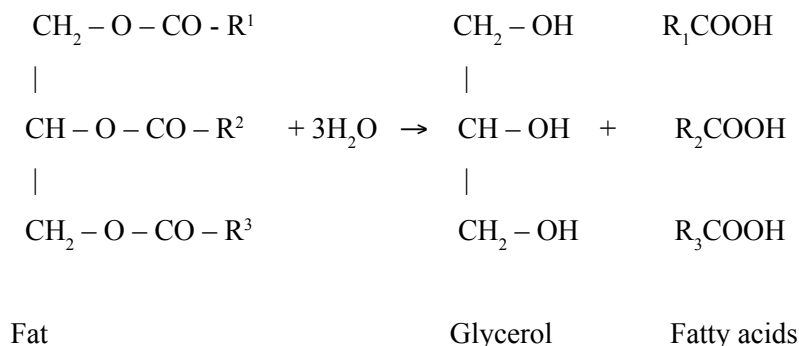
The solid or semi-solid fats as well as fatty oils (liquid fats) are Glycerol esters and carboxylic acids with great molecular weight (ca. 12 to 20 carbon atoms) known as fatty acids. Due to the fact that they are Glycerol esters they are also called Glycerides. Natural fats also have different compositions given that Glycerol can be esterified with only one type of acid molecules (simple Glyceride) or simultaneously by various different fatty acids' molecules (mixed Glyceride).

4.1 Chemical properties of fats

4.1.1 Breakdown of fat

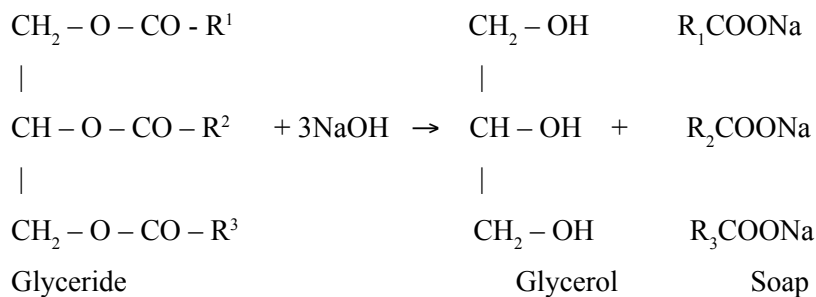
a) Hydrolysis

In Hydrolysis fats forms fatty acids and Glycerol



b) Saponification

Like all esters Glycerides suffer Alkaline Hydrolysis (Saponification) forming Glycerol and fatty acid's salts (soap).



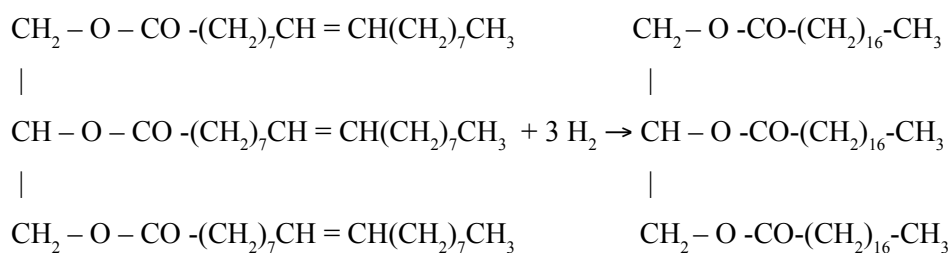


4.1.2 Solidification (Hardening)

Through catalytic Hydrogenation Glycerides can be formed off unsaturated fatty acids in solid fats.

For example from oleic Glyceride we can get estearic Glyceride.

Ex.



Glyceride Trioleine

PF: 5,5°C

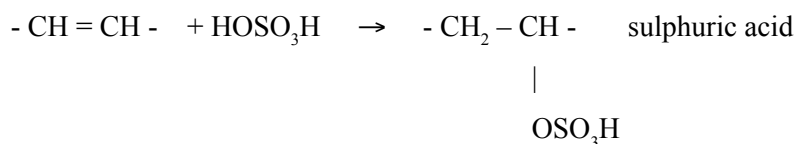
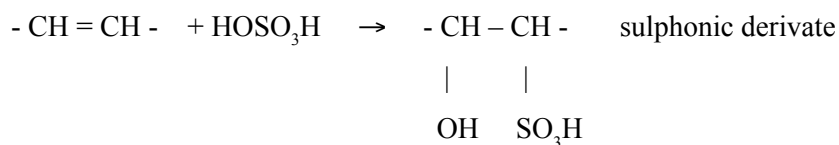
Glyceride tristearine

PF: 73,1°C

This “fat solidification” has great economic importance in the transformation of vegetal oils and cheap animals in fats properly treated for technical use.

