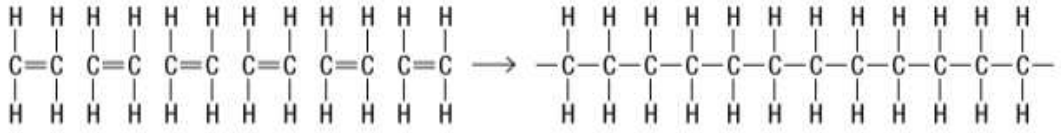
Grade 12 Chemistry

Organic Chemistry

Class 4

Polymers

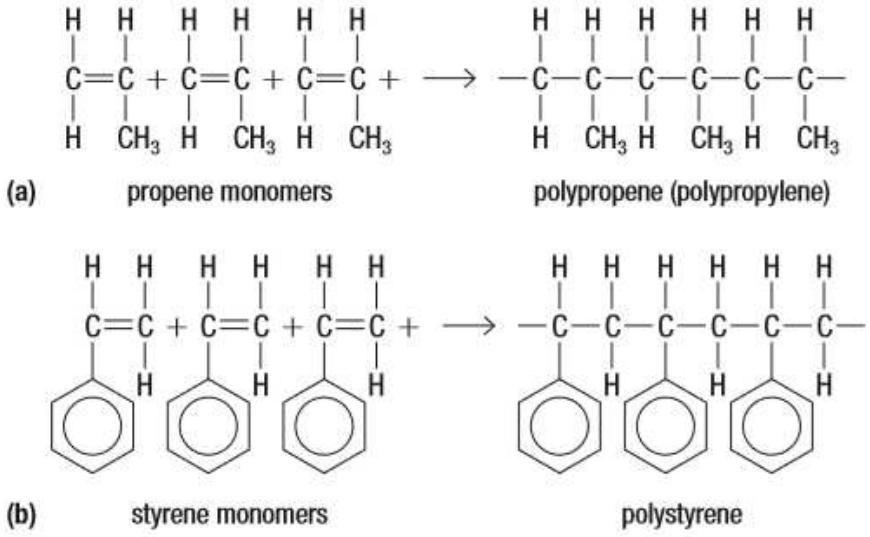
- Polymer – large molecule built from monomers
- Monomer – a simple, repeating unit
- Natural and synthetic polymers are used in textile fibres, rubber, and plastics



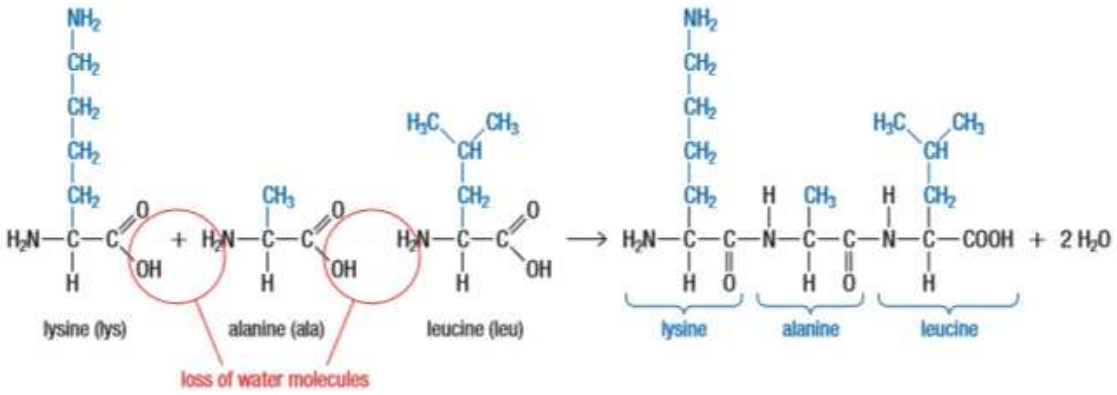
ethene monomers — polyethene (polyethylene) polymer

Figure 2 Polymerization of ethene molecules produces polyethene (polyethylene).

