Polymer Molecules

Condensation and
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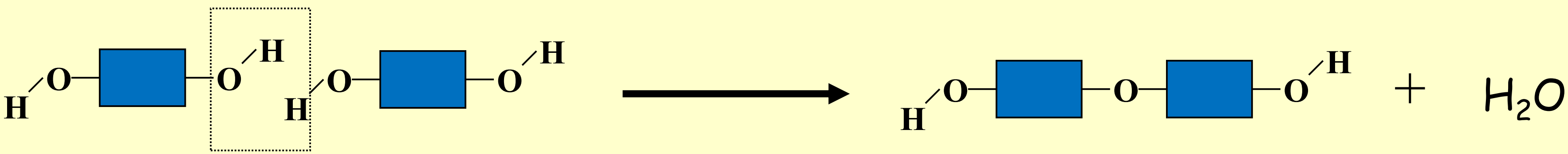
Condensation Polymers

Polymers are very large molecules made by joining small molecules called monomers, into long chains or networks.

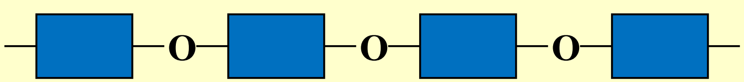
Condensation polymers are made from monomers with two functional groups which can be the same or different.

Starch is made by polymerisation of about 300 glucose molecules



Glucose **Glucose** **Maltose**

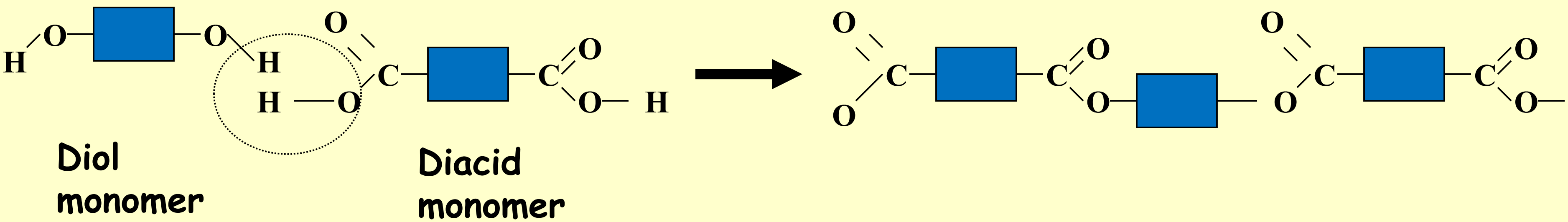
The adding together of monomers to make a polymer is called polymerisation.



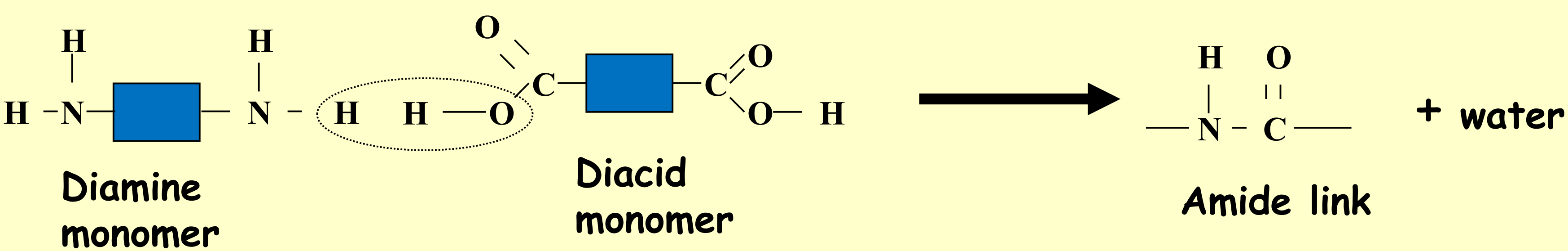
Starch

Polyesters and Polyamides

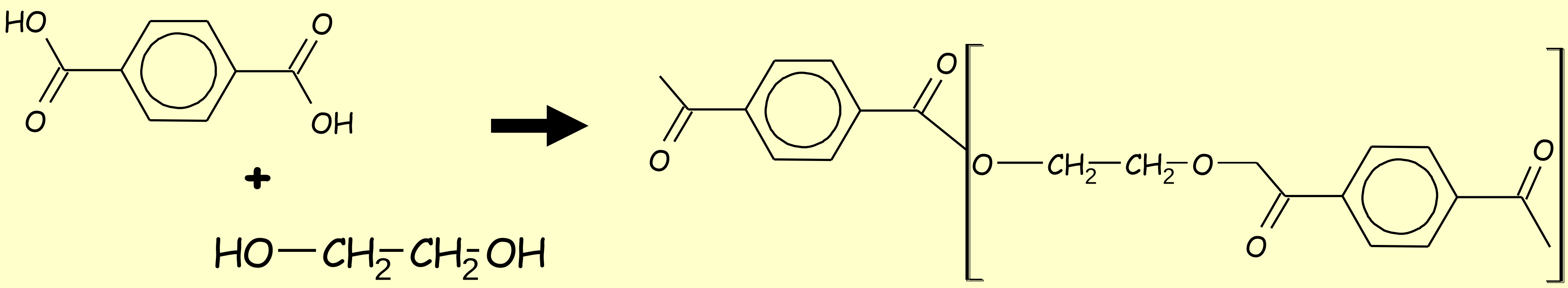
Polyesters are examples of condensation polymers and are formed when a carboxylic acid **monomer** reacts with an alcohol **monomer**.



Polyamides (eg Nylon and Kevlar) are formed when an amide link is formed by the reaction of an amino functional group with a carboxyl group.



Condensation Polymers

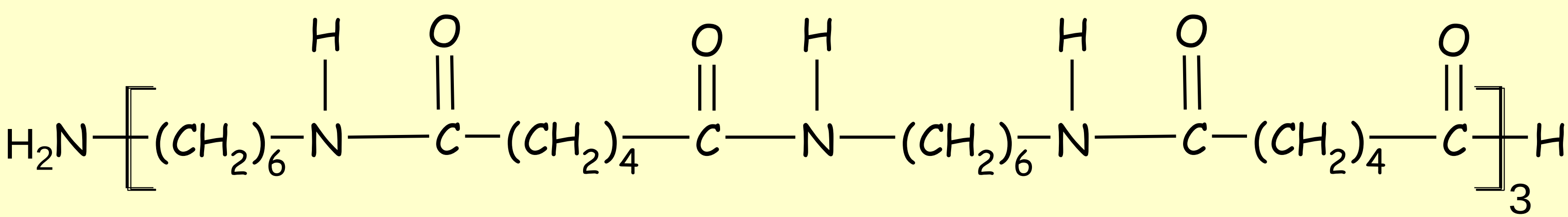


Polyester, e.g. terylene

Polyesters are used as textiles and resins. The latter have 3D structures, unlike textiles, which have a linear structure.

Polyamide, e.g. nylon, an important engineering plastic.

It's strength due to hydrogen bonding between the linear polymer chains. Engineering plastics are a group of plastics materials that exhibit superior mechanical and thermal properties

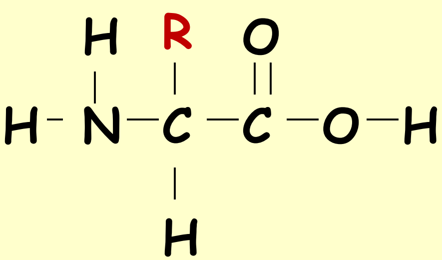


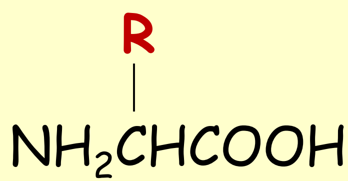
Protein Polymers

All proteins contain the elements C,O,H, N. They are condensation polymers, made by amino acids linking together. An amine group of one molecule links to the carboxyl group of another molecule to form an amide or peptide bond.

