

# Carbohydrates

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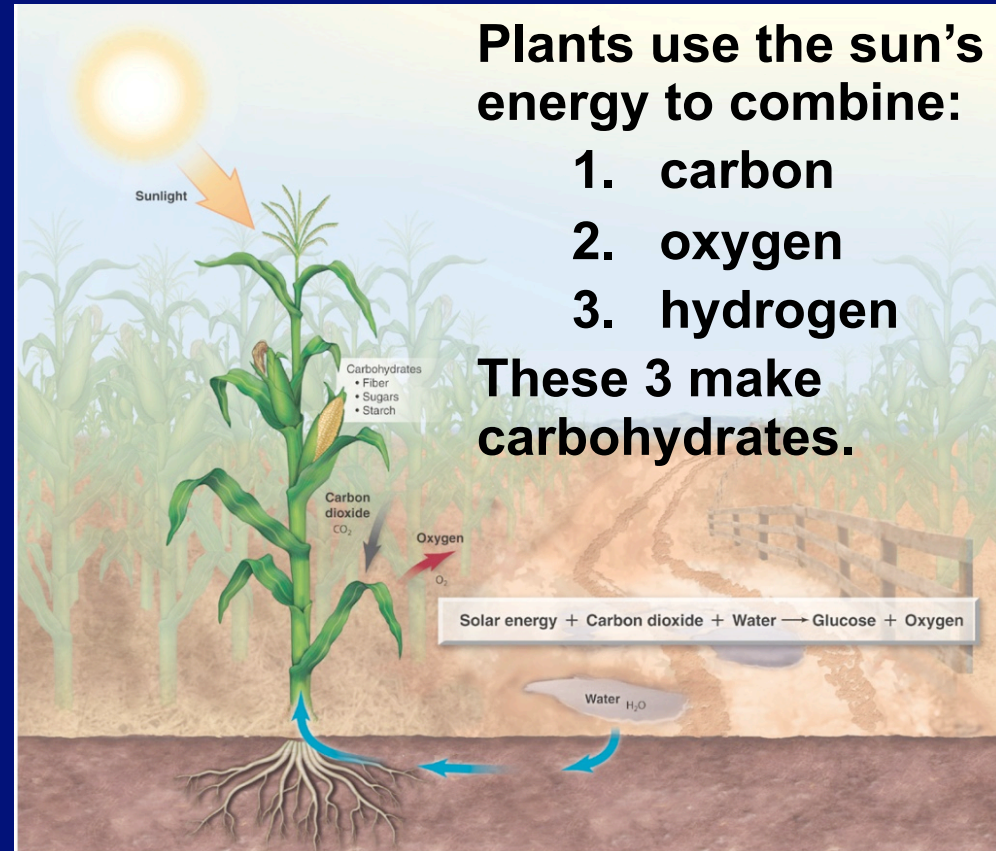
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## Chapter 5

Nutrition Chapter 5: Carbohydrates

# What are Carbohydrates?

- Carbohydrates are:
  - Major source of energy
  - Made by plants from  $\text{CO}_2$  and  $\text{H}_2\text{O}$ , using energy from the sun.
  - Often identified by the chemical name ending in “-ose” (glucose or fructose)



# Carbohydrates (Sugars)

- Three levels of sugar complexity:
  1. Monosaccharide (Mono-one) (Saccharide-Sugar)
    - Simplest form of a sugar
    - Most important have 6 carbons in their make-up
  2. Disaccharide (Di- two)
    - 2 monosaccharides attached to each other
  3. Polysaccharide (poly-many)
    - Multiple monosaccharides attached to each other

# Monosaccharides

## Glucose

- Primary fuel/energy source for cells of the body
- A.K.A. –Dextrose, Blood sugar

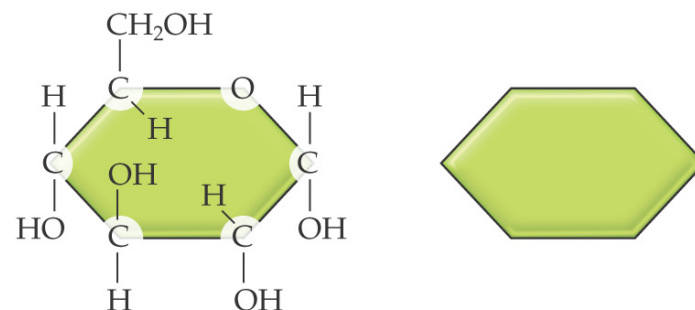
## Fructose

- A.K.A.- Fruit sugar or levulose
- The sweet tasting sugar we are used to, but our body converts it into glucose.
- Manufacturer's isolate high fructose corn syrup from corn to sweeten things like sodas

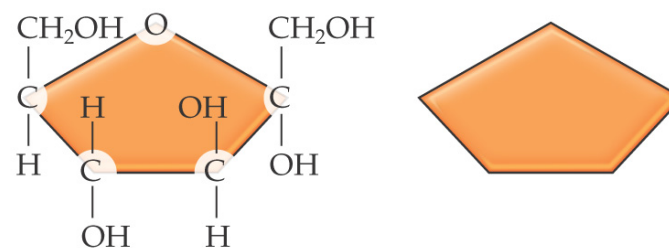
## Galactose

- Part of “milk sugar” (lactose)

