Chapter 7 - Metabolism: Transformations and Interactions
Simple Overview of Energy Metabolism

The sum of all chemical reactions that go on in living cells
Introduction

• Energy
  – Heat- body temperature
  – Mechanical- moves muscles
  – Electrical- sends nerve impulses
  – Chemical-
    • Stored in food and body

• Metabolism
  – Release of energy, water, and carbon dioxide
Chemical Reactions

• Building Reactions – Anabolism
  – Require energy

• Breakdown Reactions – Catabolism
  – Release energy
A Typical Cell

Inside the cell membrane lies the cytoplasm, a lattice-type structure that supports and controls the movement of the cell's structures. A protein-rich jelly-like fluid called cytosol fills the spaces within the lattice. The cytosol contains the enzymes involved in glycolysis.\(^a\)

A separate inner membrane encloses the cell's nucleus.

Inside the nucleus are the chromosomes, which contain the genetic material DNA.

This network of membranes is known as smooth endoplasmic reticulum—the site of lipid synthesis.

Known as the “powerhouses” of the cells, the mitochondria are intricately folded membranes that house all the enzymes involved in the conversion of pyruvate to acetyl CoA, fatty acid oxidation, the TCA cycle, and the electron transport chain.\(^b\)

A membrane encloses each cell's contents and regulates the passage of molecules in and out of the cell.

Rough endoplasmic reticulum is dotted with ribosomes—the site of protein synthesis.\(^c\)

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\(^a\)Glycolysis is introduced on p. 211.

\(^b\)The conversion of pyruvate to acetyl CoA, fatty acid oxidation, the TCA cycle, and the electron transport chain are described later in the chapter.

\(^c\)Figure 6-7 on p. 179 describes protein synthesis.

http://nutrition.jbpub.com/animations/animations.cfm?id=16&debug=0
### TABLE 7-1 Metabolic Work of the Liver

The liver is the most active processing center in the body. When nutrients enter the body from the digestive tract, the liver receives them first; then it metabolizes, packages, stores, or ships them out for use by other organs. When alcohol, drugs, or poisons enter the body, they are also sent directly to the liver; here they are detoxified and their by-products shipped out for excretion. An enthusiastic anatomy and physiology professor once remarked that given the many vital activities of the liver, we should express our feelings for others by saying, “I love you with all my liver” instead of “with all my heart.” Granted, this declaration lacks romance, but it makes a valid point. Here are just some of the many jobs performed by the liver. To renew your appreciation for this remarkable organ, review Figure 3-12 (p. 82).

#### Carbohydrates
- Converts fructose and galactose to glucose
- Makes and stores glycogen
- Breaks down glycogen and releases glucose
- Breaks down glucose for energy when needed
- Makes glucose from some amino acids and glycerol when needed
- Converts excess glucose to fatty acids

#### Lipids
- Builds and breaks down triglycerides, phospholipids, and cholesterol as needed
- Breaks down fatty acids for energy when needed
- Packages extra lipids in lipoproteins for transport to other body organs
- Manufactures bile to send to the gallbladder for use in fat digestion
- Makes ketone bodies when necessary

#### Proteins
- Manufactures nonessential amino acids that are in short supply
- Removes from circulation amino acids that are present in excess of need and converts them to other amino acids or deaminates them and converts them to glucose or fatty acids
- Removes ammonia from the blood and converts it to urea to be sent to the kidneys for excretion
- Makes other nitrogen-containing compounds the body needs (such as bases used in DNA and RNA)
- Makes many proteins

#### Other
- Detoxifies alcohol, other drugs, and poisons; prepares waste products for excretion
- Helps dismantle old red blood cells and captures the iron for recycling
- Stores most vitamins and many minerals
- Activates vitamin D
Chemical Reactions in the Body

**ANABOLIC REACTIONS**

- **Glycogen**: Uses energy
  - Glucose + Glucose

- **Triglycerides**: Uses energy
  - Glycerol + Fatty acids

- **Protein**: Uses energy
  - Amino acids + Amino acids

Anabolic reactions include the making of glycogen, triglycerides, and protein; these reactions require differing amounts of energy.

