Teacher's Guide

Information about Alcohol

Figure 1. *Alcohol has been part of societies for thousands of years, as shown by this representation of the ancient Greek god of grape growing and wines, Bacchus.*

1 Introduction

Alcohol has been used for centuries in social, medical, cultural, and religious settings. Most Americans believe alcohol can be used responsibly by adults for social and religious purposes. However, alcohol can also be used to excess resulting in health, social, legal, and other problems. Students may receive conflicting messages about alcohol from the news media, school, their friends, and their parents. On the one hand, they hear that moderate alcohol use is acceptable, and in some instances may actually be good for your health; on the other hand, they are told that alcohol is a drug that requires abstinence until age 21. In addition, advertisements and media images often present alcohol as a means to success and an enjoyable life. These conflicting messages, combined with misunderstandings and misinformation, do not help students make responsible decisions about alcohol use.

Statistics indicate that many adolescents begin consuming alcohol at an early age. In 1997, 26 percent of eighth graders, 40 percent of 10th graders, and 51 percent of 12th graders reported consuming alcohol within the month prior to the survey.[43] In addition, 16 percent of eighth graders reported **binge drinking** within the two weeks leading up to the survey. The effects of adolescent drinking involve both health- and safety-related problems, including auto crashes, domestic violence, and suicide. Alcohol abuse among teenagers may also be related to behavioral problems linked to impulsiveness and sensation seeking.[55] Youth alcohol-use data indicate that the earlier an individual begins drinking, the greater his or her risk of developing alcohol-use problems in the future. Individuals who begin drinking before age 15 are four times more likely to develop alcohol dependence during their lifetimes than are those who begin drinking at age 21.[24, 25]

The earlier an individual begins drinking, the greater his or her risk of developing alcohol-related problems in the future.

Dr. Enoch Gordis, former Director of the National Institute on Alcohol Abuse and Alcoholism (NIAAA), has written, “Although alcohol is sometimes referred to as a ‘gateway drug’ for youth because its use often precedes the use of other illicit substances, this terminology is counterproductive; youth drinking requires significant attention, not because of what it leads to, but because of the extensive human and economic impact of alcohol use by this vulnerable population.”[43]

The purpose of this supplement is to present students with the opportunity to learn about the science underlying the effects of alcohol on human biology and behavior through a series of inquiry-based classroom lessons. Young people are natural scientists. They have a curiosity about the world around them and about themselves as individuals. Since they have little in the

way of life experiences, many young people tend to view themselves as nearly invincible. Consequently, when adults caution them against engaging in risky behaviors such as drinking alcohol, some don't listen. They feel that such warnings aren't for them and apply only to those less grown up than themselves.

The aim of this supplement is to give students the opportunity to construct their own understanding about alcohol and its attendant risks. In addition, the inquiry-based lessons are designed to help students hone their critical-thinking skills. With enhanced understanding and skills, they will be better prepared to make informed decisions about real-life situations involving alcohol use.

2 Alcohol Use, Abuse, and Alcoholism: Definitions

Any alcohol use by underage youth is considered to be alcohol abuse.

In any discussion of alcohol use, it is crucial to begin with a clear understanding of terms. For the purposes of this module, we define alcohol use by adults as the consumption of alcohol for social or religious purposes without demonstrating the characteristics of alcohol abuse or alcoholism (see Tables 1 and 2). **Alcohol abuse** is defined as the continued use of alcohol despite the development of social, legal, or health problems. It is important to note that any alcohol use by underage youth is considered to be alcohol abuse.

Table 1. Characteristics of Alcohol Abuse[55]

failing to fulfill major work, school, or home responsibilities
drinking in situations that are potentially dangerous, such as driving a car or operating heavy machinery
experiencing repeated alcohol-related legal problems, such as being arrested for driving while intoxicated
exhibiting continued drinking despite having relationship problems that are caused or made worse by drinking

Table 2. Characteristics of Alcoholism[55]

craving (a strong need or compulsion to drink)
impaired control over drinking
use and abuse of alcohol despite adverse consequences
failure to acknowledge the problem
tolerance or need for increasing amounts of alcohol to feel intoxicated
physical dependence or the occurrence of withdrawal symptoms when alcohol use is discontinued

In contrast, **alcoholism,** also known as alcohol dependence syndrome or alcohol addiction, is a **chronic** disease involving a strong need to drink, the inability to stop drinking, the occurrence of withdrawal symptoms, and tolerance (see Table 2). Alcoholism is often progressive.

Alcohol abuse is not equivalent to alcoholism. A person who abuses alcohol may drink excessive amounts but does not experience an alcoholic individual's intense cravings or severe **withdrawal symptoms** (**physical dependence**) when drinking stops. Susceptibility factors that contribute to alcoholism are genetic, environmental, and **psychosocial**. Thus, while not all people who abuse alcohol become alcoholics, those with genetic susceptibility factors who place themselves in environments that encourage drinking put themselves at risk for developing alcoholism.

The definitions of alcohol abuse and alcoholism described above do not directly apply to youth drinking. As previously noted, any alcohol drinking by underage youth is considered to be alcohol abuse. Youth who abuse alcohol typically do so by drinking often,[43] or engaging in binge drinking, which is commonly defined as drinking five or more drinks in a row. Such drinking patterns put youth at increased risk for developing alcoholism later in life. Research suggests that separate criteria may be needed to distinguish between alcohol abuse and alcoholism in youth as compared with adults.[34, 43] Table 3 lists some of the risk factors associated with youth drinking.

Table 3. Risk Factors for Youth Drinking[55]

genetic factors (based on animal and human twin studies)
childhood behaviors such as impulsiveness, aggressiveness, and antisocial behavior
psychiatric disorders such as attention deficit hyperactivity disorder and depression
family environments with favorable attitudes about drinking and lack of support
acceptance of drinking by peers
child abuse and trauma

3 Misconceptions about Alcohol Use, Abuse, and Alcoholism

Generally, textbooks for middle school students present little, if any, scientific information on how alcohol affects cell function and animal behavior. If the subject is covered at all, it is likely done in a health class, or possibly in a driver's education class. Much of what students know, or think they know, comes through family, peers, the media, and personal experimentation. Very often this information is characterized by errors, half-truths, and folk wisdom. Students need to understand the changes that occur in their minds and bodies when they drink alcohol. They also need to understand that if they choose to drink, there can be both short-term (**acute**) and long-term (**chronic**) consequences, even with moderate levels of drinking. The materials contained in this curriculum supplement, *Understanding Alcohol: Investigations into Biology and Behavior*, should at least help correct the following misconceptions.

Even moderate levels of alcohol use can lead to both short-term and long-term consequences.

Misconception 1: Alcohol is a stimulant.
Alcohol has been falsely thought of as a stimulant because its initial effects on some people include feelings of **euphoria** and lowered **inhibitions**. Alcohol is classified correctly as a **depressant** because it later causes sedation and drowsiness.[30] In high concentrations, alcohol can induce unconsciousness, coma, and even death.

