# PROTEIN 1.1.2

## INTRODUCTION

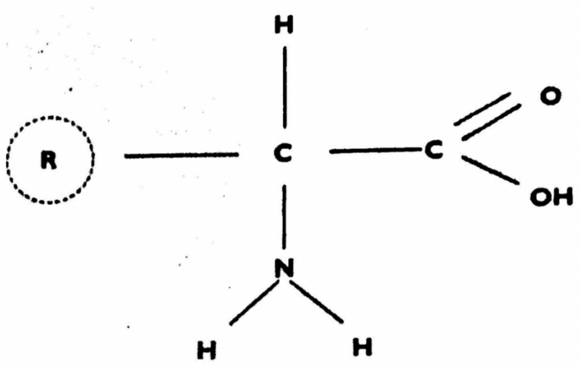
- A protein is a complex, organic compound that consists of amino acids joined by peptide bonds.
- Proteins are essential to the structure and function of all living cells and viruses.
- Many proteins are hormones, enzymes and antibodies.
- Protein is a macronutrient, therefore it is needed by the body in large amounts.
- It is measured in grammes (g).
- It is essential for every living cell as protein is the only nutrient that contains the element Nitrogen (N), which is essential for growth.

## CHEMICAL COMPOSITION

- Students should be aware that the term **chemical composition** can be used interchangeably with the term **chemical structure.**
- It should be noted that diagrams must always be included in the answer.
- Protein exists in animal and vegetable foods in the form of chains.
- The basic unit of a protein chain is called an **amino acid**.
- There are over 20 amino acids in nature.
    - **Essential amino acids** : these cannot be made by the body.
    - **Non-essential amino acids** : these can be made by the body.

- Regardless of the type of amino acid, each amino acid has five parts.
- Four of the five parts are the same for all amino acids.

### BASIC STRUCTURE OF AN AMINO ACID




**Key :**
C = Carbon
COOH = Carboxyl group
$NH_2$ = Amino group
H = Hydrogen
R = Variable

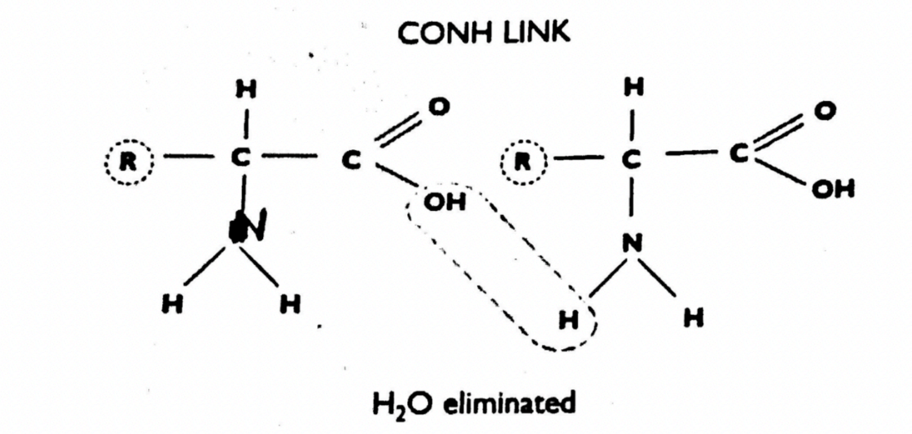
**NOTE**: The only difference between each amino acid is the variable which is denoted by R.

## EXAMPLES OF R-GROUP

- Amino acid Cysteine : R = $HSCH_2$
- Amino acid Glycine : R = H
- Amino acid Phenylalanine : R = $C_6H_5C_2$

- As protein chains are formed, amino acids link together.
- The link between any two amino acids is called a peptide link or peptide bond.
- As each peptide link is formed, one molecule of water is eliminated and this is known as a condensation reaction.

## PEPTIDE LINKAGE




- The acid group (COOH) in one molecule reacts with the basic group ($NH_2$) in the other molecules, (ie) : the OH (hydroxyl group) of the carboxyl group (COOH) combines with H (Hydrogen) of the amino group ($NH_2$ ) to form one molecule of water, a CONH link is also formed.

