Chapter 3 – Carbohydrates

Chapter Outline

I. The Chemist’s View of Carbohydrates
   A. Monosaccharides
      1. Glucose
      2. Fructose
      3. Galactose
   B. Disaccharides
      1. Sucrose
      2. Lactose
      3. Maltose
   C. Polysaccharides
      1. Starch
      2. Glycogen
      3. Fibers

II. Health Effects of Sugars and Alternative Sweeteners
   A. Sugars
      1. Sugar and Obesity
      2. Sugar and Behavior
      3. Sugar and Dental Caries
      4. Recommended Sugar Intakes
      5. Recognizing Sugars
   B. Alternative Sweeteners: Sugar Alcohols
   C. Alternative Sweeteners: Artificial Sweeteners
      1. Saccharin
      2. Aspartame
      3. Aspartame and PKU
      4. Acesulfame Potassium
      5. Sucralose
      6. Neotame
      7. Tagatose
      8. Other Artificial Sweeteners
      9. Artificial Sweeteners and Weight Control

III. Health Effects of Starch and Dietary Fibers
   A. Carbohydrates: Disease Prevention and Recommendations
      1. Heart Disease
      2. Diabetes
      3. GI Health
      4. Cancer
      5. Weight Management
      6. Harmful Effects of Excessive Fiber Intake
      7. Recommendations
   B. Carbohydrates: Food Sources
      1. Grains
      2. Vegetables
      3. Fruits
      4. Milk, Cheese, and Yogurt
      5. Meat, Poultry, Fish, Legumes, Eggs, and Nuts
   C. Carbohydrates: Food Labels and Health Claims

IV. Nutrition and Dental Health
   A. What is dental caries?
   B. How do carbohydrate-rich foods promote caries development?
C. Doesn’t saliva rinse the mouth and protect the teeth?
D. Do any foods prevent caries?
E. Besides foods, what other factors protect against dental caries development?

Multiple Choice

Circle the letter for the best response to each question.

1. Which organ depends almost exclusively on carbohydrates for energy?
   a. brain  
   c. liver
   b. heart  
   d. lungs

2. People who wish to lose fat and maintain muscle mass should do all of the following except:
   a. be physically active.
   b. watch portions sizes.
   c. consume a low-carbohydrate diet.
   d. consume carbohydrates in balance with other energy nutrients.

3. Examples of soluble fiber are:
   a. hulls of seeds and skin on corn.
   b. legumes and fruit pulp.
   c. bran and strings of celery.
   d. skin on an apple and oats.

4. A key function of insoluble fiber is to:
   a. ease eliminations.
   b. promote the absorption of minerals.
   c. slow motility.
   d. provide an important source of energy.

5. Polysaccharides are made up of:
   a. sucrose molecules.
   b. monosaccharides.
   c. a variety of all the simple sugars.
   d. glucose.

6. If a person’s blood glucose falls below normal, they:
   a. will feel fatigued.
   b. will experience stomach cramps.
   c. will become dizzy and weak.
   d. will break out in a sweat.

7. Which hormone is released when blood glucose levels are low?
   a. insulin
   b. glucagon
   c. estrogen
   d. thyroxin

8. Which is the sweetest of the natural sugars?
   a. fructose
   b. maltose
   c. sucrose
   d. glucose

9. Short chains of glucose from starch breakdown that are used as a thickening agent in foods are called:
   a. cellulose.
   b. galactose.
   c. maltose.
   d. dextrin.

10. The body stores glucose in the form of glycogen. Which body structure stores two thirds of it?
    a. muscles
    b. brain
    c. central nervous system
    d. liver

11. Our sugar consumption has increased dramatically, mainly due to an increase in the consumption of:
    a. snack foods.
    b. candy.
    c. soft drinks and sweetened fruit juice.
    d. commercially prepared cookies.
12. Avoiding sticky carbohydrates can:
   a. lower body weight.      c. reduce the risk of heart disease.
   b. reduce the risk of dental caries.          d. prevent over eating.

13. In regard to sugar consumption, the *Dietary Guidelines for Americans 2005* suggests that consumers:
   a. eliminate it from their diets.       c. take in no more than 45% of carbohydrate as sugars.
   b. use honey instead of white sugar.    d. consume foods with little added sugar.

14. In terms of kcalories, a teaspoon of brown sugar, 1 tablespoon of catsup and 1 ½ ounces of soft drink are all equal to:
   a. 1 teaspoon of white sugar.          c. ¼ cup of sugar.
   b. 1 ounce of starch.                  d. 50 kcalories.

