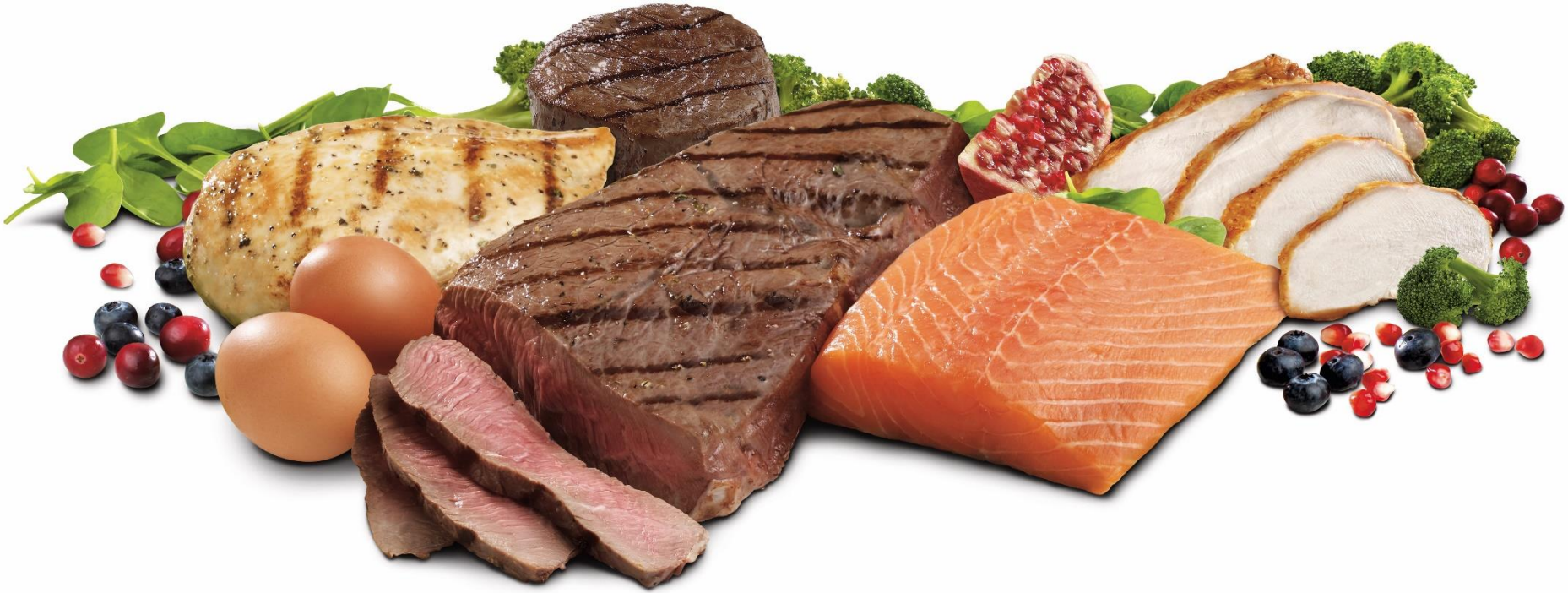
Proteins



Learning Outcomes

1(e)iii. Describe the **structure** and **properties** of **amino acids** (in proteins)

1(f)iii. Describe the **formation** and **breakage of a peptide bond**.

1(k) Explain **primary** structure, **secondary** structure, **tertiary** structure and **quaternary structure of proteins**, and describe the **types of bonds** that hold the molecule in shape (hydrogen, ionic, disulfide bonds and hydrophobic interactions).

Learning Outcomes

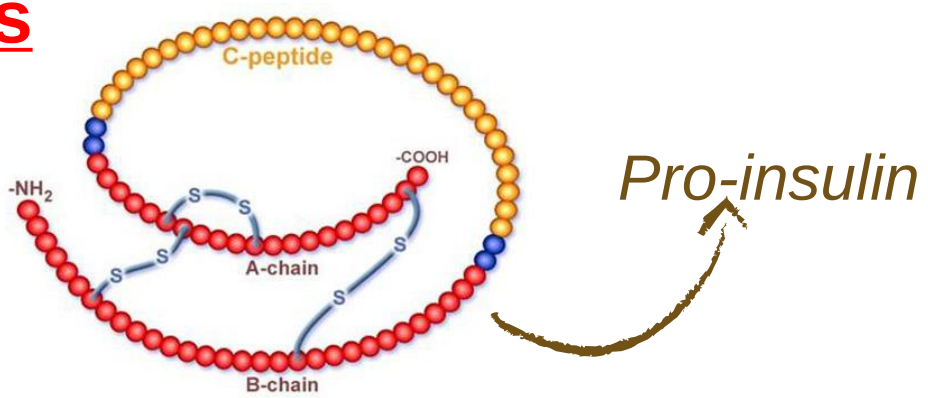
1(l) Explain the **effects of temperature** and **pH** on protein structure.

1(m) Describe the molecular **structure** of the **haemoglobin** protein and explain how its **structure** relates to its **function** in transport

1. **Amino acids**
2. **Formation of peptide bonds**
3. **Levels of organisation in proteins**
   - A. Primary Structure
   - B. Secondary Structure
   - C. Tertiary Structure
   - D. Quaternary Structure
4. **Case Studies: Haemoglobin**

Introduction

- Made up of the elements **carbon**, **hydrogen** & **oxygen**, **nitrogen** and sometimes **sulphur**
- Building blocks of proteins are monomers called **amino acids**



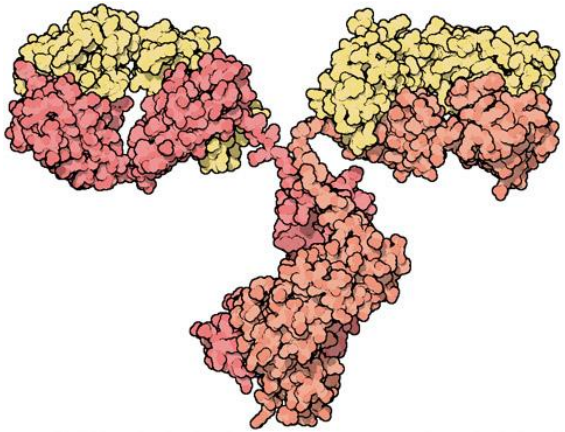
Functions of Proteins

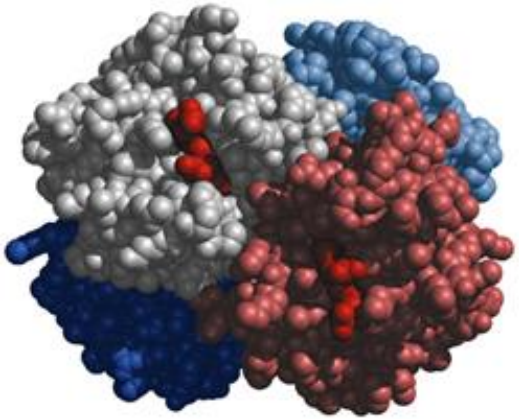
Table 5.1 An Overview of Protein Functions

Type of Protein	Function	Examples
Structural proteins Collagen	Support	Insects and spiders use silk fibers to make their cocoons and webs, respectively. Collagen and elastin provide a fibrous framework in animal connective tissues. Keratin is the protein of hair, horns, feathers, and other skin appendages.
Storage proteins Ovalbumin	Storage of amino acids	Ovalbumin 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 Haemoglobin	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 Insulin / glucagon	Coordination of an organism's activities	Insulin, a hormone secreted by the pancreas, helps regulate the concentration of sugar in the blood of vertebrates.
Receptor proteins GPCR / RTK	Response of cell to chemical stimuli	Receptors built into the membrane of a nerve cell detect chemical signals released by other nerve cells.
Contractile proteins Actin	Movement	Actin and myosin are responsible for the movement of muscles. Other proteins are responsible for the undulations of the organelles called cilia and flagella.
Defensive proteins Antibodies	Protection against disease	Antibodies combat bacteria and viruses.
Enzymatic proteins DNA polymerases, lipase	Selective acceleration of chemical reactions	Digestive enzymes catalyze the hydrolysis of the polymers in food.

Collagen –
cartilage & tendons

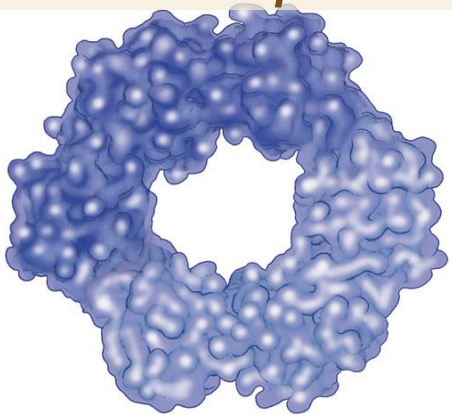
Antibody





Haemoglobin

DNA polymerase III
– DNA replication

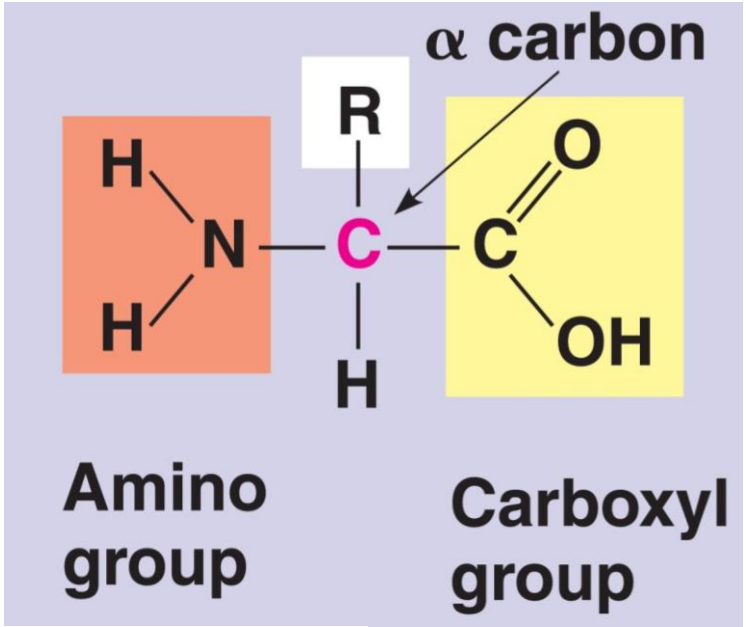


1. **Amino acids**
2. **Formation of peptide bonds**
3. **Levels of organisations in proteins**
   - A. Primary Structure
   - B. Secondary Structure
   - C. Tertiary Structure
   - D. Quaternary Structure
4. **Case Studies: Haemoglobin**

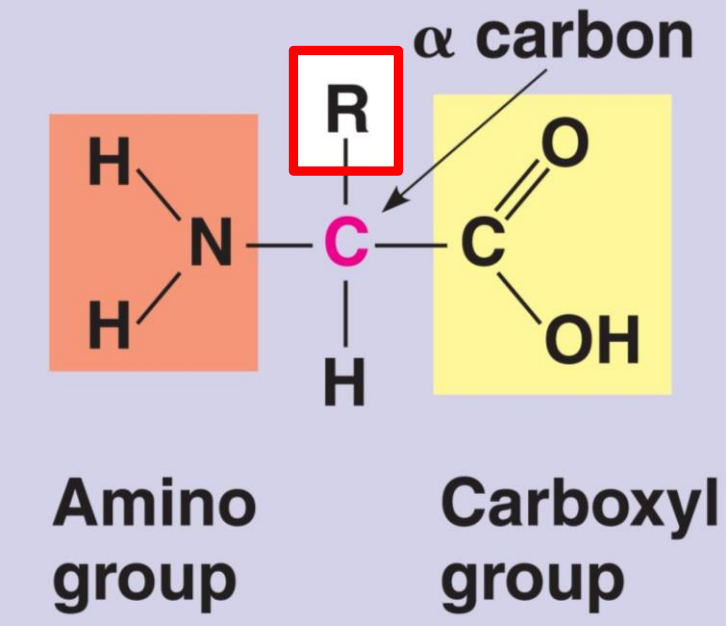
Learning Outcome

1(e)iii. ***Describe*** *the* ***structure*** *&* ***properties*** *of amino acids*

Structure of an amino acid

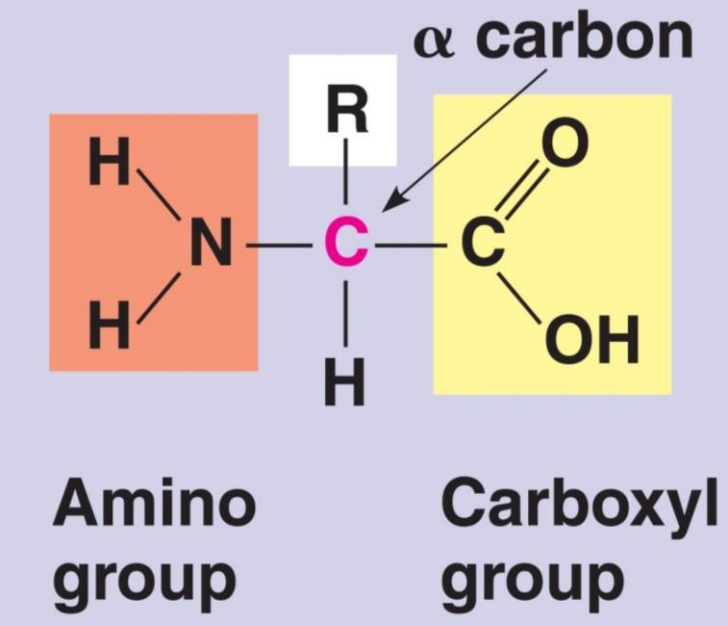


Types of amino acids



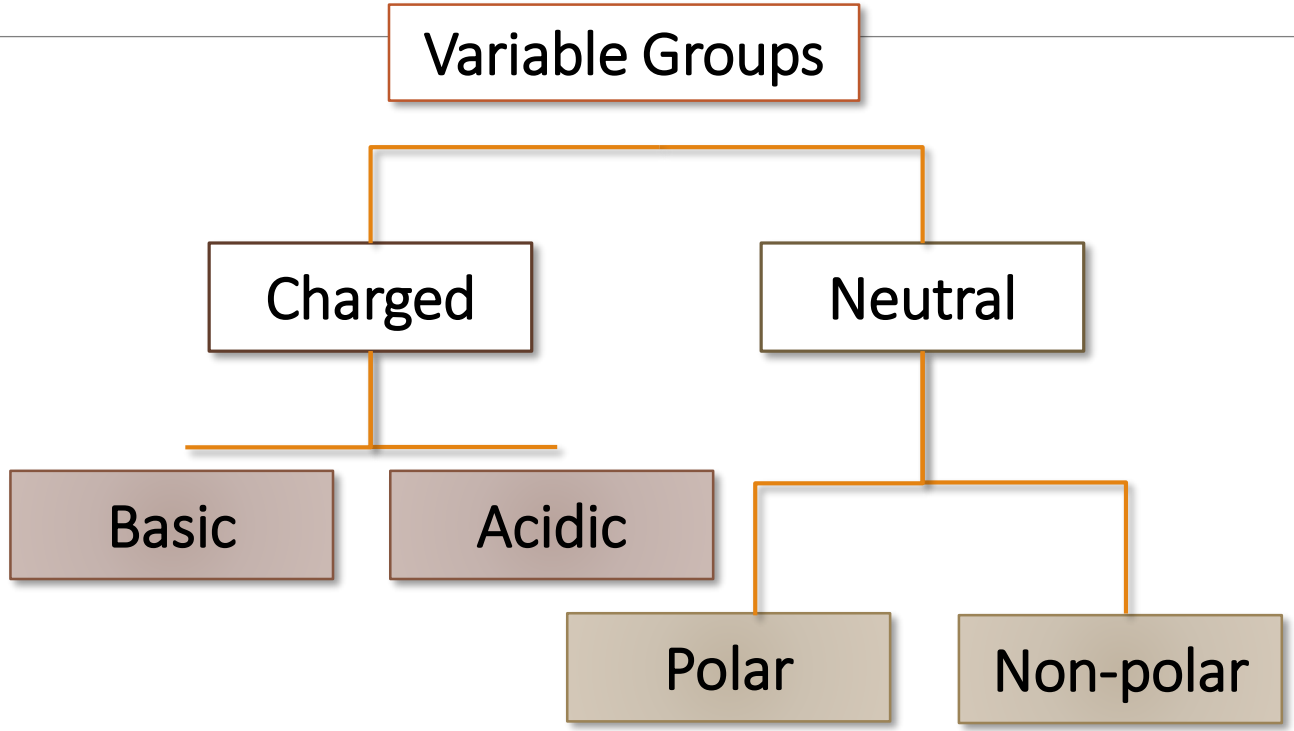
- 20 different amino acids found in proteins
- Differs only in **R groups**

Types of amino acids



Classified based on the different chemical properties of the **R groups**

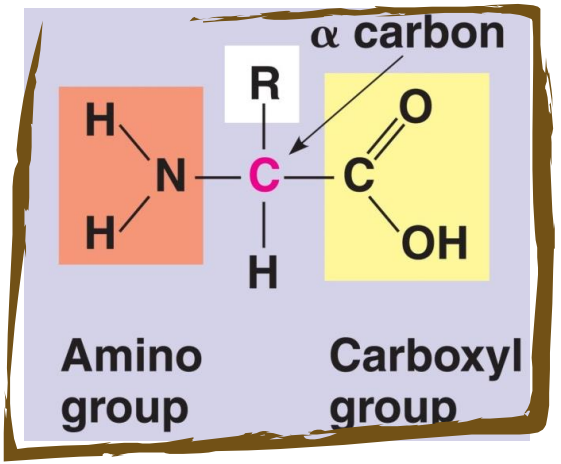
What variable groups (R groups) are there?



Classification of amino acids

Amino acids may be:

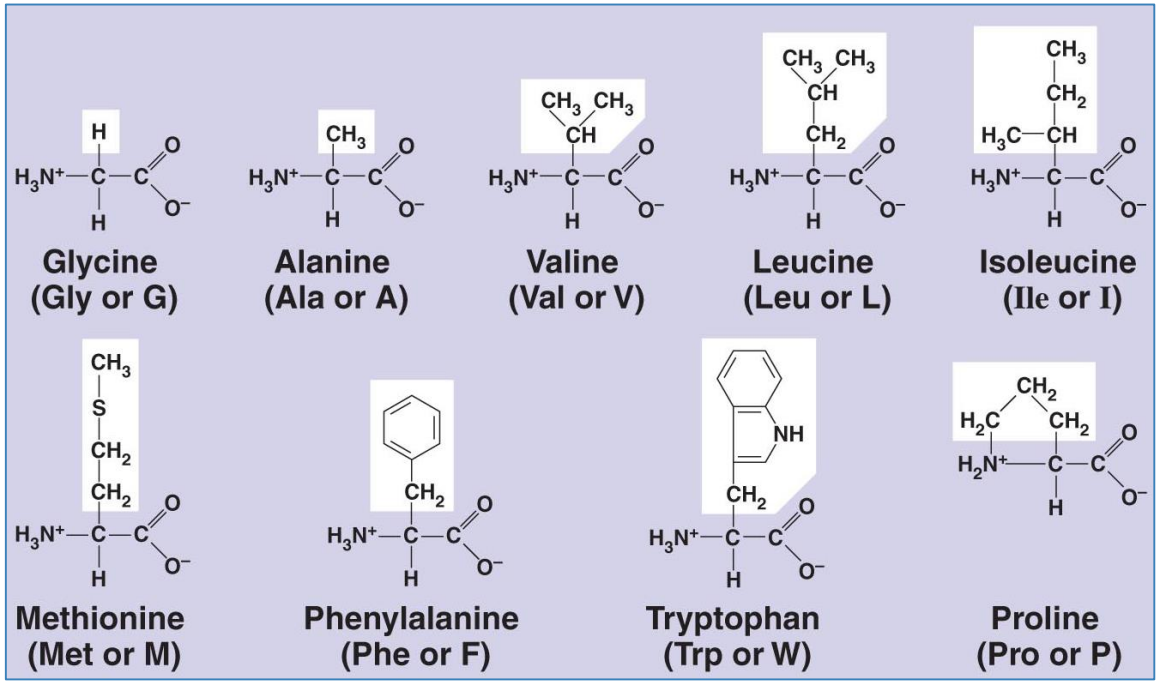
1. Non-polar
2. Polar
3. Charged
   - Acidic
   - Basic



Non-polar amino acids

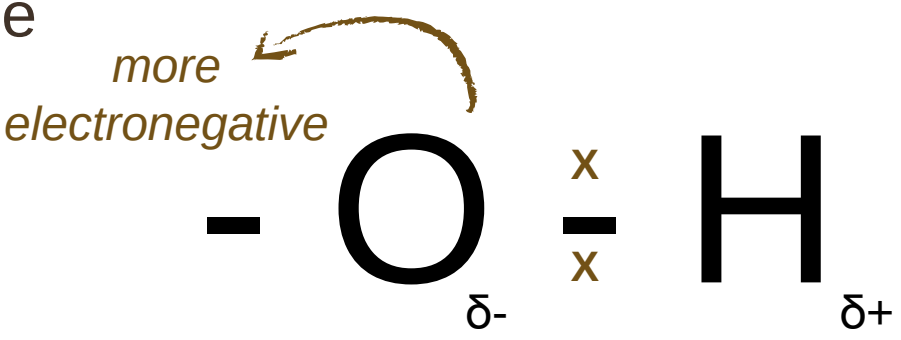
Side chains with **hydrophobic** properties:

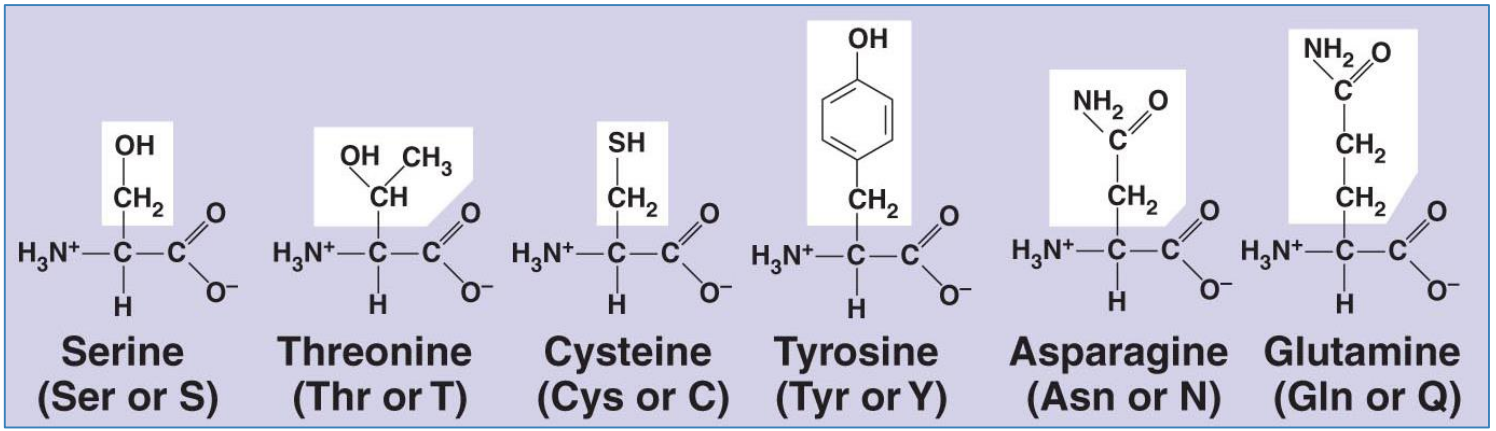
- Pure hydrocarbon alkyl groups or
- Aromatic (benzene) rings