**CATABOLIC REACTIONS**

- **Glycogen**: Yields energy
  - Glucose

- **Triglycerides**: Yields energy
  - Glycerol + Fatty acids

- **Protein**: Yields energy
  - Amino acids

Catabolic reactions include the breakdown of glycogen, triglycerides, and protein; the further catabolism of glucose, glycerol, fatty acids, and amino acids releases differing amounts of energy. Much of the energy released is captured in the bonds of adenosine triphosphate (ATP).

NOTE: You need not memorize a color code to understand the figures in this chapter, but you may find it helpful to know that blue is used for carbohydrates, yellow for fats, and red for proteins.
Energy released during catabolism is often captured by ATP - a high energy compound.
Capture and Release of Energy by ATP

Energy is released when a high-energy phosphate bond in ATP is broken. Just as a battery can be used to provide energy for a variety of uses, the energy from ATP can be used to do most of the body’s work—contract muscles, transport compounds, make new molecules, and more. With the loss of a phosphate group, high-energy ATP (charged battery) becomes low-energy ADP (used battery).

Energy is required when a phosphate group is attached to ADP, making ATP. Just as a used battery needs energy from an electrical outlet to get recharged, ADP (used battery) needs energy from the breakdown of carbohydrate, fat, and protein to make ATP (recharged battery).
Chemical Reactions in the Body

• Enzymes
  – Facilitators of metabolic reactions

• Coenzymes
  – Organic
  – Associate with enzymes
  – Without coenzyme, an enzyme cannot function
Breaking Down Nutrients for Energy

• Digestion
  – Carbohydrates – glucose (& other monosaccharides)
  – Fats (triglycerides) – glycerol and fatty acids
  – Proteins – amino acids

• Molecules of glucose, glycerol, amino acids, and fatty acids
  – Catabolism
    • Carbon, nitrogen, oxygen, hydrogen
Breaking Down Nutrients for Energy

Glucose

Fatty Acid

Amino Acid
Breaking Down Nutrients for Energy

1. All of the energy-yielding nutrients—protein, carbohydrate, and fat—can be broken down to acetyl CoA.
2. Acetyl CoA can enter the TCA cycle.
3. Most of the reactions above release hydrogen atoms with their electrons, which are carried by coenzymes to the electron transport chain.
4. ATP is synthesized.
5. Hydrogen atoms react with oxygen to produce water.
Breaking Down Nutrients for Energy

- Two new compounds
  - Pyruvate
    - 3-carbon structure
    - Can be used to make glucose
  - Acetyl CoA
    - 2-carbon structure
    - Cannot be used to make glucose

- TCA cycle and electron transport chain
Breaking Down Nutrients for Energy

• Amino acids and glycerol can be converted to pyruvate and therefore glucose
  – Needed for CNS and red blood cells
  – Without glucose, body will break down lean tissue
  – Adequate carbohydrate prevents this

• Fatty acids are converted to Actyl CoA
  – Cannot be used to make glucose
Breaking Down Nutrients for Energy--Glucose

- Glycolysis (glucose splitting) is the first step for glucose on its pathway to yielding energy.
- Glucose is converted to pyruvate
- Glycolysis occurs in the cytoplasm of the cell
A little ATP is used to start glycolysis.

Galactose and fructose enter glycolysis at different places, but all continue on the same pathway.

In a series of reactions, the 6-carbon glucose is converted to other 6-carbon compounds, which eventually split into two interchangeable 3-carbon compounds.

A little ATP is produced, and coenzymes carry the hydrogens and their electrons to the electron transport chain.

The 3-carbon compounds go through a series of conversions, producing another 3-carbon compound, each slightly different.

Eventually, the 3-carbon compounds are converted to pyruvate. Glycolysis of one molecule of glucose produces two molecules of pyruvate.