15. In addition to being lower in kcalories than sugar, sugar alcohols:
   a. are not absorbed by the body.       c. stimulate energy metabolism.
   b. reduce fat absorption.              d. do not contribute to dental caries.

16. People with phenylketonuria (PKU) should avoid the artificial sweetener:
   a. aspartame.                         c. saccharin.
   b. sucralose.                        d. neotame.

17. Insoluble fibers may be beneficial in reducing the risk of:
   a. diabetes                         c. diverticulosis.
   b. kidney disease.                 d. liver disease.

18. Fiber-rich foods tend to be:
   a. constipating.                    c. bland tasting.
   b. low in fat and added sugar.      d. low in B vitamins.

19. A harmful effect that a high-fiber diet can have is that it:
   a. can carry water out of the body, causing dehydration.
   b. may provide too much B vitamins.
   c. may cause gas.
   d. can increase a person's hunger.

20. Which fruit is considered high in fat?
   a. apple                          c. banana
   b. kiwi                          d. avocado

21. Cream and butter are found in which food group?
   a. fruit                          c. solid fats and added sugars
   b. dairy                         d. meat

22. Which food provides about 8 grams of fiber per serving equivalent?
   a. a slice of whole-wheat bread   c. baked potato with skin
   b. brown rice                    d. kidney beans

23. Dextrose is an older name for which sugar?
   a. sucrose                       c. glucose
   b. fructose                      d. maltose

24. A possible side effect of consuming too much of the sugar alcohols is:
   a. diarrhea.                     c. an increase in dental caries.
   b. an increase in hunger.        d. headaches.
25. Which fiber-containing food will help slow transit of food through the upper GI tract?
   a. cabbage c. Brussels sprouts
   b. oatmeal d. brown rice

26. Of the following, which carbohydrate-containing food will promote dental caries most?
   a. raisins c. apple juice
   b. kidney beans d. celery

27. Which food is considered anticariogenic?
   a. orange juice c. chic peas
   b. dried apricots d. cheese

28. Which carbohydrate-containing food can be used as a source of reliable protein in the vegetarian diet?
   a. corn c. raisins
   b. kidney beans d. breakfast cereal

29. Which carbohydrate is known as milk sugar?
   a. maltose c. lactose
   b. galactose d. dextrose

30. As a person increases their fiber intake, they should also increase their intake of:
   a. water c. milk.
   b. iron-rich meats d. vitamin C.

**Fill-in-the-Blank Exercises**

Try to fill in the missing words/phrases from memory to complete the chapter summary.

Carbohydrate is the body’s preferred 1.____________________ source. Six 2.____________________ are important in nutrition: the three monosaccharides (3.____________________, 4.____________________, and 5.____________________) and the three disaccharides (6.____________________, 7.____________________, and 8.____________________). The three disaccharides are pairs of 9.____________________; each contains 10.____________________ paired with one of the three 11.____________________. The 12.____________________ (chains of monosaccharides) are 13.____________________, 14.____________________, and dietary 15.____________________. Both glycogen and starch are storage forms of 16.____________________—17.____________________ in the body and 18.____________________ in plants—and both yield 19.____________________ for human use. The 20.____________________ also contain glucose (and other monosaccharides), but their 21.____________________ cannot be broken by human digestive 22.____________________, so they yield little, if any, energy.

23.____________________ pose no major health threat except for an increased risk of dental 24.____________________. Excessive sugar intakes may displace needed 25.____________________ and 26.____________________ and may contribute to 27.____________________. A person deciding to 28.____________________ daily sugar intake should recognize that not all sugars need to be restricted, just 29.____________________ with 30.____________________, which are high in 31.____________________ and
relatively lacking in other nutrients. Sugars that occur naturally in fruits, vegetables, and
32.____________________ are acceptable.

Two types of 33.____________________ are sugar alcohols and artificial sweeteners.
34.____________________ are carbohydrates, but they yield slightly less energy than 35.____________________.
Sugars that occur naturally in fruits, vegetables, and
32.____________________ are acceptable.

Two types of 33.____________________ are sugar alcohols and artificial sweeteners.
34.____________________ are carbohydrates, but they yield slightly less energy than 35.____________________.
Sugars that occur naturally in fruits, vegetables, and
32.____________________ are acceptable.

The 36.____________________ are not carbohydrates and yield no energy. Like the sugar alcohols, artificial sweeteners do not promote
38.____________________.