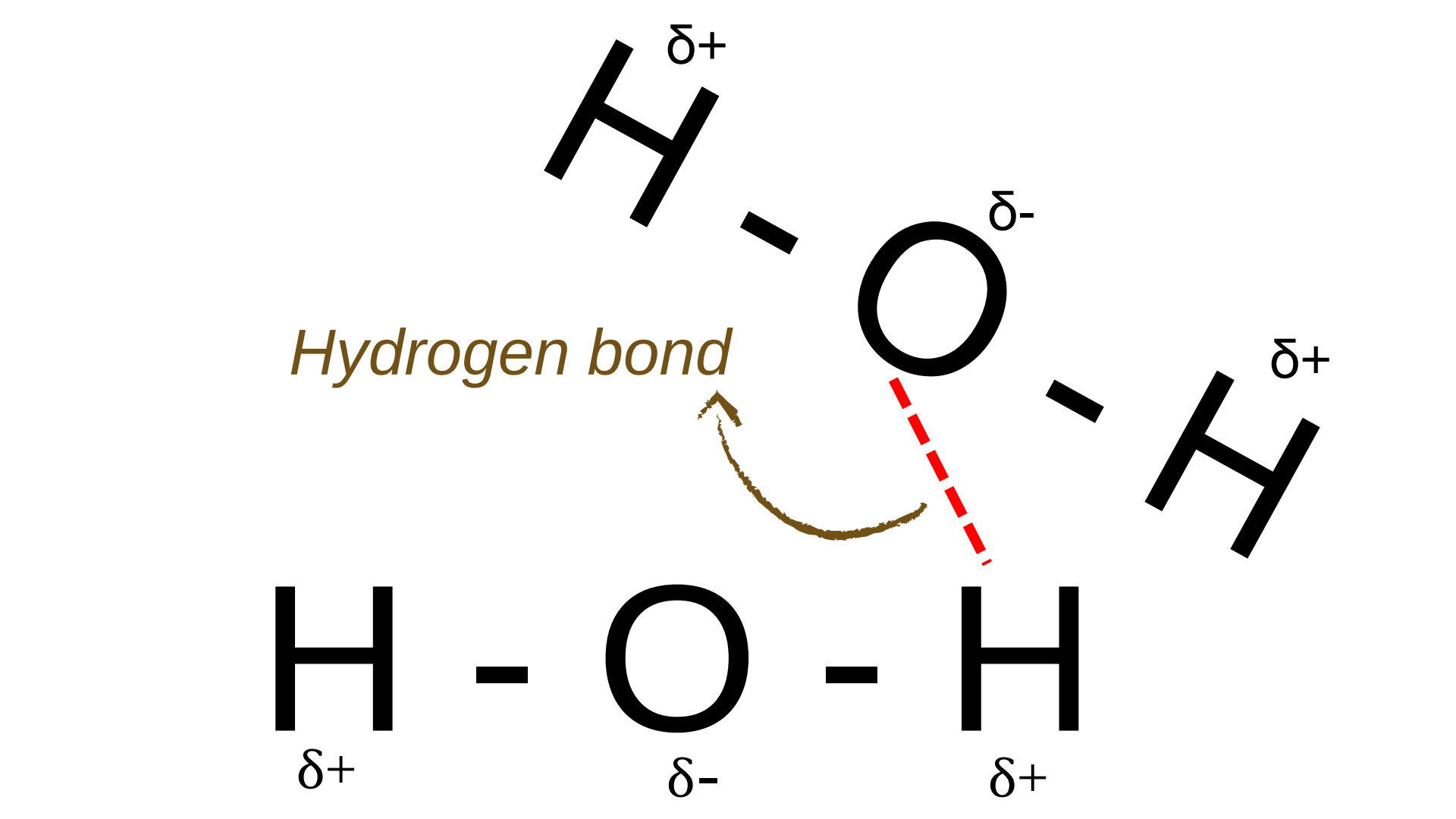


Polar amino acids

- Has **hydrophilic** side chains of various functional groups
- *e.g. –OH, -SH, -NH_2*

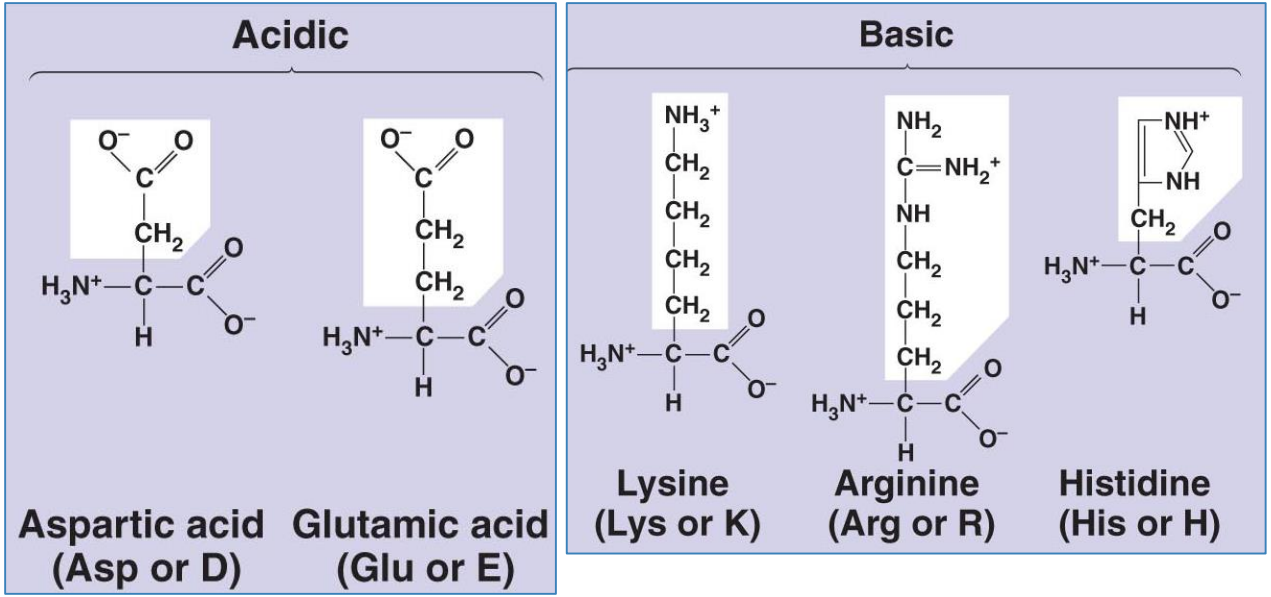




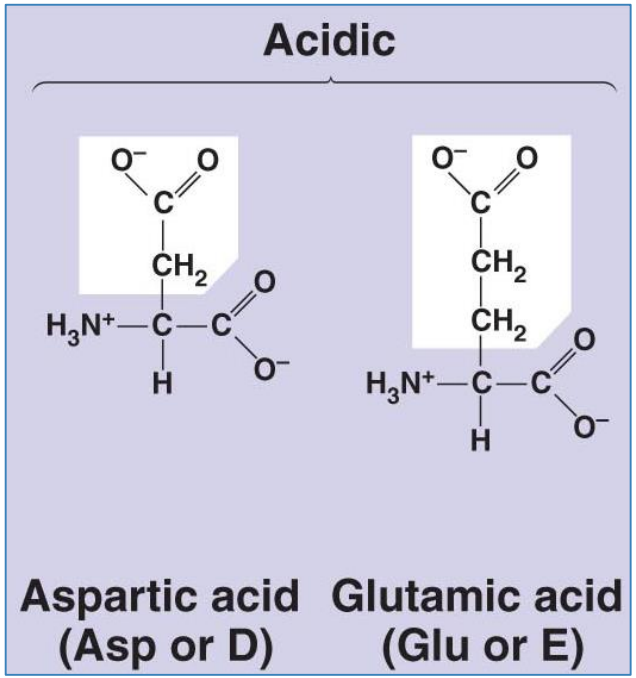

δ+
δ-
δ+
Hydrogen bond
H - O - H
δ+
δ-
δ+

Charged amino acids

- Determined by the **acidic** or **basic** functional groups of the side chain



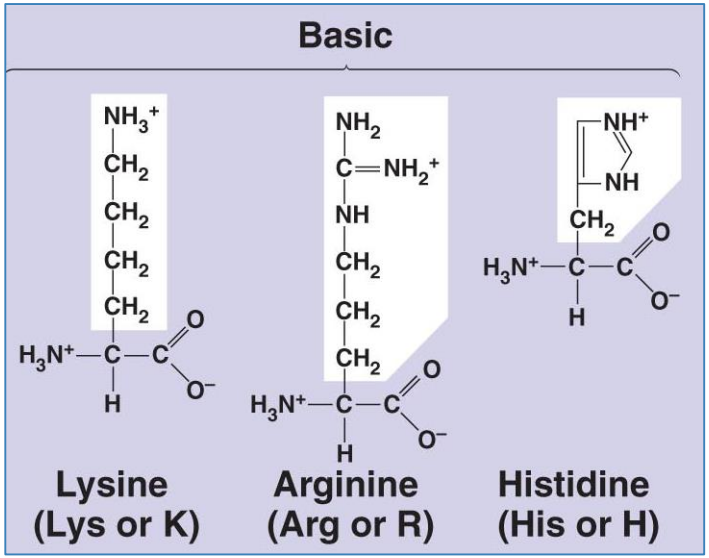
Acidic amino acids



- Have **additional –COOH** groups
- which ionize in aqueous environment to produce **COO^-** groups

=> Forming an **acidic** solution

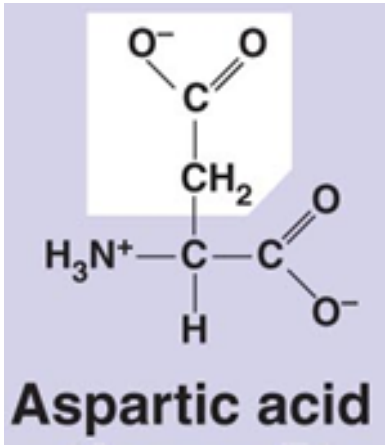
Basic amino acids



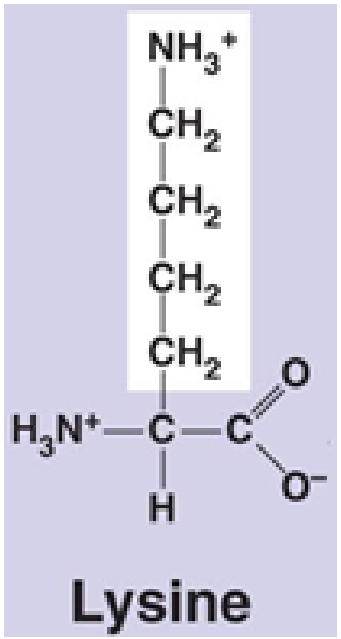
- Have **additional -NH_2** groups
- which ionize in aqueous environment to produce **NH_3^+** groups,

=> forming a **basic** solution

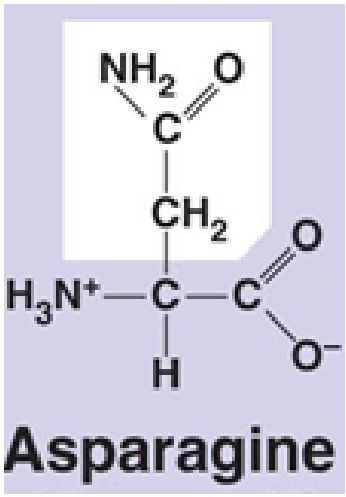
Spot the difference



Acidic



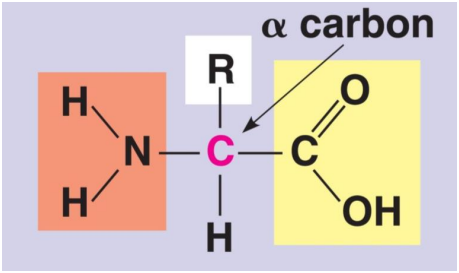
Basic



Polar
(uncharged)

Quick Check

- Describe the structure of the amino acid.



- What are the 4 types of amino acids?

1. Non-polar
2. Polar
3. Charged Acidic
4. Charged Basic

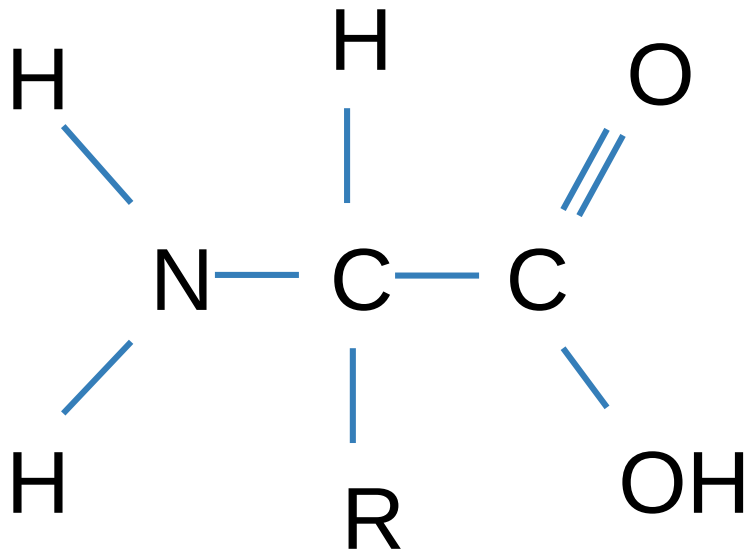
Video: amino acids

https://youtu.be/652GrZpLkPs

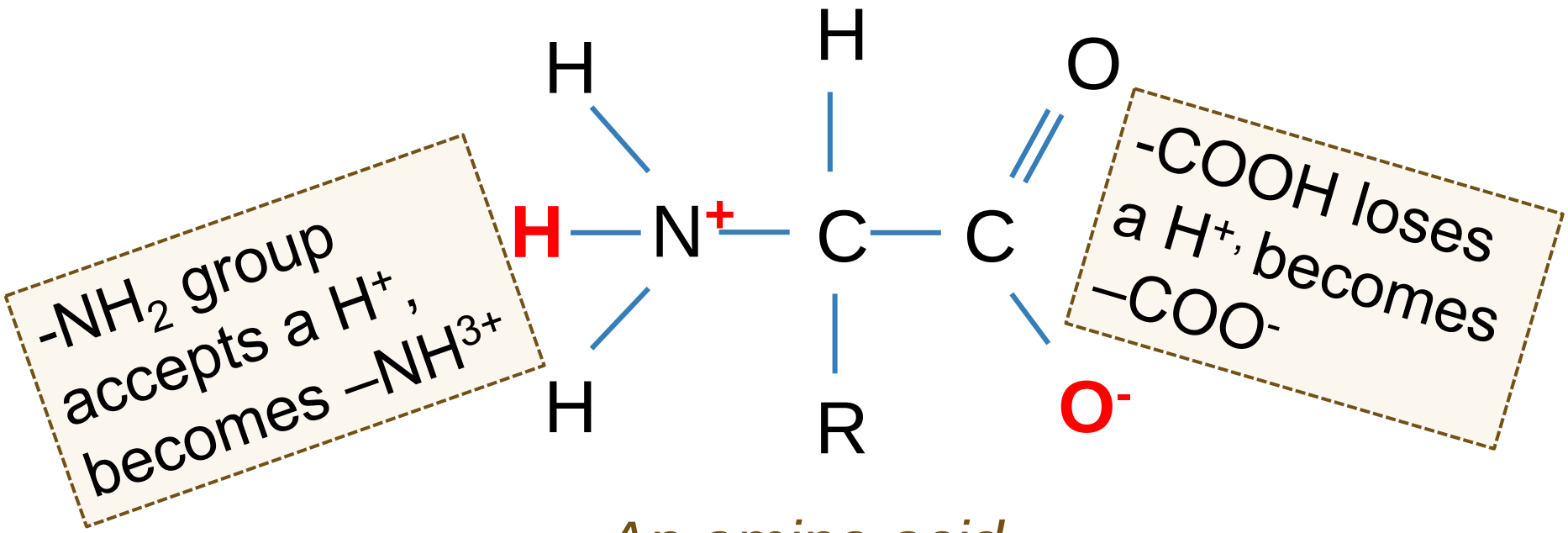
Properties of amino acids

Soluble in water but insoluble in organic solvents

Dissolve in water to form ions



An amino acid (powdered)

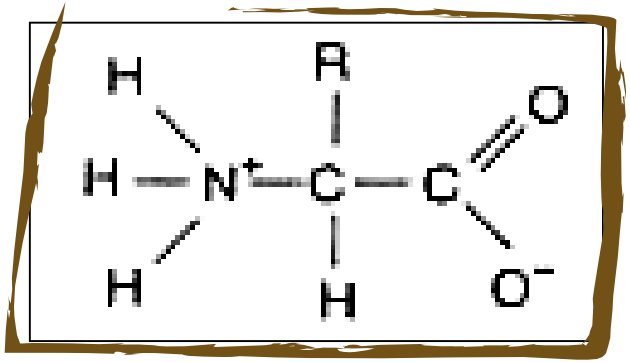


An amino acid (dissolved)

Properties of amino acids

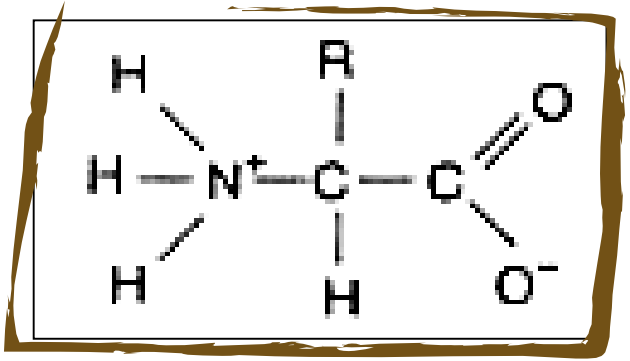
Amino acid that has both positive & negative charges

→ known as a **zwitterion**



Properties of amino acids

The **pH** at which an amino acid is a zwitterion is its **isoelectric point**



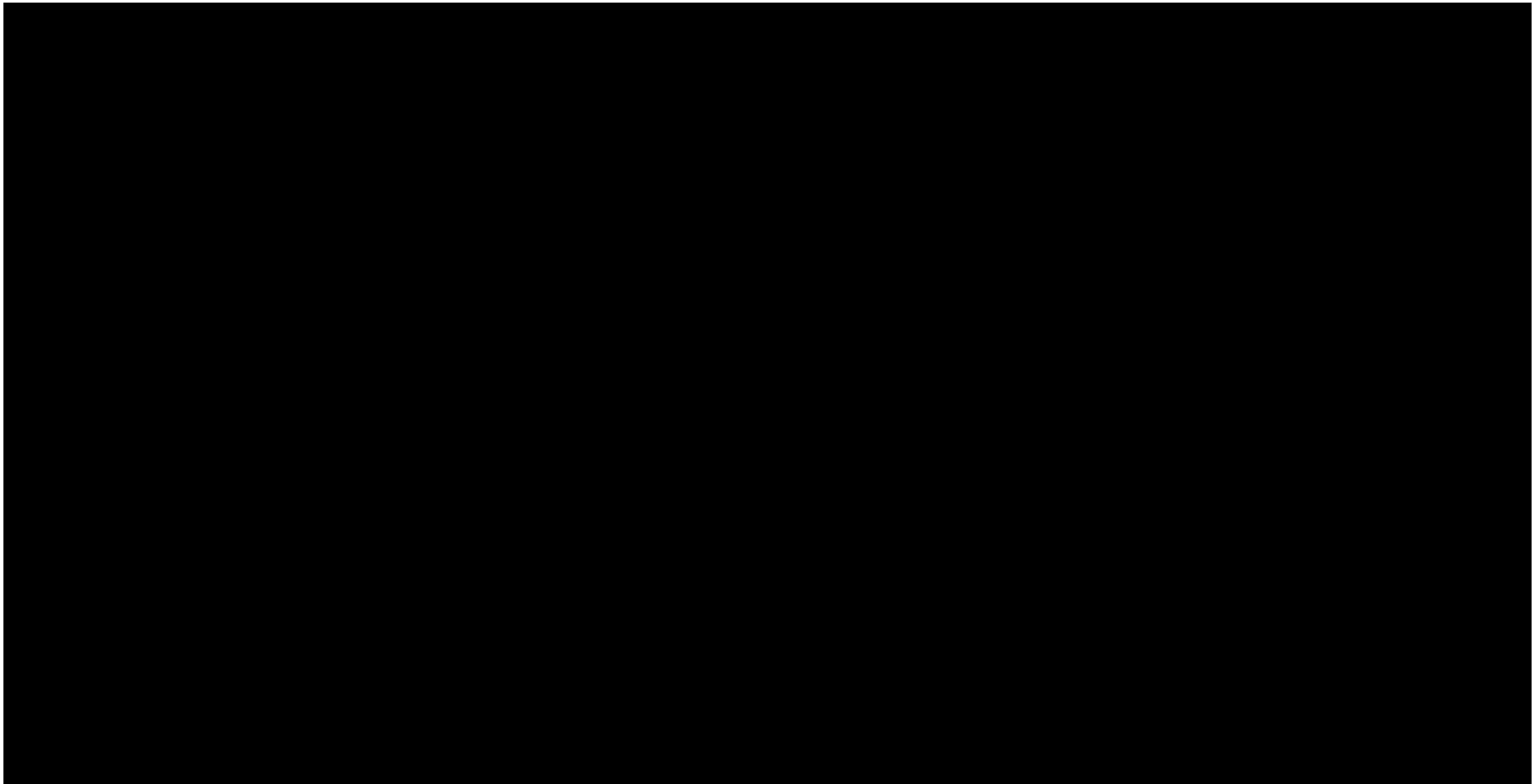
Properties of amino acids

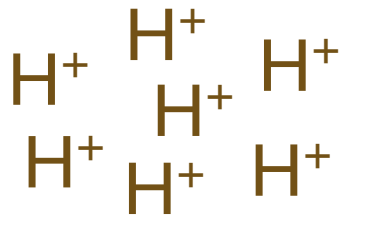
- All amino acids can act as either acids or bases (i.e. **amphoteric)**
- Can act as **pH buffers** in solutions

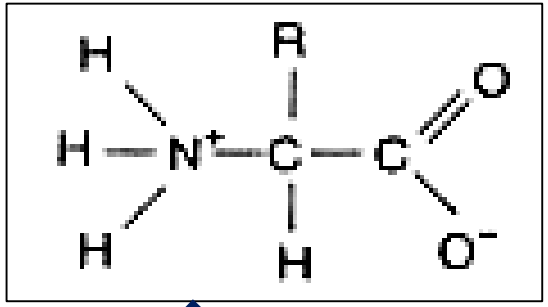
Able to resist changes in pH when a small amount of acid/base is added

Video: amino acids as pH buffers

https://youtu.be/fhosQQeCjN4

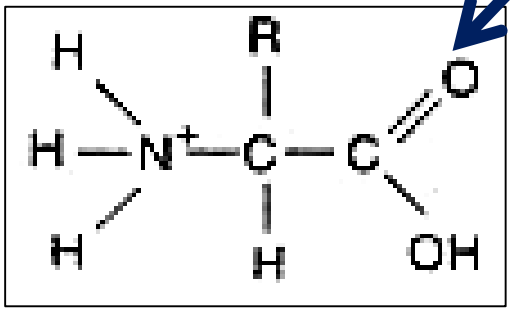






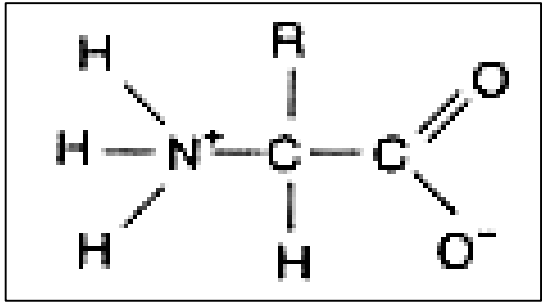
zwitterion

acidic medium



- Amino acid behaves as a base
- $-COO^-$ gains a H^+ & becomes -COOH

zwitterion

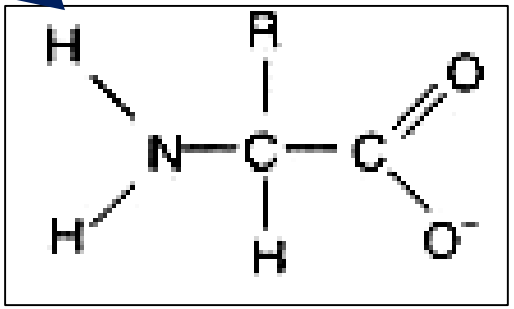


OH^-

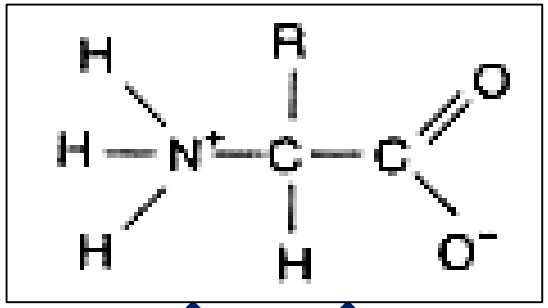
OH^- OH^- OH^-

OH^- OH^-

Alkaline medium



- Amino acid behaves as an acid
- $-NH^{3+}$ loses a proton and becomes $–NH_2$

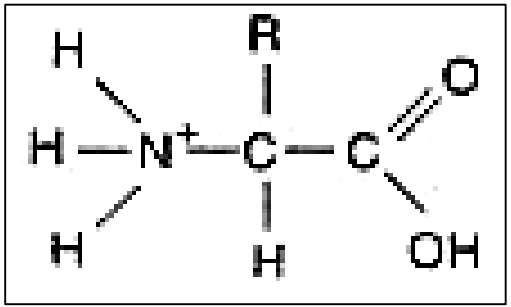


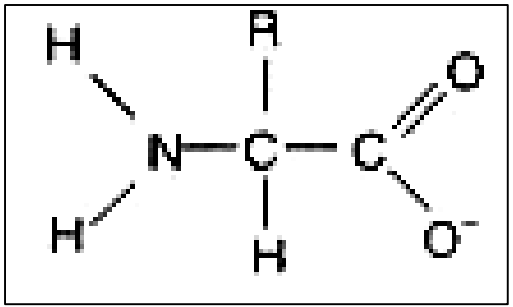
H^+ H^+ H^+ H^+ H^+ H^+ H^+

acidic medium

OH^- OH^- OH^- OH^- OH^- OH^-

alkaline medium





Quick Check

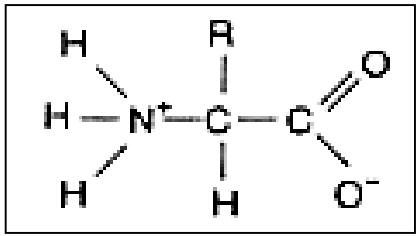
- What are some properties of an amino acid?

