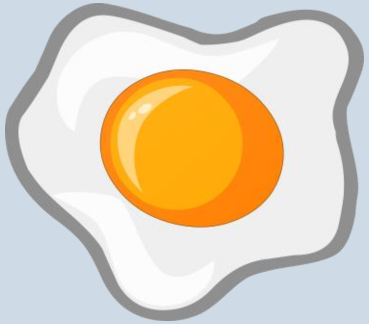
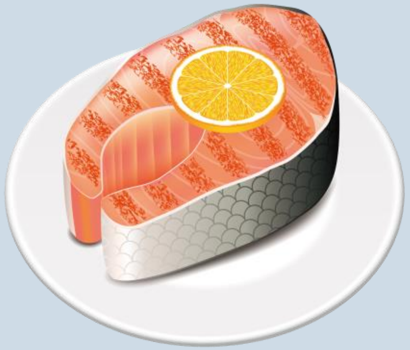
PROTEIN

B.Sc. in Nutrition and Food Engineering
Course Code: 0721-2103
Course : Food Chemistry

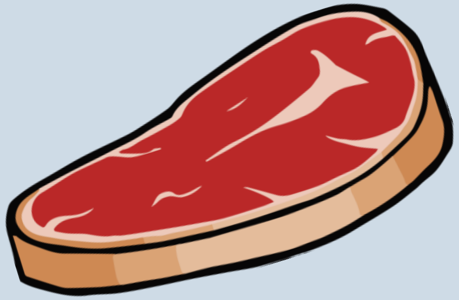
Daffodil International University

PROTEIN

- Proteins are **nitrogenous organic compounds** composed of one or more long chains of **amino acids.** It contains C,H,O,N,S. Protein is the 50% dry weight of cells.
- The word “protein” was coined by Swedish chemist **Jöns Jacob Berzelius** in 1838. It derives from the Greek word “prōteios,” meaning "primary" or "in the lead".
- After water, protein is the most plentiful substance in the body. Proteins grow, maintain, and replace the tissues in our bodies. Therefore our muscles, organs, and immune systems are mostly made of protein. Once protein is digested it is broken down into its amino acid.
- Protein is a long chain-like molecule that is made up of small units known as amino acids, joined together by peptide bonds. There are 20 amino acids. The specific order of amino acids determines the structure and function of each protein.
- Out of 20 amino acids 9 are essential that need to take everyday from food and 11 are non essential that body can make themselves

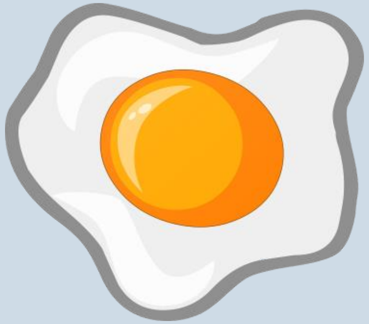
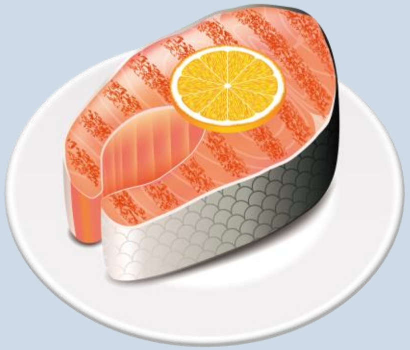





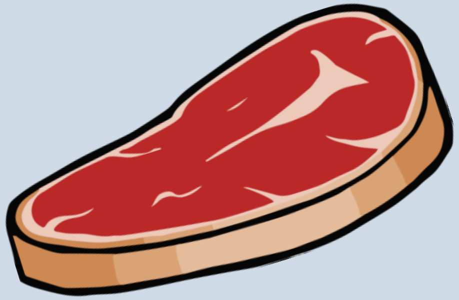


PROTEIN

- Proteins grow, maintain, and replace the tissues in our bodies. Therefore our muscles, organs, and immune systems are mostly made of protein.
- Complete protein that has all amino acids including essential ones are meat, poultry, fish, dairy products, eggs, and soy. Incomplete protein sources include nuts, grains, fruits, and vegetables. Therefore it is important for vegetarians to pair meals wisely in order to get all essential amino acids in their daily diet.
- Like carbohydrates and fats, proteins are considered a major nutrient for the body due to the energy (calories) they provide.
- Protein can be found in foods like eggs, nuts, beans, fish, meat, milk etc.

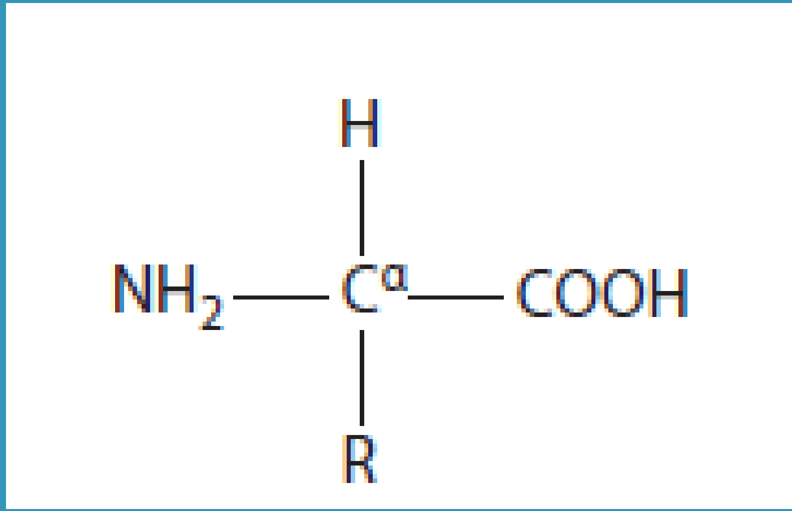







FORMATION OF PROTEIN

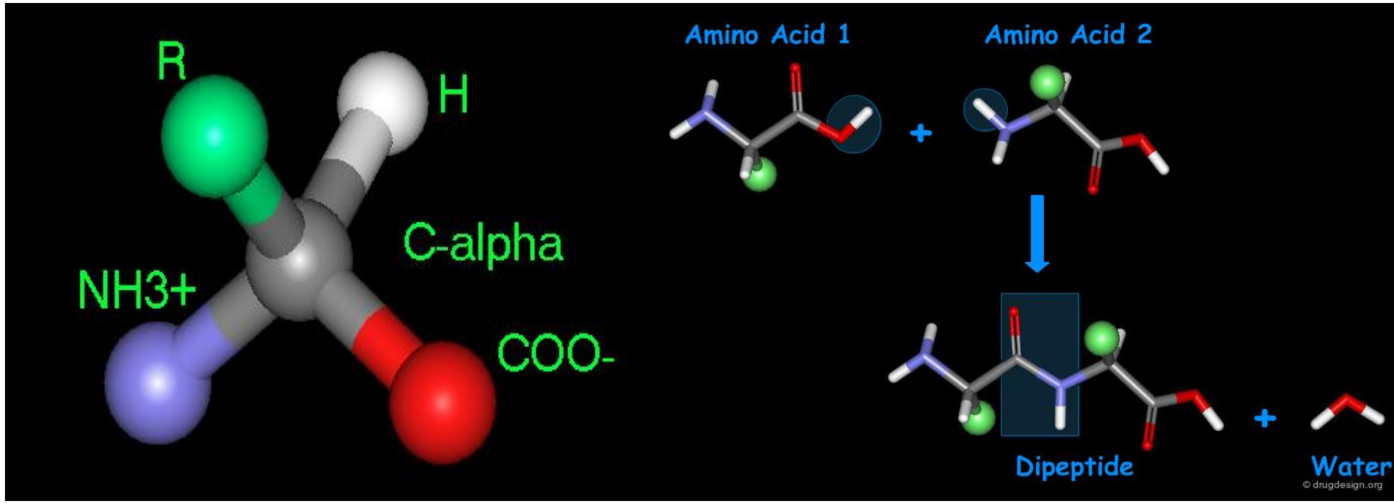
α-Amino acids are the basic structural units of proteins. These amino acids consist of an α-carbon atom covalently attached to a hydrogen atom, an amino group, a carboxyl group, and an R group, which is commonly referred to as the side chain. The structures of amino acids (shown in Figure) differ only in the chemical nature of the side chain R group. The physicochemical properties, such as net charge, solubility, chemical reactivity, and hydrogen bonding potential, of the amino acids are dependent on the chemical nature of the R group.

