Chemicals of life

Overview

All cells are made up of a variety of substances some of which organic while others are inorganic. Water forms the largest component and is also a medium for all reactions in the cell. The other substance includes acids, bases, salts, vitamins, carbohydrates, lipids and proteins. There are enzymes and nucleic acids which perform a variety of functions.

General objective

By the end of the topic, the learner should be able to describe the composition, structure, properties and importance of inorganic and organic substances to the life of organism.

Acids, bases and salts

Specific objectives

The learner should be able to

a. Describe properties of acids and bases
b. Explain the role of acids, bases and salts in maintaining a stable internal environment for physiological processes.

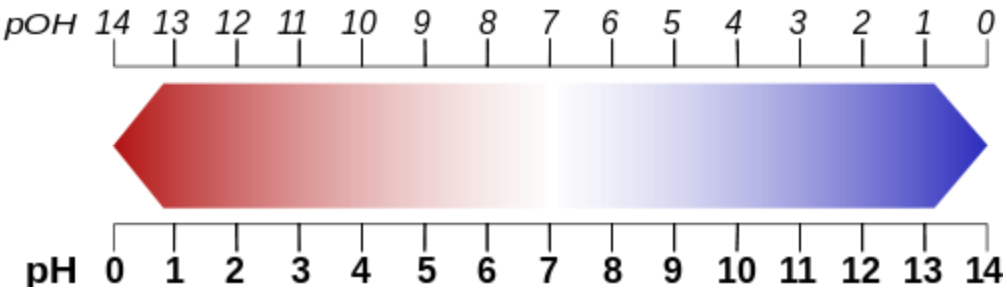
Definition

An **acid** is a molecule or ion capable of donating a hydrogen (proton or hydrogen ion H^+) in solution. They neutralize alkalis, dissolves some metals with liberation of hydrogen, and turns litmus red; typically, a corrosive or sour-tasting liquid of this kind:

A **base** is a substance that can accept a hydrogen ion (H+) from another substance

PH

In chemistry, pH is a numeric scale used to specify the acidity or basicity (alkalinity) of an aqueous solution. It is roughly the negative of the logarithm to base 10 of the concentration, measured in units of moles per liter, of hydrogen ions. More precisely it is the negative of the logarithm to base 10 of the activity of the hydrogen ion.



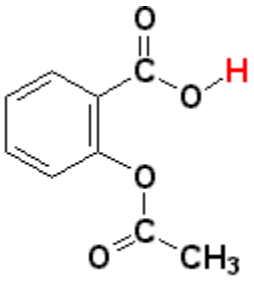
Here are some of the places that acids and bases can be found in the human body:

1. DNA is a complex NUCLEIC ACID found in cells that contains four unique nitrogen-based BASES: adenine, cytosine, guanine and thymine. Differing combinations of these four bases determine the genetic characteristics of all human life.

2. AMINO ACIDS are the building blocks of proteins! The majority of amino acids consist of both a carboxylic acid (**-COOH**) and an amino (**-NH_2**) functional group attached to the same tetrahedral carbon atom.

3. LACTIC ACID is an acid produced when sugars are processed by the body. The production of too much lactic acid can cause serious health issues and even death.

4. Vitamin C has the chemical name ASCORBIC ACID and Aspirin and other pain relief remedies are also organic acids. Here is the chemical structure of Aspirin:



acetylsalicylic acid

5. BLOOD is naturally buffered to a pH of 7.35 – 7.45 in healthy humans. While our bodies naturally work to keep a healthy acid-base balance, problems can arise when acidic or basic compounds are too concentrated or not present in high enough concentrations. The blood's acid-base balance is precisely controlled, because even a minor deviation from the normal range can severely affect many organs. The

body uses different mechanisms to control the blood's acid-base balance such as the release of CO_2 from the lungs, adjusted kidney function for excretion of substances and controlled buffering of blood via concentrations of the bicarbonate ion.

6. Acidosis and alkalosis are the two abnormalities of acid-base balance. In acidosis, the blood has too much acid (or too little base), resulting in a decrease in blood pH. In alkalosis, the blood has too much base (or too little acid), resulting in an increase in blood pH. Acidosis and alkalosis are not diseases, but rather are conditions that result for a variety of reasons.

Effects of unbalanced pH in the body

A person with mild metabolic acidosis may have no symptoms but usually experiences nausea, vomiting, and fatigue. Breathing becomes deeper and slightly faster (as the body tries to correct the acidosis by expelling more carbon dioxide). As the acidosis worsens, the person begins to feel extremely weak and drowsy and may feel confused and increasingly nauseated. Eventually, blood pressure can fall, leading to shock, coma, and death·

Systems responsible for maintenance of the acid-base balance

Several systems maintain constant pH. The list below is made according to order when they act:

1) Chemical buffering systems provides immediate and short-term response to pH changes.

The **bicarbonate buffer system** is an acid-base homeostatic mechanism involving the balance of carbonic acid (H_2CO_3), *bicarbonate* (HCO_3^-), and carbon dioxide (CO_2) in order to maintain pH in the blood. In presence carbonic anhydrase, carbon dioxide (CO_2) reacts with water (H_2O) to form carbonic acid (H_2CO_3), which in turn rapidly dissociates to form a bicarbonate ion (HCO_3^-) and a hydrogen ion (H^+) as shown in the following reaction:

$$CO_2 + H_2O \quad \leftrightarrow \quad H_2CO3 \leftrightarrow H^+ + HCO_3^-$$

When the pH of the body falls, H^+ and HCO_3^- react to form H_2CO3

and when pH rise H^+ react with OH^- to form water leading to further ionization of H_2CO3

2) Respiratory system

Respiration reacts in **1-3 minutes**. Respiratory system regulates **carbon dioxide**. Respiration is able to change pCO_2 by its elimination or retention. Respiratory centre is in **brainstem**.

