Nutrition and Biochemistry for Nurses

Nutrition and Biochemistry for Nurses

Jacob Anthikad
MA (Psy) BEd MS (Chem) DTech (Biochem)

Retired Wing Commander
Indian Air Force (IAF)
Bengaluru, Karnataka, India

Visiting Professor
Kempa Gowda College of Nursing
MS Ramaiah College of Nursing
St. John's College of Nursing
St. Philomena's College of Nursing
Bengaluru, Karnataka, India

JAYPEE BROTHERS MEDICAL PUBLISHERS (P) LTD

St Louis (USA) • Panama City (Panama) • New Delhi • Ahmedabad • Bengaluru
Chennai • Hyderabad • Kochi • Kolkata • Lucknow • Mumbai • Nagpur

Published by

Jitendar P Vij
Jaypee Brothers Medical Publishers (P) Ltd

Corporate Office
4838/24, Ansari Road, Daryaganj, **New Delhi** 110 002, India, Phone: +91-11-43574357
Fax: +91-11-43574314

Registered Office
B-3, EMCA House, 23/23B Ansari Road, Daryaganj, **New Delhi** 110 002, India
Phones: +91-11-23272143, +91-11-23272703, +91-11-23282021, +91-11-23245672
Rel: +91-11-32558559, Fax: +91-11-23276490, +91-11-23245683
e-mail: jaypee@jaypeebrothers.com, Website: www.jaypeebrothers.com

Branches

- 2/B, Akruti Society, Jodhpur Gam Road Satellite
  Ahmedabad 380 015, Phones: +91-079-26926233, Rel: +91-079-32988717
  Fax: +91-079-26927094, e-mail: ahmedabad@jaypeebrother.com
- 202 Batavia Chambers, 8 Kumara Krupa Road, Kumara Park East
  Bengaluru 560 001, Phones: +91-80-22285971, +91-80-22382956, Rel: +91-80-32714073
  Fax: +91-80-22281761, e-mail: bangalore@jaypeebrothers.com
- 282 IIIrd Floor, Khaleel Shirazi Estate, Fountain Plaza, Pantheon Road
  Chennai 600 008, Phones: +91-44-28193265, +91-44-28194897, Rel: +91-44-32972089
  Fax: +91-44-28193231, e-mail: chennai@jaypeebrothers.com
- 4-2-1067/1-3, 1st Floor, Balaji Building, Ramkote Cross Road
  Hyderabad 500 095, Phones: +91-40-66610020, +91-40-24758498, Rel:+91-40-32940929
  Fax:+91-40-24758499, e-mail: hyderabad@jaypeebrother.com
- No. 41/3098, B & B1, Kuruvi Building, St. Vincent Road
  Kochi 682 018, Kerala, Phones: 0484-4036109, +91-0484-2395739, +91-0484-2395740
  e-mail: kochi@jaypeebrothers.com
- 1-A Indian Mirror Street, Wellington Square
  Kolkata 700 013, Phones: +91-33-22651926, +91-33-22276404, +91-33-22276415
  Rel: +91-33-32901926, Fax: +91-33-22656075, e-mail: kolkata@jaypeebrothers.com
- Lekhraj Market III, B-2, Sector-4, Faizabad Road, Indira Nagar
  Lucknow 226 016, Phones: +91-522-3040553, +91-522-3040554
  e-mail: lucknow@jaypeebrothers.com
- 106 Amit Industrial Estate, 61 Dr SS Rao Road, Near MGM Hospital, Parel
  Mumbai 400 012, Phones: +91-22-24124863, +91-22-24104532, Rel: +91-22-32926896
  Fax: +91-22-24160828, e-mail: mumbai@jaypeebrothers.com
- "KAMALPUSHPA" 38, Reshimbag, Opp. Mohota Science College, Umred Road
  Nagpur 440 009 (MS), Phones: Rel: 3245220, Fax: 0712-2704275
  e-mail: nagpur@jaypeebrothers.com

North America Office
1745, Pheasant Run Drive, Maryland Heights (Missouri), MO 63043, USA Ph: 001-636-6279734
e-mail: jaypee@jaypeebrothers.com, anjulav@jaypeebrothers.com

Central America Office
Jaypee-Highlights Medical Publishers Inc., City of Knowledge, Bld. 237, Clayton, Panama City, Panama Ph: 507-317-0160

Nutrition and Biochemistry for Nurses

First Edition: **2009**

ISBN 978-81-8448-691-9

Typeset at JPBMP typesetting unit
Printed at

To

Student Nurses

around the country
whose questions and comments

continue to inspire the fine tuning
of this textbook

Preface

This textbook has been carefully prepared as per the latest basic BSc (Nursing) Syllabus of the Nursing Council (2004 revision) where nutrition has been combined with biochemistry. Nutrition is a relatively new science, which evolved from biochemistry and physiology. It is often treated as a branch of chemical science or biochemistry.

The separation of biochemistry in the syllabus is sometimes arbitrary. As an author, I have tried to separate some more principles of biochemistry from nutrition aspects and group them with the biochemistry portion of the prescribed syllabus. Blood chemistry and urinalysis have been included in Biochemistry as chapters 16 and 17 and will be essential for Pathology to be studied later in the basic BSc (Nursing) course. MCQs and plenty of study questions have been added to make the text still more student friendly. Readers' constructive suggestions are most welcome and will be implemented in the subsequent editions.

I am grateful to Shri Jitendar P Vij (Chairman and Managing Director) and Mr Tarun Duneja (Director-Publishing) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, for their constant support and encouragement.

Jacob Anthikad

Contents

Part 1: Biochemistry

Part 2: Nutrition

Normal Values

Test	Normal values	Test	Normal values
☐ FBS	70-100 mg%	Calcium	8.5-10.5 mg%
☐ RBS	80-120 mg%	☐ Phosphorus	2.5-5 mg%
☐ PPBS	100-140 mg%	☐ **LIPID PROFILE**	
☐ Urine Sugar	Nil	☐ Cholesterol	150-250 mg%*
☐ Glycosylated Hb.	4.5-8%	☐ HDL Cholesterol	30-70 mg%*
☐ Urea	10-45 mg%	☐ Triglyceride	10-160 mg%
☐ Creatinine	0.7-1.5 mg%	☐ VLDL	6-40 mg%
		☐ LDL	180 mg%
☐ Uric Acid	3-7 mg%	☐ Acid Phosphatase	0-3 KAU/dl
☐ Sodium	133-143 mEq/L	☐ Amylase	25-125 U/dl
☐ Potassium	3.9-5.3 mEq/L		
☐ Chloride	98-108 mEq/L		
☐ Blood non-protein Nitrogen (NPN)	20-40 mg%	*Better to keep serum cholesterol level below 200 mg%	

☐ **LIVER FUNCTIONS TESTS**		☐ **IRON PROFILE**	
☐ Total Protein	6-8 g/dl	☐ Iron	60-150 ug/dl
☐ Albumin	3.4-5 g/dl	☐ TIBC	230-380 ug/dl
☐ A/G Ratio	1.2-1.7	☐ Transferrin	1.2-2 g/dl
☐ Total Bilirubin	0.2-1.2 mg%	☐ Transferrin Satn.	20-50%
☐ Conj. Bilirubin	0.1-0.4 mg%	☐ **URINE**	
☐ SGOT (AST)	5-50 IU/L	☐ Creatinine	1.0-1.8
☐ SGPT (ALT)	5-50 IU/L	☐ Reducing sugars	100 mg/day
☐ Alkaline Phosphatase	100-250 IU/L	☐ Urea	30 gm/day
☐ Gamma G.T. (GGT)	10-45 IU/L	☐ Uric acid	0.8 gm/day
☐ CPK	0-192 IU/L	☐ Chloride as NaCl	10-15 gm/day
☐ CPK - B	0-13 IU/L	☐ Urobilinogen	0.4 gm/day
☐ CPK - MB	0-25 IU/L	☐ Ketone bodies	1 mg/day
☐ LDH	200-400 IU/L	☐ Phosphorus	10 gm/day
		☐ Titrable acidity	200-400 ml N/10 acid

PART – 1

Biochemistry

CHAPTER

1 Biochemical Perspective to Medicine

The term "Biochemistry ions" was introduced by Carl Neuberg in 1903. Biochemistry is the chemical language of life, basic to the understanding of biological and medical sciences. It gives us information regarding the functioning of the cells at the molecular level and also helps in finding remedies for a variety of ailments that afflict men and animals.

SCOPE OF BIOCHEMISTRY

Biochemistry is the science concerned with the chemical basis of life. It is the chemistry of the living matter in its different phases of activity, from the smallest micro-organisms such as viruses to the most complex and highly evolved ones as human beings.

It is involved in finding out answers to two fundamental phenomena of nature namely:

1. How do we grow?
2. Where do we get our energy?

The relationship of the living to their environment, the processes by which an exchange of chemicals takes place between the living organism and its environment through digestion, absorption and exeretion, the processes by which the absorbed materials are utilised for the synthetic reactions leading to growth and replenishment of tissues and multiplication of cell and the species; the metabolic breakdown of the materials to supply energy for all the above processes; the mechanisms which regulate with precision all these processes; the mechanisms by means of hormonal and neuroregulatory stimuli-all these are the subject matter of biochemistry.

Medical biochemistry which is the subbranch studied by doctors and nurses are covered by the following aspects of chemistry:

1. Tissues and foods.
2. Digestion and absorption.

3. Respiration.
4. Blood.
5. Cell membrane and physical chemistry.
6. Tissue metabolism.
7. Glands of internal secretion.
8. Chemistry of excretion.
9. Biochemistry disorders in disease.

IMPORTANCE OF BIOCHEMISTRY TO NURSING

Biochemistry is the language of life. The study of biochemistry by nurse is essential to understand the basic functions of the human body. This study will give her information regarding the functioning of the cells at the molecular level. She will know how the food is digested, absorbed and used for body building. She will also understand how the body gets energy for day today functions. She will be able to appreciate the close interrelation between various metabolic processes taking place in the body. She will get a clear insight into immunity and genes from a study of biochemistry.

Modern nursing care depends on the laboratory analysis of body fluids especially the blood. A systematic study of biochemistry will give her the close relationship between disease manifestation and changes in the composition of blood and other tissues, hence the demarcation of abnormal from the normal values of body fluids is the primary aim of the study of biochemistry by the nurse.

Applications of the basic principles of biochemistry are essential to the nursing profession. The correct diagnosis, nursing care plans, treatment, prevention and control of infectious diseases depend on a sound knowledge of medical biochemistry. Biochemistry is perhaps the most rapidly developing branch of medicine. No wonder, the major share of Nobel prizes in medicine has gone to research workers engaged in biochemistry.

STRUCTURE, COMPOSITION AND FUNCTIONS OF CELL

All living organisms are composed of cells which are minute compartments within which various processes of life occur. Microscopic organisms such as bacteria, some algae and protozoa are composed of single cells. Human body starts from a single cell

but contains about 10^{13} cells at maturity. Our body contains about 200 distinct type of cells. They are muscle cells, bone and cartilage cells, nerve cells, skin cells, visual cells in the eye and many others. Although each cell may show distinct characteristics for the particular functions performed, cells do show some fundamental characteristics. An ultrastructure of a cell is given in Figure 1.1.

The living matter in the cells is the protoplasm, the physical basis of life. The cell consists of an outer limiting membrane, the plasma membrane. The membranes are made up of lipids (mainly of

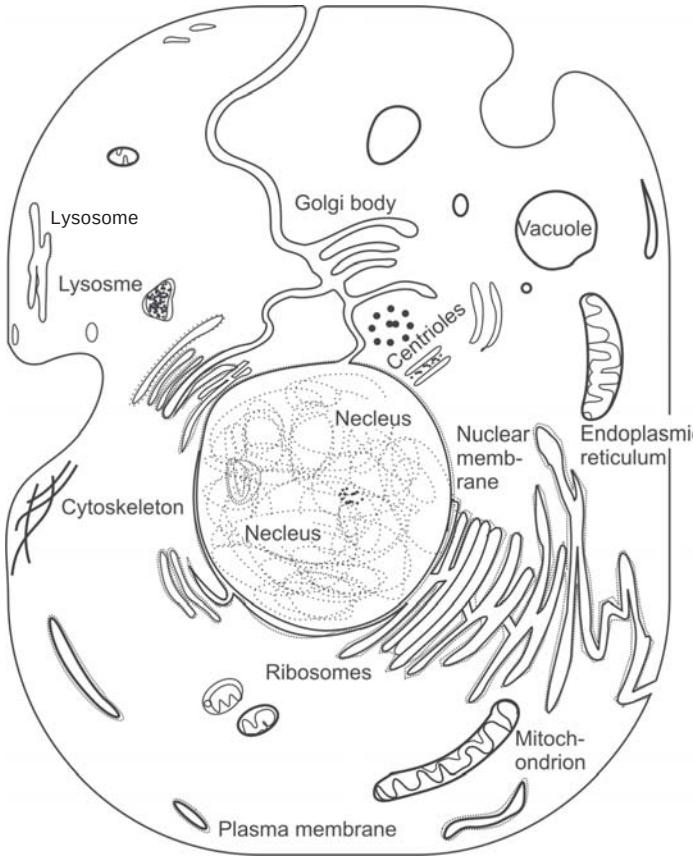


Fig. 1.1: Ultrastructure of the cell

phospholipids), proteins and small amounts of carbohydrates in the form of glycoprotein and glycolipids. Inside the plasma membrane, there are two easily distinguishable regions, i.e., an outer watery granulated cytoplasm and an inner denser almost spherical region, the nucleus. The plasma membrane is important as it helps control the materials that go into and come out of the cell. The simple sugars, amino acids, potassium ions and water can pass through the membrane rapidly but sodium ions and other substances cannot.

Cytoplasm: Organelles

In cytoplasm are suspended various structures called organelles. These are:

Nucleus: Generally it occupies a central position in the cell. It is spherical or oval and much denser than the cytoplasm. It is the seat of all metabolic activities of the cell. All cells in the human body contain nucleus, except mature RBCs in circulation. Nucleus contains DNA, the chemical basis of the genes, which governs all the functions of the cell. The very long DNA molecules are complexed with proteins to form chromatin and are further organised into chromosomes. DNA replication and RNA synthesis (transcription) are taking place inside the nucleus.

In some cells, a portion of the nucleus may be seen as lighter shaded area. This is called *Nucleolus*. This is the area for RNA processing and ribosome synthesis. The nucleus will be very prominent in cells actively synthesising proteins.

Endoplasmic reticulum: This is an elaborate system of membranes containing small particles of ribonucleic acid (RNA). These structures provide a large surface area for cellular enzymes and control the entry and exit of substances into the cell.

Ribosomes: They are spherical bodies. They contain ribonucleic acids (RNA) and are especially active in the synthesis of proteins.

Mitochondria: Within the cytoplasm there are a number of rod like (3-4 μm in length) non-cellular structures called mitochondria. Their function is production of energy in cellular respiration.

Structure of the Mitochondrion (Fig. 1.2)

The components of the electron transport chain are located in the inner membrane. Although, the outer membrane contains special

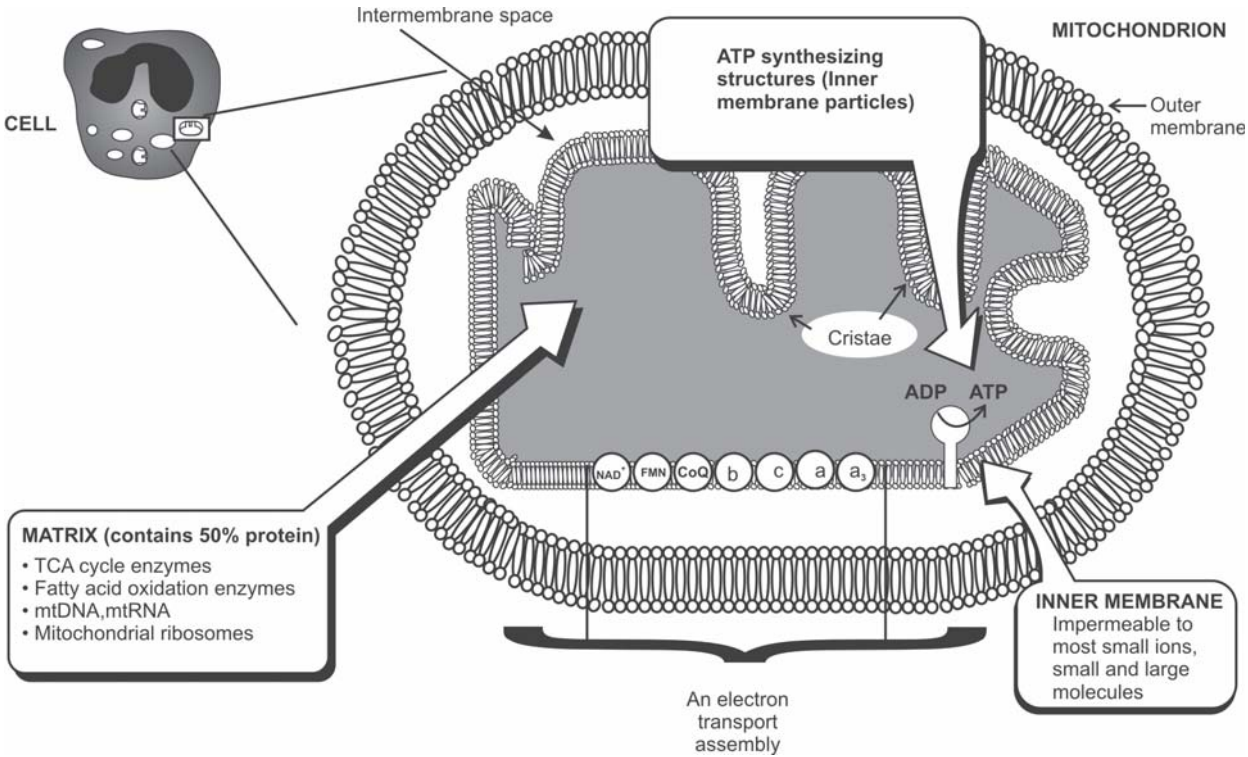


Fig. 1.2: Structure of a mitochondrion showing schematic representation of electron transport chain and ATP synthesizing structures on inner membrane. mtDNA = mitochondrial DNA; mtRNA = mitochondrial RNA

pores making it freely permeable to most ions and small molecules, the inner mitochondrial membrane is a specialized structure that is impermeable to most ions including H^+, Na^+ and K^+, small molecules such as ADP, ATP, pyruvate and other matabolites important to mitochondrial function. Specialized carriers or transport systems are required to move ions or molecules across this membrane. The inner mitochondrial membrane is unusually rich in protein, half of which is directly involved in electron transport and oxidative phosphorylation. Also it is highly convoluted. The convolutions are called CRISTAE and serve to increase greatly the surface area of the membrane.

ATP Synthetase Complexes

These complexes of proteins are referred to as inner membrane particles and are attached to the inner surface of the inner mitochondrial membrane. They appear as spheres that protrude into mitochondrial matrix.

Mitochondrion is called as the "Powerhouse of the cell" as it extracts energy from the oxidation of foodstuffs and traps as chemical energy with the formation of high energy chemical bonds of adenosine triphosphate (ATP). The final oxidation steps of carbohydrates and lipids (TCA cycle) also take place there. Urea and heme synthesis partly take place in the mitochondria.

CYTOPLASM-CYTOSOL

Cytosol is the liquid matrix of the cell, mostly water (Cytosol + organelles except nucleus = cytoplasm) that contains salts, dissolved molecules enzymes etc. Anaerobic glycolysis (energy metabolism) takes place in the cytosol.

Enzymes: These are special class of proteins that facilitate all the chemical reactions in the cell by providing energy, disposing waste, building proteins and creating new cells. Enzymes are molecular catalysts that initiate chemical reactions without being used up or inactivated in the process. There are thousands of different enzymes in each cell, each one specially designed to carry out the many individual processes on which life depends.

PROKARYOTES AND EUKARYOTES

There are two basic types of cells:
Prokaryotic and Eukaryotic.
Prokaryotic cells are small and simple but fast. The differences between prokaryotic and eukaryotic cells are listed in Table 1.1. They are more primitive, small and without organelles, e.g. bacteria, blue-green algae.

Eukaryotic Cells are Large and Versatile but Slow

They are more advanced, larger and contain organelles, e.g. all higher species: Animals, plants and fungi. Human cells are of enkaryotic type.

Table 1.1: Differentiation between prokaryotic and eukaryotic cells

Prokaryotic cell	*Eukaryotic cell*
1. Procaryotic cells are unicellular, e.g. bacteria. 2. Smaller in size, ranging from 1-10 mm in diameter. 3. They have only a single membrane which is usually surrounded a cell wall. 4. They are similar in structure within a species. 5. There is a single chromosome and a molecule of double helical DNA which is known as nuclear zone.	1. May be unicellular as well as multicellular, e.g. Hapatocyte, Erythrocyte. 2. They are approximately 10000 times large and more complex in structure. 3. They have cell membranes and several other membrane containing intracellular, mitochondria, golgi apparatus etc. 4. They vary from one tissue to another with respect to their structure as well as function e.g., Liver parenchymal cells, nerve cells, RBCs etc. 5. It contains several chromosomes which get divided into daughter chromosomes during mitosis.

MICROSCOPY

The Light Microscope

The resolving power of the light microscope is about half the wave length of the light being used. The light microscope used in microbiology and biochemistry generally employs a 90 power objective lens with a 10 power eye piece thus magnifying the specimen 900 times. Particles 0.2 μm in diameter are therefore magnified to about 0.2 mm and so become clearly visible. Further magnification would give no greater resolution in detail and would reduce the visible area.

The Electron Microscope

The high resolving power of the electron microscope has enabled observation of the detailed structures of prokaryotic and eukaryotic cells. The superior resolution of an election microscope is due to the fact that elections have a much shorter wave length than the photons of white light. The image is visualized by allowing it to impinge on a fluorescent screen and recorded on a photographic film. Viruses, with diameters of 0.01 to 0.2 μm can be easily visualized.

Dark Field Microscopy

Dark field microscopy is frequently performed on the same microscope on which bright field microscopy is performed. Illummation is obtained using a special condenser that both blocks direct light rays and deflects light off a mirror on side of the condenser at an oblique angle. This creates a "dark field" that contrasts against the high lighted edge of the specimens. This technique is particularly useful for observing organisms such as Triponema pallidum, a spirochaete which is less than 0.2 μm in diameter and therefore cannot be observed with direct light.

Phase Contrast Microscopy

The phase contrast microscope takes advantage of the fact that light waves passing through transparent objects such as cells, emerge in different phares depending on the properties of the materials though which they pass. A special optical system converts differences in phase into difference in intensity so that some structures appear darker than others. Internal structures are thus differentiated in living cells.

AUTORADIOGRAPHY

If cells that have incorporated radioactive atoms are fixed on a slide, covered with a photographic emulsion and stored in the dark for a suitable period of time, tracks appear on the developed film emanating from the sites of radioactive disintegration. If the cells are labeled with a weak emitter such as tritium, the tracks are sufficiently short to reveal the position of the radioactive label in the cell. The procedure called autoradiography has been particularly useful in following the replication of DNA.

THE FLUID MOSAIC MODEL OF CELL MEMBRANE

A theory of membrane structure called the fluid mosaic model was postulated in 1972 by Singer and Nicolson, which is now widely accepted. The main postulates of this theory are:

a. A mosaic is a structure of many different small parts. Similarly, the plasma membrane is composed of different kinds of macromolecules like phospholipids, integral proteins, peripheral proteins, glycoproteins, glycolipids and cholesterol.
b. According to this model, the matrix or continous part of membrane structure is a polar lipid bilayer.
c. The bilayer is fluid because of the hydrophobic tails of its polar lipids consist of an appropriate mixture of saturated and unsaturated fatty acids that is fluid at the normal temperature of the cell.
d. This lipid bilayer has a dual role; it is both a solvent for integral membrane proteins and a permeability barrier.
e. Proteins are interspersed in the lipid bilayer of the plasma membrane, producing a mosaic effect.
f. The fluid mosaic model proposes that the integral proteins of membrane have hydrophobic non-polar ammino acid side chain, e.g., valine and leucine which would cause such proteins to dissolve in the central hydrophobic protion of the bilayer and thus, they are embedded within the lipid layer.
g. Peripheral membrane proteins have essential hydrophilic polar amino acid side chains, such as glutamate and serine, which are bound by electrostatic attraction to the hydrophilic electrically charged polar heads of the bilayer lipids.
h. The peripheral proteins float on the surface of ″sea″ of predominantly phospholipid molecules, whereas the integral proteins are like icebergs, almost completely submerged in the hydrocarbon core.
i. There are no cavalent bonds between lipid molecules of the bilayer or between the protein components and the lipids.
j. Fluid mosaic model allows the membrane proteins to move around laterally in two dimensions unless restricted by special interactions and that they are free to diffuse from place to place within the flame of the bilayer, whereas they cannot tumble from one side of the lipid bilayer to the other. Thus, there is a mosaic pattern of membrane proteins in the fluid lipid bilayer.

The Singer-Nicolson model can explain many of the physical, chemical and biological properties of membrane. Therefore, it has been widely accepted as the most probable molecular arrangement of lipids and proteins of membranes.

TRANSPORT MECHANISMS ACROSS CELL MEMBRANE

Movement of substances across the cell membrane is dependent on their lipid solubility. Lipid bilayer of the cell membrane allows lipid soluble solutions to pass through it.

Lipid insoluble substances are selectively transported by protein molecules present in the cell membrane called transport proteins.

Transport proteins are of two types:
1. Channel proteins.
2. Carrier proteins.

Channel Proteins

They have watery spaces through the molecule and therefore, allow free movement of certain ions and molecules.

Carrier Proteins

They bind to substances that are to be transported and undergo comformational change. This causes movement of substances from one side of the membrane to the other side.

Both carrier and channel proteins are highly selective in allowing passage of ions or molecules across the membrane.

Transport mechanisms are of two broad types:

1. Passive transport.
2. Active transport.

Passive transport is by diffusion.

DIFFUSION

Diffusion is the continuous movement of molecules among one another in lipid or gaseous state. It is of two types:
1. Simple diffusion.
2. Facilitated diffusion.

Simple Diffusion

This is the movement of molecules or ions through the cell membrane without the involvement of carrier proteins. Diffusion occurs from the region of higher concentration to a region of lower concentration.

Diffusion depends on:
a. Concentration of substance.
b. Velocity of kinetic motion.
c. Number of openings in the membrane.

Simple diffusion occurs through:
a. Lipid layer.
b. Protein channels.

Diffusion through Lipid Layer

Substances like O_2, N_2, CO_2 and alcohol dissolve directly in the lipid layer and diffuse through the cell membrane. Rate of diffusion is directly proportionate to their lipid solubility.

Diffusion through Protein Channels

Substances like water can easily pass through protein channels. These channels are highly selective for transport of ions or molecules. This selective permeability depends on diameter, shape and electrical charges of the channel.

Facilitated Diffusion

This is also called carrier mediated diffusion. The substance is transported with the help of a specific carrier protein, e.g. Glucose and amino acids.

The characteristic features of facilitated diffusion are:
a. Carrier mechanisms can become saturated.
b. Can operate in both directions.
c. Rate of transport is more than simple diffusion.

OSMOSIS

Osmosis is a simple type of diffusion. It is the movement of water across a semipermeable membrane from a region of lower solute

concentration to a region of higher solute concentration. Pressure required to prevent osmosis is called osmosis pressure. Osmotic pressure depends on the number of particles in the solution and not on the type or size of the particles.

QUESTION

1. Why is mitochondrion called the powerhouse of the body?

MULTIPLE CHOICE QUESTIONS

2. The process by which solute can often pass through membrane against concentration gradient is known as:

A. Endocytosis and exocytosis
B. Passive diffusion
C. Active transport
D. Facilitated diffusion

3. The process by which solute can often pass through membrane against concentration gradient is known as:

A. Emulsification
B. Passive diffusion
C. Active transport
D. Facilitated diffusion

4. Osmosis is the flow of following through a semipermeable membrane:

A. Solute
B. Solvent
C. Solution
D. All the above

5. An example for colloid is:

A. Triglycerides
B. Vitamins
C. Nucleic acids
D. Proteins

6. Biochemistry is the study of:

A. Immunity
B. Action of drugs in the body
C. Chemistry of life
D. Structural aspects of the body.

7. **An eukaryotic cell differs from prokaryotic cell by the presence of:**
   A. Cytoplasm
   B. Nuclear membrane
   C. Nucleus
   D. Mitochondria
8. **All the following are cell organelles *except:***
   A. Lysosomes
   B. Gogi apparatus
   C. Robosomes
   D. Peroxisomes
9. **The technique used to separate cell organelles is:**
   A. Filtration
   B. Paper electrophorosis
   C. Differential centrifugation
   D. Chromatography
10. **The major complex organic biomolecules of cells are:**
   A. Proteins
   B. DNA and RNA
   C. Polysaccharides
   D. All the above
11. **Which of the following is the function of mitochondria?**
   A. Protein synthesis
   B. Intracellular sorting of proteins
   C. Oxidative phosphorylation
   D. Glycolysis
12. **The following cell organelle is involved in protein biosynthesis:**
   A. Mitochondrion
   B. Nucleus
   C. Lysosome
   D. Ribosome

ANSWERS

2(A)	3 (C)	4 (B)	5 (D)	6 (C)	7 (B)
8 (C)	9 (C)	10 (D)	11(D)	12(D)	

CHAPTER

2 Carbohydrate Chemistry

Carbohydrates include a large group of compounds commonly known as starches or sugars which are widely distributed in plants and animals. Chemically, they are polyhydric alcohols having potentially active aldehyde and ketone groups. Because the ratio of hydrogen to oxygen in these compounds is often 2 to 1, having the empirical formula $C_n (H_2O)_n$, they are given the name carbohydrates or hydrates of carbon. In general, they are white solids, freely soluble in water with the exception of certain polysaccharides. Carbohydrates of lower molecular weights have a sweet taste.

There are practical reasons for the universal use of carbohydrates in diets. The yield of cereals, the primary source of carbohydrates, is high per unit area. Therefore they are widely available and are economic source of energy. They are easily packed and have a long shelf life when stored dry. They are mild flavoured and combine well with other foods. Carbohydrate foods are easy to prepare.

BIOLOGIC IMPORTANCE

1. Carbohydrates are the main sources of energy in the body. When carbohydrates are oxidised in the body, they liberate CO_2, water and energy. They are the least expensive source of energy to the body for muscular work. Each gram of carbohydrate provides 4 Kcal of energy when oxidised. They supply the major portion of energy required by living cells. Brain cells and RBCs wholly depend on glucose as energy source.
2. The body will use carbohydrates preferably as a source of energy when it is supplied in diet, thus sparing proteins for tissue building purposes.
3. The main source of energy for CNS is glucose. Prolonged hypoglycaemia results in irreversible damage to brain tissue.
4. All carbohydrates are digested to form glucose before they can be absorbed into blood steam and get transported to different tissues of the body.

5. Glucose is the sugar of the blood and is exerected in urine in glycosuria.
6. Glucose is stored as glycogen in liver and muscles.
7. Some carbohydrates are necessary in the diet so that oxidation of fats can proceed normally.
8. Lactose has several functions in the GI tract. It promotes the growth of desirable bacteria, some of which are necessary for the synthesis of B complex vitamins.
9. Though dietary fibre yields no nutrients to the body, it adds to the stimulation of peristaltic movement of GI tract and provides ruffage to avoid constipation.
10. Carbohydrates add flavour and variety to diet.

Sources of Carbohydrates

Carbohydrates, often called starches and sugars are widely distributed in plants and animals. In plants, they are produced by photosynthesis of water from the soil and CO_2 from air. The prefix "Photo" indicates the importance of sunlight in the process. Plants are thus the primary source of food in the world.

In animal cells, carbohydrate serves as an important source of energy. Animal tissues contain glycogen and body fluids contain glucose both of which are carbohydrates. Some carbohydrates have highly specific functions such as ribose in nucleic acids, galactose in some lipids and lactose of milk.

There are three main sources of carbohydrates.

1. *Starches:* These are present in cereals, roots and tubers e.g., Rice, wheat, ragi, pulses, topiaca, yam, colcasia and potatoes.
2. *Sugars:* Disaccharides ,e.g. sucrose, lactose, maltose.
3. *Cellulose:* This is the tough fibrous lining found in vegetables, fruits and cereals. It is hard to digest and has no nutrition value. However, cellulose acts as ruffage and prevents constipation.

Glucose also known as dextrose is present in fruits and honey. It is the "sugar" of the blood. Hydrolysis of cane sugar (sucrose) maltose, lactose and starch yield glucose.

Fructose also known as levclose, is present in fruit juices, and honey. It is obtained by hydrolysis of cane sugar.

Galactose: Not found free in nature, its only source being hydrohysis of lactose, milk sugar. It also occurs in cerebrosides (glycolipids) present in brain and nerve tissue. Hence, it is nutritionally important.

Sucrose occurs in sugar cane, beet root, carrot and pineapple. It is manufactured on large scale from sugarcane and beet root.

Maltose is obtained from starch, germinating cereals and malt.

Lactose is present in the milk of all mammals.

Malnutrition: **Deficiencies and overconsumption**

If the carbohydrate intake in diet is insuffient, it leads to malnutrition and other metabolic disorders. Tissue protein and fat will be used up for energy purposes. Excess carbohydrates leads to obesity.

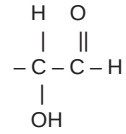
Balanced Diet

Carbohydrates rich in natural fibre should constitute 60% of energy requirements (calorie value). Proteins should give 15-20% of daily energy needs and fats 20-30% of the energy needs. Carbohydrates are the cheapest source of energy. Glucose derived from the digestion of carbohydrates is the main source of energy in the body. Hence, diet should contain adequate amounts of carbohydrates to meet a greater part of the energy needs.

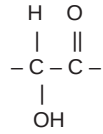
CLASSIFICATION

Carbohydrates are classified into 4 major groups as below:

Monosaccharides: Monosaccharides, called simple sugars, are those which cannot be hydrolysed into a simpler form. The general formula is $C_nH_{2n}O_n$. The simple sugars may be subdivided into trioses, tetroses, pentoses, and hexoses depending upon the number of C atoms (Tables 2.1 and 2.2). They are aldo sugars or keto sugars depending upon the aldehyde or ketone group present.



Aldehyde Group



Ketone Group

Simple sugars	*Formula*	*Aldo sugars*	*Keto sugars*
Trioses	$C_3H_6O_3$	Glycerose	Dihydroxyacetone
Tetroses	$C_4H_8O_4$	Erythrose	Erythrulose
Pentoses	$C_5H_{10}O_5$	Ribose	Ribulose
Hexoses	$C_6H_{12}O_6$	Glucose	Fructose

Disaccharides: They are carbohydrates which yield two molecules of the same or different monosaccharides when hydrolysed. Their general formula is $C_{12}H_{22}O_{11}$ and examples are sucrose, lactose and maltose (Table 2.3).

Oligosaccharides: They yield 2-8 monosaccharide molecules on hydrolysis. Examples are raffinose, stachyose and scorodose, blood group antigens.

Polysaccharides: They yield more than 8 molecules of monosaccharides on hydrolysis. The general formula is $(C_6H_{10}O_5)_x$ and examples are starch, dextrin, glycogen.

They are further subdivided into:

a. Homopolysaccharides: They are polymers of the same monosaccharide units, e.g. starch, glylcogen, cellulose, dextrin, dextran and inulin.
b. Heteropolysaccharides: Polymer of different monosaccharide units or their derivatives, e.g. mucopolysaccharides (Glycosaminoglycans).

Asymmetry

In the formula for glucose, it will be noted that a different group is attached to each of the 4 bonds of carbon atoms 2 to 5. A carbon atom to which 4 different atoms or groups of atoms are attached is called asymmetric carbon atom.

Table 2.1: Examples of pentoses

Sugars	*Sources*	*Importance*	*Reactions*
D-Ribose	Nucleic acids	Structural elements of nucleic acids and coenzymes, e.g., ATP, NAD, NADP, Flavoproteins.	Reduces Benedict's, Fehling's, Barfoed's and Haynes' solutions. Forms distinctive osazones with phenyl hydrazine.
D-Ribulose	Formed in metabolic processes	Intermediates in direct oxidative pathways of glucose breakdown.	Those of Keto sugars.

Table 2.2: Hexoses of physiologic importance

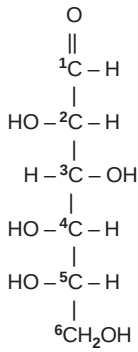
Sugars	*Sources*	*Importance*	*Reactions*
D-Glucose	Ripe grapes and most sweet fruits and honey. Sugar of the blood. Occurs in urine of the diabetics. Hydrolysis of starch, cane sugar, maltose, and lactose.	The sugar of the body, the sugar carried by the blood and the principal one used by tissues. Glucose is usually the sugar of the urine when glycosuria occurs.	As a reducing sugar, reduces Benedict's, Haynes' and Barfoed's solutions. Gives osazone with phenyl hydrazine fermented by yeast.
D-Fructose	Fruit juices, honey, hydrolysis of cane sugar. Most soluble and sweetest sugar. Double sweeter than glucose.	Can be changed into glucose in the liver and so used in the body.	Reducing sugar,reduces Benedict's, Haynes' and Barfoed's solutions. Forms osazone identical with that of glucose, fermented by yeast.
D-Galactose	Hydrolysis of lactose	Can be changed to glucose in the liver and metabolised. Synthesised in the mammary gland to make lactose of mother's milk. A constituent of glycolipids.	Reducing sugar,reduces Benedict's, Haynes' and Barfoed's solutions. Forms osazone distinct from glucose and fructose, and fermented by yeast.
D-Mannose	Hydrolysis of plant mannosans and gums	Convertible to glucose in the body. A constituent of prosthetic polysaccharide of albumins and globulins.	Reducing sugar, reduces Benedict's Haynes' Barfoed's reagents. Forms same osazone as glucose.

Table 2.3: Disaccharides

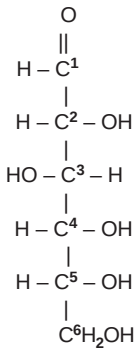
Sugars	*Occurrences*	*Reactions*
Maltose	Hydrolysis of starch, germinating cereals and malt.	Reducing sugar, forms osazone with phenyl hydrazine, fermentable. Hydrolysed to D-Glucose.
Lactose	Milk. May occur in urine during pregnancy. Formed in the body from glucose.	Reducing sugar, forms osazone with phenyl hydrazine. Not fermentable by yeast. Hydrolysed to glucose and galactose.
Sucrose	Cane and beet sugar. Carrot and pineapple.	Non-reducing sugar, does not form osazone. Fermentable. Hydrolysed to fructose and glucose.

Isomerism

The presence of asymmetric carbon atoms in a compound makes possible the isomerism of that compound. Compounds which are identical in composition and differ only in spatial configuration are called stereoisomers. Two such isomers of glucose, one of which is the mirror image of the other are shown below:



L–Glucose



D–Glucose

The form in which the hydroxyl group next to the primary hydroxyl is projected to the right of the carbon chain is the D-form, and the form in which it is projected to the left, is the L-form.

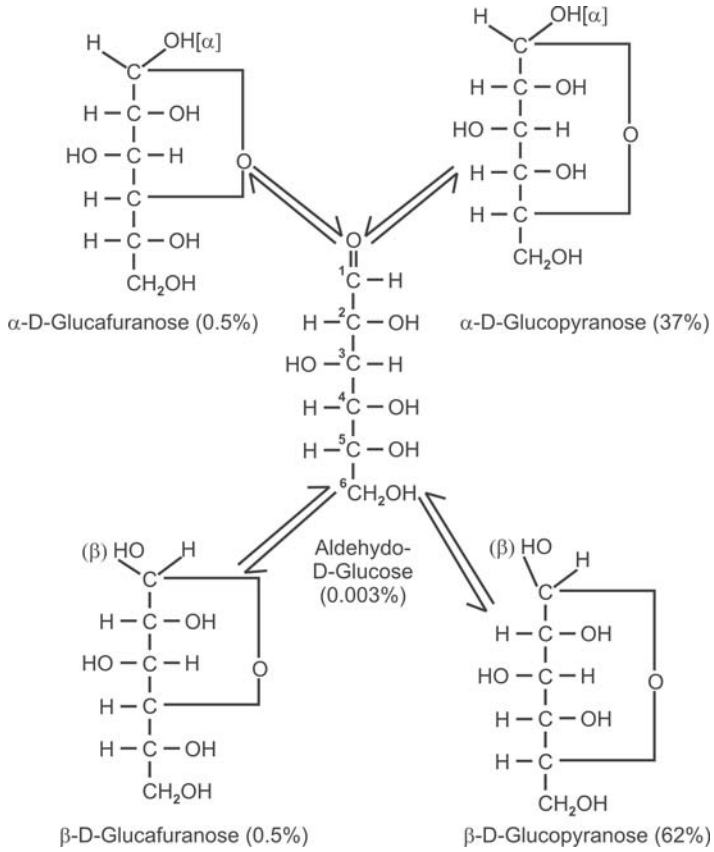
Optical isomerism: The presence of asymmetric carbon atoms also gives optical activity in the compound. When a beam of polarized light is passed through a solution exhibiting optical activity, it will be rotated to the right or left in accordance to the type of the compounds, i.e., optical isomer present. A compound which causes rotation of polarized light to the right is said to be dextrorotatory designated by plus (+) sign. Rotation of beam of light to the left is levorotatory designated by minus (-) sign.

Mutarotation

Mutarotation is defined as a change in specific rotation of optically active solution without any change in other properties.

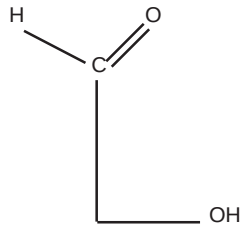
D-glucose in aqueous solution exists as an equilibrium mixture of five isomers.

When glucose is dissolved in water, the optical rotation of the solution gradually changes and attains an equilibrium value. This change in the optical rotation is called mutarotation (Invert Sugar).

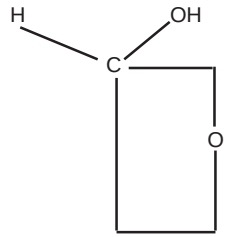


Cyclic Forms of Sugars

The close proximity of an aldehyde (or ketone) group and an alcohol group in the carbohydrate facilitates their reaction to give cyclic hemiacetals (or hemiketals). This can occur with the alcohol group of either carbon 4 or carbon 5.

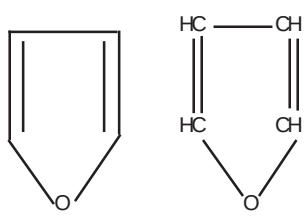


Aldehyde

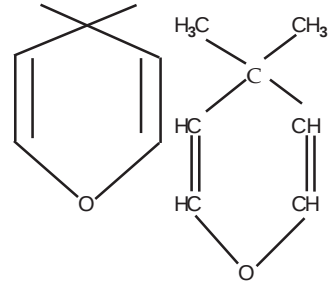


Cyclic hemiacetals

In the first case, a ring consisting of 4 carbon atoms and one oxygen atom is created. This is called a Furanose ring. In the second case the ring contains five carbon atoms in addition to oxygen. This is called a Pyranose ring.

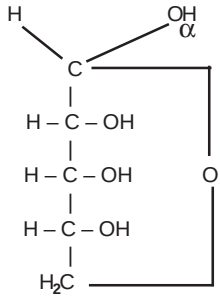


Furan

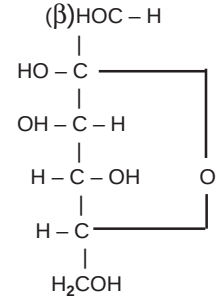


Pyran

Because of the asymmetry present in the terminal carbon, 2 forms of each ring structure can exist.



A pyranose form of D-ribose
(α-D-ribopyranose)



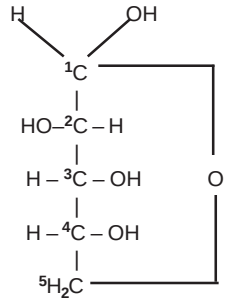
A furanose form of D-fructose
(β-D-fructofuranose)

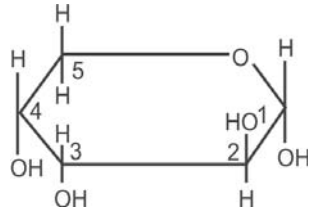
Haworth Projections

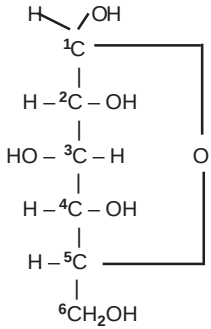
Sir Walter Haworth in 1925 established that glucose is existing in biological systems, not as a rectangle but as a pyranose ring and

was awarded the Nobel prize in 1937. To accurately represent the ring structure, the Haworth projections are used:

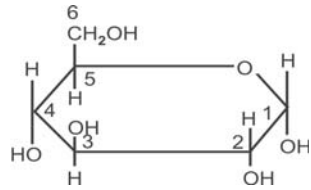
In Haworth projection, any group to the right of the carbon chain is written down, and those to the left are written up. When there are more carbon atoms in the sugar than are involved in the ring formation, the rule is that if the ring is to the right, the extra carbon or carbon will be up.

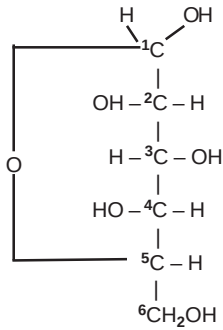




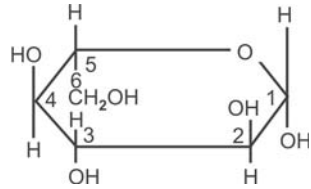


α-D-Glucopyranose





β-L-Glucopyranose



REACTIONS OF CARBOHYDRATES

The carbohydrates, being polyhydroxy aldehydes and ketones, generally are capable of undergoing all of the normal reactions of aldehydes and ketones, e.g., oxidation, reduction, dehydration, esterification, ether formation and addition to the carbonyl double bond.

Reducing and Non-reducing Sugars

Any free aldehyde or α-hydroxy ketone is capable of being oxidized, thus causing the reduction of some other substances. Any of the sugars in the free aldehyde or ketone form or in any other form in equilibrium with the free aldehyde or ketone (hemiacetal forms) can be oxidized.

Carbohydrates capable of undergoing oxidation without having to be hydrolyzed first, is a reducing sugar. Sugars like sucrose is a non-reducing disaccharide.

A variety of reagents can be used to carry out the oxidation of carbohydrates and be themselves reduced. The most common is the cupric ion (Cu^{++}) which is the active ingredient in Fehling's, Benedict's and Barfoed's reagents for the detection of reducing sugars. The reaction is as follows:

$$CuSO_4 \longrightarrow \underset{\text{Cupric}}{Cu^{++}} + SO_4^{--}$$

$$\text{Reducing sugar} + 2\,Cu^{++} \longrightarrow \underset{\text{Blue}}{} \qquad \text{Oxidized sugar} + \underset{\text{Cuprous}}{2\,Cu^{+}}$$

$$\underset{\text{Cuprous}}{2\,Cu^{+}} + 2\,OH^{-} \longrightarrow \underset{\text{Yellow}}{2\,CuOH} \longrightarrow \underset{\substack{\text{Cuprous Oxide}\\ \text{Red}}}{Cu_2O\downarrow} + H_2O$$

The colour of the solution or precipitate gives an approximate amount of reducing sugars present in the solution. This can be estimated as:

Blue colour	Nil
Green colour	Upto 0.5% (+)
Yellow colour	Upto 1.0% (++)
Orange colour	Upto 1.5% (+++)
Red colour	Upto 2.0% (++++)
Brick red precipitate	More than 2%

Benedict's qualitative reagent contains cupric sulphate, sodium carbonate and sodium citrate, whereas Fehling's solution contains cupric sulphate, sodium carbonate and sodium potassium tartrate.

Sodium citrate in Benedict's reagent and sodium potassium tartrate (Rochelle salt) in Fehling's solution prevent the precipitation of cupric hydroxide or cupric carbonate, by forming a deep blue solution, slightly dissociated complexes with the cupric ions. The complexes dissociate sufficiently to provide a continuous supply of readily available cupric ions for oxidation.

Osazone Formation

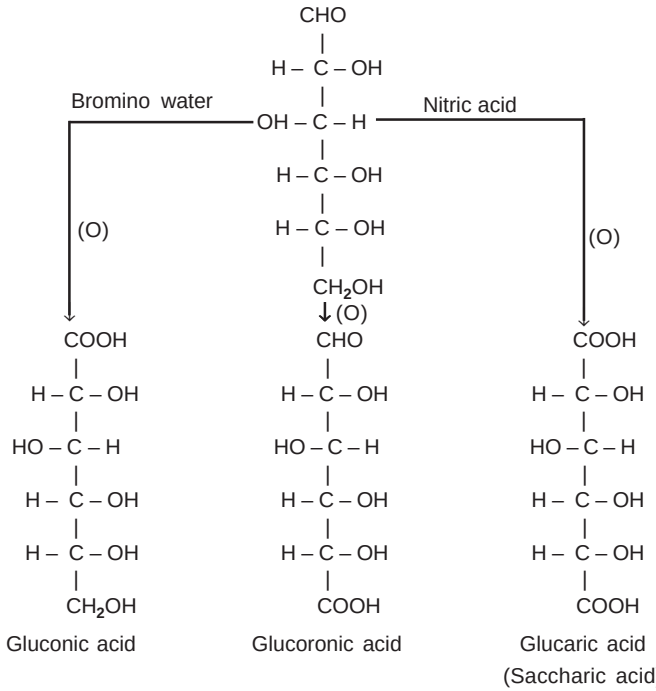
Reducing sugars can be distinguished from one another by phenyl hydrazine test when characteristic osazones are formed. These osazones have characteristic crystal structures, melting points, precipitation time and show different crystalline form under a microscope.

Glucose, fructose and mannose give the same needle shaped, yellow osazone, and they cannot be differentiated from one another by this test. But maltose gives sun flowered osazone while lactose gives cotton ball shaped osazone.

Oxidation

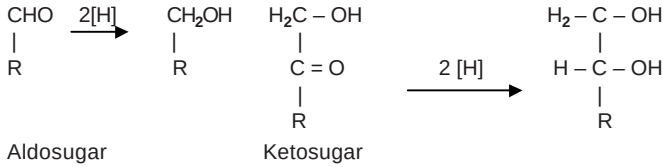
Oxidation of aldoses forms acids as end products.

Oxidation of the aldehyde group forms aldonic acids. However, if the aldehyde group remains intact and primary alcohol group at the opposite end of the molecule is oxidized, uronic acids are formed.



Reduction

The monosaccharides may be reduced to corresponding alcohols by reducing agents like sodium amalgam.



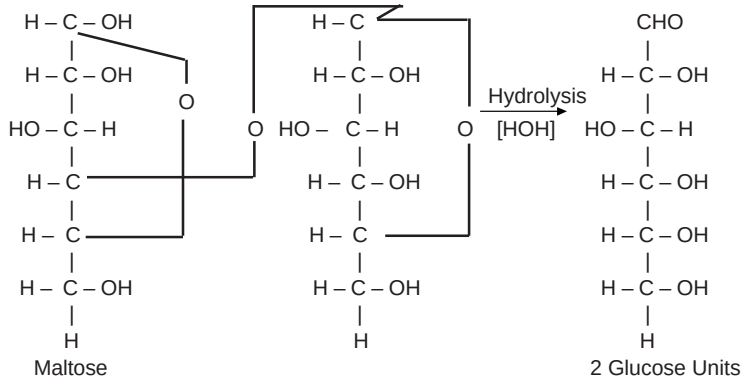
Glucose yields sorbitol, galactose yields dulcitol, and fructose yields mannitol and sorbitol.

Disaccharides

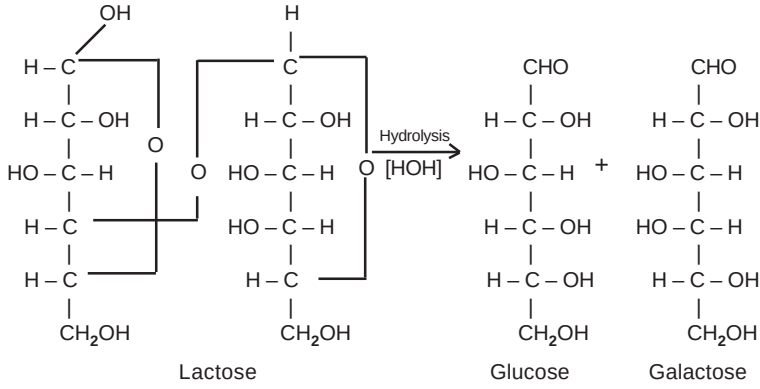
The disaccharides are carbohydrates that can be hydrolysed into two units of monosaccharides. Sucrose is a non-reducing sugar while lactose and maltose are reducing carbohydrates.

Maltose (2 Glucose Units)

Maltose consists of two molecules of D-glucose joined by a (1, 4)-glycosidic linkage. Maltose or malt sugar does not occur in free state but is formed as an important transitory intermediate product of the digestion of starch into glycogen and glucose.



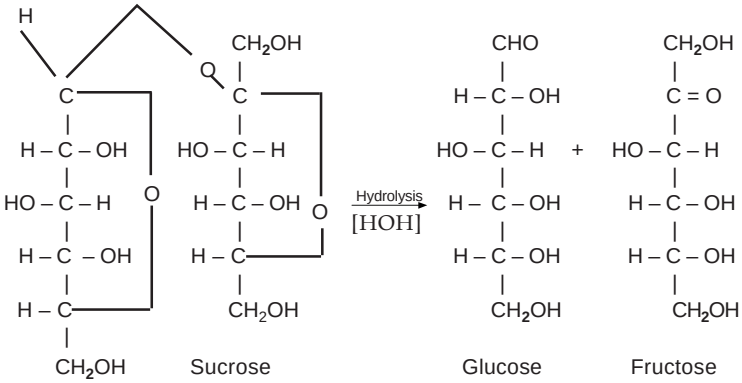
Lactose (Glucose Plus Galactose)



Lactose occurs in mammalian milk. It is a reducing sugar. It is formed by galactose and glucose linked by β 1-4 glycosidic linkage. As one of two aldehyde groups in free, it shows reducing properties and forms cotton ball osazone crystals.

Sucrose (Glucose Plus Fructose)

Sucrose is widely distributed in plants. In the case of sugar cane, sugar beets and sugar maples, the concentration is sufficient for commercial production. Sucrose is not a reducing sugar as both the – CHO and > C = O groups are involved in linkage and are not free.



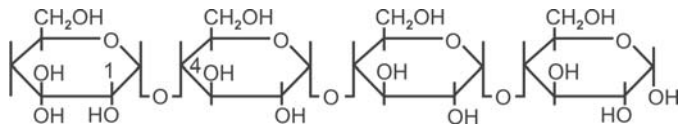
Polysaccharides

Starch

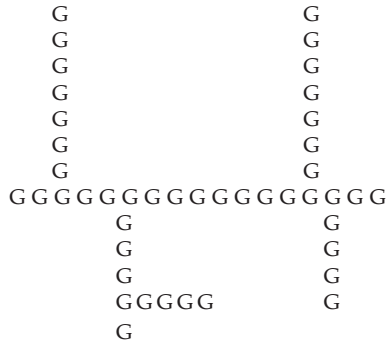
Starch is the major storage form of carbohydrate in plants. It usually occurs in the form of compact insoluble grains inside the plant cells. The starch grains are composed of two different polysaccharides having different properties, namely amylose 19-25% and amylopectin (75-83%).

Amylose: A polysaccharide in which glucose units are joined in α-1, 4-glucoside linkages to form long slender chains.

The molecular weight of amylose is 60,000 corresponding to a chain of 300 to 400 glucose units. Amylose is soluble in water and is less viscous than starch.



Amylopectin: This polysaccharide possesses the same basic chain as amylose but they are larger molecules. They have molecular weights as high as 2,00,000 or more, corresponding to 1000 to 1300 glucose units.



They are highly branched and soluble in warm water.

Hydrolysis of Starch: Starch which is composed of several glucose units is hydrolysed to form first, maltose and finally glucose molecules. Hydrolysis of starch can be brought about by both enzymes and acids.

Enzymes which hydrolyse starch are amylases, and they are present in saliva as ptyalin and in pancreatic juice as pancreatic amylase. Amylase acts on starch, hydrolysing them into fragments of dextrins, and ultimately to maltose molecules. They act at the 1-4 glucosidic linkages. The products of hydrolysis are given below:

Starch
↓
Soluble Starch
↓
Amyladextrin + $Maltose^{+}$
↓
Erythrodextrin + $Maltose^{++}$
↓
Achrodextrin + $Maltose^{+++}$
↓
Maltose + $Maltose^{++++}$

Starch when completely hydrolysed by dil. HCl fields glucose. Starch is used for the manufacture of glucose, dextran, custard powder and sago.

Test of Starch

Starch will form a blue coloured complex with Iodine. This colour disappears on heating but reappears on cooling. This is a physical change and not a chemical change.

Test for Carbohydrates (MolischTest)

To 2 ml of the unknown solution, add 2 drops of fresh 1% α-naphthol reagent and mix. Pour 2 ml of conc. H_2SO_4 so as to form a layer below the mixture. A red violet ring indicates carbohydrate.

Glycogen (Animal Starch)

This is the major carbohydrate reserve in animals. In most mammals deposits of glycogen are maintained especially in the liver and in the skeletal muscles. Liver may store 200 g and muscles 350 g of glycogen.

The structure of the glycogen is essentially the same as amylopectins, except that there is much more extensive branching. This gives an increased solubility. Glycogen is quite readily put into suspension even in cold water.

Cellulose

Cellulose forms the chief constituent of the structure of the cell wall of plants. It is similar in structure to amylose, except that all of the glucose are held together by β 1-4 glucoside linkages.

It is highly insoluble and resistant to hydrolysis. There is no enzyme in the human beings to break the β1-4 glycosidic linkage. It therefore passes through the human digestive tract without being attacked by the enzymes. Cellulose is consumed but not digested. Cellulose forms the bulk of faecal matter. When cellulose is not sufficient in the diet, constipation results.

In industry, cellulose is used for manufacture of rayon and explosives.

Dextran

Dextran is a polysaccharide, closely related to starch and glycogen. It has a molecular weight of approximately 50,000. It is a polymer

of D-glucopyranose units. It is synthesised from sucrose by certain bacteria. It is used as a blood substitute in extensive loss of blood. It is a blood volume extender. It can maintain the smotic pressure of the blood but has an adverse effect on blood clotting process.

Inulin

It is a polysaccharide, each molecule of which is composed of about 80 D-fructose units. It occurs as a reserve carbohydrate in the tubers and roots of chickory, dhalia, dandelions and in the bulb of onions and garlic. It is a white crystalline powder, sweet to taste. It is readily soluble in hot water and does not give any colour with iodine. It has no reducing property.

Inulin is not hydrolysed by enzymes of the gastrointestinal tract and does not undergo any metabolic change in the body. When injected intravenously, it is excreted quantitatively by glomerular filtration within a short time. It does not undergo any reabsorption in the tubules. This property of inulin clearance is made use of in the determination of the rate of glomerular filtration or inulin clearance in an individual (urine).

Mucopolysaccharides

Proteoglycans or carbohydrates containing uronic acid and amino sugars present in connective tissues. They are viscus and act as lubricants and shock absorbers.

Mucopolysaccharides represent a variety of polysaccharides present largely in the ground substance of connective tissue along with mucoproteins. They are acidic substances containing aminosugars or their derivatives. They are divided into the following subgroups.

a. Neutral mucopolysaccharides, such as immunologically important blood group substances, which contain only an N-acetyl hexosamine and a hexose.
b. The second group has a hexuronic acid (e.g., D-glucoronic acid) along with an N-acetyl hexosamine—The group includes hyaluronic acids which are found as components of connective tissues. They are straight chain polymers with D-glucoronic acid and N-acetyl glucosamine alternatively in the chains.
c. The third group is a complex one in which a polysaccharide may contain hexoses, aminosugars (free and acetylated)

hexuronic acids and sugar sulphates. Examples are chondroitin sulphate of cartilage (N-acetyl galactosamine, glucoronic acid and sulphate esters of these sugars) and heparin, the natural anticoagulant of blood (Glucosamine N-sulphate, glucoronic acid and their sulphate esters).

Glycosidic linkages involving uronic acids or aminosugars are very resistant to hydrolysis and hence, polysaccharides containing these units are extremely stable and are present where chemical resistance and physical strength are needed, e.g., in skin, connective tissues, insect exoskeletons, umbilical cord, etc.

QUESTIONS

1. **What are carbohydrates? What are their functions in living organism?**
2. **Classify carbohydrates with examples. What is an asymmetric carbon atom?**
3. **What are the differences between mono, di and polysaccharides?**
4. **What are the differences between cellulose and starch?**

Ans: In starch, the glucose units are linked by α (1-4) linkages. In cellulose the glucose units are linked by β (1-4) glucosidic linkages.

5. **Write short notes on:**
   A. Mucopolysaccharides
   B. Mutarotation and its causes
   C. Benedict's test
6. **What is the difference between starch and glycogen?**

Starch	*Glycogen*
1. Plant origin	1. Animal origin
2. It is a branched molecule. Branching occurs after every 20-24 glucose units	2. More branched than starch molecules. Branching occurs after every 8-10 glucose units
3. Blue colour with Iodine solution.	3. Red colour with Iodine solution.

MULTIPLE CHOICE QUESTIONS

7. **Carbohydrates are the compounds of:**
   a. C, H, N and O b. C, H and O
   c. C, N and H d. N, H and O
8. **Which of the following is a monosaccharide?**
   a. Glucose b. Lactose
   c. Sucrose d. Maltose
9. **Monomer of cellulose is:**
   a. Lactose b. Maltose
   c. Fructose d. Glucose

10. Invert sugar is a mixture of:

a. Sucrose and glucose b. Glucose and fructose
c. Maltose and glucose d. Lactose and maltose

11. A carbohydrate can be defines as:

A. Polyhydoxy alcohol
B. Hydrates of carbon
C. Aldehydes or ketone bodies
D. All of the above

12. Which one of the sugars is a ketose?

A. Xylose
B. Fructose
C. Arabinose
D. Erythrose

13. Glucose is the constituent of:

A. Insulin
B. DNA
C. Collagen
D. Starch

14. Sorbitol is:

A. Sterol
B. An amino alcohol
C. A glycerol derivative
D. A sugar alcohol

15. Inverted sugar is:

A. Sucrose
B. Fructose
C. Glucose
D. A mixture of glucose and fructose

16. All the following are reducing sugars *except:*

A. Froctose
B. Sucrose
C. Maltose
D. Lactose

17. All the following are mucopolysaccharides *except:*

A. Chondroitin sulphates
B. Hyaluronic acid

C. Amylodextrin
D. Heparin

18. Which of the following statement is correct?
A. Cellulose is a heteropolysaccharide
B. Sucrose can form osazone
C. Oligosaccharides contains 5-10 monosaccharide unit
D. Glycogen is the storage form of glucose in human beings

19. Dextrins are polysaccharides formed as intermediate compounds during the hydrolysis of:
A. Cellulose
B. Starch
C. Dextran
D. Glycogen

20. Glucose and fructose form the same osazone because both are:
A. Monosaccharides
B. Soluble in water
C. Differing in carbon 1 and 2 and Carbon 1 and 2 are involved
D. Differing in carbon 5 and 6 and Carbon 1 and 2 are involved

21. Shape of maltosozone is:
A. Sunflower shaped
B. Needle/broom shaped
C. Cotton ball shaped
D. Powder puff shaped

22. One of the following carbohydrates is not digested in the human gastrointestinal (GI) tract:
A. Starch
B. Cellulose
C. Lactose
D. Sucrose

23. Following polysaccharide is maturally occurring anti-coagulant:
A. Hyluronic acid
B. Chondroitin sulphate
C. Heparin
D. Keratosulphate

24. Blood group substances consist of N-acetyl glucosamine, galactosamine, fucose salic acid and:

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

25. Following are homopolysaccharides *except:*

A. Cellulose
B. Starch
C. Glycogen
D. Heparin

ANSWERS

7 (B)	8 (A)	9 (D)	10 (B)	11 (D)	12(B)
13(D)	14 (D)	15 (D)	16(B)	17(C)	18(D)
19 (B)	20 (C)	21 (A)	22(B)	23 (C)	24(C)
25 (D)					

CHAPTER

3 Chemistry of Lipids

Lipids are defined as a group of naturally occurring substances consisting of higher fatty acids, their naturally occurring compounds and substances found normally in association with them. They are insoluble in water but soluble in organic solvents like ether, chloroform, benzene and acetone.

They include fatty acids, triacylglycerols, ketone bodies, cholesterol, phospholipids and spingolipids.

The terms "fats" and "oils" are commonly used to denote crude lipid mixtures which are obtained from natural sources. Fats are solids and oils are liquids at room temperature (15°C).

Occurrence

Fats are widely distributed in plants and animals. In plants they are present in nuts, seeds and oils. The nervous system of animals is rich in lipids like cholesterol, phospholipids and glycolipids. Blood contains lipoproteins. The fat depots such as subcutaneous tissues, mesenteric tissues, fatty tissues around the kidney and yellow bone marrow contain large amounts of fat. Food sources rich in fat are milk, egg, meat, liver, fish oils, nuts, seeds and oils.

Biological Significance of Fats

1. Lipids form one of the three main types of foodstuffs and act as fuel in the body. It yields more heat and energy than proteins and carbohydrates. Their caloric value is 9 Kcals/gm.
2. Deposits of fat underneath the skin exert insulating effect to the body. They protect the body from excessive heat or cold. Fat people can withstand heat or cold better than thin people.
3. The mesenteric fat around organs like kidney provides padding and protect the internal organs.
4. Building materials. Breakdown products of fats can be utilised for building biologically active materials like cholesterol, which in turn can be utilised for synthesis of certain hormones.

5. Lipids supply the essential fatty acids which cannot be synthesised in the body.
6. The nervous system is particularly rich in lipids.
7. Vitamins A, D, E and K are fat soluble, hence lipid is needed for absorbing these vitamins.
8. Lipoproteins and phospholipids are important constituents of many natural membranes like cell walls and mitochondrion.

An adult ingests almost 60-150 g of lipids per day of which more than 90% is triacylglycerol (TAG). Balance is cholesterol, cholestryl esters, phospholipids and free fatty acids (FFA).

Classification of Lipids

1. Simple Lipids

Simple lipids are esters of fatty acids with various alcohols.

Neutral fats are triesters of fatty acids with glycerol.

The alcohol in fats is glycerol and the alcohol in waxes is anything other than glycerol.

2. Compound Lipids

Compound lipids contain some other chemical groups in addition to alcohol and fatty acids. There are 4 sub-divisions under this group.

Phospholipids: They contain fatty acids, glycerol, phosphoric acid and a nitrogenous compound.

1. Lecithin 2. Cephalin 3. Sphingomyelin

a. Glycolipids: They are lipids containing carbohydrate and nitrogen but no phosphoric acid and glycerol (also called cerebrosides).

b. Sulpholipids: Lipids containing sulphate groups.

c. Lipoprotein: They are attached to proteins. They are present in plasma and tissues.

3. Derived Lipids

These are substances derived from groups mentioned above by hydrolysis. They are: (a) Fatty acids, (b) Alcohols other than glycerol, (c) Glycerides, and (d) Bases. Bases include:

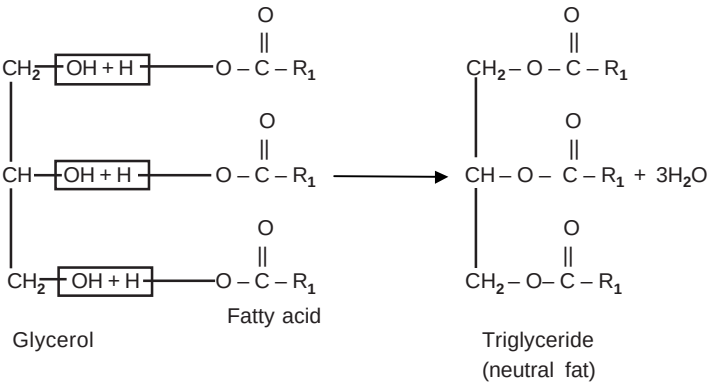
(i) Choline, (ii) Sphingosine, (iii) Glycerides, and (iv) Serine.

4. Substances Associated with Lipids

a. Carotenoids.
b. Tocopherols.
c. Vitamins A, D, E and K.
d. Steroids (Cholesterol).

Chemical Composition of Fats

Animals and vegetable fats are complex mixtures of glycerides, that is they are esters of glycerol and fatty acids. Triglycerides or (TAG) neutral fats are composed of 3 molecules of fatty acids, esterified to glycerol. A triglyceride is formed by the condensation of one molecule of glycerol with three molecules of fatty acids;



Common fatty acids present in natural fats are:

Palmitic acid	$CH_3 (CH_2)_{14} COOH$
Stearic acid	$CH_3 (CH_2)_{16} COOH$
Oleic acid	$CH_3 (CH_2)_7 CH = CH (CH_2)_7 COOH$

Properties of Fats

Physical Properties

1. They are greasy to touch and leave an oily impression on paper.
2. They are insoluble in water but soluble in organic solvents.
3. They have less specific gravity than water. Specific gravity of solid fat (0.86) is less than liquid fat (0.95).
4. Pure glycerides are tasteless, odourless, colourless and neutral in reaction. But after exposure to air for some time, they become

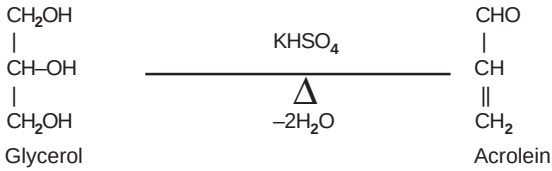
acidic and develop a yellow colour due to partial hydrolysis and oxidation of unsaturated fatty acids in them.
5. The flavour of butter is due to the presence of bacterial flora, which is carefully controlled to impart special flavour to butter. The colour of butter, human fat and egg yolk are due to the presence of carotene and xanthophil contained in them.
6. The hardness or consistency depends upon the relative amounts of saturated and unsaturated fatty acids present. Fats containing saturated fatty acids are solids at room temperature. Fats containing unsaturated fatty acids are liquids at room temperature and these are oils.
7. Fats have definite melting points. The melting point of a fat is always higher than the temperature at which it solidifies.
8. When a liquid fat is placed on water, it spreads uniformly over the surface of water and if the quantity is sufficiently small, it will form a layer of 1 molecule thickness. The effect is to lower the surface tension and help the transport of fat.
9. Though fats are insoluble in water, they can be broken down into minute droplets and dispersed in water. This is emulsification.

Essential Fatty Acids (Polyunsaturated Fatty Acids)

Polyunsaturated fatty acids like linoleic acid (C-18, 2 double bond), linolenic acid (C-18, 3 double bond) and arachidonic acid (C-20, 4 double bonds) are not synthesized by the body and hence should be taken in diet. Linseed, cotton seeds, peanut and corn oils are good sources. Essential fatty acids reduce blood cholesterol levels. 3% of energy requirements of the body come from poly unmisaturated fatty acids. Fatty acids with more than one unsaturated bond cannot be synthesised by the body. However, mammalian tissues can convert linoleic acid to linolenic and arachidonic acids. Hence, linoleic is the only fatty acid which is absolutely indispensable.

Chemical Properties

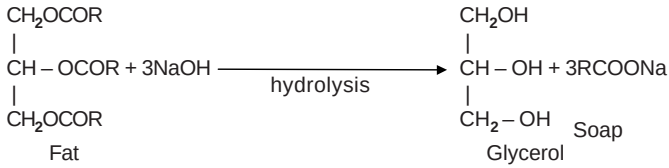
Acrolein formation: When glycerol is heated in the presence of a dehydrating agent such as potassium bisulphate, acrolein is produced.



Acrolein has a characteristic unpleasant odour and is easily identified on the basis of this smell. This reaction occurs whether glycerol is in free or esterified form as in the triglycerides.

Hydrogenation: Unsaturated fats can be hydrogenated by the addition of hydrogen across the double bonds of the fatty acids in the presence of nickel as catalyst, to give saturated fats. This process is called "hardening" of oils whereby vegetable oils are hydrogenated to produce commercial cooking fats (Dalda).

Saponification: Hydrolysis of a fat by alkali is called saponification. The products of hydrolysis are glycerol and alkali salts of fatty acids called soaps. Soaps are cleansing agents. Since the common fats contain palmitic, stearic and oleic acids predominantly, soaps used for washing consist largely of sodium salts of these acids. While the fatty acids are insoluble in water, their sodium and potassium salts are soluble in water.



Rancidity: Rancidity is a chemical change resulting in unpleasant odour and taste on storage when fats are exposed to light, heat, air and moisture. Rancidity may be due to hydrolytic or oxidation change taking place at the double bonds of the unsaturated fatty acids resulting in short chain aldehydes or ketones which have unpleasant odour.

Rancidity is more rapid at high temperature. Substances like ascorbic acid (vitamin C) and vitamin E prevent and are called antioxidants. Antioxidants are added to food fats to improve their storage qualities.

Characteristics of Fats

Saponification Number

It is defined as the number of milligrams of potassium hydroxide required to saponify one gram of fat. It is an indication of the molecular weight of the fat and is inversely proportional to it. Saponification number of a fat decreases with increase in molucular wight. Human fat has a saponification number of 194-196, butter 210-230 and coconut oil 253-262.

Iodine Number

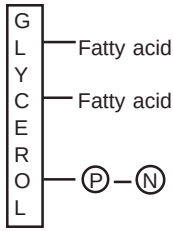
The iodine number of a fat is defined as the number of grams of iodine taken up by 100 gm of fat. It is an index of unsaturation and is directly proportional to the content of unsaturated fatty acids. Higher the iodine number, the higher is the degree of unsaturation. Different types of fats and their iodine numbers are given in Table 3.1.

Table 3.1: Different fats and their iodine numbers

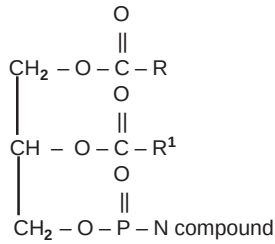
Fat/Oil	*Iodine number*
Human fat	65-69
Butter	26-28
Coconut oil	6-10
Sunflower oil	124-136
Groundnut oil	84-100
Palm oil	44-58
100 mg blood contain	
Triglycerides	80-240 mg
Phospholipids	150-250 mg
Cholesterol	130-260 mg
Free (Non-esterified) fatty acids	8-30 mg
Total	385-675 mg

PHOSPHOLIPIDS (PHOSPHOGLYCERIDES AND SPINGOMYELINS)

Any lipid containing phosphorus is called phospholipid. Phospholipids are good emulsifying agents. They are found in cell membranes and in subcellular structures where lipids and water soluble materials interact.



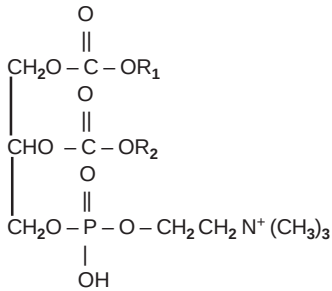
Phospholipid
or Phosphoglycerides



The most common phospholipid is the glycerol phospholipids. They contain glycerol phosphate, two fatty acids and a nitrogen compound that may be choline, ethanol amine, or serine. Lecithins and cephalins are examples of phospholipids.

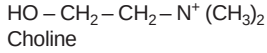
Phosphatidyl Cholines (Lecithins)

This is the most common form of phospholipids and has choline as the nitrogen compound.



Choline Phosphoglyceride

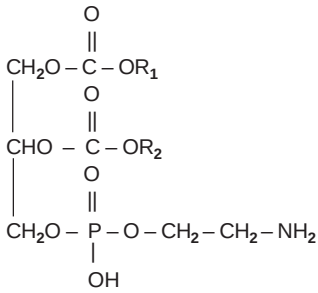
Free choline is a compound with an alcohol group. Its linkage to the phosphate portion of a lecithin like that of the glycerol to the phosphate, is that of a phosphate ester.



Choline

Lecithins are required for the normal transport and utilisation of other lipids especially in the liver. Anything which interferes with the synthesis of choline also will block the synthesis of lecithins and thus interrupt the normal transportation of lipids to and from liver. This usually results in the accumulation of lipid material in the liver giving rise to a condition called fatty liver.

Cephalin



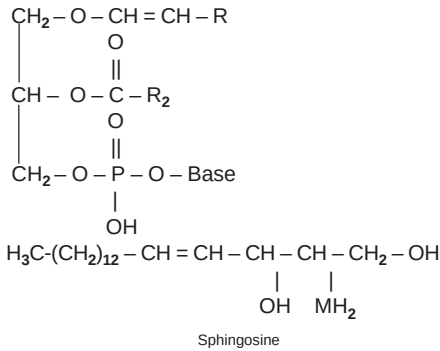
Cephalin
(Ethanolamine Phosphoglyceride)

Cephalin differs from lecithins with respect to base attached to phosphoric acid. If the base is ethanol amine, then it is called phosphatidyl ethanolamine or ethanolamine cephalin. If the base is amino acid serine, then it is called phosphatidyl serine or serine cephalin.

Cephalin on hydrolysis yields glycerol, fatty acids, phosphoric acid, ethanol amine or serine. They are found in nerve tissues Cephalins are important in the clotting of blood and as sources of phosphoric acid for the formations of new tissues.

Plasmalogens

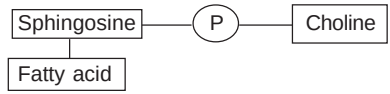
These compounds structurally resemble lecithin and cephalins, with the result that the normal ester is replaced by the ether linkage on the C_1 atom. On treatment with acid they give rise to a phosphoryl choline or phosphoryl ethanol amine. These compounds constitute as much as 10% of the phospholipids of the brain and the muscles.



Sphingosine

Sphingomyelins

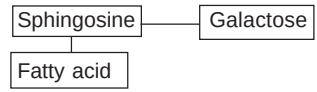
They are found in large quantities in brain and nerve tissue. No glycerol is present. On hydrolysis yield a fatty acid, phosphoric acid, choline and a complex aminoalcohol, sphingosine (in place of glycerol).



Sphingomyelin

Cerebrosides (Glycolipids)

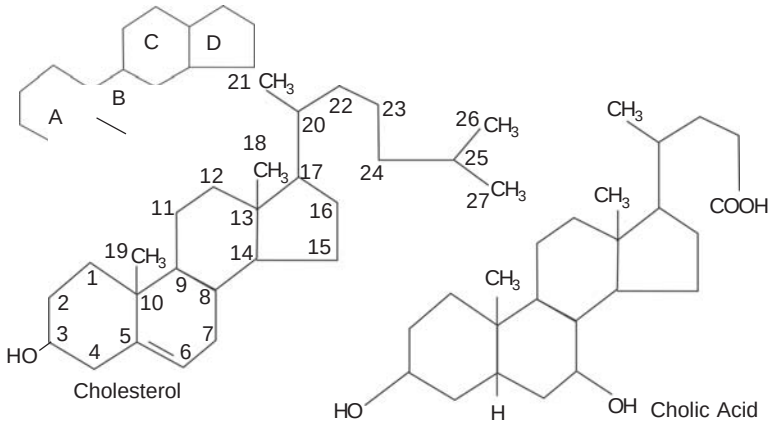
Glycolipids are carbohydrate-glyceride derivatives containing sugar, sphingosine and a fatty acid. These compounds do not contain phosphoric acid. If the sugar component is galactose, the lipid is termed as galactolipid. The term cerebroside is used because it is found in large quantities in brain tissues particularly in white matter.



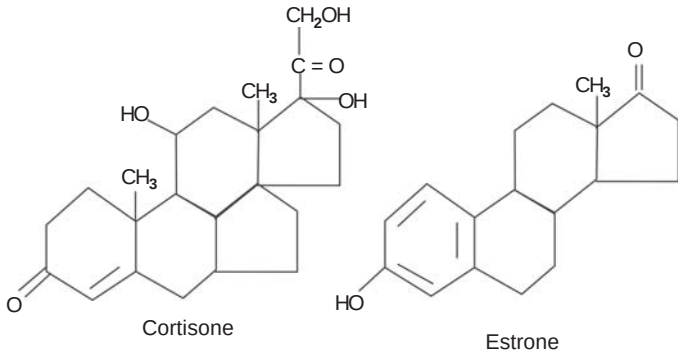
Cerebroside

Steroids

Steroids are non-saponifiable lipids, biological compounds with diverse physiological activities. All steroids are compounds having a cyclopentanoperhydrophenanthrene ring system. The structures of a number of different types of steroids having greatly varying biological activities are shown below:



When a steroid has only a hydroxyl group (–OH) as its functional group, it is called a sterol, e.g. cholesterol.



Cholesterol is a light yellow crystalline solid. It is soluble in chloroform and other fat solvents. The –OH group in the 3rd position can be get esterified with fatty acids to form cholesterol esters. Poly unsaturated acids (essential fatty acids) tend to lower the plasma cholesterol level. This is how cholesterol level in the body is regulated. The level of cholesterol in body fluids is of primary importance due to its role in the development of atherosclerosis. Cholesterol in the most abundant lipid in the human body. It is synthesised mainly in the liver, adrenal cortex, intestines, testes and skin. Acetyl CoA is the precursor of all the C atoms in cholesterol. In addition, cholesterol plays an important role as a component of biomembranes and has a modulating effect on the fluid state of the membrane.

Cholesterol in body fluids can be estimated by colour reactions, e.g., Liebermann-Burchard reaction. A solution of cholesterol in chloroform gives a blue or green colour, when acetic anhydride and concentrated sulphuric acid are added. This reaction is the basis of a colourimetric estimation of blood cholesterol (Liebermann-Burchard reaction).

Functions of Cholesterol

1. Cholesterol is an important tissue component. It has a modulating effect on the fluid state of the membrane and its intigrity and permeability .
2. Because of its low conductivity, cholesterol plays an important role in insulating nerves and brain structure.
3. For the transport of fatty acids in the body through the formation of esters of fatty acids. It is a part of lipoproteins.

4. Cholesterol neutralises the hemolytic action of a number of agents, such as snake venoms, bacterial toxins, etc.
5. Cholesterol gives rise to provitamin 'D'.
6. It is a procursor of cholic acid in the body as also bile salts.
7. It gives rise to sex hormones.

Cholesterol level in blood is increased in:

- Diabetes mellitus.
- Atherosclerosis.
- Hyperthyroidism.
- Obstructive jaundice.
- Nephrotic syndrome.
- Myxoedema.
- Xanthomatosis.

LIPOPROTEINS

Lipoproteins are conjugated proteins involved in transport and delivery of lipids to tissues. Lipids such as cholesterol and triglycerides are not soluble in water and are thus need to be complexed to water soluble carrier proteins for transporting them in the blood between different organs.

Lipoproteins transport neutral lipids in the blood. These are lipids attached to proteins. These are formed by the combination of proteins with lipids which include the phospholipids lecithin and cephalin, fatty acids, cholesterol, glycerides and fat soluble vitamins. The lipoprotein molecule has lower density than the ordinary protein molecule, due to its combination with lipids.

Lipoproteins are widely distributed in body tissues as follows:

1. Cell membranes.
2. Certain internal structures of cells, such as nucleus, mitochondria and microsome.
3. Thromboplastin which converts prothrombin to thrombin.
4. Egg yolk contains two lipoproteins called HDL and LDL.
5. The film that stabilises the fat droplets in milk contains lipoproteins.
6. Rhodopsin or visual purple is a combination of a protein, opsin and retinal aldehyde of vitamin A (fat soluble vitamin).

7. Blood lipoproteins are present in plasma. The lipid fraction consists mainly of cholesterol, phospholipids, neutral fat, traces of fat soluble vitamins and steroid hormone.

Plasma lipoproteins consist of a neutral lipid core of triglyceride and cholesterol ester that is surrounded and stabilised by free cholesterol protein and phospholipid. The relative proportion of non-polar lipid, protein and polar lipid determine the density, size and charge of the resulting lipoproteins. The density of lipoproteins has been used to classify them as shown below:

Type	*Density g/ml*	*Protein*	*Triglycerides (TAG)*	*Cholesterol*		*Phospholipids (PL)*
				Free	*Ester*	
Chylomicrons	Less than 0.95	1	85-95	1-2	1-2	3-6
Very low density lipoproteins VLDL	0.95-1.006	10	50-60	4-8	10	15-20
Low density lipoproteins LDL	1.006-1.063	22	10	10	38	20
High density lipoproteins HDL	1.063-1.21	45-60	3	5	15-20	25-30

The total plasma lipid is 700-1000 mg per dl. Roughly 1/3 is triglycerides another 1/3 is cholesterol and rest 1/3 is phospholipids. These are complexed with proteins to form lipoproteins.

The plasma cholesterol is distributed in different proteins fractions. In normal persons, cholesterol level varies from 150 to 220 mg/dl with 70% being esterified cholesterol and 30% free. In the average normal adult male, the plasma cholesterol should preferably below 200 mg/dl. The females have a lower level because of the high oestrogen level which also affords protection against atherosclerosis.

Normally, almost 60% of total cholesterol is LDL 22% HDL, 13% VLDL and 5% chylomicrons.

1. *Chylomicrons:* are the lipoprotein particles lowest in density and largest in size and contain the most lipid and smallest percentage of protein. They transport mainly TG and smaller amounts of PL, cholesterol ester and fat soluble vitamins from intestines to liver and adipose tissues. The lipids carried by

chloromicrons principally are dietary lipids. They are formed in the intestinal mucosa. VLDL are composed mainly of TAG, and are more enriched in cholesterol esters than are chylomicrons. VLDLs are synthesized in the liver and released into blood. They transport triacylglycerides synthesized in the liver and cholesterol esters from liver to peripheral tissues including adipose tisue for storage.

Fatty liver occurs in conditions in which there is an imbalance between hepatic triacylglyceride synthesis and the secretion of VLDL by the liver. Diseases such as diabetes mellitus and chronic ethanol ingestion can cause fatty liver.

As VLDL passes through the circulation their structure is altered to LDL.

LDL provides cholesterol for cellular needs. LDL promotes coronary heart disease by first penetrating the coronary artery wall and then depositing cholesterol to form atherosclerosis plaque.

Elevated LDL levels have been associated with increased risk of developing coronary artery disease, whereas elevated HDL levels appear to reduce the risk. Women have higher HDL levels than men (55 Vs 45 mg/dl) and this may account for women's lower rate of heart disease. Aerobic exercise increases HDL levels (marathon runners average 65 mg/dl).

Estimation of Plasma Lipids

For clinical purposes, the lipid portions in plasma estimated are total cholesterol, HDL cholesterol and triglycerides.
Total cholesterol is estimated colourimetrically.

1. Serum is used for Liebermann-Burchard reaction. Cholesterol in presence of ion H_2SO_4, acetic acid and acetic anhydride is oxidised to cholesterol polyenes to give blue green colour.
2. More modern is the enzymatic cholesterol oxidase method. Cholesterol is oxidised. The H_2O_2 produced in this reaction is split by peroxidase to produce nascent oxygen which is used to oxidase a colourless chromogen to a coloured product.

HDL and LDL

HDL cholesterol is estimated after precipitating LDL and VLDL. The LDL cholesterol can be calculated from total cholesterol, HDL cholesterol and serum triglycerides.

LDL cholesterol = Total cholesterol - [HDL Chol + TAG/5] 1/5 of the triglyceride value is believed to represent VLDL in fasting plasma. The sample serum should be taken after 14-16 hours of fasting.

QUESTIONS

1. **What are lipids? Classify them giving suitable examples.**
2. **Describe the chemistry and functions of phospholipids.**
3. **Describe the chemistry and functions of cholesterol.**
4. **What are plasma lipoproteins? How are they separated? What are their functions?**
5. **Write short notes on:**
   A. Essential fatty acids
   B. Rancidity
   C. Saponification number
   D. Lipoproteins
   E. Phospholipids
6. **What is the relationship between polyunsaturated acids and cholesterol?**

MULTIPLE CHOICE QUESTIONS

7. **Lipids are:**
   A. Structural components of cell membrane
   B. Components having high energy value
   C. Soluble in non-polar solvents
   D. All of the above
8. **An example of a simple lipid is:**
   A. Triglyceride (Triacyl glycerol)
   B. Cephalin
   C. Fatty acids
   D. Glycerol
9. **Glycerol is an:**
   A. Compound lipid
   B. Simple lipid
   C. Derived lipid
   D. Aliphatic alcohol
10. **All the following are polyunsaturated fatty acid *except:***
    A. Linolenic acid
    B. Palmitic acid

C. Arachidonic acid
D. Linolenic acid

11. Which compound facilitates emulsification of fats?
A. Bile salts
B. Bile pigments
C. Bile acids
D. Steroids

12. Hydrolysis of fat by an alkali is known as:
A. Esterification
B. Saponification
C. Emulsification
D. Peroxidation

13. Iodine number indicates:
A. Total number of fatty acids in fat
B. Level of rancidity of fat
C. Measure of the degree of unsaturation in fat
D. Number of volatile fatty acids in fat

14. The main lipid present in cell membrane bilayer is:
A. Cholesterol
B. Triglyceride
C. Phospholipid
D. Fatty acid

15. Major storage form of lipid is:
A. Esterified cholesterol
B. Glycerophospholipids
C. Triglycerides
D. Spingolipids

16. The highest phospholipids content is found in:
A. Chylomicron
B. VLDL
C. LDL
D. HDL

17. Which of the following transport indogenous triacyl glycerol and cholesterol from liver to tissues?
A. VL DL, HDL
B. VL DL, LDL

C. VL DL, LDL, IDL

D. VL DL, IDL

18. Which of the following transport indogenous cholesterol from tissues to liver?

A. LDL

B. IDL

C. HDL

D. VL DL

ANSWERS

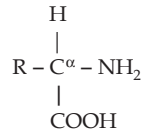
7 (D)	8 (A)	9 (C)	10 (B)	11 (A)	12 (B)
13 (C)	14 (C)	15 (C)	16 (D)	17 (C)	18(C)

CHAPTER

4 Amino Acids

The principal source of amino acids is hydrolysis of proteins. Proteins are high molecular weight substances found in all living tissues. Upon acid, base or enzyme catalysed hydrolysis, they are broken up into thousands of amino acid molecules. Most proteins produce approximately 20 different α-amino acids.

Alpha amino acids have both an amino and a carboxylic acid group attached to the same α-carbon.



Essential Amino Acids

There are 8 amino acids not synthesized by the body and therefore must be taken in the diet.