Misconception 2: Alcohol abuse and alcoholism are problems only for the individual drinker.
Alcohol abuse and alcoholism are social problems that touch many more lives than that of the individual drinker. Alcohol abuse is a contributing factor to many other social problems including auto crashes, domestic violence, and child abuse or neglect. In addition to the personal costs, alcoholism also has a severe economic impact on the country due to lost productivity, healthcare treatment, and costs attendant to administering the criminal justice system.

Misconception 3: People with alcoholism are morally weak individuals lacking will power.
Alcoholism involves more than just drinking too much. It is known to be a complex disease that involves a variety of factors including genetic, environmental, social, and behavioral components. The physical dependence of alcoholics on drinking defines alcoholism as a disease that must be diagnosed, and as separate from alcohol abuse (see ***2 Alcohol Use, Abuse and Alcoholism: Definitions***). In alcoholic individuals, the brain is affected by alcohol and promotes its continued use through both positive and negative reinforcements. Most notably, the severe physical withdrawal symptoms that result from stopping drinking serve as a strong biological force that can maintain drinking behavior.

Alcoholism is a complex disease that involves a variety of factors including genetic, environmental, social, and behavioral components.

Misconception 4: Children cannot be alcoholics.
Alcohol is the most used and abused drug among young people. A recent national poll reports that one in four eighth graders drank alcohol in the past month, and 18 percent of eighth graders got drunk at least once in the past year.[46] Research using animal models suggests that the developing brain of the adolescent responds differently to alcohol than does the adult brain.[31, 59] Children who abuse alcohol may develop alcoholism, though the criteria for making the diagnosis may be different from those used to diagnose adults.[34]

Misconception 5: Small amounts of alcohol won't impair bodily or mental functions.
Half of the states in the United States have set the legal limit for **blood alcohol concentration (BAC)** at 0.08 percent for motor vehicle operation. (BAC is usually expressed without "percent.") This does not mean, however, that an individual is unimpaired at lower BACs. A BAC of 0.02–0.04 can impair memory and judgment.[51] The effects of alcohol on an individual vary depending on the person's weight, nutritional state, gender, exposure to other drugs, and other factors. Any amount of alcohol taken during pregnancy is considered risky.

Misconception 6: Alcohol's effects are only temporary.
The adult body can process approximately one drink per

hour. A drink, according to the National Institute on Alcohol Abuse and Alcoholism (NIAAA), is one 12-ounce bottle of wine cooler or beer, one 5-ounce glass of wine, or 1.5 ounces of 80-proof distilled liquor.[42] A significant portion of the societal costs of alcohol use (for example, falls, automobile crashes, and violence) is due to acute effects. Alcohol users and abusers, as well as alcoholics, can suffer injuries related to the acute effects of alcohol. Although the acute effects of alcohol last only a short time, chronic long-term effects can develop and persist. Adolescents and adults who drink excessive amounts of alcohol may be causing chronic alterations to their brains. A recent study provides evidence that heavy drinking among teenagers can impair brain function.[7] It is not yet known if these effects are reversible.

Figure 2. *A drink can be one 12-ounce beer, one 5-ounce glass of wine, or 1.5 ounces of 80-proof distilled liquor.*

Misconception 7: Alcohol is good for your health.

Recent reports have indicated that moderate drinking (defined as one drink per day for women and two drinks per day for men) may lessen the risk for cardiovascular disease.[44] These observations, however, do not give carte blanche for drinking alcohol. In considering such findings, it is important to weigh the benefits versus the risks. Although moderate drinking is associated with decreased risk for heart disease, it is also associated with increased risk of accidents. Drinking five or more drinks per day leads to increased risks for stroke and cancer. In addition, pregnant women, people using certain medications, and those diagnosed with alcoholism or other medical problems should refrain from drinking entirely.

Figure 3. *Behavioral therapy helps patients deal with relapse and motivates them to continue with their efforts to remain sober.*

Misconception 8: Alcoholism can be cured by behavioral programs such as Alcoholics Anonymous.

Alcoholism, at present, has no known cure. However, as with other chronic diseases, such as diabetes or heart disease, alcoholism can be controlled effectively using behavioral therapies, with or without pharmacological therapies. For such treatments to be effective, however, the patient must be willing to make significant and permanent lifestyle changes. People being treated for alcoholism often experience one or more episodes of **relapse.** An important aspect of behavioral therapy is to help patients deal with such relapses and motivate them to continue their efforts to remain sober.

Misconception 9: The public knows enough about the effects of alcohol use; further research is not necessary.

It is true that we do know many of the behavioral effects of alcohol consumption, such as memory and **motor function** impairment. Nonetheless, we do not know how alcohol creates its addictive actions. Research continues to provide insight into how alcohol acts on all cells of the body and affects their functions. New scientific approaches help scientists understand more about the biological and behavioral effects of alcohol. One approach uses knockout mice (mice with a specific **gene** deleted) to identify genes that **predispose** a person to alcoholism. New imaging techniques enable scientists to see alcohol's effects in the living

brain. In addition, various sociological studies are helping us better understand the social effects of alcohol consumption. The results of these studies, "from cell to society," yield essential knowledge that is a prerequisite for more-effective ways to prevent and treat this disease.

4 Animals as Research Models

Much of the research into the effects of alcohol on humans uses animals. Scientists use animals when the use of humans is either impractical or unethical. For example, when scientists investigate fetal alcohol syndrome, they cannot give alcohol to pregnant women but they can give alcohol to pregnant animals.

Scientific research with animals has contributed to many important advances in scientific and medical knowledge. When using animal models, scientists first must choose an animal appropriate to their research. Scientists studying genetics often use fruit flies (*Drosophila melanogaster*) because they have a short generation time. However, fruit flies are not a good model to use when investigating aspects of mammalian physiology. In such cases, a mouse or rat is preferred.

Figure 4. *Mice are a useful model for studying the effects of alcohol.*

Animal models do have their drawbacks. Some animals are difficult or expensive to maintain. Consequently, many scientists try to develop nonanimal models using cell cultures or computer simulations. Unfortunately, such models usually fail to duplicate the complexity of the animal or human body. Medical and scientific research will continue to depend on animal models for the foreseeable future (see The Use of Animals in Scientific Research below).

The Use of Animals in Scientific Research

Scientists who use animals as research subjects must abide by federal policies. Public Health Service policy dictates specific requirements for animal care and use in research. This policy conforms to the Health Research Extension Act of 1985 (Public Law 99-158) and applies to all research, research training, biological testing, and other activities that involve animals. The principles for using and caring for vertebrate animals in research and testing include

- The transportation, care, and use of animals should be in accordance with the Animal Welfare Act and other applicable federal laws, guidelines, and policies.
- Procedures involving animals should be designed with consideration of their relevance to human or animal health, the advancement of knowledge, or the good of society.
- The animals selected should be of an appropriate species and quality and the minimum number required to obtain valid results. Methods such as mathematical models, computer simulations, and in vitro biological systems should be considered.
- Procedures should minimize discomfort, distress, and pain to the animals.