NOTE: These arrows point down indicating the breakdown of glucose to pyruvate during energy metabolism. (Alternatively, the arrows could point up indicating the making of glucose from pyruvate, but that is not the focus of this discussion.)
Glycolysis

Glucose

Energy released

2 Pyruvate

To be continued...
Breaking Down Nutrients for Energy – Glucose

• Pyruvate’s options
  – Quick energy needs –
    • Pyruvate is converted to lactate
    • Does not require oxygen-**anaerobic**
    • Sustained for just a few minutes
  – Slower energy needs –
    • Pyruvate-to-acetyl CoA
    • Oxygen requiring-**aerobic**
Glucose Retrieval via the Cori Cycle

• When less oxygen is available
  – pyruvate is converted to lactic acid.

• Occurs during high-intensity exercise
  – exceeds the body’s ability to delivery oxygen to the muscles and clear the CO$_2$.

• Lactic acid accumulates in muscles
  – may experience burning pain and fatigue.

• Lactic acid travels to the liver
  – the liver converts it back to glucose --This is called the Cori cycle
Breaking Down Nutrients for Energy – Glucose

Working muscles break down most of their glucose molecules anaerobically to pyruvate. If the cells lack sufficient mitochondria or in the absence of sufficient oxygen, pyruvate can accept the hydrogens from glucose breakdown and become lactate. This conversion frees the coenzymes so that glycolysis can continue.

NOTE: Other figures in this chapter focus narrowly on the carbons of pyruvate. Its oxygen group is included in this figure to more clearly illustrate this reaction. See definitions for the chemical structures of pyruvate and lactate.

Liver enzymes can convert lactate to glucose, but this reaction requires energy. The process of converting lactate from the muscles to glucose in the liver that can be returned to the muscles is known as the Cori cycle.
Pyruvate-To-Acetyl CoA

- If the cell needs energy, and oxygen is available
  - pyruvate enters the mitochondria,
  - where a carbon group is removed and the remaining compound combines with Coenzyme A
  - produce 2 acetyl CoA.
- This is an aerobic reaction (oxygen requiring)

http://nutrition.jbpub.com/animations/animations.cfm?id=17&debug=0
The Paths of Pyruvate and Acetyl CoA

NOTE: Amino acids that can be used to make glucose are called glucogenic; amino acids that are converted to acetyl CoA are called ketogenic.

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Fats to Energy

- **Triglyceride**
  - breaks down to glycerol and fatty acids.

- **Glycerol**
  - can either be converted to pyruvate and go down the pathway
  - it can go up the pathway and be converted to glucose.

- **Fatty acids are broken into 2-carbon units which combine with CoA to make acetyl CoA.**

- **Fatty Acids cannot be used to make glucose**
Glycerol enters the glycolysis pathway about midway between glucose and pyruvate. Fatty acids are broken down into 2-carbon fragments that combine with CoA to form acetyl CoA (shown in Figure 7-11).

**IN SUMMARY**  A 16-carbon fatty acid yields 8 acetyl CoA.
Amino Acids

• Most amino acids can be converted to glucose
  – Amino acids must be deaminated first (remove the nitrogen amino group).
  – Most can be converted to pyruvate (used for CNS, RBCs)
  – Some amino acids can be converted to acetyl CoA
    • they can be used for energy or converted to fatty acids and stored as triglyceride.
  – Some enter the TCA cycle directly
Amino acids

Most amino acids can be used to synthesize glucose; they are glucogenic.

Some amino acids are converted directly to acetyl CoA; they are ketogenic.

Some amino acids can enter the TCA cycle directly; they are glucogenic.

NOTE: Deamination and the synthesis of urea are discussed and illustrated in Chapter 6, Figure 6-13 (p. 186). The arrows from pyruvate and the TCA cycle to amino acids are possible only for nonessential amino acids; remember, the body cannot make essential amino acids.
Amino Acids-to-Energy Pathway
Final Steps of Catabolism

• TCA Cycle
  – Inner compartment of mitochondria
  – Circular path
    • Acetyl CoA
    • Oxaloacetate – made primarily from pyruvate
  – Carbon dioxide release
  – Hydrogen atoms and their electrons
    • Niacin and riboflavin
Final Steps of Catabolism