1. Leucine
2. Isoleucine
3. Threonine
4. Tryptophan
5. Phenylalanine
6. Valine
7. Metheonine
8. Lysine.

Mnemonic

Pvt. Tim hall

Pvt. Tim Hall — H-histidine

563 427 18 — A-arginine

Adequate amounts of essential amino acids are required to maintain the proper nitrogen balance in the body.

Deficiency of one or more essential amino acids in the diet reduces protein synthesis leading to failure in growth of the child, negative nitrogen balance in adults and fall in plasma proteins and haemoglobin levels.

Semi-essential Amino Acids

Arginine and histidine are synthesized partially by the body but not at the rate to meet the requirement in growing children, pregnant and lactating women.

Non-essential Amino Acids

These can be synthesized by the body and may not be required in the diet. These amino acids are derived from the carbon skeletons of lipids and carbohydrates during their metabolism or from the transamination of essential amino acids, e.g. alanine, aspartic acid, serine, proline.

Classification and Structure of Amino Acids

Amino acids can be classified into 3 groups depending upon their reaction in solution, i.e., (i) Neutral, (ii) Acidic, and (iii) Basic.

Basic is the largest group and can be further sub-divided into aliphatic, aromatic, heterocyclic and sulphur containing amino acids.

Functions of Amino Acids

1. Building blocks of proteins.
2. Specific amino acids give rise to specialized products example:
   a. Tyrosine forms thyroid hormones T_3, T_4 and a pigment called melanin.
   b. Tryptophan can synthesize a vitamin called niacin.
   c. Glycine, arginine and methionine synthesize creatinine.
   d. Glycine and cysteine help in the synthesis of bile salts.
   e. Cysteine and methionine are sources of sulphur.

Occurrence of Amino Acids

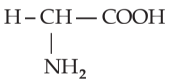
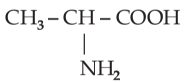
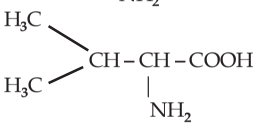
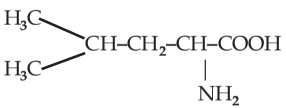
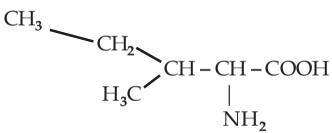
All the amino acids in Table 4.1 are present in proteins. Cereals are rich in acidic amino acids Asp and Glu. Collagen is rich in basic amino acids and also proline and hydroxy proline.

Properties of Amino Acids

Physical Properties

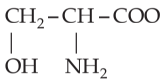
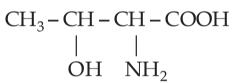
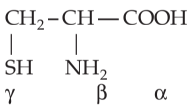
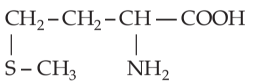
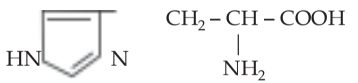
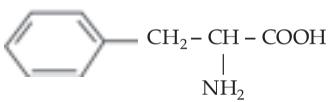
Colourless crystalline substances, more soluble in water than in organic solvents like ether (this is due to Zwitter ion form). High melting points, usually more than 200°C and high dielectric constants.

Table 4.1: L-α-Amino acids found in protein

Groups	*Trivial names*	*Abbreviations*	*Chemical names*	*Structural formula*
	Neutral Amino acids			
I.	With aliphatic side chains			
	Glycine	Gly	Amino acetic acid	
	Alanine	Ala	α-amino propionic acid	
	Valine	Val	α-amino isovaleric acid	
	Leucine	Leu	α-amino isocaproic acid	
	Isoleucine	Ile	α-amino-β-methyl valeric acid	

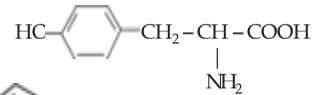
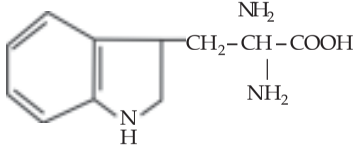
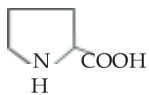
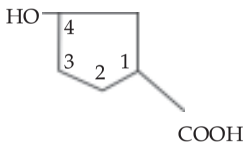
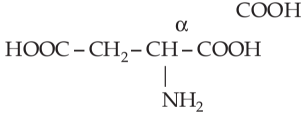
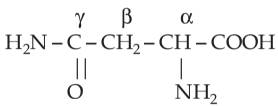
Contd...

Contd...

Groups	*Trivial names*	*Abbreviations*	*Chemical names*	*Structural formula*
II.	With side chains containing hydroxylic groups (-OH)			
	Serine	Ser	α-amino-β-hydroxy propionic acid	
	Threonine	Thr	α-amino-β-hydroxy-n-butyric acid	
III.	With side chains containing sulphur atoms			
	Cysteine Cistine is formed by the linkage of two cysteine side chains through a disulphide bond	Cys	α-amino-β-mercapto propionic acid	
	Methionine	Met	α-amino-γ-methylthio-n-butyric acid	
IV.	Containing aromatic rings			
	Histidine	His	α-amino-β-imidazole propionic acid	
	Phenyl alanine	phe	α amino-β–phenyl propionic acid	

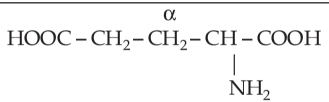
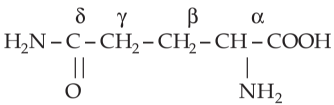
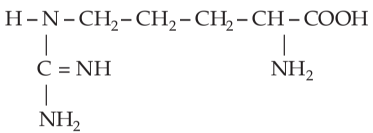
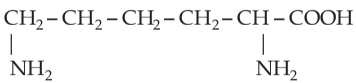
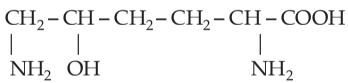
Contd...

Contd...

Groups	*Trivial names*	*Abbreviations*	*Chemical names*	*Structural formula*
	Tyrosine	Tyr	α-amino-β-(Hydroxyphenyl) propionic acid	
	Tryptophan	Trp	α-amino-β-3 indolepropionic acid	
V.	Amino Acids			
	Proline	Pro	Pyrrolidine-2-carboxylic acid	
	4-Hydroxy proline	Hyp	4-Hydroxypyrrolidine-2-carboxylic acid	
VI.	Acidic Amino Acids With side chains containing Acidic groups or their amides			
	Aspartic acid	Asp	α-amino succinic acid	
	Asparagine	Asn	α-amide of α-amino succinic acid	

Contd...

Contd...

Groups	*Trivial names*	*Abbreviations*	*Chemical names*	*Structural formula*
	Glutamic acid	Glu	α-amino glutaric acid	
	Glutamin	Gln	δ-amide of α-amino glutaric acid	
VII.	Basic Amino acids			
	With chains containing basic group			
	Arginine	Arg	α-amino-δ-glunidino-n-Valeric acid	
	Lysine	Lys	α–ε Diamino caproic acid	
	Hydroxylysine	Hyl	α–ε Diamino-δ-hydroxy-n-caproic acid	
	Histidine (see above)			

Chemical Properties

Properties due to carboxylic group [-COOH]

a. Formation of esters with alcohols.
b. Reduction to amino alcohol in presence of lithium aluminium hydride.
c. Formation of amines by decarboxylation.
d. Formation of amides.

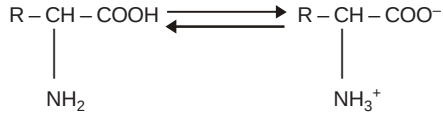
Properties due to amino group [-NH_2]

a. Salt formation with acids like HCl.
b. Liberation of N_2 when reacting with nitrous acid HNO_2.
c. Reaction with formaldehyde.

Sorensen, a Danish physical biochemist who originated the use of the pH scale as a measure of acidity of solutions, found that addition of large excess of formaldehyde ties up amino groups, permitting the attainment of sharp end points when titrating amino acids with alkali. Such a titration is called formol titration and is used for the estimation of free carboxyl group in amino acid and mixture of amino acids.

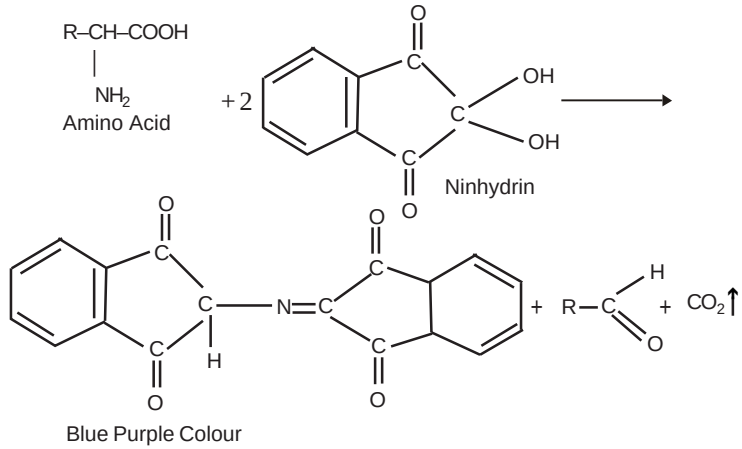
The isoelectric pH of an amino acid is that pH at which it has no net charge and hence does not move in an electric field.

Zwitterion formation: The acidic and basic group within the same molecule of an amino acid react with each other.



Such a doubly charged ion is known as an inner salt, as a Zwitterion or a dipolar ion. Amino acids exist over 50% in the dipolar or Zwitterion form. This gives them a salt like character, as revealed by their large solubility in water and insolubility in ether, benzene, etc., and by their relatively high melting points.

Ninhydrin reaction: Ninhydrin, a powerful oxidizing agent, causes oxidative decarboxylation of α amino acids, producing CO_2, NH_3 and an aldehyde with one less carbon atom than parent amino acids. The reduced ninhydrin then reacts with the liberated amino acids forming a blue complex (blue purple colour).

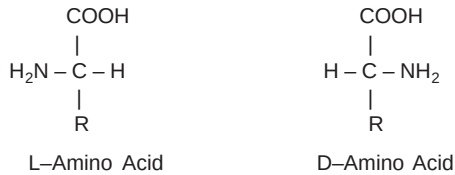


Aminoacid +2 molecules of ninhydrin $\xrightarrow{\text{heat}}$ Aldelyde with one carbon atom less $+CO_2$+blue purple complex.

The intensity of the blue purple colour produced under standard conditions is the basis of a quantitative estimation of α amino acids. Amines other than α amino acids also react with ninhydrin, forming blue purple colour but without evolving CO_2. The evolution of CO_2 is thus indicative of an α amino acid. Proline and 4 hydroxy proline produce a yellow colour with ninhydrin.

Isomerism

Stereoisomerism: All amino acids except glycine (no asymmetric C atom) exist as D and L-isomers. In D-amino acids–NH_2 group is on the right.



Optical Isomerism

All amino acids except glycine have asymmetric C atom. Consequently, all but glycine exhibit "optical" activities and rotate the plane of polarized light and exist as dextrorotatory (d) and laevorotatory (l) isomers. Optical activity depends on pH and side chain.

QUESTIONS

1. **Classify amino acids with examples.**
2. **Give the names of essential amino acids.**
3. **Short notes on:**
   A. Essential amino acids
   B. Properties of amino acids
   C. Amphoteric nature of amino acids

MULTIPLE CHOICE QUESTIONS

4. **Which class of amino acids contain only non-essential amino acids?**
   A. Aromatic
   B. Basic
   C. Sulphur containing
   D. Acidic
5. **The high intake of which amino acid can prevent pellagra in people consuming a niacin deficient diet:**
   A. Lycine
   B. Methionine
   C. Theonine
   D. Tryptophan
6. **Which one of the following is an acidic amino acid?**
   A. Palmitic acid
   B. Aspartic acid
   C. Pyruvic acid
   D. Lysine
7. **A basic amino acid is:**
   A. Phenyl alanine
   B. Serine
   C. Arginine
   D. Glutamic acid
8. **Which one of the following is not a sulphur containing amino acid?**
   A. Histidine
   B. Cystomic

C. Cystine
D. Methionine

9. All the following are essential amino acids *except*:
A. Phenyl alanine
B. Tryptophan
C. Tysoine
D. Isolencine

10. The semiessential amino acids are:
A. Histidine and alanine
B. Arginine and glycine
C. Poline and methionine
D. Arginine and histidine

11. An example for neutral amino acid:
A. Tyrosine
B. Prolene
C. Lysine
D. Leucine

12. Test for L amino acid is:
A. Molisch test
B. Biuret test
C. Ninhydrin test
D. Murexide test

13. Which amino acid is important in the buffering action of proteins at physiologic pH?
A. Tyrosine
B. Histidine
C. Lysine
D. Glutamic acid

ANSWERS

4 (D)	5 (D)	6 (B)	7 (C)	8 (A)	9 (C)
10 (D)	11 (D)	12 (C)	13 (B)		

CHAPTER

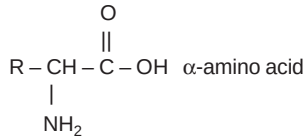
5 Chemistry of Proteins

Biologic Importance

The word protein is derived from the Greek word "proteios" which means primary. Proteins are high molecular weight (5,000 to 25,000,00) substances. About half the dry weight of living materials is protein. They are the source to replace nitrogen as almost 30 g of nitrogen is lost everyday by an adult chiefly as urinary urea.

Composition of Proteins

In addition to C, H and O which are present in carbohydrates and lipids, proteins contain N. They are macro molecules. They are all polymers, that is, they are chainlike molecules produced by the linking together of a number of small units, chiefly almost 20 α-amino acids belonging to L form.

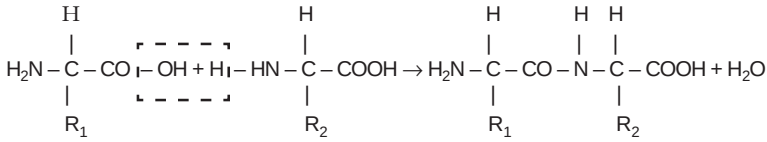


These units are joined through the peptide bonds (C–O–NH–). The peptide linkage is formed between two amino acids by the release of one water molecule. The amino group of the first amino acid and the carbonyl group of the next amino acid are involved in the formation of peptide bonds.

Peptide Bonds

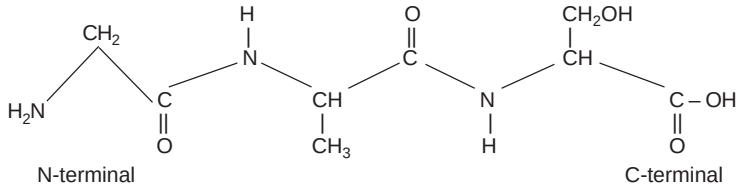
When two amino acids are joined together by the peptide bond the resulting is called a dipeptide.

Proteins contain more than 100 amino acid residues; polypeptides 100 or less than 100.



A diptide

A tripeptide consists of 3 amino acids linked by 2 peptide bonds



A tripeptide composed of glycine, alanine and serine.

A polypeptide consists of a large number of amino acids joined together by peptide bonds. Each polypeptide can have any number of any one or different types of amino acids which can be present in any sequence. The individual amino acid of a peptide is called the amino acid residue. Each polypeptide has one free carboxylic acid group (-COOH) at one end which is called the C-terminal and a free amino group at the other end called N-terminal.

BIOMEDICAL IMPORTANTCE OF PROTEINS

1. Proteins are the main dietary constituents for supply of nitrogen and sulphur.
2. Biochemical catalysts known as enzymes are proteins.
3. Proteins called immunoglobulins are the frontline of defence against bacterial and viral infections.
4. Structural proteins furnish mechanical support for the movement of muscles.
5. Several hormones are proteins.
6. Some proteins present in cell membrane, cytoplasm and nucleus of the cell act as receptors. They bind specific substances such as vitamins, hormones, etc. and mediate their circular action.
7. The transport proteins carry out the function of transporting specific substances either across the membrane or in body fluids.

8. Storage proteins bind with specific substances and store them, e.g. iron is stored as ferritin.
9. Some proteins are constituents of respiratory pigments present in the electron transport chain or respiratory chain, e.g. cytochromes, myoglobin, and haemoglobin.
10. Proteins by means of exerting osmotic pressure help in maintenance of electrolyte and water balance in the body.

Structure of Proteins

Proteins exhibit four levels of organisation.

Primary structure	refers to amino acid sequence.
Secondary structure	refers to folding of polypeptide chain into specific coiled structure which is repetitive.
Tertiary structure	refers to arrangement and interrelationship of twisted chain into a three-dimensional structure
Quarternary	refers to the association of different monomeric subunits into a composite polymeric protein.

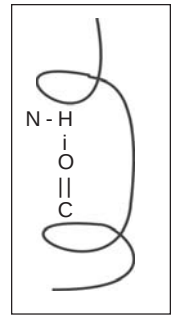
Primary Structure

The primary structure is the sequence in which the amino acids are arranged in a protein. The amino acid sequence of a protein determines the function of the protein. Even a change of just one amino acid in sequence drastically alters properties of the entire protein molecule. For example, the haemoglobin molecule has 574 amino acid units. Changing one specific amino acid in the sequence results in a defective haemoglobin found in patients suffering from sickle cell anaemia.

–Val–His–Leu–Thr–Pro–Glu–Glu–Lys
Normal Haemoglobin
–Val–His–Leu–Thr–Pro–Val–Glu–Lys
Sickle cell Haemoglobin

Insulin has 51 amino acids present in two polypeptide chains. These chains are cross linked at two places by disulphide bonds. One chain contains 21 amino acid units and the other has 30 amino acids. The molecular weight of insulin is 5733.

Secondary Structure

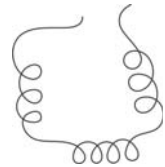


Secondary structure determines the coiling of the polypeptide chain into a helical structure because of folding or twisting of polypeptide chains into a coiled or spiral forms due to hydrogen bonding. The hydrogen bonding arises due to the bonding between the carbonyl oxygen and amide nitrogen. Since peptide bonds occur at regular intervals, the hydrogen bonding of the secondary structure also occurs regularly. The right handed helix, i.e., the alpha helix is the most preferred configuration. The diameter of the helix is 10A°.

Tertiary Structure

Tertiary structure refers to the coiling of several helical portion of single helix into three dimensional structure. Interaction among amino acids relatively widely separated in primary position yield tertiary structure. The tertiary structure of proteins is stabilised by:

a. Hydrogen bonding
b. Disulphide bonding
c. Ionic interaction
d. Hydrophobic interaction
e. van der Waal's forces.



The tertiary structure acquired by native protein is always thermodynamically most stable.

Quarternary Structure

This is the molecular structure arising from the interaction of individual peptide chains to form a specific aggregate. Numerous globular proteins and enzymes possess quarternary structure. They are composed of a number of subunit peptide chains linked together by any or all of the forces that can act between amino acid side-chains.

Haemoglobin, the oxygen transporting protein of blood is an example of quarternary structure. This protein consists of four peptide chains of two types. Each of these subunits is itself complexly folded. The two pairs of folded peptides interact with each other to give a quite stable, compact bundle, which is the active protein, haemoglobin.

Denaturation of Proteins

Native state is the conformation of protein in the most stable form as it exists in the cells or tissues of the living organism. If a protein is exposed to different set of environmental conditions, its conformation may change, with attendant alterations in its physical properties and most significantly, in the ability of the proteins to perform its biological role. Such a change in a protein is termed denaturation. A number of relatively weak secondary bonds are broken and new bonds formed during denaturation.

The boiling of an egg is an example of denaturation. Raw egg white is a globular protein, a soluble form and on boiling gets converted into a fibrous form which coagulates and hardens.

The formation of cheese is another example. When the pH of milk is brought down to 4-5 or below, casein (milk protein) precipitates and cheese, an insoluble form of milk protein is formed.

During denaturation, the protein molecule uncoils from an ordered and specific configuration into a more random configuration and thus precipitates from the solution.

Denatured protein molecules often tend to form large aggregates and precipitates from solution—a process described as *Coagulation*.

Classification of Proteins

Classification as per Solubility
(Fibrous proteins and globular proteins)

The **fibrous proteins** are insoluble in water and include the following:

Collagens: In bone, teeth, tendons, skin and soft connective tissue. When such tissue is boiled with water, the portion of its collagen that dissolves is called gelatin.

Elastins: Elastin is found in ligaments, the walls of blood vessels, and the necks of the grazing animals. Elastin is rich in hydrophilic side chains. Cross links between elastin strands are important to its recovery after stretching.

Keratins: In hair, wool, animal hooves, nails and porcupine quills.

Myosins: The proteins in contractile muscles.

Fibrin: The protein of a blood clot. During clotting, it forms fibrin from its precursor, fibrinogen by series of complex reactions.

Globular proteins are soluble in water or in water with 5% NaCl and include the following:

Albumins: In egg white and in blood. Albumins serve many functions. Some are buffers, some carry water insoluble molecules of lipids or fatty acids. Some carry metal ions.

Globulins: Globulins include the γ-globulin that are part of body's defence mechanism against disease. The globulins need the presence of dissolved salt (5% NaCl) to be soluble in water.

Classification as per Composition

From nutritional points of view, proteins are classified as:

a. Complete proteins e.g. egg, albumin, casein (milk)
b. Partially incomplete proteins
c. Incomplete proteins.

Proteins are classified into three groups as per their composition:

a. Simple proteins
b. Conjugated proteins
c. Derived proteins

a. *Simple proteins*: On hydrolysis yield only amino acids and their derivatives.
b. *Conjugated proteins*: On hydrolysis give amino acids and a non-protein compound.
c. *Derived proteins:* are produced by the action of chemical, enzymatic and physical forces on the other two classes of proteins. Derived proteins include proteoses, peptones, polypeptides, tripeptides and dipeptides.

Conjugated Proteins

The nature of the prosthetic group in these proteins are subdivided as:

Glycoproteins:	Proteins with sugar units, e.g., Gamma globulin.
Hemoproteins:	Proteins with heme units such as haemoglobin, myoglobin and certain cytochromes (enzymes that help cell use oxygen).
Lipoproteins:	Proteins that carry lipid molecules including cholesterol.
Metalloproteins:	Proteins that incorporates a metal ion like many enzymes.
Nucleoproteins:	Proteins bound to nucleic acids such as ribosomes and certain viruses.
Phosphoproteins:	Proteins with a phosphate ester to a side chain—OH group, such as in serine, e.g., casein.

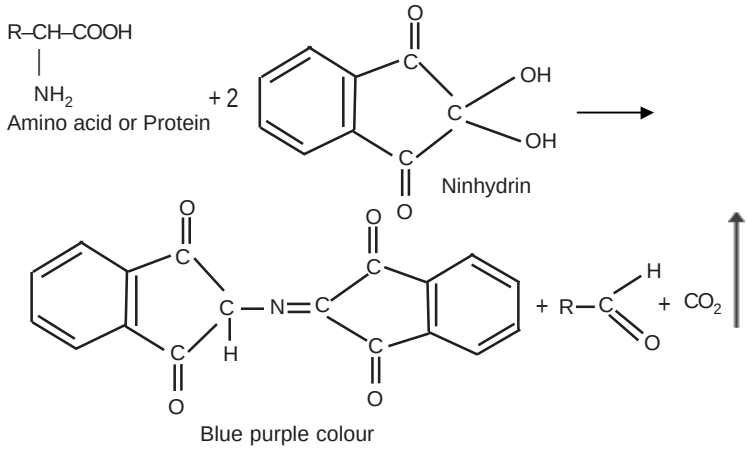
DERIVED PROTEINS

Classification as per Biological Function

1. Enzymes: The body catalysts.
2. Contractile muscle: With stationary filaments, myosin and moving filaments, actin.
3. Hormones: Such as growth hormone, insulin and others.
4. Neurotransmitters, e.g., Eukephalins and endorphins.
5. Storages proteins: Those that store nutrients that organism will need such as seed proteins in grains, casein in milk or albumin in egg white and ferritin, the iron storing protein in human spleen.
6. Transport proteins: Those that carry things from one place to another. Haemoglobin and the serum albumins. Cerulo-plasmin is copper carrying protein.

PROPERTIES OF PROTEINS

1. Ninhydrin reactions: Ammonia, many amines, peptides and any protein will give a blue purple colour, when boiled with ninhydrin, a benzene type compound.



2. *Colloidal nature:* Proteins form colloidal dispersions in water. Being colloidal, proteins will pass through a filter paper but not through a membrane. Serum proteins cannot pass through cell membranes. Thus, there should be no protein material present

in the urine. Proteinuria indicates damage to the membranes in the kidneys possibly nephritis.

3. *Denaturation:* Denaturation of a protein refers to the unfolding and rearrangement of the secondary and tertiary structure of protein without breaking the peptide bonds (primary structure). Protein that is denatured looses its biological activity.
   Reagents and conditions that cause denaturation are:
   a. Heat
   b. Salts of heavy metals (addition of positive ions)
   c. Salting out
   d. Alcohol
   e. Alkaloidal reagents
   f. Oxidising and reducing agents
   g. pH
   h. Radiation

4. *Heat:* Gentle heating causes reversible denaturation of proteins whereas vigouons heating denatures proteins irreversibly by disrupting several types of bonds. Egg white, a substance containing high percentage of protein, coagulates on heating. Heat coagulates and destroys proteins present in bacteria. Hence, sterilization by heat in microbiology. The presence of protein in urine can be detected by heating a sample of urine, which will cause the coagulation of any protein material that is present (usually albumin).

5. *Precipitation reactions:* For many estimations, it is necessary to get protein free filtrate from blood and other biological fluids. Precipitation of protein is called deproteinization. Precipitation reactions are also employed in the isolation of proteins and precipitation of protein derivatives. Proteins may be precipitated and separated from solution by the following methods:

Addition of neutral salt solution: Proteins are precipitated from solution by the addition of concentrated salt solutions like ammonium sulphate and sodium sulphate. This process is also called Salting out. Lesser concentration of salt is required for protein molecules of larger size and higher concentration is required for protein molecules of smaller size.

Fractionation by solvents: Precipitation by salting out introduces the difficult problem of the added salt, particularly when pure fraction of plasma proteins are required for clinical purposes. This problem is overcome by alcohol fractionation at low temperature and drying the protein precipitated in vacuum. Addition of alcohol to an aqueous solution of protein lowers its dielectric constant, thus reducing the solubility of the proteins resulting in its precipitation.

Addition of positive ions: The commonly used positive ions for precipitation of proteins are those of heavy metals such as Zn^{++}, Hg^{++}, Fe^{+++}, Cu^{++} and Pb^{++}. These ions precipitate proteins in alkaline solution, where the proteins are negatively charged and combine with the positively charged heavy metals to form insoluble metallic proteinate. Antidote for $AgNO_3$ and $HgCl_2$ taken internally is egg white.

Addition of negative ions: Proteins are positively charged in acid medium and combine with negatively charged complex alkaloidal reagents like picric acid, sulphosalicylic acid, tannic acid and phosphotungstic acid and get precipitated.

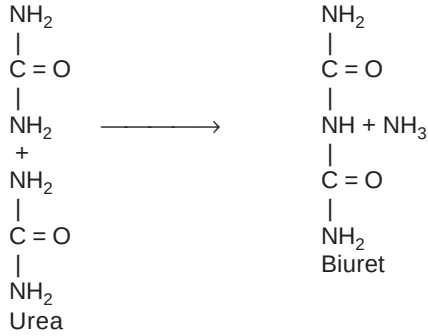
Dialysis: Protein molecules being large in size may be dialyzed. This involves removal of smaller sized crystaloidal constituents from plasma other than proteins by selective diffusion through a semipermiable membrane.

COLOUR REACTIONS (TESTS) OF PROTEINS

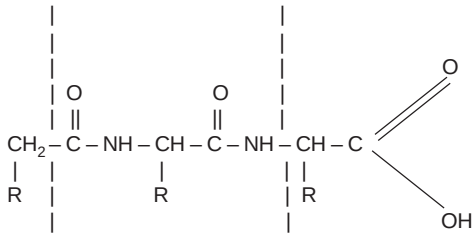
Colour tests for the presence of proteins depend on the presence of certain amino acids in that protein. These tests which are generally common to amino acids, peptides and proteins are useful for detection and sometimes for their quantitative estimation.

1. *Xanthoproteic test:* The word "Xanthoproteic" means yellow proteins. The test consists of adding concentrated HNO_3 to a protein. The protein will then turn yellow and get precipitated. Anyone who has spilled Nitric acid on hand will recall the yellow colour produced by the reaction of HNO_3 with the protein of the skin. The test is answered only by proteins consisting of amino acids with a benzene ring, such as tyrosine, phenyl alamine or tryptophan.

2. *Ninhydrin test:* When proteins are boiled with ninhydrin (a benzene type compound), a blue purple colour and CO_2 are produced. The test indicates the presence of α amino acids or peptide groups.
3. *Bluret test:* When urea is heated, it forms biuret. The compound biuret contains two-peptide linkage.



If biuret or any similar structure having two peptide bonds linked by not more than one carbon atom, is made alkaline with NaOH solution and $CuSO_4$ solutions added, a violet colour is produced. Any peptide having 3 amino acid units or more will give biuret test positive. The dipeptides and free amino acids do not give the biuret test. Biuret test is due to coordination of cupric ions with unshared electron pairs of peptide nitrogen and the oxygen of water to form a coloured coordination complex.



(The required unit for biuret test is shown between broken lines).

The biuret reaction is used widely both as a qualitative test for proteins and as a quantitative measure of protein concentrations.

QUESTIONS

1. **Describe the classification of proteins with suitable examples.**
2. **What are proteins? Give their biological importance.**
3. **Describe the structure of proteins. Discuss how proteins are precipitated.**
4. **Short notes:**
   A. Two colour reactions of proteins.
   B. Denaturation of proteins.

MULTIPLE CHOICE QUESTIONS

5. **Number of amino acids in insulin is:**
   A. 21
   B. 31
   C. 41
   D. 51
6. **Two polypeptide chains in insulin are cross linked as:**
   A. One sulphide link
   B. One disulphide link
   C. Two disulphide links
   D. Three disulphide links
7. **Protein can have the following structure:**
   A. Fibrous
   B. Sheet
   C. Globular
   D. All the above
8. **Structure of protein is stabilized by:**
   A. Hydrogen bonding
   B. Ionic bonding
   C. Covalent bonding
   D. All the above
9. **Number of amino acids present in protein are:**
   A. 10
   B. 20
   C. 100
   D. 200

10. The amino acids found in biological protein are of :
A. sD-Configuration and dextrorotatory
B. L- Configeration and levorotatory
C. D- Cofigeration and levo or dextroratatory
D. L- Configeration and dextro or levorotatory

11. Which amino acid does not occur in proteins of biological system:
A. Orithine
B. Arginine
C. Cystine
D. Histidine

12. Albumin and globulins are:
A. Simple proteins
B. Conjugated protein
C. Primary derived proteins
D. Secondary derived proteins

13. All the following are conjugated proteins *except:*
A. Metallo proteins
B. Hemoproteins
C. Histones
D. Lipoproteins

14. Which one of the following is a fibrous protein?
A. Collagen
B. Myoglobin
C. Haemoglobin
D. None of the above

15. Plasma proteins can be separated into different fractions by:
A. Chromotography
B. Electrophoresis
C. Dialysis
D. Centrifugation

16. Denaturation of protein involves:
A. Changes in primary structure
B. Loss of biological activity
C. Irreversible changes
D. None of the above

17. In a quarternary structure, subunits are linked by:
A. Peptide bonds
B. Disulphide bonds
C. Covalent bonds
D. Non-covalent bonds

18. A coagulated protein is:
A. Insoluble
B. Biologically infunctional
C. Unfolded
D. All the above

19. During denaturation of proteins, all the following are disrupted *except:*
A. Primary structure
B. Secondary structure
C. Tertiary structure
D. Quarternary structure

20. The largest protein amongst the following is:
A. Fibrinogen
B. Globulin
C. Albumin
D. Haemoglobin

21. A disulphide bond can be formed between:
A. Two methionine residue
B. Two cystine residue
C. A methionine and cystine residue
D. All of the above

22. Aromatic amino acids in protein can be detected by:
A. Sakaguchi reaction
B. Millon-Nasse reation
C. Hopkins cole reaction
D. Xanthoproteic reaction

23. The least soluble protein among the following is:
A. Albumin
B. Globulin
C. Casein
D. Collagen

ANSWERS

5(D)	6(C)	7(D)	8(A)	9(B)	10(D)
11(A)	12(A)	13(C)	14(A)	15(B)	16(B)
17(D)	18(C)	19(A)	20(A)	21(B)	22(D)
23(D)					

CHAPTER

6 Nucleic Acids and Nucleotides

NUCLEIC ACIDS

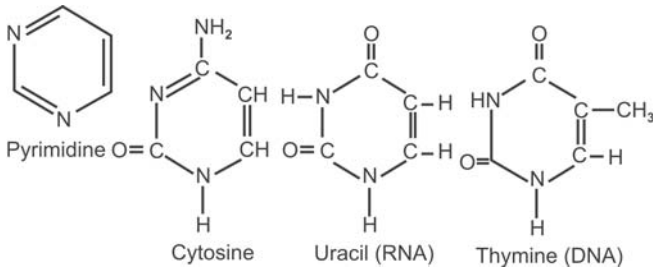
The nucleic acids, like the proteins and polysaccharides are another class of biological polymers or macromolecules that are present in all living cells. Also, a nucleic acid is an essential component of all viruses. The main function of DNA is the storage, transmission and use of genetic information upon which the continuation of cell structure depends.

Each chromosome is made up of long strands of DNA. A gene is a specific segment of the DNA that contains instructions for making proteins. There are about 30,000 genes in 23 pairs of chromosomes. Project "genome" has recently located these genes on the chromosomes.

The fundamental components of nucleic acids are the pyrimidine and purine bases, the pentose sugars (ribose and 2 deoxyribose), and phosphoric acid.

Pyrimidines of Nucleic Acids

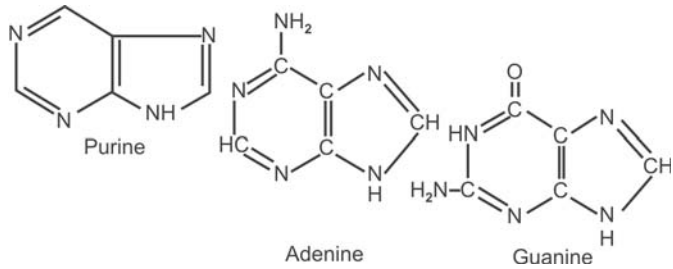
The pyrimidines bases contain the six membered ring with two nitrogen atoms, that constitutes the compound pyrimidines. The



three major pyrimidines found in humans are cytosine, uracil and thymine.

Purines of Nucleic Acids

The purine bases consist of pyrimidine ring fused to an imidazole ring.

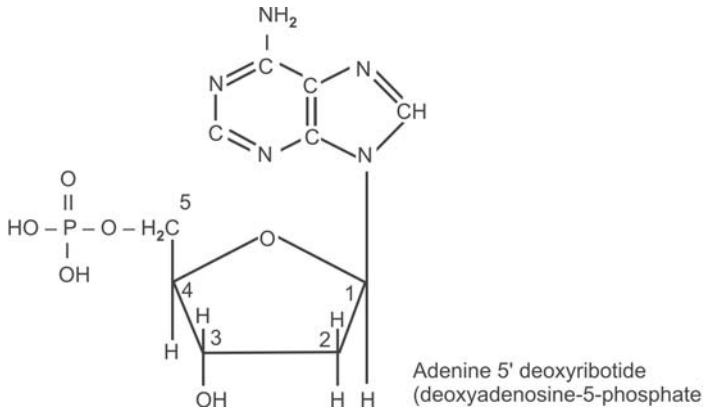


NUCLEOSIDES (NITROGEN BASE + SUGAR)

When a heterocyclic nitrogenous base is connected through one of the nitrogen atoms to the glycosidic carbon of a sugar, the resulting compound is called a nucleoside. If the sugar is a ribose, the compound is a ribonucleoside or a riboside. Deoxyribose gives a deoxyriboside.

NUCLEOTIDES (NITROGEN BASE + SUGAR + PHOSPHATE)

A nucleotide is a phosphate ester of a nucleoside. The structure of the 5' deoxyribotide of adenine is an example of a purine nucleotide.



The monomeric unit of the nucleic acids is termed as nucleotide. This monomer can undergo further hydrolysis giving three subunits: a nitrogen containing ring compound (a nitrogen base) a pentose and molecule of phosphoric acid. On the basis of hydrolysis there are two types of nucleic acids. One of these yields D-ribose as the only sugar component and is called ribonucleic acid (RNA). The other yields D-2 deoxyribose and is called deoxyribonucleic acid (DNA).

DNA is found in the cells as a major component of the chromosomes of the nucleus. Small amounts of DNA are present in the chloroplasts of green plants and in the mitochondrial particles of cell cytoplasm. Certain viruses are DNA protein particles.

The RNA of cells are of three types, ribosomal RNA occurs in combination with proteins in the small subcellular particles called ribosomes. These particles are distributed throughout the cell, chiefly in the cytoplasm. The second type, the soluble RNA is found in the free form in the cytoplasm. A third type of RNA, messenger RNA occurs in small quantities, associated with ribosomes. RNA molecules in conjunction with proteins are major components of many viruses.

Structure of DNA

The three-dimensional structure of DNA molecules was elucidated by James Watson and Francis Crick in Cambridge in 1953. Their results were based on the X-ray diffraction patterns obtained from DNA by Maurice Wilkins in London. A DNA chain consists of two strands of polynucleotide chains coiled around each other in the form of a double helix (Figs 6.1 and 6.2). The nucleotides of each strand of DNA are connected by phosphate ester bonds. This forms the backbone of each DNA strand from which the bases extend. The bases are held in position by the hydrogen bonding between them.

The bases of one strand of a DNA molecule are held in position by the bases of the other strand to which they are bound by strong hydrogen bonds. The two strands of the DNA molecule are said to be complementary to each other in the sense that the sequence of bases in one strand automatically controls (or decides) that of the other. This specific base pairing is the most important principle of the structure of the DNA molecule. Watson, Crick and Wilkins were jointly awarded the Nobel prize in chemistry (1962).

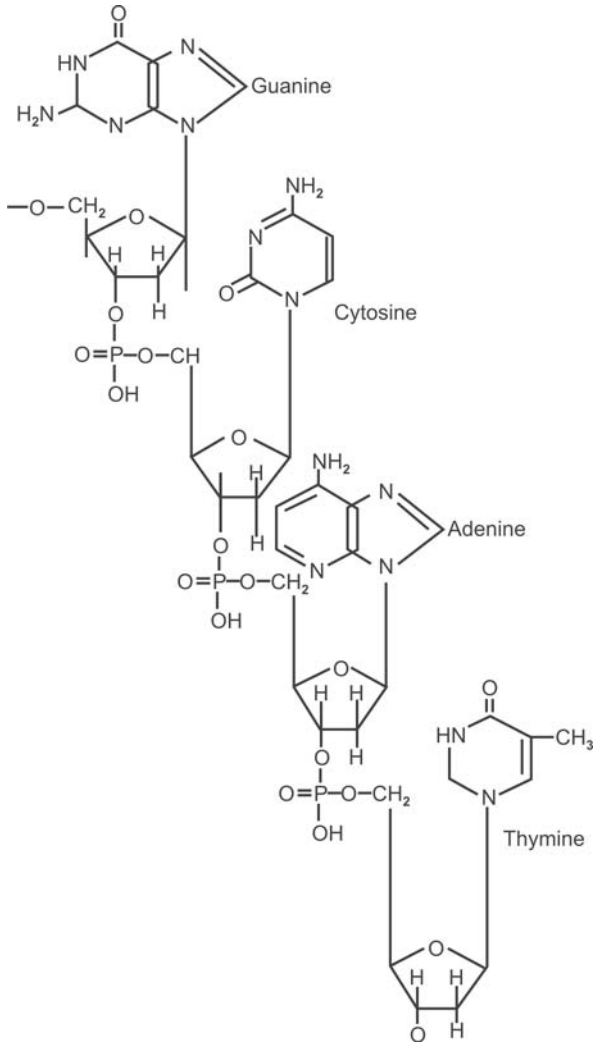


Fig: 6.1: A portion of DNA chain

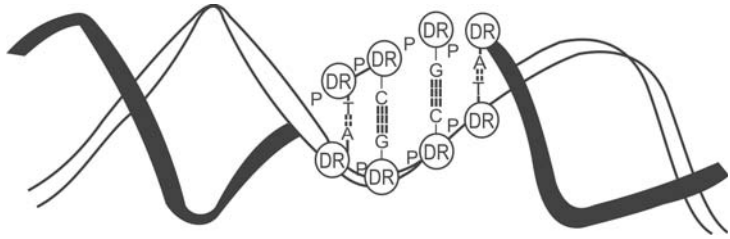


Fig. 6.2: A representation of the double helix structure of a DNA molecule. A, T, G and C represent adenine, thymine, guamine, and cytosine respectively P Phosphate, DR = Deoxyribose

Secondary Structure of RNA

Free RNA generally occurs as a single polyribotide chain probably lacking fixed secondary structure. However, each chain is free to fold back upon itself many times in numerous ways.

Size of Nucleic Acids

The nucleic acids are truely macromolecules. The smallest, the soluble—RNA molecules have molecular weights of about 30,000. The single RNA chain of a Tobacco Mosaic Virus particle has a molecular weight of over 2 million, corresponding to 6,500 nucleotide units.

The molecular weight of the DNA duplex of T_2 bacteriophage is 130 million. The DNA of the chromosome of the bacterium *Escherichia coli* is one unit with molecular weight of about 10^9.

Functions of Nucleic Acids

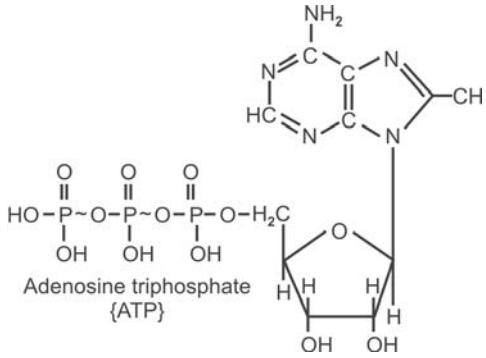
Nucleic acids perform two important functions namely replication (DNA) and protein synthesis (RNA). Replication of DNA takes place whenever a cell divides. The genetic information for the cell is contained in the sequence of the bases A, T, G and C in the DNA molecule. During replication both the strands of the DNA get separated and act as a template (mould) for the synthesis of a new strand. A new strand complementary to each of the parent strands is produced. Thus, two double helical molecules are formed. The specificity of base pairing ensures the exact duplication of the sequence of the bases in the newly synthesized strand of DNA. This process is called replication. RNA has only one strand and does not replicate.

Nucleotides of Biological Importance

Free Nucleotides

Besides the nucleotides which form integral components of nucleic acids the following nucleotides exist in free state in the tissues.

a. Adenosine nucleotide coenzymes:
   Adenosine monophosphate (AMP)
   Adenosine diphosphate (ADP)
   Adenosine triphosphate (ATP) are the body's energy compounds. They are involved in various metabolic, process involving storage and release of energy from their phosphate bonds.



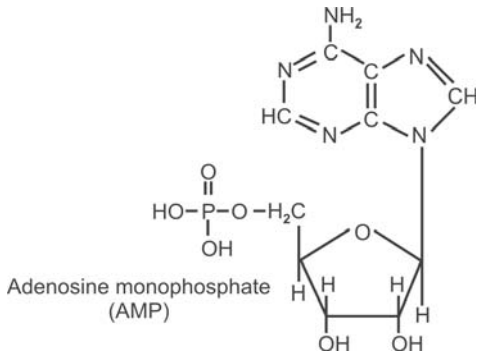
Adenosine triphosphate
{ATP}

The ultimate purpose of tissue respiration is the phosphorylation of ADP to produce ATP. The overall direction of cellular metabolism is regulated by this process. ATP, ADP and AMP form a system of coenzymes that have the function of influencing the direction of flow of metabolic pathways. Both ADP and AMP act as transfer agents for the phosphate group and are involved in oxidative phosphorylation. ATP serves as sources of high energy phosphates.

Cyclic AMP: Adenosine 3-5 cyclophosphate. This is an unusual cyclic derivative of adenosine 5 monophosphate. It is involved in the activation of phosphorylation

Coenzyme A: It is a coenzyme of pantothenic acid, having as part of its structure a molecule of AMP. Coenzyme A is required for a number of the metabolic reactions in which organic acids are involved.

Coenzyme A is a complex molecule which contains a free sulphydryl (-SH) group. This group can react with a carboxyl

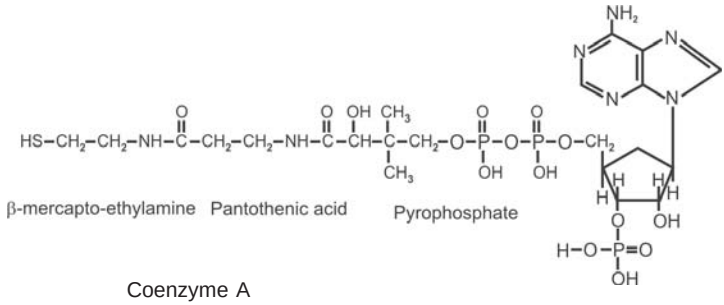


group to form a thioester. In acetyl coenzyme A, an acetyl group is linked to the S-atom. In the body, cholesterol is synthesized from acetyl coenzyme A.

Oxidation-Reduction Nucleotides

NAD^+ and $NADP^+$ and their reduced forms NADH and NADPH: They are involved in many dehydrogenase reactions in the mitochondrion, cytosol and endoplasmic reticulum of the cell. They are water soluble and are usually free to diffuse away from the enzyme, after conversion to the oxidized or reduced form to take part in another dehydrogenase reaction catalysed by another enzyme.

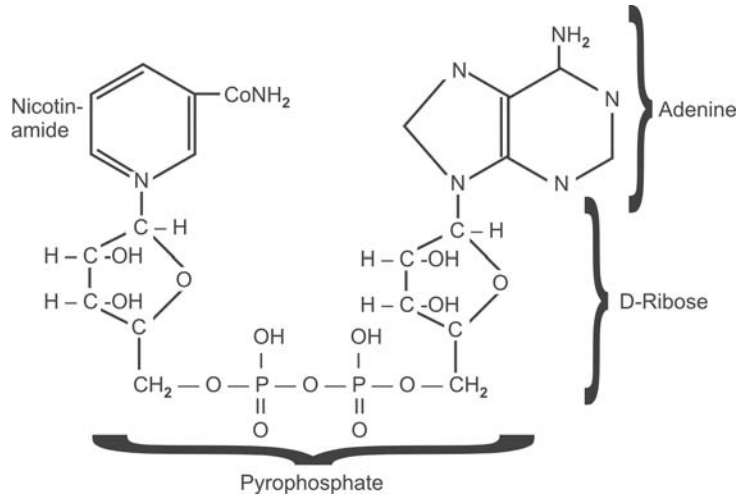
Nicotinamide adenine dinucleotide (NAD^+) and nicotinamide adenine dinucleotide phosphate ($NADP^+$) are derived from vitamin niacin or nicotinamide (B_3). These coenzymes can accept two electrons and a proton (a hydride ion H^-) to get converted to reduced forms, NADH and NADPH respectively.



Coenzyme A

If the – OH of the carbonyl group of niacin (vitamin B_3) is replaced by – NH_2 nicotinamide is produced. When nicotinamide is attached to ribose and phosphate and linked to AMP, NAD^+ is formed.

NAD and NADP are coenzymes to dehydrogenases. They serve as agents transferring hydrogen atoms from one substrate to another in biological oxidations, e.g., when a carbonyl group is oxidised to a carboxyl group or an alcohol group is oxidised to carbonyl (i.e., aldehyde or ketone). NAD^+ is one of the compounds which living organisms have evolved to act as intermediates in oxidation-reduction reactions under physiological conditions.



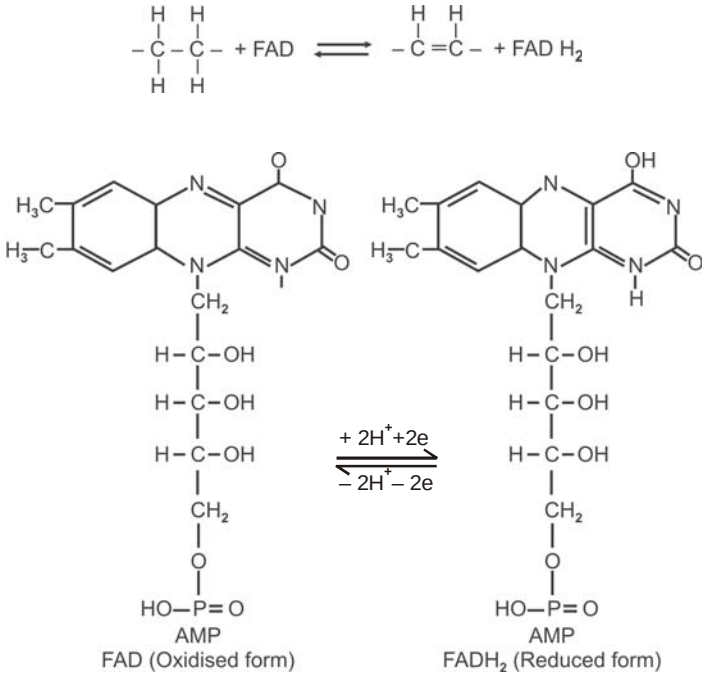
Pyrophosphate Nicotinamide Adenine dinucleotide (NAD), DPN^+ (NAD^+) (Oxidized form) electron removed

Flavin Nucleotide Coenzymes: FMN and FAD.

Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) are two other coenzymes participating in oxidation-reduction reactions.

They are derivatives of vitamin B_2 (riboflavin). These compounds can accept two protons and two electrons and get reduced to $FMNH_2$ and $FADH_2$.

FAD is the coenzyme involved in the dehydrogenation reaction such as:


+ FAD
+ FAD H2
+ 2H+ +2e
– 2H+ – 2e
AMP
FAD (Oxidised form)
AMP
FADH2 (Reduced form)

QUESTIONS

1. **What are nucleic acids?**
2. **What are the bases present in DNA and RNA?**
3. **What are the sugars present in DNA and RNA?**
4. **What are the functions of DNA and RNA?**
5. **Name the purine base in DNA and also a biologically important nucleotide.**
6. **What vitamin is a part of ?**
   A. NAD^+
   B. FAD
   C. CoA
7. **What nitrogenous base is present in:**
   A. NAD^+
   B. FAD
   C. CoA
8. **What function does each of the following perform?**
   A. NAD^+
   B. FAD
   C. CoA

MULTIPLE CHOICE QUESTIONS

9. **Nucleic acids are:**
   A. Small molecules
   B. Polymeric in nature
   C. Compounds of C, H and O
   D. Special types of proteins
10. **The sugar present in nucleic acids is:**
    A. Glucose
    B. Fructose
    C. Ribose
    D. Ribose or deoxyribose
11. **Structure of DNA molecule is:**
    A. Linear
    B. Branched
    C. Single helix
    D. Double helix.

12. Function of DNA is:
A. To store genetic information
B. In replication
C. In protein synthesis
D. All the above

13. Nucleoprotein are:
A. Simple proteins
B. Conjugated protein
C. Primary derived protein
D. Secondary derived protein

14. Following base is present only in DNA:
A. Adenine
B. Guanine
C. Cytosine
D. Thymine

15. Nucleotides are composed of:
A. Base + Phosphoric acid
B. Sugar + Phosphoric acid
C. Base + Phosphoric acid
D. Base + Sugar + Phosphoric acid

16. The number of hydrogen bonds present between guanine and cytosine are:
A. One
B. Two
C. Three
D. Four

17. RNA is synthesized from DNA in the process of:
A. Translation
B. Transcription
C. Replication
D. Reverse Transcription

18. The number of hydrogen bonds present between a adenine and thymine are:
A. One
B. Two
C. Three
D. Four

19. Gene is a segment of the DNA molecule containing base pairs about:

A. 300
B. 400
C. 500
D. 600

20. In nucleotides, phosphate is attached to sugar by:

A. Salt bond
B. Hydrogen bond
C. Ester bond
D. Glycosidic bond

21. The number of nucleotides of RNA molecule are:

A. 40 to 4000
B. 50 to 5000
C. 60 to 6000
D. 70 to 7000

22. The number of DNA nucleotides in DNA molecule are:

A. 800 to 4000
B. 1000 to 6000
C. 1200 to 8000
D. 800 to 9000

23. The purine nucleotides act as components of :

A. FAD
B. NAD+
C. NADP
D. All the above

24. The pyrimidine nucleotides act as the high energy intermediates in:

A. UDPG
B. ATP
C. ADP
D. AMP

25. Nucleic acids are:

A. Structural molecules
B. Information molecule
C. Second messengers
D. Communication molecules

26. The base present in DNA but not present in RNA is:

A. Guanine
B. Uracil
C. Cytosine
D. Thymine

27. Which of the following bases is a constituent of RNA but not DNA?

A. Thymine
B. Cytosmic
C. Ademine
D. Uracil

28. Molecule of genetic information is:

A. Protein
B. DNA
C. RNA
D. Enzyme

29. Two strands of double helical DNA are linked by:

A. Peptide bonds
B. Phosphodiester bonds
C. Glycosidic bonds
D. Hydrogen bonds

30. DNA can be denatured by:

A. Acid
B. Alkali
C. Heat
D. All of the above

31. Proteins present in nucleo proteins are:

A. Histones
B. Albumin
C. Histidine
D. Globulins

ANSWERS

6 (A) Vit B_3 (Nicotinamide)
(B) Vit B_2 (Riboflavin)
(C) Pantothenic acid

7 (A) Adenine
(B) Adenine
(C) Adenine

8 (A) Co-enzyme to hydrogenases
(B) Co-enzyme participating in oxidation-reduction reaction.
(C) Co-enzyme of pantothenic acid, having as part of its molecule of AMP. Acetyl CoA is the precursor of cholesterol.

9(B)	10(D)	11(D)	12(D)	13(B)	14(C)
15(D)	16(C)	17(B)	18(B)	19(D)	20(C)
21(C	22(D)	23(D)	24(A)	25(B)	26(D)
27(D)	28(B)	29(D)	30(D)	31(A)	

CHAPTER

7 Enzymology

Enzymes are biological catalysts which bring about chemical reactions in living cells. They are produced by the living organism and are present in very small amounts in various cells.

Almost all the functions of the body such as digestion, breathing, synthesis and breakdown of carbohydrates, fats and proteins are catalysed and controlled by specific enzymes. Most chemical reactions of the living cells would have occurred very slowly had it not been catalysed by enzymes.

The substance upon which an enzyme acts is called the substrate. The enzyme will convert the substrate into the product or products. The enzymes are generally named by adding the suffix-ase to the name of the substrate. Thus, the enzyme lactase acts on the substrate lactose and the products glucose and galactose are formed.

All enzymes are proteins. Enzymes follow the physical and chemical reaction of proteins.

They are heat labile, soluble in water, precipitated by protein precipitating reagents (Ammonium sulphate or trichloroacetic acid) and contain 16% weight nitrogen.

General Properties of Enzymes

1. All enzymes are proteins.
2. They accelerate the reaction, but
   a. Do not alter the reaction equilibrium
   b. Not consumed in overall reaction
   c. Required only in very small quantities.
3. They have enormous power for catalysis.
4. Enzymes are highly specific for their substrate.
5. Enzymes possess active sites at which interaction with substrate takes place.
6. Enzymes lower activation energy.
7. They form substrate complex as intermediates during their action.
8. Some enzymes are regulatory in function.

Classification of Enzymes

As per the International Union of Biochemists, enzymes are divided into six major classes.

$$\text{Lactate} \xrightarrow[\text{NAD}\ \ \text{NADH+H}^+]{\text{Lactate dehydrogenase}} \text{Pyruvate}$$

Oxidoreductases: One compound oxidised, another reduced, e.g., tyrosinase, urease, lactic dehydrogenase, catalase and peroxidase.

Transferase: This class of enzymes transfer group containing C, N or S from the substrate to another substrate. They are important in biological synthesis, e.g., transaminases, hexokinases transcylases, transaldolases.

$$\text{Serine} \xrightarrow[\text{Methyl transferase}]{\text{Serine dehydrogenase}} \text{Glycine}$$

Hydrolases: They catalyse hydrolysis of esters, ether, peptide or glycosidic bond by addition of water molecules across the bond which is split, e.g., esterases, peptidases.

$$\text{Urea} + \text{H}_2\text{O} \xrightarrow{\text{Urease}} \text{CO}_2 + 2\text{NH}_3$$

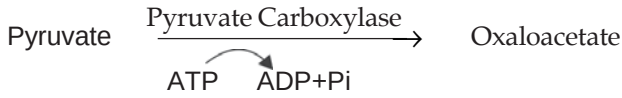
Lyases: They catalyse the addition or removal of groups without hydrolysis, oxidation or reduction, producing double bonds at times, e.g., decarboxylases, carboxylases, carbonic anhydrase.

$$\text{Pyruvate} \xrightarrow[\text{Dehydrogenase}]{\text{Pyruvate}} \text{Acetaldehyde} + \text{CO}_2$$

Isomerases: These can produce optical, geometric or position isomers of substrates by intermolecular rearrangement, e.g., reacemases, epimerases, isomerases.

$$\text{Methyl Malonyl CoA} \xrightarrow{\text{Mutase}} \text{Succinyl CoA}$$

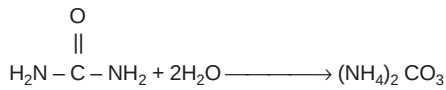
Ligases: These enzymes also called synthetases link two substrates together usually with the linking of pyrophosphate bound in ATP (Ligare = to bind), e.g., glutamine synthetase.



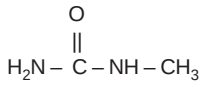
ENZYME SPECIFICITY

Some enzymes are very specific and show activity with only one substrate. Some others are much less particular. Generally three types of enzymatic specificities are observed.

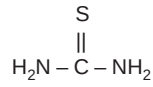
1. Stereospecificity: Some enzymes show specificities only with a specific group of a substrate, e.g., urease catalyses the hydrolysis of urea.



The catalysis does not take place when structure of urea is altered, e.g., N-methyl urea and thiourea are not hydrolysed by urease.



N-Methyl Urea



Thiourea

D-amino acid-oxidase acts only on the D-form of amino acid and not on L-form.

2. Substrate specificity: Some enzymes catalyse similar type of reaction but differ in their action due to substrate specificity, e.g., (a) Pepsin hydrolyses peptide bonds involving aromatic amino acids like phenyl alanine and tyrosine. (b) Trypsin hydrolyses peptide bonds involving carboxyl groups of basic amino acids like arginine or lysine.
3. Reaction specificity: A substrate can undergo many reactions but in reaction specificity, one enzyme can catalyse only one of the various reactions. For example, oxalic acid can undergo different reactions, but each of these reactions is catalysed by separate enzymes.

Mechanism of Enzyme Action

According to Michaelis and Menten, the enzyme molecule (E) first combines with a substrate molecule (S) to form an enzyme-

substrate (ES) complex which further dissociates to form product (P) and enzyme (E) back.

$$E + S \rightleftarrows ES \rightarrow E + \text{products}$$

Enzymes once dissociated from the complex is free to combine with another molecule of the substrate.

The site at which a substrate can meet with the enzyme molecule is extremely specific and is called active site or catalytic site. Normally the molecular size and shape of the substrate molecule is extremely small compared to the enzyme molecules. The active site is made up of several amino acid residues that come together as a result of the foldings of secondary and tertiary structures of the enzymes. So the active site possesses a complex three dimensional form and shape, provides a predominantly non-polar cleft or crevice to accept and bind the substrate.

Factors Affecting Enzyme Activity

Substrate Concentration

At a low substrate concentration the initial velocity of an enzyme catalysed reaction is proportional to the substrate concentration. However, as the substrate concentration is increased, the initial velocity increases less as it is no longer proportional to the substrate concentration. With a further increase in the substrate concentration and the velocity assumes a constant rate as a result of enzyme being saturated with its substrate.

It was Michaelis and Menten who suggested an explanation for these findings by postulating that at low substrate concentrations, the enzyme is not saturated with the substrate and the reaction is not proceeding at maximum velocity, whereas, when the enzyme is saturated with substrate, maximum velocity is observed. The enzyme combines with the substrate to form an enzyme-substrate complex and the rate of decomposition of the substrate is proportional to the enzyme-substrate complex. The velocity of the reaction at this high substrate concentration is termed as maximum velocity (V_{max}). The substrate concentration at which the velocity is half of the maximum velocity is called the Michaelis' constant (K_m). K_m indicates the affinity of the substrate towards the enzyme and is inversely proportional to the affinity.

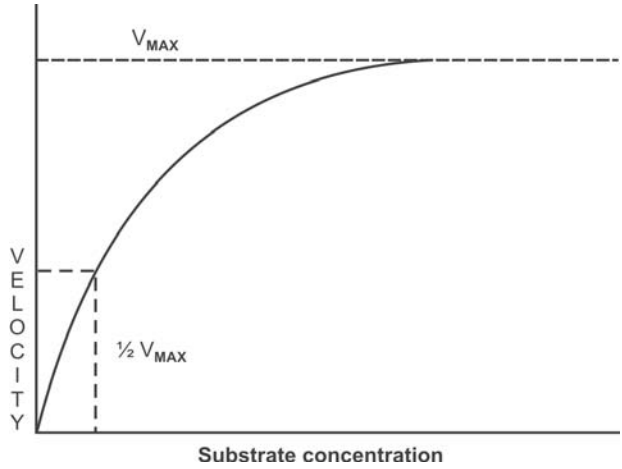


Fig. 7.1: Enzyme activity and substrate concentration

$$K_m = \alpha \frac{1}{\text{Affinity}}$$

Higher the affinity the smaller will be the K_m and lower the affinity, the higher will be the K_m (Fig. 7.1).

The Michaelis – Menten equation is given by the expression

$$Vo = \frac{V_{max}[S]}{K_m + [S]}$$

Where Vo = Initial velocity
V_m = Maximum velocity
K_m = Michaelis constant
[S] = Substrate concentration

When the initial velocity is exactly half the maximum velocity,

$$\tfrac{1}{2} V_{max} = \frac{V_{max}[S]}{K_m + [S]}$$

$$K_m + [S] = 2\,[S]$$

$$K_m = [S]$$

Therefore, K_m is equal to substrate concentration at which the velocity is half the maximum.

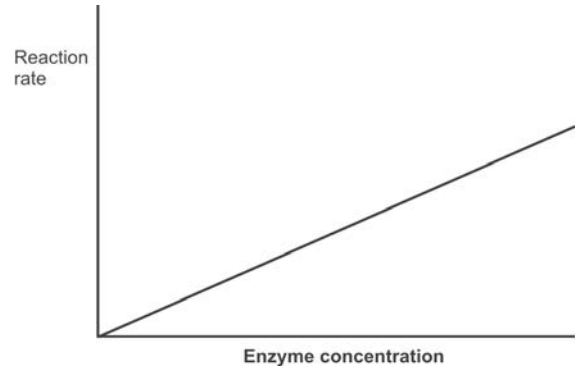


Fig. 7.2: Enzyme activity and enzyme concentration

Effect of Enzyme Concentration

The rate of an enzyme catalysed reaction is directly proportional to the concentration of the enzyme. The greater the concentration of enzyme, the faster will be reaction taking place (Fig. 7.2).

Effect of pH

The enzyme activity is maximum at a particular pH which is called the optimum pH. This is due to the changes in the net

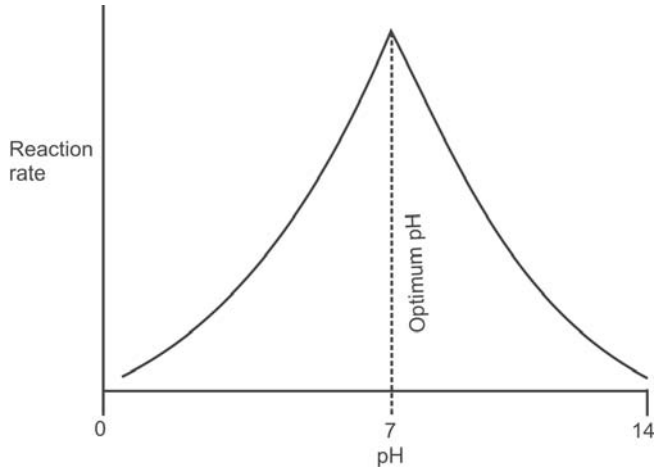


Fig. 7.3: Enzyme activity and pH

charge on enzymes resulting from changes in pH. Excessive changes in pH brought on by addition of strong acids or bases may completely denature and inactivate enzymes (Fig. 7.3).

Effect of Temperature

The velocity of enzyme reaction increases when temperature of the medium is increased; reaches a maximum and then falls. The temperature at which maximum amount of substrate is converted to the product per unit time is called the optimum temperature (Fig. 7.4).

As temperature is increased, more molecules get activation energy, or molecules are at increased rate of motion, and so their collision probabilities along with the reaction rate is increased. Above this temperature the reaction rate decreases as enzymes being protein in nature are denatured by heat and becomes inactive.

Effect of Time

The time required for completion of an enzyme reaction increases with decrease in temperature from its optimum. Under the optimum conditions of pH and temperature, time required for enzyme reaction is less.

Enzyme Inhibition

Enzymes are proteins and they can be inactivated by the agents that denature them. The chemical substances which inactivate the

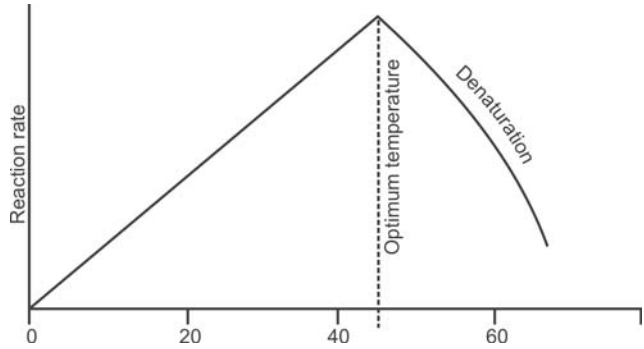


Fig. 7.4: Enzyme activity and temperature

enzymes are called as inhibitors and the process is called enzyme inhibition. Most of the substances commonly referred to as poisons are harmful in that they inhibit one or more essential enzymes.

The inhibitors may be classified in two broad groups. First, compounds or ions which are specific in their effect, inhibiting only one enzyme or several closely related enzymes. And second, substances which are nonspecific, inhibiting many enzymes.

Specific Inhibition

The inhibitor molecule is a structural analog of the normal substrate of the enzyme, i.e., it is chemically similar to the substrate. The inhibitor is capable of combining with the active site by virtue of its similar structure. As long as the active site is bound to the inhibitor, the enzyme is not a catalyst. Since, both are competing for combination with the same active site, the term competitive inhibition (Fig. 7.5) is often used.

An important example is provided by the sulfa drugs. These are structural analogs of para-aminobenzoic acid, a compound required by many bacteria for synthesising their food (Vitamin) tetrahydrofolic acid (THFA) but which is not used by higher

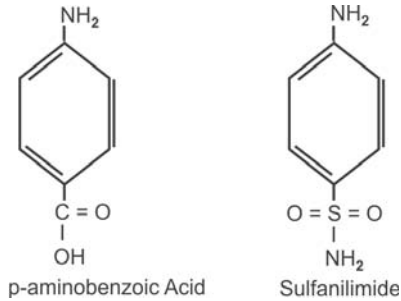


Fig. 7.5: Competive Inhibition

organisms such as man. The sulfa drugs inhibit growth of the bacteria in man by competing with the paraaminobenzoic acid for the active site of some bacterial enzyme.

Non-Specific Inhibition

Every protein molecule has a number of reactive groups present on side chains of the constituent amino acids, groups such

as – CO_2H, – SH, – NH_2, etc. Any substance capable of combining with a common group of this type is a potential inhibitor of all. Heavy metal ions are non-specific inhibitors. They can bind to a number of protein groups in particular – SH and – CO_2H at the active site inhibiting the normal catalytic activity. In sufficient concentration, heavy metal ions will inhibit most enzymes and are therefore poisonous to all living things. However, some of these heavy metal ions Cu^{++}, Zn^{++}, Co^{++} are absolute requirements in low concentrations for cells as cofactors for a variety of enzymes. Thus, classification of a metal ion as poison depends on its concentration. Mostly non-specific inhibition is non-competitive in nature.

CO-ENZYMES

Many enzymes require the presence of small non-protein organic molecules for their efficient performances. Only when both enzyme and co-enzyme are present catalysis will occur. Co-enzymes are low molecular weight, non-protein organic compounds that are heat resistant, and function as cosubstances. Usually, it binds loosely and can be a easily separated from its enzyme by dialysis, but when it binds tightly, it is considered as a prosthetic group of the enzyme. Co-factor differs from a co-enzyme only because it usually is a metallic ion (Fe^{++}, Mg^{++}, Zn^{++}, Cu^{++}) rather than an organic molecule. Water soluble vitamins (Vit B complex and Vit C) from Co-enzymes.

The term apo-enzyme refers to the protein part of the enzyme. The apo-enzyme with its prosthetic group (or co-enzyme) constitute a complete enzyme or holoenzyme.

Conjugated protein enzyme $\rightleftharpoons$ Protein + prosthetic group

or Holoenzyme $\rightleftharpoons$ Apo-enzyme + co-enzyme

= Protein part + non-protein part (prosthetic group)

Classification of Co-enzyme

Co-enzymes for group transfer of groups other than H

Co-enzymes for transfer of H

1. ATP and its relatives
2. Sugar phosphates
3. CoA
4. Thiamine pyrophosphate
5. B_6 phosphate
6. Folate co-enzyme
7. Biotin
8. Cobamide (B_{12}) Co-enzyme
9. Lipoic acid.

1. NAD^+, $NADP^+$
2. FMN, FAD
3. Lipoic acid
4. Co-enzyme Q

Water Soluble Vitamins as Co-Enzymes

Vitamins of B complex and vitamin C (Ascorbic acid) act as co-enzymes as shown in Table 7.1

Table 7.1: Relationship along water-soluble vitamins, their co-enzyme forms and metabolic reactions in which they participate

Vitamins	*Co-enzymes*	*Types of reactions*
Thiamine (B_1)	Thiamine pyrophosphate TPP	Decarboxylation of α-Keto acid, certain reactions of ketosugars.
Riboflavin (B_2)	Flavin mononucleotide (FMN) Flavin adanine dinucleotide (FAD)	Several kinds of oxidation-reduction reactions.
Pyridoxine (B_6)	Pyridoxal phosphate	Several kinds of reactions involving amino acids, e.g. decarboxylation, transamination.
Niacin (B_3)	Nicotinamide adenine dinucleotide (NAD^+), Nicotinamide adenine, dinucleotide phosphate ($NADP^+$)	Numerous oxidation-reduction reactions.
Pantothenic acid	co-enzyme 'A'	Many reactions of fatty acids, particularly those involving transfer of acetyl groups.
Biotin	Enzyme bound biotin	Certain carbon dioxide fixation reactions.
Folic acid	Tetrahydrofolic acid	Various reactions involving single carbon compounds.
Cyanoco-balamine	Several "Cobamide" co-enzymes	Carbon chain isomerizations, certain methyl group transfers.

Diagnostic Value of Plasma Enzymes

When a tissue is injured some cells of that tissue are destroyed and their contents including enzymes are released into the blood stream. The increase of enzymes in blood stream will indicate the disease (Table 7.2).

Table 7.2: Increase of Different Enzymes in Diseases

Enzymes	*Increased in*
Amylase	Acute pancreatitis.
Acid Phosphatase (Optimum pH = 5	Prostatic carcinoma.
Alkaline Phosphatase (Optimum pH = 10)	Liver disease, rickets.
Aspartate transaminase AST (previously GOT)	Myocardial infarction.
Alanine transaminase ALT (previously GPT)	Liver disease especially with liver cell damage.
Lactate dehydrogenase LDH	Myocardial infarction but also increased in liver disease and some blood disease.
Creatine kinase (CK)	Myocardial infarction and skeletal muscle diseases (muscular dystrophy, dermatomyositis).
γ Glutamyl transferase (γGT)	Diagnosis of liver disease, particularly biliary obstruction and alcoholism.

Urinary Elevation

N-acetyl glucosaminidase in the urine can be used to indicate renal transplant rejection.

QUESTIONS

1. **Define an enzyme. Classify the enzymes and add a brief note on the factors influencing enzyme activity.**
2. **Name the enzymes catalysing the following reactions:**
   i. Glucose 6 phosphate to Glucose.
   ii. Glucose 6 phosphate to Fructose 6 phosphate.
3. **Short essay on transaminases.**
4. **Write the co-enzyme forms of the following vitamins with examples:**
   A. Riboflavin
   B. Niacin
   C. Pyridoxine.
5. **Differentiate between co-enzymes and iso-enzymes.**

MULTIPLE CHOICE QUESTIONS

6. **The enzyme maltase can act on:**
   A. Glucose
   B. Maltose
   C. Starch
   D. Cellulose
7. **An enzyme is specific:**
   A. For a substrate
   B. For reaction which it can catalyse
   C. Both A and B are correct
8. **Co-enzymes:**
   A. Alter the equilibrium of reactions
   B. Are consumed by reactions
   C. Usually consist of polypeptides
   D. Include Mg^{++}, Zn^{++} and Fe^{++}
9. **Which of the following co-enzymes is not derived from vitamins?**
   A. CoA-SH
   B. Peridoxal phosphate
   C. TPP
   D. Lipoamide

10. Which vitamin cannot serve as antioxidant?
A. Vitamin A
B. Vitamin C
C. Vitamin E
D. Vitamin K

11. Which of the following non-proteins can act as an enzyme?
A. DNA
B. Phospholipids
C. Glycolipids
D. RNA

12. The enzymes regulated by phosphorylation dephosphorylation (e.g., Covalent binding and later cleavage of the phosphate to the enzyme) include all the following *except:*
A. Glucose-6-phosphatase
B. Glycogen synthase
C. Pyruvate dehydrogenase
D. Glycogen phosphorylase

13. A non-competitive enzyme inhibitor will do all the following *except:*
A. Decrease V_{max}
B. Act independently of (s)
C. Decrease K_m
D. Not attach to a substrate binding site

14. Enzymes are:
A. Biocatalysts
B. Proteins except ribozymes
C. Products of germs
D. All of the above

15. Lactate hydrogen belongs to the class of:
A. Legasen
B. Lyases
C. Oxidoreductases
D. Isomerases

16. All the following gastrointestinal enzymes are secreted on zymogens *except:*
A. Ribonucleases
B. Pepsin

C. Chymotrypin
D. Trypsin

17. An example of an entracellular enzyme is:
A. Glucokinase
B. Pancreatic amylase
C. Hexokinase
D. Glucose-6-Phosphatase

18. All the following are co-czymes *except:*
A. NAD^+
B. TPP
C. ALT (SGPT)
D. Pyridoxal phosphate

19. The function of a co-cnzyme in a enzymatic reaction is to:
A. Act as co-subrate
B. Activate the substrate
C. Raise the activation energy of the co-ezymatic reaction
D. Enhance the specificity of the substrate

20. A cofactor in an enzymatic reaction is:
A. An organic molecule
B. A metal ion
C. Both the above
D. A hormone

21. Co-enzyme A contains the following vitamin:
A. Thiamin
B. Pantothenic acid
C. Vitamin B6
D. Folic acid

22. Co-enzyme required for transamination is:
A. NAD^+
B. Thiamin pyrophosphate
C. FMN
D. Pyridoxal phosphate

23. Enzyme increases the rate of reaction by:
A. Decreasing the energy of activation
B. Increasing the energy of activation

C. Increasing the free energy change of the reaction
D. Decreasing the free energy change of the reaction

24. Normal level of SGOT (AST) and SGPT (ALT) at 37° C is:
A. 0-50 IU/L
B. 0-80 IU/L
C. 60-180 IU/L
D. 100-250 IU/L

25. Acid phosphate level in serum is elevated in:
A. Acute pancreatitis
B. Osteomalacia
C. Prostatic carcinoma
D. Obstructive jaundice

26. The diagnostic enzyme in muscular dystrophy is:
A. Lipase
B. Alkaline phosphatase
C. Lactate dehydrogenase A(LDH)
D. Creative phosphobimase (CPK)/creative kinase (CK)

27. All the enzymes are increased in myocardial infraction *except* :
A. Alkaline phosphatase
B. LDH
C. CPK
D. SGOT (AST)

28. Which of the following enzymes in serum is specifically elevated in alcoholism?
A. SGPT (ALT)
B. SGOT (AST)
C. V glutanyl transpeptidase (V-GT)
D. Acid phosphatase

29. Serum amylase is highly raised in:
A. Diabetes mellitus
B. Acute pancreatitis
C. Bone disorders
D. Liver disorders

30. The group transferring cocnyme is:
A. Coenzyme A
B. NAD^+

C. NADP
D. FAD

31. Creatin kinase is found in:
A. Myocardium
B. Brain
C. Muscles
D. All of the above

32. Following mycocardial infection, the last serum enzyme to return to normal is:
A. Creatin bimase
B. GOT
C. LDH
D. GPT

33. The following serum enzyme rises in viral hepatitis:
A. LDH
B. GPT
C. GOT
D. All of the above

34. The following serum enzyme rises in myocardiac infarction:
A. Creatin kinase
B. GOT
C. LDH
D. All of the above

35. Following myocardiac infarction the earliest serum enzyme to rise is:
A. Creatin kinase
B. GOT
C. GPT
D. LDH

36. Enzymes which contain lightly bound metal ions are called:
A. Co-enzyme
B. Metalloenzyme
C. Metal activated enzyme
D. Activated metal enzyme

37. Enzymes increase the rate of reaction by:
A. Increasing the free energy rate of activation
B. Decreasing the free energy of activation

C. Charging the equilibrium constant of the reaction
D. Increasing the free energy change of reaction

38. The group transferring co-enzyme is:

A. CoA
B. NAD+
C. NADP
D. FAD

ANSWERS

6(B)	7(C)	8(D)	9(D)	10(D)	11(D)
12(A)	13(C)	14(D)	15(C)	16(A)	17(B)
18(B)	19(D)	20(B)	21(B)	22(D)	23(A)
24(A)	25(C)	26(D)	27(B)	28(C)	29(B)
30(A)	31(D)	32(C)	33(D)	34(D)	35(A)
36(B)	37(B)	38(A)			

CHAPTER

8 Digestion and Absorption

All foodstuffs except water, inorganic salts, vitamins and non-saccharides are hydrolysed into smaller molecules in the digestive tract before absorption from the intestines. The hydrolysis is accomplished by the enzymes of digestive fluids namely saliva, gastric juice, pancreatic juice and the intestinal juices.

Salivary Digestion

Saliva provides α-amylase. The flow is stimulated by the sight, smell, taste and even thought of food. Besides water (99.5%), saliva includes a food lubricant called nucin (a glycoprotein) and an enzyme, α-amylase. This enzyme catalyses the partial hydrolysis of starch to dextrins and maltose and it works best at the pH of saliva in between 5.8 to 7.1. Proteins and lipids pass through the mouth unchanged.

Gastric Juice

Gastric juice starts the digestion of proteins with pepsin. When food reaches the stomach, the cells of the gastric glands are stimulated by hormones to release the fluids that combine to give gastric juice. One kind of gastric gland secretes mucin, which coats the stomach to protect it against its own digestive enzymes and its acid. Mucin, is continuously produced and only slowly digested. When the protection of the stomach is hindered, part of the stomach itself could be digested leading to ulcers.

Another gastric gland secretes hydrochloric acid (pH 1 to 2) about a million times more acidic than blood. The acid coagulates proteins and activates the enzyme protease. Protein coagulation retains the protein in the stomach longer for exposure to the protease.

The third gastric gland secretes the zymogen pepsinogen. Pepsinogen is changed into pepsin and protease, by the action of

hydrochloric acid and traces of pepsin. The optimum pH is 1.0 to 1.5, which is found in the stomach fluid. Pepsin catalyses the only important digestive work in the stomach, namely the hydrolysis of some of the peptide bonds of proteins to make short polypeptides.

Adult gastric juice also has a lipase, but it does not start its work until it arrives in the higher pH medium of upper intestinal tract. The gastric juice of infants is less acidic than adults. To compensate for the protein coagulating work normally done by the acid, infant gastric juice contains rennin, a powerful protein coagulator. Because the pH of an infant's gastric is higher than that in adult, its lipase gets an early start on lipid digestion.

The churning and digesting activities in the stomach produce a liquid mixture called chyme. This is released in portions through the pyloric valve into the duodenum, the first 12 inches of the upper intestinal tract.

Pancreatic Juice

The pancreatic juice furnishes several zymogens and enzymes. As soon as the chyme appears in the duodenum, hormones are released that circulate to the pancreas and induce this organ to release two juices. One is dilute sodium bicarbonate, which neutralises the acid in the chyme. The other is usually called pancreatic juice and it carries enzymes or zymogens involved in the digestion of practically everything in food. It contributes an α-amylase similar to that present in saliva, a lipase, nucleases and zymogens for protein digestion enzymes.

The conversion of the proteolytic zymogens to active enzymes begin with the enzyme called enteropeptadase released from cells that line the duodenum when chyme arrives. It catalyses the formation of trypsin from its zymogen, trypsinogen.

$$\text{Trypsinogen} \xrightarrow{\text{enteropeptidase}} \text{trypsin}$$

Trypsin then catalyses the change of the other zymogen into active enzymes.

$$\text{Procarboxypeptidase} \xrightarrow{\text{trypsin}} \text{carboxypeptidase}$$

$$\text{Chymotrypsinogen} \xrightarrow{\text{trypsin}} \text{chymotrypsin}$$

$$\text{Proelastase} \xrightarrow{\text{trypsin}} \text{elastase}$$

Trypsin, chymotrypsin and elastase catalyse the hydrolysis of large polypeptides to smaller ones. Carboxypeptidase working in form C-terminal ends of small peptides, carries the action further to amino acids and dipeptides or tripeptides.

Intestinal Juice

The intestinal juice contains the following enzymes
1. Disaccharidases
2. Peptidases
3. Polynucleotidases
4. Nucleosidases
5. Enterokinases
6. Phosphatases
7. Lecithinase.

Disaccharidases : They are enzymes to hydrolyse disaccharides. They attack the glucosidic linkage of the disaccharides to convert them to the corresponding monosaccharides. For example:
1. Maltase splits maltose into 2 molecules of glucose.
2. Sucrase splits sucrose into glucose and fructose.
3. Lactase splits lactose into glucose and galactose.

Peptidases: These are enzymes hydrolysing peptide chains. There are two main types of peptidases:
a. Aminopeptidases act on the peptide linkage of terminal amino acids, possessing a free amino group.
b. Tripeptidases and dipeptidases split tripeptides and dipeptides into their individual amino acids.

Polynucleotidases: It hydrolyses and splits the nucleotide into phosphoric acid and nucleoside.

Nucleosidase: It splits nucleosides into their nitrogenous bases and sugars.

Enterokinase: This enzyme is secreted by the duodenal and mucosal cells. It converts trypsinogen to trypsin. It does not have any direct digestive action.

Phosphatase: Enzyme phosphatase presents in the intestinal juice splits the phosphate from organic phosphate derivatives, such as glycerophosphate and hexose phosphate.

Lecithinase: Intestinal juice contains the lecithinase which splits lecithins to yield fatty acids, glycerol, phosphoric acid and choline.

DIGESTION OF CARBOHYDRATES

In the mouth, Saliva contains salivary amylase (ptyalin) which catalyzes the hydrolysis of starch into maltose. However, this enzyme becomes inactive at a pH below 4, so that its activity ceases when it is mixed with the contents of the stomach where the pH falls to 1.5. Salivary amylase does not serve a very important function in digestion because the food does not remain in the mouth long enough for any appreciable hydrolysis to take place. Some hydrolysis of carbohydrates catalysed by salivary amylase may take place in the stomach before the food is thoroughly mixed but this is of little importance because there are instestinal enzymes capable of hydrolyzing starch and maltose. The principal function of saliva is to lubricate and moisten the food so that it can be easily swallowed.

In the stomach: The stomach contains no carbohydratases. So no digestion of carbohydrates takes place there except for that catalyzed by salivary amylase. The activity of the salivary amylase ceases as soon as it becomes mixed with the acid contents of the stomach.

In the small intestine: The major digestion of carbohydrates takes place in the small intestine through the action of enzyme pancreatic amylase that catalyzes the hydrolysis of starch and dextrins into maltose. The maltose thus produced is hydrolysed to glucose through the activity of the enzyme maltase from the intestinal mucosal cells. The optimum pH of pancreatic amylase is 7.1. The intestinal mucosal cells also contain the enzymes sucrose and lactose which catalyse the hydrolysis of sucrase and lactase respectively.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)\,n} + n\,H_2O \xrightarrow[\text{amylase}]{\text{Pancreatic}} \underset{\text{maltose}}{C_{12}H_{22}O_{11}}$$

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{maltose}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

If a monosaccharide such as glucose is eaten, digestion is not necessary because the monosaccharide is already in its simplest form and can undergo absorption into blood stream. Many adults cannot digest milk because they lack mucosal lactase. Such adults show milk intolerance with symptoms of abdominal cramps, bloating and diarrhoea.

DIGESTION OF FATS

In the Mouth

A lingual lipase secrteted by the dorsal surface of the tongue acts on the triglycerides particularly of the type found in milk. Lingual lipase has a pH range of 2.0 to 7.5 with optimum pH 4.0 to 4.5 so that it can continue its activity even at the low pH of the stomach.

In the Stomach

Although, gastric lapase is present very little digestion of fat takes place because the pH of the stomach (1to2) is far below the optimum pH of that enzyme (7 to 8). Also fats must be enmulsified before they cam be digested by lipase and there is no mechanism for emulsification of fats in the stomach. In infants, whose stomach pH is higher, fat hydrolysis of milk takes place in the stomach.

In the Small Intestine

In the small intestine, the pancreatic lipase catalyses the hydrolysis of fats into fatty acids and glycerol. This action is aided by bile salts which emulsify the fats so that they can be acted upon readily by pancreatic lipase.

$$\text{Fat+water} \xrightarrow{\text{Pancreatic Lipase}} \text{Fatty acids + glycerol}$$

DIGESTION OF PROTEINS

In the Mouth

As the saliva contains no enzymes for the hydrolysis of proteins, no digestion of protein takes place in the mouth.

In the Stomach

The precursor enzyme pepsinogen is converted to pepsin when it is mixed with the HCl of the stomach. Pepsin catalyzes the hydrolysis of proteins to polypeptides

$$\text{Protein + Water} \xrightarrow{\text{Pepsin}} \text{Polypeptides}$$

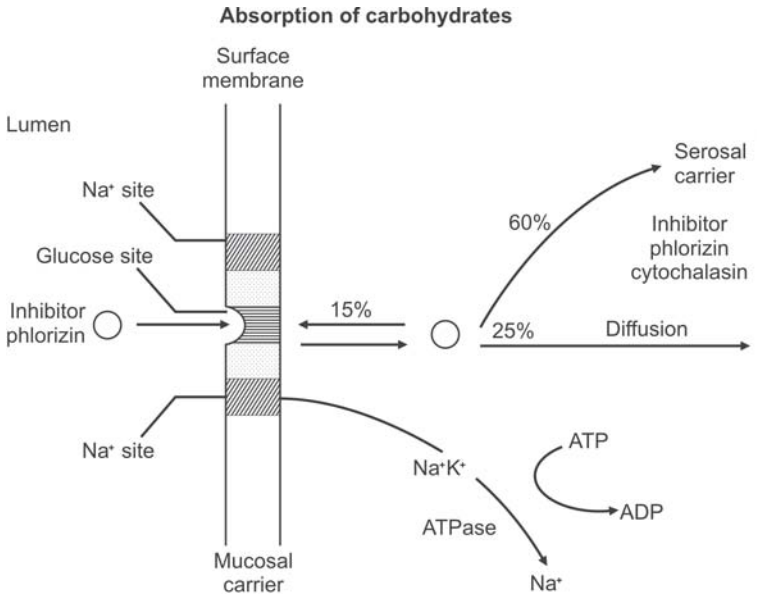
In the Small Intestine

In the small intestine, the zymogen, trypsinogen from the Pancreatic juice is changed into trypsin by the intestinal enzyme enterokinase Trypsin in turn changes chymotrypsinogen, another pancreatic zymogen into chymotrypsin. Both trypsin and chymotriypsin catalyze the hydrolysis of protein, proteoses and peptones to polypeptides. The optimum Ph of trypsin and chymotrypsin is 8 to 9.

The intestine enzymes aminopeptidase and dipeptidase catalyse the hydrolysis of polypeptides and dipeptides to amino acids. Carboxypeptidase, an enzyme of pancreative juice, also catalyzes the hydrolysis of polypeptides to amino acids. Carboxypeptidase contains the element Zn.

Proelastase from pancreatic juice is converted to elastase by trypsin: Elastase acts on protein and polypeptides to convert them into polypeptides and dipeptides respectively.

ABSORPTION OF CARBOHYDRATES



ACTIVE TRANSPORT OF GLUCOSE OR GALACTOSE BY THE INTESTINAL EPITHELIAL CELLS

Two mechanisms are responsible for the absorption of monosaccharides.

i. Active transport against a concentration gradient, and
ii. Simple diffusion.

Glucose and galactose are transported by active transport mechanism accomplished by a Na+ symport system. The membrane carrier has binding sites for both Na+ and sugar. The molecular configuration that seem necessary for active transport are the OH on carbon 2 should have the same configuration as in glucose, a pyranose ring should be present and a methyl or substituted methyl group should be present on carbon-5.

When the concentrations of glucose or galactose are very high in the lumen as immediately after a meal, the system accomplishes transport of sugar down its concentration gradient into the cell. When the lumenal concentration of monosaccharide falls, the system performs up hill or active transport into cell. The driving force for this active transport is provided by the Na^+ K^+ at the basolateral membrane of the epithelial cell which pumps Na^+ out of the cell, thus maintaining the Na^+ gradient. Thus, as Na^+ moves into the cell down its concentration gradient the coupled transport monosaccharide against its concentration gradient is able to occur. The carrier is an integral membrane protein that binds and transports two Na^+ ions for each sugar molecule. Its glucose site can be blocked by the glycoside phlorizin. Inhibitors of Na^+ K^+ ATPase system such as Ouabain also block glucose absorption because of the resultant inability of the epithelial cell to transfer Na^+ from its seosal side to the plasma. Since, ouabain causes intracellular [Na^+] to rise equilibrium with [Na^+] on the mucosal side of the cell, the Na^+ gradient is abolished and transport of glucose becomes impossible.

