Chapter 3
Proteins

INTRODUCTION

Mulder coined the term "proteins" to describe the complex organic nitrogenous compounds found in animal and plant tissues in 1838. Proteins are the most significant of all known organic compounds since they are the building blocks of all living cells. It is the sole nutrient capable of generating new cells and regenerating those that have died.

DEFINITION

Proteins are large, complex, organic compounds made up of carbon, hydrogen, oxygen and nitrogen. The presence of nitrogen distinguishes proteins from carbohydrates and fats. Apart from nitrogen, some other elements such as Sulphur, phosphorus, copper and iron are also found in some proteins.

The basic unit or proteins is amino acid. Each amino acid contains an acidic group and an amino group. Proteins consist of chains of amino acids that are linked to each other by a peptide linkage.

AMINO ACID

Amino acids are tiny units that make up proteins. The human body requires 24 amino acids, nine of which are termed Essential Amino Acids (EAA) because our bodies cannot synthesis them in sufficient proportions. As a result, they must come from dietary proteins. If a protein includes all essential amino acids in the required amounts, it is said to be "biologically complete." When one

or more EAAs are missing, the condition is referred to as "biologically incomplete." The amino acid pattern of dietary protein is intimately connected to its quality. Animal proteins are superior to vegetable proteins in terms of nutrition since they are biologically complete. Non- essential amino acids does not mean that these amino acids are not required by the body. If they are lacking in the diet, they can be synthesized by the body from other amino acids.

CLASSIFICATION OF AMINO ACIDS

Essential Amino Acids

- Leucine
- Isoleucine
- Histidine
- Lysine
- Tryptophan
- Phenylalanine
- Methionine
- Threonine
- Valine