  - Soluble in water
  - Exist as Zwitterions
  - Amphoteric → Can act as buffers

Quick Check

- In aqueous medium, an amino acid can become a zwitterion. What is a zwitterion?

  An Amino acid with **both** positive and negative charges



- What is isoelectric point?

  pH at which an amino acid is a zwitterion is its **isoelectric point**

1. Amino acids
2. Formation of peptide bonds
3. Levels of organisations in proteins
   A. Primary Structure
   B. Secondary Structure
   C. Tertiary Structure
   D. Quaternary Structure
4. Case Studies: Haemoglobin

Learning Outcome

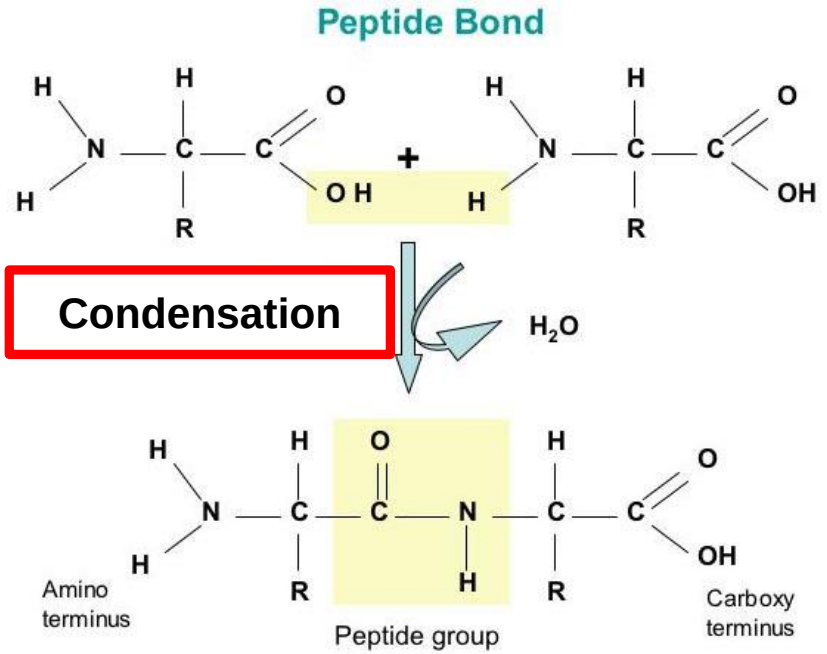
1(f)iii. Describe the formation & breakage of a peptide bond

Formation of peptide bonds

Amino acids are linked by **peptide bonds**

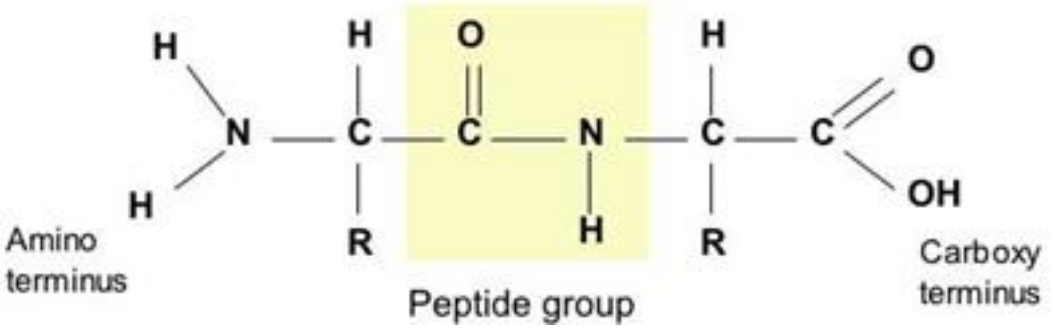
A **covalent** bond formed between **-COOH** group of one a.a. & the **-NH_2** group of the next a.a.

A water **molecule** is released



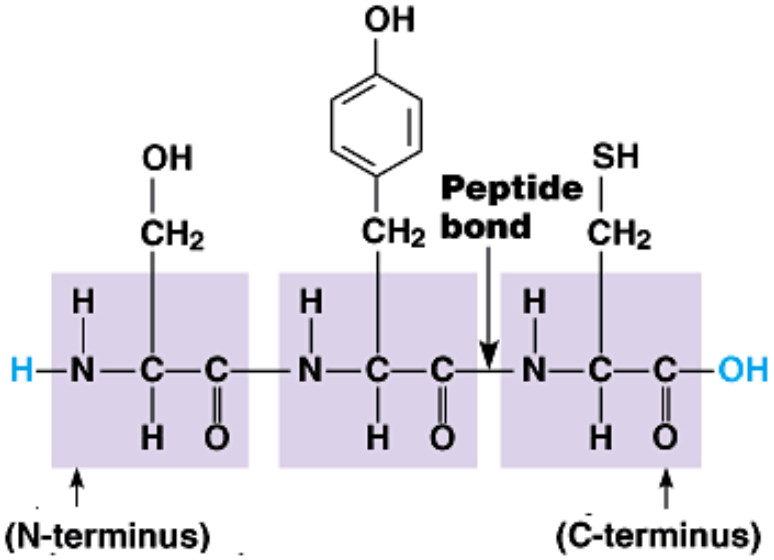
Formation of peptide bonds

- Once 2 a.a. are joined via a peptide bond, a dipeptide is formed
- Has a free NH_2 at one end & a free COOH at the other



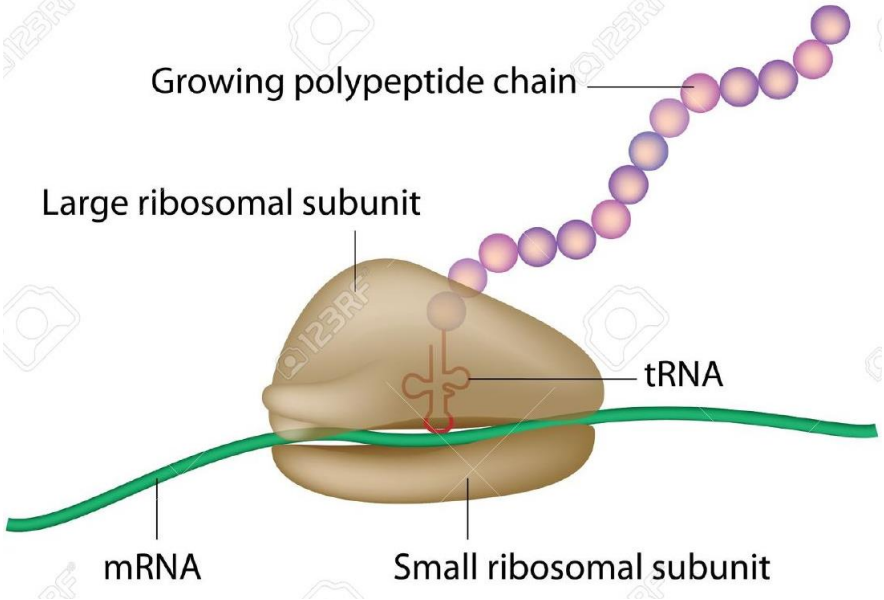
Formation of peptide bonds

Continued condensation leads to formation of a long chain of a.a. called a **polypeptide**.



Formation of peptide bonds

Occurs at ribosomes during translation, catalyzed by peptidyl transferase

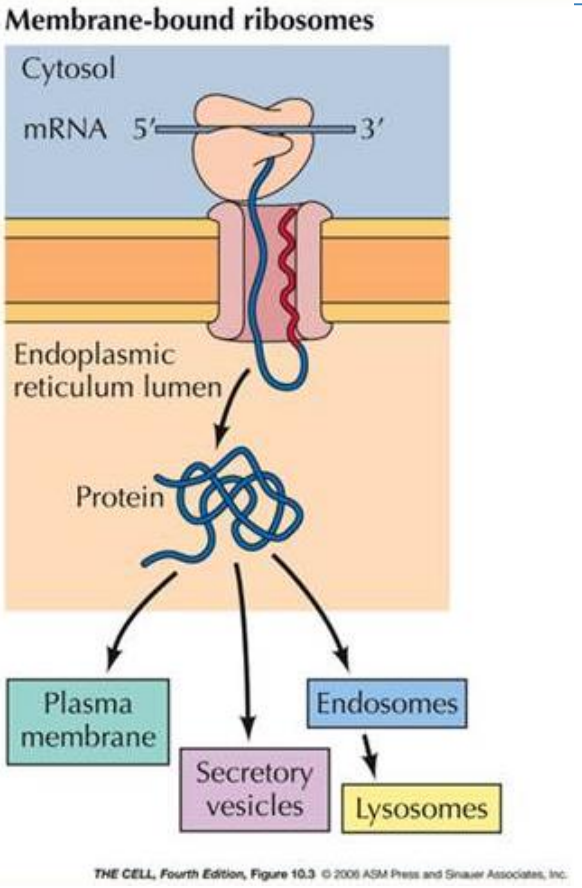


Formation of peptide bonds

Linear polypeptide will then fold, coil, or attach to other polypeptide chains to form a functional protein.

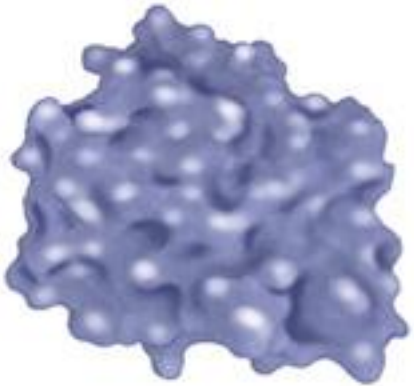
Occurs in

RER & Golgi body



folds into

globular structure



Are these two tripeptides the same?

N - alanine – lysine – serine - C

N - serine – lysine – alanine - C

- A polypeptide has direction
- N-terminus is the beginning of the polypeptide
- C-terminus is the end

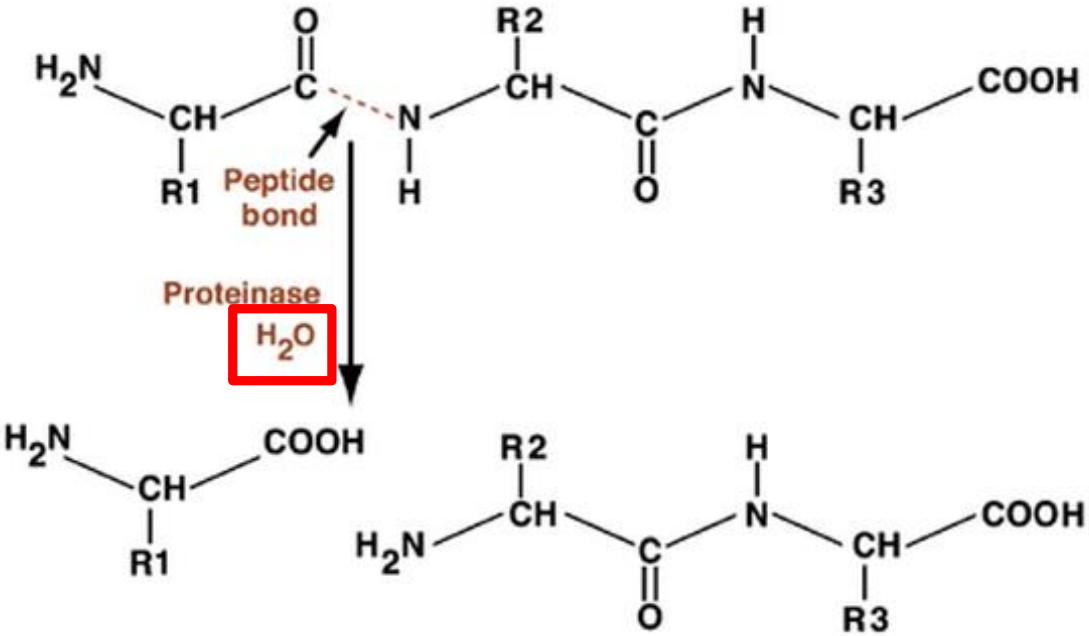
Hydrolysis of peptide bonds

- Add one H_2O across each peptide bond

Can be catalysed by enzymes (e.g. protease)

At high temperature, with acid

Hydrolysis of peptide bonds



Learning Outcomes

1(e)iii. Describe the **structure** and **properties** of **amino acids** (in proteins)

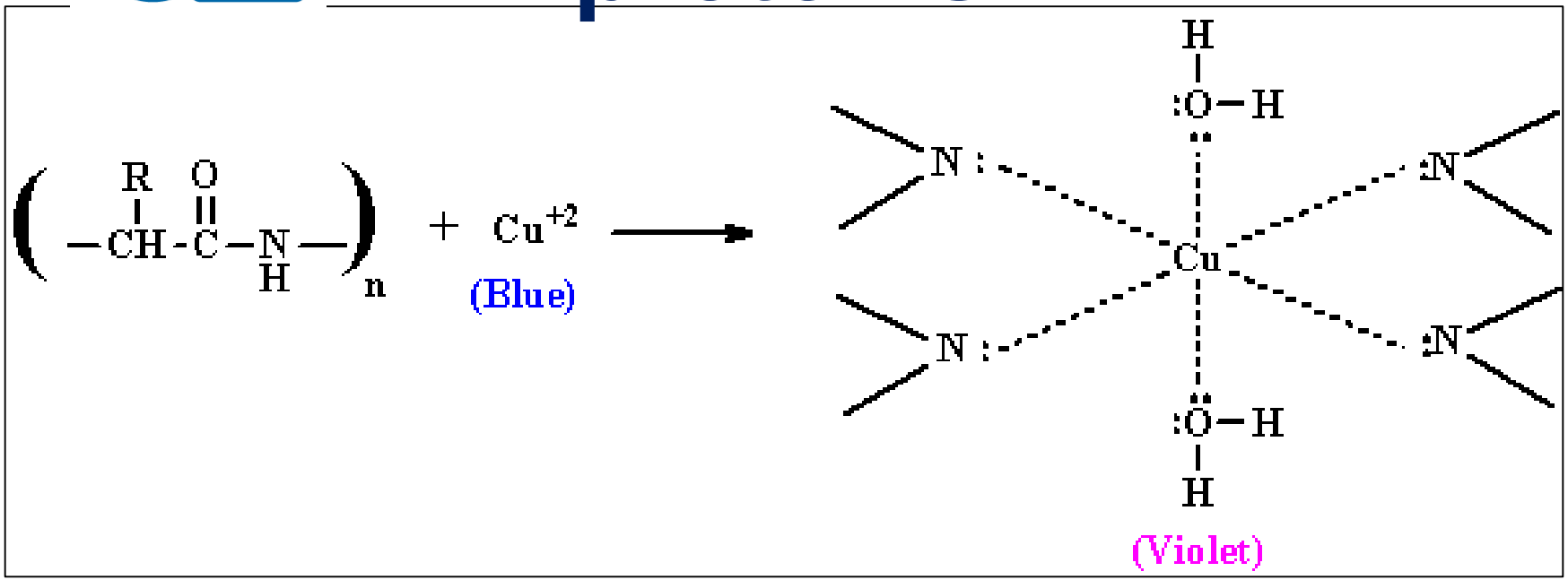
1(f)iii. Describe the **formation** and **breakage of a peptide bond**.

1(k) Explain **primary** structure, **secondary** structure, **tertiary** structure and **quaternary structure of proteins**, and describe the **types of bonds** that hold the molecule in shape (hydrogen, ionic, disulfide bonds and hydrophobic interactions).

Biuret test for proteins

- Add an **<u>equal volume</u>** of Biuret's solution to sample solution.
- Shake to mix contents thoroughly.
- Add dilute $CuSO_4$ **drop by drop**, shaking after every drop

Biuret test for proteins

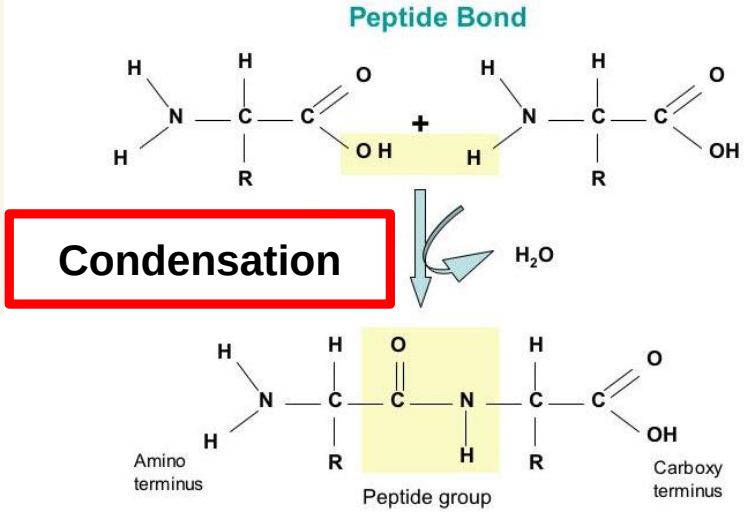


Quick Check

- Describe how two amino acids are joined together.

Amino acids are linked by **peptide bonds**

A **covalent** bond formed between **-COOH** group of one a.a. & the **-NH_2** group of the next a.a. and a water **molecule** is being released

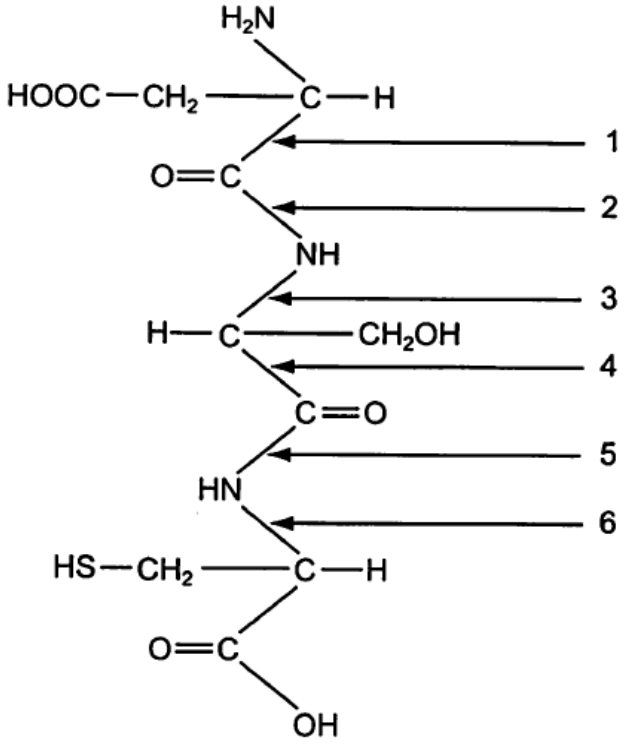


Tutorial 2: Proteins MCQ 3

- The diagram represents a tripeptide.

- At which bonds does hydrolysis occur to release the amino acids from the tripeptide?

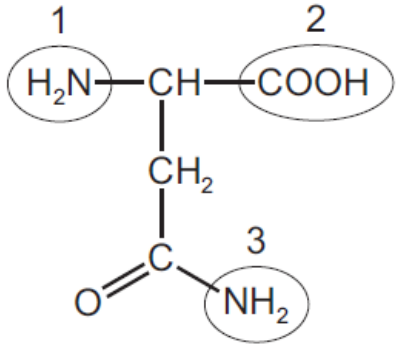
A	1 and 4
B	2 and 5
C	2 and 6
D	3 and 6

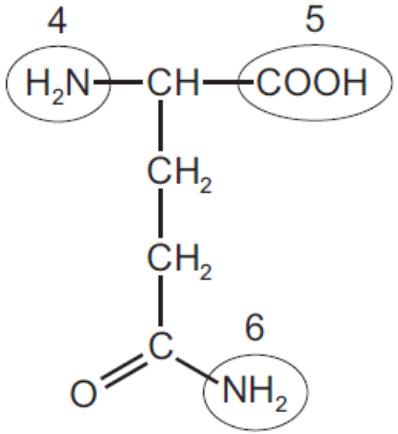


Tutorial 2: Proteins MCQ 4

The diagrams show the structures of two amino acids, each of which has two amino (–NH2) groups. A peptide bond is formed between the two amino acids. Which groups form the peptide bond?

