Chapter 4: Carbohydrates: Sugars, Starches, and Fiber
Objectives for Chapter 4

• Describe what carbohydrates are and why you need them.
• Explain the process of digesting dietary carbohydrates.
• Explain how the body regulates blood glucose levels and the hormones involved in the process.
• Describe the guidelines for carbohydrate intake, including the AMDR for carbohydrates, the DRI for fiber, and the recommendation for consuming added sugars.
• Describe the difference between natural and added sugars in the diet.
• Define type 1 and type 2 diabetes and describe how the types differ.
• List alternative sweeteners used as sugar substitutes.
• Describe the importance of fiber in the body and diet.
What Are Carbohydrates and Why Do You Need Them?

• Found primarily in plant-based foods
  • Grains, vegetables, fruits, nuts, legumes
  • Carbohydrate-based foods are staples in numerous cultures around the world
• Most desirable form of energy for body
  • Glucose
  • Brain and red blood cells especially rely on glucose for fuel source
What Are Carbohydrates and Why Do You Need Them?, Continued

- Plants convert the sun's energy into glucose by **photosynthesis**
- **Glucose** is most abundant carbohydrate in nature
  - Used as energy by plants or combined with minerals from soil to make other compounds, such as protein and vitamins
  - Glucose units are linked together and stored in form of starch
Photosynthesis: How Glucose Is Made

Carbon dioxide in air

Oxygen

Photosynthesis

Glucose

Water in soil

Figure 4.1
What Are Carbohydrates and Why Do You Need Them?, Continued-1

- Two categories, simple and complex, based on number of units joined together
- Simple carbohydrates contain one or two sugar units: monosaccharides and disaccharides
  - Three **monosaccharides**: glucose, fructose, galactose
  - **Disaccharides**: two monosaccharides joined together
    - **Maltose** = glucose + glucose
    - **Sucrose** (table sugar) = glucose + fructose
    - **Lactose** (milk sugar) = glucose + galactose
What Are Carbohydrates and Why Do You Need Them?, Continued-2

- **Complex carbohydrates**: polysaccharides
  - Long chains and branches of sugars linked together
  - Starch, fiber, and glycogen
- **Starch** is the storage form in plants
  - Amylose: straight chains of glucose units
  - Amylopectin: branched chains of glucose units
Creating Monosaccharides, Disaccharides, and Polysaccharides

a Monosaccharides

Fructose  Glucose  Galactose

b Disaccharides

Sucrose (glucose and fructose)  Maltose (glucose and glucose)  Lactose (glucose and galactose)

c Polysaccharides (starch)

Amylose (straight chain)  Amylopectin (branched)
Fiber is a nondigestible polysaccharide

- Examples: cellulose, hemicellulose, lignins, gums, pectin
- Humans lack digestive enzyme needed to break down fiber

Dietary fiber: naturally found in foods

Functional fiber: added to food for beneficial effect
  - Example: psyllium added to cereals

Total fiber = dietary fiber + functional fiber
Fiber is also sometimes classified by its affinity for water

- **Soluble fiber**: dissolves in water and is fermented by intestinal bacteria
  - Many are viscous, have thickening properties
  - Move more slowly through GI tract
  - Examples: pectin in fruits and vegetables, beta-glucan in oats and barley, gums in legumes, psyllium

- **Insoluble fiber**: cellulose, hemicellulose, lignins
  - Moves more rapidly through GI tract, laxative effect
  - Examples: bran of whole grains, seeds, fruits, vegetables
Most Plant Foods Contain Both Soluble and Insoluble Fibers

Cellulose: insoluble fiber

Pectin: soluble fiber
What Are Carbohydrates and Why Do You Need Them?, Continued-5

- Glycogen is the storage form of glucose in animals
  - Branched glucose similar to amylopectin
  - Stored in liver and muscle cells
    - Only limited amounts
  - Glycogen stored in animals breaks down when the animal dies, so these carbohydrates are not accessible for humans
What Happens to the Carbohydrates You Eat?

- You digest carbohydrates in your mouth and intestines
  - Saliva contains amylase enzyme, which starts breaking down amylose and amylopectin into smaller starch units and maltose
  - In small intestine, pancreatic amylase breaks down remaining starch into maltose
  - Maltose and other disaccharides are broken down to monosaccharides and absorbed into blood
  - Fiber continues to the large intestine, where some is metabolized by bacteria in the colon and the majority eliminated in your stool
Carbohydrate digestion begins in the mouth and ends with the absorption of the monosaccharides glucose, fructose, and galactose in the small intestine.