- Procedures that may cause more than momentary or slight pain should be performed with appropriate sedation, analgesia, or anesthesia.
- Animals that would suffer severe or chronic pain or distress that cannot be relieved should be painlessly killed.
- The living conditions of animals should be appropriate for the species. The housing, feeding, and care of animals must be directed by a veterinarian or a trained, experienced scientist.
- Investigators who work with animals must be appropriately qualified and trained for conducting procedures on living animals.
- Exceptions to any of these principles must be reviewed and approved by an appropriate committee prior to the procedure.
- An Institutional Animal Care and Use Committee (IACUC) oversees all animal use in each institution where animal research is conducted. The IACUC must give approval for the research plan and species to be used. IACUCs include scientists and nonscientists from outside the institution. Nonscientists are often representatives of humane organizations.

5 Alcohol: Pharmacokinetics

Alcohol is classified as a drug in the context of abuse.

Because of its legal status and prevalence in society, alcohol should be considered apart from other drugs. The term *drug* is not always easy to define. In a medical context, a **drug** may be defined as any substance used in the diagnosis, prevention, treatment, or cure of a disease. In an abuse context, a **drug** may be described as any substance that alters consciousness and may be habit forming. According to these definitions, alcohol is classified as a drug in the context of abuse.

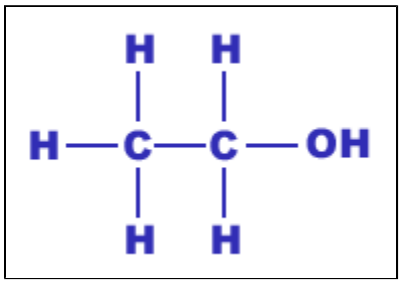

Figure 5. *Chemical structure of ethanol.*

The alcohol contained in alcoholic beverages is called **ethanol**. Ethanol is a small molecule having a 2-carbon (C) backbone with 5 attached hydrogens (H) and a hydroxyl (OH) group at one end. This terminal hydroxyl group is characteristic of an alcohol (Figure 5). Ethanol is formed by a natural conversion process called **fermentation** where yeast, a fungus, converts sugar into alcohol and carbon dioxide. The natural sugars found in fruit, berries, and malted grains are fermented to produce beer and wine. Liquors, however, are produced through the process of **distillation**.

5.1 Absorption and distribution of alcohol in the body

When an alcohol-containing drink is consumed, the alcohol is quickly absorbed in the blood by **diffusion** and is then transported to the tissues and throughout the water-containing portions of the body as part of the process of distribution. About 20 percent of the alcohol is absorbed through the stomach, and about 80 percent is absorbed through the upper portion of the small intestine.[6, 28]

5.2 Measurement of blood alcohol concentration (BAC)

The concentration of alcohol in the breath and urine mirrors the concentration of alcohol in the blood. This means that alcohol in breath can be detected, measured, and used to calculate a person's blood alcohol concentration (BAC).

Metabolism refers to the process by which the body breaks down food to extract energy from it. With respect to alcohol, metabolism refers to the transformation of ethanol to acetaldehyde and other products. The primary site of alcohol metabolism is the liver. Only a tiny fraction (less than 10 percent) of the alcohol consumed is not metabolized and is excreted from the body in breath, sweat, and urine.[6] This process of metabolism and excretion is known as elimination. The concentration of alcohol in breath and urine mirrors the concentration of alcohol in blood. This means that alcohol in breath can be detected, measured, and used to calculate a person's **blood alcohol concentration (BAC)**. The BAC calculation is the standard means of determining the extent of a person's alcohol impairment.

BAC, although expressed as a percentage when a unit of measure is shown, is actually a weight-per-volume measurement: grams of ethanol per 100 milliliters, or deciliter, of blood. The calculation of an individual's BAC depends partially on the total amount of water in the body. For example, males average 58 percent of their total body weight as water, while females average 49 percent.[38] Other factors important to calculating BAC are the amount of alcohol consumed and the burnoff, or rate at which the alcohol is metabolized.

In a practical sense, the only factor influencing the BAC calculation likely to be known with great precision is the amount of alcohol consumed. The total body water and burnoff are themselves influenced by several factors. Total body water is a function not only of a person's gender, but also of his or her weight and body type. Alcohol metabolism (burnoff) also varies among people. Heavy drinkers, for example, can have elevated rates of alcohol metabolism due to higher-than-normal concentrations of alcohol-metabolizing enzymes. Higher levels of these enzymes increase the burnoff. The average metabolism for a moderate drinker results in a decline in BAC of about 0.017 per hour, while a heavy drinker may have a decrease of 0.020 per hour. The range of metabolism rate per hour is from above 0.040 to below 0.010.[38] For more detailed descriptions of BAC effects on the brain and body, see ***6.1 Alcohol and the brain*** and ***6.2 Alcohol and body systems***, as well as **Table 4**.

5.3 Factors affecting alcohol absorption and elimination

Humans vary widely in their ability to absorb and eliminate alcohol. This section describes some of the most important factors that influence how quickly alcohol is absorbed into the blood.

Food. Absorption of alcohol is faster when the stomach is empty; the empty stomach allows rapid passage of the alcohol into the small intestine, where absorption is most efficient. This means that the apparent sobering effect of eating prior to alcohol consumption is due to a delay in stomach emptying. A recent study showed that people who drank alcohol after a meal that included protein, fat, and carbohydrates absorbed alcohol nearly three times more slowly than when they drank alcohol on an empty stomach (see Figure 6). The rate of alcohol absorption depends not only on the presence or absence of food, but also on the type of food present. Foods with a higher fat content require more time to leave the stomach; consequently, eating fatty foods will allow alcohol absorption to take place over a longer time.

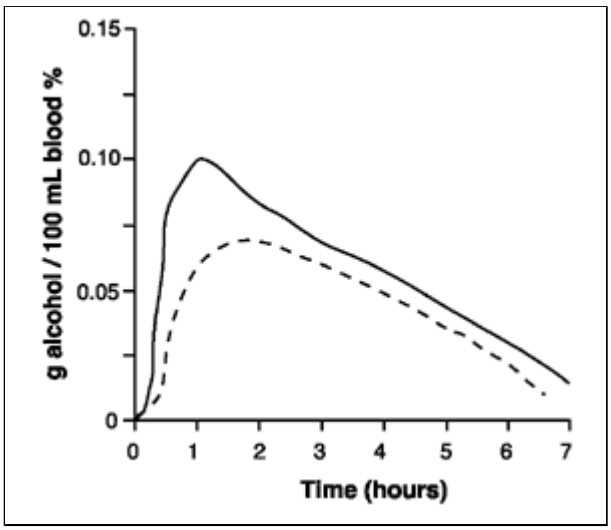

Figure 6. *The effect of food on blood alcohol concentration. The graph shows BAC after a person drank alcohol following an overnight fast (solid line) and immediately after breakfast (dotted line).*

Although alcohol's effects are delayed by the presence of food in the stomach, they are not prevented. Individuals may drink too much alcohol in a short time, believing that it isn't having an effect. Only after the delay in the absorption and elimination of the alcohol is the impact of their drinking felt, perhaps with disastrous consequences.