A	1 and 4
B	1 and 5
C	2 and 6
D	3 and 5



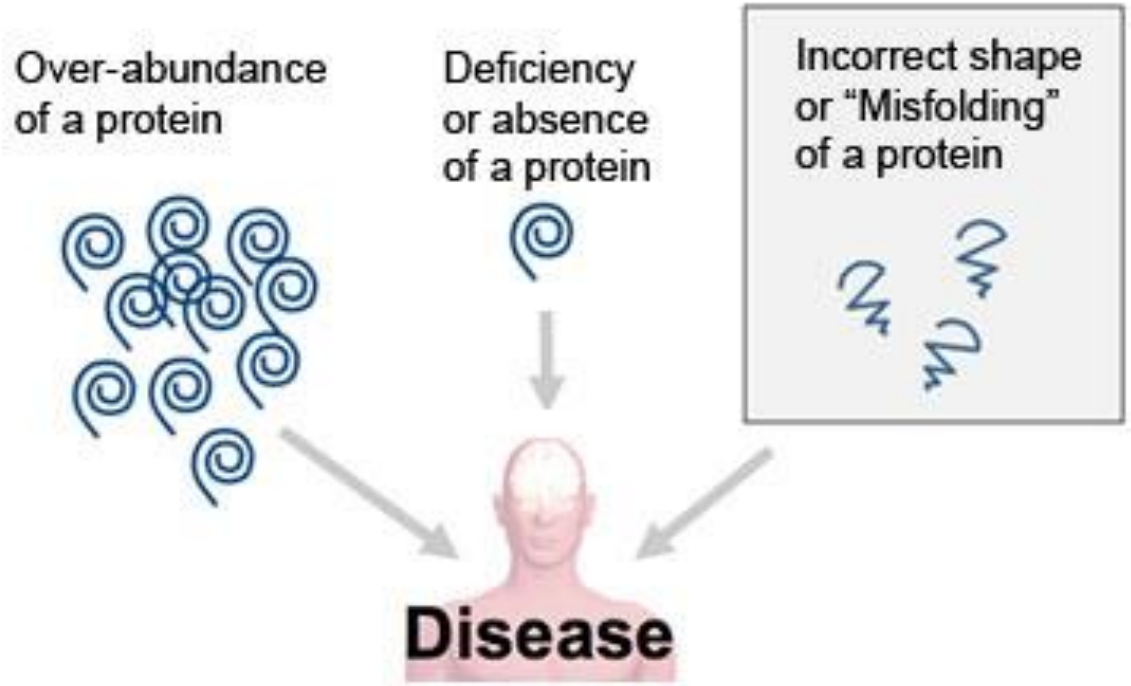


1. Amino acids
2. Formation of peptide bonds
3. Levels of organisations in proteins
   - A. Primary Structure
   - B. Secondary Structure
   - C. Tertiary Structure
   - D. Quaternary Structure
4. Case Studies: Haemoglobin

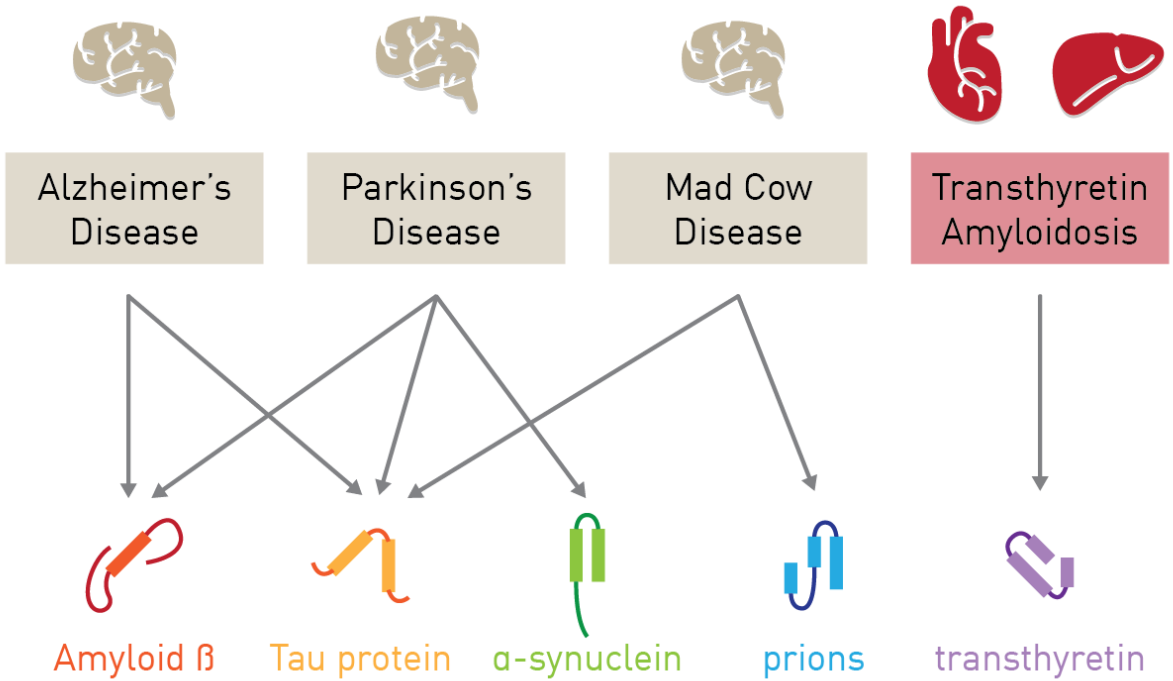
Learning Outcome

1(m) ***Explain*** *the meaning of the terms* ***primary***, ***secondary***, ***tertiary*** *&* ***quaternary structure*** *of proteins & describe the* ***types of bonds*** *which hold the molecule in shape.*

Why is protein folding important?



Some diseases caused by protein misfolding



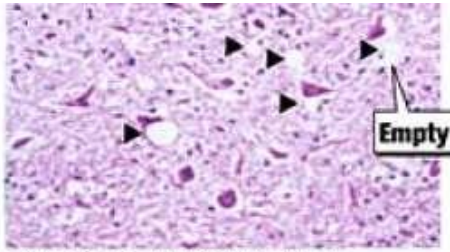
Some Diseases CAUSED BY ABNORMAL proteins

What causes fatal mad cow disease?

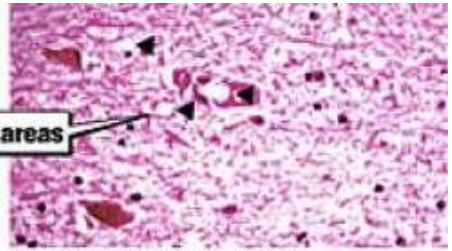
❶ A cow eats feed supplemented with sheep bone meal containing infectious proteins called prions. There has been a ban on such rendered feed since 1997.

❷ The prions are suspected of corrupting normal protein production.

❸ Prions are absorbed by the stomach and are thought to travel along nerve fibers to the brain stem, destroying brain tissue.



Cow brain tissue showing bovine spongiform encephalopathy (BSE)

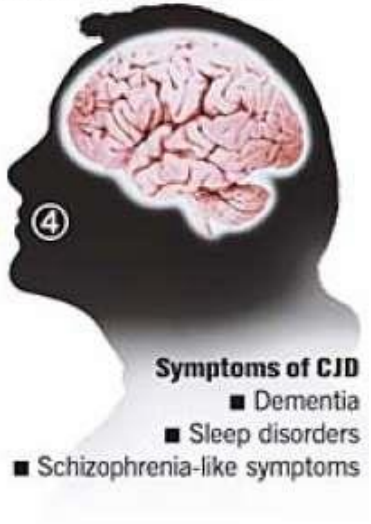


Human brain tissue showing Creutzfeldt-Jakob disease (CJD)

Symptoms of BSE
- Disorientation
- Fearfulness
- Wobbly movement

Sources: UCSF, World Health Organ

❹ When humans eat processed meat products that might contain prion-infected tissues, they too can come down with a similar fatal syndrome, dubbed variant Creutzfeldt-Jakob disease. All the various bans on cattle and beef products are designed to eliminate human consumption of the tainted meat.



Symptoms of CJD
- Dementia
- Sleep disorders
- Schizophrenia-like symptoms

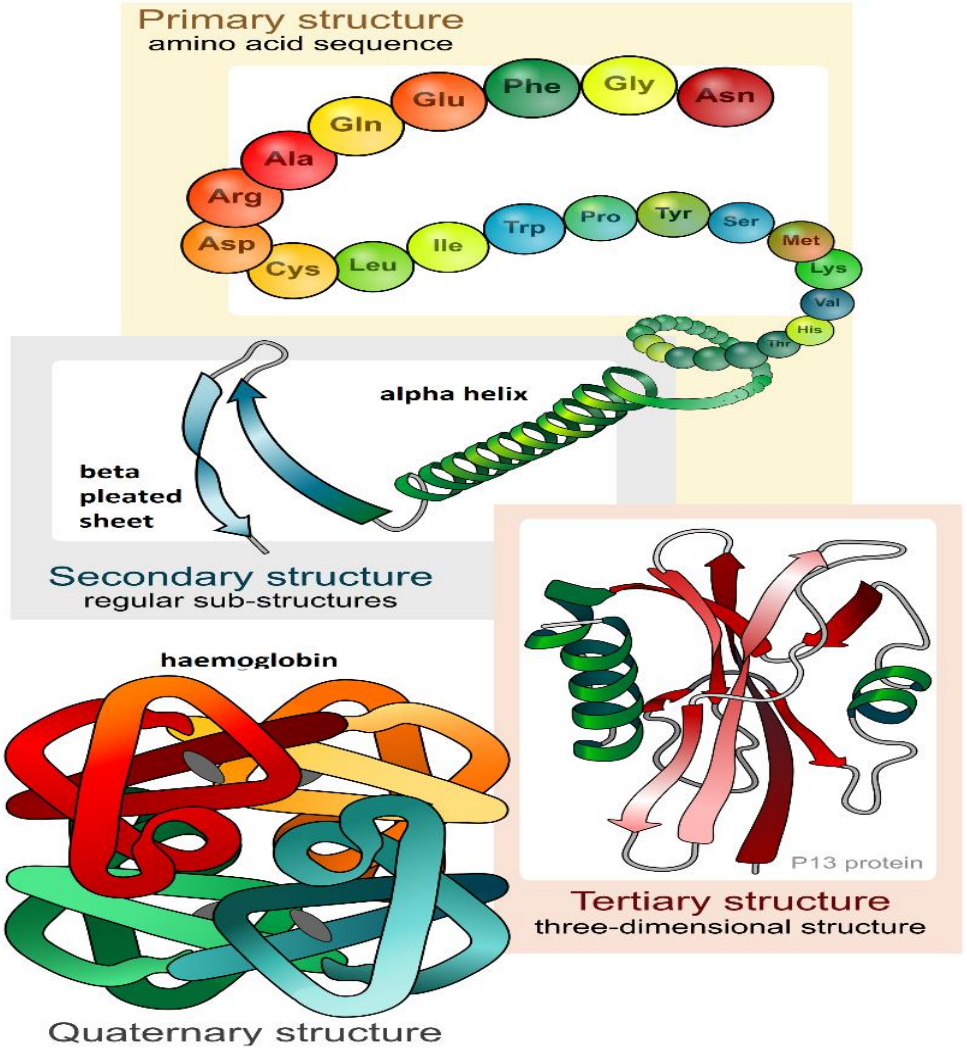
JOHN BLANCHARD / *The Chronicle*

Cumulatively, through the end of 2015, more than **184,500 cases of BSE** had been confirmed in the United Kingdom alone in more than 35,000 herds

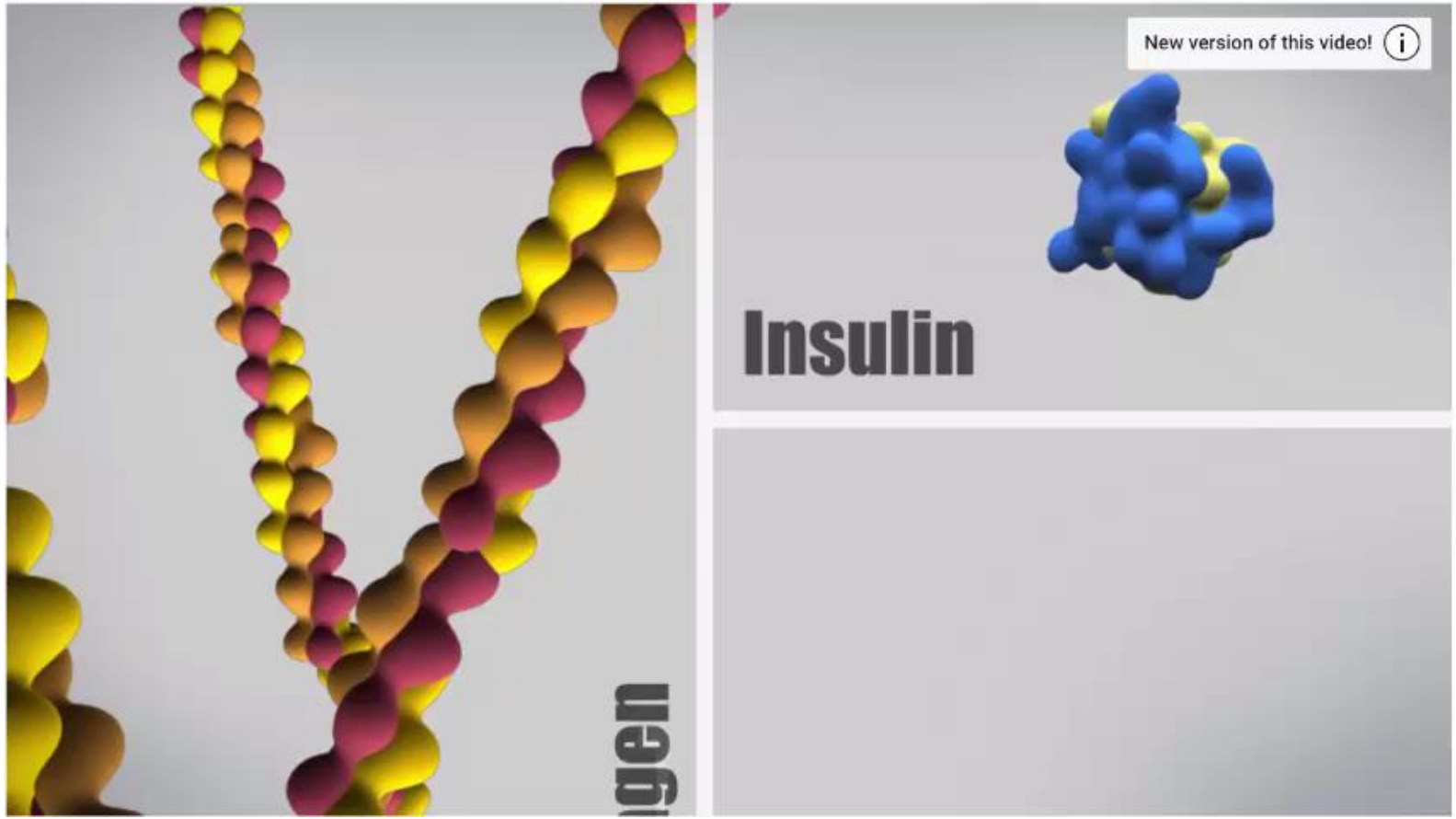
Video: Why study protein folding?

https://youtu.be/KpedmJdrTpY

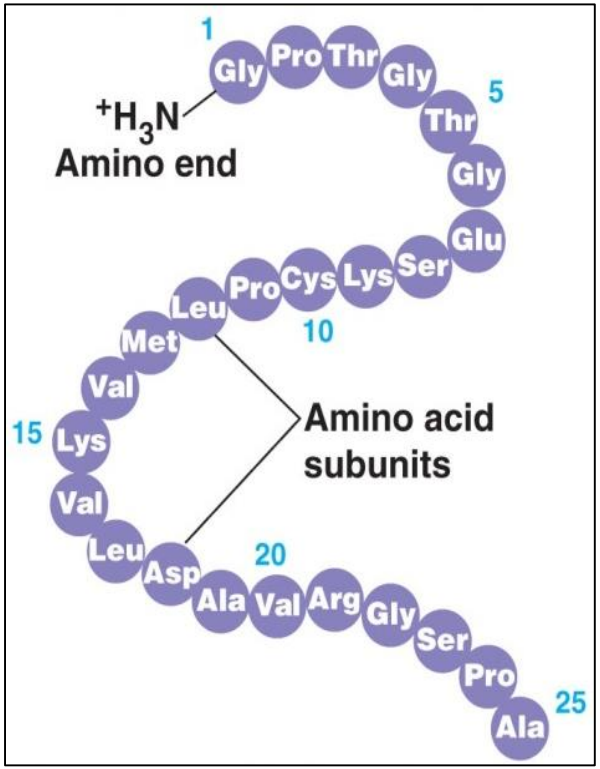
4 levels of protein folding



https://www.youtube.com/watch?v=qBRFIMcxZNM



Primary structure

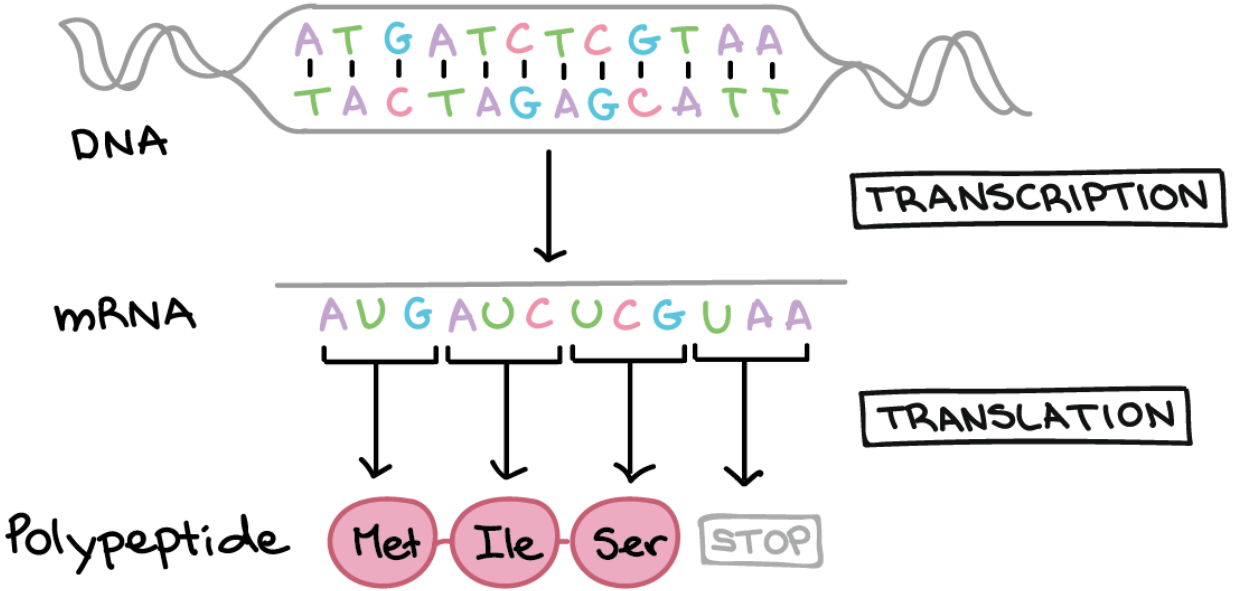


Refers to the **number**, **sequence** & **type** of a.a. in a **linear** polypeptide chain.

Peptide bonds are involved

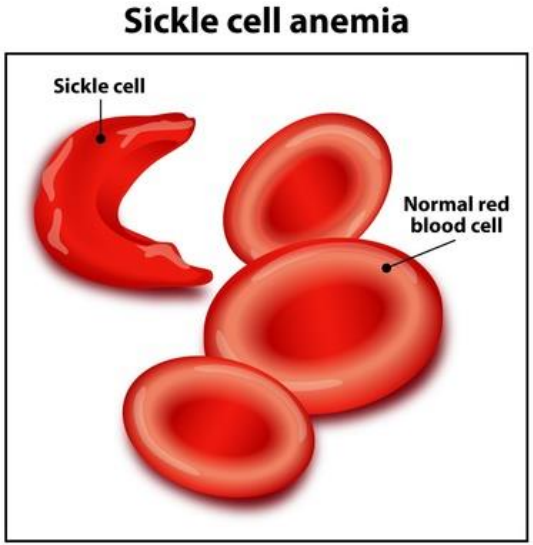
Primary structure

Seq. of a.a. is determined by **seq. of nucleotide bases** in the **gene** encoding the protein.



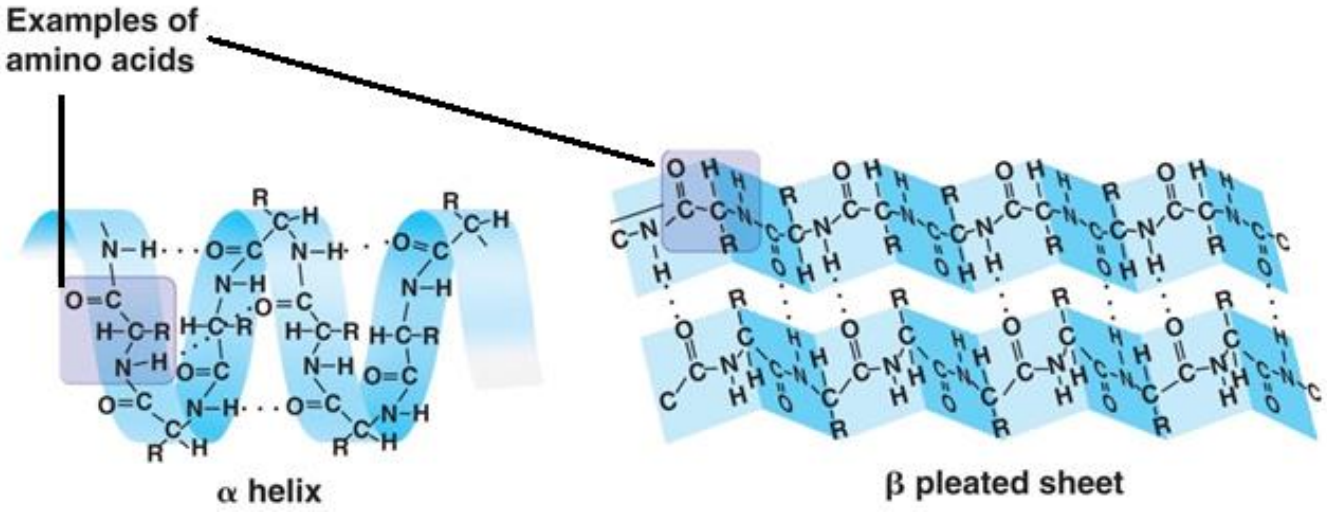
Primary structure

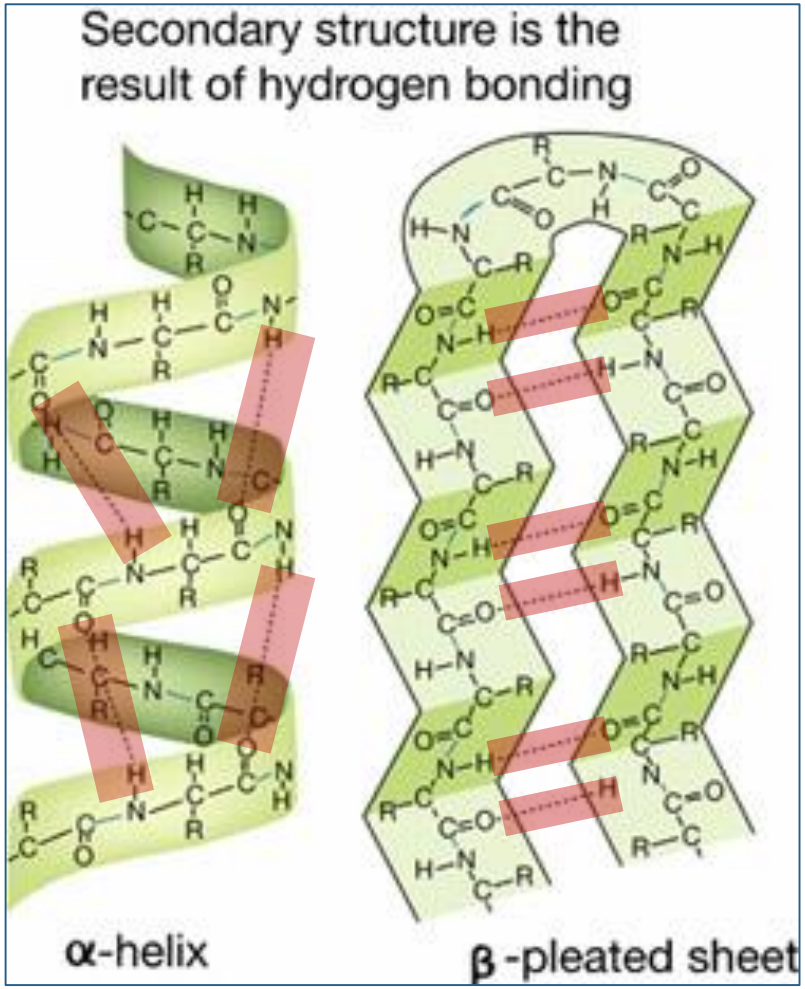
- A change in the DNA seq. may change the polypeptide sequence & can affect a protein's **3D conformation** & **function**
- e.g. sickle cell anaemia



Secondary structure

Refers to the folding of polypeptide chain into **regular structures** such as **α-helices** & **β-pleated sheets**