**ORGANS OF THE GI TRACT**

**MOUTH**
Modification mixes food with saliva. Salivary amylase breaks down amylase and amylpectin into smaller chains of carbohydrates.

Amylose → Smaller chains

Amylpectin → Smaller chains

**STOMACH**
The acidity of the stomach inactivates the salivary amylase; thus, very little digestion of carbohydrates occurs in the stomach.

**SMALL INTESTINE**
Pancreatic amylase breaks down the amylose, amylpectin, and smaller chains of carbohydrates into maltose, a disaccharide.

Smaller amylose chains → Maltose

Smaller amylpectin chains → Maltose

Brush border enzymes break down all disaccharides to the monosaccharides glucose, fructose, and galactose, which are then absorbed into the bloodstream.

Glucose → Glucose

Maltose → Glucose

Lactose → Glucose

**LARGE INTESTINE**
All starches and simple sugars are broken down and absorbed in the small intestine; only fiber passes into the large intestine. Bacteria in the colon metabolize some of this fiber. The majority of fiber is eliminated in the stool.

**ACCESSORY ORGANS**

**SALIVARY GLANDS**
Produce salivary amylase.

**PANCREAS**
Produces pancreatic amylase that is released into the small intestine via the pancreatic duct.

**LIVER**
Glucose is taken up by the liver from the bloodstream. Most glucose is returned to the blood to be picked up and used by body cells. The body can use glucose for energy, convert it to glycogen, or store it as fat.

Figure 4.4
What Is Lactose Maldigestion and Lactose Intolerance?

• **Lactose**: principal carbohydrate found in dairy products
  • People with a deficiency of the enzyme *lactase* cannot digest lactose properly
• Lactose maldigestion is natural part of aging
  • People with lactose maldigestion can still consume dairy and should not eliminate it from their diets.
• **Lactose intolerance**: when lactose maldigestion results in nausea, cramps, bloating, diarrhea, and flatulence within two hours of eating or drinking foods containing lactose
What Is Lactose Maldigestion and Lactose Intolerance?, Continued

• Tips for tolerating lactose:
  • Gradually add dairy products to your diet
  • Eat smaller amounts throughout day rather than large amount at one time
  • Eat dairy foods with a meal or snack
  • Try reduced-lactose milk and dairy products
  • Consume lactase pills with lactose-laden meals or snacks
Carbohydrate Digestion
Carbohydrate Absorption
How Does Your Body Use Carbohydrates?

- Glucose supplies energy for body
- Hormone *insulin* regulates glucose in blood
- Insulin is released by the pancreas in response to rising blood glucose levels after a meal that contains carbohydrates
  - Directs conversion of glucose in excess of immediate energy needs into glycogen (*glycogenesis*) in liver and muscle cells (limited capacity)
  - Rest of excess glucose converted to fat
Generating Energy from Glucose

1. First, glucose is broken down to two sets of a three-carbon compound, which generates the first release of energy.

2. Then the three-carbon compounds are further broken down for another release of energy.

3. Lastly, the most abundant amount of energy is released from these remnants of glucose.
Hormones Regulate Blood Glucose

Our bodies regulate blood glucose levels within a fairly narrow range to provide adequate glucose to the brain and other cells. Insulin and glucagon are two hormones that play a key role in regulating blood glucose levels.

**HIGH BLOOD GLUCOSE**

1. Insulin secretion: When blood glucose levels increase after a meal, the pancreas secretes the hormone insulin into the bloodstream.

2. Cellular uptake: Insulin travels to the tissues where it alters the cell membranes to allow the transport of glucose into the cells by increasing the number of glucose transporters on the cell membrane.

3. Glucose storage: Insulin also stimulates the storage of glucose in body tissues. Glucose is stored as glycogen in the liver and muscles (glycogenesis), and is stored as triglycerides in fat tissue (lipogenesis).

**LOW BLOOD GLUCOSE**

1. Glucagon secretion: When blood glucose levels are low, the pancreas secretes the hormone glucagon into the bloodstream.

2. Glycogenolysis: Glucagon stimulates glycogenolysis in the liver to break down stored glycogen to glucose, which is released into the blood and transported to the cells for energy.