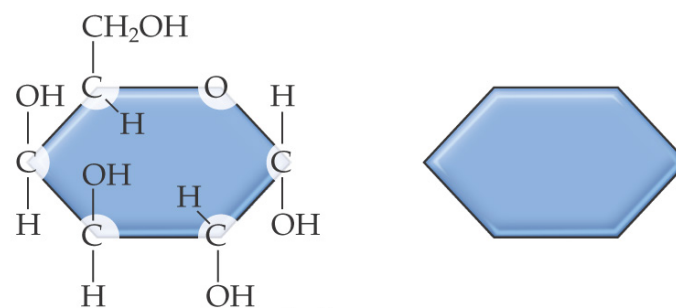
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Glucose



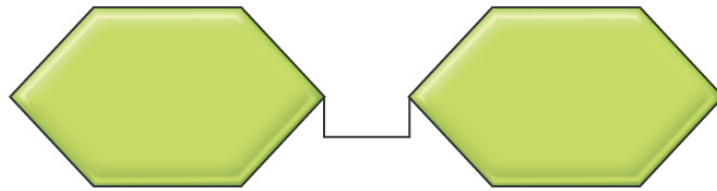
Fructose



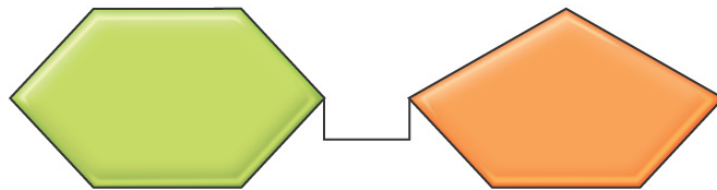
Galactose

# Disaccharides

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a. Maltose



b. Sucrose



c. Lactose

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## Maltose

– glucose + glucose

## Sucrose

– glucose + fructose

– Table sugar

## Lactose

– glucose + galactose

– Found in milk & ice cream

# Sucrose- Table sugar

- Table sugar:
  - Almost 100% sucrose
  - Made from sugar **cane** or sugar **beets**
  - Refinement strips away small amounts of vitamins and minerals naturally in cane & beets
- Occurs naturally in honey, maple syrup, carrots, and sweet fruits such as pineapples

# Nutritional Comparison of Selected Sweeteners



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**TABLE 5.1** *Nutritional Comparison of Selected Sweeteners*

Sugar/Syrup 1 Tablespoon	Water %	Kcal	Protein g	Carb g	Vit. C mg	Calcium mg	Folate mcg	Potassium mg	Iron mg	Zinc mg
<i>Honey</i>	17	64	0	17	0.1	1	0	11	0.09	0.05
<i>Raw sugar</i>	2	46	0	12	0	10	0.125	42	0.23	0.03
<i>Brown sugar</i>	<1	36	0	9	0	8	0	33	0.18	0.02
<i>White granulated sugar</i>	0	48	0	13	0	0	0	0	0	0

# Names for Sugars

**TABLE 5.2** *Names for Sugars*

Sugars Can Be:		
brown sugar	glucose	polydextrose
confectioner's or powdered sugar	granulated cane juice	raw sugar
corn sweeteners, corn syrup, high-fructose	honey	sorbitol*
corn syrup (HFCS), cultured corn syrup	invert sugar	mannitol*
date sugar	lactose	xylitol*
dextrose	maltose, high-maltose corn syrup	table sugar (sucrose)
evaporated cane juice	maltodextrin	turbinado sugar
fructose (levulose)	maple syrup	
fruit juice concentrate or concentrated	molasses	
fruit juice sweetener		

\* Alcohol forms of sugars

If one of these names is the 1<sup>st</sup> or 2<sup>nd</sup> ingredient in a product listing it means that product contains a high amount of added sugar

**TABLE 5.3** *How Much Added Sugar Is in That Food?*

Food	Serving Size	Kcal	Approximate Teaspoons Added Sugars
<i>Doughnut, cake, plain</i>	3/4" diameter	226	2
<i>Chocolate chip cookies, commercial brand</i>	2 medium (50 g)	239	4
<i>Sugar-frosted cornflakes</i>	3/4 cup	114	3
<i>Chocolate-flavored 2% milk</i>	1 cup	158	3
<i>Ice cream, vanilla, light, soft-serve</i>	1/2 cup	111	2
<i>Chocolate candy bar with almonds</i>	1.76 oz	235	5
<i>Apple pie, double crust</i>	1/8" diameter pie	277	4
<i>Snack sponge cake with cream filling</i>	1 cake (43g)	157	4
<i>Yogurt, vanilla low-fat</i>	8 oz	193	4
<i>Cola, canned</i>	12 fl oz	136	8
<i>Fruit punch drink</i>	12 fl oz	175	10
<i>Chocolate milkshake, fast food</i>	16 fl oz	580	10



# Nutritive vs. Nonnutritive Sweeteners

## Nutritive sweeteners

- Contribute energy to foods
  - Provide 4 kcal/g
- Added sugars
  - Nutritive sweeteners added during processing or preparation
    - e.g., sucrose and high fructose corn syrup

## Nonnutritive Sweeteners

- Intensely-sweet synthetic compounds that sweeten foods without providing kcal
- FDA approved nonnutritives:
  - Saccharin, aspartame, acesulfame-K, sucralose, neotame, and “stevia”
- Saccharin used for >100 yrs
  - Most scientific evidence supports its safety
- Cyclamates banned in the U.S. since 1970
  - Despite being determined as safe by panel of experts from FDA and NAS

# Alternative Sweeteners

## What are alternative sweeteners?

- Substances added to a food to sweeten it but provide no or few calories

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**TABLE 5.4** *Comparing Nonnutritive Sweeteners*

