POLYMERS AND POLYPEPTIDES

• The term POLYMER simply means a structure built from many parts. Polymers are generally large chains made from smaller carbon containing units that become linked under appropriate conditions of temperature, pressure and the presence of certain initiator substances or energy input.

• A polypeptide is a type of natural polymer made from amino acids and is the basis of the proteins in most life forms on the planet.

CLASSIFICATION:

► Plastics can be divided into four basic categories: -

- **Thermoplastics** such as polyethylene, which soften on heating and harden again on cooling (e.g. Milk bottles).
- **Thermosetting plastics** or resins are plastics which cannot be melted and re-moulded when heated (e.g. printed circuit boards and fibre glass resin)
- **Elastomers** or rubbers (e.g. Car tyres, rubber-bands, tennis balls)
- **Natural polymers** such as cellulose, lignin and protein, which provide the mechanical basis for most plant and animal life (e.g. wood, straw and silk).

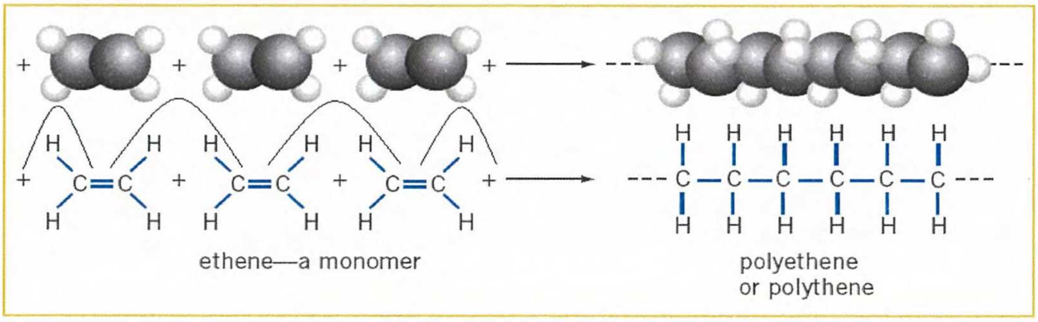
POLYMERISATION PROCESSES:

► There are two major types of polymerisation reaction, **ADDITION** and **CONDENSATION**.

ADDITION:

► Addition polymerisation is where large numbers of the same MONOMER, containing a double bond, are linked or joined together and the polymer is produced without any other products. The double bonded segment of the monomer molecule is known as a VINYL unit.

• The vinyl unit has a sigma bond (α) and a pie bond (π) and under conditions of excitation the pie bond electrons can jump into a zone between two approaching monomer units forming a new covalent bond (α) that act as a link between the two.

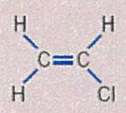
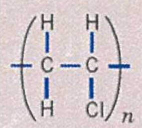
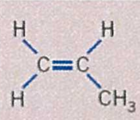
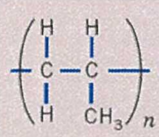
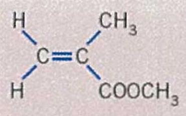
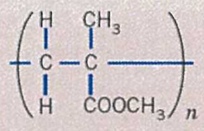
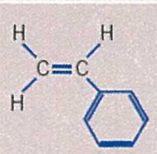
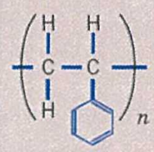


Formation of polyethene from ethene by addition polymerisation

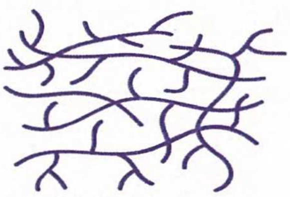
$$nCH_2{=}CH_2 \xrightarrow{\text{catalyst}} \left(\begin{array}{c} H\ \ H \\ |\ \ \ | \\ -C-C- \\ |\ \ \ | \\ H\ \ H \end{array}\right)_n \quad (\text{or } {-}\!\!(CH_2-CH_2)\!\!{-}_n)$$

• By substituting hydrogen on the vinyl unit with other groups, the structure of the monomer and hence polymer can be varied almost infinitely, producing desired properties beneficial for intended use.

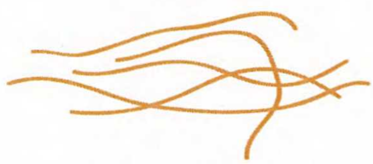
COMMERCIALLY IMPORTANT ADDITION POLYMERS

Polymer	Formula and name of monomer	Formula of polymer	Examples of uses
Poly(vinyl chloride), PVC	 Vinyl chloride (chloroethene)		Pipes, cable insulation, water tanks
Polypropene	 Propylene (propene)		Rope, carpet, plastic parts for cars
Poly(methyl methacrylate)	 Methyl methacrylate (methyl 2-methylpropen-2-oate)		Plexiglass, paints
Polystyrene	 Styrene (phenylethene)		Insulation, packaging

• Depending on the conditions chosen and the particular reaction catalyst, polymer chains can be made to form in a linear fashion or a branched fashion. The presence or absence of branching effects how well the polymer chains can "fit together" and how effective the dispersion forces between them will be. The different polymers formed in this way are known as HIGH DENSITY or LOW DENSITTY.