Once inside the cell several routes of exit are possible for glucose. About 15% is carried back to the lumen by the transport system: 25% diffuses passively through the basal membrane of the cell. The remainder (60%) is transported out of the cell by a distinct carrier system at the serosal surface. This carrier is distinguished by its specific inhibition by phlorezin and sytochalasin B.

The transport system is so efficient that under physiology circumstances glucose never accumulates within the intestinal epithelial cells. The overall process of carbohydrate digestion and absorption is so efficient that ordinarily all dietary carbohydrate has been absorbed by the time the ingested material reaches the lower jejunum.

Fructose is absorbed by facilitated diffusion on a membrane carrier. The system moves the sugar from high concentrations in the lumen to low concentration within the cell and cannot accomplish uphill.

Absorption of Lipids

The main products of lipase action-fatty acids and mono-acylglycerols are solubilized by incorporation into mixed micelles with conjugated bile salts. The micelles markedly increase the rate of delivery of the fatty acids and monoacylglyerols to the intestinal mucosa, which represents the absorptive surface. Since, these products are rapidly resterified to triacylglycerols within the mucosal cell, their conc. at the inner surface of the intestinal cell, membrane is very low. Thus, fatty acids and monoacyl glycerols leave the surface of the intestinal cell, and being lipid soluble, passively diffuse across the membranes of the epithetical cells down their conc. gradients. This process of absorption of free fatty acids and monoacylglycerols is largely completed in the upper jejunum. The conjugated bile salts are reabsorbed in the ileum where they are actively transported and enter the enterohepatic circulation.

The products of the digestion of medium chain triacylglycerols (C8 to C12) are water soluble and they do not require micellar solubilization and are directly absorbed into the intestinal cell.

The free glycerol released in the intestinal lumen is not reutilized but passes directly to the portal vien. All long chain fatty acids absorbed by intestinal wall mucosal cells are utilized to form triacylglycerols. The enzymes involved in the process are in the endoplasmic reticulum. In the first reaction, the fatty acids are transformed to their corresponding acyl CoA derivatives by acyl CoA synthetase. Then, monoacylglycerol react with one molecule of fatty acyl CoA to give diacylglycerol, catalyzed by monoacyl glycerol transacylase. Finally, in the presence of diacylglycerol

transacylase diacylglycerol reacts with one molecule of acyl CoA to give triacyglycerol.

An alternate and minor pathway for triacylglycerol resynthesis involves fatty acid esterification with phosphatidic acid which in turn is derived from cellular glucose metabolism.

The final step in the absorption of the resynthesized triacylglycerols from the intestine are their incorporation into chylomicrons, which renders them water soluble, followed by secretion into the intestinal lymphatic drainage. Once secreted into the lymph, the chylomicrons enter the blood via the thoracic duct.

Cholesterol absorption also occurs in the small intestine. Cholesterol and its esters are sparingly soluble in water and are present in the lipid emulsion phase of the intestinal contents. Cholesterol esters are hydrolyzed by pancreatic esterases and the free cholesterol is incorporated into mixed micelles with bile salts. Cholesterol crosses the intestinal membrane and after absorption cholesterol is largely reesterified within the mucosal cell and incorporated within chylomicrons before secretion into the lymph.

ABSORPTION OF PROTEINS

The end products of hydrolysis of proteins are aminoacids. Absorption of aminoacids occurs chiefly in the small intestine and is an active enzyme-requiring process resembling the active transport of glucose. There are six or more specific transport systems for aminoacids being carried into the blood stream:

1. A system for small neutral amino acids such as glycine.
2. A system for large neutral amnioacids such as phenyl alanine.
3. A system of basic aminoacids such as lysine.
4. A system for acidic amino acids such as aspartic acid.
5. A system for protine.
6. A system for very small peptides.

Amino acids compete with one another for absorption via a particular pathway. Thus, high levels of leucine lower the absorption of isoleucine and valine.

Occasionally, proteins also escape digestion and are absorbed directly into the blood. This occurs more often in the very young since the permeability of their intestinal mucosa is greater, allowing the passage of antibodies of colostral milk. This passage

of protein into blood may be sufficient to cause immunological sensitization and related food allergies.

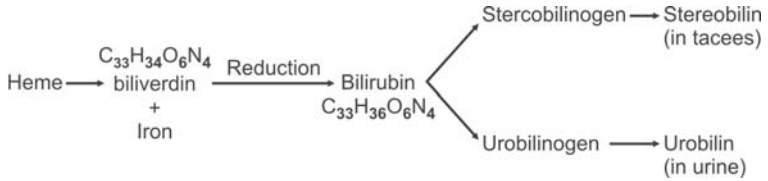
The L amino acids are absorbed more rapidly than D isosmers and pass through the capillaries of the villi directly into the blood stream which carries them to the tissues to be used to build or replace tissue. The amino acids are also oxidized to furnish energy. Although, the body can store carbohydrates and fat, it cannot store protein.

ABSORPTION OF VITAMINS

Most vitamins are absorbed in the upper small intestine. The fat soluble vitamins (A,D,E &K) need fat and bile salts to be absorbed. Taking a multi-vitamin capsule with water does not provide the fat necessary for the absorption of fat soluble vitamins. Vitamin B12 absorption depends on its binding to an intrinsic factor produced in the stomach. This complex along with calcium ions finds acceptor sites in the lower small intestine.

BILE PIGMENTS : BILIVERDIN AND BILIRUBIN

When RBCs die, the haemoglobin is liberated and the haeme is separated from the globin. The body removes the iron from haeme and reuses it. The haeme with iron removed becomes BILIVERDIN. Biliverdin is reduced in the reticuloendothelial cells of the liver, spleen and bone narrow to form BILIVERDIN, the main bile pigment exereted into bile by the liver. In the intestines, some bilimbin is converted into stercobilinogen and stercobilin, a pigment that gives faeces its characteristic yellow-brown colour, some bilirubin is absorbed into the blood stream and comes to the liver where it is converted into urobilinogen and then to urobilin, which appears in the urine giving that fluid its characteristic colour. Reactions are below:



Biliverdin, bilirubin and urobilirubin are the bile pigments. If the bile duct is blocked, bile pigments remain in the blood stream producing jaundice. When the bile duct is blocked, no bile

pigment can enter the intestine and the feces will appear clay coloured or nearly colourless.

Bilirubin is an orange yellow bile pigment, whereas biliverdin is a green bile pigment, the oxidized form of bilibubin. Their presence in urine is detected by (a) Gmelin's test and (b) Fouchet's test.

Bilirubin in the bile is reduced by bacteria in the intestine to urobilinogen (stercobilinogen). The greater part of the urobrlinogen is reabsorbed and brought again in blood to the liver.

Bile

Fresh human bile is a clear golden yellow liquid formed and secreted by the liver. It is slightly viscus and tastes bitter. It has a pH 7.5 to 8.5.

About 500 to 700 ml of bile are secreted daily by the liver. A part of it, about 500 ml, is stored in the gallbladder, where it is concentrated and periodically discharged into small intestines. The bile in the gallbladder is more viscus and has a greenish tinge because of the presence of bile pigments. During digestion, the gallbladder contracts to supply bile to the intestines, via the common bile duct. The bile mixes with the pancreatic juice and helps to emulsify the water insoluble fatty materials and thus greatly increase the exposure to water and lipase. Triacyl-glycerols are hydrolysed to fatty acids, glycerol and some mono-acylglycerols.

Normally, bile is exereted by the liver into small intistine and eventually end up in the feces. The presence of bile in urine indicates obstruction to the flow of bile to the intestimes. Bile in the urine in indicated by a greenish brown colour. Bile in the urine is also indicated by the presene of yellow foam, when urine is shaken.

Bile Salts

Sodium and potassium glycolate and sodium and potassium taurocholate are both bile salts derived from cholic acid. They have the ability to lower the surface tension and increase surface area, thus aiding in the emulsification of fats. They also increase the effectiveness of pancreatic lipase in its digestive action on emulsified fats.

In addition, bile salts aid the absorption of fatty acids through the walls of the intestine. After absorption of these fatty acids, the

bile salts are removed and carried back by portal circulation to the liver, where they are again returned to the bile. Bile salts also stimulate intestinal motility. Bile salts keep cholesterol in solution form.

The bile salts also assist in the absorption of the fat soluble vitamins (A, D, E and K) from the digestion tract into blood. This work reabsorbs some bile pigments some of which eventually leave the body through urine. Presence of bile salts in the urine is tested by Hay's Sulphur powder test.

Summary of Digestion

Type of digestion	*Location of digestion*	*Digestive juice and enzymes*	*Substrate*	*Products*
Salivary	Mouth	*Saliva*		
		salivary amylase (ptyalin)	Starch	*Dextrins*
		Lingual lipase	Milk	Fatty acids + 1,2 diglycerides
Gastric	Stomach	*Gastric juice*		
		Hydrochloric acid	Pepsinogen	Pepsin
		Pepsin	Protein	Polypeptides
		Lipase	Fats	Fatty acids + Glycerol
Intestinal	Small intestine	*Intestinal juice*		
		Enterokinase	Trypsinogen	Trypsin
		Aminopeptidase	Polypeptides	Amino acids
		Dipeptidase	Peptides	Amino acids
		Maltase	Maltose	Glucose
		Sucrase	Sucrose	Glucose + Fructose
		Lactase	Lactose	Glucose + Galactose
		Pancreatic juice		
		Trypsin	Protein	Polypeptides
		Chymotrypsin	Protein	Polypeptides
		Pancreatic amylase	Starch + dextrins	Maltose
		Pancreatic lipase	Fats	Fatty acids + Glycerol
		Carboxy peptidase	Polypeptides	Amino acids

QUESTIONS

1. **Name any four digestive enzymes. How are proteins digested and absorbed?**
2. **How is starch digested and absorbed?**

MULTIPLE CHOICE QUESTIONS

3. **Pancreative amylase digests starch and glycogen to:**
   A. Isomaltose
   B. Dextrin
   C. Maltose
   D. All of the above
4. **Carbohydrates are mainly absorbed from:**
   A. Jejunum
   B. Stomach
   C. Duodenum
   D. Ieum
5. **Which sugar is absorbed at the fastest rate from the small intestine?**
   A. Fructose
   B. Glucose
   C. Galactose
   D. Ribose
6. **The active transport of glucose is inhibited by:**
   A. Ouabain
   B. Phlorhizin
   C. Both of the above
   D. Digitonin
7. **Which of the following hormones increases the absorption of glucose from GI tract?**
   A. Insulin
   B. Glucagon
   C. ADH
   D. Thyroid hormones
8. **Which enzyme is involved in lipid digestion?**
   A. Elastrase
   B. Lactase

C. Lipase
D. Lactate dehydrogenase

9. Digestion of triglycerides requires:
A. Bile salts
B. Bile pigments
C. Intrinsic factor
D. Bile acids

10. Absorption of fats occurs mainly in:
A. Stomach
B. Duodenum
C. Jejunum
D. Ileum

11. Majority of absorbed fat appears in the form of:
A. VLDL
B. LDL
C. HDL
D. Chylomicrons

12. Milk protein is digested in the stomach by:
A. Tryprin
B. Remin
C. Rennin
D. HCL

13. The site of indestinal absorption of amino acid is:
A. Jejunum
B. Stomach
C. Ileum
D. Duodenum

14. Free L-amino acids are absorbed across the intestinal mucosa by:
A. Sodium dependent active transport
B. Facilitated diffusion
C. Passive diffusion
D. Osmosis

15. Pancreative amylase is most active in the range:
A. pH 1.8 to 2.2
B. pH 4.0 to 5.0

C. pH 6.2 to 7.2
D. pH 8.0 to 9.0

16. Trypsin slows its optimum activity at:
A. pH 1.8
B. pH 4.0
C. pH 8 9
D. pH 7.5

17. The optimum pH for pepsin action:
A. Between pH 1.5 to 2.2
B. pH 4.0
C. Between pH 7.0 to 7.1
D. pH 7.5

18. Pancreatic juice contains the precursors of all of the following *except:*
A. Trypsin
B. Chymotrypsin
C. Carboxypepsidase
D. Aminopepsidase

ANSWERS

3(D)	4(A)	5(C)	6(C)	7(D)	8(C)
9(A)	10(C)	11(D)	12(C)	13(A)	14(A)
15(C)	16(C)	17(A)	18(D)		

CHAPTER

9 Vitamins

DEFINITION

Vitamins are defined as organic compounds, occurring in natural food either as such or as utilisable precursors which are required in minute quantities for normal growth, maintenance and reproduction.

Vitamins differ from hormones in that they are supplied with the diet whereas hormones are produced by glands in the body. Most vitamins and hormones, however, are involved in affecting enzyme activity directly or indirectly. Several vitamins are coenzymes or prosthetic groups of enzymes in both plants and animals.

Vitamins differ from other organic foodstuffs in following aspects:

a. Vitamins do not enter tissue cultures unlike proteins.
b. Unlike carbohydrates, proteins and lipids, vitamins do not undergo degradation for providing energy.

Classification

Vitamins belong to several chemical groups. They are classified according to their solubility. Vitamins A, D, E and K are fat soluble and vitamins B and C are water soluble.

Difference between Fat Soluble and Water Soluble Vitamins

1. Water soluble vitamins function as precursors for coenzymes whereas fat soluble vitamins do not form coenzymes.
2. Water soluble vitamins are nontoxic since excess amounts of these vitamins are excreted in the urine. Fat soluble vitamins are not excreted in urine, being not water soluble and are toxic in excessive quantities.

3. Water soluble vitamins are not stored extensively except vitamin B_{12}. Hence, they have to be taken frequently as compared to fat soluble vitamins which are stored.

VITAMINS NOT ACTING AS CO-ENZYMES OR FAT SOLUBLE VITAMINS

Vitamin A

Vitamin A is a complex primary alcohol with empirical formula $C_{20}H_{29}$ OH and exists in two forms: Vitamin A_1 or Retinol and Vitamin A_2 or Dehydroretinol.

Sources

Vitamin A occurs only in animal tissues—in cod liver oil, butter, eggs, cheese. Its precursor β-carotene occurs in green vegetables and yellow coloured vegetables like carrots, tomatoes, apricots, sweet potatoes and corn; also yellow fruits papaya, mango and pumpkin. It is stable to heat, acid and alkali but is distroyed by oxidation (When butter turns rancid) Ordinary cooking does not destroy Vit A.

Conversion of Beta-Carotene to Retinal (Vitamin A Aldehyde)

β-carotene, the yellow pigment present in vegetables is the precursor which can be converted into vitamin A in human liver. One molecule of β-carotene can give rise to two molecules of vitamin A.

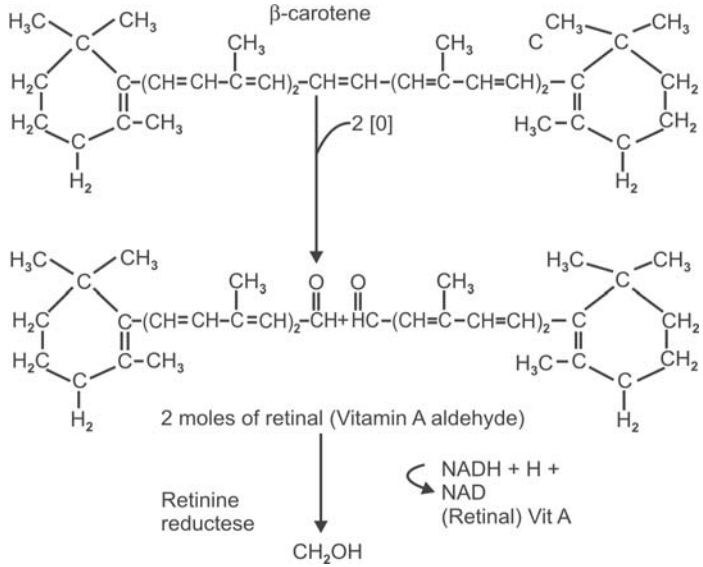
Requirements

Recommended Dietary Allowance (RDA) is the average daily dietary intake that meets the nutrient requirement of more than 97% of the healthy population.

Daily requirements of vitamin A for adults is 750 μg. The requirements for infants and young children is 300 μg. Women during pregnancy and lactation need 1200 μg per day.

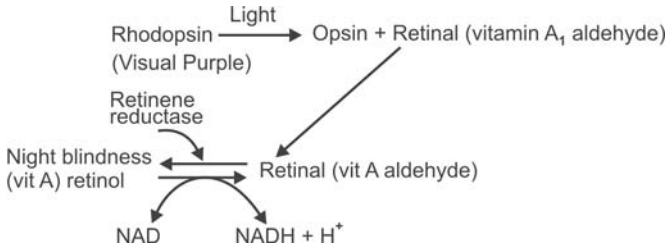
Functions

1. Vitamin A is indispensable for normal vision. It contributes to the production of retinal pigment, Rhodopsin neded for vision in dim light.
2. In the maintenance of proper health of epithelium tissues.
3. For the stability and integrity of cellular and subcellular membranes, which lines intestinal, respiratory and urinary tract as well as skin and eyes.



4. Necessary for the synthesis of mucopolysaccharides.
5. In the nucleic acid metabolism.
6. Involved in the electron transport chain and oxidative phosphorylation.
7. It increases the release of calcium and phosphate in the bones and is necessary for normal growth and development especially skeletal growth.
8. It is anti-infective. There is increased susceptibility to infection and lowered immune response in vitamin A deficiency.
9. It may protect against some epithelial cancers and bronchial cancers.

VITAMIN 'A' AND VISION



An early sign of vitamin A deficiency in man is inability to see objects in dim light especially after exposure to bright light. This condition is known as night blindness or nyctalopia.

Wald's visual cycle:
The overall mechanism through which vitamin A takes active part in visual system is known as Wald's visual cycle or Rhodopsin discovered by George Wald for which he was given the Nobel prize in 1967.

Retina contains two types of receptor cells:

Cones: These are specialized for colour and detailed vision in bright light.

Rods: These are specialized for visual activity in dim light (night vision). Light waves striking these receptors produce chemical changes which in turn give rise to nerve impulses. Vitamin A plays a significant role in the photochemical phase of this process.

The retinal pigment rhodopsin, or visual purple, which has long been recognized in the rod cells of the retina, is a conjugated protein with a molecular weight of approximately 40000. When light strikes the retina, rhodopsin is split into its protein component opsin and the associated non-protein carotenoid, retinal vitamin A_1 aldehyde. Retinal is slowly converted by reduction to the alcohol, retinol. The regeneration of retinal from retinol is done by the oxidation of the terminal alcohol group by the enzyme retinene reductase involving NAD as a co-enzyme. The retinal can then combine with opsin to regenerate rhodopsin in the cycle. If there is a lack of vit. A, rhodopsin is regenerated very slowly causing night blindness.

Keratinization: A lack of vitamin A causes a shrinking and hardening of epithelial tissues of the membranes in the eye, digestive tract, respiratory tract and urinary tract. Such a hardening is called keratinisation.

When keratinization occurs in the lining of the respiratory tract, the patient is more likely to suffer from colds, pneumonia and other respiratory infections because of the drying of the membranes.

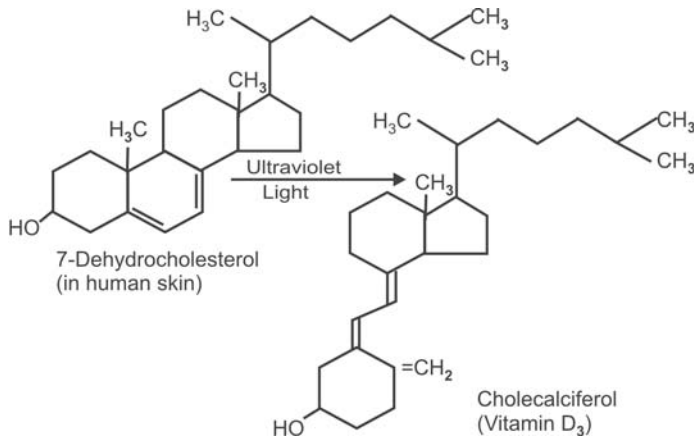
Xerophthalmia: When keratinization occurs in the eyes, the tear ducts become keratinized and are not longer able to secrete tears to wash the eyes. When this occurs, bacteria are able to attack the corneal tissue of the eyes, producing an infection called Xerophthalmia and

(Bitot's spot) in this disease the cornea becomes cloudy and does not allow light to pass through, so sight is lost permanently.

Hypervitaminosis: A excess accumulation of vitamin A in the liver can lead to toxicity which manifests in bone pain, hepatosplenomegaly, nausea and diarrhoea, night blindness, increases susceptibility to infections, dry and scaly skins, loss of smell and appetite, fatigue, defective teeth and gums retarded growth.

Vitamin D

Vitamin D is called Solar vitamin, because its synthesis involves the ultraviolet irradiation of sterols, such as 7-dehydrocholesterol in human skin. People not exposed to sunlight, e.g., people hospitalised for long time, people living in polar region or ladies in purdah suffer from vit. D deficiency.



Sources: Eggs, butter, liver, fatty fish and fish oils such as cod liver oil and vitamin D fortified milk, are good natural sources. Humans exposed to bright sunlight year round do not require dietary Vitamin D. Daily requirement for adult is 5 µg. Pregnant and lactating mothers and children may need up to 10 µg/day.

Physiological action: The principal action of vitamin D is to increase the absorption of calcium and phosphorus from small intestine. It also increases the release of calcium and phosphate in

the bones and is necessary for normal growth and development. Vitamin D is required for the proper activity of the parathyroid hormone and so it is used therapeutically in the treatment of hypoparathyroidism.

A lack of vitamin D may cause hypocalcemia and hypophosphatemia.

Deficiency: Vitamin D deficiency in children, known as rickets is most common in areas lacking sunshine. Rickets deforms the growing bones of children. Phosphorus and Vitamin D deficiency in adults, is called osteomalacia—adult form of rickets. A lack of calcium and vitamin D can cause osteoporosis in adults. This disease like osteomalacia is characterised by decalcification and softening of bones but to a much greater extent.

Hypervitaminosis D: Excess of Vitamin D causes loss of apetite, vomiting, growth failure, weight loss, drowsiness, polyurea, increased Ca deposit in soft tissues blood vessels and kidneys.

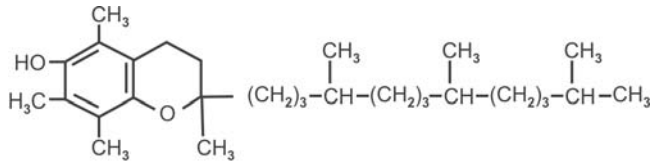
Vitamin E

Vitamin E consists of a group of tocopherols, the α-tocopherols being most active.

Vitamin E occurs so widely in vegetable oils that it is almost impossible not to obtain enough of it. It also occurs in grains and leafy vegetables. Daily requirement is 6 mg.

Vitamin E protects the poly unsaturated fats and vitamin A from oxidation. As an antioxidant, it also protects the erythrocytes.

In the absence of vitamin E, the activities of certain enzymes are reduced, and red blood cells hemolyse more readily. Anaemia and oedema are reported in infants with vitamin E deficiency. It can also contribute to an increased susceptibility to sudden heart attacks, especially in males under stress. Excess leads to interference with utilisation of Vitamin A and K, prolonged prothrombin time, intestinal irritability, headache dizziness and fatigue.



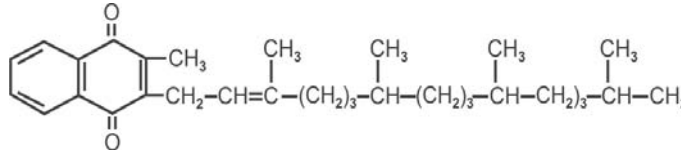
α-tocopherol

Vitamin K (Coagulation Vitamin)

Vitamin K is a group of naphthoquinones with long branched hydrocarbon side chains

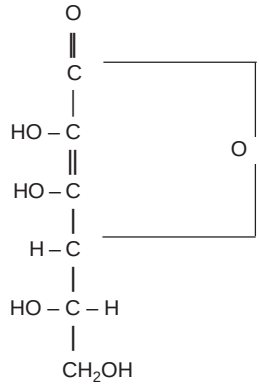
Vitamin K is an anti-haemorrhagic vitamin. It is present in fish liver oils, green leafy vegetables and deficiencies are rare. It works as a cofactor in the blood clotting mechanism. Deficiency leads to generalised bleeding, prolonged clotting time in adults and haemorrhagic diseases of the new born.

Excess leads to hyperbilirubinaemia in infants and newborn.



THE WATER SOLUBLE VITAMINS

Vitamin C or Ascorbic acid (a special case of sugar acid). It is a white crystalline substance highly soluble in water. It aids in utilisation of iron. It helps in the production of collagen. It acts as a cementing material between endothelial cells of the blood vessels and maintain their integrity.



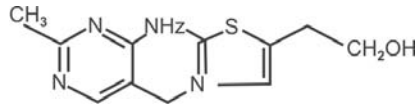
Sources: Fresh fruits and vegetables, including oranges, lime, lemons, green chillies, grapefruits, gooseberries, guava, berries, melons, tomatoes, raw cabbages and leafy green vegetables. It is destroyed by extended cooking. Even when Vitamin C is kept in regrigerator in wellcapped bottles, it slowly deteriorates.

Vitamin C is an antioxidant like vitamin E. It prevents scurvy. It is involved in the metabolism of amino acids, in the synthesis of some adrenal hormones and resistance to infection in the healing of wounds. Sufficient dosages, i.e., upto several grams per day is believed to prevent common cold. The vitamin is non-toxic at these high levels. Maximum daily requirement is 60 mg. Excess intake may lead to kidney stones, urinary tract infections polyneurities mental confusion, muscular weakness, calf tenderness, loss of deep jerk, cardiac enlargement.

Excess may also lead to rapid pulse, headache, weakness, irritability and insomnia.

B Complex Group of Vitamins

These vitamins are chemically not related. They are grouped together because all the vitamins of B complex group function in the cells as co-enzymes.



Thiamine (Vitamin B_1)

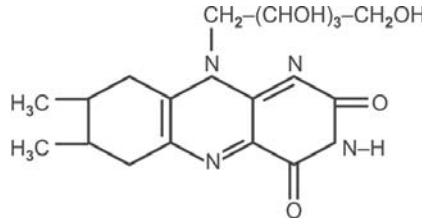
Thiamine consists of a substituted pyrimidine ring joined by a methylene bridge to substituted thiazole ring.

Thiamine is needed for the breakdown of carbohydrates. Its deficiency disease is beriberi, a disorder of the nervous system. Good sources are lean meats, legumes and whole grains. It is stable when dry but destroyed by alkaline conditions or prolonged cooking. Thiamine is not stored and excess are excreted in the urine. Daily requirement is 1.5 mg for adults and children. Parboiled rice is superior to raw (polished) rice as this form has bran containing vitamin B_1 and looses only 30% of vitamin B_1 on washing whereas raw rice has no bran and has no vitamin B_1 and looses 80% on washing.

Riboflavin (Vitamin B_2) or Lact Flavin

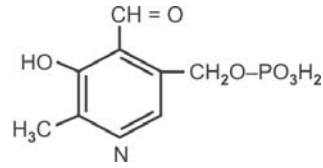
Riboflavin is an orange yellow crystalline compound. It is relatively heat stable but is destroyed by light. It occurs in bound forms as flavin adenine nucleotide or as flavo proteins.

Riboflavin exists as component of two co-enzymes called flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) which act as co-enzymes or prosthetic groups.



Riboflavin is required by a number of oxidative processes in metabolism. Deciencies lead to the inflammation and break-down of tissue around the mouth, tongue and nose, a scaliness of the skin and burning itching eyes. Wound healing is impaired. Sources are milk and certain meats like kidney, liver and heart. Daily requirement is 1.5 mg. During pregnancy and lactation additional 0.2 to 0.4 mg are required. People aged above 60 years, may also need more. Excess causes ulcer, elevated blood glucose levels, and increased uric acid levels in blood.

Pyridoxine (Vitamin B_6)



Vitamin B_6 refers to a group of pyridoxine, pyridoxal and pyridoxamine compounds having similar biological activity. All these change in the body to the active form, pyridoxal phosphate. The activities of at least 60 enzymes involved in the metabolism of various amino acids depend on pyridoxal phosphate.

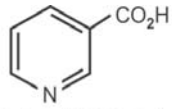
Adults need 2 mg/day, during pregnancy and lactation, the requirement is increased to 2.5 mg/day.

Vitamin B_6 deficiency is found in many pregnant women and also in alcoholics as well as after chronic administration of B_6 antagonists such as isoniazid and pancillamine. Its features include hypochromic anaemia, peripheral neuropathy, irritability, convulsions and glossitis. Vitamin B_6 deficiency can lead to niacin deficiency, because B_6 is required to convert tryptophan to niacin.

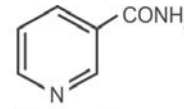
Vitamin B_6 is required in proportion to protein intake. It is present in meat, wheat, yeast and corn. It is relatively stable to heat, light and alkali. Excess leads to bloating, depression, headache, fatigue, irritability and brain damage.

Niacin (Vitamin B_3) Formerly known as Nicotinic Acid

Both nicotinic acid and nicotinamide, are essential for nearly all biological oxidation. It is found in liver, kidney and heart as well as in yeast, peanuts and wheat germ. Nicotinamide along with thiamine and riboflavin serves as a co-enzyme in tissue oxidation. It functions in the mitochondria in the form of NAD^+ and $NADP^+$. Recommended daily intake of niacin is 16-19 mg for males and 13-15 mg for females with a slight increase in requirements for adolescents and during pregnancy and lactation. It is needed by every cell of the body every day. Its deficiency disease is pellagra, a deterioration of the nervous system and the skin. Pellagra is particularly a problem where corn (maize) is the major item of the diet as in Rajasthan and central America.



Nicotinic Acid (Niacin)



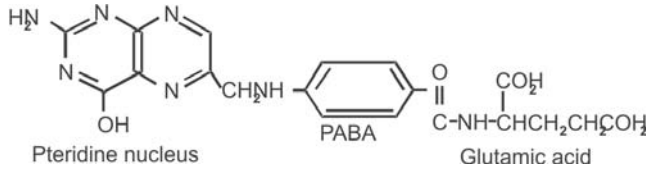
Nicotinamide

Maize is deficient is tryptophan.

Humans convert a fraction of their dietary tryptophan to nicotinamide and hence deficiency tryptophan cause pellagra. Pellagra can cause 3D's i.e., dermatitis, diarrhoea and dementia. If untreated it may cause, death. Excess of miacin leads to ulcer, liver disfunction, elevated blood glucose levels, increased blood and uric acid levels, diarrhoea, nausea and flushing.

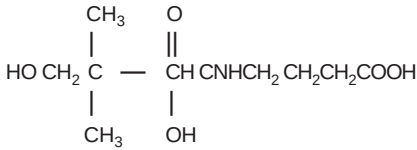
Folacin or Folic Acid

It is needed for the synthesis of nucleic acids and heme. Its deficiency disease is megaloblastic anaemia. Several drugs, including alcohol, cause folic acid deficiency. Good sources are fresh leafy green vegetables, asparagus, liver and kidney. Relatively unstable to heat, air and ultraviolet light, its activity is lost by cooking and storage. Daily requirement for male 200 μg and 180 μg for female. Deficiency causes macrocytic anaemia excess causes diarrhea, insomnia, irritability, masking of Vitamin B_{12} deficiency.



Pantothenic Acid

It is used to make co-enzyme A (Symbol: CoA-SH) which the body needs to metabolise fatty acids. Pantothenic acid, a B complex vitamin combines with ATP and cysteine in the liver to generate CoA-SH.

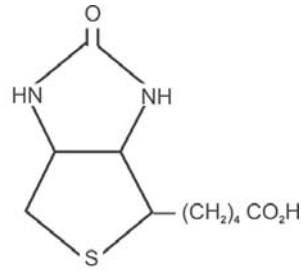


This vitamin is supplied by liver, kidney, egg yolk and skimmed milk, and its deficiency is rare. Its requirement is 4 to 7 mg per day. Excess causes increased need of thiamine, occassionally diarrhoea and water retention.

Biotin

Humans acquire biotin, a B complex vitamin, both from the diet and from intestinal bacteria. Egg yolk, liver, tomatoes and yeast are its good sources.

Biotin is required for all pathways in which CO_2 is temporarily used as a reactant as in synthesis of fatty acids.



Cobalamine (Vitamin B_{12})

Its deficiency can cause megaloblastic anaemia, leukopenia and thrombocytopenia similar to folic acid deficiency. This deficiency

Name	*Sources*	*Recommended daily allowance*	*Functions*	*Deficiency diseases*
	Fat Soluble Vitamins			
Vitamin A	Fish liver oils, butter, milk, kidneys and muscle meat. β-carotene is present in yellow fruits and leafy green vegetables	Adults-750 µg Children-300 µg Women during pregnancy and lactation-1200 µg	Helps vision, keeps skin healthy	Xerophthalmia, Nyctalopia
Vitamin D Cholecalciferol "Sunshine" vitamin	Eggs, butter, fatty fish, fish liver oils. Humans exposed year round to bright sunlight do not require dietary vitamin D	Adult-5 µg Children-10 µg Women during pregnancy and lactation-10 µg	Needed for strong teeth and bones	Rickets Osteomalacia Osteoporosis
Vitamin E Tocopherol	Green leafy vegetables—spinach, cabbage, alfalfa, putrified fish meal, liver, eggs and cheese	Male-15 IU Female-12 IU	Keeps skin and RBCs healthy antioxidant prevents oxidation of vit A and unsaturated fatty acids	Muscular weakness creatinuria and fragile RBCs
Vitamin K Coagulation vitamin	Green leafy vegetables—spinach, cabbage, alfalfa Putrified fish meal, fish liver oils, liver, eggs and cheese	Adult-50 to 100 µg Children 1 µg/Kg	Needed for blood clotting. Essential for the synthesis of clotting factors including prothrombin by liver	Retarded/delayed blood clotting
	Water Soluble Vitamins			
B Complex vitamins Thiamine (B_1)	Lean meats, legumes and whole grains	1-1.5 mg per day	Needed for healthy nerves	Beriberi, a disorder of the nervous system with dependent oedema involving the trunk and extremities.
Riboflavin (B_2)	Liver, dried yeast, egg,whole milk, milk powder, fish, whole cereals, legumes and green leafy vegetables	Adult 1.5 mg, pregnancy and lactation-1.72 mg	Yellow crystalline compound helps cells usc energy in foods. FMN and FAD are coenzymes required for oxidation reaction in metabolism	Inflammation and break down of tissue around the mouth, tongue and nose, wound healing is impaired

Contd...

Contd...

Name	*Sources*	*Recommended daily allowance*	*Functions*	*Deficiency diseases*
Niacin (B_3) formerly known as nicotinic acid	Liver, kidney, heart, yeast, peanuts and wheat germ. Amino acid tryptophan can supply much of body's need of niacin, 60 mg of tryptophan can produce 1 gm niacin	Adult 20 mg Pregnancy-22 mg Lactation-25 mg	Helps cells use energy in foods. Niacinamide along with thiamin and riboflavin, serves as a co-enzyme in tissue oxidation. It functions in the mitochondria in the form of NAD^+ and $NADP^+$	Pellagra, a determination of the nervous system and skin rashes and glossitis.
Folic Acid	Liver, kidney and fresh leafy vegetables, cauliflower	Male-200 µg Female-180 µg	In reactions involving transfer of methyl groups as in the synthesis of hemoglobin, nucleic acids and methionine	Megaloblastic anemia and gastrointestinal disturbances.
Biotin	Liver, egg yolk, kidney, yeast and milk	200-300 µg	As a co-enzyme for carboxylation reactions in the formation of fatty acids.	Delay dermatitis, muscle pains, nausea and depression
Pyridoxine	Yeast, liver, egg yolk and the germs of the various grains and seeds, less in milk and leafy vegetables	Male-2.0 mg Female-1.6 mg	Pyridoxal phosphate and pyridoxamine serve as co-enzymes for decarboxylation of amino acids. Takes part in the reactions occurring in gray matter of the CNS. Pyridoxine is involved in the absorption of zinc by the intestine	Epileptic seizures
Pantothenic Acid	Egg yolk, yeast, kidney, lean meats, skimmed milk, sweet potatoes and molasses	4 to 7 mg	One of the constituents of co-enzymes A (CoA) which is involved in the metabolism of carbohydrates, fats and proteins and in the synthesis of cholesterol	Normally there is no deficiency as the RDA is easily met with an ordinary diet

Contd...

Contd...

Name	*Sources*	*Recommended daily allowance*	*Functions*	*Deficiency diseases*
Cobalamine Vitamin B_{12} Antipernicious anemia factor	Liver, kidney, fish, eggs, milk, oysters and clams. It contains the element cobalt (4.35%)	2.0 µg	In the transfer of methyl groups, in the maintenance of the myelin sheath, in the synthesis of nucleic acids and hemoglobulin, in the metabolism of carbohydrates and lipids.	Pernicious anemia, similar to folic acid deficiency
Vitamin C Ascorbic acid	Amla, guava gooseberry, orange, lemons lime, papaya, tomatoes, green chillies, green leafy vegetables	50 g per day	Tissue healing increased, resistance to infection, antioxidant	Scurvy, poor wound healing, bleeding gums, mucous membranes loose teeth.

is very rare as liver, kidney, lean meats, eggs and milk products are good sources of B_{12}. A strict vegetarian diet, which excludes milk and eggs has virtually no B_{12}.

The liver stores relatively large amounts of this vitamin. Strict vegetarians in India may continue for decades without developing vitamin B_{12} deficiency because with a normal stomach and terminal ileum, they reabsorb most of the B_{12} they excrete into the bile.

The central portion of the molecules consists of four reduced and extensively substituted pyrrole rings surrounding a single cobalt atom.

Deficiency Manifestations: Pernicious Anemia

Persons with subnormal serum concentration of Vitamin B_{12} develop symptoms like glossitis and peripheral sensory disturbances.

Gross deficiency of vitamin B_{12} causes pernicious anaemia which manifests the same abnormalities of blood formation as in folic acid deficiency, namely evidences of accumulation of megaloblasts and myeloblasts. Peripheral blood picture shows macrocyptic type of anaemia. Other characteristics of pernicious anemia are:

i. Atrophy of the mucous membrane of mouth and tongue with inflammation resulting in glossitis, stomatitis and pharyngitis.
ii. Degenerative lesions of the posterior and lateral columns of the spinal cord, resulting in peripheral sensory disturbances, hyperactive reflexes and paralysis.

Pernicious anaemia arises due to failure of the secretion of the intrinsic factor by the gastric fundus in adequate quantity to facilitate absorption of vitamin B_{12} from the intestines. Pernicious anaemia may occur in patients following surgical removal of the stomach (total gastrectomy) and extensive resection of small intestines, the later causing the problem of reduced surface area for absorption of the vitamin.

QUESTIONS

1. **Name the water soluble vitamins. Describe the chemistry and role of thiamine.**
2. **Describe the source, daily requirements, functions and deficiency symptoms of vitamin A.**
3. **What are B complex vitamins? Describe the role of any one of them.**
4. **Name the fat soluble vitamins. Describe the chemistry and functions of vitamin D.**
5. **Write the co-enzyme forms of the following vitamins with two examples.**
   A. Riboflavin
   B. Niacin
   C. Pyridoxine
6. **Define vitamins. How are they classified? Give a note on vitamin K.**
7. **Describe the deficiency diseases, daily requirements and biochemical role of vitamin D.**
8. **Describe the sources, daily requirements and biochemical role of vitamin A.**
9. **Describe the sources, daily requirements, physiological action and deficiency diseases associated with vitamin C.**
10. **Describe the sources, function, daily requirements and deficiency diseases associated with niacin.**

MULTIPLE CHOICE QUESTIONS

11. **Retinol is transported in the blood as attached to:**
    A. Albumin
    B. α_1-Globulin
    C. α_2-Globulin
    D. β-Globulin
    E. γ-Globulin
12. **Increased carbohydrate consumption increases the dietary requirement of:**
    A. Thiamine
    B. Riboflavin
    C. Pyridoxine

D. Folic acid
E. Niacin.

13. The disease pellagra is due to the deficiency of:
A. Vitamin B_6
B. Nicotinic acid
C. Pantothenic acid
D. Folic acid
E. Biotin

14. The deficiency of one of the following vitamins causes creatinuria:
A. Vitamin E
B. Vitamin K
C. Vitamin A
D. Vitamin B_6
E. Vitamin B_1

15. Which of the following vitamin is associated with synthesis of coagulation factor prothrombin?
A. Vitamin A
B. Vitamin C
C. Vitamin K
D. Vitamin E
E. Vitamin D

16. Vitamins are:
A. Accessory food factors
B. Required in small quantities
C. Not used to provide energy
D. All of the above

17. Which is the fat soluble vitamin:
A. Riboflavin
B. Folic acid
C. Vitamin K
D. Vitamin C

18. The provitamin of Vitamin A is:
A. Cholesterol
B. Torcopherol

C. Retinol
D. β-carotene

19. Which form of Vitamin A participates in Wald's usual cycle (Rhodopsin cycle):
A. Retinal
B. Retinoic acid
C. Retinol
D. None of the above

20. Vitamin A is stored mainly in:
A. Kidney
B. Liver
C. Brain
D. Spleen

21. All the following are deficiency symptom of Vitamin A *except:*
A. Keratomalacia
B. Nyctalopia
C. Xerophthalmia
D. Osteomalacia

22. Hypervitaminosis A results in:
A. Skin disorders
B. Metastatic calcification
C. Hepatolenticular regeneration
D. Night blindness

23. Pyridoxal phosphate is a co-enzyme for:
A. Oxidative decarboxylation
B. Transamination
C. CO_2 fixation
D. Decarboxylation

24. Biologically active form of vitamin D is:
A. 7 dehydro-cholesterol
B. 25 OH cholecalciferol
C. 1, 25 dihydroxy-cholecalciferol
D. 24, 25 dihydroxy-cholecalciferol

25. Provitamin D is:
A. 7 Dehydro-cholesterol
B. 25 OH cholecalciferol

C. 1.25 dihydroxy-cholecalciferol
D. 24, 25 dihydroxy-cholecalciferol

26. Renal calculi may be due to the deficiency of:
A. Vit A
B. Vit D
C. Vit K
D. Folic acid

27. FMN and FAD can accept:
A. Two hydrogen atoms
B. Two electrons
C. One hydrogen atom
D. One electron

28. People consuming Polished rice as their staple food are prone to:
A. Beriberi
B. Pellagra
C. Scurvy
D. None of the above

29. Poor souce of Vitamin D is:
A. Liver
B. Eggs
C. Milk
D. Butter

30. Retinal is reduced to retinol by retinine reductase in presence of the coenzyme:
A. NAD^+
B. NAD + NADP
C. NADH + H^+
D. NADPH + H^+.

31. Nicotinic acid is essential for normal function of :
A. A skin
B. Intestinal tract
C. Neurons system
D. All of the above.

32. Increased protein intake is accompanied by an increased dietary requirement of:

A. Ascorbic acid
B. Nicotinic acid
C. Pantothenic acid
D. Folic acid.

33. Pantothenic acid exists in tissues as:

A. Co-enzyme A
B. β-mercaptoethylamine
C. Pantonic acid
D. β-alanine.

34. One of the amino acids is constituent of vitamin folic acid is:

A. Aspartic acid
B. Arginine
C. Gutamic acid
D. Histidine

35. Vitamin D deficiency causes:

A. Decrease of Ca and P
B. Increase of Ca and P
C. Decrease of Ca and increase of P
D. Increase of Ca and decrease of P

36. People whose staple food is maize suffer from deficiency of Vitamin:

A. Riboflavin
B. Pyridoxin
C. Niacin
D. Pantothenic acid

37. Active co-enzyme form of folic acid is:

A. Folate
B. Dihydrofolate
C. Trihydrofolate
D. Tetrahydrofolate

38. The metal ion present in Cobalamine is:

A. Iron
B. Cyanide

C. Cobalt
D. Calcium

39. Bran layer of cereals is rich sources of vitamin:
A. Riboflavin
B. Niacin
C. Folic acid
D. Thiamine

40. Intake of which Vitamin is associated with the intake of unsaturated fatty acid.
A. Vitamin A
B. Vitamin D
C. Vitamin E
D. Vitamin K

41. Biologically active form of thiamine (vitamin B).
A. Thiamine monophosphate
B. Thiamine diphosphate
C. Thiamine triphosphate
D. Thiamine pyrophosphate

42. Which of the following vitamins is also called as child bearing vitamins?
A. Vitamin E
B. Vitamin K
C. Vitamin D
D. Vitamin C

43. Antioxidant property of Vitamin E is due to:
A. Phenolic hydroxyl group
B. Active reducing group
C. Alcoholic group
D. Sulphydric group

ANSWERS

11(B)	12(A)	13(B)	14(A)	15(C)	16(D)	17(C)
18(D)	19(A)	20(B)	21(D)	22(A)	23(B)	24(C)
25(A)	26(A)	27(A)	28(A)	29(B)	30(C)	31(D)
32(C)	33(A)	34(C)	35(C)	36(C)	37(D)	38(C)
39(D)	40(C)	41(D)	42(B)	43(A)		

CHAPTER

10 Basic Concepts of Metabolism

DEFINITION OF METABOLISM

Catobolic pathways (reactions) break down complex molecules such as proteins, polysaccharides and lipids to a few simple molecules like CO_2, NH_3 and H_2O. Anabolic pathways (reactions) form complex end products from simple precursors. Smaller molecules are used to synthesise big and complex molecules by anabolic reactions.

Anabolic and metabolic reactions are collectively called metabolic reactions. Metabolism is the total chemical changes taking place in the cell.

SOURCE OF ENERGY

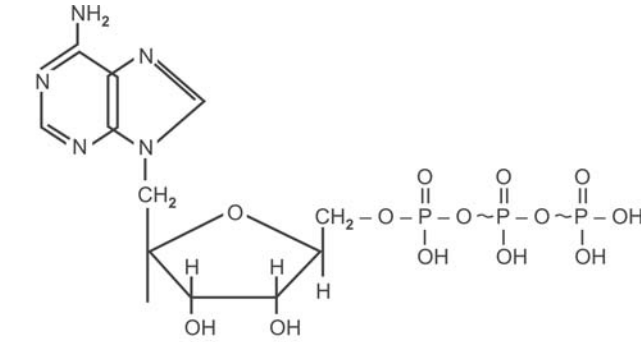
Where does a muscle get its energy to contract? Where does the body get the energy necessary to synthesize protein, to send nerve impulses, to form countless other functions?

The energy necessary for body functions comes from certain high energy compounds that yield a large amount of energy on hydrolysis. The key compound of this type is adenosine triphosphate (ATP), Hydrolysis of ATP, to ADP (adenosine diphosphate) and inorganic phosphate liberates about 7600 cal/mol. This hydrolysis breaks one of the two high energy bonds designated by ~ in the structure.

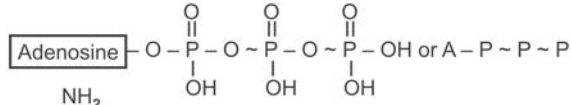
However the supply of ATP in the body is limited. There must be some mechanism for regulating this high energy compound so that it will be available for continued use. Body changes ADP back to ATP by adding a high energy phosphate group to ADP. This process is called phosphorylation.

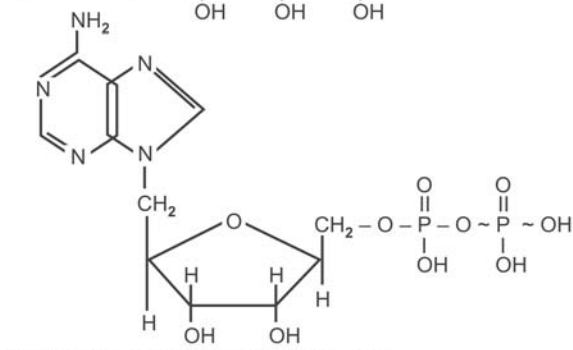
BIOLOGICAL OXIDATION

Substrate molecules are oxidised by removal of hydrogen by dehydrogenases. The reduced dehydrogenases are then reoxidised

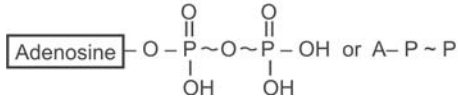


The formula for ATP can be abbreviated as:





The formula for ADP can be abbreviated as:



by a group of respiratory catalysts known as Catachrome system or Electron Transport or Respiratory chain.

Mnemonics **OIL RIG** Oxidation is loss (of electrons) Reduction is gain (of electrons)

ELECTRON TRANSPORT (RESPIRATORY) CHAIN

Biological oxidation consists of a series of reactions which passes electrons to oxygen in a stepwise fashion. Each of these involves the

loss of two electrons by the original organic compound and these electrons are passed to oxygen indirectly.

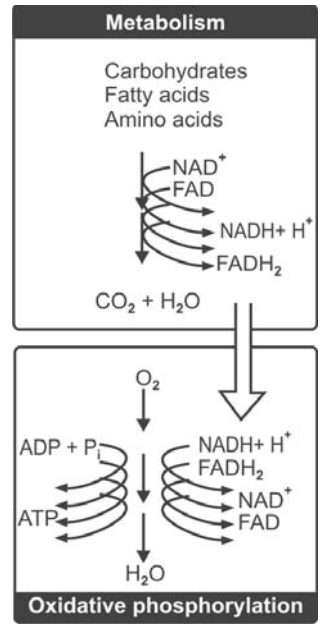
Energy rich molecules such as glucose or fatty acids are metabolized by a series of oxidation reactions ultimately leading to CO_2 and water. The metabolic intermediates of these reactions donate electrons to specialised coenzymes, nicotinamide adenine dinucleotide (NAD^+) and flavin adenine dinucleotide (FAD) to form the energy-rich reduced coenzymes, NADH and $FADH_2$. These reduced coenzymes, in turn donate a pair of electrons to a specialised set of electron carriers, collectively called as Electron Transport Chain or Respiratory Chain.

Each carrier of the electron transport chain can receive electrons from an electron donor and can subsequently donate electrons to the next carrier in the chain, ultimately to combine with oxygen and protons to form water. This requirement for oxygen makes the electron transport process, the respiratory chain, which accounts for the greatest portion of the body's utilisation of oxygen.

As electrons are passed down the electron transport chain, they lose much of their free energy. Part of this free energy can be captured and stored by the production of ATP from ADP and inorganic Pi.

The process by which ADP is phosphorylated to ATP as a result of reactions of electron transport system is called oxidative phosphorylation. The process is limited to mitochondrion. Various oxidations occur in other parts of the cell which liberate only heat without producing any ATP.

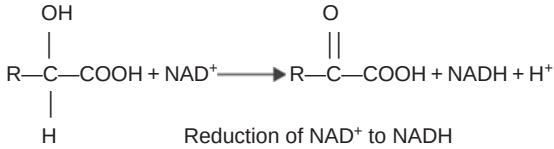
The electron transport chain is present in the inner mitochondrial membrane and is the final common pathway by which electrons derived from different fuels of the body flow to oxygen. Electron transport and ATP synthesis by oxidative phosphorylation proceed continuously in all the cells of the body that contain mitochondria.



Major Electron Carriers

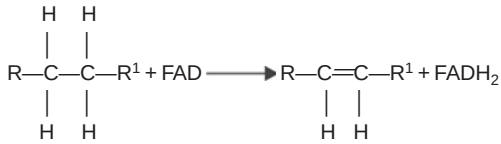
A wide variety of dehydrogenases participate in the oxidation of metabolic fuels (carbohydrates, lipids and proteins). Most of these enzymes use either NAD^+ or FAD as electron acceptors. The major carrier of electrons in reductive biosynthetic reactions is NADPH.

1. *NAD^+* is the electron acceptor in reactions involving oxidations of hydroxylated carbon atom. NAD^+ accepts a hydride ion H^- (two electrons and a proton) to form NADH and the hydroxyl group is oxidised to Carbonyl group.



Reduction of NAD^+ to NADH

2. *FAD* is electron acceptor in reactions involving the oxidation of two adjascent atoms, resulting in the formation of a carbon-carbon double bond. A hydrogen atom is removed from each carbon atom and is transferred to FAD to form $FADH_2$.



The reduction of FAD to $FADH_2$

3. *NADPH* is the major source of reducing power for biosynthetic pathways. In contrast to NADH which is generated and used primarily in the mitochondria, most of the NADPH is formed and used in the extra mitochondrial reactions.

In A Nut-Shell

Electron acceptors = NAD^+, FAD
Electron donors = NADH, NADPH

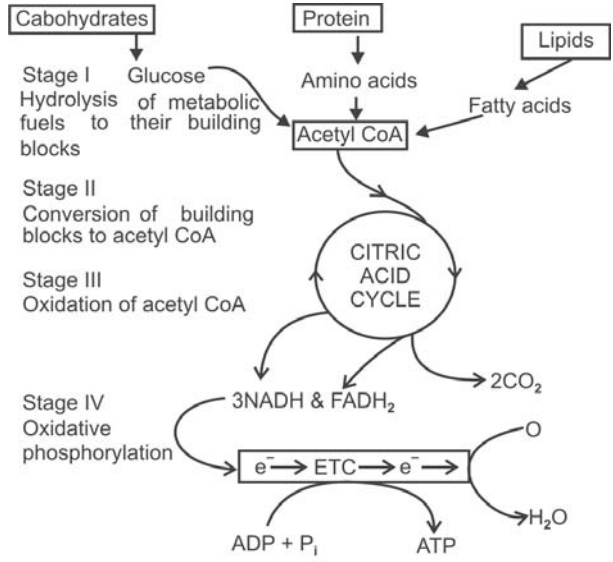
EXTRACTION OF ENERGY FROM METABOLIC FUELS

Energy is extracted from food via oxidation, resulting in the end products CO_2 and water. This occurs in four stages.

In the first stage, metabolic fuels (carbohydrates, lipid and proteins) are hydrolysed to their monomeric building blocks namely glucose, fatty acids and amino acids.

In the second stage, the building blocks are degraded by various pathways to a common metabolic intermediate, Acetyl CoA. Most of the energy contained in the metabolic fuels are conserved in the chemical bonds (electrons) of acetyl CoA.

In the third stage, the citric acid cycle oxidises acetyl CoA to CO_2 and the electron pairs present in the carbon-carbon and carbon-hydrogen bonds are transferred to electron carriers NADH and $FADH_2$.



Extraction of Energy from Metabolic Fuels

The final stage is the extraction of energy from oxidative phosphorylation, when the energy in electron pairs of NADH and $FADH_2$ is released via Electron Transport Chain (ETC) and is used to synthesize ATP.

BIOMEDICAL IMPORTANCE OF METABOLISM

1. The concept of metabolism provides a sound understanding of many diseases.
2. The variations and adaptations due to starvation, exercise, pregnancy and lactation are included in normal metabolism.
3. Abnormal metabolism results from nutritional deficiency, enzyme deficiency and excessive secretion of hormones.

4. Diabetes mellitus is an example of a disease caused by abnormal metabolism.

Carbohydrate Metabolism

1. Pyruvate and lactate are formed in the mammalian cells as a result of oxidation of glucose by glycolysis.
2. In the absence of oxygen, glycolysis occurs in the cytoplasm of the cells producing lactate only.
3. Under aerobic conditions pyruvate is metabolised to acetyl CoA which enters citric acid cycle for complete oxidation to CO_2 and H_2O.
4. Glucose also takes part in other metabolic processes:
    a. It is converted to glycogen for storage particularly in liver and skeletal muscles.
    b. The HMP shunt or the pentose phosphate pathway arriving from intermediates of glycolysis is a source of reducing equivalents (2H) for biosynthesis of fatty acids, cholesterol, etc. and is a source of ribose which is required for nucleic acids formation.
    c. Triose phosphate of glycolysis is a source of glycerol of fat.
    d. Pyruvate and intermediates of TCA cycle form amino acids and cholesterol, the precursor of all steroid hormones in the body.

Lipid Metabolism

1. The long chain fatty acids are synthesised from acetyl CoA derived from carbohydrates or from dietary lipids.
2. In the tissues, fatty acids are oxidised to acetyl CoA or esterified to acyl glycerol to form fat which is the main calorie reserve of the body.
3. Acyl CoA formed by the β oxidation has the following significant roles in the body:
    a. It liberates CO_2 and H_2O and also yields high energy. Therefore during oxidation of fatty acids by β oxidation for their complete oxidation, more energy is formed.
    b. It is a source of cholesterol biosynthesis.
    c. In liver it forms ketone bodies which are alternate water soluble tissue fuels. These fuels become important sources of energy under certain conditions like starvation.

Amino Acid Metabolism

1. Amino acids are required for protein synthesis.
2. The essential amino acids must be supplied in diet since they are not synthesized by the tissues.
3. Diet can supplement non-essential amino acids which are also formed from the intermediates of citric acid cycle by transamination.
4. Excess amino nitrogen as a result of deamination give the following products:
   a. CO_2 and H_2O via citric acid cycle.
   b. Glucose by gluconeogenesis.
   c. Ketone bodies.
5. Amino acids are precursors of many other important compounds like purenis, pyrimidines and hormones such as epinephrines and thyroxine.

Inter-relationship in the Metabolism of Proteins, Lipids and Carbohydrates

Glucose is converted into glycerol through triosephosphate and acetyl CoA through pyruvate. Acetyl CoA helps the formation of fatty acids with malonyl CoA. Glycerol and fatty acids combine to form triacylglycerol (neutral fat). The ketoacids in TCA cycle are converted into amino acids by transamination.

Fat is oxidised to form acetyl CoA which enters the citric acid cycle. Malate of citric acid cycle is permeable to pass through the mitochondrial membrane into cytosol where it is converted ultimately to glucose by gluconeogenesis. Fatty acids with odd number of carbon atoms also enter citric acid cycle being converted to propionate. Protein is hydrolysed to amino acids.

QUESTIONS

1. **How is energy extracted from food.**
2. **Define anabolism, catabolism and metabolism.**
3. **Write short notes on:**
   A. Oxidative phosphorylation
   B. Major electron carriers
   C. Respiratory chain

MULTIPLE CHOICE QUESTIONS

4. **All the following statements regarding metabolism are correct *except:***
   A. It constists of anabolism (synthesis) and catabolism (defradation)
   B. It can be studied by *in vitro* and *in viv*o methods
   C. During anabolism, energy is liberated
   D. It indicates the sequence of chemical reactions undergone by the food from ingestion to excretion of metabolites
5. **All the following *in vivo* methods are used to study metabolism *except:***
   A. Studies with purified vaccines
   B. Use of radioactive isotopes
   C. Respiratory exchange experiment
   D. Organ perfusion technique
6. **Major methods to separate and purify biomolecules is:**
   A. Salt fractionation
   B. Gel filtration
   C. Ultracentrifugation
   D. All of the above
7. **Radioactive isotope used to study carbohydrate metabolism:**
   A. 131 I2
   B. 14 C
   C. 24 C
   D. 59 Fe
8. **Radioactive isotope study thyroid function in:**
   A. 14 C

B. 131 I
C. 32 P
D. 45 Ca

9. Oxidation in defined as the following *except:*
A. Loss of electron
B. Loss of hydrogen
C. Addition of oxygen
D. Gain of electron

10. Oxidoreductases involved in biological oxidation are all of the following *except:*
A. Dehydrogenases
B. Hydroperoxydases
C. Transaminases
D. Oxygenases

11. The sequence of enzymes and electron carries for the transport of reducing equivalent from subtractes to molecular oxygen:
A. Ornithine cycle
B. Cori cycle
C. Respiratory chain
D. V. Glutamyl

12. The respiratory chain (electrotransport chain) is located in:
A. Nucleus
B. Ribosomes
C. Lysosomes
D. Mitochondria

13. All of the following electron carriers are components of the electron transport chain *except:*
A. $NADP^+$
B. NAD^+
C. FAD
D. Co-enzyme Q

14. When the substrate enters the respiratory chain through NAD linked dehydrogenase the AT pyrild is:
A. 4
B. 3

C. 5
D. 6

15. Number of ATP molecules produced when reducing equivalents entering ETC through EAD linked dehydrogenesis:
A. 2
B. 3
C. 5
D. 6

16. The energy currency of the cell is:
A. GRP
B. ATP
C. ADP
D. Glucose

17. Cytotromes are enzymes which function as electron transfer agent in:
A. Transamination
B. Hydrolysis
C. Conjugation reaction
D. Oxidation and reduction

18. Oxidation phosphorylation is a process for:
A. APhosphorylation of glucose
B. Generating creation phosphate
C. Generating ATP
D. Utilising ATP

19. All of the following are concerned with mechanism of oxidative phosphorylation *except:*
A. Conformational coupling hypothesis
B. Chemiosmotic theory
C. Chemical coupling hypothesis
D. Beer – Lambert's law.

ANSWERS

4(C)	5(A)	6(D)	7(B)	8(B)	9(D)	10(C)
11(C)	12(D)	13(A)	14(B)	15(A)	16(B)	17(D)
18(C)	19(D)					

CHAPTER

11 Metabolism of Carbohydrates

Carbohydrate metabolism is basically the metabolism of glucose and substances related to glucose. Carbohydrates supply more than 50% of the energy requirements of the body.

FATE OF GLUCOSE AFTER ABSORPTION

In the liver, glucose undergoes a variety of chemical changes depending upon the physiological need of the body.

1. When there is physiological demand for energy, glucose may be oxidised completely to CO_2, water and energy (Glycolysis and citric acid cycle).
2. Excess glucose may be converted to glycogen and deposited in liver, muscle and tissues (Glycogenesis).
3. To maintain the blood glucose level, liver glycogen is reconverted to glucose which enters the blood (Glycogenolysis).
4. Excess glucose after conversion to glycogen may be converted to fatty acids and stored as triglycerides in the fat depots.
5. In muscle contraction, only partial degradation (glucosis) may take place, resulting in the formation of lactic acid, which is largely disposed off by the liver.
6. Small amounts of glucose may be utilized for the synthesis of ribose and deoxyribose for the synthesis of nucleic acids.

INTERMEDIARY METABOLISM OF CARBOHYDRATE

The metabolism of carbohydrate may be subdivided in the following categories:

Glycogenesis: The synthesis of glycogen from glucose.

Glycogenolysis: Breakdown of liver and muscle glycogen (hydrolysis of glycogen into glucose).

Glycolysis: The oxidation of glucose or glycogen to pyruvate by Embden-Meyerhof pathway.

The hexose monophosphate shunt: This is an alternate aerobic pathway to the Embden-Meyerhof pathway for oxidation of glucose.

Oxidation of pyruvate to Acetyl CoA: The necessary step prior to the entry of the products of glycolysis into the citric acid cycle.

Gluconeogenesis: Formation of glucose or glycogen from non-carbohydrate sources.

Transport of Glucose to Cells: Facilitated Transport

Glucose cannot directly diffuse into the cell but enters by one of the two transport mechanisms. The first mechanism, the facilitated (active) transport is mediated by a family of at least five glucose transporters in the cell membrane designated GLUT 1 to GLUT 5.

Glycolysis—Embden-Myerhof Pathway (Fig. 11.1)

Glycolysis is the central pathway of glucose metabolism. It occurs in the cytosol of all cells. Glycolysis is defined as the pathway that converts glucose to pyruvate.

The glycolytic pathway is employed by all tissues for the breakdown of glucose to provide energy (in the form of ATP) and intermediates for other metabolic pathways. Carbohydrate metabolism is the metabolism of glucose because all sugars (whether arising from the diet or from catabolic reactions in the body) ultimately can be converted into glucose.

Reactions of Glycolysis

The conversion of glucose to pyruvate can be summarised as follows:

Glucose-6-P + 2 ADP $\longrightarrow$ 2 Pyruvic acid + 2 ATP
(from Glycogen or glucose) (or pyruvate)

The ATP formed is utilised for muscle contraction. As ATP is used it is converted to ADP and then must be regenerated. Over 90% of energy is the RBCs is produced by glycolysis.

Net production of ATP = 6 + 4 – 2=8 (in aerobic glycosis).

Aerobic Glycolysis

Pyruvate is the end product of glycolysis in cells with mitochondria and an adequate supply of oxygen. This series of 10 reactions is called aerobic glycolysis because oxygen is required to reoxidise the NADH formed during the oxidation of glyceraldehyde-3-phosphate. Aerobic glycolysis is followed by the oxidative decarboxylation of pyruvate to acetyl CoA, the fuel for citric acid cycle.

Anaerobic Glycolysis

(Short supply of oxygen)

Alternatively, the pyruvate can be reduced by NADH to form lactate. This conversion of glucose to lactate is called anaerobic glycolysis because there is no net formation of NADH and therefore it can occur in the absence of oxygen. Anaerobic glycolysis allows the continued production of ATP in tissues that lack mitochondria, (e.g., RBCs).

Net Production of ATP = 4 – 2 = 2

GLYCOLYSIS

All the enzymes of Embden-Myerhof pathway are present in the cytosol. The 10 steps of glycolysis are:

1. *Phosphorylation of glucose:* Glucose enters the glycolytic pathway by the phosphorylation to glucose-6-phosphate. It takes place in all tissues but mainly in the liver and muscles.
2. *Isomerism of glucose-6-phosphate:* To Fructose-6-phosphate by the enzyme phosphoglucose isomerase.
3. *Phosphorylation of fructose-6-phosphate:* Fructose-6-phosphate is changed to 1, 6 diphosphate by the action of enzyme phospho-fructokinase. ATP is converted to ADP during this reaction.
4. *Cleavage of fructose 1, 6-diphosphate:* Enzyme adolase cleaves Fructose 1, 6-Biphosphate to two three-carbon compounds, glyceraldehyde 3 phosphate and dehydroxy acetone phosphate.
5. *Isomerisation of dehydroxy acetone phosphate:* Dihydroxy acetone phosphate is converted to glyceraldehyde 3-phosphate by the action of the enzyme phosphotrioisomerase. This isomerisation results in the production of two molecules of glyceraldehyde 3 phosphate from the cleavage products of fructose 1-6-biphosphate.
6. *Oxidation of glyceraldehyde 3 phosphate*: The conversion of glyceraldehyde 3 phosphate to 1, 3 biphosphoglycerate by glyceraldehyde 3 phosphate dehydrogenase is the first oxidation-reduction reaction of glycolysis. During this reaction, NAD^+ is reduced to $NADH + H^+$.

Because there is only a limited amount of NAD^+ in the cell, the NADH formed must be reoxidised to NAD^+ for glycolysis to continue. Two major mechanisms for oxidising NADH are:

1. The NADH linked conversion of pyruvate to lactate, and
2. Oxidation via respiratory system.

7. *Formation of ATP from 1, 3 diphosphoglycerate:* 1, 3 diphosphoglycerate is changed to 3 phosphoglycerate by the action of enzyme phosphoglycerokinase. In this reaction two ADPs (one each for 3 carbon compound) are changed to two ATPs which replaces the two ATPs consumed in the earlier formation of glucose-6 phosphate and fructose 1, 6 biphosphate.
8. *Shift of the phosphate group from carbon 3 to carbon-2*-3: Phosphoglycerate is changed to 2 phosphoglycerate by the action of the enzyme phosphoglyceromutase.
9. *Dehydration of 2 phosphoglycerate:* 2 phosphoglycerate is changed to phosphoenol pyruvate by the action of enzyme enolase.
10. *Formation of pyruvate:* The phosphoenol pyruvate is changed to pyruvate by the action of enzyme pyruvic kinase. During this reaction, two ADPs are changed to ATPs (one for each three-carbon compounds).

The sequence of reactions involved in glycolysis is summarised below:

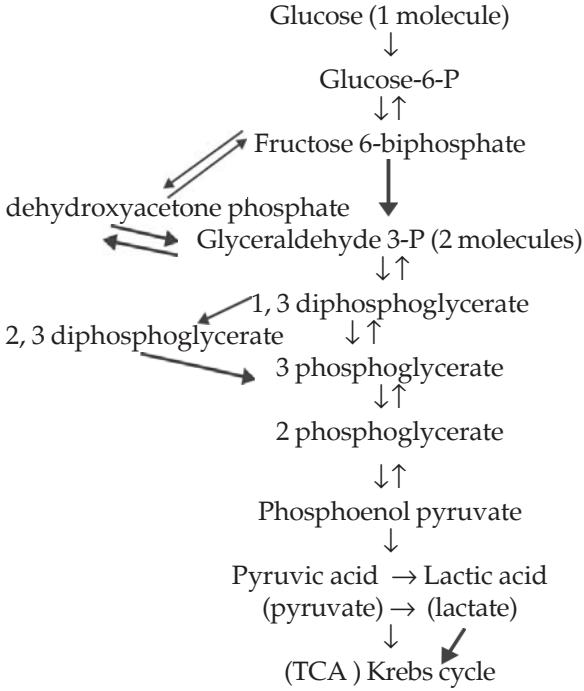


Fig. 11.1: Glycolysis—The Embden-Meyerhof pathway

Reduction of Pyruvate to Lactate

Pyruvate is changed to lactate through the enzyme lactic dehydrogenase. At the same time, NADH + H^+ are changed to NAD^+.

The formation of lactate is the major steps for pyruvate in RBC's, lens and cornea of the eye, kidney, medulla, tears and leukocytes.

Energy Production in Glycolysis

The net gain of ATP molecules during glycolysis is 8 (Table 11.1).

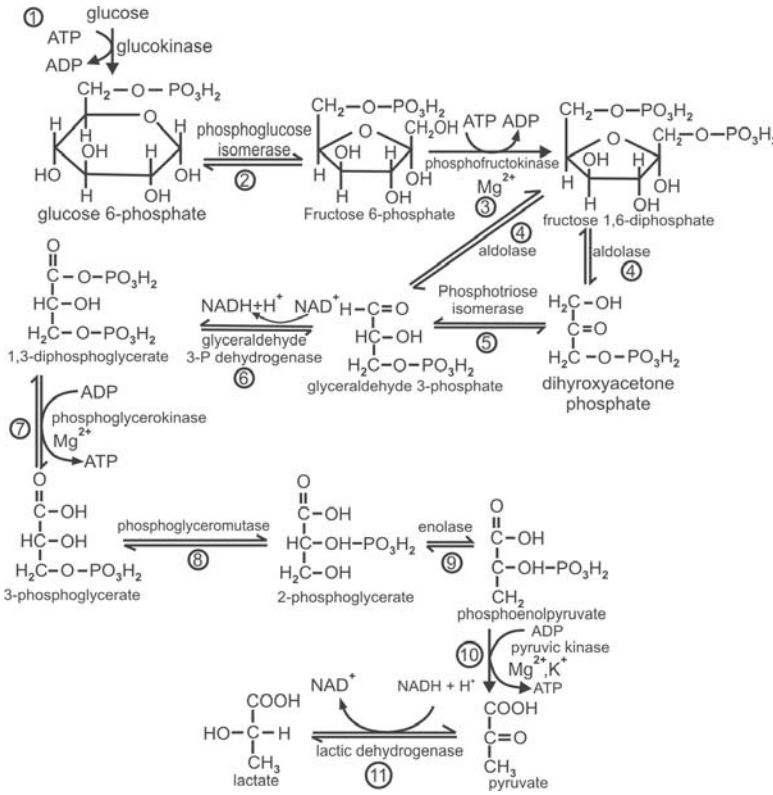


Table 11.1: ATP molecules gain in aerobic glycolysis

Reactions *Aerobic Phase*	*ATP used*	*ATP formed*
1. Glucose + ATP → Glucose-6-phosphate	1	
2. Fructose-6-phosphate+ATP→Fructose-1, 6-diphosphates	1	
3. Reoxidation of 2 ($NADH + H^+$) formed in reaction catalysed by glyceraldehyde-3-phosphate dehydrogenase, in the respiratory chain (aerobic phase)		6
4. 2 (1, 3-diphosphoglyceric acid) 2 (3)-Phosphoglyceric acid)		2
5. 2 (Phosphoenol pyruvic acid) to 2 (enolpyruvic acid)		2
	2	10

Tricarboxylic Acid Cycle or Krebs' Cycle

Unlike glycolysis, which takes place in the cytoplasm, the tricarboxylic acid (TCA) cycle (Fig. 11.2) occurs within the mitochondria. Erythrocytes differ from most other human cells in that they lack mitochondria, and cannot therefore use TCA cycle.

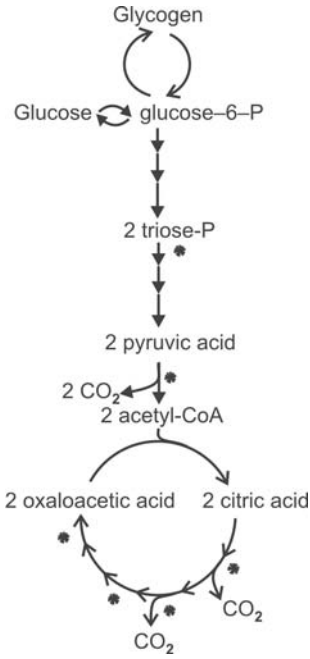


Fig. 11.2: A simplified view of glycolysis and the tricarboxylic acid cycle. Each of the six starred reactions is an oxidation which passes electrons to the electron transport system with subsequent formation of ATP and the reduction of oxygen to water

The TCA cycle also called citric acid or Krebs' cycle is so named because several of its intermediates have three carboxyl groups; citrate, cis-aconitate and isocitrate. The remaining six intermediates are dicarboxylic acids.

The TCA cycle is the final common pathway of oxidation (the metabolism) of carbohydrates, fatty acids and proteins (amino acids) through which acetyl CoA is completely oxidised to CO_2 and finally water. Although its primary function is energy production, it also provides intermediates to synthesize the amino acids and porphyrins.

The TCA cycle oxidises acetyl CoA completely to the two moles of CO_2 plus eight hydrogen atoms, which enter the electron transport system.

$$CH_3CO\text{-}CoA \longrightarrow 2CO_2 + 8\ H^+$$

Citric acid cycle starts with condensation of oxaloacetate with acetyl CoA to form citric acid (citrate). Acetyl-CoA derived mainly from oxidation of either glucose or β-oxidation of fatty acid and partly from certain amino acids combines with oxaloacetic acid (OAA) to form citrate. In this reaction acetyl-CoA transfers its acetyl group (2-C) to OAA.

$$\text{Oxaloacetate + Acetyl-CoA} \longrightarrow \underset{\text{(Citric Acid)}}{\text{Citrate + CoA.}}$$

The Kreb's (Citric Acid) Cycle

The aerobic sequence converts the pyruvic and lactic acids (from anaerobic glycolysis) into CO_2, H_2O and energy although a series of 8 reactions called citric acid cycle or Kreb's cycle. The cycle uses oxygen transported to the cells by haemoglobin; hence the term aerobic. The cycle takes place in the mitochondrion, the "powerhouse" of the cell.

The first step in the aerobic process is the formation of Acetyl CoA (active acetate) form pyruvic acid. Hence, Acetyl CoA is the, acetyl derivative of coenzyme A and is the converting substance in the metabolism of carbohydrates, lipids and fats. Acetyl CoA becomes the fuel for Kerb's cycle.

Aectyl CoA reacts with oxalo acetic acid and goes through the 8 steps of Kerb's cycle. At the end of the cycle, oxalo acetic acid is regenerated and picks up another molecule of acetyl CoA to carry it through the cycle. During the cycle Acetyl CoA is oxidized to

CO_2 and at the same time NADH and $FADH_2$ are produced. These enter into the electron transport chain that functions in the inner membranes of the mitochordion. The overall reaction of the Kreb's cycle can be summarized in the following equation:

$$\text{Acetyl CoA} + 3NAD^+ + FAD + GDP + Pi + 2\,H_2O \longrightarrow$$
$$+$$
$$\text{CoA} + 2\,CO_2 + 3NADH + 3\,H^+ + FADH_2 + GTP$$

Two C atoms enter the cycle as acetyl CoA and leave as CO_2. four pairs of electrons are transferred during one turn of the cycle, three pairs of electrons for reducing NAD^+ to $NADH^+H^+$ and one pair for reducing FAD to $FADH_2$.

EIGHT STEPS IN CITRIC ACID CYCLE

1. *Synthesis of citric acid* from acetyl CoA and oxalo acetic acid.
2. *Isomerisation of citric acid to isocitric acid.*
3. *Oxidation and decarboxylation of isocitric acid* yielding the first NADH molecule produced in the cycle and first release of CO_2
4. *Oxidative decarboxylation of α ketoglutaric acid:* The mechanism of this oxidative decarloxylation is similar to that used for conversion of pyruric acid to acetyl CoA. The reaction releases the second CO_2 and produces the second NADH in the cycle.
5. *Clevage of succinyl CoA:* Succinate thiokinase cleaves the ligh energy thioester bond of succinyl CoA. The reaction in coupled to phosphorylation of GDP to GTP. The energy content of GTP is the same as that of ATP and the two molecules are interchangeable.
6. *Oxidation of succinc acid:* Succinic acid is oxidized to fumaric acid by succinate dehydrogenase producing the reduced co-enyme $FADH_2$. FAD rather than NAD^+ is the electron acceptor because the reducing power of succinic acid is not sufficient to reduce NAD^+.
7. *Hydrolysis* of fumaric acid to produce maleic acid.
8. *Oxidation* of maleic acid to oxalo acetic acid. This reaction produces the third and final NADH of the cycle. Steps 6,7 and 8 are for the regeneration of oxalo acetic acid.

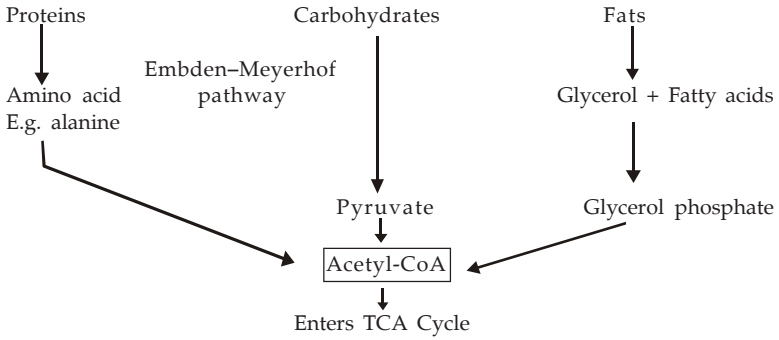
CITRIC ACID CYCLE: SUMMARY

Acetyl co-enzyme A is joined by oxaloacetate to form citrate. Citrate loses two molecules of CO_2 stepwise and in the last step of the cycle

oxaloacetate is regenerated for initiating a new cycle by reaction with another molecule of acetyl co-enzyme A. In the citric acid cycle two molecules of carbon dioxide are formed as end product. During the oxidation of acetate to CO_2 some co-enzyme molecules are reduced. The reduced co-enzyme molecules are oxidized (regenerated) via a series of reactions which involve the transfer of hydrogen atoms from acetate and other intermediates to oxygen. Such series of oxidation-reduction reactions are known as the electron-transport chain. Thus the electron transport chain produces most of ATPs formed in the oxidation of glucose.

Citric Acid Cycle: The Common Pathway

Citric acid is the common pathway for the metabolism of carbohydrates, fats and proteins since it provides the complete oxidation of acetyl-CoA to CO_2 and water.



ENERGETICS

Energy Production in Glycolysis Plus TCA Cycle

From the lowest to the highest forms of life, ATP is universally used as the principal carrier of energy for bodily functions. It is the chief means used by the body to trap energy available by oxidation. Virtually all biochemical energetics comes down to the synthesis and use of ATP.

Almost any energy—demanding activity of the body consumes ATP. An adult human being at rest consumes about 40 kilograms of ATP per day. Muscle contract can be written as a chemical reaction of ATP changing to adenosine diphosphate and inorganic phosphate (P_i).

ATPs Generated in TCA Cycle

If we start from pyruvic acid, there are six sites at which energy is generated and if we start from acetyl CoA only five sites of energy generation are left. These sites are as follows:

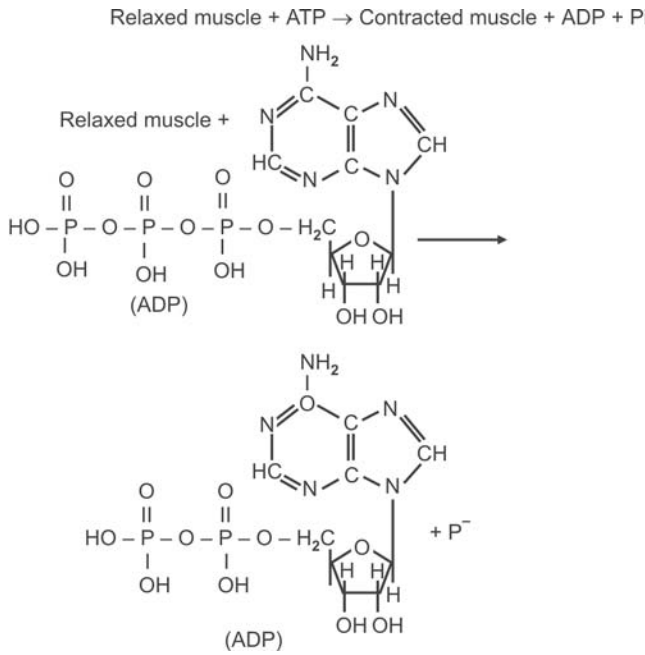
Conversion of

1. Pyruvic acid to Acetyl CoA 1 NADH	= 3 ATP
2. Isocitric acid to α ketoglutaric acid 1 NADH	= 3 ATP
3. α ketoglutaric acid to succinyl CoA 1 NADH	= 3 ATP
4. Succinyl CoA to succinic acid 1 GTP	= 1 ATP
5. Succinic acid to fumaric acid 1 FAD	= 2 ATP
6. Malic acid to oxaloacetic acid 1 NADH	= 3 ATP
Total	15 ATP

Net ATP produced per glucose molecule = 15 × 2 = 30
Total ATP per glucose (aerobic oxidation) = 30+ 8 = 38

When one molecule of glucose is broken down, 38 molecules of ATP are produced (30 from citric acid cycle and 8 from glycolysis).

When one mole of glucose (180 gm) is converted into CO_2 and H_2O, 2868 KJ of energy is released. This energy is enough to



produce 100 ATP molecules. However, in cells only 38 molecules of ATP are produced on the oxidation of one molecule of glucose. Thus the efficiency of energy conversion is only 38%. This is more than any man-made device designed for energy utilisation. The rest 62% of energy is liberated as heat and is utilised to maintain the body temperature.

Glycolysis and Kreb's cycle: To get maximum available energy from glucose, it has to be oxidized completely to CO_2 and H_2O.

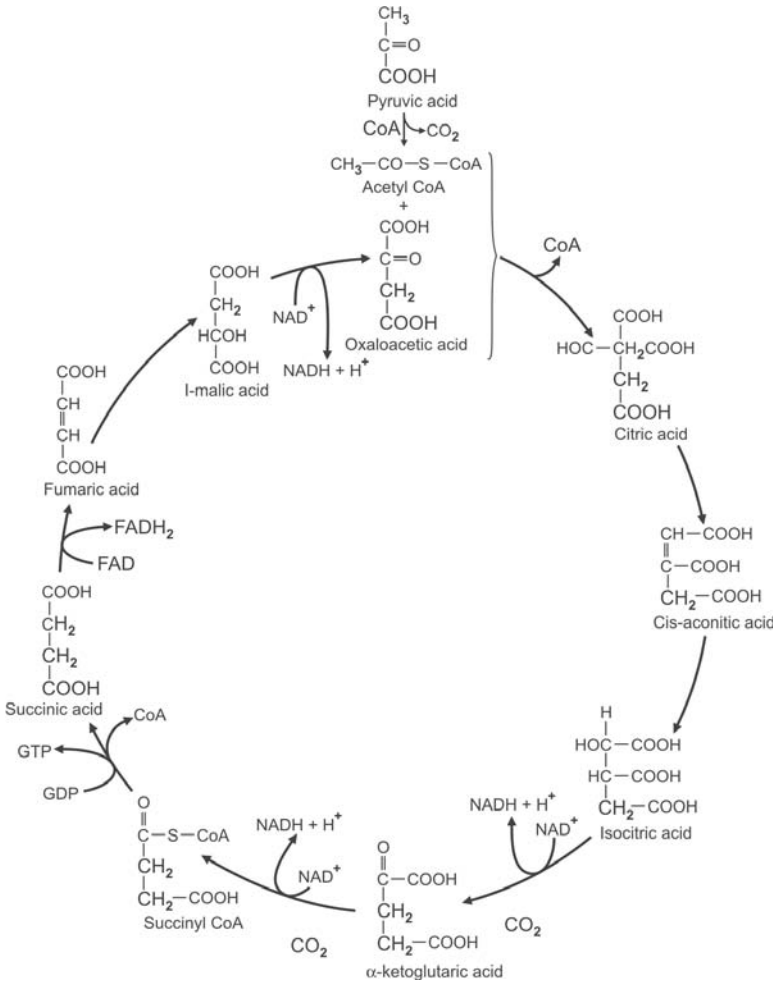


Fig. 11.3: Kreb's (Critic acid) cycles

The pyruvic acid or lactic acid produced by the muscle and liver is oxidised to acctyl CoA which combines with a molecule of oxalo acetate to form citric acid. During the citric acid cycle (Fig. 11.3), the acetyl CoA is oxidized to CO_2 and H_2O with the production of large amounts of energy and oxalo acetate molecule is regenerated.

HMP Shunt and Uronic Acid Pathway

Glucose is also metabolized through certain other pathways which are not so important for energy production but are extremely important as synthetic pathways for a number of substances. Hexose monophosphate pathway and the uronic acid pathway are of this category.

Uronic Acid Pathway

Uronic acid pathway is another alternative pathways for oxidation of glucose. It provides D gluconic acid which is used for the synthesis of glucose.

HMP SHUNT/HEXOSE MONOPHOSPHATE SHUNT is an alternate pathway for oxidation of glucose. It is not meant for energy. ATP in not produced. This pathway provides NADPH which is used for reductive synthesis of pentoses which is used for nucleic acid synthesis. This pathway operates only in certain special tissues like liver, adipose tissue, lactating mammary gland, lens of the eye, adrenal cortex, gonads, etc.

It is a multicyclic process, three molecules of glucose-6-phosphate enter the cycle, producing three molecules of CO_2 and 3 molecule's of 5 carbon residues to give two molecule of glucose-6-phosphate and one molecule of glyceraldelyde-3-phosphate.

$NADP^+$ is used as hydrogen acceptor and not NAD^+ and CO_2 is produced in this pathway which is not produced in glycolysis.

BLOOD SUGAR LEVEL AND ITS CLINICAL SIGNIFICANCE

Normal Value

The range of normal fasting or post-absorptive blood glucose taken at least 13 hours after last meal as per glucose-oxidase method is 70 to 100 mg per cent.

The concentration of glucose in the blood is the net result of two processes:

1. Rate of glucose enterance into blood stream.
2. Rate of glucose removal from the blood stream.

Sugar is added to the body by:

a. Absorption from intestine
b. Breakdown of liver glycogen
c. Gluconeogenesis from amino acids, glycerol, lactate, etc.

Sugar is removed from the blood by:

a. Glycolysis and citric acid cycle incomplete oxidation of glucose to water and CO_2
b. Conversion to liver glycogen
c. Conversion to muscle glycogen
d. Synthesis of fats
e. Synthesis of glycoproteins such as nucleic acids.
f. Loss in the urine in diabetes

The blood glucose level is most efficiently regulated by a mechanism in which liver, extrahepatic tissues and several hormones like insulin play an important part.

Abnormalities in Blood Glucose Level

Increase in blood glucose level above normal is hyperglycaemia and decrease is hypoglycaemia.

Causes of Hyperglycaemia

a. Diabetes mellitus in which fasting blood sugar may vary from normal to 500 mg per cent and more depending on the severity of the disease.
b. Hyperactivity of the thyroid, pituitary and adrenal glands.
c. In pancreatitis and carcinoma of pancreas.
d. Sepsis and in many infectious diseases.
e. Emotional stress.

Diabetes Mellitus

Diabetes mellitus is a metabolic disease due to absolute or relative insulin deficiency. The word mellitus is related to sugar, as the urine of the patient contains sugar. The disease causes loss of weight as the body mass is syphoned off through urine.

Diabetes mellitus is a common condition. About 10% of the total population, and about 1/5 of persons above age of 50 suffer from this disease. It is a major cause of morbidity and mortality. The disease may be classified into two clinical types:

1. "Juvenile" onset diabetes. Now called as Type I—Insulin dependent diabetes mellitus (IDDM).
2. Maturity onset diabetes. Type II—Non-insulin dependent diabetes mellitus (NIDDM).

Causes

1. *Disorder of carbohydrate metabolism*, cause of which is deficiency or diminished effectiveness of insulin resulting in hyperglycaemia and glycosuria.
2. *Heredity*: In both types, diabetic familial tendency is noted. Genetic factors are more important in those who develop after 40 years.
3. *Autoimmunity*: Insulin dependent juvenile type may be an autoimmune disorder and has been found to coexist with other autoimmune disorders.
4. *Infections*: Certain virus infections may precipitate juvenile type.
5. *Obesity*: Majority of middle aged maturity onset diabetes is caused by obesity. Stress like pregnancy may also precipitate the disease.
6. *Diet*: Over eating and under activity are also predisposing factors in elderly/middle aged maturity onset diabetes.
7. *Insulin antagonism*: In maturity onset diabetes, the deficiency of insulin is relative and glucose induced insulin secretion may be greater and more prolonged than normal. The relative deficiency may be due to insulin antagonism.

Clinical Features and Biochemical Correlations

Large amounts of glucose may be excreted in the urine (may be 90 to 100 gm per day in some cases). When the blood glucose level exceeds the renal threshold of 180 mg% glucose is excreted in urine. Due to osmotic effect more water accompanies the glucose in the urine (polyuria). To compensate for this loss of water the thirst centre is activated and more water is taken (polydipsia). The loss and ineffective use of glucose leads to breakdown of fat and protein. This leads to loss of weight. To compensate for the loss of glucose and protein, patient will take more food (polyphagia).

Causes of Hypoglycaemia
(blood glucose is below 40 mg%)

a. Overdosage of insulin in the treatment of diabetes mellitus.
b. Hypoactivity of thyroid, hypopituitarism and hypoadrenalism.
c. Severe liver diseases.
d. In childhood, an idiopathic hypoglycaemia, due to sensitivity to the amino acid leucine.
e. In glycogen storage diseases like Van Gierke's disease, liver phosphorylase disease; due to impaired ability to produce glucose from glycogen.

Glycosuria Although normal urine contains virtually no sugar under certain circumstances, glucose or other sugars may be excreted in urine, e.g. glycosuria, fructosuria, galactosuria.

Diabetes Mellitus Oral Glucose Tolerance Test (GTT)

Carbohydrates tolerance: The ability of the body to utilise carbohydrates may be ascertained by measuring its carbohydrates tolerance. It is indicated by the nature of blood glucose curve following the administration of glucose.