Sweetener	Comparison to Sugar	Brand Name	Kilocalories/tsp
<i>Aspartame</i>	200 times sweeter	NutraSweet, Equal	Nearly 0
<i>Saccharin</i>	200 to 700 times sweeter	Sweet'N Low, Sweet Twin, Necta Sweet	0
<i>Acesulfame-K</i>	200 times sweeter	Sunett, Sweet One	0
<i>Neotame</i>	7,000 to 13,000 times sweeter	Neotame	0
<i>Sucralose</i>	600 times sweeter	Splenda	0
<i>Stevia extracts</i>	200 to 300 times sweeter	Truvia, SweetLeaf	0

Source: Artificial sweeteners: No calories...sweet! *FDA Consumer Magazine*. 2006. [www.fda.gov/fdac/features/2006/406\\_sweeteners.html](http://www.fda.gov/fdac/features/2006/406_sweeteners.html)

# Alternative Sweeteners

## Aspartame

- Brand names include
  - Nutrasweet and Equal
- Made-up of 2 amino acids:
  - Phenylalanine + Aspartic acid
- People with phenylketonuria (PKU) must avoid aspartame.

## Stevia

- From leaves of South American shrub *Stevia rebaudiana* Bertoni
- *Rebiana* - sweet chemical in stevia leaves
- Considered safe by FDA

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# Complex Carbohydrates a.k.a. polysaccharides

- Contain  $\geq 10$  monosaccharides bonded together
- Storage form of carbohydrate in plants and animals
- Structural component of plants in stems and leaves

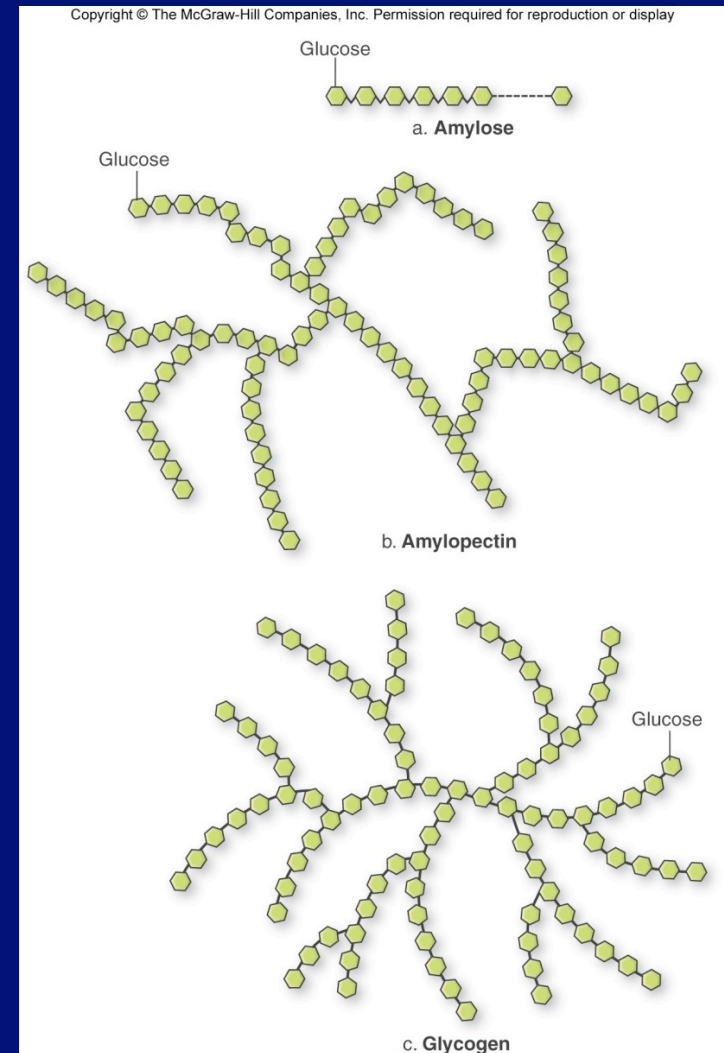
# Starch and Glycogen

## Starch

- Storage form of carbohydrate in plants
- Mainly in seeds, roots, and tubers

## Glycogen

- Storage form of carbohydrate in humans and other animals
- Stored primarily in *liver* and *muscles temporarily*



# Fiber

- Most forms of fiber are complex carbohydrates that the human body cannot digest.
- Two types: Soluble and Insoluble

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**TABLE 5.6** *Classifying Fiber*

Type	Component(s)	Physiological Effects	Food Sources
<i>Insoluble</i>	Cellulose, hemicelluloses	* Increases fecal bulk and speeds fecal passage through GI tract	All plants Wheat, rye, brown rice, vegetables
	Lignin	Increases fecal bulk, may ease bowel movements	Whole grains, wheat bran
<i>Soluble</i>	Pectins, gums, mucilages, some hemicelluloses	* Delays stomach emptying; slows glucose absorption; can lower blood cholesterol	Apples, bananas, citrus fruits, carrots, oats, barley, psyllium seeds, beans, and thickeners added to foods