3. Gluconeogenesis: Glucagon also activates gluconeogenesis in the liver, stimulating the conversion of amino acids to glucose.
Hormonal Control of Blood Glucose
Carbohydrates Fuel Your Body between Meals

- When blood glucose begins to drop, pancreas releases the hormone **glucagon** to raise blood glucose levels
  - Directs release of glucose from stored glycogen in liver = **glycogenolysis**
  - Signals liver to start **gluconeogenesis** = making glucose from noncarbohydrate sources, mostly protein
- Your body will also break down fat stores to provide energy for your tissues
- Epinephrine (adrenaline) also stimulates glycogenolysis and increases blood glucose levels
  - "Fight-or-flight" hormone: stress, bleeding, low blood glucose levels trigger its release
Carbohydrates Fuel Your Body during Fasting and Prevent Ketosis

- Liver glycogen stores depleted after about 18 hours.
- Without glucose, fat can't be broken down completely and acidic ketone bodies are produced.
  - **Ketosis**: elevated ketone levels after fasting about two days.
- Protein from muscle and organs broken down to make glucose.
  - Brain switches to using ketone bodies for fuel to spare protein-rich tissues.
  - If fasting continues, protein reserves are depleted and death occurs.
How Much Carbohydrate Do You Need and What Are the Best Food Sources?

- Minimum amount of carbohydrates needed daily
  - DRI: 130 grams per day for brain function
  - Consume diet with low to moderate amounts of simple carbohydrates and higher amounts of fiber and other complex carbohydrates
  - Choose carbohydrates from a variety of nutrient dense, low saturated fat foods
How Much Carbohydrate Do You Need and What Are the Best Food Sources?, Continued

- Whole grains can help meet starch and fiber needs
  - Select whole-grain breads and cereals that have at least 2-3 grams of total fiber per serving
- Fruits and vegetables provide sugars, starch, and fiber
- Legumes, nuts, and seeds are excellent sources of carbohydrates and fiber
- Low-fat and fat-free dairy products provide some simple sugars
- Be careful when selecting packaged foods
  - Can be good sources of carbohydrates, but may also have added sugar, salt, fat, and calories
Food Sources of Carbohydrates

*Based on a 2,000 calorie diet
How Much Carbohydrate Do You Need and What Are Its Food Sources?, Continued

- Filling up on fiber
  - DRI: 14 grams of fiber per 1,000 calories to promote heart health
    - Most Americans fall short: about 15 grams per day
  - Gradually increasing fiber in your diet will minimize side effects, such as flatulence
    - As you add fiber to your diet, you should also drink more fluids
### Table 4.1 What Are Your Fiber Needs?

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Grams of Fiber Daily* Males</th>
<th>Grams of Fiber Daily* Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 through 18 years old</td>
<td>38</td>
<td>26</td>
</tr>
<tr>
<td>19 through 50 years old</td>
<td>38</td>
<td>25</td>
</tr>
<tr>
<td>51 through 70+ years old</td>
<td>30</td>
<td>21</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Lactation</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

*Based on an Adequate Intake (AI) for fiber.

Nutrition in the Real World: Grains, Glorious Whole Grains

- **Grains**: important staple and source of nutrition
  - Three edible parts: bran, endosperm, germ
- **Refined grains**: milling removes bran and germ
  - Some B vitamins, iron, phytochemicals, and dietary fiber lost as a result
  - Examples: wheat or white bread, white rice
- **Enriched grains**: folic acid, thiamin, niacin, riboflavin, and iron added to restore some of the lost nutrition
- Whole-grain foods contain all three parts of kernel
  - Examples: brown rice, oatmeal, whole-wheat bread
Food Sources of Fiber

Figure 4.8

ChooseMyPlate.gov

Grains (g) of Soluble and Insoluble Fiber

Vegetables
- Carrots, cooked: 1 cup
- Broccoli: raw: 1 cup
- Bell pepper, red: 1 cup
- Broccoli, raw: 1 cup
- Tomato, red: 1/4 cup
- Beans, black: 1/2 cup
- Beans, white: 1/2 cup
- Beans, pinto: 1/2 cup

Fruits
- Apple, raw: 1 cup
- Pear, raw: 1/4 cup
- Orange, raw: 1/4 cup
- Orange, whole: 1 cup
- Peach, whole: 1/2 cup
- Apple, raw: 1/4 cup
- Mango, raw: 1/4 cup
- Pear, raw: 1/4 cup

Grains
- Whole wheat bread: 1 slice
- Brown rice: 1/2 cup
- Oatmeal, cooked: 1/2 cup
- Corn, white: 1/2 cup
- Pasta, whole wheat: 1/2 cup
- Cereals, bran: 1/4 cup
- Raisins: 1/4 cup
- Peanut butter: 1/4 cup
- Beans, kidney: 1 lbs

Protein
- Chicken, cooked: 1/4 cup
- Beef, cooked: 1/4 cup
- Fish, cooked: 1/4 cup