Body weight and build. Greater body weight provides a greater volume in which alcohol can be distributed. This means a larger person will be less affected by a given amount of alcohol than a smaller person would be. Alcohol is more **soluble** in water than in fat. This means that tissues rich in water, like muscle, take up more alcohol than do tissues rich in fat. A leaner person with a greater muscle mass (and less fat) provides a larger volume for alcohol to be distributed in compared with a person who weighs the same but has a higher percentage of body fat. In summary, if you compare two people of equal size but who differ in amount of body fat, the effects of alcohol will be different in them. The person with low body fat will be affected less than the person with a higher level of body fat.

Gender. Females, on average, have a smaller body mass and a higher proportion of body fat than do males. These characteristics mean that, on average, females have a lower proportion of total body water in which to distribute alcohol. Females also may have a lower activity of the alcohol-metabolizing enzyme **alcohol dehydrogenase (ADH)** in the stomach; therefore, more of the ingested alcohol reaches the blood. These factors mean that females generally exhibit higher BACs than do males after consuming the same amount of alcohol and are more vulnerable to alcohol's effects. Females are also more susceptible than males to alcoholic liver disease, heart muscle damage, and brain damage.[45]

Figure 7. *Alcohol's effects are influenced by gender, body weight, and body type.*

5.4 Alcohol metabolism

The primary place where alcohol is metabolized is the liver. Liver cells contain ADH, which converts alcohol to **acetaldehyde**. Other enzymes in turn convert the acetaldehyde to carbon dioxide and water, which are excreted from the body. If the rate of alcohol consumption exceeds the rate at which the alcohol can be metabolized, then the concentration of alcohol in the blood rises and the individual may become intoxicated.

The effects of absorption, distribution, and elimination combine to produce a characteristic blood alcohol curve (Figure 8). Immediately after a person drinks alcohol, the BAC rises sharply during the **absorption phase** to a maximum that depends on the amount consumed. Typically, the greatest alcohol concentration is reached 45–90 minutes after drinking. BAC then quickly declines due to diffusion of alcohol into the body tissues as part of the **distribution phase**. Finally, BAC falls more slowly during the **elimination phase**. Alcohol is removed from the body through the normal routes of excretion as part of this process. During periods of high BAC, about 5 percent of the alcohol is excreted in breath and another 5 percent in urine, with negligible amounts excreted in sweat and feces.

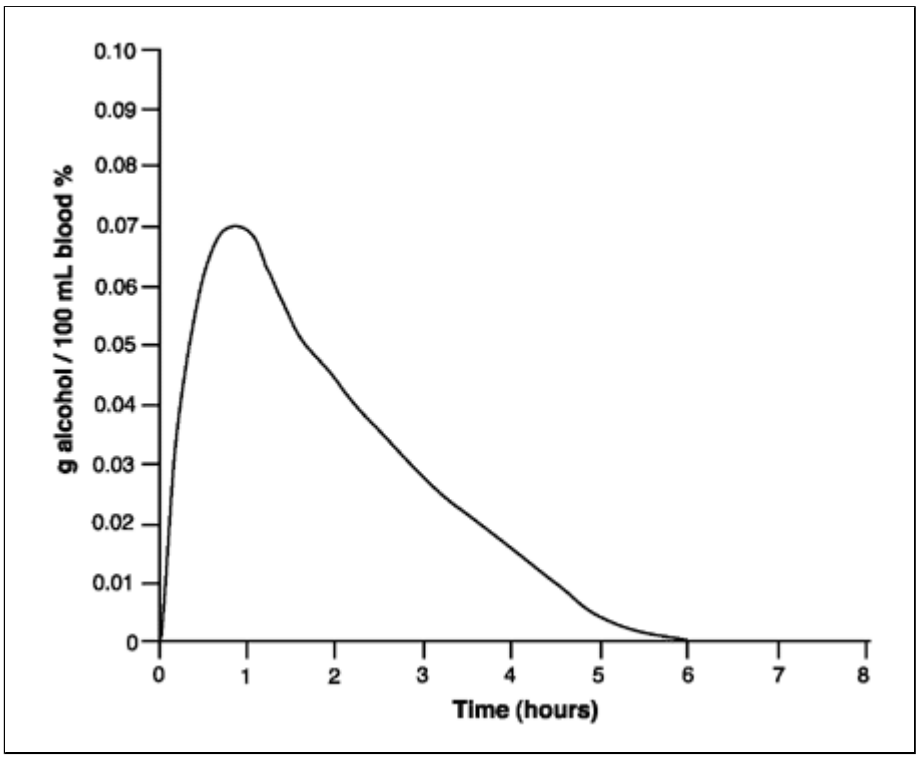

Figure 8. *Blood alcohol concentration over time.*

The shape of the blood alcohol curve is influenced by many factors including such variables as body size, gender, build, amount and type of beverage ingested, duration of drinking, fatigue, and the presence and type of food. These variables are also major determinants of the timing and peak of the blood alcohol curve.

6 Alcohol: Biological Effects

Upon consumption, alcohol is distributed throughout the water-containing portions of the body, affecting primarily those organs having a high water content. One of these is the liver, which is the organ that metabolizes alcohol. Another is the brain, the organ that is the seat of cognition and behavior.

6.1 Alcohol and the brain

The brain is composed of billions of nerve cells called **neurons.** A typical neuron has three important parts (Figure 9). The **cell body** is responsible for directing all of the neuron's activities. The **dendrites** are a cluster of small fibers that receive chemical messages from other neurons. The **axon** is a single, long fiber that transmits messages from the cell body to other neurons or other cells of the body, such as muscle cells.

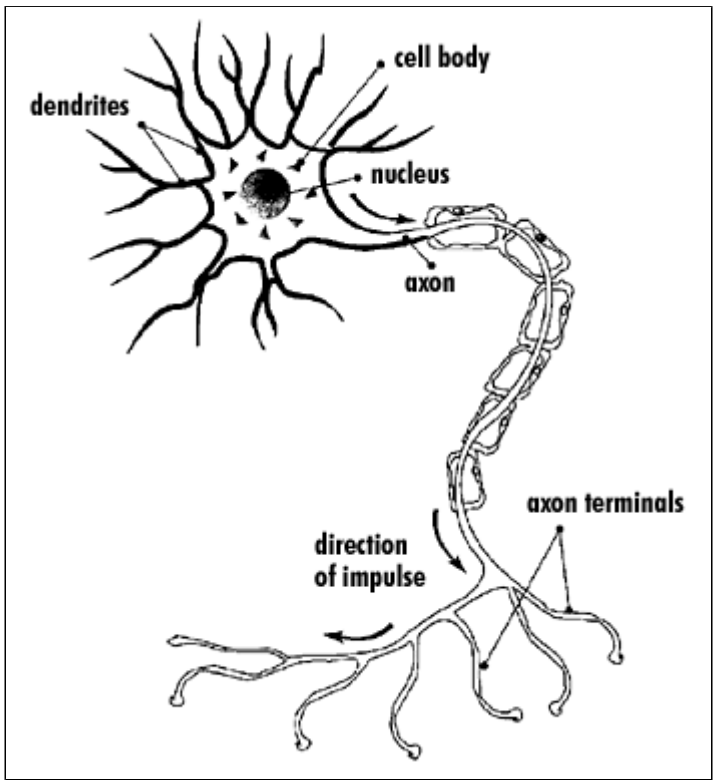

Figure 9. *A typical neuron.*

Although the axon of a neuron is extremely close to the dendrites of an adjoining neuron, they do not touch. The tiny amount of space between the neurons is called the **synapse**. The process by which neurons transmit messages to each other is known as **neurotransmission**. A message is an electrical impulse in the cell body that moves down the axon toward the synapse. At the synapse, it triggers the release of molecules called **neurotransmitters**, which diffuse across the synapse and bind to receptor molecules located in the cell membranes of the adjoining neuron's dendrites. The binding of the neurotransmitter either stimulates or inhibits the electrical impulse in the receiving neuron (see Figure 10).