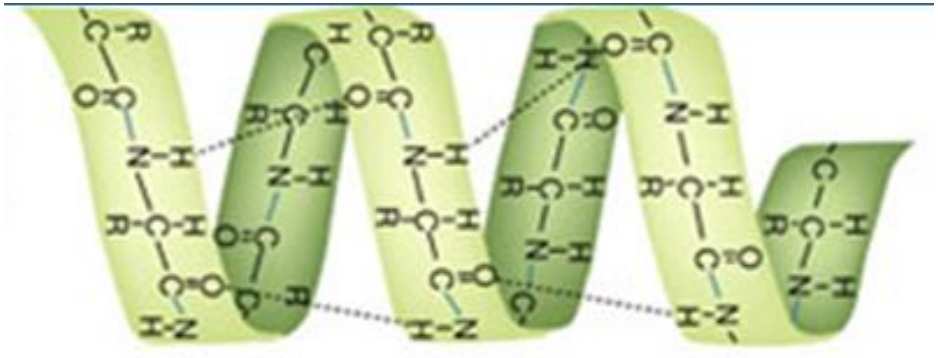
Bonds involved:

Hydrogen bonds form between –CO group of a **peptide bond** on one a.a. & the –NH group on a peptide bond of another a.a. in the **same** polypeptide chain.

hydrogen bonds

α-helix

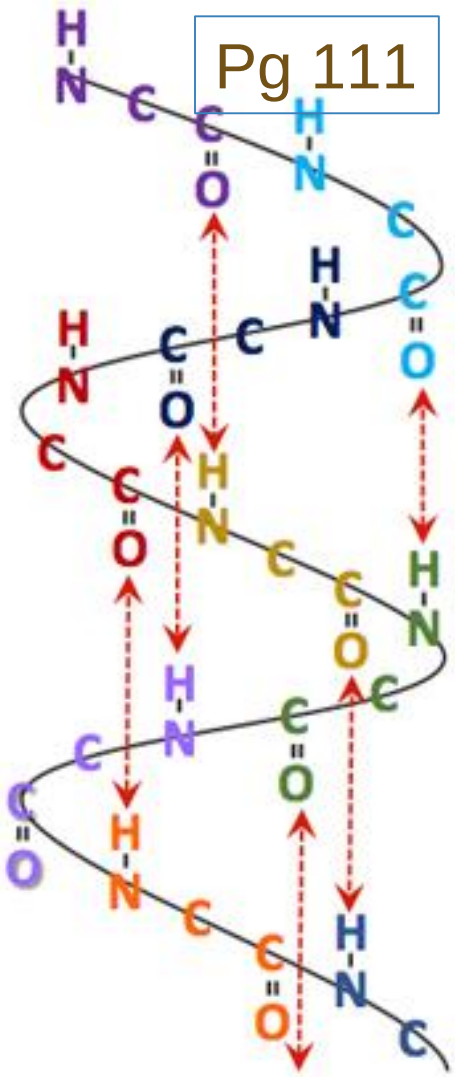
Coiling of polypeptide chain into a **helical** conformation



α-helix

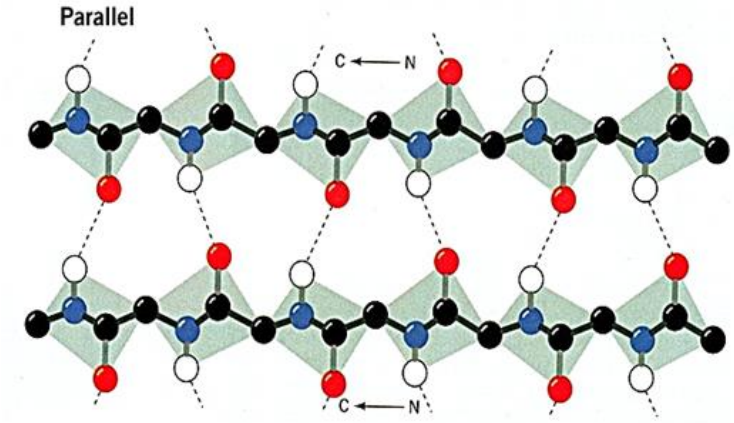
Carbonyl oxygen (**C=O**) of each a.a. in the peptide bond is **hydrogen bonded** to the hydrogen on the amino group (**N-H**) of the a.a. that is **four a.a. away** in the linear sequence

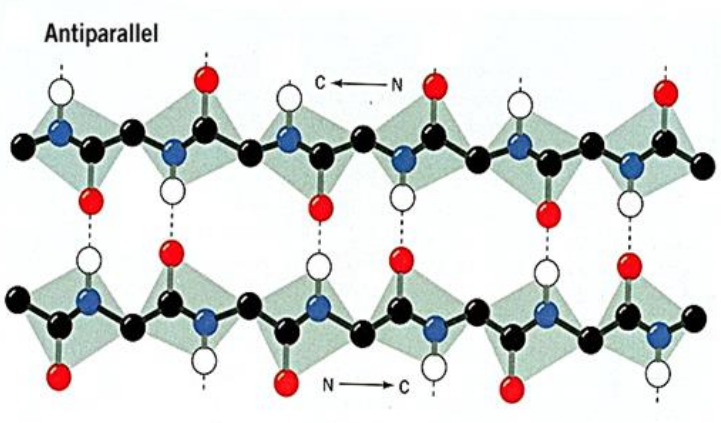
e.g. keratin



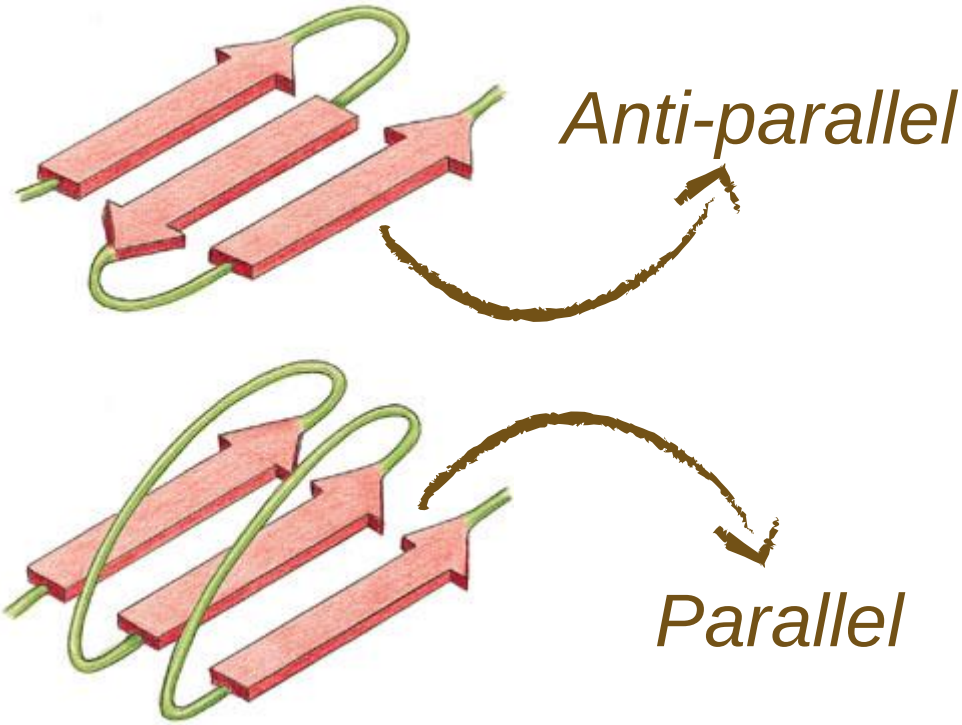
β –pleated sheets

Made up of different sections of a single polypeptide running parallel or anti-parallel to each other



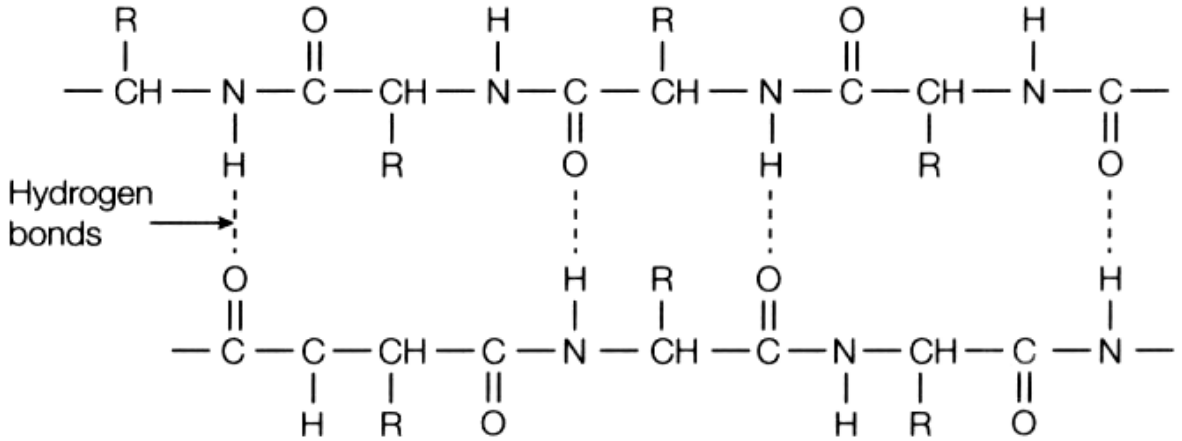


β –pleated sheets



β –pleated sheets

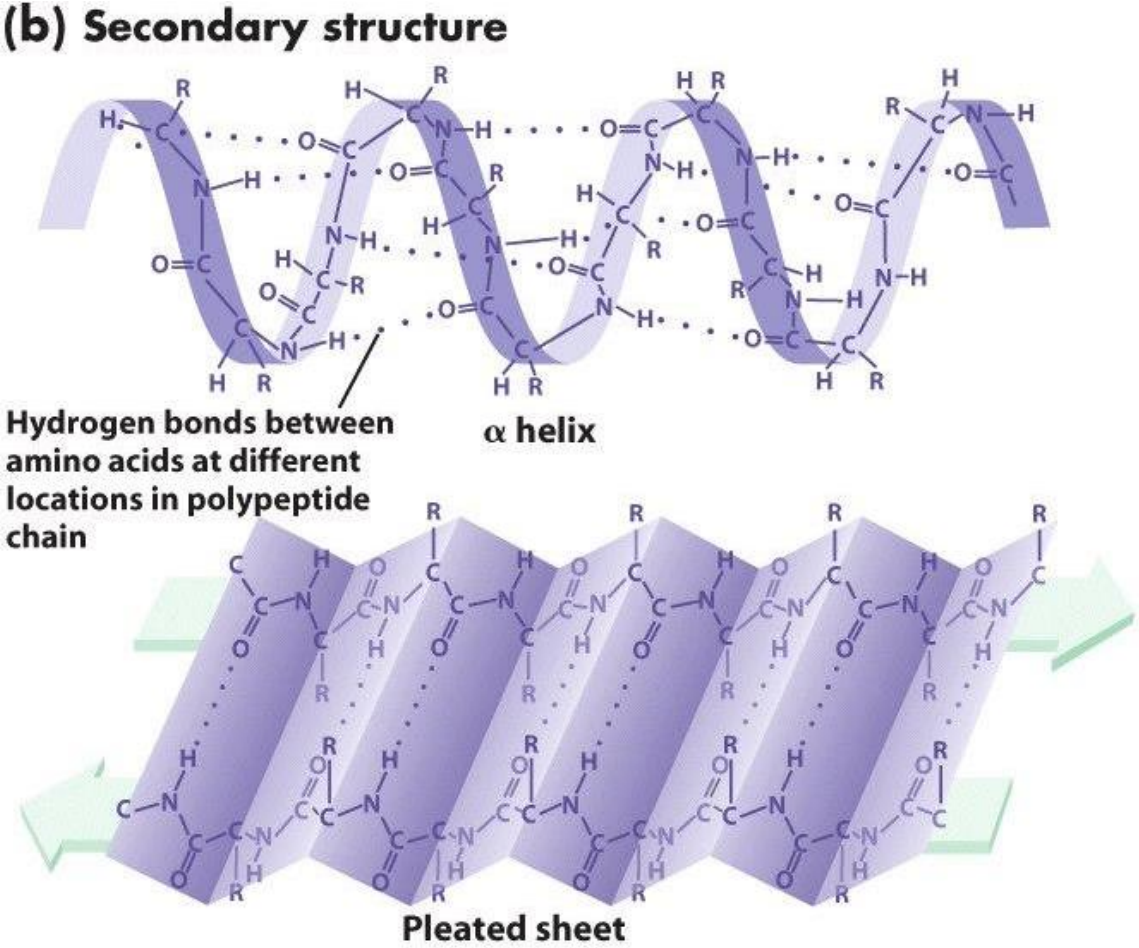
Stabilised by **hydrogen bonds** formed between the peptide bonds in different sections of the **same** polypeptide chain.



β –pleated sheets

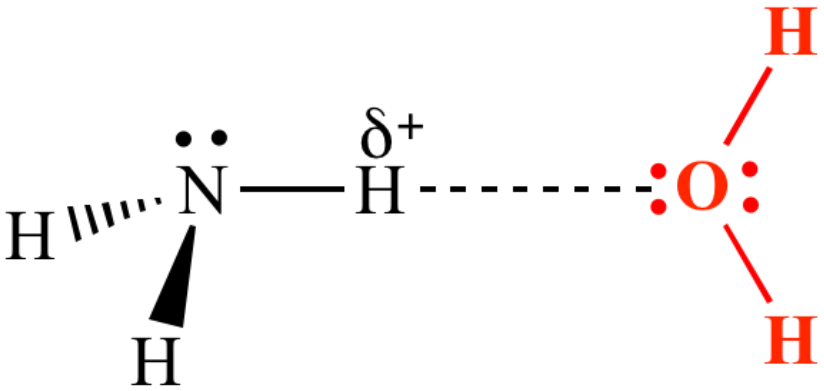
- Multiple β –pleated sheets provide **strength & resilience** in many structural proteins
- e.g. silk fibroin consists of stacks of antiparallel β –pleated sheets

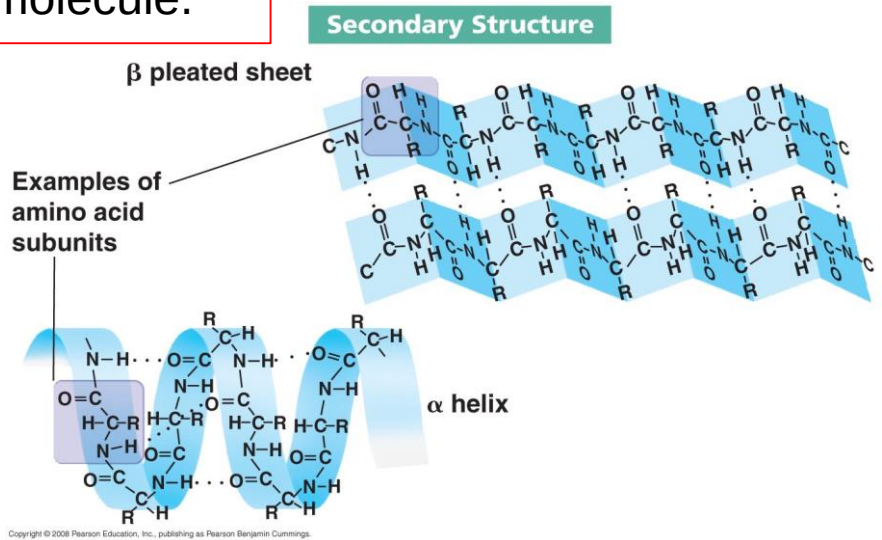
Compare


(b) Secondary structure
Hydrogen bonds between amino acids at different locations in polypeptide chain
α helix
Pleated sheet

Are Hydrogen Bonds Strong Bonds??

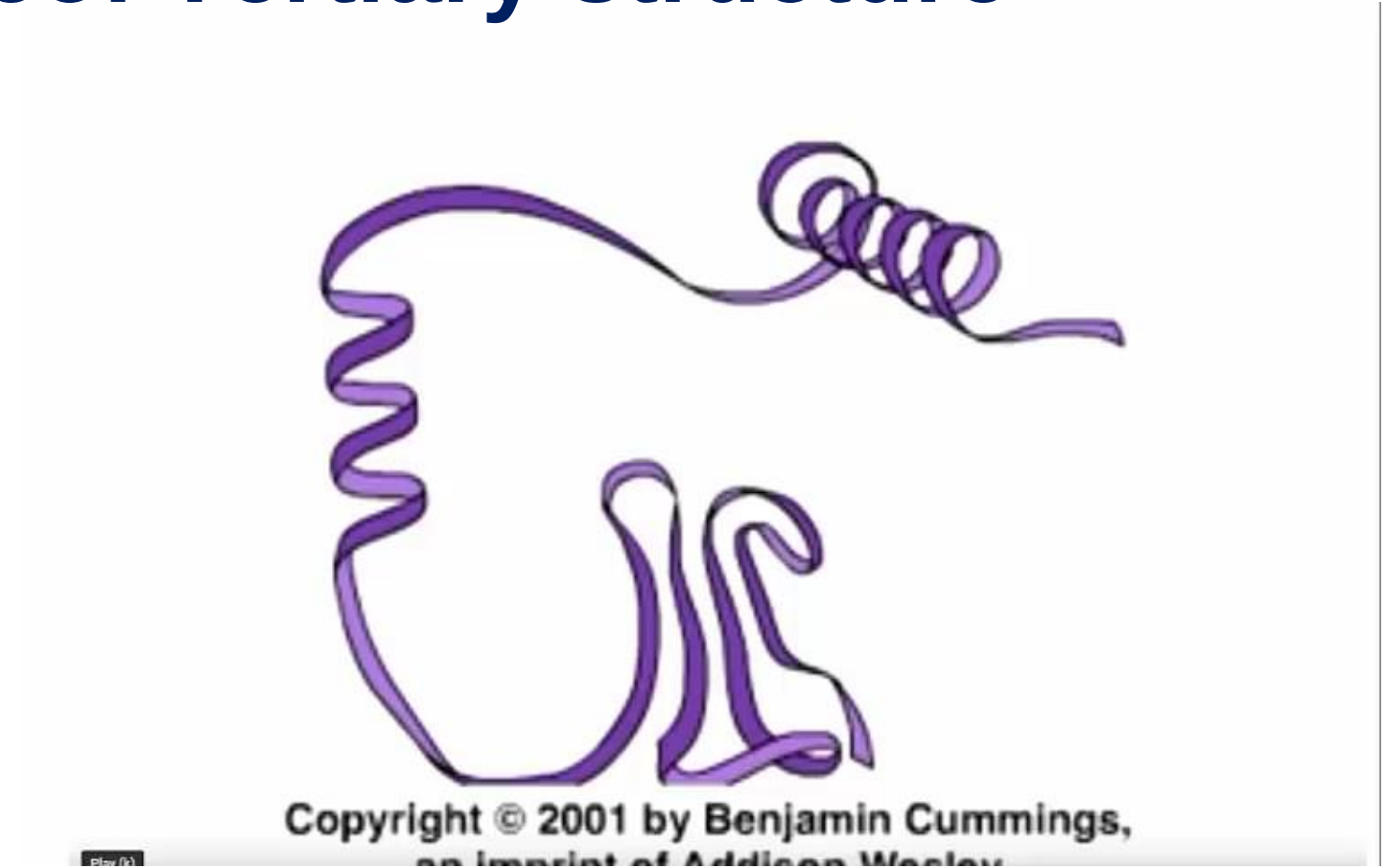
Ans: While each hydrogen bond is very <u>weak</u>, the <u>large</u> number of such bonds means that they play an important role in maintaining the shape and stability of a polypeptide molecule.





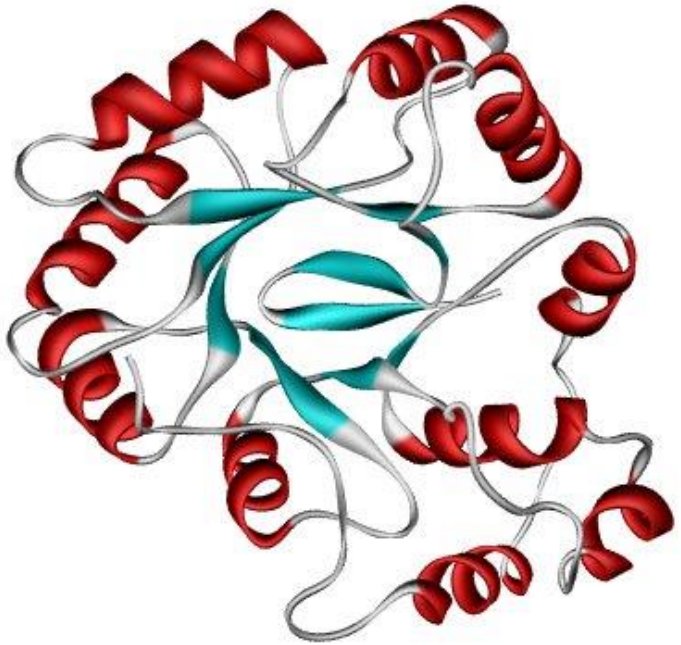
1. **Amino acids**
2. **Formation of peptide bonds**
3. **Levels of organisations in proteins**
   A. Primary Structure
   B. Secondary Structure
   C. Tertiary Structure
   D. Quaternary Structure
4. **Case Studies: Haemoglobin**

Video: Tertiary structure



Tertiary structure

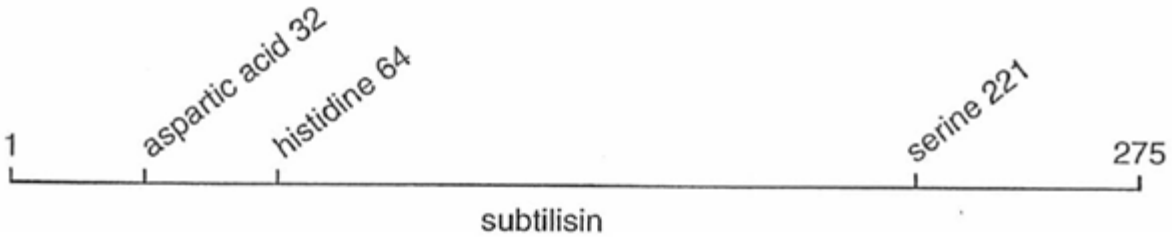
Refers to the folding of the polypeptide chain into its **unique 3D globular conformation**

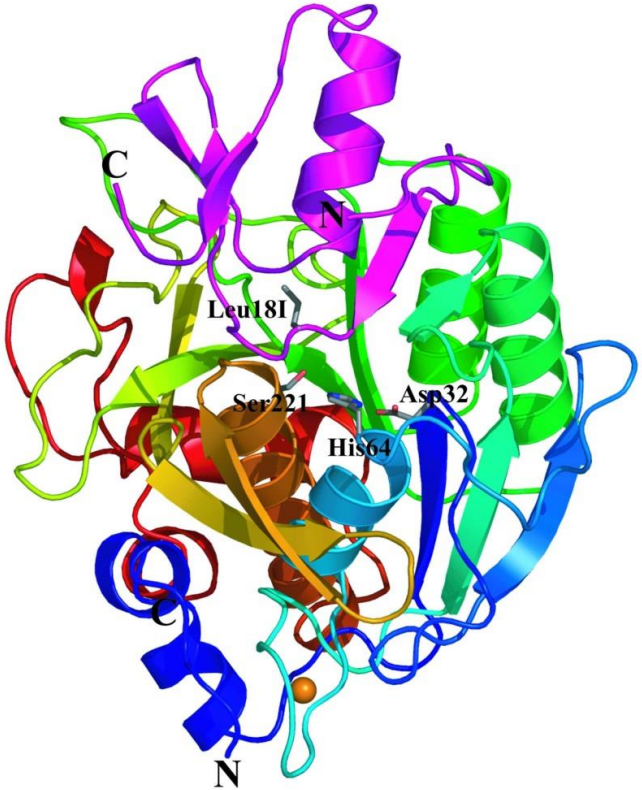


Folding from primary to secondary to tertiary structure

Tertiary structure

Refers to the relationship of a.a. residues that are **far apart in the linear sequence**