Daily Needs

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From Wheat Kernel to Flour

A kernel of wheat

1. **Bran**
   - High fiber
   - B vitamins
   - Phytochemicals
   - Minerals

2. **Germ**
   - Vitamin E
   - Healthy unsaturated fats
   - Antioxidants
   - Phytochemicals
   - Minerals
   - B vitamins

3. **Endosperm**
   - Starch
   - Protein
   - B vitamins

b. Whole kernel used

c. Only endosperm used

d. Only endosperm used

- **Whole-Wheat Flour**
  - Missing ingredients: Enriched folic acid

- **Enriched Wheat Flour**
  - Missing ingredients: Bran (fiber)
  - Phytochemicals
  - Calcium
  - Vitamin E
  - Heart-healthy fats
  - Antioxidants

- **Wheat Flour (not enriched)**
  - Missing ingredients: Bran (fiber)
  - Phytochemicals
  - Calcium
  - Vitamin E
  - Heart-healthy fats
  - Antioxidants
  - Folic acid
  - Thiamin
  - Niacin
  - Riboflavin
  - Iron
ABC News Video: Grain Labels Do Not Reflect 'Whole' Truth

World News Tonight
February 7, 2012

>> It is one of the hottest trends of the supermarket, the surge of products,
ABC News Video: Grain Labels Do Not Reflect 'Whole' Truth, Continued

Discussion Questions

1. How can we raise consumer awareness that there is a discrepancy between the marketing of grain products and the actual contents of grain products for consumption?

2. How can companies be held to a better standard to be more honest regarding the contents of products?

3. Provide an argument for the need for the FDA to define whole grains.
What's the Difference between Natural and Added Sugars?

• Naturally occurring sugars found in fruits and dairy
  • Usually more nutrient dense; provide more nutrition per bite

• Added sugars are added by manufacturers and are often "empty calories" (provide little nutrition)
  • Examples: soda, candy

• Taste buds can't distinguish between naturally occurring and added sugars
## Slices of an Orange versus Orange Slices

<table>
<thead>
<tr>
<th></th>
<th>Fresh orange</th>
<th>Candy orange</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>65</td>
<td>300</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>130% DV</td>
<td>0% DV</td>
</tr>
<tr>
<td>Fiber</td>
<td>1/2 gram</td>
<td>0</td>
</tr>
<tr>
<td>Added sugar</td>
<td>0</td>
<td>15 tsp</td>
</tr>
</tbody>
</table>

**Legend:**
- 🌾 = 1 gram of fiber
- ✂️ = 1 tsp of added sugar
Processed Foods and Sweets Often Contain Added Sugars

- Yearly consumption of added sugars has increased since 1970
- Finding the added sugars in your foods:
  - Sugars on food labels appear under many different names
    - Honey and fructose are not nutritionally superior to sucrose
  - Naturally occurring sugars are not distinguished from added sugars on the Nutrition Facts panel
Processed Foods and Sweets Often Contain Added Sugars, Continued

- Are added sugars bad for you?
  - Research doesn't support claims of sugar causing hyperactivity and diabetes
  - Too much sugar can increase the blood triglycerides, lower the "good" HDL cholesterol, may increase risk of heart disease
  - Moderation, balance, and staying within daily calorie needs essential when it comes to added sugars
Finding Added Sugars on the Label

**Ingredients:** Granola (whole grain rolled oats, rice flour, whole grain rolled wheat, partially hydrogenated soybean and cottonseed oils* with TBHQ and citric acid added to preserve freshness and/or sunflower oil with natural tocopherol added to preserve freshness, whole wheat flour, molasses, sodium bicarbonate, soy lecithin, caramel color, barley malt, salt, nonfat dry milk), corn syrup, crisp rice (rice, sugar, salt, barley malt), semisweet chocolate chunks (sugar, chocolate liquor, cocoa butter, soy lecithin, vanillin [an artificial flavor]), sugar, corn syrup solids, glycerin, high-fructose corn syrup, partially hydrogenated soybean and/or cottonseed oil*, sorbitol, fructose, calcium carbonate, natural and artificial flavors, salt, soy lecithin, molasses, water, BHT (a preservative), citric acid.

* Adds a dietarily insignificant amount of trans fat.
Where Are All These Added Sugars Coming From?

Figure 4.11
### Table 4.2 Sugar Smacked!