  - A Dipeptide is formed when two amino acids link together AA-AA.
  - A Tripeptide is formed when three amino acids link together (AA-AA-AA). All other protein chains composed of many amino acids are called …
  - Polypeptides (AA-AA-AA-AA-AA-..), therefore protein chains are called polypeptide chains.

## ELEMENTAL COMPOSITION

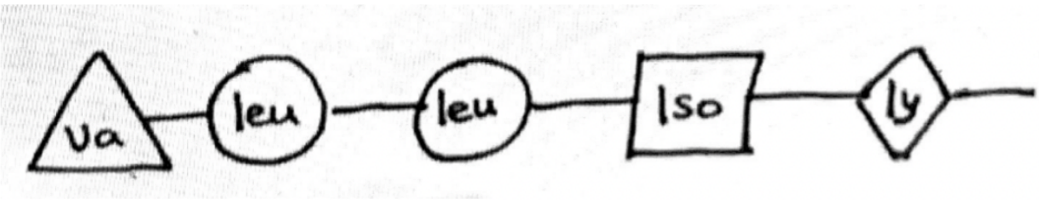
- Proteins are composed of the elements C (Carbon), H (Hydrogen), O (Oxygen) and N (Nitrogen).
- Sometimes, proteins contain S (Sulphur) and P (Phosphorous).

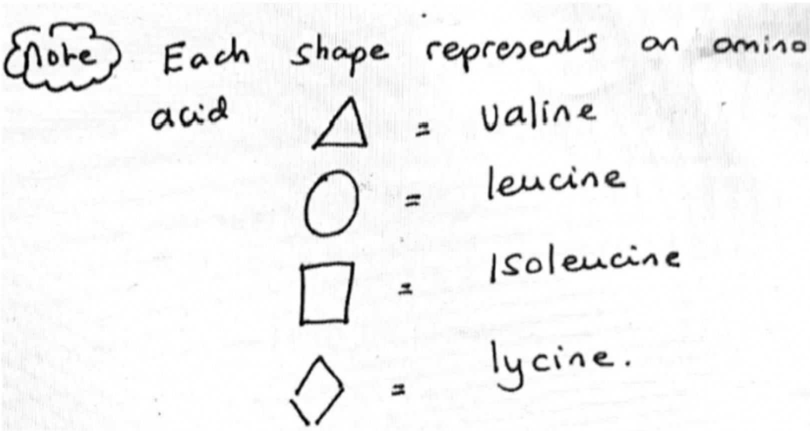
**NB : PROTEIN STRUCTURE**

- Protein chains (polypeptide chains) are not always straight. Sometimes the protein chains are spiral, zig-zag, spherical, have double helix structures etc.
- Protein structure is classified according to :

## (1) : PRIMARY STRUCTURE

- Refers to the order/sequence that amino acids appear on a protein chain.



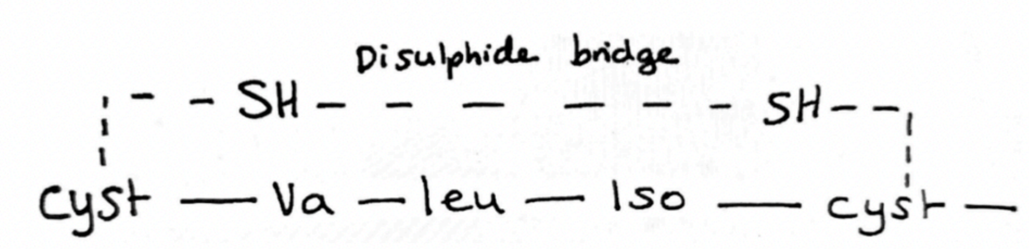

- The linkage between the amino acids on the protein chain is known as peptide linkage.