- Homopolymer – polymer formed by reactions involving a single type of monomer

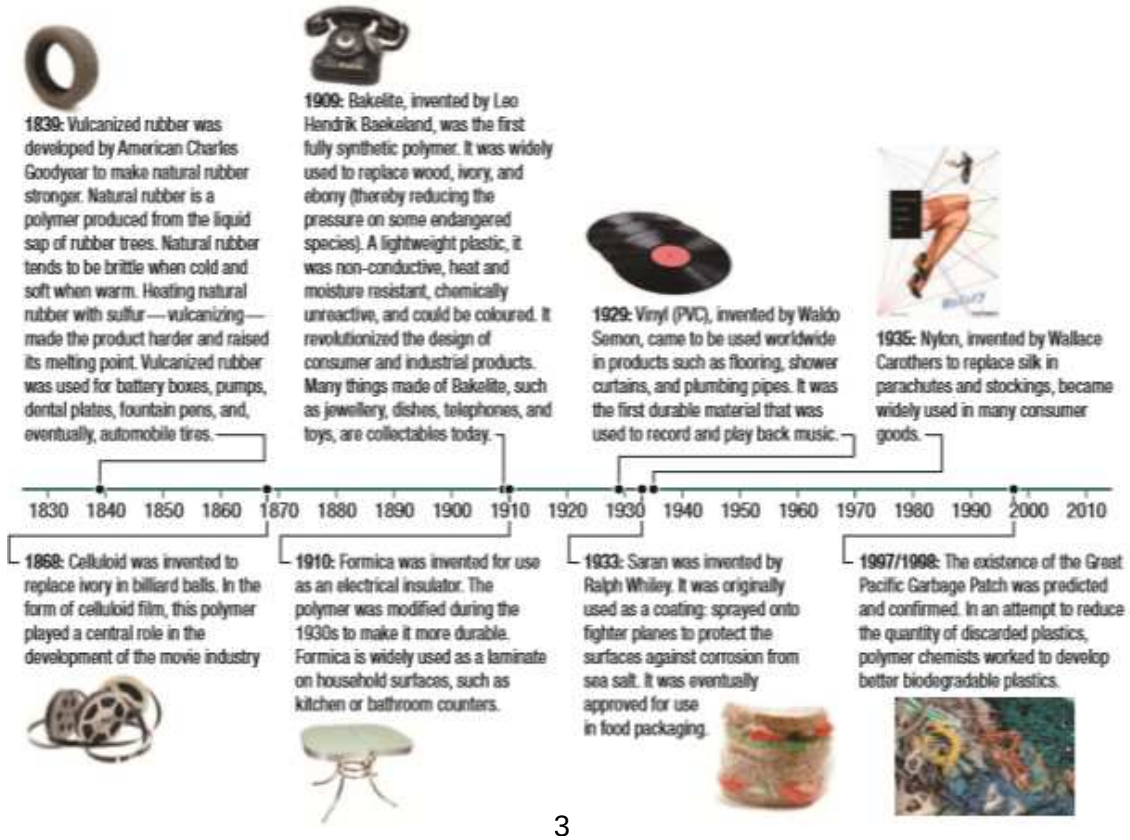


- Copolymer – different types of monomers combined to form the polymer chain
  - May join in an addition reaction or in a condensation reaction
  - Ex: Silk – a natural polymer is formed by joining amino acids in multiple condensation reactions



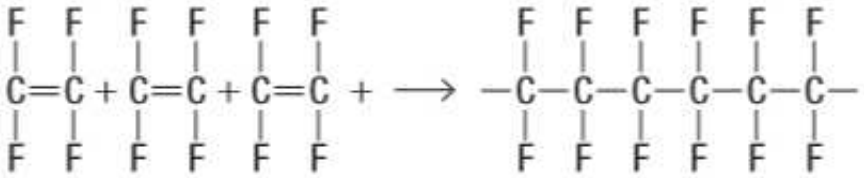
Natural vs. Synthetic

Natural	Synthetic
• Starch • Cellulose • Glycogen • DNA/RNA • Silk • Spider silk • Amber • Rubber • Animal horns	• Polyester • Polyethene • Polypropene • Fluoropolymers – used in non-stick coating on cookware • Rubber tires • Kevlar fibres in body armour



