Chapter 5 Carbohydrates

Overview

In Chapter 5, the authors present the first of the energy-yielding nutrients, carbohydrates. The chapter begins with the chemistry of carbohydrates and an introduction to basic carbohydrate structures, including monosaccharides, disaccharides, oligosaccharides, and polysaccharides. The differences between and functions of digestible and indigestible carbohydrates are discussed with a particular emphasis on the health benefits of indigestible carbohydrates (e.g., dietary fiber). Food sources and uses of the various types of carbohydrates are given along with a discussion of uses and safety of nutritive and non-nutritive sweeteners. Students will learn about the recommendations of various health agencies for carbohydrate intake - from total carbohydrates to dietary fiber to added sugars - and how typical North American food intake patterns compare to these recommendations. The processes of digestion and absorption are reviewed as they specifically relate to carbohydrates. The chapter wraps up with a discussion of health concerns associated with carbohydrate intake, including type 1 and type 2 diabetes, lactose intolerance, and dental caries

Learning Objectives

1. Identify the major types of carbohydrates and give examples of food sources for each.
2. List alternative sweeteners that can be used to reduce sugar intake.
3. Describe recommendations for carbohydrate intake and health risks caused by low or excessive intakes.
4. List the functions of carbohydrates in the body.
5. Explain how carbohydrates are digested and absorbed.
6. Explain the cause of, effects of, and dietary treatment for lactose intolerance.
7. Describe the regulation of blood glucose, conditions caused by blood glucose imbalance, types of diabetes, and dietary treatments for diabetes.
8. Describe dietary measures to reduce the risk of developing type 2 diabetes.

Teaching Strategies, Activities, Demonstrations, and Assignments

1. Ask students to conduct an internet search for advertisements by chiropractors, homeopaths, naturopaths, and health/diet food stores offering treatment and products for constipation and “irregularity.” Investigate other possible sources of advertising for laxative products and “colonic irrigation” that might be found in local newspapers and magazines. Discuss the cost of these treatments and determine if there is a potential for harm from such treatments or products.
2. Visit pharmacies, supermarkets, and health food stores to determine the types of laxatives and diarrhea medications offered for sale. Make a list of these OTC drugs and medications that promise relief from gastrointestinal disorders. Read labels and determine the active ingredients in these products. Do any come with warning labels?
3. Visit health-food stores selling enzymes and other aids to digestion. Where are these products made and what are the basic ingredients? What sort of health claims do they make? Discuss the potential harm in taking megadoses of these enzymes.
4. Have students watch television commercials for several evenings (particularly around the dinner hour) and record the number of commercials devoted to promoting OTC laxatives, antacids, and products to treat heartburn. Determine the volume of advertising devoted to these products in the local market. Consult marketing specialists for the dollar volume of business generated by these products.
5. Using the previous printout from NutritionCalc Plus diet analysis assignment, determine the fiber intake in a day's menu. Discuss how students can increase their fiber intake. Sort foods by their content of water-soluble and water-insoluble fibers.
6. Have students diagram the digestion and absorption pathways for a sample afternoon “coffee break” composed of CHO-rich foods.

7. Complete the following student assignment to discover what diet changes and possible treatments need to be made to adjust for when the lactase enzyme fails to function.

STUDENT ASSIGNMENT

LACTOSE INTOLERANCE

Talk with a person who has been diagnosed with lactose intolerance. Consider helping this person learn more about the intolerance and how to best adjust.

1. What are the major complaints or symptoms?
2. What physiologically has caused these symptoms?
3. Persons with lactose intolerance usually have individual intolerances. Which dairy foods cannot be tolerated? (Be specific as to which kinds of cheeses, milks, yogurt, etc.)
4. How can this individual ensure getting enough calcium in the diet with these food limitations? What alternative calcium-rich food choices do they have?
5. What commercial products are available to be taken or chewed to increase the tolerance of fluid milk? (List product names and the forms in which they can be purchased, such as in tablet, liquid, etc.)
6. On what basis do these commercial products work?
7. What are the directions for their safe use?
8. Have students bring in a can/bottle/label of their favorite calorie containing beverage OR look up the nutrition facts on their favorite coffee store beverage. How many grams of sugar are in the item? What might they be able to drink as a lower sugar/calorie replacement?
9. On the whiteboard, write Type 1 Diabetes, Type 2 Diabetes and Both. Split the class into 2-4 teams. Starting with team 1, have them list a fact that falls under one of the categories. Write it under the category and ask the next team if that is correct. If the first team was correct, they get a point. If they were incorrect and the 2nd team can identify the error, the 2nd team gets a point. If both teams are incorrect, nobody gets the point. Provide prompts, as needed (complications, medication differences, etc). Use incorrect answers as opportunities for teaching moments.