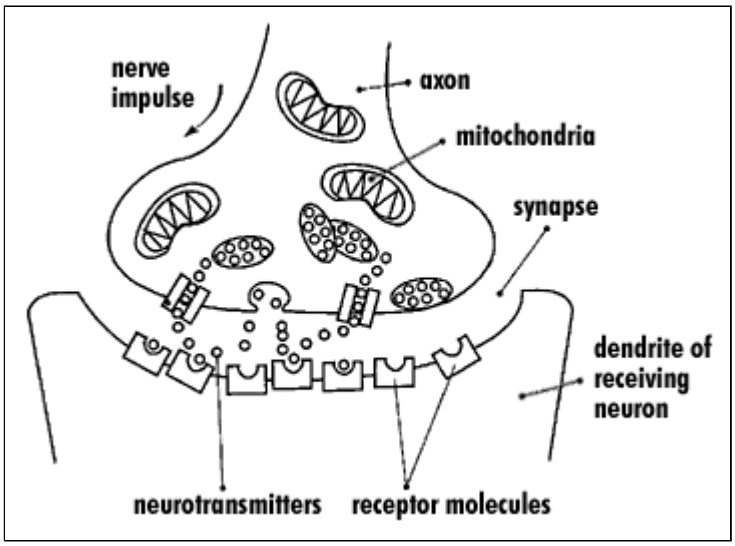

Figure 10. *Neurotransmission across a synapse.*

There are many types of neurotransmitters in the brain, each with a specific function. The binding of a neurotransmitter to its receptor is specific—that is, a neurotransmitter fits its own receptor much like a key fits only the appropriate lock. Once a neurotransmitter has passed on its message, it is either broken down by an enzyme or reabsorbed by the same neuron that released it.

For many years, scientists thought that alcohol altered the function of neurons in the brain by interacting with fat molecules in the cell membranes. More recently, it has become apparent that alcohol interacts with proteins found in the cell membranes, particularly those involved in neurotransmission. Like other drugs of **addiction**, alcohol acts via the brain's **reward pathway** in the **limbic system** (see "**Reward pathway or pleasure circuit**"). However, alcohol is unlike other drugs in that it interacts with multiple systems in the brain, sometimes stimulating and at other times inhibiting neurotransmission.

After drinking a sufficient amount of alcohol, many individuals experience a pleasurable state of mind. This pleasurable sensation leads some individuals to seek repeated exposure to alcohol. If drinking is excessive, it can lead to confusion, loss of coordination, sedation, coma, and even death. Long-term exposure to alcohol can lead to tolerance of its effects and eventually to physical dependence. The term "tolerance" refers to a decrease in brain sensitivity to alcohol following long-term exposure (see ***2 Alcohol Use, Abuse, and Alcoholism: Definitions***, and "**Tolerance**."). If alcohol-dependent individuals stop drinking, they experience withdrawal symptoms, which may include tremors, anxiety, sweating, **hallucinations**, and seizures. The site of action of all these effects is the brain.

The physiological and behavioral changes associated with intoxication reflect the effects of alcohol on various parts of the brain.

Intoxication. The physiological and behavioral changes associated with intoxication reflect the effects of alcohol on various parts of the brain. For example, the loss of coordination observed in intoxicated individuals may result from the effects of alcohol on a portion of the brain called the **cerebellum**, which functions in the control of movement (see Figure 11). Alcohol-induced memory lapses may result from impairment of the **hippocampus**, a part of the brain that helps store new memories. Drinking can be sufficiently excessive that death results from suppression of the **brainstem** activity that controls breathing and circulation.

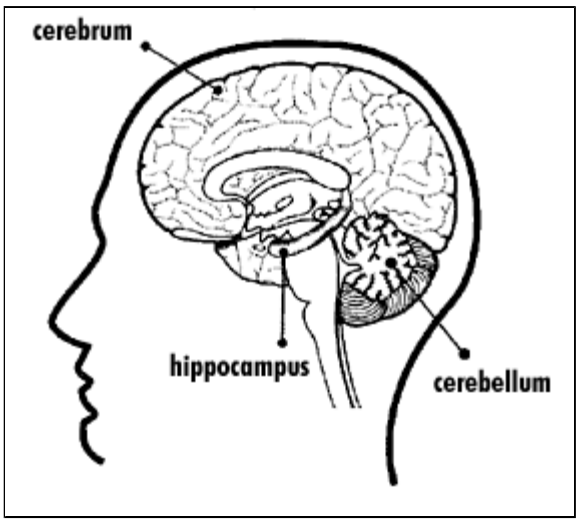

Figure 11. *Regions of the brain affected by alcohol.*

Reinforcement. The properties of alcohol that can cause continued drinking, such as its pleasurable and anxiety-reducing effects, are the very ones that contribute to chronic alcohol abuse and alcoholism. This is known as **reinforcement**. Scientists are currently exploring the brain chemistry involved in reinforcement. Research suggests that specific brain regions, such as the **hypothalamus** (which is involved in hunger, thirst, and emotions), as well as the amygdala, nucleus accumbens, and prefrontal cortex, play a role in reinforcement. Specific neurotransmitters are also implicated in alcohol's reinforcing effects.

Tolerance. **Tolerance** refers to the body's ability to adapt to chronic alcohol use. With continued use, the brain becomes less sensitive to alcohol. This means that higher BACs are needed to produce intoxication. Both alcohol abusers and alcoholics can display tolerance. BACs that can render nonabusers unconscious can leave abusers and alcoholics appearing nearly sober.

Chronic alcohol use leads to increased concentrations of the liver enzymes that metabolize alcohol. This allows the liver to break down alcohol more efficiently; therefore, the individual must consume more alcohol to reach a given BAC. There also is a behavioral component to tolerance. Subjected to chronic, excessive alcohol exposure, an individual learns to function under the influence of alcohol. For example, **functional tolerance** can reduce the impairment that would ordinarily accompany the performance of a task. Individuals may be able to drive home successfully after drinking because the route is familiar and nothing unexpected happens. However, if they encounter a detour or another car unexpectedly darts in front of them, they will be at the same risk for a crash as a driver with the same BAC who is unfamiliar with the route. The increased amounts of alcohol consumed by a person experiencing tolerance can severely damage the body's physiological systems despite their apparent normalcy.