NOTE: Knowing that glucose produces pyruvate during glycolysis and that oxaloacetate must be available to start the TCA cycle, you can understand why the complete oxidation of fat requires carbohydrate.
Electron Transport Chain

Coenzymes carry hydrogens with high-energy electrons → Hydrogens with lower-energy electrons → Hydrogens with still lower-energy electrons → Hydrogens with very low-energy electrons

Energy released → Energy released → Energy released → Energy released

Energy captured in ATP → Energy captured in ATP → Energy captured in ATP → Energy captured in ATP

Electron transport chain carrier → Electron transport chain carrier → Electron transport chain carrier → Electron transport chain carrier

Oxygen → Water
Final Steps of Catabolism

A mitochondrion

Outer compartment

Inner membrane

Inner compartment

Electron Transport Chain

Passing electrons from carrier to carrier along the chain releases enough energy to pump hydrogen ions across the membrane.

ATP Synthesis

Hydrogen ions flow “downhill”—from an area of high concentration to an area of low concentration—through a special protein complex that powers the synthesis of ATP.

Coenzymes deliver hydrogens and high-energy electrons to the electron transport chain from the TCA cycle, glycolysis, and fatty acid oxidation.

Oxygen accepts the electrons and combines with hydrogens to form water.

\[
\text{ADP} + \text{P} \rightarrow \text{ATP}
\]
Central Pathways of Energy Metabolism
Energy Balance – Feasting

• Metabolism favors fat formation
  – Regardless of excess from protein, fat, or carbohydrates
    • Dietary fat to body fat is most direct and efficient conversion
    • Carbohydrate and protein have other roles to fulfill before conversion to body fat
  – Fuel mix
Feasting

A When a person overeats (feasting): When a person eats in excess of energy needs, the body stores a small amount of glycogen and much larger quantities of fat.

Food component: Carbohydrate
- Is broken down in the body to: Glucose
  - And then used for: Liver and muscle glycogen stores, Body fat stores, Loss of nitrogen in urine (urea), Body proteins

Food component: Fat
- Is broken down in the body to: Fatty acids

Food component: Protein
- Is broken down in the body to: Amino acids

^Alcohol is not included because it is a toxin and not a nutrient, but it does contribute energy to the body. After detoxifying the alcohol, the body uses the remaining two carbon fragments to build fatty acids and stores them as fat.
Fasting

B When a person draws on stores (fasting): When nutrients from a meal are no longer available to provide energy (about 2 to 3 hours after a meal), the body draws on its glycogen and fat stores for energy.

Storage component:
- Liver and muscle glycogen stores
- Body fat stores

Is broken down in the body to:
- Glucose
- Fatty acids

And then used for:
- Energy for the brain, nervous system, and red blood cells
- Energy for other cells

*The muscles’ stored glycogen provides glucose only for the muscle in which the glycogen is stored.*
Extended Fasting

C If the fast continues beyond glycogen depletion: As glycogen stores dwindle (after about 24 hours of starvation), the body begins to break down its protein (muscle and lean tissue) to amino acids to synthesize glucose needed for brain and nervous system energy. In addition, the liver converts fats to ketone bodies, which serve as an alternative energy source for the brain, thus slowing the breakdown of body protein.
Fasting

- Carbohydrate, fat and protein all used
- Glucose is needed for the brain
  - Brain and nerve cells use 1/2 of total glucose used each day
- Protein breakdown meets glucose needs
- Body shifts to using ketone bodies (ketosis)
  - After about 10 days
  - Can provide fuel for brain, RBC, nervous system
- Appetite suppression
- Metabolism slows
- Starvation
## Energy Balance – Transition from Feasting to Fasting

### A. When a person overeats (feasting): When a person eats in excess of energy needs, the body stores a small amount of glycogen and much larger quantities of fat.

<table>
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<th>Is broken down in the body to</th>
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<td>Liver and muscle glycogen stores</td>
</tr>
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<td>Fatty acids</td>
<td>Body fat stores</td>
</tr>
<tr>
<td>Protein</td>
<td>Amino acids</td>
<td>Loss of nitrogen in urine (urea)</td>
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<td></td>
<td></td>
<td>Body proteins</td>
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### B. When a person draws on stores (fasting): When nutrients from a meal are no longer available to provide energy (about 2 to 3 hours after a meal), the body draws on its glycogen and fat stores for energy.

