# biochemistry

## proteins

Amino acids are the building blocks (monomers) of which proteins (polypeptides) are made up.

Simple proteins are linear polymers of 2-amino acids. The structural units of proteins are joined together by amide linkages (also known as peptide bonds) in strict order and orientation.

## proteins

Most proteins contain several hundred to several thousand structural units.

Shorter polymers composed of less than 20 residues of 2-amino acids are called peptides.

## proteins

From more than 500 naturally occurring amino acids, only 20 are proteinogenic, that is, used by living organisms as building blocks of proteins.

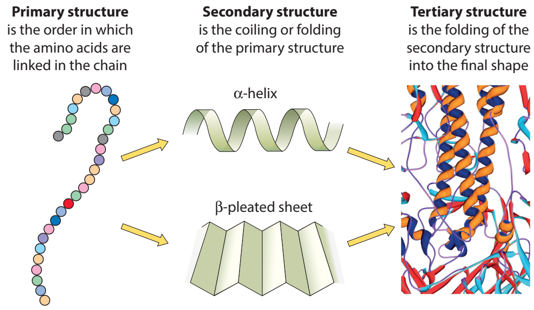
There are approximately a million different proteins in the body, and these differ only in the number and sequence of amino acids in their chains.

## proteins

The sequence of amino acids determines the overall structure (and therefore function) of the protein;

it allows the protein to exist in a particular shape, this shape being maintained by bonds and forces between the different amino acids in the chain.

## the structure of proteins



**Primary structure**
is the order in which
the amino acids are
linked in the chain

**Secondary structure**
is the coiling or folding
of the primary structure

**Tertiary structure**
is the folding of the
secondary structure
into the final shape

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## the structure of proteins

The order of amino acids along the polypeptide chain of a protein is described as its ***primary structure***.

Once the primary structure has formed, the protein chain automatically forms a precise shape. First, the chain folds or twists itself into the ***secondary structure***, which is usually either a helix (coil) or a sheet.

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## the structure of proteins

The secondary structure then folds further to form a tertiary structure.

This folding happens spontaneously because of intermolecular forces between different parts of the chain.

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## the structure of proteins

**Primary structure** is the order of amino acids in a protein chain.

**Secondary structure** is the coiling or folding of chains into a helix or sheet.

**Tertiary structure** is the folding of helices and sheets into the final shape.

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## primary structure

The exact sequence of amino acid residues joined together by peptide linkages is known as the primary structure of a protein.

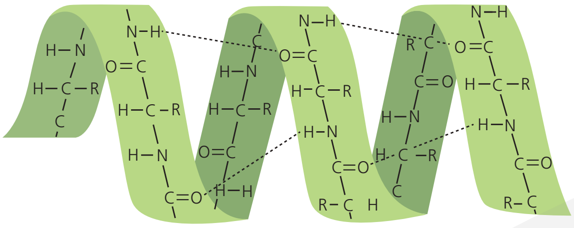
**Gly-Lys-Cys-Gly-Ser-Ala-Ala**

## 11 secondary structure

Primary structures usually fold themselves into one of two secondary structures.

The α-helix is a tight coil with the R groups sticking out from the coiled polypeptide chain. The coil is held together by hydrogen bonding between NH and CO groups along the polypeptide chain.

## 12 α-helix

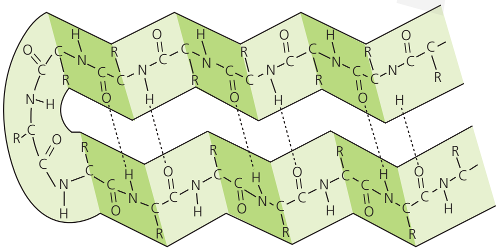


α-helix

## 13 β-sheets

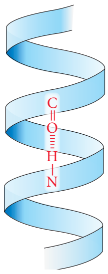
The β-pleated sheet is a flat sheet made from polypeptide chains lying alongside each other and held together by hydrogen bonds.

## 14 β-sheets

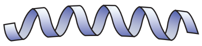


β-pleated sheet

## 15 secondary structure

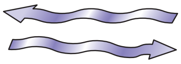


α-helix



Shorthand representation

β-pleated sheet

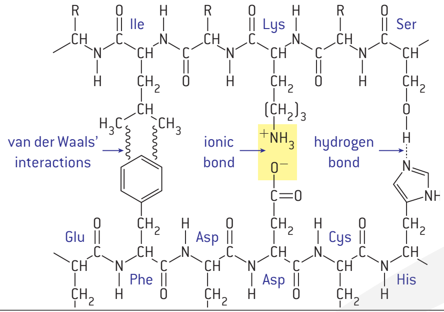


Shorthand representation

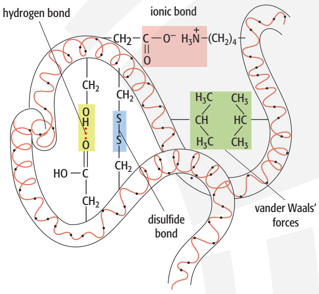
## 16 tertiary structure

While the secondary structure of proteins is stabilized exclusively by the hydrogen bonds between peptide linkages, the side-chains of amino acid residues can also participate in various types of intra- and intermolecular interactions.

## 17 tertiary structure



## 18 tertiary structure



## 19 tertiary structure

For example, two non-polar or slightly polar side-chains (such as $-CH_2CH(CH_3)_2$ in leucine or $-CH_2C_6H_5$ in phenylalanine) can interact via weak van der Waals' forces.

## 20 tertiary structure

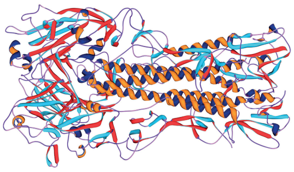
Oppositely charged ionized groups (such as $-CH_2-CO_2^-$ in aspartic acid and $-(CH_2)_4NH_3^+$ in lysine) can experience electrostatic attraction and form ionic bonds.