## (2) : SECONDARY STRUCTURE

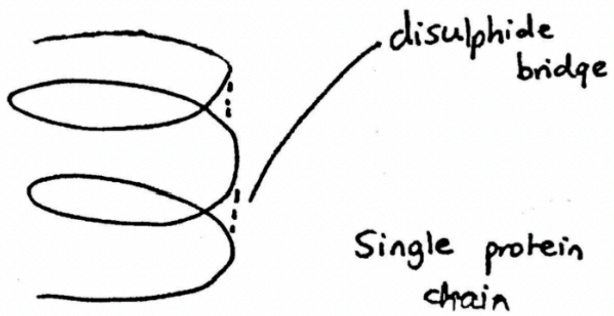
- Refers to further linking on the protein chain (ie) : beyond peptide linkage.
- Often due to the presence of disulphide bridges or hydrogen bonds on the protein chains.
- As a result of this linkage the protein chains can have spiral or helix structures.

### (A) : Disulphide Bridges

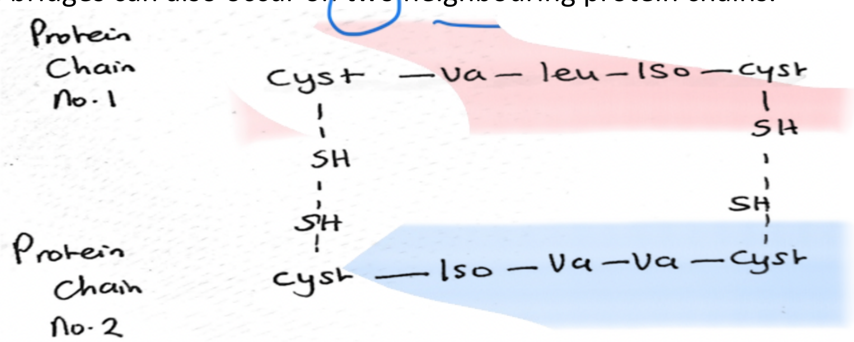
o Disulphide bridges are sometimes present on single protein chains.




- The SH (Sulphur containing) group of one amino acid cysteine links with the SH group of another cysteine on the same protein chain.
- **Result** : The protein chain will have a spiral structure.



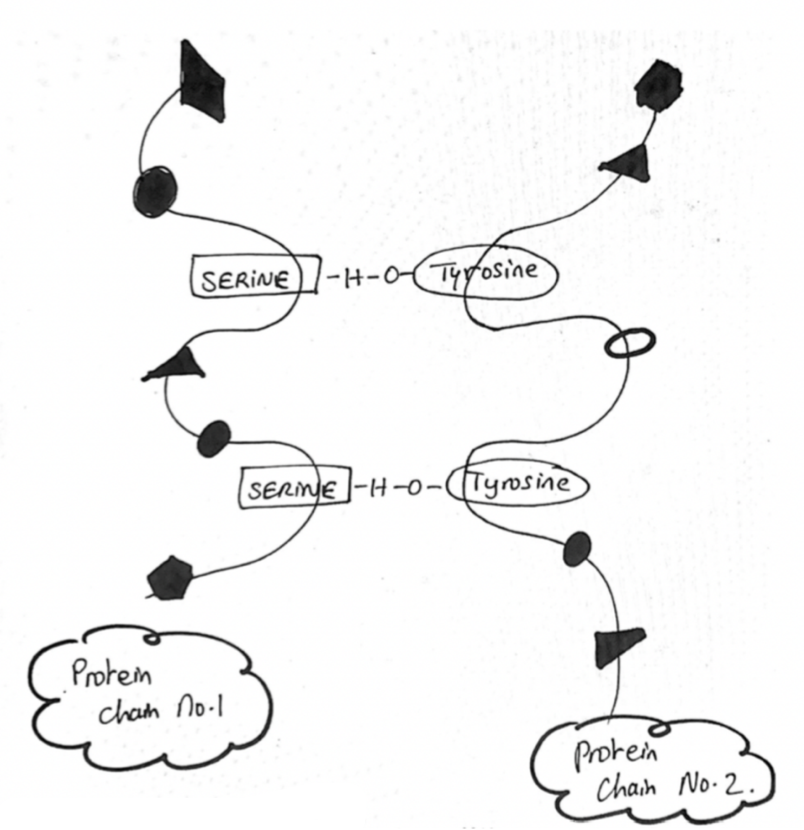

- Disulphide bridges can also occur on two neighbouring protein chains.




- The SH group of cysteine on one protein chain links with the SH group of cysteine on a separate protein chain.
- Result : The protein chains have a double helix structure.