LOW DENSITY (L.D.P.E.)



HIGH DENSITY (H.D.P.E.)

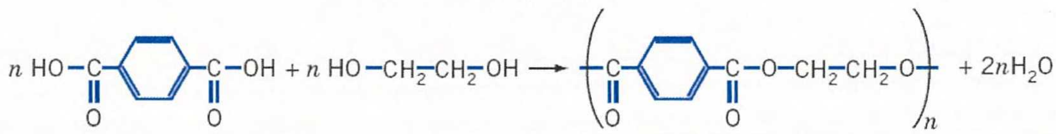
CONDENSATION:

► Condensation polymerisation usually involves two different monomers fusing together. The molecules of at least one but generally both monomers contain two reactive sites that allow them to link together in a continuous fashion. Chemical interaction of these monomers produces a polymer and molecules of such simple substances as water, ammonia or hydrogen chloride.

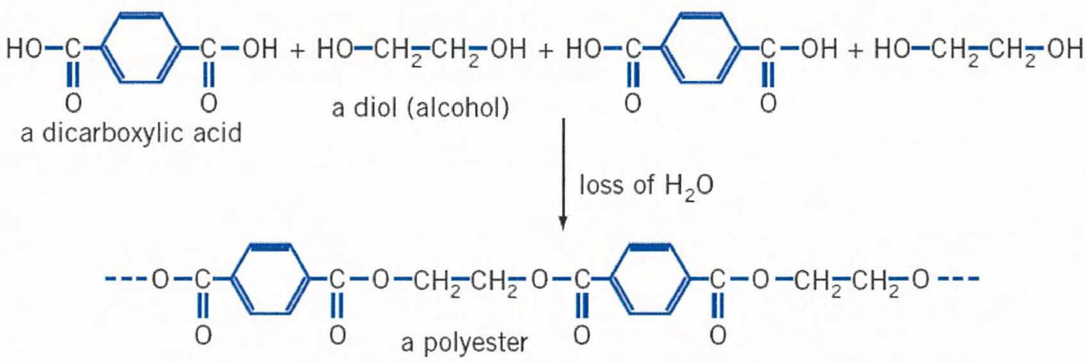
• The fact that ***two different monomers*** are used and linked in an alternating fashion and that there are ***by-products*** in these reactions, sets them apart from addition polymerisation.

• The basis for the linkage in this type of polymer is generally an **ESTER** linkage or an **AMIDE** linkage. An ester linkage is formed if the monomers are a **diol** and a **dioic** acid. Amide links form in a condensation reaction between **diamines** and **dioic** acids.

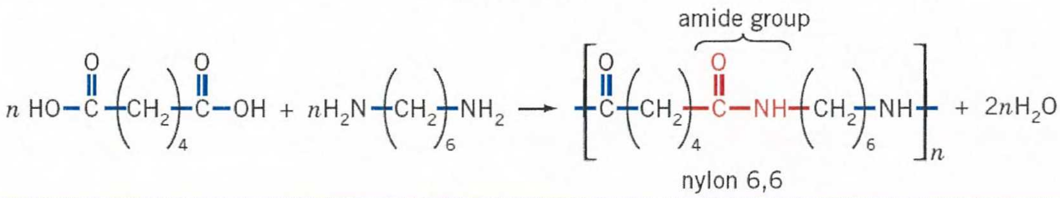
GENERAL: Polyester



ESTER Linkage



GENERAL : Polyamide



THERMOPLASTICS AND THERMOSETS:

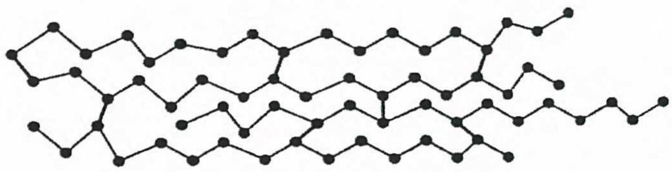
►THERMOPLASTICS (thermo softening) have the main characteristic that they become soft when heated. This can be an advantage as they are easy to mould and when cooled they retain their shape.