The body cannot make every type of amino acids that it needs.
So our diet must contain **essential** amino acids. (about 10 of them).
We synthesis the others.

Amino Acids



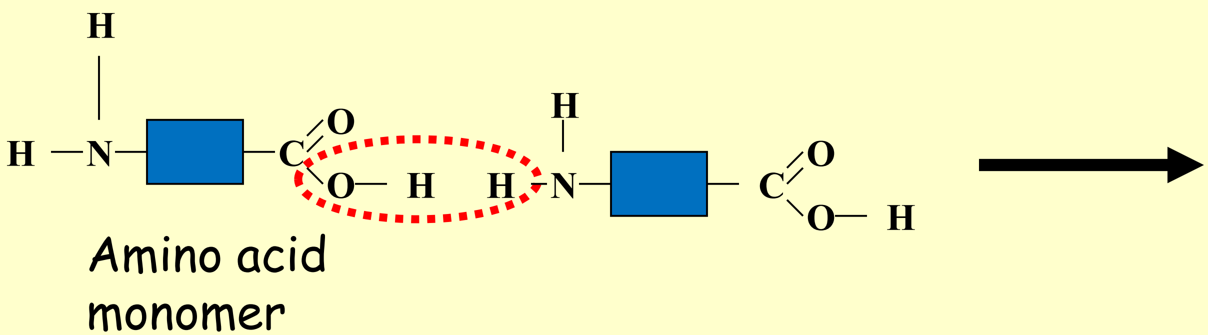


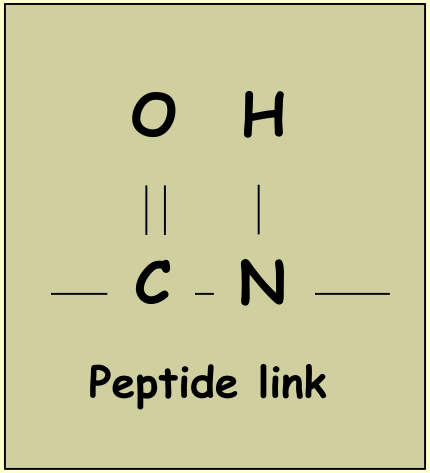
Most proteins contain 20+ different amino acids

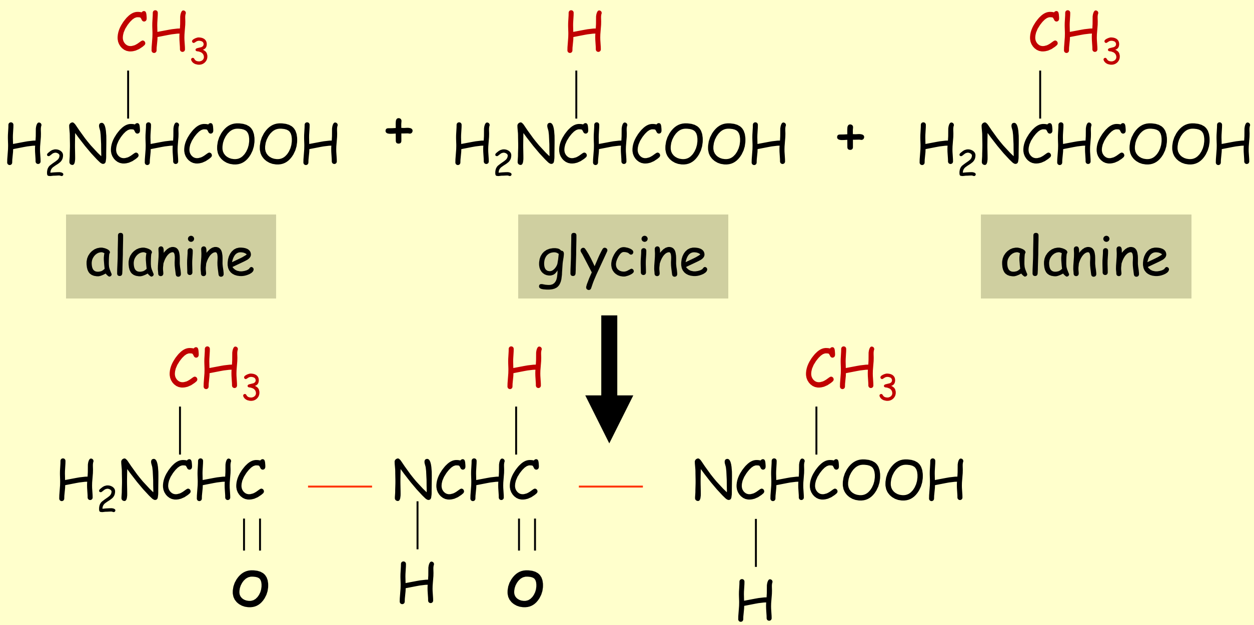
When R is Hydrogen, the amino acid is glycine (Gly) (aminoethanoic acid)

When R is CH_3, the amino acid is alanine (Ala) (2-aminopropanoic acid)