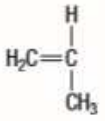
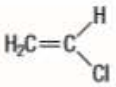
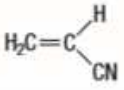
Synthetic Addition Polymers

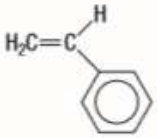
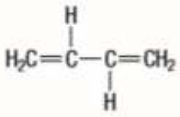
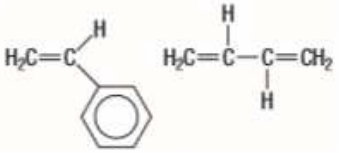
- Addition polymer – result of the reaction between monomers with unsaturated carbon-carbon bonds



tetrafluoroethene polytetrafluoroethene

- Polytetrafluoroethene (PTFE) is commonly known as Teflon on non-stick pans

Monomer		Polymer	
Name	**Formula**	**Name**	**Uses**
ethene	$H_2C=CH_2$	polyethene (polyethylene)	plastic bottles and pipes, insulation on electric wires, toys
propene		polypropene (polypropylene)	rope, packaging film, carpet fibres, toys 
chloroethene (vinyl chloride)		polyvinyl chloride (PVC)	pipes, construction materials, floor tile, clothing, reusable bags 
cyanoethene (acrylonitrile)		polyacrylonitrile (PAN)	carpet fibres, synthetic fabrics
tetrafluoroethene	$F_2C=CF_2$	polytetrafluoroethene (Teflon)	non-stick cookware, electrical insulation, ball bearings

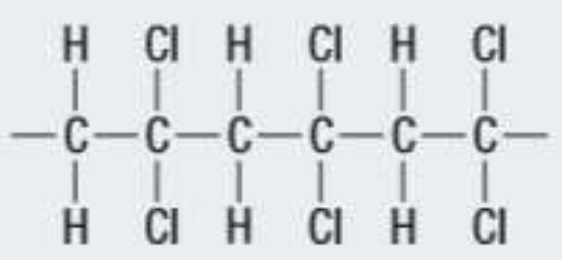
vinylbenzene (styrene)		polystyrene	food and beverage containers, insulation, toys 
butane-1,3-diene (butadiene)		polybutadiene	tires, industrial coatings
vinylbenzene (styrene) and butane-1,3-diene (butadiene)		styrene–butadiene rubber (a copolymer)	synthetic rubber

Checkpoint

Draw a structural diagram showing three repeating units of the addition polymer formed from cis-but-2-ene

Checkpoint

Draw a structural diagram of the monomer used to make Saran wrap. Name the monomer.



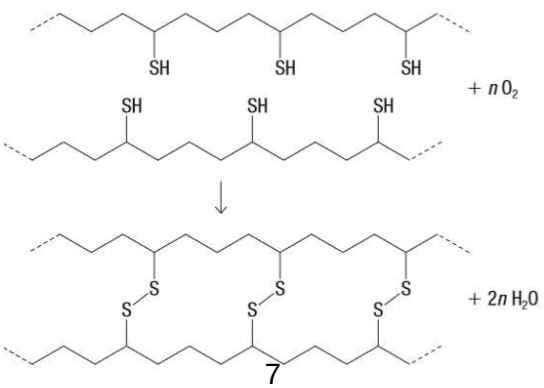
Plastics

- A synthetic substance that can be moulded (often under heat and pressure) and retains its given shape
- Held together by single carbon-carbon bonds; very strong and less reactive than double bonds
- Weak intermolecular forces between carbon atoms allow the plastic to flex and stretch

- Plastics are categorized based on their density
- Low-density polyethene (LDPE) has more branches in its structure prevent it from packing as tightly as High-density polyethene (HDPE)
- LDPE is used in plastic bags, packaging materials
- HDPE is used in blow-moulded products such as milk jugs and water bottles

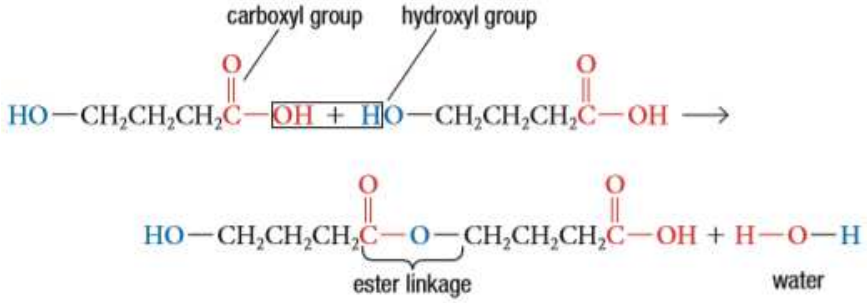
Polymer Cross-Linking

- Formation of chemical bonds between separate polymer strands
- The more cross-links, the more rigid and inflexible the polymer

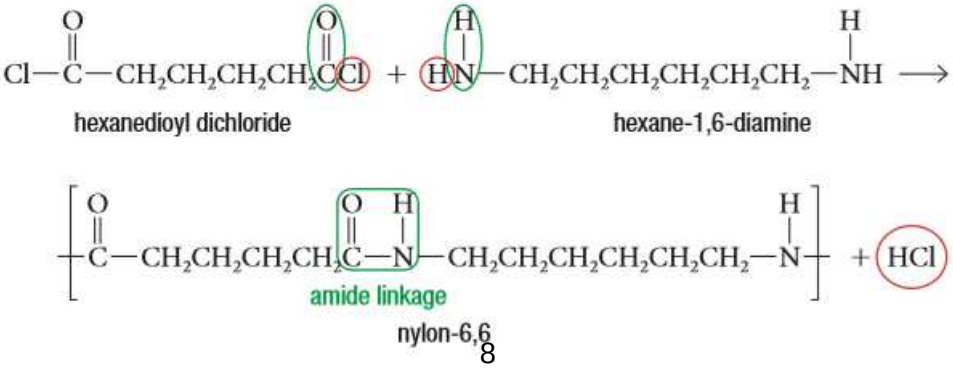


Synthetic Condensation Polymers

- Composed of repeating groups of monomers with two reactive functional groups involved in the polymerization reaction
- Polyesters are formed by a series of esterification reactions that produce a water



- Polyamides are formed by the condensation of an amine and a carboxylic acid
- Ex: Kevlar in body armour
- Nylon 6,6 is a copolymer with two types of monomers

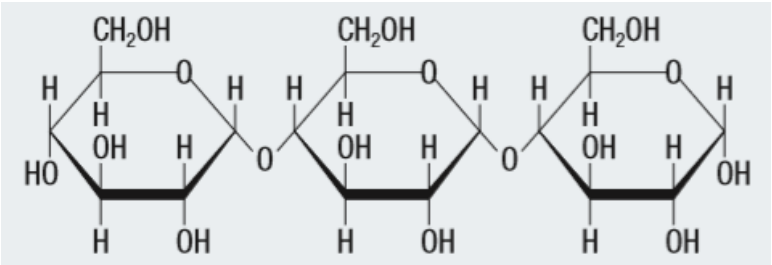


Checkpoint

Draw a condensed structural diagram of the polymer made from repeating units of a 4-carbon diamine and a 6-carbon dicarboxylic acid

Checkpoint

Starch is a polymer formed in a condensation reaction in which molecules of water are eliminated from the new bonds. Draw the monomer that makes up starch.



Checkpoint

Draw a structural diagram of the polymer formed by the reaction of:

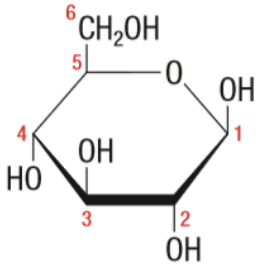
a) Propane-1,3-diol and pentanedioic acid

b) Butanedioic acid and a 5-carbon diamine

c) Hexanedioic acid and a 3-carbon diamine

Natural Polymers

- Carbohydrates – polymer of monosaccharides (simple sugars) to form a polysaccharide
  - Ex: starch, cellulose, glycogen