Chapter 5 Carbohydrates

Lecture Outline

5.1 Structures of Carbohydrates

A. General
1. Includes sugar, starch, and fiber
2. Composed of carbon, hydrogen, and oxygen
3. Plants (the main source) produce glucose by photosynthesis from carbon (air), oxygen (air), hydrogen (water), and energy (sun)

B. Monosaccharides: Glucose, Fructose, Galactose, Sugar Alcohols, and Pentoses
1. Single sugars, $C_6H_{12}O_6$
2. Each monosaccharide contains 6 carbon, 12 hydrogen, and 6 oxygen molecules, but in slightly different configurations (see Figure 5-3)
3. Having 6 carbon molecules classifies these monosaccharides as hexoses
4. Glucose
   a. Most abundant monosaccharide
   b. Linked with other additional sugars
   c. "blood sugar"
5. Fructose
   a. Found in fruits, vegetables, honey, and high-fructose corn syrup
6. Galactose
   a. Most in our diets is combined with glucose to form lactose (milk sugar)
7. Sugar alcohols are derivatives of monosaccharides; used as sweeteners in sugarless gum and dietetic foods
   a. Sorbitol
   b. Mannitol
   c. Xylitol
8. Pentoses: 5 carbon sugars that are not supplied by the diet
   a. Essential part of cell's genetic material
      i. Ribose (part of RNA)
      ii. Deoxyribose (part of DNA)

C. Disaccharides: Maltose, Sucrose, and Lactose
1. Contain 2 monosaccharides linked together in a condensation reaction, which forms 1 molecule of water (see Figure 5-4)
   a. Alpha bonds: found in maltose and sucrose
   b. Beta bonds: found in milk sugar and dietary fiber; not easily broken down by digestive enzymes
2. Maltose
   a. 2 glucose molecules
   b. Found in seeds and alcoholic beverages
3. Sucrose
   a. Glucose + fructose
   b. Table sugar
   c. Found in plants such as sugar cane, sugar beets, maple tree sap
4. Lactose
   a. Glucose + galactose
   b. Found in milk and milk products

5. Simple sugars include monosaccharides and disaccharides

D. Oligosaccharides
1. Oligosaccharides
   a. Complex carbohydrates
   b. Contain 3 - 10 simple sugar units
2. Raffinose and Stachyose
   a. Onions, cabbage, broccoli, whole wheat, legumes
   b. Contain beta bonds
   c. Pass indigested into the large intestine
   d. Bacteria metabolize, producing intestinal gas
3. Enzyme preparation (e.g., Beano) breaks down indigestible oligosaccharides

E. Polysaccharides: Starch, Glycogen, and Fiber
1. General
   a. Polysaccharides are complex carbohydrates that contain hundreds to thousands of glucose molecules
   b. Digestibility is determined by type of bonds (alpha or beta)
2. Digestible Polysaccharides: Starch and Glycogen
   a. Starch
      i. Major digestible dietary polysaccharide
      ii. Storage form of glucose in plants
      iii. Amylose: linear, unbranched chain of many glucose molecules linked by alpha 1-4 bonds, which are broken by amylase produced in mouth and pancreas
      iv. Amylopectin: highly-branched chain of many glucose molecules linked by alpha 1-4 bonds and alpha 1-6 bonds (broken by an intestinal enzyme called alpha-dextrinase); causes more rapid rise in blood glucose than amylose because there are more sites for enzyme action
   b. Glycogen
      i. Storage form of carbohydrate in humans and animals
      ii. Glucose units linked by alpha bonds
      iii. More highly branched than amylopectin
      iv. Stored in liver and muscle cells
3. Indigestible Polysaccharides: Dietary and Functional Fiber
   a. Total fiber: dietary fiber + functional fiber
   b. Dietary fiber: occurs naturally in foods
   c. Functional fiber: added to foods
   d. Nutrition Facts panel only includes dietary fiber
   e. Nonstarch polysaccharides with beta bonds
      i. Cellulose
      ii. Hemicelluloses
      iii. Pectins
      iv. Gums
      v. Mucilages
   f. Non-carbohydrate component
      i. Lignins
   g. Metabolized by bacteria of large intestine to produce short-chain fatty acids and gases
   h. Body adapts to higher fiber intake - decreased bloating, gas, discomfort
   i. Insoluble fibers