The test is normally carried out in the morning after a night's fast but if necessary it may be done 4 to 5 hours after the last food was taken.

Blood is taken for the determination of the fasting blood sugar and a specimen of urine is collected. 50 gm of glucose is dissolved in about 100 to 150 ml of water and are then given. Blood for the estimation of blood sugar is drawn at half hourly intervals for 2½ hours after the glucose has been consumed. Urine specimens are collected at the intervals soon after blood is taken. The blood sugar estimation is carried out and a graph is plotted with sugar in mgm against time in hours (Fig. 11.4).

Explanation and Significance of a Normal Curve

1. A sharp rise to a peak, averaging about 50% above the fasting level within 30 to 60 minutes. Extent of the rise varies considerably from person to person, but maximum should not exceed 160 to 180 mg per cent in normal subjects.
   Reason: Rise is due directly to the glucose absorbed from the intestine, which temporarily exceeds the capacity of the liver

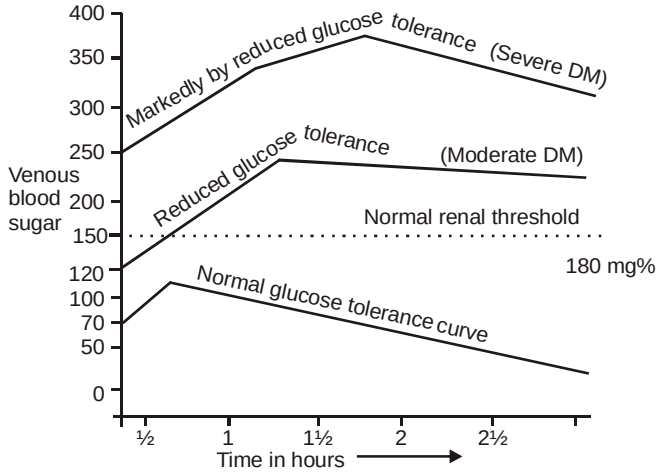


Fig. 11.4: Glucose tolerance test

and tissues to remove it. As the blood glucose concentration increases, regulatory mechanisms come into play.

2. A sharp fall to approximately the fasting level at the end of 1½ to 2 hours.
   Reason: Glucose now leaves the circulation faster than it is entering.
3. Hypoglycaemic dip: Continuing fall to a slightly subfasting (10 to 15 mg lower than fasting value) at 2 hours and subsequent rise to fasting level at 2½ to 3 hours.
   Reason: The hypoglycaemic dip is due to "intertia" of the regulatory mechanisms. The decreased output of glucose by liver and increased utilisation induced by the rising blood glucose are not reversed as rapidly as the blood sugar falls.

Diabetic Type of GTC

a. Fasting blood glucose is definitely raised. 110 mg per cent or more.
b. The highest value is usually reached after 1 to 1½ hrs.
c. The highest value exceeds the normal renal threshold of 180 mg%.
d. Urine samples always contain glucose except in some chronic diabetes or nephritis which may have raised renal threshold.

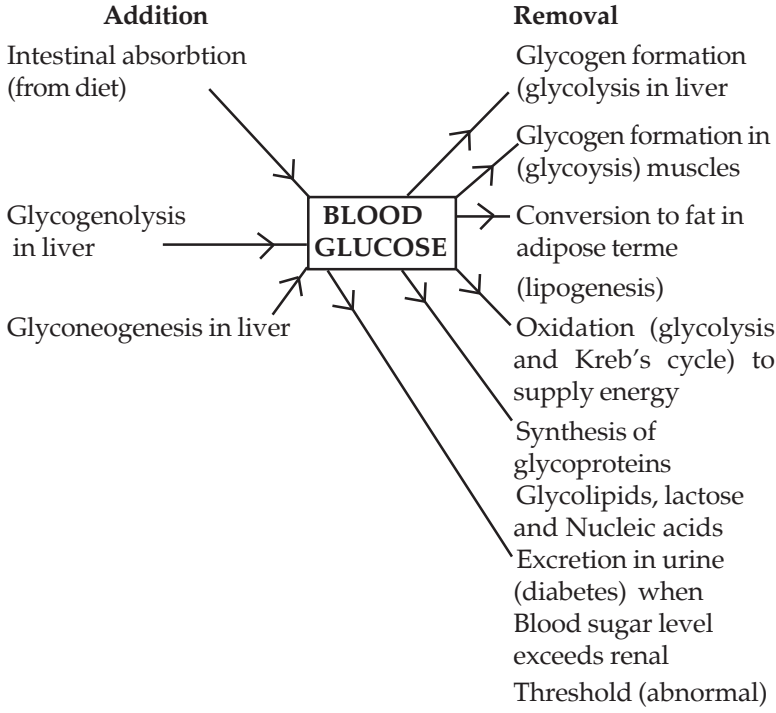
e. The blood glucose does not return to the fasting level within 2½ hours. This is the most characteristic feature of the true diabetes mellitus.

REGULATION (HOMEOSTASIS) OF BLOOD GLUCOSE LEVEL

The maintenance of blood sugar level at

FBS = 70-100 mg%
RBS = 80-120 mg%
PPBS = 100-140 mg% under all conditions is known as homeostasis of blood sugar level. It is regulated by hormonal and nervous factors. The blood sugar level is maintained by two factors:

a. Factors adding glucose to blood and
b. Factors that remove glucose from blood



Glycogenesis (Glycogen Synthesis)

Liver and muscle cells can convert glucose to glycogen by a series of steps called glycogenesis (glycogen creation). The liver holds 70 to 110 g of glycogen (5% of its weight) and the muscles taken as a whole, contain 170 to 250 g.

The initial step of glycogenesis is the conversion of glucose -6-P to glucose-1-P by phosphoglycomutase. Next, glucose -1-P reacts with UTP to create UDP-glucose.

$$\text{Glucose-6-P} \xrightarrow{Mg^{++}} \text{Glucose-1-P}$$

$$\text{Glucose-1-P} + \text{UTP} \longrightarrow \text{UDP-Glucose} + PP_1$$

Glycogen synthase then adds this bound glucose in α-1-4 linkage to the glycogen polymer, liberating UDP (Uridine diphosphate).

$$\text{UDP-glucose–(Glucose)}_n \longrightarrow \text{Glucose)}_{n+1} + \text{UDP}$$

In this manner addition of glucose molecules takes place up to 8 units. Now a second enzyme called the branching enzyme acts by establishing connection between the first and the sixth carbon atoms of the amylose chains and a glycogen molecule is formed ultimately.

Glycogenolysis

When muscles need glucose, they take it back out of glycogen. When the blood needs glucose because the blood sugar has dropped too much, the liver hydrolyzes as much of its glycogen reserves as needed and puts the glucose into circulation. The process of breakdown of liver glycogen to glucose is called glycogenolysis. The process is controlled by several hormones.

Blood Glucose in Post-absorptive State

The post-absorptive state or fasting state is the condition obtaining 12 to 14 hours after the last meal. There is no intestinal absorption at this time. At the same time, it is not prolonged starvation which itself leads to several abnormalities in metabolism. The condition of a subject (patient) between 8AM to 10AM if he had his dinner the previous evening at 8PM and has eaten nothing, thereafter in the night or morning, is said to be post-absorptive.

Under these conditions, the only source of glucose to blood is from liver glycogen. At rest, the tissues of an adult man will be utilizing almost 200 mg glucose per minute by taking up the glucose from blood. This much will be added by the liver. The glycogen concentration of the liver averages 5% of its weight. Thus an adult liver weighing 1800 gm can store about 90 gms of glycogen which can supply at the rate of 200 mg/minute for only 7-8 hours.

The skeletal muscles (about 28 kg in an adult male) has a glycogen content of 1% and can hold 280 gms of glycogen. This can indirectly supply glucose and blood lactose and liver glycogen for almost 24 hours. But blood sugar levels are maintained fairly constant during long periods of starvation by gluconeogenesis from non-carbohydrates sources such a amino acids.

Gluconeogenesis: The formation of glucose or glycogen from non-carbohydrates sources is called gluconeogenesis. During periods of prolonged starvation when no carbohydrate is available from food, it is by gluconeogenesis that the liver maintains a continous supply of glucose for the metabolism of brain, erythrocytes and for anaerobic metabolism of skeletal muscles. Glyconeogenesis occurs mainly in the liver and kidneys.

Glycogenic amino acids, lactates and pyruvic, glycerol and propionic acid can form glucose. The mechanism involved are essentially the reversal of Kreb's cycle and glycolysis.

ROLE OF HORMONES IN THE HOMEOSTASIS OF BLOOD SUGAR LEVEL

Hormones play a very important role in regulating the blood glucose levels. There are two sets of hormones which are involved in blood glucose regulation and these two sets of hormones show opposite actions to each other.

1. Insulin causes a fall in blood glucose levels (Hypoglycaemic in nature).
2. The hormones of the second group raise the level (hyper-glycaemic in nature).

Such hormones are glucagon, glucocorticoids, growth harmones, adrenocorticotropic hormone (ACTH) and thyroxine. Thus, all these are antagonistic to insulin (Diabetogenic hormones).

Insulin

This hormone of the β cells of the islets of Langerhans lowers the blood sugur concentration. Shortly after a meal, there is post-prandial (after meal) hyperglycaemia. The β cells of the islets of Langerhans of pancreas sense this hyperglycaemia and release insulin. The hormone enhances the uptake of glucose by tissues probably by enhancing the transport of glucose across the cell membrane. Insulin acts as a key that "unlocks" the "door" on cell surface to allow glucose to enter the cell. Insulin decreases the blood glucose level in the following ways:

a. It increases the uptake of glucose by muscle and adipose tissue.
b. Increases glycogenesis, glycolysis and HMP shunt pathway.
c. It inhibits gluconeogenesis and glycogenolysis.
d. It increases the synthesis of protein.
e. It inhibits catabolism of proteins and lipid thus insulin is an anabolic hormone.

Glucagon

This hormone is secreted from α cells of pancreas in response to hypoglycaemia. It increases blood glucose level by

a. Increasing glycogenolysis and glycogenesis in the liver
b. Decreasing glycolysis and glycogenesis

Epinephrine

Epinephrine (Adrenaline) is secreted by the adrenal medulla in response to any form of stress, hypoglycaemia, emotions like fear, anger, joy, sorrow, etc. It increases blood glucose level by:

a. Promoting glycogenolysis in the liver and muscles
b. Enhancing gluconeogenesis
c. Inhibiting insulin secretion, and
d. Decreasing glycolysis and increasing lypolysis in adipose cell (release of glycerol).

GLUCOCORTICOIDS

Cortisol is the major glucocorticoid from adrenal cortex and has a hyperglycemic effect by:

a. Increasing gluconeogenesis
b. Increasing protein breakdown in muscle and liberating amino acids for gluconeogenesis

c. Inhibiting insulin stimulated uptake of glucose by tissues
d. Increasing glycogenesis and
e. Inhibiting glycogenolysis.

GROWTH HORMONE

This is secreted from a anterior pituitary in response to hypoglycemia. It increases blood glucose level by:

a. Decreasing the uptake of glucose by muscle and its utilization for glycolysis
b. Promoting the release of fatty acids from adipose tissue into blood thus inhibiting glucose utilization.

ACTH (Adreno Corticotropic hormone) are also secreted from anterior pituitary and acts similar to growth hormone to increase blood glucose level. They increase gluconeogenesis in the liver. They also increase protein breakdown in tissues and make amino acids available to liver for gluconeogenesis. They also decrease the uptake of glucose by tissues. The overall affect is an increase in the blood sugar level.

THYROID HORMONE (THYROXINE)

Thyroxine is produced from the thyroid gland and is diabetogenic. It increases blood sugar lay:

a. Increasing intestinal absorption of glucose
b. Increasing hepatic glycogenolysis
c. Increasing glycogenolysis in the liver.

Anything which lowers insulin activity or raises the activity of other hormones will produce hyperglycemia and glycosuria, a condition known as Diabetes.

QUESTIONS AND ANSWERS

1. **Can muscle glycogen be a source of blood glucose?**
   Ans: No, as it lacks the enzyme glucose-6-phosphate.
2. **What is galactosemia?**
   Ans: Excretion of galactose in urine due to the deficiency of enzyme galactose-1-phosphate uridyl transferase leads to a condition known as galactosemia.
3. **What is true glucose?**
   Ans: True glucose means glucose only, without taking into account the presence of any other reducing substance in the blood.
4. **How will you estimate true glucose?**
   Ans: By glucose oxidase method.
5. **What are the conditions in which blood sugar level is low?**
   Ans: A. Overdosage of insulin in the treatment of diabetes.
   B. Hypothyroidism
   C. Addison's disease.
6. **What are the conditions in which blood sugar level is raised?**
   Ans: A. Diabetes mellitus
   B. Hyperthyroidism
   C. Hyperadrenalism
   D. Hyperpituitarism
   E. Thyrotoxicosis.
7. **What is the normal blood sugar level?**
   Ans: 80-100 mg%.
8. **What is the kidney threshold of glucose?**
   Ans: 180 mg.
9. **What is the hormone which regulate blood sugar level?**
   Ans: Insulin.
10. **What are the functions of insulin?**
    Ans: A. Insulin promotes the entry of glucose in all the tissues of the body except liver.
    B. It helps in glycogenesis
    C. It prevents glycogenolysis
    D. It inhibits gluconeogenic enzymes.

11. What are the hormones which keep the blood sugar level high?

Ans: A. Glucogen
B. Epinephrine
C. Adrenal cortex hormones
D. Growth hormones and ACTH
E. Thyroid hormone.

12. Why cannot insulin be given orally?

Ans: Insulin is a polypeptide and is digested by the enzymes of the digestive system into amino acids before it reaches in blood. Hence it cannot be given orally.

13. What is renal glycosuria?

Ans: As a result of low kidney threshold, glucose appears in the urine. Blood sugar level remains normal.

14. What is the abnormality in the urine sample of diabetic patient and starving patient?

Ans: In a diabetic patient, urine will show the presence of glucose and ketone bodies.

In starving patient only ketone bodies will be present.

15. What are the different reducing sugars that appear in the urine and under what conditions?

Ans: A. Glucose appears in the urine in renal glucosuria and diabetes mellitus.
B. Lactose: During later stages of pregnancy and lactation
C. Galactose: In galactosuria due to the deficiency of the enzyme galactose-1-phosphate uridyl transferase. This condition is encountered in children.
D. Fructose: Due to consumption of lots of fruits containing fructose such as grapes, plums and cherry.
E. Pentoses: Due to consumption of lots of fruits containing pentoses. Also in congenital abnormality to metabolise L-xylulose.

16. What is glycolysis?

Ans: The breakdown of glucose to pyruvic acid or lactic acid is called glycolysis.

17. What is the enzyme in glycogen?

Ans: Phosphofructokinase (PFK).

18. What is the ATP yield in glycolysis under an aerobic condition?

Ans: Two ATP per molecule of glucose metabolised.

19. What is the ATP yield under aerobic conditions?

Ans: 38 ATP per molecule of glucose metabolised, i.e.
glycolysis
8 ATP
TCA cycle 30 ATP.

20. How many ATP are formed in the TCA cycle?

A. From Acetyl CoA

Ans: 12 ATP

B. From Pyruvate

Ans: 15 ATP

21. Why is citric acid cycle considered the common pathway for carbohydrate, fat and protein metabolism?

Ans: Acetyl CoA comes from all the three metabolism

Carbohydrate metabolism	:	Glycolysis
Fat metabolism	:	B oxidation
Protein metabolism	:	Transamination.

Citric acid cycle provides the complete oxidation of acetyl CoA to CO_2 and water and hence is the common pathway for all the above three metabolisms.

22. What is oxidative decarboxylation?

Ans: Oxidation accompanied by decarboxylation.

23. What is the oxidative decarboxylation product of pyruvic acid?

Ans: Pyruvic acid $\xrightarrow[-2H, -CO_2]{\text{Oxidative decarboxylation}}$ Acetyl-CoA

24. What is the enzyme for the above oxidative decarboxylation reaction?

Ans: Enzyme involved is pyruvate dehydrogenase complex consisting of 3 enzymes:

A. Pyruvate dehydrogenase
B. Dihydro lipoyl transacetalase
C. Dihydro lipoyl dehydrogenase.

25. What are the cofactors of the above reaction?

Ans: A. Thiamine pyrophosphate (TPP)
B. Lipoic acid

C. Co-enzyme A (COA-SH)
D. Flavin Adenine dinucleotide (FAD)
E. Nicotinamide adenine dinucleotide (NAD)
F. Mg^{++} ions

26. What is β-oxidation?

Ans: Oxidation taking place at b carbon atom and the β carbon is oxidised to carboxyl group.

27. Where does β-oxidation take place?

Ans: Mitochondria.

28. Describe briefly two mechanisms of blood sugar level.

29. What is the normal fasting level of blood glucose? Discuss the factors controlling the blood glucose level.

30. Write short notes on:

A. Insulin
B. Glucose tolerance test (GTT).

31. Define and give examples of anabolism and catabolism.

32. How many gms of glucose would be necessary to supply 2500 kcal?

33. List the starting material and end product(s) of each of the following:

A. Glycolysis
B. Krebs' cycle
C. Glycogenolysis
D. Glycogenesis
E. Electron transport.

MULTIPLE CHOICE QUESTIONS

34. The glycolytic pathway is located in:

A. Mitochondria
B. Cytosol
C. Microsomes
D. Nucleus

35. The end product of aerobic glycolysis is:

A. Acetyl CoA
B. Lactate
C. Pyruvate
D. CO_2 and H_2O

36. Glycolysis is always anaerobic in:
A. Liver
B. Brain
C. Kidney
D. Erythrocytes

37. In glycolysis, glucose is degraded to give:
A. 4 molecules of pyruvate
B. 2 molecules of acetate
C. 2 molecules of pyrurate
D. 4 molecules of acetate

38. Glucose is the only source of energy for:
A. Mycardium
B. Kidneys
C. Erythrocytes
D. Thrombocytes

39. Complete outdating of one molecule glucose into CO_2 and H_2O yields:
A. 8 ATP equivalents
B. 15 ATP equivalents
C. 30 ATP equivalents
D. 38 ATP equivalents

40. Each turn of citric acid cycle produces:
A. 2NADH + $FADH_2$ + 2GTP
B. 3 NADH + 1 ATP + 1GTP
C. 4 NADH + 2 ATP + 2GTP
D. 3 NADH + 2ATP + 1GTP

41. The cofactor required by hexokinase is:
A. Fe^{++}
B. Mn^{++}
C. Mg^{++}
D. Zn^{++}

42. Glycogenesis is increased by:
A. Glucagon
B. Insulin
C. Epinephrine
D. C AMP

43. Glucose 3 phosphate for the synthesis of triglycerides in adipose tissue is derived from:
A. Glucose
B. Phosphatidic acid
C. Diacylglycerol
D. Glycerol

44. Gluconeogenesis takes place in:
A. Adipose tissue
B. Muscles
C. Kidneys
D. Brain

45. Glyconeogenesis is decreases by:
A. Glucagon
B. Epinephrine
C. Insulin
D. Glucocorticoids

46. Hexose Monophosphate shunt provides:
A. Glucose 1 phosphate for glycogen synthesis
B. Glycerol 3 phosphate for triglyceride sysnthesis
C. NADPH for fatty acid synthesis
D. Glucoronic acid for mucopolysaccharides synthesis.

47. Substrate for invertase is:
A. Lactose
B. Maltose
C. Sucrose
D. Dextrin

48. Between meals, blood glucose level can be maintained by:
A. Glucogenolysis in the liver
B. Glycogenolysis in muscles
C. Both of the above
D. None of the above

49. The enzyme which spilts a 6 carbon compound into two 3 carbon compounds in glycolysis is:
A. Phosphotrios isomerase
B. Enolase
C. Phosphoglycerate mutase
D. Adolase

50. Glucagon can affect the rate of glycogenesis and glycogenolysis in:
A. Liver and skeletal muscle
B. Liver and heart muscles
C. Liver
D. Skeletal and heart muscles

51. Blood glucose level is increased by all of the following *except* :
A. Glucagon
B. Glucocorticoids
C. Insulin
D. Epinephrine

52. The complete oxidation of glucose occurs in:
A. Glycolysis
B. HMP shunt
C. TCA cycle
D. Glycolysis and TCA cycle

53. Glycogenesis is a process by which glycogen is synthesized from:
A. Pyruvic acid
B. Lactic acid
C. Glycerol
D. Glucose

54. Glucose tolerance decreases in the following condition:
A. Hyperthyroidism
B. Diabetes mellitus
C. Hyperadrenalism
D. Hyperthyroidism

ANSWERS

34(B)	35(C)	36(D)	37(C)	38(C)	39(D)
40(A)	41(C)	42(B)	43(A)	44(C)	45(C)
46(C)	47(C)	48(A)	49(D)	50(B)	51(C)
52(D)	53(D)	54(D)			

CHAPTER

12 Metabolism of Lipids

Atherosclerosis, the deposition of lipid plaques on the lining of arteries, is a leading cause of death. Because of the association between atherosclerosis and hyperlipoproteinaemia (elevated serum lipoproteins, an extensive campaign of medical research has been launched to study lipid metabolism.

PLASMA LIPIDS

In mammals, principal lipids that have metabolic significance are: Triacyl glycerol (TG) also called neutral fats (NF), phospholipids, steroids, mainly cholesterol, together with products of their metabolism such as long chain fatty acids (free fatty acids), glycerol, and ketone bodies.

Extraction of plasma lipids with a suitable lipid solvent and subsequent separation of the extract into various classes of lipids show the presence of equal quantities of:

a. Triacyl glycerol (TG),
b. Phospholipids (PL), and
c. Cholesterol and much smaller fraction of non-esterified long chain fatty acid (NEFA) or free fatty acid.

Much of the carbohydrates of the diet is converted to fat before it is utilised for the purpose of energy. Its calorific value is more than double (9.3 Kcal/gm) that of carbohydrates and proteins and therefore fat is the most concentrated form in which potential energy is stored in the body.

A minimal amount of fat is essential in the diet to provide an adequate supply of certain polyunsaturated fatty acids (the essential fatty acids) and of fat soluble vitamins. Besides being a carrier of these essential compounds, dietary fat is necessary for their efficient absorption from the gastrointestinal tract.

Transportation of Plasma Lipids

Fats are insoluble in water and hydrophobic. To transport them in blood, the most insoluble lipids are associated with more polar ones such as phospholipids and then combining them with cholesterol and protein to form a hydrophilic lipoprotein complex. Thus the triglycerides derived from intestinal absorption of fat or from the liver are transported in the blood as chylomicrons and very low-density lipoproteins (VLDL). Fat is released from adipose tissues in the form of free fatty acids (FFA) and carried in unesterified state in the plasma as an albumin FFA complex.

Digestion and Absorption of Lipids

No digestion of lipids occurs in the mouth or stomach because:

1. The amount of lipase present in saliva and gastric juice is insignificant,
2. There is no mechanism for emulsifying fatty materials in this region, and
3. The pH of gastric juice is not conducive for lipid digestion.

The major site of lipid digestion is the small intestine. The main requisites are pancreatic lipase and bile salts. Bile salts derived from bile lower the surface tension and emulsify fats, dissolve fatty acids and water insoluble soaps. The alkaline content of the pancreatic biliary secretions neutralises and shifts the pH of the food material to the alkaline side for the action by the pancreatic lipase. The lipase hydrolyses the triglycerides to 40 per cent free fatty acids and glycerol, 50-57 per cent mono and diglycerides. 3-10 per cent is absorbed as triglycerides.

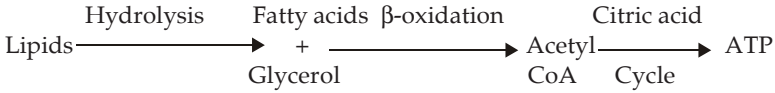
The 2 monoglycerides produced as intermediates are converted to I monoglycerides by an enzyme isomerase which is then digested by lipase to glycerol and free fatty acids. Of the 4 products of triglyceride hydrolysis namely free fatty acids, glycerol, mono and diglycerides, free fatty acids and glycerol are easily absorbed as they are water soluble and are then carried away by blood.

Higher fatty acids, mono and diglycerides are absorbed with the help of bile salts in the form of water soluble aggregates. Inside the intestinal epithelial cell, I monotriglycerides are hydrolysed by intracellular lipases to give fatty acids and glycerol, whereas diglycerides are used for triglyceride synthesis.

Higher fatty acids are largely utilised for the triglycerides synthesis inside the intestinal epithelial cells and are carried as chylomicrons which are hydrophobic water soluble triglycerides covered with a layer of hydrophilic phospholipids, free and esterified cholesterol and some proteins.

Lipid Metabolism

Most of the energy in fats is contained in the long hydrocarbon chains of fatty acids. They are the main energy reserve of the body producing 43.62 kj per gm on oxidation much more than that generated by the oxidation of carbohydrates or proteins (16.8 kj/gm). The fatty acids are oxidised in mitochondria of liver cells and skeletal muscles. During this process two carbon fragments are removed sequentially to generate acetyl CoA which enters the citric acid cycle for production of ATP as described in the previous chapter. Palmitic acid a C-16 fatty acid produces 129 molecules of ATP.



Lipolysis

Lipolysis is defined as triglyceride hydrolysis, liberates fatty acids from their main storage depots. Lipolysis begins with the intestinal hydrolysis of dietary triglycerides by pancreatic lipase. Once absorbed into the intestinal mucosa, the resultant free fatty acids (FFA), glycerol and monosaccharides are resynthesised into triglycerides, which combine with lesser amount of protein, phospholipid and cholesterol to form chylomicrons. Plasma lipoprotein lipase hydrolyses triglycerides in the chylomicrons into FFA and glycerol. Adipose tissue contains a hormone sensitive lipase that hydrolyses its triglycerides.

The glycerol released in lipolysis travels to the liver, where it is phosphorylated to glycerol -3-P. For every 2 moles of glycerol 3-P, I mole of glucose can be synthesised in gluconeogenesis. Glycerol -3-P also serves as a precursor to triglyceride synthesis.

Oxidation of Fatty Acids

Large proportions of the absorbed fat is temporarily stored in the liver, which is also the main site for the oxidation, and synthesis of fatty acids.

β-Oxidation of Fatty Acids

As the principal route for catabolising fatty acids, oxidation occurs in the mitochondria, the intracellular "power house". β-oxidation is so named because it oxidizes the β-carbon atom of a fatty acid to a β-keto acid with sequential remoal of two carbon fragment, Acetyl CoA.

α-oxidation of fatty acids occurs in the human brain. The rare inherited absence of an enzyme required for α-oxidation causes Refsum's disease. α-oxidation of fatty acids is a minor pathway that is found in the liver.

The β-oxidation basically consists of 4 reactions that can be summarised as follows:

1. $-CH_2-CH_2- + FAD \xrightarrow{\text{Dehydrogenation}} -CH=CH- + FADH_2$

2. $-CH=CH- + H_2O \xrightarrow{\text{Hydrolysis}} -\underset{\displaystyle OH}{\underset{|}{CH}}-CH_2-$

3. $-\underset{\displaystyle OH}{\underset{|}{CH}}-CH_2- + NAD^+ \xrightarrow{\text{Dehydrogenation}} -\underset{\displaystyle O}{\underset{\|}{C}}-CH_2- + NADH + H^+$

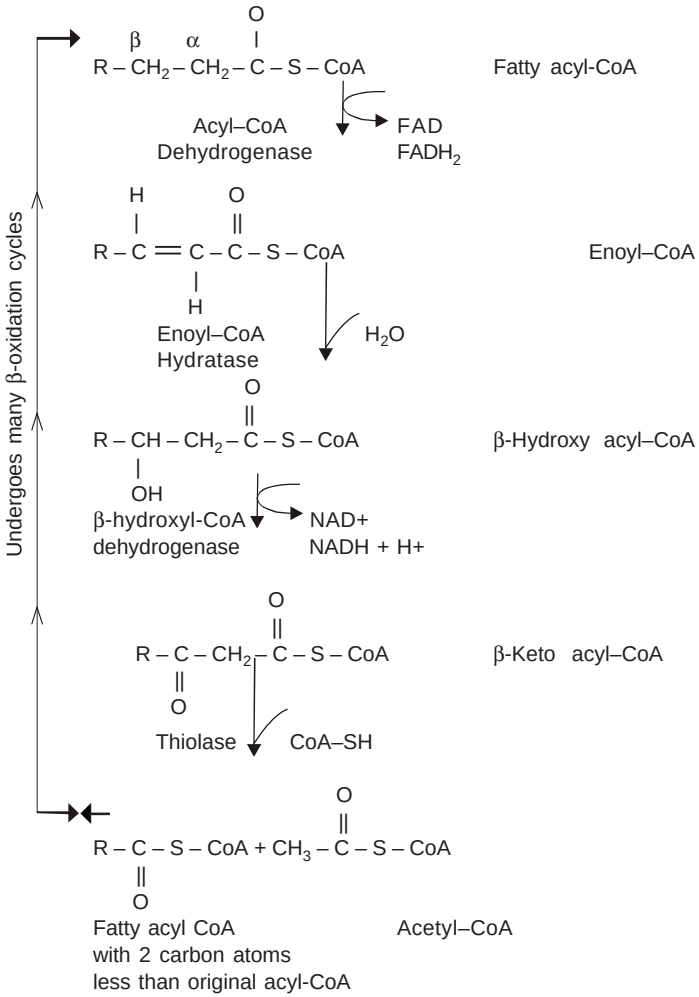
4. $-\underset{\displaystyle O}{\underset{\|}{C}}-CH_2- + CoA-SH \xrightarrow[CoA\ —\ SH]{\text{Cleavage by}} -\underset{\displaystyle O}{\underset{\|}{C}}-S-CoA + CH_3-CoA$

   Fatty acyl CoA — Acetyl CoA

The pathway of β-oxidation begins as Acyl—CoA dehydrogenase oxidises the fatty acid to create a trans double bond between the α- and β-carbon atoms, thereby reducing FAD to $FADH_2$.

This monoenoic is named enoyl–CoA. A hydratase then hydrolyses (hydrates) this double bond yielding β–hydroxyacyl CoA. A second dehydrogenase oxidises this β–hydroxy group to a β-keto group, creating β–keto acyl–CoA, and reducing NAD^+ to NADH. Finally, a thiolase uses SH binding of CoA—SH to cleave

the bond between α and β C atoms liberating acetyl CoA. The remaining fatty acyl CoA, with two less carbon atoms than the original, can then reenter β-oxidation.



ENERGETICS

Each passage through β-oxidation removes two carbon atoms from the fatty acid as acetyl CoA and produces one molecule of $FADH_2$ and one mole NaDH, which yield 5 moles of ATP under reoxidation to FAD and NAD^+ in the electron transport chain

(2 moles ATP per mole of $FADH_2$ oxidised and 3 moles ATP per mole of NADH oxidised). The complete β-oxidation of palmitic acid ($C_{15}H_{31}COOH$) on completion of β-oxidation produces 8 acetyl CoA. Transport of electrons in the respiratory chain from reduced $FADH_2$ and NADH in each cycle produces 5 high energy phosphate bonds. Hence 7 cycles (7 acetyl CoA) = 7 × 5 = 35 ATP.

Total 8 molecules of acetyl CoA,

when oxidised in TCA cycle will produce 12 × 8 = 96 ATP

Total high energy phosphate bonds produced = 131

In initial activation of FA, ATP utilized = 2

Hence net ATP produced from 1 mole of palmitic acid is 129. Energy production = 129 × 7.6 = 980 Kcal per mole of palmitic acid.

Calorie value of palmitic acid (Bombcalorimeter) = 2340 Kcal per mole.

Hence, efficiency = $\frac{980}{2340} \times 100 =$ 41 per cent of the total energy of combustion of FA.

The remaining energy is used as heat by the body.

Metabolism of Adipose Tissue

The adipose tissue serves as a storage site for excess fat as well as reserve store of energy that can be mobilised when needed. It is a storage depot for fats under well fed conditions and reserve source under conditions of starvation.

The triglycerides stored in the adipose tissue are not inert. They undergo daily turnover with new triacyl glycerol molecules being synthesised and a definite fraction being broken down.

The triglyceride stores in adipose tissue are continually undergoing lipolysis (hydrolysis) and esterification. These two processes are not the forward and reverse phases of the same reaction but are entirely different pathways involving different reactants and enzymes.

The resultant of these two processes determines the size of the free fatty acid (FFA) pool in adipose tissue which in turn is the source and determinant of the level of FFA circulating in the plasma.

Under well fed conditions active lipogenesis occurs in the adipose tissue. The dietary fatty acids transported by the chylomicrons and the endogenously synthesised triglycerides brought by VLDL from liver are both taken up by adipose tissue and esterified and stored as TAG. The lipoprotein molecules are broken down by the lipoprotein lipase present on the capilary wall. The glycerol phosphate used for esterification is derived from

glycolysis. The pyruvate formed in the adipose tissue by glycolysis may be oxidatively decarboxylated to acetyl CoA and used for fatty acid synthesis. The citrate from the mitochondria reaches the cytoplasm and gets hydrolysed to acetyl CoA and oxaloacetate. The hexose monophosphate shunt is also active in adipose tissue to provide sufficient reducing power in the form of NADPH for fatty acid synthesis.

Thus, it is seen that in the well fed conditions, the adipose tissue stores excess calories as TAG and takes up the dietary TAG. The process of glycogenesis by adipose tissue is favoured by insulin by increasing the activity of several of the enzymes involved (See section on fatty acid synthesis).

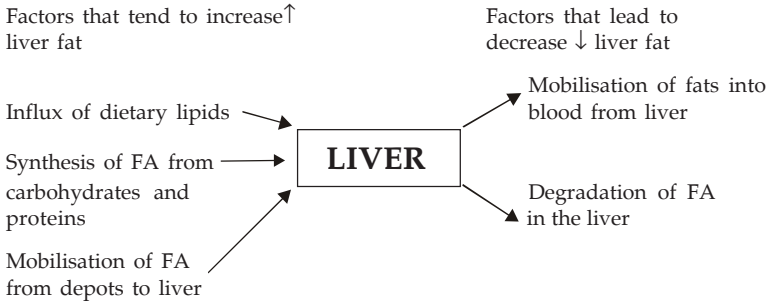
The metabolic pattern totally changes under conditions of fasting. TAG from adipose tissue is mobilised under the effects of hormones, glucagon and epinephrine that are lipolytic. The intracellular hormone sensitive lipase of the adipose tissue is activated by the cAMP mediated activation cascade. The phosphorylated form of the enzyme is active which acts on TAG and liberates fatty acids. These fatty acids are transported by plasma bound to albumin and taken up by tissues like skeletal muscle, heart muscle and liver and used as an alternative source of fuel.

FATTY LIVER AND LIPOTROPIC FACTORS

Fatty liver refers to the disposition of excess triglycerides in the liver cells in excess of 5% of the weight of liver. The liver is able to take up fatty acids from blood stream and esterify it into triacylglycerol (TAG). These triglycerides along with endogenously synthesised by the liver is incorporated into VLDL and secreted from the liver. The balance between the storage of triacylglycerol in adipose tissue and liver is delicate and can revert to a net transfer of fatty acids to the liver resulting in accumulation of TAG in liver.

The net accumulation of fat in liver is mainly due to three reasons:

1. The hepatic uptake of fatty acids from the blood stream is dependent on their concentration in blood.
2. The liver has only a limited capacity to dispose off the fatty acids by oxidation.
3. The capacity of the liver to secret VLDL is also limited.



FATTY LIVER

Causes

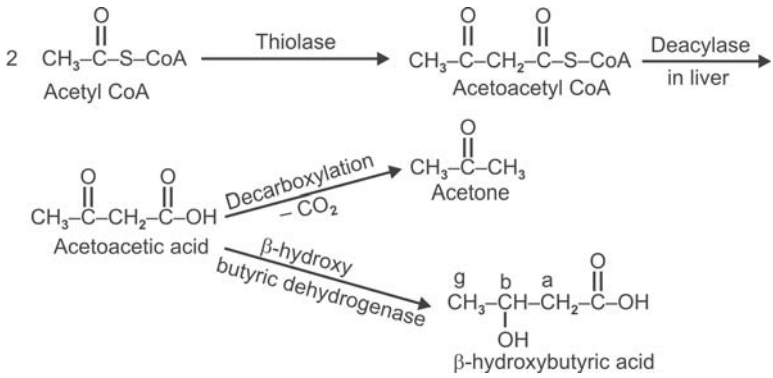
1. Increased mobilization of fats from depots to liver. This type of fatty lever is known as physiological fatty liver. This occurs in:
   a. Diabetes mellitus
   b. Starvation
   c. Carbohydrate deprivation.
2. Impaired utilization of fat in the liver and impaired transport of fat from liver. This type is called pathological fatty liver. In this there is a metabolic blockage in the synthesis of VLDL. It may be due to:
   a. Deficiency of fatty acids
   b. Choline deficiency
   c. Deficiency of pyridoxine, inositol, Vitamin E, pantothenic acid
   d. Poisoning by CCl_4, ethionamide
   e. Alcoholism.

Lipotropic Agents

Agents such as choline, methionine, betaine and inositol effect removal of fat from the liver and thus prevent accumulation of fat in liver cells. Such substances which prevent accumulation of fat in liver are called lipotropic agents.

Ketone Body Metabolism

Acetoacetic acid, β-hydroxybutyric acid and acetone are classified as ketone bodies, acetone bodies or ketones. The process of their formation is known as ketogenesis. Ketone bodies are produced in the liver. They are acidic and detected by Rothera's test.



Ketogenesis

In a diabetic patient, in starvation, or in any situation in which carbohydrate metabolism is restricted, the body utilises oxaloacetate to produce glucose for brain and muscles. This reduces the amount of oxaloacetate available for Krebs' cycle and acetyl CoA cannot be properly metabolised. When this occurs, acetyl CoA is changed into acetoacetyl-CoA which is converted into acetoacetic acid in the liver by the enzyme deacylase. Acetoacetic acid may be changed into acetone and β-hydroxybutyric acid:

The ketone bodies pass into the blood stream in very small amounts under the normal circumstances. The total ketone bodies concentration in blood is normally, below 1 mg per 100 ml of blood and the average excretion in urine in 24 hours is less than 125 mgm. Normally the ketone bodies are carried in the blood stream, mainly to the kidneys and muscles, where acetoacetic acid is oxidised after conversion to acetoacetyl CoA. The latter is then cleaved by thiolase when 2 moles of acetyl CoA are formed. They then enter the (citric acid) tricarboxylic acid cycle. This process of oxidation of ketone bodies is called ketolysis and is an alternate source of energy for the peripheral tissues.

Ketosis

When the rate of ketogenesis in the liver exceeds the rate of ketolysis in the periphery, the concentration of ketone bodies in the blood increases resulting in ketonemia. At this stage, ketone bodies are excreted in detectable quantity in the urine. This is

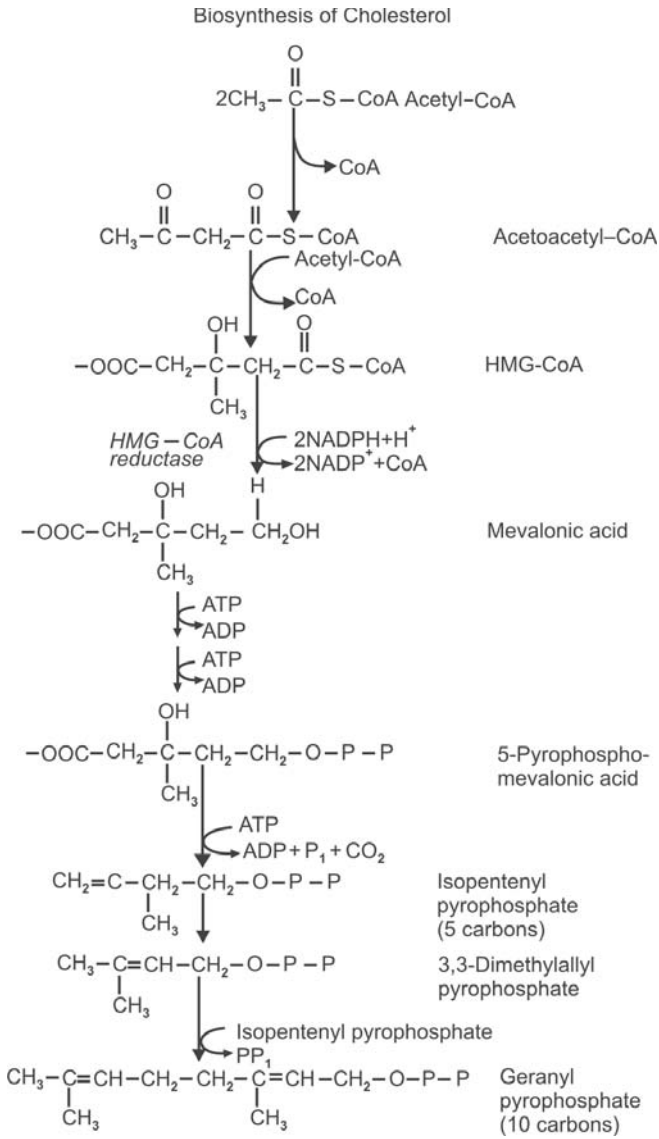


Fig. 12.1: Cholesterol biosynthetic pathway from acetyl—CoA to geranyl pyrophosphate

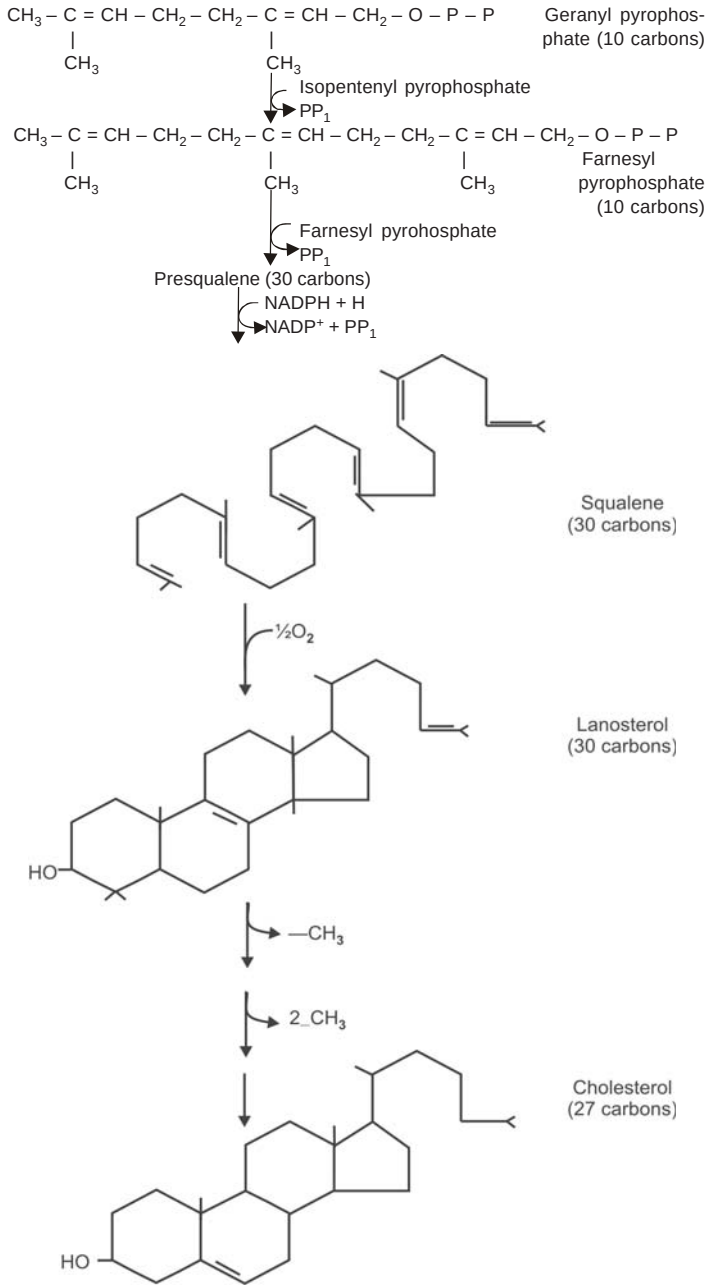


Fig. 12.2: Cholesterol biosynthetic pathway from geranyl pyrophosphate to cholesterol

ketonuria—when ketonuria and ketonemia are marked, acetone which is volatile escapes in the exhaled air giving rise to acetone smell in the breath. Ketonemia, ketonuria and the acetone odour of the breath together is ketosis. If ketosis is severe, acidosis will set in and this is accompanied by excretion of large amounts of water to carry the ketone bodies. At this stage, the patient becomes profoundly acidotic and passes into comatose stage.

Two main causes of ketosis are starvation and diabetes mellitus. In starvation there is deprivation of carbohydrates and in diabetes, carbohydrates are not efficiently utilised. The person survives on his own stores of glycogen in the liver for energy. When this is depleted, energy is derived by the breakdown of fats in the body. The accelerated fat metabolism leads to the formation of large amounts of acetyl CoA and ketone bodies giving rise to ketosis and ketonuria.

Biosynthesis of Cholesterol

Normal adult synthesises about 1 to 1.5 gm of cholesterol per day. Liver is the main site of cholesterol biosynthesis but intestines (intestinal mucosa) is also an important site. Other tissues where cholesterol synthesis takes place are skin, adrenal cortex, testes and aorta. The cholesterol biosynthesis takes place in the extra-mitochondrial compartment of the cell.

The sources of all the carbon atoms in cholesterol is acetyl CoA. Acetyl CoA is the fundamental or building block unit of cholesterol synthesis.

Synthesis of cholesterol takes place in various stages (details are given in Figures 12.1 and 12.2).

1. Formation of mevalonate from acetyl CoA via HMG CoA.
2. Three successive phosphorylation followed by decarboxylation to give isoprene units, mainly isopentenyl pyrophosphate.
3. Condensation of six isoprene units to give C-30 terpene, i.e. squalene.
4. Cyclisation of squalene to lanosterol.
5. Conversion of lanosterol to cholesterol.

Cholesterol is transported in the blood as lipoproteins. Humans have two sources of cholesterol: Dietary cholesterol and synthesis from acetate. The greater the dietary intake of cholesterol the lower the rate of cholesterol biosynthesis in the liver and adrenal cortex. Although cholesterol itself has no calorific value in foods, its presence in the diet spares the energy necessary to synthesise cholesterol.

QUESTIONS AND ANSWERS

1. **How is fat digested and absolved?**
2. **Describe the β-oxidation of fatty acids. Mention how many ATPs are released on complete oxidation of palmitic acid?**
3. **How are fatty acids synthesised in the body?**
4. **What are ketone bodies?**
   Ans: 1. Acetoacetic acid
   2. β-hydroxybutyric acid
   3. Acetone.
5. **What is the nature of ketone bodies?**
   Ans: Ketone bodies are acidic.
6. **Who is the net producer of ketone bodies?**
   Ans: The liver.
7. **Can liver utilise the ketone bodies? If not why?**
   Ans: Liver cannot utilise ketone bodies because of the activating enzyme for ketone bodies utilisation is absent in the liver.
8. **What are the tissues which prefer ketone bodies for utilisation?**
   Ans: Extrahepatic tissues prefer ketone bodies for utilisation because they possess the activating enzymes.
9. **How are the ketone bodies formed?**
   Ans: Ketone bodies are formed as intermediate breakdown products of fat metabolism. If carbohydrate metabolism is defective, more fat breaks down for energy purposes. Hence more ketone bodies are formed.
10. **What is fatty liver? What are its causes?**
    Ans: Fatty liver refers to the deposition of excess of triglycerides in the liver cells.
11. **What are the lipotropic agents? Name them.**
    Ans: They are agents such as choline, methionine, betanine and inositol which help removal of fat from the liver.

MULTIPLE CHOICE QUESTIONS

12. **β-oxidation of fatty acids requires all the following co-enzymes *except:***
    A. Co A
    B. FAD

C. NAD
D. NADP

13. The following can be oxidized by β-oxidation pathway:
A. Saturated fatty acids
B. Monounsaturated fatty acid
C. Polyunsaturated fatty acid
D. All of the above

14. Ketone bodies are synthesized in:
A. Adipose tissue
B. Muscles
C. Brain
D. Liver

15. All of the following statements about the ketone bodies are true *except:*
A. Their synthesis increases in diabetes mellitus
B. They are synthesized in mitochondria
C. They can deplete the alkali reserve
D. They can be oxidized in the liver

16. Net generation of energy on complete oxidation of palmitic acid is:
A. 129 ATP equivalents
B. 131 ATP equivalents
C. 146 ATP equivalents
D. 148 ATP equivalents

17. Net ATP production on complete oxidation of stearic acid in:
A. 129
B. 131
C. 146
D. 148

18. Histamine is formed from histidine by:
A. Deanimation
B. Dehyrogenation
C. Decarboxylation
D. Carboxylation

19. Following are the ketone bodies *except:*
A. Acetoacetate
B. Acetone
C. Oxaloacetate
D. β-hydroybutyrate.

20. Ketone bodies production is more in starvation because of:
A. Availability of more glucose for oxidation
B. Availability of more fatty acids for oxidation
C. Availability of less glycerol and oxaloacetate
D. Availability of more CoA

21. In β-oxidation of fatty acids, co-enzymes required are:
A. NAD and NADP
B. FAD and NAD
C. FAD and FMN
D. $FADH_2$ and $NADH^+ H^+$.

22. Fatty liver is due to:
A. Overmobilisation fat from liver to fat depot
B. Undermobilisation of fat from tissues to fat depot
C. Over feeding of fat
D. All of the above

23. Serum triglycerides are contributed by all the following *except:*
A. Dietary fat
B. Fat synthesized in the body
C. Fat retained by kidney
D. Fat synthesized from glucose

24. Conditions and agents that cause fatty liver include:
A. Alcoholism
B. High fat diet
C. Deficiency of lipotropic factors
D. All the above

25. Bile facilitates action of lipase by:
A. Emulsification
B. Saponification
C. Inhibition of emulsification
D. Inhibition of soap formation

26. Cholesterol is transported from liver to adipose tissue by:
A. Chylomicrons
B. VLDL
C. LDL
D. HDL

27. Diet having a high ratio of polymsaturated, saturated fatty acid can cause:
A. Increase in serum glycerides
B. Decrease in serum cholesterol
C. Decrease in serum HDL
D. Skin lesions

28. VL DL remnants can be converted into:
A. VL DL
B. LDL
C. HDL
D. Chylomicrons

29. HDL is synthesized in:
A. Adipose tissue
B. Liver
C. Intestine
D. All of the above

30. Pancreatic lipose requires for its acton:
A. Colipase
B. Bile salts
C. Phospholipids
D. All of the above

31. Lipogenesis is decreased in all the following *except:*
A. Restricted calorie intake
B. High fat intake
C. Deficiency of insulin
D. High carbohydrates intake.

32. Plasma becomes milky:
A. Due to high level of HDL
B. Due to high level of LDL
C. During fasting
D. After a meal

ANSWERS

12(D)	13(D)	14(D)	15(D)	16(A)	17(C)
18(C)	19(C)	20(C)	21(B)	22(D)	23(C)
24(D)	25(A)	26(B)	27(B)	28(B)	29(D)
30(D)	31(C)	32(D)			

CHAPTER

13 Metabolism of Proteins

DIGESTION OF PROTEIN BY VARIOUS ENZYMES

Twenty amino acids are present in dietary proteins. Proteins are hydrolysed to their constituent amino acids by the action of the following enzymes:

1. Pepsin	:	Converts proteins to proteoses and peptones
2. Trypsin	:	Cleaves peptide bonds involving carboxyl groups of arginine and lysine.
3. Chymotrypsin	:	Cleaves peptide bonds involving carbonyl groups of phenylalanine, tyrosine and tryptophan.
4. Carboxypeptidases	:	Cleaves proteins and peptides from the carbonyl end.
5. Amino peptidases	:	Cleaves proteins and peptides from the amino end.
6. Dipeptidases	:	Cleaves dipeptides.

Absorption

Amino acids present in dietary proteins are in L–form. The L–form of amino acids are absorbed much faster than the D–form. All amino acids are absorbed by active process. Active process requires ATP, periodoxal phosphate, Mn^{++}, Na^{+} and K^{+}.

Metabolic Pool

Amino acids from blood diffuse in the body fluids and reach all the tissue cells, where they are taken up by tissues by active transportation process. At the same time, most of the tissue proteins undergo disintegration constantly and release their amino acid content to the blood stream. This is the endogenous source of amino acids. They mix with the exogenous amino acids derived

from food and build up the reservoir of amino acids called metabolic pool of amino acids (Fig. 13.1).

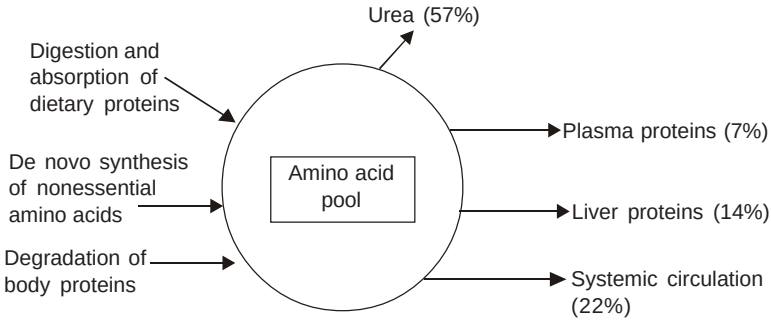


Fig. 13.1: Metabolic pool of amino acids

Nitrogen Balance

In a healthy adult maintaining a constant weight, the intake of nitrogen in food (mainly as dietary proteins) will be balanced by an excretion of an equal amount of nitrogen in urine (in the form of urea, uric acid, creatinine and amino acids) and in faeces as unabsorbed nitrogen. The individual is then in nitrogen balance. An individual whose intake of nitrogen is greater than the output, has a positive nitrogen balance. In growing period and during convalescence from illness, the body puts on weight and nitrogen intake will be more than output since some of the nitrogen is retained as tissue proteins.

An individual whose intake of nitrogen is less than the output has a negative nitrogen balance. In old age and during illness and starvation, weight is lost resulting in negative nitrogen balance.

Nitrogen balance is determined by subtracting fecal and urinary nitrogen from ingested nitrogen.

GENERAL PATHWAY OF PROTEIN METABOLISM (FIG. 13.2)

The amino acids from the "pool" are utilised for two purposes:

Anabolic phase (Synthesis)	Catabolic phase (Breakdown)
1. Protein biosynthesis, tissue proteins, blood proteins, enzymes, hormones	1. Transamination 2. Oxidative deamination

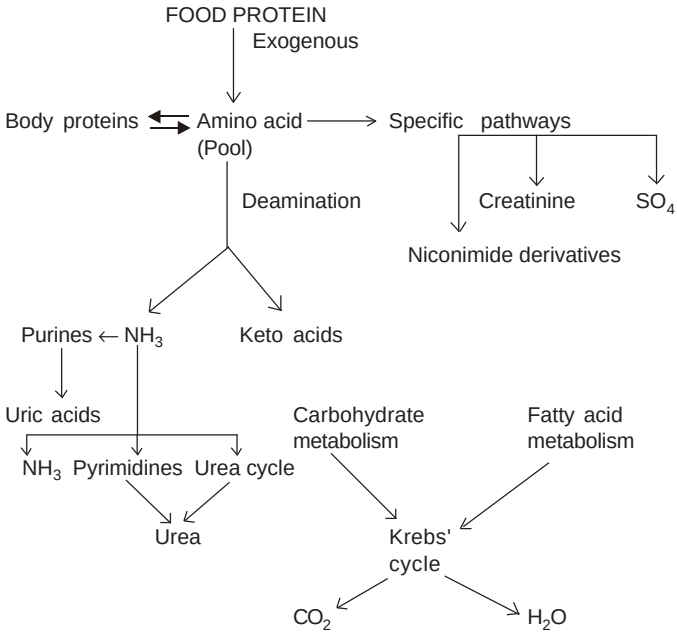


Fig. 13.2: General scheme of the pathway of proteins and amino acid metabolism

2. Synthesis of non-protein nitrogen substances like creatinine, purines, pyrimidines, glutathione and choline
3. Decarboxylation
4. Utilisation of nitrogen residue
   (i) Glutamine synthesis
   (ii) Urea cycle.

Metabolism of Amino Acids (Break Down)

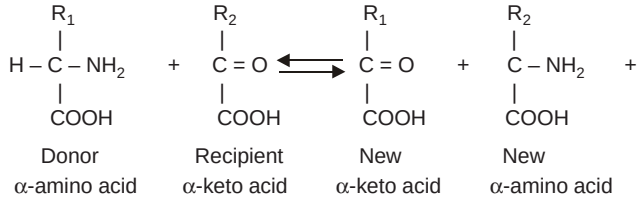
α–NH_2 group of amino acids, derived either from the diet or breakdown of tissue proteins is converted first to NH_3 and then to urea and is excreted in the urine.

Formation of NH_3 and urea can be discussed under the following heads:

1. Transamination
2. Oxidative deamination
3. Decarboxylation
4. Formation of urea.

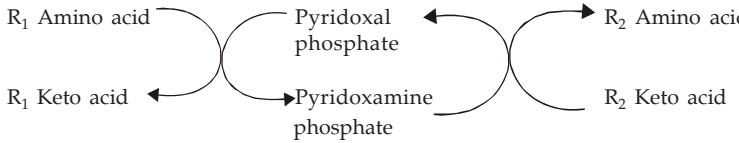
Transamination

It is a reversible reaction in which α- NH_2 group of one amino acid is transferred to a α-keto acid resulting in the formation of a new amino acid and a keto acid. The general reaction is represented as:



By transamination, the body can synthesise any nonessential amino acid, it needs. The body can control the concentrations of nonessential amino acids by converting excess amino acids to needed acids by transamination.

The transaminases require pyridoxal phosphate as the co-enzyme. The pyridoxal phosphate acts as a carrier of amino group from amino acid to keto group as represented below:



Transaminases are present in practically all the tissues. The most abundant are the glutamate oxaloacetate transaminase (GOT) or Aspartate transaminase (AST) and glutamate pyruvate transaminase (GPT) or Alanine transaminase (ALT). ALT is predominant in the heart. AST levels are increased in cardiac infarction and cirrosis of the liver ALT levels are raised in liver diseases infective hepatitis. Determination of the concentration of AST and ALT in serum is used to assess the degree of cardiac and liver damages.

Examples

L–Glutamic acid + Oxaloacetic acid $\xrightarrow{\text{SGOT or AST}}$ α –Keto glutaric acid + L–Aspartic acid

L–Glutamic acid + Pyruvic acid $\xrightarrow{\text{SGPT or ALT}}$ α–Keto glutaric acid + L–Alanine

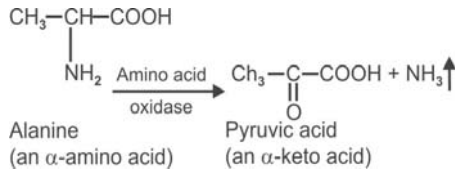
Decarboxylation

Amino acids are decarboxylated to give the corresponding amines. The enzyme is decarboxylase with Pyridoxal phosphate as co-enzyme. Decarboxylation of amino acids gives rise to some of the biologically active amines.

Histidine ⟶	Histamine (Powerful vasodilator)
Tyrosine ⟶	Tyramine (Increases blood pressure)
Glutamic acid ⟶	α-Aminobutyric acid (Stimulates neuronal activity)
Tryptophan ⟶	Tryptamine
5-Hydroxy tryptophan ⟶	5 Hydroxy tryptamine
Arginine ⟶	Agotomine (in bacteria only)

Oxidative Deamination

It involves the removal of α-amino group of amino acids to produce their keto acids. The enzyme is amino acid oxidase. The amino acid is first dehydrogenated by the flavoprotein of the enzyme, α-amino acid oxidase forming an α-amino acid. In the next step, water molecule is added spontaneously and decomposes to the corresponding α-keto acid with the loss of α-imino nitrogen as NH_3.



Urea Synthesis: Urea Cycle (Krebs-Henseleit Cycle) or Ornithine Cycle

Urea is the chief end product of amino acid metabolism and it is synthesised in the liver. Increase in the dietary protein is followed by increase in urine urea. A normal healthy adult excretes 25 to 30 gm of urea per day. The normal blood urea level is 15 to 35 mgm per 100 ml.

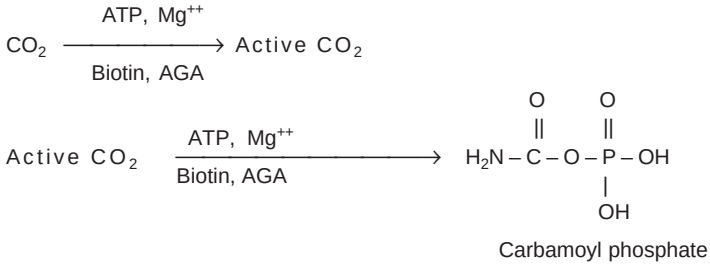
The deamination of amino acids produces ammonia which is toxic. By Krebs-Henseleit cycle, it is converted to urea, a non-toxic compound which is transported via the blood to the kidneys and excreted in urine. Krebs and Henseleit have elucidated the following five steps of urea synthesis, i.e. five sequential enzymatic reactions taking place in the liver:

1. Synthesis of carbamoyl phosphate, an unstable intermediate
2. Synthesis of citrulline

3. Synthesis of argininosuccinate
4. Cleavage of argininosuccinate
5. Cleavage of arginine to form orinthine and urea.

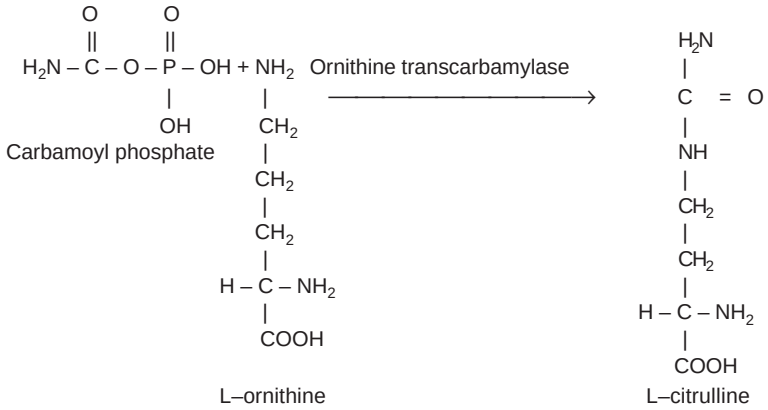
1. Synthesis of Carbamoyl Phosphate

The enzyme required is carbamoyl phosphate synthetase present in the mitochondria. The enzyme requires biotin and N-acetyl glutamic acid (AGA) as co-enzymes.



2. Synthesis of Citrulline

Carbamoyl phosphate and orinthine combine to form citrulline. The catalyst is ornithine transcarbamylase.

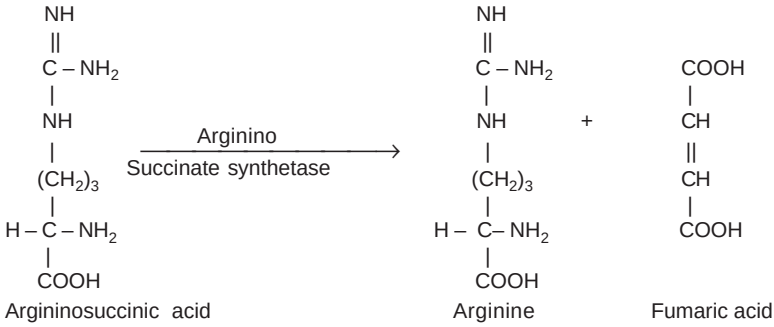


3. Synthesis of Argininosuccinic Acid

Citrulline and aspartic acid combine to form argininosuccinic acid. The reaction is catalysed by enzyme arginosuccinate synthetase.

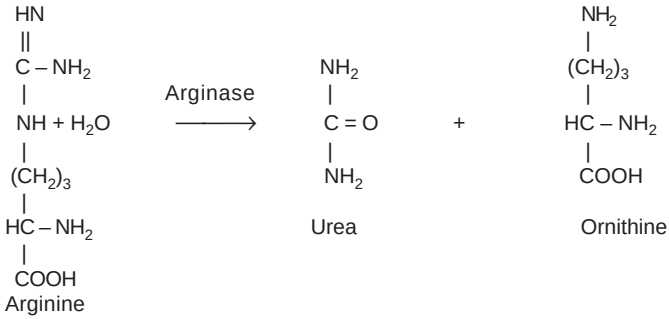
4. Cleavage of Argininosuccinic Acid

Cleavage of argininosuccinic acid by enzyme argino succinase yields arginine and fumaric acid.



5. Synthesis of Urea

Enzyme arginase splits anginine to urea and ornithine.



Ornithine so formed again enters in the urea cycle at the second step and hence the cycle continues. Urea is absorbed by blood, brought to kidneys and excreted in urine.

This is a catalytic process. The enzymes are located partly in the mitochondria for first 2 steps and partly for next 3 steps in the cytoplasm. One molecule of NH_3 and one molecule of CO_2 are converted to one molecule of urea for each turn of the cycle and ornithine is regenerated at the end. The overall process in each turn of the cycle requires 3 molecules of ATP (Fig. 13.3).

Significance of Urea Cycle: Detoxification of NH_3

Major biological role of this pathway is the detoxification of NH_3. Toxic ammonia is converted into a non-toxic substance urea and

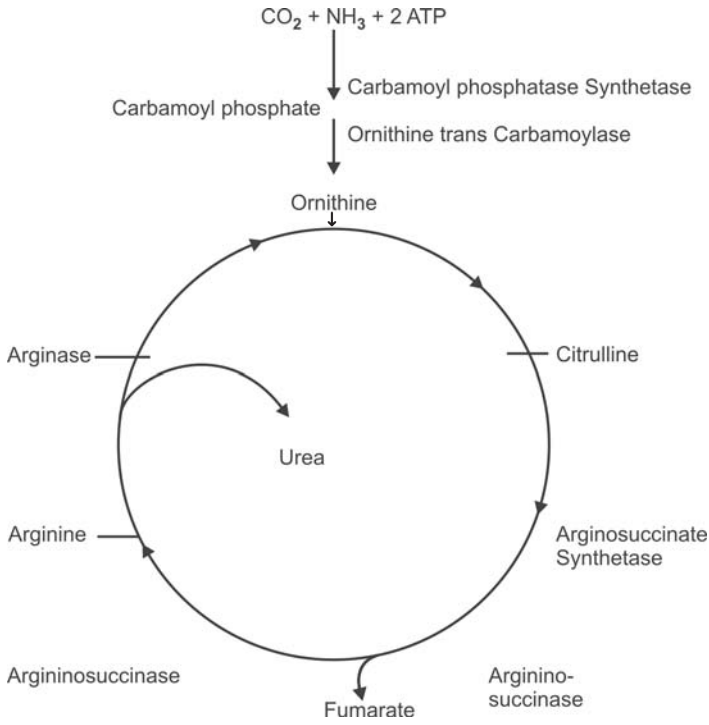


Fig. 13.3: The urea cycle

excreted in urine. The urea cycle occurs predominantly in the liver, although it also exists in the brain and kidneys. Ammonia is also used up in the formation of glutamine and for amination of α-Keto acid to form α-amino acid.

Urea synthesis is not an independent process, but is connected with vital metabolic reactions in the body. Synthesis of urea is important because of its integration with the citric acid cycle which serves as the source of supply of aspartate. Also the fumerate derived from arginosuccinate integrates with the citric acid cycle.

Uraemia: This is a pathological clinical state when blood urea increases above 50 mg%. Acute uraemia is associated with anuria (suppression of excretion of urine).

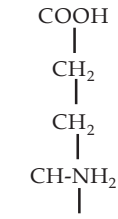
Metabolic Disorders of Urea Cycle

For each enzyme of the urea cycle, there is a rare inherited deficiency disorder that is almost always fatal in infancy. The urea concentration is extremely low in affected individuals.

Hyperammonaemia gives rise to mental retardation. Any defect of urea cycle enzymes gives elevated levels of ammonia. Hyperammonaemia is because of increased level of ammonia in the blood.

METABOLISM OF GLUTAMIC ACID

It is alpha-aminoglutaric acid. Glutamic acid plays an important role in the metabolism of amino acids. It is generated during transamination reactions.



Glutamic acid

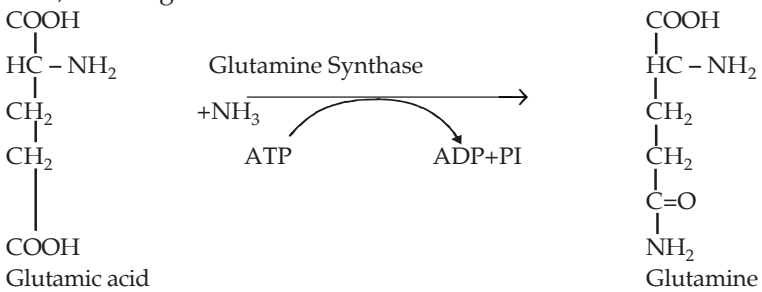
Most amino acids transfer their ammogroup to alpha ketoglutaric acid to form glutamic acid

Amino acid

Alpha-Ketoglutarate $\xrightarrow{\text{Aminotransferse}}$ Alphaketoacid + Glutamic acid

Glutamic acid is also formed during the metabolism of other amino acids such as histidine, proline and arginine

Glutamic acid can react with a molecule of NH_3 in presence of ATP, to form glutamine



The formation of glutamine from glutamic acid in the brain and instestine of significance in the disposal of NH_3, from the intestine tract in a nontoxic from. It helps to change ammonia into a nontoxic form.

QUESTIONS

1. **How are the proteins digested and absorbed in the body?**
2. **Describe the urea cycle in detail.**
3. **Give the methods of deamination of amino acids. What is the fate of liberated ammonia?**
4. **Describe the importance of transamination in amino acid metabolism.**
5. **Discuss the formation and disposal of ammonia in the liver.**
6. **Describe the metabolic pathways available for the detoxification of ammonia in the body.**

MULTIPLE CHOICE QUESTIONS

7. **Positive nitrogen balance is seen in:**
   A. Starvation
   B. Wasting diseases
   C. Growing age
   D. Intestinal mal absorption
8. **Alanine can be synthesized from:**
   A. Glutamate and α-ketoglutarate
   B. Pyruvate and glutamate
   C. Pyruvate and α-ketoglutarate
   D. Aspartate and α-ketoglutarate
9. **During catabolism of amino acids their amino groups are transferred mainly to:**
   A. Pyruvate
   B. Oxaloacetate
   C. α-ketoglutarate
   D. Ornithine
10. **The organ which is extremely sensitive to ammonia toxicity is:**
    A. Liver
    B. Brain
    C. Kidney
    D. Heart

11. Immediate detroxification of ammonia is done in the brain by fixing it in the form of:
A. Glutamine
B. Alanine
C. Aspartate
D. Asparagine

12. The major site of urea synthesis is:
A. Brain
B. Kidneys
C. Liver
D. Muscles

13. The carbon atoms of urea are provided by:
A. CO_2
B. Aspartate
C. Ornithine
D. None of the above

14. Some amino acids are considered non-essential for man because:
A. They are not required for protein syntesis
B. They do not form any biologically important compound
C. They can be synthesized in the body
D. They are formed from essential amino acids

15. Some amino acids are considered essential for man because:
A. Their half lives are very long
B. They cannot be synthesized in the human body
C. They can form other non-essential amino acids
D. Besides proteins, they form other specialized compounds

16. Pancreatic juice contains proteolytic enzymes *except:*
A. Pepsin
B. Trypsin
C. Chymotrypsin
D. Carboxy pepsidase

17. Gastric juice contains proteolytic enzymes *except:*
A. Pepsin
B. Trypsin

C. Rennin
D. Gilatinase

18. Following proteolytic enzymes are absent in adults:
A. Pepsin
B. Elastase and collagenase
C. Rennin
D. Tripsin and chymotripsin

19. Positive nitrogen balance is seen in all *except:*
A. Convalescence
B. Fever
C. Growth
D. Pregnancy

20. Negative nitrogen balance means:
A. Nitrogen intakes is more than excretion
B. Nitrogen excretion is more than intake
C. Nitrogen intake and excretion are the same
D. Nitrogen excretion is less than intake

21. The α-amino acids are absorbed from the intestine by:
A. Active transport
B. Endocytosis
C. Facilitated diffusion
D. Passive diffusion

22. Transamination requires the following enzymes:
A. Co-enzyme A
B. Pyridoxal phosphate
C. TPP
D. Nicotinamide

23. Urea is produced in the body because:
A. It is stored in the liver
B. It is used for synthetic purpose
C. It is used for synthetic purpose
D. It is for detoxify ammonia

24. Urea synthesis involves all the following *except:*
A. Transferase
B. Synthase

C. Lyase
D. Oxidase

25. Fate of ammonia is:
A. Urea synthesis
B. Sythesis of amino acids
C. Glutamine formation
D. All of the above

26. Normal concentration of urea in blood is:
A. 20-40 mg%
B. 20-40 mg%
C. 20-40 μg%
D. 20 to 40 mg%

27. Urea synthesis requires the following *except:*
A. Ammonia
B. CO_2
C. Aspartate
D. NAD^+

28. In liver failure, serum ammonia concentration is increased due to:
A. Decreased ammonia excretion
B. Increased protein articulation
C. Inefficient urea synthesis
D. Decreased glutamine synthesis

29. Urea cycle is associated with TCA in the following respects:
A. For the synthesis of arginine
B. For the synthesis of citrulline
C. For the synthesis of ornithime
D. For the conversion of fumerate to aspartate

30. Creatin phosphate is high energy compound because:
A. It is equal to ATP
B. It gives less than 7.3 K cal energy
C. It gives more than 7.3 K cal energy
D. It gives less than 10.3 K cal energy

31. Amino acids involved in creatinine formation are
A. Glycine, arginine and methionine
B. Glycine, arginine and cysteine

C. Glycine, cysteine and glutamine
D. Glycine, arginine and glutamic acid

32. Cholin is synthesized from:
A. Cysteine
B. Cytosine
C. Methionine
D. Arginine

33. The substance from which ammonia is produced by the kidney is:
A. Glycine
B. Alanine
C. Valine
D. Phenyl alamine

34. Most of the amino acids are metabolished in:
A. Kidney
B. Liver
C. Heart
D. Intestine

35. The urea cycle spans two cellular compartments which are:
A. Cytosol and vacuole
B. Cytosol and endoplasmic reticulum
C. Cytosol and mitochondria
D. Cytosol and nucleus

36. The reaction in which α-amino group is transferred to the AL carbon atom of α-ketoglutarate is called as:
A. Decarboxylation
B. Transamination
C. Deamination
D. Hydroxylation

37. Milk protein is digested in the stomach by:
A. Trypsin
B. Revin
C. Rennin
D. DHCL

38. All the following are catabolic pathway of amino acids *except:*
A. Acytalation
B. Transamination

C. Transamination
D. Deamination

39. Which co-enzyme is required for the removal of the amino group?
A. NAD +
B. Pyridoxal phosphate
C. FAD +
D. Thiamine

40. Which amino acid is not involved in urea cycle?
A. Arginine
B. Aspastic acid
C. Glycine
D. Ormithane

41. The link between TCA cycle and urea cycle is through:
A. Citrate
B. Pyruvate
C. Fumaric acid
D. Malate

42. Phenyl ketonuria (PKU) is characterized by:
A. Urine becoming dark on standing
B. Urine with a mousy odour
C. Urine with smell of burnt sugar
D. Increased tyrosine lent in urine

ANSWERS

7(C)	8(B)	9(D)	10(B)	11(A)	12(C)
13(A)	14(C)	15(B)	16(A)	17(D)	18(C)
19(B)	20(B)	21(A)	22(B)	23(D)	24(A)
25(A)	26(A)	27(D)	28(C)	29(A)	30(A)
31(A)	32(C)	33(A)	34(B)	35(C)	36(B)
37(C)	38(A)	39(B)	40(D)	41(C)	42(B)

CHAPTER

14 Immunochemistry

Immunity is the ability of the body to resist invasion by micro-organisms and influence of toxins that cause tissue damage.

Types

1. Inmate immunity
   - Non-specific
   - Specific
2. Acquired immunity
   - Active
   - Passive

Antigen: Antigen is a substance which when introduced into the body stimulate the production of antibody with which it specifically reacts.

Haptens: These are substances which cannot induce antibody formation but can react specifically with antibodies

The smallest unit of antigenicity is know as antigenic determinant or epitope.

They are peptides or monosaccharide residues. They have a specific chemical structure, electrical charge and are capable of stimulating an antibody which reacts at that site.

IMMUNE RESPONSE

The specific reactivity induced by an antigenic stimulus in a host is known as immune response.

The immune response is of two types:

1. Antibody mediated (humoral) response AMI.
2. Cell mediated response CMI.

ANTIBODY MEDIATED (HUMORAL) RESPONSE

This provides defence against bacterial pathogens and viruses that invade through respiratory or gastrointestinal tract. It also

prevents recurrence of viral infections. It participates in the pathogenesis of immediate hypersensitivity reactions.

The production of anitibodies occurs in 3 steps:

a. Entry of antigen, its distribution in the tissue and contact with appropriate immunocompetent cells.
b. Processing of antigen by cells.
c. Secretion of antibody.

CELL MEDIATED IMMUNE RESPONSE (CMI)

It is a type of specific immune response that does not involve antibody.

It is mediated by T-lymphocytes. CMI provides protection against fungi, viruses and intracellular bacterial pathogen. It participates in graft virus host reaction. It provides immunity against cancer. CMI is provided by T-lymphocytes and their products – lymphokines.

- Monokines secreted by monocytes and macrophages help in CMI.
- Lymphokines and monokines together constitute cytokines.
- Cytokines are soluble products secreted by lymphocytes, macrophages, neutrophils and natural killer cells.
- For further details, please refer to immunology in microbiology.

MICHANISMS OF ANTIBODY PRODUCTION

There are two broad groups of theories of antibody formation:

1. Instructive theories.
2. Selective theories.

The instructive theories postulate that an immunocompetent cell (ICC) is capable of synthesizing antibodies of all specificity. The antigen instructs ICC to produce the complementary antibody. Selective theories on the contrary, postulate that ICCs have only a restricted immunological range. The antigen selects the appropriate ICC to synthesise an antibody. The most accepted theory is "Clonal selection theory".

Clonal selection theory: This theory was proposed by Burnet (1957). The theory states that during foetal development of a large number of clones of immunological competent cells (ICCs) bearing specific antibody patterns are produced by a process of somatic mutation of ICCs against all possible antigens. Clones of cells

with immunological reactivity with self antigens are eliminated during embryonic life. Such clones are called "forbidden clones". Persistence of forbidden clones or their development in later life by somatic mutation lead to autoimmune processes. Each ICC is capable of reacting with one antigen or a small number of antigens. Contact with specific antigens leads to a cellular proliferation to form clones synthesing the antibody. The conical selection theory is widely accepted.

Major Histocompatibility Complex (MHC)

The major histocompatibility complex (MHC) in humans is known as the human leucocyte antigen (HLA) complex.

The HLA Complex

Histocompatibility antigens mean cell surface antigens that evoke immune response to an incompatible host resulting in allograft rejection. These alloantigens are present on the surface of lencocytes in man and are called human lencocyte antigens (HLA) and the set of genes coding for them is called the HLA complex.
The HLA complex of genes is grouped in three classes:

1. *Class I MHC antigens: HLA – A, HLA – B, HLA – C:*
   The MHC class I antigens are present on the surface of all nucleated cells. They are involved in graft rejection and cell mediated cytolysis
2. *Class II MHC antigens (HLA – DR, HLA – DQ AND HLA – DP:*
   They have a very limited distribution and are principally found on the surface of macrophages, monocytes, activated T lymphocytes (CD4) and B lymphocytes. They are primarily responsible for the graft virus host response.
3. *Class III MHC antigens:*
   Class III genes encode C2, C4 complement components of the classical pathway and properdin factor B of alternate pathway.

FREE RADICALS

Free radicals are atoms or molecules containing one or more unpaired electrons in their outer orbit. They are highly reactive species and have a tendency either to loose an electron, thereby acting like a reducing agent or gain an electron, thereby acting as oxidizing agents. Thus, they can initiate chain reaction by

extracting an electron from a neighboring molecule to complete its own orbit.

a. The most important radicals are derived from molecular oxygen and contain oxides of nitrogen especially nitric oxide.
b. These free radicals may act as signaling molecule in physiological and biochemical activities or may provide defence against invading micro-organisms.
c. Failure of these protective mechanisms may lead to pathological conditions.
d. Oxygen derived free radicals and related non-radical compound (H_2O_2) are referred to as reactive oxygen species (ROS).
e. Not all reactive oxygen species are free radicals e.g., Singlet oxygen and hydrogen peroxide.

Formation of Reactive Oxygen Species

When the oxygen molecule (O_2) is introduced into a reducing environment, it may undergo a series of reactions leading to the formation of ROS. The reactive intermediates which are formed usually remain tightly bound in the active sites of the enymes, until the reaction is completed. Thus free radicals usually have only a transient existence in the catalystic process. But occasionally they may escape from the active site of the enzyme and lead to destructive effect.

ENZYME REACTIONS IN WHICH FREE RADICALS ARE BYPRODUCTS

Various reactions occurring in cells depend on a supply of oxygen (dioxygen). In such type of reactions free radicals are generated as byproducts. The enzyme catalyzing oxygen requiring reactions can be classified into:

a. Oxidases
b. Monoxygenases
c. Dioxygenases

Free radicals can be neutral, positive or negatively charged. To gain stability it removes electrons from neighbouring molecules thereby initiating chain reactions like lipid peroxidation thereby causing immense tissue damage leading to cancer, cardiovascular diseases, cataract, ulcerative collititis, rheumatoid arthritis, Crohn's disease e.g., Superoxide anion O_2, Hydroxyl radical OH.

ANTIOXIDANTS

These are substances which counteract the deleterions effect of free radical, e.g. Enzymes like catalase, peroxidase, ceruloplasmin, etc.

Vitamins like vitamin E, vitamin C, B, Carotene, selenium, etc.

Oxidized LDL is a risk factor for atheroscleros is Vitamin E prevents oxidation of LDL and thereby reduces atherosclerosis.

ACTION OF ANTIOXIDANT

Different antioxidants act at different levels:

a. They may prevent the initiation of chain reactions by removing free radicals.
b. They may scavenge free radicals generated in chain reactions, thereby interrupting the chain sequenec.
c. They may remove peroxides thereby preventing further generation of ROS.
d. There are two main lines of defence against ROS enzymatic antioxidant system also called scavenger enzymes.

Non-enzymatic (nutrient) antioxidant systems:

Vitamin E:

1. The antioxidant property of Vitamin E is most important and natural property which prevents peroxidation of poly-unsaturated fatty acids contained in cellular phospholipids by removal of free radicals such as OH; superoxide [O_2] anions.
2. Antioxidant action of tocopherols prevents the peroxidative effects of atmospheric pollutants like O_2, H_2O_2 and NO_2 on membrane lipids of bronchi, bronchioles and alveoli.
3. Antioxidant action of tocopherol protects selenide at their active sites of membrane proteins against free radicals.
4. Tocopherols prevent oxidation of vitamins A and carotenes and reduce their wastage.

Vitamin C:

a. Vitamin C, flavoprotein and carotenoids are able to regenerate Vitamin E which can act as antioxidant.
b. Vitamin C, β-carotene, flavoprotein are also able to reduce and detoxify oxygen intermediate in cells.

STRUCTURAL AND CONTRACTILE PROTEINS

Collagen

The major structural protein found in connective tissue is collagen (Greek word meaning substance to produce glue) is the most abundant protein in the body. Almost 25-30% of the total weight of protein in the body is by collagen. It is present in almost all organs and serves to hold together the cells in the tissues. It is the major fibrons element of tissues like bone, teeth, tendons, cartilage and blood vessels. The other connective tissue proteins that play a structural role an elastin and proteoglycans.

The immature collogen is soluble. The insoluble mature is unsuitable for carrying out structural studies. The basic structural unit of collagen is tropocollagen. The tropocollagen is made up of three polypeptide chains of the same size.

Collagen is synthesized by fibroblasts intracellularly, the polypeptide chains of collagen are synthesized in the form of large precursors called procollagen.

It is then secreted and entracellular procollagen is eleaved by specific peptidases to form procollagen. This removal of the peptides is important for the proper formation of triple helical rod like structure of tropocollagen.

Elastin

Elastin is a protein found in the connective tissue and it is the major component of elastic fibres. The elastic fibres can stretch and then can resume their original length. They have high tensil strength. They are found in the ligaments as well as the walls of blood vessels especially large vessels like aorta.

Elastin has a distinct amino acid composition. One-third of the residues are glycine. Proline is present in large amounts, so also alanine. Hydroxyproline is present in small amounts while hydroxylysine is absent. When elastin matures desmosine cross-links are formed from four lysine residues. Copper deficiency blocks the formation of aldehydes which are essential for cross-linking.

Keratins

Keratins proteins present in hair, nails and skin. They are also present in epidermal appendages like horn and hoof. The fibres

present are called alpha-keratins and matrix as keratohyalin. The Keratin fibrins are first formed which aggregate into bundles. They mainly have the alpha helical structure. The keratohyalins matrix has cystein-rich polypeptide chains which are held together by disulphide bonds. The proportion of keratins vary depending on the degree of cross-linking and the number of disulphide bonds: The more the number of disulphide bonds, the harder the keratin is. In addition to the disulphide bonds, covalent bonds are also seen between lysine and glutamic acid residues of adjacent polypeptide chains, forming amide bonds.

The keratin present in the chain has more number of disulphide bonds which give mechanical strength. On disrupting these bonds by reduction, the solubility increases while the tensil strength decreases. This is used in artificial waving of hair.

CONTRACTILE PROTEINS ACTIN AND MYOSIN

Movement is an important property of life especially of members of the animal kingdom. The orgamism may move as a whole (walking) or movement of cells may occur or it may occur at subcellular level. The function of movement is performed by contractile proteins, which convert chemical energy into mechanical energy. The important contractile proteins are actin and myosin in muscles.

The muscle fibrils are mainly proteins. These proteins are characterized by their elasticity or contractile power. Myosin is the most abundant protein in muscle. It is a globulin, soluble in dilute salt solutions and insoluble in water. Myosin is composed of submits of about 80 mm in length with molecular weight approximately 2,00,000.

Actin is a globulin, molecular weight 60000 which binds one ATP per molecule. The immediate source of energy required for muscular contraction is derived by the hydrolysis of ATP to ADP.

MULTIPLE CHOICE QUESTIONS

1. **During respiratory burst, all the following ROS are formed *except:***
   A. Superoxide
   B. Hydogen peroxide
   C. Hydroxy radical
   D. Nitric acid
2. **The main biological target for attack by free radicals are *except:***
   A. PUFA
   B. Protein
   C. DMA
   D. Glycosaminoglycan
3. **All the following are antioxidant nutrients *except:***
   A. Vitamin E
   B. Vitamin C
   C. Carotinoid and flavonoid
   D. Phylloquinone
4. **The minerals function as antioxidants *except:***
   A. Manganese
   B. Copper
   C. Zinc
   D. Iron
5. **The following enzymes act as antioxidants *except:***
   A. Superoxide dismutase
   B. Lactate dehydrogenase
   C. Catalase
   D. Glucathione peroxidase
6. **α-tocopherol prevents rancidity by virtue of this property:**
   A. Antioxidant
   B. Oxidant
   C. Hydrogenation
   D. Phosphorylation
7. **Free radicals are:**
   A. Chemical species with unpaired electron
   B. Ion having both positive and negative charge

C. Positively charged ion
D. Negatively charged ion

ANSWERS

1(D) 2(D) 3(D) 4(D) 5(B) 6(A) 7(A)

CHAPTER

15 Hormones: Outline Chemistry and Functions

INTRODUCTION

Hormones are chemicals produced by ductless glands and are transported by blood to target tissues to produce inhibiting or simulatory effect in these tissues. Hormones are synthesised in the body unlike vitamins. The role of hormones is to provide communications between cells to regulate their development and coordinate various cellular activities. Since the communication among cells is done by hormones, they are called chemical messengers. Hormones present in the blood are bound to plasma protein fractions and transported along with them. For example, thyroxine and corticosteroids are bound to globulin; estrogens and androgens are bound to albumin.

Hormones are substances synthesised in the body in small quantities but have a profound biochemical effect in the control and regulation of metabolic events and contribute in some cases to intercellular and intracellular communication.

Functions of hormones cover four major areas namely: (a) reproduction, (b) growth and development, (c) maintenance of internal environment, and (d) energy production, utilization and storage.

Similarities with Enzymes

1. They act as body catalysts resembling enzymes in many respects.
2. They are required only in small quantities.
3. They are not used up in reactions.

Differences from Enzymes

1. They are produced in an organ other than the target tissues.
2. They are secreted in blood prior to use. Thus the target levels of hormones can give some indication of endocrine gland activity and target organ exposure.

3. While all enzymes are proteins, only some hormones are proteins, a few are peptides. Some hormones are derived from amino acids while some are steroids in nature.

Hormone Secretion

Hormones are secreted by specialised cells known as glands. Hormones are recognised by special structures called receptors located on the cell surface of the target cells. On receiving a chemical signal with the help of a hormone, the receptors trigger a cell response by bringing about particular changes in the properties of the cells

The secretion of hormones is controlled by the anterior lobe of the pituitary gland. This gland is located at the base of the brain. These pituitary hormones are transported to other glands, such as adrenal cortex, thyroid, and sex glands, etc. to stimulate the production of other hormones. Hormones are highly potent and so are produced in small quantities.

Hormone Secreting Glands

Major hormone secreting glands are:
1. Pituitary
2. Thyroid
3. Parathyroid
4. Adrenal
5. Pancreas
6. Ovaries
7. Testes

Classification of Hormones

Hormones do not have any special structural feature in common. Chemically they belong to different classes of compounds.

Based on their Chemical Structure

Hormones can be classified into the following three major classes namely steroids, polypeptides and amino acid derivatives.
1. Steroid hormones: For example adrenocorticosteroid hormones, androgens, estrogens and progesterone.
2. Peptide protein hormones: For example, insulin, glucagon, parathormone, calcitonin, pituitary hormones.

3. Amine hormones: These are derived from amino acid tyrosine. For example, epinephrine, norepinephrine and thyroid hormones.

Based on the Mode of Action

1. Hormones which act by binding to their receptors on the plasma membrane, e.g. insulin.
2. Hormones which act through the second messenger, cAMP, for example, glucagon.
3. Hormones which bind to high affinity receptor proteins in the cytosol move to the nucleous as a complex, interact with chromatin there, increases the production of mRNA and thereby proteins, for example, steroids.
4. Hormones which straight away move to the nucleus and interact with specific receptor proteins in the nucleus and increase transcription and translation, for example, triiodothyrosine (T_3).
5. Hormones which increase the extent of translation without increasing transcription for example, insulin, ACTH (Adrenocorticotropic hormone).

