CHAPTER 13: POLYMER

TOPIC	LEARNING OUTCOMES	MAPPING COGNITIVE DOMAINS			
		C1	C2	C3	C4
Polymers	a) Explain the terms: monomer; polymer, homopolymer, copolymer, straight chain polymer and cross-linked polymer		√		
	b) Give examples of natural polymers such as proteins, carbohydrates and natural rubber	√			
	c) Explain the preparation of synthetic polymers through: i. Condensation polymerization to produce polyamides (e.g Kevlar, Nylon 6, Nylon 6,6) and polyester (e.g Dacron / Terylene) ii. Addition polymerization (e.g polyethylene, polyvinyl chloride, polystyrene, Teflon)			√	
	d) Identify type of addition polymers and condensation polymers		√		
	i. Deduce monomers of a given polymer				√
	ii. Write equations to show the preparation of polyamides, polyesters and addition polymers			√	
	e) State the uses of synthetic polymers	√			

SUBTOPIC	LEARNING OUTCOMES	MAPPING COGNITIVE DOMAINS			
		C1	C2	C3	C4
Polymers	a) Explain the terms: monomer; polymer, homopolymer, copolymer, straight chain polymer and cross-linked polymer		√		
	b) Give examples of natural polymers such as proteins, carbohydrates and natural rubber	√			

INTRODUCTION

[redacted]

The **basic molecular units**.
Small repeating units that **build up polymers**.

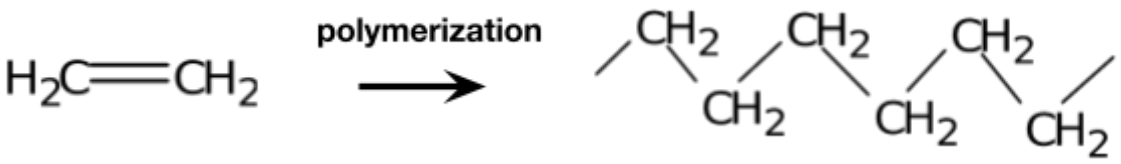
POLYMERISATION

the process that **combines monomers to form polymer**.

[redacted]

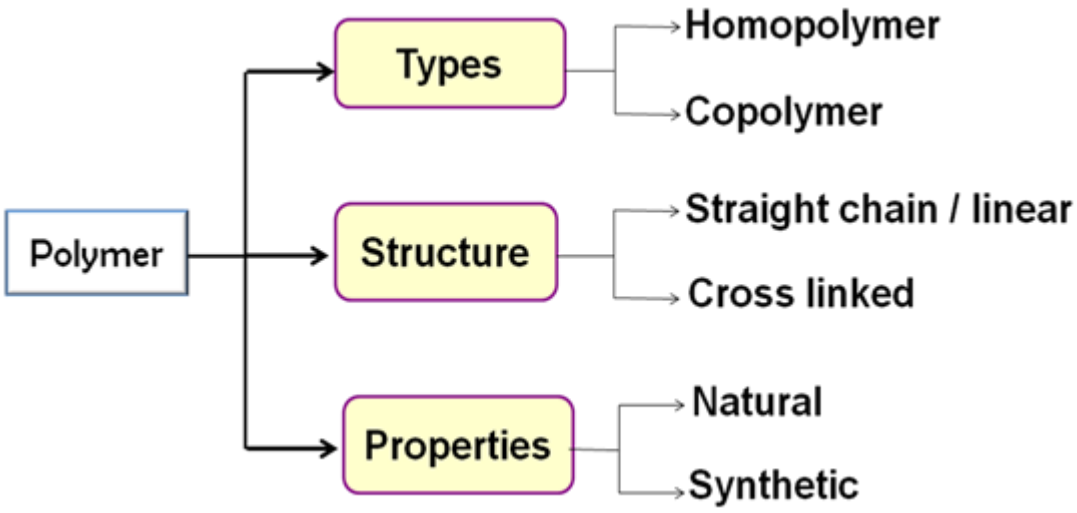
Is a **macro molecule** that is **made up of many small repeating units** called **monomers** linked together by **covalent bond**.