i. Do not dissolve in water
ii. Form structural part of the plant cell
iii. Cellulose, hemicellulose, lignins
iv. Examples: cellulose (skin of fruits and vegetables, legumes, celery, whole grains), hemicelluloses (whole grains and cereal fibers, some vegetables), lignins (seeds of fruits, bran layer)

j. Soluble fibers
i. Dissolve in water
ii. Found inside and around plant cells
iii. Pectins, gums, mucilages, and some hemicelluloses
iv. Examples: pectin (fruits), some hemicelluloses (oat bran), gums and mucilages (psyllium)

5.2 Carbohydrates in Foods

A. Starch
1. Much of carbohydrate in our diets
2. From plant-based foods: legumes, tubers, grains

B. Fiber
1. Found in many of the same foods as starch
2. Highly processed grains are low in fiber

C. Soluble fiber
1. Skins and flesh of fruits and berries; thickeners in jams, yogurts, sauces, and fillings; psyllium and seaweed

D. Nutritive Sweeteners
1. Can be metabolized to yield energy
2. Monosaccharides (glucose, fructose, galactose)
3. High-fructose corn syrup
a. Treatment of cornstarch with acids and enzymes break starch down into glucose
b. Enzymes convert glucose to fructose
c. Final syrup is about 55% fructose
d. Similar in sweetness to sucrose
e. Found in soft drinks, candies, jam, jelly, and desserts
4. Sugar Alcohols
a. Examples
i. Sorbitol
ii. Mannitol
iii. Xylitol
b. Used in sugarless gums and candies
c. Not easily metabolized by bacteria in the mouth; do not promote dental caries
d. Contribute energy but are absorbed and metabolized more slowly

E. Non-nutritive (Alternative) Sweeteners (see Table 5-1)
1. General
a. Non-caloric or very-low-calorie sugar substitutes for diabetes or weight loss
b. Safety determined by FDA, indicated by Acceptable Daily Intake guideline: amount of alternative sweetener considered safe for daily use over one's lifetime
c. ADIs are based on studies in laboratory animals and are set at a level 100 times less than the level at which no harmful effects were noted in animal studies
2. Saccharin (Sweet n' Low)

a. Oldest alternative sweetener
b. 300 times sweeter than sucrose
c. ADI set at 5 mg/kg body weight/day
d. Used as a tabletop sweetener and in foods and beverages
e. Cannot be used in cooking

3. Aspartame (NutraSweet, Equal)
a. Sweetened beverages, gelatin desserts, chewing gum, cookies, toppings and fillings of bakery goods
b. Cannot be used in cooking
c. NutraSweet®, Equal®
d. 160 to 220 times sweeter than sucrose
e. ADI set at 50mg/kg body weight/day
f. Some people may be sensitive to aspartame
g. Those with phenylketouria (P K U) should avoid; contains phenylalanine

4. Neotame
a. Found in a wide variety of food products
b. Heat stable and can be used in cooking and as a tabletop sweetener
c. 7,000-13,000 times sweeter than sucrose
d. ADI set at 18mg/kg body weight/day

5. Acesulfame-K
a. Sunette®
b. 200 times sweeter than sucrose
c. Can be used in cooking
d. ADI set at 15mg/kg body weight/day

6. Sucralose
a. Splenda®
b. 600 times sweeter than sucrose
c. Made from sucrose
d. Heat stable
e. ADI set at 5mg/kg body weight/day

7. Tagatose
a. Naturlose®
b. Isomer of fructose
c. Heat stable
d. Prebiotic effect

8. Stevia
a. Derived from a plant from Amazon rain forest
b. 250 times sweeter than sucrose
c. Approved to be used in beverages and to be sold as a dietary supplement
d. PureVia™, Truvia®, Sun Crystals®
e. ADI set at 4 mg/kg body weight/day