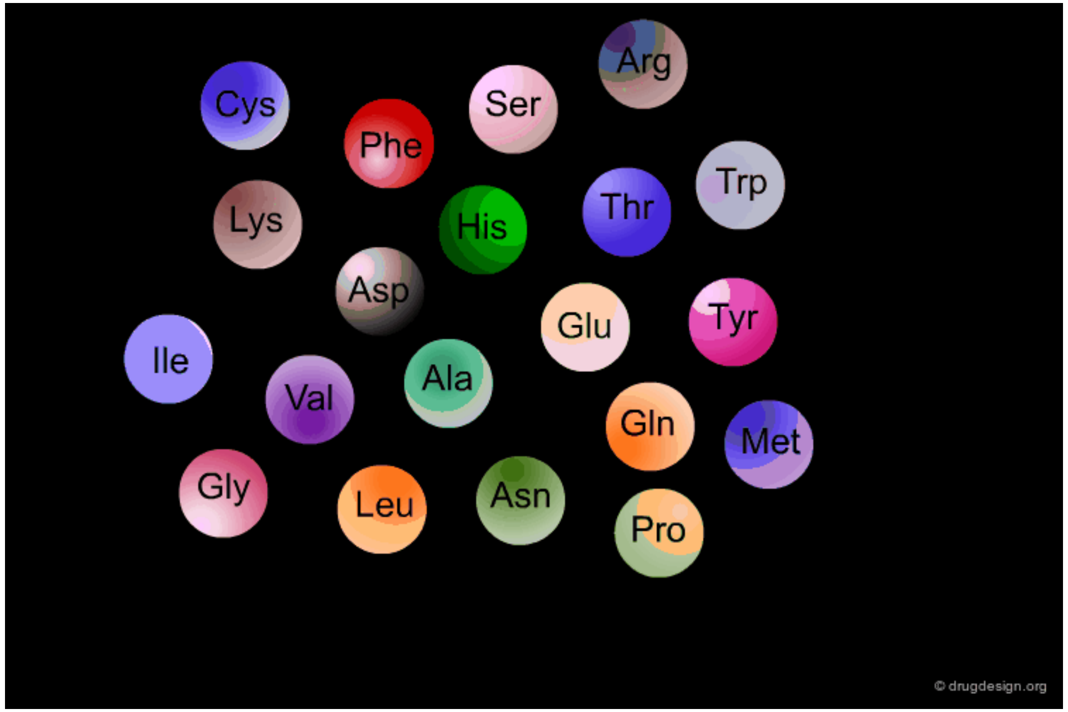


α-Amino acids

FORMATION OF PROTEIN

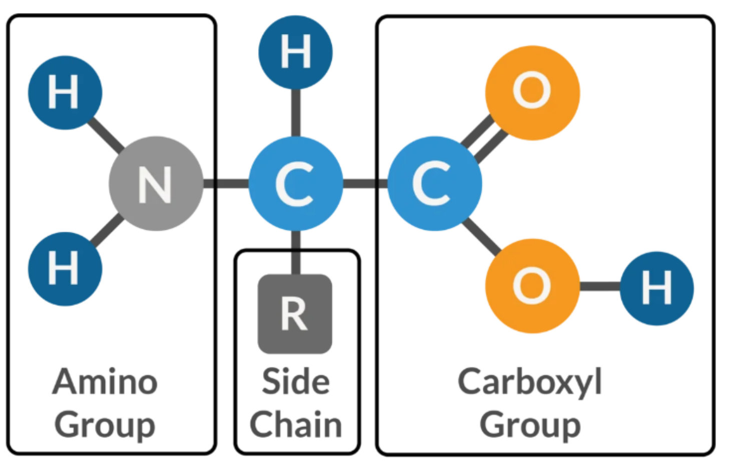
Amino acids can be covalently linked together by the formation of an amide bond between the α-amino group of one amino acid and the α-carboxyl group of another amino acid. The resulting amide bond is known as "peptide bond". The formation of a dipeptide from two amino acids in a condensation reaction is accompanied by the removal of a water molecule. A majority of natural proteins usually contain up to 20 different amino acids linked together via amide bonds.





AMINO ACIDS

- Amino acids are organic or carbon-based compounds that have two functional groups: an amino group and a carboxylate group.
- The amino group is slightly basic, while the carboxylate group is acidic. See the illustration below for an example. The R group or side chain mainly determines the amino acid's chemical and physical properties. It can be of various sizes, shapes, and reactivities.
- So far, more than 500 amino acids have been identified, but only 20 of these are commonly found in the human body. These are the ones that have direct correspondence to our genetic codes. Out of these 20, there are just nine essential amino acids.
- These are all important in many functions of the human body, but they cannot be synthesised by the body; we have to get them from food.
- Amino acids are organic compounds that combine to form proteins. Amino acids and proteins are the building blocks of life.
- When proteins are digested or broken down, amino acids are left. The human body uses amino acids to make proteins to help the body. Break down food.

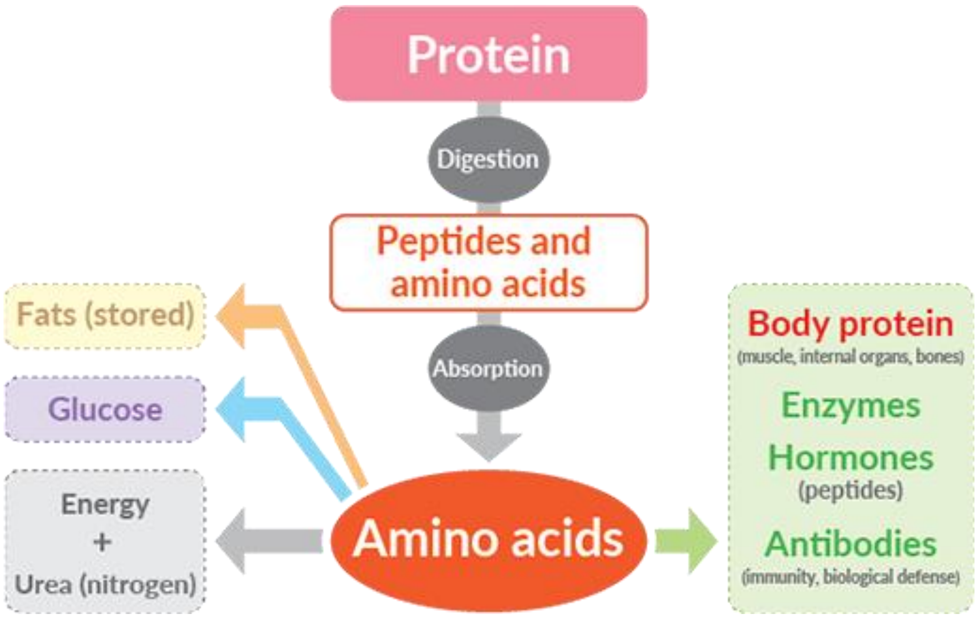


Essential amino acids

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

How is protein used?

The body breaks down consumed protein into amino acids, and absorbs it. It is used to build muscles and organs, to make hormones and antibodies, to be stored as fat, and to be burned as energy.