Example:



ethene polyethene

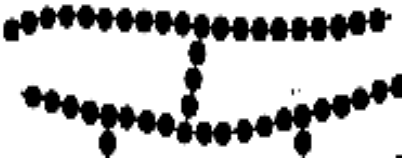
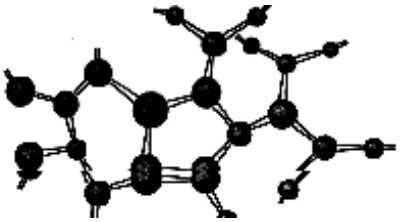
Monomer	Repeating Unit	Polymer



HOMOPOLYMER	COPOLYMER
Polymers formed from the **same type** of **monomer** $\left[\text{–A–A–A–A–A–A–A–A–}\right]_n$	Polymers formed from the **two or more different types** of **monomer** $\left[\text{–A–B–A–B–A–B–A–B–}\right]_n$

[redacted]

STRAIGHT CHAIN POLYMER	CROSS-LINKED POLYMER
▯ Consists of monomer that are linked in **straight /long chain**	▯ Contain branches that connect **linear polymer chain**
▯ Recyclable	▯ Not recyclable
▯ **Soft** and **can be reformed** when heated.	▯ Harder (rigid), more elastic, and can't be remolded again.
Example: **–A–A–A–A–A–A–A–A–** ⇒ link together in a straight chain	Example: **–A–A–A–A–A–A–A–A–** **X** **X** **–A–A–A–A–A–A–A–A–** ⇒ long polymer chain cross-linked by branched

 Monomers link together in a straight chain  Folded linear polymer in a random fashion	 Minor cross-linked polymer  Massive cross-linked polymer

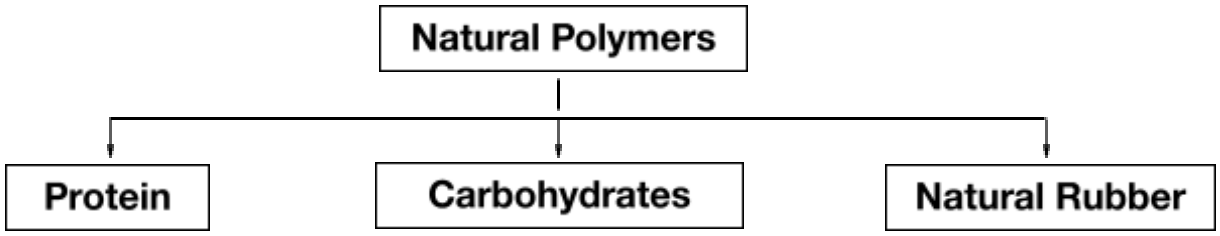
[redacted]

NATURAL POLYMERS	SYNTHETIC POLYMER
• **Found naturally** Example: **(i) Protein** **(ii) Carbohydrates** **(iii) Natural rubber**	• **Prepared chemically** in industry through Example: a) **<u>addition polymerisation</u>** to produce polyalkene. (i) Polyethylene (ii) Poly vinyl chloride (iii) Polystyrene (iv) Teflon b) **<u>condensation polymerisation</u>** to

	produce: (i) Polyamide (eg: Kevlar, nylon 6, nylon 6,6,) (ii) Polyester (eg: Dacron, terylene)

[redacted]

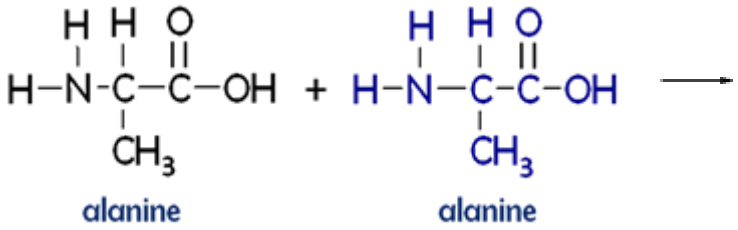
- An **extremely large molecules** occurred naturally.