Physical dependence and withdrawal. When alcohol use is stopped, withdrawal symptoms include severe alcohol cravings as well as physical and psychological problems. The biochemical changes associated with withdrawal lead to short-term

When alcoholic individuals stop drinking, they may experience severe alcohol cravings, short-term memory loss, disruption of cognitive and motor

memory loss, disruption of cognitive and motor function, reduced perceptual abilities, and emotional and personality changes.[3] Another consequence of withdrawal is delirium tremens (sometimes referred to as the DTs). **Delirium tremens** is characterized by severe agitation and hallucinations. The DTs can begin within a couple of days after alcohol consumption has stopped and can last for a week or more. The mechanisms behind tolerance and physical dependence involve relationships among nerve cell membranes, neurotransmitters and their receptors, and the reward pathway. All of these are areas of active research.

function, reduced perceptual abilities, and emotional and personality changes.

Reward pathway or pleasure circuit. The reward pathway is a powerful biological force. Strong motivations such as eating, drinking, and sex can activate neurons that produce and regulate feelings of pleasure. The reward pathway consists of a network of neurons found in the middle of the brain (see Figure 12). When activated by a positive experience, a group of neurons near the top of the brainstem (called the **ventral tegmental area**) releases the neurotransmitter **dopamine**. This message is relayed to a structure called the **nucleus accumbens** (part of the emotional limbic system) and to a related part of the **prefrontal cortex**, resulting in a pleasurable sensation.

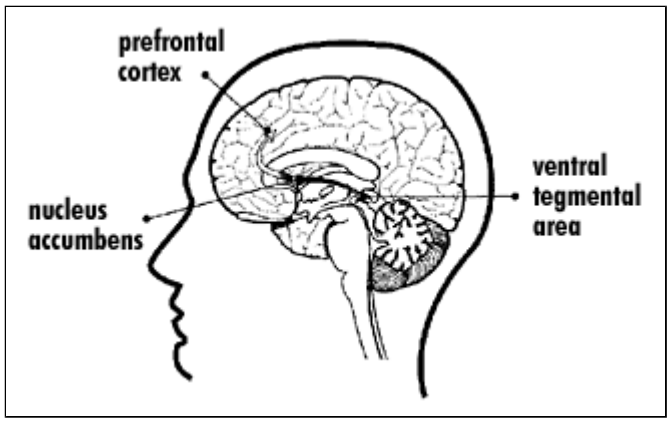

Figure 12. *The reward pathway.*

The reward pathway can also be activated by a negative experience. Animal studies have shown that concentrations in the brain of a neurotransmitter associated with stress rise sharply during withdrawal from alcohol. The animal is motivated to seek the reward (alcohol) to avoid the pain of withdrawal. A similar process propagates the human cycle of alcohol addiction: individuals are motivated to continue consuming alcohol to avoid the discomfort of withdrawal, even though this behavior maintains addiction.

6.2 Alcohol and body systems

Once consumed, alcohol enters the bloodstream and becomes distributed throughout the body. Although heavy drinking is most commonly associated with liver damage, it can also affect the digestive, cardiovascular, immune, and endocrine systems.

The liver. Excessive drinking can harm nearly every organ in the body; however, it is most commonly associated with liver damage. The liver is especially sensitive to the effects of alcohol because it receives blood directly from the intestines, the major site of

The liver is the primary site of alcohol metabolism, yet a number of the byproducts of this metabolism are toxic to the liver itself.

alcohol absorption. The liver is the primary site of alcohol metabolism, yet a number of the byproducts of this metabolism are toxic to the liver itself. Accumulation of these byproducts leads to alcohol-induced liver damage, which can take the form of either **inflammation** (**alcoholic hepatitis**) or liver scarring (**fibrosis** or **cirrhosis**). Often both types of damage exist within the same person. Alcohol abuse is the leading cause of liver-related deaths in the United States. It is estimated that over 2 million people suffer from some form of alcoholic liver disease.[17]

The mechanisms by which alcohol damages the liver are complex and incompletely understood. We do know that when liver cells metabolize alcohol, they use oxygen. Byproducts of this metabolism are highly reactive compounds called **free radicals**. Free radicals react with proteins, lipids, and DNA to cause cell damage or even cell death. Furthermore, drinking alcohol can cause the bacteria lining the gut to release **endotoxin** (a component of bacterial outer cell membranes). Endotoxin in turn activates certain liver cells to a higher metabolic state, which generates more free radicals and leads to cell damage.

The digestive system. Excessive drinking has been shown to cause chronic inflammation of the **esophagus**, which can lead to **esophageal cancer**. During swallowing, the esophagus contracts and relaxes to help food reach the stomach. By inhibiting this contraction, alcohol allows acidic stomach juices to back up into the lower esophagus. The presence of stomach acids in the esophagus can lead to inflammation, ranging from mild to severe. Long-term exposure to stomach acid can cause the cells lining the esophagus to progress toward esophageal cancer. Heavy alcohol use has also been linked to **pancreatitis** (inflammation of the pancreas) and cancers in various other body parts, including the mouth, throat, breast, colon, and rectum.

Although drinking alcohol is not specifically associated with increased risk for stomach cancer, it may be involved in **gastritis** (inflammation of the stomach). A bacterium called *Helicobacter pylori* (*H. pylori*) has been shown to cause gastritis and stomach ulcers; heavy drinkers have higher rates of gastritis and *H. pylori* infection than do light drinkers. Since gastritis among alcoholics is not reduced by stopping drinking, but rather by treatment with antibiotics, it may be the bacterial infection rather than the alcohol that causes gastritis. However, heavy alcohol use may increase susceptibility to gastritis. Scientists currently are investigating whether the higher rate of gastritis among heavy drinkers is due to alcohol or to *H. pylori* infection.

The cardiovascular system. At high concentrations, alcohol can interfere with the pumping action of the heart. Its effects can be acute or chronic. Alcohol exerts its effects through a variety of mechanisms, including interfering with the **sodium-potassium pump** (which is needed to move an electrical impulse through the heart) and disturbing the heart's response to certain **hormones**. The short-term effects of alcohol disturb the electrical events that control the contraction of the heart muscle and interfere with the rhythm of the heartbeat. These effects are thought to be major reasons for sudden death among alcoholics.

At high concentrations, alcohol can interfere with the pumping action of the heart.

Long-term effects of heavy drinking may involve interfering with the action of the energy-producing parts of the heart cell called mitochondria. Studies of alcohol-fed hamsters have shown that after 14 weeks' of high BACs, the heart loses some of its ability to beat properly.

This effect was accompanied by a lower-than-normal energy output from the mitochondria.[54] When hamsters, which have life spans of approximately three years, were given longer exposures to high BACs, they were able to bring the energy output of their mitochondria back to normal, but their hearts still didn't beat as well as they normally do. This study suggests that the body's adaptive response to long-term alcohol use is unable to fully restore normal heart function.