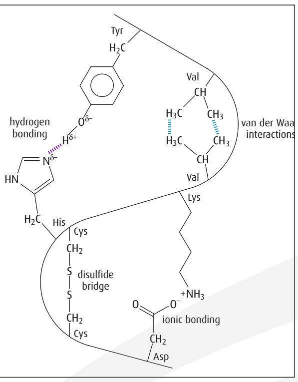
Hydrogen bonds are often formed between non-ionized hydroxyl and/or amino groups.

## 21 tertiary structure

Covalent bonds, like disulfide bridges, can also be formed between between two –SH groups of cysteine residues.

## 22 tertiary structure





## 23 tertiary structure

The tertiary structure of a protein is held together by:

- hydrogen bonds,
- permanent dipole and induced dipole attractions,
- ionic attractions between $CO_2^-$ and $NH_3^+$ on the R side chains,
- disulfide (– S – S – ) bridges between neighbouring Cys residues.

## 24 tertiary structure

These bonds work together to stabilise the protein in exactly the right shape.

Understanding the three-dimensional structure of a protein molecule (tertiary structure) is very important, because it helps scientists to explain how the protein functions.

## 25 tertiary structure

Most proteins contain a combination of helixes and sheets, folded together into a tertiary structure with the exact final shape.

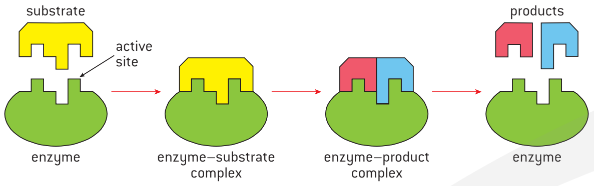
## 26 enzymes

Enzymes are biological catalysts which are far more efficient than most inorganic catalysts.

Enzymes are also highly specific, meaning that they catalyse only one type of reaction with a specific type of reactant, called the substrate.

## 27 lock & key

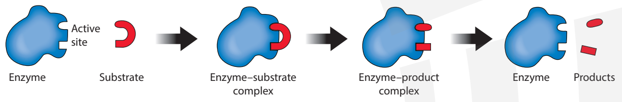
The lock and key model is a simple explanation of enzyme action.



## 28 lock & key

Enzymes have a precise molecular shape.

The enzyme has a particular location on its surface, called the active site, into which molecules of substrate fit exactly.



## 29 lock & key

The active site is shaped exactly to fit the particular shape of the substrate molecule, but no other. An enzyme may have more than one active site.

The substrate binds to the active site by intermolecular attractions such as hydrogen bonding.

## 30 lock & key

This weakens bonds in the substrate so they break more easily, or it may bring atoms in the substrate into the correct configuration for reaction.

The substrate is converted to products at the active site, which then leave the enzyme, so it is free to accept another substrate molecule.

## 31 lock & key

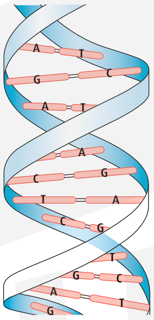
Locks and keys are complementary structures and this would also explain enzyme specificity. Only one substrate will fit into the active site, just as only one key fits a lock.

## 32 DNA

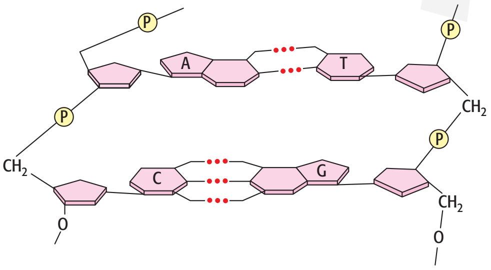
DNA molecules consist of two polynucleotide strands in which each nitrogenous base from one strand forms a complementary pair with a nitrogenous base from another strand.

## 33 DNA

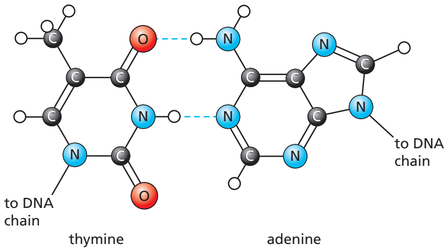
The double-helix shape of the DNA molecule is stabilized by hydrogen bonds between complementary nitrogenous bases.



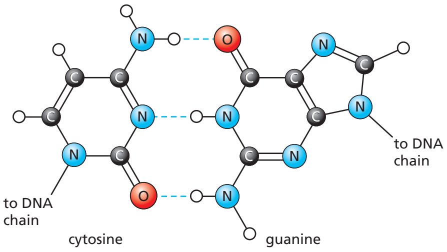
## 34 DNA



## 35 base pairs



## 36 base pairs



## 37 dna replication

When a cell divides to form two new cells, it needs to pass on an exact copy of the DNA in its nucleus.

So DNA must have a mechanism for making exact copies of itself. This is where the ‘double helix’ structure of DNA comes in.

## 38 dna replication

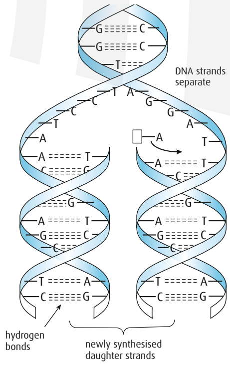
The two helices are held together by hydrogen bonds between pairs of neighbouring bases.

As a cell divides into two, the two coils of DNA separate, and the two halves quickly build a new matching coil alongside each separated coil.

## 39 dna replication

the two halves quickly build a new matching coil alongside each separated coil.

Two new double helices are produced.



## 40 dna replication