Factors Regulating Hormones Action

Action of a hormone at a target organ is regulated by four factors:
1. Rate of synthesis and secretion of hormones.
2. In some cases specific transport systems in plasma.
3. Hormone-specific receptors in target cell membranes which differ from tissue to tissue.
4. Ultimate degradation of the hormone usually by the liver or kidneys.

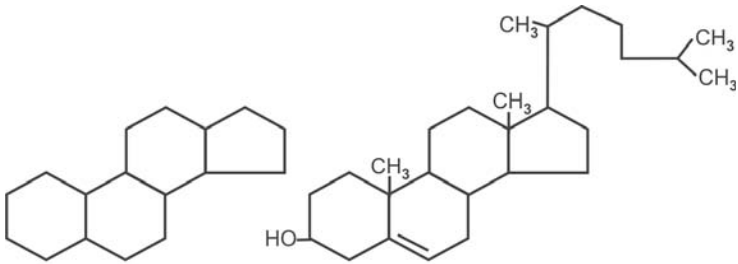
Mode of Action of Hormones

1. Induction of enzyme synthesis at the nuclear level, for example, thyroxine, steroid hormones.
2. Some hormones do not influence transcription, i.e. mRNA production.
3. Some hormones act at the level of the bio-membranes first. They may have no activity in membrane free preparation.
4. Many hormones will be functionless if cAMP does not serve them, hence cAMP is called the second messenger of those hormones which are themselves first messengers.

5. Action through calcium. Many hormones discharges its function through calcium.

STEROID HORMONES

Steroid hormones are those which have a steroid nucleus. The steroid nucleus has a four ring network, consisting of three cyclohyexane rings and one cycleopentane ring joined in a particular manner. In addition to hormones, the steroid is also present in vitamin D, drugs and bile acids.



Steroid Nucleus Cholesterol

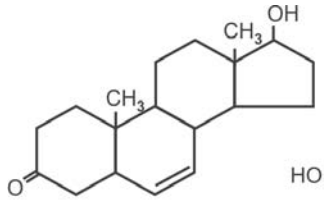
If an alcoholic hydroxyl group is present in the steroid it is known as a sterol. Cholesterol is the most common sterol present in animals.

Sex Hormones

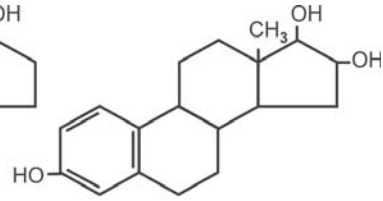
Sex hormones are the important steroid hormones. In males, steroid hormones are synthesised in the testes and the adrenal cortex. Testosterone, dihydrotestosterone and androgens are the male sex hormones. During puberty, these stimulate the development of male sex characteristics. Oestrogens are the female sex hormones which are produced primarily in ovaries. Female sex hormones are responsible for the development of female sex characteristics during puberty.

Some other steroids such as cortisone, corticosterone and aldosterone affect metabolism, minerals and water balances. The deficiency of these hormones leads to loss of fluids, while an excess of these hormones causes an increase in blood pressure. Androgens and oestrogens have significant affect on the anabolic systems. Androgens and oestrogens are abused by athletes,

weight-lifters and other sports persons to increase their muscle mass and strength. Such uses of anabolic steroids is now banned in competitive sports. Some female sex hormones which are synthesised on a large scale are used as oral contraceptives.



Testosterone



Esteriol

Androgens

Androgens are produced by testes.

Biochemical Effects

1. Influence protein metabolism:
   Anabolic effect on protein conservation and retention of nitrogen and thereby muscle growth and maintenance of muscle mass.
2. Mineral metabolism.
3. Carbohydrate metabolism.
4. Citric acid cycle and fatty acid synthesis are stimulated by androgens.

Oestrogens

Ovarian hormones produced by the graafian follicles of the ovary. Responsible for the regulation of menstrual cycle as well as reproductive cycle.

Biochemical Effects

Oestrogen stimulates the development, maturation and function of the female sex organs and thereby the secondary sex characteristics:

1. Proliferation of vaginal epithelium, endometrium.
2. Increases secretion of mucus by the cervical glands.
3. Growth of uterine tissue and mammary gland.
4. Reduces hyperlipidaemia, hypercholesterolaemia, prevents atherosclerosis.
5. Oestrogen administration elevates calcium and phosphorus.

Progesterone

Secreted by corpus lentium during the later half of the menstrual cycle. Development of mammary luster and maintenance of uterus during gestation period.

PEPTIDE HORMONES

Insulin

Insulin is a protein hormone, secreted by the β-cells of the Islets of Langerhans of pancreas. It has been isolated and prepared in the crystalline form. Crystalline insulin contains Zn. It has a molecular weight of 5734.

Insulin molecule is composed of two polypeptide chains the glycyl or 'A' chain and phenylalanine or B chain containing a total of 51 amino acids. The glycyl chain is acidic and contains 21 amino acids. The phenylalanine chain is basic and contains 30 amino acids. Both the chains are held together by disulphide bridges.

The target tissues of insulin are the muscles, liver, adipose tissue and heart.

Insulin circulates in blood mostly along with β- and γ-globulin of plasma protein. The normal concentration of plasma insulin is 6-25 mIU per litre. Insulin promotes the entry of glucose in all tissues of the body except liver.

Metabolic Actions of Insulin

1. Lowering of blood glucose level.
2. Increase in the rate of oxidation of glucose in tissues.
3. Increasing glycogen formation in the liver and muscles.
4. Depressing gluconeogenesis.
5. Accelerating the rate of conversion of glucose to fat (lipogenesis).
6. Depressing ketogenesis.
7. Increasing protein synthesis.

Insulin is administered parenterally to reduce hyperglycaemia in diabetes mellitus.

It brings down blood glucose level by increasing the oxidation of glucose and promoting glycogenesis in liver and muscles.

Insulin Deficiency: Diabetes Mellitus

- Due to inadequate insulin production
- Insulin not binding to the receptors

- Accelerated insulin destruction
- Insulin inhibitors and antagonists.

Diabetes Mellitus—Two Types

- Real deficiency or shortage of insulin in the circulating plasma.
- Because of resistance to the hormone due to lack of receptors or their decreased number in proportion to body size.

  90%—NIDDM (Non-insulin dependent diabetes mellitus, Type II)

  10%—Juvenile IDDM (Insulin dependent diabetes mellitus, Type I)

Type II: No injection–by diet/oral hypoglycaemic drugs enhance the action of receptor.

Type I: Injection of insulin.

Glucagon

Glucagon is a hyperglycaemic, glycogenolytic hormone. It is secreted by the α-cells of the islets of Langerhans in pancreas. It is a protein consisting of a straight polypeptide chain, which contains, 29 amino acid residues. It has a MW of 3485. Glucagon is very active when administered intravenously and has an effect opposite to that of insulin. The blood sugar rises immediately, reaches a peak in about 30 minutes and returns to the original level in one hour.

AMINE HORMONES

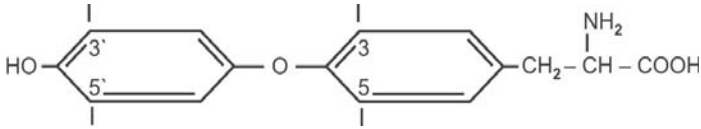
These are water soluble compounds having an amino group, e.g. adrenaline (epinephrine) and thyroid hormones.

Adrenaline

Adrenaline is needed to prepare people for emergency in several ways. Adrenaline increases the rate of heart beat, the heart output and blood pressure and thus prepares the cardiovascular system for emergency section. It stimulates the breakdown of liver glycogen into blood glucose which is the fuel for anaerobic muscular work. These properties make adrenaline one of the most valuable drugs.

Thyroid and its Hormones

The normal adult thyroid gland weighs about 20 gm. It contains protein, thyroglobulin which releases thyroid hormones into the blood of capillaries surrounding the cells. Main hormones secreted are tetraiodothyronine T_4 (Thyroxine) and tri-iodothyronine (T_3).



3, 5, 3', 5' tetraiodothyronine (T_4) (Thyroxine)

Biosynthesis and Secretion

The thyroid gland contains more than half of the total iodine content in the body. It has a remarkable capacity to concentrate iodide brought to it by the circulating blood.

Transport

The thyroid hormones are carried in plasma in combination with albumin and two specific plasma proteins.

One of them is the thyroxine-binding globulin (TBG) and the other thyroxine-binding prealbumin (TBPA).

A small amount is free thyroxine 0.05% which is a metabolically active hormone.

Mechanism of Action

Two important functions—in growth and development of the body as well as having a stimulating effect on the total metabolism.

Calorigenic action: Stimulate most of the oxidation reactions and regulate the metabolic rates in the body.

Done by stimulation of enzymatic system–BMR low in hypothyroidism, increases in hyperthyroidism.

Carbohydrate metabolism: Thyroid hormones accelerate the rate of glucose oxidation, promote intestinal absorption of glucose and increase glycogenolysis in the liver.

Thyroxine (T_4)

This hormone secreted by thyroid gland has a MW of about 680,000. It is synthesised in thyroid gland from tyrosine. It is stored

in the colloid of the thyroid follicles, in the form of a glycoprotein called thyroglobulin, hydrolysis of which gives tri-iodothyronine and tetra-iodothyronine (thyroxine). They are also abbreviated as T_3 and T_4. T_3 is 5-10 times biologically more active than T_4.

Metabolic effects: Thyroxine produces a widespread enhancement of metabolism in almost all the tissues of the body as follows:

Calorigenic effect: Thyroxine increases the rate of energy exchange and oxygen consumption of all tissues except the thyroid gland itself. BMR increases.

Protein metabolism: In small physiological doses, thyroxine promotes protein anabolism, resulting in retention of nitrogen and positive nitrogen balance.

Carbohydrate metabolism

a. Increases the rate of intestinal absorption of glucose.
b. Hyperglycaemia is associated with increased degradation of insulin.
c. Thyroxine enhances gluconeogenesis.
d. Glycolysis, Krebs' cycle and HMP pathway are enhanced.

Lipid metabolism: Thyroxine increases the rate of oxidation of fats. It promotes liberation of free fatty acids from adipose tissues and raises the concentration of free fatty acids in blood.

Effect as Na^+/K^+ ATPase pump: Enhance the function of Na^+/K^+ ATPase pump thus increasing the ATP utilisation.

Anti-thyroid Agents

1. Agents which retard the synthesis of thyroid hormone, e.g. thiocyanate, thiocarbamide, sulpha drugs, perchlorate.
2. Synthetic analogues of the thyroxine 2'-6' di-iodothyronine.
3. Deep X-ray therapy destroys the thyroid tissue and thus depresses the thyroid activity.
4. Cobalt chloride administration interferes with thyroid hormone synthesis and clinical myxoedema and goitre may result.
5. Certain organic compounds are present in vegetables like cabbage and turnip which act as natural goitrogens and depress thyroid activity. Present as goitrins in the raw foods and are destroyed on cooking.

Hypothyroidism

In child: Cretinism–slow growth, dwarfism, mental retardation, dry skin, scatty hair, saddled nose, puffy lips, vacant expression.

In adult: Myxoedema–BMR and body temperature decreases. Sensitivity to cold, puffiness of face, anaemia and reduction of physical and mental functions.

Hyperthyroidism

Increased activity accompanied by excessive secretion of the thyroid hormone occurs in Grave's disease (exophthalmic goitre) and toxic adenoma.

Nervousness, irritability, loss of weight, increased body temperature, increased appetite, protrusion of the eyeballs.

Goitre

Enlargement of thyroid gland caused by deficiency of iodine in the diet. Iodine enriched salt is now compulsory.

Parathyroid Glands and their Hormones

Closely associated with the thyroid gland as two pairs of small glands. Weight 50–300 mg. It produces a parathyroid hormone (PTH). Parathormone having a profound influence on Ca and phosphate metabolism. It maintains the Serum Ca^{++} level within normal physiological limits.

Biochemical Effects

1. The serum calcium is raised but serum phosphorus is lowered.
2. The excretion of both Ca and P is increased.
3. Ca from the bone gets mobilised and added to the serum.
4. The serum alkaline phosphates activity is increased.

ADRENAL MEDULLA

Medullary portion releases two hormones—epinephrine and norepinephrine.

Epinephrine is elaborated by the adrenal medulla as a result of sympathetic stimulation produced during fight, fright and flight and in emergencies like cold, fatigue and shock.

Neural stimulation, fright, emotional conditions like anger, etc. are responsible for a quick release of catecholamine hormones.

Physiological and Biochemical Functions

1. Sympathomimetic function: Epinephrine cause a rise in BP due to arteriolar vasoconstriction particularly in the skin, mucus membrane and splanchnic viscera.

Arterioles of skeletal muscle undergo vasodilation.

Overall effect is a rise in BP, pulse rate, heart rate and cardiac output.

Norepinephrine

Rise in BP by increasing peripheral resistance. Overall vesoconstriction and has no effect on cardiac output.

Action on smooth muscle: Epinephrine dialates bronchial musculature, relaxes the musculature of the gastrointestinal tract and contracts the pyloric sphincter.

Effects on carbohydrate metabolism: Epinephrine promotes glycogenolysis in the muscle and liver and produces an increase in blood lactic acid level and as well as blood glucose level. Norepinephrine has only, 1/8 activity of epinephrine in glycogen breakdown.

Effects on lipid metabolism: Stimulates lypolysis in adopose tissues and releases free fatty acids into the blood.

PANCREATIC ISLET CELLS

Endocrine part—islets of Langerhans.
Islets cells are of 4 types: A, B, D and F Cells
A Cells — α-Cells—Produce glucagon
B Cells — β-Cells—Insulin
D Cells — Somatostatin

ADRENAL CORTEX

Although all the six steroid hormones are biosynthesised from cholesterol by the adrenal cortical tissues of man, only two of this, corticosterone and cortisol are released into the blood stream with small amounts of aldosterone.

Biochemical Effects of Corticosteroids

1. Effects on metabolism.
   Corticosteroids exert a profound action on carbohydrate, lipid, nucleic acid and protein metabolism.
2. Action on digestive secretion.
   HCl production and pepinogen secretion by the cells of the gastric mucosa are enhanced by cortisone.
3. Hematological changes.
4. Electrolyte and water metabolism. Regulate the concentration of Na^+ and K^+ in the extracellular fluid.
5. Bone and calcium metabolism.
6. Immune response and anti-inflammatory response.

GASTROINTESTINAL HORMONES

Gastrin
- By antral gastric mucosa
- Stimulates gastric secretion.

Secretin: Stimulates the pancreas to produce an increased volume of pancreatic juice.

Cholecystokinin: Stimulate the contraction of gallbladder enhancing the flow of bile into the duodenum.

HYPOTHALAMIC HORMONES AND PITUITARY

The hypothalamus produces two types of endocrine factors.
a. The hypothalamic neuropeptides.
b. The hypothalamic releasing factors.

It releases six hormones which are called `Releasing factors'. Some stimulate the release of pituitary hormone while a few inhibit their release. They are release inhibiting hormones. Releasing factors exert a tonic control on the production and release of pituitary hormones.

1. Thyrotropin releasing hormone (TRH)/TRF.
2. Corticotropin releasing hormone (CRH)/CRF.
3. Growth hormone releasing hormone (GHRH).
4. Growth hormone release-inhibiting hormone (GHRIH)/(Somatostatin).
5. Gonadotropin-releasing hormone.
6. Prolactin-release-inhibiting hormone.

HORMONES OF THE ANTERIOR PITUITARY

The anterior pituitary hormones are mostly trophic in nature, stimulating the secretion of other hormones. There are three types of cells secreting hormones—acidophils, basophils and chromophobes. Secretion of all anterior pituitary hormones are under the control of hypothalamic releasing or inhibitory factors. In following six hormones are secreted by the anterior pituitary:

1. Growth hormone (GH) or somatotropin
2. TSH (Thyroid stimulating hormone)
3. ACTH (Adrenocorticotropic hormone)
4. Interstitial cell stimulating hormone (ICSH)
5. FSH (Follicle stimulating hormone)
6. Lactogenic hormone.

GROWTH HORMONE (GH) OR SOMATOTROPIN

Its major effect is to stimulate growth. The effect of GH is mediated through Somatomedin—C also known as IGF-1 (Insulin-like growth factor-1). The growth of long bones and soft tissues is stimulated by this factor. The uptake of amino acids by cells is increased, with a resultant increase in the rate of protein synthesis. The anti-insulin effect causes lipolysis and hyperglycemia. The secretion of GH is stimulated by hypoglycemia and suppressed by hyperglycemia. The GHRH is the major secretory stimulant. Somatostatin inhibits secretion of GH. Somatostatin is secreted mainly by hypothalamus.

The abnormalities of GH secretion may have different manifestations depending on the age of onset. Excess secretion in children leads to gigantism and in adults acromegaly. GH secreting tumour is often the cause and removal of the tumour leads to cessation of growth.

ADRENOCORTICOTROPIC HORMONE OR ACTH OR CORTICOTROPIN

ACTH is one of the pituitary hormones secreted as a large precursor molecule which is cleaved to give several peptides each with important biological effect. The precursor or polypeptide is known as pro-opiomelanocortin (POMC). The secretion of POMC is under the control of CRF. The active ACTH is a polypeptide with 39 amino acids, of which the N-terminal 25 amino acids alone are

required for biological activity. ACTH binds to specific receptors on the adrenal gland, then activates adenylate cyclase as so c-CAMP level is raised. ACTH increases the synthesis of corticosteroids by the adrenal cortex and also stimulates their release from the gland. It also increases the transfer of cholesterol from plasma lipoproteins to fasciculata cells.

TSH (Thyroid Stimulating Hormone) or Thyrotropic Hormone

This is produced by basophil cells of anterior pituitary and is glycoprotein in nature. Functions are as follows:

a. The TSH stimulates the synthesis of thyroid hormones at all stages and on iodine uptake, organification and coupling.
b. It enhances the release of stored thyroid hormones.
c. It increases DNA content, RNA and translation of proteins, cell size.
d. It stimulates glycolysis, TCA cycle, PPP and phospholipid synthesis.
e. It activates adipose tissue lipase to enhance release of fatty acids (lipolysis).

QUESTION

1. Short notes on:
(i) Thyroxin, Insulin
(ii) Gastrointestine (GI) Hormones
(iii) Thyroid Hormones
(iv) Adrenal Gland Hormones.

MULTIPLE CHOICE QUESTIONS

2. All the following are protein/peptide hormones *except:*
A. Oxytocin
B. Insulin
C. Epinephrine
D. Glucagon

3. A steroid hormone is:
A. Thyroxine
B. Parathyroid hormone
C. Oxytocin
D. Cortisol

4. Factors regulating hormone action are:
A. Rate of synthesis and secretion
B. Hormone specific receptors
C. Specific transport systems in plasma
D. All of the above

5. Which is a hormone derived from thyrosine?
A. Glucagon
B. Thyroxine
C. PABA
D. Alloxan

6. Insulin is secreted by:
A. α-cells of islets of Langerhans of pancreas
B. Anterior lobe of pituitary gland
C. α-cells of islets of Langerhans of pancreas
D. β-cells of the islets of Langerhans of pancreas

7. α-cells of islets of Langerhans of pancreas secrete:
A. Insulin
B. Glucagon

C. Oxytocin
D. Gastrin

8. **Which hormone contains sulphur in its structure?**
   A. Glucagon
   B. Insulin
   C. LD
   D. Epinephrine
9. **All the following are hyperglycaemic hormones *except:***
   A. Epinephrine
   B. Thyroxine
   C. Insulin
   D. Glucagon
10. **The hormone whose deficiency causes diabetes mellitus is:**
   A. Glucagon
   B. Cortisol
   C. Epinephrine
   D. Insulin
11. **An example of a glucocorticol is:**
   A. Cortisol
   B. Aldosterone
   C. Glucagon
   D. Insulin
12. **Which of the following hormones is most important in regulating sodium and potassium balance?**
   A. Cortisol
   B. Estradiol
   C. Progesterone
   D. Aldosterone
13. **All steroid hormones are formed from:**
   A. Arachidonic acid
   B. Acetyl CoA
   C. Glycine
   D. Cholesterol
14. **Epinephrine is synthesised from:**
   A. Tryptophan
   B. Tyrosine

C. Glycine
D. Arginine

15. Diabetes insipidus occurs due to the abnormal secretion or action of:

A. Aldosterone
B. Insulin
C. ADH
D. Oxytocin

ANSWERS

2(C)	3(D)	4(D)	5(B)	6(D)	7(A)
8(B)	9(C)	10(D)	11(A)	12(D)	13(C)
14(B)	15(C)				

CHAPTER

16 Blood Chemistry

Constituents of Blood

The chemical composition of blood is complex. It is an aqueous solution of ions and organic molecules which also have suspended particles. Suspended particles in blood are red blood cells (erythrocytes), white blood cells (leukocytes) and platelets.

Blood without suspended particles is called blood plasma. Blood serum is obtained when fibrinogen, a particular protein is removed from plasma. The major blood constituents are shown in Table 16.1.

The Clotting of Blood

a. When blood is drawn and allowed to clot, a clear liquid (serum) licudes from the clotted blood. Plasma on the other hand separates from the cells only when blood is prevented from *clotting.*
b. The blood clot is formed by a protein (fibrinogen) which is present in the soluble form in the plasma and which is transformed to an insoluble network of fibrous material (fibrin, the substance of the blood clot) by the clotting mechanism.
c. The change of fibrinogen into fibrin is caused by thrombin, which in fluid blood looks as prothrombin. The conversion of prothrombin to thrombin depends on the action of thromboplastin and calcium.

Anticoagulants

Clot formation may be prevented by a number of substances as well as by vitamin K deficiency. Dicemerol, related to coumarin which comes from clover, inhibits prothrombin synthesis in the liver. It may be used clinically when there is danger of thrombosis by reducing clotting tendency.

Heparin: Heparin, a sulphated polysaccharide which inhibits the formation of thrombin from prothrombin, is the most satisfactory

Table 16.1: Blood constituents

Compounds	*Normal values*	*Possible pathology*
Haemoglobin	14-16 g/100 ml whole blood	High in polycythaemia. Low in anaemias
Non-protein nitrogen	25-35 mgm/100 ml whole blood	High in nephritis and Addison's disease
Uric acid	3-5 mgm/l00 ml whole blood	High in gout
Total plasma proteins	6.5-8.2 g/100 ml plasma	Low in nephrotic syndrome and malnutrition
Cholesterol	150-250 mgm/l00 ml plasma or serum	High in nephrotic syndrome and hypothyroidism. Low in pernicious anaemia and liver disease
Glucose	80-110 mgm/l00 ml whole blood	High in diabetes. Low in Addison's disease
CO_2 combining power	53-80 ml. CO_2/l00 ml plasma	Low in acidosis, uncontrolled diabetes and nephritis.
Inorganic phosphates	3-4 mgm/l00 ml plasma or serum	High in renal rickets and nephritis. Low in infantile rickets
Chloride	570-620 mgm (as NaCl) per 100 ml plasma or serum	High in nephritis. Low in fever or pneumonia

anticoagulant, since it produces no change in the composition of the blood. However, oxalate and citrate have been most widely used as they are cheaper. Use of more of these salts may bring appreciable changes in the distribution of water between the cells and plasma.

Potassium oxalate: It has been most commonly used since it is more soluble. It acts by precipitating calcium ions as calcium oxalate.

Sodium citrate: Citrate does not precipitate calcium but converts it to non-ionized form. Citrated plasma is not as satisfactory as serum for calcium estimation.

Ethylenediamine tetra acetic acid (EDTA) and its salts act by chelating calcium ions.

Sodium fluoride: It also acts as an anticoagulant but large amounts are required. For blood glucose estimation a mixture of sodium fluoride and potassium oxalate is used as fluoride acts as a preservative by inhibiting glycolytic enzymes.

Functions of Blood

1. Carrying the products of digestion from the small intestine to various organs and tissues.
2. Accepting oxygen in the lungs and releasing it in the tissues.
3. Carrying CO_2 from the tissues for elimination by the lungs.
4. Removal of waste products from tissues for excretion by the kidneys.
5. Maintenance of water balance and temperature control.
6. Synthesis of antibodies for the protection against bacterial infection.
7. Distribution of hormones, vitamins and enzymes to their sites of action.

Oxygen Transport

During respiration, gases CO_2 and O_2 are interchanged between the body and the environment. This process can occur due to the haemoglobin present in red blood cell (RBC). The function of the RBC is to carry the inhaled oxygen from lungs to tissues, where it is utilised for their growth, development and sustenance.

Haemoglobin is a globular protein. It consists of four polypeptide chains arranged in a tetrahedral configuration. Haemoglobin contains a non-protein constituent called heme. Heme is an iron porphyrin and is responsible for the red colour of blood. Each of the polypeptide chains of haemoglobin is associated with one heme unit.

Haemoglobin combines with oxygen in the lungs (where oxygen is present in higher concentrations). Such a combination results in the formation of oxyhaemoglobin. Myoglobin stores oxygen in the muscle tissues. In contrast to haemoglobin it consists of only a single polypeptide chain and is associated with one heme unit.

Formation of CO_2 and its Distribution in Blood

CO_2 is formed in large amounts in the body as the end product of normal metabolism. In tissues about 200 ml of CO_2 is formed per minute at rest and 4 litres at maximal exercise. CO_2 enters the blood stream and from there reaches the lungs. The chief acid present in the blood is CO_2.

CO_2 dissolves in water to form H_2CO_3 which on dissociation yields H^+ and HCO_3^-.

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO^-_3$$

The only alkali present as such in blood is bicarbonate HCO_3. It dissociates in water as follows:

$$NaHCO_3 + H_2O \longrightarrow H_2CO_3 + NaOH$$

Plasma Proteins

Plasma proteins constitute almost 70 per cent of the plasma and are usually divided into 3 groups: albumin, globulins and fibrinogen. Approximately 55 per cent of the plasma protein is albumin, 38.5 per cent globulins and 6.5 per cent is fibrinogen.

Albumin, like other plasma proteins, cannot pass through the walls of the blood vessels (because they are colloids and colloids cannot pass through membranes). Since albumin is principal plasma protein and the smallest plasma protein both in size and weight (it consists of a single chain of 610 amino acids), it accounts for most of the colloid osmotic pressure of the blood.

This colloidal osmotic pressure is caused by the small amounts of plasma that pass through the capillary membranes and tend to accumulate as the venous end of the capillaries.

If the plasma protein (primarily albumin) are present in decreased amounts (as during a low protein diet or in nephritis) the osmotic pressure of the plasma decreases. This decreased osmotic pressure of the blood causes a greater net pressure outward at the arterial end of the capillary and a lower net inward venous pressure at the venous end of the capillary. When this occurs, water (fluid) accumulates in the tissues. Such a condition is known as an Oedema.

Kwashiorkor

A severe protein deficiency disease, is characterized by edema of the abdomen and extremities. In children a swollen belly is characteristic. Kwashiorkor is caused by a drop in plasma protein particularly albumin. Under these conditions, water moves from the blood stream into the tissues causing swelling.

Oedema can also occur because of heart disease, whereby there is an increase in venous hydrostatic pressure. Many terminal illnesses cause oedema. This becomes a serious problem and tapping and draining may be necessary. Concentrated albumin infusions (25 g in 100 ml diluent) are helpful in the treatment of shock, to increase the blood volume, and to remove fluid from the tissues.

The amount of albumin present in the blood is lowered in liver disease because albumin is formed in the liver.

Another function of albumin in the blood is to act as a carrier for fatty acids, trace elements and many drugs.

Globulins

The globulins present in the plasma can be separated into different groups by a process known as electrophoresis whereby charged protein particles migrate at varying rates to electrodes of opposite charge, with albumin migrating the fastest. The distribution of the plasma proteins during electrophoresis is as below:

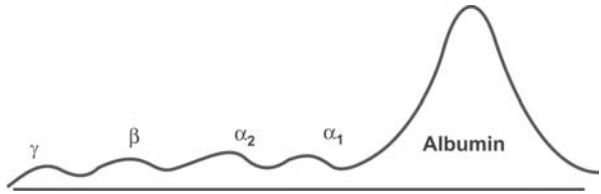


Fig. 16.1: Distribution of plasma proteins during electrophoresis

The globulins are subdivided into α, β and γ

The globulins from complexes (loose combination) with such substances as carbohydrates (mucoprotein and glycoprotein), lipids (lipoprotein) and metal ions (transferrin for Fe and ceruloplasmin for Cu). These complexes can be transported to all parts of the body.

The γ-globulins (immunoglobulins) include the antibodies with which the body fights infectious diseases. γ-globulin has been found to contain as many as 20 different antibodies for immunity against such diseases as measles, infective hepatitis, poliomyelitis, mumps and influenza.

Some people lack the ability to make γ-globulin. These people are quite susceptible to infections because they have no antibodies to counteract such diseases. The lack of γ-globulin is called

agammaglobinemia and can be combated by the administration of γ-globulin.

A/G RATIO

In severe liver disease, there is lowered concentration of plasma albumin but globulin fraction may not decrease (as it is not synthesized by the liver). The A/G ratio 1.2–1.7 may be reversed in liver disease.

SEPARATION OF PLASMA PROTEINS

1. Salting out
2. Electrophoresis
3. Ultracentrifugation
4. Immunoelectrophoresis.

ELECTROPHORESIS

One of the most powerful tools for separating mixtures of proteins is electrophoresis, which is used routinely in clinical laboratories. It is the movement of a charged particle in an electric field towards oppositely charged electrodes is called electrophoresis.

Principle: Proteins having different amounts of charge at a particular pH, when placed in an electric field, move at different rates. The rate of movement is determined by the charge/size ratio. It is directly proportional to the charge and inversely proportional to the size of the protein .

In this clinical laboratory, the electrophoresis of plasma proteins is usually carried out at pH=8.6. The plasma proteins have a negative charge, and will migrate to the positive electrode (cathode) when placed in the electric field.

Electrophoretic scanning from cellulose acetate strip converts bands to characteristic peaks of albumins, α-globulin, α_2-globulin, β-globulin and γ-globulin (Fig. 16.1).

REGULATION (HOMEOSTASIS) OF pH OF BLOOD

The normal pH range of the blood is 7.35 to 7.45. When the pH falls below this range, the condition is called acidosis. Alkalosis occurs when the pH rises above its normal value. Acidosis is more common

than alkalosis because many of the metabolic products produced during digestion are acidic.

Maintenance of Acid-base Balance (pH)

The mechanisms operating in the body to accomplish the maintenance of acid-base balance are:

1. Buffer systems of the blood.
2. Respiratory mechanisms.
3. Renal mechanisms.
   a. Excretion of excess acid or base.
   b. Formation and excretion of ammonia.

Blood Buffers

The blood maintains its pH between 7.35 and 7.45 because of buffers. These buffers are present both in the plasma and in the RBCs. Those in the plasma are primarily sodium buffers; those in blood cells are mainly potassium buffers. Buffers are substances, usually a mixture of a weak acid and a salt of a weak acid, that resist change in pH. The blood buffers consist of:

a. Bicarbonate buffers
b. Phosphate buffers
c. Protein buffers (including hemoglobin and oxyhemoglobin).

Bicarbonate Buffers

The bicarbonate buffer system in the red blood cells consists of carbonic acid (H_2CO_3) and potassium bicarbonate ($KHCO_3$). The bicarbonate buffer system in the blood plasma consists of carbonic acid and $NaHCO_3$. If a strong acid (such as HCl) is added to a sample of blood, it will react with the salt part of the buffer and undergo the following reactions.

$$HCl + KHCO_3 \longrightarrow H_2CO_3 + KCl \text{ (in blood cells)}$$
$$HCl + NaHCO_3 \longrightarrow H_2CO_3 + NaCl \text{ (in blood plasma)}$$

The carbonic acid (H_2CO_3) produced is part of the original buffer. Note that the strong acid HCl, has been replaced by a very weak acid H_2CO_3. The other products, KCl and NaCl are neutral salts and will not affect the pH of the system.

If a strong base like KOH or NaOH is added to a sample of blood, the following reactions will occur with the bicarbonate buffer systems:

$KOH + H_2CO_3 \longrightarrow KHCO_3 + H_2O$ (in blood cells)
$NaOH + H_2CO_3 \longrightarrow NaHCO_3 + H_2O$ (in blood plasma)

The salts $KHCO_3$ and $NaHCO_3$ are part of the original buffer systems and the water produced is neutral, so the pH again is not affected.

In both cases (reaction with a strong acid or a strong base) more of the buffer is produced plus a neutral compound.

The bicarbonate buffers control the pH of blood and the phosphate buffers have an important role inside the cell and the urine.

Phosphate Buffers

The phosphate buffers consist of mixtures of K_2HPO_4 and KH_2PO_4 (also Na_2HPO_4 and NaH_2PO_4) which function similarly the bicarbonate buffers in neutralising excess acid and base.

$HCl + K_2HPO_4 \longrightarrow KH_2PO_4 + KCl$
$KOH + KH_2PO_4 \longrightarrow K_2HPO_4 + H_2O$
More buffer

Haemoglobin Buffers

The haemoglobin buffers account for more than half of the buffering action in the blood. These are haemoglobin buffers and oxyhaemoglobin buffers.

$\left.\begin{matrix} HHb \\ KHb \end{matrix}\right\}$ Haemoglobin buffer $\qquad$ $\left.\begin{matrix} HHbO_2 \\ KHbO_2 \end{matrix}\right\}$ Oxyhaemoglobin buffer

These buffers, as well as other proteins that act as buffers in the blood stream, pick up excess acid or base to help keep the pH of the blood at 7.35 to 7.45.

Respiratory Mechanism

The process of respiration, i.e. the intake of oxygen and removal of CO_2 requires the transport of these substances by blood. Since CO_2 reacts to form HCO_3^- and oxygen forms oxyhaemoglobin which is more acidic than haemoglobin, the respiratory process is involved

in the delicate acid-base balance of the body. Maintenance of a constant pH of 7.35 to 7.45 is required for health.

The respiratory centre in the medulla of the brain is particularly sensitive to any change in the pH of the blood and immediately causes an increase in the rate and depth of breathing until excess CO_2 (and hence excess H^+) is removed. Changes brought about by respiration are rapid.

Renal Mechanisms

This is by far the most effective mechanism, but it is slow, requiring hours to show result. The kidneys excrete more HCO_3^- and HPO_4^-, when the blood pH is too high and more H^+ (which it gains in exchange for Na^+) and H_2PO_4 when pH is too low.

Also the kidney can increase its production of NH_3 (ammonia) which will trap H^+ to form NH_4, thus lowering the acidity of the blood. Since the cell membrane is not permeable to the charged NH_4, it is "trapped" and excreted in the urine as ammonium salts. Ammonia is produced in the renal epithelial cells largely by the deamidation of glutamine taken up from the arterial blood.

$$\text{Glutamine} + H_2O \longrightarrow \text{Glutamic acid} + NH_3$$

Urine is slightly acidic because of the phosphates and sulphates, formed principally from catabolism of the food, and extracted mainly as acid ions, $H_2PO_4^-$ and HSO_4^-. Also organic acids formed in metabolism are excreted by the kidney if they do not undergo further metabolism.

Measurement of Acid-base Balance

The definite way of assessing the state of acid-base balance of the body is to determine the pH of the blood. But clinically this is not always possible. As an alternative method, determination of the CO_2 content of the plasma is considered suitable for clinical purposes. Typical changes in plasma pH, pCO_2 and HCO_3^- concentrations for various acid-base disorders cue shown in Table 16.2.

Acidosis and Alkalosis—Acid-Base Imbalance—Disturbance in H^+ Homeostasis

Changes in the CO_2 level in blood and corresponding changes in HCO_3^- and pH may be caused by respiratory acidoses, respiratory alkalosis, metabolic acidoses and metabolic alkalosis. If the pH is abnormally high or low, the alkalosis or acidosis is said to be uncompensated. Disturbances in the acid-base balance are known as acidosis and alkalosis and these occur mostly due to abnormalities in respiratory system or due to disturbances in metabolism. Accordingly acidosis and alkalosis are classified as:

1. a. Respiratory acidosis.
   b. Respiratory alkalosis.
2. a. Metabolic acidosis.
   b. Metabolic alkalosis.

Respiratory acidosis: It is caused by depression of the respiratory centres by drugs, e.g., barbiturate poisoning, narcotics ingestion, in pulmonary disorders (pneumonia) due to mechanical obstruction of air passage and during breathing of air with high CO_2 content. There will be a decrease in blood HCO_3^- content and increased levels of CO_2 (H_2CO_3). The condition is compensated by the action of the kidneys.

Respiratory alkalosis: It is relatively uncommon. It is caused by hypoventilation as in high fever, hysteria, high altitudes and salicylate poisoning or due to dry hot weather. It can also occur during anaesthetic procedures with manual control of breathing causing expulsion of CO_2 and in certain diseases of central nervous system affecting the respiratory system.

Metabolic acidosis: In this condition, there is a deficit of plasma bicarbonate, without much change in the carbonic acid content. Metabolic acidosis can occur in the following conditions:

Table 16.2: Typical changes in plasma pH, pCO_2 and HCO_3^- concentration for various acid-base disorders

	pH	$[HCO_3]$	pCO_2
Metabolic acidosis	↓	↓	↓
Metabolic alkalosis	↑	↑	↑
Respiratory acidosis	↓	↑	↑
Respiratory alkalosis	↑	↓	↓

a. Uncontrolled diabetes, complicated with ketosis.
b. Vomiting with loss of fluid not containing acid.
c. Poisoning by an acid salt.
d. Starvation, high fever.
e. Violent exercise.
f. Lactic acidosis due to shock or haemorrhage.
g. Ingestion of acidifying salts like acetyl salicylic acid, phosphoric acid. HCl, NH_4Cl.
h. Renal insufficiency: Retention of acids normally produced, e.g. Terminal stages of nephritis, destructive renal lesions, such as polycystic kidneys, pyelonephritis, renal TB.

The CO_2/bicarbonate buffer system in blood reflects the changes in all buffer systems during disturbances. When pH falls, the ratio $HCO_3^-/CO_2 + H_2CO_3$ also decreases. Excess of CO_2 is blown off through lungs that brings back the original ratio and pH. Thus, acidosis is compensated by a respiratory response.

Metabolic alkalosis: In metabolic alkalosis, the bicarbonate content of the plasma is increased without undue changes in the carbonic acid content. Metabolic alkalosis occurs in the following conditions:

a. Ingestion of large doses of alkalies in the treatment of peptic ulcer.
b. Excessive vomiting with loss of large amount of gastric juice as in cases of intestinal obstruction.
c. Removal of large amounts of gastric secretion as in gastric suction.

There is also loss of chloride. Compensation is attempted by a depression of respiration so that more CO_2 is retained.

QUESTIONS

1. **What is the normal pH of blood? How is it regulated?**
2. **Describe the mechanism of regulation of acid-base balance in the body.**
3. **Write a short note on blood buffers.**
4. **What is the normal pH of blood? Name the buffer system and explain how they regulate the pH of the blood.**
5. **Write short notes on:**
   i. Acidosis
   ii. Alkalosis.

MULTIPLE CHOICE QUESTIONS

6. **Normal pH of arterial blood is:**
   A. 4.35-4.45
   B. 6.35-6.45
   C. 6.95-7.25
   D. 7.35-7.45
7. **Mechanisms for the regulation of acid-base balance include:**
   A. Renal mechanism
   B. Respiratory mechanism
   C. Blood buffers
   D. All of the above
8. **The chief physiological buffer in the blood is:**
   A. Bicarbonate buffer
   B. Haemoglobin buffer
   C. Proteinate buffer
   D. Phosphate buffer
9. **The major acid produced in the body during oxidation of food in the cells is:**
   A. Hydocholoric acid
   B. Acetic acid
   C. Carbonic acid
   D. Phosphoric acid

10. Renal mechanism for regulation of acid-base balance include:

A. Phosphate mechanism
B. Bicarbonate mechanism
C. Ammonia mechanism
D. All of the above

11. If the pH of the blood is 7.4, the ratio of $NaHCO_3/H_2CO_3$ will be:

A. 5 : 1
B. 10 : 1
C. 20 : 1
D. 25 : 1

12. In a solution containing phosphate buffer the pH will be 7.4, if the ratio of monohydrogen phosphate to dihydrogen phosphate is:

A. 4 : 1
B. 5 : 1
C. 10 : 1
D. 20 : 1

13. Metabolic acidosis can occur in all the following *except:*

A. Diabetes mellitus
B. Addisons disease
C. Diarrhoea
D. Vomiting

14. During compensation of respiratory alkalosis, all the following changes occur *except:*

A. Decreased secretion of hydrogenions by renal tublules
B. Increased excretion of sodium in urine
C. Increased excretion of bicarbonate in urine
D. Increased excretion of ammonia in urine

15. Metabolic alkalosis can occur in:

A. Renal failure
B. Recurrent vomiting
C. Severe diarrhoea
D. Excess use of carbonic anhydride inhibitors

16. All the following features are present in blood chemistry in uncompensated metabolic alkalosis *except:*

A. Increased pH

B. Increased bicarbonate

C. Normal chloride

D. Normal pCO_2

ANSWERS

6(D)	7(D)	8(A)	9(C)	10(D)	11(C)
12(A)	13(D)	14(B)	15(B)	16(C)	

CHAPTER

17 Urinalysis

Collection of Urine

Many urine estimations are carried out on timed specimens (24 hrs). The accuracy of the result depends largely on that of urine collection. Therefore, more care should be taken to ensure that the collection of urine for 24 hours is done properly. For example, when a 24 hours collection is required between 10 AM on Monday and 10 AM on Tuesday, the following procedure should be adapted.

On Monday 10 AM, empty bladder completely and discard the specimen. Then collect all the urine passed in the bottle containing the preservative till 10 AM on Tuesday. The bladder is emptied at 10 AM on Tuesday and this is also added to the above pooled urine.

Preservative for Urine

A preservative must be added to the urine to prevent bacteria growth and destruction of the substance being estimated.

Hydrochloric acid: Acidification of the specimen is very satisfactory. 10 cc of conc HCl is adequate for 24 hours specimen. This is suitable for the determination of urea, ammonia, total nitrogen, calcium and phosphorus.

Toluene is a commonly used preservative. It is convenient for sodium, potassium, uric acid and protein analysis. This only prevents further surface contamination with bacteria.

Thymol is also used as a preservative (a few crystals or 5 ml of 10% solution). This is a satisfactory preservative for a wide range of substances. However, it cannot be used for the estimation of 17-oxosteroids using Zimmermann reaction.

Composition of Urine

Colour

Normal urine is clear and straw coloured. The colour is due to the pigment urochrome. The colour is lighter when large amount of

water is consumed and darker in fevers and after excessive perspiration. In jaundice, the urine is yellow due to excretion of bile pigments. In alkaptonuria and methaemoglobinaemia urine is dark brown in colour.

Odour

Freshly voided urine has a mild aromatic odour. It develops ammoniacal odour on standing, due to the formation of ammonia by bacterial decomposition of urea. Urine in ketosis emits the smell of acetone.

Volume

The daily urinary output varies widely and is dependent on the fluid intake and environmental conditions. The volume excreted varies between 1000-2000 ml. Polyuria or increase in the volume of urine to more than 2000 ml is seen in diabetes mellitus. A fall in the urinary output is termed as oliguria when excretion is less than 500 ml which is found in renal failure, some diseases of the heart and lungs, fevers and diarrhoea. Anuria, a complete cessation of urine output is seen in the terminal stages of renal failure (less than 50 ml).

Appearance

Normal urine is ordinarily clear and transparent when freshly voided. It may become cloudy on standing because of the precipitation of phosphates. Urine may be turbid when RBCs or pus cells are present.

Specific Gravity

Specific gravity varies from 1.010 to 1.030 depending upon water and food intake. It is determined in clinical practice by means of a urinometer. It consists of a weighted cylinder which floats in urine and a stem caliberated in degrees of specific gravity usually from 1.000 to 1.060. The depth to which the urinometer sinks depends on the density of the urine. The instrument is usually caliberated for use at 15°C.

Procedure

1. Fill the cylinder with urine without producing bubbles.
2. Float the urinometer so that it does not touch the sides.
3. Make the reading from the bottom meniscus.

Temperature Correction

The urinometer is usually caliberated for use at 15°C and specific gravity should be corrected to room temperature by adding .001 for every 3°C above the temperature at which the urinometer is caliberated (15°C).

Room temperature	=	30°C
Specific gravity read	=	1.009
Temperature correction	=	1.009 + 5 × .001
	=	1.014

Total Solids

Under normal conditions, the total solids present is about 1500 ml of urine varies from 60 to 70 gm. The output of urinary solids is influenced by the intake of fluid diet.

The total solids per litre of urine is obtained by multiplying the last two digits of the specific gravity by a factor of 2.6 which is called the Long's coefficient. If the specific gravity is 1.020, the total solids would be 52 g/litre.

Reaction

Normally urine is acidic (pH = 6) in reaction due to monobasic salts of phosphoric acid plus small amounts of organic acids. The acidity of urine is influenced by diet, fluid intake and also by various drugs. Meat diet will increase acidity whereas fruit decreases. Fasting and starvation in which the body proteins are metabolised also tend to increase titrable acidity. Urine on standing turns alkaline due to the formation of ammonia by the bacterial decomposition of urea.

Constituents of Normal Urine

Normal urine is composed of: 1. Water, 2. Inorganic salts, 3. Organic compounds.

Major Inorganic Ions

Anions = Cl^-, PO_4^{---}, SO_4^{--}
Cations = Na^+, K^+, Ca^{++}, Mg^{++}, $[NH_4]^+$

Organic Constituents

NPN: Nonprotein nitrogen is nitrogen in the blood that is not a constituent of protein, e.g. nitrogen associated with urea, uric acid, creatine, creatinine and polypeptides. NPN substances in urine are urea, creatine, creatinine, uric acid, amino acids, allantoin and hippuric acid.

Urea: About 25 to 30 gm of urea is excreted daily in urine. As urea is the end product of protein metabolism, urea excretion in urine is an index of protein intake in diet. Urea in urine is increased in exaggerated protein metabolism, fevers and increased adrenocortical activity. It is decreased in the last stages of severe hepatic diseases and in acidosis.

Urea can be detected by sodium hypobromide test, where it undergoes decomposition to nitrogen on being exposed to the reagent and a brisk effervescence ensues.

Sodium hypobromide test: Add about 5 drops of sodium hypobromide solution to a test tube containing about 5 ml of the sample urine and note the brisk effervescence of the liberated nitrogen gas.

Urease test: The enzyme urease converts the urea into ammonia and carbonic acid both of which react with each other to form ammonium carbonate under experimental conditions. This results in an alkaline solution that can be detected by the addition of phenolphthalein indicator when a pink colour is produced.

Procedure: Label two test tubes as "test" and "control" containing 5 ml of urine in each. Add 2 ml of urease suspension to the test tube marked as "test"and 2 ml of inactivated urease suspensions to the test tube marked "control".

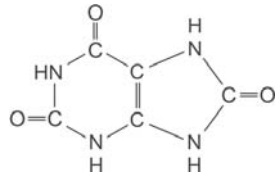
Incubate both the test tubes at room temperature for 15 minutes and then add 2 drops of phenolphthalein indicator solution to each test tube. Pink colour will be produced in the test tube having active enzyme.

Uric Acid: It is derived as an end product of the breakdown of cellular nucleoproteins. The daily excretion is 0.6 to 1g. An increase in the excretion of uric acid is observed in leukaemia, in severe liver disease and in various stages of gout. Deposits of urates and uric acid in the joints and tissues are also characteristics of gout, so that this disease appears to be a from of arthritis.

Under certain conditions uric acid or urates crystallize in the kidneys and are called kidney stones or calculi.

An increase in the nucleoproteins in the diet also causes an increased excretion of uric acid in the urine.

Schiff's test: Uric acid reduces ammoniacal silver nitrate solution to metabolic silver and can be detected by the conversion of colourless silver nitrate to silver, seen as a black precipitation. Wet a piece of filter paper with a few drops os ammoniacal $AgNO_3$ solution and add a couple of drops of the sample urine to it. Note the formation of black carbon.



Uric acid

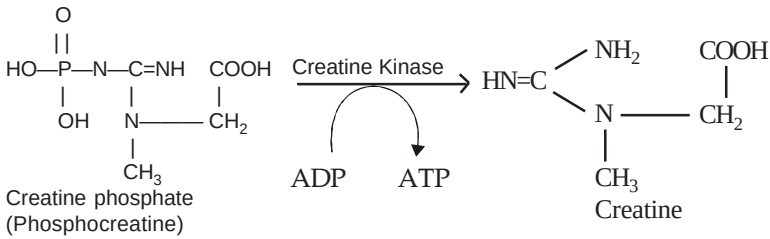
Creatinine

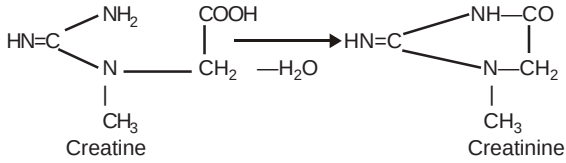
Creatinine is the anhydride of creatine and it is in this form that creatine is excreted in normal health. Creatinine is a waste product formed from creatinine phosphate which is the stored form of energy in muscle. Skeletal muscle contains a reservior of high-energy phosphoryl group in the form of creation phosphate or phosphocreatine, which transfers its high energy phosphogroup to ADP to form ATP, catalysed by creatine kinase.

Creatin phosphate maintains a high concentration of ATP in skeletal muscle during period of muscular exertion.

Under physiological pH and temperature, phosphocreatine spontaneously looses phosphoric acid, leaving behind creatine. Creatine loses water to form creatinine which is excreted in urine.

Normal blood plasma contains 0.2 to 0.6 mg of creatin per 100 ml. In 24 hours urine, 1-5 to 2 gm of creatinine is exereted by males and 0.8 to 1.5 gm by females.



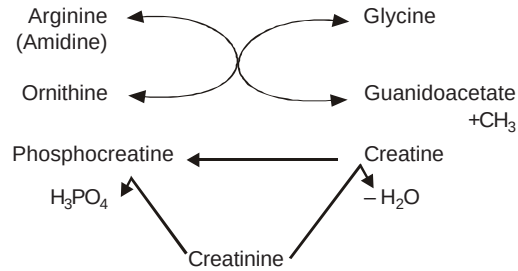


98% of the total creatine in the body is in the muscles of which 80% is in the phosphorylated form.

Creatine Synthesis

Three amino acids, glycine, arginine and methionine participate in the synthesis which takes place in two steps.

a. The first step involves transamidination, by which the amidine group of arginine is transferred to glycine to form guanidoacetate. This reaction is reversible and takes place in the kidneys. Arginine after losing the amidine group forms ornithine.
b. The second step involves transmethylation when the methyl group from activated methionine is transferred to guanidoacetate to form creatine. This reaction takes place in the liver.



Creatine coefficient is the urinary creatinine plus creatine nitrogen expressed in mg/kg body weight. The value is elevated in muscular dystrophy. Normal range is 20-25 mg/kg for males and 15-21 mg/kg for females.

The estimation of creatinine is also helpful in finding out the nephrotic syndrome. The proteins and creatinine are estimated in the urine and expressed as a ratio. A ratio less than 0.2 rules out any renal pathology and a ratio more than 3.5 indicates nephrotic syndrome.

Jaffe's Test

Creatinine is detected by its reaction with alkaline pierate solution to give an orange coloured creatinine picrate.

Procedure: Add 2 ml of saturated solution of picric acid and a few drops of 10% NaOH solution to about 2 ml of the sample of urine. Perform a control test with water in place of urine. Observe the distinct orange colour in the sample test tube and the yellow colour in the control test tube.

Analysis of Normal Urine

Physical Examination

Note the colour, appearance and odour. Test the acidity with blue or red litmus paper.

Determine the specific gravity using urinometer. Apply the correction for temperature variation. Calculate the total solids present and perform the following tests with the sample.

Test for chlorides: Place 5 ml of albumin free urine in a test tube and add 3 drops of Con HNO_3 to prevent precipitation of protein. Add 5 drops of $AgNO_3$. White precipitate of AgCl indicates presence of chlorides.

Test for phosphates: To 3 ml of urine add 1 ml of Con HNO_3 and 5 ml of ammonium molebdate and warm. A canary yellow precipitate indicates the presence of phosphate.

Test for inorganic sulphates: To 3 ml of urine add 1 ml of Con HCl followed by 10% $BaCl_2$ solution. A white precipitate of $BaSO_4$ indicates inorganic sulphate. Filter and set aside the filtrate for the next experiment.

Test for ethereal sulphate: Take the above filtrate and boil. A white precipitate is formed again indicating the presence of ethereal sulphate.

Test for ammonia: Boil urine with equal volume of 10% NaOH. Smell of ammonia gas indicates the presence of ammonium ion in the urine sample.

Analysis of Pathological Urine

In the case of abnormal urine, glucose, ketone bodies, proteins, blood, bile salts and bile pigments are tested in the clinical biochemical laboratory.

Test for Reducing Sugar: Benedict's Test

Reducing carbohydrates like glucose reduces $CuSO_4$ in alkaline media to insoluble Cu_2O. Colour of the solution depends upon the particle size of Cu_2O formed.

Procedure: Take 5 ml of Benedict's qualitative reagent. Boil for a minute and add 8 drops (0.5 ml) of urine, boil for 2 minutes, cool and note the colour change.

Green	0.5% sugar
Yellow	1.0%
Orange	1.5%
Brick red	2.0% and above.

Test for Proteins (Albumin)

Heat and acetic acid test : Proteins are coagulated by boiling, CO_2 driven out of the solution, pH of the urine is increased which may precipitate phosphates. Thus when a sample of urine is heated precipitate may be due to protein or phosphate. Addition of a few drops of acetic acid will dissolve phosphate, if present.

Procedure: Fill up 2/3 of a test tube with urine. Boil the upper portion of the test tube. Add a drop of two% acetic acid. A white cloud in the heated portion shows the presence of albumin.

Heller's Nitric Acid Test (Cold Test)
This sensitive test is based on the fact that protein is converted into a meta protein which is insoluble in concentrated mineral acids.

Procedure : Take 3 ml of Con HNO_3 in a test tube and pour 2 ml of urine along the sides. A white ring at the junction of the two layers shows the presence of proteins.

Sulphosalicylic Acid Test

Place 1 ml urine in a test tube, add 3% sulphosalicylic acid and allow to stand for 10 min. Presence of cloudiness is due to albumin.

Benzidine Test for Blood in Urine

Prepare a saturated benzidine solution in glacial acetic acid; mix well equal parts of benzidine solution and H_2O_2. Take 2 ml of urine and add 2 ml of this mixture. A green or deep blue colour indicates presence of blood in urine.

Any catalyst or enzyme which splits up H_2O_2 and liberates nascent oxygen will give this test. The pus cells (WBCs in urine) contain an enzyme called peroxidase, which can split H_2O_2 and liberate nascent oxygen. To test haemoglobin in presence of pus cells, the urine must be boiled to destroy the pus cells enzyme before performing this test.

Bile Salts and Bile Pigments

Normally bile salts and bile pigments do not enter in the general circulation, and therefore, they are absent in normal urine. But if there is intrahepatic or extrahepatic obstruction to the flow of bile, bile regurgitates into the general circulation and appears in urine as in obstructive jaundice. Bile pigments give urine a greenish yellow or brown colour.

a. *Hay's test for bile salts:* When powder of sulphur is sprinkled on the urine containing bile salt, the sulphur powder sinks due to lowering of surface tension by bile salts. A positive test indicates the liver damage or obstruction of bile duct.

b. *Gmelin's test for bile pigments*: When Con HNO_3 is added to urine, there is a play of colour. Green indicates presence of bile pigments. Nitric acid oxidises bilirubin to form a series of coloured compounds, biliverdin (green), billicyanin (blue), choletelin (Yellow), etc.

To 2 ml of Con HNO_3 in a test tube, add 3 ml of sample urine slowly along the sides. Play of coloms at the junction of the two layers indicates the presence of bile pigments.

c. *Fouchet's test for bile pigments:* Add 5 ml of 10% $BaCl_2$ solution to about 10 ml of urine. Mix and filter. Pour a few drops of Fouchet's reagent ($FeCl_3$ the oxidising agent) on the precipitate in the air dried filter paper. In the presence of bile pigments, bilirubin turns green and blue due to oxidation (UBG and SBG).

d. *Ehrlich's aldehyde test for urobilinogen:* Take 10 ml of urine in a test tube. Add 2.5 ml of $BaCl_2$ solution and filter. Take 3 ml of filtrate add Ehrlich's aldehyde reagent (para dimethyl amino-benzaldehyde) shake well and allow to stand for 3 minutes. Pink colour indicates a positive test. Urobilinogen is absent in obstructive jaundice.

Acetone Bodies

The acetone bodies in urine include acetoacetic and hydroxy butyric acids in addition to acetone.

a. *Rothera's test for acetone and acetoacetic acid:* Take 3 ml of urine in a test tube and fully saturate with saturated ammonium sulphate. This is to precipitate and remove proteins which may interfere with the test. Add 1 or 2 crystals of sodium nitroprusside. Mix well and add liquor ammonia. A permanganate coloured ring indicates the presence of acetone and acetoacetic acid.

b. *Gerhardt's test for acetoacetic acid* : To 5 ml of urine add 10% $FeCl_3$ solution drop by drop till a maximum precipitate of ferric phosphate is obtained. This is to eliminate the phosphate which may otherwise obscure the colour in the test. Filter and to the filtrate add excess of $FeCl_3$. A bordeaux wine red colour indicates the presence of acetoacetic acid in urine.

QUESTIONS

1. **What are the normal constituents of a given sample of urine? Describe the tests conducted to detect proteins and blood in a given sample of abnormal urine.**
2. **How do you test the following in urine?**
   a. Blood
   b. Protein
   c. Sugar
   d. Ketone bodies
   e. Bile salts
   f. Bile pigments
3. **Name the pathological constituents of urine. How are they detected in the laboratory?**
4. **Name the nitrogen constituents of urine. How are they identified (NPN substances)?**
5. **Write short notes on:**
   i. Urea clearance test
   ii. Inulin clearance test
   iii. Creatinine clearance test
   iv. Urine concentration test

MULTIPLE CHOICE QUESTIONS

6. **Urine turbidity may be caused by any of the following *except:***
   A. Phosphates
   B. Proteins
   C. RBCs
   D. WBCs
7. **Urine pH tends:**
   A. To remain below 4.5
   B. Remains above 8.0
   C. Same as that of blood
   D. Reflects the acid-base status of the body
8. **Urine specific gravity 1.050 indicates:**
   A. Presence of glucose or proteins in urine
   B. Excellent renal function

C. Inappropriate excretion of ADH
D. The need for dilution test

9. Ketonuria can occur and Rotheras test may be positive in all following situations *except:*
A. A very high fat diet
B. In starvation
C. Following ether anaesthesia
D. Diabetes meltilus

10. Urinary excretion of protein in 24 hours urine in normal individual is:
A. 1-5 mg
B. 5-20 mg
C. 20-40 mg
D. 50-100 mg

11. Normal renal plasma flow in healthy adults arranges about:
A. 12.5 ml/mt
B. 200 ml per minute
C. 450 ml/mt
D. 574 ml/mt

12. In adults, the upper limit of normal serum creatinine concentration is:
A. 0.75 mg/dl
B. 71.2 mg/dl
C. 1.6 mg/dl
D. 201 mg/dl

ANSWERS

6(B) 7(D) 8(D) 9(C) 10(D) 11(D) 12(C)

CHAPTER

18 Renal Function Tests

FUNCTION OF KIDNEY

Formation of Urine

The kidney not only excretes the non-volatile metabolic waste materials of the body but also maintains the homeostasis of the body fluids. The kidney function is made up of the following four processes:

1. Filtration of protein free plasma by glomeruli.
2. Selective reabsorption by the tubule.
3. Secretion by the tubule.
4. Maintenance of acid-base balance.

Urine is formed as a result of these four processes. A large volume of blood, approximately 1 litre/minute flows through the kidneys. The filtrate contains all other constituents of plasma except the proteins. It contains many substances necessary for normal metabolism such as water, glucose, amino acids and chlorides as well as substances to be rejected such as urea, creatinine and uric acid. Substances which are necessary for the body are reabsorbed by the tubule along with nearly 99% of the water of the filtrate. Certain other substances are added to produce the final urine which is passed out into the bladder at the rate of about 1 ml per minute.

Renal Function Tests

The kidneys are the major excretory organs and they also maintain the acid-base, fluid and electrolyte balance. Therefore it is very important to detect any abnormal function of kidney as early as possible.

Renal functions tests are grouped into three:

1. Routine clinical tests which include, (a) complete urinalysis, (b) measurement of NPN in blood, (c) measurement of serum electrolytes.
2. Tests done for detailed assessment are, (a) clearance tests, (b) urinary and plasma osmolality, and (c) concentration and dilution tests.
3. Tests done for specific diagnosis or research purposes.

Tests of Glomerular Function

The glomerular filtration rate (GFR) depends on the net pressure being exerted across the glomerular membrane, the physical nature of the membrane and the surface area of the membrane. GFR gives an index of the number of functioning glomeruli. This can be evaluated by:

a. Urea clearance test .
b. Inulin clearance test.
c. Creatinine clearance test.

Clearance: The clearance of any substance is defined as the number of ml of plasma/ blood which contains the amount of that substance excreted in one minute by the kidneys.

Blood Urea and Urea Clearance Test

The normal blood urea level ranges from 20 to 40 mg per 100 ml. Urea clearance is the volume of plasma cleared of urea per minute.

$$\text{Urea clearance} = \frac{U \times V}{B}$$

Where U = Concentration of urea in urine (in mg/100 ml)
V = Volume of urine (in ml/mt)
B = Concentration of urea in blood (in mg/100 ml)

Maximum urea clearance: Normal maximum urea clearance is 75 ml per minute. When the volume of urine excreted per minute is 2 ml or more, urea clearance is maximum.

Standard urea clearance: When the urinary volume is less than 2 ml/mt the urea clearance is reduced. Such clearance is termed as standard clearance and the average normal value is 54 ml/min.

Procedure for urea clearance test: The patient is asked to take a light breakfast with two glasses of water. The first sample of urine passed after the water intake is discharged. Time is noted. Two urine samples are collected at 1 hour interval along with two blood samples. Urea clearance is calculated using the formula UV/B. In severe renal failure the clearance falls below 20% of the average normal.

Creatinine Clearance Test

Creatinine clearance is more than 100 ml/min in healthy adults. Creatinine clearance measurements correlate fairly closely with inulin clearance measurements except in patients in whom GFR is severely impaired. Because a portion of creatinine is secreted by tubules, the clearance value is slightly raised.

Procedure: 24 hours urine is to be collected. At the start of the collection period, usually at 8 AM, the patient is instructed to empty the bladder and to discard the specimen. After this, all the urine samples are collected and placed in toluene (preservative) till 8 AM the following day. The volume of pooled urine is noted.

A specimen of blood is collected during the period of urine collection. Creatinine clearance is calculated by using the formula $\frac{UV}{B}$.

The creatinine clearance is impaired in acute and chronic renal failure.

Inulin Clearance Test

This test is done to find glomerular filtration rate (GFR). Inulin is filtrated by the glomeruli but neither secreted nor absorbed by the tubules. The amount of inulin excreted in each minute is the amount filtered by the glomeruli. The concentration of inulin in the glomerular filtrate is equal to that in the plasma. Thus the clearance value of inulin is the same as glomerular filtration rate.

During the period of urine collection, a constant plasma inulin level is maintained by intravenous drip. The normal inulin clearance value is about 125 ml per minute.

URINE CONCENTRATION TEST

This is designed to test the concentration power of the kidneys. The capacity of the kidneys to concentrate urine is a sensitive test

to detect early loss of kidney function. The test is simple as it does not require any laboratory facilities.

At 6 p.m give the patient, a meal with good protein content but not more 200 ml of fluid to drink. Allow no more fluid after this meal. Discard any urine passed during the night. On the following morning collect three samples of urine as follows:

8 AM — Urine sample I
9 AM — Urine sample II
10 AM — Urine sample III

Measure the specific gravity of the all samples. The specific gravity of at least one specimen should exceed 1.022. A maximum specific gravity of less than 1.022 indicates impaired renal function.

When the kidney loses its capacity to do osmotic work, the urinary solids must be excreted in more dilute solution. The advantage of this test is that it is useful for the detection of renal defect when the blood urea is normal.

DILUTION TEST

In addition to the loss in power of the kidneys to produce concentrated urine, there is also an impairment in its ability to excrete dilute urine.

In this test, no water is taken after midnight, the bladder is emptied at 7 a.m. and the patient is given 1200 ml of water to drink in 30 minutes. Urine samples are collected hourly for next four hours, i.e. at 8, 9, 10 and 11 a.m. The volume and specific gravity of each specimen are noted.

Specific gravity of at least one sample should fall to 1.003 or below. Almost all the water drunk (1200 ml) should be excreted within those 4 hours. When renal impairment is severe, volume may be less than 100 ml with the specific gravity of 1.010 or more.

Phenolsulphonphthalein (PSP) Test or Phenol Red Excretion Test for Kidney Function

The PSP test indicates a general loss of kidney function. The dye is nontoxic and is exclusively excreted by the kidney. After intravenous injection of the dye, the 15 minutes sample collected should contain 25% or more of the injected dye which is estimated calorimetically.

Measurement of Renal Blood/Plasma Flow

Renal blood flow can be determined by using paraamino hippuric acid, which at low blood concentration is removed entirely by the tubular excretion in a single circulation through the kidney. It is a measure of the plasma flow which is normally 574 ml per minute per 1.73 sq.m body surface area.

MULTIPLE CHOICE QUESTIONS

1. **All of the following substances have been used to estimate GFR *except:***
   A. Insulin
   B. Creatinine
   C. Phenol red
   D. Mannitol
2. **Relationship between GFR and serum creatine concentration is:**
   A. Nonexistent
   B. Inverse
   C. Direct
   D. Indirect
3. **Normal maximum urea clearance in adult averages about:**
   A. 60
   B. 65
   C. 70
   D. 75
4. **In patients with renal failure all the following are typically elevated in serum *except:***
   A. Urea nitrogen
   B. Phosphate
   C. Uric acid
   D. Albumin
5. **Excretion of BSP primarily reflects:**
   A. Liver function test
   B. Glomerular fitration rate
   C. Maximal tubular excretory capacity
   D. Kupfer cell activity
6. **Kidney functions which are important in maintaining acid-base balance include:**
   A. Bicarbonate mechanism
   B. Ammonia mechanism
   C. Phosphate mechanism
   D. None of the above

7. **Renal tubular functions can be assessed by:**
   A. Creative clearance test
   B. Insulin clearance test
   C. Urea clearance test
   D. Concentration and dilution tests
8. **Excretion of phenolsulphonphthalein (PSP) reflects:**
   A. Glomerular filtration rate
   B. Liver function
   C. Tubular excretory capacity
   D. None of the above
9. **Clearance is measured to assers quantitativly the rate of excretion of a given substance by the:**
   A. Liver
   B. Spleen
   C. Intestine
   D. Kidney
10. **Creatinine clearance is decreased in:**
   A. Liver diseases
   B. Renal diseases
   C. Brain diseases
   D. Bone diseases

ANSWERS

1(D)	2(B)	3(D)	4(D)	5(C)	6(D)
7(D)	8(C)	9(D)	10(B)		

CHAPTER

19 Abnormalities of Bilirubin Metabolism Jaundice

What is Jaundice?

Normal serum bilirubin concentration is almost 1 mg per 100 ml. This is made up of 0.8 mg of bilirubin and 0.2 mg of bilirubin diglucuronide.

When the total bilirubin level exceeds 1 mg, the condition is called hyperbilirubinaemia. Hyperbilirubinaemia may be due to:

a. Production of more bilirubin than the normal liver can exerete.
b. The failure of damaged liver to execrete bilirubin produced in normal amounts.
c. Block in the excretion of bile.

In these cases, bilirubin accumulates in the blood and beyond 2.0 mg% it diffuses into the tissues, which then become yellow. This condition is called icterus or jaundice.

In haemolytic and hepatic jaundice, the liver looses the capacity to remove urobilinogen from the blood. Therefore, the urobilinogen in the circulation in the liver is all excreted by the kidneys and the excess of urobilinogen appears in the urine (Detected by Fonchet's test and Gmelin's test).

BILIRUBIN: PIGMENT METABOLISM

Bilirubin is executed in urine in the following diseases:

a. Obstructive jaundice.
b. Hepatic cirrhosis, infective hepatitis.
c. Haemolytic jaundice, following malaria, haemolytic anaemia and non-compatible blood transfusions.

van den Bergh Test for Serum Bilirubin

Bilirubin forms a reddish compound with the diazo reagent (diazotized sulphainlic acid) and can be estimated colourimetrically.

The bilirubin of bile is combined chemically (conjugated) with glucoronic acid to form the mono and diglucoromide salts of the bilirubin. Free bilirubin is very soluble. Conjugated bilirubin develops red colour directly on addition of diazo reagent within one minute. Hence, it is known as 1 minute bilirubin or direct reacting bilirubin.

Normal blood plasma contains 0.2 to 0.8 mg% of the indirect type (unconjugated). The van den Bergh reaction in one minute will be negative. In jaundice, serum bilirubin level exceeds 2 mg%.

In haemolytic jaundice, indirect test is positive because of the accumulation of uncongugated bilirubin (insoluble).

In obstructive jaundice, direct test is positive because of accumulation of conjugated bilirubin (soluble).

In hepatic jaundice the test is biphasic positive because of the increased levels of both conjugated and unconjugated bilirubin.

Three Different Types of Jaundice

Jaundice is of three different types, depending upon the ways in which it is caused.

a. *Haemolytic (prehepatic) jaundice*: This type is due to excessive destruction of RBCs. Since the cause is increased production of bilirubin and not an abnormality in the hepatic conjugation or excretion. It is characterised by the presence of only unconjugated bilirubin.
b. *Hepatic jaundice:* This type is due to the damage to parenchymal liver cells. Damage may be due to liver poisons e.g., chloroform, carbon tetrachloride, phosphorus, toxins, hepatitis virus, etc.
c. *Obstructive (regurgitation or post-hepatic jaundice:* This type is caused by an obstruction (blockage) if the bile duct by e.g., gallstone, carcinoma of the bile duct or carcinoma of the head of the pancreas. Consequently the conjugated bilirubin returns to the blood and hence serum contains excessive amount of conjugated bilirubin.

van den Bergh Test

In differential diagnosis of jaundice, measurement of bilirubin in the serum is of great value. This is done by van den Bergh test. The test is based on the coupling of diazotized sulphanitric acid and bilirubin to produce a reddish purple ago compound. While

conjugated bilirubin (bilirubin mono and diglucoronide water soluble) gives colour with the reagent directly.

Abnormalities observed in bilirubin and its metabolism in the different types of jaundice (Table 19.1).

Table 19.1: Abnormalities observed bilirubin in different types of jaundice

	Haemolytic Jaundice	*Hepatic Jaundice*	*Obstructive Jaundice*
Serum bilirubin Total Direct	Increased Less than 20% of total	Increased	Increased
Indirect	Markedly increased	Variable	A slight Increase
Urine bilinogen	Increased	Usually mereased	May be present
Urine bile salts	Absent	Increased	Markedly increased
Faecal urobilinogen	Markedly increased	Usually low	Absent

Unconjugated bilirubin gives colour only after adding methanol. Unconjugated bilirubin is insoluble in water but soluble in methanol, thus conjugated bilirubin is called "Direct reacting (one minute bilirubin) bilirubin and free or unconjugated bilirubin is called "Indirect reacting" bilirubin.

For estimation of total billirubin, serum is treated with van den Brugh reagent and methanol and the colour is read in a colourimeter. For estimation of conjugated bilirubin, serum is treated with the reagent and colour is read. Difference between total bilirubin and conjugated bilirubin gives the free or unconjugated bilirubin.

Total bilirubin minus conjugated bilirubin = free or unconjugated bilirubin.

van den Bergh reaction with serum from hemolytic jaundice is an indirect one as the condition is characterized by a high level of unconjugated bilirubin. Reaction with normal serum is also an indirect one as the concentration of unconjugated bilirubin is much more than the conjugated bilirubin. Reaction with obstructive jaundice serum is "direct" as the serum is characterized by a high level of conjugated bilirubin. Reaction with hepatic jaundice serum is also "direct".

Difference between Haemolytic Jaundice and Obstructive Jaundice with Respect to Execution of Urobilirubin and Bilinogen

In haemolytic jaundice, the increased production of bilirubin in the tissues leads to increased production of urobilinogen which appears in the urine in large amounts. Thus, Ehrlich test for urine bilirubin is distrinctly positive. Since bilirubin is water insubtle, it is not excreted as urine in this condition. Thus, a combination of increased urobilinogen and no bilirubin in urine is suggestive of haemolytic jaundice.

In complete obstruction (obstructive jaundice) of the bile duct, no urobilinogen is found in the urine, since bilirubin does not reach the intestine. Since in this condition there is a high level of conjugated bilirubin (water soluble form) in blood, it is excreted in urine. Thus, Fonchet's test (for bilirubin) is distinctively positive. Thus, a combination of no urobilinogen and the presence of bilirubin is urine is suggestive of obstructive jaundice.

MULTIPLE CHOICE QUESTIONS

1. Test based on abnormalities of bile pigment metabolism is:
A. Creatinine clearance test
B. Hippuric acid synthesis test
C. van den Bergh's test
D. Rothera's test

2. Obstruction of the common bile duct leads to:
A. Prehepatic jaundice
B. Posthepatic jaundice
C. Hepatic jaundice
D. Physiological jaundice

3. In case of jaundice, if there is no trace of bile pigments in urine, the most probable diagnosis is:
A. Infective jaundice
B. Hemolytic jaundice
C. Serum hepatitis
D. Obstructive jaundice

4. Jaundice is clinically detected in sclerae when serum bilirubin concentration reaches above:
A. 1 to 2 mg/100 ml
B. 0.5-1 mg/100 ml
C. 2 to 3 mg/100 ml
D. 3-4 mg per 100 ml

5. In haemolytic jaundice the urinary bilinogen is:
A. Normal
B. Small amount is present
C. Increased more than normal
D. Absent

ANSWERS

1(C) 2(B) 3(B) 4(C) 5(C)

CHAPTER

20 Liver Function Tests

Liver performs numerous metabolic, secretory, excretory, storage and detoxifying functions. Several biochemical tests are available to test the functional efficiency of liver. The pathological processes that may be present singly or in combination are:

1. Liver cell damage caused by viral infections.
2. Cholestasis caused by impaired secretion of bile by the liver cells.
3. Reduced functional mass due to chronic liver damage.

LIVER FUNCTION TESTS

Chemical tests for the diagnosis and follow-up of liver diseases are:

1. Bilirubin metabolism and excretion
2. Assessment of hepatic transport function—BSP excretion test
3. Plasma protein abnormalities (albumin/globulin ratio)
   a. Protein synthesised in the parenchymal cells
   b. Abnormalities of immunoglobin synthesis
4. Estimation of plasma enzymes:
   a. Albumin phosphatase
   b. SGOT (AST)
   c. SGPT (ALT)
   d. Gamma Glutamyl transferase (γGT)

Test for Hepatic Transport Function

Bromsulphalein Excretion Test (BSP Test)

A measured amount of an anionic dye is injected intravenously. The liver rapidly removes the dye and excretes in the bile. If the liver function is impaired, the excretion is delayed and larger portion of the dye remains in the serum. It is a very sensitive test and is most useful in liver cell damage without jaundice, in cirrhosis and chronic hepatitis.

PLASMA PROTEINS (Albumin/Globulin Ratio)

The liver has dominant role in plasma protein synthesis, being the source of plasma albumin and fibrinogen along with other proteins associated with blood coagulation). The liver contributes important components of α and β globulin fractions and is also involved in the synthesis of γ globulins. The serum albumin level is lowered in cirrhosis, in viral hepalitis, in nutritional liver disease and in neoplastic disease of liver. There is generally an equal simultaneous rise in globulin level with the γ globulin accounting for much of the increase in total globulin of serum. While the serum γ globulin content rarely exceeds 1.6 g/100 ml in healthy subjects, in liver diseases concentrations as high as 2-5 times the normal are seen. The normal serum albumins globulin ratio is 2:1. In advanced liver disease, albumin is decreased and the globulin is increased so that albumin globulin ratio is reversed.

Protein Electrophoresis

Electrophoresis gives abnormal patterns in liver diseases. In cirrhosis, serum albumin is reduced and the gammaglobulin is increased. In cholestasis, there is an increase in the concentrations of α and β globulin factors.

COAGULATION FACTORS (PROTHROMBIN TIME)

Prothrombin time is the time required for clotting to take place in citrated plasma to which optimum amounts of thromboplastin and calcium have been added. Prothrombin is formed by liver cells, vitamin K being required. When bile salts are not present in the intestine the absorption of vitamin K from intestine is impaired. The normal prothrombin time is 16-18 sec. It is prolonged in jaundice and liver diseases.

Tests for Detecting Changes in Serum Proteins

In the *thymol test*, adding thymol, in barbital buffer, to serum produces marked turbidity.

1. In the presence of liver disease (parenchymatous) and flocculation appears on longer standing. Similarly in the presence of liver disease, diluted serum forms a flocculent precipitate when treated with a suspension of cephalin and cholesterol in water.

2. Using *Biuret reagent:* Total proteins may be determined and repeating this after suitable fractionation of serum, concentration of different type of proteins in the serum is obtained.
3. *Serum enzymes:* A number of enzymes in serum exihibit changes in activity during parenchymal liver disease and the following studies are routinely employed.
   a. *Alkaline phosphatase:*
      Alkaline phosphatase activity of the serum often assists in the differentiation of liver disease of parenchymal origin from that due to obstruction and other lesions of the biliary tract. Biliary obstruction is characterized by a persistent increase in alkaline phosphotase activity to two or more times the normal values (in the range of 1.5-4 units per 100 ml in adults and 5-12 units per 100 ml in children) with moderate changes occurring during hepatocellular disease.
   b. *Amino transferases:*
      Amino transferases or transaminases are used in the diagnosis of a variety of disorders eg. (1) SGOT (serum glutamic oxalo acetate transaminase) (old name) or AST (aspartate transferase) (new name). This enzyme occurs in high concentration in heart muscles. Increased levels of AST in the blood stream indicates, cirrhosis of the liver or myocardial infarction (which results from the reduction in blood flow to the heart muscle caused by a clot in the coronary artery. (2) SGPT (serum glutamic pyruvic transaminase) (old name) or ALT (alanine transaminase) (new name) levels are increased during infective hepatitis (refer "Transamination" of amino acids in Chapter 13)

Elevated AST or SGOT is observed soon after exposure to hepatitis virus, even before the appearance of clinical symptoms with striking elevations to the extent of 20 or more times the normal at the ouset of active illness. A similar rise may be observed on exposure to various chemicals and drugs but in contrast, only moderate increases occur in case of biliary obstruction, cholestatic syndrome or cirrhosis. ALT or SGPT is much more abundant in liver than in other tissues. However the rise of ALT in liver disease is often delayed and may not become evident until AST has begun to fall. Hence the specificity attributed to ALT often fails to work out in practice. Neverthless, ALT activity remains high throughout the subsequent course of

illness and returns to normal values much later than AST (as the former is cleared more slowly from the blood) and helps in monitoring the illness more effectively.

4. *γ-GT:* Gamma-glutamyl transferase is a letter index for the diagnosis of alcohol-induced liver disease.

QUESTIONS

1. **Mention the various liver function tests and their clinical significance.**
2. **Short note on:**
   (i) Jaundice
   (ii) Prothrombin time

MULTIPLE CHOICE QUESTIONS

3. **The following are the important liver function tests *except:***
   A. Urea clearance test
   B. Galactose clearance test
   C. Prothrombin time
   D. Bromsulphalein test
4. **In alcoholics the marker enzyme estimated in serum is:**
   A. SGOT
   B. SGPT
   C. CPK
   D. γGT

ANSWERS

3(A) 4(D)

PART – 2

Nutrition

CHAPTER

21 Food, Nutrition and Health

HISTORY

Nutrition as a new field of study is about one hundred years old. Even though Hippocrates had recognized diet on a component of health as early as 300 BC, only during the past one hundred years, people began to realize the importance of carbohydrates, lipids and proteins for normal growth and development. The next nutrition breakthrough was the discovery of vitamins – Vitamin A in 1913,Vitamin C in 1919, Vitamin D in 1925, Vitamin K in 1935, Vitamin E in 1936, Vitamin B_1 Thiamine in 1936, Vitamin B_2 riboflavin in 1935, Vitamin B_6 pyridoxine in 1936, Vitamin B_9 in 1948 and so on.

Nutrition was officially recognized as an independent field of study only in 1928 with the formation of American Institute of Nurtrition. It took about half a century more for nutrition to achieve its current status as one of the most talked about scientific disciplines.

Nutrition encompasses not only the study of vitamins, minerals and other foods but also diverse subjects as alcohol, caffeine and pesticides. Besides, nutrition research tries to find out the impact of food on our body by examining the progress in allied fields, such as physics, chemistry, biochemistry, immunology.

CONCEPTS

1. Nutrition

Nutrition is defined as the science of food and its relationship to health. Nutrition is food at work in the body. It includes everything that happens to food. It is the study of nutrients and processes by which they are used by the body. It is concerned with the part played by nutrients in the body-growth, development and maintenance.

2. Dietics

It is the practical application of the principles of nutrition which includes planning of meals for the healthy as well as the sick. Good nutrition means maintenance of nutritional status that enables us to grow well and enjoy good health.

3. Food

Food is vital for human existence just as air and water. Food may be difined as anything eaten or drunk, which meets the needs of tissue building, regulation and protection of the body and its energy needs. Food is the raw material from which our bodies are made. Intake of right kinds and amounts of foods can ensure good nutrition and health which may be evident in our appearance, well being and efficiency.

Food is basic to life. The food we eat is digested and assimilated in the body and used for its growth and development. Food also provides the necessary energy for doing work. The selection of best food for promoting good health is by trial and error. Use of milk of different mammals as food for infants has been practiced from very early times. Man has shown great foresight and inguinity in cultivating a variety of food grains, fruits, vegetables, oil seeds and nuts and rearing of animals and birds for food. The food that is ingested by the body is digested, absorbed and metabolized.

4. Diet

Diet refers to whatever people eat, drink each day. It includes the normal diet people consume and the diet people consume in groups (Hotel diet) but will also be modified for the sick as part of their therapy (Diet therapy).

5. Nutrients

Useful chemical substances derived from the food by the body are called nutrients. Human beings require more than 45 different nutrients for their well being. Nutrients include:

1. Carbohydrates
2. Lipids
3. Proteins

4. Water
5. Minerals
6. Vitamins

CLASSIFICATION OF NUTRIENTS

1. Major nutrients (Macronutrients): Carbohydrates, lipids, proteins and water.
2. Minor nutrients (Micronutrients): Vitamins and minerals.

The Major Nutrients

Are utilized for energy converted to structural components of cells or are stored as fat, depending on their level of supply e.g., Carbohydrates form 65-80%, proteins 7-15% and lipids 10-13% of food. The proper utilization of these nutrients requires, appropriate concentrations of micronutrients.

The Minor Nutrients

Unlike carbohydrates, lipids and proteins, vitamins and minerals do not supply energy or calories, instead they regulate the the metabolism. There are B complex vitamins each with its special functions.

Scientific research have shown that to some extent, we are really what we eat. With this, many consumers have become more confused than ever about how to incorporate the research findings into their food habits. With the amount of nutrition information and the number of alternative foods ever on the increase, choosing a healthy diet is becoming more and more challenging.

Should I take Vitamin substitute or antioxidants? Do diet pills work? Can a sports drink enhance my performance? Can vitamin C supplement prevent cancer and heart diseases? Fruits, vegetables and tea are loaded with antioxidants, but can their beneficial effect be captured in a pill?

NUTRITION AND HEALTH

The basic study of nutrition is of primary importance as:

1. It is fundamental for our own health, and
2. It is essential for the health and well being of our patients and clients from the time of eating till it is utilized for various functions. The scope of such study involves.

1. Nutrition helps growth and development
2. Prevents malnutrition
3. Resists infection and
4. Prevents diseases

Growth and Development

Good nutrition is essential for attainment of normal growth and development both physical and intellectual. Learning and behaviour are affected by malnutrition. Nutrition controls human beings from womb to tomb. Malnutrition during pregnancy affects the growth of the foetus.

NUTRITIONAL PROBLEMS IN INDIA

A survey in South India has revealed that about 1% children aged 1-5 years showed signs of kwashiorkor, 2% marasmus and 3-5% vitamins A dificiecy. Community studies have shown that many mothers give only breast milk to children upto 2 years. Thus, no additional food is added to the child's diet. Papaya which is rich in vitamin A is considered as a hot food that will cause miscarriage is avoided by pregnant women. It is a belief that if a pregnant woman eats more the baby will be big and delivery difficult, so expectant mothers are not fed adequately both in quality and quantity.

FACTORS INFLUENCING FOOD HABITS AND SELECTION OF FOOD STUFFS

1. Superstitions
2. Social and cultural factors
3. Religions factors
4. Income
5. Geography/availability
6. Advertising and media

Superstitions and Cultural Factors

Food habits are handed over from generation to generation in the society particularly in the developing countries. Though these factors have very little or no scientific basis, people rigidly adhere to them. In many parts of India pregnant women are not allowed

to consume papaya as it is believed that papaya produces a lot of heat in the body which in turn induces abortion. Pineapple also is not given for the same reason. Pregnant ladies are given milk with a few strands of saffron in it as it would supposedly result in a baby with a very fair complexion. Consumption of a lot of garlic is for secretion of milk. In parts of Bengal, people believe that consumption of tongue of goat by children will make them more talkative.

Religious Belief

Hindus do not eat beef, since cow is an animal sacred to them. Among Hindus some communities do not eat fruits, onions and garlic. Many Hindus are vegetarians. Jains do not eat curds and do not eat after sunset. The central tenet of Buddhism is vegetarianism. To eat meat is to destroy the seeds of compassion. All plant foods are considered appropriate to eat except the "five pungent foods" garlic, onions, leeks, scallions and chives. These foods are considered unclean and are believed to generate lust when eaten cooked and to induce rage when eaten raw. Islamic food laws prohibit the consumption of "unclean" foods such as swine and animals killed in a manner that prevents their blood from being fully drained from their bodies. Jews do not eat pork and shellfish. It is a custom in most communities in India that women and girls eat only after men and boys finish their eating. Thus, the health of the female is affected as they eat poorly with the left over food.

Child Rearing Practices

Another factor that blocks the normal food patterns in India is child rearing practices. The late introduction of weaning foods, prolonged breastfeeding and the adoption of commercially produced baby foods play an important part in the nutrition of children and have adverse effects in their growth and development.

The traditional cooking practices also act as a barrier to achieving a balanced diet e.g., Using polished rice, draining away the rice water and prolonged boiling of vegetables add to the great loss of nutrients in the diet of Indians which lead to nutritional deficiencies.

Geography/Availability

In the olden days, man would eat what ever was available to satisfy his hunger. The food he got was the type he could cultivate in his locality. Rice is the main food crop grown in tropical areas.

The nutrition value of natural foods do not vary from country to country. But there is a great variation in the composition of prepared foods such as bread, biscuits, cakes etc., due to variation in recipes and basic ingredients used in different regions.

EXCHANGE LISTS

In 1950, the American Diabetes Association developed a system of food lists to help diabetic patients to select foods in their diet. Since, India is a large country, there are three agencies who have brought out similar exchange lists. These agencies are the dietric departments of major regional hospitals.

Each list includes a group of foods which supply about the same calories in the portions indicated. Each food choice within a list is called "exchange". It represents an amount of food that has almost the same macronutrition value as other foods in the same group. The exchange lists are very useful in diet planning in hospitals and personal diet management in homes.

To determine what nutrients we need each day and how much to keep us in good health, a lot of research has been done. The results of these studies have been used to work out the nutritional requirements of Indian people. After adding a factor safety, the Reconcluded Dietary Allowances (RDAs) for Indians have been set up. RDA has been defined as the amount of nutrient that would meet the nutritional requirements of 97 to 98% of people in a group.

An advisory committee of Indian Council of Medical Research (ICMR) is responsible for the setting up, review and revision of these RDAs.

INCOME

Financial resources determine the type of food we consume. Depending on the availability one selects the food. People in lower income groups in India consume, a combination of cereals and cheaply available green leafy vegetables, roots and tubers. People

of higher income groups, can choose food from all groups irrespective of season.

Functions of Food

1. Provide energy
2. Body building
3. Regulating the activities of the body including
   a Beating of the heart
   b Maintenance of body temperature
   c Muscle contraction
   d Clotting of blood
   e Control of water balance
   f Elimination of the waste products of the body
4. Provide resistance to diseases
5. Social function: Feasts are served on specific stages of life—birth, naming ceremonies, birth days, marriages etc. Prasad is distributed in temples. Pedhas are distributed to announce success in exams or birth of a baby. Laddus are associated with Deepawali and marriages, cakes with Christmas and Weddings. Refreshments served at get together and meetings create a relaxed atmostphere.
6. Psychological functions of food. Breastfeeding provides closeness and security to the child. Food also satisfy some emotional needs like security, attention and friendship and acceptance. Food can be used as a weapon to fight against diseases. An insecure child sometimes refuses food, so that mother will be concerned about the child and bow to its demand.

Role of Food and its Medicinal Value

Most deficiency diseases have been eliminated in the West by abundance of food supplies. Yet diseases related to malnutrition in the form of dietary excess and imbalance are quite common in the Western countries. Four of the ten leading causes of death—heart diseases, cancer, stroke and diabetes have been linked to diet.

Poor dietary habits and a sedentary life style together account for three lakh deaths in the US every year. Dictary factors account for a third or more of all cases of both cancer and heart diseases.

A high fat diet raises risk of some types of cancer, heart diseases and obesity which in turn contribute to a number of other problems including dibetes and high blood pressure. Studies carried out have shown that the quality of diets consumed by people in the UK and USA during the period 1911–1960 have been steadily increasing and consequently the growth rate of children also was increasing during the same period. After 1960, the growth rate of children did not show any significant improvement showing that the diet had been adequate for providing maximum growth in children. On the other hand, the rate of growth of children in the developing countries continues to be poor. The children are malnutritioned, emaciated and stunted.

Nutritional Status

Nutritional status is the state of our body as the results of the foods consumed and their use by the body. Nutritional status can be good, fair or poor.