Hypertension (high blood pressure), strongly associated with drinking more than four drinks per day, can be another result of long-term alcohol use. Several mechanisms have been proposed to explain the relationship between drinking and hypertension. One proposed mechanisim involves changes in the levels of various hormones and neurotransmitters that regulate cardiac function. Another proposed mechanism states that alcohol interferes with the ability of muscles in the **arteries** to contract. Alcohol-induced hypertension is not permanent, and among heavy drinkers, it disappears within two or three weeks after drinking stops. The long-term presence of alcohol-induced hypertension in alcoholics may play a role in the association between drinking and the risk of stroke.

Coronary artery disease is the leading cause of death in Western societies, accounting for about 25 percent of all deaths. Despite the clear association between heavy drinking and heart disease, moderate drinking is correlated with reduced risk for coronary artery disease.[44] Scientists currently are attempting to establish whether the protection comes from the alcohol or the lifestyles of moderate drinkers. For example, a number of studies suggest that drinking moderate levels of wine produces the most protection against coronary heart disease. The reason for this is not clear. Wine drinkers are also associated with leading healthier lifestyles than are people who prefer to drink beer or liquor. This protective effect of moderate alcohol drinking must be weighed against its increased accident risk. These benefits are also offset at higher drinking levels due to increased risks of other types of disease and traumas.

The immune system. It is well documented that people who drink heavily suffer more infectious diseases than do people who only drink moderately. For example, various studies have found that drug and alcohol abusers are infected by the bacterium that causes **tuberculosis** at a rate that is 15 to 200 times greater than that of nonabusers. Today, we know that alcohol abuse can alter the distribution and function of immune cells called **lymphocytes** by interfering with molecules called **cytokines** that help orchestrate lymphocyte activities. Alcohol can increase cytokine production in liver cells, which leads to the scar formation and impaired blood flow associated with cirrhosis. In turn, abnormal cytokine concentrations can lead to a poorly regulated immune system that is less capable of fighting off infections.

Alcohol's effects on the immune system can be even more severe. If alcohol damages the immune system to a level where it fails to accurately distinguish self from nonself, the immune system attacks the body. This can result in, or worsen, alcohol-induced organ damage such as alcohol liver disease. Regrettably, children born with **fetal alcohol syndrome** (**FAS**) must cope with the effects of alcohol on their immune systems throughout their lives (see ***10.4 Drinking and pregnancy*** and **Table 4**). FAS results from alcohol consumption by pregnant women. Prenatal exposure to alcohol can disrupt the normal formation of the fetal immune system, leading to increased frequencies of infection and an increased risk of organ damage, among other adverse, lifelong effects.

The endocrine system. Long-term alcohol use can also disrupt the function of the endocrine

system and affect the balance of the hormones **insulin** and **glucagon**, which regulate blood glucose concentrations. Drinking alcohol can alter the release of **reproductive hormones**, **growth hormone**, and **testosterone**. Alcohol-induced changes in hormone concentrations are associated with sexual dysfunction in both men and women. Alcoholics also face increased risk of osteoporosis. The disruption of certain hormones, such as parathyroid hormone, vitamin D–related hormones, and calcitonin, may lead to a calcium deficiency.

7 Alcohol: Behavioral Effects

The brain is the origin of all human behavior, so it is not surprising that exposure to alcohol leads to changes in behavior. As discussed in ***6.1 Alcohol and the brain***, the human brain has a high water content. Consequently, it is very sensitive to the effects of alcohol consumption. Alcohol induces several behavioral changes because it affects various areas of the brain. For example, the cerebellum (movement), the hippocampus (memory), the ventral tegmental area (reward), and even the brainstem (breathing) are all affected by drinking alcohol.

The short-term behavioral effects of alcohol follow the typical dose-response relationship characteristic of a drug; that is, the greater the dose, the greater the effect.

The short-term behavioral effects of alcohol follow the typical dose-response relationship characteristic of a drug; that is, the greater the dose, the greater the effect [see ***5.2 Measurement of blood alcohol concentration (BAC)***]. Table 4 shows that increased blood alcohol concentrations lead to changes in personality as well as loss of control over physical functions. An early (and nearly universal) effect of alcohol on personality is the loss of inhibition. Other effects experienced at lower BACs (0.01–0.05) include a sense of well being and lowered alertness. These BAC values also impair thought, judgment, coordination, and concentration in most individuals.

Table 4. Progressive Effects of Alcohol

Blood Alcohol Concentration	Changes in Feelings and Personality	Brain Regions Affected	Impaired Activities (continuum)
0.01–0.05	Relaxation Sense of well being Loss of inhibition	Cerebral cortex	Alertness Judgment
0.06–0.10	Pleasure Numbness of feelings Nausea, Sleepiness Emotional arousal	Cerebral cortex + forebrain	Coordination (especially fine motor skills) Visual tracking
0.11–0.20	Mood swings Anger Sadness Mania	Cerebral cortex + forebrain + cerebellum	Reasoning and depth perception Inappropriate social behavior (e.g., obnoxiousness)
0.21–0.30	Aggression Reduced sensations Depression Stupor	Cerebral cortex + forebrain + cerebellum + brain stem	Slurred speech Lack of balance Loss of temperature regulation

0.31–0.40	Unconsciousness Death possible Coma	Entire brain	Loss of bladder control Difficulty breathing
0.41 and greater	Death		Slowed heart rate

Source: Advisory committee and NIAAA scientists.

It is easier to predict the physical effects of alcohol than the behavioral ones, especially at BACs in the range of 0.06–0.20. Personality influences behavioral responses. Loss of inhibition combined with additional drinking leads some individuals to become increasingly boisterous while others become withdrawn. Still others become angry and aggressive. Not surprisingly, inappropriate expression of anger and aggression can lead to abusive behavior and violence (see ***10.5 Drinking and violence***). Excessive drinking may also cause some individuals to experience severe emotional swings and even trigger severe depression. At BACs of 0.21–0.29, loss of muscle control leads most individuals to experience **stupor** and impaired sensations. Since BACs over 0.30 affect breathing and heart rate, all individuals experiencing this BAC are at risk for unconsciousness, coma, and even death.

Though the behavioral effects of alcohol are unpredictable and vary from one individual to another, a number of factors are known to influence alcohol's effects on behavior. One important factor that influences both personality and susceptibility to alcohol abuse is genetics (see ***8.2 Alcoholism and genetics***). Genetic influences work at both the individual and the population levels. For example, certain genetic variations that exist more often in Chinese and Japanese populations lead to an increased sensitivity to alcohol's effects, which in turn leads to a decreased susceptibility to alcoholism. An individual possessing these genetic variations experiences facial flushing, an elevated heart rate, and a burning sensation in the stomach upon consumption of alcohol. These negative consequences generally deter further alcohol consumption. In other populations, different genetic variations lead to an increased susceptibility to alcoholism. In still other populations, genetics has not been shown to influence an individual's drinking behavior. It is important to remember that an individual cannot control his or her genetic makeup, but being aware of it can help a person decide whether the choice to drink alcohol would be risky.

Drinkers expect to feel and behave in certain ways when drinking. Expectations about drinking can begin at an early age, even before drinking begins.