<table>
<thead>
<tr>
<th>Food Groups</th>
<th>Teaspoons of Added Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bread, Cereal, Rice, Pasta</strong></td>
<td></td>
</tr>
<tr>
<td>Bread, 1 slice</td>
<td>0</td>
</tr>
<tr>
<td>Cookies, 2 medium</td>
<td></td>
</tr>
<tr>
<td>Doughnut, 1 medium</td>
<td></td>
</tr>
<tr>
<td>Cereal, sweetened flakes</td>
<td></td>
</tr>
<tr>
<td>Cake, frosted, 1/16 average</td>
<td></td>
</tr>
<tr>
<td>Pie, fruit, 2 crust, 1/6, 8” pie</td>
<td></td>
</tr>
<tr>
<td><strong>Fruit</strong></td>
<td></td>
</tr>
<tr>
<td>Fruit, canned in juice, ½ cup</td>
<td>0</td>
</tr>
<tr>
<td>Fruit, canned in heavy syrup, ½ cup</td>
<td></td>
</tr>
<tr>
<td><strong>Milk, Yogurt, and Cheese</strong></td>
<td></td>
</tr>
<tr>
<td>Milk, 1% fat, 1 cup</td>
<td>0</td>
</tr>
<tr>
<td>Chocolate milk, 2% fat, 1 cup</td>
<td></td>
</tr>
<tr>
<td>Yogurt, low fat, plain, 8 oz</td>
<td>0</td>
</tr>
<tr>
<td>Yogurt, fruit, sweetened, 8 oz</td>
<td></td>
</tr>
<tr>
<td>Chocolate shake, 10 fl oz</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
<tr>
<td>Energy drink, 8 oz</td>
<td></td>
</tr>
<tr>
<td>Chocolate bar, 2 oz</td>
<td></td>
</tr>
<tr>
<td>Fruit drink, 12 fl oz</td>
<td></td>
</tr>
</tbody>
</table>

= 1 teaspoon of sugar

Avoiding a Trip to the Dentist

- Carbohydrates play role in dental caries
  - Fermentable sugars and starch feed bacteria coating teeth, producing acid to erode tooth enamel
- To minimize tooth decay:
  - Eat three balanced meals daily
  - Keep snacking to a minimum, choosing whole fruits and raw vegetables
  - Include foods that fight dental caries: cheese, sugarless gum
  - Regular dental care and good dental hygiene
How Much Added Sugar Is Too Much?

• Latest conclusions from the report of the 2015 *Dietary Guidelines for Americans*:
  • 10% or less of your total daily calories should come from added sugars
• The American Heart Association has recommended:
  • Women should consume no more than 100 calories (6 tsp) of added sugar daily
  • Men should consume no more than 150 calories (9 tsp) of added sugar daily
• American adults currently consume 99 grams of added sugar daily (about 25 tsp)
Do Sugar-Sweetened Beverages Cause Obesity?

• Every day 50 percent of Americans consume some form of sugary drinks equivalent to about one 12-ounce soda.

• Major theories on relationship between sugar-sweetened drink consumption and weight gain
  • Additional calories leads to excess overall calorie intake
  • Sugar in liquid form increases our appetite

• Overall, there is not yet enough evidence to say that sugar sweetened beverages alone contribute more to obesity than other calorie sources
## Consumption Patterns of Sugar-Sweetened Beverages

**Table 1 Consumption Patterns of Sugar-Sweetened Beverages**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Teaspoons*</th>
<th>Calories**</th>
<th>% of Total Calories per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>12-19</td>
<td>18.4</td>
<td>294</td>
<td>11.6</td>
</tr>
<tr>
<td></td>
<td>20-39</td>
<td>18.1</td>
<td>289</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>40-59</td>
<td>12.6</td>
<td>202</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>&gt;60</td>
<td>5.9</td>
<td>94</td>
<td>4.6</td>
</tr>
<tr>
<td>Females</td>
<td>12-19</td>
<td>12.1</td>
<td>194</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>20-39</td>
<td>10.8</td>
<td>173</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>40-59</td>
<td>7.7</td>
<td>123</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>&gt;60</td>
<td>3.8</td>
<td>60</td>
<td>4.0</td>
</tr>
</tbody>
</table>

*Teaspoons of sugar consumed per day from sugar-sweetened beverages

**Total calories consumed per day from sugar-sweetened beverages

The Many Sizes of Soft Drinks

Teaspoons of added sugar

- 8 fluid oz bottle of cola
- 12 fluid oz can of cola
- 20 fluid oz bottle of cola
Practical Nutrition Tips Video: Hidden Sugar Nutrition Tip

Practical Nutrition Tips
Joan Salge Blake

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On average, Americans consume a 110 grams of added sugar per day which is way more
ABC News Video: Ditching Sugar, Continued