9. Luo han guo
a. Monk fruit
b. Fruit from Asia
c. Juice from fruit is 150 to 300 times sweeter than sugar
d. Heat stable
e. Tabletop sweetener: Monk Fruit in the Raw®, Nectresse™

f. No ADI set; Generally Recognized as Safe (GRAS)

10. Advantame
    a. One of the newest approved alternative sweeteners.
    b. Derived from aspartame and vanillin
    c. 20,0000 times sweeter than sugar
    d. FDA has set an ADI of 32.8 mg per kilogram of body weight

5.3 Recommended Intake of Carbohydrates

A. Recommendations for total carbohydrate intake
1. RDA for adults: 130 g/day of digestible carbohydrate to supply adequate glucose for the brain and central nervous system to prevent the partial replacement of glucose by ketone bodies
2. Food and Nutrition Board recommends that carbohydrates comprise 45 - 65% of total energy intake
3. Carbohydrates should come mainly from rich fruits, vegetables, and whole grains with little added sugars and caloric sweeteners

B. Recommendations for added sugars
1. Dietary Guidelines for Americans recommend limiting added sugars to no more than 10% of daily total energy intake
2. World Health Organization recommends limiting added sugars to 10% to total energy intake
3. American Heart Association recommends limiting sugar intake to half of one's discretionary calorie allowance based on the relationship between sugar intake and increased risk of cardiovascular disease

C. Recommendations for dietary fiber
1. AI is based on goal of 14 g/1000 kcal
2. Before age 50:
    a. 25 g for women
    b. 38 g for men
3. After age 50:
    a. 21 g/day for women
    b. 30 g/day for men
4. Adequate Intake is aimed to reduce the risk of:
    a. Diverticular disease
    b. Cardiovascular disease

D. Our Carbohydrate Intake
1. Typical North Americans consume 50% of total energy intake as carbohydrates
2. Types of carbohydrates consumed do not meet recommendations
    a. Added sugars from sugar-sweetened beverages and caloric sweeteners: 14.5%
3. Fiber intake is 25-50% less than recommended
    a. Low intakes of fruits and vegetables
    b. High consumption of refined grains
4. Many individuals lack knowledge about fiber-rich foods and their benefits.
5. Food labels can be confusing
    a. "Wheat flour" or "wheat bread" may be enriched white flour
    b. "Whole-wheat flour" must be listed first; ensures product is truly a whole-wheat bread and contains more fiber

E. Suggestions for Reducing Simple-Sugar Intake: At the Supermarket
1. Many foods we enjoy are sweet. These should be eaten in moderation.

2. Read ingredient labels. Identify all the added sugars in a product. Select items lower in total sugar when possible.
3. Buy fresh fruits or fruits packed in water, juice, or light syrup rather than those packed in heavy syrup.
4. Buy fewer foods that are high in sugar, such as prepared baked goods, candies, sugared cereals, sweet desserts, soft drinks, and fruit-flavored punches. Substitute vanilla wafers, graham crackers, bagels, English muffins, diet soft drinks, and other low sugar alternatives.
5. Buy reduced fat microwave popcorn to replace candy for snacks.
6. Read ingredient labels. Identify all the added sugars in a product. Select items lower in total sugar when possible.
7. Buy fresh fruits or fruits packed in water, juice, or light syrup rather than those packed in heavy syrup.
8. Buy fewer foods that are high in sugar, such as prepared baked goods, candies, sugared cereals, sweet desserts, soft drinks, and fruit-flavored punches. Substitute vanilla wafers, graham crackers, bagels, English muffins, diet soft drinks, and other low sugar alternatives.
9. Buy reduced fat microwave popcorn to replace candy for snacks.

F. Suggestions for Reducing Simple-Sugar Intake: In the Kitchen
1. Reduce the sugar in foods prepared at home. Try new low sugar recipes or adjust your own. Start by reducing the sugar gradually until you've decreased it by one-third or more.
2. Experiment with spices, such as cinnamon, cardamom, coriander, nutmeg, ginger, and mace, to enhance the flavor of foods.
3. Use home-prepared items with less sugar instead of commercially prepared products that are higher in sugar.