Protein

- Built from **amino acids** linked by **amide bonds**

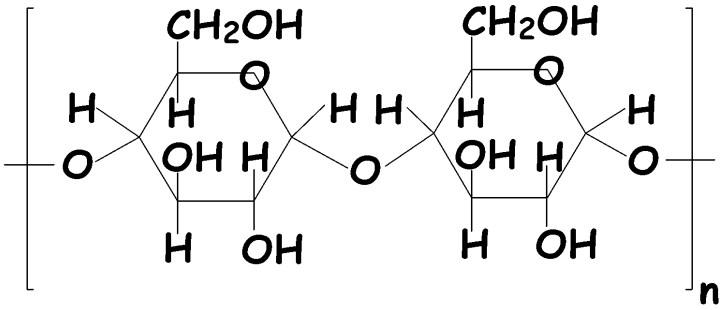
Example:



Monomer	Repeating Unit	Polymer

Carbohydrates

- **Carbohydrates** such as **starch** is also a **polymer.**



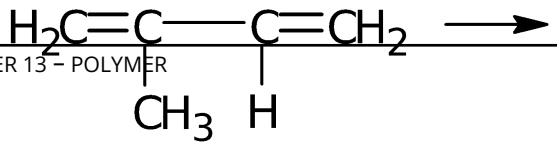
Starch (amylose)

Natural Rubber

- Natural rubber is soft, sticky and perishable. These characteristics make it less useful.

Example:

Natural rubber : **polyisoprene (2–methyl–1,3–butadiene)**



isoprene

Monomer	Repeating Unit	Polymer

SUBTOPIC	LEARNING OUTCOMES	MAPPING COGNITIVE DOMAINS			
		C1	C2	C3	C4
Polymer	c) Explain the preparation of synthetic polymers through: i. Condensation polymerization to produce polyamides (e.g Kevlar, Nylon 6, Nylon 6,6) and polyester (e.g Dacron / Terylene) ii. Addition polymerization (e.g polyethylene, polyvinyl chloride, polystyrene, Teflon)			√	

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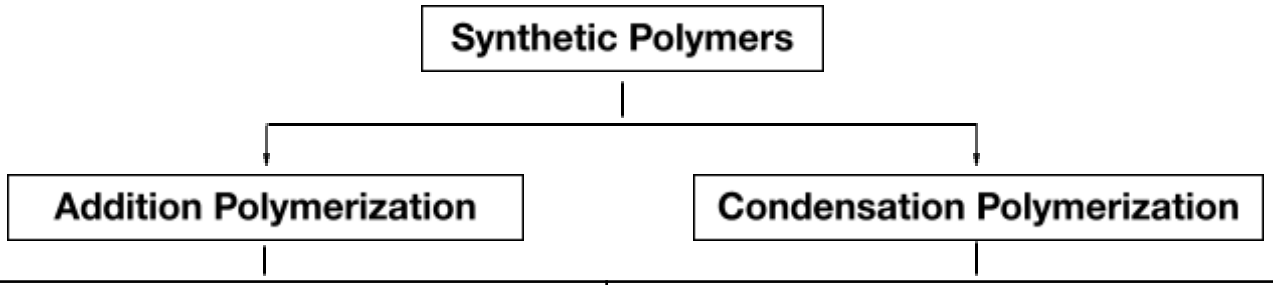
- **Synthetic polymers** are polymers that are **prepared in industries** from monomers that have gone through **polymerization process**.
- **Polymerization** is a process that combines **monomers to form polymers.**



Addition Polymerization	Condensation Polymerization
Involved the **addition reaction** of **unsaturated monomers without elimination of any small molecule**. Always involves the polymerization of monomers which have **double bond** within the monomers.	Is a process that **combines the monomers** with **elimination of a small molecule** such as **water, methanol, hydrogen chloride** to form a polymer. The monomers must have at least **two identical** or **different functional group** in the molecule.
Addition Polymerization: • Reaction to produce **polyethene** • Reaction to produce **polyvinyl chloride** • Reaction to produce **polystrene** • Reaction to produce **teflon**	**Condensation Polymerization:** Polyamides: • Formation of **Nylon 6,6** • Formation of **Nylon 6** • Formation of **Kevlar** Polyester • Formation of **Dacron** • Formation of **Terylene**