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<td>Energy for the brain, nervous system, and red blood cells</td>
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<tr>
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<td>Fatty acids</td>
<td>Energy for other cells</td>
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### C. If the fast continues beyond glycogen depletion: As glycogen stores dwindle (after about 24 hours of starvation), the body begins to break down its protein (muscle and lean tissue) to amino acids to synthesize glucose needed for brain and nervous system energy. In addition, the liver converts fats to ketone bodies, which serve as an alternative energy source for the brain, thus slowing the breakdown of body protein.

<table>
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<th>Body component</th>
<th>Is broken down in the body to</th>
<th>And then used for:</th>
</tr>
</thead>
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<tr>
<td>Body protein</td>
<td>Amino acids</td>
<td>Energy for the brain, nervous system, and red blood cells</td>
</tr>
<tr>
<td>Body fat</td>
<td>Fatty acids</td>
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</tr>
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*Alcohol is not included because it is a toxin and not a nutrient, but it does contribute energy to the body. After detoxifying the alcohol, the body uses the remaining two carbon fragments to build fatty acids and stores them as fat.*

*The muscles’ stored glycogen provides glucose only for the muscle in which the glycogen is stored.*
Energy Balance

• Fasting—Inadequate Energy
  – Symptoms of Starvation
    • Muscle wasting
    • Decreased heart rate, respiratory rate, metabolic rate, and body temperature
    • Impaired vision
    • Organ failure
    • Decreased immunity
    • Depression, anxiety, and food-related dreams
Low-Carbohydrate Diets

• Metabolism similar to fasting
  – Uses glycogen stores first
  – Gluconeogenesis when glycogen is depleted
    • Body tissues used somewhat even when protein provided in diet

• Urine monitoring

• Ketosis
Alcohol and Nutrition

Highlight 7
Short Term Effects

- 20% of all boating fatalities
- 25% of all emergency-room admissions
- 23% of all suicides
- 47% of all homicides
- 65% of all domestic violence incidents
- 39% of all traffic fatalities
- 40% of all residential fire victim fatalities
Alcohol in Beverages

• Beer, wine and distilled liquor (hard liquor)
• Alcohol behaves like a drug, therefore altering body functions.
• Moderation of drinks
  – 5 ounces of wine
  – 10 ounces of wine cooler
  – 12 ounces of beer
  – 1 ½ ounces distilled liquor (80 proof)
12 oz beer
10 oz wine cooler
5 oz wine
1½ oz liquor (80 proof whiskey, gin, brandy, rum, vodka)
Alcohol in the Body

• Alcohol’s special privileges
  – No digestion
  – Quick absorption

• Stomach
  – Alcohol dehydrogenase (women produce less)
  – Food slows absorption

• Small intestine
  – Priority over nutrients
Alcohol Arrives in the Liver

• Liver cells
  – First to receive alcohol-laden blood
• Alcohol dehydrogenase
• Disrupts liver activity
• Fatty acids accumulate
• Can permanently change liver cell structure
• Rate of alcohol metabolism
  – $\frac{1}{2}$ ounce per hour
Acetyl CoA molecules are blocked from getting into the TCA cycle by the high level of NADH. Instead of being used for energy, the acetyl CoA molecules become building blocks for fatty acids.
Alcohol Disrupts the Liver

- Development of a fatty liver is the first stage of liver deterioration.
- Fibrosis is the second stage.
- Cirrhosis is the most advanced stage of liver deterioration.
- Microsomal ethanol-oxidizing system (MEOS) metabolizes alcohol and drugs.
Metabolic Work of the Liver

**TABLE 7-1 Metabolic Work of the Liver**

The liver is the most active processing center in the body. When nutrients enter the body from the digestive tract, the liver receives them first; then it metabolizes, packages, stores, or ships them out for use by other organs. When alcohol, drugs, or poisons enter the body, they are also sent directly to the liver; here they are detoxified and their by-products shipped out for excretion. An enthusiastic anatomy and physiology professor once remarked that given the many vital activities of the liver, we should express our feelings for others by saying, “I love you with all my liver,” instead of “with all my heart.” Granted, this declaration lacks romance, but it makes a valid point. Here are just some of the many jobs performed by the liver. To renew your appreciation for this remarkable organ, review Figure 3-12 on p. 85.

