CHEM 9.2.2 BIOLOGICAL POLYMERS

Some scientists research the extraction of materials from biomass to reduce our dependence on fossil fuels

2.1 Discuss the **need for alternative sources** of the compounds presently obtained from the petrochemical industry

- Dependence on crude oil – **only 3-5% reserved** for petrochemical industry (making polymers)
- **Limited and non-renewable**, run out w/in next few decades
- Alternative source – renewable **biomass** (material produced by living organisms)
  - Plant material, animal excreta, organic household waste
- **Cellulose** (M comp/t) as a source for starting materials, + **starch and sugar** (m comp/t)
  - Fermentation to ethanol, dehydration to ethylene (heat + H_2SO_4)

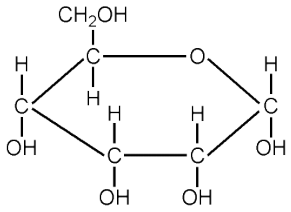
2.2 Explain what is meant by a **condensation polymer**

- Polymers that form by the **elimination of a small molecule** (often water) when pairs of monomer molecules join together, and is **biodegradable** (unlike addition polymers)
- Example is **cellulose:**
  - Monomer – **glucose** $C_6H_{12}O_6$, structure $HO–C_6H_{10}O_4–OH$
  - OH joins with H to form water, remaining **O** links to become polymer
- Others include nylon, carbohydrates, proteins, and silk

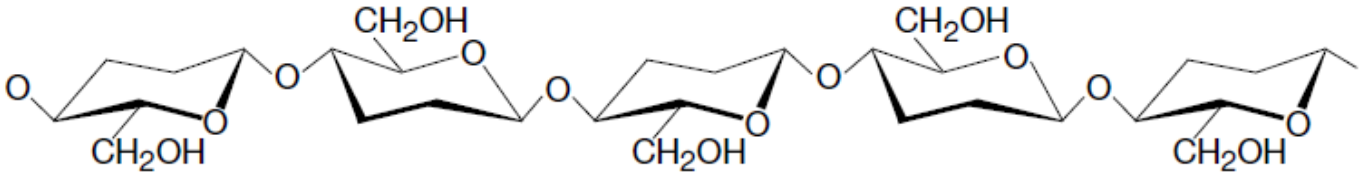
2.3 Describe the **reaction** involved **when a condensation polymer is formed**

- A pair of monomers join together, with a molecule of water being split out between the function groups
- For **nylon-6 (polyamide):**
  - Monomer – **6-aminohexanoic acid**, structure $H_2N–(CH_2)_5–COOH$
  - OH joins with H, NH links with CO to form a **amide link**/peptide link (–CO–NH–)

2.4 Describe the **structure of cellulose** and identify it as an example of **a condensation polymer** found as a major component of **biomass**



- Glucose: **5 C, 1 O** atoms forming a **puckered ring** – **OH's on all C's**
- Cellulose is formed by **alternate glucose units being inverted** (α down, β up)
- Cellulose is very **linear** – geometry of rings and C–O–C bond angles
  - Very strong – closely packed rings and hydrogen bonds



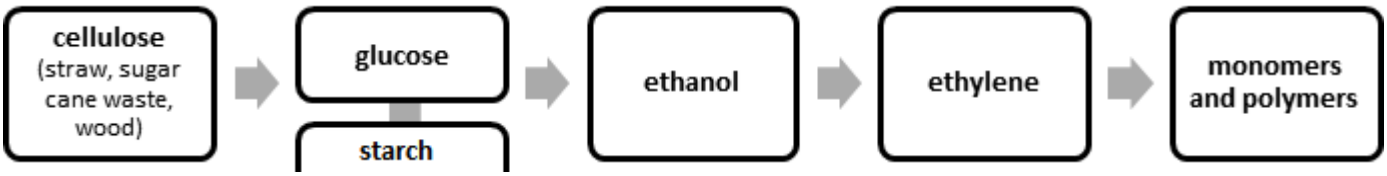
- Cellulose is major component of plant **material/biomass**
  - Biomass is material produced by **living organisms**; mainly it is **plant material**, though the term also includes **animal excreta** and material made by **algae**

- Main part of plant cell walls, structural component of woody plants and natural fibres such as cotton, flax and hemp

2.5 Identify that cellulose contains the basic carbon-chain structures needed to **build petrochemicals** and discuss its **potential as a raw material**

CELLULOSE FOR PETROCHEMICALS

- Cellulose is a source for ethanol and ethylene instead of using starch – **far more cellulose than starch**
- Each cellulose has 6 C atoms – regarded as **basic structure for making starting molecules**
  - Ethylene (2 C atoms), propylene (3 C atoms), butane (4 C atoms – synthetic rubber)



- Difficult to break cellulose than starch into glucose
  - **Digestion by cellulose enzymes** – finely ground materials treated with NaOH/hot water, swells cellulose fibres, digests with enzymes (present in bacteria)
  - **Digestion with strong acid** – heating with mod'ly conc. H_2SO_4, impurities removed, acid neutralised
- Energy required (mixtures hot, driving machinery) – more oil used than for cracking the oil

POTENTIAL AS A RAW MATERIAL

- Biopolymers – polymers made totally or in large part by living organisms
- Biopolymers made from cellulose (itself a biopolymer):
  - **Rayon (viscose)**: reconstituted cellulose, silky fabric, **cellophane**: form of rayon