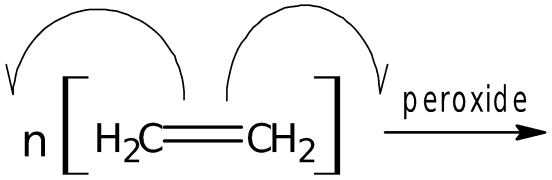
SUBTOPIC	LEARNING OUTCOMES	MAPPING COGNITIVE DOMAINS			
		C1	C2	C3	C4

Polymer	d) Identify type of addition polymers and condensation polymers		√		
	i. Deduce monomers of a given polymer				√
	ii. Write equations to show the preparation of polyamides, polyesters and addition polymers			√	

[redacted]

- Involves the polymerization of monomers which have **double bond** within the monomers.
- **Peroxide** is used as **initiator in addition polymerization**.

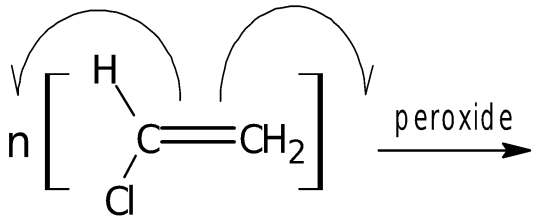
Formation of Polyethene



ethene

Monomer	Repeating Unit	Polymer

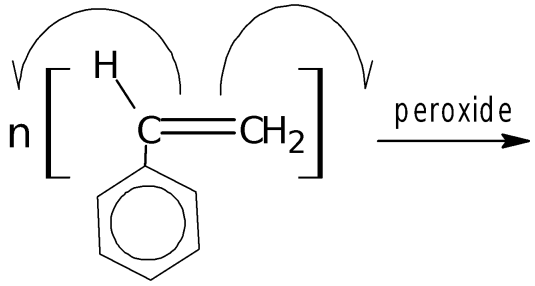
Formation of Polyvinyl Chloride, PVC



vinyl chloride
(chloroethene)

Monomer	Repeating Unit	Polymer

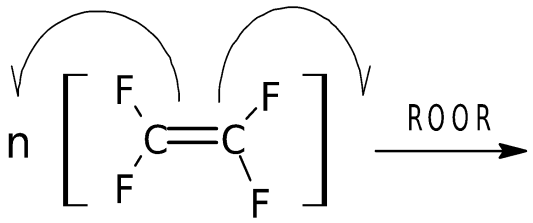
Formation of Polystyrene



styrene
(phenylethane)

Monomer	Repeating Unit	Polymer

Formation of Teflon



tetrafluoroethene

Monomer	Repeating Unit	Polymer

[redacted]

- A chemical process in which 2 monomers react to form a **larger molecule** and eliminate a smaller molecule, such as **water, methanol, hydrogen chloride**.

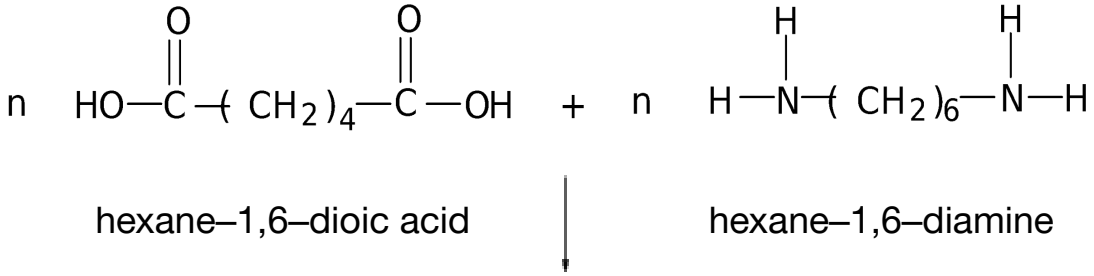
Condensation Polymerization

- **Polyamides**
- **Polyester**

[redacted] Nylon 6,6, Nylon 6, Kevlar

- Polyamides are polymers in which individual units are joined by **amide bonds**.
- Formed when a **carboxylic acid** with **two –OH groups** reacts with an **amine** with **two –NH_2 groups**