• Thermoplastic polymers are made of linear chains that become free to move when heated as their dispersion force interactions are relatively weak and can be overcome. Eg: Glad Wrap.

► THERMOSETS have the main characteristic that they do not soften on heating. These polymers are made of networks with ***"cross – linking"*** between the chains of molecules.

• The movement of chains across each other is prevented by the cross links and they remain rigid as a result, even when heated. Eg: Araldite Glue.

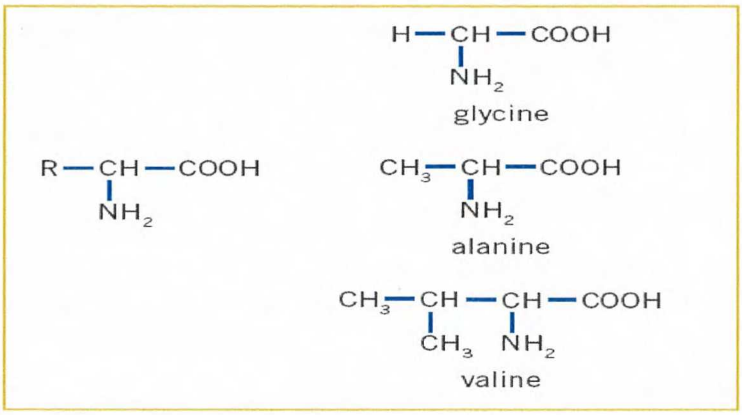
THERMOPLASTIC



THERMOSET

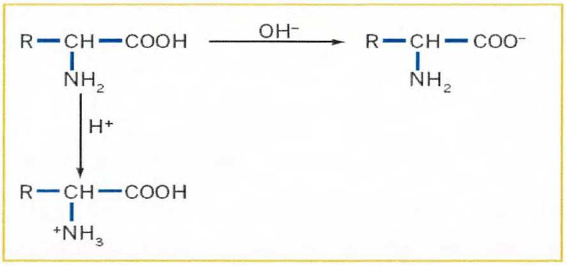
POLYPEPTIDES:

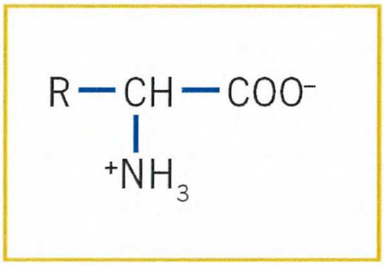
► Polypeptides are the protein molecules that make up our flesh and blood. They are polymers of a group of molecules known as **amino acids**. As the name suggests an amino acid is both an amine and a carboxylic acid, it has one of each functional group at either end and provides the capacity for continued amide links at each point. There are 20 amino acids that are used to construct human proteins.



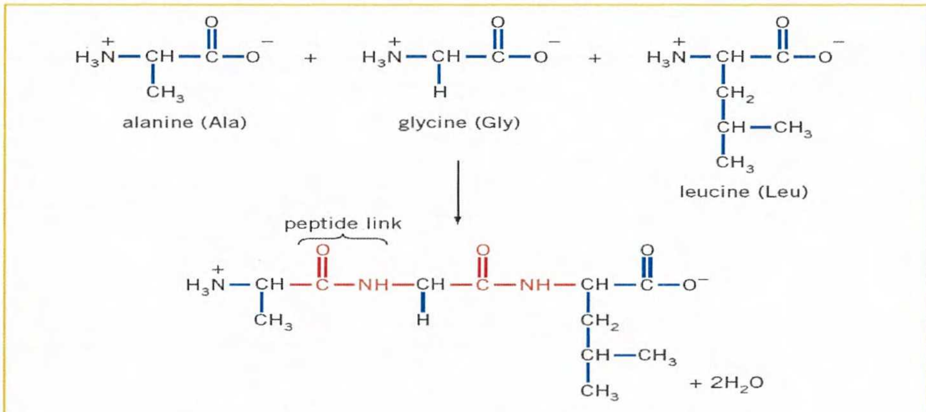
α -amino acids are specifically those that have the amino group attached to the carbon atom next to the carboxylic acid functional group!

• Having an acidic functional group at one end and a basic group at the other the amino acids can react with both acid and base and are described as being AMPHOTERIC. In neutral solution such as that encountered in biological systems they exist in ionic forms with charges at both ends; ions such as these are known as **ZWITTERIONS**.





• These zwitterions condense to form the protein polymer. The precise order in which the amino acids are linked to produce a protein will vary its properties. Parts of the protein chain have a basis for intermolecular force interactions such as hydrogen bonding and this leads to them coiling up in specific patterns to produce a unique secondary structure.



Tripeptide symbolically represented as Ala-Gly-Leu