The body can't store protein so once needs are met, any extra is used for energy or stored as fat

How much protein does the body need?

The daily maximum amount the body can use for protein synthesis is said to be around 2 grams per 1 kilogram of body weight. Consuming more protein will not increase synthesis, but increase the amount consumed as energy, and lead to an increase in body fat. Too much protein can also burden the liver and kidneys.

Recommended daily protein intake

Recommended quantity (g/day)

Age	Male	Female
10～11	50	50
12～14	60	55
15～17	65	55
18～29	60	50

*Junior high and high school students require the most protein, and this amount will increase when they exercise.

From Dietary Reference Intake for Japanese (2015 edition)

Approximate amount of protein required by athletes

For endurance sports	1.2-1.4g per day / 1kg weight
For muscle work / fast-paced sports	1.7-1.8g per day / 1kg weight

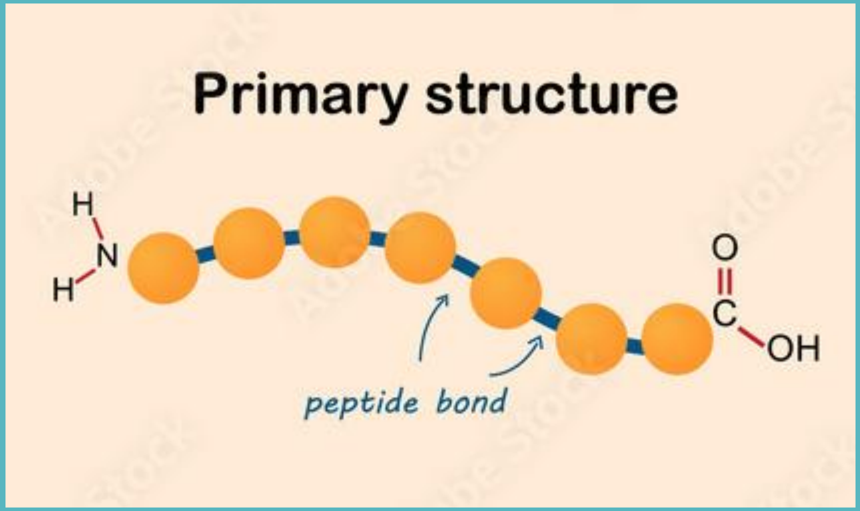
Reference: the Japan Amateur Sports Association (Nutrient intake and meals for athletes)

STRUCTURE OF PROTEIN

Proteins are macromolecules with different levels of structural organization. The primary structure of proteins relates to the peptide bonds between component amino acids and also to the amino acid sequence in the molecule.

Primary Structure

The sequence of amino acid in a poly peptide chain is called primary structure. Each protein has a unique sequence of amino acids linked together by peptide bonds



Secondary Structure

The secondary structure is the shape of the polypeptide chain through twisting and folding. There are two types of secondary structures:

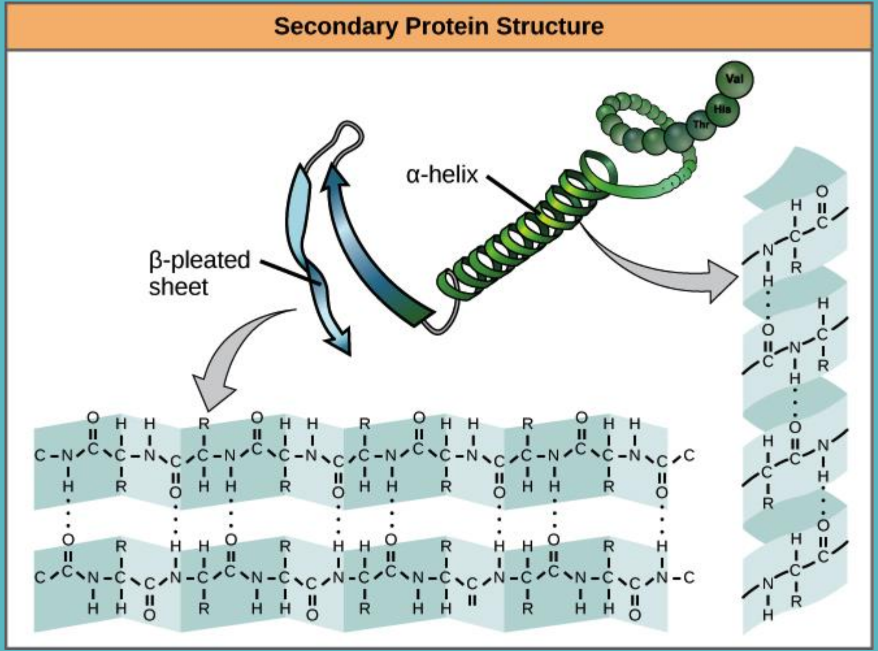
1. α-helix (alfa-helix)
2. β-sheet (beta-sheet)

α-helix It is the most common spiral structure of the protein in which the amino acids are tightly packed and coiled.

The formation of alfa-helix requires the lowest energy.

β-sheet In this, hydrogen bonds are formed between the neighbouring segments of polypeptides.

The peptide is held together giving a sheet-like structure. Can be parallel (same direction) or antiparallel (opposite direction).



STRUCTURE OF PROTEIN

Tertiary Structure

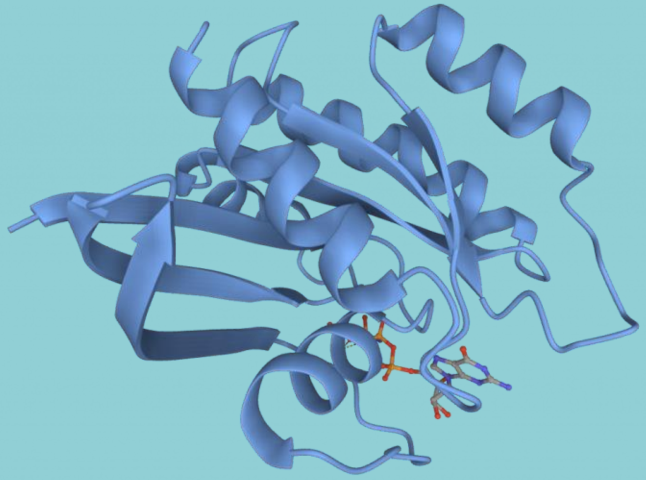
It is the three-dimensional arrangement of protein structure. In this, the hydrophobic side chain is held inside and hydrophilic groups are held outside (surface). The above arrangement gives stability to the molecule.

Quaternary Structure

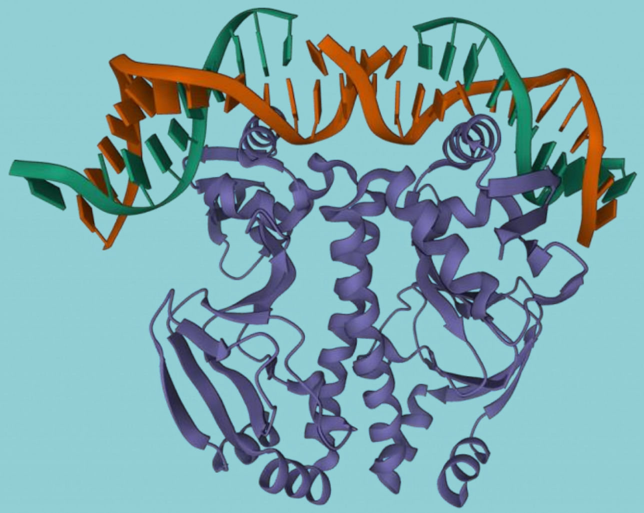
Quaternary means four.

• It is the arrangement of multiple folded protein or coiling protein molecules in a multi-subunit complex.

A variety of bonding interactions including Hydrogen bonding, salt bridges and disulfide bonds holds the various chains into a particular geometry.

