UNIT 2: BIOCHEMISTRY

TOPIC C: CARBOHYDRATES & LIPIDS

Essential Idea(s)

- Carbohydrates and lipids provide the energy of life.

IB Assessment Statements and Class Objectives:

2.1.S1: Drawing molecular diagrams of glucose, ribose, and fatty acids.
- Draw molecular diagrams of ribose, glucose, and a saturated fatty acid.
- Identify the carboxyl and methyl groups on your fatty acid drawing.

2.1.S2: Identification of biochemicals such as sugars and lipids from molecular drawings.
- State the generalized chemical formula of carbohydrates.
- Describe the physical appearance of carbohydrates and lipids.

2.3.U1: Monosaccharide monomers are linked together by condensation reactions to form disaccharides and polysaccharide polymers.
- Define monosaccharide, disaccharide and polysaccharide. Include an example for each.

2.3.A1: Structure and function of cellulose and starch in plants and glycogen in humans.
- State the structural difference between alpha and beta glucose.
- Contrast the structures and functions of cellulose, amylose, amylpectin and glycogen.

2.3.U2: Fatty acids can be saturated, monounsaturated and polyunsaturated.
- Describe the differences between saturated and unsaturated fatty acids.

2.3.U3: Unsaturated fatty acids can be cis or trans isomers.
- Describe the differences between cis- and trans- fatty acids.

2.3.U4: Triglycerides are formed by condensation from three fatty acids and one glycerol.
- Outline the differences between fats and oils.
- State two functions of triglycerides.

2.3.A2: Scientific evidence for health risks of trans fat and saturated fatty acids.
- Discuss the relationship between saturated fatty acids and/or trans-fat intake and rates of coronary heart disease.

2.3.S2: Determination of body mass index by calculation or use of a nomogram.
- Calculate your BMI using the formula.
- Describe how to determine BMI using a nomogram.
- Outline the effects of a BMI that is too high or too low.

2.3.A3: Lipids are more suitable for long term energy storage in humans than carbohydrates.
- Explain the energy storage of lipids compared to that of carbohydrates.

D.1.S1: Determination of the energy content of food by combustion.
- Explain how a calorimeter can be used to determine the energy content in food.
- Describe how to calculate the energy content of a food sample using calorimetry data.
REVIEW
Four classes of biological macromolecules:
1. carbohydrates
2. lipids
3. proteins
4. nucleic acids

Polymers are made up of smaller parts called monomers.
Polymers are formed through condensation reactions.
Polymers are broken apart through a hydrolysis reaction.

Carbohydrates

STRUCTURE:
- Made of C, H, and O
- "Carbo" contains C
- "Hydrate" - H₂O
- Often end in... ose

FUNCTIONS:
1. Immediate... energy source
2. Energy storage for... later use
3. Raw material for... building materials
4. Important role in... cell membrane recognition

About 17 KJ of energy per dry gram. About the same as protein, but ½ that of lipids.

Types of carbohydrate
- sugars
  - mono
  - di
  - poly

MONOSACCHARIDES:
- Backbone... 3-7 carbon
- Form... ring structures
- Characterized by... sweet taste
- Have several... polar OH groups
  - so they are... soluble in H₂O
  - (The many -OH groups can hydrogen bond with water molecules)

DISACCHARIDES:
- Two... sugars bonded
- Formed through... condensation reactions

POLYSACCHARIDES:
- Polymers of... many sugar molecules
- Costs little... energy to build
- Easily reversible = release energy when digested
<table>
<thead>
<tr>
<th>Carbohydrate</th>
<th>Type</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha-Glucose</td>
<td>Mono</td>
<td><img src="image" alt="Structure" /></td>
<td>product of photosynthesis make ATP in C.R.</td>
</tr>
<tr>
<td>$C_6H_{12}O_6$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta-Glucose</td>
<td>Mono</td>
<td><img src="image" alt="Structure" /></td>
<td></td>
</tr>
<tr>
<td>$C_6H_{12}O_6$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-Ribose</td>
<td>Mono</td>
<td><img src="image" alt="Structure" /></td>
<td>building blocks for nucleic acids</td>
</tr>
<tr>
<td>$C_5H_{10}O_5$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deoxyribose</td>
<td>Mono</td>
<td><img src="image" alt="Structure" /></td>
<td></td>
</tr>
<tr>
<td>$C_5H_{10}O_4$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maltose</td>
<td>Di</td>
<td><img src="image" alt="Structure" /></td>
<td>energy for germinating seeds between C1 and C5</td>
</tr>
<tr>
<td>$C_{12}H_{22}O_{11}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>Di</td>
<td><img src="image" alt="Structure" /></td>
<td>transport sugar used by plants + animals</td>
</tr>
<tr>
<td>$C_{12}H_{22}O_{11}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>Type</td>
<td>Structure</td>
<td>Function</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------</td>
<td>------------------------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Lactose $C_{12}H_{22}O_{11}$</td>
<td>Di</td>
<td><img src="image" alt="Lactose Structure" /></td>
<td>milk Sugar that nourishes baby mammals</td>
</tr>
<tr>
<td>Starch – amylose</td>
<td>Poly</td>
<td><img src="image" alt="Amylose Structure" /></td>
<td>Storage plants roots/seeds to store glucose</td>
</tr>
<tr>
<td>Starch – amylopectin</td>
<td>Poly</td>
<td><img src="image" alt="Amylopectin Structure" /></td>
<td>Storage animals</td>
</tr>
<tr>
<td>Glycogen</td>
<td>Poly</td>
<td><img src="image" alt="Glycogen Structure" /></td>
<td>Storage animals formed in liver to store glucose</td>
</tr>
<tr>
<td>Cellulose</td>
<td>Poly</td>
<td><img src="image" alt="Cellulose Structure" /></td>
<td>Structure cell walls indigestible for animals</td>
</tr>
</tbody>
</table>
Functions of Lipids

Both bile acids and vitamin D are manufactured from steroid fats.

Waterproofing

Nutrition

Honeycomb

Storage

Water repellent

Attraction

Thermal insulation

Physical protection

Hormones

Myelin is secreted by Schwann cells and insulates some neurons in such a way that nerve impulse transmission is made much more rapidly.

Phospholipids are found in all cell membranes.

Oily secretions of the sebaceous glands help to waterproof the fur and skin. The preen gland of birds produces a secretion which performs a similar function on the feathers.

What are lipids?

- All lipids contain large, nonpolar hydrocarbons.
- Most lipids are therefore hydrophobic.
- Diverse in structure.
- Do not form polymers.

High energy yield per mass and insolubility in water make fats and oils ideal energy storage compounds particularly where dispersal or locomotion requires mass be kept to a minimum, as in some seeds and fruits.

The waxy cuticle of insects and plants reduces water loss by evaporation since water cannot cross the insoluble lipid layer.

Plant scents are derivatives of fatty acids. They are attractive to insects and thus aid pollination.

Fats conduct heat very poorly; subcutaneous fat stores help heat retention in endothermic animals. Incompressible blubber is an important insulator in diving mammals.

An important group of hormones, including cortisone, testosterone and estrogen are steroids.
A fatty acid is a long chain of mostly carbon and hydrogen atoms with a −COOH group ("carboxyl") at one end.

The hydrocarbon chain can vary in length, from about 4 to about 24 carbons long, depending on the types of fatty acids.

Fatty Acids

Saturated
- Have mostly... single C–C bonds
- Are typically... solid
- Are often from... animals

Unsaturated
- Have one (mono-) or more (poly-)... C=C double bonds
- Are typically... liquid
- Are often from... plants

Cis-unsaturated
- natural
- "same side"
- causes a kink

Trans-unsaturated
- not in nature
- "opposite side"
- causes a straighter chain
<table>
<thead>
<tr>
<th>Type of Lipid</th>
<th>General Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triglycerides</td>
<td>Formed by condensation reactions: 3 fatty acids + glycerol $\rightarrow$ triglyceride</td>
</tr>
<tr>
<td>FAT =</td>
<td></td>
</tr>
<tr>
<td>OIL =</td>
<td></td>
</tr>
<tr>
<td>Function:</td>
<td>long-term energy storage</td>
</tr>
<tr>
<td>Compared to carbohydrates:</td>
<td>2x energy in carbs slower to build up + break down</td>
</tr>
<tr>
<td>Waxes</td>
<td>Composed of long... hydrocarbon chains + hydrophobic</td>
</tr>
<tr>
<td>Form...</td>
<td>water-proof coatings</td>
</tr>
<tr>
<td>Highly...</td>
<td>saturated</td>
</tr>
<tr>
<td>Solid...</td>
<td>at room temp</td>
</tr>
<tr>
<td>Steroids</td>
<td>Have a backbone of... 4 carbon rings</td>
</tr>
<tr>
<td>i.e. cholesterol</td>
<td>different functional groups to rings</td>
</tr>
<tr>
<td>Other examples include:</td>
<td>different functions</td>
</tr>
<tr>
<td>1. cortisol</td>
<td></td>
</tr>
<tr>
<td>2. aldosterone</td>
<td></td>
</tr>
<tr>
<td>3. testosterone</td>
<td></td>
</tr>
<tr>
<td>4. estradiol</td>
<td></td>
</tr>
<tr>
<td>5. progesterone</td>
<td></td>
</tr>
</tbody>
</table>
**Phospholipids**