3) Kidneys

Kidneys react in **hours-days**. In the kidney carbon dioxide react with water to form hydrogen ions (H^+) and hydrogen carbonate (HCO_3^-)

$CO_2 + H_2O \leftrightarrow H_2CO3 \leftrightarrow H^+ + HCO_3^-$

When the pH is low the collecting duct and distal convoluted tubules secrete hydrogen ions and retain hydrogen carbonate ions producing urine with low pH.

Conversely, if blood too alkaline, then the collecting duct can secrete bicarbonate into urine and retain H^+ lowering the pH of blood leading to alkaline urine.

4) Liver

Liver is pivotal organ of the energetic metabolism it also has important influence on the acid-base balance. Liver is the most important tissue where ammonium is detoxified in both urea cycle, and glutamine synthesis. Which one of these fates of ammonium is favored closely depends on status of the acid-base balance:

1. a) $NH_4^+ \rightarrow$ **urea** + 2 $H^+ \rightarrow$ acidification of the body

   $CO_2 + 2\ NH_4^+ \rightarrow CO(NH_2)_2 + 2\ H^+ + H_2O$

   $H^+ + HCO_3^- \rightarrow H_2O + CO_2$ (**consumption of bicarbonate**$^-$ causing a rise in pH

1. b) $NH_4^+ \rightarrow$ **glutamine synthesis** $\rightarrow H^+$ is not produced, glutamine is taken up by the kidneys. In the kidney is **H^+ excreted as NH_4^+**

Water

Specific objectives

The learner should be able to

a. Describe the molecular structure of water
b. State the function of water
c. Explain the importance of water as solvent
d. Relate the water properties to its role in the life of organism
e. To test for water
f. Determine water content in tissue by using dry weight method.

Water

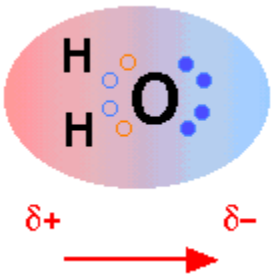
This is the most abundant compound, typically making up of 60-95% fresh mass of an organism.

Structure of water

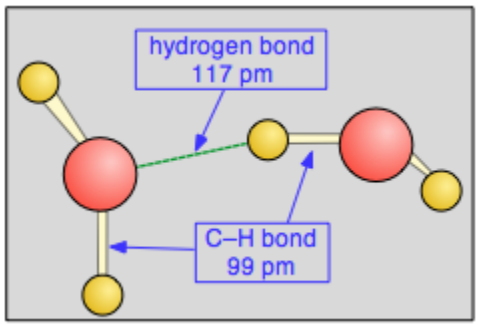
Water is made of hydrogen and oxygen.

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

The H_2O molecule is electrically neutral, but polar because the positive and negative charges are not distributed uniformly. This lead to apartial positive charges on hydrogen atoms and a partial negative charge on oxygen atom



In liquid and solids these partial charge attract to form hydrogen bonds



The hydrogens are responsible high melting and boiling point and strong surface tension of water.

Uses of water in living organisms

(i) It makes up structures of organism
(ii) It is a solvent
(iii) It is a reagent in hydrolysis
(iv) Provide support for aquatic organism
(v) Is a medium of fertilization through which gametes swim.
(vi) Medium for removal of waste products
(vii) Temperature control
(viii) Hearing and balance as endolymph

Uses of water to the plants

(i) Aid seed dispersal
(ii) Provide support to herbaceous plants
(iii) Breaks up the testa of a seed during germination
(iv) Reagent in photosynthesis
(v) Loss of water through the leaves cools the plant.
(vi) Medium of fertilization

Uses of water to the plants

(i) A medium of transport
(ii) Evaporation cools the animal
(iii) Lubricates joints, eyes, lungs
(iv) Constituent of protecting fluids such as tears, mucus.

Adaptation of Water to its function

- Water is the **universal solvent**:

Polar and ionic substances have an electrostatic charge, so they are attracted to the charges on water molecules and dissolve readily. Non-polar substances, such as oil, do not dissolve in water, as they do not have charged molecules. When a salt dissolves in water, the ions separate and a layer of water molecules form around the ions. These layers prevent ions or polar molecules from clumping together, keeping the particles in solution.

- Water has a high **surface tension**:

At an interface between air and water, a water molecule on the surface forms hydrogen bonds with other molecules around and below it, but not with air molecules above it. The unequal distribution of bonds produces a force called surface tension; this causes the water surface to contract and form a surprisingly tough film or 'skin' enabling small animals like insects to walk over. It also protects blood capillaries of gill filaments from bursting.

- Ice **floats** on water:

Water is at its most dense at 4^{o}C. When water freezes the hydrogen bonds between the molecules forms a rigid lattice, that holds the molecules further apart then in liquid water. Ice, having expanded when freezing, is less dense than its liquid counterpart and so floats on water. This protests water from further freezing because ice insulates the surface of water.

- Water is **adhesive** and **cohesive**:

Water is 'wet' because it sticks to things. This is because its molecules can form hydrogen bonds with other polar substances. This is called adhesion. The attraction between molecules of similar substances is called cohesion. In this way water molecules stick together which allows water to enter and move along very narrow spaces, in a process called capillarity. This enables water ascend in the xylem of a tall tree.

- Important **thermal** properties:

Water has a high **specific heat capacity** meaning that it needs to gain a lot of energy to raise its temperature. Conversely it also needs to lose a lot of energy to lower its temperature. Water's specific heat capacity is 4.2 kJ/g/^{o}C. Thus, this minimizes increase in temperature on hot days.

Water has a high **latent heat of vaporization** which means a lot of energy is required to evaporate it. When it evaporates, water draws thermal energy out of the surface it's on, which can be observed in sweating. Thus, sweating cools, the body.

Water also has a high **latent heat of fusion** meaning that at 0^{o}C water must lose a lot of thermal energy before it freezes, thus liquid water can reach temperatures of down to -10^{o}C before it forms ice. This implies too much heat loss is required to freeze water body.