# Dietary Fiber Content of Common Foods

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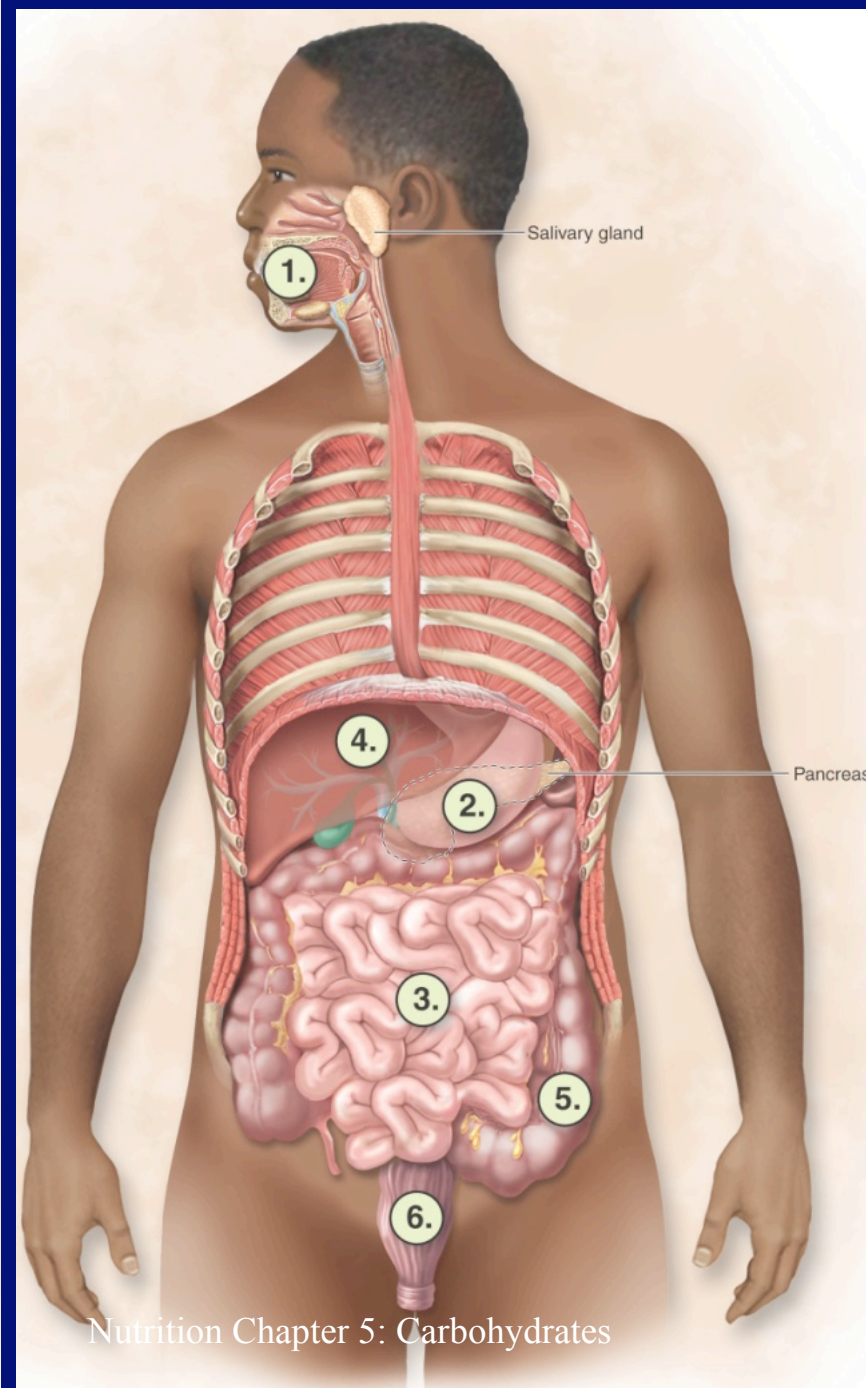
**TABLE 5.7** *Dietary Fiber Content of Common Foods*

Food	Fiber (g)	Food	Fiber (g)
Split peas, cooked (1 cup)	16.3	Banana, sliced (1 cup)	3.9
Black beans, cooked (1 cup)	15.0	Almonds (24 almonds)	3.5
Kidney beans, canned (1 cup)	13.6	Carrots, raw, sliced (1 cup)	3.4
Kellogg's All-Bran cereal (1/3 cup)	12.9	Strawberries, raw, sliced (1 cup)	3.3
Chickpeas, cooked	12.5	Orange, raw (1 orange)	3.1
Dates, chopped (1 cup)	11.8	Barley, cooked (1/2 cup)	3.0
Baked beans, canned (1 cup)	10.4	Baked potato, medium, with skin (approx. 4.5 oz)	3.0
Frozen peas, cooked (1 cup)	8.8	Prunes, dried uncooked (4 prunes)	2.7
Raspberries, raw (1 cup)	8.0	Whole-grain bread (1 slice)	1.9
Blackberries (1 cup)	7.6	Romaine lettuce (1 cup)	1.0
Kellogg's Raisin Bran (1 cup)	6.5	Iceberg lettuce (1 cup)	0.7
Oat bran, ready-to-eat (1 1/4 cup)	5.6	White bread (1 slice)	0.6
Apple, with skin (approx. 6 oz)	4.4		
Beans, green snap, cooked (1 cup)	4.0		

Source: Data from U.S. Department of Agriculture, Agricultural Research Service: *USDA nutrient database for standard reference, Release 22, 2009.*  
[www.ars.usda.gov/Services/docs.htm?docid=8964](http://www.ars.usda.gov/Services/docs.htm?docid=8964)

# What happens to carbohydrates in your body?

- 1. Mouth**  
Some starch is broken down to maltose by salivary amylase.
- 2. Stomach**  
The activity of salivary amylase soon stops in the acidic environment of the stomach.
- 3. Small intestine**  
An amylase secreted by the pancreas (pancreatic amylase) breaks down starch into maltose. Maltase digests maltose into glucose. Sucrase digests sucrose into glucose and fructose. Lactase breaks down lactose into glucose and galactose.
- 4. Liver**  
Glucose, fructose, and galactose are absorbed by intestinal cells and transported to the liver by the portal vein.
- 5. Large intestine**  
Some soluble fiber is fermented by bacteria in the large intestine.
- 6. Rectum**  
Very little dietary carbohydrate is excreted in feces.