Formation of Nylon 6,6

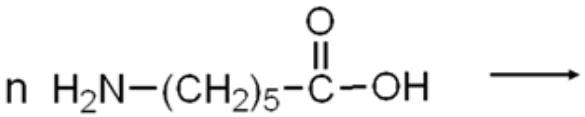


hexane–1,6–dioic acid

hexane–1,6–diamine

Monomer	Repeating Unit	Polymer

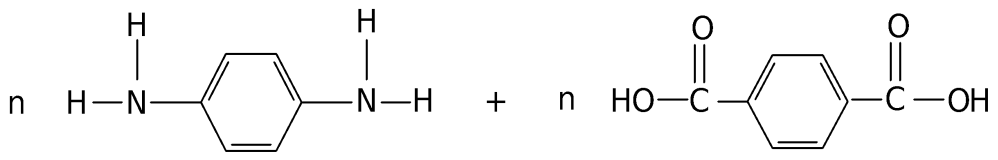
Formation of Nylon 6



6-aminohexanoic acid

Monomer	Repeating Unit	Polymer

Kevlar



1,4–diaminobenzene | 1,4–benzenedicarboxylic acid

@ terephtalic acid

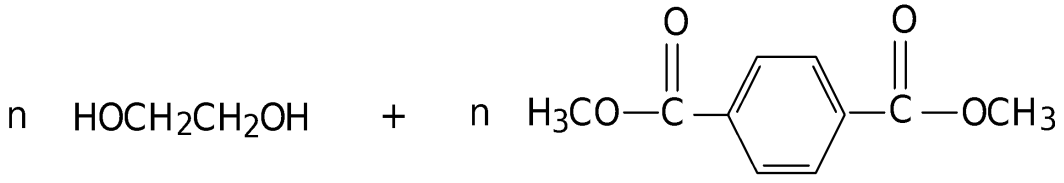
Monomer	Repeating Unit	Polymer

[redacted] **Dacron, Terylene**

- The repeating functional group in this polymer chain are **ester.**
- Formed when a **carboxylic acid** with **two –COOH @ –COOR groups** reacts with an **alcohol** with **two –OH groups.**

Formation of Dacron

- In the process, a molecule of **methanol (CH_3OH) is removed**.

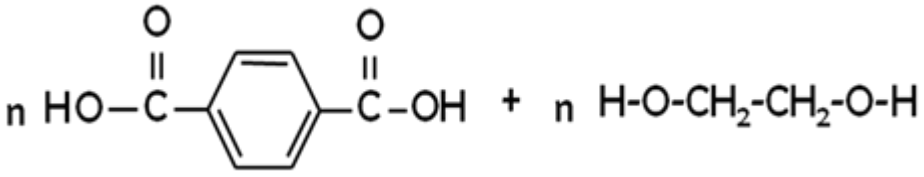


1,2-ethanediol | dimethyl terephthalate

Monomer	Repeating Unit	Polymer

Formation of Terylene

- In the process, a molecule of **water (H_2O) is removed**.



1,4–benzenedicarboxylic acid | 1,2–ethanediol

Monomer	Repeating Unit	Polymer

SUBTOPIC	LEARNING OUTCOMES	MAPPING COGNITIVE DOMAINS			
		C1	C2	C3	C4
Polymer	e) State the uses of synthetic polymers	√			

USES OF SYNTHETHIC POLYMER

TYPE OF POLYMER	USAGE
Polyethylene	Drinking bottles
Polyvinyl chloride	Wire covering
Polystyrene	Toys, food container
Teflon	Non-stick pans
Nylon 6	Textile
Nylon 6,6	Sweater
Kevlar	Bullet proof vest
Dacron / Terylene	Fabric, Fiber-optic material