G. Suggestions for Reducing Simple-Sugar Intake: At the Table
1. Reduce use of white and brown sugars, honey, molasses, syrups, jams, and jellies.
2. Choose fewer foods high in sugar, such as prepared baked goods, candies, and sweet desserts.
3. Reach for fresh fruit instead of cookies or candy for dessert and between-meal snacks.
4. Add less sugar to foods—coffee, tea, cereal, and fruit. Cut back gradually to a quarter or half the amount. Consider using sugar alternatives to substitute for some sugar.
5. Reduce the number of sugared soft drinks, punches, and fruit juices you drink. Substitute water, diet soft drinks, and whole fruits.

H. Whole Grain Stamps
1. The Whole Grains Council has created while grain stamps to help shoppers quickly locate foods containing whole grains

5.4 Functions of Carbohydrates in the Body

A. Digestible Carbohydrates
1. Primary Source of Energy
   a. Most digestible carbohydrates are broken down to glucose
   b. Red blood cells and CNS cells use glucose almost exclusively
2. Sparing Protein from Use as an Energy Source
   a. Amino acids from dietary protein are needed to build body tissues
   b. Gluconeogenesis (synthesis of new glucose from amino acids) occurs when you do not consume enough carbohydrates
   c. When enough carbohydrates are consumed, protein is "spared" from use as energy
3. Preventing Ketosis
   a. Carbohydrates are needed to complete breakdown of fats
   b. If consumption is low:
      i. Release of insulin decreases

ii. Fatty acids from adipose tissue are released to provide energy for the body
iii. Fatty acids are not completely broken down
iv. Ketone bodies are formed (ketosis)

c. Ketosis occurs in:
i. Untreated diabetes
ii. Low carbohydrate/high fat weight reduction diets: Atkins®, South Beach Diet®

B. Indigestible Carbohydrates

1. Promoting Bowel Health
a. Fiber adds bulk to feces to ease bowel movements, preventing constipation
b. Straining during defecation can lead to
i. Hemorrhoids
ii. Formation of diverticula (diverticulosis), which may become inflamed (diverticulitis)
iii. Fiber intake must be limited during episodes of diverticulitis, but high-fiber, high-fluid diet with physical activity is recommended for prevention of future attacks of diverticulitis
c. High-fiber diets may reduce risk of colon cancer, likely due to nutrients present in high-fiber foods
2. Reducing Obesity Risk
a. Absorb water and expand in the GI tract, contributing to satiety
3. Enhance blood glucose control
a. Soluble fiber slows glucose absorption
b. Decreases insulin release from pancreas
4. Reduce cholesterol absorption
a. Soluble fiber inhibits:
i. Absorption of cholesterol
ii. Reabsorption of bile acids

C. Expert Perspective from the Field: Taxing Sugar-Sweetened Beverages

1. Consumption of sweetened beverages in the U.S. has added an extra 155 calories to our daily diets
2. Sugar-sweetened beverages are associated with an increased risk of obesity, diabetes, and heart disease
3. It is estimated that a tax of 1 cent per ounce of sugar-sweetened beverage could generate about $15 million each year
a. May also lead to a decrease in calorie intake
4. Beverage industry argues that the increase in obesity rate is not related to sugar-sweetened beverages but inactivity and poor overall dietary habits
5. However, sweetened beverages are the single largest source of added sugar in the American diet

5.5 Carbohydrate Digestion and Absorption

A. General

1. Starts with food preparation - softens tough, fibrous tissues of vegetables, fruits, and grains; starch granules soak up water and make them easy to digestion

B. Digestion

1. Mouth: salivary amylase breaks down starch into smaller polysaccharides and disaccharides
2. Stomach: salivary amylase inactivated by acidity of stomach
3. Pancreas: Pancreatic amylase and dextrinase are secreted into the small intestine to break polysaccharides from starch into disaccharides.
4. Small intestine
a. Enzymes in the wall of the small intestine break down the disaccharides into monosaccharides.
b. Disaccharides are digested to monosaccharides by specific enzymes

i. Maltase – breaks maltose into glucose + glucose
ii. Sucrase – breaks sucrose into glucose +fructose
iii. Lactase – breaks lactose into glucose + galactose

5. Liver: The absorbed monosaccharides are transported to the liver by the portal vein.
6. Large intestine: Some soluble fiber is metabolized into acids and gases by bacteria in the large intestine.
7. Rectum and anus: Insoluble fiber escapes digestion and is excreted in feces.