A diet rich in 39.____________________ and 40.____________________ helps prevent heart disease,
41.____________________, GI disorders, and possibly some types of 42.____________________. It also supports efforts to manage 43.____________________. For these reasons, recommendations urge people to eat plenty of
whole 44.____________________, vegetables, legumes, and 45.____________________—enough to provide
46.____________________% of the daily energy from carbohydrate.

Grains, vegetables, fruits, and legumes contribute 47.____________________ to the diet and, like
48.____________________, also contribute energy-yielding starches and dilute 49.____________________.
50.____________________ list grams of total 51.____________________ and also provide separate listings of grams of 52.____________________ and 53.____________________.

**Word Problems**

*Try to solve the following problems. See the answer key for solutions and explanations.*

1. Identify the fiber content of each food in this meal, and then select an appropriate substitute to increase the fiber content of the meal. Include the value for the higher-fiber food.

<table>
<thead>
<tr>
<th>Low-fiber meal</th>
<th>Fiber (g)</th>
<th>Higher-fiber replacement</th>
<th>Fiber (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken noodle soup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey sandwich on white bread</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macaroni salad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watermelon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. According to the World Health Organization (WHO), no more than 10% of kcalories on a 2000-kcalorie diet should come from sugar. How many kcal from sugars would this be? How many grams of sugar? Identify four examples of food choices that would meet the criterion of 10% or less of kcal from sugar.
3. If a person consumes 2,500 kcalories a day, how much carbohydrate should this include, expressed as kcal from carbohydrate and g of carbohydrate?

Matching

A. Write the letter for the appropriate description beside each type of simple carbohydrate.

1. _____ added sugars
2. _____ disaccharides
3. _____ fructose
4. _____ galactose
5. _____ glucose
6. _____ lactose
7. _____ maltose
8. _____ monosaccharides
9. _____ naturally occurring simple sugars
10. _____ sucrose
11. _____ sugars

a. the monosaccharides and the disaccharides.
b. single sugar units.
c. a monosaccharide, the sugar common to all disaccharides and polysaccharides.
d. a monosaccharide; sometimes known as fruit sugar and abundant in fruits, honey, and saps.
e. a monosaccharide; part of the disaccharide lactose.
f. sugars and syrups added to a food for any purpose.
g. sugars that are not added to a food but are present as its original constituents.
h. pairs of sugar units bonded together.
i. a disaccharide composed of glucose and fructose.
j. a disaccharide composed of glucose and galactose.
k. a disaccharide composed of two glucose units.

B. Write the letter for the appropriate description beside each type of complex carbohydrate.

1. _____ glycogen
2. _____ dietary fibers
3. _____ polysaccharides
4. _____ resistant starches
5. _____ starch

a. long chains of monosaccharide units arranged as starch, glycogen, or fiber.
b. a plant polysaccharide composed of glucose and digestible by human beings.
c. a polysaccharide composed of glucose, made and stored by liver and muscle tissues of human beings and animals as a storage form of glucose.
d. a general term denoting in plant foods the polysaccharides cellulose, hemicellulose, pectins, gums, and mucilages, as well as the nonpolysaccharide lignins, that are not digested by human digestive enzymes.
e. starches that escape digestion and absorption in the small intestine of healthy people.

Discussion

Answer the following questions on a separate sheet of paper. See the answer key for correct responses or examples.

1. Discuss the trend in soft drink consumption over the last 30+ years and how this relates to weight gain.
2. Discuss the overall health benefits of a diet that emphasizes whole grains, vegetables, legumes and fruits.

3. What is the benefit of a fiber-rich diet to the diabetic?

4. Compare and contrast 4 ounces of apple juice and one apple for kcalories, carbohydrate (CHO), fiber, vitamin A and potassium. Based on this comparison, state which food you think is healthier.