## (B) : Hydrogen Bonds

- Hydrogen bonds are weaker than disulphide bridges orbonds.
- Hydrogen links with oxygen.
- The hydrogen bonds form between the backbone oxygens and amide hydrogens.
- These hydrogen bonds have an important role as they help stabilise the secondary structure (eg) : alpha helix, beta sheets etc.



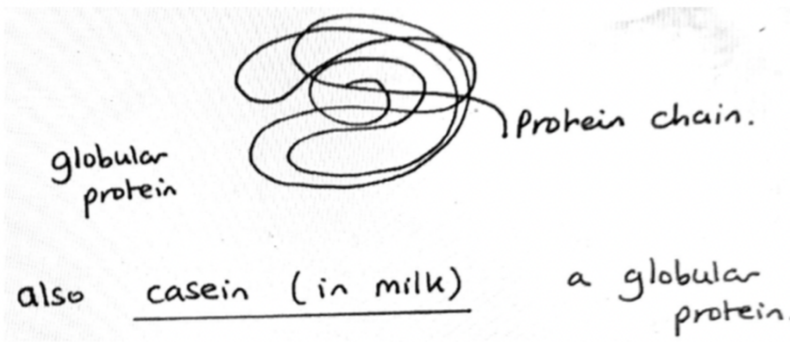

Hydrogen bonds – H from the $NH_2$ of the amino acid serine on one protein chain bonds with the O of the COOH of the of the amino acid - tyrosine

## (3) : TERTIARY STRUCTURE

- This refers to the pattern of folding on protein chains.
- Resulting in the protein chains having a three-dimensional (3D) structure.
- The protein chains maintain these 3D structures due to the presence of cross-links.

### (A) : Globular Proteins

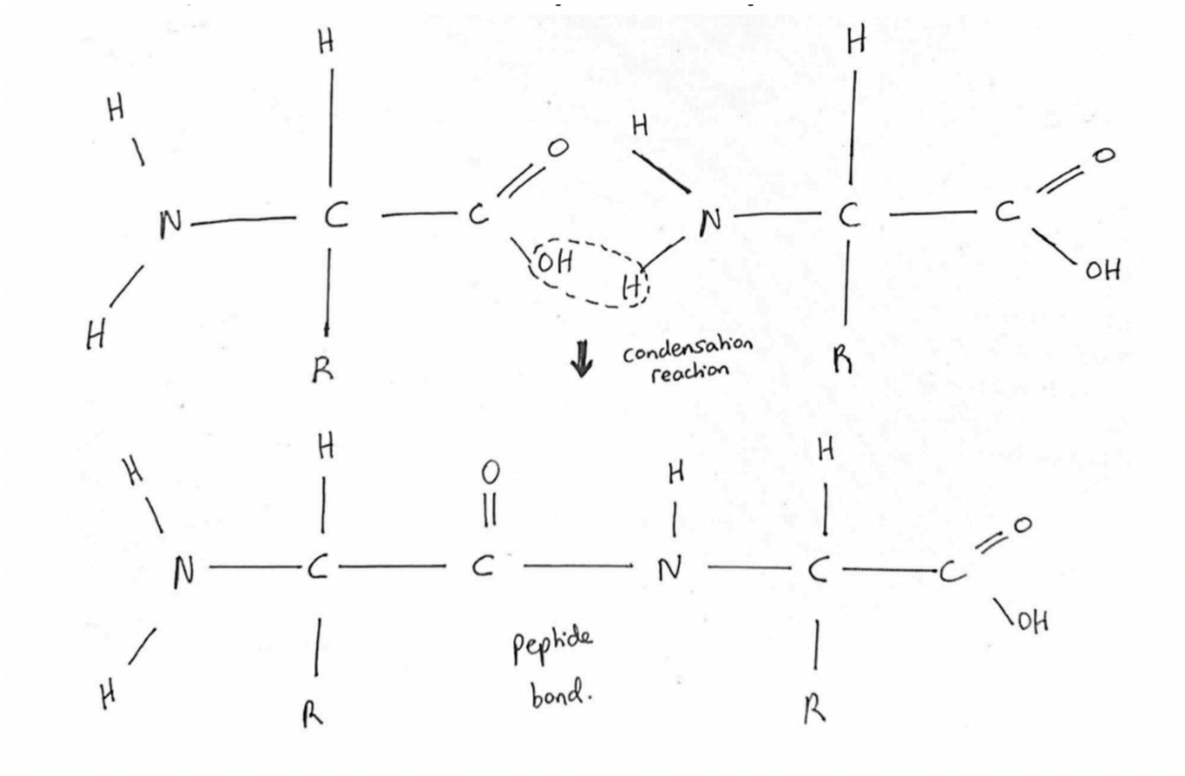
- Example : Ovalbumin in egg white.
- The protein chain folds back on itself forming a 3D shape that roughly resembles a ball of wool or twine (it is quite irregular in shape).