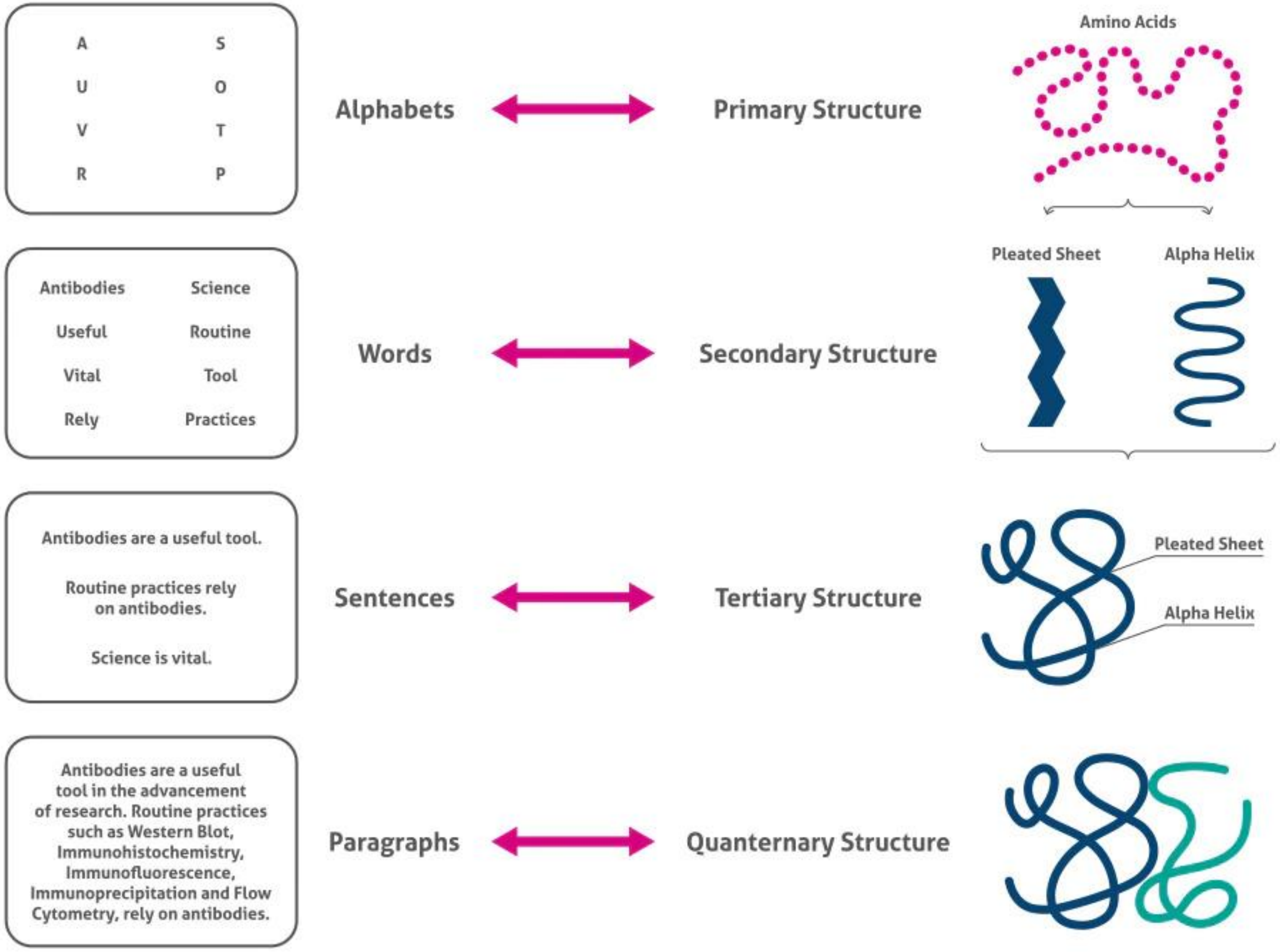


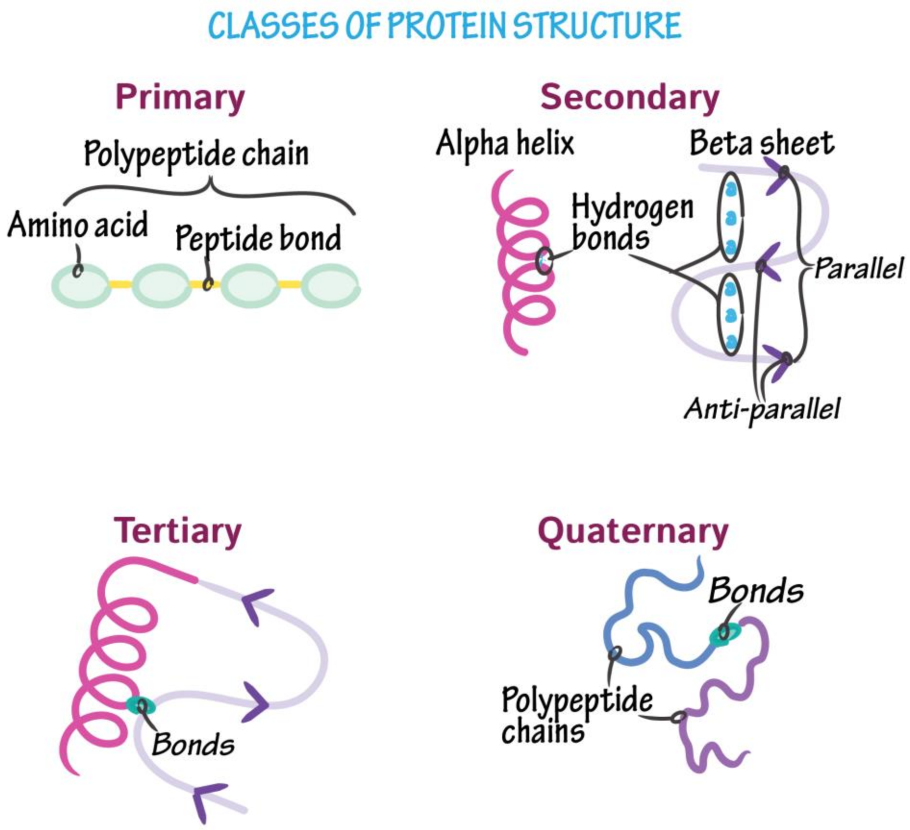
Tertiary Structure



Quaternary Structure

STRUCTURE OF PROTEIN





CLASSIFICATION

Protein can be classified from different aspect. Generally they are classified on the basis of composition, shape of molecules, function etc.

On the basis of shape of molecules

1. Fibrous proteins

Fibrous proteins are long and thread or ribbon like and tend to lie side by side to form fibers. They are generally insoluble in water as the intermolecular forces in these proteins are rather strong. They serve as the chief structural material of animal tissues. Examples are keratin, myosin, collagen etc.

2. Globular proteins

Globular proteins are spheroidal in shape. They are generally soluble in water or aqueous solution of acids, bases or salts as intermolecular forces in these proteins are relatively weaker. These proteins are generally involved in physiological processes of the animal body. Examples are enzymes, some hormones, haemoglobin, etc.

CLASSIFICATION

On the basis of composition

On the basis of composition proteins are classified into three groups *viz.* simple proteins,

conjugated proteins

and derived proteins.

1. Simple proteins

These are the proteins which consist of only amino acids – They do not contain other

class of compounds.