The characteristics of good nutritional status are an alert, good natured personality, a well developed body, with normal weight for height, well developed and firm muscles, healthy skin, reddish pink colour of eyelids and membranes of mouth, good layer of subcutaneous fat, clear eyes, smooth and glossy hair, good general health. Apepite, digestion and elimination are normal. Well nourished persons are more likely to be mentally and physically alert and have a positive outlook on life. They are more able to resist infections than undernourished persons. They have extended years of normal functioning and ever increasing life expectancy.

Malnutrition

Malnutrition means an undesirable kind of nutrition leading to ill health. It results in a lack, excess or imbalance of nutrients in diet. It includes under nutrition and over nutrition. Under nutrition is a state of an insufficient supply of essential nutrients. Over nutrition refers to an excessive intake of one or more nutrients which creates a stress in bodily functions.

Causes of Malnutrition

1. Social factors
   (a) People themselves
   Income
   Ignorance
   Illiteracy
   (b) Increased birth rate results in over population
   (c) Cultural factors, food fads, attitudes, faulty food habits
   Religious beliefs
   Traditional child rearing practices
   Traditional cooking and eating habits
2. Agriculture
   (a) Lack of rain
   (b) Poor soil
   (c) Insects and pests
   (d) Inadequate storage facilities for food grains

Malnutrition can be primarily due to insufficient supply of one or more essential nutrients or it can be secondary, which means it results from an error in metabolism and drugs used in treatment.

Malnutrition is directly responsible for certain specific nutritional deficiency diseases like kwashiorkor, marasmus, vitamin A deficiency, anaemia, goiter etc. Good nutrition is therefore essential for prevention of disease and promotion of good health.

Resistance to Infection

Malnutrition predisposes the body to infections like tuberculosis. It also influences the course and outcome of many diseases. Infections in turn aggregate malnutrition and metabolism.

Mortality and Morbidity

The indirect effect of malnutrition on the community are long lasting. A high general death rate, high infant immorality rate(IMR) high sickness rate and lower life expectancy, over nutrition is responsible for obesity, diabetes, hypertension, cardiovascular diseases, renal diseases and diseases of the liver and gallbladder.

Thus, food plays a prominent role in providing physical, mental and social well being which is the WHO definition of health.

CLASSIFICATION OF FOOD

1. Based on its origin
   a. Foods of animal origin
   b. Foods of vegetable origin

Based on Chemical Composition

a. Proteins
b. Fats
c. Carbohydrates
d. Minerals
e. Vitamins

Based on its Function

a. Body building foods – amino acids, proteins
b. Energy giving foods – carbohydrates (wheat, rice)
c. Protective foods – vitamins and minerals (vegetables)

Based on Nutrition Value

Five Food Group System

a. Cereals and millets
b. Pulses and legumes
c. Milk, milk products and meat
d. Fruits and vegetables
e. Fats and sugars

Based on their functions, foods are grouped into energy-yielding foods, body building foods and protective foods. Carbohydrates, fats and proteins release energy on metabolism in our body.

Cereals like rice, wheat, ragi and maize, roots and tubers like potato, sweet potato and tapioca are good sources of carbohydrate. Fats are more concentrated source of energy. Proteins are considered as body building food even though they can supply energy as well. Protein, calcium, phosphorus, iron and water are body building nutrients.

Protein foods like milk, meat, fish, eggs, pulses, grams and nuts are essential to build our tissues and to form blood.

Our body functions are regulated by water, minerals and vitamins. They are called the protective foods. Water is necessary for various body processes.

Vitamins are essential for regulating the body processes such as growth, muscular coordination of various organs and functions of several organs like eyes, ears, nose and skin.

Minerals like Ca help in controlling blood clotting, muscular contraction and for efficiency of heart muscles. Iron is essential for blood formation. Iodine is necessary for regulating body functions through the thyroid gland.

Food Guide Pyramid—A Guide to Daily Food Choices

One of the most helpful, easy to use diet planning tools is the food guide pyramid (Fig. 21.1) which separates foods into specific groups and then specifies the number of servings form each

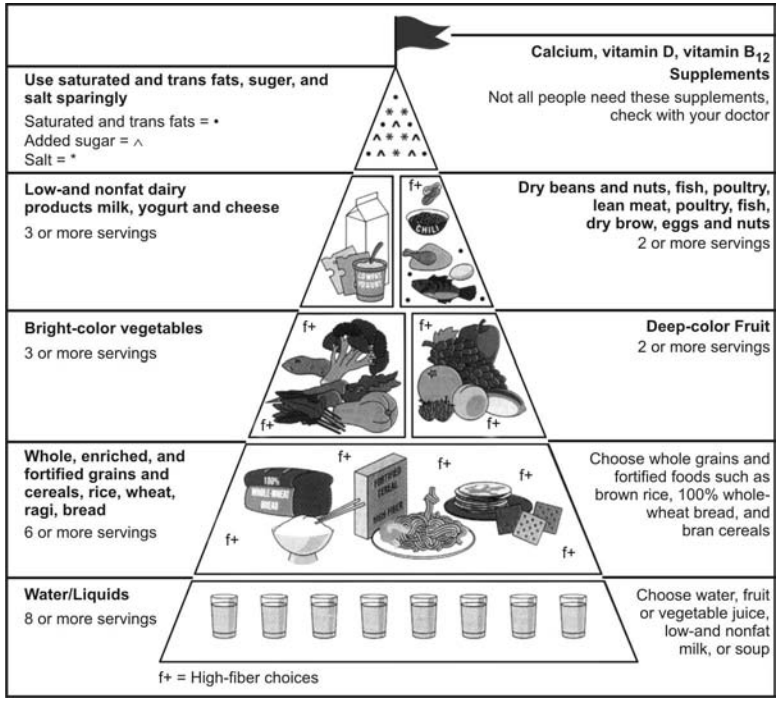


Fig. 21.1: Food guide pyramid for older adults

group to each day. The placement of this five food groups on the pyramid emphasizes their role in the diet. The grains that form the base should serve as the foundation of a healthy diet because breads, cereals, rice and wheat are high in carbohydrates and low in fat. The grains are followed by fruits and vegetables which supply the vitamins, minerals and fibre. The next level suggests eating smaller amounts of dairy products as well as meat, poultry, fish, beans, eggs and nuts. While foods from these group provides proteins, calcium, iron, zinc and other nutrients, they often contain large amount of fat and should be chosen carefully.

Not considered one of the food groups, the tip of the pyramid consists of fats, oils and sweets. They supply lot of fat and/or calories and few nutrients. These items should be added to diet sparingly.

Calorie

The qualitative food requirements are estimated in term of energy is calories.

Physiologic calorie or kilocalorie is the unit of energy, which is the amount of heat necessary to raise the temperature of one kilogram of water by 1ºC, from 14.5ºC to 15.5ºC. This is 1000 times the physical calorie unit. The international unit of energy is Joule. 1 kilocalorie = 42 kilojoules

Calorie Value of Food

	(kilocalories/gm)
Carbohydrates	4
Fat	9
Proteins	4

RESPIRATORY QUOTIENT (RQ)

The Respiratory Quotient (RQ) is the ratio of the volume of CO_2 eliminated to the volume of O_2 utilized.

$$RQ = \frac{\text{Volume of } CO_2 \text{ eliminated}}{\text{Volume of } O_2 \text{ utilized}}$$

Carbohydrates

The RQ is 1 because in carbohydrates diet, the volume of CO_2 produced is the same on the volume of O_2 consumed.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

$$\frac{CO_2 \text{ produced}}{O_2 \text{ consumed}} = \frac{6}{6} = 1$$

Fats The RQ for fat is 0.7
Protein RQ for protein is about 0.8

Mixed Diets

In mixed diets containing varying proportions of proteins, fats and carbohydrates, the RQ is about 0-85.

Clinical Conditions

RQ increases in acidosis and fever. RQ decreases in alkalosis, uncontrolled diabetes mellitus and starvation.

Significance of RQ

RQ denotes the type of food burning in the body.

FACTORS AFFECTING ENERGY EXPENDITURE

1. The Basic Metabolic Rate (BMR)
2. Specific Dynamic Action (SDA) or the Thermogenic effect of food.
3. Physical activity
4. Environmental temperature.

THE BASAL METABOLIC RATE (BMR)

The BMR is the energy expenditure necessary to maintain basic physiologic conditions such as:

a. The activity of the heart
b. Respiration
c. Conduction of nerve impulses
d. Ion transport across membranes
e. Reabsorption in the kidney, and
f. Metabolic activity such as synthesis of macromolecules under standard conditions.

About 60% or more of the energy the average person spends goes to support the ongoing metabolic work of the body's cells,

the basic metabolism. This is the work that goes on all the time, without conscious awareness. The beating of the heart, the inhaling and exaling of air, the maintenance of the body temperature and sending the nerve and hormonal messages to direct these activities are the basal procedures that maintain life. Basal metabolic needs are surprisingly large. A person whose total energy expenditure amounts to 2000 calories per day spends as much as 1200–1400 calories to support usual metabolism.

Definition of BMR

BMR is defined as the energy expenditure of a subject at complete physical and mental rest, awake (and not during sleep) having normal body temperature and in the post absorption state (12 hours after the last meal) and 8–12 hours after any significant physical activity.

Measurement of Basal Metabolism

Basal metabolism can be measured by:

a. Calorimeter directly by measuring the heat dissipated under basal conditions (or)
b. Indirectly by measuring oxygen consumption.

Factors Affecting BMR

BMR differs among different individuals. It depends on:

a. Variable factors
b. Invariable factors

Variable Factors Affecting BMR

a. *Nutritional state:* BMR is low in starvation and under-nourishment as compared to well fed state. Starvation leads to an adaptive decrease in BMR, which results from a decrease in lean body mass.
b. *Body size or surface area:* The BMR is directly proportional to the surface area of the subject. Larger the surface area, greater will be the heat loss and equally higher will be the heat production and BMR.
c. *Body composition:* The BMR is proportionate to lean body mass (LBM). LBM is the body weight minus non-essential (storage

triacyl glycerol) weight. Adipose tissue is not as metabolically active as lean body mass. BMR is often expressed as per kilogram of lean body mass or fat free mass. Therefore, higher the percentage of adipose tissue in the body lower the BMR/ kg body weight.

d. *Endocrinal or hormonal state*: In hyperthyroidism, the BMR is increased and in hypotheproidism it may be decreased by upto 40%, leading to weight loss.
e. *Environmental temperature or climate:* In colder climate the BMR is higher and in tropical climate the BMR is proportionately low. Stress, anxiety and disease states, especially infections, fever, burns and cancer also increases the BMR.
f. *Drugs:* Smoking (nicotine), coffee (coffine) and tea (theophylline) increase the BMR whereas β-blockers tend to decrease energy expenditure.

Invariable Factors Affecting BMR

a. *Gender or sex:* The BMR of males is slightly higher than that of females particularly due to:
   i. Womens lower percentage of muscle mass (lean body mass) and higher percentage of adipose tissue (that has lower rate of metabolism) when compared to men of the same body weight, and
   ii. The difference in sex hormone profile of the two genders.
b. *Age:* Decrease in BMR with increasing age is probably related to loss of muscle mass (lean body mass) and replacement of muscle with adipose tissue that has lower rate of metabolism.

Normal Value of BMR

BMR values are expressed as K cal or KJ per square meter of body surface per hour. In adults BMR for :- Healthy males is 40 K cal (168 KJ) per hour and healthy females is 37 K cal (155 KJ) per hour.

This means that the total caloric expenditure in 24 hours to complete basal state is 1800 K cal (7500 Kj) for adult males and 1400 K cal (5859 KJ) for females assuming that the total body surface across are 1.8 sqm and 1.6 sqm respectively.

Clinical Applications of BMR

a. BMR estimation is used to diagnose thyroid disorders.
b. BMR is used in calculating food and drugs.

THE THERMOGENIC EFFECT (Specific dynamic action, SDA) OF FOOD

Another component of energy expenditure in man is the diet induced thermogenesis also known as postprandial themogenesis.

This is the energy expended in the digestion, absorption, storage and subsequent processing of food. This is called thermogenic effect of processing of food because these processes require energy and generate heat. The thermogenic effect of food is equivalent to almost 5 to 10% of total energy expenditure.

This effect was originally attributed solely to the metabolic processing of protein and was termed specific dynamic action (SDA) but is now recognized as an effect produced by the consumption of all dietary fuels.

The consumption of protein produces the greatest increase in energy loss compared to fat or carbohydrates as shown below:

Protein	20 – 30% intake
Fat	2.5 – 4% of intake
Carbohydrate	5 to 6% of intake

PHYSICAL ACTIVITY

Physical activity is the largest variable affecting energy expenditure and represents 20–40% of the energy expenditure.

The energy requirements of an adult in India was reviewed by the "Expert group" of the FAO / WHO in terms of reference man and reference woman. The reference man is in the age group of 20-39 years. With a weight of 55 Kgs without any disease and with a capacity to perform 8 hours of moderate activity. When not engaged in work, a reference man spends 8 hours in bed and 4 to 6 hours in moving around or in a sitting position and 2 hours either walking or doing household activities.

In the case of a reference woman, the difference is only in her body weight (45 Kg). Instead of the physical activity of the occupation, the woman does household duties. Other conditions are the same in case of a reference man.

The energy expenditure for men and woman is calculated considering their internal and external activities. The FAO /WHO expert group (1983) made the following recommendations (Table 21.1).

Table 21.1: Energy allowances for various groups

Category	*Reference body weight*	*Activity*	*Energy allowances*	*K cals*
Man	55 kg	Light	2400	
		Moderate	2800	
		Heavy	3900	
Woman	45 kg	Light	1900	
		Moderate	2200	
		Heavy		
	Pregnancy	2nd and 3rd Trimester	+ 300	
	Lactation	First 6 months	+ 550	
		6–12 months	+ 400	25

Additional energy is needed for the growth of the foetus, placenta and tissues during pregnancy. The BMR is also increased due to increased internal activities. Daily 150 K cals during the first semester and 300 K cal during the rest of the pregnancy is recommended. The energy cost during the term of pregnancy is 62,500 K cals. Additional energy requirements during lactation is for the secretion of milk. For a normal output of 850 ml per day, during the first six months, 550 K cal per day is recommended.

The activities which demand maximum energy are in the following order.

Walking very fast, severe exercise, running, swimming, sawing wood, labourer's work, carpentry, metal and industrial work, walking slowly, laundry work and ironing.

Classification of Activities Based on Occupation

Sedantary Male

Teacher, tailor, priest, executive, shoe maker, retired personnel, landlords peon.

Female: Teacher, nurse, house wife, executive.

Moderate Male

Fisherman, weaver driver, porter, fitter, turner, carpenter, agricultural labourer.

Female : Servant maid, basket maker, beedi maker.

Heavy male: Stone cutter, blacksmith, mineworker, wood cutter.

Female: Stone cutter etc.

Environmental Temperature

Environmental temperature affects the metabolic rate. Low temperature increases energy expenditure by inducing shivering and non-shivering thermogenesis.

Shivering provides a regulated means of producing heat by measuring muscle activity in response to cold stress.

Another mechanism, non-shivering thermogenesis can also produce heat in response to cold stress. The site of non-shivering thermogenesis is the brown adipose tissue.

High temperature also has an effect on energy expenditure by increasing heat loss through sweating.

Calculating the Energy Requirements for Indians

Important factors for the calculation of the daily energy requirement are sex, height, weight and activity.

BODY MASS INDEX : QUETELETS INDEX

The basal mass index is used as a reference standard for assessing the prevalence of obesity in the community.

$$\text{BMI} = \frac{\text{Weight in kg}}{\text{Height in meters}}$$

Ideal body mass index for Indian woman = 19–24
Ideal body mass index for Indian man = 20–26

Once the BMI exceeds the normal limit, the person can be termed as overweight or obese.

CHAPTER

22 Carbohydrates: Sugar, Starch and Fibre

CARBOHYDRATES

They are widely distributed in plants in which they are formed from carbon dioxide of the atmostphere by photosynthesis.

Sources of Carbohydrates

Following are main sources of carbohydrates:

1. *Starches:* These are present in cereals, roots and tubers e.g., Rice, wheat, ragi, pulses, potatoes, tapiaco, yam and colassia.
2. *Sugars*
   a. Monosaccharides (simple sugars) glucose, fructose and galactose
   b. Disaccharides (Double sugars) sucrose, lactose, maltose.
   c. Polysaccharides (Complex carbohydrates) e.g., cellulose.

Functions of Carbohydrates

1. They supply energy for body functions and for doing work and for the cells. They burn in the body at the rate of 4 k cals/gm.
2. They are essential for the absorption of fats.
3. They have a sparing action on proteins.
4. They provide carbon skeleton for the synthesis of some non-essential amino acids.
5. Some carbohydrates are present in some tissue constituents.
6. They add flavour to the diet.

Special Tissue Function

Carbohydrates serve many special functions in many body tissues and organs.

Liver: Glycogen reserves in the liver and muscles provide a constant exchange with the body's over all energy balance systems. These reserves especially in the liver, protect cells from depressed metabolic functions and resulting injury.

Protein and Fat: Carbohydrates helps regulate both protein and fat metabolism.

REQUIREMENTS

No daily allowances has been fixed for carbohydrates. The body has specific need for carbohydrates as a source of energy for brain and other tissue cells.

The carbohydrates calorie should be atleast 40% in a well balanced diet. The range of carbohydrates requirements are as below:

Adults	50–70%
Expecting and lactating mothers	40–50%
Infants	40–50%
Preschool children	40–60%
Other children and adolescents	60–70%

A minimum of 100 g carbohydrates are needed in the diet to ensure efficient oxidation of fat. Most diets supply more. If the proteins supply about 10% of the calories, fats 20%, then carbohydrates must supply the remaining 70% calories. Being the cheapest source of food energy, it supplies upto 80% of the calories in the low cost Indian food.

Reserve Fuel Supply

Glycogen reserves supply the back up fuel. The total amount of carbohydrate in the body, including both glycogen and blood glucose is relatively small. Without constant supply, the total amount of available glucose only provides enough energy for only half a day of moderate activity. Therefore to maintain a normal blood glucose level and prevent breakdown of fat and protein in tissues, individuals must eat carbohydrate rich food regularly to meet their energy requirements.

Dietary Fibre: Uses

This is the high fibrons lining found in vegetables, fruits and cereals. It is hard to digest and has no nutrition value.

Fibre has two forms – Insoluble and Soluble.

Insoluble fibres: The type in wheat bran hold water in the colon, thus increasing bulk, which stimulates the muscles of the digestion tracts so that they retain their health and tone.

The toned muscles can move easily more waste products through the colon for excretion. This prevents constipation.

1. Soluble fibres, the type in beans and oats reduce the risk of heart and artery disease – atherosclerosis, by lowering the level of cholesterol in the blood.
2. It helps prevent constipation by forming large bulk of faces and helps in GI motility (roughage action).
3. Dietary fibre improves glucose tolerance by the body. It diminishes the rate of glucose absorption from intestine.
4. Soluble fibre found in the legumes and fruits like gums and pectins can lower blood cholesterol probably by binding to bile acids and dietary cholesterol, thus preventing their absorption.
5. By increasing bulk and needing more chewing, cellulose may reduce the food intake. Thus it can help obese persons to reduce total energy intake and loose weight.
6. *Satiety Value:* Fibre add bulk to the food stuff and gives a sensation of fullness of stomach. Thus satiety is achieved without consumption of excess calories.
7. It also slows down carbohydrate absorption thereby reducing blood glucose and insulin need of diabetics.
8. Large soft stools dilute potential carcinogens. Rapid transit of stools may reduce the content of carcinogens in colon mucosa and thus reduce the risk of colon cancer.

Adverse Effects of Diatary Fibres

1. Intestinal absorption of some minerals and trace elements is decreased.
2. Intestinal bacteria ferment some fibres causing flatulence and abdominal discomfort.
3. An excessive intake of fibre results in intestinal obstruction, if it is not accompanied by water.
4. If fibre intake is suddenly increased, complaints like craming, diarrhea, excessive instenal gas are common. To minimize these effects, fibre content of diet should be gradually increased over a period of several weeks.
5. Dietary fibre is best taken from natural foods and not from fibre supplements. Food source provide a variety of fibres, vitamins and minerals in combination, whereas fibre supplements do not supplement any nutrients.

SUGAR SUBSTITUTES

Artificial sweetners are used by people who wish to reduce their calorie intake. Two commonly available sugar substitutes are saccharin and aspartame.

a. *Saccharine:* O-sulphobenzimide. It is 300-500 times as sweet as sucrose and pass through the body unchanged. It has been used in beverages and desserts. It has no adverse effects. The only drawback is it leaves a bitter after taste.
b. *Aspartame:* is a dipeptide of two amino acids, aspartic acid and phenyl alamine. Its trade names are Neutra sweet and equal. As the dipeptides are unstable to heat, this sweetner cannot be used cooked and baked foods. People who suffer from phenyl ketonuria (PKU) should avoid aspartame.

Carbohydrate Excess: Clinical Problems

1. *Obesity:* It is very easy and common to eat sweets, mithais, candy and soft drinks in excess of one's needs. Most of these contain excess of carbohydrates. When the energy intake exceeds expenditure, the excess is deposited as fat leading to obesity and over weight. Obsesity is a predisposing factor for a number of health problems.
2. *Dental caries:* If sugar remains in contact with teeth, it can lead to tooth decay. If it is not checked, it may lead to dental caries. Chewing sweets makes it remain longer periods, unless children are taught to rinse their mouth thoroughly after eating candy as also food.

CHAPTER

23 Nutritional Aspects of Fats

Dietary fats are divided into two types:
- Visible fats – butter, ghee, oil.
- Invisible fats – Egg, fish, meat, cereals, oil seeds.

Important Sources of Fats

RICH SOURCES	FAT %
Pure oils and fats	100
Ghee and vanaspathi	100
Butter	80–81
Good sources:	
Nuts and oil seeds	40–60
Milk powder	26
Eggs	14
Meat and fish	10–15
Fair sources:	
Cow's milk	4
Buffalo milk	7
Whole pulses	3.5
Whole cereals and millets	2.3

Fat Requirements of Individuals

1. Infants: Birth to one year	25 to 30% of total calories from fat.
2. Children and adolescents (1 to 18 years)	15 to 20% of total calories from fat.
3. Adults expectant and nursing mothers	10 to 20% of total calories from fat.

Atleast 50% of the fat should consist of oils rich in essential fatty acids (EFA).

Fat is Required for

1. Energy needs, and
2. Essential fatty acid needs. About 10% of the total energy need is met by the invisible fat in the diet.

A minimum of 5% of the total energy is needed as visible fat. This works out 12g of fat per day. A higher level intake of 20g per day is desirable to provide energy density and palatability for normal adults. To meet the EFA needs, the diet should contain at least 20g of vegetable oil, which is an excellent source of juice of linolec acid (EFA).

An upper limit of 20g per day of fat intake is desirable to prevent heart ailments. Recommended fat intake is 20 – 30% daily calorie requirement which should contain about 30% PUFA (Polyunsaturated fatty acids). Visible fat should be restricted to 10% to be calorie intake.

FUNCTIONS OF LIPIDS

The lipids present in the diet and animal and human body are:

1. Triglycerides (neutral fats).
2. Phospholipids, and
3. Cholesterol (present only in animal fats).

FUNCTIONS OF TRIGLYCERIDES [NEUTRAL FAT]

1. It is a concentrated source of energy yielding 9 kcal/gm i.e., more than twice the energy supplied by carbohydrates and proteins per unit weight.
2. 95% of lipids in food is triglycerides.
3. Fats reduce the bulk of the diet as they produce twice as much calories as carbohydrates per unit weight. Further starchy food absorbs a lot of water during cooking and reduces the bulk of the diet.
4. Fat is essential for absorption of fat soluble vitamins, i.e. vitamins A, D, E and K especially carotenoids (provitamins).
5. Some animal fats e.g., Mutton and fish liver oils are good sources of vitamins A. Most vegetable fat are good sources of vitamins E. Red palm oil is a good source of carotene. Contain vegetable fats are rich sources of essential fatty acid, e.g. linoleic acid.
6. Fats are deposited in the adipose tissue and serve as a reserve source of energy during starvation and illness. Further, adipose

tissue functions as an insulating material against cold and physical injury.
7. Fats provide aroma and flavour to food. Fats improve the palatability and gives a feeling of fullness to the stomach.

FUNCTIONS OF PHOSPHOLIPIDS

a. They are present in plasma in combination with proteins and lipoproteins which are involved in the transport of fat and cholesterol.
b. They are important constituents of all membranes to different substances.
c. They are concerned with selective cation transport across the erythrocytic membrane.
d. They form a part of certain enzymes, e.g., Cytochrome oxidate, succinic oxidase.
e. They are present in the nutochondria in large amounts and are essential for the organization and function of the mitochondrial electron transport system.
f. They are essential components of thromboplastin a factor in blood coagulation.
g. They are present in large amounts in nerve tissues and essential for their function.

Functions of Cholesterol

a. As a precursor of bile acids.
b. Precursor for some steroids.
c. As a precursor for the formation of dehydro-cholesterol in the skin for coversion to vitamin D by UV rays present in sunlight.
d. It is present in all membranes and is essential for maintaining the cell membranes in good condition.
e. Present in large amounts in the nerve tissues and is essential for their function.

Essential Fatty Acids

Deficiency of essential fatty acids leads to the cessation of growth and development of the skin and hemorrhage. Scales also develops on the dorsal and plantar surfaces of feet and around the ears. Hair is lost from the face and the back, blood may appear in the urine.

PHRYNODERMA: EFA DEFICIENCY

It is also known as "toad skin". This condition is characterized by the presence of horny papular eruptions on the posterior and lateral aspects of the limbs, on the back and buttocks. Phrynoderma is rapidly cured by the administration of linseed or sunflower seed oil, rich in essential fatty acids (EFA) along with vitamin B complex.

EFA Deficiency also Affects

a. Integrity of cell membranes and cell functions.
b. Certain enzyme systems.
c. Reproduction and lactation.
d. Transfer of cholesterol and.
e. Water balance.

EFA Contents of Vegetable Sources

Sunflower, niger seed, cotton seed, linseed, corn, walnut, sesame and soyabean oils are rich sources of EFA (40 – 78%) These oils must form atleast 50% of fat in diet.

FATS AND HEART AILMENT

Fat is essential for health, but too much of its is harmful. The well to do section of Indians have a high intake of saturated fats from milk, sweets, egg and meat. They lead a very sedentary life style. Their energy intake is in excess of actual needs which leads to obesity and dangerous plasma lipid profiles. If unchecked this causes atherosclerosis, high blood pressure and many cardiac diseases. Reducing total fats and saturated fats and maintaining a low – cholesterol diet are necessary for disease prevention and health promotion.

TO LOWER BLOOD CHOLESTEROL LEVELS

1. Eat no more than 30% calories as fat.
2. Eat no more than 8-10% of calories as saturated fat.
3. Eat no more than 10% calories as polyunsaturated fats.
4. Monounsaturated fats must make upto 10-15% calories.
5. Limit daily cholesterol intake to less than 300 mg.

CHAPTER

24 Proteins

Proteins are classified into complete proteins, partially incomplete proteins and incomplete proteins based on the presence of essential amino acids in them. The presence of amino acids helps a protein to perform all functions of proteins in our body. A complete protein food contains all essential amino acids in correct proportions. It helps the protein to promote growth, maintenance and repair.

Examples of complete protein foods are fish, egg and milk.

Partially incomplete proteins lack some essential amino acids and so they will help to maintain our body but growth is not promoted. Vegetable proteins are good examples.

Incomplete proteins neither help maintenance nor growth. Gelatin is an example.

When a mixture of protein from different sources is consumed, mutual supplementation takes place. For example rice or wheat protein is low in lysine whereas pulse is rich in lysine and low is methionine. Rice is rich in methionine and a neutral supplementations results when rice and pulse are consumed together.

PROTEIN QUALITY

Protein quality depends on the kinds and amounts of essential amino acids present in the food proteins. Qualitative data regarding the suitability to meet the protein requirements of the body have been obtained by the experiments on animals and human beings.

BIOLOGICAL VALUE (BV)

It measures the quality of dietary proteins utilized by the animal for meeting its protein needs for maintenance and growth. Groups of albino rats (28 days old) were fed successively on the following diet for a period of 10 days (1) Protein free diet and (2) diet containing

10% of protein to be tested. Urine and faeces were collected by keeping the rats in metabolism cages. Records of food intake were maintained. The diet, urine and faeces are analysed for nitrogen.

$$\text{Biological value} = \frac{\text{Nitrogen digested} - \text{Nitrogen lost in metabolism x 100}}{\text{N retained by the body (dietary N} - \text{faecal N)}}$$

The quality of protein is directly related to BV. The BV increases with the increase in the percentage of nitrogen absorbed being retained. The BV of milk is 84, brown rice is 73 and whole wheat is 65.

NET PROTEIN UTILISATION (NPU)

Net Protein Utilisation is the digestability of protein multiplied by its BV.

PROTEIN EFFICIENCY RATE (PER)

Protein efficiency rate is not based on intake and output of food protein residues. Therefore, it is less accurate than BV and NPU. But the technique is easy and also easy to use. In this method, a known amount of test protein in an adequate diet is fed to young rats for four weeks under standard conditions and the weight gain is determined. The PER is obtained by dividing the weight gain by grams of protein fed.

$$\text{PER} = \frac{\text{Weight gain in grams}}{\text{Protein fed in grams}}$$

The PER of milk is 3 and polished rice 2.2

CHEMICAL SCORE

Chemical score is the ratio between the content of the most limiting amino acid in the test protein to the content of the same amino acid in egg protein expressed as a percentage. Since egg protein contains all essential amino acids in adequate amounts and posesses the highest nutrition value among dietary proteins, it is given the chemical score of 100.

The most limiting amino acid in milk is the S-amino acids. Chemical score of milk protein is

$$\frac{3.4}{5.5} \times 100 = 65$$

The chemical score of gelatin and zein is zero.

RECOMMENDED DIETARY ALLOWANCE

The requirement of the body for protein as recommended by nitrogen balance studies is 0.5 to 0.6 g/kg of the body weight in adults when the source of protein supplies amino acids in the proportion needed by the body. In practice, the supply may not be in the required proportions. Therefore, the recommended dietary allowance of protein is raised to 1.0 g/kg body weight for adults. The daily recommended protein intake for normal men, women and children and at the time of pregnancy and lactation is shown in Table 24.1.

During infancy, pregnancy and lactation, there is an increased demand of protein for growth. Persons suffering from burns or wasting diseases such as tuberculosis and rheumatic fever also need additional protein for regulation of wasted tissues. Similarly, more protein in the diet is required in case of blood losses due to excessive menstruation, haemorrhages and blood donation.

RECOMMENDED INTAKE OF PROTEIN

Table 24.1: Daily recommended protein intake

Particulars of the Individual	*Proteins in gms per day*
Man (60 kg)	60
Woman(50 kg)	50
Woman, pregnant (later half of pregnancy)	65
Woman, nursing mother 10 to 6 months of lactation	75
Infant 0 – 6 months	21 g/kg body weight
Infant 7 – 12 months	1.6 g/kg body weight
Children 1 – 3 years	21
Children 4 – 6 years	29
Children 7 – 9 years	40
Girls 13 – 15 years	67
Girls 16 – 18 years	60
Boys 13 – 15 years	67
Boys 16 – 18 years	75

DIETARY SOURCES OF PROTEINS

Protein content of some common food stuffs is shown in Table 24.2.

Plant Sources

Cereal grains, pulses, nuts, legumes.

Animal Sources

Meat, fish, poultry, eggs, milk and milk products.

Table 24.2: Protein content of some food stuffs

Food stuff	*Protein content in gms/100 gms*
Plant foods	
Bengal gram dal	20.8
Black gram dal	24.0
Cow pea	24.1
Green grams	24.5
Horse gram	22.0
Khesari dahl	28.2
Soya bean	43.2
Ground nut	25.0
Cashew nut	21.2
Almond	20.8
Pistachio	19.8
Walnut	15.8
Animal foods	
Milk	3.2
Meat	18.0
Egg	13.0
Fish	15.0
Paneer	18.3

FUNCTIONS OF PROTEINS

1. Primary Tissue Building

Protein is the fundamental structural material of every cell in the body. The primary functions are to repair the worn out, wasted or damaged tissue and build up new tissue. Thus, protein meets the growth needs and maintains tissue health during adult years. In addition to body building functions, protein has other body functions related to energy, water balance, metabolism and body's defence mechanism.

Energy System

Carbohydrates are the primary fuel source for the body assisted by fat as stored fuel. In times of need (e.g., Starvation) protein may also furnish additional fuel to sustain heat and energy. Fuel supplied by protein is 4 k cal/gm (like carbohydrates).

Water Balance

Plasma proteins, especially albrumin helps to control water balance throughout the body by exerting osmotic pressure to maintain internal circulation of body fluids and capillary blood flow.

Metabolism

Protein aids metabolic functions through enzymes, hormones and transport agents. Digestive and cell hormones are hormones that control metabolic functions. Enzymes are necessary for the digestion of Carbohydrates (amylase) fats (lipase) and proteins (proteases) are all proteins. Proteins also act as vehicles in which nutrients are carried throughout the body. Lipoproteins are necessary to transport fats in the water soluble blood supply. Other examples are haemoglobin and transferrin, the iron transport proteins in blood. Hormones such as insulin and glucagen are also proteins that have a major role in the metabolism of glucose.

The Body Defence System

Protein is used to build special white blood cells (lymphocytes) and antibodies as part of body's immune system to help defend against infection and diseases.

Energy Supply

A small part of body's need for energy (about 6 to 12%) is supplied by products of protein metabolism.

PROTEIN-CALORIE MALNUTRITION IN CHILDREN

Deficiency of protein foods during growth period produces kwashiorkor and marasmus (Table 24.3). Protein calorie malnutrition is one of the largest nutritional problems of India.

SALIENT FEATURES OF KWASHIORKOR AND MARASMUS

Table 24.3: Features of kwashiorkor and marasmus

Kwashiorkor	*Marasmus*
1. Moderate to severe failure or growth	1. Severe muscle wasting
2. Lack of proper involvement of muscle and lack of muscle tone	2. Lack of subcutaneous fat
3. Presence of oedema, potbelly in children	3. High incidence of diarrhoea
4. Dry and flaky skin	4. Severe growth failure
5. Hair turns reddish	5. Decreased blood protein
6. Anorexial diarrhoea	6. Skin changes
7. Low hemoglobin level	7. General severity leads to mental retardation
8. Decreased production of amylase, trypsin and lipases	8. Period of recovery is much longer
9. Patient recovers within a short period of time	

TREATMENT AND PREVENTION OF PROTEIN CALORIE MALNUTRITION (PCM)

1. In developing countries, breastfeeding should be encouraged to ensure adequate supply of nutrients and antigens.
2. Food stuffs that contain sufficient amounts of amino acids should be provided.
3. Improvement of sanitation and programme of immunization.
4. Fluids with electrolytes of sodium and potassium to maintain electrolytic balance.

EFFECT OF EXCESS

When diet rich in protein are eaten, the excess protein is oxidized and nitrogen is excreted as urea. The excess protein is used mainly as a source of energy. Prolonged feeding of high protein diets will be a strain on the kidneys and may produce

hypertrophy of the kidneys. The diet consumed by Eskimos provide practical evidence that human beings can maintain good health over long periods of high protein diets. Human beings may live on meat alone for a year when sufficient fat was supplied as a source of calorie.

PROTEIN EXCESS: CHEMICAL PROBLEMS

Though protein is a vital need of the body, intake of excess creates stress on the body function. The liver has to deaminise the excess amino acids and synthesis urea. The loss of calcium in urine is increased with high protein intake. High protein from animal foods carries undesirable saturated fats also along with it.

As protein foods are expensive, their increased intake might lead to lesser intake of nutrient rich foods and thus, reduce the quality of the diet. Adequate protein is good but excess is not desirable.

CHAPTER

25 Mineral Metabolism

Minerals are inorganic elements required for a variety of functions. The minerals required by the human body are grouped into macrominerals and microminerals (trace elements) (Table 25.1). The macrominerals are required in amounts in excess of 100 mg/day. The microminerals are required in amounts less than 100 mg/day.

Table 25.1: Minerals required in human nutrition

Macrominerals	*Microminerals or Trace elements*
Calcium	Iron
Phosphones	Copper
Sodium	Iodine
Potassium	Manganese
Chlorine	Zince
Magnesium	Moybdenum
Sulphur	Cobalt
	Fluorine
	Selinium
	Chromium

Calcium is the most abundant mineral present in the body.

Dietary Sources: Milk and milk products, meat, fish, cereals, pulses and green leafy vegetables.

Recommended Dietary Allowance (RDA) Per Day

Infants	300–500 mg/day
Children	800–1200 mg/day
Adults	800 mg/day

Women during pregnancy and bactation and teenagers 1200 mg/day.

Absorption

Mainly occurs in duodenum by energy dependent process. Absorption is increased by:

a. Vitamins D through its active form calcitriol is 1/25 dihydroxy cholcaliferol. It induces the synthesis of calcium binding protein in the intestinal epithelial cells and promotes calcium absorption.
b. Gastric acidity, sugars like lactose promote calcium uptake by intestinal cells.

Absorption is decreased by oxalates, phytates, fatty acids – These form insoluble salts with calcium.

Distribution

Total content in the body = 1 to 1.5 kg.

99% is present in the bone and teeth as hydoxyapatite.

1% is present in blood and tissues.

Normal serum level 9 – 11 mg/100 ml.

Functions

Intracellular calcium is involved in:

a. Muscle contraction.
b. Release of hormones, neurotrausmitter and neuromodulators.
c. Activation of a number of enzymes.
d. Glycogen metabolism.
e. Cell division.

Extracellular calcium provide calcium ion for the:

a. Maintenance of intracellular calcium.
b. Bone mineralisation.
c. Blood coagulation.
d. Membrane excitability.
e. Plasma membrane potential.

Ca : P Product

The product of Ca and P is around 50 in children and 40 in adults. In rickets, it is less than 30. The product of Ca : P is important for calcification of bones.

CLINICAL SIGNIFICANCE

HYPERCALCAEMIA

Serum calcium level is more than 12 mg%. It is seen in hyperparathyroidism, hypervitaminosis 'D' and malignancies.

Features

Most patients have no symptoms but if untreated, they may develop kidney stone, polyuria, bone pain and pancreatitis.

HYPOCALCAEMIA

Hypocalcemia leads to osteoporosil and tetany.

Tetany

This is a more serious and life threatening condition. This provokes a characteristic hyperexcitable state of the nerves and muscles called tetany.

Symptoms include numbness of extremities, nerve irritability and spasms of muscles.

Causes

- Hypoparathyroidism
- Rickets
- Osteomalacia

Total serum calcium level may be less than 7 mg%.

OSTEOPOROSIS

Increased demineralization of bones. Therefore, there is a less of bone mass. Seen in elderly people, postmenopausal women. Results in increased incidence of fractures.

Treated with calcium, vitamin D supplementation and estrogen asministration.

RICKETS

Defective calcification of bones. Decreased level of Vitamin D in the body. Decreased Ca and phosphate due dietary deficiency. Serum Ca and P levels are low Ca:P product is less than 30.

Increased alkaline phosphatase activity is seen.

PHOSPHORUS

Phosphorus is a widely distributed important element in the human body. Adults contain about 400-700gm of phosphorus, about 80% of which is combined with calcium in bones and teeth. It is present in the form of organic and inorganic phosphates.

Functions

a. *Constituent of bones and teeth inorganic:* Phosphorus is a major constituent of hydroxyapatite in bone, thereby playing an important part in structural support of the body.
b. *Acid-Base regulation:* Mixture of $HPO^{-}_{4}^{-}$ and $H_2PO_4^-$ constitutes the phosphate buffer for maintaining the pH of body fluids.
c. *Energy Storage and Transfer reactions:* High energy compounds e.g., ATP, ADP, creatine phosphate which store and transport energy.
d. *Essential constituent:* Phosphate is an essential part of phospholipids of cell membrane, include acids (RNA and DNA), nucleotides (NAD, NADP, C-AMP and C-CMP).
e. *Enzyme Action:* Phosphate present in nucleotides, some of which function as coenzymes are pyridoxal phosphate, thiamme pyrophosphate, NADP and flavin coenzymes.
f. *Regulation of enzymes activity:* Phosphorylation and dephosphorylation of enzymes modify the activity of many enzymes.

Dietary Sources: The foods rich in calcium are also rich in phosphorus namely milk, cheese, beans, eggs, cereals, fish and meat.

Recommended Dietary Allowance Per Day

800 mg/day for both men and women. The amount during pregnancy and lactation is 1200 mg/day.

Normal Values

Serum 3-4 mg% adults
4-6 mg% children

HYPOPHOSPHATEMIA

Seen in rickets, hyperparathyroidism.

HYPERPHOSPHATEMIA

Occurs in hypoparathyriodism, hypervitaminosis D and in renal failure.

SODIUM

Sodium is the major cation of the extracellular fluid. The total sodium in an average man 1.8 gm per kg weight, of which approximately 75% is exchangeable and 25% non-exchangeable, which is incorporated into tissues such as bone. Most of the exchangeable sodium is in the extracellular fluid. Normal serum Sodium Na^+ level is 135-145 mEq/L.

Functions

a. It maintains the osmotic pressure and water balance.
b. It is a constituent of buffer and involved in the maintenance of acid-base balance.
c. It maintains the muscle and nerve irritability.
d. It is involved in cell membrane permeability.
e. To raise the osmotic pressure thereby maintaining the volume of blood.
f. To regulate the electrolyte and pH balance of extracellular compartment.
g. To control electric potentials of excitable tissues such as nerve and muscle.
h. Helps in active transport of glucose, galactose and amino acids across the intestinal mucosa.

CLINICAL CONDITIONS RELATED TO PLASMA SODIUM LEVEL ALTERATION

HYPERNATREMIA

Hypernatremia is an increase in serum sodium concentration above the normal range of 135 to 145 mEq/L.

Causes of Hypernatremia

a. *Water depletion:* May arise from a decreased intake of or excessive loss with normal sodium content e.g., Diabetes insipidus.
b. *Water and sodium depletion:* If more water than sodium is lost e.g., Diabetes mellitus (osmotic diuresis) and excessive sweating and diarrhoea in children.

c. *Excessive sodium intake or retention:* In the ECF due to excessive aldosterone secretion e.g., Cohn's syndrome and Cushing's syndrome.

Symptoms of Hypernatremia

If hypernatremia is due to water loss, then the symptoms are therefore those of dehydration and if it is due to excess salt gain, it leads to hypertension and oedema.

HYPONATREMIA

Hyponatremia is a significant fall in serum sodium concentration below the normal range of 135-145 mEq/L.

Causes of Hyponatremia

a. *Retaining of water*: Retention of water dilutes the constituents of the extracellular space causing hyponatremia e.g., In heart failure, liver disease, nephritic syndrome, renal failure, syndrome of inappropriate ADH secretion (SIADH).
b. *Loss of Sodium*: This occurs only when there is pathological sodium loss. Such losses may be from gastrointestinal tract e.g., Vomiting, diarrhoea, fistula and in urine. Urinary loss may be due to aldosterone deficiency (Addison's disease).

Symptoms of Hyponatremia

Constant thirst, muscle cramps, nausea, vomiting, abdominal cramps.

Dietary Food Sources

Table salt (NaCl), fatty foods, milk, baking soda, baking powder, carrot and tomato.

Recommended Dietary Allowance Per Day

a. 1 to 5 gm.
b. 5 gm NaCl is recommended for adults without history of hypertension.
c. 1 gm of NaCl per day with history of hypertension.

NA^+ K^+ PUMP

Na^+, K^+ ATPase transports Na^+ from the intracellular compartments against electrochemical gradient. It also transports

K^+ intracellularly. The pump requires energy which is obtained from the hydrolysis of ATP. This in turn helps in maintaining high concentration of sodium in the extracellular fluid and potassium in the intracellular fluid.

POTASSIUM

Potassium is the main intracellular cation. About 98% of total potassium is in cells and 2% in ECF. Most of the body's potassium is found in muscles.

Dietary Food Sources

Fresh vegetables, fruits like oranges and bananas whole grain, meat, milk, legumes and tender coconut water. Average diet provides 4 gm K^+/day.

Recommended Dietary Allowances Per Day

2 to 5 gm.

SERUM POTASSIUM

The concentration is serum is 4.5 mEq/L. Serum potassium concentration does not vary appreciably in response to water loss or retention. But even a small change in intracellular potassium concentration will cause a big change in serum potassium contents.

Metabolic Functions

a. Potassium maintains the intracellular osmotic pressure, water balance and acid base balance.
b. It influences neuromuscular activity of cardiac and skeletal muscles.
c. Several glycolytic muscles need potassium for their formation.
d. Potassium is required for transmission of nerve impulses.
c. Nuclear activity and protein synthesis are dependent on potassium.

HYPERKALAEMIA

This is due to increased serum potassium and occurs in the following conditions:

a. Renal failure
b. Advanced dehydration
c. Addison's disease
d. Shock
e. Intravenons administration of excess amount of potassium.

HYPOKALAEMIA

This is due to low levels of serum potassium and occurs in case of:
a. Diarrhoea and vomiting.
b. Metabolic alkalosis.
c. Familial periodic paralysis.
d. Over activity of adrenal cortex (Cushing's syndrome).
e. Prolonged administration of deities because of excretion of potassium in urine.
f. During heart failure.

CHLORIDE

Chloride is the major anion in the extracellular space.

Dietary Food Sources

Common salt, whole grains, leafy vegetables, eggs, milk.

Recommended Dietary Allowance (RDA) Per Day

2 to 5 gm.

Normal Serum Level

95-110 mEq/L.

Functions

a. As a part of sodium chloride, chloride is essential for water balance, regulating osmotic pressure and acid-base balance.
b. Chloride is essential for the formation of HCl by the gastric mucosa and for activation of enzyme amylase.
c. It is involved in chloride shift.

HYPOCHLOREMIA

Seen in low salt diet, persistent vomiting, renal tubular damage, excessive sweating, Addison's disease.

HYPERCHLOREMIA

Seen in Cushing's syndrome, decreased renal flow, excessive saline therapy and excess steroid therapy.

SULPHUR

The body receives sulphur through the proteins as sulphur containing amino acids e.g., Methionine and cysteine.

Food Sources

Plant and animal proteins, legumes, eggs, cerials and cauliflower.

Functions

Sulphur is a constituent of

a. Protein.
b. Glycosaminoglycans e.g., Heparin and chondroitin sulphate.
c. Bile acids e.g., Taurocholic acid.
d. Compounds like insulin and glutathione.

Excretion

Sulphur is excreted by the kidneys in urine in the form of inorganic, organic and ethereal sulphate.

MAGNESIUM

Magnesium is the second most abundant intracellular cation after potassium.

Function

a. Magnessium is a co-factor for more than 300 enzymes in the body.
b. In the oxidative phosphorylation, glycolysis, cell replication, nucleotide metabolism, protein synthesis and many ATP dependent reactions.
c. Magnessium along with sodium, potassium and calcium controls the neuromuscular irritability.
d. It is an important constituent of bone and teeth.

Dietary Sources

Abundant in the chlorophyll of green leafy vegetables, cereals and meat.

Recommended Dietary Allowances (RDA) Per Day

RDA of the adult man is 350 mg/day and for woman it is 300 mg/day.

MICROMINERALS

Copper

Sources

Fish, liver, nuts, green vegetables, meat, egg. Milk is a poor source.

Dietary Requirement

2-3 mg/day

Function

a. Copper containing enzymes include cytochrome oxidase, lysyloxidase, tyrosinase.
b. It converts ferrous iron into ferric iron which is the transport form of iron.
c. It is necessary for the synthesis of haemoglobin.

Zinc

Sources

Meat, egg, fish, beans, nuts, oil seeds and vegetables.

Daily Requirement

15-30 mg/day.

Function

a. Zinc is a component of enzymes like
   - Carbonic anlydrase
   - Alcohol dehydrogenase

- Alkaline phosphatase
- Super oxide dismutase
- Carboxypeptidase
- DNA polymerase

b. Zinc is used for the storage and secretion of insulin from the B cells of pancreas. Zinc with insulin prolongs half life of insulin.
c. To maintain normal levels of Vitamin A helps in release of Vitamin A from liver into blood and thus increases its plasma level and its utilization in rhodopsin synthesis.
d. Zinc is important in taste sensation.
e. Zinc plays an important role in expression of genetic potential in synthesis, repair, structural integrity of nucleric acids.
f. Zinc stabilizes membrane structures and gives protection at the cellular level by preventing lipid peroxidation and reducing free radical formation.
g. Zinc is required for normal growth and reproduction.
h. Zinc is also included in native structure of insulin.
i. Zinc is an important element in wound healing as it is a necessary factor in the biosynthesis and integrity of connective tissue.
j. Zinc stabilizes structure of protein and nucleic acids.

Absorption and Excretion

Approximately 20 to 30% of ingested dietary zinc is absorbed in small intestine. It is transported in blood plasma mostly by albumin and α2-macroglobulin. Zinc is excreted in urine, bile, in pancreatic fluid and in milk in lactating mothers.

SELENIUM

Selenium is present in the body as selenium analogues of sulphur containing amino acids e.g., Selenomethionine, selenocysteine, selenocystine.

Sources

Liver, kidney, sea foods, cereals.

Requirements (RDA)

50-200 mg/day.

Functions

a. Along with vitamin E, it prevents membrane lipid peroxidation.
b. It prevents hepatic necrosis, muscular dystrophy.
c. Selenium acts as a prosthetic group of enzyme glutathione peroxidase which is present in cell cytosol and mitochondria and functions to reduce H_2O_2. This enzyme protects the cells against the damage caused by H_2O_2 and acts as an antioxidant.
d. To protect from carcinogenic chemicals.
e. It reduces the requirement of vitamin E.

SELENIUM DEFICIENCY

Causes liver necrosis, pancreatic degeneration, cardiomyopathy, muscular dystrophy and infertility.

Excess: Toxicity

Selenosis is due to excessive intake of selenium. It leads to weight loss, dermitis, diarrhoea and emotional disturbances.

IODINE

There are about 25 to 30 mg Iodine in the body. Of this about 33% is present in the thyroid gland. Skin and skeleton contain small amounts. Nearly half of the I_2 in the body is in the muscles.

Dietary Food Sources

Sea food, drinking water, iodized table salt, onions and vegetables grown in soils containing iodine.

Recommended Dietary Allowances Per Day

150 µg

Functions

Required for the synthesis of thyroid hormones thyroxine (T4) and triidothyronine (T3) T3 is more active than T4.

Deficiency Manifestation

Deficiency occurs in several parts of the world. In high altitude regions like Himalayan region, water plants and soil are deficient

in Iodine. A deficiency of Iodine in children leads to critinism and in adults, endemic goitre.

Goitre

Goitre is an enlarged thyroid with decreased thyroid hormone production. An Iodine deficiency in adults stimulates the proliferation of thyroid epithelial cells, resulting in the enlargement of the thyroid gland. The thyroid gland collects Iodine from the blood and uses it to make thyroid hormones. In Iodine deficiency, the thyroid gland undergoes compensatory enlargement in order to extract Iodine from blood more efficiently.

When mothers suffer from prolonged Iodine defiency, they give birth to babies, who are physically and mentally deformed.

Goitrogenic Factors

Excessive intake of cabbage, cauliflower and radish leads to Goitre. The compound responsible is 5-Vinyl 2-thio-oxazolidone which binds to Iodine.

Potassium iodide or Iodate is used for the fortification of table salt to prevent goitre.

IRON

Total body iron in an adult body is 3-5 gms. Iron containing compounds in the body are

a. Haemoglobin
b. Myoglobin
c. Catalase and peroxidase
d. Cytochrome, b,c, aa3
e. Ferritin and haemosiderin
f. Transferrin.

Sources

Liver, meat, fish, egg yolk, green leafy, vegetables, whole wheat, legumes, cashewnuts, molasses, dates. Milk is a poor source of Iron.

Recommended Dietary Allowance Per Day

For adult male	10 mg/day.
Adult female	18 mg/day to compensate per losses during menstruation.

Pregnancy and lactation 40 mg (to replemish the stores)
Children = 10-15 mg/day

Iron is stored in the liver spleen and bone marrow in the form of protein ferritin. Men have higher stores of ferritin than women.

Utilisation of Iron

Iron needs of the body is met by:
a. Use of Iron released from RBCs over and over again.
b. Absorption of Iron form diet.
c. Use of stores of ferritin.

Absorption of Iron from food takes place mostly in the duodenum and the small intestine. Only 3 to 10% of Iron is absorbed by a well nourished adult.

Iron found in the food is mainly in the ferric (Fe^{3+}) from which is bound to proteins or organic acids. In the acid medium provided by the gastric HCl. The ferric form is released from the foods. Absorbic acid and cysteine convert ferric iron (Fe^{+++}) to ferrous (Fe^{2+}) iron. Iron in the ferrous form is soluble and readily absorbed.

Factors which Promote Iron Absorption

Acidity, ascorbic acid, and cysteine increase Iron absorption.

Factors which Decreases Iron Absorption

Phytates, oxalate, phosphates, alkaline pH, malabsorption syndromes.

Transport in the Plasma

The Iron released from the mucosal cells enter the portal blood, mostly in the ferrous state. In the plasma, Fe^{2+} is oxidized rapidly to the ferric state (Fe^{3+}) and is then incorporated into a specific Iron binding proteins, Transferrin. Ceruloplasmin exerts a catalystic activity (serum ferroxidase) in plasma to convert Fe^{2+} into Fe^{3+} form.

Storage of Iron

Iron is stored in the liver, spleen and bone marrow in the form of ferritin. In the nucosal cells of intestine, ferritin is the temporary storage form of Iron.

Haemosiderin is another Iron storage protein. Haemosiderin accumulates in the body (spleen, liver) when the supply of Iron is in excess of body demands.

Excretion

Iron loss from the body is around 1 mg/day which may occur through bile or through sloughing of GI epithelium.

Iron is not excreted in urine.

Deficiency of Iron

1. Anaemia is a condition where the haemoglobin level is lowered in the blood. When the haemoglobin falls below 12.5 gm/100 ml of blood, it results in the diminished oxygen-carrying power of the blood. Iron deficiency anaemia is otherwise known as hypochromic anaemia. In this condition, the number of RBCs is not much reduced but the quantity of haemoglobin is less.

   Causes

   Haemorrhage, malabsorption, hookworm infestation, inadequate dietary intake.

   Manifestation

   Generalized weakness, sluggish metabolic activities, loss of appetite, retarded growth.
2. *Haemosiderosis:* Occurs due to excess of Iron in the body. Seen in patients with repeated blood transfusions, prolonged iron injunctions. Haemosiderin is deposited in the cells. Seen in Bantu tribal people of Africa who cook food in Iron pots.
3. *Haemochromatosis:* It is a rare disease where Iron is directly deposited in tissues like liver, spleen, pancreas and skin.

It is characterized by bronzed pigmentation of the skin, cirrhosis of the liver and pancreatic fibrosis. This leads to bronze diabetes.

MANGANESE

About 20 mg of manganese is present in an adult. Bones, liver, pancreas, kidney and pituitary gland contain manganese.

Sources

Cereals, Bean, dried beans, peas, green vegetables and nuts are good sources. Tea and coffee have high manganese content. But animal foods are relatively poor in it.

Manganese functions in many enzyme systems. It activates certain enzymes which take part in the digestion and metabolism of carbohydrates, proteins and lipids. It plays an important part in the synthesis of cholesterol, fatty acids, RNA and ATP. Manganese deficiency in human beings is not known.

CHROMIUM

An adult body contains about 6mg of chromium present in skin, hair, muscles, brain, adrenal glands and in body fats.

An important function of chromium is its role in glucose tolerance factor formation in the body. Chromium niacin factor helps the action of insulin on glucose. Chromium is also essential for activating enzymes involved in carbohydrate, protein and fat digestion and metabolism.

Sources

Organ meat like liver meat, whole grain cereals and brewer's yeast are good sources of chromium.

Requirements

For healthy adults it is 0.05 to 20 mg per day.

COBALT

Cobalt is necessary for the biological activity of vitamin B_{12}. It also takes part in enzymatic action and thyroid function.

Dietary Food Sources

Cereals beans, peas and organ meats like kidney and liver.

Recommended Dietary Allowances Per Day

Not established. Deficiency of cobalt is not common among human beings.

Deficiency Manifestation

A cobalt deficiency is accompanied by all the signs and symptoms of B_{12} deficiency. The most important is anaemia.

FLUORINE

Dietary Food Sources

The body receives fluorine mainly from drinking water. Some sea fish and tea also contain small amounts of fluoride.

Recommended Dietary Allowance Per Day

1.4 to 4 mg per day

Absorption and Excretion

Inorganic fluoride is absorbed readily in the stomach and small intestine and distributed entirely to bone and teeth. Almost 50% of the daily intake is excreted through urine.

Functions

Fluoride is required for the proper formation of bone and teeth. Fluoride become incorporated into hydroxyappetite, the crystalline mineral of bones and teeth to form fluoroappetite which increases hardness of bone and teeth and provide protection against dental caries and attack by acids.

Deficiency Syndromes

Deficiency of fluoride leads to dental caries and osteoporosis.

Toxicity

a. Excessive amount of fluoride can result in dental fluorosis. This condition results in teeth with a patch, dull white, even chalk looking appearance. A brown mottled appearance can also occur.
b. It is known to inhibit several enzymes especially enolase of glycolysis.

MOLYBDENUM

Dietary Food Sources

Whole grain cereals, dried beans, peas and dark green vegetables and legumes.

Recommended Daily Allowance Per Day

0.15 to 0.5 mg.

Functions

Molybdenum serves as a co-factor for metalloenzymes. It is incorporated into

a. Xanthene oxidase.
b. Aldehyde oxidase, and
c. Sulphite oxidase.

Absorption and Excretion

Dietary molybdenum is readily absorbed by the intestine and is excreted in urine and bile.

Deficiency Manifestation

Deficiency causes xanthinuria with low plasma and urinary uric acid concentration.

SUMMARY

Principal functions and deficiency manifestations of various micronutrients and macronutrients are summarized in Table 25.2.

Table 25.2: Principal functions and deficiency manifestations of macrominerals and microminerals

Elements	*Metabolic Functions*	*Deficiency Manifestation*
Macrominerals or trace elements		
Sodium	Principal extracellular cation, buffer constituent, water and acid base balance, cell membrane permeability.	Dehydration, acidosis, excess leads to oedema and hypertension.
Potassium	Principal intracellular cation, buffer constituent, water and acid base balance, neuromuscular imitability.	Muscle weakness, paralysis and mental confusion, acidosis.
Chloride	Principal extracellular anion, eletrolyte, osmotic balance, and acid base balance, gastric HCI formation.	Deficiency secondary to vomiting and diarrhoea.
Calcium	Constituent of bone and teeth, blood clotting, regulation of nerve, muscle and hormone function.	Tetany, muscle cramps, convulsions, osteoporosis, rickets.
Phosphorus	Constituent of bone and teeth, nucleic acids, and NAD, FAD, ATP, etc. Required for energy metabolism.	Growth retardation, skeletal deformities, muscle weakness, cardiac arrhythmia.
Magnesium	Cafactor for phosphate transferring enzymes, constituent of bones and teeth, muscle contraction, nerve transmission.	Muscle spasms, tetany, confusions, osteoporosis, rickets.
Sulfur	Constituent of proteins, bile acid, glycosoaminoglycans, vitamins like thiamine, lipoic acid, involved in detoxication reactions.	Unknown.

Contd..

Contd..

Elements	*Metabolic Functions*	*Deficiency Manifestation*
Microminerals or trace elements		
Chromium	Potentiate the effect of insulin.	Impaired glucose metabolism.
Cobalt	Constituent of Vitamin B_{12}.	Macrocytic anaemia.
Copper	Constituent of oxidase enzymes, e.g., tyrosinase, cytochrome oxidase, ferroxidase and ceruloplasmin, iron absorption and mobilization.	Microcytic hyporchromic anaemia, depigmentation of skin, hair. Excessive deposition in liver in Wilson's disease.
Fluoride	Constituent of bone and teeth, strengthens bone and teeth.	Dental caries.
Iodine	Constituent of thyroid hormones (T_3 and T_4)	Cretinism in children and goitre in adults.
Iron	Constituent of haem and non-haem compounds and transport, storage of O_2.	Microcytic anaemia.
Manganese	Cofactor for number of enzymes, e.g. arginase, carboxylase, kinases etc.	Not well defined.
Molybdenum	Constituent of xanthine oxidase, sulfite oxidase and aldehyde oxidase.	Xanthinuria.
Selenium	Antioxidant, cofactor for lutathione peroxidiase, protects cell against membrane lipid perodixation.	Cardiomyopathy.
Zinc	Cofactor for enzymes in DNA, RNA and protein synthesis, constituent of insulin, carbonic anhydrase, carboxypeptidase, LDH, alcohol dehydrogenase, alkaline phosphatase etc.	Growth failure, impaired wound healing, defects in tase and smell, loss of apetite.

CHAPTER

26 Water Metabolism

Water is the commonest liquid with the most uncommon properties. Water content of the body changes with age. It is almost 75% in the newborn and decreases to less than 50% in older individuals. Water content is maximum in brain tissue and least in adipose tissue.

Water is distributed throughout the body, being closely associated with the distribution of electrolytes in the body. It is present in the body both inside and outside the cells. There are two water compartments in the body.

1. Intracellular water (water present inside the cell)
2. Extracellular water (water present outside the cell)

   Extracellular water is further subdivided into:

   a. Plasma
   b. Interstitial fluid
   c. Dense connective tissue, i.e. water content in the bones and cartilages
   d. Transcellular fluids.

Importance (Functions) of Water

1. It acts as a carrier of nutritive elements to tissues and removes waste materials from tissues.
2. It provides the media in which chemical reactions of the body take place.
3. The fluidity of blood is because of water.
4. It is the solvent for electrolytes and regulates the electrolytic balance of the body. It maintains the equilibrium of osmotic pressure extended by the solutes dissolved in water.
5. It is a regulator of body temperature, because of its high specific heat, it can absorb or give off heat without any appreciable change in temperature. Also, because of its high latent heat, it

provides the mechanism for the regulation of heat loss by sensible (sweating) and insensible (through the respiratory tract) perspiration.

Water Balance

Water balance is maintained by a body when water gained by the body is equal to the water lost from the body (Table 26.1).

Table 26.1: Average water balances in normal adult

Water intake in gm per day		*Water output in gm per day*	
Water intake as such	= 1200	Water excreted in urine	= 1500
Water intake in diet	= 1200	Water excreted in stools	= 50
Water produced during metabolism	= 300	Water lost through skin and lungs	= 1150
Total intake	**= 2700**	**Total output**	**= 2700**

Electrolytes

Electrolytes are positively and negatively charged ions which are in solution in all body fluids. Normal cellular functions and survival require electrolytes which are maintained within narrow limits. The concentration of electrolytes are expressed as milliequivalent/litre (mEq/L).

Distribution of Electrolytes (Table 26.2)

Table 26.2: Electrolytes content of ECF and ICF

Ions	*Extra cellular fluid (mEq/L)*	*Intra cellular fluid mEq/L*
Cations		
Na^+	142	10
K^+	5	150
Ca^{++}	5	2
Mg^{++}	3	40
Total	155	202
Anions		
Cl^-	100	2
HCO_3^-	27	10
HPO_4^-	2	140
SO_4^-	1	5
Organic acids	6	5
Protein	16	40
Total	155	202

Total concentration of cations and amions in each compartment (ECF and ICF) is equal to maintain electrical neutrality. The concentration of electrolytes in extracellular and intracellular fluid is shown in Table 26.2.

Sodium is the principal cation of the extra cellular fluid and comprises over 90% of the total cations, but is very low in intracellular fluid.

Potassium by contrast is the principal cation of the intra cellular fluid and has a low concentration in extracellular fluid.

Similar differences exist with the anions. Chloride(Cl^-) and bicarbonate (HCO_3^-) predominate in the extra cellular fluid, while phosphate is the principal anion within the cells.

The four ions in the plasma, Na^+, K^+ $Cl^-$and HCO_3^- exert the greatest influence on water balance and acid base balance.

The body water balance is closely associated with the balance of dissolved electrolytes, the most important of which are Na^+ and K+. The osmotic pressure of extracellular fluid is determined by the concentration of Na^+ as it accounts for over 90% of the osmolality. Thus, Na^+ concentration determines the extracellular fluid volume because water flows from or into other compartment to restore osmotic homeostasis if disturbed. K^+ similarly determines intracellular osmality to a large extent.

DISORDERS OF WATER AND ELECTROLYTE BALANCES

Dehydration

Dehydration is defined as a state in which loss of water exceeds the intake as a result of which the body's waste content gets reduced and the body is in negative water balance.

Dehydration may be of Two Types

a. Due to pure water deficiency without loss of electrolytes called simple dehydration.
b. Due to combined deficiency of water and electrolyte sodium.

Over Hydration or Water Intoxication

Over hydration is a state of water excess or water intoxication. A normal healthy individual can consume a large volume of water without producing any deleterious effect, as the normal

individual has the capacity to excrete large volume of dilute urine, when excess of free water without electrolyte is given.

More often water intoxication results due to the retention of excess water in the body, which can occur due to:

a. Renal failure
b. Excessive administration of fluids parenterally
c. Hypersecretion of ADH (Syndrome of inappropriate ADH secretion SIADH)

Symptoms of Overhydration

Nausea, vomiting, headache, muscular weakness, confusion and in severe cases, convulsions, coma and even death.

CHAPTER

27 Cookery Rules and Preservation of Nutrients

PURPOSE OF COOKING

Cooking is an art. It is linked with the dietary habits and cultural pattern of the people. Food preparation requires creativity in blending of flavor, texture as well as colour. To achieve high quality of products with efficient use of time, money and material, one should have knowledge of the effect of heat in its various forms on the nutrients present in the food. All the methods of preparation are based on certain principles and the physical and chemical characteristic of various food groups.

AIMS AND OBJECTS OF COOKING FOOD

1. Cooking makes food attractive in appearance .
2. Cooking makes the food soft making it easily chewable, masticated and easily digestible. Complex foods are split into simple substances during cooking. This helps the body to absorb and utilize the food more readily than raw food.
3. Cooking partly sterilizes the food. It kills the micro-organism at 40°C and makes food safe for consumption. Above 40°C the growth of bacteria decreases rapidly and in general it ceases above 45°C. Non-sporing bacteria are killed at temperature above 60°C for varying periods of time.

   For instance, to make milk safe it is pasteurized at 62.8°C for 30 minutes. Boiling kills living cells with the exception of spores in a few second. Spore bearing bacteria take 4 to 5 hours boiling to be destroyed. To destroy them in a shorter time higher temperatures are used.
4. Cooking brings about physical and chemical changes in food where by colour, texture and appearance are improved. This increases palatability, taste and digestability of food.
5. Cooking enhances the availability of some nutrients e.g., it destroys tryptophan inhibitors present in the protein foods.

This makes trypsin freely available to the body. Similarly, starch is more easily available to the body after cooking.

6. Cooking also improves the storage quality of food. Boiling sterilizes the milk which can then be stored for a longer time.
7. Cooking helps to make food more digestible. Complex foods are usually split into simpler substances during cooking. This helps the body to absorb and utilize food more readily than raw food.
8. Some vegetables like soyabeans naturally contain some anti-nutritional factors such as haemagglutins and trypsin inhibitors. These can be destroyed only by heating and cooling.
9. Cooking makes food more attractive in appearance and therefore more appetizing.
10. Cooking helps to prepare innumerable products from the same food materials and provide variety and avoid monotony.
11. Cooking enables mixing of different foods in order to provide good quality preparations with other nutrients.
12. Cooking helps to provide a balanced diet. The different ingredients combined together in one dish make it easier to provide a balanced meal.

METHODS OF COOKING

Heat can be transferred to food by conduction, convection, radiation or microwave energy.

Conduction

In conduction, heat flows from source to food. For efficient conduction from one hot surface to another, the area of contact has to be as large as possible. Hence, the bottom of pans should be flat and thick e.g., Steaming, poaching.

Convection

When a liquid or air is heated, the parts nearest to the heat becomes warm and less dense. Roasting is mainly by convection e.g., Baking.

Radiation

When heat radiations reach food, only the surface is heated by them. They do not penetrate the food. The rest of the food is cooked by conduction and to a less extent by convention e.g., Boiling or toasting of bread.

Cooking Media

Food can be cooked in various media or no media at all. Air, water, steam and fat or their combinations are used as cooking media. Food can be cooked by a combination of media e.g., Upma and halwa involve the combination of fat and water.

Cooking in Air

Grilling, roasting and baking take place in air. Roasting and baking are essentially the same. The term roasting is used to meat cooking and baking is used for breads, buns, cakes and biscuits. Food is cooked partially in dry heat and partially in moist heat.

Cooking in Water

Boiling or simmering involves cooking in water. The medium transferring heat is water.

While the correct preparation of ingredients and correct mixing are necessary, greater skill is needed in actual cooking. Some of the different methods of cooking include roasting, baking, frying, boiling, poaching, streaming, stewing, braising, boiling and grilling.

1. Roasting

a. *Split roasting*: Is done only with good quality meats. The food is brought in contact with direct flame in front of a bright fire. The food is pasted over with fat and is turned regularly to ensure even cooking and browning. Roast meats have an excellent flavour and are served in large hotels and special restaurants e.g., Barbe eued meat.
b. *Oven roasting*: This is done in a closed oven with the aid of fat. First class meat, poulty and vegetables are put into a fairly hot oven for 5 to 10 minutes and temperature is lowered to allow

the joint to be cooked. Cooking in a moderate oven for a longer time produces a better cooked joint than cooking at a higher temperature for shorter period. Aluminium foil is used. The joint is larded or raised with fat. This cooking is an improvement on oven roasting as the meat retains its moisture and flavour.

c. *Pot roasting:* This is for cooking small joint and boils when no oven is available. A thick heavy pan is available and enough fat is melted to cover the bottom of the pan. The joint is browned when the fat is hot. The joint is then placed on a couple of skewers to prevent the joint from sticking to the pan. The pan is then covered tightly with the lid and cooked over a very low fire.

2. Baking

Bread, cakes, pastries, puddings, potatoes and vegetables are cooked by baking. The food is surrounded by hot air in a closed oven. The action of the dry heat is modified by steam arising the food being cooked.

3. Frying

Here the food is brought in contact with hot fat. Even though fried foods are a bit difficult to digest, if the frying is carefully carried out, the fried food is suitable for normal people. Frying provides variety, keeping quality is better and the food is really apetising. Two types of frying are shallow fat frying and deep fat frying.

a. *Shallow fat frying:* This method is applied to precooked food unless the food takes very little time to cook (omelette, liver etc.) only a little fat is used and the food is turned over to get both sides equally browned. Fat absorption is more in shallow frying than in deep fat frying.

b. *Deep fat frying:* A large quantity of fat is required to completely immerse the food. The large amount of fat will need extra time for heating. However, extra care is needed to prevent overheating of fat which will spoil both the fat and food. Both sweets and savouries can be cooked by this method. Food cooked by deep fat frying has a better look than that cooked by shallow frying, as food is evenly browned.

4. Boiling

Food is cooked by surrounding it by boiling or simmering liquid (stock or water). Only sufficient amount of liquid should be used just to cover the items to be cooked. Vegetables grown above the ground are cooked in boiled salted water and vegetables grown below the ground are cooked in cold salted water. Dry vegetables are cooked in cold water. Salt is added only after the vegetables become soft. Fish is put into hot liquid and allowed to simmer.

5. Poaching

Poaching is cooking slowly in a minimum amount of liquid which is not allowed to boil but kept below boiling point. Fish, eggs and fruits are poached. When poaching eggs, a little vinegar is added to the liquid for quick coagulation and to prevent disintegration.

6. Steaming

This is a slow process of cooking and used for easily cooked food. The food to be cooked is surrounded by plenty of steam by placing in steam or boiling water.

Advantages of Steaming

a. All nourishment and flavours are preserved in the food.
b. Food by this method is easily digested.
c. Food cannot be overcooked.

7. Stewing

This is a very gentle method of cooking in a cold pan with only a small quantity of liquid. Meat and vegetables may be cooked and served together to make an appetizing dish saving fuel and labour. Even tough meat and unripe fruits and vegetables are made tender by this slow moist method. All nourishment and flavours are retained and hence food is very apetizing and healthy.

8. Grilling/Boiling

In boiling, food is cooked uncovered on a hot metal grill or a frying pan. The pan or grill is oiled slightly to prevent sticking.

9. Microwave Cooking

Microwave is electromagnetic radiation similar to that found in radio, radar or TV. Microwaves penetrate the food and are absorbed. The heating is very fast. Foods placed in the microwave oven are heated by microwaves from all the directions. This helps in easy cooking.

10. Pressure Cooking

Steam cooking are of three types—Steam cooking, waterless cooking and pressure cooking. In steaming, food is cooked by steam from added water. In waterless cooking the steam originates from food itself.

Pressure cooking is a device to reduce the cooking time by increasing the pressure so that the boiling point is quickly reached. The food is cooked as a result of steam condensation on food e.g., rice, dal, puttu.

CHANGES IN COOKING

When food is subjected to heat many changes take place. Some carbohydrates, lipids and proteins are destroyed. Some changes are beneficial. Heat treatment also improves food presentation.

a. *Changes in Carbohydrates:* Starch molecules when heated with water, swell and break, which permit quicker enzymatic digestion, thereby increasing the digestablility of carbohydrates. When starch is subjected to dry heat, the starch breaks down to dextrins e.g., Roasting of bread/vermicelli.
b. *Changes in Lipids:* Due to heat, fats undergo oxidative changes. Exposure of fats to high temperature gives a volatile odour and unpleasant taste. Rancidity which gives food an unpleasant oily flavour is the result of exposure to oxygen (air) and water (moisture).
c. *Changes in Proteins:* The main effect of heat on proteins is deamination. This results in destruction of micro-organisms and some enzymes present in food. Cooking would destroy some toxines present in food, like the enzymes that affect the health seriously. E.g., Legumes contains trypsin inhibitors, antivitamins etc., which otherwise when consumed may inhibit haemoglobin. These are destroyed by heat.

d. *Changes in Vitamins and Minerals:* Some vitamins and minerals are lost by bleaching, oxidation of water soluble nutrients and destruction by heat. Vitamin C is lost due to exposure to air. The media of cooking also destroy nutrients. Minerals are mainly destroyed by heating.

e. *Changes in Colours*: Various colours of food are affected by heat e.g., Chlorophyll of greens, carotenoids of carrot, anthocynin of beetroot, onion and red cabbage and myoglobin of meat. Not only heat, but also acid/alkali brings about changes in colours of food. Therefore, cooking conditions should be combined in such a way that there is minimum loss of nutrients.

CHAPTER

28 Food Preservation: Principles and Methods

Food preservation is the science dealing with the process of dealing with the prevention of decay or spoilage of food, thus allowing it to be stored in a fit condition for future use. The process used may be varied with the period of storage. It may be as simple as boiling milk to preserve it for 24 hours or pickling vegetables, fish or meat to last for a year.

Need for Food Preservation

There is always a shortage of food in developing countries like India due to demands of the growing population. Increasing production to meet the shortage results in wastage due to inadequate facilities available for storage and preservation. It is therefore all the more important to improve and expand facilities for storage and preservation of food. Preservation increases availability of foods, thus improving the nutrition of the people. Availability of seasonal foods throughout the year also helps in stabilising prices of food stuffs.

Causes of Food Spoilage

Food is spoiled due to the action of microorganisms such as mould, yeast and bacteria or by the action of enzymes present in foods or due to infestation with insects and worms. Enzymes are biological catalysts produced by living cells. They are proteins and hence denatured by heat. Enzymes include those present in the food as well as those from the micro-organisms. Some micro-organisms can exist either in the vegetative form or in the highly resistant spore form.

Bacteria are unicellular organisms. They occur in different sizes and shape and are classified as cocci, bacilli, viobrios and spirilla. Some of them need oxygen for growth (aerobic) while others will

grow only when oxygen is absent (anaerobic). They are classified into three groups as per temperature requirement.

Thermophiles require temperature above 45°C. Mesophiles need temperature below 20-25°C. Psychrophil's need temperatures 20°C. Foods likely to be spoiled by bacteria are vegetables, milk, milk products, eggs, meat and fish. Foods liable to be spoiled by yeast are fruit juices, syrups, molasses, honey, jams and jellies.

PRINCIPLES OF FOOD PRESERVATION

1. Prevention or delay of microbial decomposition by
   a. Keeping out micro-organisms (asepsis).
   b. Removal of micro-organism, e.g. by filtration.
   c. Inhibiting the growth and activity of microbes by the use of lower temperature, drying, anaerobic conditions or chemicals.
2. Destroying the microorganisms by radiation or by heat.
3. Preventing or delay of self decomposition of the food by
   a. Destroying or inactivation of food enzymes e.g., by blanching or boiling.
   b. Prevention or delay of purely chemical reactions e.g. prevention of oxidation by antioxidants.
   c. Prevention of damage by insects and rodents.

METHODS OF FOOD PRESERVATION

1. Bacteriostatic Methods

Which inhibit the growth and multiplication of micro-organisms in food e.g., Freezing, dehydration, pickling, salting and smoking.

2. Bactericidal Methods

In which the microorganisms are killed, e.g., cooking, canning and irradiation.

a. Cold Storage and Freezing

Refrigeration is widely used both in homes and in commercial plants as a means of maintaining the low temperature necessary for storage of perishable foods. Micro-organisms are much less active at low temperature even though they may not be destroyed by severe cold. Fresh milk, and fish are kept just

above the freezing point. A refrigerator thermometer is kept in the refrigerator at all times. Left over foods from a meal should not stay out of refrigeration longer than two hours. Certain fruits and vegetables also keep better when cold.

b. Boiling

Boiling food at 100°C kills all vegetative cells and spores of moulds and yeast but not bacterial spores. Cooking of rice, vegetables, meat etc. is usually done in homes by boiling. Many foods are preserved at home by boiling e.g., Milk. Cooked food can be preserved from 12 to 24 hours at room temperature.

c. Canning

If the effectiveness of pasteurization and sterilization has to last for a long time, the material thus treated must be protected from fresh contamination by canning. Various foods eg. Fruit juices, milk, baby foods, soups and fish are preserved by canning. The food is first sterilized at temperature above 100°C for a few seconds and then cooked and filled in presterilised containers in a sterile atmosphere. There is some loss of heat labile vitamins during the process of canning.

d. Addition of Salt or Sugar

Certain chemicals are useful in preserving food, either by retarding or preventing the growth of microorganisms. There may be either added to the product or produced in it by fermentation. Dry salting is used for the preservation of tamarind, raw mango, amla, fish and meat. Pickling of mango, lemon, fish and meat is by addition of 15 to 20% salt. Rosagulla and gulabjamoon are preserved by sugar syrup. The principle is high osmotic pressure produced by salt or sugar.

e. Jams and Marmalades

Jams and marmalades are prepared by boiling the fruit pulp or shredded fruit peels with sugar (above 55% by weight) to a thick consistency, firm enough to hold the fruit tissues in position. Later on, they are packed hot into glass jars or tin cans and sealed. The same process is used for jellies except that fruit

juices are used in place of fruit pulps. The high concentration of sugar (68%) binds the moisture making it not available for microorganism to grow and multiply. Anaerobic conditions are obtained by sealing. Application of heat kills most of the moulds and yeast. All these increase the shell life of the products.

f. pH

Low pH inhibits the growth of many organisms. Vinegar used in pickling is acetric acid. Citric acid is added to many fruit squashes, jams and jellies to increase acidity and to prevent mould growth. Formation of curd from milk is an example of lactic acid produced from lactose. The lactic acid inhibits the growth of bacteria. By adding certain condiments along with salt, certain foods like mangoes, vegetables, meat and fish are preserved.

g. Chemical Preservation

Benzoic acid is used to preserve fruits, fruit juices, squash and jams because it is soluble in water and easily mixes up with food products. Potassium metabisulphite or sodium metabisulphite is used to preserve colourless food stuff such as fruits, juices and squash. These preservatives, on reaction with fruit acids liberate SO_2 (sulphur dioxide) which is quite effective in killing the harmful microbes present in food. SO_2 is a bleaching agent and cannot be used as a preservative for coloured food materials.

CHAPTER

29 Food-borne Diseases

Food-borne diseases are of two types:
Intoxication
Infection.

Food Intoxication

Occurs when a chemical or toxin transmitted through food causes the body to malfunction. For example, vomiting, nausea, abdominal cramps, sweating and chills by eating food contaminated by *Staphylococcus aureus*. Enterotoxin of this bacteria causes severe gastrointestinal distress. The time between the consumption of the food and the appearance of symptoms can range from one to six hours. Recovery takes about a day or two and mortality is very low.

Pasteurization kills all staphylococci present in food/milk. Refrigeration of food immediately after cooking prevents the growth and formation of enterotoxins by *Staphylococcus*. Personnel suffering from staphylococcal infection such as colds and boils should not be allowed to handle foods.

Clostridium botulinum is a spore forming, anaerobic bacteria found in the soil. Foods such as fish, meat, beans, peas and corn are likely to be contaminated with its spores. If this contaminated food is not given sufficient heat treatment during canning, these spores survive and the clostridium botulinum will multiply in the can as it is anaerobic and produces botulism, a severe form of food poisoning. The toxin is killed by heating the food for 15 minutes.

Poisoning by Other Organisms

Moulds, especially of the Aspergillus species cause aflatoxins in groundnuts and sometimes in cereals like wheat, rice an jower. These aflatoxins can cause death in poultry and cancer in rats but no illness has been so far reported in human beings.

Poisonous Plants and Animals

Certain varieties of mushrooms are poisonous and could be fatal if consumed. Snakeroot poisoning could result from drinking milk from cows that have been fed on this poisonous food. Sea foods like crabs and prawns may cause food poisoning.

Food-borne Infections

Food borne infections occur as a result of eating food that contains living organisms such as bacteria, viruses or parasites. Ingested in large amounts, these micro-organisms can cause infection in the digestive tracts and other parts of the body e.g., vibrio bacteria often present in raw sea food like oysters and prawns. Inside the body, the bacteria settle down fast and cause abrupt onset of chills, fever or prostration.

LATHYRISM

Lathyrism is a disease seen in India and Spain where there is a high concentration of the pulse, kesari dal (lathyrus satives) in specific regions of the countries.

In India Lathyrism is seen in Madhya Pradesh, the border districts of Uttar Pradesh, Bihar and Orissa. In the districts of Reva and Satna in MP, 2.6% of the population is affected. Lathyrism is ten times more common in men than in women. In women, the disease is not set in during reproductive years.

Kesari dal is cheap and is consumed by people in the low economic stratum. Among them, Lathyrus satives constitute about 40% of the diet.

The toxic factor in Lathyrus satives is the water soluble β(N) oxyly amino alanine (BOAA).

Clinical Manifestations

The disease affects only the pyramidal tracts. The onset is sudden, usually after exertion or exposure to cold, with the contraction of calf muscles during sleep and pain in the lower back. A static paralysis of the lower limps develops with rigidity, weakness, exaggerated knee and ankle jerks and ankle clonus.

Prevention

Lathyrism can be prevented. The contaminated dal is made safe for consumption, by soaking the pulses in 4 times its volume of hot water for an hour. This removes not only 90% of the BOAA but also the water soluble vitamin B complex. The water is removed and the pulse is sundried and ground to make floor. Parboiling the dal, a process similar to that for rice, preserves its B complex vitamins.

CHAPTER

30 Food Laws and Food Standards

Prevention of Food Adulteration Act 1954 (PFA)

The prevention of food adulteration act 1954 came into effect from june 1, 1955. The purpose of the Act is to ensure that food articles sold to the consumers are pure and wholesome, also to prevent deception or fraud and to ensure fair trade practices. The act was amended in 1964 and 1976 to plug the loopholes and to ensure deterant punishment to the offenders.

As per the Act, food can be considered adulterated when any one of the following modes (or acts) are resorted to:

i. Admixture of inferior or cheaper substance.
ii. Extraction of certain quality ingredients from the food.
iii. Preparing or packing under insanitary conditions.
iv. Sale of insect infected food.
v. Obtaining the food from a diseased animal.
vi. Incorporation of a poisonous component.
vii. Entry of injurious constituents from the container used.
viii. Use of colouring matter other than or in greater quantities than that approved for the food.
ix. Sale of substandard products which may or may not be injurious to health. These are all prohibited acts under the prevention of Food adulteration act.

Persons found guilty of selling such adulterated food, can be convicted. The severity of sentence would depend on the gravity of the offence.

The Fruit Products Order (FPO)

The Government of India promulgated a fruit products order in 1946 and amended it in 1955. The order lays down the statutory minimum standards in respect of the quality of various facilities. Packing fruits and vegetables of a standard below the minimum prescribed standard is punishable under law. Periodical inspection

by government inspectors are also conducted to ensure conformity of standard by processor.

Meat Products Order

This makes it illegal to transport meat unless it has been prepared and processed according to the provision of the order and carries the mark of inspection. It provides the means to:

i. Detect and destroy meat of diseased animals
ii. Ensure that the preparation and handling of meat products be conducted in a clean and sanitary manner.
iii. Prevent the use of harmful substances in meat foods and
iv. See that every cut of meat is inspected before sale to ensure its wholesomeness.

The order also lays down rules and conditions to be adopted per selecting disease free animals, slaughter house practices and further treatment of the meat as to maintain the meat in a wholesome manner without disease producing pathogens.

ENFORCEMENT

The FPO and PFA are enforced by the department of Health. Under the law, slaughter houses, markets, factories, ware houses and other establishments involved in food trade may be inspected to ascertain that the raw materials, as also the processing packaging and storage facilities are clean and upto the minimum standard as per the law. The food inspectors from the department are authorized to sieze, destroy or relabel the adulterated and misbranded products and legal action initiated against the offenders as considered necessary. The court may impose rigorous imprisonment and/or fine.

MISBRANDING

A food is considered as misbranded, if it has a label, which gives false or misleading information about the product. Failure to specify weight, measure names of additives (color, flavourings and preservatives) limitations in use of the product are all considered as misbranding of food which is a punishable offence under law.

In addition, voluntary agencies such as Indian Standards Institute (ISI) the Directorate of Marketing and Inspection have also laid down quality standards for food. These are voluntary.

ISI STANDARDS

ISI consists of representative of government, consumers and industry to formulate ISI standards for vegetable and fruit products, spices and condiments processed foods and animal products. When these standards are accepted, the manufacturers are allowed to use the ISI label on each unit of their products.

THE AGMARK STANDARD

This was set up by the Directorate of Marketing and Inspection, Government of India, by the Agricultural Produce Act, 1937. The act defines quality of cereals, spices oil seeds, oil, butter, ghee, legumes, eggs etc. The commodities are graded into grades 1, 2, 3, and 4 or special, good, fair and ordinary. These standards also specify the types of packaging to be used for different products.

The ISI standards and the Agmark Standards have benefited the manufacturer and the consumer.

Some simple tests to detect adulteration in items of daily use

Food article	*Possible adulterant*	*Tests*
Artificial milk	1. Urea emulsifier-oil, starch, detergent	1. Add bromocresol blue (an indicator) to the suspected milk. If it gives dark blue colour, it indicates the presence of urea in it. 2. Add bromocresol purple to the milk and if it gives faint blue colour, it indicates the presence of detergent. 3. Add a few drops of iodine solution to the milk. If it turns blue, the presence of starch is confirmed.
Milk	1. Added water 2. Fat/cream removed	1. Specific gravity of the milk can be checked by lactometer. A reasonably good quality milk has 1.030 to 1.034. 2. Non-sticking of milk to the dipped finger, is an indication of removal of fat.
Ghee and butter	Hydrogenated fat (Vanaspati)	Dissolve 1 teaspoon of sugar in 11 ml of hydrochloric acid (HCl), and 10 cc of melted ghee/butter and shake for 1 minute and allow it to remain for 10 minutes. If vanaspati is there, the aqueous layer becomes red.
Edible oils	Argemone oil	Add concentrated nitric acid (HNO_3) to the smple. A red to reddish brown colour in the acid layer indicates the presence of argemone oil.
	Castor oil	Dissolve some oil in petroleum ether in a test tube and cool it with ice. Presence of turbidity within 5 minutes indicate the presence of castor oil.
	Mineral oil	Take 2 ml of oil and add equal quantity of N/2 alcoholic potash. Heat in boiling water bath for few minutes and add 10 ml of water. If there is turbidity, it shows the presence of mineral oil.
Chilli powder	Coloured saw dust Brick powder or talcum	Add the sample chilli powder on the surface of water, saw dust will float. Upon heating, the talcum or brick powder will leave large quanity of ash.

Contd..

Contd..

Food article	*Possible adulterant*	*Tests*
Turmeric powder	Harmful colours like metanil yellow	Add concentrated hydrochloric acid (HCl) to a solution of turmeric powder. A magenta red colour develops upon dilution with water. The red colour disappears if turmeric is pure, the red colour will persist if metanil yellow is present.
	Starch	Add few drops of iodine solution to the sample and if it turns blue, it indicates the presence of starch.
Powdered sugar (icing sugar)	Washing soda	1. Add few drops of HCl. It is gives foam, it indicates the presence of washing soda. 2. The red litmus turns blue if soda is present.
Cardamom	Oil is extracted	The extracted pods will be white whereas the genuine ones are green. They appear shrunk.
Cloves	Oil is extracted	The oil extracted cloves are dull in colour and have less aroma besides being short in size.
Silver foils	Aluminium foil	The genuine silver oil burns completely leaving a glittering white spherical ball of mass.
Saffron	Scented coloured hair of maize	1. The pieces of pure saffron do not break easily whereas maize hair break quite easily. 2. Pure saffron gets dissolved easily in water whereas the adulterated material remains undissolved. 3. Pure saffron will have one end bulging, thick while the adulterated has uniform size.
Tea	1. Used tea 2. Dried coloured leaves	1. Spread the tea leaves mixed with water on a white paper. If adulterant is present, colour of the paper will change.
Red gram dal	Kesari dal which causes Lathyarism, a disease causes disfunctioning of legs and hands	Kesari dal is bit orange in colour and has different size compared with real dal.

Contd..

Contd..

Food article	*Possible adulterant*	*Tests*
Honey	Jaggery syrup	1. Mix one spoon of honey in boiling water. Pure honey won't dissolve in water whereas syrup will. 2. Pure honey burns while adulterated honey burns with a sound.
Sweet meats like jalebi, ice creams, sherbats, etc.	Metanil yellow (a banned local tar dye)	Extract with lukewarm water from the article, add a few drops of concentrated Hydrochloric acid. A magenta colour shows up if metanil yellow is present.
Asafoetida (Hing)	1. Artificial aroma 2. Coloured resins or glue	1. Pure hing dissolves in water producing milky white emulsion. 2. If ignited, pure hing burns with a bright flame.