4.1.3 Sulphonic derivate

Glycerides of non saturated acids react with Sulfuric acid forming derived sulphonics having the group $-\text{SO}_3\text{H}$; the sulfuric ester having the group $-\text{OSO}_3\text{H}$

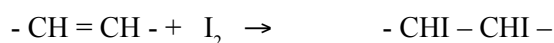


This reaction has great industrial importance in the production of detergents.



4.1.4 Halogenations

The unsaturated Glycerides add halogens

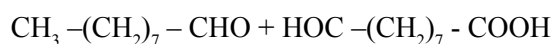
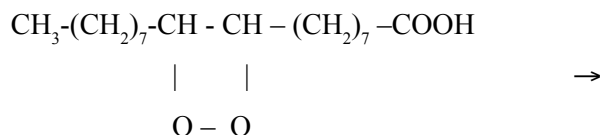
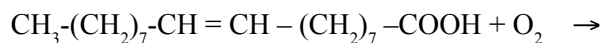


This reaction has importance in the characterization of oils and fats through the level of Iodine.

4.1.5 Rancidity (Rancity)

Oils and fats in contact with air become rancid with time, meaning they deeply change getting a sour taste and strong smell. This is a complex phenomenon of oxidative chemical changes and of partial decomposition of Glycerides with the formation of substances of ketone and Aldehyde nature which are the most responsible for the rancid taste and smell.

In this process there are also formed free acids that increase the acidity of the oil.

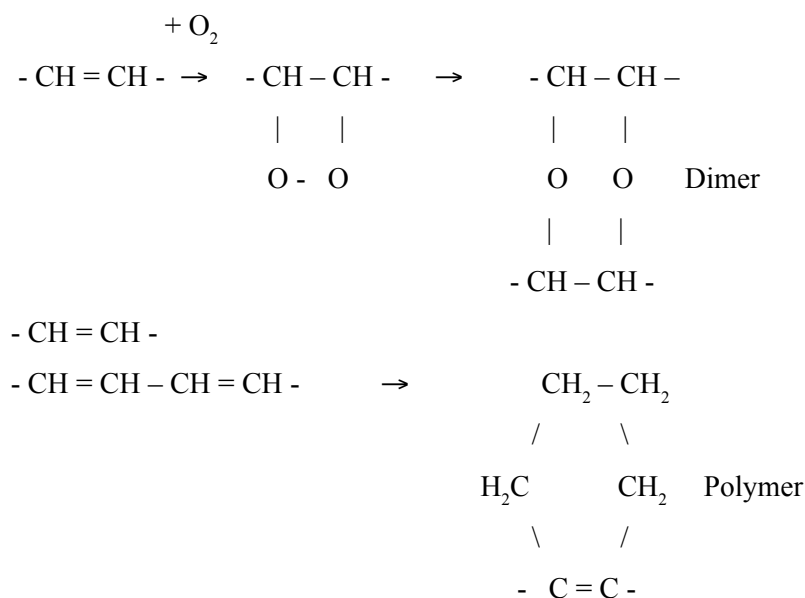


4.1.6 Secativity (Dryness)

Glycerides with a high degree of insaturation (oils) absorb oxygen without rancing.

Oxidative processes turn them into plastic products and resins that harden completely. This phenomenon is called Secativity.

The Secativity originates from the formation of peroxide which because of the strong insaturation, form dimers and finally Polymers; this is resinous products and hard.



Oils secativity can be increased by heat and used in the making of polishes and oil paints.

4.2 Characterization of Fats

Fats are technically characterized based on their capacity of absorbing (index) Iodine, Potassium Hydroxide or by the amount of free acids it has.

We have:

4.2.1 Iodine index

Is a measurement to the insaturation degree of acids in the Glyceride.

Is expressed as mass in grams of halogen (Iodine) that can be added 100g of fat.

4.2.2 Saponification degree

Number of mg of KOH needed for the Saponification of 1g of fat.