Discussion Questions

1. What can you do to avoid overconsumption of sugar?

2. Why is added sugar unhealthy? What diseases can occur due to consuming high amounts of added sugar?

3. What are some of the replacement (counterconditioning) tactics that can help cut back on our "want" of added sugar?
Practical Nutrition Tips Video: Sweet Tooth

Satisfy a Sweet Tooth

with Joan Salge Blake
Diabetes Mellitus, a Growing Epidemic

- **Diabetes mellitus**: individual has high blood glucose levels due to insufficient insulin or insulin resistance
  - Glucose can't enter cells
    - Without glucose, acidic ketone bodies build up, causing life-threatening diabetic ketoacidosis: if untreated can result in coma, death
- **Type 1 diabetes**: 5 to 10 percent of cases
  - Autoimmune disease: insulin-producing cells in pancreas destroyed—insulin injections required
  - Develops in childhood, early adult years
Diabetes Mellitus, a Growing Epidemic, Continued

• Type 2 diabetes: 90 to 95 percent of cases
  • Cells are resistant to insulin; eventually insulin-producing cells are exhausted and medication and/or insulin is required
• People 45 and older or at risk for diabetes should be tested
• Prediabetes: may be precursor to type 2
  • Blood glucose higher than normal but not yet high enough to be classified as diabetes
  • Heart disease and stroke can occur
Diabetes is a chronic disease in which the body can no longer regulate glucose within normal limits, and blood glucose becomes dangerously high.

**NORMAL**

1. Liver releases glucose into bloodstream.
2. The cells of the pancreas release insulin into bloodstream.
3. Insulin stimulates uptake of glucose into cells.
4. As glucose is taken into interior of cells, less glucose remains in the bloodstream.

**TYPE 1 DIABETES**

1. Liver releases glucose into bloodstream.
2. The cells of the pancreas are damaged or destroyed. Little or no insulin is released into bloodstream.
3. In the absence of insulin, glucose is not taken up by cells.
4. High levels of glucose remain in the bloodstream.

**TYPE 2 DIABETES**

1. Liver releases glucose into bloodstream.
2. The cells of the pancreas release insulin into bloodstream.
3. Insulin is present, but cells fail to respond adequately. Progressively higher amounts of insulin must be produced to stimulate cells to uptake glucose.
4. High levels of glucose remain in the bloodstream.
Diabetes Mellitus, a Growing Epidemic, Continued-2

- What effects does diabetes have on your body?
  - Diabetes can result in long-term damage
    - High blood glucose levels damage vital organs
      - Nerve damage, numbness, poor circulation
        » Infections, leg and foot amputations
      - Eye damage, blindness
      - Tooth and gum problems
      - Kidney damage
      - Increased risk of heart disease
Diabetes Mellitus, a Growing Epidemic, Continued-3

• Low blood sugar levels can also be dangerous

• **Hypoglycemia**: blood glucose level below 70 mg/dl
  • Symptoms: hunger, shakiness, dizziness
  • May occur in people with diabetes when they don't eat regularly to balance effects of insulin or blood glucose-lowering medication
    • Can cause fainting, coma
  • Uncommonly, may occur after eating (reactive hypoglycemia) or fasting (fasting hypoglycemia)
How is diabetes treated and controlled?

- Blood glucose control is key
- Nutrition and lifestyle goals:
  - Physical exercise
  - Well-balanced diet containing:
    - High-fiber carbohydrates from whole grains, fruits, vegetables
    - Low-fat milk
    - Adequate lean protein sources
    - Unsaturated fats
Glycemic index (GI) and glycemic load (GL) classify effects of carbohydrate-containing foods on blood glucose.

- GI: ranks foods' effects on blood glucose compared with equal amount of pure glucose.
- GL: adjusts GI to take into account the amount of carbohydrate consumed.

Eating carbohydrate-heavy foods with protein, fat lowers GI.

Sugar is not prohibited; starch causes same rise in blood glucose levels.