- Other physical properties of water:

It is transparent to sunlight. This allows animals to seen in water also photosynthesis in aquatic plants.

It has a relatively high density compared to air, this support aquatic animals while swimming.

It is difficult to compress. Thus, support aquatic animals while swimming.

It conducts electricity (when it contains dissolved ions) enable conduction of heat, keeping water hot.

Inorganic compounds/mineral salts

(a) Inorganic salts include those needed in large amounts such as salts of Na^+, Mg^{2+}, Cl^-, K^+ and those needed in trace amounts such as manganese, iron, cobalt, copper, zinc, boron, aluminium, silicon, vanadium, molybdenum and iodine

Functions of inorganic salts

(i) They are components of proteins, e.g. nitrogen, phosphorus and Sulphur.
(ii) They are components of tissues; e.g. calcium and phosphorus are components of bones
(iii) They are constituents of enzymes; e.g. copper and iron.
(iv) They are metabolic activators for example, magnesium activates enzymes in phosphate metabolism.
(v) They are constituent of pigments for example, iron in hemoglobin and magnesium in chlorophyll.
(vi) They are determinants of anion-cationic balance in the cell example Na^+, Cl^-, and K^+.
(vii) They are determinants of osmotic pressure, e.g. Na^+, Cl^-, and K^+.

Carbohydrates

Specific objectives

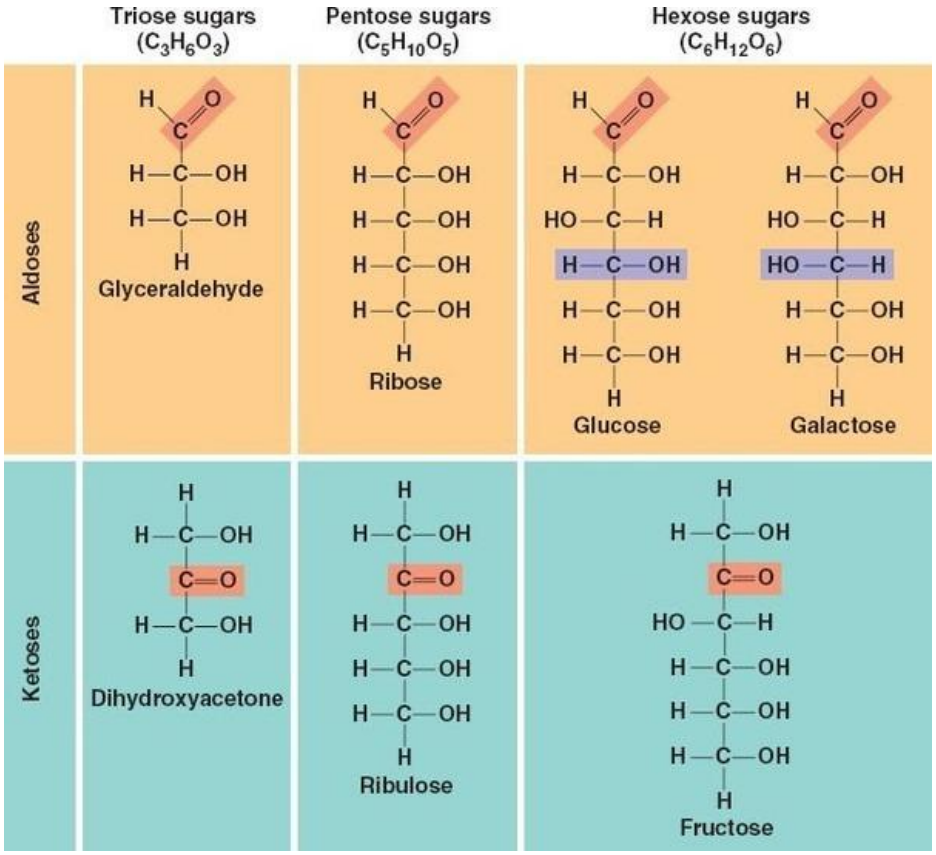
The learner should be able to:

a. Describe the structure and components of various carbohydrates
b. Explain the properties of carbohydrates.
c. Explain the functions of carbohydrates in organisms.
d. Describe the condensation of carbohydrates
e. Describe the hydrolysis of carbohydrates
f. Identify the various categories of carbohydrates.

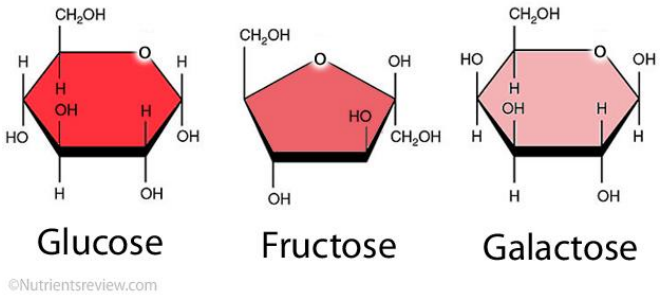
Carbohydrates are food substances with a general formula $(CH_2O)_n$ where n is natural number.

Classification

(i) Monosaccharides e.g. glucose, galactose and fructose



Ring structures of common monosaccharides.



Sources: honey, fruits

Properties

- They are sweet
- Are soluble in water
- They reduce blue copper II ions to red precipitates in alkaline medium.