### (B) : Fibrous Proteins

- Example : Gluten in wheat.
- Gluten is made up of two polypeptide chains, glutenin and gliadin. These protein chains interlock forming a 3D zig-zag structure (this gives gluten it's elastic property).

**PEPTIDE BOND/PEPTIDE LINKAGE (2006 Q1B)**

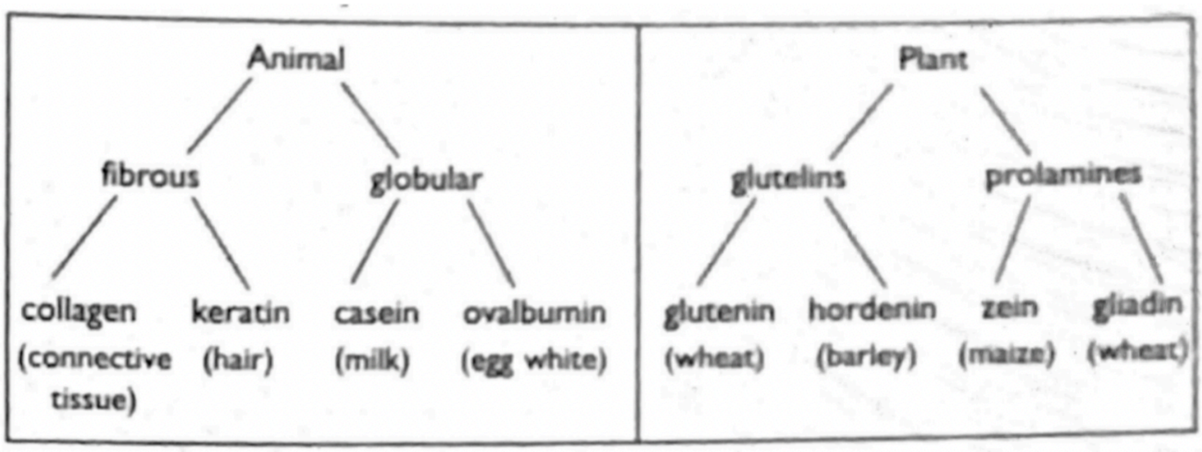


## CLASSIFICATION OF AMINO ACIDS

| Essential Amino Acids | Non-Essential Amino Acids |
| --- | --- |
| ○ **Cannot be produced by the body.**<br>○ **Adults need 8.**<br>○ **Children need 10** | ○ Can be produced by the body |
| **Valine (Val)** | Glycine (gly) |
| **Leucine (Leu)** | Alanine (Ala) |
| **Isoleucine (Ile)** | Tyrosine (Tyr) |
| **Lycine (Ly)** | Serine (Ser) |
| **Threonine (Thr)** | Cysteine (CySH) |
| **Methionine (met)** | Cystine (CySSCy) |
| **Tryptophan (Trp)** | |
| **Phenylalanine (Phe)** | |
| **Arginine (Arg) (children)** | |
| **Histidine (His) (children)** | |

## CLASSIFICATION OF PROTEINS

**SIMPLE PROTEINS:**



## CONJUGATED PROTEINS

| Type | Examples |
|---|---|
| **Lipoproteins** | LDL (low density lipoprotein)<br>i.e. 'good cholesterol' |
| **Chromoproteins** | Haemoglobin (red pigment in blood) |
| **Nucleoproteins** | RNA and DNA |
| **Phosphoproteins** | Casein in milk |
| **Glycoproteins** | Some enzymes an hormones |