Bonds in 3° structure

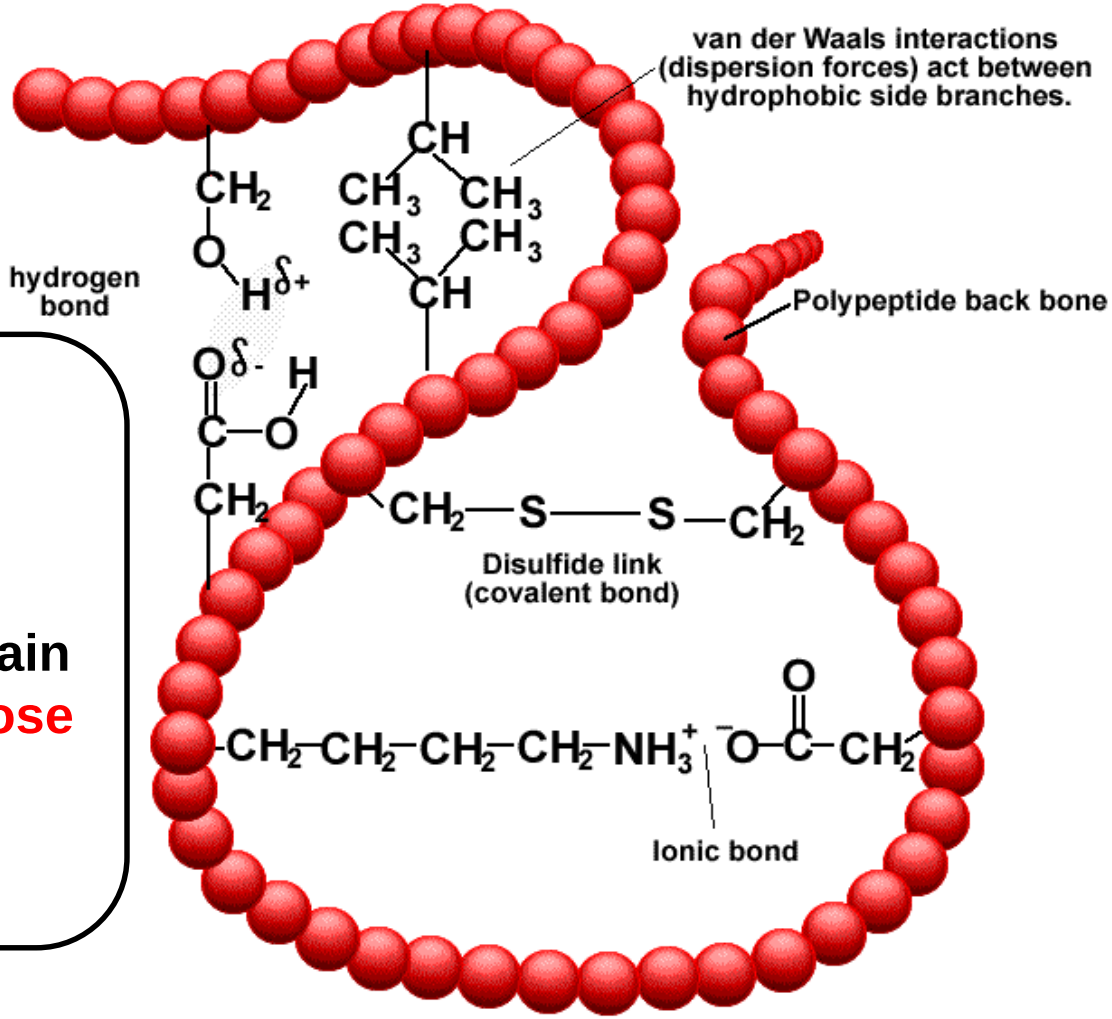
Hydrogen bonds b/w polar R groups

Ionic bonds b/w acidic & basic R groups

Disulfide bonds b/w -SH groups of cysteine

Hydrophobic interactions b/w non-polar R groups

Interacting R groups may be located **very far apart in the polypeptide chain** and **brought close together** by the **folding** of the polypeptide.



Tertiary structure

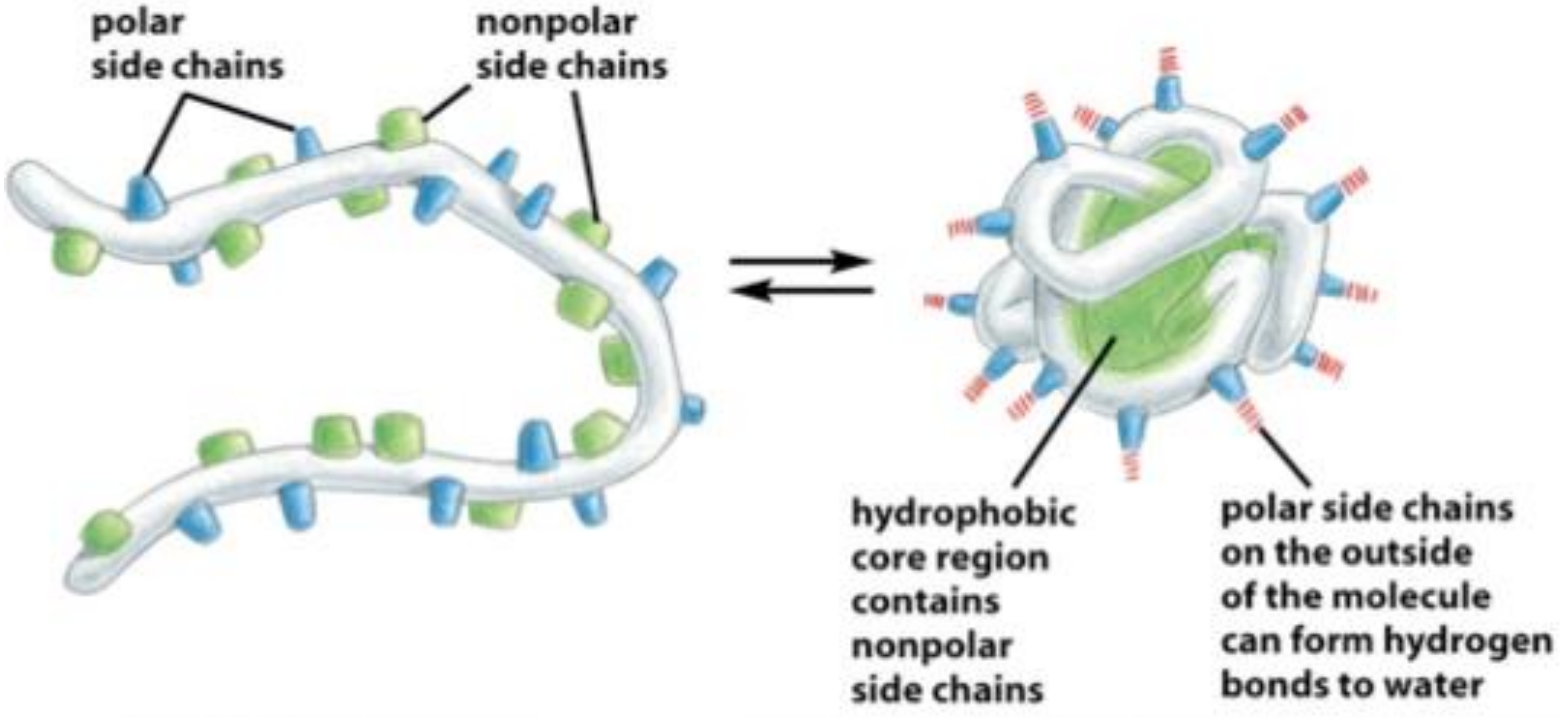
Water-soluble globular proteins fold spontaneously

so that

majority of its hydrophobic side chains of non-polar a.a are buried in the interior

majority of polar, charged side chains of polar and charged a.a. are on the surface

Tertiary structure



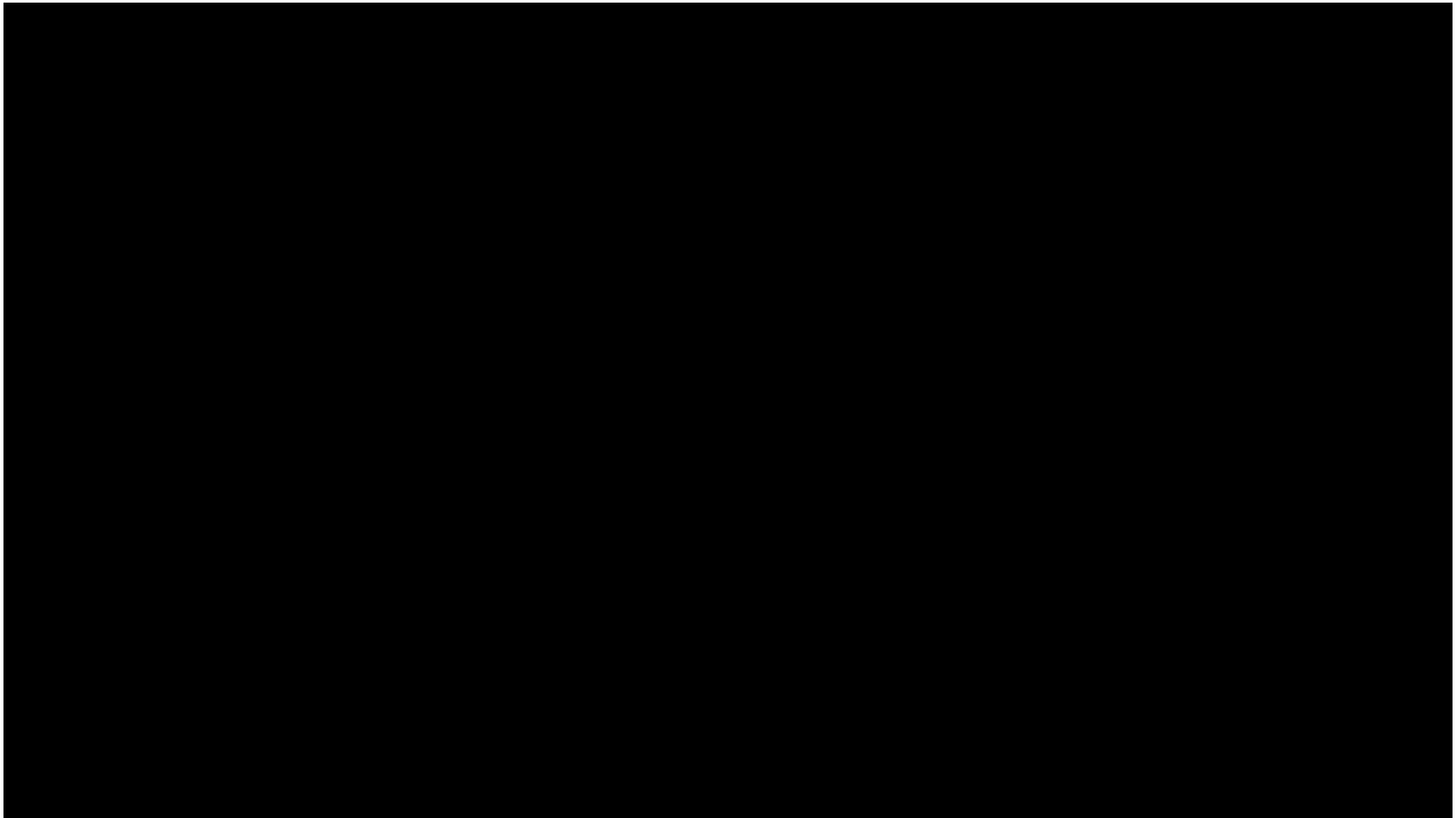
Tertiary structure

Once folded, the 3-dimensional biologically active conformation of the protein is maintained by the **four types of bonds**

What are they?

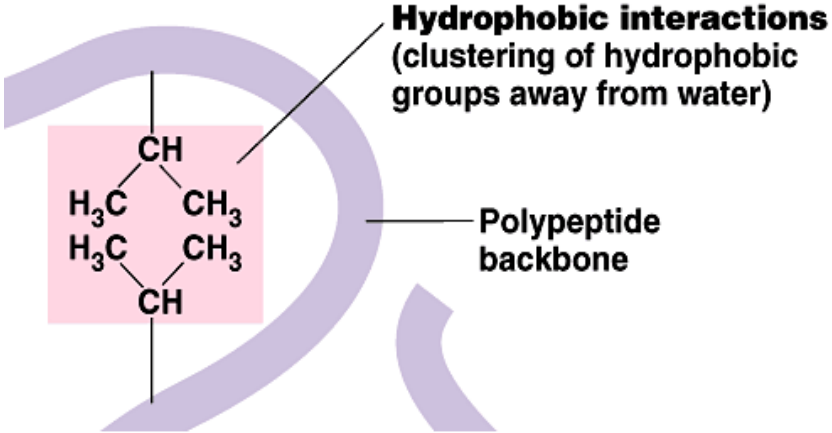
Video: Protein folding

https://youtu.be/hok2hyED9go



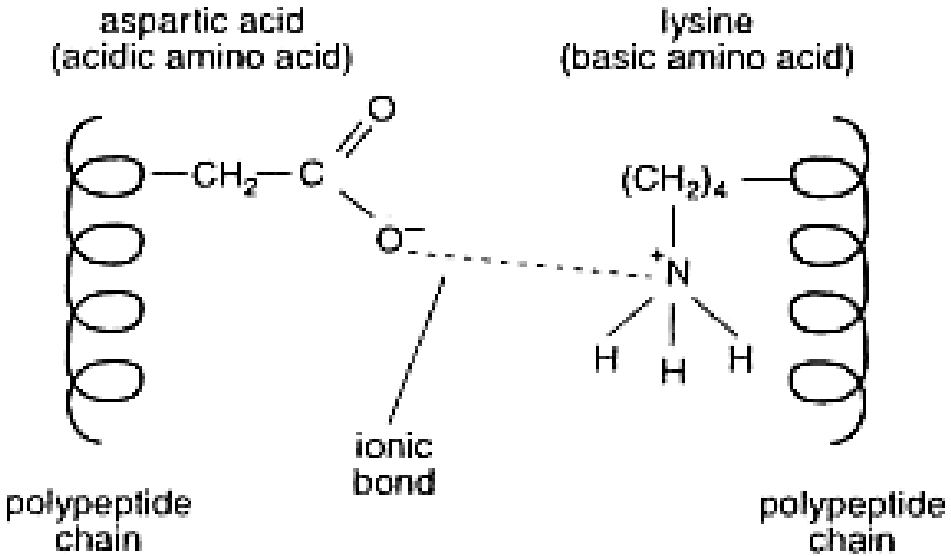
Hydrophobic interactions

During polypeptide folding, hydrophobic R groups will cluster at interior of protein, out of contact with water



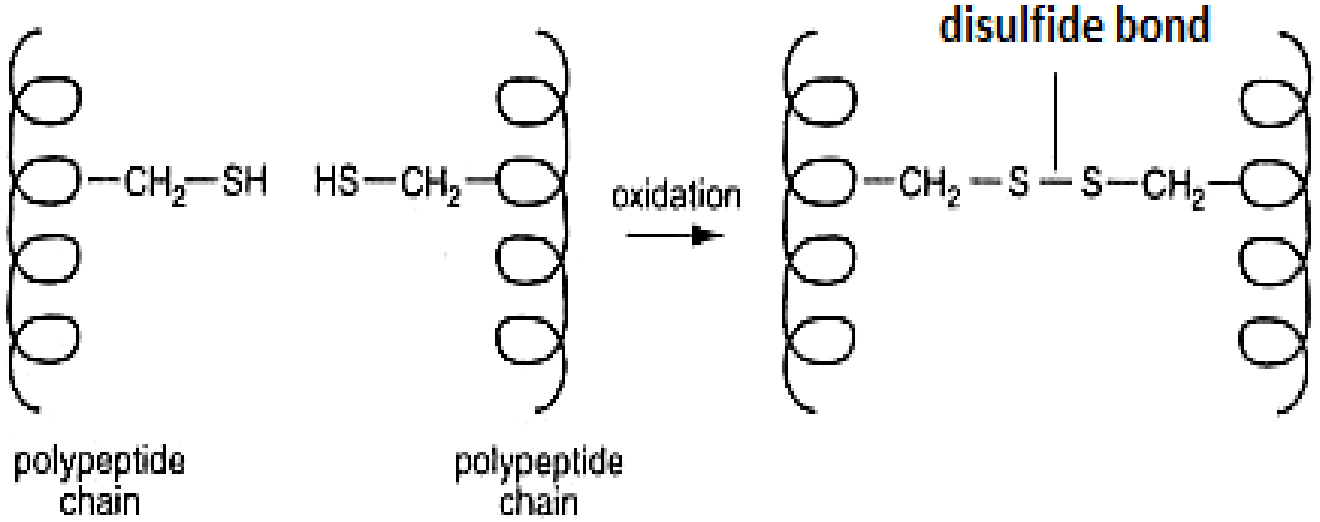
Ionic bonds

Formed between acidic (-ve) & basic (+ve) R groups

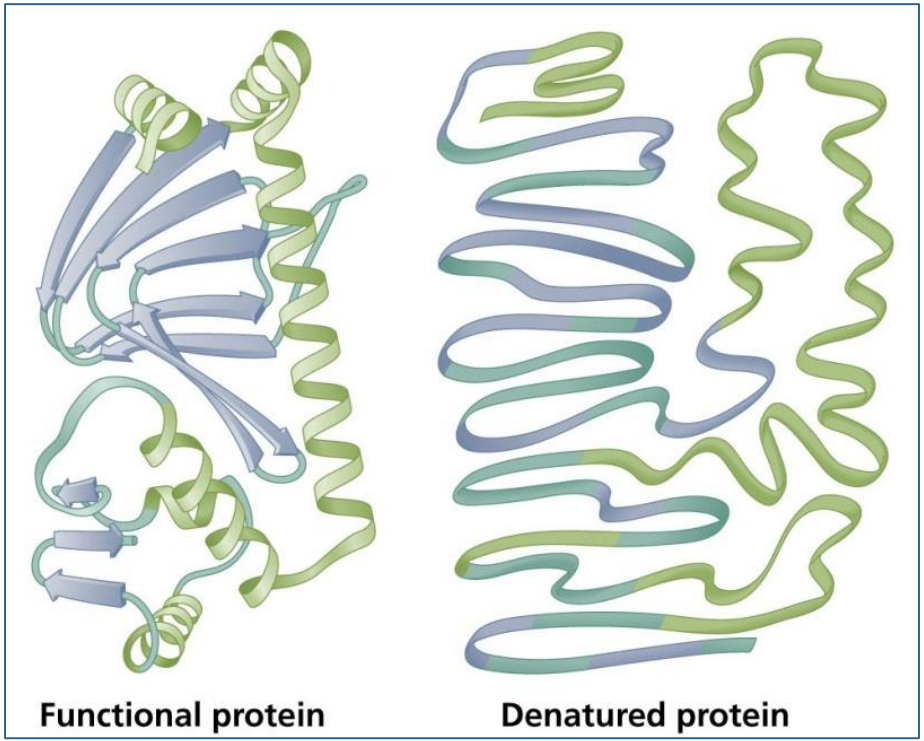


Disulfide bonds

Formed between two –SH groups of cysteine residues



Denaturation



Denaturation

- Loss of / alteration of the **specific 3D conformation** of a protein molecule
- May be permanent or temporary
- 1° structure remains unchanged
- Once denaturation occurs, the protein molecule unfolds & loses normal biological function.

Denaturation

Caused by the following factors :

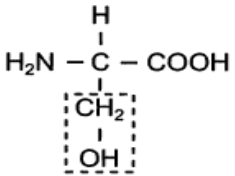
- **High temperature**
- **pH alteration**
- UV irradiation
- High ionic concentration
- Heavy metals
- Organic solvents

Tutorial 2: Proteins MCQ 1

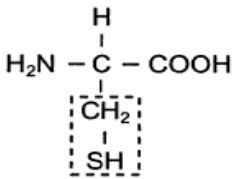
The diagram shows four different amino acids, each with a different R group (side chain).

Which amino acids could form a hydrophobic interaction between their R groups?

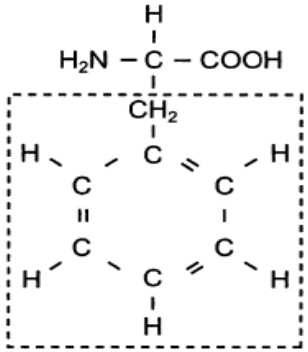
1



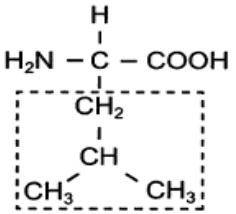
2



3



4



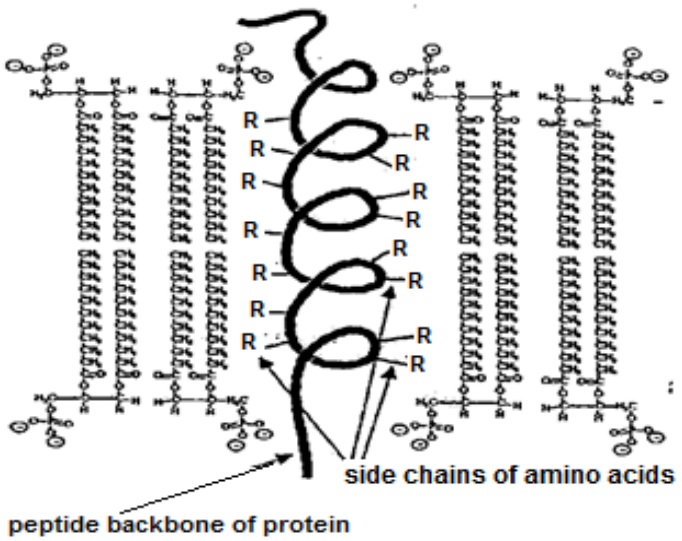
Tutorial 2: Proteins MCQ 1

Which amino acids could form a hydrophobic interaction between their R groups?

A	1 and 2
B	1 and 3
C	2 and 4
D	3 and 4

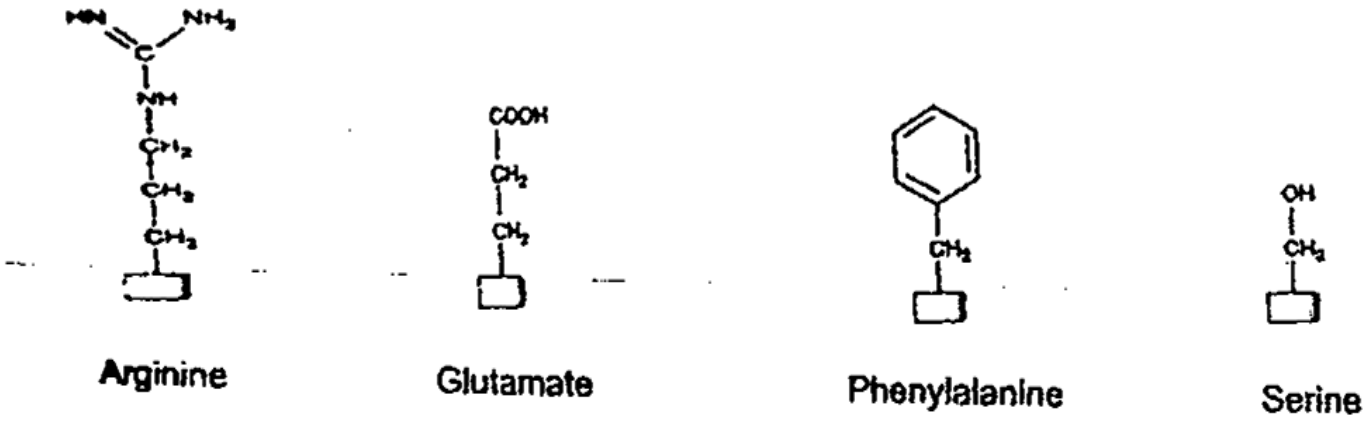
Tutorial 2: Proteins MCQ 2

✢With reference to the figure, which one of the following amino acids, with only the side chains indicated, is likely to be found at any of the positions protruding from the peptide backbone of the protein?