Protein Polymers





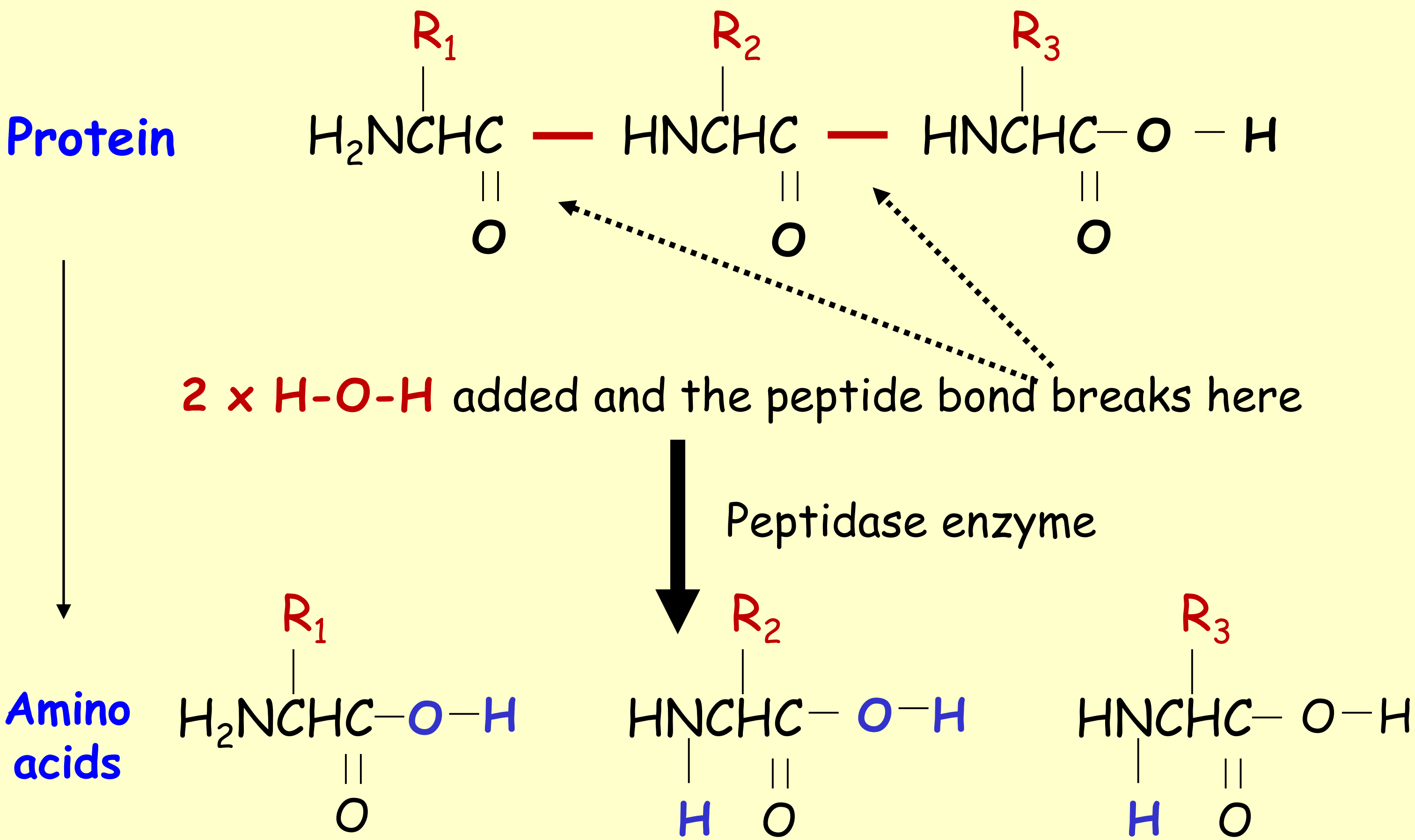


Tripeptide, ala-gly-ala

Polypeptide chain can have 10000 amino acids

Protein Digestion

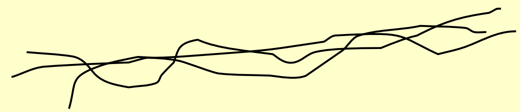
Proteins are broken down during digestion.
Digestion involves the **hydrolysis** of proteins to form amino acids



Protein Structures

Some proteins are composed of a single polypeptide chain, but many consist of two or more polypeptide chains.

Proteins are classified according to their shape into **fibrous** and **globular** proteins.



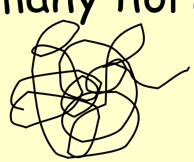
Fibrous proteins

These have their polypeptide chains interwoven. The polypeptide chains are held together by hydrogen bonding, between the N-H and the C=O groups.

This gives these proteins their properties of toughness, insolubility, and resistance to change in pH and temperature. So they are found in skin,tissue, (collagens), hair, nails (keratins).

Globular proteins

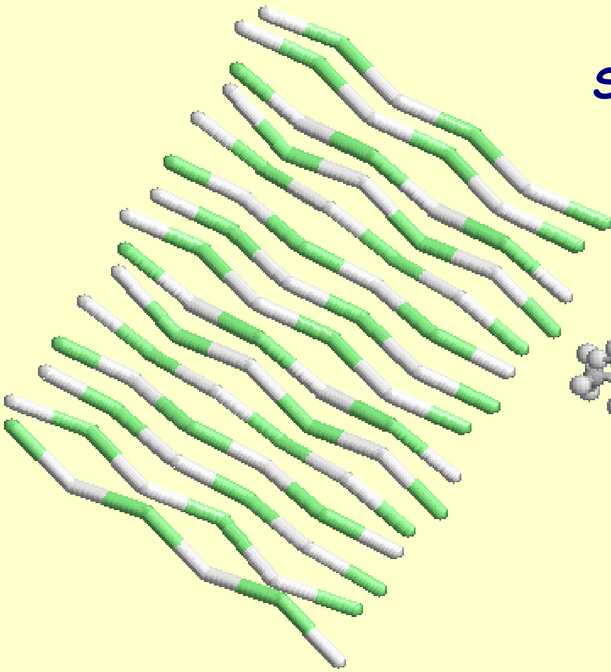
Proteins which operate within cells need to be soluble. The polypeptide chains are coiled together in spherical shapes. E.g. Haemoglobin and many hormones. e.g. Insulin, was the first protein structure to be worked out.

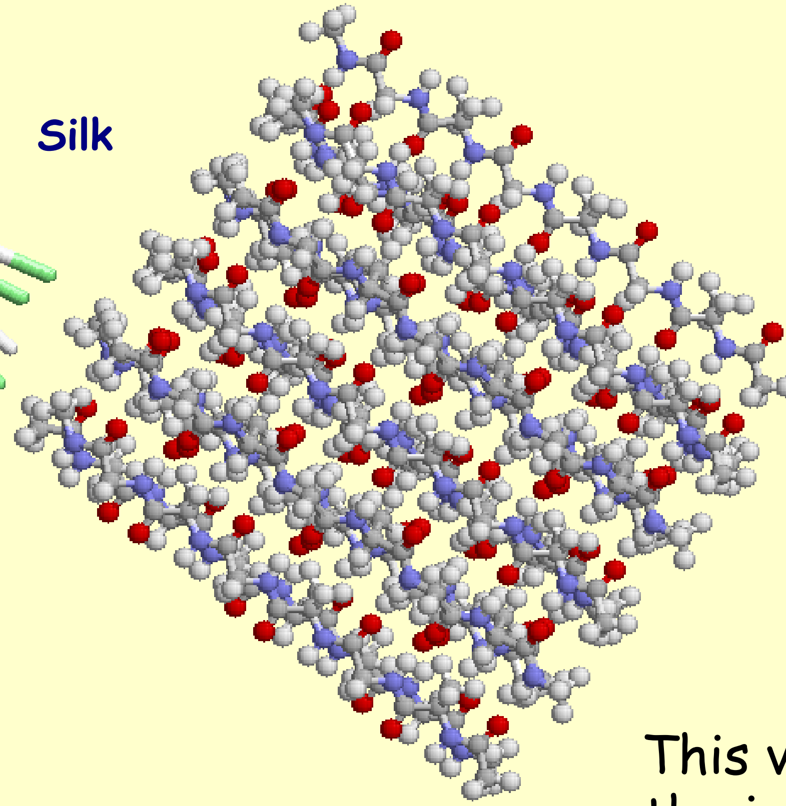


Enzymes are globular proteins.

Protein Structures

Silk is a typical example of a fibrous protein.





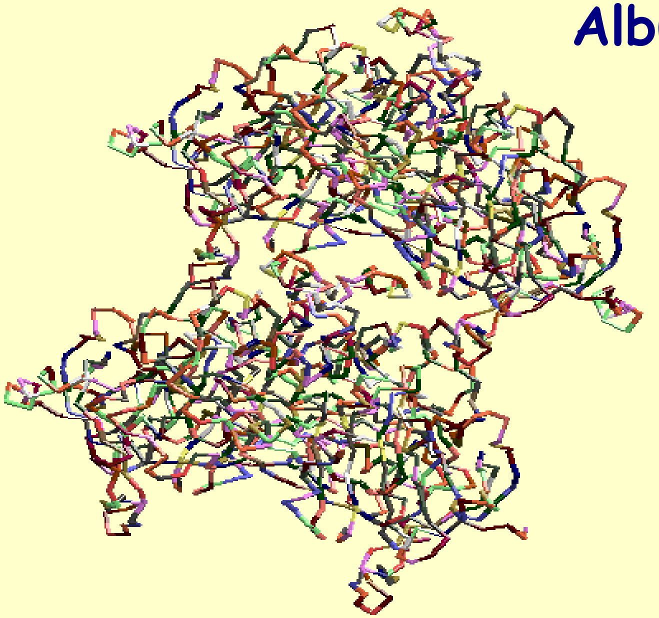
This view shows the protein chains contain 2 different amino acids.

This view shows the individual atoms in the protein chains.