4.2.3 Acid degree

Measures the amount of free acids that exist in natural fats. Is expressed as the number of mg of KOH needed for the neutralization of free acids in 1g of fat.



Formative assessment 4

- Define the following concepts: Fat, and oil
- How are fats characterized
- Give two properties of fats

Task 5: Waxes

Waxes are esters of carboxylic acids with long chains (fatty acids) and primary superior monovalent alcohol.

They are in general solid materials, moldable and impermeable to water. There are different types of waxes.

Animal waxes were the first to be discovered. For example we have linen tallow, wax from bees, esparmacete (white and fat substance that is found in cachalote's head with which candles and cosmetics are made off) etc.

Vegetal waxes, just like animal waxes are mixtures of esters of alcohols of long chains (superior alcohols) and superior carboxylic acids.

Basically waxes are fatty acids' esters that are found both in the vegetal kingdom and animal kingdom.

There are also mineral waxes like Paraffin obtained from petroleum refinement.

Ex.

Name	Formula	Source
Palmitate of mericil from bees)	$\text{CH}_3 - (\text{CH}_2)_{14} - \text{COO}(\text{CH}_2)_{29}\text{CH}_3$	bees (C_{26} - C_{28}) (wax
Cetil Palmitate	$\text{C}_{15}\text{H}_{33}\text{COOC}_{16}\text{H}_{33}$	Whales' foam
Ceretinate of ceril	$\text{C}_{15}\text{H}_{51}\text{COOC}_{26}\text{H}_{53}$	China wax
Miricilester of palmitic Ac.	$\text{CH}_3 - (\text{CH}_2)_4 - \text{COOC}_{31}\text{H}_{63}$	palmitic acid

Formative assessment 5

- What are waxes!
- Mention the application of wax.



Glossary (key terms)

- 1- Lipid
- 2- Fat
- 3- Oil
- 4- Glyceride
- 5- Fatty acids
- 6- Waxes
- 7- Phosphatides
- 8- Saponification
- 9- Iodine index
- 10- Saponification index

1. Lipid

The animal and vegetal fats like lard, butter, olive oil, oil fats, natural waxes and Phosphatides are all known as Lipids. They are natural compounds with little or no solubility in water. In this group are also included mineral oils (Hydrocarbon) and oleos etericos (terpens and steroids). In general they are esters of carboxylic acids with high molecular weight (fatty acids).

2. Fat

Are esters of Glycerol with carboxylic acids of high molecular weight (fatty acids) saturated.

3. Oil

Are esters of Glycerol with carboxylic acids of great molecular weight (fatty acids) unsaturated.

4. Glyceride

Glycerides are esters of Glycerol with fatty acids

5. Fatty acids

Fatty acids are carboxylic acids with great molecular weight (C_{12} - C_{29})

6. Waxes

7. Phosphatides

Are esters of phosphoric acid. In these cases Glycerol is esterified with two moles de fatty acids and by Phosphoric acid. Phosphatides or phospholipoydes exist in every cell, particularly in the nervous cells, egg yolks, liver and kidneys.

**8. Saponification**

Alkaline Hydrolysis of esters of carboxylic acids.

9. Iodine index

Is a measurement to the insaturation degree of acids in the Glyceride.

Is expressed as mass in grams of halogen (Iodine) that can be added 100g of fat.

10. Saponification index

Amount of KOH (mg) necessary to saponify 1g of fat.

Formative assessment**Formative assessment 1**

- c) define lipid!
- d) List some application and functions of lipids.

Formative assessment 2

- a) Define and classify fat acids!
- b) Give some examples of occurrence of fat acids!

Formative assessment 3

- b) What are Glycerides?
- c) How are Glycerides classified?

Formative assessment 4

- d) Define fat and oil
- e) How are fats classified?
- f) List two properties of fats

Formative assessment 5

- a) What are waxes?
- b) List two applications of waxes!



Learning Activity 4

Title of learning activity: **Practical work**

The learning activity 4 provides opportunity for experimental application of knowledge and skills developed in learning activities 1, 2 and 3.

In this activity using easily accessible materials (for example from your everyday life) or with simulations computerized, students will be familiarized with basic techniques of practical work and handling of materials for identification of some vital biological compounds.

To do the suggested tasks the student will need approximately 10 hours.

When possible use material from your quotidian.