CHAPTER

31 Hospital Diets

Hospital diets suitable for feeding are:
a. Clear fluid diets
b. Full fluid diets
c. Soft diets

CLEAR FLUID DIETS

Clear fluids are prescribed for patients with marked intolerance. An acute illness may produce nausea, vomiting, anorexia, distention and diarrhoea. Clear fluid diets are meant to provide very few calories and make up the water loss in the body. Clear fluid diets include:
a. Tender coconut water
b. Clear fruit juices
c. Glucose water
d. Albumin water
e. Clear vegetable or meat soup
f. Whey water

The clear fluids are used for 1 or 2 days till the patient is able to retain and digest a more liberal liquid diet.

FULL FLUID DIET

This diet bridges the gap between clear fluid and soft diet. These consist of inclusion of eggs, milk, cereal, porridges, conjees or gruels, vegetable, chicken or mutton soup, fruit milk shakes etc. This diet will meet the minimum requirement of all protein calories, vitamins and minerals.

SOFT DIET

This bridges the gap between acute illness and convalescence. It is used in acute infection following surgery and for patients unable to chew. The soft diet is:

a. Made of simple foods
b. Easily digestable
c. Contains no fibre
d. Near to a normal diet
e. Not highly spiced or seasoned.

It is nutritionally adequate when planned on the basis of normal diet.

PREPARATION OF SIMPLE BEVERAGES AND DIFFERENT TYPES OF FOOD

a. Fluid Diets

Beverages

Tea, coffee, barley water and fruit juice
Whey, curd, butter milk, lactic acid milk

Egg Preparation

Egg flip, albumin water
Soups – Bones, vegetables, dhal (pulses) liver.

BEVERAGES

Clear Tea

Have ready water which is just started boiling. Do not use water which has been boiling for sometime as it spoils the flavour. When it boils pour a little into the teapot (one teaspoon) to warm it). Empty out this water and put the tea into the pot (one teaspoon of tea to each person) pour the boiling water over the tea and allow to stand for 3 to 5 minutes. Strain and pour. Dilute with hot water if desired, add a few drops of lime or lemon juice and sugar to taste.

Black Coffee

One heaped tea spoon of pure coffee powder and 300ml of freshly boiled water. Heat the coffee jug thoroughly. Put the coffee in the jug. Pour in boiling water and allow to stand near the fire for 10 minutes. Strain, reheat and serve as black coffee with sugar/ jagary, if desired.

Barley Water

50 gram of pearl barley – one pint of cold water. Blanch the barley by covering with cold water. Simmer the barley slowly, with one part of water till it is reduced to two-thirds of a pint (about 1½ hrs) and strain. A fresh supply should be made atleast twice daily. Lime juice may be added to the water before boiling if desired and sugar added to taste.

Fruit Juice

Fruit juice may be prepared from fresh fruit or by dilution of commercially prepared fruit squashes. Remove the juice from citrous fruit by means of a squeezer, strain, dilute with water and add sugar or glucose to taste.

Raw Tomato Juice

Select ripe, juicy tomatoes, pour boiling water over the tomatoes and let stand for 2 minutes to loosen the skin. Remove skin, mash the tomatoes and press through the strainer as much of the juice and soft part as possible. Add salt/ pepper or sugar to taste.

MILK PREPARATIONS

Whey

This is prepared from curds. It contains fats, sugar, salts and vitamins but no protein. Break up the curds with a fork, then drain off whey by straining through gauze.

Albumin Water

Take the whites of two eggs. Add one cup of water. Put into a wide necked bottle. Cork it and shake thoroughly. Add a little lime juice and sugar. If preferred, orange juice may be substituted for lime juice.

EGG PREPARATIONS

Egg Flip or Egg Nog

Beat an egg thoroughly (yolks not used in albumin water may be used) and add 250 ml of milk, stir well and strain before serving. This may be flavoured with sugar, cinamon or lime juice. If desired, it may be added to coffee, tea or cocoa.

Soft Cooked Egg

a. Place egg in cold water and bring it to boil. Let it boil for about half a minute, remove with spoon.
b. Lower the egg gently with a spoon into a saucepan of boiling water deep enough to cover it. Put the lid on the pan and allow to stand for 4-5 minutes. Serve immediately after the egg is removed from hot water.

Hard Cooked Egg

Lower the egg into hot water and keep it at simmering temperature for 10-15 minutes according to the size of the egg and how hard it is required. If the egg is to be used cold, it should be cooled immediately after cooking by placing in cold water. The shell may then be removed easily.

Scrambled or Buttered Egg

Beat the egg well, adding salt and pepper and a tablespoon of milk. Melt just enough butter in a saucespan to cover the bottom of the pan. Put the egg, and cook slowly over a very gentle heat, stirring lightly to prevent the egg from sticking to the pan. The egg should be soft and creamy when cooked and should be served immediately.

Poached Egg

Use a small pan with water coming about two-thirds up the pan. Add a level tea spoon of salt and a teaspoon of vinegar to each pint of water used. This helps to set the egg. Bring the water almost to boiling point, break the egg into cup, taking care to keep it whole and slide it gently into water. Tilt the pan and with a table spoon gently gather the white round the york. Simmer until the white is nicely set (about three minutes) lift out the egg carefully, draining off the water and serve on hot buttered toast.

SOUPS

Dhal soup

Dhal – ½ cup, water – 2 cups, onion – 1 ghee or oil – one teaspoon. Salt to taste.

Grind the dhal firmly, chop and fry the onion, mix all the ingredients and boil for 20-30 minutes.

Vegetable Soup

Half a cup small part butter (about one teaspoon) salt and pepper, cups of meat stock (meat stock water in which bones or meat had been simmered shortly for a long time).

Prepare and slice the vegetables. Place in a saucepan and melted butter for a few minutes. Add the boiling stock, salt and pepper to taste and boil gently until the vegetables are tender. Mix 45gm flour with a little cold stock, add boiling stock stirring continually, then return the flour mixture to the soup and boil until thickened. If desired, the vegetables may be rubbed through a strainer, before thickening the soup.

LIGHT DIETS

Steamed Fish

Clean the fish and cut it into pieces. Drain free from water carefully. Sprinkle a little pepper and salt on the fish, fold in two, lay on a buttered plate and cover with buttered paper and lid. Place the plate over a pan of boiling water and steam for 15 to 20 minutes or until the fish looks quite white and the flakes separate easily. Serve on a hot dish with juice poured over it. A small piece of lime or lemon may be served with the fish.

Light Cereal Preparations

Double boiled rice
Rice – 2 tablespoons
Milk – 240 ml, water or milk (water mixed)

Wash the rice and add it to the milk. Simmer gently for 1 to 1 ½ hours, till it is reduced to a pulpy mass. Add sugar if desired, before serving. Cooking in a double boiler or milk cooker is more easily regulated than in an ordinary sauce pan.

Ragi Conjee

Ragi, after being ground, should be sifted two or three times through muslin. One tablespoon of the ragi floor stored be mixed

till smooth with a little cold water. Then gradually add 30ml boiling water with a pinch of salt and boil for 15 minutes. If preferred, half milk and half water may be used.

Arrow Root Conjee

Arrow root-one table spoon
Boiling water-125 ml
Cold water-2 table spoons
Hot milk-125 ml
Salt-1/4 tea spoon
Sugar to taste

Mix the arrow root to a smooth paste with the cold water and add the boiling water gradually. Boil for 10 minutes, stirring constantly. Then add milk and salt and boil for 10 minutes. Before serving add sugar if desired.

Sago Porridge

Sago-2 table spoons
Milk-150 ml
Water-150 ml
Pinch of salt
Sugar to taste

Wash the sago and add milk and water. Bring it to the boiling point, gently stirring in between. After it starts boiling, simmer gently for 15-20 minutes. Add salt and sugar to taste. Serve hot.

If milk and sugar are added to the conjee it is called porridge.

CHAPTER

32 Budgeting of Food Balanced Diet

Plans for Food Budget

In practice, one must make daily menus for a week and base the food purchase on them. This step is essential whether the plan is for a single person, a family or an institution. Food purchase is guided by nutrient needs and the food budget. Planning helps to make the best use of the available money to meet needs of the family.

The food choices within a group can be guided by ones food budget. The steps which help to get the best returns for food money include:

a. Buying the staple food, dahls and pulses in bulk, when the prices are competitive just after the harvest.
b. Buying milk and milk products from government daily outlets.
c. Buying fruits and vegetables from main markets at competitive rates.
d. Buying seasonal vegetables and fruits.
e. Buy sugar, jaggery in bulk from wholesale dealers.
f. Buy oils from whole sale depots in bulk.
g. Make butter and ghee at home.
h. Buy spices in bulk and prepare the spices mix at home.

There are several government programmes, which subsidise foods for the various socioeconomic strata. These include rationed food grains, food given to children in grade schools to ensure attendance, school level programmes and supplementary feeding of expectant and nursing mothers. These programmes help to meet the nutritional needs. To some extent, these reduce the food budget of the family.

SELECTION—STORAGE AND PREPARATION OF FOOD

1. Plan the daily diet for family so that it contains food from each of the five food groups. The diet shoud be varied to make it more apetizing.

2. Buy foods which are in season because they will be cheaper and plenty. Buy atleast one which can be served as raw.
3. Select fruits and vegetables which look fresh. Buy just enough for one day.
4. Discard any damaged or decayed portion and store in a well ventilated container or food safe in a cool place from the sun. Keep potatoes and onions open in a dry place.
5. Clean and wash vegetables and fruits before cutting to preserve nutrients. Do not soak cut vegetables in water.
6. Well scrubbed vegetables and fruits do need to be peeled or scraped before cooking or eating. Vegetables such as potatoes cooked with their skins retain more nutrients.
7. Clean and cut vegetables just before cooking or serving raw in order to preserve nutrients.
8. Many kinds of leaves and tops of vegetables e.g., Beetroot, radish, cauliflower, knolkol, turnip, drumstick and carrot are rich in protein nutrients and should be used in curries or other dishes.
9. Preserve nutrients in food during cooking by
   a. Cooking with minimum amount of water, not throwing away excess water after cooking rice or vegetables and using any amount of water left, for making a soup or drink by adding savoury or sweet seasonings.
   b. If cereals or dhals are soaked before cooking, using the same water for cooking because it contains dissolved nutrients.
   c. Covering root vegetables so as to cook them in their own steam and also to reduce cooking time.
   d. Cooking leafy green vegetables quickly in a little boiled water.
   e. Not using soda to preserve the colour of vegetables or to soften them, because it destroys nutrients.
   f. Avoiding over cooking or reheating vegetables or keeping them warm on the fire as these practices destroy the nutrients.

FOOD GROUPS AND GUIDE LINES FOR FOOD SELECTION

Foods are classified into different groups based on their nutritive value. These groups are:

1. Cereals and millets
2. Pulses (legumes)
3. Nuts and oil seeds
4. Vegetables
5. Fruits
6. Milk and milk products
7. Eggs
8. Meat, fish and other animal foods
9. Fats and oils
10. Sugar and other carbohydrate foods
11. Spices and condiments.

Nutritional importance of the above food groups are as follows:

1. Cereals and Millets

Cereals contain 6-12% of protein and vitamin thiamine, niacine, pantothenic acid and vitamin B_6. They also contain minerals like phosphorus and iron. Cereals are poor in calcium except ragi which is a rich source of calcium (poor mans milk) cereals are deficient in vitamin A, D, B_{12} and C.

Cereals and millets form the staple food of majority of the population in developing countries because milk, fruits and fish are very expensive and beyond the reach of many. Puffed cereals are consumed widely as a snack.

If the cereals consumed is milled rice it should be atleast partly substituted by undermilled or parboiled rice, whole wheat or ragi.

2. Pulses (Legumes)

Pulses are rich in proteins (20-24%) they are also good sources of Vitamin B and minerals but deficient in Vitamin A, D, B12 and C. They are palatable and tasty. Puffed pulses are consumed by majority of low income group families as snack.

Pulses contain anti-digestive factor trypsin inhibitor which gets destroyed during cooking. Germination of pulses increases their vitamin content. Combination of cereals and pulses provide enough protein of high biological value.

3. Nuts and Oil Seeds

Nuts and oil seeds are also rich sources of proteins (20-40%) some are rich in calcium e.g., Sesame seeds. Richest in protein is

soyabean. They are also good sources of fats, B complex vitamins, Vitamin E and minerals like phosphorus and iron.

The common nuts used in tropical countries are coconuts, cashewnuts, groundnuts and walnuts. They are ideal foods for supplying high calories in a palatable form and are used in milk substitutes for infants.

4. Vegetables

Vegetables include green leafy vegetables, roots and tubers and other vegetables.

Green leafy vegetables are rich in carotene (provitamin A), riboflavin, folic acid, vitamin C and calcium. Because of their cellulose content (cellulose is not digested in man) they form the bulk of faecal matter and avoid constipation.

Roots and tubers like potatoes, sweet potato, tapiaco and carrots are good sources of carbohydrates and poor sources proteins. They can act as partial substitutes for cereals. Excess consumption may cause protein calorie malnutrition.

Other vegetables include snakeguard, parivar, cucumber, ashguard and drumstick. Some of them are rich in vitamin C. Yellow pumpkin is a rich source of carotene.

5. Fruits

Many fruits like amla (Indian gooseberry) guava and citrous fruits are rich in vitamin C. Apple, grapes and banana are poor sources of Vitamin C. Banana is rich in potassium and is the cheapest and most extensively used fruit in India. Mango and papaya are good sources of carotene.

6. Milk and Milk Products

Milk is rich in protein, carbohydrates, fat, vitamin and minerals like calcium. It is deficient only in iron and vitamin C and D. Milk protiens are first class proteins containing all the essential amino acids and therefore have high biological value. Milk is used as a complete food for infants and as supplement in the diets of children and adults.

Full Fat Milk Powder

Contains about 25-26% fat. It is reconstituted by adding warm water (7 times its weight). It is a subsititute for fresh milk.

Skimmed Milk Powder

Skimmed milk powder is prepared from fat free milk. It contains 35% proteins but no fat or vitamin A. It is used as a supplement to the diet of children.

Dahi, lassi, butter, ghee, khoya and chhana are some of the other milk products used.

7. Eggs

Eggs of hen or duck contain protein of high biological value(13%). It is a rich source of vitamin A and B complex vitamins and a fair source of vitamin D but does not contain vitamin C. Egg yolk contains saturated fatty acids which increase cholesterol level.

Egg is used as a supplement to the diet of infants. A large number of vegetaraians eat eggs and non vegetarians usually take eggs during breakfast.

Eggs are digested and digested completely and therefore form ideal nutritive food for acutely ill and convalescent patients and in the diseases of the colon.

8. Meat, Fish and other Animal Food

Meat is rich in protein which contains all essential amino acids and high biological value. It does not contain Vitamin A, D or C but is a fair source of vitamin B. High meat diet is indicated in protein malnutrition, anaemias and nephrosis. Liver is rich in protein (18-20%) Vitamin A and B complex especially B_{12}.

Fish contains 18-20% of protein of high biological value. It is fair source of vitamin B. Fat fishes are rich in vitamin A and D. Large fishes are rich in phosphorus and small fishes in calcium (as they are eaten with their bones).

9. Fats and Oils

Butter, ghee and vanaspatti are good sources of vitamin A Common vegetable oils do not contain vitamin A. Many fats and oils are good sources of vitamin E. They are used for taste, as sources of energy and for providing the required quantity of essential fatty acids.

10. Sugar and other Carbohydrates

Cane sugar, jaggery, glucose, honey and custard powder are used as a source of energy. Honey and jaggery also contain small quantities of vitamins.

11. Condiments and Spices

The essential oils present in them improve flavour and enhances the taste of food. They stimulate apetite. They irritate the intestine and help excretion of bowels in constipated persons.

FUCTIONAL CLASSIFICATION OF FOODS

Functionally foods are divided into:
1. Energy yeilding foods
2. Body building foods
3. Protective foods.

1. Energy Yielding Foods

This group includes foods rich in carbohydrates and fats and also pure fats and carbohydrates. Cereals also provide in addition to energy, the greater part of the proteins, certain minerals and vitamins in the diets of the low income groups in the developing countries.

2. Body Building Foods

Foods rich in protein are called body building foods e.g.:
a. Milk, eggs, meat, fish. They contain protein of high biological value.
b. Pulses, oil seeds and nuts containing proteins of medium nutritive value.

3. Protective Foods

Foods rich in proteins, vitamins and minerals are called protective foods. They are of two types:
a. Foods rich in proteins, vitamins and minerals are called protective foods e.g., Milk, egg, fish, liver.
b. Foods rich mainly in vitamins and minerals only e.g., Fruits and green leafy vegetables.

PLANNING OF A BALANCED DIET

A balanced diet is the one which contains various groups of food stuffs such as energy yielding, body building and protective foods in the correct proportion and also make provision for extra nutrients to withstand short duration of leanness. The components of balanced diet will differ according to age, sex, physical activity, economic status and physiologic state namely pregnancy, lactation, etc.

Balanced Diet at High Cost

Balanced diet with high cost can include liberal amounts of costly foods such as mile, fish, fruits, meat, egg and moderate amounts of cereals and pulses.

Balanced Diet with Moderate Cost

Balanced diet with moderate cost includes moderate amounts of cereals, pulses, nuts and green leafy vegetables.

Balanced Diet with Low Cost

Balanced diets of low cost will include large amounts of cereals, pulses and vegetables but small amounts of milk, eggs, fish and meat.

A balanced diet has become an accepted means to safeguard the population from nutritional deficiencies. Its goals are:

a. The requirements of protein should be met which amounts to 15-20% of daily energy needs.
b. Fat should be limited to 20-30% daily energy needs.
c. Carbohydrates rich in natural fibre stored constitute the remaining food energy.

Refer to Table 32.1 for the ICMR recommended composition of balanced diet for Indians.

Table 32.1: The recommended composition of balanced diet for Indians (ICMR)

Food	**Adult (man)**			**Adult (Woman)**	
Items	*Sedentary*	*Moderate*	*Heavy*	*Sedentary*	*Moderate*
Cereals	460 gm	520 gm	670 gm	410 gm	440 gm
Pulses	40 gm	50 gm	60 gm	40 gm	45 gm
Leafy green vegetables	40 gm	40 gm	40 gm	100 gm	100 gm
Other vegetables	60 gm	70 gm	80 gm	40 gm	40 gm
Roots and tubers	50 gm	60 gm	80 gm	50 gm	50 gm
Milk and milk products	150 gm	200 gm	250 gm	100 gm	150 gm
Oils and fats	40 gm	45 gm	65 gm	20 gm	25 gm
Fruits	60 gm	60 gm	60 gm	60 gm	60 gm
Sugar and jaggery	30 gm	35 gm	55 gm	20 gm	20 gm

N.B. Balanced Diet of heavy worker

For non-vegeterians, pulses should be reduced by 50% + one egg or 30 gm fish or meat.

If no pulses 2 eggs or 50 gm fish or meat.

CHAPTER

33 Assessment of Nutritional Status

The nutritional status of a community is the sum of nutritional status of individual who form that community. The aim of nutritional assessment of a community is to know the magnitude and geographic distribution of malnutrition as a public problem, to analyse the factors responsible for it and to effectively plan to control and eradicate them to maintain good nutrition. The nutritional status of a population is influenced profoundly by diet and infections and parasitic diseases. Malnutrition and under nutrition affect adversely the growth and health of children and the health and physical efficiency of adults. The incidence of malnutrition is high among pregnant women, weaned infants and preschool children among low income groups in developing countries.

NUTRITIONAL ASSESSMENT

The methods employed include:
1. Clinical examination
2. Anthropometric examination
3. Laboratory and biochemical examination
4. Dietary examination
5. The study of vital statistics
6. Assessment of ecological factors.

1. Clinical Examination

The goal is to assess the levels of health of individuals or by population groups in relation to the food they consume. The following draw backs are possible in clinical examinations:
a. Malnutrition cannot be quantified on the basis of clinical signs.
b. Many deficiencies are unaccompanied by physical signs.
c. Lack of specific as well as subjective nature of most of the physical signs.

To minimize subjective and objective errors in clinical examination, standard schedules have been devised to cover all the areas of the body.

2. The Study of Anthropometric Data

Anthropometric measurements such as weight, height, median circumference, head circumference and skin fold thickness are valuable indicators of nutritional status. Anthropometric measurement recorded over a period of time would show the patterns of growth and development when correctly interpreted.

If children do not get sufficient food, they fail to grow properly. Similarly, adults without enough to eat loose weight and those who overeat gain weight. Measurements of adults and large groups of children at various ages have been used as an index of nutritional status. The weighing machine has also been widely used in school medical services and at child health clinics as a simple diagnostic tool for screening children who may be undernourished.

It is important to realize that there are other factors besides food intake that determine weight notably constitutional or genetic make up. There are tall, thin, light people and short and thickest heavy individuals who may each be equally healthy. Weighing machine alone cannot determine their relative nutritional status. Other physical measurements and particularly height are useful.

Height should be measured against a flat surface and the subject must stand as upright as possible without raising the heels from the ground.

Mid Upper Arm Circumference

The weight recording is a useful method but at times it is not measured accurately by paramedical personnel. Height may give a fallacious impression in a genetically tall or short children.

The mid-arm circumference gives an assessment of muscle mass, subcutaneous tissue and hence indirectly to the nutritional status. It is relatively simpler to measure for a rapid community survey and varies very little between age 1 to 4 years. The upper arm is uniformly round and free from oedema and does not vary with the height of the child. It can be measured quickly, requires

no specific equipment and can be measured accurately by any trained paramedical personnel as below:

a. It is measured at the mid point of the left upper arm.
b. Midpoint is marked by making central point of the distance between the olecranon of the ulna and the acronion of the scapula when the arm is fixed at the elbow.
c. The left arm will be hanging loosely on the side. With a steel tape, the circumference of the arm is measured by passing it around the arm applying firmly but without disturbing the contours of the arm.

3. Laboratory Examination

Lab tests

Haemoglobin

The estimation of haemoglobin plays a vital role in health in nutritional surverys, as it acts as a major index for overall nutrition state.

Stool and Urine

Stool examination would detect any intestinal parasites present. Urine can be examined for albumin and sugar.

Biochemical Tests

Biochemical tests are time consuming and expensive and hence they cannot be applied in large scale. Most of the biochemical tests would give information about the current nutritional status.

4. Dietary Examination

The value of nutrition assessment is greatly enhanced when it is supplemented by the food consumption assessment. A diet survey may be carried out by any of the following methods:

a. Weighing of raw foods
b. Weighing of cooked foods
c. Oval questionnaire methods
d. Checking of stock inventory.

The data collected by any one of the above methods are analysed for:

a. Mean intake of food in terms of cereals, pulses, vegetables, milk, meat, fish etc.
b. For mean intake of calories, proteins, fats, vitamins, carbohydrates and minerals. The best guide for the analysis of the dietary questionnaire is the use of ICMR publications.

5. The Study of Vital Statistics

Vital statistics here involve mortality and morbidity data in a community which enables one of identify high risk and extent of such risk to the community. Mortality data may not give a satisfactory picture, but morbidity (data from hospital or community health and morbidity surveys) would throw sufficient light on problems related to protein energy malnutrition, anaemia, vitamin A deficiency and endemic goitre.

6. Analysis of Ecological Factors

In any nutritional survey, it is necessary to collect certain background information of the given community in order to make the assessment complete. The ecological factors related to malnutrition are:

a. *Conditioning influence:* Bacterial, viral and parasitic agents (amoebiasis, ascariasis etc).
b. *Cultural influence:* Food habits and practices. Cooking beliefs and taboos, child rearing practices feeding of pregnant or lactating mothers.
c. *Socio-economic factors:* Family size, occupation, education, income, housing, expenditure on food.
d. *Food production:* Customs related to the methods of cultivation of food, storage and distribution.
e. *Health and educational services*: The number of hospitals and health personnel, preventive and curative services. Mass media and communication.

Before iniating, steps for prevention and control of malnutrition, it is essential to make an ecological diagnosis of various causative factors which coexist with other factors responsible for the malnutrition in the community.

NATIONAL AND INTERNATONAL AGENCIES WORKING TOWARDS FOOD/NUTRITION

Food and Agricultural Organization (FAO)

FAO is one of the specialized agencies of the United Nations organization, formed in 1945 with headquaters in Rome. The functions of FAO include:

1. To help nations raise their living standards.
2. To improve nutritional level of people of all countries.
3. To secure improvement in production and distribution of all food and agricultural products.
4. To improve the condition of rural masses.

The main activity of FAO is to promote production of food to meet the requirements of ever increasing world population. The joint WHO/FAO expert committee provides the base for many cooperative activities such as nutritional surveys, training courses, seminars and coordination of allied research programmes.

CARE (Cooperative for Assistance and Relief Every-Where)

CARE was founded in North America in 1945. It is one of the world's largest independent nonprofit, non-sectarian international relief and developmental organization. CARE provides emergency aid and long term development assistance.

CARE began its operation in India in 1950. Till the end of 1980s, the primary objective of CARE India was to provide food for children in the age group of 6-11 years. From mid 1980s CARE India focussed its food support in the ICDS programme and in development programmes in the areas of health and income supplementation.

CARE India has given help in the field of medicine, literacy, vocational training and agriculture. It also helps schools by providing garden tools, pumps and improved seeds to grow more food. It also provides mobile medical vans, X-ray machines, diagnostic equipments, eye glasses and frames, medical books, medicine and vitamins.

NIN (National Institute of Nutrition), Hyderabad

Set up under Indian Council of Medical Research (ICMR) is the premier research institution of the country. It has published many

research publications including "The nutritive value of Indian Foods". This handbook provides detailed information on the nutrients composition of a wide range of common Indian foods. Upto date information on nutritional requirement and Recommended Dietary allowances and guidelines for formulation of nuturitionally rich diets are also provided by NIN for the benefit of health professionals and informed public. The data on nutrient composition of foods given are based mainly on Indian research work carried out at the National Institute of Nutrition, Hyderabad itself.

Central Food Technological Research Institute (CFTRI), Mysore

The Bengal famine of 1943 and the ravages of the second world war made the Government of India realize that the key to food security was in the right intervention of science and technology to conserve, preserve, process and distribute the available food resources. CFTRI was declared open on 21st October 1950 as the next step.

Through the decades since then, CFTRI has produced and provided scores of technology solutions that have given a powerful thrust to the development of indigenous food industries and played a notable role in the socio-economic transformation of the nation.

Technology Milestones of CFTRI

a. Formation of infant food using buffalos milk.
b. Extraction of plant protein for the nutrition base for a new class of food supplements: Energy food, Indian multipurpose food, miltone, bal ahar and several weaning foods.
c. Improvement in the efficiency of process for handling, drying and willing of staple cereals.
d. Design and fabrication of energy efficient and cost effective equipment for milling food grains and pulses.
e. Refinement of millets and production of diversified millet products with enhanced nutritive value.
f. Efficient methods for parboiling paddy.
g. Formulation of products for preparing traditional Indian snacks.
h. Production of spice and oil resins by indigenous technology.
i. Fermentation and drying of cocoa mass, cocoa butter and cocoa powder by indigenous technology.

Support Area Milestones

- Establishment of the International Food Technology Training Centre (IFTTC) in collaboration with FAO—The nucleus of an internationally referred centre of excellence in advanced knowledge in foods.
- Selection by the UNU as an Associated Institution.
- Recognition by the University of Mysore for postgraduate studies and research in food technology, food science and allied disciplines.
- Adoption by the National Information System for Science and Technology (NISSAT) as a sectoral information centre (NICFOS) for food science and technology in India.
- Establishment of a state-of-the-art pilot plant.
- Establishment of the International School of Milling Technology: An Indo-Swiss venture.
- ISO 9001 certification.

CHAPTER

34 Role of Nurse in Nutritional Programmes

COMMUNITY NUTRITION PROGRAMMES IN INDIA

The government of India, through various ministries have iniated large scale supplementary feeding programmes and programmes aimed at overcoming specific defiency diseases as follows:

Programme	Ministry
1. Vitamin A prophylaxis programme	Ministry of health and family welfare
2. Prophylaxis against nutritional anaemia	Ministry of health and family welfare
3. Iodine deficiency disorders control	Ministry of health and family welfare
4. Special nutrition programme	Ministry of health and social welfare
5. Balwadi nutrition programme	Ministry of health and social welfare
6. Integrated child development scheme (ICDS)	Ministry of health and social welfare
7. Mid-day meal programme	Ministry of education.

1. Vitamin A Prophylaxis Programme

As a part of the National Programme of Prevention of Nutritional blindness is to administer a single massive dose of an oily preparation of vitamin A containing 200,000 IU (110 mg of retinol palmitate) orally to all preschool children of 1-5 years of age in the community every 6 months through peripheral health workers. The scheme developed based on the technology by National Institute of Nutrition, Hyderabad and launched by the ministry of Health and Family Welfare in 1970 is a remarkable success in preventing blindness.

2. Control of Iodine Deficiency Disorders

The National Goitre Control Programme was launched by the government of India in 1962, in the conventional goitre belt in the Himalayan region to supply iodinised salt in place of common salt. But surveys slowed that the deficiency disorder was more widespread with nearly 145 million people with iodine deficiency. As a result, a major national programme—the IDD control programme was initiated in 1986 with the objective to replace the entire edible common salt with iodinised salt.

3. ICDS Programme

Integrated Child Developments (ICDS) programme was started in 1975, in pursuance of the National Policy on Children. The nutrition part of this programme include supplementary nutrition, Vitamin A phophylaxis and iron and folic acid distribution.

4. Midday Meal Programme (MDMP)

MDMP is also called the school lunch programme with following principles:

a. The meal should be a supplement and not a subsititute to the home diet.
b. The meal should supply at least one-third of the total energy requirement and half of the protein used.
c. Cost of the meal should be reasonably low.
d. Cooking should be easy, no complicated cooking process should be involved.
e. As far as possible, locally available foods should be used to reduce its cost.
f. The menu should be frequently rotated to avoid monotony.

A model menu for a mid-day school meal

Food stuffs	*gms per day/child*
Cereals and millets	75
Pulses	30
Oil and fats	8
Leafy vegetables	30
Non-leafy vegetables	30

OBJECTIVES OF NUTRITION EDUCATION

a. To develop nutition advisory services and nutrition education programmes for the public
b. To participate and coordinate in community nutrition programme with the cooperation of people working in other disciplines like social workers, village health workers and nurses and also with the help of social welfare agencies.
c. To help in developing supplementary nutrition programmes, whereever necessary.
d. To improve the nutritional levels of the community by available means.

MEANS FOR NUTRITION EDUCATION

a. The basic facts regarding the nutrition problems in a community can be had by nutrition survey and compiling the results of study of prevalent problems especially with reference to vulnerable groups like infants, preschoolers, pregnant and lactating mothers.
b. Studying the socio-economic factors, religions beliefs, customs and traditions affecting dietary patterns and local prevalent problems.
c. Development of nutrition education material in local languages.
d. Supplementary feed programmes in the mother and child activities.

METHODS OF NUTRITION EDUCATION OF THE COMMUNITY

Important methods are:
a. Lectures and demonstration
b. Workshops
c. Films and slide shows
d. Postures, charts and exhibitions
e. Books, pamphlets, bulletins and newspaper
f. Radio and television.

ROLE OF NURSES IN NUTRITIONAL ASSESSMENT AND NUTRITION EDUCATION

Nurses are concerned about the nutritional status of all their patients. What people eat affects their health from conception

through oldage. Chromic malnutrition affects physical and mental development. In industrialized societies. Many diet related diseases result from nutritional excess than undernourishment. For example, Coronary heart disease is the result of excessive intake of saturated fats and cholesterol, cancer is linked to high fat, fibre and alcohol consumption, hypertension, a risk factor for strokes is associated with intake of excessive calories and salt; liver diseases are associated with heavy alcohol consumption and diabetes mellitus with excessive calorie intake and subsequent obesity.

Community health nurses are often the contact between community residents and health care system. Because of frequent and extended contact with patients in the community, nurses have excellent opportunities to provide information and counselling about the importance of nutrition in preventing illness and promoting health.

The role of the nurse has changed with the current preventive health care focus and emphasis upon wellness and with the expanding responsibilities the nurses are assuring in the care of their patients in the hospitals as well as in primary health care centers. The nurse must follow an epidemiologic approach while taking numerical histories and developing care plans for patients with nutritional inadequacies.

Nutritional problems are the result of multiple factors. All patients (hosts) have a genetic core and this together with the influence of past life experiences may make them more susceptible to problems. The factors influencing nutrition are biological, psychological, sociocultural and environmental factors.

The nurse within any health care setting should assume responsibility for provision of optimal nutrition and nutrition counselling for patients. Preventive health teaching should be initiated during first visit to patient or patient's first visit to the agency. Referral to appropriate community resources helps the patients to maintain a preventive approach to health care.

ROLE OF COMMUNITY HEALTH NURSE IN NUTRITION

1. The community health nurse will have to study the food habits of people in her community, their views etc.
2. She must impart the knowledge of the importance of good nutrition without hurting their cultural habits.

3. She must use all media of health education in nutrition education.
4. She needs to demonstrate simple receipes which are affordable and locally available.
5. She will identify the malnutritioned children and refer them to appropriate nutrition programmes.
6. She assists in nutrition rehabilitation programmes.
7. She also takes part in nutrition research.

CHAPTER

35 Nutrition in Pregnancy

Pregnancy and lactation are normal physiological processes. During pregnancy foetus draws its nourishments from the mother's diet. This increases the requirement of proteins, vitamins and minerals of the mother, as her body stores are used by the foetus.

Duing the first trimester of pregnancy, the food intake is generally lowered because of nausea and vomiting (morning sickness). During this period, frequent small easily digestible foods including fresh fruits, fruit juices and vegetables should be given.

ENERGY

The increase in calories trimester-wise is as follows:

I	Trimester	10 Kcal/day
II	Trimester	90 K cal/day
III	Trimester	200 K cal/day

The increase in energy is to support the growth of the foetus, placenta and maternal tissue and for the increase in basal metabolic rate due to additional work of the growing foetus and the increase in maternal size.

PROTEINS

The normal protein requirement of an adult is 50 g/day. ICMR has increased the requirement during pregnancy by 15 gm/day. The additional protein is for:

a. The transfer of amino acids from the mother to foetus.
b. Rapid growth of the foetus.
c. Formation of amiotic fluid and storage reserves during delivery, labour and lactation.
d. The enlargement of the uterus, plecenta and mammary glands.
e. For increase in maternal circulating blood volume and subsequent demand for increased plasma protein.

VITAMINS

Anaemia due to B_{12} deficiency during pregnancy is not very common. Milk, fruits and vegetables can supply all necessary vitamins. Thus, when a good balanced diet is given, there is no, need for vitamin supplements.

There is increased use for vitamin D to enhance the maternal calcium absorption and calcium metabolism in the foetus.

Vitamin K is of vital importance for the synthesis of prothrombin which is necessary for normal coagulation of blood for preventing neonatal haemorrhage.

The water soluble vitamins B complex and vitamin C must be supplied in adequate amounts. There is an increased requirement of folic acid for promoting foetal growth and to prevent macrocytic anaemia during pregnancy. Deficiency of iron puts additional stress on folate metabolism.

MINERALS

An increased intake of calcium by mother is very essential not only for the calcification of foetal bones but also protection of calcium reserves of the mother to meet the large demands during lactation. Use of vitamin D and calcium supplements reduce muscular cramps during pregnancy.

IRON

During pregnancy, there is also an increased requirement of iron due to the following:

a. Iron is necessary for the growth of foetus and plecenta.
b. It is necessary for the promotion of haemoglobin as there is 40-50% increase in the maternal blood volume.
c. To replace the maternal iron losses.
d. To achieve high levels of haemoglobin in the infants which is stored in the liver for 3-6 months. Iron must be transfused to uterus of the mother during gestation.

FATS

Fats must be provided according to the normal requirements.

NUTRITIONAL REQUIREMENTS DURING LACTATION

Milk is secreted by the mother for feeding the baby. Therefore, during lactation nutritional requirements are increased.

1. Calories

Mother requires total amount of about 13000 K cal during lactation period of 6 months. Mother needs additional 700-750 K cal daily to convert food energy into milk.

2. Proteins

Daily milk produced is about 850-1000 ml during lactation. Human milk contains about 1% protein and thus there is daily excretion of 8-10 gm of protein. Therefore, lactating woman should take about 20-25 gm of extra protein daily. In vegetarians 2-3 cups of milk and milk products will supply this need.

Non-vegetarians should take one average helping of either meat, chicken, egg or fish daily. In addition, two cups of milk also should be taken as extra. Balanced diet for pregnant women is given at Table 35.1

Table 35.1: Menu plan for pregnancy

Time	*Menu plan*	*Ingredient*	*Quantity*	*Energy Kcal/g*	*Protein*	*Fat*	*CHO*	*Ca*	*Fe*	*pH*	*Vit.A*	*Vit. B_1*	*Vit. B_2*	*Folic acid*	*Vit. C*
7 am	**Bed coffee**	Milk sugar	1 cup	104	38	3.4	14.4	0.10	1.2	0.10	154	0.04	0.018	-	1.4
8.30 am	**Break fast**														
	Masala dosa	White rice Blackgram	2 nos	424	9.2	16.8	58.8	0.08	3.4	0.16	420	0.18	0.12	28.1	7.2
	Sambar	Dal Potato Tomato Beetroot Drumstick Ladyfinger Pumpkin Cucumber Snake guard Carrot Onion Chilly	1 serving	296.7	11.38	1.05	60.62	0.074	3.43	0.18	48.9	0.156	0.133	103.9	7.88
	Egg omelette	Egg Onion Pepper	1 cup	77	5.8	5.7	0.5	0.03	1	0.10	940	0.06	0.15	71.8	-
	Boiled banana	Banana	1	153	1.3	0.2	36.4	0.01	.4	0.05	80	0.05	0.08	–	7
	Tea	Milk sugar	1 cup	72	14	1.6	13	0.06	-	0.04	76	0.02	0.1	5.6	.6
	Total			1126.7	32.9	28.8	183.7	.354	9.43	.632	1718.9	.506	.763	215	24.1
12.30 pm	**Lunch** Rice mutton Pulav	Rice mutton Onion Carrot Beans Peasdry	1 serving	343	10.2	19.5	31.8	.05	1.75	.11	50	.10	3.10	7.5	.56

Contd...

Contd...

Time	Menu plan	Ingredient	Quantity	Energy Kcal/g	Protein	Fat	CHO	Ca	Fe	pH	Vit.A	Vit. B_1	Vit. B_2	Folic acid	Vit. C
	Vegetable salad	Tomato Cucumber Carrot Onion Curd Chilly		20.11	1.21	1.06	2.79	0.044	0.4	0.391	105.6	0.023	0.019	36.4	4.75
5 pm	**Evening coffee**	Milk sugar	1 cup	104	3.8	3.4	14.4	0.10	1.2	0.10	154	0.04	0.18	5.6	1.4
	Ragi rotti		2 nos	460	8	9	87	0.40	6	0.30	255	0.50	0.13	5.2	-
		Total	-	927.1	23.12	32.9	135.9	0.594	9.35	0.901	564.6	0.663	3.43	54.7	6.7
8 pm	**Dinner**														
	Chapathi	Wheat	2 nos	193	5	5.5	30.8	0.02	3	0.13	128	0.20	0.05	12.1	-
	Amaranth Curry	Amaranth Onion Coconut oil	1serving	47	1.4	2.3	5.1	0.04	6.6	0.04	1942	0.03	0.03	54.2	51
	Fruit salad	Apple Banana Grape		101.8	0.925	0.023	24.1	.083	0.725	0.035	43.8	0.065	0.055	–	4.4
10 pm	**Milk**	Milk sugar	1 cup	130	7	7.4	9.8	0.24	0.8	0.2	280	0.06	0.34	5.6	4
		Total		471.8	14.33	15.22	69.8	0.323	11.13	0.405	293.8	0.355	0.645	71.9	59.4
		Grant total		2525.5	70.3	76.9	389.5	0.913	29.91	1.36	4678.2	1.52	4.84	341.6	90.18
			RDA	2525	65	30		1000	38		2400	1.3	1.5	400	40

CHAPTER

36 Nutrition in Infancy

In early infancy most of the nutrient requirements are met by breast milk and weaning foods should start by 4-5 months.

ENERGY

The energy requirements of infants are much higher. Infants require 120 Kcal/kg body weight.

Proteins

In an infant protein requirements are higher. In the initial months, the human milk provides the essential amino acids needed for growth.

The protein requirement of an infant are as follows:

0–3 months	2.3 gm/kg body weight (a)
3–6 months	1.8 gm/kg body weight (a)
6–9 months	1.8 gm/kg body weight (b)
9–12 months	1.5 gm/kg body weight (b)

a. In terms of milk protiens.
b. Partly vegetable proteins also.

If the protein and calorie requirements are not met adequately, it could lead to protein calorie malnutrition.

MINERALS

Rapid growth requires large quantities of minerals, especially calcium and phosphorus. Though mother's milk has less calcium it is better absorbed from breast milk. The intake of cows milk leads to hypocalcaemia due to its high phosphate content.

VITAMINS

Vitamins are essential for the rapid growth of infant. Breast milk provides sufficient vitamins. Cows milk is deficient in vitamins C and D.

FAT

About 35-45% of calories are provided by fat in the initial stages of infancy. Supplementary foods provide fat in the later stages.

CARBOHYDRATES

Lactose in human milk provides 25-55% of calories.

FLUID

Water intake in full term infants is 60 ml/kg body weight on day one. It increases to 150-170 ml/kg by day 3-4. As weaning starts boiled, cooled water should be given along with fresh fruits and juices or pouridges and gruels.

Table 36.1 shows the comparison of nutrient value of human and cow milk.

Table 36.1: Comparison of nutrient value of human and cow milk

Nutrient	*Unit*	*Human milk*	*Cow milk*
Water	ml	88.0	87.5
Fat	gm	1.1	3.2
Protein	gm	1.2	3.2
Energy	K cal	65.0	67.0
Calcium	mg	34.0	117.0
Sodium	mg/L	7.0	22.0
Zinc	mg/L	4.0	4.0
Iron	mg/L	0.5	0.5
Vitamin A	IU/L	1898.0	1025.0
Vitamin B	mg/L	46.0	11.0
Vitamin C	IU/L	22.0	14.0

BREASTFEEDING

Most infants start feeding by first few hours of birth. Early feeding helps to maintain normal metabolism and growth, promotes maternal infant bonding and decreases risk of hypoglycaemia, hyperkalaemia, dehydration, fever and hyperbilirubinemia.

Advantages of Breastfeeding

1. Infant derives the sense of security and belongingness by the comfort of being held in the arms during the process of breast feeding. There is an unbreakable bond created between the two.
2. It is economical to breastfeed the infant as it is naturally available food which is clean and hygienic.
3. Breastfeeding helps in birth control. The hormone prolactin which stimulates milk production also decreases the synthesis of various hormones. It is a cost effective method of contraception. By breast feeding the uterus comes back to normal size and would stop bleeding by the secretion of oxytocyn. It also helps to reduce weight in mothers.
4. Risk of breast cancer is higher in women who have not breastfed their babies.
5. There is proper development of jaws and teeth and they are not crowded as the infant must suckle hard to extract milk.
6. Reduced likelihood of child being allergic to milk as human milk proteins do not cause allergies.
7. There is less danger of the feed being contaminated which could lead to gastrointestinal problems. Mortality rates are lower among breastfed infants.
8. Human milk contains bacterial and viral antibodies including high concentration of secretary IgA which provide local gastrointestinal immunity.
9. It is available at correct temperature and needs no time for preparation.
10. It is convenient to feed the baby when it is in the mother's arms.
11. It protects the babies from obesity.
12. There is rapid maturation of the gastrointestinal tract due to the presence of growth factors and certain hormones.
13. The fats and proteins present are more easily digestible and there is less chance of child developing gastric and intestinal distress.
14. Milk has other anti-infective proteins due to the presence of microphages, complement, lysozyme and lactoferrin. All these provide protection against diarrhoea and respiratory infections.
15. The breast milk also provides many biochemical advantages like prevention of neonatal hypoglycaemia.

Conditions When Mothers are Advised not to Breastfeed

Septicaemia, nephritis, active tuberculosis, typhoid fever, malaria, renal failure, grade IV cardiac failure, severe neurosis.

Supplementary Foods for Infants and Toddlers

A menu plan for a 9-month-old infant is at Table 36.2

The first solid foods are introduced at 5 to 6 months of age. The foods given are cereals, cereal milk or cereal dahl preparations such as suji halwa, rice milk, upma, rice dahl, khichdi, pongal, bread, rice flakes/poha etc. Fruits such as ripe banana, mango, papaya which are soft and pulpy are also given. Well cooked non fibrous vegetables such as ash gourd, potato, pumpkin are fed along with rice.

Most of the problems of food acceptance begin in the toddler stage. The child will show a remarkable decrease in apetite in the second year as compared to the first year. So, it is important to give small portions of food and let the child enjoy the food. Allow the child some freedom to decide when he is satisfied. Allow some flexibility in choices and help the child form good food habits.

Toddlers

Children can share family meals, by the time they are two years old. A few alterations may be needed when the family makes highly spiced food. Toddler should not be given foods which are too fatty or too sweet. Such foods may fill his limited space, without providing the nutrients needs. The child may be encouraged to eat sweets towards the end of the meal so that he may not eat these to the exclusion of other foods.

It is good to give appetising beverages such as fruit juices and milk to the children. It is good to serve part of his milk needs in the form of soups, kheer, custard or ice cream. Fruits are ideal snacks. Crisp crackers or toast are liked and children can eat these without help which help him feel independent.

Menu plan for toddlers (1-3 years) is at Table 36.3

Table 36.2: Menu plan for a 9-month infant

Time	*Menu Plan*	*Ingridient*	*Amount*	*Calorie*	*CHO*	*Protein*	*Fat*	*Ca^{2+}*	*Fe^{21}*	*Vit A*	*Thiamine*	*Riboflavin*	*Niacin*	*Vit C*
6 am	Breast-feeding	-	-	-	-	-	-	-	-	-	-	-	-	-
8 am	Carrot Mashed	Carrot	25 g	12.711	2.675	0.225	0.05	0.02	0.375	472.5	0.01	0.0005	0.1	0.75
10 am	Breast-feeding	-	-	-	-	-	-	-	-	-	-	-	-	-
12 pm	Banana Mashed	Banana	25 g	39.55	9.1	0.325	0.05	0.0025	0.1	0.2	0.0125	0.02	0.075	1.75
3 pm	Breast-feeding	-	-	-	-	-	-	-	-	-	-	-	-	-
5 pm	Raggi Porridge	Raggi Milk Jaggery	25 g	183.8	37.48	2.88	1.46	0.135	3.55	58.87	0.12	0.117	0.4	0
7 pm	Breast-feeding	-	-	-	-	-	-	-	-	-	-	-	-	-
9 pm	Breast-feeding	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total RDA			236.06 784	49.255	3.43 18	1.56	0.1575 540	4.025 15	531.57 2000	0.1420 0.5	0.1425 0.6	0.575 8	2.5 35

Table 36.3: Menu plan for toddler (1-3 years)

Time	*Menu Plan*	*Ingridient*	*Quantity*	*Net Energy Kcal/d*	*Protein g/d*	*Fat g/d*	*CHO g/d*	*Ca mg/d*	*Iron mg/d*	*Vit A mg/d*	*Thiamine mg/d*	*Riboflavin mg/d*	*Niacin mg/d*
7 am	Milk	Milk sugar	100ml	65	3.5	3.7	4	0.12	0.4	140	0.03	0.17	0.1
10 am	Pongal (hot)	Rice Dal Vegetables	1 serving	200	5.5	6	30.6	0.03	1.6	174	0.09	0.08	0.6
		Total		265	9	9.7	34.6	0.15	2	314	0.12	0.25	0.7
12 pm	Rice	Rice	1/2serving	148.7	2.97	0.22	0.33	0.005	1.2	-	0.05	0.02	0.75
	Fish Curry	Fish-masala	1/2serving	55	4.3	4.05	0.35	0.012	0.3	54	0.02	0.32	0.02
	Apple	Apple	1 nos.	85.9	.3	0.1	13.4	0.01	1.7	-	0.12	0.03	0.12
		Total		289.6	5.5	4.37	14.08	0.027	3.2	54	0.197	0.377	0.89
4 pm	Milk	Milk Sugar	50 ml	32,5	1.75	1.8	2	0.06	02	70	0.015	0.08	0.5
	Ragi-Roti	Ragi flower salt	1 nos.	249	4	4.9	47	0.22	3.2	137	0.27	0.07	0.70

Contd...

Contd...

Time	*Menu Plan*	*Ingridient*	*Quantity*	*Net Energy Kcal/d*	*Protein g/d*	*Fat g/d*	*CHO g/d*	*Ca mg/d*	*Iron mg/d*	*Vit A mg/d*	*Thiamine mg/d*	*Riboflavin mg/d*	*Niacin mg/d*
8 pm	Masala Dosa	Rice flower Potato Peas	1 nos.	212	4.6	8.4	20.4	0.04	1.7	210	0.09	0.06	3.6
	Milk	Milk sugar	100 ml	65	3.5	3.7	4.0	0.12	0.4	140	0.03	0.17	0.1
		Total		558.5	13.85	18.8	73.4	0.54	5.7	557	0.405	0.385	4.9
		Grand		1112	28.4	32.87	122.0	0.617	10.9	925	0.722	1.01	6.4
		Total RDA		1240	22	25	-	0.4	12	400	0.6	0.7	8

CHAPTER

37 Menu for Preschool, School Age Children and Adolescents

DIET FOR A PRESCHOOL CHILD

Preschoolers have a very short span of attention and are easily distracted from eating. Their response to food is rather inconsistent. The muscle coordination is limited and eating behaviour is generally messy. When apportunity is provided, the preschooler learns things faster by taking advantages of parents. Young children have extreme taste sensitivity and prefer mildly falvoured foods.

Three times meal pattern along with mid-morning and mid-afternoon snacks are the best for extremely active children.

Types of Food Suitable for a Preschooler (Refer Table 37.1)

a. Fresh fruit juices.
b. Milk and milk beverages, curd, cheese pieces.
c. Fruit pieces like slices of apple, papaya, mango, sapota.
d. Boiled/raw vegetables, carrots, cucumber, potato, cauliflower, beans.
e. Mixed cereals like ragi, cornflakes, puffed rice, idlis.

DIET FOR SCHOOL CHILDREN (Refer Table 37.2)

Calories and Proteins

The requirements of calories are increased steadily in this age group. It increases further during adolescence. The increased requirements of proteins would meet demands of growth. Girls require more protein to meet the needs of approaching menarche.

Minerals

10-12 years old children require more calcium than adults to meet skeletal growth. As the blood volume increases, there is an increased demand for iron.

The Adolescent (12-16 years)

This is an age of rapid growth and intense activity. Individual variation is marked in this age group. A number of physical, emotional and mental changes occur in this period of life. Girls mature between 11 and 13 years whereas major changes occur in boys between 13 and 15 years.

It is normal for boys to eat a lot at this age especially if they are fond of out door sports.

DIETARY CONSIDERATION FOR TEENAGERS

The transition phase from childhood to adulthood is known as adolescence with speeded physical, biochemical and emotional development. It is during this period that the final growth occurs. There are many changes in the body due to hormones. Even boys and girls who had an excellent pattern of food intake are likely to succumb to strange inbalanced diets during adolescence. They feel independent and seek own identity and freedom to make their own decisions. Emotional difficulties often stem from feelings of social inadequacy or pressure of school work.

Meeting Food Needs of Adolescents

Adolescence is the age of group activities. Therefore, if nutrition education is introduced as a group activity, it may help in improving eating habit.

Boys may need to consume a lot of energy rich foods. Girls must give special attention to foods rich in protein, iron and other nutrients necessary for synthesis and regeneration of red blood cells. Girl's diet should include iron rich foods such as dahls, leafy green vegetables, dried fruits, egg, liver and red meat (if acceptable).

It is important for adolescents to gain appropriate weight for their height and body build. Any deviation from normal indicates some feeding problem, which must be indentified and corrected with the help of a dietician. Checking a three day food intake record, may help in identifying the specific lack or excess and thus form the basis or a plan of action.

Menu plan for preschool child is in Table 37.1.
Menu plan for school age children (6-12 years) is in Table 37.2.
Menu plan for an adolescent boy is in Table 37.3.

Table 37.1: Menu plan for preschool

Time	*Food Preparation (Meal Plan)*	*Ingredient*	*Quantity*	*Calorie*	*Protein*	*Fats*	*CHO*	*Ca*	*P.*	*Fe*	*Vit A*	*Thiamine*	*Riboflavin*	*Niacin*	*Vit C*
7 am	Milk	Milk+ sugar	1 cup	100	7.0	7.4	9.8	0.24	0.20	8	280	0.06	02	0.34	4.0
9 am	Dosa	Rice+ blackgram	2 nos.	216	4.1	9.7	28.2	0.03	0.07	1.5	239	0.10	0.3	0.06	-
	Sambar	Vegetable+ Oil+chilly	1/2serving	202.5	6.75	2.55	38.1	0.04	0.08	1.7	66	0.10	0.85	0.05	2.5
Total				518.5	17.8	19.6	76.1	0.31	0.35	4	585	0.26	1.3	0.45	6.5
12.30 pm	Rice +		1/2serving	74.3	1.4	1.11	16.6	0.002	0.025	0.6	-	0.025	0.3	0.01	-
	Fish fry			110	8.75	8.1	0.7	0.025	0.225	0.6	108	0.055	0.65	0.01	0.5
	Grapes Juice		1 cup	45	1	0.1	10	0.03	0.03	0.02	-	0.12	0.3	-	-
Total				229	11.15	9.31	27.3	0.05	0.28	1.22	108	0.2	1.25	0.02	0.5
3.30 pm	Milk+	Milk+Sugar	1 cup	100	7.0	7.4	9.8	0.24	0.20	0.8	280	0.06	0.2	0.34	4.0
	Raggi rotti		1 nos.	230	4	4.5	43.5	0.2	1.15	3	127.5	0.25	0.6	0.065	-
7 pm	Chappathi		2 nos.	193	5.0	5.5	30.8	0.02	0.13	3	128	0.20	2.0	0.05	-
	Green gram	1/2serving		42.7	1.75	1.92	4.6	.02	2.25	0.67	8.25	0.035	1.2	0.27	0.04

Contd...

Contd...

Time	*Food Preparation (Meal Plan)*	*Ingredient*	*Quantity*	*Calorie*	*Protein*	*Fats*	*CHO*	*Ca*	*P.*	*Fe*	*Vit A*	*Thiamine*	*Riboflavin*	*Niacin*	*Vit C*
8pm	Curry Milk		1 cup	100	7.0	7.4	9.8	0.24	0.20	0.8	280	0.06	0.2	0.34	4
Total				665.75	24.75	26.72	98.5	53.58	2.93	8.27	411.97	605	4.2	0.822	8.04
Grand Total				1413.5	53.75	55.68	201.9	1.0875	3.56	13.49	931.7	0.865	5.55	1.292	15.04
RDA				1690	30	25	40-60%	400	40	18	400	0.9	1.0	11	40

Table 37.2: Menu plan for school age children (6-12 years)

Time	*Menu Plan*	*Ingredient*	*Quantity*	*Energy (kcal/d)*	*Protein (g/d)*	*Fats (g/d)*	*CHO (gm)*	*Cal. (mg/d)*	*Iron (g/d)*	*Vit A (mg)*	*Thiamine (mg/d)*	*Riboflavin (mg/d)*	*Niacin (mg/d)*	*Vit C (mg/d)*
6 am	Coffee	Milk Sugar Coffee powder	1 cup (200 ml)	104	3.8	3.4	14.4	0.10	1.20	1.54	0.04	0.18	1.18	1.6
8 am	Idli	Bangal gram Rice	2 nos.	130	4.6	0.02	27.6	0.03	0.8	8	0.10	0.05	1.2	-
	Radish	Radish												
	Sambar	Tomato Potato Lady's finger Dal	1 seeve (100 gm)	52	1.2	1.8	67	0.02	1.1	37	0.04	0.02	0.026	1.6
	Banana	Banana	1 nos.	153	1.3	0.2	36.4	0.01	0.04	80	0.05	0.08	0.3	7
	Milk	Milk Sugar	1 cup (100 ml)	65	3.5	3.7	4.9	0.12	0.64	140	0.03	0.17	0.1	2
Total				504	25.3	9.3	150.3	0.28	3.64	419	0.26	0.5	1.806	11.9
1pm	Rice	Rice	1 sea	118	2.4	0.2	26.8	0.004	1.0	-	00.04	0.02	0.60	-
	Curd	Milk	1 sea	51	2.9	2.9	3.3	0.1	0.3	3.9	0.05	0.06	0.1	1.2
	Papad	Wheat salt	1 sea	288	18.8	0.3	52.4	0.08	17.2	-	-	-	-	-
	Potato curry	Potato Coconut oil Chilly	1 sea	99	1.6	0.1	22.9	0.01	0.7	24	0.10	0.01	1.2	17.1

Contd...

Contd...

Time	*Menu Plan*	*Ingredient*	*Quantity*	*Energy (keal/d)*	*Protein (g/d)*	*Fats (g/d)*	*CHO (gm)*	*Cal. (mg/d)*	*Iron (g/d)*	*Vit A (mg)*	*Thiamine (mg/d)*	*Riboflavin (mg/d)*	*Niacin (mg/d)*	*Vit C (mg/d)*
	Apple	Apple	1 no.	56	0.3	0.1	13.4	0.01	1.7	-	0.12	0.03	0.2	2.6
Total				612	26	3.6	118.8	0.204	20.9	27.9	0.31	0.12	2.1	20.9
4 pm	Raggi Porridge	Raggi Milk Coconut	1 cup	263	6.9	6.3	44.7	0.30	1.7	3.21	0.20	0.34	0.2	2
8 pm	Chappati	Wheat salt	1 sea	193	5	5.5	30.8	0.02	3	128	0.20	0.05	2	-
	Egg curry	Egg Onion Chilly	1 sea	7.7	5.8	5.7	9.5	0.03	1.0	940	0.06	0.15	0.1	-
10 pm	Milk	Milk sugar	1 cup (200 ml)	130	7	7.4	9.8	0.24	0.8	280	0.06	0.34	0.2	4
Total				663	24.7	24.9	94.8	0.59	6.5	1351.21	0.52	0.88	2.5	611
Grand Total				1779	66	37.8	363.9	1.07	31.04	17798.11	1.09	1.5	6.40	38.9
RDA Value=				1690 kcal/d	40 g/d	25 g/d	350 gm	1 mg/d	26 mg	1600 mg	1.0 mg/d	1.2 mg/d	13 mg/d	40 mg/d

Table 37.3: Meal plan for adolescent boy

Time	*Food Prepared*	*Ingredient*	*Quantity*	*Weight serving*	*Calorie*	*Protein*	*Fats*	*CHO*	*Cal.*	*Phos.*	*Iron*	*Vit A*	*Thiamine*	*Ribo-flavin*	*Niacin*	*Vit C*
6 am Breakfast	Bed Coffee	Milk+ sugar	1 cup	100	52	1.9	1.7	7.2	0.05	0.05	0.10	0.77	0.02	0.90	0.90	0.7
8 pm	Idli	Rice flour Black gram	5 nos.	340	325	11.5	0.5	69	0.075	0.2	2	20	0.25	3	0.125	-
	Radish Sambar	Radish Dal, potato carrot chillies pumkein	1 1/2 cup	196	101	04.1	3.6	13.1	0.02	0.04	1.1	37	0.04	0.26	0.02	1.5
	Egg omlette	Egg coconut chilly onion	1/2 cup	50	98.5	7.45	7.3	0.65	0.04	0.13	1.3	1205	0.075	0.13	0.19	-
	Banana	Banana	1 serving	100	0.4	1.3	0.2	36.4	0.01	0.05	0.4	18	0.05	0.3	0.08	7
	Tea	Milk sugar	1 cip	100	36	0.7	0.8	6.5	0.03	0.02	-	38	0.01	0.05	0.05	0.3
Total				836	612.1	126.9	14.1	132.8	0.225	0.49	4.9	1395	0.44	3.83	0.46	9.5
1 pm	Plain Rice	Rice	2 serving	504	595	11.9	0.9	134.8	0.02	0.20	4.8	-	0.20	3.0	0.09	
	Amara-nth curry	Amara-nth leaves cocunut chillies onion	1/2 Plate	28	47	1.4	2.3	5.1	0.04	0.04	6.6	1942	0.03	0.4	0.03	51

Contd...

Contd...

Time	*Food Prepared*	*Ingredient*	*Quantity*	*Weight serving*	*Calorie*	*Protein*	*Fats*	*CHO*	*Cal.*	*Phos.*	*Iron*	*Vit A*	*Thiamine*	*Ribo-flavin*	*Niacin*	*Vit C*
	Fish fry	Fish oil	1 serving	100	220	17.5	16.2	1.4	0.05	0.45	1.2	216	0.11	1.3	0.02	1.0
	Curd	Curd salt chilly	1 serving	50	51	2.9	2.9	3.3	0.12	0.19	0.3	39	0.05	0.1	0.06	1
Total				682	913	33.7	22.3	144.6	0.23	0.88	12.9	1197	0.39	4.8	0.2	53
4pm	Tea	Milk Sugar	1 cup	100	36	0.7	0.8	6.5	0.03	0.02	-	38	0.01	0.05	0.05	0.3
	Ragi roti	Ragi coconut	2 nos	185	460	8	9	87	0.40	0.30	6.0	255	0.50	1.2	0.13	-
8.30 pm	Chapathi	Wheat flour	3 nos.	85.5	289.5	7.5	8.25	46.2	0.03	0.19	4.5	192	0.3	3	0.75	-
	Bengal gram dalpary	Bengal gram dal flour	1 1/2 cup	151	284	9	16.4	25.2	0.07	0.13	3.8	366	0.14	2.4	0.10	2
10.30 pm	Milk	Milk sugar	1 cup	100	65	3.5	3.7	4.9	0.12	0.10	0.4	140	0.03	0.1	0.17	20
Total				621.5	17345	28.7	29.1	169	0.65	0.74	14.3	861	0.98	6.7	0.5	22.3
Total				218.9	2660.4	89.35	65.5	447.71	1.105	2.57	32.1	3443	1.81	15.3	1.185	84.8
RDA					2640	78	22	-	0.50	2.5	30	2400	1.8	17	1.6	40

CHAPTER

38 Geriatric Nutrition

The process of aging brings about marked physiological changes in the body and these changes influence the nutritional requirements. Geriatric nutrition deals with the nutritional requirements of old people.

PHYSIOLOGICAL CHANGES IN AGING

1. *Reduced BMR*: Basal Metabolic Rate (BMR) is reduced in all tissues. BMR is highest in infants and then it goes on decreasing as age advances. Because of reduction of BMR in all organs, functions of all the organs are lowered to a certain extent.
2. *Nervous system:* There is decreased memory, decreased ability and rate of learning, decreased reaction time, and dimness of vision. Due to arteriosclerosis and lack of vitamins the mental faculty is depressed. This leads to lack of interest in living. Changes in behaviour take place due to lack of work, isolation and loneliness.
3. *Gastrointestinal tract:* There is reduction in secretion of most of the digestive juices, gastric acidity is also reduced. This leads to indigestion and affects absorptions. In addition, there are certain changes in the intestinal mucosa which cause reduced absorption of nutrients. The motility of GI tract is also reduced and there is tendency to develop constipation. Appetite is reduced due to lack of physical activity. Digestion is also affected because of improper mastication due to lack of teeth/artificial denctures.
4. *Cardiovascular system:* As the age advances cholesterol is deposited in the inner walls of arteries. This leads to atherosclerosis. Atherosclerosis occurring in the arteries going to important organs (such as coronary arteries supplying the heart) causes decreased blood flow to these organs thereby decreasing their efficiency. Atherosclerosis in the vessels also increases the tendency of clot formation (thrombosis) in the vessels leading to almost complete

blockage of blood flow e.g., Cerebral thrombosis, coronary thrombosis etc.

5. *Renal system:* Over all functioning of the kidney is reduced.
6. *Skin:* As age advances, elasticity of the skin is reduced. Wrinkles appear.
7. *Endocrine system:* Activities of the endocrine glands such as thyroid, adrenal cortex and islets of Langerhans (pancreas) are diminished. Hormones of these glands are responsible for different metabolic activities in the cells. So overall cellular metabolism is influenced to a considerable extent.

Nutritional Requirements

Diet of old people becomes imbalanced due to:

1. Often they live alone. They are reluctant to cook and also reluctant to go to a restaurant. The result is that they miss their meals.
2. In many, food intake is limited due to restriction in diet because of various diseases such as diabetes, hypertension and renal diseases. Therefore, certain foods are to be avoided.
3. There is constipation and worry about the falling health which also reduces the appetite.
4. The teeth are lost due to decay. Many people use artificial teeth. Digestion is affected as there is improper mastication by artificial teeth.

Nutritional Requiements for Various Food Components is Discussed Below:

1. Calories

Because of reduction in BMR and restrictions in physical activity caloric requirement is reduced. Caloric intake is so adjusted that body weight remains constant preventing any tendency for obesity. But if there is loss of weight or emaciation, sufficient calories should be supplied to regain the normal weight.

2. Protein

Due to decreased appetite and poor digestion, the food intake is generally inadequate to meet the protein requirements of old people. Deficiency of proteins leads to anaemia, oedema and lowered resistence. The daily intake of protein should be increased. It should

be about 70 g/kg body weight. For non-vegetarians, meat, fish and can be given but these may be problem of chewing or mastication. So minced meat, half boiled egg, milk and milk products should be given.

For vegetarians pulses are rich sources of proteins. If the diet is not able to provide sufficient proteins it should be given in the form of food supplements such as skimmed milk powder.

3. Fats

Older people tend to have high cholesterol levels. Fats are also difficult to digest. So in old age, daily intake above 40-50 g of fat is avoided. Half this quantity should be in the form of vegetable oils rich in essential fatty acids to reduce serum cholesterol level.

4. Carbohydrates

Old people tend to take cheaper readily available food which does not require cooking e.g., Bread, buiscuits, cakes etc., diet containing larger quantities of these substances, produces protein deficiency. It also causes constipation, loss of appetite resulting in further malnutrition.

5. Minerals

Osteomalacia and osteoporosis are common in old age. Though exact reason is not known, osteoporosis is partly due to diminished intake and absorption of calcium. Osteomalacia is due to diminished vitamin D because of limited exposure to sunlight. The daily calcium intake should be increased to 0.8-1.0 gm and iron intake 30-40 mg. For calcium supply the person should take atleast ½ a litre milk and two eggs. Exposure to sunlight is essential for supply of vitamin D.

6. Vitamins

In old age, vitamin C deficiency is common in those who do not eat fruits and food is unbalanced. It is desirable that old people take one multivitamin tablet daily.

7. Fluids

Water intake should be liberal (more than 1.5 litres) to ensure that the volume of water excreted is not less than 1.5 litres per day. This

will keep up the elimination of waste metabolic products such as urea, uric acid and creatine. Old people are reluctant to take liquid as they have to urinate frequently, especially old people with dietbetes and enlarged prostrate. They should be advised to take sufficient liquid during day and refrain from drinking at night so that sleep is not disturbed.

8. Roughage

Old people have a tendency to constipate. They should therefore take sufficient amount of fibre in the form of fruits and vegetables in the diet.

Meal Pattern

As far as possible, old people should take small frequent meals. They should take dinner early evening to prevent gaseous distribution and disturbance of sleep. Physical exertion after meals should be avoided especially in the people who have a poor coronary circulation.

Daily allowance of nutrients and balanced diet for adults and old people are given in Tables 38.1 and 38.2

Table 38.1: Menu plan for adults

Time	*Menu plan*	*Ingredient*	*Quan.*	*Calorie*	*Protein*	*Fats*	*CHO*	*Cal.*	*Phos.*	*Iron*	*Vit A*	*Vit B_1*	*Vit B_2*	*Vit B_3*	*Vit C*
6 am	Coffee	Milk+Sugar	1 cup	52	1.9	1.7	7.8	0.05	0.05	0.10	77	0.02	0.09	0.09	0.7
8 am	Idli	Blackgram dal	4 nos.	260	9.2	0.4	44.2	0.06	0.16	1.6	16	0.2	2.4	0.10	-
	Radish Sambar	Radish+ onion+ Masala Powder	1 1/2 serving	101	4.1	3.6	13.1	0.04	0.07	2.2	73	0.07	0.6	0.03	3.0
	Tea	Milk+ sugar	1 cup	72	1.4	1.6	13	0.06	0.04	-	76	0.02	0.10	0.10	0.6
	Apple	Milk+ sugar	1 nos	56	0.3	0.1	13.4	0.01	0.02	1.7	-	0.12	0.03	0.2	2
	Total			483	15	5.7	84.6	0.17	0.29	4.06	242	0.43	0.73	2.43	5.6
1 pm	Rice		2 serving	595	11.9	0.9	134.8	0.20	0.20	4.8	-	0.20	0.09	3.0	-
	Fish curry	Sardine fish+oil	100g	101	21	1.9	-	0.09	0.06	2.5	-	-	-	2.6	-
	Dal Rasam	Dal Rasam mix+ onion, garlic	1 1/2 cup	29	1.6	0.9	3.8	0.03	0.03	0.9	72	0.03	0.2	0.2	1.5
	Curd	milk	1 cup	36	1.8	2.8	2.0	0.07	0.07	0.2	102	0.03	0.11	0.10	0.9
	Banana			153	1.3	0.2	36.4	0.01	0.05	0.4	80	0.05	0.08	0.3	7
	Total			914	37.6	6.7	177	0.22	0.71	8.8	254	0.31	0.48	6.2	9.4

Contd...

Contd...

Time	*Menu plan*	*Ingredient*	*Quan.*	*Calorie*	*Protein*	*Fats*	*CHO*	*Cal.*	*Phos.*	*Iron*	*Vit A*	*Vit B_1*	*Vit B_2*	*Vit B_3*	*Vit C*
4pm	Coffee	Milk+sugar	1 cup	52	1.9	1.7	7.8	0.05	0.05	0.10	77	0.02	0.09	0.09	0.7
	Raggi Rotti	Ragi powder +Sugar	2 nos.	460	8	9	87	0.40	0.30	6	2.55	0.50	0.13	1.3	-
9pm	Rice Mutan pulav		2 serving	402	12	22.8	37.4	0.06	0.12	2.06	58	0.12	0.12	3.6	0.64
	Vegetable salad	Cucumber +bectroot+ onion	100gm	52.33	1.1	0.1	9.33	0.13	0.046	1.06	5	0.05	0.036	0.33	9.33
	Total			966.3	23	33.6	141.5	0.64	0.516	9.22	142.5	0 .69	0.376	5.22	10.67
	Grand Total			2363.3	47.6	38.1	510.1	1.03	1.51	22.08	638.5	1.43	1.586	14.13	31.67
	RDA Value			2875 kcal/d	60 g/d	20 g/d	- g/d	0.08 g/d	0.08 g/d	28 mg/d	600 mg/d	1.4 mg/d	1.6 mg/d	18 mg/d	40 mg/d

Table 38.2: Meal plan for old age (above 65 years)

Time	*Food Prepared*	*Ingre-dient*	*Quan-tity*	*Weight (wt)*	*Calorie (kcal)*	*Protein (g)*	*Fats (gm)*	*Carbo hydrate*	*Calc-cium*	*Phos-phorus*	*Iron*	*VitA*	*Thiamine*	*Nico-tin*	*Ribo-flavin*	*Vit C*
7 am	Milk	Milk	1 cup	100	65	3.5	3.7	4.9	0.12	0.10	0.4	140	0.03	0.1	0.17	2
Break fast 9 am	Idli	Black gram Raw material Rice	3 nos.	204	195	6.9	0.3	41.4	0.45	0.12	1.2	12	0.15	1.8	0.045	-
	Green gram sundal	Green gram	1 plate	142	259	13.1	9.2	30.9	0.08	0.20	4.8	120	0.24	1.2	0.10	1.1
	Coffee	Milk coffee powder sugar	1 cup	200	104	3.8	3.4	14.4	0.10	0.10	1.20	154	0.04	0.18	0.18	1.4
11am	Raggi Rotti	Raggi	1 nos	925	230	4	4.5	43.5	0.2	0.15	3	127.5	0.25	0.6	0.065	-
		Total		738.5	853 kcal	31.3 g	21.1 g	135 g	545 g	0.67 g	10.6 mg	550.4	0.71	3.88	0.59	4.5
Lunch 12.30 pm	Rice	Rice	1 serving	252	297.5	5.95	.45	67.4	0.01	.10	2.4	-	0.1	1.5	0.045	-
	Dhal Rasam	Dal Tam-rinta	3/4 cup	98	14.5	0.75	.45	1.9	0.015	0.015	0.45	36	0.015	0.1	0.1	0.15

Contd...

Contd...

Time	Food Prepared	Ingredient	Quantity	Weight (wt)	Calorie (kcal)	Protein (g)	Fats (gm)	Carbo hydrate	Calc-cium	Phos-phorus	Iron	VitA	Thiamine	Nico-tin	Ribo-flavin	Vit C
	Brinjal curry	Brinjal onion chilly	1/2 plate	45	122	1.4	10.7	4.9	0.02	.05	0.9	9	0.03	0.5	0.06	10.1
	Meat	Meat chilly powder salt, onion	1 serving	128	220	11.6	18	2.7	0.10	.10	2.1	277	0.10	0.9	0.20	2.4
4.30 pm	Tea	Milk Tea powder sugar	1 cup	200	72	1.4	1.6	13	0.06	-	-	76	0.02	0.10	0.10	0.6
	Wheat upma	Wheat onion, ginger green chilly	1/2 serving	64	81.5	1.9	2.7	12.35	0.005	.02	0.35	70.5	0.025	0.2	0.005	0.6
		Total		787	807.5	23	33.9	102.5	0.21	.235	6.2	468.5	0.29	3.3	0.51	14.45
8 pm	Raggi ball	Raggi cocunut	1/2 nos.	169	223	3	3.8	43.4	0.20	.15	3	115	0.25	0.6	0.65	-

Contd...

Contd...

Time	*Food Prepared*	*Ingredient*	*Quantity*	*Weight (wt)*	*Calorie (kcal)*	*Protein (g)*	*Fats (gm)*	*Carbo hydrate*	*Calc-cium*	*Phos-phorus*	*Iron*	*VitA*	*Thiamine*	*Nico-tin*	*Ribo-flavin*	*Vit C*
	Amar-anth sambar	Amranth potato, onion, tomato	1/4 cup	23.33	16.167	1.275	0.675	2.167	0.083	0.013	1.33	334.8	0.116	0.1166	0.005	8.83
	Banana	Banana	1 nos.	93.2	142.59	1.2116	0.1864	33.925	0.0093	0.0466	0.3728	74.56	0466	0.2796	0.0746	6.524
10 am	Milk	Milk	1 cup	100	65	3.5	3.7	4.9	0.12	0.10	0.4	140	0.03	0.1	0.17	2
				384.56	446.786	8.9876	8.3614	84.392	0.4123	0.3096	5.102	664.36	0.3382	1.0962	0.3146	17.354
Total				1910	210Ç.2	56.887	63.4	321.742	1.Ç167	1.21	21.902	1683.6	1.33	8.2762	1.415	36.304
RDA Value					2100 kcal	55 g/d	50.70 gm	7500 gm	0.5 gm	0.6 gm	20 gm	750 gm	1.2 mg	16 mg	1.3 mg	50 mg

CHAPTER

39 Naturopathic Medicine

CONCEPTS AND PRINCIPLES

Basic Concepts

In fact, Nature Cure is a way of life of which we find a number of references in the Vedas and other ancient texts. The morbid matter theory, concept of vital force and other concepts upon which Nature Cure is based are already available in old texts which indicate that these methods were widely practised in ancient India.

The whole practice of Nature cure is based on the following three principles:

- Accumulation of morbid matter
- Abnormal composition of blood and lymph
- Lowered vitality

Nature Cure believes that all the diseases arise due to accumulation of morbid matter in the body and if scope is given for its removal it provides cure or relief. It also believes that the human body possesses inherent self-constructing and self-healing powers. The fundamental difference in Nature Cure with other systems is that its theory and practice are based on holistic view point whereas the later's approach is specific. Nature Cure does not believe in the specific cause of disease and its specific treatment but takes into account the totality of factors responsible for diseases such as one's un-natural habits in living, thinking, working, sleeping, relaxation, sexual indulgence etc, and also considers the environmental factors involved, which on the whole disturbs the normal functioning of the body and lead it to a morbid, weak and toxic state.

For treatment, it primarily stresses on correcting all the factors involved and allowing the body to recover itself.

Nature Cure physician helps in Nature's effort to overcome disease by applying correct natural modalities and controlling the natural forces to work within safe limits. The five main modalities of treatment are air, water, heat, mud and space.

Principles

1. All diseases, their cause and their treatment are one.
2. The basic cause of disease is not bacteria. Bacteria develops after the accumulation of morbid matter when a favourable atmosphere for their growth develops in body. Basic cause is morbid matter and not the bacteria.
3. Acute diseases are our friends and not enemies. Chronic diseases are the outcome of wrong treatment and suppression of the acute diseases.
4. Nature is the greatest healer. Body has the capacity to prevent itself from diseases and regain health if unhealthy.
5. In Naturopathy, patient is treated and not the disease.
6. In Naturopathy, diagnosis is easily possible. Ostentation is not required. Long waiting for diagnosis is not required for treatment.
7. Patients suffering from chronic ailments are also treated successfully in comparatively less time in Naturopathy.
8. After emerging suppressed diseases can be cured by Naturopathy.
9. Nature Cure treats physical, mental, social (moral) and spiritual. All four aspects at the same time.
10. Nature Cure treats body as a whole instead of giving treatment to each organ separetely.
11. Naturopathy does not use medicines. According to Naturopathy 'Food is Medicine.
12. According to GandhiJi 'Rama Nama is the best Natural Treatment", means doing prayer according to one's spiritual faith is an important part of treatment.

In short, Nature Cure includes all the available non-invasive treatments and diagnostic modalities which do not interfere with the body' s natural functional capacity and healing process and are in affirmity with nature's constructive principles.

Develoment and its Status

Naturopathy is a system of healing science stimulating the body's inherent power to regain health with the help of five great elements of nature — Earth, Water, Air, Fire and Ether. Naturopathy is a call to "Return to Nature" and to resort to simple way of living in harmony with the self, society and environment.

Naturopathy provides not only a simple practical approach to the management of diseases, but a firm theoretical basis which is applicable to all the holistic medical care and by giving attention to the foundations of health; also offers a more economical frame work for the medicine of future generation.

Though the basic Nature Cure deals only with Pancha Mahabhoota's, the recent developments advocate the practice of drugless therapies like Massage, Electrotherapy, Physiotherapy, Acupuncture and Acupressure, Magnetotherapy etc., Diet plays a major role, above all.

History

Nature Cure movement started in Germany and other western countries with "Water cure" (Hydrotherapy). Water cure was synonymous with Nature Cure in those early days. The credit of making Water cure world famous goes to Vincent Priessnitz (1 799- 1 85 1) who was a farmer. Dr. Henry Lindlahr and others go to the extent of crediting him as 'Father of Naturopathy". The word "Naturopathy" has been coined by Dr. John Scheel in the year 1895 and was propagated and popularised in the western world by Dr. Benedict Lust. A number of doctors of modern medicine arid others became Nature Cure enthusiasts and gradually added a number of modalities within the fold of Naturopathy and scientifically developed them. Nature Cure movement gained momentum in India as Mahatma Gandhi, Father of the Nation became much interested in this system and included it in his programmes. He has also established a Nature Cure Hospital in Uruli Kanchan, Distt. Poona, Maharashtra which is still functioning.

Background

Naturopathy adopts the following diagnostic methods:

- Full life case history covering all the facts of life, since birth.
- Facial diagnosis the science of facial expressions by studying the various characteristic features upon the body.
- Iris diagnosis—study of iris indicating the condition of various visceral organs.
- Modern clinical diagnosis to some extent.

The Methods Applied for Cure in Naturopathy are the following:

1. Water therapy: Water is the most ancient of all the remedial agents. It is employed in different forms in treatment and produces several types of physiological effects depending upon temperature and duration. Hydrotherapy is employed in almost all types of disease conditions.
2. Air therapy: Fresh air is essential for good health. Air therapy is employed in different pressures and temperatures in variety of disease conditions.
3. Fire therapy: Existence of all the creatures and forms depends upon "Agni" (Fire). In Nature Cure Treatment, different temperatures are employed through different heating techniques to produce different specific effects.
4. Space therapy: Congestion causes disease. Fasting is the best therapy to relieve congestion of body and mind.
5. Mud therapy: Mud absorbs, dissolves and eliminates the toxins and rejuvenates the body. It is employed in treatment of various diseases like constipation, skin diseases etc.
6. Food therapy: Most of the disease are amenable to food therapy. As you eat so will you be physically as well as mentally. Your food is your medicine. These are the main slogans of Nature Cure.
7. Massage therapy: Massage is generally employed for tonic, stimulant and sedative effects. It is an effective substitute for exercise.
8. Acupressure: There are different points on hands, feet and body which are associated with different organs. By applying pressure on these selected points, related organs can be influenced for getting rid of their ailments.
9. Magnetotherapy: Magnets influence health. South and North poles of different powers and shapes are employed in treatment. By applying directly on different parts of the body or through charged up water or oil.
10. Chronotherapy: Sun rays have seven colours—violet, indigo, blue, green, yellow, orange and red. These colours are employed through irradiation of body or by administering charged water, oil and pills for treatment.

NATURAL FOOD REMEDIES

Nature Cure

Apple	:	Iron, Vit. C, good for nerves and brain
Amla	:	Contains maximum Vit. C,
(Gooseberry)	:	Good for Hair, Bile, Phlegm
Banana	:	Constipation E'r Diarrhoea
Bitter Gourd	:	Diabetics, Vit. C, Iron, Copper, etc.
Carrots	:	Eye sight, Teeth and Bone weakness, Vit. A
Curd	:	Good for digestion, Teeth and Skin
Fig	:	Laxative, Liver, Asthma
Garlic	:	BP, Arthritis, Asthma, Cough, Cold and Rheumatic pains, Gout
Ginger	:	Gas'trouble, Indigestion, Ginger Tea for Cold and Cough
Grape and Raisin	:	Rich in Iron, Copper, Manganese and Potassium
Honey	:	General debility, Lungs, Cough
Isaph Gul	:	Piles, Diarrhoea and Constipation
Lemon	:	Heart and Skin Diseases, Vit. 'C'
Lettuce	:	Nervousness and Palpitation
Neem Leaves	:	Fresh and Powder—Good for Skin, Blood,
Onion	:	Blood Cholesterol
Papaya	:	Dyspepsia, Laxative, Digestive, Vit. C, A and Iron
Pomegranate	:	Haemorrhage, Diarrhoea
Radish	:	Kidney Stone, Jaundice and Scanty Menses
Red Tomatoes	:	Anaemia, Blood purifier, VIt. A, B, C
Soyabean	:	Diabetes, Asthma, Cough
Spinach	:	Constipation Vit A, E, Iron and Potassium
Triphala	:	Removes Constipation, wind, increases appetite memmy.
Tulasi Tea	:	Fever, Cold and Cough.

All Sicknesses are caused by wrong eating, wrong drinking, wrong thinking and wrong living.

WATER THERAPY (NATURE CURE)

Every cell in our body depends upon water to function properly. Yet most of us do not understand the role of this vital nutrient.

It is a simple and good cure for new and old illnesses, Benefits—BP, Constipation, Diabetes, Headache, Anemia, Arthriris, Asthma, Bronchitis, Hyperacidity, Gastritis, Dysentery, Irregular mensuration, cough, pulmonary TB.

Dosage: Early morning before washing your face and brushing your teeth drink 1 to 3 large glasses of water (1½ litres). If you cannot take 3 glasses, start with one glass and go on increasing gradually.

Instructions: For 45 minutes nothing to be taken such as tea, coffee, milk. Avoid taking water for 1½ to 2 hours after breakfast, lunch and dinner. All persons, healthy and sick, should do the water therapy. Healthy persons will not fall sick and sick persons will restore good health.

Secret: Therapy by drinking water seems unbelievable and unconceivable but proved reliable and commendable. Drinking sufficient quantity of water at a time, renders the colon for more effective function of mucosa folds and turns them into new/fresh blood. Water is an essential nutrient. Even small shortage of water can disrupt body's chemistry because adequate water dissolves and eliminates waste products, uric-acid and urea through the body cells.

The process is curative and promotes better health. The treatment is simple, inexpensive and a boon to the poor and the rich alike.

CHAPTER

40 Diet Therapy

PRINCIPLES OF DIET THERAPY

Diet therapy is concerned with the modification of the normal diet to meet the requirements of the sick individual. Its purposes are:

1. To maintain good nutitional status.
2. To correct deficiencies which may have occurred.
3. To afford rest to the whole body or to ascertain body's ability to metabolise the nutrients.
4. To bring about changes in body weight whenever necessary.

Therapeutic nutrition begins with the normal diet. Advantages of using normal diet , as the basis for therapeutic diets are:

a. It emphasizes the similarity of psychologic and social needs of those who are ill and those who are well even though there is quantitative and qualitative differences in requirements.
b. Food preparation is simplified when the modified diet is based upon the family pattern and the number of items required in special preparation is reduced to a minimum.
c. The calculated values for the basic plan are useful in finding out the effects of addition or omission of certain foods, for example, if vegetables are restricted vitamin A and C deficiency can occur.

FACTORS TO CONSIDER IN PLANNING THERAPEUTIC DIETS

The alteration of the normal diet require an appreciation of:

1. The underlying disease conditions which require a change in the diet.
2. The possible duration of the disease.
3. The factors in the dietary which must be observed.
4. The patients tolerance for food by mouth.

In planning meals for a patient his economic status, his food preferences and his occupation and time of meals should also be considered.

MODIFICATION OF NUTRIENTS IN THERAPEUTIC DIETS

The normal diet may be modified:
1. To provide change in consitency as in fluid and soft diets.
2. To increase or decrease the energy value.
3. To include greater or lesser amounts of one or more nutrients, for example, high protein, low sodium etc.
4. To increase or decrease bulk-high and low fibre diets.
5. To provide foods bland in flavour.

TYPES OF DIET USED IN HOSPITALS

1. Clear-fluid diet.
2. Full-fluid diet.
3. Soft diet.
4. Normal diet.

1. Clear-fluid Diet

Whenever an acute illness or surgery produces a marked intolerance for food as may be evident by nausea. Vomiting, anorexia, distention and diarrhoea, it is advisable to restrict the intake of food. In acute infection, in acute inflammatory conditions of the intestinal tract, following operations upon the colon or rectum when it is desirable to prevent evacuation from the bowel, clear fluid diet is suggested. This diet is also given to relieve thirst, to supply the tissues with water, to aid in the removal of gas.

The diet is made up of clear liquids that leave no residue, and it is non-gas forming action. This diet is entirely inadequate from a nutritional standpoint. Since it is deficient in protein, minerals, vitamins, and calories. It should not be continued for more than 24 to 48 hours. The amount of fluid is usually restricted to 30 to 60 ml per hour at first, with gradually increasing amounts being given as the patients tolerance improves.

This diet can meet the requirement of fluids and some minerals and can be given in 1 to 2 hour intervals.

2. Full-fluid Diet

This diet bridges the gap between the clear fluid and soft diet. It is used following operations in acute gastritis, acute infections and in diarrhoea. This diet is also suggested when milk is permitted and

for patients not requiring special diet but too ill to eat solid or semisolid foods.

In this diet, foods which are liquid or which readily become liquid on reaching the stomach are given. This diet may be made entirely adequate and may be used over an extended time without fear of deficiencies developing, provided it is carefully planned. This diet is given at 2-4 hours interval.

3. Soft Diet

It bridges the gap between acute illness and convalescence. It may be used in acute infections, following surgery, and for patients who are unable to chew. The soft diet is made up of simple, easily digestable food and contains no harsh fibre. Patients with dental problems are given mechanically soft diet. It is often modified further for certain pathologic conditions as bland and low residue diets. In this diet, three meals with intermediate feedings should be given.

4. Normal Diet

It is used for ambulatory and bed patients whose conditions do not necessitate a special diet as one of the routine diets. Many special diets progress ultimately to a regular diet.

The regular hospital diet is simple in character and preparation, easy of digestion and calculated to afford maximum nourishment with minimum effort to the body. The diet is well balanced, adequate in nutritional value and attractively served to stimulate a possible poor appetite.

SPECIAL FEEDING METHODS (MANAGEMENT OF SPECIAL DIETS)

Oral feeding is the best for the nourishment of a patient. But in the following conditions it is not possible to give the feeding orally:

a. Those who cannot swallow due to paralysis of the muscles of swallowing (diphtheria, poliomelitis) etc or cancer of the oral cavity or larynx.
b. Those who cannot be persuaded to eat.
c. Those with persistent anorexia requiring forced feeding.
d. Semiconscious or unconscious patients.

e. Severe malabsorption requiring administration of unpalatable formula.
f. Short bowel syndrome.
g. Those who are undernourished or at risk of becoming so.
h. Those who cannot digest and absorb.
i. After surgery.
j. Patients with neurological and renal disorders or have continued fevers or diabetes.
k. Babies of very low birth weight.

TUBE FEEDING

This is done by passing a tube into the stomach or duodenum through the nose which is called nasogastric feeding or directly by surgical operation known as gastrostomy and jejunostomy feeding.

A satisfactory tube feeding must be:

a. Nutritionally adequate.
b. Well tolerated by the patient so that vomiting is not induced.
c. Easily digested with no unfavourable reactions such as distension, diarrhea or constipation.
d. Easily prepared, and
e. Inexpensive.

Nutrition supplied through the tube may be:

- Natural liquid foods.
- Blenderised to make liquid food.
- Commercially supplied polymeric mixtures or elemental diet (predigested diet).

FEEDING REQUIREMENTS

A concentration of about 1 kcal per millilitre is satisfactory. Lesser concentration increases the volume which must be given to meet the nutrient and energy needs and greater concentration are more likely to produce diarrhoea and may be too thick to pass through a nasogastric tube.

The feeding is started through a continuous drip at a rate of 50 ml per hour. The rate is increased by 20 ml every 24 hours until the required volume is achieved. Usually with 100-120 ml per hour. The concentration or rate of flow may have to be reduce, if there is vomiting, abdominal cramps or diarrhoea.

Feeding requirements are based on previous nutritional status and other feeds given to the patient.