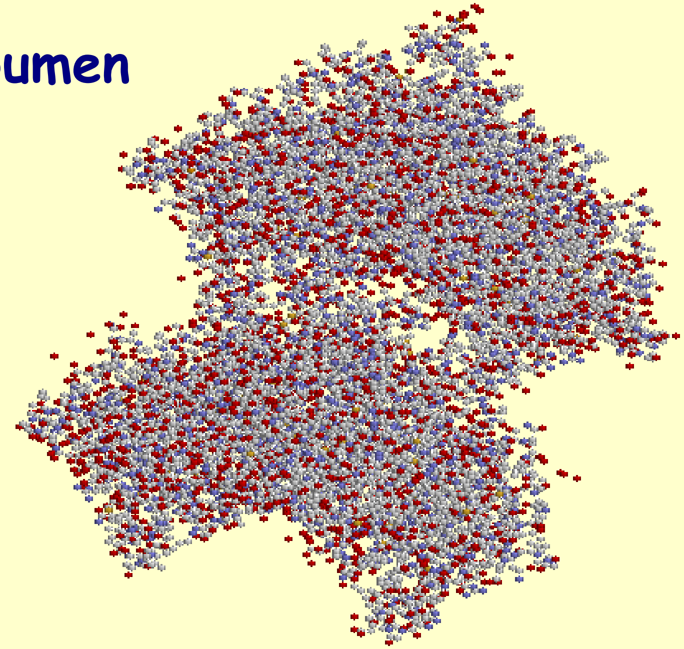
Protein Structures

Albumen, in egg white, is a globular protein..

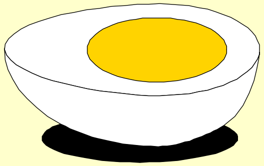
Albumen



backbone view

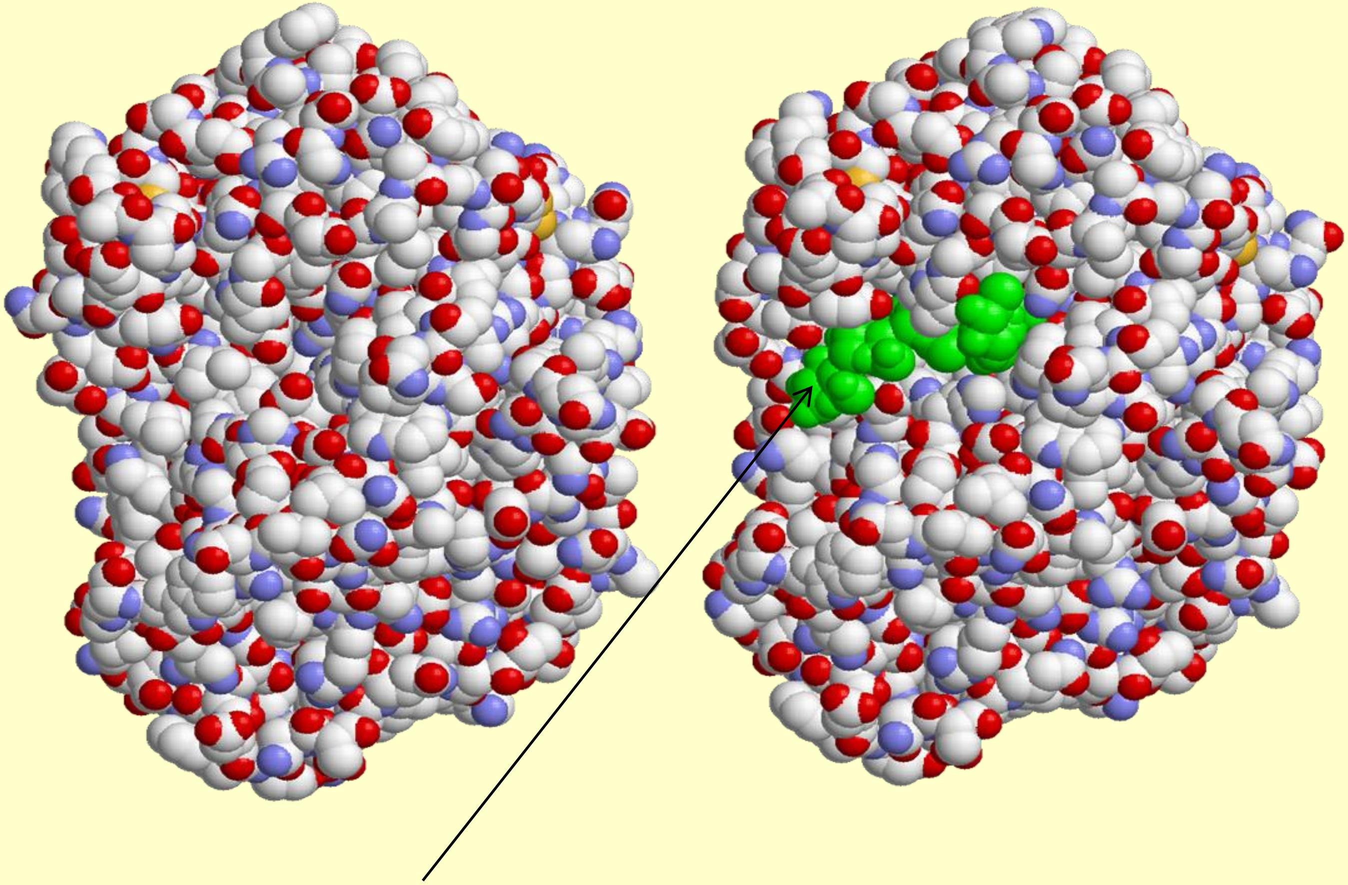


atom view



Protein Structures

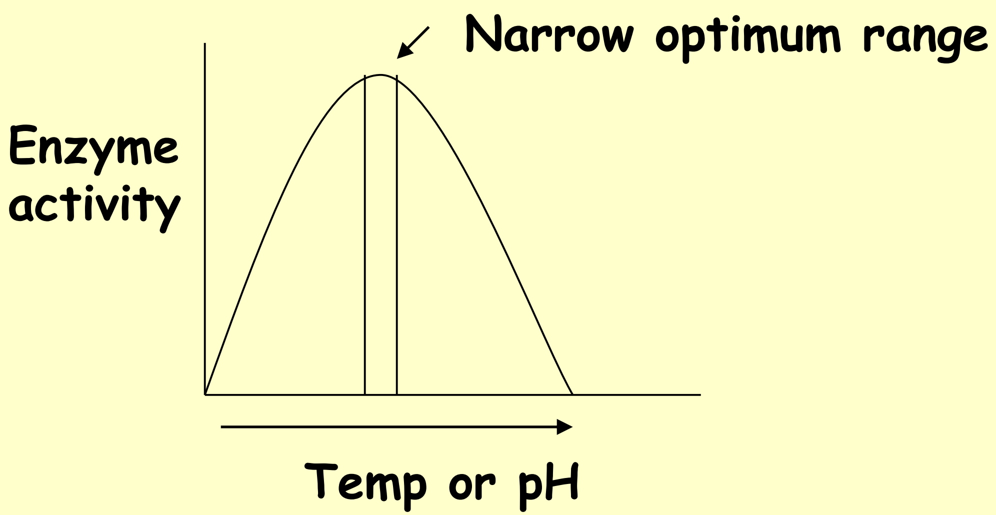
Enzymes are globular proteins. The structure of **amylase** is shown below.



Starch molecule in the enzyme's active site.

Enzyme Activity

Enzymes catalyse chemical reactions in the body. Each enzyme has a unique shape held together by many weak bonds. Changes to pH and temperature can denature the enzyme. This changes the enzymes shape stops it working properly.



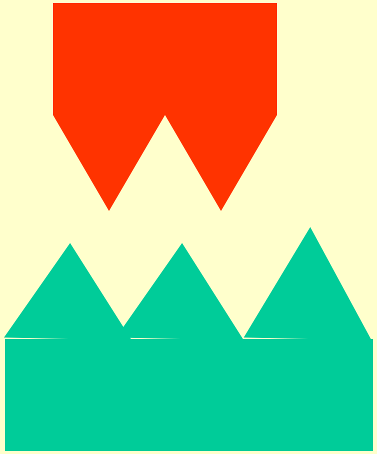
The bonds that hold most biological enzymes are broken around 60°C.