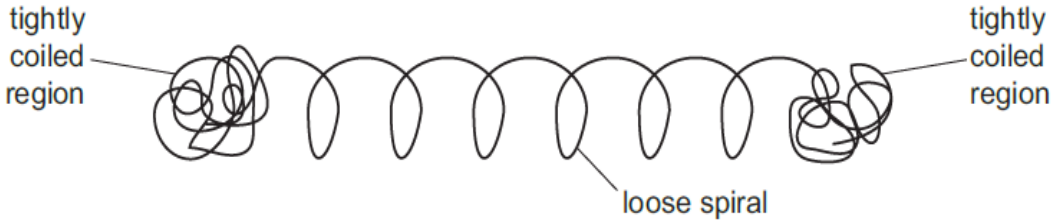
Tutorial 2: Proteins MCQ 2

A	Arginine
B	Glutamate
C	Phenylalanine
D	Serine



Tutorial 2: Proteins MCQ 5

- The protein glutenin gives bread dough its elasticity. The diagram represents a polypeptide of glutenin.



- What describes the structure of glutenin?

A	secondary structure because the loose spiral is an α-helix
B	tertiary structure because the different regions form a 3D shape
C	quaternary structure because there are both globular and fibrous regions
D	quaternary structure because there are both spiral and tightly coiled regions

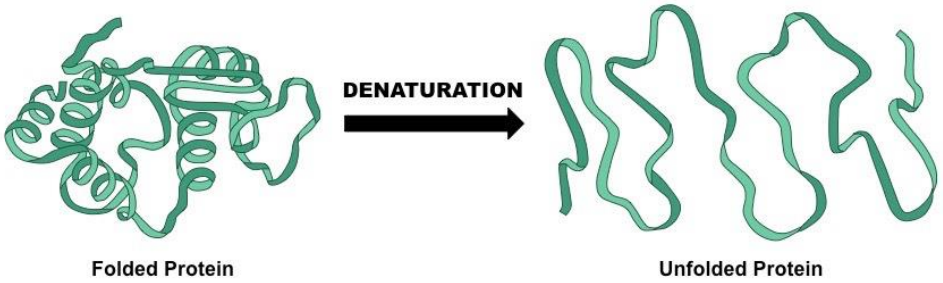
Learning Outcome

1(l) ***Explain*** *the effects of* ***temperature*** *and* ***pH*** *on protein structure.*

Denaturation by high temperature

At high temperature, protein gains **kinetic energy**

Thermal agitation disrupts **hydrogen, ionic bonds & hydrophobic interactions**



Loses specific 3D conformation & biological function

Denaturation by alteration of pH

Δ in pH alters $[H^+]$ & $[OH^-]$ in environment

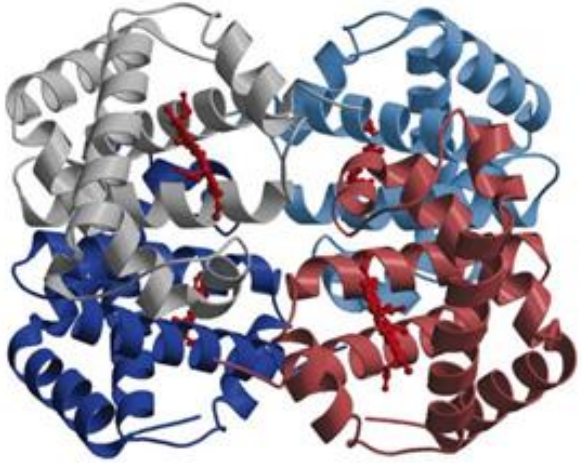
→ **Alters ionic charges** of acidic & basic R groups

→ **disrupts ionic & hydrogen bonds**

→ Loses specific 3D conformation & biological function

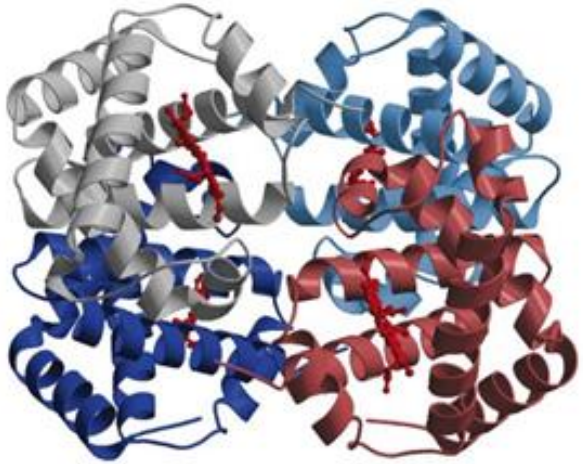
Quaternary structure

Refers to arrangement of polypeptide subunits within a protein that is made up of **more than one polypeptide chains**



Quaternary structure

i.e. spatial arrangement of **more than one polypeptide chain**



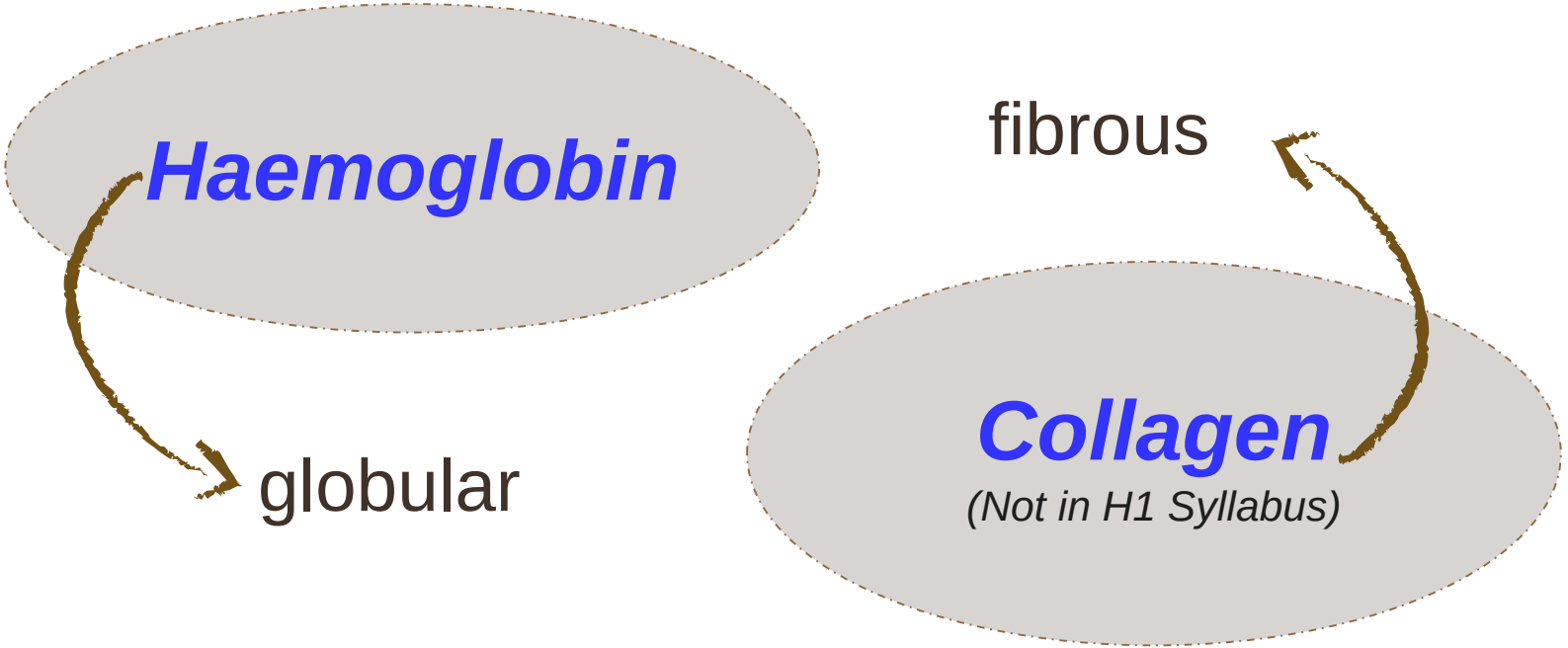
Quaternary structure

Bonds involved :

- ※ Same as those in tertiary structure
- ※ But they form between R groups of **different polypeptide chains in the same protein**

Quaternary structure

Examples:



Quick summary

Level of organisation	Bonds holding molecule in shape	Formed between …
Primary	Peptide bonds	NH_2 & COOH groups of adjacent amino acids
Secondary	Hydrogen bonds	-CO & -NH of peptide bonds
Tertiary	Ionic bonds Hydrogen bonds Disulfide bonds Hydrophobic interactions	R groups of amino acids within same polypeptide
Quaternary	Ionic bonds Hydrogen bonds Disulfide bonds Hydrophobic interactions	R groups of amino acids of different polypeptides

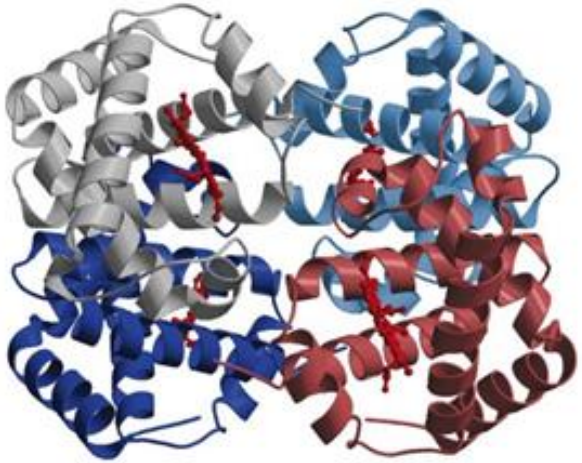
1. **Amino acids**
2. **Formation of peptide bonds**
3. **Levels of organisations in proteins**
   - A. Primary Structure
   - B. Secondary Structure
   - C. Tertiary Structure
   - D. Quaternary Structure
4. **Case Studies: Haemoglobin**

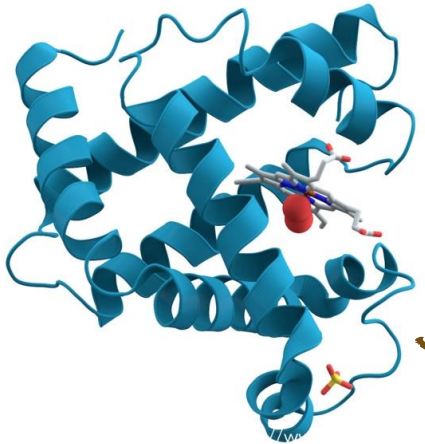
Learning Outcome

*1(m) Describe the **molecular structure** of the **haemoglobin** protein and explain how its structure relates to **its function** in transport*

Haemoglobin

- Haemoglobin is one of two oxygen-binding **proteins** found in vertebrates.
- It is found exclusively in **red blood cells**.



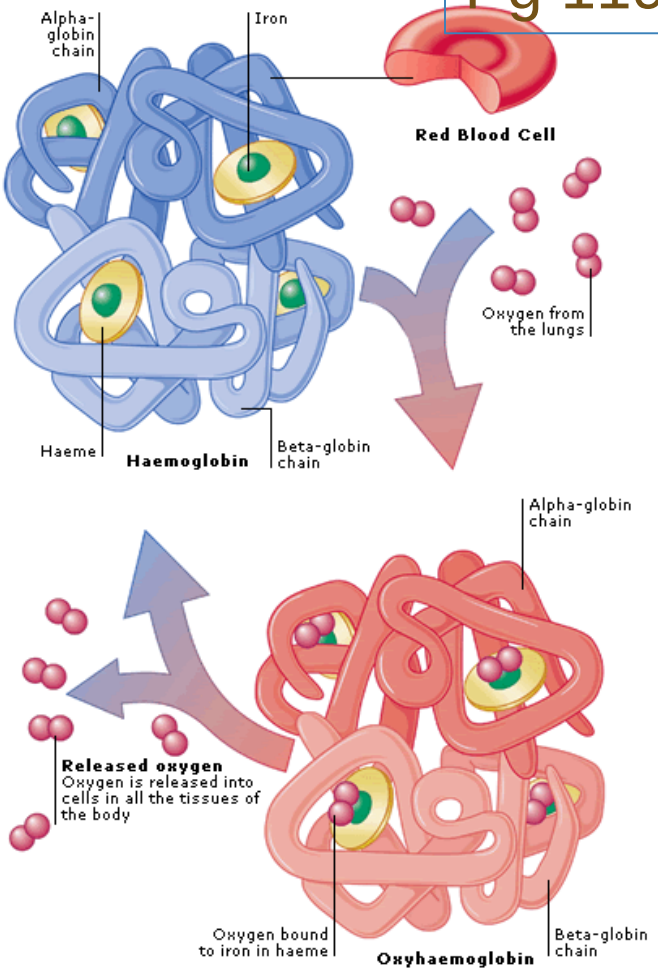


Myoglobin

Haemoglobin

Function:

A transport protein, it **carries** O_2 in the blood from the lungs to the capillaries of tissues, in order to supply cells with O_2.

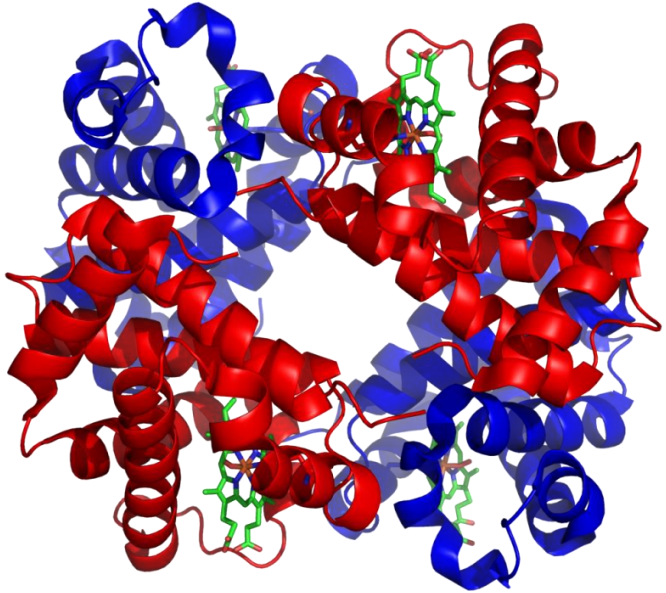


Haemoglobin Structure

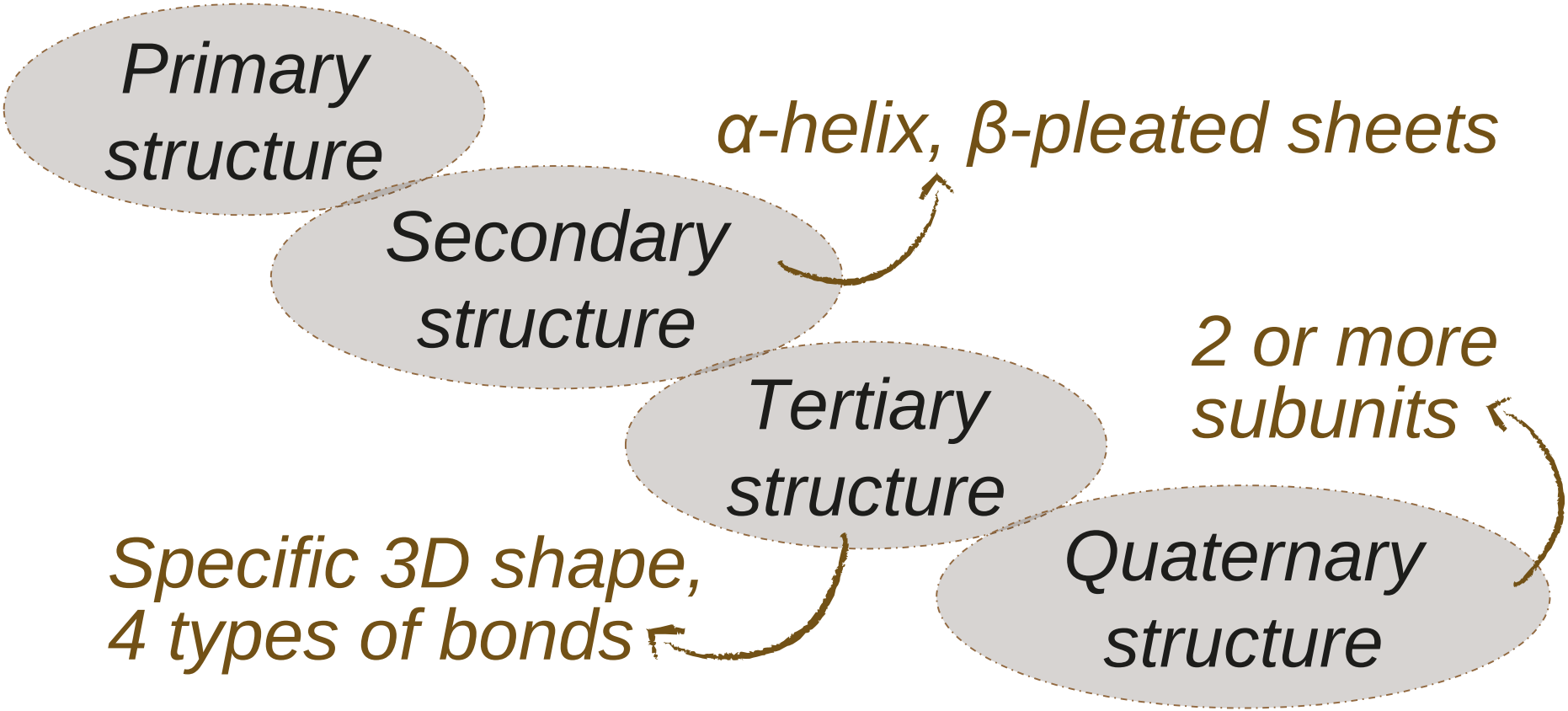
Quaternary – 4 subunits (each subunit has tertiary structure)

2 α -chains & 2 β -chains subunits

Each chain is primarily α-helical

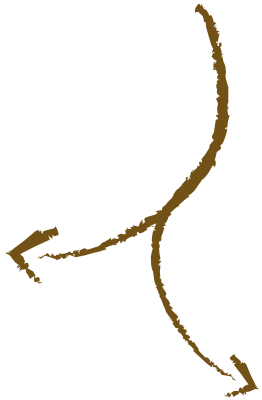


RECAP


Primary structure
Secondary structure
α-helix, β-pleated sheets
Tertiary structure
Specific 3D shape, 4 types of bonds
Quaternary structure
2 or more subunits

Haemoglobin Structure

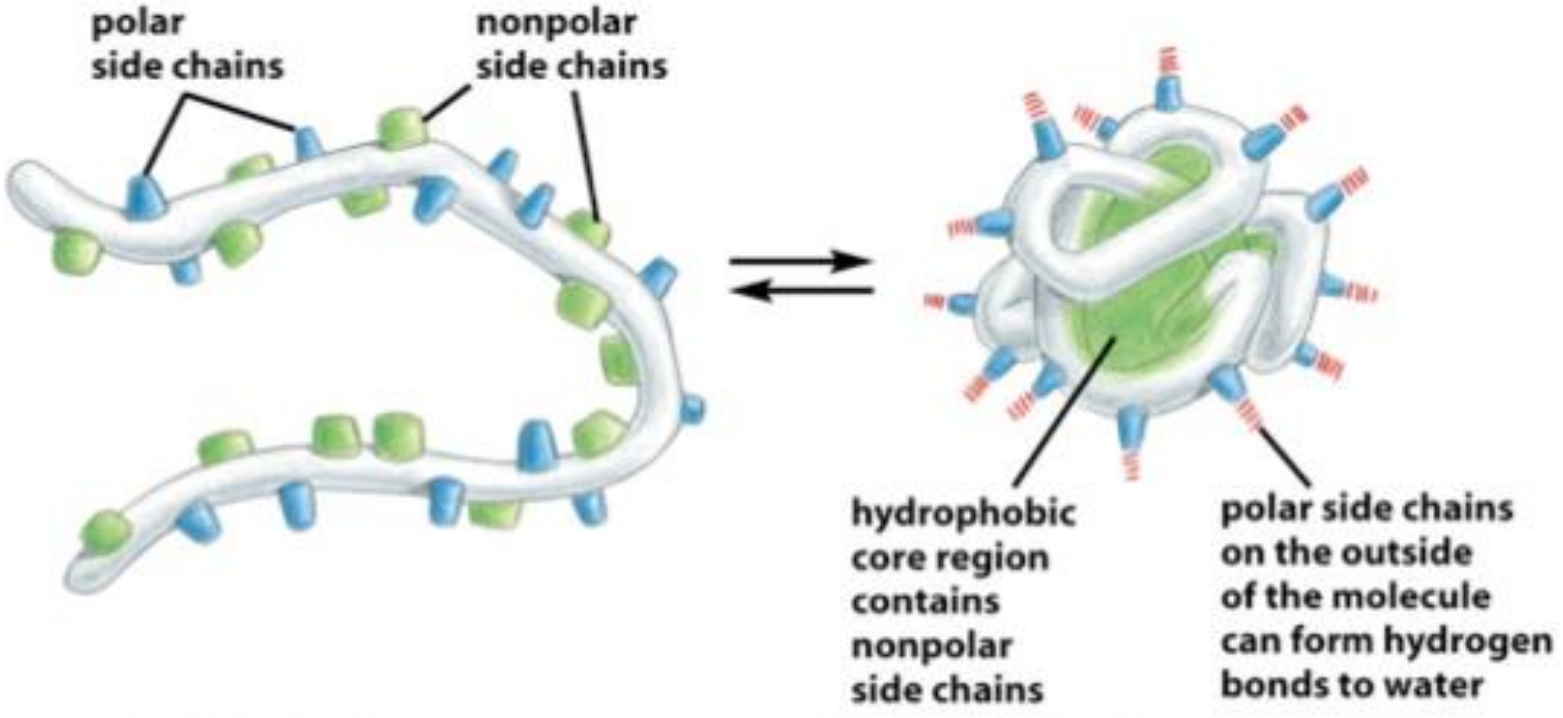
Each polypeptide has hydrophobic & hydrophilic a.a. residues



3° structure folded so that **non-polar** R groups are buried in the **interior**

Polar & charged R groups are on the **surface**

Tertiary structure



Haemoglobin Structure

Within & between the 4 subunits

Held together by

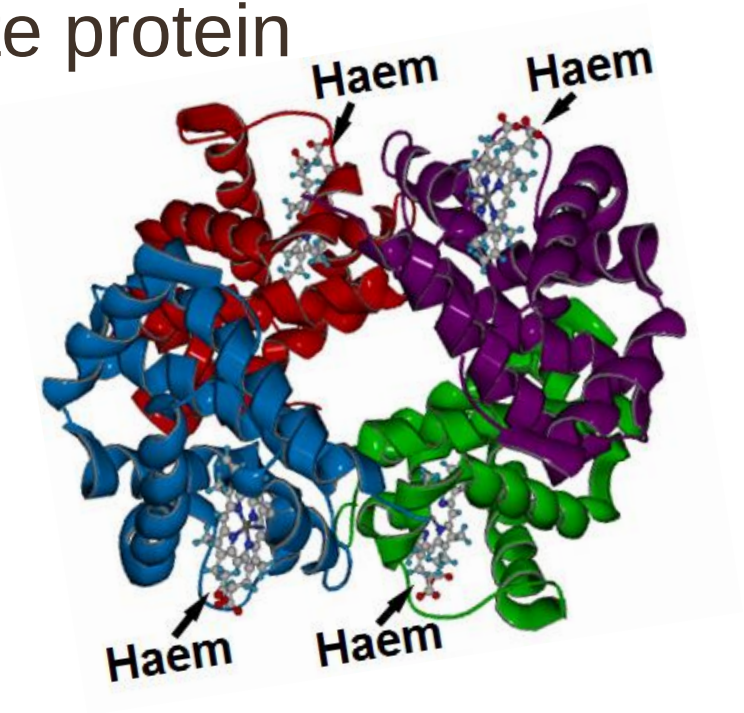
Hydrophobic interactions, ionic & hydrogen bonds

No disulfide bonds!!