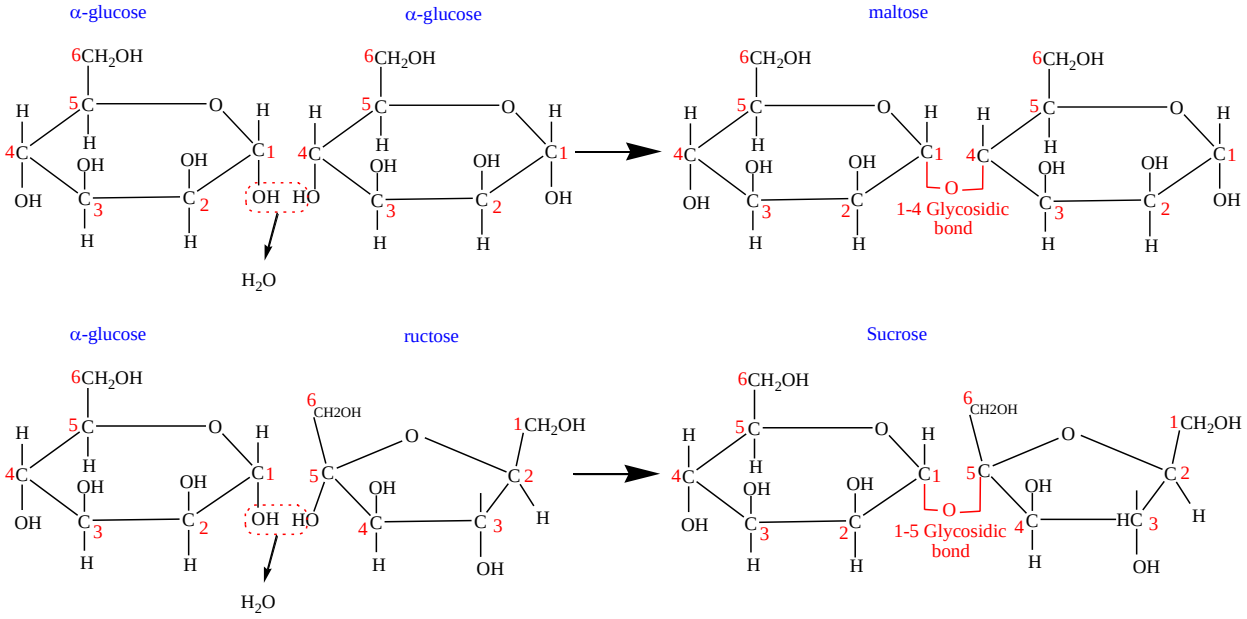
Testing for reducing sugars

When boiled with Benedict's or Fehling's solutions the color changes from blue to green to yellow to oranges ppt.

(ii) Disaccharides

They are made of two simple sugars by condensation

Illustration



- Maltose, lactose and sucrose are sweet and are referred to as sugars. Maltose and lactose are reducing sugars whereas sucrose in not and referred to as non-reducing sugar.

Testing for non-reducing sugars

Disaccharides	Composition	Source
Maltose	glucose + glucose	malt
Lactose	Glucose + galactose	milk
Sucrose	Glucose + fructose	Sugar cane Sugar beets
Cellubiose	Glucose + glucose	wood

1. When boiled with Benedict's solution or Fehling's' solution, the color remains blue.
2. When boiled with HCl, the solution cooled, neutralized by NaOH, boiled Benedict's or Fehling's solution, the color changes from green, to yellow to orange.

HCl hydrolyses non-reducing sugars
NaOH neutralizes the excess acid because Benedict's or Fehling's solution does not work in acidic medium.

Polysaccharide $(CH_2O)n$

These are made of very many mono saccharides per unit molecule e.g. starch and cellulose

Testing for starch

It changes the color of iodine black or blue.

Functions of carbohydrates

1. Glucose, galactose and fructose are oxidized to release energy in he body
2. Glyceraldehyde is an intermediate molecule in photosynthesis.
3. Ribose is component nucleotides.
4. Sucrose is a form in which carbohydrates are transported in plants
5. Lactose is a source of energy in milk
6. Storage of energy (starch in plants, glycogen in animals, inulin is some plants like Dahlia)
7. Formation of cellular structures (cellulose in plant cell walls, chitin is

Lipids

Specific objectives

The learner should be able to:

a. Describe the structure and components of lipid molecules.
b. State the properties of lipids.
c. Explain the functions of lipids in organism.
d. Describe the structure of steroids
e. Explain the effects of lipids and steroids to organisms
f. Describe the condensation of fatty acids and glycerol to form lipids
g. Describe the hydrolysis of lipids to fatty acids and glycerol
h. Compare waxes and lipids
i. State importance of cholesterol in organism
j. To carry out tests to identify lipids on food and extracts.

(a) Lipids

These include natural fats and oil. Fats are solids at room temperature while oils are liquids