Enzyme Activity, Lock and Key

The critical part of an enzyme molecule is called its active site.

This is where binding of the substrate to enzyme occurs and where catalysis takes place.

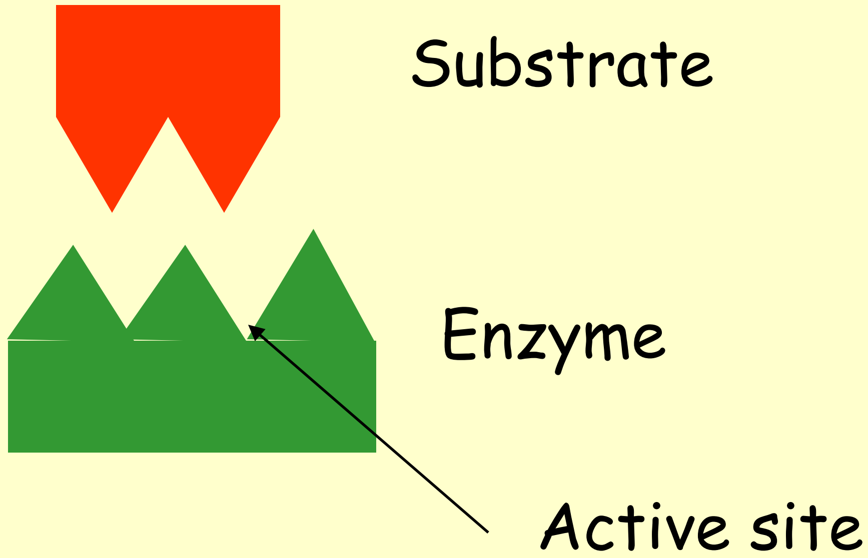
Most enzymes have one active site per molecule.