5. What are the benefits or disadvantages of food manufacturers using alternative sweeteners in processed foods?


**Answer Key**

**Multiple Choice**

1. a (p. 61)  
9. d (p. 63)  
17. c (p. 74)  
25. b (p. 75)
2. c (p. 61)  
10. a (p. 63)  
18. b (p. 74)  
26. a (pp. 82-83)
3. b (p. 64)  
11. c (p. 65)  
19. a (p. 75)  
27. d (p. 83)
4. a (p. 64)  
12. b (pp. 82-83)  
20. d (p. 78)  
28. b (p. 68)
5. d (p. 63)  
13. d (p. 65)  
21. c (p. 78)  
29. c (p. 62)
6. c (p. 61)  
14. a (p. 67)  
22. d (p. 77)  
30. a (p. 75)
7. b (pp. 61-62)  
15. d (p. 69)  
23. c (p. 67)
8. a (p. 62)  
16. a (p. 71)  
24. a (p. 69)

**Fill-in-the-Blank Exercises**

1. energy  
19. energy  
37. artificial sweeteners
2. simple sugars  
20. dietary fibers  
38. tooth decay
3. glucose  
21. bonds  
39. starches
4. fructose  
22. enzymes  
40. dietary fibers
5. galactose  
23. Sugars  
41. diabetes
6. sucrose  
24. caries  
42. cancer
7. lactose  
25. nutrients  
43. body weight
8. maltose  
26. fiber  
44. grains
9. monosaccharides  
27. obesity  
45. fruits
10. glucose  
28. limit  
46. 45 to 65
11. monosaccharides  
29. concentrated sweets  
47. dietary fiber
12. polysaccharides  
30. added sugars  
48. milk
13. glycogen  
31. kilocalories  
49. sugars
14. starches  
32. milk  
50. Food labels
15. fibers  
33. alternative sweeteners  
51. carbohydrate
16. glucose  
34. Sugar alcohols  
52. fiber
17. glycogen  
35. sucrose  
53. sugar
18. starch  
36. dental caries

**Word Problems**

1. **Sample answer:**

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<th>Higher-fiber replacement</th>
<th>Fiber (g)</th>
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</thead>
<tbody>
<tr>
<td>Chicken noodle soup</td>
<td>1 g</td>
<td>Split pea soup</td>
<td>3 g</td>
</tr>
<tr>
<td>Turkey sandwich on white bread</td>
<td>2 g</td>
<td>Turkey sandwich on multigrain bread</td>
<td>4 g</td>
</tr>
<tr>
<td>Macaroni salad</td>
<td>2 g</td>
<td>Waldorf salad</td>
<td>3 g</td>
</tr>
<tr>
<td>Watermelon</td>
<td>1 g</td>
<td>Pear</td>
<td>4 g</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6 g</strong></td>
<td><strong>Total</strong></td>
<td><strong>14 g</strong></td>
</tr>
</tbody>
</table>

2. This would be equal to 200 kcalories or 50 g of sugar. Examples of food choices would include: 1 baked potato with cheese; 1 cup of trail mix; ½ cup Mexican rice; 1 slice of cherry pie (1/8 cut).

3. 45-65% of kcalories should come from carbohydrate.  
   $2,500 \times .45 = 1125$ kcalories / 4 kcal per g = 281 grams  
   $2,500 \times .65 = 1625$ kcalories / 4 kcal per g = 406 grams
Matching

Set A
1. f  2. h  3. d  4. e  5. c  6. j  7. k  8. b  9. a  10. i  11. g

Set B
1. c  2. d  3. a  4. e

Discussion

1. The intake of fruit drinks and punch doubled during this period, and soft drink consumption tripled. The incidence of obesity in the U.S. also increased as the consumption of these items increased. Sugar contributes to obesity to the extent that it contributes to excess kcal intake.

2. The consumption of these plant foods, which are rich in fiber, antioxidants, vitamins and minerals, can reduce the risk of obesity, cancer, cardiovascular disease, diabetes, dental caries, gastrointestinal disorders and malnutrition.

3. Soluble fiber slows GI transit of food, making a person feel full longer, and also slows the absorption of glucose. The result is generally a reduction in the number of kcalories consumed during the day, and more normal blood glucose levels.

4. Exact nutrient contents will vary depending on the source of data used.
   Apple juice: 58 kcal, 14 g CHO, <1 g fiber, 0 µg RAE vitamin A, 148 mg potassium
   Apple: 72 kcal, 19 g CHO, 3 g fiber, 4 µg RAE vitamin A, 148 mg potassium

   Pulling together a number of ideas, the apple is a better source of fiber and it will be more satisfying in the long run. So choose the apple.

5. Benefits: lower sugar consumption; fewer kcals than sugar. If the alternative is a sugar alcohol, lower risk of dental caries.
   Disadvantages: sugary foods, whether made with sugar or alternates, tend to be lower in fiber, higher in fat. If “diet soda” is being consumed instead of a low-fat milk, lack of calcium and vitamin D in the diet. Consumption of foods with sugar substitutes does not change poor eating habits.