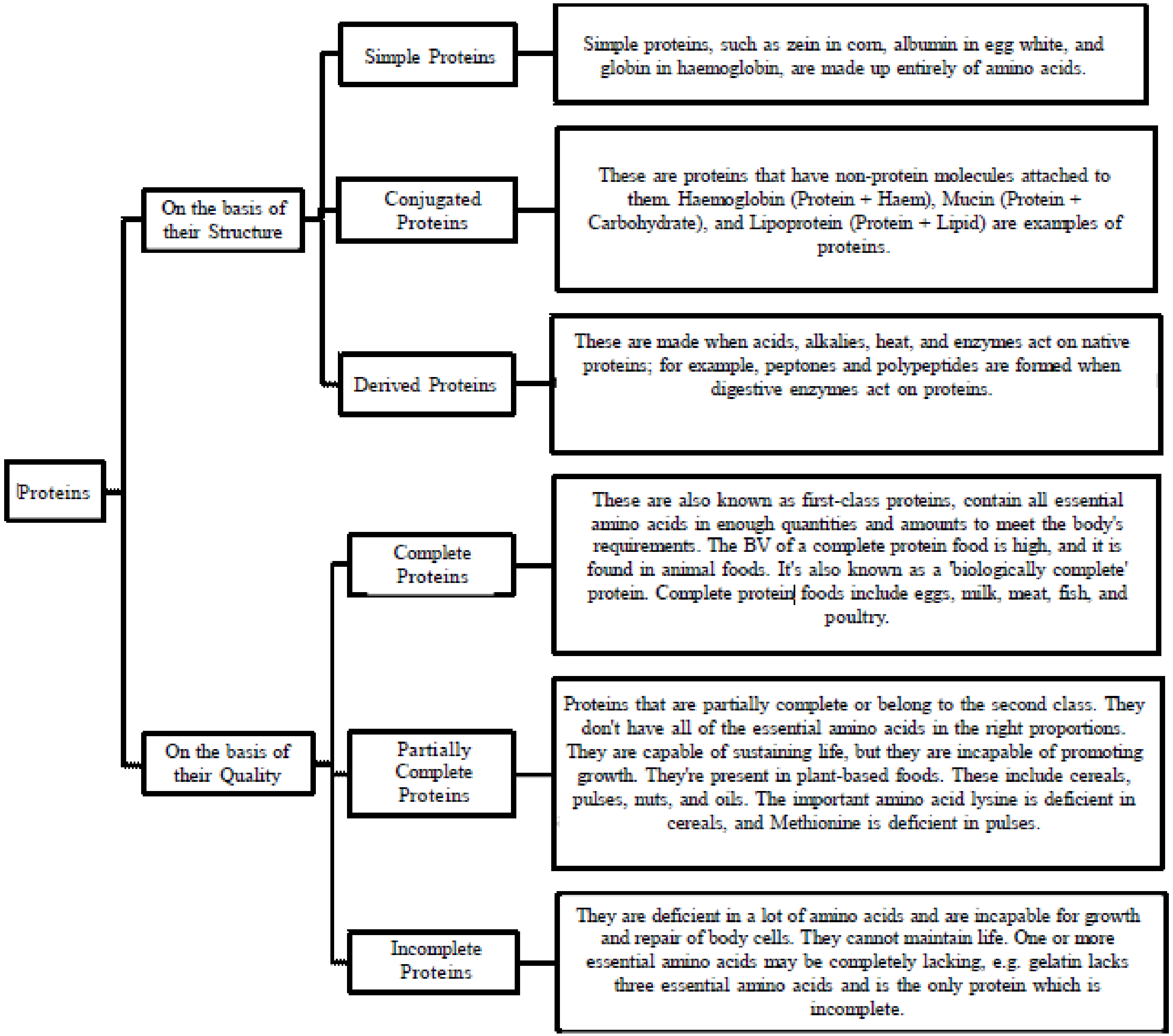
Semi-Essential Amino Acids

- Arginine
- Tyrosine
- Cysteine
- Glycine
- Serine

Non-Essential Amino Acids

- Glutamic Acid
- Aspartic Acid
- Alanine
- Proline
- Hydroxy Proline

CLASSIFICATION OF PROTEINS – I



CLASSIFICATION OF PROTEINS – II

Type of Protein	Function	Examples
Structural Proteins	Support	Insects and spiders use silk fibers to make their cocoons and webs, respectively. Collagen and elastin provide a fibrous framework in animal connective tissue. Keratin is the protein of hair, horns, feathers and other skin appendages.
Storage Proteins	Storage of Amino acids	Albumin is the protein of egg white, used as an amino acid source for the developing embryo. Casein, the protein of milk, is the major source of amino acids for baby mammals. Plants have storage proteins in their seeds.
Transport Proteins	Transport of other substances	Hemoglobin, the iron containing protein of vertebrate blood transports oxygen from the lungs to other parts of the body. Other proteins transport molecules across cell membranes
Hormonal Proteins	Coordination of an organization	Insulin, a hormone secreted by the pancreas, helps to regulate the concentration of sugar in the blood of vegetables.

CLASSIFICATION OF PROTEINS – II

Type of Protein	Function	Examples
Receptor Proteins	Response of cell to chemical stimuli	Receptors built into the membrane of a nerve cell detect chemical signals released by other nerve cells. Cellular receptors are proteins either inside a cell or on its surface which receive a signal. In normal physiology, the cellular receptors are chemical signals where a protein ligand binds a protein receptor
Contractile Proteins	Movement	Actin and myosin are responsible for the movement of Proteins muscles. Other proteins are responsible for the undulations of the organelles called cilia and flagella.
Defensive Proteins	Protection against diseases	Antibodies combat bacteria and viruses. Examples - Immunoglobulin A, IgD, IgG.
Enzymatic Proteins	Selective acceleration of chemical reactions	Naturally occurring digestive enzymes are proteins that body makes to breakdown food and aid in digestion. Digestive enzymes catalyze the hydrolysis of the polymers in food

FUNCTIONS OF PROTEIN

- **Body Building and Growth:** Protein's principal role is the synthesis of body cells. Protein is found in all bodily tissues and fluids except urine and bile. Muscles, organs, endocrine glands, and collagen are all made up of proteins. The fundamental structural protein of bones, tendons, ligaments, skin, blood vessels, and connective tissue is collagen. Proteins make up all enzymes and certain hormones. Additional proteins are required during periods of fast growth.
- **Wear and Tear:** Protein is essential for the continual upkeep of all body cells in all age groups. Protein is required to replace the old and worn out cells, which have a varied life span.
- **Regulatory Functions :** Certain amino acids and proteins have highly specialized functions in the regulation of body processes and protection against diseases. Their regulatory functions are listed below:
  - The oxygen is carried to the tissues by hemoglobin, an iron-containing protein found in red blood cells.
  - Plasma protein regulates osmotic pressure and maintains water equilibrium in the body.
  - Antibodies are proteins that defend us by boosting our immune system's resistance to sickness.
  - Blood sugar levels are regulated by all enzymes and some hormones, such as insulin. Enzymes operate as particular catalysts in the body's metabolic processes.
  - Some amino acids have specialized activities, such as tryptophan, which is a niacin precursor. When combined with iodine, tyrosine aids in the formation of thyroxine.
  - Energy: Proteins have the potential to be an energy source. On an average, each gram of protein generates 4 kcal. Protein will be oxidized to meet the body's energy needs if the diet does not provide enough calories from fats and carbohydrates.
  - Another significant role of the protein is the synthesis of specific molecules such as antibodies, enzymes, hormones, and coagulating factors.
  - Protein offers amino acids for foetal growth during pregnancy and milk production during lactation; hence, more proteins are recommended during pregnancy and lactation.