Total calories important for weight management.
## The Glycemic Index of Commonly Eaten Foods

<table>
<thead>
<tr>
<th>Foods</th>
<th>GI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice, low amylose</td>
<td>126</td>
</tr>
<tr>
<td>Potato, baked</td>
<td>121</td>
</tr>
<tr>
<td>Cornflakes</td>
<td>119</td>
</tr>
<tr>
<td>Jelly beans</td>
<td>114</td>
</tr>
<tr>
<td>Green peas</td>
<td>107</td>
</tr>
<tr>
<td>Cheerios</td>
<td>106</td>
</tr>
<tr>
<td>Puffed wheat</td>
<td>105</td>
</tr>
<tr>
<td>Bagel, plain</td>
<td>103</td>
</tr>
<tr>
<td>White bread</td>
<td>100</td>
</tr>
<tr>
<td>Angel food cake</td>
<td>95</td>
</tr>
<tr>
<td>Ice cream</td>
<td>87</td>
</tr>
<tr>
<td>Bran muffin</td>
<td>85</td>
</tr>
<tr>
<td>Rice, long grain**</td>
<td>80</td>
</tr>
<tr>
<td>Brown rice</td>
<td>79</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>79</td>
</tr>
</tbody>
</table>

*GI = Glycemic Index

**Boiled for 25 minutes.

***Boiled for 5 minutes.
The Glycemic Index of Foods, Continued

<table>
<thead>
<tr>
<th>Foods</th>
<th>GI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Popcorn</td>
<td>79</td>
</tr>
<tr>
<td>Corn</td>
<td>78</td>
</tr>
<tr>
<td>Banana, overripe</td>
<td>74</td>
</tr>
<tr>
<td>Chocolate</td>
<td>70</td>
</tr>
<tr>
<td>Baked beans</td>
<td>69</td>
</tr>
<tr>
<td>Sponge cake</td>
<td>66</td>
</tr>
<tr>
<td>Pear, canned in juice</td>
<td>63</td>
</tr>
<tr>
<td>Custard</td>
<td>61</td>
</tr>
<tr>
<td>Spaghetti</td>
<td>59</td>
</tr>
<tr>
<td>Rice, long grain***</td>
<td>58</td>
</tr>
<tr>
<td>Apple</td>
<td>52</td>
</tr>
<tr>
<td>Pear</td>
<td>47</td>
</tr>
<tr>
<td>Banana, underripe</td>
<td>43</td>
</tr>
<tr>
<td>Kidney beans</td>
<td>42</td>
</tr>
<tr>
<td>Whole milk</td>
<td>39</td>
</tr>
<tr>
<td>Peanuts</td>
<td>21</td>
</tr>
</tbody>
</table>

*GI = Glycemic Index

**Boiled for 25 minutes.

***Boiled for 5 minutes.
Diabetes Mellitus, a Growing Epidemic, Continued-6

- Why is diabetes called an epidemic?
- Diabetes incidence on the rise
  - Seventh leading cause of death in the United States
  - Adult cases more than tripled since 1980s
  - Rapid increase among children
    - Obesity, overweight, and physical inactivity increase risk
- Preventing type 2 diabetes:
  - Lose excess weight, exercise more, eat heart-healthy, plant-based diet
ABC News Video: Two Meals a Day Could Help Diabetics Control Blood Sugar
What Are Sugar Substitutes and What Forms Can They Take?

• Sugar substitutes are as sweet or sweeter than sugar, but contain fewer calories
  • Must be approved by FDA and deemed safe before allowed in food products in the United States
  • Many of these substitutes will not promote dental caries and do not affect blood glucose levels
Growing Interest in Sugar-Free Foods and Beverages

<table>
<thead>
<tr>
<th>Year</th>
<th>Millions of Adult Americans consuming sugar-free products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>78</td>
</tr>
<tr>
<td>1991</td>
<td>101</td>
</tr>
<tr>
<td>1996</td>
<td>151</td>
</tr>
<tr>
<td>2004</td>
<td>180</td>
</tr>
<tr>
<td>2010</td>
<td>187</td>
</tr>
</tbody>
</table>
What Are Sugar Substitutes and What Forms Can They Take?, Continued

• Polyols (sugar alcohols): sorbitol, mannitol, xylitol
  • Absorbed more slowly than sugar, don't cause spike in blood glucose but not calorie free
  • Not completely absorbed; can cause diarrhea
What Are Sugar Substitutes and What Forms Can They Take?, Continued