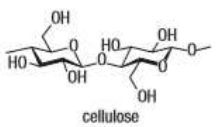
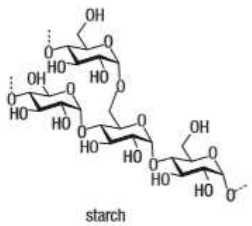
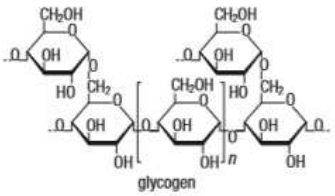
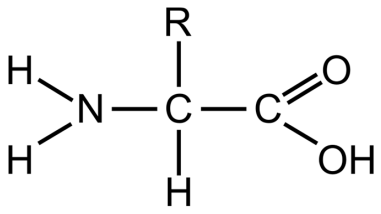


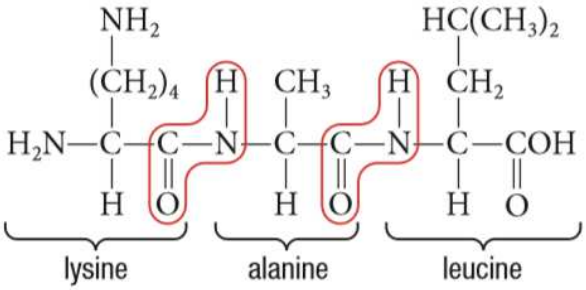
Figure 3 Three polymers of glucose

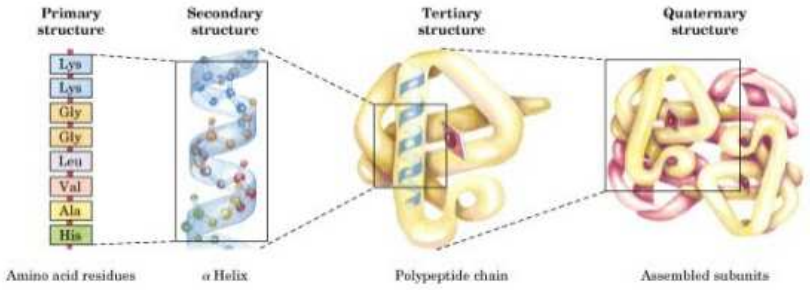




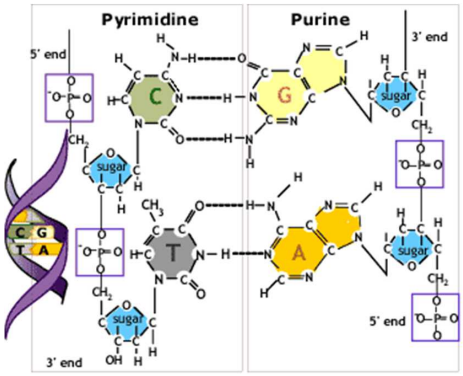
- Protein – polymer made of amino acids joined together by peptide bonds through a condensation reaction

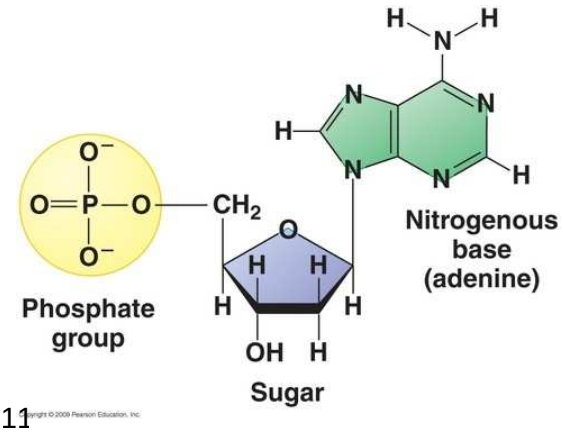






- Nucleic Acids – polymer made of nucleotides consisting of a 5-carbon sugar, a nitrogen-containing base and a phosphoric acid molecule
- Nucleotides link together through condensation reactions





Summary of Natural Polymers

Macromolecule	Monomer	Bond/Linkage	Polymer
Carbohydrate	Monosaccharides	Glycosidic Linkage	Polysaccharides
Protein	Amino Acid	Peptide Bonds	Polypeptide
Nucleic Acids	Nucleotide	Phosphodiester Linkages	Strand