Substrate

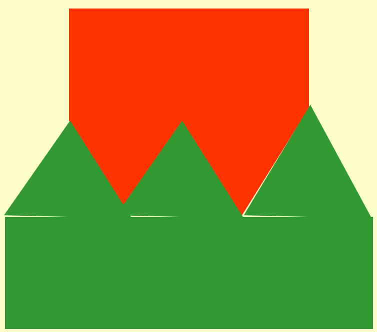
Enzyme

Enzyme Activity, Lock and Key



Enzyme Activity, Lock and Key

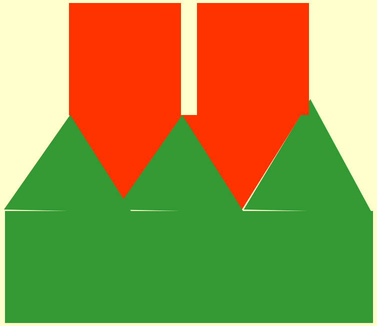
The substrate becomes activated



Enzyme

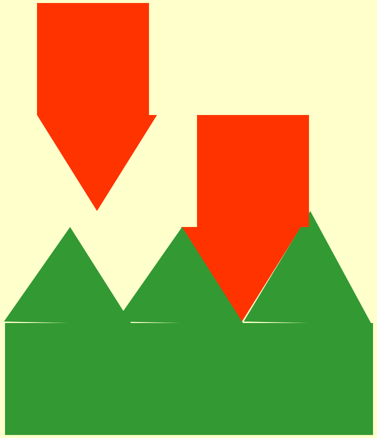
Enzyme Activity, Lock and Key

The substrate becomes activated



Enzyme

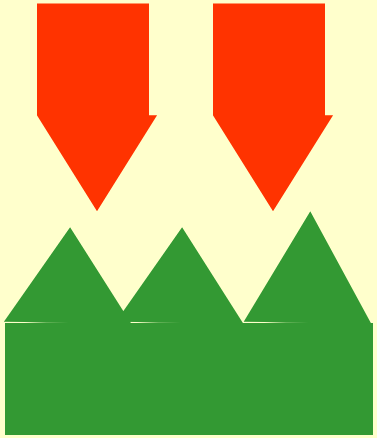
Enzyme Activity, Lock and Key



The complex molecule splits

Enzyme

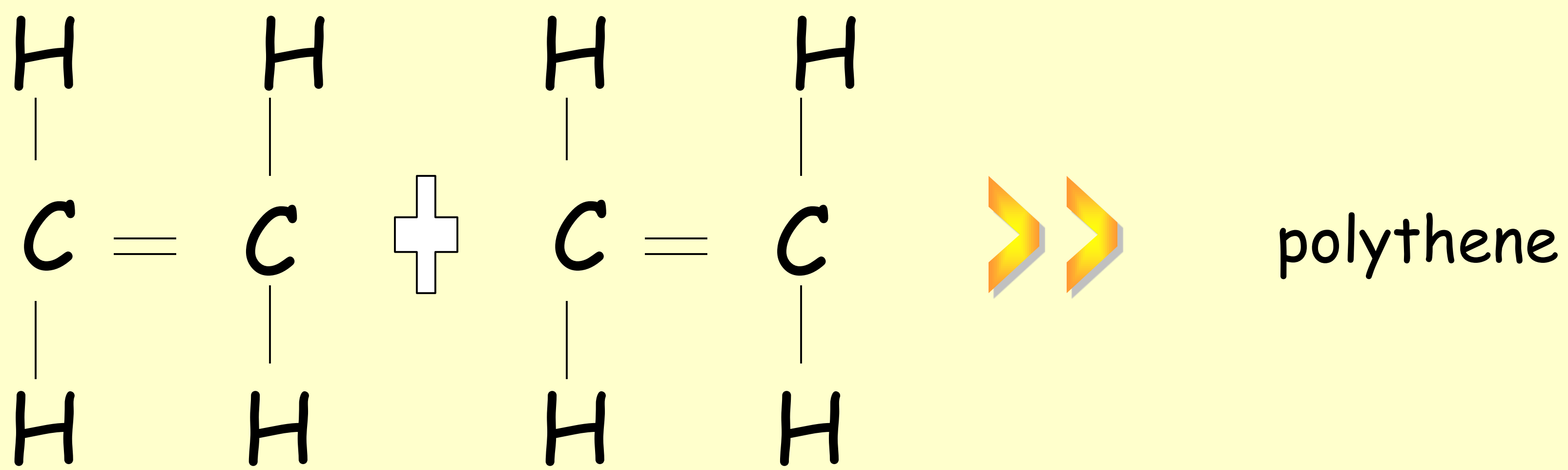
Enzyme Activity, Lock and Key



The complex molecule splits

Enzyme

Linear Addition Polymers



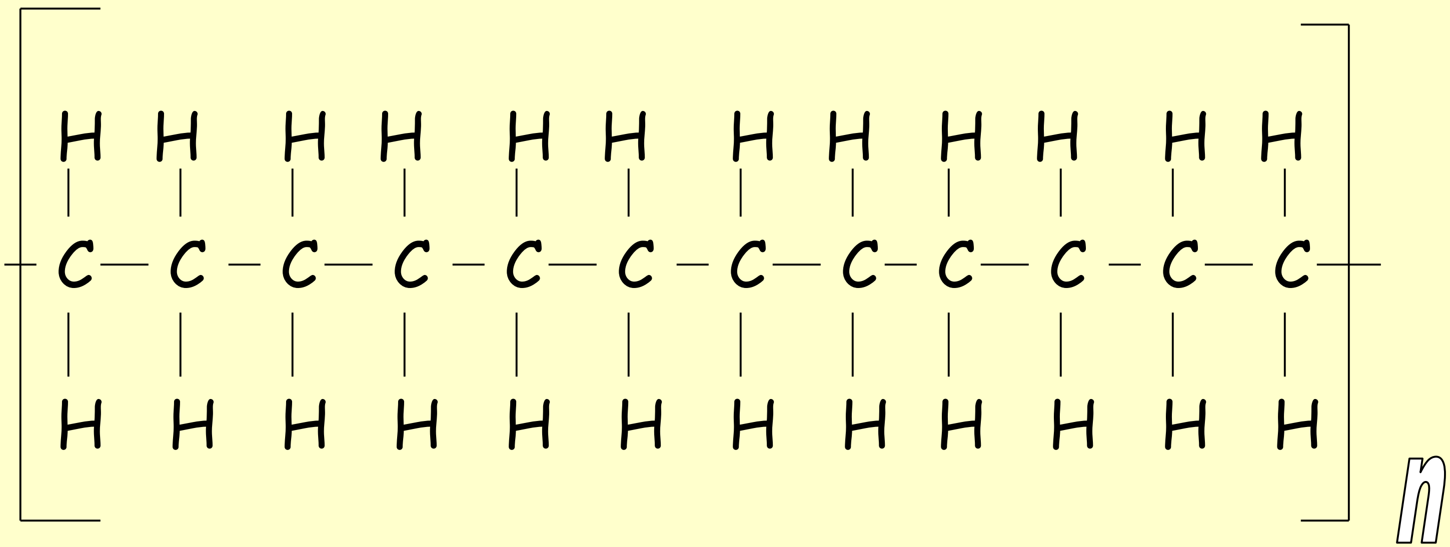
Under the right conditions ethene molecules can be made to join together.

The double bond must be broken for this to happen

Polymerisation

The ethene molecule is called a monomer.

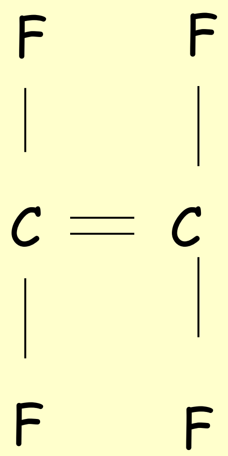
Adding monomers together makes a polymer, in this case, Polythene. (a linear addition polymer)

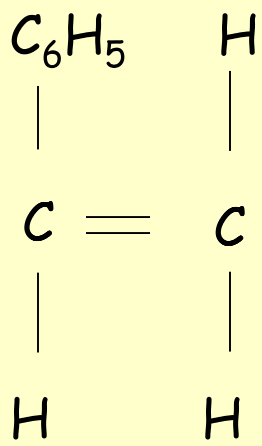


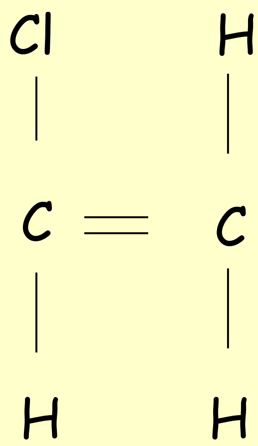
Polythene can be made photodegradable by putting some C=O groups into the chain

Other Addition Polymers

By replacing a H in the ethene molecule, further addition polymers can be made. Three monomers are shown:





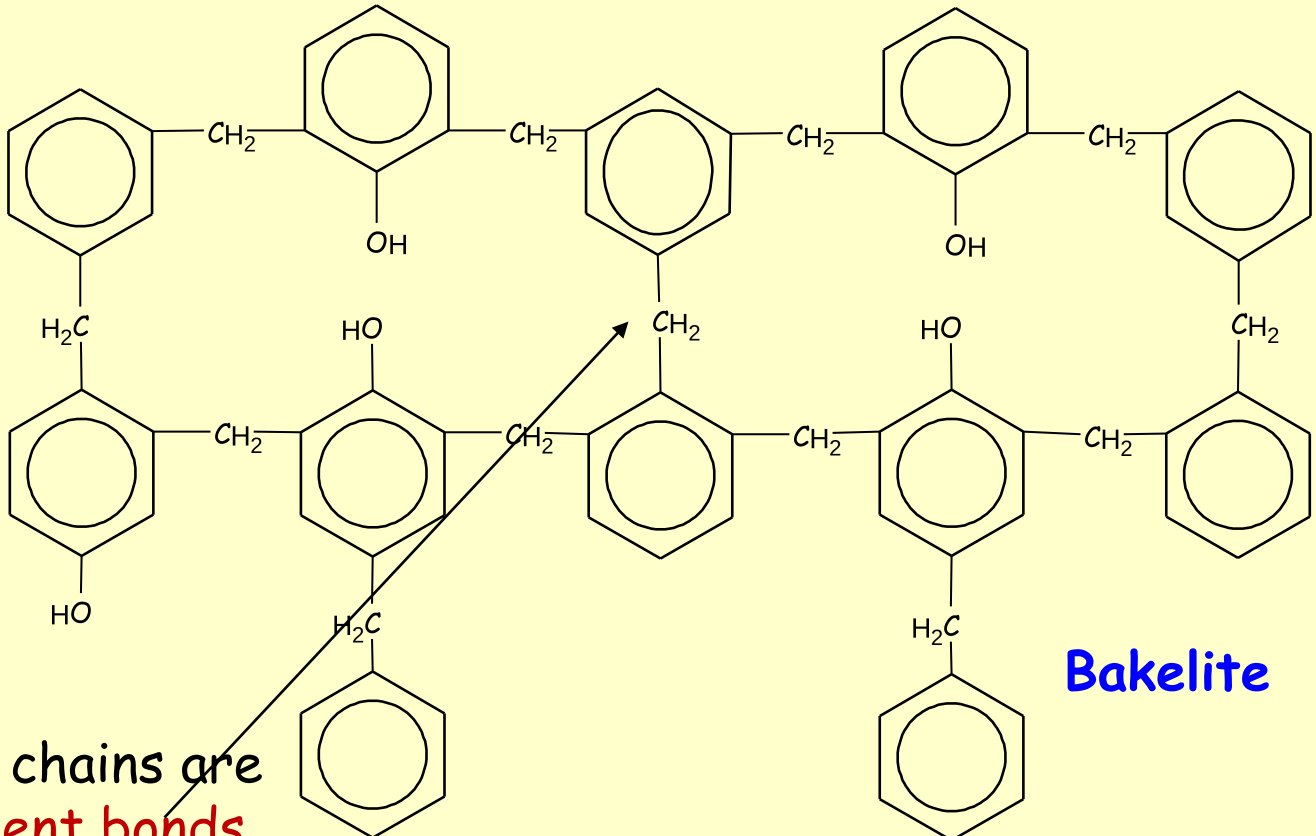


Tetrafluoroethene
(teflon)
Non-stick coating on frying pans

Phenylethene
(Polystyrene)
Expanded foam for packaging

Chloroethene
(P.V.C.)
Artificial leather

Cross-Linked Polymers



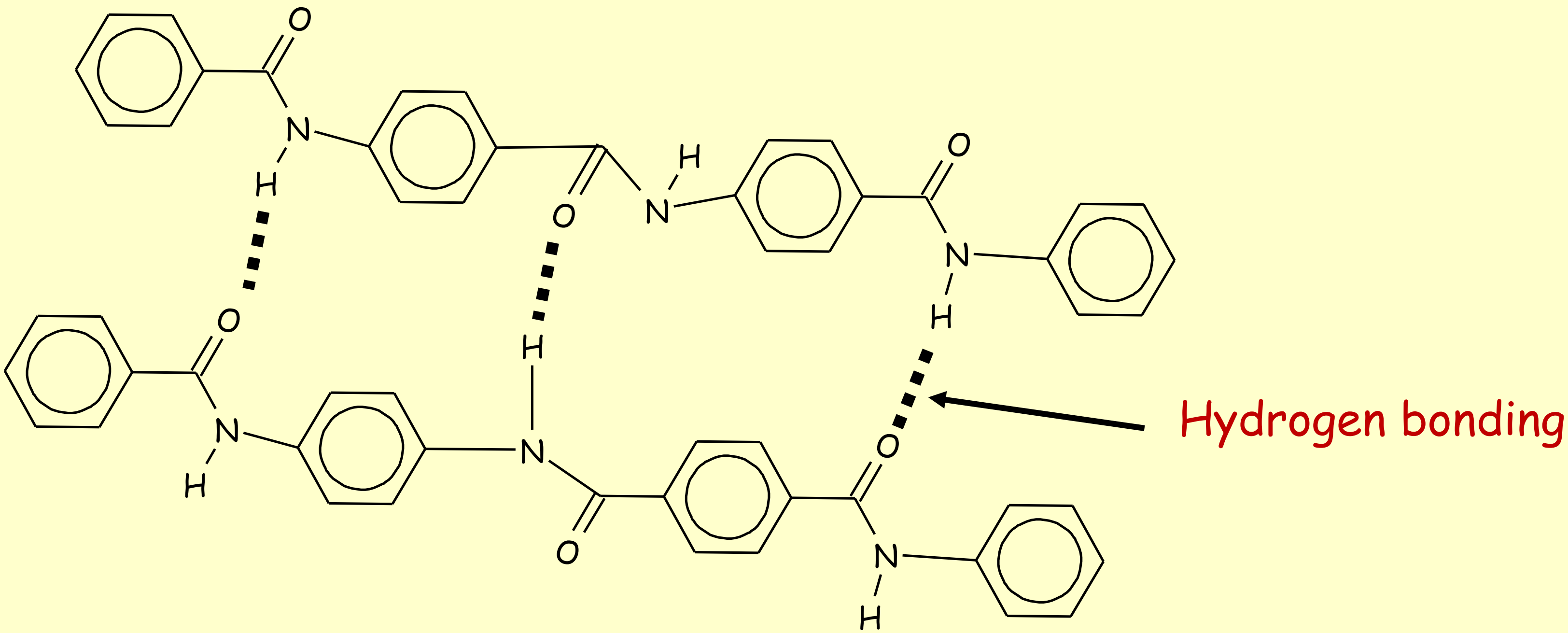
Bakelite

When polymer chains are linked by covalent bonds the polymer is then described as cross linked.

The resulting cross-linked structure means that the polymer is hard, rigid and heat resistant.
It is a thermosetting plastic.

Specialised Polymers

Kevlar is an aromatic polyamide. Both monomers are aromatic.



The polymer chains are long, flat, and lined up in a regular pattern held by hydrogen bonding. Used in bullet proof vests, ropes and fire proof clothing.

Uses of Kevlar

Uses include:

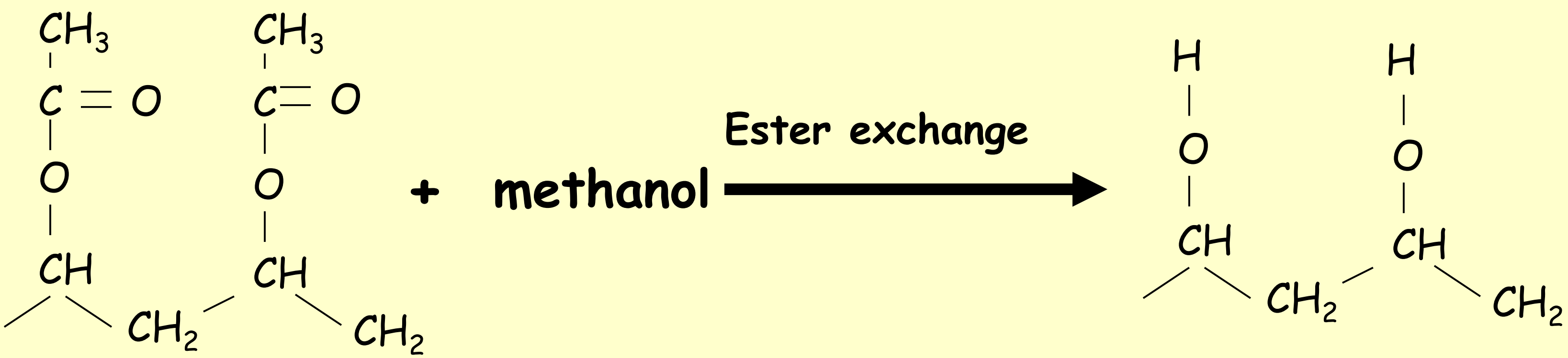
- as a substitute for steel
- Fabric for windsurfing sails and protective clothing
- Bullet proof vests and body armour
- Reinforcing fibre in composites, often with carbon fibre.

Disadvantages of Kevlar fibres:

- they are difficult to cut
- It is much weaker in compression
- Very prone to UV degradation

Specialised Polymers

Poly(ethenol) is an addition polymer. It is made by converting an existing polymer which has ester side groups with hydroxyl groups.
The polymer can be made to be water soluble, by controlling the amount of ester exchange, 90% ester exchange is soluble in cold water. Soiled hospital laundry can be collected in bags made from poly(ethenol).



Polyethenyl ethanoate

Polyethenol (polyvinyl alcohol)

Both hydrogen bonding and van der Waals' forces operate between poly(ethenol) molecules. The stronger these forces the less soluble the polymer. <90% of –OH replacement are soluble in cold water.

Specialised Polymers

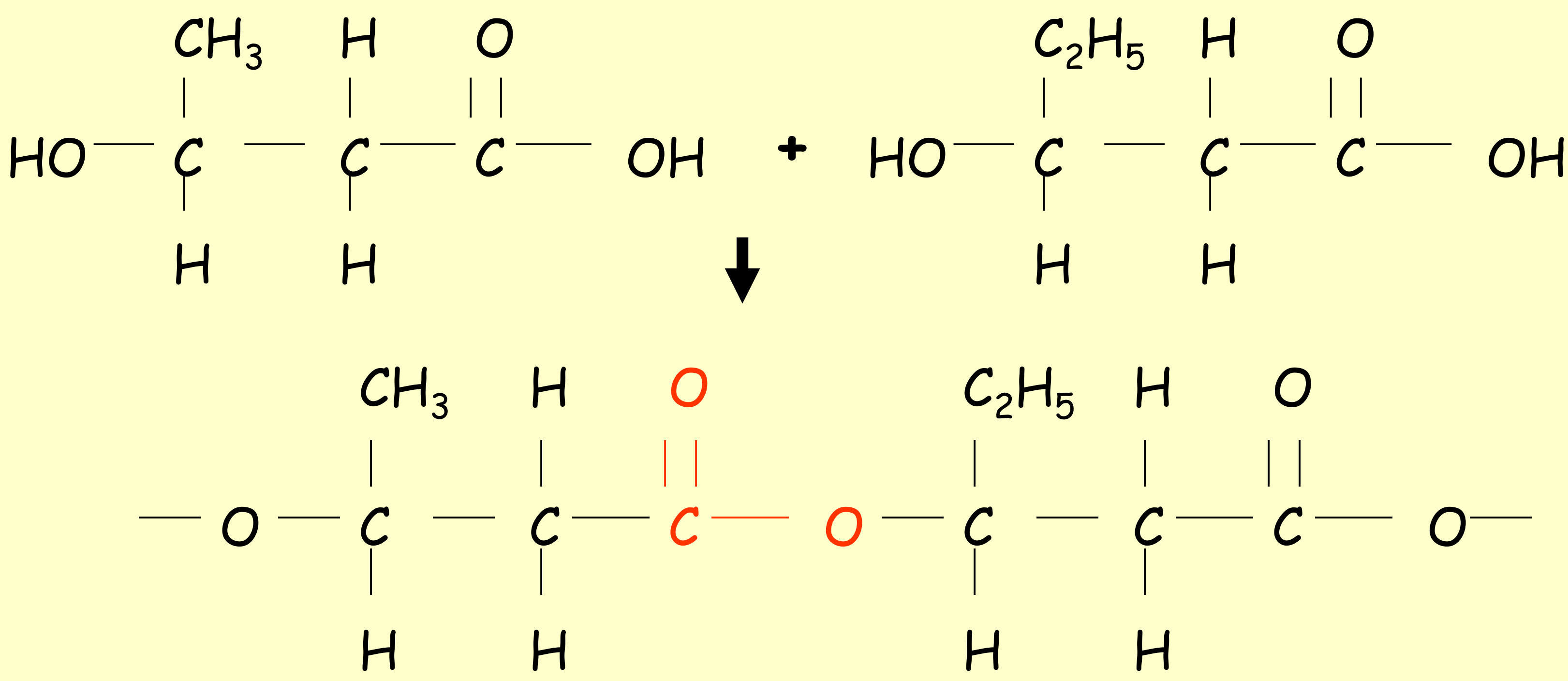
- Most plastics are not biodegradable.
- Most polymers, including polyethylene, polypropylene, polyamides and polycarbonate, are highly resistant to microbial attack.
- Natural polymers are generally more biodegradable than synthetic polymers.
- Polymers containing an ester linkage, especially aliphatic polyesters, are potentially biodegradable