**Carbohydrates:**
- Converts fructose and galactose to glucose
- Makes and stores glycogen
- Breaks down glycogen and releases glucose
- Breaks down glucose for energy when needed
- Makes glucose from some amino acids and glycerol when needed
- Converts excess glucose to fatty acids

**Lipids:**
- Builds and breaks down triglycerides, phospholipids, and cholesterol as needed
- Breaks down fatty acids for energy when needed
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**Proteins:**
- Manufactures nonessential amino acids that are in short supply
- Removes from circulation amino acids that are present in excess of need and converts them to other amino acids or deaminates them and converts them to glucose or fatty acids
- Removes ammonia from the blood and converts it to urea to be sent to the kidneys for excretion
- Makes other nitrogen-containing compounds the body needs (such as bases used in DNA and RNA)
- Makes plasma proteins such as clotting factors

**Other:**
- Detoxifies alcohol, other drugs, and poisons; prepares waste products for excretion
- Helps dismantle old red blood cells and captures the iron for recycling
- Stores most vitamins and many minerals
Alcohol Arrives in the Brain

- Alcohol acts as a narcotic, anesthetizes pain
- Alcohol suppresses antidiuretic hormone (ADH) resulting in the loss of body water.
Judgment and reasoning centers are most sensitive to alcohol. When alcohol flows to the brain, it first sedates the frontal lobe, the center of all conscious activity. As the alcohol molecules diffuse into the cells of these lobes, they interfere with reasoning and judgment.

Speech and vision centers in the midbrain are affected next. If the drinker drinks faster than the rate at which the liver can oxidize the alcohol, blood alcohol concentrations rise: the speech and vision centers of the brain become sedated.

Voluntary muscular control is then affected. At still higher concentrations, the cells in the cerebellum responsible for coordination of voluntary muscles are affected, including those used in speech, eye-hand coordination, and limb movements. At this point people under the influence stagger or weave when they try to walk, or they may slur their speech.

Respiration and heart action are the last to be affected. Finally, the conscious brain is completely subdued, and the person passes out. Now the person can drink no more; this is fortunate because higher doses would anesthetize the deepest brain centers that control breathing and heartbeat, causing death.
<table>
<thead>
<tr>
<th>Drinks</th>
<th>Body Weight in Pounds—Men</th>
<th>Drinks</th>
<th>Body Weight in Pounds—Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>120</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.04</td>
<td>.03</td>
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<tr>
<td></td>
<td>1</td>
<td></td>
<td>.08</td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td>.09</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>.15</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>.30</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>.34</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>.38</td>
<td>.31</td>
</tr>
</tbody>
</table>

NOTE: In some states, driving under the influence is proved when an adult's blood contains 0.08 percent alcohol, and in others, 0.10. Many states have adopted a “zero-tolerance” policy for drivers under age 21, using 0.02 percent as the limit.

*aTaken within an hour or so; each drink equivalent to ½ ounce pure ethanol.

SOURCE: National Clearinghouse for Alcohol and Drug Information

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**TABLE H7-2** Alcohol Blood Levels and Brain Responses

<table>
<thead>
<tr>
<th>Blood Alcohol Concentration</th>
<th>Effect on Brain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>Impaired judgment, relaxed inhibitions, altered mood, increased heart rate</td>
</tr>
<tr>
<td>0.10</td>
<td>Impaired coordination, delayed reaction time, exaggerated emotions, impaired peripheral vision, impaired ability to operate a vehicle</td>
</tr>
<tr>
<td>0.15</td>
<td>Slurred speech, blurred vision, staggered walk, seriously impaired coordination and judgment</td>
</tr>
<tr>
<td>0.20</td>
<td>Double vision, inability to walk</td>
</tr>
<tr>
<td>0.30</td>
<td>Uninhibited behavior, stupor, confusion, inability to comprehend</td>
</tr>
<tr>
<td>0.40 to 0.60</td>
<td>Unconsciousness, shock, coma, death (cardiac or respiratory failure)</td>
</tr>
</tbody>
</table>