Structure of lipids

Lipids are ester of glycerol and fatty acids

Formation of triglyceride from glycerol and fatty acids

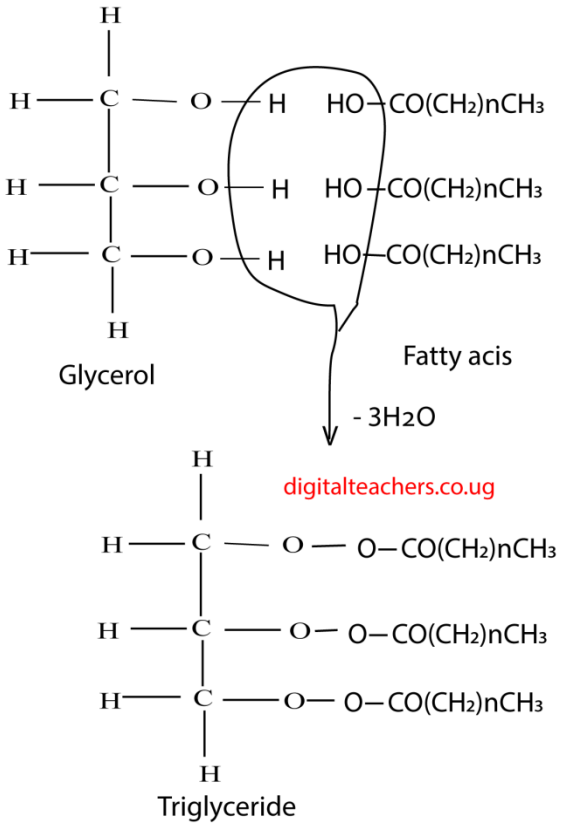


Table of nature and occurrence of some fatty acid

Name of fatty acid	formula	Saturated/unsaturated	occurrence
Butyric acid	C_3H_7COOH	Saturated	Butter fat
Linoleic	$C_{17}CH_{31}COOH$	unsaturated	Linseed oil
Oleic	$C_{17}H33COOH$	unsaturated	All fats
Palmitic	$C_{15}H_{31}COOH$	Saturated	Animal and vegetable fats
Stearic	$C_{17}H_{35}COOH$	Saturated	Animal and vegetable fats
arachidic	$C_{19}H_{39}COOH$	Saturated	Peanut
Ceritic	$C_{25}H_{51}COOH$	Saturated	Wool oil

Uses of lipids

Structural functions

- Make up cell membrane
- Protection: lipids are constituents of the waxy cuticle of plants and insects
- Lipids are water repellant thus prevent water loss from or entry into an animal skin
- Their spongy nature protects delicate organs as shock absorbers.
- Being bad conductors, they reduce water loss from the body when deposited beneath the skin for insulation
- Storage ; they are better storage compounds than carbohydrates due high calories value, due to high hydrogen content, they are light, insoluble in water, compact to fit in a small volume and are easily used when required.

Physiological functions

- Source of metabolic water
- Store fat soluble vitamins (ADEK)
- Source of metabolic water
- Raw materials for hormones

Testing for lipids

a. They form a translucent mark on paper that does not disappear when the paper is dried on a flame.
b. Emulsion test
   When $2cm^3$ of fats or oil are dissolved in $2cm^3$ of absolute ethanol followed by water, a white cloudy suspension is formed.
c. Sudan III
   When a few drops of Sudan III are added to a mixture of 2cm3 of water and 2 cm3 of oil and shaken, a red stained oil layer separates out.

Phospholipids.

These are lipids in which of the fatty acid is replaced by phosphoric acid. The phosphoric acid attracts water (hydrophilic) whereas the rest of the group repel water (hydrophobic). This property enables them to form a cell membrane.

Waxes

Waxes are formed by combination with an alcohol other than glycerol. This alcohol is much larger than glycerol, and therefore waxes have a more complex chemical structure. The main role of waxes is waterproofing plants and animals although, they form storage compounds in a few organisms, e.g., castor oil and in fish.

Advantage of storing fats over carbohydrate

(i) Has high energy content than carbohydrates

(ii) It is lighter
(iii) It is compact and requires less space
(iv) It is a raw material for hormones
(v) Insoluble in water that they have low osmotic value

Proteins

Specific objectives

The learner should be able to:

b. Describe the structure and composition of proteins.
c. Describe the properties of proteins
d. Explain the importance of proteins
e. Explain the functions of proteins in organisms
f. Describe the condensation of amino acids to form proteins.
g. Describe the hydrolysis of proteins to amino acids
h. The effect of heat/temperature changes on proteins
i. To carry out test and identify proteins on food /extracts.

Proteins

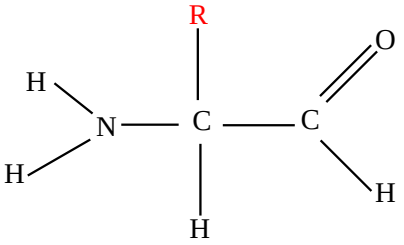
These are classified into two groups

(i) **Structural proteins**: insoluble proteins that make up body structures like bones and muscles. Fibrinogen is a soluble structure protein used in blood clotting.

(ii) Globular proteins are soluble proteins such as enzymes, antibodies, hormones and so on.

Composition of proteins

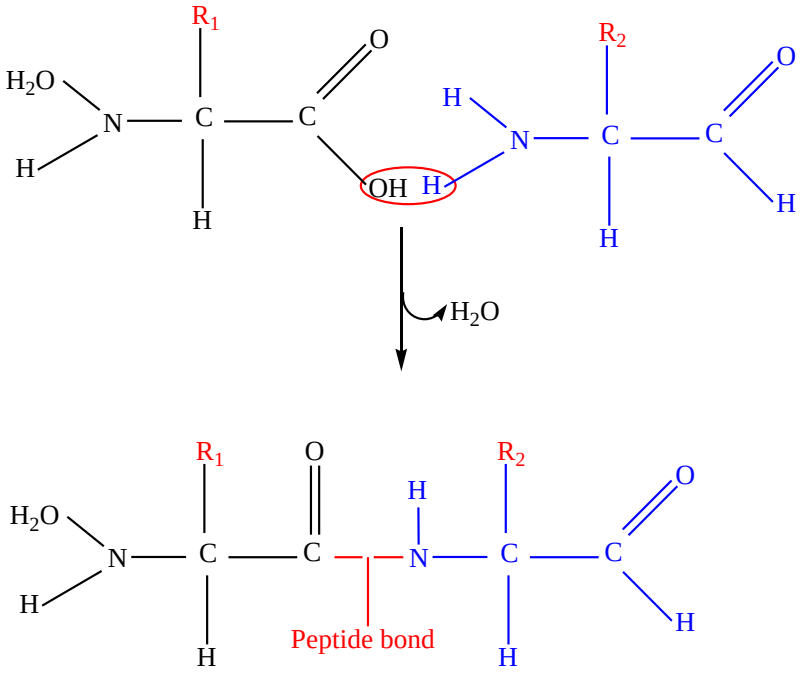
The basic unit of proteins are amino acids



R =alkyl group

There are about 22 different amino acids in the body of which isoleucine, leucine, methionine, phenylamine, proline, threonine and valine cannot be synthesized in human body and they are referred to as **essential amino acids.**

Amino acids unite to form proteins through formation of peptide bonds by a condensation reaction in which a water molecule is eliminated.