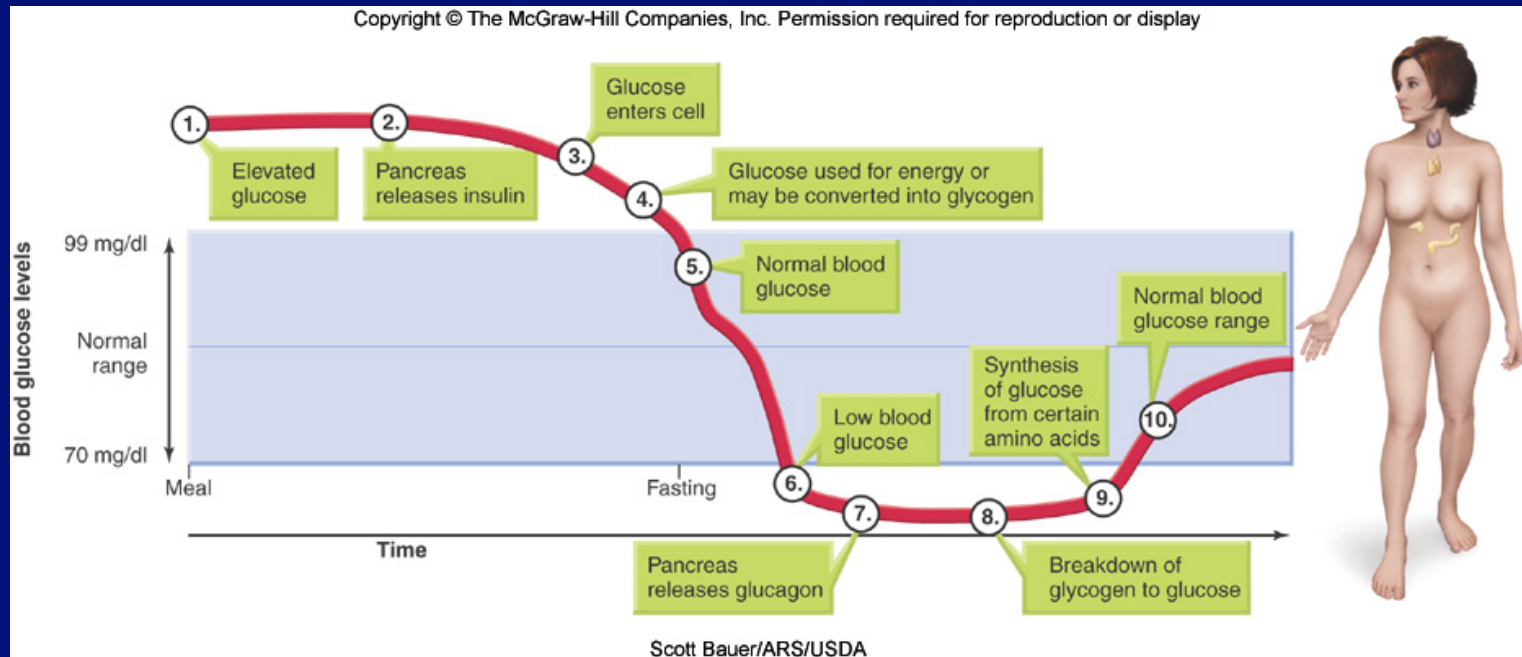
Nutrition Chapter 5: Carbohydrates



# Maintaining Blood Glucose Levels

Hormone	When Secreted	Action on Glucose
Insulin	↑ Blood glucose	Uptake by cells
Glucagon	↓ Blood glucose	Glycogen breakdown ↑ Synthesis of glucose

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Scott Bauer/ARS/USDA

# To eat or not to eat

## What Happens After Eating Carbohydrates?

Insulin released from pancreas:

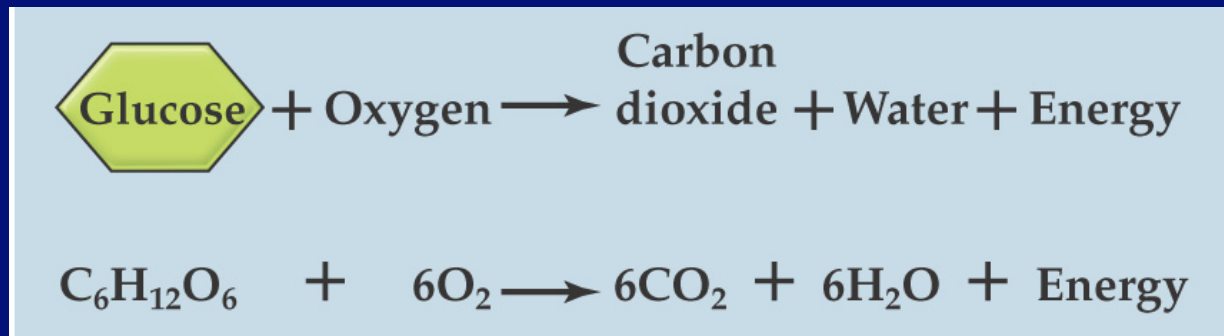
- Enables glucose to enter cells
- Enhances production/storage of:
  - Fat
  - Glycogen
  - Protein
- Decreases hunger