NOTE: Blood alcohol concentration depends on a number of factors, including alcohol in the beverage, the rate of consumption, the person’s gender, and body weight. For example, a 100-pound female can become legally drunk (≥ 0.10 concentration) by drinking three beers in an hour, whereas a 220-pound male consuming that amount at the same rate would have a 0.05 blood alcohol concentration.
Alcohol and Malnutrition

• Heavy drinkers may have inadequate food intake.
• Impaired nutrient metabolism will result from chronic alcohol abuse.
• Vitamin $B_6$, folate, thiamin deficiencies
• Wernicke-Korsakoff syndrome is seen in chronic alcoholism.
Alcohol’s Effect on Vitamin Absorption

Food in digestive tract

Intestinal cells

Body tissue

Thiamin in food can’t be absorbed

Thiamin supplement (high concentration)

Alcohol

Some gets into body
Alcohol’s Long-Term Effects

- Abuse during pregnancy
- Third leading cause of preventable death
<table>
<thead>
<tr>
<th>Health Problem</th>
<th>Effects of Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthritis</td>
<td>Increases the risk of inflamed joints</td>
</tr>
<tr>
<td>Cancer</td>
<td>Increases the risk of cancer of the liver, pancreas, rectum, and breast; increases the risk of cancer of the lungs, mouth, pharynx, larynx, and esophagus, where alcohol interacts synergistically with tobacco</td>
</tr>
<tr>
<td>Fetal alcohol syndrome</td>
<td>Causes physical and behavioral abnormalities in the fetus (see Highlight 15)</td>
</tr>
<tr>
<td>Heart disease</td>
<td>In heavy drinkers, raises blood pressure, blood lipids, and the risk of stroke and heart disease; when compared with those who abstain, heart disease risk is generally lower in light-to-moderate drinkers (see Chapter 18)</td>
</tr>
<tr>
<td>Hyperglycemia</td>
<td>Raises blood glucose</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>Lowers blood glucose, especially in people with diabetes</td>
</tr>
<tr>
<td>Infertility</td>
<td>Increases the risks of menstrual disorders and spontaneous abortions (in women); suppresses luteinizing hormone (in women) and testosterone (in men)</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>Enlarges the kidneys, alters hormone functions, and increases the risk of kidney failure</td>
</tr>
<tr>
<td>Liver disease</td>
<td>Causes fatty liver, alcoholic hepatitis, and cirrhosis</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>Increases the risk of protein-energy malnutrition; low intakes of protein, calcium, iron, vitamin A, vitamin C, thiamin, vitamin B₆, and riboflavin; and impaired absorption of calcium, phosphorus, vitamin D, and zinc</td>
</tr>
<tr>
<td>Nervous disorders</td>
<td>Causes neuropathy and dementia; impairs balance and memory</td>
</tr>
<tr>
<td>Obesity</td>
<td>Increases energy intake, but is not a primary cause of obesity</td>
</tr>
<tr>
<td>Psychological disturbances</td>
<td>Causes depression, anxiety, and insomnia</td>
</tr>
</tbody>
</table>