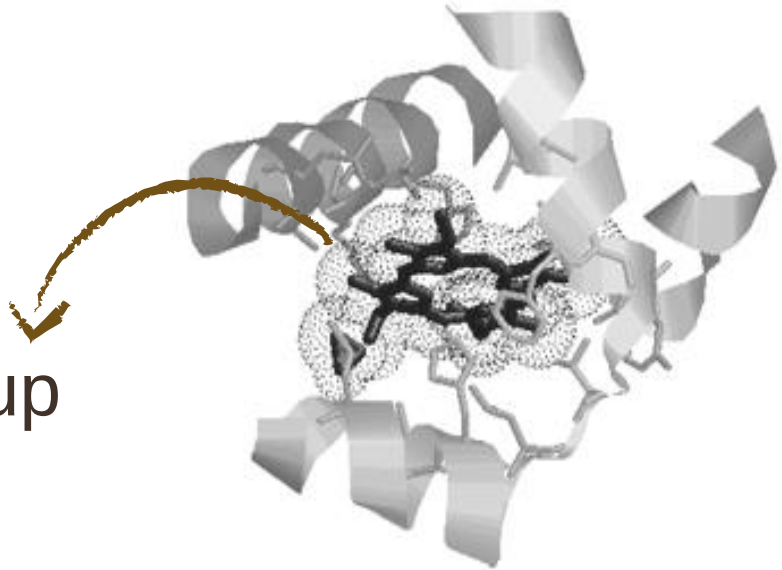
Haemoglobin Structure

Each subunit is a conjugate protein

Contains **haem prosthetic group**



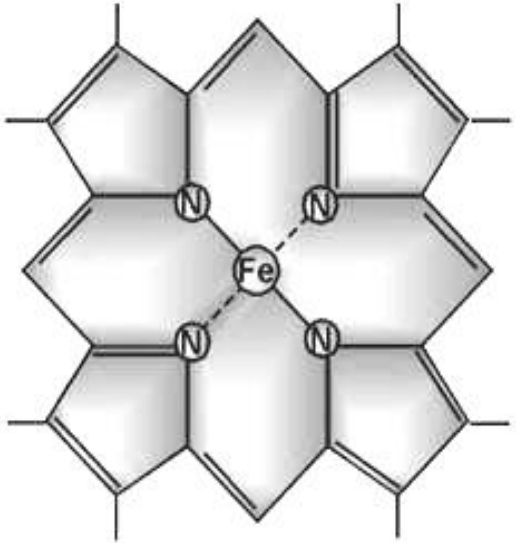
Haem-binding site



Haem group

Porphyrin ring & Fe^{2+}

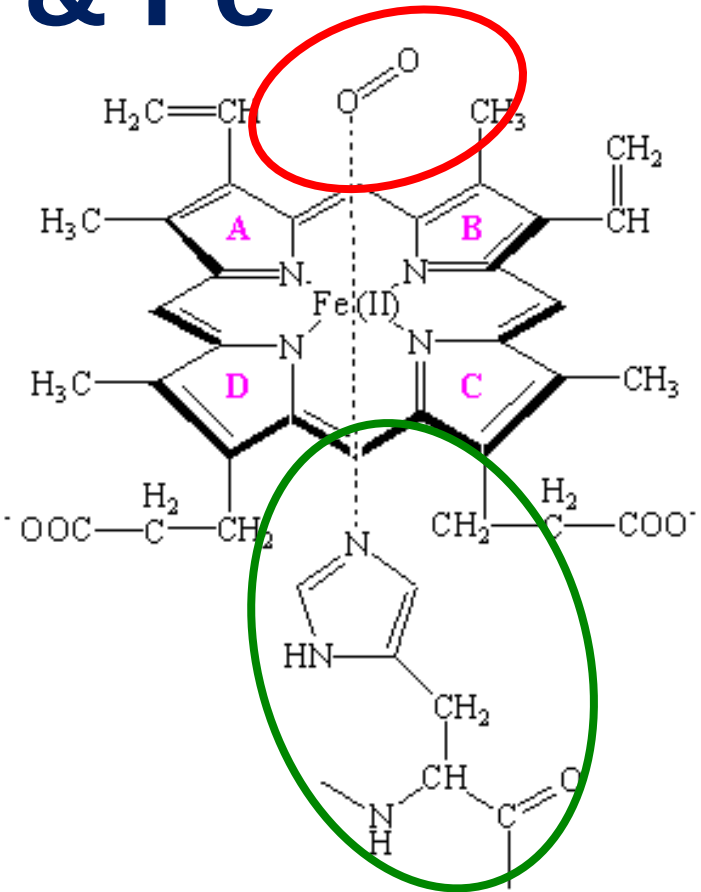
Haem group = a porphyrin ring + Fe^{2+}



Porphyrin ring & Fe^{2+}

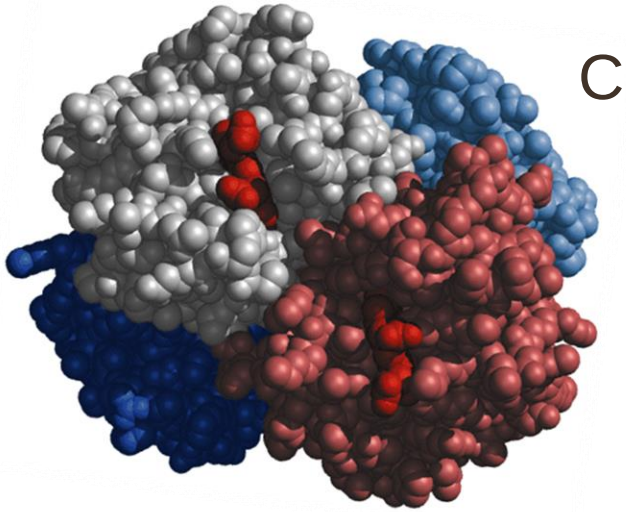
Fe^{2+} is at the center of the planar porphyrin ring.

The haem is orientated so that its Fe^{2+} on **one face is complexed to an a.a. residue**, while the **other face is accessible for O_2 binding.**



Haemoglobin Structure

Globular structure



Compact

More oxygen transported

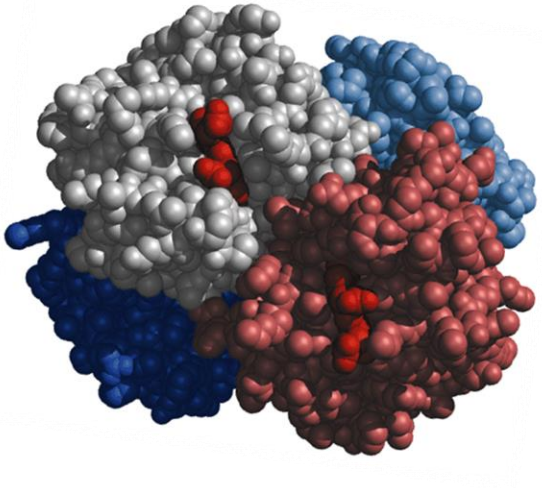
hence

Many Hb molecules can be packed into a RBC

Haemoglobin Structure

4 subunits

Each bind 1 oxygen molecule



Increases capacity for transport of oxygen.

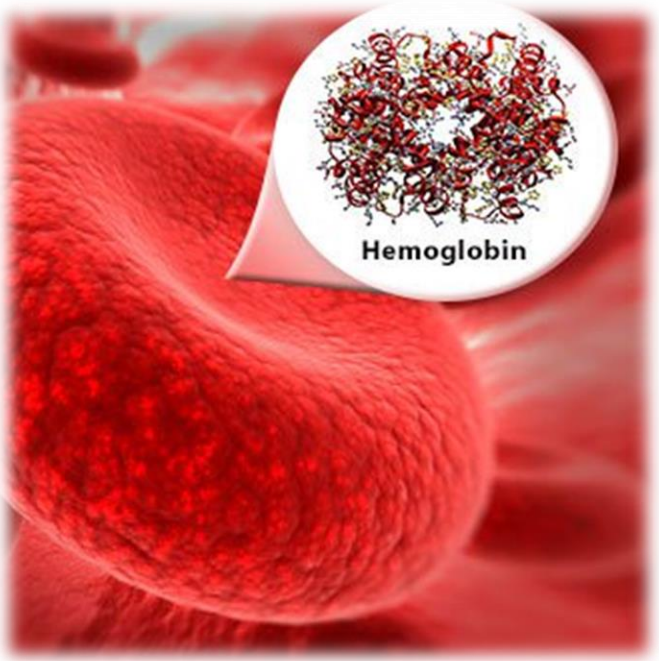
More oxygen transported

Haemoglobin Structure

Globular structure with a hydrophobic core and a hydrophilic exterior.

Hb soluble in RBC cytoplasm

A good transport protein for O_2 in blood



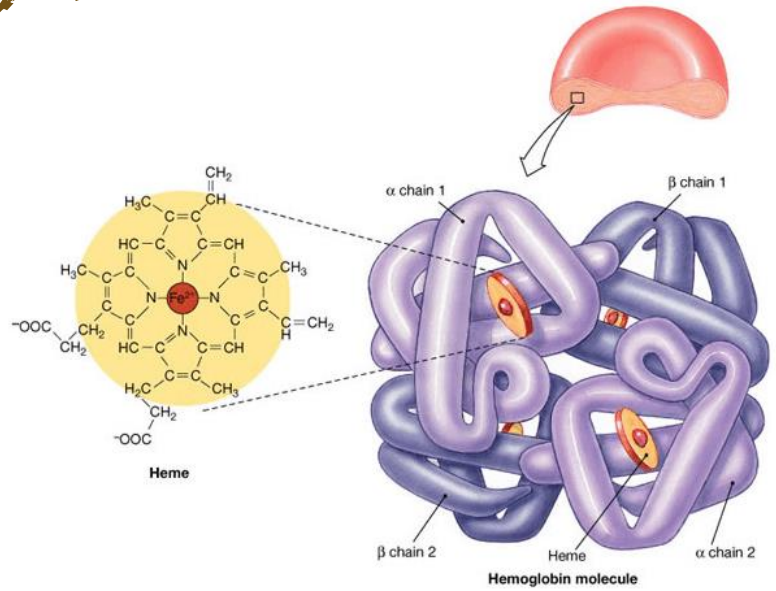
Haemoglobin Structure

Haem-binding site in each subunit

for binding of

Haem group (hydrophobic)

Lined with non-polar a.a. residues

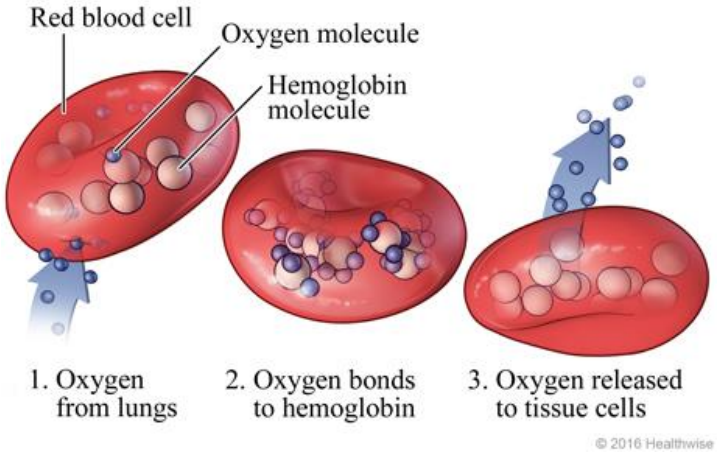


Haemoglobin Structure

Haem group (hydrophobic)

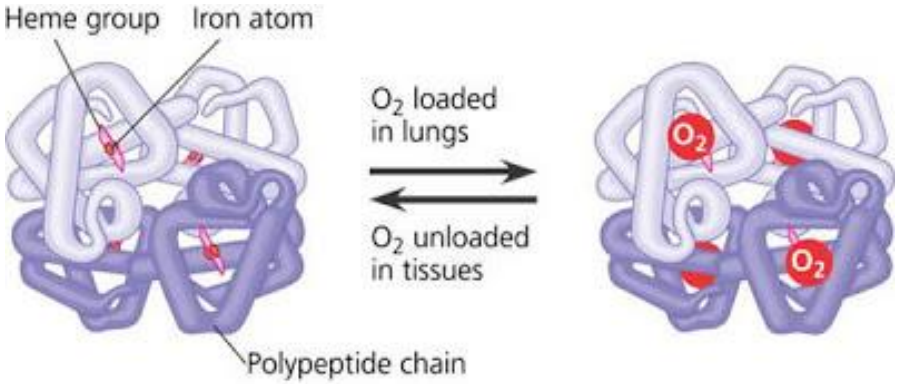
Allows **reversible binding of oxygen,** enhancing release in metabolically active tissues

porphyrin ring bound to an iron ion



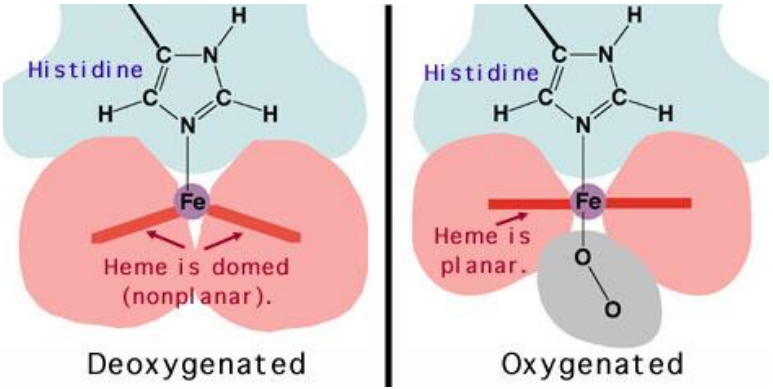
Cooperative binding

- Each Hb molecule consists of four subunits, each capable of binding <u>one</u> O_2
- This greatly facilitates <u>transport of</u> O_2 by Hb.



Cooperative binding

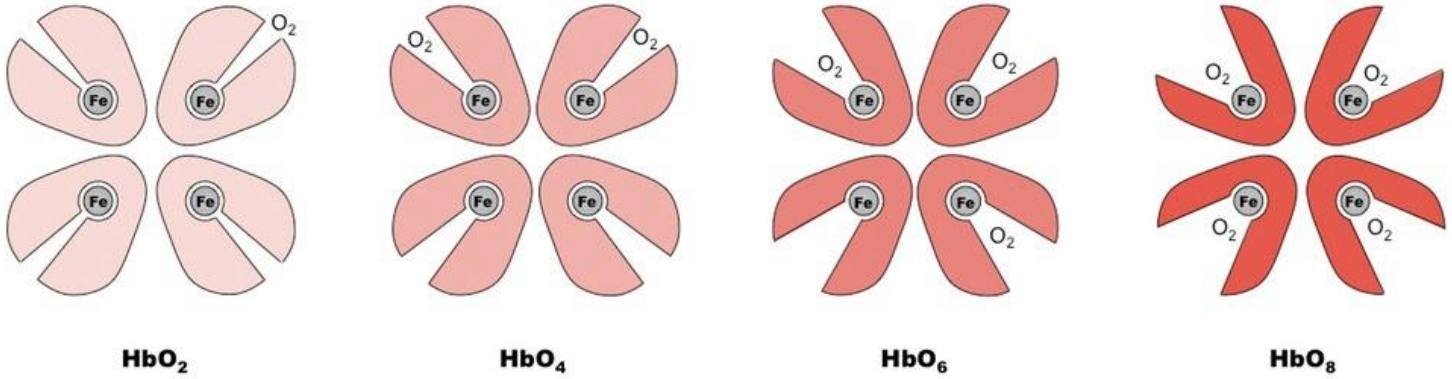
Binding of one O_2 molecule to one subunit induces the remaining unfilled subunits to **change their shape slightly** so that their **affinity for O_2 increases**.



Loading of the first O_2 molecule results in rapid loading of 3 more O_2

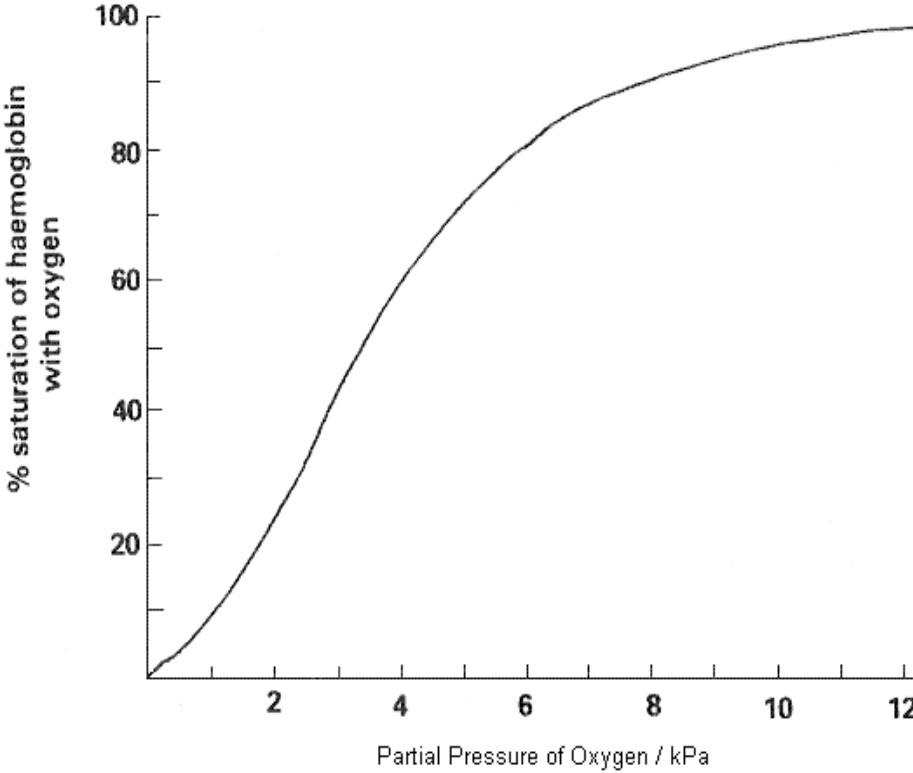
Cooperative binding

- Binding of O_2 to haemoglobin is said to be **cooperative**
- Conversely, when one subunit unloads O_2, the other three more readily unload as a conformation change lowers their affinity of O_2.

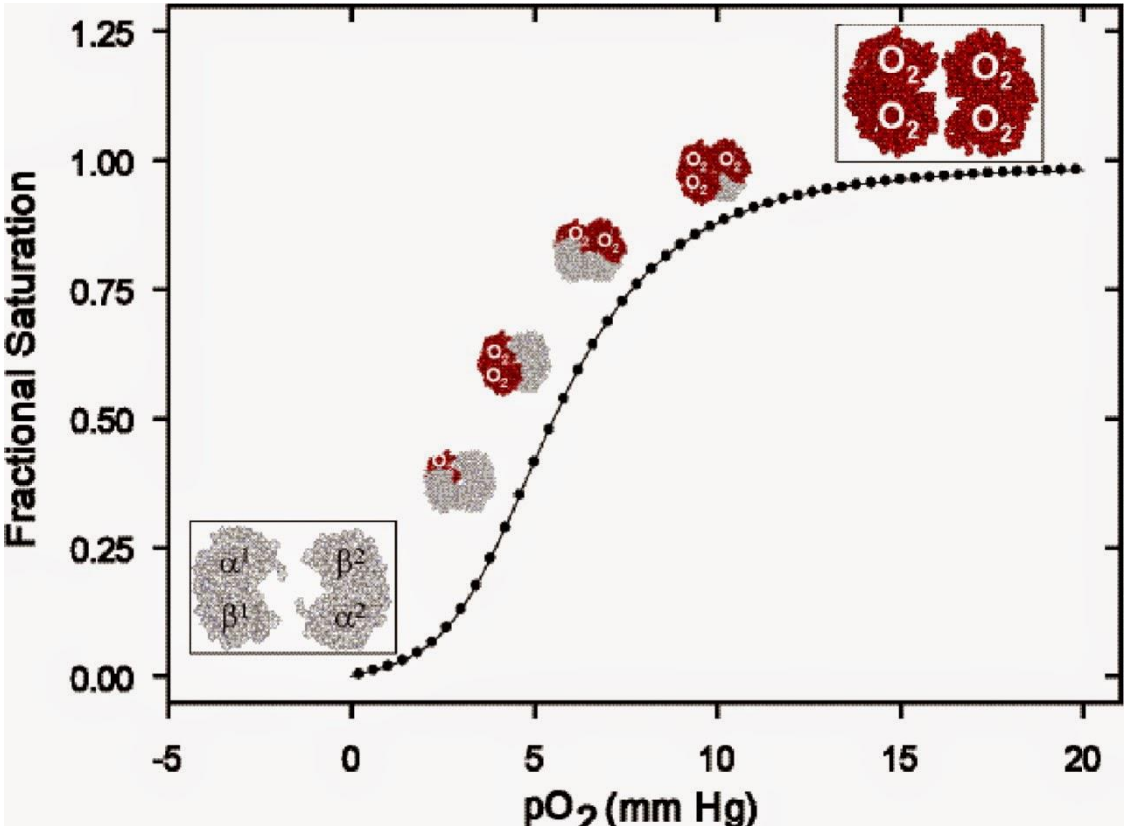


Cooperative binding

The oxygen dissociation curve of haemoglobin has a steep slope (**S-shaped or sigmoid**), as even a slight change in the $[O_2]$ causes haemoglobin to load/unload a substantial amount of O_2

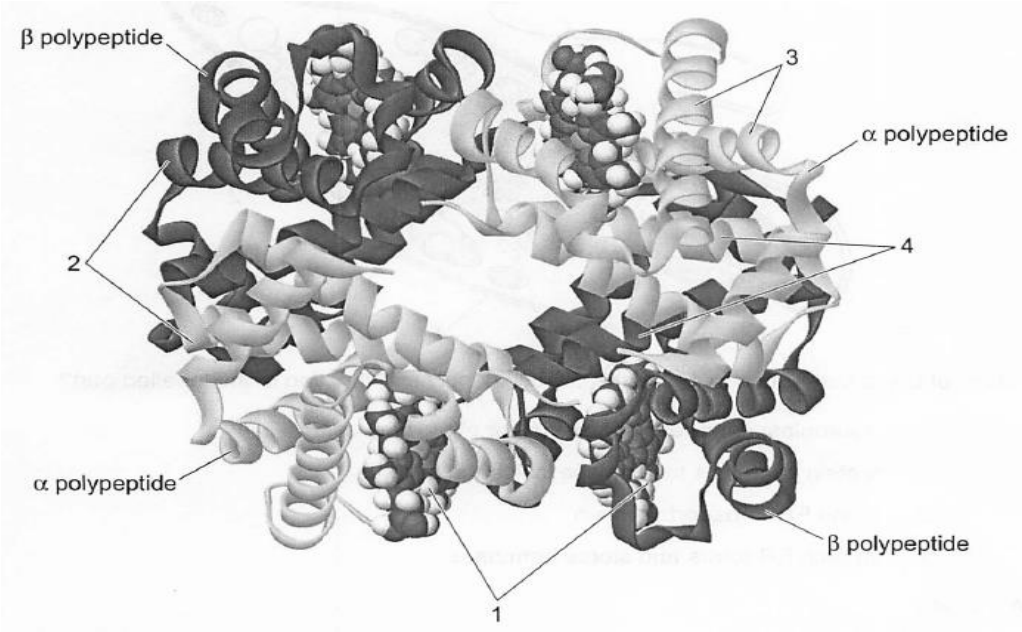


Cooperative binding



Tutorial 2: Proteins MCQ 6

- The diagram shows a haemoglobin molecule.
- Which identifies the different parts of the molecule?



Tutorial 2: Proteins MCQ 6

Which identifies the different parts of the molecule?

	1	2	3	4
A	alpha helix	beta pleated sheet	binding site	hydrophobic amino acids
B	hydrophobic amino acids	beta pleated sheet	prosthetic group	binding site
C	prosthetic group	hydrophobic amino acids	alpha helix	hydrophilic amino acids
D	prosthetic group	hydrophilic amino acids	alpha helix	hydrophobic amino acids

Video