## What Happens When You Don't Eat?

- When blood glucose decreases, pancreas releases glucagon, stimulating:
  - Glycogenolysis
    - Glycogen breakdown—releasing glucose into the blood
  - Lypolysis
    - Breakdown of triglycerides (fat) for energy

# Glucose = bodies main source of energy

- Cells use oxygen to release energy stored in glucose's chemical bonds.
- Carbon dioxide and water are formed in the process.



# What happens when you don't eat carbs?

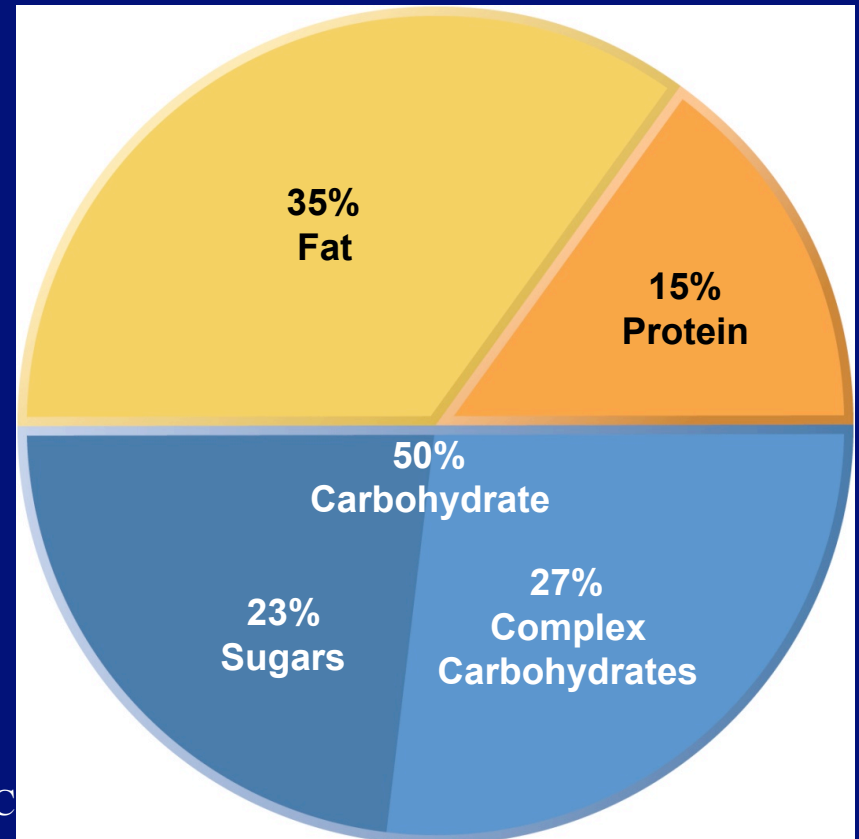
- If the body wants to use fats as fuel, it needs some glucose to do it properly.
- If you do not have enough glucose, this results in incomplete fat breakdown.
  - These incomplete products are called Ketone Bodies
- **Ketone bodies**
  - Form as a result of incomplete fat breakdown
    - Poorly controlled diabetes
    - Fasting or starving
    - Low-carbohydrate, high-protein diet (e.g., Atkins)
    - Used by certain cells for energy
- **Ketosis**
  - Condition that occurs with very high blood ketone bodies
  - Unconsciousness and death may occur

# Carbohydrate Consumption Patterns

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- Average American  
~23% kcal (~30 tsp)  
from added sugars
- According to MyPlate  
added sugars are  
empty calories. Most  
people only have room  
for 100-300 empty  
calories/day.

Average Percentage  
of Calories per Person (One Day)



# How can you reduce your intake of refined carbohydrates?

## Sources of Refined Carbohydrates

- **Soft drinks**→
- **Cookies**→
- **Candy**→
- **Chips**→

## Substitutes

- **Plain water**
- **Whole grains and nuts**
- **Fresh fruits**
- **Raw vegetables**

# Understanding Nutrition Labeling: Carbohydrate and Fiber

- Information about total carbohydrates, sugar, and fiber content in a serving of food.
- Notice there is no indication of added sugar
- Calculations
  - Total carbs= 17g
  - Fiber= 2g
  - Sugars=3g
  - Thus carbs from starch are:
    - $17g - 2g - 3g = \underline{12g \text{ of carbs from starch}}$

Nutrition Facts	
Serving Size 1 slice (38 g)	
Servings Per Container 18	
Amount Per Serving	
<b>Calories</b> 100	
Calories from Fat 20	
	% Daily Value*
<b>Total Fat</b> 2g	<b>3%</b>
Saturated Fat 0g	0%
Trans Fat 0g	
Polyunsaturated Fat 1g	
Monounsaturated Fat 0g	
<b>Cholesterol</b> 0mg	<b>0%</b>
<b>Sodium</b> 160mg	<b>7%</b>
<b>Total Carbohydrate</b> 17g	<b>6%</b>
Dietary Fiber 2g	<b>8%</b>
Sugars 3g	
<b>Protein</b> 4g	
Vitamin A	<b>10%</b>
Vitamin C	<b>0%</b>
Calcium	<b>10%</b>
Iron	<b>8%</b>

\* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower, depending on your calorie needs:

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

**INGREDIENTS:** Whole-wheat flour, Water, Brown sugar, Wheat gluten, Cracked wheat, Wheat bran, Yeast, Salt, Molasses, Soybean oil, Calcium propionate (preservative), Mono- and diglycerides, Lecithin, Reduced fat milk

# Carbohydrates and Health

## Frequently Asked Questions:

1. Are all high-carbohydrate foods fattening?
2. What is diabetes?
3. What causes hypoglycemia?
4. Is belly fat linked to metabolic syndrome?
5. How do carbohydrates contribute to tooth decay?
6. Why do some people have lactose intolerance?
7. Does sugar cause hyperactivity?
8. Do we really need to eat more fiber?



# Are Carbohydrates Fattening?

It may depend on the type of carbohydrate...

## Probably “fattening” :

- Added sugars
- Refined starches
- High-fructose corn syrup

## Healthier choices:

- Fiber-rich foods (e.g., fruits, vegetables, and unrefined grains)



# What is Diabetes?

## Diabetes mellitus\_

- Group of serious chronic diseases characterized by abnormal glucose, fat, and protein metabolism
- Primary symptom is hyperglycemia
  - (Hyper-excess Glycemia-Blood glucose)
  - Type 1 diabetes
    - Autoimmune disease
    - Beta cells stop making insulin
  - Type 2 diabetes
    - Most common type
    - Insulin resistant cells

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**TABLE 5.8** *Classifying Diabetes Mellitus*

Blood glucose level (fasting)	Classification
70 to 100 mg/dl	Normal
Between 100 and 125 mg/dl	Pre-diabetes
126 mg/dl or more	Diabetes

After fasting for at least 12 hours blood test results.

# Signs and Symptoms of Diabetes Mellitus

*Use the American Diabetes Association's questionnaire to assess your risk of type 2 diabetes.*

[www.diabetes.org/risk-test/text-version.jsp](http://www.diabetes.org/risk-test/text-version.jsp)

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**TABLE 5.9** *Signs and Symptoms of Diabetes Mellitus*

Elevated blood glucose levels
Excessive thirst
Frequent urination
Blurry vision
Vaginal yeast infections (adult women)
Foot pain, abdominal pain
Numbness
Impotence (male)
Sores that do not heal
Increased appetite with weight loss*
Breath that smells like fruit*
Fatigues easily*
Confusion*

\*Typical symptoms of poorly-controlled type 1 rather than type 2 diabetes.

# Controlling Diabetes

1. Maintenance of normal or near normal blood glucose levels
  - Daily self-testing of blood glucose
  - Periodic measurement of glycosylated hemoglobin
2. Maintain healthy body weight
3. Follow special diet
4. Obtain regular physical activity

# Can Diabetes Be Prevented?

- Type 1 probably cannot be prevented.
- Risk for developing Type 2 can be reduced.

## How to reduce the risk?

- ✓ Avoid excess body fat
- ✓ Exercise daily
- ✓ Follow a “prudent diet”



# Diet vs. Diet

## Western Diet

- High amounts of red meat, processed meat, French fries, high fat dairy foods, refined sugars, & refined starches.



## Prudent Diets

- Poultry, fish fiber-rich whole grains, fruits & vegetables
- Normally at lower risk of developing Type 2 diabetes



# What is Hypoglycemia?

## Hypoglycemia (hypo-below)

- Abnormally low blood glucose levels
  - Fasting blood glucose < 70 mg/dl (healthy person)*
- Blood glucose level is too low to provide cells adequate energy.
- True hypoglycemia is rare in non-diabetics.

## Reactive hypoglycemia

- In some people, blood glucose drops after eating highly refined carbohydrates.
  - *Pancreas responds to the carb intake by secreting excess insulin.*

# Metabolic Syndrome

- Seen in ~47 million of adult Americans
- Characterized by having more than 3 of these signs →
- Those with metabolic syndrome are 5X more likely to develop type 2 diabetes and 2X more likely to develop cardiovascular disease.
- XS ab fat & insulin resistance are the greatest risk factors for metabolic syndrome

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**TABLE 5.10** *Signs of Metabolic Syndrome*

Sign	Defining Value
<i>Large waist circumference*</i>	≥ 40 inches (men) ≥ 35 inches (women)
<i>Chronically elevated blood pressure (hypertension)</i>	≥ 130 mm Hg systolic (upper value) or ≥ 85 mm Hg diastolic (lower value) or Drug treatment for hypertension
<i>Chronically elevated fasting blood fats (triglycerides)</i>	≥ 150 mg/dl or Drug treatment for elevated triglycerides
<i>Low fasting high-density lipoprotein cholesterol (HDL cholesterol)</i>	< 40 mg/dl (men) < 50 mg/dl (women) or Drug treatment for reduced HDL
<i>High fasting blood glucose</i>	≥ 100 mg/dl or Drug treatment for elevated glucose

- Reducing your risk?
  - Lower BP, glucose, insulin, & triglyceride levels
  - Loss xs weight exercise regularly reduce salt, saturated fat, cholesterol, and simple sugar intake
  - Eat oily fish at least twice a week.