C. Absorption

1. Glucose and galactose are actively absorbed and pumped into absorptive cells with sodium
2. Fructose is absorbed by facilitated diffusion; slower process than active transport
3. Some fructose is converted to glucose in absorptive cells, but the rest is converted in the liver
4. Galactose is converted to glucose in the liver
5. Glucose is then sent to cells for use
6. Liver stores extra as glycogen
7. If glycogen storage capacity is exceeded, glucose is converted to fat
8. Stored in adipose tissue

5.6 Health Concerns Related to Carbohydrate Intake

A. General

1. Adequate intake of carbohydrates is important for maintaining health and decreasing risk of chronic disease
2. Excessive intakes can be harmful to overall health.

B. Very-High-Fiber Diets

1. Fiber intakes about 50 - 60 g/day
2. Can result in hard, dry stools, leading to painful elimination, hemorrhoids, rectal bleeding, or intestinal blockages
3. May decrease absorption of some minerals (e.g., zinc and iron) and increase risk of deficiencies
4. May lead to inadequate calorie consumption in children, elderly, and malnourished individuals
   a. May not be getting adequate amounts of foods and nutrients
   b. May cause a sense of fullness and reduce overall intake of foods

C. High Sugar Diets

1. Replace with intake of more nutritious foods
   a. Special concern for children and adolescents
2. Increased risk of weight gain and obesity due to extra energy intake
3. Increased risk of cardiovascular disease
   a. Increased levels of triglycerides and L D L-cholesterol, decreased levels of H D L-cholesterol
4. Development of dental caries
   a. Bacteria in the mouth metabolize sugars into acids
   b. Acids dissolve tooth enamel

D. Lactose Intolerance

1. Lactase production begins to decrease after early childhood.
2. *Primary* lactose intolerance
   a. Insufficiency of lactase production
   b. Symptoms include abdominal pain, bloating, gas, diarrhea
   c. Amount of lactose tolerance varies by individuals, but hard cheeses, yogurt, and acidophilus milk are more easily tolerated
3. *Secondary* lactose intolerance

a. Conditions of the small intestine damage the lactase producing cells (Crohn's disease, diarrhea)
b. Causes temporary symptoms

E. Glucose Intolerance
1. Abnormal regulation of blood glucose levels
2. Hyperglycemia is more common and associated with diabetes and metabolic syndrome
3. Regulation of Blood Glucose
a. Fasting blood glucose typically varies from 70 to 100 mg/dl
b. Hyperglycemia: high blood glucose, above 126 mg/dl
i. Hunger
ii. Thirst
iii. Frequent urination
iv. Weight loss
c. Hypoglycemia: low blood glucose, below 50 mg/dl
i. Hunger
ii. Shakiness
iii. Irritability
iv. Weakness
v. Headache
d. Liver regulates how much glucose from a meal is released into the blood and how much is stored as glycogen
e. Pancreas releases hormones to regulate blood glucose
i. Insulin is released after eating, when blood glucose levels are high and promotes increased glucose uptake by cells, use of glucose as energy, and storage of excess glucose as glycogen; lowers blood glucose levels
ii. Glucagon prompts breakdown of glycogen to glucose and gluconeogenesis when blood sugar is too low
f. Epinephrine and norepinephrine also trigger gluconeogenesis
g. Cortisol and growth hormone decrease amount of glucose used by muscle cells

F. Metabolic Syndrome
1. Group of factors that increase risk of type 2 diabetes and CVD
a. Insulin resistance or glucose intolerance (e.g., FBG >110 mg/dl)
b. Abdominal obesity (e.g., waist circumference >35" for women or 40" for men)
c. High blood triglycerides (e.g., >150 mg/dl), high LDL, low HDL (e.g., <40 mg/dl for men or <50 mg/dl for women)
d. Elevated blood pressure (e.g., >130/85 mmHg)
e. Increased inflammatory blood proteins (e.g., C-reactive protein)
2. Hypoglycemia
a. Can occur with or without diabetes
b. Among people with diabetes, hypoglycemia may occur with use of too much insulin, low food intake, or exercising without eating carbohydrates
c. If nondiabetic, 2 types are possible:
d. Reactive hypoglycemia
i. Exaggerated insulin response after eating
e. Fasting hypoglycemia
i. Low blood glucose after fasting for 8 hours or more