List of Required Readings

- <http://www.google.com/search?hl=en&q=Caracter+redutor+do+acucar>
(identification of carbohydrates / proteins / lipids)

List of Relevant Useful

- http://www.google.com/search?hl=en&q=Identificacao+da+ligacao+peptidica&lr=lang_pt
(protein identification/ peptide bond)

Detailed description of the activity

- Read the instructions
- Provide at your home or institution of education recommended apparatus and substances.
- Following instructions do the experiments.
- Carefully take note of all observations
- Write the equations of main reactions you do.
- Write a short summary with main conclusions.



Learning activities

Task 1. Properties of carbohydrates

- 1.1 Proof of carbon in sugar
- 1.2 Production of starch from potatoes
- 1.3 Preparation of starch's glue
- 1.4 Reaction of starch's glue and Iodine
- 1.5 Acid hydrolyze of starch

Task 2. Proteins

- 2.1 Preparation of proteins' solution
- 2.2 Precipitation of proteins with ammonium sulphate
- 2.3 Biuret test
- 2.4 Proof of sulphur in proteins
- 2.5 Test of proteins in potatoes (Biuret reaction)

Task 3. Properties of fats

- 3.1 Identification of multiple bounds
- 3.2 Proof of solubility
- 3.2 Proof of fat acids

Tasks 1, 2 and 3

These activities complement learning acquired in units 1, 2 and 3.

These tasks provide opportunities to manipulate and to observe some basic properties of vital macromolecular compounds for the biological system.

Carbohydrates

Proof of carbon in Sugar

Apparatus and reagents: porcelain capsules, pint of sugar, concentrated sulphuric acid.

Procedure

Pour a little of water into porcelain capsule with sugar. Add to the mixture dripping 1ml of concentrated sulfuric acid.

Take note of your observations.



Production of Starch from Potatoes

Apparatus and reagents: Becker (250ml) or normal glass, shredder/grater, cloth to filter, Erlenmeyer flask, rod, spatulas, potatoes.

Procedure

Shred potatoes until you get approximately 100ml of the mass of volume. Keep part of the mass (5-10ml) in a test tube. In the Becker container with the rest of potatoes mass add 150ml of distilled water and shake.

Filter the mixture. Leave the filtered product for approximately 10 minutes and decant the mixture. Add water to the precipitated which formed in the filtered product shake and decant again. Repeat this operation two times.

Keep the purified precipitated (starch) for the following experiments.

Preparation of 'starch glue'

Apparatus and reagents: Becker, rod, starch (prepared in the preceding task).

Procedure

Mix starch with approximately 20ml of cold water and shake. Then, pour starch glue into a glass (becker) containing approximately 100ml of boiling water.

Take notes of your observations and explain.

Reaction of starch glue and Iodine

Apparatus and reagents: tube for reaction, dropper, starch glue, Lugol solution (Iodine/KI).

Procedure

Introduce in a test tube approximately 3ml of diluted solution of egg-white and add equal volume of saturated solution of ammonia and shake (proteins and globulins will precipitate). Wait for 5-6 minutes and filter. In the filtered product, there are still albumins.

To precipitate albumins, add to the filtered, ammonium sulphate crystalline up to complete saturation. (In this way albumins will be precipitated). Filter to separate.

Finally do the Biuret test to the filtered product.

Biuret test

Apparatus and reagents: test tubes, solution of protein, solution of sodium hydroxide 10% and 30%, solution of cuprum sulphate 1%.

Procedure

Pour 2ml of solution of egg-white into the test tube and add 4ml of sodium hydroxide solution 30%. Mix carefully and add two or three drips of cuprum sulphate 1%. Leave the test tube for a moment and observe the contact zone between the two interfaces



Proof of Sulphur in Proteins

Apparatus and reagents: Test tubes, solution of egg-white, feather of a bird (white), solution of sodium hydroxide 11%, lead acetate.

Procedure

Heat small amounts of proteins with 5ml of sodium hydroxide until boiling. After the protein is dissolved add 1ml of lead acetate.

Test of proteins in potatoes (Biuret reaction)

Apparatus and reagents: reaction tube, dropper, grated potatoes (exp. 1) sodium hydroxide (11%), cuprum sulphate (II) (11%).

Procedure

Add into a test tube 3ml of potatoes mass and NaOH solution. Then add 3-4 drips of cuprum (II) sulphate and shake well.