Biodegradable polymers include poly(lactic acid) (**PLA**) which is made from the self-condensation of lactic acid. **PLA** breaks down into lactic acid which can be metabolised and has found uses in, drug delivery systems and wound healing. **Biopol** is another biodegradable plastic.

Specialised Polymers

Biopol

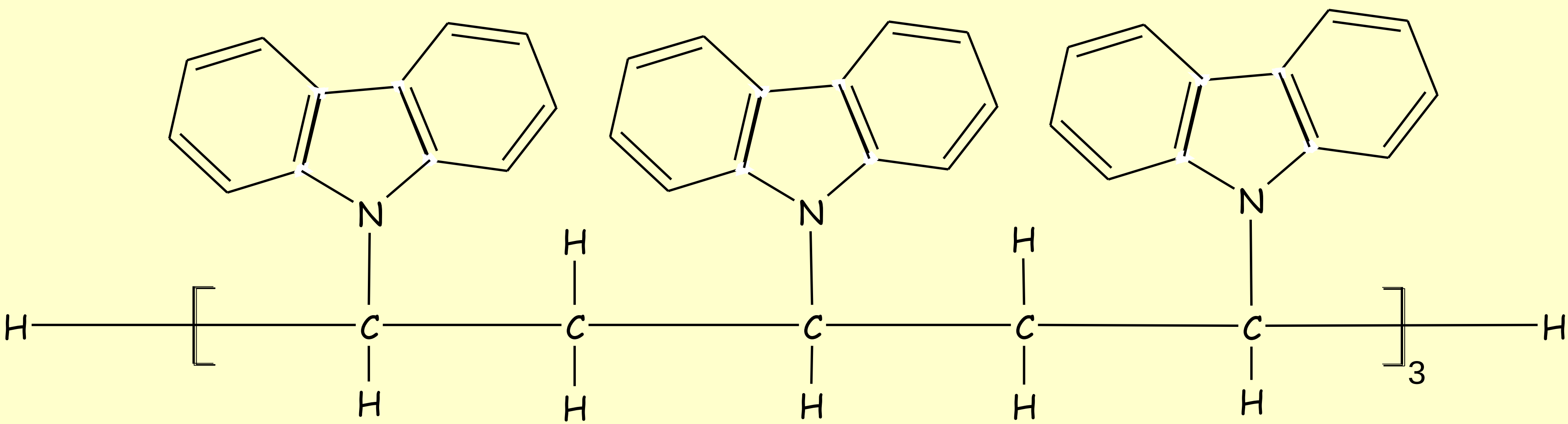
This plastic is biodegradable. This plastic is produced by the fermentation of ethanoic and propanoic acids by bacteria. Biopol is therfore unsuitable For foods requiring a long shelf life. High production costs and the recycling of polymers has meant that Biopol has lost its importance.



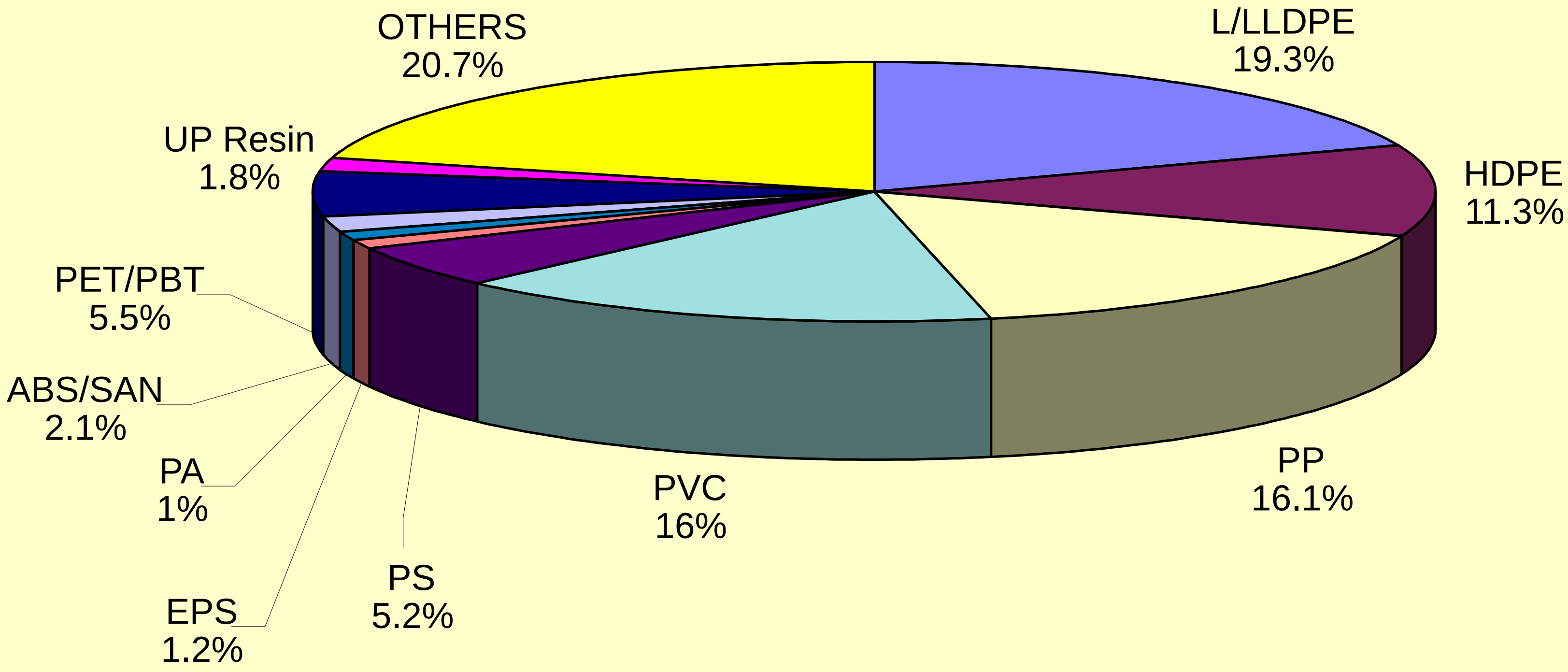
Specialised Polymers

Poly(vinylcarbazole)

This polymer can conduct electricity when exposed to light. It is widely used in photocopying machines as a replacement for selenium, which is poisonous.



UK Consumption of Plastics by Type



47% of the polymer used is polyolefins, based on ethylene or propylene

UK Consumption of Plastics by Market