# Tooth Decay

- Linked to high-carbohydrate diet, especially sticky simple sugars that remain on teeth leaving residue.
- Bacteria in mouth →
  - Use this residue on teeth for energy
  - Produce acid as by-products of their metabolism
- This acid damages tooth enamel →
  - Damaged enamel allows decay

# Lactose Intolerance

- Inability to digest lactose
  - Caused by inadequate lactase
    - Affects millions of Americans
    - Very common in people of African, Asian, or Eastern European descent
- Because your body lacks the lactase once lactose gets into your large intestine, the bacteria in the large intestine break down undigested lactose, resulting in:
  - intestinal cramps, bloating, gas, and diarrhea

# Low-Lactose Milk Products



- In the process of making yogurt and hard cheeses, lactose is converted to lactic acid or removed.

- Lactase-treated milk does not contain lactose.
- The enzyme breaks down the disaccharide to glucose and galactose.

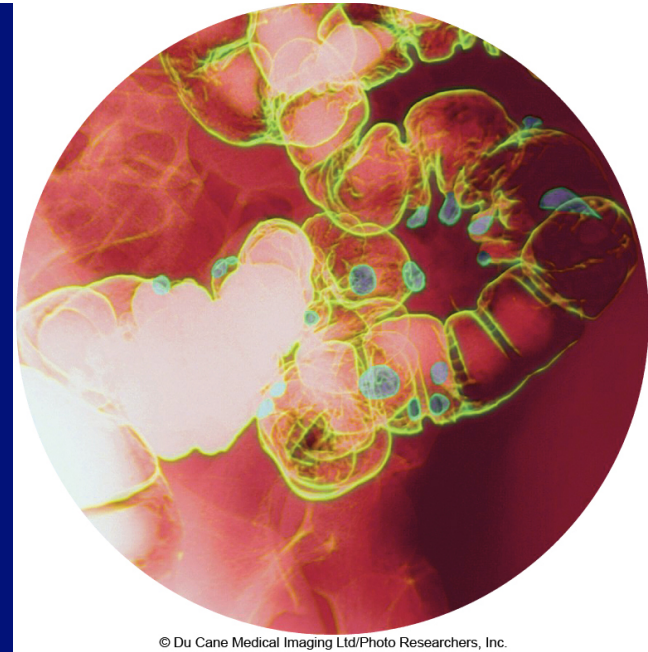
# Does Sugar Cause Hyperactivity

Results of scientific studies do not indicate that sugar increases children's physical activity level, causes ADHD, or negatively affects behavior.

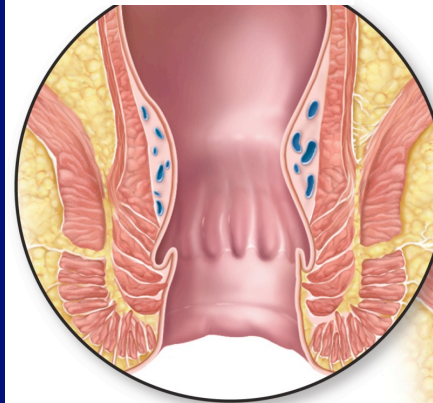


# Fiber and GI-tract Health

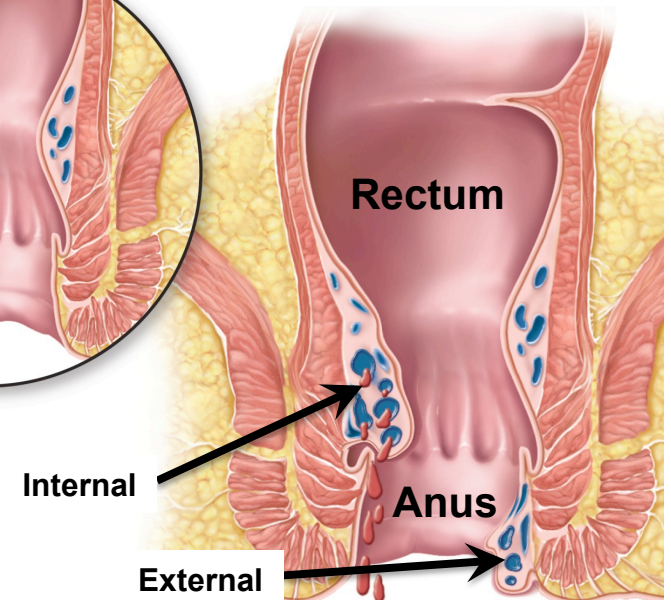
- Low fiber intake is linked to constipation and straining to expel feces causing increases in internal pressure.
  - Diverticula (abnormal tiny sacks that form in wall of colon) may result from this straining
    - Inflammation of these can cause pain and the condition is called *Diverticulitis*
  - Hemorrhoids (when clusters of small rectal veins become swollen making them likely to bleed & cause discomfort and itching)
    - Although not life threatening if one experiences bleeding from the rectum they should consult a physician, as rectal bleeding is one sign of colon cancer



Cross-section-  
Healthy rectum



Cross-section-  
Rectum w/Hemorrhoids



# Fiber and Health (cont)

- Fiber and Colorectal Cancer
  - High fiber diets protect against colorectal cancer (Maybe)
- Fiber and Heart Health
  - Soluble fibers promote heart health.
  - Liver uses cholesterol to make bile.
    - Normally liver will recycle bile from the intestine.
    - Soluble fiber prevents this recycling, meaning that the liver has to take cholesterol from the blood and make the bile from scratch thus decreases blood levels of cholesterol.
- Fiber and Weight Control
  - High fiber foods are “filling” resulting in satiety.