NOTE: This list is by no means all-inclusive. Alcohol has direct toxic effects on all body systems.
<table>
<thead>
<tr>
<th>Myth</th>
<th>Truth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard liquors such as rum, vodka, and tequila are more harmful than wine and beer.</td>
<td>The damage caused by alcohol depends largely on the <em>amount</em> consumed. Compared with hard liquor, beer and wine have relatively low percentages of alcohol, but they are often consumed in larger quantities.</td>
</tr>
<tr>
<td>Consuming alcohol with raw seafood diminishes the likelihood of getting hepatitis.</td>
<td>People have eaten contaminated oysters while drinking alcoholic beverages and not gotten as sick as those who were not drinking. But do not be misled: hepatitis is too serious an illness for anyone to depend on alcohol for protection.</td>
</tr>
<tr>
<td>Alcohol stimulates the appetite.</td>
<td>For some people, alcohol may stimulate appetite, but it seems to have the opposite effect in heavy drinkers. Heavy drinkers tend to eat poorly and suffer malnutrition.</td>
</tr>
<tr>
<td>Drinking alcohol is healthy.</td>
<td>Moderate alcohol consumption is associated with a lower risk for heart disease. Higher intakes, however, raise the risks for high blood pressure, stroke, heart disease, some cancers, accidents, violence, suicide, birth defects, and deaths in general. Furthermore, excessive alcohol consumption damages the liver, pancreas, brain, and heart. No authority recommends that nondrinkers begin drinking alcoholic beverages to obtain health benefits.</td>
</tr>
<tr>
<td>Wine increases the body's absorption of minerals.</td>
<td>Wine may increase the body's absorption of potassium, calcium, phosphorus, magnesium, and zinc, but the alcohol in wine also promotes the body's excretion of these minerals, so no benefit is gained.</td>
</tr>
<tr>
<td>Beverage</td>
<td>Amount (oz)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Beer</td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>12</td>
</tr>
<tr>
<td>Light</td>
<td>12</td>
</tr>
<tr>
<td>Nonalcoholic</td>
<td>12</td>
</tr>
<tr>
<td>Cocktails</td>
<td></td>
</tr>
<tr>
<td>Daiquiri, canned</td>
<td>6.8</td>
</tr>
<tr>
<td>Daiquiri, from recipe</td>
<td>4.5</td>
</tr>
<tr>
<td>Piña colada, canned</td>
<td>6.8</td>
</tr>
<tr>
<td>Piña colada, from recipe</td>
<td>4.5</td>
</tr>
<tr>
<td>Tequila sunrise, canned</td>
<td>6.8</td>
</tr>
<tr>
<td>Whiskey sour, canned</td>
<td>6.8</td>
</tr>
<tr>
<td>Distilled liquor (gin, rum, vodka, whiskey)</td>
<td></td>
</tr>
<tr>
<td>80 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>86 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>90 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>94 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>100 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>Sake</td>
<td>1.5</td>
</tr>
<tr>
<td>Liquers</td>
<td></td>
</tr>
<tr>
<td>Coffee and cream liqueur, 34 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>Coffee liqueur, 53 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>Coffee liqueur, 63 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>Crème de menthe, 72 proof</td>
<td>1.5</td>
</tr>
<tr>
<td>Mixers</td>
<td></td>
</tr>
<tr>
<td>Club soda</td>
<td>12</td>
</tr>
<tr>
<td>Cola</td>
<td>12</td>
</tr>
<tr>
<td>Cranberry juice cocktail</td>
<td>4</td>
</tr>
<tr>
<td>Ginger ale or tonic water</td>
<td>12</td>
</tr>
<tr>
<td>Grapefruit juice</td>
<td>4</td>
</tr>
<tr>
<td>Orange juice</td>
<td>4</td>
</tr>
<tr>
<td>Tomato or vegetable juice</td>
<td>4</td>
</tr>
<tr>
<td>Wine</td>
<td></td>
</tr>
<tr>
<td>Champagne</td>
<td>5</td>
</tr>
<tr>
<td>Cooking</td>
<td>5</td>
</tr>
<tr>
<td>Dessert, dry</td>
<td>5</td>
</tr>
<tr>
<td>Dessert, sweet</td>
<td>5</td>
</tr>
<tr>
<td>Red or rosé</td>
<td>5</td>
</tr>
<tr>
<td>White</td>
<td>5</td>
</tr>
<tr>
<td>Wine cooler</td>
<td>10</td>
</tr>
</tbody>
</table>
Personal Strategies

• Serve and consume nonalcoholic beverages.
• Drink slowly and consume alcohol moderately.
• Do not drive.
End of Chapter 7

Metabolism