Fluids	-	30 ml/kg
Energy	-	32 Kcal/kg
Protein	-	1 g/kg body weight
Sodium	-	30-40 mmol/(Provided there are no external losses)
Potasium	-	1 mmol/gram of protein

Vitamins and minerals supplementation should be given.

CARE OF THE SOLUTION

Feeding solutions have to be treated with full hygienic precautions during the preparation, storage and administration. Feeds should be stored in a refrigerator to avoid bacterial growth and taken out before admin in time to reach room temperature; very cold feeds are not tolerated. A feed should be discarded when it has been more than 2 hours out of storage.

DOCUMENTATION

Nursing staff should accurately record:

1. The time when a feed is started and completed.
2. The volume administered.
3. Water used to irrigate the tubing, and
4. The patients output of urine. Careful monitoring is needed to see that the patient is in fluid balance.

PARENTERAL FEEDING

Here the nurtrient preparations are given directly into a vein. This method may be used to supplement normal feeding by mouth but can provide all the nutrients necessary to meet a patients requirements. Then, it is known as Total Parenteral Nutrition or TPN.

The same process is called hyperalimentation when atleast 150% of the daily requirements are provided to produce a positive nitrogen balance for gain in weight.

Patial parenteral nutrition provides 30-50% of daily requirements.

PRE-AND POSTOPERATIVE DIET

Good nutrition prior to and following surgery ensures fewer post-operative complications better wound healing. Short convalescence,

lower mortality, and chronic diseases increase the nutritional requirements.

Malnutrition can lead to weight loss, poor wound healing, decreased intestinal motility, anaemia, oedema or dehydration and ulcers. The circulating blood volume and the concentration of the serum proteins hemoglobin and electrolytes may be reduced.

PREOPERATIVE NUTRITIONAL ASSESSMENT

The objectives in the dietary management of surgical conditions are:
1. To improve the preoperative nutrition whenever the operation is not of an emergency nature.
2. To maintain correct nutrition after operation or injury as far as possible, and
3. To avoid harm from injudicious choice of foods.

Protein

A satisfactory state of protein nutrition ensures:
a. Rapid wound healing.
b. Increases the resistance to infection .
c. Exerts a protective action upon the liver against the toxic effects of anaesthesia, and
d. Reduces the possibility of oedema at the site of the wound.

The level of protein to be used in preoperative and postoperative diets depends on the previous state of nutrition, the nature of the operation and the extent of the postoperative losses. Intake of 1.0 to 1.5 per kilogram of body weight or about 100 g of protein are necessary as a rule.

Energy

With 2500 to 3000 Kcal patients make progress. Obesity constitutes a hazard in surgery. Whenever possible it should be corrected. Rapid weight loss results in loss of lean body mass and should be avoided.

Minerals

A liberal intake of protein and ascorbic acid and administration of iron salt is necessary.

Fluid

A patient should not go to operation in a stage of dehydration since the subsequent dangers of acidosis are great. If the patient is unable to ingest sufficient liquid by mouth, parental fluids are administered.

Vitamins

Vitamin C is important for wound healing. Loss of vitamin K results in bleeding. Haemorrhage is especially likely to occur in patients who have diseases of the liver.

POSTOPERATIVE DIET

Following minor surgery, liquids are oftern tolerated within a few hours and rapid progression to a normal diet is made after major surgery, oral intake may be delayed for days. Complete nutritional support are provided by conventional intravenous feedings, catheter jejunostomy, total parenteral nutrition, tube feedings or semisynthetic fibre free diets.

DIET THERAPY IN FEVERS

Fever is an elevation in body temperature above the normal which may occur due to exogenous and endogenous factors. Types:

a. Short duration fever : Colds, tonsillitis and influenza
b. Chronic fever : Tuberculosis
c. Intermitent : Malaria

GENERAL DIETARY CONSIDERATIONS

Energy

The caloric requirement may be increased as much as 50%, if the temperature is high and the tissue destruction is great. The patient may be able to ingest only 600 to 1,200 K cal daily, but this should be increased as rapidly as possible.

Protein

About 100 g protein or more is prescribed for the adult when a fever is prolonged. High protein beverages may be used as supplements to the regular meals.

Carbohydrates

Glycogen stores are replenished by a liberal intake of carbohydrates. Glucose which is readily absorbed is preferred.

Fats

The energy intake may be rapidly increased through the judicious use of fats but fried foods and rich pastries are to be avoided.

Minerals

A sufficient intake of NaCl is accomplished by the use of salty broth and soups and by liberal sprinklings of salt on food. Fruit juices and milk are relatively good sources of minerals.

Vitamins

Fevers apparently increase the requirement for vitamin A and vitamin C just as the B complex vitamins are needed at increased levels.

Fluids

Daily 2500-5000 ml is necessary including beverages, soups, fruit juices and water.

Ease of Digestion

Bland readily digested food should be used to facilitate digestion and rapid absorption. The food may be soft or of regular consistency. Fluid diets can be used initially.

Intervals of Feeding

Small quantities of food at interval of 2 to 3 hours will permit adequate nutrition without overtaking the digestive system at any time. During an acute fever the partients appetite is often very poor and small feedings of soft or liquid foods as desired should be offered at frequent intervals. Sufficient intake of fluids and salt is essential. If the illness persists for more than a few days high protein, high calorie foods will be needed.

Typhoid

Typhoid is an infectious disease with an acute fever of short duration and occurs only in human. Salmonella typhi causes typhoid. Faeces

and urine of the patients or carriers of the disease are the source of infection. Drinking water or milk and food contaminated by intestinal contents of the patients or carriers or by flies often transmit the disease.

The disease is characterized by a continued and high inflammation of the intestine. Formation of intestinal ulcers, haemorrhage and enlargement of spleen can occur. The patient may complain of diarrhoea or constipation and severe stomach ache. Abdominal absorption of nutrients can cause headache.

Principles of Diet

A high calorie, high protein, high carbohydrates, low fat, high fluid, low fibre and bland diet is suggested for typhoid patents.

At first clear fluid diet is given followed by full fluid and soft diet is suggested because of the intestinal inflammation. Great care must be exercised to eliminate all irritating fibres and spices in the diet. Refined cereals , bread, eggs, boiled potato and simple desserts like custards, porridges can be given. Adequate nutrition reduces convalescence period.

Foods to be Included

Fruit juices with glucose, coconut water, barley water, milk, milk-shakes if there is no diarrhoea, custards, thin dal curries, eggs, baked fish, minced meat, curds, cottage cheese, cereals, gruels, steamed vegetable juices, milk puddings, vegetable puree.

Foods to be Avoided

Butter, ghee, vegetable oil, no irritating fibrous food, chillies and other spices, rich pastries, fried foods, heavy puddings and cream soups.

Influenza

General priciples of dietary treatment is followed for influenza patients.

Tuberculosis

Tuberculosis is an infectious disease caused by the bacillius mycobacterium tuberculosis. It affects the lungs most often but may also be localized in other organs such as the lymph nodes or kidneys or it may be generalized.

Pulmonary tuberculosis is accompained by wasting of tissue, exhaustion, cough, expectoration and fever. The acute phase resembles pneumonia with high fever and increased circulation and respiration. As the disease progresses, the patient begins to exhibit loss of appetite, pain in the chest, worsening cough.

Principles of Diet

A high calorie, high protein, high vitaminised and mineralized, high fluid, soft diet is recommended.

Energy

Since the metabolic rate is not as high as in other fevers, satisfactory weight can be maintained with 2500 to 3000 kcals.

Protein

A protein intake somewhat in excess of normal requirements is necessary in tuberculosis. The daily requirement may be from 80 to 120 gm.

Minerals

Calcium, especially should be provided liberally, since, it is essential for the healing of tuberculosis lesion. Atleast 1 litre of milk should be taken daily. The iron needs may also be increased if there has been haemorrhage. Calcium, iron and phosphorus help in regeneration of cells, blood and fluids.

Vitamins

The metabolism of vitamin A is adversely affected in tuberculosis. Ascorbic acid deficiency is present with slight tuberculosis. Vitamin C is essential for many regenerative purposes.

DIETARY MANAGEMENT

1. Many patients with tuberculosis have very active peristalsis so that the selection of food should be from those bland in flavour, non-stimulating and easily digested.
2. Since patients have poor appetite, food must be appetizing and patients likes and dislikes must be considered.

3. During the acute stage, a high calorie fluid and soft diet are prescribed followed by high calorie soft regular diet.
4. Initially small quantities of fluid diet should be given once in 3 hours when the fever comes down the interval can be increased to every 4 hours.
5. In meeting the protein requirement, good quality protein like eggs should be included.
6. Fatty foods, highly fibrous foods, very spicy foods which are hard to digest should be avoided.

DIET IN RELATION TO CONDITIONS OF GASTROINTESTINAL TRACT

Diarrhoea

This is the passage of stools with increased frequency, fluidity or volume compared to the usual for a given individual. Diarrhoea is a symptom of underlying fuctional or organic disease and is acute or chronic in nature.

1. *Chemical toxins:* Such as arsenic, lead, mercury or cadmium.
2. *Bacterial toxins:* Such as salmonella or staphylococcal food poisoning.
3. *Bacterial infections:* Such as streptococcus, *E. coli*.
4. *Drugs:* Such as quinidine, neomycin.
5. *Psychogenic factors:* Such as emotional instability.
6. *Dietary factors:* Such as food sensitivity or allergy.

Chronic Type

1. Malabsorptive lesions of anatomic, mucosal or enzymatic origin.
2. Metabolic diseases, such as diabetic neuropathy, uraemia or Addison's disease.
3. Alcoholism.
4. Carcinoma of small bowel or colon.
5. Post-irradiation to small bowel or colon.
6. Cirrhosis.
7. Laxative abuse.

Nutritional Considerations in Diarrhoea

Fluid electrolyte and tissue protein losses are usually severe if diarrhoea is prolonged.

Fluids

Losses of fluids should be replaced by a liberal intake to prevent dehydration, especially in susceptible age groups.

Electrolytes

Losses of sodium, potassium and others with severe diarrhoea. Potassium loss is detrimental as potassium is necessary for normal muscle tone of the gastrointestinal tract. Losses can be replaced by liberal fluids such as fruit juices that are high in potassium.

Nutrient Malabsorption

Long continued diarrhoea may result in depletion of tissue, proteins and decreased serum protein levels. Fat losses are considerable in certain disorders with consequent loss of calories and fat soluble vitamins. Intake of calories as high as 3000 with 100 to 150 g protein, 100 to 120 g fat and the remainder as carbohydrates.

Vitamin deficiencies frequently seen in chronic diarrhoea are related to the decreased intake of vitamins and the increased requirements because of losses in the stools.

Iron deficiency owing to the increased losses of iron in the faeces, the occasional blood losses and the reduced intake of iron rich foods because of fear that some foods might aggravate an existing lesion.

Dietary Considerations

In acute diarrhoea, current recommendations include oral intake of glucose electrolyte solutions for those able to drink with progression to foods as tolerated in small frequent feedings as appetitie improves.

Many patients with chronic diarrhoea do not tolerate milk or foods high in fat or fibre content. Generally speaking, however the need is for a diet high in protein and calories with adequate amounts of vitamin and minerals and liberal amounts of fluids.

CONSTIPATION

In this condition, there is the duodenum and intrevent or difficult evacuation of faeces from the intestine.

Insufficient or infrequent emptying of the bowel may lead to malaise, headache, coated tongue, foul breath and lack of appetite. These symptoms usually disappear after satisfactory evacualtion has taken place.

Correction of constipation depends in large measure on establishing regularity in habits, eating, rest, exercise and elimination.

DIETARY CONSIDERATIONS

The diet should contain sufficient fibre to induce peristalsis and to contribute bulk to the intestine. A regular diet with an abundance of both raw and cooked fruits and vegetables is suitable for such patients. Whole grain cereals should be substituted for refined ones. Bran is useful but excesses are to be avoided since it may act as an irritant to sensitive intestinal tracts. Fat containing foods are useful because of the stimulating effect of the fatty acids on the mucous membranes. Excesses may cause diarrhoea and should be avoided. Mineral oil, if used should not be taken at mealtime because of its interference with the absorption of fat soluble vitamins.

A fluid intake of 8 to 10 glasses a day is useful in keeping the intestinal contents in a semisolid state for easier passage along the tract. Some individuals find that 1 or 2 glasses of hot or cold water plain or with lemon are helpful in intitating peristalsis when taken before breakfast.

PEPTIC ULCER

The term peptic ulcer is used to describe any localized erosion of the mucosal lining of those portions of the alimentary tract that come in contact with gastric juice. The majority of ulcers are found in the stomach although they also occur in the deudenum, jejunum or any other part of the GI tract exposed to the gastric juice.

Dietary Management

It was customary to suggest bland diet for ulcer patients. Bland diet is a diet which is mechanically, chemically and thermally non-irritaiting.

Protein Foods

Milk and protein foods do have some buffering effect but they also evoke gastric secretions more than carbohydrates and fats. Milk should be included as a source of nutrients factors for healing purposes. Protein provides the necessary amino acids for synthesis of tissue proteins which helps in healing ulcer.

Fat

Moderate amounts of the fat help to suppress gastric secretion and motility through the enterogastrone mechanism.

Foods believed to be *chemically irritating* because of their stimulatory effect on gastric secretion include meat extratives, caffeine, alcohol, citrus fruits and juices and some spicy foods. *Mechanically irritating* foods include those with indigestible carbohydrates such as whole grains and most raw fruits and vegetables. Foods believed to be *thermally irritating* are those ordinarily served at extremes of temperatures such as very hot or iced liquids. In addition, certain foods traditionally forbidden include strongly flavoured vegetables such as cabbage, cauliflower, onions and turnips and fried foods. Restriction of these foods is based on subjective evidence from patients who experience distress following ingestion of these items including good food.

FOODS TO BE INCLUDED

Diary products like milk, cream, butter, mild cheese and eggs (not fried) steamed fish, rice, rice flakes, puffed rice, margarine, well cooked cereal, semolina, cooked green leafy vegetables, custards, malted drinks.

FOODS TO BE AVOIDED

Alcohol, strong tea, coffee, cola, beverages, gravies, soups, pickles, spices, curries, condiments, all fried foods, pastries, cakes, heavy sweets like halwa, barfi, raw unripe fruits, raw vegetables like cucumber, onions, radish and tomatoes.

MODIFICATON OF DIET IN BLEEDING ULCER

The degree of dietary modification in bleeding ulcer depends on the peculiarities of the individual case. The severe haemorrhage, it is customary to give no food until the bleeding has been controlled and the patients conditions is stabilized. If haemorrhage is not severe and if nausea and vomiting are not a problem, the patient may desire food and tolerate it well. Initial dietary treatment consists of mild alternated at 2 hours interval with small feedings of easily puddings toast and tender cooked fruits and vegetables. Gradual progression in amounts and types of foods is made as the patient improves.

DIET IN RELATION TO DISEASE OF THE LIVER AND GALLBLADDER

Infective Hepatitis (Jaundice)

Infective hepatitis is otherwise known as viral hepatitis. This is the comman cause of jaundice. The two viruses responsible are hepatitis A and B virus. The former enters the body through oral faecal route like through food or water, while the latter is passed through by using infected blood products from carriers, use of unsterilised needles and through sexual contact.

Symptoms

Anorexia, fever, headache, rapid weight loss, loss of muscle tone and abdominal discomfort.

Dietetic Management

A high protein, high carbohydrate, moderate fat diet is recommended. Small attractive meals at regular intervals are better tolerated.

Energy

In nasogastric feeding stage about 1000 Kcal are supplied. In severe cases, 1600 Kcal to 2000 Kcal are suggested.

Protein

For the liver cells to regenerate an adequate supply of proteins is needed. Protein requirements vary according to the severity of the disease with severe jaundice 40 g, while in mild jaundice 60-80 g of protein is permitted with hepatic precoma and coma, protein containing foods are with held and only high carbohydrate containing foods are given.

Fats

During hepatic precoma and coma due to severe liver failure, fats are not metabolized by the liver and so fat is restricted, in severe jaundice 30 g and in moderate jaundice 50-60 g.

Carbohydrates

High carbohydrate content in the diet is essential to supply enough calories so that tissue proteins are not broken down for energy.

Vitamins

They are essential to regenerate liver cells: 500 mg of vitamin C along with 10 mg vitamin K and supplements of vitamin B.

Minerals

Oral feeds of fruit juice, vegetable and meat soups with added salt, given orally or through a nasogastric tube help in maintaining the electrolyte balance.

FOODS INCLUDED

Cereal porridge, soft chapattis, bread, rice, skimmed milk, tapioca, potato, yam, fruit, fruit juices, sugar, jaggery, honey, biscuits, soft custards without butter cream and non-stimulant beverages.

FOODS AVOIDED

Pulses, beans, meat, fish, chicken, egg, soups, sweet preparations where ghee, butter or oil are used, bakery products, dried fruits, nuts, spices, papads, chutney, alcoholic beverages, fried preparations, whole milk creams.

CIRRHOSIS OF LIVER

Cirrhosis is a condition in which there is destruction of the liver cell due to necrosis, fatty infiltration and fibrosis.

The cirrhotic process may commence many years before it becomes clinically obvious and usually the patient when first seen is at a very late stage with complications, such as ascites, ruptured oesophageal varices or hepatic coma. Almost 85-90% of liver damage also do not produce symptoms. The initial change in cirrhosis is wide spread liver cell necrosis due to viral hepatic, alcohol etc.

Causes

1. Viral infection by hepatitis A and B viruses
2. Alcohol

3. Nutrition-malnutrition
4. Toxins of food, aflatoxin, Bush tea.

Symptoms

The onset of cirrhosis may be gradual with gastrointestinal disturbances such as anorexia, nausea, vomiting, pain and distension. As the disease progresses jaundice and other serious changes occur.

Ascites is the accumulation of abnormal amounts of fluids in the abdomen.

PRINCIPLES OF DIET

A high calorie, high protein, high carbohydrate, moderate or restricted fat, high vitamin diet helps in regeneration of liver and helps to prevent the formation of ascites. Low fat with supplements of fat soluble vitamin and minerals should be given. Sodium should be restricted only when there is ascites.

When there is danger of oesophageal varices or portal hypertension, fibre should be restricted.

DIETARY TREATMENT

Energy

Consumption of food is difficult because of anorexia and ascites. The patients are usually emaciated and require highly nutritious food i.e., high calorie diet is necessary because of prolonged undernourishment. The calorie requirement should be between 2000-2500 Kcal.

Proteins

A high protein diet is helpful for regeneration of the liver. In the absence of hepatic coma a high intake of proteins about 1.2 g/kg of body weight can be given. If the patient is in precoma or coma, proteins should be withheld till the patient tides over the crisis. Vegetable proteins containing more valine is beneficial in preventing encephalopathy.

Fats

About 1g of fat/kg of body weight is given. Even if fatty changes are present in the liver, fats should be given provided adequate amounts

of protein is supplied. Medium chain triglycerides containing C8 to C10 fatty acids can be given as these are digested and absorbed in the absence of bile salts. Coconut oil contains medium chain fatty acids.

Carbohydrates

Should be supplied liberally so that the liver may store glycogen. Liver function improves when an adequate store of glycogen is present in liver cells. 60% of the calories should come from carbohydrate so that liver damage is minised.

Vitamins

The liver is the major site of storage and conversion of vitamins into their metabolically active form. In cirrhosis, the liver concentration complex of folate, riboflavin, niacin, vitamin B_{12} and vitamin A are decreased. Vitamin supplementation especially of B vitamins is required to prevent anaemia.

Minerals

Sodium is restricted in oedema and ascites. Potassium salt is administered for ascites and oedema to prevent hypokalaemia. Anaemia is common among cirrhosis patients, so iron supplementation is essential.

FOODS INCLUDED

Are cereals in a soft form cooked rice, chapathi, bread and idli, milk pudding, milk shakes, curds, puree, cooked vegetables, kichidi and porridge, pulses, beans, meat, fruit and fruit juices.

Hepatic Coma

Complex syndrome characterized by neurologic disturbances which may develop as a complication of severe liver disease. It results from entrance of certain nitrogen containing substances such as ammonia into the cerebral circulation without being melabolised by the liver.

PRECIPITATING FACTORS

Gastrointestinal bleeding, severe infections, surgical procedures and excessive dietary protein and sedatives may precipitate hepatic coma.

Symptoms

Confusion, restlessness, irritability, inappropriate behaviour, delirium and drowsiness are present. There may be incoordination and a flapping tremor of the arms and legs when extended. Electrolyte imbalance occurs. The patient may go into coma and may have convulsions. Breath has a faceal odour. Prompt treatment is imperative or death occurs.

DIETARY MODIFICATIONS

Low protein diet should be given. At the same time, catabolism of tissue proteins must be avoided.

Energy

About 1500 to 2000 kcals are needed to prevent breakdown of tissue proteins for energy and are provided chiefly in the form of carbohydrates and fats. Although anorexia may occur attempts should be made to keep the calorie intake as high as is practical to minimize tissue breakdown.

Protein

First 2 or 3 days protein is completely omitted or 20-30 g/day are given. As the patient improves the protein intake is gradually increased to 1 g/kg of body weight. Nitrogen balance can be achieved on protein intake as low as 35 g/day, if high quality protein is used and calorie intake is adequate.

DIETARY MANAGEMENT

These patients pose problems in feeding because of anorexia and behavioural patterns ranging from apathy, and drowsiness and hyperexcitability. The protein free diet consisting of commercial sugar, fat emulsions, a butter sugar mixture or glucose in beverages or fruit juices may be used initially through oral or tube feeding. With improvements, the diets providing 20, 40 and 60 g protein may be gradually introduced.

Cholelithiasis

The *function* of the *gallbladder* and *bile ducts* is to *concentrate, store* and *deliver bile* into the *duodenum* at appropriate times to assist *digestion:*

Hormonal and *nervous* factors play a part in this *process*. The stimulus for this activity is the entry of food into the small intestine. This causes the mucosa of the duodenum and jejunum to secrete a harmone, cholecystokinin, which is carried in the blood to the gall-bladder and causes it to contract. Fats and foods rich in fats are especially effective for this purpose.

The bile is concentrated in the gallbladder and when it is super saturated gallstones are likely to form. Super saturation arises when there is insufficient amount of solublising agents such as bile acids and to a lesser extent lecithin to keep cholesterol and bile pigments in solution. By far the most common gallstones are mixed stones composed of cholesterol, bile pigment and various calcium salts including calcium palmitate.

Gallstones are more common in women than in men. Advanced age, repeated pregnancies and sedentary life and use of oral contraceptives are the contributing factors.

In man, it has been suggested that high cholesterol diets, lack of dietary fibre and an insufficiency of polyunsaturated fats predispose to gallstones.

Energy

Excess calorie intake appears to be a risk for development of gallbladders disease. The disease is more common in obese persons.

Fat

The patient receives no food initially during attacks of cholecystitis. Progression to a 20 to 30 g fat diet is made. If this is tolerated, the fat can then be increased to 50 to 60 g per day.

THERAPEUTIC DIET IN CONDITIONS OF ENDOCRINE GLANDS AND METABOLIC DISORDER

Diabetes Mellitus

Diabetes mellitus is a chronic metabolic disorder that prevents the body to utilize glucose completely or partially. It is characterized by raised glucose concentration in the blood and alterations in carbohydrate, protein and fat metabolism. This can be due to failure in the formation of insulin or liberation or action.

Causes

1. Genetic factors—Heredity
2. Obesity
3. Sugar intake
4. Infections
5. Acute stress—Body releases adrenaline, nor-adrenaline and cortisol hormones that raise blood glucose levels.
6. Secondary diabetes—Results of diseases which destroy the pancreas and lead to impaired secretion of insulin e.g., Pancreatitis, haemochromatosis, carcinoma of the pancreas and pancreatectomy.

Symptoms

Initially

1. Polydipsia – Increased thirst
2. Polyuria– Increased urination
3. Polyphagia – Increased hunger
4. Weight loss

Other Possible Symptoms

1. Blurred vision
2. Skin irritation or infection
3. Weakness, loss of strength
4. Decreased healing capacity

Continued Symptoms

1. Fluid and electrolysis imbalance
2. Acidosis (ketosis, ketonuria)
3. Coma

Weight loss	-	*20 kcals*
Bed patient	-	25 kcals
Light work	-	30 kcals
Medium work	-	35 kcals
Heavy work	-	40 kcals

Types

Type I

Insulin dependent diabetes mellitus IDDM also known as juvenile onset diabetes and patients depend on insulin. There is usually sudden onset and occur in the younger age group of 10 to 12 years, and there is an inability of pancreas to produce adequate amount of insulin.

Type II

NIDDM (Adult onset diabetes) In its non-insulin dependent form diabetes develops slowly and is usually wilder and more stable. Insulin may be produced by pancreas but action is impaired.

Table 40.1: Insulin and meal distibution of calories and carbohydrates

Types of Insulin	*Breakfast*	*Noon*	*Midafternoon*	*Evening*	*Bedtime*
1. None	1/3	1/3		1/3	
2. Short acting (before B/F and D)	2/5	1/5		2/5	
3. Intermediate acting NPH	1/7	2/7	1/7	2/7	1/7
4. Long acting	1/5	2/5		2/5	20-40g of CHO
5. Long acting with regular insulin at B/F	1/3	1/3		1/3	20-40g of CHO

DIABETIC DIET PRESCRIPTION

The nutrition and diet prescription (Table 40.1) is based on:
1. History of both the patient and his family.
2. Sex, age, weight, height, and activity of the patient.
3. Type I or Type II diabetes.
4. Type of insulin taken by the patient amount.

Food exchange: Lists are groups of measured foods of the same calorific value and similar protein, fat and carbohydrate and can be substituted one another in a meal plan.

Food exchange list helps to:
1. To restrict the food intake according to the insulin prescription.
2. To have variety in the diet.
3. Easy learning of the principles of diets.

DIETARY FIBRE

Dietary fibre and complex carbohydrates and restricted fat, benefit type I and type II diabeties. Such diets lower

1. Insulin requirements.
2. Increase peripheral tissue insulin sensitivity.
3. Decrease serum cholesterol and triglyceride values.
4. Aid in weight control, and
5. Lower BP.

Soluble fibres such as pectin, gums, hemicellulose (in fruits) increase intestinal transit time, delay gastric, emptying slow glucose absorption and lower serum cholesterol.

Insoluble fibres such as cellulose and liguin (vegetables, grains) decrease intestinal transit time, increase faecal bulk, delay glucose absorption and slow starch hydrolysis.

FIBRE CONTENT OF FOODS

1-3%

Maize, whole wheat, coriander, mint, carrots, bringal, cauliflower, french beans, ladies finger, green mango.

3.5%

Ragi, whole legumes, groundnut, cluster beans, double beans, peas, guava.

NUTRITIONAL REQUIREMENTS (TABLE 40.2)

Calories 1700-1800, CHO – 180 g, Fats – 60 g and Protein – 90 g

A minimum amount of 100 g of CHO should be given to prevent ketosis. Suggested calories from protein is 15-20% from carbohydrate 55-60 and 20 to 25% as fat, cholesterol 100 mg/100 Kcal 50 g of fibre. This diet reduces insulin requirements, improves glucaemic control, lower lasting serum cholesterol and triglyceride values and promote weight loss.

A diet high in protein is good for the health of diabetic patient. It supplies essential amino acids. It does not raise blood sugar during absorption as carbohydrate.

Excess fat is avoided as diabetics are prone to suffer from atherosclerosis, ketone bodies. The intermediary products of fats are accumulated when carbohydrate is deficient.

Table: 40.2: Daily nutrition evaluation sheet

Physicians details: **Patients details:** **Date:**

Name of the Doctor: Name of the Patient:

Hospital/Nursing Home: Age: Year Sex:M/F

Address:

Phone No:

Physical Evaluation:

Height: (mts) Weight: (kg) BMI:

Waist (cms) Hip: (cms) Waist:Hip ratio:

Lifestyle Evaluation: **Nutrition Prescription:**

Sedentary: ☐ Moderate: ☐ Strenuous: ☐ Calories /day

Dear Sir/Madam,

You have been diagnosed for diabetes and are advised a diet plan to keep a check on your sugar levels. The good news is that our traditional Indian diet with a slight modication is quite close to what is considered "diet diabetic diet".

Basic Advice

AVOID simple carbohydrate like

- Sugar
- Jaggery
- Honey
- Glucose
- Sweets
- Oily pickles
- Soft drinks
- Pastries
- Cakes
- Ice creams
- Jams
- Jelly
- Candy
- Beer
- Sweet wines
- Drinking chocolate etc

The above tend to cause a sharp rise in the blood glucose levels.

Based on your calorie requirement, the diet plan that suits you is given overleaf.

FOODS TO BE INCLUDED

Clear soups, lemons, salted pickle, pepper water, plain coffee or tea (without sugar) skimmed buttermilk, unsweetened lime juice, tomato juice, soda water, raw vegetables, salads, soup cubes, salt seasonings like onion, mint, pepper, garlic, curry leaf, coriander, vinegar, mustard and spices.

FOODS TO BE AVOIDED

Sugar, glucose, honey, syrup, jaggery, sweets, halwas, burfies, nuts, jam, jellies, preserved fruits, dried fruits, aerated drinks, cake, pastries, candy, fried foods, alcohol.

VARIOUS METABOLIC DISORDERS

Hyperthyroidism

Hyperthyroidism is a disturbance in which there is an excessive secretion of the thyroid gland with a consequent increase in the metabolic rate. It is believed to be an autoimmune disease occurring in genetically predisposed persons. The disease is also known as exophthalmic goitre, thyrotoxicosis, Grave's disease, or Beasedow's disease.

The chief symptoms are weight loss, sometimes to the point of emaciation, excessive nervousness, prominence of the eyes and a generally enlarged thyroid gland. Increased appetite, weakness, and signs of cardiac failure are also present.

The increased level of energy metabolism increases the requirement of B vitamins. The excretion of calcium and phosphorus is greatly increased in hyperthyroidism.

125 g protein. Frequent feedings will help satisfy hunger. A liberal calcium intake is desirable and may be provided in addition to the liberal use of milk.

Hypothyroidism

Decreased production or activity of the thyroid hormone or hypothyroidia is a relatively common problem.

Obesity is a problem for some patients with hypothyroidism, since they may continue in their earlier patterns of eating even though the energy metabolism has been significantly reduced. In other patients,

the appetite may be so poor that undernutrition results. For overweight persons, reduction of calories is necessary. Reduction of dietary cholesterol may be indicated. Adequate fluids and foods high in dectary fibre are needed to overcome constipation.

JOINT DISEASES

The term *Arthritits* and *Rheumatism* are applied to many joint diseases.

The most common form of arthritis is *osteoarthritis* or *degenerative* arthritis. Joint stiffness is characteristic. Pain is confined to joints. Joints of the fingers, knees, hip and spine are involved.

Rheumatoid Arthritis

Rheumatoid arthritis is a highly inflammatory and very painful condition having its onset in young women. This is characterized by fatigue, pain, stiffness, deformity which may be severe and limited function.

DIETARY COUNSELLING

Arthritic patients require the same amount of calories as other persons need.

Obesity is a common problem in osteoarthritis. Weight loss should be brought about in order to bring down the added stress on weight bearing joints.

Many patients with rheumatiod arthritis have lost weight and are in poor nutritional status. A high calorie high protein diet is given.

Gout

This is a disorder of purine metabolism occurring principally in middle-aged and older men, women are susceptible after menopause.

Low purine diet with moderate calories for obese individuals their calories can be reduced upto 1200 to 1600 Kcals.

Protein

Because the nitrogen of the protein nucleus is supplied by protein the intake is restricted to 0.9 g/kg body weight. Fat is often restricted to about 60 g per day.

Fluids

The daily intake of fluids should be atleast 3 litres.

THERAPEUTIC DIET IN CONDITIONS OF THE URINARY SYSTEM

Glomerulonephritis

Is an inflammatory process affecting the glomeruli, the small blood vessels in the head of the nephron, most common in its acute form in children 3 to 10 years of age.

Symptoms

Haematuria, proteinuria, oedema, shortness of breath, tachycardia and elevated BP anorexia. There may be *oliguria* or *anuria.*

PRINCIPLES OF THE DIET

Fluids

The fluid intake will be adjusted to output including losses in vomiting or diarrhoea. Daily fluid replacement should be 1000 ml plus daily amount excreted in the urine.

Insensible water loss is
30 ml/kg body weight for infants
20 ml/kg body weight for older children
10 ml/kg body weight for adults.

Energy

Sufficient calories is given without increasing the protein intake by means of sugar, honey, glucose.

Protein

Usually the diet contains 0.5 g of protein/kg body weight for older children and 1 to 1.5g/kg per day for younger children. A low protein diet is recommended so as to give rest to the kidney. An intake of 20-40 g/day is considered sufficient. Out of the recommended protein 50 should be from animal protein.

Sodium

The restriction of sodium varies with the degree of oliguria and hypertension. If renal function is impaired the sodium will be restricted to 500 to 1000 mg/day. If oedema is present, Na is restricted.

Potassium

When the kidneys do not work properly, potassium builds up in the body and causes heart to beat uneven and stop suddenly.

Phosphorus

Eating foods high in phosphorus will raise the phosphorus in the blood and this can cause Ca to be pulled from the bones. This will make bones weak and cause them to break easily.

NEPHROSIS (Degenerative Bright's Disease)

Symptoms

Heavy proteinuria, hypoalbuminaemia and peripheral oedema.

PRINCIPLES OF DIET

High protein, high calorie, high carbohydrate, salt restricted moderate fat with restricted fluid are recommended. Vitamin supplements especially vitamin C are given.

DIETARY TREATMENT

To ensure protein use for tissues synthesis, sufficient kcals must always be provided. 200 kcals is suggested.

About 100 to 120 g of protein should be provided. A high protein diet is required to meet the heavy loss of albumin and protein depletion of the tissues.

Sodium is restricted to prevent accumulation of oedema fluid and prevent hypertension.

SPECIAL INSTRUCTIONS

1. Since Ca and K deficiency may accompany severe proteinuria, bone refraction and hypokalaemia are common and hence.
2. The diet has to be soft.
3. Low quality proteins like pulses should be mixed with cereals or milk to improve quality of protein, high quantity proteins like egg, meat are preferred.
4. Vitamin supplements especially vitamin C are essential.

ACUTE RENAL FAILURE

There is a sudden shutdown of renal function following metabolic or traumatic injury to normal kidneys.

Symptoms

Anuria or obiguria—low urine volume i.e., 20 to 200 ml/day. Accumulation of waste products of protein metabolism in blood, excretion of K is diminished. There is also increased phosphate and sulphate with decreased Na, Ca and base bicarbonate. Lethargic, anorexia, nausea, vomiting, blood pressure, uraemia.

DIETARY MANAGEMENT

Energy

A minimum of 600-100 kcal is necessary. A high calorie intake is desired mainly form carbohydrate and fats.

Protein

All foods containing protein is stopped if the patient is under conservative treatment and blood urea nitrogen is rising. However, 40 g is allowed when he is on haemodialysis or peritoneal dialysis.

Carbohydrates

A minimum of 100 g/day is essential to minimize tissue protein breakdown.

Fluids

The total fluid permitted is 500 ml + losses through urine and gastrointestinal tract with visible perspiration an additional 500 ml may be necessary.

Sodium

Na loss through urine is measured and replaced. Na restriction is also judged based on Na loss in the urine.

Potassium

Hyperkalaemia occurs with a daily rise of 0.7 mEq, Serum potassium. It has deleterious effects on heart.

CHRONIC RENAL FAILURE

It is also known as uraemia as the level of urea in blood is very high when 90% if function renal tissue is destroyed, uraemia occurs. It may be the end result of acute glomerulonephritis, pyelonephritis and nephritic syndrome.

DIETARY MANAGEMENT

Diet should be palatable, must have varieties, adjusted according to altered biochemistry and physiology (hyperphosphataemia and hypertension) adequate enough for growth in children.

Energy

Adequate kilocalories are mandatory. Carbohydrate and fat must supply sufficient non-protein kilocalories to spare protein for tissue protein synthesis and to supply energy.

Requirements

Infancy	-	100-120 kcal/kg/day
Childhood	-	80-110 kcal
Adults	-	35-50 kcal

Protein

Failing kidney need to be given rest. Protein intake can be reduced to 0.5 g/kg of body weight per day.

Fluid

The usual fluid permitted is volume of daily urine plus 500 ml.

Sodium

1 to 2 mmol/kg of body weight for infants
40-60 mmol/day for older children

Strict restriction is necessary only if hypertension and oedema are present.

Potassium

This has to be restricted to 1mmol/kg of body weight. Double boiling and draining excess water reduces potassium content.

UROLITHIASIS OR URINARY CALCULI

Are found to be lodged in the urinary system to namely kidney, ureters, bladder or urethra.

Small foci are formed and supersaturated urinary salts are precipitated around the foci of mucoid structures.

Causes

1. *Climate:* In warm climate the urine volume is low.
2. *Occupation:* People working under the sun and perspire a lot and pass concentrated urine.
3. *Infection of urinary tract:* Frequent infection of urinary tract may be contributory in that pus cells and epithelial cells may form a focus around which the stone may be formed.
4. *Dietary habits:* Foods rich in oxalates, calcium, purines and phosphate may predispose to formation of renal calculi.
5. Heredity.
6. Vitamin A and B complex deficiency.
7. Hyperthyroidism.

Types of Calculi

1. Calcium phosphate
2. Calcium oxalate – Mostly found in India
3. Uric acid
4. Magnesium ammonium phosphate.

DIETARY MANAGEMENT

a. *Planning acid*—Ash diet
   - A liberal fluid intake
   - Salt in moderation
   - The fruits and vegetables so selected should not contribute more than 25 ml of base daily.

b. *Planning alkaline—Ash diet:* If stones of uric acid or cystine type occur, the diet should give alkaline ash, Alkaline producing foods such as fruits, vegetables and milk while acid producing foods use meat, eggs and cereals are restricted.

c. *Planning low oxalate diets:* An acid or alkaline reaction of the diet is of little value for oxalate urolithiasis. Sources of oxalates should be omitted which include beans, beet greens, chocolate, cocoa, dried figs, plums, potatoes, spinach, tea and tomatoes.

Fluid

About 0.2 to 2.5 litres should be given. Water coconut and barley water, fruits.

DIET THERAPY IN CONDITIONS OF THE CIRCULATORY SYSTEM

Cardiovascular diseases are characterized by a thickening of the arterial valves and their loss of elasticity.

Types

1. *Atherosclerosis:* It is a degenerative disease of the arteries and consists of focal accumulation in the intimal lining of arteries of a variable combination of lipids, complex carbohydrates blood and blood products, fibrous tissue and Ca deposits.
2. *Coronary heart disease:* It is syndrome arising from failure of the coronary arteries to supply sufficient blood to the myocardium. Also known as IHD (Ischemic Heart Diseases).
3. *Myocardial infarcation:* Necrosis or destruction of part of the heart muscle due to failure of blood supply and may lead to sudden death.
4. *Angina pectoris:* Pain in the chest, exercise or excitement provokes severe chest pain and so limits patients physical activities.

DIETARY MANAGEMENT

Objectives

1. Maximum rest for the heart.
2. Prevention or elimination of oedema.
3. Maintenance of good nutrition.
4. Acceptability of the programme.

PRINCIPLES OF DIET

Low calories, low fat particularly low saturated fat, low cholesterol, high in PUFA (polyunsaturated fatty acids), low carbohydrate and

normal protein, minerals and vitamins, high fibre diet is also recommended.

Energy

Usually a 1000 to 1200 calorie diet is suitable for an obese patient in bed. Those patients with desirable level are permitted a maintenance level of calories during convalescence and their return to activity.

Fat

The first step involves restriction of fats to no more than 30% of the total calories consumed. Levels as low as 20% are tolerated without side effects.

Total fat 30% met by *saturated 10% monounsaturated vegetable oil.*

Proteins, Vitamins and Minerals

Normal allowances.
Duration of meal: 3 or 4 smaller meals are suggested instead of two big meals. The evening meals must be two hours before retiring to bed.

Sodium: It is restricted when there is hypertension.

Fluid: The restriction of fluid is not required as long as Na is not restricted.

High fibre diet: Increasing fibre will serve to reduce cholesterol.

HYPERTENSION

Elevation of the blood pressure above normal is a symptom which accompanies many cardiovascular and renal diseases.

High BP of unknown cause is known as essential hypertension.

Causes

Cardiovascular diseases, renal diseases, tumours of the brain or adrenal glands, hyperthyroidism or diseases of ovaries and pituitary may cause hypertension.

Types

1. *Mild hypertension:* Diastolic pressure is 90 to 104 mmHg.
2. *Moderate hypertension*: Diastolic pressure is 105 to 119 mmHg.
3. *Severe hypertension:* Diastolic pressure is 120 to 130 mmHg.

Symptoms

Headache, dizziness, impaired vision, failing memory, shortness of breath, pain over the heart and gastrointestinal disturbance, unexplained tiredness.

PRINCIPLES OF DIET

Low calorie, low fat, low sodium diet with normal protein intake is prescribed.

Energy

Obese patient must be reduced to normal body weight with low calorie diet.

Protein

A diet of 50 g protein is necessary to maintain proper nutrition.

Fats

About 40 g fat, partly as vegetable oil is permitted.

Soduim

Restrictions for a moderate low sodium diet (1000 mg).

Do not use:

1. Salt in cooking or at the table.
2. Salt preserved foods, pickles, canned foods.
3. Highly salted foods such as potato chips.
4. Spices and condiments such as ketchup, sauce.
5. Cheese, peanut butter, salted butter.
6. Frozen peas.
7. Shell fish.
8. Regular baking powder, sodium metabisulphite, Ajinomoto.
9. Prepared mixture.

APPENDICES

APPENDIX–1

COURSE DESCRIPTION–BIOCHEMISTRY

Placement: First year
Time: Theory 30 Hours

The course is designed to assist the students to acquire knowledge of the normal biochemical composition and functioning of human body and understand the alterations in biochemistry in diseases for practice of nursing.

Unit	Time (Hours)	Objective	Content	Teaching learning activities	Assessment methods
I	3	• Describe the structure Composition and functions of cell • Differentiate between Prokaryote and Eukaryote cell • Identify techniques of Microscopy	**Introduction** • Definition and significance in nursing • Review of structure, composition and functions of cell. • Prokaryote and Eukaryote cell organization. • Microscopy.	• Lecture discussion using charts, slides • Demonstrate use of microscope	• Short answer questions • Objective type
II	6	• Describe the structure and functions of cell membrane	**Structure and functions of cell membrane** • Fluid mosaic model tight junction, cytoskeleton • Transport mechanism: Diffusion, osmosis, filtration, active channel, sodium pump • Acid-base balance—maintenance and diagnostic tests – pH buffers	• Lecture discussion	• Short answer questions • Objective type
III	6	• Explain the metabolism of carbohydrates	**Composition and metabolism of Carbohydrates** • Types, structure, composition and uses – Monosaccharides, Disaccharides, Polysaccharides, Oligosaccharides	• Lecture discussion • Demonstration of blood glucose monitoring	• Short answer questions • Objective type

Contd.

Contd.

Unit	*Time (Hours)*	*Objective*	*Content*	*Teaching learning activities*	*Assessment methods*
			• Metabolism – Pathways of glucose: - Glycolysis - Gluconeogenesis: Cori's cycle, Tricarboxylic acid (TCA) cycle - Glycogenolysis - Pentose phosphate pathways (Hexose mono-phosphate) – Regulation of blood glucose level Investigations and their interpretations		
IV	4	• Explain the metabolism of Lipids	**Composition and metabolism of Lipids** • Types, structure, composition and uses of fatty acids. – Nomenclature, Roles and Prostaglandins • Metabolism of fatty acid –Breakdown –Synthesis • Metabolism of triacylglycerols • Cholesterol metabolism	• Lecture discussion using charts • Demonstration of laboratory tests	• Short answer questions • Objective type

Contd.

Contd.

Unit	*Time (Hours)*	*Objective*	*Content*	*Teaching learning activities*	*Assessment methods*
V	6	• Explain the metabolism of Amino acids and Proteins	–Biosynthesis and its Regulation -Bile salts and bilirubin -Vitamin D -Steroid hormones • Lipoproteins and their functions: – VLDLs-IDLs, LDLs and HDLs – Transport of lipids – Atherosclerosis Investigations and their interpretations **Composition and metabolism of Amino acids and Proteins** • Types, structure, composition and uses of Amino acids and proteins • Metabolism of Amino acids and proteins – Protein synthesis, targeting and glycosylation – Chromatography – Electrophoresis – Sequencing • Metabolism of Nitrogen – Fixation and Assimilation – Urea Cycle – Hemes and Chlorophylls	• Lecture discussion using charts • Demonstration of laboratory tests	• Short answer questions • Objective type

Contd.

Contd.

Unit	*Time (Hours)*	*Objective*	*Content*	*Teaching learning activities*	*Assessment methods*
			• Enzymes and co-enzymes – Classification – Properties – Kinetics and inhibition – Control Investigations and their interpretations		
VI	2	• Describe types, composition and utilization of vitamins and minerals.	**Composition of vitamins and minerals** • Vitamins and minerals: – Structure – Classification – Properties – Absorption – Storage and transportation – Normal concentration Investigations and their interpretations	• Lecture discussion using charts • Demonstration of laboratory tests	• Short answer questions • Objective type
VII	3	• Describe immuno-chemistry	**Immunochemistry** • Immune response • Structure and classification of immunoglobulins • Mechanism of antibody production • Antigens: HLA typing	• Lecture discussion • Demonstrate laboratory tests	• Short answer questions • Objective type

Contd.

Contd.

Unit	*Time (Hours)*	*Objective*	*Content*	*Teaching learning activities*	*Assessment methods*
			• Free radical and Antioxidants • Specialised Protein: Collagen, Elastin, Keratin, Myosin, lens Protein. • Electrophoretic and quantitative determination of immunoglobulins–ELISA, etc. Investigations and their interpretations.		

APPENDIX–2

COURSE DESCRIPTION–NUTRITION

Placement: First Year
Time: Theory 60 Hours

The course is desigend to assist the students to acquire knowledge of nutrition for maintenance of optimum health at different stages of life and its application for practice of nursing.

Unit	Time (Hours) Th.	Pr.	Learning Objective	Content	Teaching learning activities	Evaluation
I	4		• Describe the relationship between nutrition and health.	Introduction • Nutrition: – History – Concepts • Role of nutrition in maintaining health • Nutritional problems in India • National nutritional policy • Factors affecting food and nutrition: Socioeconomic, cultural, tradition, production, system of distribution, life style and food habits, etc. • Role of food and its medicinal value • Classification of foods • Food standards • Elements of nutrition: Macro and micro •Calorie, BMR	• Lecture discussion • Explaining using charts • Panel discussion	• Short answers • Objective type
II	2		• Describe the classification, functions, sources and	**Carbohydrates** • Classification	• Lecture discussion • Explaining using charts	• Short answers • Objective type

Contd...

Contd...

Unit	*Time (Hours)* *Th.*	*Pr.*	*Learning Objective*	*Content*	*Teaching learning activities*	*Evaluation*
			recommended daily allowances (RDA) of carbohydrates	• Caloric value • Recommended daily allowances • Dietary sources • Functions • Digestion, absorption and storage, metabolism of carbohydrates • Malnutrition: Deficiencies and over consumption.		
III	2		• Describe the classification, functions, sources and recommended daily allowances (RDA) of fats	**Fats** • Classification • Caloric value • Recommended daily allowances • Dietary sources • Functions • Digestion, absorption and storage, metabolism • Malnutrition: Deficiencies and over consumption.	• Lecture discussion • Explaining using charts	• Short answers • Objective type
IV	2		• Describe the classification, functions, sources and recommended daily allowances (RDA) of proteins	**Proteins** • Classification • Caloric value • Recommended daily allowances	• Lecture discussion • Explaining using charts	• Short answers • Objective type

Contd...

Contd...

Unit	*Time (Hours)* *Th.*	*Pr.*	*Learning Objective*	*Content*	*Teaching learning activities*	*Evaluation*
				• Dietary sources • Functions • Digestion, absorption, metabolism and storage • Malnutrition: Deficiencies and over consumption		
V	3		• Describe the daily calorie requirement for different categories of people.	**Energy** • Unit of Energy–Kcal • Energy requirements of different categories of people. • Measurements of energy • Body Mass Index (BMI) and basic metabolism • Basal Metabolic Rate (BMR) –Determination and factors affecting	• Lecture discussion • Explaining using charts • Exercise • Demonstration	• Short answers • Objective type
VI	4		• Describe the classification, functions, sources and recommended daily allowances (RDA) of Vitamins.	**Vitamins** • Classification • Recommended daily allowances • Dietary sources • Functions	• Lecture discussion • Explaining using charts	• Short answers • Objective type

Contd.

Contd...

Unit	Time (Hours) Th.	Pr.	Learning Objective	Content	Teaching learning activities	Evaluation
				• Absorption, synthesis, metabolism storage and excretion • Deficiencies • Hypervitaminosis		
VII	4		• Describe the classification, functions, sources and recommended daily allowances (RDA) of minerals.	**Minerals** • Classification • Recommended daily allowances • Dietary sources • Functions • Absorption, synthesis, metabolism, storage and excretion • Deficiencies • Over consumption and toxicity	• Lecture discussion • Explaining using charts	• Short answers • Objective type
VIII	3		• Describe the sources, functions and requirements of water and electrolytes.	**Water and electrolytes** • Water: Daily requirement,regulation of water metabolism, distribution of body water • Electrolytes: Types, sources, composition of body fluids	• Lecture discussion • Explaining using charts	• Short answers • Objective type

Contd.

Contd...

Unit	*Time*	*(Hours)*	*Learning Objective*	*Content*	*Teaching learning activities*	*Evaluation*
	Th.	*Pr.*				
				• Maintenance of fluid and electrolyte balance • Over hydration, dehydtration and water intoxication • Electrolyte imbalances		
IX	5	15	• Describe the Cookery rules and preservation of nutrients. • Prepare and serve simple beverages and different types of foods.	**Cookery rules and preservation of nutrients** • Principles, methods of cooking and serving –Preservation of nutrients • Safe food handling-toxicity • Storage of food • Food preservation, food additives and its principles • Prevention of food adulteration Act (PFA) • Food standards • Preparation of simple beverages and different types of food	• Lecture discussion • Demonstration • Practice session	• Short answers • Objective type • Assessment of practice sessions
X	7	5	• Describe and plan balanced diet for different categories of people	**Balanced diet** • Elements • Food groups	• Lecture discussion • Explaining using charts	• Short answers • Objective type

Contd.

Contd...

Unit	*Time (Hours)* Th.	Pr.	*Learning Objective*	*Content*	*Teaching learning activities*	*Evaluation*
				• Recommended daily allowances • Nutritive value of foods • Calculation of balanced diet for different categories of people • Planning menu • Budgeting of food • Introduction to therapeutic diets: Naturopathy diet	• Practice session • Meal planning	• Exercise on menu planning
XI	4		• Describe various national programmes related to nutrition. • Describe the role of nurse in assessment of nutritional status and nutrition education.	**Role of nurse in nutritional programmes** • National programmes related to nutrition – Vitamin A deficiency programme – National iodine deficiency disorders (IDD) programme – Mid-day meal programme – Integrated child development scheme (ICDS)	• Lecture discussion • Explaining with • Slide/Film shows • Demonstration of Assessment of nutritional status	• Short answers • Objective type

Contd.

Contd...

Unit	*Time (Hours)*		*Learning Objective*	*Content*	*Teaching learning activities*	*Evaluation*
	Th.	*Pr.*				
				• National and international agencies working towards food/nutrition – NIPCCD, CARE, FAO, NIN, CFTRI (Central food technology and research institute), etc. • Assessment of nutritional status • Nutrition education and role of nurse		

APPENDIX–3

UNIVERSITY EXAM QUESTION PAPERS

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

First Year B.Sc. Nursing (Basic) Degree Examination, March 2009 (Revised Scheme)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Krebs critic acid cycle is the final common pathway of metabolism. Justify the statement, describe the cycle.
b. Give the sources, functions, deficiency manifestations and requirement of vitamin C.

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Name of ketone bodies. Give their formation and fate.
b. Describe the digestion of proteins. How are the amino acids absorbed?
c. Outline the β-oxidation of fatty acids. Give the energy formed from oxidation of palmitic acid.
d. What are transaminases? Give the reactions and clinical applications.
e. Role of kidney in acid-base balance.

III. Short Answers **5 × 2 = 10 Marks**

a. Name and indicate the role of two hormones that regulate blood glucose levels.
b. Coenzyme forms of vitamin B_6 and nicotinic acid.
c. Tests for detection of glucose and fructose in urine.
d. Normal serum levels of cholesterol and calcium.
e. Rickets: Cause and prevention.

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

First Year B.Sc. Nursing Degree Examination, March 2009 (Revised Scheme–2)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Give an account of the citric acid cycle and explain why it is called the common renal metabolic pathway. Write a short note on its energetics.
b. Discuss the sources. Daily requirement, biochemical functions of vitamin A.

II. Short Essays (Any three) **3 × 5 = 15 Marks**

a. Classify lepoproteins. Explain their biological significance
b. Give the sources and fate of acetyl-Co A.
c. Functions and deficiency symptoms of pyridoxine.
d. Renal regulations of blod pH.

III. Short Answers **5 × 3 = 15 Marks**

a. Antioxidants
b. Significance of isoenzymes in diagnosis of myocardial infarction.
c. Invert sugar.
d. Functions of Vit. E.
e. Normal levels of
   i. Clacium .
   ii. Urea
   iii. Sodium in blood.

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

First Year B.Sc. Nursing Degree Examination
September/October 2008
Nutrition and Biochemistry (Revised Sheme 2)

Nutrition

I. Long Essays **2 × 10 = 20 Marks**

a. Discuss the various methods of cooking and its effects on nutrients. How can you preserve the nutrients while cooking the foods?
b. Discuss proteins under the following heading:
   i. Classification
   ii. Dietary sources and requirements
   iii. Functions
   iv. Deficiency.

II. Short Essays **5 × 5 = 25 Marks**

a. Definie food adulteration. What are the various food adulterants commonly found in foods and how can it be prevented.
b. Discuss the digestion and absorption of carbohydrates.
c. CFTRI.
d. Short notes on pressure cooking and simmering.
e. Write the functions and imbalance of sodium in the body.

III. Short Answers **5 × 3 = 15 Marks**

a. Various food standards used to ensure food quality.
b. Rickets.
c. What are macronutrients? Write its calorific value.
d. Clear liquid diets.
e. Functions of fat in the body.

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

First Year B.Sc. Nursing Degree Examination, March 2009 (Revised Scheme-2)

Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

a. i. Discuss the various methods of food preservation.
   ii. Write a note on food adulteration and its prevention.
b. Discuss the dietary management in diabetes mellitus.
c. Define balanced diet. What factors do you consider while planning?

II. Short Essays (any five) **5 × 5 = 25 Marks**

a. Special nutrition programme.
b. Dietary sources, functions and requirements and deficiency of calcium.
c. Steps to be taken to prevent food contamination.
d. List the nutrients which supply energy and basic factors influencing the energy needs of the body.
e. Digestion of fat in the GI-Tract.
f. Xerophthalmia.
g. Protein energy malnutrition.

III. Short Answers **5 × 3 = 15 Marks**

a. Pasteurization.
b. Bland diets.
c. Megaloblastic anaemia.
d. EGG Flip and whey water.
e. Weaning.

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

First Year B.Sc. Nursing Degree Examination
September/October 2008 (Revised Scheme–2)

Biochemistry

I. Long Essays **1 × 10 = 10 Marks**

a. Describe the sources, biochemical functions normal requirements and deficiency manifestations of thiamine.

II. Short Essays **3 × 5 = 15 Marks**

a. Classify enzymes, give examples of each class.
b. Homeostasis of blood calcium.
c. Hexose monophosphate shunt and its significance.

III. Short Answers **5 × 3 = 15 Marks**

a. Bile salts in urine
b. Polysaccharides
c. Metabolic role of zinc
d. Pyruvate dehydrogenase enzyme complex
e. Normal levels of:
   - Glucose
   - Uric acid and
   - Creatinine in blood.

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

Second Year B.Sc. Nursing (Basic) Degree Examination September/October 2008 (Revised Scheme)

Growth and Development

I. Long Essays (any two) **2 × 10 = 20 Marks**

a. Discuss the growth and development of an infant.
b. Discuss the various factors that influence growth and development of foetus.
c. What is the calorie requirement of a preschooler? Prepare a diet plan for the preschooler noster to meet the requirements.

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Principles of growth and development.
b. Embryonic development.
c. Thermoregulation of newborn.
d. Health needs of middle adult.
e. Secondary sexual characteristics.
f. Factors influencing marital adjustment of adult.
g. Weaning.
h. Balanced diet.
i. Preservation of water.
j. Methods of cooking.

III. Short Answers **10 × 2 = 20 Marks**

a. Under five clinic.
b. Immunization schedule.
c. Xerophthalmia.
d. Co-operative play.
e. Juvenile delinquency.
f. Moro reflex.
g. Family planning.
h. RDA.
i. Fluid diet.
j. Neonatal mortality.

September/October 2008

Nutrition

Maximum: 35 Marks

I. Define the following **5 Marks**

a. Nutrition
b. Dietetics
c. Growth
d. Dietician
e. Development

II. What is food? Write the classification of food with examples . 12 Marks

III. What are the functions food arid also write the composition of our body in terms of the food constituents. 12 Marks

IV. What are the functions of proteins. 6 Marks

First Year B.Sc. Nursing (Basic) Degree Examination, 2004

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Describe various mechanisms of acid-base balance.
b. Describe Beta oxidation of fatty acids.

II. Short Essays **4 × 5 = 20 Marks**

a. Digestion of proteins and absorption of amino acids.
b. Functions of Vitamin D and its deficiency manifestations.
c. Name abnormal constituents of urine. Give their significance. How are they detected?
d. Glucose Tolerance Test (GTT).

III. Short Answers **5 × 2 = 10 Marks**

a. Functions of nucleic acids.
b. Coenzymes of Pyridoxine and Riboflavin.
c. Normal blood urea and creatinine level.
d. Rickets.
e. Renal glycosuria.

RAJIV GANDHI UNIVERSITY EXAM QUESTION PAPERS
April 2005

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Describe Citric Acid Cycle
b. Explain sources, Biochemical functions and deficiency (ascorbic acid).

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Name essential fatty acids. Write its importance.
b. Define Buffers. Name blood buffers and explain its role in acid-base balance.
c. Classify proteins on the basis of functions giving examples.
d. Renal Function tests.

III. Short Answers **5 × 2 = 10 Marks**

a. Glutamine formation and its importance.
b. Coenzymes of thiamin and niacin.
c. Benedict's Test.
d. Night blindness.
e. Normal Blood Levels of Calcium and Phosphorus.

April 2003

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Explain metabolism of glycine and state its metabolic importance
b. Explain sources, daily requirement, functions and deficiency diseases of Vitamin A.

II. Short Essays **4 × 5 = 20 Marks**

a. Diagnostic importance of enzymes.
b. Mucopolysaccharides.
c. Fatty liver and lipotrophic factors.
d. Liver function tests.

III. Short Answers **5 × 2 = 10 Marks**

a. Blood glucose level and renal threshold value
b. Nucleotides of biological importance
c. Functions of Vitamin K.
d. Test for urinary ketone bodies. Sodium and potassium levels in plasma.

September 2003

Biochemistry

I. Long Essay (any one) **1 × 10= 10 Marks**

a. Describe the digestion and absorption of proteins.
b. What are the normal physical characteristics of urine? Mention the pathological components of urine, how are they detected.

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Explain in detail the significance of the pentose phosphate pathway.
b. Write briefly on phenyl ketonuria.
c. Explain in brief alkalosis and acidosis.
d. Outline the transamination reaction with a suitable example. Give its clinical significance.
e. Describe GTT

III. Short Answers **5 × 2 = 10 Marks**

a. Name two biologically important compounds derived from cholesterol.
b. Give four hormones formed from tyrosine.
c. Beri - Beri.
d. RDA of Vitamin D and Vitamin C.
e. Name the Renal Function Tests based on glomerular filtration.

April 2002

Nutrition

I. Long Essay (any one) **1× 10 = 10 Marks**

a. What is balanced diet? Name essential nutrients. Mention basic functions of this nutrients.
b. Enumerate kidney function tests. Describe any one test which will help for the assessment of kidney function.

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Physical characteristics of urine.
b. Serum electrolyte levels.
c. Acidosis and alkalosis.
d. Digestion of carbohydrates.
e. Homeostasis of blood.

III. Short Answers **5 × 2 = 10 Marks**

a. Mention the normal range of fasting and post-prandial blood sugar, serum cholesterol and total protein.
b. Enumerate the kidney function tests.
c. Name two fat soluble vitamins and their food sources.
d. Name two water soluble vitamins and their requirements.
e. Name the tests which detect carbohydrates and protein in urine. Explain one test for the detection of protein in urine.

October 2000 (Old Scheme)

Nutrition

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Define homeostasis. How do hormones maintain blood glucose homeostasis?
b. Give the dietary sources, requirements, functions and deficiency manifestations of vitamin A.

II. Short Essays **4 × 5 = 20 Marks**

a. How is a 5% dextrose solution preferred and sterilised? What are its uses?
b. Why should an uncontrolled diabetes mellitus patient develop metabolic acidosis?
c. Give the functions of bile in digestion.
d. Name the digestive enzymes of pancreas. Give their functions.

III. Short Answers **5 × 2 = 10 Marks**

a. Give the significance of blood urea estimation.
b. What is the normal colour of urine? What do you infer when the urine of a patient is deep yellow?
c. A sample of urine reduces Benedict's reagent. Give two reasons for the reduction.
d. What is the nutritional value of ripe papaya fruit?
e. How is parboiled rice nutritionally superior to raw rice.

April 2001

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Discuss about the digestion and absorption of lipids.
b. What is the normal fasting blood glucose level? Discuss in detail about blood glucose homeostasis.

II. Short Essays **4 × 5 = 20 Marks**

a. Structure of starch.
b. Respiratory acidosis.
c. Ketosis.
d. Primary structure of proteins.

III. Short Answers **5 × 2 = 10 Marks**

a. Name any four enzymes of diagnostic importance.
b. Write the normal serum levels of (a) Total bilirubin (b) Total cholesterol (c) Bicarbonate (d) Uric acid.
c. What is uronic acid? Mention the functions of glucuronic acid.
d. Name the key enzymes of gluconeogenesis.
e. Pellagra.

September 2001

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Describe digestion and absorption of proteins.
b. Mention the normal pH of blood. How is it maintained— Explain?

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Describe the pathway of fatty acid oxidation.
b. Regulation of plasma calcium level.
c. Role of insulin in regulation of blood glucose level.
d. Sources and functions of vitamin A.
e. Structure and functions of glycogen.

III. Short Answers **5 × 2 = 10 Marks**

a. Ketogenesis.
b. Test for detection of proteins in urine.
c. Essential fatty acids.
d. Glycosuria.
e. Vanden Berghtest.

October 2000 (New Scheme)

Biochemistry

I. Long Essay (any one) **1 × 10 = 10 Marks**

a. Discuss glycolysis in liver
b. Write the dietary sources of proteins, requirements, functions and deficiency disorders

II. Short Essays **4 × 5 = 20 Marks**

a. Discuss the sources, requirements and functions of vitamin C
b. What is the normal biochemical composition of CSF? How do they vary in disease
c. How are proteins digested
d. Give the significance of breastfeeding

III. Short Answers **5 × 2 = 10 Marks**

a. NPN substances excreted in urine
b. Isotonic saline, its preparation and uses
c. Normal levels of total cholesterol and HDL cholesterol in serum
d. Creatinine clearance Test
e. Gout

May 2001 (New Scheme)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Write an essay on digestion and absorption of proteins
b. Name B complex vitamins with an essay on the biochemical functions of any one of them.

II. Short Essays **4 × 5 = 20 Marks**

a. Polysaccharides
b. Classification of lipids
c. Clearance tests
d. Vitamin K

III. Short Answers **5 × 2 = 10 Marks**

a. Sources of vitamin D
b. Test for ketone bodies
c. Calorific value of proteins and fats
d. Xerophthalmia
e. Insulin effect on carbohydrate metabolism.

May 2001 (Old Scheme)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Describe glycogen metabolism in the liver in the fed and fasting state
b. Write an essay on essential nutrients

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Name the dietary essential amino acids and classify them.
b. Name the plasma lipoproteins and give their functions.
c. Discuss the water balance
d. Describe the renal tubular mechanism operating for the reabsorption of sodium
e. What are the functions of Vitamin C

III. Short Answers **5 × 2 = 10 Marks**

a. Name the enzymes catalysing the following reactions
   i. Arginine $\rightarrow$ Ornithine+ urea
   ii. $CO_2 + H_2O \rightarrow H_2CO_3$
b. What is the percentage of NaCl in isotonic saline?
c. How is glutamine synthesised in the brain?
d. What is the clinical significance of plasma HDL cholesterol.
e. Give the normal range of values in blood of
   i. fasting glucose
   ii. Serum creatinine
   iii. Blood urea
   iv. Serum total cholesterol

October 2001 (New Scheme)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Describe glycogen metabolism
b. Describe the sources, daily requirement, functions and deficiency diseases of Vitamin A

II. Short Essays **4 × 5 = 20 Marks**

a. Digestion and absorption of lipids
b. Functions of plasma proteins
c. Urea cycle
d. Classification of amino acids

III. Short Answers **5 × 2 = 10 Marks**

a. Benedict's test
b. Dietary sources and RDA of vitmain C
c. Protein digesting enzymes secreted by pancrea
d. Bile salts
e. Milk sugar

October 2001 (Old Scheme)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Write about the dietary sources, daily requirements and functions of vitamin A
b. How is oral glucose tolerance test performed? How is blood glucose level maintained?

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Essential amino acids
b. Digestion and absorption of Carbohydrates
c. Name bile acids and mention about the functions of bile salts
d. Metabolic acidosis
e. Benedict's qualitative test

III. Short Answers **5 × 2 = 10 Marks**

a. What is a simple protein? give two examples
b. What is lacithin
c. van den Bergh test
d. What is normal Sodium and Potassium level?
e. Give two important functions of insulin.

May 2002 (New Scheme)

Biochemistry

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. How are carbohydrates digested and absorbed?
b. Name the renal function tests. Indicate their significance. How is the creatinine clearance test performed?

II. Short Essays **4 × 5 = 20 Marks**

a. Oral glucose tolerance test
b. Ketone bodies
c. Classification of Proteins
d. Ascorbic acid

III. Short Answers **5 × 2 = 10 Marks**

a. Sources and daily requirements of Vitamin A
b. What are essential fatty acids? Name them.
c. Name the major plasma lipoproteins
d. What is the normal pH of blood? Name two plasma buffers
e. What is the function of 1,25 dihydroxy cholecalciferol?

Second Year B.Sc. Nursing (Basic) Degree Examination, November 2003

Growth and Development—Theory Paper (Revised Scheme) (1998-99 Batch and Onwards)

I. Long Essays (any two) **2 × 10 = 20 Marks**

a. Explain the developmental stages of foetus.
b. Describe the growth and development of a school age child?
c. Explain old age is the golden age.

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Normal signs and symptoms of pregnancy.
b. Assessment of newborn.
c. Adjustment of newborn to extrauterine life.
d. Needs of Elderly.
e. Anticipatory Guidance and discipline of school age child.
f. Health promotion of preschooler.
g. Behavioral characteristics of toddler.
h. Pre-marital counseling.
i. Factors influencing food habits.
j. Diet plan for a pregnant woman.
k. Sources, requirements and deficiency of vitamin.

III. Short Answers **2 × 10 = 20 Marks**

a. Morning sickness.
b. Moro reflex.
c. Vitamin E.
d. Balanced diet.
e. Juvenile delinquency.
f. Soft diet.
g. Malnutrition.
h. Macronutrients
i. Zygote
j. Immunization.

Second Year B.Sc. Nursing (Basic) Degree Examination, 2001

Growth and Development Including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

1 a. Describe the physical and psychosocial development of the infant? **6 Marks**

b. Discuss the needs of infants? **4 Marks**

2 a. Enumerate the physiological changes associated with ageing. **6 Marks**

b. Discuss the safety precautions for the elderly people? **4 Marks**

3 Mention the water Soluble vitamins and write about any one of them. **10 Marks**

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Play therapy.
b. Primary dentition.
c. Problems of preschool children.
d. Developmental tasks of toddlers.
e. Effects of hospitalization.
f. The nutritional require of adolescents.
g. Composition of body fluids.
h. Protein calorie malnutrition in children.
i. Chemical composition of milk.
j. Factors affecting calcium absorption

III. Short Answers **10 × 2 = 20 Marks**

a. Define the term Growth.
b. Cephalhaematoma.
c. Problems of school age children.
d. Moro reflex.
e. Marriage counseling.
f. Dementia.
g. Functions of carbohydrates.
h. Sources of iron.
i. Functions of protein.
j. Effects of vitamin B deficiency.

May 2002 (Old Scheme)

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Which are normal physiological characteristics of urine? Mention the pathological Components of urine. How are they detected
b. Discuss the regulation of glucose level in blood by hormones

II. Short Essays (any four) **4 × 5 = 20 Marks**

a. Role of bicarbonate buffer system
b. Food sources, dietary requirement and deficiency manifestations of Vitamin A
c. Biological value of proteins
d. Metabolic alkalosis
e. Lypolytic enzymes

III. Short Answers **5× 2 = 10 Marks**

a. Mention the normal range of Calcium, hemoglobin and serum electrolytes
b. What is specific dynamic action
c. Role of lipids in the diet
d. Name renal function tests based on glomerular filtration
e. Name the factors which maintain homeostasis of blood

November 2002

I. Long Essays (any one) **1 × 10 = 10 Marks**

a. Name the fat soluble vitamins. Write an essay on Vitamin D
b. What is the normal pH of blood? How is it maintained?

II. Short Essays **4 × 5 = 20 Marks**

a. Essential amino acids
b. Classification of carbohydrates
c. Tests for bile salts and bile pigments in urine
d. Basal metabolic rate.

III. Short Answers **5 × 2 = 10 Marks**

a. Calorific value of fats and proteins
b. Benedict's test
c. Kwashiorkor
d. Tests for proteinuria
e. Beriberi

First Year B.Sc. Nursing (Basic) Degree Examination, September 1997

Time: 3 Hours **Maximum: 80 Marks**

Instruction to Candidates

Answer Section 'A' and Section 'B' in separate answer books.
Your answers shall be specific to the questions asked.
Draw neat and labeled diagrams wherever necessary.

SECTION A

I. Long Essay **10 Marks**

Enumerate the factors which influence food intake and food habits. Explain the role of culture in detail

II. Short Essays **4 × 5 = 20 Marks**

a. What are the deficiency conditions of vitamin D? Give any two rich sources of vitamin D.
b. List the functions of carbohydrates.
c. Applied Nutrition programme.
d. What are the different techniques used for identification of malnutrition in children?

III. Short Answers **5 × 2 = 10 Marks**

a. Define "Pernicious Anaemia".
b. List different methods used for preservation of food.
c. What are Millets?
d. What is the caloric requirement of preschool children?
e. What is "Steaming"?

SECTION B

I. Long Essay **10 Marks**

What is balanced diet? What factors you need to consider while planning balanced diet?

II. Short Essays **4 × 5 = 20 Marks**

a. What is the role of UNICEF in promotion of child nutrition?
b. What are the effects of washing and cooking on rice?
c. Define essential fatty acids and give examples.
d. List the deficiency symptoms of riboflavin and write the sources of riboflavin.

III. Short Answers **5 × 2 = 10 Marks**

a. Define "Nutrition".
b. What is the biological importance of protein?
c. What are the effects of cooking on green leafy vegetables?
d. What is the daily requirement of folic acid for a healthy adult?
e. List important food sources of iron.

First Year B.Sc. Nursing (Basic) Degree Examination, 1998

I. Long Essays **2 × 10 = 20 Marks**

a. Discuss the relation of food to health?
b. Discuss in detail the nutritional requirements during pregnancy .

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Explain the functions of proteins in our body.
b. What are the different methods used for preservation of food.
c. What is the role of FAO to improve the nutrition of people of all countries?
d. How can a nutritional anaemia be prevented?
e. List and briefly explain the deficiency symptoms of vitamin A.
f. What are the two different types of vitamins? Give two examples of each type.
g. What are the factors affecting meal planning?
h. What is the influence of socio-economic factors on nutrition?
i. What are the effects of washing and cooking on rice?
j. Protein calorie malnutrition.

III. Short Answers **10 × 2 = 20 Marks**

a. Define "Rickets"
b. Write the classification of lipids with examples.
c. Define pressure cooking.
d. What is weaning?
e. What is the caloric requirement of preschool child?
f. List any four important sources of vitamin C.
g. What is dietary fibre?
h. What is emulsification?
i. List out the food sources of calcium.
j. What are the effects of excessive fluorine in drinking water?

First Year B.Sc. Nursing (Basic) Degree Examination, 2001 (1996-97 and 1997-98 Batches)

I. Long Essays (any two) **2 × 10 = 20 Marks**

a. Define balanced diet. What factors you would consider while planning a balanced diet?
b. Write the definition, classification food sources, daily requirements functions and deficiency effects of carbohydrates?
c. Explain the role of the nurse in relation to improve the nutrition of the community.

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Nutritional classification of foods.
b. List and write about the main nutritional problems which our country is facing today.
c. How does age brings about changes in nutritional requirements?
d. What are the nutritional requirements of pregnant women?
e. What are the functions of proteins in our body?
f. Write about the various factors effecting the food habits in detail.
g. Menu plan for school going child.
h. List the functions of calcium and write the factors affecting calcium absorption.
i. List the different types of vitamins. Discuss the deficiency symptoms of vitamin D.
j. Applied nutrition programme.

III. Short Answers **10 × 2 = 20 Marks**

a. Vitamin A prophylaxis programme.
b. Scurvy.
c. Characteristics of lipids.
d. Deficiency of riboflavin.
e. Pica.
f. Methods of cooking.
g. Therapeutic diet.
h. What foods you will include in the diet of the patient suffering from anaemia?
i. Weaning foods.
j. Name the essential amino acids.

First Year B.Sc. Nursing Degree Examination, 1998

I. Long Essay **10 Marks**

Mention food classification according to chemical composition and write functions, sources and deficiencies of proteins.

II. Short Essay (any four) **4 × 5 = 20 Marks**

a. Define balanced diet. Plan high cost balanced diets for pre-school children.
b. Write physiological functions of vitamin A and D.
c. Discuss effects of cooking on all food groups.
d. What are the objectives of applied nutrition programme?
e. What are the various methods of diet survey?

III. Short answers **5 × 2 = 10 Marks**

a. Vitamin C.
b. Define Malnutrition.
c. Define Nutrients.
d. Characteristics of lipids.
e. Toxic effects of excess of fluorine in human beings.

SECTION B

I. Long Essay **10 Marks**

Write essay on effects of socio-economic factors on food pattern and food habits.

II. Short Essay (any four) **4 × 5 = 20 Marks**

a. Write functions of minerals.
b. Differences between kwashiorkor and marasmus.
c. FAO.
d. What are the deficiency conditions of vitamin D.
e. Relation of nutrition to health.

III.Short answers **5 × 2 = 10 Marks**

a. Define steaming, backing.
b. How and where is iron stores in the body?
c. Effects of imbalance of niacin.
d. Functions of phosphorus.
e. Dietary sources of calcium.

Second Year B.Sc. Nursing (Basic) Degree Examination, 2000

Growth and Development Including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

1. a. Discuss the physical and psychosocial development of the toddlers? **6 Marks**
   b. Describe the needs of the toddler? **4 Marks**
2. a. Enumerate the current concepts of growth and development? **5 Marks**
   b. Discuss the reflexes of the newborn infants. **5 Marks**
3. Assessment of nutritional status.

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Development tasks of 8 years child.
b. Problems of adolescent.
c. Normal physiological changes associated with ageing.
d. Apgar score
e. Safety precautions for the elderly.
f. Erikson's theory of development.
g. Effects of cooking on various nutrients.
h. Effects of Vitamin A deficiency.
i. Marasmus.
j. Essential amino acids.

III. Short Answers **10 × 2 = 20 Marks**

a. Write the reasons for weaning the infants.
b. Needs of the toddlers.
c. Problems preschooler.
d. Factors promoting adequate supply of breast milk.
e. Puberty.
f. Embryo/foetal development at 4th week.
g. Nutritional classification of foods.
h. Dietary sources of calcium.
i. Factors influencing a diet plan.
j. Functions of vitamin C.

Second Year B.Sc. Nursing (Basic) Degree Examination, 1998 and 1999 Batch

Growth and Development Including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

1. a. Discuss the laws of growth and development. **5 Marks**
   b. Enumerate the factors influencing growth and evelopment. **5 Marks**
2. a. What are the secondary sex characteristics of adolescents ? **5 Marks**
   b. Describe the problems of the adolescents. **5 Marks**
3. Discuss the nutritional requirements during pregnancy and lactation. **10 Marks**

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Developmental problems of a toddler.
b. Reflexes of the infant.
c. Immediate care of the newborn.
d. Freud's stage of development.
e. Weaning of infants.
f. Psychosocial development of young adult based on Erik 1 theory.
g. Iron deficiency—Anemia.
h. Prepare a diet plan for adolescent.
i. Effect of folic acid deficiency.
j. Physiological changes in ageing.

III. Short Answers **10 × 2 = 20 Marks**

a. Colostriurn.
b. Nutritional requirement of infant.
c. Psychosocial dcvelopment of preschooler.
d. Genetic counselling.
e. Developmental task of the older adult.
f. Teratogenesis.
g. Vitamin K.
h. Iodine deficiency in human beings.
i. Classification of proteins.
j. Effect of vitamin B deficiency.

Second Year B.Sc. Nursing (Basic) Degree Examination, 2001

Growth and Development including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

1. a. Describe the physical and psychosocial development of the infant. **6 Marks**
   b. Discuss the needs of infants. **4 Marks**
2. a. Enumerate the physiological changes associated with ageing. **6 Marks**
   b. Discuss the safety precautions for the elder1 people. **4 Marks**
3. Mention the water soluble vitamins and write about any one of them. **10 Marks**

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Play therapy.
b. Primary dentition.
c. Problems of preschool children.
d. Developmental tasks of toddlers.
e. Effects of hospitalization.
f. The nutritional requirements of adolescents.
g. Composition of body fluids.
h. Protein calorie malnutrition in children.
i. Chemical composition of milk.
j. Factors affecting calcium absorption.

III. Short Answers **10 × 2 = 20 Marks**

a. Define the term Growth.
b. Cephalhematoma.
c. Problems of school age children.
d. Moro reflex.
e. Marriage counseling.
f. Dementia.
g. Functions of carbohydrates.
h. Sources of iron.
i. Functions of protein.
j. Effects of B deficiency.

Second Year B.Sc. Nursing (Basic) Degree Examination, 2002 (Revised Scheme) (1998-1999 Batch and Onwards)

Growth and Development Including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

1. a. Sex education during adolescence. **5 Marks**
   b. Describe the physical growth from 6 years to 12 years age? **5 Marks**
2. a. Emotional and social development from 1 year to 5 years age. **5 Marks**
   b. Neuromuscular development in the newborn? **5 Marks**
3. a. List and discuss the factors influencing food habits? **10 Marks**

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Complications of pregnancy.
b. Emotional problems of adults.
c. Planned parenthood.
d. Developmental tasks of late maturity.
e. Factors influencing growth and development.
f. Special problems of adolescence in society.
g. Food selection.
h. Role of fibre in diet.
i. Nutritional needs of infant.
j. Balanced diet.

III. Short Answers **10 × 2 = 20 Marks**

a. Breastfeeding.
b. Quickening.
c. Erickson theory.
d. Vernix caseosa.
e. Pulse polio.
f. Beverages.
g. Cholesterol.
h. Iodised salt.
i. RDA.
j. Nutritional status.

Second Year B.Sc. Nursing (Basic) Degree Examination, 2003 (Revised Scheme) (1999 Batch)

Growth and Development Including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

a. Discuss the principles of growth and development? **10 Marks**

b. Discuss the Eric-Ericson's theory of growth and development? **10 Marks**

c. What is Balanced diet ? Discuss steps would you consider while planning a diet plan for an 70 years aged person?

II. Short Essays (any eight) **2 + 8 = 10 Marks**

a. Physical growth of an infant.
b. Common behavioral problems of a Toddler.
c. Prevention of food adulteration.
d. Health problems and needs of the adolescent.
e. Purposes and methods of cooking food.
f. Sex education.
g. Diet during pregnancy.
h. Effects of heat on cooking food.
i. Weaning in infants.
j. Types, sources and requirements of proteins.
k. Importance of learning growth and development in nursing.

III. Short Answers **10 × 2 = 20 Marks**

a. Reflexes of the newborn.
b. Planned parenthood.
c. Sources of carbohydrates.
d. Puberty.
e. Oedipal complex.
f. Embryo.
g. Fluid diet.
h. Developmental task.
i. Sources of iron.
j. Effects of vitamin D deficiency.

RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARNATAKA

Second Year B.Sc. Nursing (Basic) Degree Examination October 2006 (Revised Scheme)

Growth and Development including Nutrition

I. Long Essays (any two) **2 × 10 = 20 Marks**

a. (i) Define growth and development.
   (ii) Discuss the factowrs influencing growth and development.
b. Discuss the neuromuscular endowment of the new born?
c. Enumerate the common behaviour problems of children.

II. Short Essays (any eight) **8 × 5 = 40 Marks**

a. Sex education.
b. Intellectual development of pit schooler.
c. Psychological changes during old age and their management.
d. Anthropometric measurement.
e. Night blindness.
f. Planning diet for old age.
g. Sources, requirement arid deficiency of fat.
h. Pregnancy test.
i. Age wise selection of toys.
j. Concept of baby friendly hospital initiative.

III.Short Answers **10 × 2 = 20 Marks**

a. Small for date.
b. DPT.
c. Micronutrients.
d. EGG flip.
e. Identity vs. role diffusion.
f. Nail biting.
g. Enuresis.
h. Classification of neonates, according to birth weight.
i. Chronic villi.
j. Positive signs of pregnancy.

Nutrition

I. Long Essay (any one) **3 + 7 = 10 Marks**

a. What is balanced diet?
b. What factors do you need to consider while preparing balance diet.

II. Discuss different methods of cooking and their effects on food constituent **4 × 5 = 20 Marks**

a. Plan one day menu for a pregnant lady.
b. Preservation and storage of food.
c. Impact of religion on food.
d. Drinking water source requirements and preservation
e. Weaning and supplement foods.

III. Answer Questions in not more than Six Sentences

5 × 2 = 10 Marks

a. Arrowroot Conjie.
b. Deficiency diseases of protein.
c. Food fortification.
d. Milk hygiene.
e. Source of vitamin 'A'.

KERALA UNIVERSITY

Paper II—Physiology Including Biochemistry Response Sheet for MCQs

Time: 10 Minutes **Maximum: 5 Marks**

Directions

1. Write the name of examination, month and year, subject of the day's examination and register number in the space provided.
2. *Select the* **one** *most appropriate response and encircle the corresponding alphabet against each Question Number in the Response Sheet.*
3. Enter the total number of your responses in the appropriate box provided at the end.

Question No.

1.	A	B	C	D
2.	A	B	C	D
3.	A	B	C	D
4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D

Total Number of Responses ☐

Name of Examination…..…….2008
Subject……
Resister Number……. ☐

CALICUT UNIVERSITY

First Year B.Sc. Nursing Degree Nursing Examination 2008
(Revised Syllabus-2007)

Nutrition and Biochemistry

Time: 2 hours 30 minutes **Maximum: 75 Marks**

(SECTION –A Nutrition -50 Marks
and
SECTION –B Biochemistry-25 Marks)

TEST DESIGN –Details of weightage. For Nutrition
(50 Marks)

I. Objective type–(20%)	
a. MCQs	5 Marks
b. Matching type	5 Marks
II. Very Short Answer type (40%)	
a. Definitions/List	5 Marks
b. Give reasons/differentiate between	5 Marks
III. Short Answers (20%)	
To answer 3 questions out of 4	3 × 5 = 15 Marks
IV. Essay Type (20%)	
One essay question	1 × 15 = 15 Marks
Total	50 Marks

TEST DESING – Details of weightage. For Biochemistry
(25 Marks)

I. MCQs	5 Marks
II. Short Answers	10 Marks
III. Essay	10 Marks

DIFFICULTY INDEX

SI. No.	*Difficulty Index*	*Percentage*
1.	Average	60
2.	Difficult	20
3.	Easy	20

KERALA UNIVERSITY

Paper II–Physiology

MULTIPLE CHOICE QUESTIONS

Time: 10 Minutes **Maximum: 5 Marks**

Note: 1. *Do not write anything on the question paper.*
2. Write your register number on the answer-sheet provided.
3. *Select the* **appropriate answer** *and encircle the alphabet against each question in the answer-sheet provided.*
4. In the answer-sheet enter the total number of your answers in the appropriate box provided.
5. *Each question carries ½ mark.*

1. Hypermetropia is a corrected by: **(10 × ½ = 5 Marks)**
A. Biconvex lens B. Biconcave lens
C. Cylindrical lens D. None of the above.

2. Hormone which increases blood calcium level is:
A. Insulin B. Parathormone
C. Glucagon D. Calcilonin.

3. Hormone responsible for secretion of milk is:
A. Oxytocin. B. Prolactin.
C. Estrogen. D. FSH.

4. Intrinsic factor is secreted by:
A. Chief cells. B. Mucus neck cells.
C. Parietal cells. D. Peptic cells.

5. Renal threshold for glucose in a normal individual is:
A. Zero mls/min. B. 300 mls/min.
C. 180 mls/min. D. 325 mls/min.

6. Lateral geneculate body receives:
A. Auditory fibers. B. Touch fibers.
C. Olfactory fibers. D. Visual fibers.

7. Hyperbaric oxygen therapy is useful in following condition:
A. High attitude. B. Severe anemia.
C. Cyanide poisoning. D. Congestive cardiac failure.

8. Gastric acid secretion is inhibited by:
A. Acetyl choline B. Histamine.
C. Gastrin. D. Somatostatin.

9. Pacenian corpuscle is:

A. Pain receptor. B. Taste receptor.
C. Temperature receptor. D. Pressure receptor.

10. In conduction deafness:

A. Air condition is better than bone conduction.
B. Bone conduction is better than air conduction.
C. There is no relationship between air conduction and bone conduction.
D. Both air conduction and bone conduction are equal.

KERALA UNIVERSITY

(Pages : 1 + 2 =3)

Name……
Reg. No……

First Year B.Sc. (Nursing) Degree Examination,
September/October 2008
Part I–Biological Sciences
Paper II–Physiology Including Biochemistry

Time: Two Hours **Maximum: 50 Marks**

Answer Sections A and B in separate *answer-books.*
Draw diagrams wherever necessary.
Question I should be answered first in the response sheet provided.

SECTION A (PHYSIOLOGY)

I. Multiple Choice Questions (on attached separate sheet). **(5 Marks)**

II. Enumerate the clotting factors. Explain the Intrinsic mechanism of coagulation. **(3 + 5 = 8 Marks)**

III. Write briefly on any *four* questions: **(4 × 2 = 8 Marks)**

a. Vital capacity.
b. Juxtaglomerular apparatus.
c. Reflex arc.
d. Normal E.C.G. as in lead-II.
e. Tests for ovulation.

IV. Explain the mechanism of skeletal muscle contraction. (4 Marks)

SECTION B (BIOCHEMISTRY)

V. a. Write an essay on liver function tests. **(6 Marks)**
b. Write briefly the regulation of blood glucose level. (4 Marks)

VI. Write briefly on: **(2 × 3 = 6 Marks)**

a. Phenyl ketonuria.
b. Metabolic acidosis.

VII. Write briefly on: **(3 × 3 = 9 Marks)**

a. Plasma proteins.
b. Hypocalcemia.
c. Lysosomes.

KERALA UNIVERSITY

Name……
Reg. No……

First Year B.Sc. Nursing Degree Examination, January 2008

Part III–Community Health, Paper II–Nutrition (New Scheme)

Time: 2 Hours **Maximum: 50 Marks**

SECTION A

I. a. Bring out the importance of protein in human body.
b. Discuss protein under the following headings:
(5 + 10 = 15 Marks)

i. Metabolism
ii. Sources
iii. Requirements

II. Write briefly on any *two* of the follwing: (2 × 5 = 10 Marks)

a. Anaemia.
b. Kwashiorkor.
c. Food spoilage.

SECTION B

III. a. **Explain the principles of food preservation.**
(5 + 10 = 15 Marks)

b. Enumerate the various methods adopted in home situation for food preservation and strorage.

IV. Write any *two* short notes given below or answer the essay:
(2 × 5 = 10 Marks)

a. Nutritional needs of infants.
b. Rickets.
c. Ariboflavinosis

Or

Give an account of functions and deficiencies of thiamine.
(10 Marks)

KERALA UNIVERSITY

I. Short notes on any five **5 × 4 = 20 Marks**

1. Nutritional Problems in India
2. Classification of foods
3. Food standards in India
4. Better methods of cooking
5. Food adulteration Act
6. Food additives and its principles
7. Methods to retain nutrients in food.

II. Multiple choice **10 × ½ = 5 Marks**

1. Optimum of nutrition means
   a. Lack of nutrition
   b. Correct amount of nutrition
   c. Imbalance of nutrition
   d. Correct amount and proportion of nutrition.
2. All enzymes are:
   a. Protein
   b. Carbohydrate
   c. Vitamin
   d. Mineral.
3. One of the most important function of vitamin is:
   a. Energy giving
   b. Protection from infection
   c. Body building
   d. Production of enzymes.
4. The maximum energy source in ones diet should be from:
   a. Fat
   b. Protein
   c. Carbohydrate
   d. Water.
5. The energy contribution from protein is:
   a. 4 Kcal
   b. 6 Kcal
   c. 7 Kcal
   d. 9 Kcal.

6. Nutrients needed in amounts of a gram or more per day are categorized as:
   a. Micronutrients
   b. Macronutrients
   c. Essential nutrients
   d. Mineral nutrients.
7. The source of cellulose is:
   a. Liver
   b. Meat
   c. Plant food
   d. Sugar
8. Storage form of carbohydrate in the body:
   a. Glycerol
   b. Glycogen
   c. Fattyacid
   d. Fiber.
9. Malnutrition means:
   a. Lack of nutrition leading to ill health
   b. Undesirable kind of nutrition leading to ill health
   c. Correct amount of nutrition
   d. Correct proportion of nutrition.
10. Scurvy is a deficiency disease of:
   a. Vitamin A
   b. Vitamin D
   c. Vitamin C
   d. Iodine.

Index

C

D

E

J

K

L

M

O

P

V

X

Z