Uses of proteins

(i) Make up structures, e.g., collagen make up connective tissues.
(ii) Make up enzymes such as catalyze and amylase.
(iii) Are constituent of hormone such as insulin
(iv) Are constituents of antibodies that protect the body from foreign particles.
(v) Make up muscles such as myosin and actin
(vi) They are storage food e.g. egg white
(vii) Constitute toxins such as snake venom for protection.

Protein denaturation

Protein denaturation is the destruction of the highly ordered structure of the protein in its natural (native) state leading to loss of its function by breaking bonds (e.g., hydrogen bonds), within a protein .

Factors that can cause protein denaturation

- Heat, which can disrupt hydrogen bonds and non-polar hydrophobic interactions.
- Freezing, which can cause ice crystals to form and damage the protein structure.
- pH change, which can alter the charge and polarity of amino acids and affect their interactions.
- Ionic strength change, which can affect the electrostatic forces between amino acids and their surroundings.
- Surface changes, which can expose the protein to different environments and solvents.

- exposure to UV light and radiation breaks bond in the proteins
- chemicals such as alcohol and heavy metals precipitate proteins from solution
- mechanical agitation can distort protein structures leading to denaturation

Testing for proteins

a. They coagulate on heating
b. They coagulate on addition of Melon's reagent and on heating they form a pink precipitate.
c. They form a purple color when mixed with equal amount of NaOH followed by 3 drops of copper sulphate solution.

Vitamins

Specific objects

The learner should be able to:

a. State the type of vitamins i.e., water soluble and fat soluble; essential and nonessential.
b. State the importance of vitamins in organism
c. Test for vitamin C.
d. Demonstrate effect of over boiling vegetables
e. Demonstrate the effects of storage on the quality of fresh food.

Vitamins are complex organic compounds present in very small quantities in natural food which are essential for good healthy body and maintains its normal metabolic activities. Some vitamins are fat soluble (ADEK) while others are not.

Vitamin C / ascorbic acid

Sources: citrus fruits, green vegetables, potatoes, tomatoes, etc.

Function of vitamin C

Concerned with the metabolism of connective tissues and the production of strong skin.

Deficient disease : anemia and scurvy: the germs bleed, wounds fail to heal.

Testing for Vitamin C

It decolorizes DCPIP.

Other vitamins and their deficient diseases

Vitamin	
A	Night blindness
K	Delayed clotting
E	Reduced fertility in rats

Functions of vitamins

- protect the body against diseases
- formation of coenzyme that facilitate enzyme reactions
- blood clotting
- components of visual pigment

Revision questions

1. Lack of iodine in the diet causes cretinism because iodine
   A. Controls metabolism
   B. Is essential in the formation of metabolic enzymes
   C. Influence growth of bones
   D. Is required for synthesis of thyroxine
2. In the body, proteins combine with acids or bases depending on the
   A. Temperature of the medium
   B. Hydrogen ion concentration in the medium
   C. Number of solvent molecules present in the medium
   D. Number of amino acid molecules in the protein

3. Starch, glycogen and cellulose are all composed of

   A. α-glucose
   B. β-glucose
   C. monosaccharides
   D. polysaccharides

4. Some amino acids are known as essential because they are

   A. more important in the body metabolism than other
   B. not made by the body
   C. contained in first class proteins
   D. required in larger amounts than others.

5. Which of the following sugars is not reducing?

   A. Maltose
   B. Fructose
   C. Galactose
   D. Sucrose

6. Among the following compounds, one cannot be hydrolyzed is

   A. Glycogen
   B. Galactose
   C. Lactose
   D. Maltose

7. Which one of the following is the correct formula of a polysaccharide?

   A. $(C_6H_{10}O_5)_n$
   B. $(CH_2O)_n$
   C. $(C_6H_{12}O_6)_n$
   D. $C_{12}H_{22}O_{11})_n$

8. Which one of the following statements is true of essential fatty acids? They

A. They are the most required lipids in the body
B. Are required in the body in large quantities
C. Cannot be synthesized in the body
D. Are most abundant in animal tissues

9. Which one of the following properties of water facilitates its efficient transportation of glucose?

A. Forms hydrogen bonds with other molecules
B. Has high surface tension
C. Has low freezing points
D. Has high boiling point

10. Which of the following vitamins is water soluble?

A. A
B. B
C. D
D. C

11. Lack of iodine in diet causes cretinism because iodine

A. Controls metabolism
B. Is essential for formation of metabolic enzymes
C. Influence growth of bones
D. Is required for synthesis of thyroxine

12. A property of water that makes it suitable component of a hydrostatic skeleton is it

A. High density
B. High surface tension
C. Low viscosity
D. Incompressibility

13. Aquatic organism survives under solidified water body because

A. Water solidifies from bottom to top of lakes
B. Ice is less dense than water at 4^0C
C. Cold water is more dense than hot water and falls to the bottom
D. Warm water floats on top of cold water

14. In the body, proteins combine with acids or bases depending on the

A. Temperature of the medium
B. Hydrogen ion concentration in the medium
C. Number of solvent molecules present in the medium
D. Number of amino acid molecules in the protein

15. Which one of the following is not a fibrous protein

A. Keratin
B. Globulin
C. Elastin
D. Collagen

16. Sucrose is a non-reducing sugar because it

A. It is not fully digested
B. It lacks reducing groups
C. Is a disaccharide molecule
D. Is a ketose sugar

17. Which one of the following is a fibrous soluble protein?

A. Myosin
B. Collagen
C. Myoglobin
D. Fibrinogen

18. A green plant develops yellow leaves as a result of being deficient in

A. Magnesium
B. Manganese
C. Nitrogen
D. Calcium

19. Which of the following elements is **not** required by plants?

A. copper
B. iodine
C. iron
D. zinc

20. In the blood plasma, proteins can act as bases or acids depending on the

A. Temperature of the medium
B. Hydrogen ion concentration of the medium
C. Nature of the protein
D. Concentration of the solute in the plasma

21. Which of the following is the function of manganese in the human body?

A. Essential for formation of erythrocytes
B. Activate enzymes
C. Acts as growth factor in bone development
D. Utilized as a component of bone and teeth

22. Which of the following substances consists of globular proteins

A. Enzymes
B. Keratin
C. Elastin
D. collagen

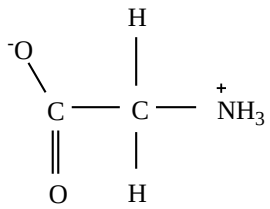
23. Which one of the following symptoms is likely to be caused by magnesium deficiency in plants?