## SOURCES OF PROTEIN AND ITS CONTRIBUTION IN FOOD

| (i) Animal Protein Foods | | (ii) Plant Protein Foods | |
|---|---|---|---|
| Protein | Source | Protein | Source |
| **Ovalbumin** | Egg white | Gluten | Wheat, oats |
| **Vitellin, livetin** | Egg yolk | Gliadin | Wheat |
| **Lactalbumin, casein** | Milk | Zein | Maize |
| **Myosin, actin** | Fish | Hordenin | Barley |
| **Myosin, albumin** | Meat | | |
| **Collagen** | Connective tissue | | |
| **Gelatine** | Bones, connective tissue | | |
| **Caseinogen** | Cheese | | |

## FUNCTIONS OF PROTEIN

### (1) : NUTRIENT PROTEINS

- Protein provides a supplementary energy source.
- Protein foods provide a source of essential amino acids.

### (2) : PHYSIOLOGICALLY ACTIVE PROTEINS

- Production of hormones (eg) : insulin.
- Production of enzymes (eg) : pepsin.
- Production of antibodies**.**

### (3) : STRUCTURAL PROTEINS

- Production of keratin in skin, hair and nails.
- Production of cells.
- Production of myoglobin in muscle

## EFFECTS OF TOO LITTLE & TOO MUCH PROTEIN

| Too little Protein | Too much Protein |
|---|---|
| **PROTEIN DEFICIENCY**<br>○ Fatigue.<br>○ Insulin resistance.<br>○ Hair loss/loss of hair pigment (hair that should be black becomes reddish).<br>○ Loss of muscle mass.<br>○ Hormonal irregularities | ○ Build-up of ketones in the body which may cause kidney damage.<br>○ Loss of calcium in the urine. |

## PROPERTIES OF PROTEIN

### EFFECT OF DRY HEAT (MAILLARD REACTION)

- Non enzymic browning.
- Food containing a mixture of amino acids and carbohydrates (eg) : sugar, are exposed to dry heat (oven, grill).
- A chemical reaction takes place between the HN 2 (amino group) in the protein and the OH (hydroxyl group) of the carbohydrate resulting in food turning brown (eg) : sponge cake, roast potatoes.

### EFFECT OF MOIST HEAT (STEWING)

Tough cuts of meat (eg) : lamb gigot (neck) chops, are stewed slowly for a number of hours. The protein (collagen) in connective tissue dissolves and converts to gelatine.
**Result : the meat becomes tender.**

## EFFECT OF ENZYMES (CHEESEMAKING)

- During the initial stages of cheese production, rennin (stomach enzyme from calf) or chymosin is added to pasteurised milk and heated to 30°C. Proteins in milk (casein) coagulate and curds are formed from which cheese is made.

## FOAM FORMATION (MERINGUES / PAVLOVA)

- Foam formation is an example of coagulation. Egg protein has the property of creating a foam. When egg white is beaten, air bubbles are formed. The globular protein chains unravel, beating generates heat to slightly coagulate the ovalbumin which forms a thin layer and sets around the air bubbles. The mixture becomes opaque and stiff.

## GEL FORMATION (MOUSSES / CHEESECAKES)

- Gelatine is an animal protein with 0% biological value. Powdered gelatine is sprinkled on to warm water, as the gelatine is hygroscopic this water is absorbed and a gel is formed (sponging gelatine). The gel is heated above 35°C and added to mousse or cheesecake mixtures. This liquid gelatine is called a sol. The dessert is then chilled in a refrigerator and the mixture sets.

## ELASTICITY

- Protein in wheat/oats and rye known as gluten has elastic properties when moisturized. This is due to the fibrous zig-zag structure of gluten. This property is necessary in bread, cake and pastry making as gluten allows the mixtures to stretch during baking.

## SOLUBILITY

- Most proteins are insoluble in water. However, egg white is soluble in cold water. As mentioned earlier, gelatine (animal protein) dissolves during moist cooking.

## EFFECT OF PH

- Marinades used to tenderise meat proteins have an acid pH (eg) : red wine, yoghurt, lemon juice, vinegar.