SOURCES OF PROTEINS

Animal Sources

- All of the EAA are present in sufficient concentrations in these proteins. Because of their excellent biological value and digestibility, egg proteins are considered the best among dietary proteins.
- Milk, meat, eggs, cheese, fish, and fowl are all animal sources.

Plan Sources

- They have a low EAA score.
- Vegetable protein sources include pulses, grains, beans, nuts, and oil seeds.
- Cereals and pulses are the principal sources of dietary protein in developing countries like India because they are inexpensive, readily available, and consumed in large quantities.

Protein Content Range in Different Groups of Good

Food Groups	Protein in g/100 gm
Eggs	12-14
Meat, Fish	18-20
Milk Fresh	3.5-4
Milk dried whole	26-28
Milk dried skimmed	33-38
Oilseeds and nuts	18-40
Pulses	18-24
Cereals a millets	6-14
Fresh Vegetables (roots and tubers)	1-1.5

PROTEIN SUPPLEMENTATION

Protein is obtained from a number of food sources by humans. Some sources, such as cereal proteins lack lysine and theonine, while pulse proteins lack methionine. These amino acids are known to be "limited." As a result, when we combine two or more vegetarian food (for example, rice and daal), their proteins complement each other and give a protein that is comparable to animal protein in terms of EAA. This is known as the supplemental effect of proteins, and it is extremely useful for nurses and other medical personnel who are advising individuals to eat a varied diet. Thus, with careful planning, vegetarians can acquire high-quality protein at a moderate cost from a diversified diet of grains, pulses, and vegetables.

PROTEIN STATUS ASSESSMENT

Growth monitoring is a key criterion for determining protein status. Arm circumference, serum albumin, translocation, and total body nitrogen are some of the other tests available. Serum albumin concentration is the most accurate indicator. It must be greater than 3.5 g/dl. Malnutrition is indicated by a reading below this level.

Daily Requirements

In 1989, the Indian Council of Medical Research (ICMR) advised 1.0 gram protein/kg body weight for an adult Indian. The daily requirements for various age groups.

DAILY REQUIREMENT OF PROTEINS

Particulars		Gm/kg body wt.	Total
Man	Moderate worker, 55 kg	1g/kg	55 gms
Woman	Moderate workers, 45 kgs weight Pregnancy Lactation	1g/kg 1g/kg+15g 1g/kg+25g	45 gms 60 gms 70 gms
Infants	0-3 months 3-9 months 9-12 months	2.3 g/kg 1.8g/kg 1.5g/kg	-
Children	1-3 years 4-6 years 7-9 years 9-12 years	1.8g/kg 1.56/kg 1.35g/kg 1.10/kg	20 gms 22 gms 33 gms 40 gms
Adolescents (13-15 years)	Boys Girls	-	55 gms 50 gms
Adolescents (16-18 years)	Boys Girls	-	60 gms 50 gms

DIGESTIONAND NUTRIENT ABSORPTION

The stomach and intestines are where protein is digested. Pepsin is a proteolytic enzyme found in gastric juice. It operates on proteins in an acidic environment and hydrolyzes them into simpler polypeptides. Proteolytic enzymes (trypsin, chymotrypsin, and peptidases) found in pancreatic and intestinal fluids hydrolyze polypeptides into free amino acids in the intestine. Amino acids are absorbed in the small intestine and then enter the bloodstream via the portal vein. They are transported throughout the body by blood.