A. Yellow leaves and stunted growth
B. Poor root growth
C. Weak stems
D. Yell spotted leaves

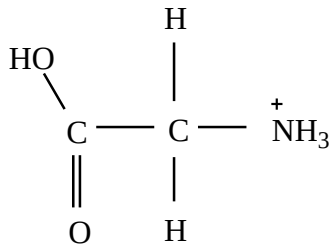
24. Which one of the following is not a function of globular proteins in the body?

A. Acts as buffers in blood plasma
B. Form structural proteins
C. Are vital constituents of plasma membrane
D. Form enzymes

25. The following structural formula is for an amino acid in solution



A substance was added to this solution and the structure of the amino acid molecule changed to



What substance was added and what effect would this have had on the final pH of the solution?

A. Salt added, pH unchanged
B. Acid added, pH lowered
C. Acid added, pH unchanged
D. Base added, pH higher

26. We need to eat iodized salt in order to

A. Prevent obesity
B. Get a balanced diet
C. Improve vision
D. Avoid goiter

27. Water has comparatively high surface tension and boiling point in relation to other substances of similar sized molecules because its molecules are

A. doubly bonded
B. polar
C. ionic
D. covalent

28. Evaporation of water from the body surface causes cooling because water has a high

A. Latent heat of vaporization
B. Latent heat of fusion
C. Boiling point
D. Specific heat capacity

29. The complexity and variety of organic molecules is due to the ability of the carbon atom to

A. form covalent and ionic bond
B. form covalent bonds in three dimensions
C. form strong chemical bonds
D. bonds with very many other elements

30. When a lipid is combined with a phosphate group, it becomes

A. saturated
B. a complex molecule
C. water soluble
D. amphoteric

31. A property of water which facilitates its efficient transportation of glucose

A. ability to form hydrogen bonds with other molecules
B. high surface tension
C. low freezing point
D. high boiling point

32. When a lipid is combined with a phosphate group, it becomes

A. saturated.

B. a complex molecule.

C. water soluble.

D. amphoteric.

33. Water has a comparatively high surface tension and boiling point in relation to other substances of similar sized molecules because its molecules are

A. doubly bonded. B. polar. C. ionic. D. covalent.

34. Starch and glycogen are suitable storage molecules because they

A. are large in size which makes them less soluble in water

B. are chemistry reactive in the cell

C. can easily be hydrolyzed

D. exert an osmotic pressure in the cell

35. The high heat capacity of water has biological importance of

A. minimizing temperature changes in animal fluids

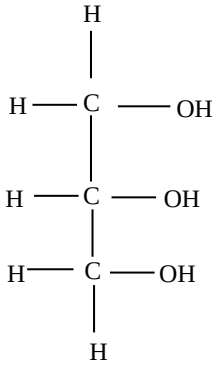
B. cooling animals

C. Preventing freezing of cell contents

D. controlling heat loss in animals

Paper 1 section 1

36. Fat and glycogen are energy storage compounds in animals
    (a) Compare the suitability of the two substances as storage compounds (4marks)
    (b) State advantage of storing fat over glycogen (3marks)
    (c) Why is glycogen more suitable energy compound in muscle than fat? (3marks)
37. Using the structural formula



For glycerol, and molecular formula $CH_3(CH_2)_nCOOH$ for a fatty acid show the formation of triglyceride from fatty acids and glycerol. (2marks)

(b) What properties do lipids possess as storage food substances? (2marks)

(c) Outline the structural and physiological functions of lipids in living organisms.

(i) Structural (3marks)

(ii) Physiological (2marks)

38. (2000/1/43) (a) state three ways in which water has similar functions in both plants and animals. (3marks)

(b) Give two ways, in each case, in which flowering plants minimize water loss through

(i) behavioral means (4marks)

(ii) physiological means (4marks)

39. Explain how the structure of proteins enable them to form body tissues and structures

(4marks)

40. (a) Describe the significance of physical properties of water to organism. (12marks)
    (b) Explain why lipids are better storage material in animals than carbohydrates (8marks)
41. (a) Giving examples, describe the use of nitrogen to plant and animal bodies
    (b) how is the concentration of nitrogen maintained at constant level in nature?

42. Distinguish between the following
    (a) Monosaccharide and polysaccharide (05marks)
    (b) Starch and cellulose (04marks)
    (c) Saturated and unsaturated fats (05marks)
    (d) Globular and fibrous proteins (06marks)
43. Relate the properties of water to its biological importance. (20 marks0

Answers to objective questions

1	D	6	B	11	D	16	D	21	B/C	26	D	31	A
2	B	7	A	12	D	17	D	22	A	27	B	32	C
3	C	8	C	13	B	18	A	23	D	28	A	33	B
4	B	9	A	14	B	19	B	24	B	29	D	34	C
5	D	10	D	15	B	20	B	25	C	30	C	35	

36. Solution

Similarities

- They are both compactly arranged to take up little space.
- they are both less soluble in water and little or none can be lost in solution

Differences

Fat	Glycogen
-Has a high calorific valve. -Has a higher hydrogen- oxygen content and can yield more metabolic water. Others - Has less weight and keeps body weight to a minimum which allows buoyancy	-Has a lower calorific valve. -Has a lower hydrogen- oxygen content and yield less metabolic water -Is heavier and can lead to overweight.