There are, of course, nongenetic factors that influence drinking behavior. The term **expectancy** refers to what a person expects will happen in a given drinking situation. Research has shown that drinkers expect to feel and behave in certain ways when drinking. Expectations about drinking can begin at an early age, even before drinking begins.[48] Students who engage in binge drinking during high school are more likely to do so in college.[57] Young people are also influenced by their perceptions of how much they think their friends drink. Studies have shown that college students tend to think their friends drink more than they actually do.[40] This belief can cause them to increase their level of drinking in an effort to "fit in." Other social factors that promote increased alcohol consumption are drinking in groups and serving oneself.[20, 21]

8 Alcoholism

8.1 Signs of a problem

There is no simple test to identify someone with a drinking problem. However, clinicians often use a short series of questions as a screening tool. Honest answers to the following four questions can help individuals decide whether a problem may exist. To make the questions easier to remember, they have been written in such a way that the first letter of a key word in each question spells **CAGE**.[41]

1. Have you ever felt that you should **c**ut down on your drinking?
2. Have people **a**nnoyed you by criticizing your drinking?
3. Have you ever felt bad or **g**uilty about your drinking?
4. Have you ever had a drink first thing in the morning to steady your nerves or to get rid of a hangover (**e**ye opener)?

A "yes" answer to one of these questions may suggest that a drinking problem exists, while more than one "yes" response is highly indicative of a problem. Even if a person answers "no" to all four questions, an alcohol problem can still exist. If the screening procedure suggests that an alcohol-abuse or alcohol-dependence problem may exist, then that individual should be further evaluated by a qualified healthcare provider.

The criteria used by healthcare providers to diagnose alcohol abuse and alcoholism continue to be refined. Prior to the 1970s, subjective judgments and clinical experience were used to diagnose alcoholism. More recently, the diagnostic criteria have relied more on data and research. Today, researchers and clinicians in the United States rely on the *Diagnostic and Statistical Manual of Mental Disorders (DSM*) published by the American Psychiatric Association.[1] The *DSM* recognizes separate criteria for the diagnosis of alcohol dependence (alcoholism) and alcohol abuse.

8.2 Alcoholism and genetics

Most people who use alcohol do so without problems. However, about 17 percent of alcohol users either abuse it or are dependent on it.

Most people who use alcohol do so without problems. However, about 17 percent of current regular drinkers either abuse it or are dependent on it. Regular drinkers are defined as those who have consumed 12 or more drinks in the past year. An individual's susceptibility to alcoholism is influenced by many factors. Scientists believe that, among other factors, there is a genetic basis for alcoholism because children or siblings of alcoholics are at much greater risk for developing the disease.

It is important to keep in mind that members of the same family share both genes and a common environment. To distinguish between the effects of nature versus nurture, scientists have conducted twin and adoption studies. Identical twins have the same set of genes. In contrast, fraternal twins, like nontwin siblings, share an average of half their genes. Thus, both types of twins share environmental influences to a similar degree, but they differ in the amount of genetic information they share. If a trait shows greater similarity among identical twins compared with fraternal twins, then genes contribute to that trait.

Children who are adopted at an early age provide an opportunity to separate genetic from environmental effects. The assumption is that any similarities for a trait between biological parents and their adopted-away offspring are due to genetics. Conversely, similarities between

adoptive parents and their adopted children reflect shared environmental influences. Twin and adoption studies indicate that there are strong genetic influences on alcoholism. It is important to stress, however, that many individuals who are **genetically predisposed** to become an alcoholic do not do so. Genetic influence speaks to an individual's risk, not their destiny. The environment, including the social setting of the individual, is a very important factor. The individual must engage in the behavior of drinking before the genetic predisposition can set the stage for alcoholism to develop.

The genetic influence on alcoholism is described as being **polygenic**, meaning that there is more than one gene influencing the trait. Scientific research has identified regions on many **chromosomes** (1, 2, 3, 4, 7, 11, 15, and 16) that may predispose an individual to alcoholism.[16, 18, 32, 50] In addition, other regions on chromosome 4 may help protect an individual from alcoholism. One such region is near the location of the genes for the ADH enzyme (see "**The cardiovascular system**"). This is especially interesting because certain **alleles**, or versions of the ADH gene, have been shown to reduce the risk for alcoholism in Chinese and Japanese populations. Individuals having the *ADH2* and *ADH3* alleles produce enzymes that metabolize alcohol to acetaldehyde at a high rate. The accumulation of toxic acetaldehyde can cause facial flushing, an elevated heart rate, and a burning sensation in the stomach. These negative effects of alcohol consumption are responsible for the reduced rates of alcoholism among people with these **genotypes**.

8.3 Alcoholism treatments

Although it is a chronic disease, alcoholism can be treated successfully. Any successful physiological treatment for alcoholism must also include a psychological component. Similar to other chronic diseases, such as heart disease or diabetes, relapse is common during the course of alcoholism. Thus, successful treatment is defined in terms of recovery, not cure. Research continues to develop both pharmacological and psychosocial (behavioral) therapies for alcoholism.[54]

Any successful physiological treatment for alcoholism must also include a psychological component.

Pharmacological treatment has for many years included the use of disulfiram (Antabuse), which affects the metabolism of alcohol in the liver. A person who drinks alcohol while taking disulfiram will experience severe discomfort and illness or, in extreme cases, even death. The expectation of illness deters the ingestion of alcohol. Often, however, alcohol abusers do not take the medication, or take it but continue to drink despite the consequences. Moreover, disulfiram treats only the effects, but not the causes, of the disease. This reduces its effectiveness unless used in conjunction with other behavioral therapies.

Figure 13. *Disulfiram is a drug approved by the Food and Drug*

More recently, the drug **naltrexone** has been approved as a pharmacological agent to help a person maintain **sobriety**.[58] **Endorphins** are among the hormones believed to be involved in alcohol craving. Naltrexone blocks the receptors for endorphins, thus helping reduce the desire for alcohol. Although clinical trials of naltrexone have been promising, the drug must be taken consistently to be effective. This drug should be used in conjunction with psychosocial therapies. Research is now under way to identify other medications that can be used alone, or in

Administration to treat alcoholism.

combination with other medications, to treat alcoholism.

Individual-initiated (or "self-help") therapies have traditionally been the backbone of alcohol recovery. The first such program, Alcoholics Anonymous (AA), describes itself as a "worldwide fellowship of men and women who help each other to stay sober." There are formal treatment programs, which include standard behavioral psychology interventions, relapse prevention, and family intervention, all of which can help some patients.

9 Alcohol and Youth

Alcohol abuse and alcoholism affect not just individuals, but whole families. Children become aware of alcohol at an early age. By about five or six years of age, most children can identify alcoholic beverages by smell alone.[48] Interviews with eight- and nine-year-old children living in New Zealand revealed that one-third of them were aware of alcohol-related problems in their own environments.[11] Most acquired their knowledge about alcohol from siblings. However, one-third cited television as their information source.

By about five or six years of age, most children can identify alcoholic beverages by smell alone.

The prevalence of alcoholism in the United States is such that 76 million Americans, or about 43 percent of the adult population, have been exposed to alcoholism in their families.[36] There are thought to be more than 28 million children of alcoholic parents in the United States, with over 11 million of them under the age of 18.[37] