Chapter 1

Carbohydrates, Lipids, and Proteins
Three Macronutrients

- Carbohydrates
- Lipids
- Proteins
Carbohydrates

- Three Classifications of Carbohydrates
  - Monosaccharides
    - Basic unit of carbohydrates
  - Oligosaccharides
    - 2-10 monosaccharides bonded chemically
  - Polysaccharides
    - 3 to thousands of sugar molecule linkages
Reaction driven by energy from sun interacting with chlorophyll

Leaves, wood, bark
cellulose, hemicellulose
Fruits
sugars, starch, cellulose
Grains
starch, cellulose
Vegetables
starch, cellulose
Monosaccharides

- Glucose or dextrose (blood sugar)
- Fructose (fruit sugar)
- Galactose (milk sugar)
Oligosaccharides

- The major oligosaccharide is the disaccharide or double sugar
  - Maltose = Glucose + Glucose
  - Lactose = Glucose + Galactose
  - Sucrose = Glucose + Fructose
Polysaccharides

• Plant polysaccharides
  - Starch is the storage form of carbohydrates in plants
    • Amylose
    • Amylopectin
  - Fiber occurs exclusively in plants
    • Cellulose
Daily Recommended Intake of Fiber

- Under 50
  - 38g for men
  - 25g for women
- Over 50
  - 30g for men
  - 21g for women
- Ratio of 3:1 for water-insoluble to soluble fiber
Glycogen Synthesis
Daily Recommendation of Carbohydrates

- Sedentary 70kg person
  - 300g or 40-50% of total calories
- Physically active person
  - 400-600g or 60% of total calories
- Athlete
  - 70% of total calories (8-10g per kg of body mass)
Review

Which classification of carbohydrate is made up of 3 to thousands of sugar molecules linked together?

a. Monosaccharides
b. Disaccharides
c. Polysaccharides
d. All of the above
Answer

Which classification of carbohydrate is made up of 3 to thousands of sugar molecules linked together?

a. Monosaccharides
b. Disaccharides
c. Polysaccharides
d. All of the above
Role of Carbohydrates

- Energy source
  - Energy is derived from the breakdown of blood-borne glucose
  - Muscle glycogen powers various forms of biologic work including muscle contraction
- Protein saver
  - Adequate carbohydrate intake helps to preserve tissue protein
Role of Carbohydrates (continued)

- Metabolic primer
  - The depletion of glycogen causes fat mobilization to exceed fat oxidation
  - Can lead to ketosis

- Fuel for the central nervous system
  - The brain almost exclusively uses blood glucose as its fuel source
  - Hypoglycemia is the reduction of blood glucose to <45mg/dL
Carbohydrate Dynamics in Exercise

- Intensity and duration determine the fuel mixture during exercise
  - High-intensity exercise
    - One hour of high-intensity exercise decreases liver glycogen by 55%
    - Two hours almost depletes the liver and muscle glycogen
Carbohydrate Dynamics in Exercise (continued)

- Moderate and prolonged exercise
  - During low-intensity exercise fat serves as the main energy substrate
Dynamics of Nutrient Metabolism

A. Plasma glucose (μM)

B. Serum fatty acids (μM)

C. Plasma 3-OHbutyrate (μM)

D. Exercise intensity (% of maximum)

A and B show the changes in plasma glucose and serum fatty acids with exercise time. C shows the increase in plasma 3-OHbutyrate with exercise time. D shows the decrease in exercise intensity with exercise time.
Fatigue

- Occurs when exercise continues to the point that compromises liver and muscle glycogen
- Commonly referred to as “hitting the wall”
Lipids

- Lipids are synthesized by plants and animals
- Three groups of lipids
  - Simple
  - Compound
  - Derived
Simple Lipids

- Consist primarily of triacylglycerols (TAG)
  - Major storage form of fat in adipocytes
  - Contain one glycerol and three fatty acid chains
  - The longer the fatty acid chain the less water-soluble the molecule
Fatty Acids

- Saturated fatty acids
  - When the carbon binds to the maximum number of hydrogens
  - Occur primarily in animal products
    - Beef, lamb, pork, egg yolk

- Unsaturated fatty acids
  - Monounsaturated contains one double bond
  - Polyunsaturated contain two or more double bonds
    - Linolenic acid is an essential fatty acid
Composition of Fatty Acids

![Chart showing the composition of fatty acids in various food items.](chart.png)
Review

• Lipids are synthesized by plants and animals.
  a. True
  b. False
Answer

- Lipids are synthesized by plants and animals.
  
a. True

b. False
TAG Formation
TAG Catabolism

Step 1: Triacylglycerol molecule

Step 2: 1,2-diacylglycerol

Step 3: 2-monoacylglycerol

Glycerol

Fatty acid

H₂O

HSL

HSL

Monoglyceride lipase + HSL

Fatty acid
Trans Fatty Acids

- Health concerns
  - Increases amount of low-density lipoprotein cholesterol (LDL)
  - Decreases amount of beneficial high-density lipoprotein cholesterol (HDL)
Lipids in the Diet

44% Meat, fish, poultry, eggs
24% Dairy
19% Cereal
7% Fruits, vegetables
5% Beans, peas, nuts
1% Fats, oils
Compound Lipids

- Phospholipids have four main functions
  - Interact with water and lipid to modulate fluid movement across cell membranes
  - Maintain the structural integrity of the cell
  - Play important role in blood clotting
  - Provide structural integrity to the insulating sheath that surrounds nerve fibers

- Glycolipids
- Lipoproteins
Lipoproteins

- Four types
  - Chylomicrons – transport Vitamins A, D, E, and K
  - High-density lipoprotein (HDL) – “good” cholesterol
  - Very low-density lipoprotein (VLDL) – transport TAGs to muscle and adipose
  - Low-density lipoprotein (LDL) – “bad” cholesterol
Derived Lipids

- Cholesterol
  - Exists only in animal tissue
  - Diets high in cholesterol can cause increased risk of coronary heart disease and atherosclerosis
**Daily Recommended Lipid Intake**

- A diet that contains 20% of total calories from lipids
- Replace high fat foods with fruits, vegetables, whole grains, fish, poultry, and lean meat
Role of Lipids in the Body

- Energy source and reserve
  - Carries large quantities of energy per unit weight
  - Transports and stores easily
  - Provides a ready source of energy
- Protection of vital organs
- Thermal insulation
- Vitamin carrier and hunger suppressor
Fat Dynamics in Exercise

- Light to moderate exercise
  - Energy comes from fatty acids

- Moderate intensity exercise
  - Energy comes from equal amounts of carbohydrate and fat supply

- High intensity exercise
  - Carbohydrates, primarily muscle glycogen is the source of energy
Proteins

• Amino acids are the “building blocks”

• Peptide bonds link together amino acids
  – Dipeptide is two amino acids joined together
  – Tripeptide is three amino acids joined together
  – Polypeptide is 50 to more than a 1000 amino acids
Essential Amino Acids

- Amino acids that the body can not synthesize
  - Isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tyrosine, and valanine
Review

What is the name of “bad cholesterol”?

a. High Density Lipoproteins (HDL)
b. Low Density Lipoproteins (LDL)
c. Very Low Density Lipoproteins (VLDL)
d. Chylomicrons
Answer

• What is the name of “bad cholesterol”?  
  a. High Density Lipoproteins (HDL) 
  b. Low Density Lipoproteins (LDL) 
  c. Very Low Density Lipoproteins (VLDL) 
  d. Chylomicrons
Protein Sources

- Complete proteins contain all of the essential amino acids
  - Eggs, milk, fish, and poultry
- Incomplete proteins lack one or more of the essential amino acids
  - Vegetables such as lentils, dry beans and peas, nuts, and cereals
Example Food Label

1. **Product name**
2. **Manufacturer name and address**
3. **Weight or measure**
4. **Ingredients in descending order of predominance by weight**
5. **Serving size, number of servings per container, and calorie information**
6. **Nutrition information panel provides quantities of nutrients per serving, in both actual amounts and as “% Daily Values” based on a 2000-Calorie energy intake**
7. **Descriptive terms if the product meets specified criteria**
8. **Approved health claims stated in terms of the total diet**
Daily Recommended Protein Intake

- 0.83g of protein per kg of body mass
  - Stress, disease, and injury increase protein requirements

- Excessive protein intake can have harmful side effects like strained liver and kidney function
Role of Protein in the Body

- Major sources of body protein
  - Blood plasma
  - Visceral tissue
  - Muscle
- Protein makes up 12-15% of body mass
Protein Metabolism

• Process of deamination (nitrogen removal) forms urea which leaves body as urine

• Remaining carbon skeletons from deamination follow one of three diverse biochemical routes
  – Gluconeogenesis
  – Energy source
  – Fat synthesis

• Excessive protein catabolism promotes fluid loss
Nitrogen Balance

- Occurs when nitrogen intake equals nitrogen excretion
  - Positive nitrogen balance
    - Growing children
    - During pregnancy
    - Recovery from illness
    - During resistance exercise training
Nitrogen Balance (continued)

- Negative nitrogen balance
  - Diabetes
  - Fever
  - Burns
  - Dieting
  - Growth
  - Steroid use
  - Recovery from illness
Review

• Can you eat too much protein?
  a. Yes
  b. No
Answer

• Can you eat too much protein?
  a. Yes
  b. No