Properties of fats

Apparatus and reagents: Test tube, filter paper, pipette, fat, oil, ethanol, bromine water, Iodine water, distilled water, rancid butter , KOH 5% and phenolphthalein.

Procedure

Identification of multiple bonds

In a test tube, pour approximately 0.5ml of fat and add some drips of bromine water solution, shaking. Repeat the same operation with Iodine water.

Proof of Solubility

In three test tubes pour approximately 3ml of water, 3ml of ethanol and 3ml of diethyl ether respectively. Add into each other, 2-3 drips of fate and shake.

With pipette take out some drips from each test tube and drop on different places of the filter paper. Wait for the spots to dry and observe

Proof of fat acids

Dissolve in a test tube 2g of butter and 5ml of ethanol under heat.

Heat in another test tube solution of sodium hydroxide and add some drips of phenolphthalein. Add drip by drip, the second solution on the first and observe.



XI. Compiled List of all Key Concepts (Glossary)

Glucids

Carbohydrates or Glucids

Carbohydrates or Glucids are chemically Aldehydes or Ketones containing polyhydroxyl group or compounds which by hydrolyze, can be transformed in Aldehydes or Ketones.

Monosaccharide

Simple sugars constituted by basic unit non hydrolysable, generally with 5-6 atoms of carbon.

Oligosaccharide

Sugars constituted by 2 to 10 basic units of monosaccharides. Oligosaccharides are hydrolysable in simpler compounds (monosaccharides)

Polysaccharides

Are carbon hydrates which can hydrolyze in many units of monosaccharides (can reach ca 10000 units).

Aldose

Sugar which main functional group is the aldehyde group.

Ketose

Sugar which main functional group is the aldehyde group.

Oxycycle-tautomerism

Equilibrium of three tautomeric forms, of monomers α , β and the cyclic form of sugar denominated oxo-cycle-tautomerism.

Mutarotation

The occurrence of changes in the deviation angle of monomers α , β up to the magnitude of equilibrium is denominated mutarotation.

Reducer sugar

Sugar with at least one free functional group capable of doing reaction of oxidation and reduction.

Asymmetric carbon

Carbon with four different substituents. Chiral carbon.



Proteins

Amino acids

Amino acids (AA) are compounds bifunctionals which have one acid function due to the presence of carboxyl group and one basic function originated by the presence of amino group. They are basic constituents of proteins.

Proteins

Proteins are natural polymers constituted by units of amino acids bounded by peptide bond.

Peptide

Molecule formed by some amino acids bounded by peptide bond.

Peptide bond

amide group

(-NH-CO-) which links amino acids in peptides and proteins.

Nucleoside

Group constituted by organic bases linked by glycosidic linkage.

Nucleotide

Group constituted by organic bases linked by glycosidic linkage and esterified by phosphoric acid, in the position 5 of the hydroxyl group.

Nucleoproteins

Association of special proteins and nucleic acids.

Prosthetic group

Non proteic group linked to protein

RNA

Ribonucleic acid.

DNA

Deoxyribonucleic acid



Lipids

Animal and vegetal fats like lard, butter, olive oil, fatty oil, natural waxes and phosphatides are all called lipids. They are natural compounds insoluble or not much soluble in water. In this group are also included mineral oils (hydrocarbons) and etheric oils (terpens e steroids). In general they are esters of carboxylic acids of high molecular weight (fatty acids).

Fat

Are esters of glycerol and saturated carboxylic acids of high molecular weight (fatty acids).

Oil

Are esters of glycerol and unsaturated carboxylic acids of high molecular weight (fatty acids).

Glyceride

Are ester of glycerol and fatty acids

Fatty acids

Are carboxylic acids of high molecular weight (C_{12} - C_{29}).

Phosphatides

Are esters of phosphoric acid. In this case glycerol is esterified with two moles of fatty acids and phosphoric acid.

Phosphatides or phospholipoids exist in all cells, particularly in nervous cells yolk of eggs, liver and kidney.

Saponification

Alkaline hydrolyze of carboxylic acids' esters.

Index of Iodine

Is a measurement for the level of unsaturation of acids in Glyceride. It is defined as the mass in grams of the halogen (Iodine) to which can be added 100g of fat.

Index of saponification

Number of mg of KOH necessary to saponify 1g of fat.