- Calorie-free sweeteners:
  - Saccharin (Sweet'N Low): 200-700% sweeter than sucrose
  - Aspartame (Nutrasweet, Equal): 200% sweeter
    - People with PKU need to monitor all dietary sources of phenylalanine, including aspartame
  - Acesulfame-K (Sunette): 200% sweeter
  - Sucralose (Splenda): 600% sweeter
  - Rebaudioside A (Truvia, PureVia): 200% sweeter
  - Neotame: 7,000-13,000% sweeter
  - Monk fruit (Nectresse): 150-300% sweeter
  - Advantame is the newest sugar substitute made from aspartame and vanillin: 20,000% sweeter than sugar, 100% sweeter than aspartame
<table>
<thead>
<tr>
<th>Calories/Gram</th>
<th>Trade Names</th>
<th>Sweetening Power</th>
<th>The Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sweetener</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>4</td>
<td>Table Sugar</td>
<td>—</td>
</tr>
<tr>
<td><strong>Reduced-Calorie Sweeteners</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorbitol</td>
<td>2.6</td>
<td>Sorbitol</td>
<td>50-70% as sweet as Sucrose</td>
</tr>
<tr>
<td>Mannitol</td>
<td>1.6</td>
<td>Mannitol</td>
<td>50-70% as sweet as Sucrose</td>
</tr>
<tr>
<td>Xylitol</td>
<td>2.4</td>
<td>Xylitol</td>
<td>Equally sweet as sucrose</td>
</tr>
<tr>
<td>Hydrogenated starch hydrolysates (HSH)</td>
<td>3.0</td>
<td>HSH</td>
<td>50-70% as sweet as sucrose</td>
</tr>
<tr>
<td>Tagalose</td>
<td>1.5</td>
<td>Naturlose</td>
<td>92% as sweet as sucrose</td>
</tr>
</tbody>
</table>
### Oh So Sweet!, Continued

**Table 4.3 Oh So Sweet!, Continued**

<table>
<thead>
<tr>
<th>Calories/Gram</th>
<th>Trade Names</th>
<th>Sweetening Power</th>
<th>The Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calorie-Free Sweeteners</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saccharin</td>
<td>0</td>
<td>Sweet’N Low</td>
<td>200-700% the sweetness of sucrose</td>
</tr>
<tr>
<td>Aspartame</td>
<td>4*</td>
<td>Nutrasweet, Equal</td>
<td>Approximately 200% the sweetness of sucrose</td>
</tr>
<tr>
<td>Neotame</td>
<td>0</td>
<td>Neotame</td>
<td>7,000-13,000% the sweetness of sucrose</td>
</tr>
<tr>
<td>Acesulfame-K</td>
<td>0</td>
<td>Sunette</td>
<td>200% the sweetness of Sucrose</td>
</tr>
<tr>
<td>Sucralose</td>
<td>0</td>
<td>Splenda</td>
<td>600% the sweetness of Sucrose</td>
</tr>
<tr>
<td>Rebaudioside A</td>
<td>0</td>
<td>Truvia, PureVia</td>
<td>200% the sweetness of Sucrose</td>
</tr>
<tr>
<td>Monk fruit</td>
<td>0</td>
<td>Nectresse</td>
<td>150-300% the sweetness of sucrose</td>
</tr>
<tr>
<td>Advantame</td>
<td>0</td>
<td>Not available</td>
<td>20,000 times the sweetness of sucrose</td>
</tr>
</tbody>
</table>

*Because so little aspartame is needed to sweeten foods, it provides negligible calories.*
Why Is Fiber So Important?

• Fiber is nondigestible but has many powerful health effects
• Fiber helps lower risk of developing:
  • Constipation
  • Diverticulosis, diverticulitis
  • Obesity: high-fiber foods add to satiation
  • Heart disease: soluble fibers lower elevated blood cholesterol levels
  • Colorectal cancer
  • Diabetes mellitus: slows digestion and absorption of glucose
• Too much fiber can cause health problems, such as diarrhea, flatulence, and bloating
  • Gradually increase fiber intake to allow your body time to adjust
# Type-Casting Fiber

## Table 4.4 Type-Casting Fiber

<table>
<thead>
<tr>
<th>Type</th>
<th>Found in</th>
<th>Can Help Reduce the Risk of</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insoluble Fiber</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellulose</td>
<td>Whole grains, whole-grain cereals, bran, oats, fruit, and vegetables</td>
<td>Constipation</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td></td>
<td>Diverticulosis</td>
</tr>
<tr>
<td>Lignins</td>
<td></td>
<td>Certain cancers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heart disease</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obesity</td>
</tr>
<tr>
<td><strong>Soluble, Viscous Fibers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pectin</td>
<td>Citrus fruits, prunes, legumes, oats, barley, brussels sprouts, carrots</td>
<td>Constipation</td>
</tr>
<tr>
<td>Beta-glucan</td>
<td></td>
<td>Heart disease</td>
</tr>
<tr>
<td>Gums</td>
<td></td>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Psyllium</td>
<td></td>
<td>Obesity</td>
</tr>
</tbody>
</table>
Practical Nutrition Tips Video: Fiber Labels

Nutrition Tip
Diverticulosis and Fiber