## COAGULATION

- Most proteins coagulate or set when heated (eg) : cooking eggs – egg white coagulates at 60°C, yolk coagulates at 68°C
- Meat fibres shrink when heated releasing water, extractives and vitamins.

## DENATURATION

- The protein structure is altered considerably from its original state.
- Protein chains are unravelled.
- Irreversible reaction.
- May be caused by heat mechanical action (eg) : whipping egg white, addition of acid to milk.

## NB : BIOLOGICAL VALUE

- Biological value of protein is the amount of protein in a food retained and utilised by the body. It is always expressed as a %.
- There are two types of BV :
  (A) : High Biological Value (HBV)
  (B) : Low Biological Value (LBV)

## (A) HIGH BIOLOGICAL VALUE (HBV)

- Protein foods with a HBV are usually animal in origin with a BV above 70%.
- These foods are often referred to as complete protein foods which means they contain all 10 essential amino acids.
- **Example** : Eggs HBV 100%. Meat HBV 80%-90%.
- **Exception** : Soya beans even though of plant origin are HBV protein foods (HBV 74%). They are particularly valuable in the diet of vegans.

## (B) LOW BIOLOGICAL VALUE (LBV)

- Protein foods with a LBV are usually plant in origin with a BV below 70%.
- These foods are often referred to as incomplete protein foods because they are deficient in one or more of the essential amino acids.
- Example : Wheat LBV 53%, wheat is lacking in lycine. Beans LBV 58%, beans are lacking in methionine.
- Exception : Gelatine LBV 0%.

## COMPLIMENTARY/SUPPLEMENTARY VALUE

- This is the ability of one protein food to compensate for the amino acid deficiency of another protein food.
- Ideally this should be done as part of the same meal.
- **Example** : Beans on Toast.

| Food | Limiting amino acid |
|---|---|
| **Beans** | Methionine ↓ |
| **(Toast) Wheat** | Lycine ↓ |

- Limiting amino acid is the amino acid which is the lowest in a food, below the body's requirement.

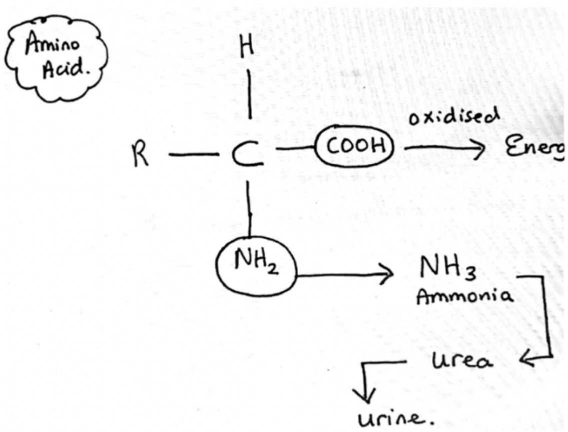
| | | |
|---|---|---|
| Beans | ↓ Methionine | ↑ Lycine |
| Toast | ↑ Methionine | ↓ Lycine |

Other examples of complementary value include :

- Tofu with brown rice.
- Beans and brown rice.
- Hummus with wholewheat pitta bread.
- Peanut butter sandwich on whole grain bread.

## DEAMINATION

- This is a process that involves breaking down excess amino acids in the body.
- It takes place in the liver.



- Protein provides a secondary (supplementary) energy source during deamination. Ideally this energy should only be used for the body's internal work.
- Excess amino acids travel to the liver via a large blood vessel called the hepatic portal vein.
- In the liver, the following takes place.
- The carboxyl groups are oxidized to release energy (secondary source).
- The amino group is broken down to ammonia, then urea and converted to urine which is then excreted.

## RDAs (PROTEIN REQUIREMENTS)

| | |
|---|---|
| **Adult** | **55-75g** |
| **Teenager** | 60-80g |
| **Pregnant woman** | 70-85g |
| **Child** | 30-50g |

- 1g protein when oxidized releases 4 kilocalories (kcal) or 16.8 kilojoules (kJ) of energy for the body.
- Protein foods should provide the average person with 17-18% of their total energy requirements.