G. Clinical Perspective: Diabetes Mellitus
1. General
a. Diagnosis of diabetes is based on fasting blood glucose >126 mg/dl

b. Affects over 8% of North Americans, leads to over 200,000 deaths/year
c. 35% of North Americans show evidence of pre-diabetes (FBG 100 - 126 mg/dl)

2. Type 1 Diabetes (insulin-dependent, juvenile-onset)
   a. Classic symptoms of hyperglycemia
      i. Increased hunger
      ii. Excessive thirst
      iii. Excessive urination
      iv. Weight loss
   b. Caused by autoimmune attack on pancreas, leading to insufficient insulin production, thus regulating blood glucose levels
   c. Genetic predisposition
   d. Excess glucose excreted in urine
   e. Complications of type 1 diabetes
      i. CVD
      ii. Kidney disease
      iii. Nerve disease (constipation, diarrhea, amputations)
      iv. Blindness
      v. Infections
   f. Treatment
      i. Insulin (injections, pumps)
   g. Diet
      i. Regular meals and snacks
      ii. Regulated ratio of carbohydrates to protein and fat in order to maximize insulin action and moderate glucose excursions
      iii. Ample fiber
      iv. Balance calorie intake with expenditure
      v. Meets overall nutritional needs
      vi. Carbohydrate counting and diabetic exchange system are tools to regulate dietary intake
   h. Exercise enhances glucose uptake by muscles independent of insulin action
   i. Diabetes Control and Complications Trial demonstrated that development of CVD and nerve damage can be delayed with aggressive blood glucose control
3. Type 2 Diabetes (non-insulin-dependent, adult-onset)
   a. 90% of all cases of diabetes
   b. Characterized by insulin resistance, wherein cells become resistant to the action of insulin, thereby decreasing uptake of glucose by cells
   c. Risk factors
      i. Strong genetic predisposition
      ii. Obesity
      iii. Physical inactivity
      iv. Ethnicity (e.g., Latino/Hispanic, African, Asian, Native American, Pacific Islander)
      v. Metabolic syndrome
      vi. Pre-diabetes
   d. Treatment
      i. Diet
      ii. Energy-controlled
      iii. Meets nutrient needs

iv. Regular mealtimes
v. Limit total and saturated fat
vi. Moderate alcohol (1 drink/day) may increase HDL to reduce CVD risk, but must be consumed in conjunction with meals to avoid hypoglycemia
vii. Exercise
viii. Oral medications
ix. Reduce glucose production by liver
x. Increase insulin synthesis by pancreas
xi. Slow intestinal absorption of glucose
xii. Decrease insulin resistance
xiii. Insulin (in advanced cases)

H. Glycemic Index and Glycemic Load
1. Indicates how blood glucose responds to various foods
2. Glycemic index (GI): ratio of blood glucose response of a given food compared with a standard (e.g., glucose or white bread)
   a. Influenced by
      i. Starch structure (amylose or amylopectin)
      ii. Fiber content
      iii. Food processing
      iv. Physical structure
      v. Temperature
      vi. Protein and fat content in a meal
   b. Based on serving of food that supplies 50 g carbohydrate, which may or may not reflect typical serving size
3. Glycemic load: better reflects a food's effect on blood glucose because it accounts for GI and amount of carbohydrate consumed: (g carbohydrate X GI)/100
4. Table 5-7 shows the GI and GL of common foods
5. Why GI and GL?
   a. High GL foods elicit increased insulin response followed by rapid drop in blood glucose
   b. Chronically high insulin increases blood triglycerides, fat deposition in adipose tissue, fat synthesis in liver, and rapid return of hunger after a meal
   c. Reference food glucose = 100
      i. All other foods compared to glucose
   d. Low G I foods – below 55
   e. Intermediate G I foods – between 55 and 69
   f. High G I foods – more than 70
   g. Low G L foods – below 10
   h. Intermediate G L foods – between 11 and 19
   i. High G L foods – more than 20