XII. Compiled List of Compulsory Readings

Reading #1

Complete reference

Origin of carbohydrate: Wikipédia, free encyclopedia

1. <http://pt.wikipedia.org/wiki/Carboidrato>
(Function, Nomenclature, Classification / Mono/ Diss/Oligo/Poly)
2. <http://www.uac.pt/~cgomes/TE/Estagio/03-04/WQs/WQS/wq/outros/Carboi.htm>
(Carbohydrates / general concepts/ Mono s/ Dissac)
3. http://www.notapositiva.com/trab_estudantes/trab_estudantes/biologia/biologia_trabalhos/hidrolenzimsac.htm
(work reductor character of sugars)

Abstract : Reference 1 (one) offers information about function of Glucids in the organism, nomenclature, classification as well as main characteristics of monosaccharide, disaccharides and polysaccharides.

Reference 2 (two) elaborates on the concept of carbohydrate, discuss and apply knowledge about carbohydrates (mono-, disaccharides).

Reference 3 (three) deals with carbohydrates reactivity. Shows reducing character of sugars and allow practical work.

The above references 1, 2 and 3 provide basic knowledge for the student about carbohydrates namely:

Concept, nomenclature, classification and examples of reactivity.

Reading #2

Complete reference :

4. http://pt.wikipedia.org/wiki/Liga%C3%A7%C3%A3o_pept%C3%ADica
(Peptide bond)

QMCWEB://the world of Proteins

5. <http://www.qmc.ufsc.br/qmcweb/artigos/proteinas.html>
(Structure/Proteins functions / essential amino acids/ simple and conjugated Proteins)



Abstract : The above references (4, 5) provide information about Amino acids, structure and types of Amino acids. This complements information about peptide bond and also deepens knowledge about proteide (DNA, NRA).

Rationale : Working with this references confer to the student knowledge and important skills about vital biological compounds (Amino acid and Proteins)

Reading #3

Complete reference :

6. <http://pt.wikipedia.org/wiki/L%C3%ADpido>
(Definition and composition) / strurure /Classif
7. <http://naeg.prg.usp.br/puni/modulos/quimica6.pdf>
(Oils and fats Pgs 38 – 40 / Soaps and detergents)

Abstract: Reference 6 present lipids, discuss it's structure and classification.

Reference 7 deepens knowledge about basic structure of Amino acids and peptide bond, provides information about oils, fats and their bonds (soaps and detergents).

In the same article are also deepen knowledge and skills about carbohydrates.

Rationale: The literature offered presents an overview about important biological molecules (Lipids, proteins and carbohydrates) as well as it's properties.



XIII. Compiled List of Useful Links

Useful Link # 1

Title : Carbohydrate's metabolism

URL : <http://www.probiotica.com.br/artigos.asp?id=110&tabela=saudeInformativo>

Description : The reference focus on carbohydrates' metabolism. It offer useful information about metabolic absorption and storage of carbohydrates in the organism.

Rationale : The reading can help to understand the importance of carbohydrates in organisms.

Useful Link # 2

Title : Inverted sugars

URL : <http://www.google.co.ke/search?hl=en&q=a%C3%A7ucar+redutor&btn=Seas>

(properties of sugars /discussion inverted sugar

Description : The article focus on sugars' properties.

Correlations stereochemical are explained based on Saccharose.

Rationale : The article makes links between structure and properties of compounds.

Useful Link # 3

Title: Properties of sugars

URL : www.esalq.usp.br/departamentos/lan/pdf/Mono%20e%20Dissacarideos%20-%20Propriedades%20dos%20Acucares.pdf

Description : The reference deepens information of the module about properties of sugars namely: monosaccharide, disaccharides.

Rationale : Monosaccharide are basic units of oligosaccharides and polysaccharides. Are compounds with energetic functions and structures.

Useful Link # 4



Title: General biochemistry

URL : <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>

(Carbon Hydrates/nucleic acids/lipids /functions)

Description : The reference presents hydrates of carbon and links it with important functions in the organism.

The chapter establishes links between sugars, nucleic acids and lipids.

Rationale: The readings deepen information about importance and function of biomolecules.

Useful link #5

Title: Carbohydrates' analyze

URL : <http://campus.fct.unl.pt/gdeh/mestrado/Teoricas/An%Elise%20de%20carbohidratos.pdf>

(Carbohydrates analysis/ experimental activity)

Description : The chapter introduces the analyze of carbohydrates.

It is an important contributes to the developments of skills to practical work.

