POLYMERIC MACROMOLECULES: CARBOHYDRATES, PROTEINS
CARBOHYDRATES

Sugars, starches, glycogens, celluloses

C\textsubscript{n}(H\textsubscript{2}O)\textsubscript{n}  "carbo-hydrate"

Glucose (representative monomer) \( \text{(C}_6\text{H}_{12}\text{O}_6) \)
Different sugars have different numbers of carbons

Or different arrangements of -OH and -H

Six-carbon sugars

α-Mannose  α-Galactose  Fructose
Cellulose (representative glucose polymer)

Condensation reaction joins two glucoses
Cellulose (representative glucose polymer)

More condensation, longer chains
Starch (unbranched), glycogen (branched) glucose polymers
PROTEINS

Large: MW average 30,000 daltons (AMU)

Many different types
- Unique three-dimensional structures
- Different structures give different functions
Primary structure

Monomer: amino acid
- Alpha-carbon
- Carboxylic acid group
- Amino group
- R group: side chain

20 different side chains make 20 different amino acids, some polar, some non-polar
Peptide bonds: connections between monomers
**Amino acid sequences**

Each amino acid, distinguished by its side chain (R), has a name:

- alanine         -CH$_3$     ala
- glycine         -H          gly
- serine          -CH$_2$OH   ser
- aspartic acid   -CH$_2$-COOH asp

A polypeptide chain as a sequence of amino acids:

gly-ala-ser-asp-gly-gly-
Summary: Primary structure

- Amino acid sequences
- Peptide bonds holding together the amino acid residues
- One-dimensional structure

Notice the N-C-C-N-C-C- "backbone"
Secondary structure

Hydrogen bonds
- Bonds holding together 2 electronegative atoms (O,N) with H in the middle
- 1/16 of the strength of a C-C covalent bond

Hydrogen bonds between water molecules:
Hydrogen bonds stabilize polypeptide backbone atoms:

Summary: secondary structure

- Hydrogen bonds in polypeptide backbone
- Alpha-helix and beta-pleated sheet structures
**Tertiary structure**

Further detailed three-dimensional structure involving positions of side chains and the interactions between the side chains.
**Tertiary structure**

Bonds formed between *side chains:*

1. Hydrogen bonds
2. Ionic (electrostatic) interactions
3. Disulfide bridges
4. Hydrophobic bonds
5. Van der Waals interactions ("London forces")
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Polarized electron shells produce electrostatic attractions.

Force depends on distance \(F = f(r^{-7})\) for noble gases), maximum attraction at 0.4 nm for Ar-Ar.

Stabilize close packing of many atomic pairs.
Summary: tertiary structure

- Detailed three-dimensional structure of protein; positions of side chains
- Bonds between side chains

Note “domains”: semi-independent units of structure; some proteins related by sharing similar domains.
**Quaternary structure**

Combination of separate polypeptide chains

Held together by interactions between side chains
**Protein denaturation**

Irreversible change in the three-dimensional structure of a protein

Weak bonds: H-, ionic, hydrophobic, Van der Waals): easily broken by:

- Heat
- Acid
- Alcohol (a hydrophobic solvent)
- Detergents

Once broken, bonds may reform inappropriately
The energy of folding a protein is low (-5 to -15 Cal/mol), so proteins are easy to denature, but is is also easy just to change their shape in minor ways. How could this be useful? Pick an analogy that applies.

(a) It is easy to turn a cell phone off by closing the lid.

(b) I crumple up a newspaper before throwing it away.

(c) I can pass my computer’s electrical cord through a hole in my desk top by uncoiling it.

(d) A slinky walks down stairs by uncoiling and recoiling.
Example of protein denaturation: egg whites

Example: silver fizz
  1 1/2 oz gin
  1 oz lemon juice
  1 tbsp sugar
  1 egg white
  ice, soda

First mix gin, lemon juice with ice (dilutes alcohol and acid); then add egg whites. **Do not** mix egg white directly with gin.

Protein functions depend on 3-dimensional structures; denaturation ruins functions properties of proteins by changing their structures

Denaturation is why heat, acid, alcohol destroy living cells.
What else, besides egg whites, should not be mixed with gin?
(a) lemon juice
(b) sugar
(c) ice
(d) driving
(e) bungee jumping