PROTEIN METABOLISM

- Protein is primarily used to provide building material for the body. Protein can also be used as a source of energy for the body. Excess protein and inappropriate protein are broken down in the liver to produce glucose, which is used as a source of energy, and urea, which is a nitrogenous waste product. This process is called Deamination of amino acids. The amino acids' nitrogenous content is first transformed into ammonia, which, for the most part, mixes with carbonic acid in the liver and breaks into urea and water.
- Glucose is either burned or stored depending on the situation. The urea is easily soluble, and because it is ineffective as a fuel source, it is taken away by the bloodstream and expelled. Protein can also be used as a source of energy when a peron is hungry.
- Urea, uric acid, and creatinine are waste products of protein metabolism. The kidneys eliminate all of these protein wastes in the urine.
- Every day, about 30 gm of urea, as well as traces of uric acid and creatinine, exit the body in this way.

PROTEIN METABOLISM

- Protein is primarily used to provide building material for the body. Protein can also be used as a source of energy for the body.
- Protein biological value is a measure of how good a protein is. It's the quantity of ingested nitrogen that's kept in the body. The Biological Value (BV) of a protein food is a quantitative measure of its nutritional value. A protein with high BV retains more nitrogen than one with low BV. The BV of the ideal protein is 100. The BV of an egg is 100, that of milk and fish is 85, and that of meat is 75. Cereals and pulses ingested together have a higher BV than cereals or pulses consumed separately. The amino acids available in pulses will compensate for the amino acids lacking in cereals.

EFFECTS OF DEFICIENCY OF PROTEINS

A sustained reduction in protein intake causes weight loss, anaemia, nutritional oedema, impaired resistance to infection, and poor wound healing. Protein insufficiency is more noticeable during times when protein requirements are higher, such as during youth, pregnancy, and lactation. Pre- school children in underdeveloped nations such as India suffer from PEM (Protein Energy Malnutrition) or PCM (Protein Calorie Malnutrition). In India, the prevalence of PEM in preschool children is 12%.

In India, Protein Energy Malnutrition (PEM) has been highlighted as a major health and nutritional issue. It is not only a leading cause of morbidity and mortality in children, but it also causes permanent physical and mental growth retardation. Kwashiorkor and Marasmus are the two clinical manifestations of PEM.

PROTEIN ENERGY MALNUTRITION (PEM)

- WHO definition of PEM states that "*PEM is a range of pathological condition arising out of coincident lack of protein and energy in varying proportions, most frequently seen in infants and young children and usually associated with infections.*"
- Kwashiorkor - Dr. Cicely Williams initially described this condition in Africa in 1935. This is caused by protein shortage in the diet. Growth failure, oedema, diarrhoea, anaemia, and changes in skin and hair are all important sign and symptoms.
- Nutritional Marasmus is induced by a significant protein and calorie (both) shortage in the diet. Growth failure, fat loss, dehydration indicators, and mental abnormalities are all symptoms of this condition.

Principal Features of Severe PEM

S. No	Signs and Symptoms	Marasmus	Kwashiorkor
1	Muscle wasting	Obvious	Sometimes hidden by oedema and fat
2	Fat loss	Severe loss of subcutaneous fat	No fat loss
3	Oedema	Not present	Usually present on lower Limbs and lower arms, and face.
4	Weight for height	Very low	Sometimes low
5	Face looks	Like monkey's face	Moon face
6	Mental changes	Sometimes quiet and apathetic	Very rare
7	Appetite	Usually good	Poor
8	Diarrhea	Often	Often
9	Skin changes	Usually none	Diffuse pigmentation, sometimes flaky pain, dermatosis
10	Hair changes	Usually none	Sparse, silky and easily pulled out.
11	Liver enlargement	None	Sometimes present due to accumulation of fat.

Cause of PEM

- Inadequate food intake in terms of both quantity and quality.
- Infection contributes to hunger, and starvation contributes to infection, creating a vicious cycle.
- Poor environmental conditions, big familysize, poor maternal health, lack of lactation, premature termination of breast feeding, and bad cultural behaviors linked to child care and weaning are all contributory elements in the web of causation.

Detection of PEM

- The first indicator of PEM is under weight for age.
- Maintaining of growth chart (Road-to-health) is the most practical method to detect PEM. These charts indicate at a glance whether the child is gaining or losing weight.

Classification of PEM

PEM is a spectrum of conditions ranging from growth failure to kwashiorkor or Marasmus. Gomez's and Waterlow's classification of PEM is given below:

1. Gomez's Classification

It is based on weight retardation. It locates the child on the basis of his/her weight in comparison with a normal child on the same age. The normal reference child is in the 50th centile of the Boston Standards. The cut off values were set during a study of risk of death based on weight for age at admission to a hospital unit. This classification therefore has a prognostic value for hospitalized children.

