Bio 366: Biological Chemistry 2

Lecture 1: Course Introduction and Review of Carbohydrate Structure

Instructor: Dr. Caro-Beth Stewart
Teaching Assistant: Mr. Tom Mennella

Course URL:
METABOLISM---
the biosynthesis (anabolism) and degradation (catabolism) of complex metabolites.

We'll focus on metabolism of "food" in humans over the next few weeks:

1. Carbohydrates (sugars)
2. Lipids (fats)
3. Amino acids (proteins)
4. Nucleic acids (DNA and RNA—not used for major nutritional purposes in humans, but are metabolized for energy purposes by some animals)
Fig. 13.2
OVERVIEW OF CATABOLISM:

Glycolysis,

TCA (citric acid) cycle,

Oxidative-phosphorylation

Sugars, proteins & fats all feed into these cycles.
CARBOHYDRATE metabolism

- GLYCOGEN metabolism.
  To understand this material, you must first learn (review) some basic SUGAR structures (especially GLUCOSE).

Most of this material comes from Chapter 8 of Voet, Voet and Pratt (VVP).
Figure 8.1. The α-aldoses with three to six carbon atoms.
You're expected to know:

- Carbohydrate and sugar nomenclature, especially pertaining to GLUCOSE monomers and polysaccharides.
- The numbering system of glucose (and, later, ribose)
- The reducing end of sugars
- Storage polysaccharide structures (α-amylose and amylopectin)
- The structural polysaccharides, cellulose and chitin.
- The peptidoglycan wall of bacteria
Carbohydrates or saccharides are the most abundant biological molecules, and are composed of (see figures in Chapter 8 for structures):

Simple sugars:
- **Monosaccharides** have a single unit.
- **Disaccharides** have two units.

Sucrose = "sugar" legally!

You must know the numbering system of glucose (see next slide, Fig. 8-4), as it helps make sense of the bond names.
α-D-glucopyranose  D-glucose  β-D-glucopyranose
(linear form)

(pyanose = sugar with a six-membered ring)
• **GLUCOSE** is a major metabolic **fuel source** in living organisms which is **degraded via glycolysis** to produce ATP.

• Higher organisms protect themselves from potential fuel shortages by storing glucose by polymerizing it into high molecular mass **GLUCANS, or glucose polysaccharides** — complex carbohydrates with monosaccharides held together by "glycosidic" **bonds** (the bond connecting the anomeric carbon to the acetyl oxygen) between neighboring units.

• Enzymes that hydrolyze glycosidic bonds are referred to as **glycosidases**.
In PLANTS:
The major glucose storage substance is STARCH, which is a mixture of...

\[ \alpha\text{-amylose,} \]
\[ \text{an } \alpha(1\rightarrow4)\text{-linked glucan (glucose polymer), usually several thousand glucose units long} \]

\[ \& \]

\[ \text{amylopectin,} \]
\[ \text{like amylose, but has } \alpha(1\rightarrow6)\text{ branches every 24-30 residues on average; up to } 10^6 \text{ glucose units/molecule} \]

These are stored in the cytoplasm of plant cells.
In ANIMALS:

The storage glycan of animals is **GLYCOGEN**, which differs from amylopectin only in that the branches occur every 8-12 residues.

Glycogen occurs in **granules** of about **100-400 Å diameter** in cytoplasm of cells that use it most.

For example:

- **Muscle** has a maximum of **1-2%** of its weight in glycogen.
- **Liver** has a maximum of **10%** by weight. Combined, this is about a **12 hour** energy supply for the body (about 1 day).

["Carbohydrate loading" fills these glygogen stores.]
Fig. 8-11: A beautiful micrograph of a liver cell showing stored glycogen:

Glycogen granules also contain the enzymes that catalyze glycogen synthesis and degradation, as well as some regulatory enzymes.
Cellulose

Glucose

\[ \text{CH}_2\text{OH} \]

\[ \text{OH} \]

\[ \text{H} \]

\[ \text{O} \]

\[ \text{H} \]

\[ \text{H} \]

\[ \text{OH} \]

\[ \text{H} \]

\[ \text{H} \]

\[ \text{H} \]

\[ \text{CH}_2\text{OH} \]

\[ \text{OH} \]

\[ \text{H} \]

\[ \text{O} \]

\[ \text{H} \]

\[ \text{H} \]

\[ \text{H} \]

\[ \text{O} \]

\[ \text{n} \]
Chitin

$N$-Acetylglucosamine

$N$-Acetylglucosamine
Figure 8-15. Peptidoglycan.