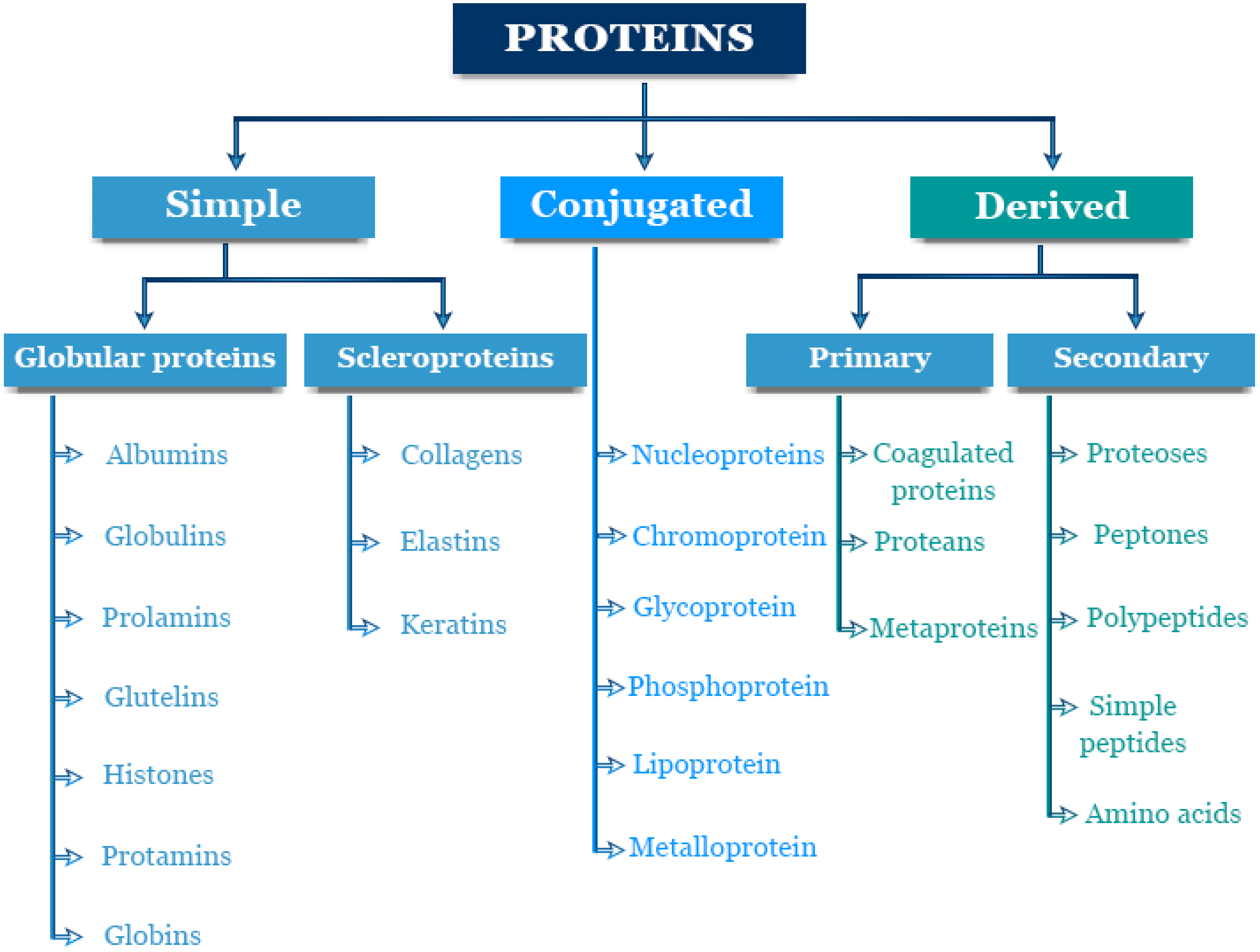
2. Conjugated proteins

These are the proteins which consist of amino acids as well as other class of compounds

3. **Derived proteins**

They represent various stages of hydrolytic cleavage of simple or conjugated proteins. e.g.

proteoses, peptones, peptides, etc.


PROTEINS
Simple
Conjugated
Derived
Globular proteins
Scleroproteins
Primary
Secondary
Albumins
Globulins
Prolamins
Glutelins
Histones
Protamins
Globins
Collagens
Elastins
Keratins
Nucleoproteins
Chromoprotein
Glycoprotein
Phosphoprotein
Lipoprotein
Metalloprotein
Coagulated proteins
Proteans
Metaproteins
Proteoses
Peptones
Polypeptides
Simple peptides
Amino acids

Classification of protein based on function

Enzymic Proteins- They are the most varied & highly specialized proteins with catalytic activity. Enzymes catalyze a variety of reactions

Structural Proteins- These proteins aid in strengthening or protecting biological structures. Example: Keratin

Transport protein: these protein helps in transport of ions and molecoules in the body. Example: hemoglobin

Nutrient and storage protein: These protein provide nutrition to growing embryos and store ions

Defense Proteins- These proteins defend against other organisms. Example: Antibodies

Regulatory Proteins- They regulate cellular or metabolic activities. Example: Hormones:- Insulin

Toxic Proteins - These proteins hydrolyze or degrade enzymes. Exa mple: snake venom

Enzymes:

Transport and Storage:

Signaling proteins:

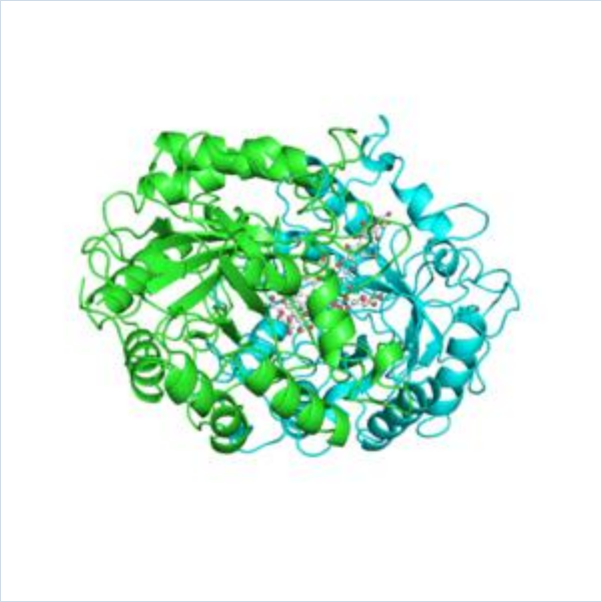
Receptor proteins:

Structural proteins:

Defense proteins:

Gene regulatory proteins:

Enzymes: Catalyze all vital chemical reaction of the cell. Each enzyme catalyzes one particular reaction of covalent bond breakage or formation.



PHYSICAL & CHEMICAL PROPERTIES

Color and Taste: Proteins are generally colorless and tasteless in their natural state. However, some hydrolyzed proteins, like those found in protein powders, can have a slightly bitter taste.

Shape and Size: Proteins come in a wide range of shapes and sizes. They can be globular (spherical), fibrous (elongated), or membrane-bound.

Molecular Weight: Proteins have large molecular weights, ranging from a few thousand to millions of Daltons (Da). A Dalton is a unit of mass equal to the mass of one proton. The size and complexity of a protein determine its molecular weight.

Solubility: Proteins have varying solubility in water, which is influenced by pH, ionic strength, temperature, and the presence of other solutes. Solubility is a critical factor in protein purification, food processing, and formulation

Optical Activity: Most proteins are optically active, meaning they can rotate the plane of polarized light.

Adsorption and Surface Activity: Proteins can adsorb at interfaces (air-water or oil-water), reducing surface tension and stabilizing emulsions and foams. This property is exploited in food products like ice cream and salad dressings

Colloidal Nature: Proteins are colloids, which means they exist as suspended particles in a liquid. Colloids are larger than individual molecules but smaller than microscopic particles. This colloidal nature gives proteins some unique properties, such as the ability to form gels and foams.

Amino Acid Composition and Sequence: Proteins are polymers of amino acids linked by peptide bonds. The sequence and composition of these amino acids determine the protein's structure and function

Peptide Bond Formation: The peptide bond, formed through a dehydration reaction between the amino group of one amino acid and the carboxyl group of another, is fundamental to the protein structure.

Ionizable Groups : Proteins contain ionizable groups, particularly in the side chains of amino acids, which can accept or donate protons depending on the pH of the environment.

Isoelectric Point (pI): The isoelectric point is the pH at which a protein carries no net electric charge. At this point, a protein is least soluble in water and may precipitate out of solution.

Enzymatic Activity: Many proteins function as enzymes, catalyzing biochemical reactions with high specificity.

Hydrophobic and Hydrophilic Interactions: The amino acid side chains of proteins can be hydrophobic or hydrophilic, influencing how proteins fold and interact with their environment.

Binding and Recognition: Proteins have the ability to bind specifically to other molecules, including substrates, inhibitors, DNA, and signaling molecules

Oxidation-Reduction (Redox) Reactions: Certain proteins, such as those containing cysteine residues, can participate in redox reactions, which are important for cellular processes like metabolism and signal transduction

FUNCTIONAL PROPERTIES

Water Absorption and Retention

Proteins that are made up of mostly hydrophilic amino acids will tend to absorb and retain more water. For example, bakery products containing high-protein ingredients such as soy and other pulses will be more moist and heavier due to greater water retention. This is an important functional property for bakers because more water retention means greater product yield and higher profits.

Solubility

Proteins that are made up of mostly hydrophilic amino acids will be more soluble. This is particularly important when you are making beverages. For example, soybean protein and pea proteins are found to be highly soluble in water. This makes them ideal for use in beverages and soups.

Color

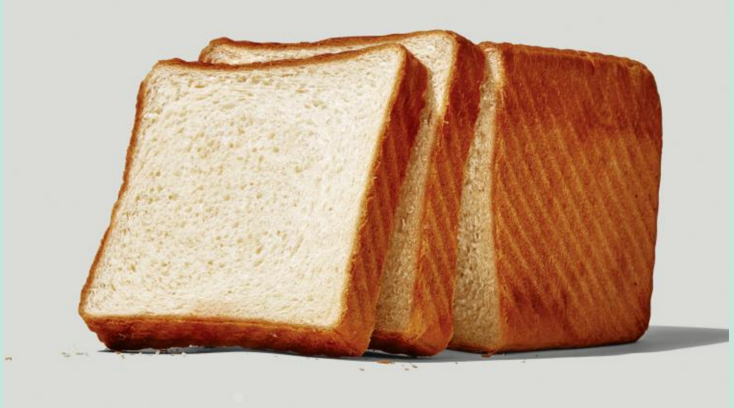
Proteins react with reducing sugars to form flavors and color compounds in a process called Maillard reaction. The dark colors that you see on the surface of bread, and the grill marks on steak is due to Maillard reaction. For this reason, bread containing milk or soy flour will have a darker color.

Gelation

Some proteins have the ability to form a gel. A prime example of this type of protein is gelatin. Gelatin is made from collagen which is a rope-like protein polymer from the bones and tissue (skin, tendons, and ligaments) of animals (usually pigs and cows). When gelatin is heated, it dissolves and is dispersed in solution. But, as it cools, the rope-like strands bond together and trap water between them in the process. This results in the formation of a gel.

FUNCTIONAL PROPERTIES

Emulsification



Emulsifiers are substances that are able to prevent the separation of oil and water in food. They are able to do this because part of their structure allows them to interact with water and another part with oil. Therefore they can grab onto both water and oil to form a bridge between them. Many proteins have this property because they contain both hydrophilic and hydrophobic amino acids. For example, milk in ice cream contributes to an emulsification effect by helping to prevent the separation of fat and water.

Viscosity and Texture

Proteins can make foods not only more viscous (thicker), but also elastic. this property is called visco-elasticity. The best example of this is seen in gluten proteins. As water is added to wheat and the mixture is molded, dough is formed. We are able to stretch this dough like an elastic which recoils when it is released. This is an important characteristic that gives bread its texture. As the bread dough rises during fermentation, the strong visco-elastic property of the gluten proteins prevents the bread from collapsing. Higher protein content in bread and bakery products will produce a firmer texture. Cakes are generally made using wheat with a low protein content (7-9%) to give a soft texture, whereas bread flours have high protein (14-16%) for firmness.

Foam Formation

A food foam is formed when air bubbles are dispersed in water. Examples of food foams are whipped cream, ice cream, marshmallows, and beaten egg whites. Proteins stabilize foams by forming a protective coat around the air bubbles in the foam, which prevents the bubbles from collapsing. They are able to form this coat because of their hydrophilic/hydrophobic nature. The hydrophilic part of the protein will bind to water and the hydrophobic part will bind with the air, creating a stable bridge.

FUNCTIONAL PROPERTIES

Flavor-Binding

Proteins are generally odorless compounds on their own, but they can bind flavor compounds and therefore impart new flavor to foods. The ability of proteins to bind favors can have a negative impact on the flavor of end-products if off-flavors are trapped. On the positive side, manufacturers can use this property to trap and retain certain flavor ingredients in food.

Curdling

Proteins can coagulate with the addition of acids. The point at which proteins precipitate or fall out of solution, is called the isoelectric point. It is a point where the charge on the protein changes to neutral. At a neutral charge, it is no longer capable of dissolving in water. For example, the production of yogurt and cheese.

Enzymatic Browning

One type of browning is called enzymatic browning. That is when browning is caused by enzymes. Enzymes are proteins that speed up the rate of chemical reactions in living systems. One type of reaction that they speed up is the browning reaction. This reaction is caused by the action of the enzyme polyphenol oxidase on phenol compounds in foods, in the presence of oxygen. The result is a brown compound called melanin. This reaction is evidenced in apples and potatoes after they are cut and left exposed to oxygen.

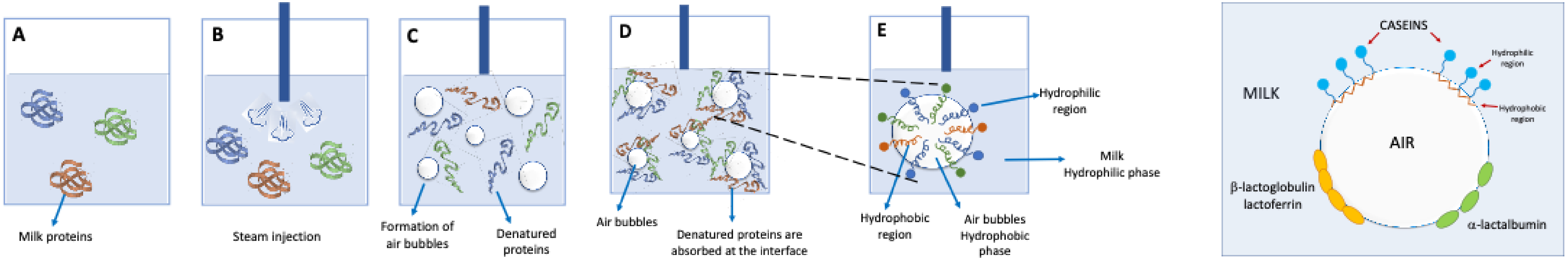
Why is skimmed milk best for cappuccinos?

Proteins make the foam stable by forming a film at the air-liquid interfaces around the air bubbles stabilising them.

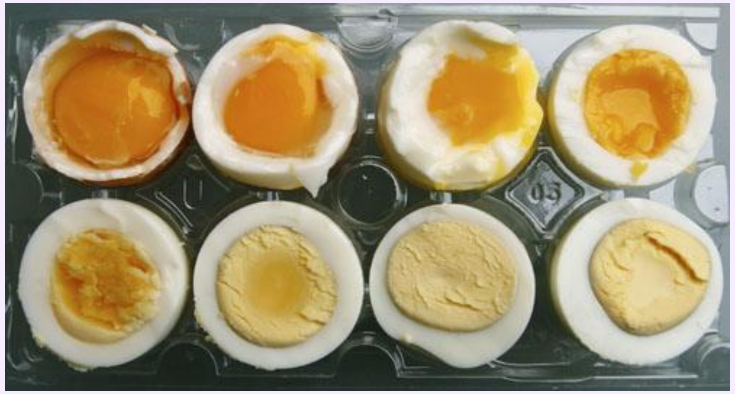
Mixing at high speed or injection of steam causes a suspension of air bubbles in the aqueous phase to form. Foams are inherently unstable so break down over time by :

1. air bubbles may float to the surface (creaming) whilst the liquid drains away, 2. bubbles may join together (coalescence),

Fat particles simply increase the rate of foam disintegration by increasing the rate of coalescence.



CHANGES OF PROTEIN DURING PROCESSING



1. **Denaturation:**
- Heat exposure during cooking causes proteins to denature. Weak chemical forces that hold tertiary and secondary protein structures together break down. As a result, proteins lose their original shape and functionality. For instance, when you cook an egg, the egg white proteins denature, leading to the solidification of the egg white.

2. **Aggregation and Gelation**:
- Aggregation occurs when proteins clump together due to changes in pH, temperature, or other factors. This can affect the texture of foods. For example, cheese curds form due to protein aggregation during cheese-making.
- Gelation involves proteins forming a network-like structure, resulting in gels. Gelatin desserts (like Jello-O) are classic examples. Gelation impacts the texture and mouthfeel of foods.

3. **Enzymatic Reactions:**
Enzymes can modify proteins during food processing. For instance:
- Proteases break down proteins into smaller peptides during fermentation (e.g., soy sauce production).
- Transglutaminase cross-links proteins, enhancing their functionality (used in meat products).
- Amylases modify starch-protein interactions, affecting dough properties in baking.

CHANGES OF PROTEIN DURING PROCESSING

4. **Hydrolysis:**
   - Hydrolytic enzymes break peptide bonds, leading to protein breakdown. This process occurs during aging (e.g., tenderizing meat) or in the production of hydrolyzed protein ingredients (used in soups, sauces, and snacks).

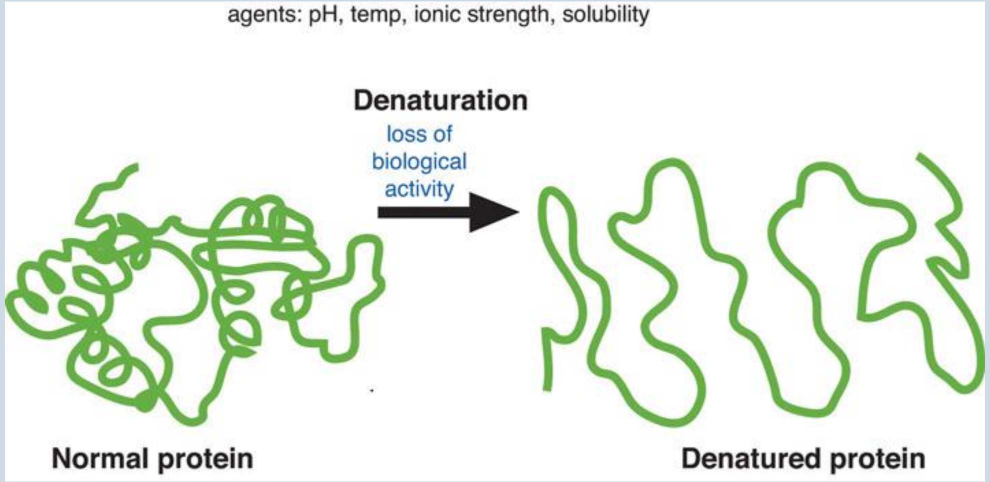
5. **Emulsification and Foaming:**
   - Proteins can act as emulsifiers, helping oil and water mix (e.g., in salad dressings).
   - Whipped egg whites create foams due to protein denaturation and air incorporation (think cream/pastry).

6. **Dehydration and Rehydration**
   - During food drying (dehydration), proteins may undergo structural changes. Upon rehydration (adding water back), proteins regain some functionality.

these protein modifications are essential for creating diverse and delicious foods!

DENATURATION

Denaturation is a process that changes the molecular structure without breaking any of the peptide bonds of a protein. The process is peculiar to proteins and affects different proteins to different degrees, depending on the structure of a protein. Denaturation can be brought about by a variety of agents, of which the most important are heat, pH, salts, and surface effects. Considering the complexity of many food systems, it is not surprising that denaturation is a complex process that cannot easily be described in simple terms. Denaturation usually involves loss of biological activity and significant changes in some physical or functional properties such as solubility. The destruction of enzyme activity by heat is an important operation in food processing. In most cases, denaturation is nonreversible; however, there are some exceptions.



DETERMINATION OF PROTEIN

Basic principles of determination of protein content

Numerous methods have been developed to measure protein content.

The basic principles of these methods include:

a) Determinations of nitrogen,
b) Peptide bonds,
c) Aromatic amino acids,
d) Dye-binding capacity,
e) Ultraviolet absorptivity of proteins,
f) Light scattering properties

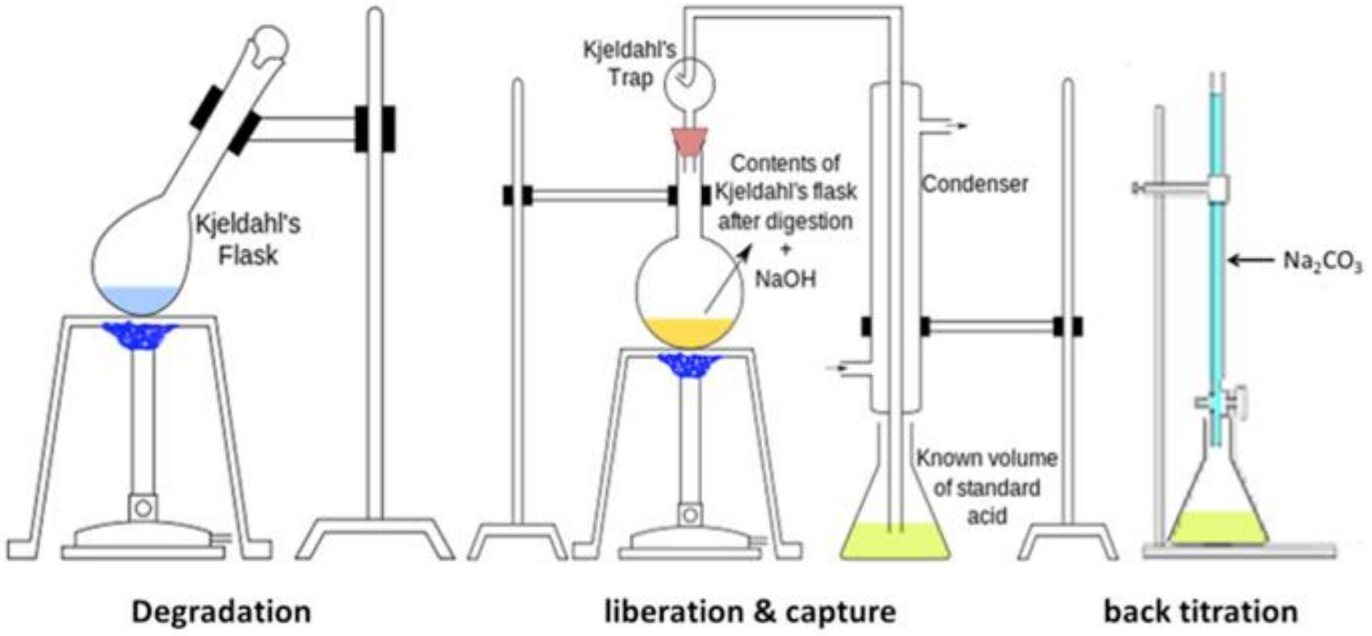
Methods of protein analysis

There are several methods of protein analysis

a) Kjeldhal method
b) Dumas method c) Infrared spectroscopy
d) Biuret method
e) Lowry method
f) Bradford method
g) Bicinchoninic acid (BCA)
h) Ultraviolet absorptivity of proteins,

Kjeldahl Method

The protein content is determined from the organic Nitrogen content by Kjeldahl method. The various nitrogenous compounds are converted into ammonium sulphate by boiling with concentrated sulphuric acid. The ammonium sulphate formed is decomposed with an alkali (NaOH) and the ammonia liberated is absorbed in excess of standard solution of acid and then back titrated with standard alkali.



Advantages:

1) Applicable to all types of foods
2) Inexpensive (if not using an automated system)
3) Accurate; an official method for crude protein content
4) Has been modified (micro Kjeldahl method) to measure microgram quantities of proteins

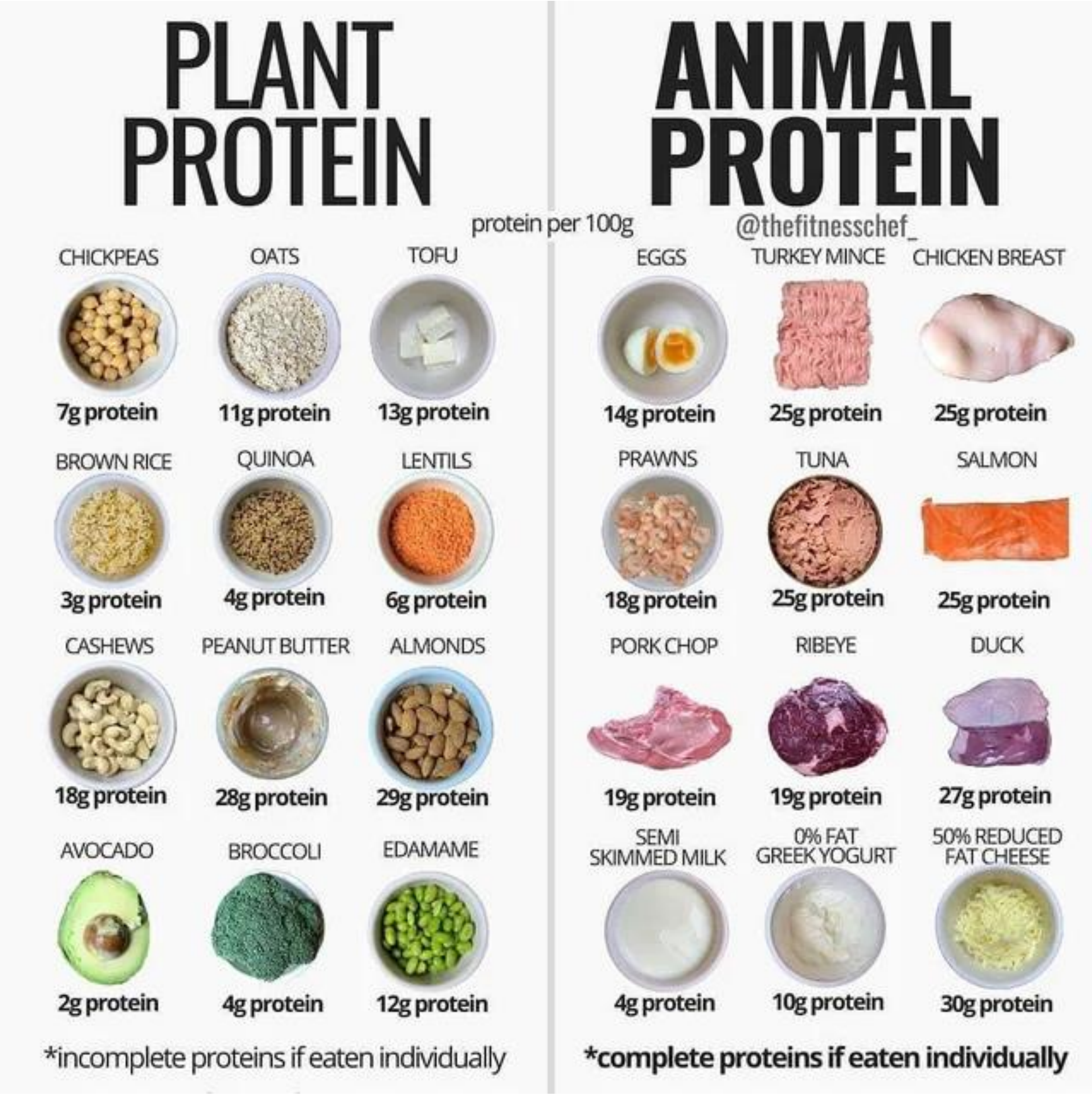
Disadvantages:

1) Measures total organic nitrogen, not just protein nitrogen
2) Time consuming (at least 2 h to complete)
3) Poorer precision
4) Corrosive reagent

FOOD PROTEIN & THEIR SOURCES

Animal Source	
Protein Name	**Source**
Albumin	Egg whites, milk, and blood serum
Keratin	Hair, nails, and the outer layer of skin
Gelatin	Derived from collagen in animal connective tissues; used in desserts and gummy candies
Myosin	Muscle protein found in meat, especially in skeletal muscles
Actin	Muscle protein that works alongside myosin in muscle contraction
Fibrinogen	Involved in blood clotting; found in blood plasma
Collagen	Abundant in skin, tendons, and bones
Hemoglobin	Carries oxygen in red blood cells
Casein	Main protein in milk
Fibroin	Makes up silk fibers produced by silkworms
Elastin	Provides elasticity to skin, blood vessels, and other tissues
Lactoferrin	Found in milk; has antimicrobial properties
Tubulin	Component of microtubules in cells
Histones	Proteins that help package DNA in the cell nucleus
Caseinogens	Precursors to casein in milk
Ovalbumin	Major protein in egg whites

Plant source	
Protein Name	**Source**
Leghemoglobin	Soybeans (used in plant-based meat substitutes)
Lectins	Legumes (e.g., beans, lentils) and grains
Phytohemagglutinin	Raw kidney beans
Globulins	Legumes, nuts, and seeds
Glutelin	Rice and other grains
Zein	Corn (maize)
Vicilin	Peas and other legumes
Phaseolin	Common beans (e.g., kidney beans)
Avenalin	Oats
Gliadin	Component of gluten in wheat
Gluten	Present in wheat, barley, and rye
prolamin, glutelin, globulin, and albumin	Rice


PLANT PROTEIN
ANIMAL PROTEIN
protein per 100g
@thefitnesschef_
CHICKPEAS
7g protein
OATS
11g protein
TOFU
13g protein
BROWN RICE
3g protein
QUINOA
4g protein
LENTILS
6g protein
CASHEWS
18g protein
PEANUT BUTTER
28g protein
ALMONDS
29g protein
AVOCADO
2g protein
BROCCOLI
4g protein
EDAMAME
12g protein
*incomplete proteins if eaten individually
EGGS
14g protein
TURKEY MINCE
25g protein
CHICKEN BREAST
25g protein
PRAWNS
18g protein
TUNA
25g protein
SALMON
25g protein
PORK CHOP
19g protein
RIBEYE
19g protein
DUCK
27g protein
SEMI SKIMMED MILK
4g protein
0% FAT GREEK YOGURT
10g protein
50% REDUCED FAT CHEESE
30g protein
*complete proteins if eaten individually

Question?

THE 20 COMMON AMINO ACIDS