Rationale : The article abilities the student to recognize the basic characteristics of carbohydrates.

Useful link #6

Title: Sweet like sugar

URL : <http://www.qmc.ufsc.br/qmcweb/artigos/sugar.html>

(Concept/Functions/organism's basic necessities)

Description : The reference presents information about concept of sugar, functions of sugars and human basic needs.

Rationale : The article deepens knowledge about sugars as well as human needs in regard this compounds.

Useful Link # 7



Title : General Biochemistry

URL : <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>

(Carbon Hydrates/Nucleic acids/lipids)

Description : The reference deals with structure of amino acids and of proteins. It includes differentiation between simple proteins and conjugated proteins.

Rationale : The readings above provide relations between structure and functions of amino acids and proteins.

Useful Link #8

Title : Protein structure

URL : <http://www.amtechs.com/folding/education/prstruc.html>
<http://verjo2.iq.usp.br/aula-2-aminoac-estrut-primaria-prot.pdf>

Description : The articles provide information about structure and formation of proteins.

Useful Link #9

Title : Protein structure

URL : <http://www.google.com/search?hl=en&q=Estrutura+das+proteinas>

Description : The references present primary, secondary, tertiary and quaternary structures of proteins.

Rationale: The student will find illustrations of proteins' structure correlated with its functions.

Useful Link #10

Title : Fats

URL : <http://pt.wikipedia.org/wiki/Gordura>

(Composi/structure and functions)

Description : In the article the student will find introduction on the concept of structure, classification and sources of fats.

Rationale : The article disserts about biological compounds with structural and energetic functions in organism.



Useful Link #11

Title : Lipids

URL : <http://www.dq.fct.unl.pt/cadeiras/pb/download/Prob%20Serie%204%2004-05.pdf>

Description : The article presents the concept, structure and important functions of lipids.

Rationale : The article provides links between structure and properties of lipids.

Useful Link #12

Title : Phospholipids

URL : <http://pt.wikipedia.org/wiki/Fosfol%C3%ADpido>

(fosfolipidos)

Description : The article presents the structure of esterified lipids with phosphoric acid.

Rationale : Lipids are compounds of diverse nature which composition is closely linked with its function in the organism.

Useful Link #13

Title : Lipids

URL : <http://www.dbio.uevora.pt/jaraujo/biocel/lipidos.htm>

Defi/ structure/classific/glycerides/conjugated lipids

Description : The reference presents lipids, its classification and basic structures (Glycerides). It also presents aggregated lipids and other structures.

Rationale : Glycerides are basic structures of lipids resulting from glycerol esterification.



XIV. Synthesis of the Module

In this module were presented and studied some of the representative macromolecular compounds in the biological system vital to the equilibrium, growth, maintenance and supplement of living organisms.

The module consolidates and expands knowledge gained in previous modules, especially about Aldehydes, Ketones and amino acids connecting them to vital functions of the organisms.

Module 8 (macromolecules in biological system) offers basic foundations about key theoretical and practical aspects of macromolecular chemistry.

It deals systematically with some of main classes of macromolecular organic biological compounds, respectively: Carbohydrates (Glucids), proteins and lipids.

In this module are analyzed relations between structure, properties, reactivity and chemical and physical behavior of organic compounds of high molecular weight.

The learning of this module deepens knowledge about organic compounds and helps to establish relations between matter structure and its properties.

Develops ability of reasoning and critical observation allowing the best use of these compounds.

Carbohydrates are Aldehydes and Ketones containing Polyhydroxyl group. These compound with chiral structure are usually classified in three groups (mono – di and polysaccharides) and they have energetic functions structures and in organisms.

Proteins constituted by basic units of amino acids are considered basilar units in the organisms' compositions. They have protection, structural or metabolic functions according to their composition and structure..

Lipids, compounds of diverse nature are basically esters of glycerol and fatty acids.