Others

Fat is completely insoluble in water and more can be lost in solution. Also. It prevents desiccation.

Fat forms an insulating layer under the skin that helps in temperature regulation.

Fat has a low density hence provide buoyancy in aquatic animals.

Muscles have a high content of glycolytic enzymes which readily breakdown glycogen to utilizable glucose.

The glycolytic enzymes, glycogen phosphorylase, has an allosteric site for binding AMP. When content is low in muscle, AMP content rises and activates this glycolytic enzyme which readily break down glycogen to glucose that can be used by the muscle.

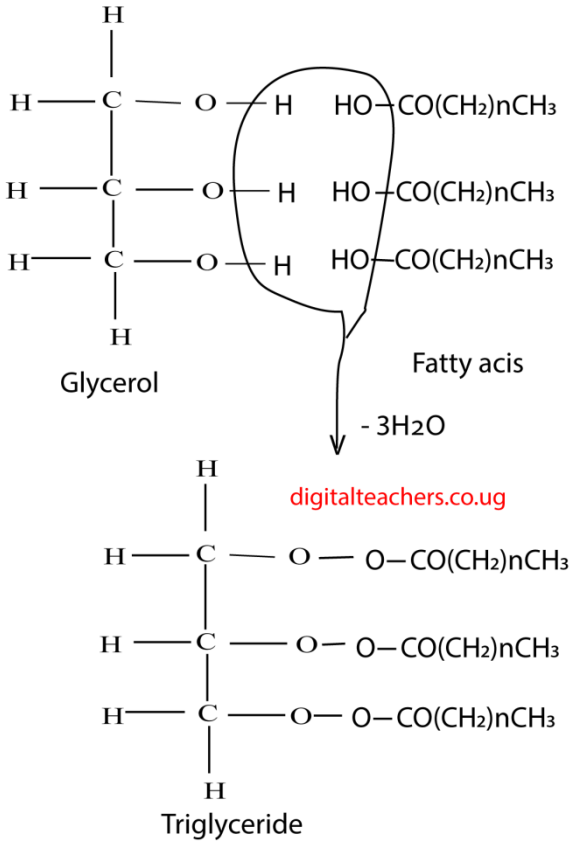
Break down of fat to free fatty acids which can be utilized by the muscle is a slow process because it is hormone- mediated.

41. (a) use of nitrogen

(i) protein synthesis
(ii) production of enzymes
(iii) production of muscles and tissues
(iv) production of nucleic acid

(b) nitrogen cycle

37 (a) Formation of triglyceride from glycerol and fatty acids



(c) Properties of fats as storage compounds

i. Has high energy content than carbohydrates
ii. It is lighter
iii. It is compact and requires less space
iv. It is a raw material for hormones
v. Insoluble in water that they have low osmotic value

(d) (i) Structural functions

- Make up cell membrane
- Protection: lipids are constituents of the waxy cuticle of plants and insects
- Lipids are water repellant thus prevent water loss from or entry into an animal skin
- Their spongy nature protects delicate organs as shock absorbers.
- Being bad conductors, they reduce water loss from the body when deposited beneath the skin for insulation
- Storage ; they are better storage compounds than carbohydrates due high calories value, due to high hydrogen content, they are light, insoluble in water, compact to fit in a small volume and are easily used when required.

(ii) Physiological functions

- Source of metabolic water

- Store fat soluble vitamins (ADEK)
- Source of metabolic water
- Raw materials for hormones

38 (a) similar functions of water in plants and animals

(v) It is a solvent and medium for transport
(vi) It is a medium of fertilization
(vii) Evaporation cools the body
(viii) Provides support to aquatic organism
(ix) Component of the cell
(x) A reagent in hydrolytic reaction
(xi) A medium in which biological reaction occur.

(b) (i) Minimizing water by behavioral means

- Folding or rolling of leaves on a hot day
- Reduction of number of stomata
- Storage of water in leaves
- Sunken stomata

(ii) minimizing water loss by physiological means

- Shedding leaves in hot season
- Reversal of normal stomata rhythm
- Thickening of waxy cuticle

39. How structure of proteins enable them to form body tissues and structures

(a) **Globular** - These tend to form ball-like structures where hydrophobic parts are towards the centre and hydrophilic are towards the edges, which makes them water soluble. They usually have metabolic roles, for example: enzymes in all organisms, plasma proteins and antibodies in mammals.

Fibrous - They proteins form long fibres and mostly consist of repeated sequences of amino acids which are insoluble in water. They usually have structural roles, such as: Collagen in bone and cartilage, Keratin in fingernails and hair.

42. (a) Monosaccharide and polysaccharide (05marks)

Monosaccharide	Polysaccharide
Made of 3 to 6 carbon atoms	Many carbon atoms
Composed of one sugar unit	Composed of many sugar units
Low molecular mass	High molecular mass
Soluble	Insoluble
Used for respiration	Used for storage
Low energy content	High energy content

(a) Starch and cellulose (04marks)

Starch	cellulose
Polymer of alpha glucose	Polymer of beta glucose

(b) Saturated and unsaturated fats (05marks)

Saturated fatty acids lack double bonds **between** the individual carbon atoms, while in **unsaturated fatty acids** there is at least one double bond **in the** fatty acid chain.

Saturated fats tend to be solid at room temperature and from animal sources, while **unsaturated fats** are usually liquid and from plant sources.

(c) Globular and fibrous proteins (06marks)

Fibrous proteins are insoluble in water, weak acids and weak bases but soluble in strong acids and alkalis whereas **globular proteins** are soluble in water, acids and bases.

Fibrous proteins are highly resistant to digestion by enzymes and are extremely tensile