- Its formula is:

$$\frac{\text{Weight of the child}}{\text{Weight of a normal child of same age}} \times 100$$

Degrees of PEM are calculated as follows:

Weight as % of the standard	Nutritional Status
Between 90 - 110	Normal
Between 75 - 89	1st degree (mild) malnutrition
Between 60- 74	2nd degree (moderate) malnutrition
Below 60	3rd degree (severe) malnutrition
Fresh Vegetables (roots and tubers)	1-1.5

Modified Gomez Classification:

Weight as % of the standard	Nutritional Status
More than 80%	Normal
71 – 80%	Grade 1
61 – 70%	Grade 2
51 – 60%	Grade 3
Below 50%	Grade 4

2. Waterlow's Classification

This is done with help of age (if known). Measurements of height assess the effect of nutritional status on long term growth. Following table shows the Waterlow's classification :

Waterlow's classification of PEM

Weight/Height \ Height/age	m - 2SD	m - SD
m - 2SD	Normal	Wasted
m - 2SD	Stunted	Wasted and Stunted

This classification defines two groups for PEM:

- Malnutrition with retarded growth in which a drop in the height / age ratio points to a chronic condition of shortness or stunting.
- Malnutrition with a low weight for a normal height in which the weight for height ratio is indicative of an acute condition of rapid weight loss or wasting.

Interpretation of Indicators:

Weight / Height (%) :

$$\frac{\text{Weight of the child}}{\text{Weight of a normal child of same height}} \times 100$$

Height/ age (%) :

$$\frac{\text{Height}}{\text{Height of a normal child of same age}} \times 100$$

Nutritional Status	Stunting (% of height/age)	Wasting (% of height/age)
Normal	95	90
Mildly impaired	87.5 - 95	80 - 90
Moderately impaired	80 – 87.5	70 - 80
Severely impaired	80	70

Arm Circumference: It is a reliable estimation of the body's muscle mass but it cannot be used before the age of one year.

Arm circumference exceeding 13.5 cm is a sign of a satisfactory nutritional status, between 12.5 to 13.5 cm indicates mild to moderate malnutrition and below 12.5 cm indicate malnutrition.

Nutritional Status	MUAC
Normal	>13.5 cm
Moderately malnourished	12.5 – 13.4 cm
Severely malnourished	<12.5 cm

Preventive Measures of PEM

The following strategy is adapted from the 8th FAO / WHO committee on Nutrition for the prevention and treatment of PEM.

1. Health Promotion

- Education and nutritional supplements are targeted for pregnant and nursing women.
- Breast-feeding is encouraged.
- The creation of low-cost weaning foods.
- Improving the family's diet.
- Nutritional instructions.
- Domestic economies.
- Family planning and child spacing.

2. Specific Protection :

- The child's diet should include protein and energy-dense foods such as milk, eggs, and fresh fruits.
- Anti-disease immunization.
- Food fortification is a term used to describe the process of adding nutrients to food.
- Detection and treatment at an early stage.
- Surveillance on a regular basis.
- Detection of malnutrition at an early stage.
- In the case of PEM, 3-4 g/kg body weight per day of high-quality protein should be administered.
- ORS is a diarrhea treatment for children.
- Infested children are dewormed.

3. Rehabilitation

- Nutritional rehabilitation services include nutritional rehabilitation formula given by NIN Hyderabad. They have suggested to prepare nutritious LADDDUS or mixture with following method.

Whole wheat (Roasted)	= 40 g
Bengal Grams	= 16 g
Ground nut	= 10 g
Jaggery	= 20 g
Total	= 86 g

Preventive Measures of PEM

- Take roasted wheat, grams and ground nut and grind them.
- Boil little water and jaggery together and add this solution to above materials and mix again.
- Now add some fat if available (ghee or oil) to make it tastier and make laddus.

EFFECTS OF EXCESSIVE INTAKE OF PROTEINS

- An excessive amount of protein is converted to fat and stored in the body's adipose tissue as energy.
- An excessive protein consumption puts a strain on the liver and kidneys' ability to digest and eliminate toxins. Toxic wastes tend to build in the body if those organs are unhealthy.
- A high protein diet causes more calcium to be lost in the urine.
- Animal proteins including meat, poultry, and whole milk products make up a large part of a high-protein diet. Cholesterol levels in the blood can be dangerously high.