XV. Summative Evaluation

1. Glucids or carbohydrates are:

- a) Compounds constituted exclusively by carbon and hydrogen
- b) Compounds that contain water
- c) Aldehydes and Ketones containing polyhydroxyl group
- d) Compounds of fat family

2. Chemically fat are:

- a) Esters of Glycerol and fat acids
- b) Esters of superior alcohols and fat acids
- b) Aldehydes with high molecular weight
- c) Acids of high molecular weight

3. Proteins are compounds constituted by:

- a) Glucose units bounded by glycosidic linkage
- b) Amino acids units bounded by peptide bond
- c) Monosaccharide units bounded by glycosidic linkage
- d) Products from polysaccharides' decomposition

4. Fat acids are:

- a) Acid with many ramifications
- b) Acid of fat people
- c) Acid of high molecular weight
- d) Carboxyl acids

5. Glycosidic linkage occurs between

- a) Fat
- b) Amino acids units
- c) Monosaccharide units
- d) Proteins

**6. Peptide bond occurs between**

- a) Fats
- b) Amino acids units
- c) Monosaccharide units
- d) Proteins

7. Polysaccharides are constituted by:

- a) Thousands of units of acids bounded by glycosidic linkage
- b) Thousands of amino acids units bounded by peptide bond
- c) Thousands of monosaccharide units bounded by glycosidic linkage
- d) Thousands of amino acids units bounded by peptide bond

8. Isomerism is the occurrence of:

- a) Molecules of same molecular mass
- b) Molecules absorbing all light
- c) Existence of molecules with the same composition but different structure
- d) Molecules differing in one segment constituted by one atom of carbon and two of hydrogen

9. Glucose is

- a) Aldose
- b) Ketose
- c) Pentose
- d) Hexoketose

10. Fructose is

- a) Aldose
- b) Ketose
- c) Pentose
- d) Hexoaldose

11. The atom of carbon which determines series D in sugars is:

- a) The closest to the main functional group
- b) The furthest to the main functional group
- c) The central atom
- d) None of these

**12. Reducer sugars are:**

- a) Easily soluble
- b) Those which have free functional group
- c) The sweeter
- d) Those which do not have free functional group.

13. Oils are:

- a) Esters of glycerol and saturated fat acids
- b) Esters of glycerol and unsaturated fat acids
- c) Esters of superior alcohols and saturated fat acids
- d) Esters of superior alcohols and sulfuric acid.

14. Waxes are:

- a) Esters of glycerol and saturated fat acids
- b) Esters of glycerol and unsaturated fat acids
- c) Esters of superior alcohols and saturated fat acids
- d) Esters of superior alcohol and sulphuric acid

15. Enantiomers are isomers:

- a) Which differ in the position of the central atom
- b) Which rotate the light in the same magnitude but opposite directions
- c) Which rotate differ in a position of the central atom
- d) Which rotate the light in different magnitude but same direction

16. Glycosidic linkage is:

- a) Linkage between amino group and carboxyl group
- b) Between two amino groups
- c) Between carboxyl and hydroxyl groups
- d) Between two monosaccharides

17. The typical bound in proteins is:

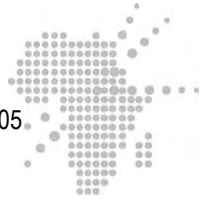
- a) Glycoside
- b) Peptide
- c) Acetalic
- d) None of these

**18. Cellubiose is:**

- a) Monosaccharide
- b) Disaccharide
- c) Polysaccharide
- d) None of these answers

Answer key

1. Glucids or carbohydrates are:
 - c) Aldehydes or Ketones containing carboxyl group
2. Chemically fat are:
 - a) Esters of glycerol and fat acids
3. Proteins are compounds constituted by:
 - b) Amino acids units bounded by peptide bond
4. Fat acids are:
 - c) Acids of high molecular weight
5. Glycosidic linkage occurs between:
 - c) Monosaccharides units
6. Peptide bond occurs between:
 - b) Amino acids units
7. Polysaccharides are constituted by:
 - c) Thousands of units of monosaccharides bounded by glycosidic linkage
8. Isomerism is the occurrence of
 - c) Existence of molecules with the same composition but different structure
9. Glucose is:
 - a) Aldose
10. Fructose is:
 - b) Ketose
11. The atom of carbon which determines series D in sugars is:
 - c) The furthest to the main functional group



12. Reducers sugars are:
 - b) Those which have free functional group
13. Oils are:
 - b) Esters of glycerol and unsaturated fat acids
14. Waxes are:
 - d) Esters of superior alcohol and saturated fat acids
15. Enantiomers are isomers:
 - b) Which rotate light in the same magnitude but in opposite directions.
16. Glycosidic linkage is:
 - e) Between two monosaccharides
17. Typical linkage in proteins is:
 - b) Peptide
18. Cellubiose is:
 - b) disaccharide



XVI. References

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