Formed by attachment of two fatty acids plus a phosphate group to a glycerol in condensation reactions

- membranes

**Why is this important?**

- barrier out vs. in life is ORGANIZED

**HYDROPHOBIC AND HYDROPHILIC**

- Fatty acid tails = **hydrophobic**
- PO₄ head = **hydrophilic**

Phospholipids in water can self-assemble into:

- micelles
- bilayer

*Early evolutionary state of cells?*
Health Risks of Trans fat and Saturated Fatty Acids

- [http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/Trans-Fats_UCM_301120_Article.jsp#.VrJZs9IrJpg](http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/Trans-Fats_UCM_301120_Article.jsp#.VrJZs9IrJpg)
- [http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/Saturated-Fats_UCM_301110_Article.jsp#.VrJaVNIrJpg](http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/Saturated-Fats_UCM_301110_Article.jsp#.VrJaVNIrJpg)

**TRANS-FATS**

1. What are trans-fats?
   - Manufacturers turn liquid oils → solid fats
   - shortening, margarine

2. Where did trans-fats come from? Why are they used?
   - ↑ shelf life & flavor stability

3. Which foods contain trans-fats?
   - shortening, dressings, fried foods, cereal, crackers

4. How do trans-fats affect health?
   - clog arteries w/ plaque
   - raise LDL (bad cholesterol)
   - Cardiovascular issues

**SATURATED FATS**

5. What are saturated fats?
   - no double bonds → saturated w/ hydrogens

6. Which foods contain saturated fats?
   - meat + dairy

7. How do saturated fats affect health?
   - clog arteries

8. Are all fats bad?
   - No - some are needed for functions in your body... just limit
Nutritional Content of Food

1. Determine your estimated calorie needs per day: **2,000**

2. Determine the recommended amount of food from each group PER DAY given your daily calorie needs

<table>
<thead>
<tr>
<th>FOOD GROUP</th>
<th>SUGGESTED DAILY AMOUNT</th>
<th>ACTUAL AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARBOHYDRATES: Vegetables</td>
<td></td>
<td>2.5 c.</td>
</tr>
<tr>
<td>CARBOHYDRATES: Fruits</td>
<td></td>
<td>2 c.</td>
</tr>
<tr>
<td>CARBOHYDRATES: Grains</td>
<td></td>
<td>6 oz.</td>
</tr>
<tr>
<td>CARBOHYDRATES/PROTEINS/LIPIDS: Dairy</td>
<td></td>
<td>3 c.</td>
</tr>
<tr>
<td>PROTEINS: Protein</td>
<td></td>
<td>5.5 oz</td>
</tr>
<tr>
<td>LIPIDS: Oils</td>
<td></td>
<td>27 g</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>270</td>
</tr>
</tbody>
</table>

Body Mass Index

Body Mass Index (BMI) is a person’s weight in kilograms divided by the square of height in meters. A high BMI can be an indicator of high body fatness. BMI can be used to screen for weight categories that may lead to health problems but it is not diagnostic of the body fatness or health of an individual.

\[
\text{BMI} = \frac{\text{weight (lb)} \times 703}{\text{height}^2 \text{ (in}^2\text{)}}
\]

OR

\[
\text{BMI} = \frac{\text{weight (kg)}}{\text{height}^2 \text{ (m}^2\text{)}} \quad \text{(metric)}
\]

<table>
<thead>
<tr>
<th>TOO HIGH</th>
<th>TOO LOW</th>
</tr>
</thead>
</table>