2.4. PROTEINS

AMINO ACIDS AND POLYPEPTIDES

Amino acids are linked together to form polypeptides.

Polypeptides: They are chains that are formed when multiple amino acids are linked together by condensation reaction.

→ It happens on ribosomes by translation.

→ They are the main component of proteins.

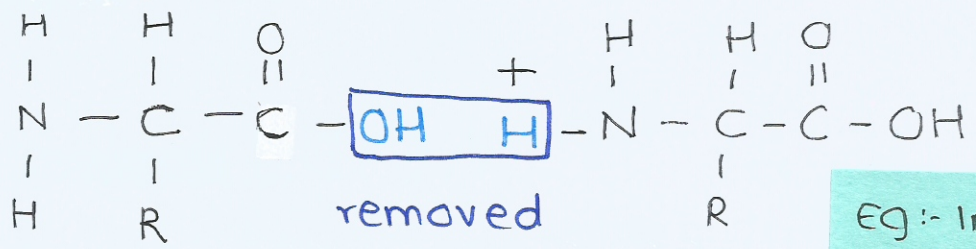
Amino acids:

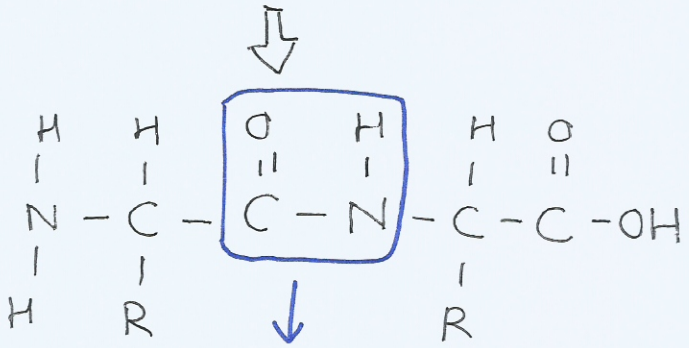
They have 2 functional groups COOH group and NH_2 group.

The condensation reaction:-

$(-NH_2)$ and $(-COOH)$ are bonded together.

H_2O is eliminated.





Eg:- Insulin contains 2 polypeptides.

21 amino acids

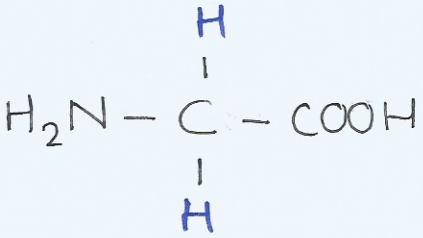
and

30 amino acids.

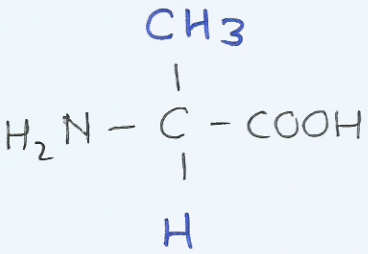
Largest polypeptide is TITIN - 34,350 amino acids

Polypeptides can contain any number of amino acids.

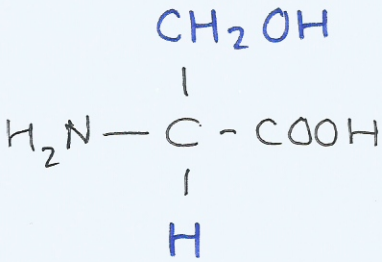
Chains of fewer than 20 amino acids are known as OLIGOPEPTIDES.



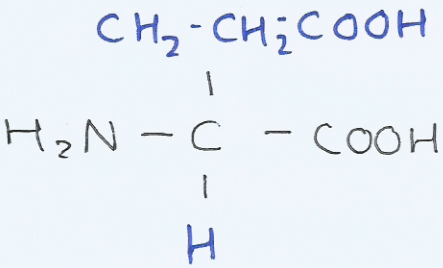
GLYCINE



ALANINE



SERINE



GLUTANIC ACID

The amine groups and the carboxyl groups are used to form a peptide link. Therefore the R group of the amino acid gives a polypeptide its character. This allows living organisms to make a wide range of proteins.

DIVERSITY OF AMINO ACIDS

- There are 20 different amino acids in polypeptides synthesized on ribosomes.
- The R groups of the amino acids are responsible for its character (polypeptide character)

Example of modification of amino acids

→ In collagen, a structural protein provides strength in tendons, ligaments, skin and blood vessel walls.

The proline gets converted into hydroxyproline, which makes the collagen more stable.

POLYPEPTIDE DIVERSITY

- Amino acids can be linked together in any sequence giving a huge range of polypeptides.
- The ribosome can make a peptide bond between any pair of amino acids. ∴ The sequences of amino acids can be of any number.

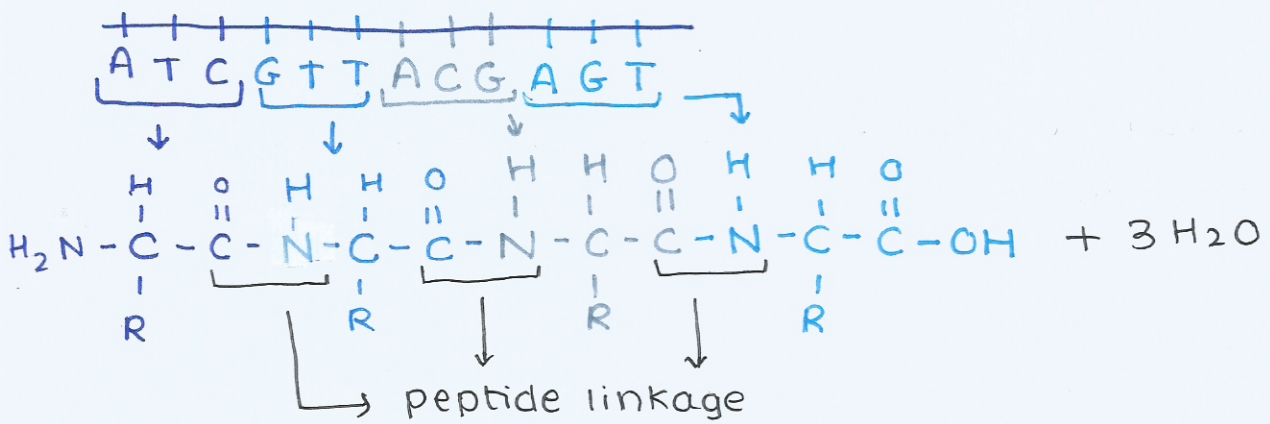
For a polypeptide of n number of aminoacids, there are 20^n possible sequences.

Example: In a peptide with 3 amino acids, the number of possible sequences will be 20^3.

GENES AND POLYPEPTIDE

- The amino acid sequence of polypeptides is coded for by genes.
- It is stored in a coded form in the base sequence of a gene.

Three bases of the gene are required to code one amino acid in a polypeptide.



Genes are always longer, with extra base sequences at both ends and sometimes also at certain points in the middle.

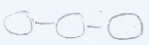
PROTEINS AND POLYPEPTIDES

A protein can contain one or more than one polypeptides linked together.

Integrin

- membrane protein
- 2 polypeptides

Collagen



- 3 polypeptides
- rope like structure - gives tensile strength.

Haemoglobin

- 4 polypeptides
- interact to transport oxygen more effectively to tissues.

No. of polypeptide

1 - Lysozyme

- enzyme in secretions like nasal mucus and tears
- kills bacteria by digesting peptidoglycan in their cell walls.

2 - Integrin

- membrane protein
- used to make connections between structures inside & outside cells.

3 - Collagen

- structural protein
- present in tendons, skin, etc.
- high tensile strength
- limited stretching

4 - Hemoglobin

- transport protein in RBCs
- binds with oxygen in the lungs

PROTEIN CONFORMATION AND STRUCTURE

The amino acid sequence determines the 3-D conformation of a protein.

PRIMARY STRUCTURE

→ The order of the amino acid sequence is called the primary structure and it determines how the chain will fold.

→ The different amino acid sequences will fold into different configurations due to the chemical properties of the variable side group (R).

example: insulin

- Primary structure

SECONDARY STRUCTURE

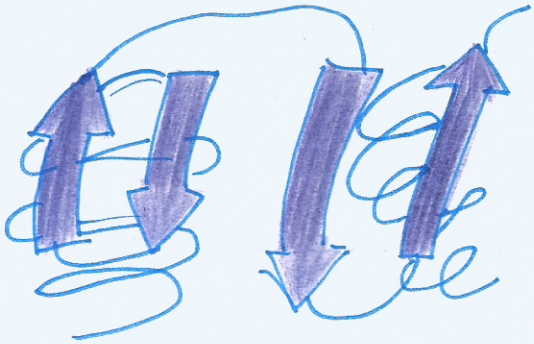
When the amino acids fold into (a coil / spiral arrangement - Alpha helices or a pleated sheet formation - Beta pleated sheets) 2 stable configurations, they have secondary structure

Alpha helix

Beta pleated sheet

TERTIARY STRUCTURE

It is determined by the interactions between the variable side chains.



- tertiary structure

QUATERNARY STRUCTURE

→ These proteins have a fourth level of structural organization

→ Found in proteins that have more than one poly peptide chain linked together.

- quaternary structure

eg. haemoglobin

→ 4 poly peptide chains 2α & 2β

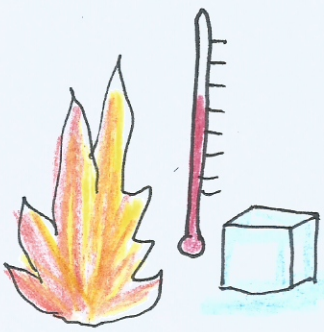
→ composed of iron containing haeme groups.

DENATURATION

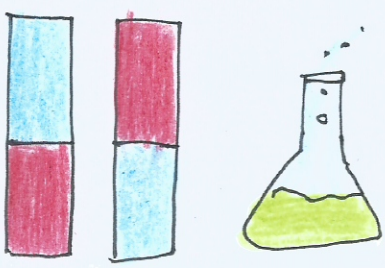
- It is a structural change in a protein that results in the loss of its biological properties.
- The way of folding of proteins determines its functions that is why any change in the structure can lead to change in its activity.

Factors affecting denaturing of proteins

TEMPERATURE



pH



Temperature:

- High levels of heat energy can break the hydrogen bonds that hold the protein.
- Because of this the protein unfolds and loses its functions.
- Human proteins function optimally at 37°C (body temp.)

pH:

- Amino acids contain 2 functional groups (COO^-) and (NH_3^+)
- Changing the pH will result in a change in the charge which will effect the protein solubility.
- All proteins have an optimal pH which is dependent on the environment where it functions.

Stomach proteins - acidic environment
blood proteins - neutral environment

PROTEIN FUNCTIONS

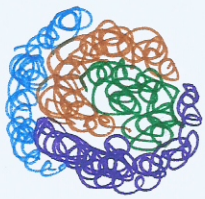
- Catalysis:- there are many enzymes to catalyse specific chemical reactions inside and outside the cell.
- muscle contraction:- actin and myosin cause the muscle contractions in locomotion & transport around the body.
- Cytoskeletons:- tubulin gives animal cells their shape and pull on chromosomes during mitosis.
- Tensile strengthening:- fibrous proteins provide tensile strength in skin, tendons, ligaments etc. eg. collagen.
- Blood clotting:- plasma proteins cause the blood to turn from liquid to a gel in wounds.
- Transport of nutrients & gases:- proteins in blood help transport oxygen, iron, carbon dioxide eg:- haemoglobin

- Cell adhesion:- membrane proteins cause animal cells to stick to one another in tissues.
- membrane transport:- membrane proteins are used for facilitated diffusion & active transport & for electron transport during photosynthesis.
- Hormones:- eg. insulin, FSH and LH are proteins
- Receptors:- binding sites in membranes and cytoplasm for hormones, neurotransmitters, taste, smell & receptor for light in the eye & plants.
- Packing of DNA:- histones help chromosomes to condense during mitosis.
- Immunity:- most diverse group of proteins; huge no. of antibodies are made in the human body.

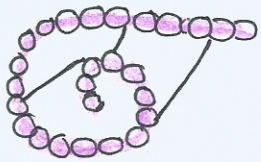
BIOTECHNOLOGIAL USES for proteins including enzymes are:

- removing stains
- monoclonal antibodies for pregnancy tests
- insulin for treating diabetes.

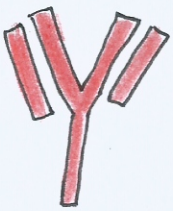
EXAMPLES OF PROTEINS



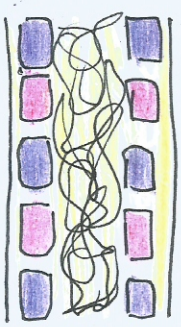
RUBISCO



INSULIN

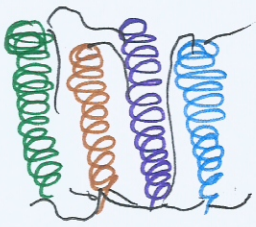


IMMUNOGLOBIN



SPIDER SILK

COLLAGEN



RHODOPSIN

RUBISCO

- most important enzyme
- catalyses the reaction that fixes CO_2 from the atmosphere
- provides the source of carbon
- present at high concentrations in leaves
- one of the most abundant proteins on earth.

INSULIN

- hormone which is produced as a signal to cells
- the cells absorb glucose and reduce the glucose concentration in the cell.
- it is secreted by β cells in the pancreas and is transported by the blood.

IMMUNOGLOBIN

- also known as antibodies.
- they can cause a response
- they act as a marker for phagocytes to engulf the pathogen.
- binding sites are hypervariable.
- body can produce immunoglobins with different types of binding sites.
- basis of specific immunity.

RHODOPSIN

- membrane protein of rod cells in the retina.
- absorb light
- consists of a light sensitive rentinal molecule.
- it absorbs a photon of light and it changes shape.
- can detect low intensities of light.

COLLAGEN

- rope like structure
- increases tensile strength in skin, tendons etc.
- gives vessels and ligaments immense strength
- forms a part of structure of teeth and bones
- prevents cracks & fractures.

SPIDER SILK

- different silks have different functions
- dragline silk is stronger than silk
- used to make spokes and the lifelines on which spiders suspend themselves.
- extensible and resistant to breaking.

PROTEOMES

- A proteome is all of the proteins produced by a cell, tissue or an organism at a certain time.

The proteome of every individual will be unique as protein expression patterns are determined by their genes.

- Even the proteome of identical twins can become different with age.
- The proteome is always significantly larger than the number of genes in an individual.

(The proteins may get modified following translation to give further variations)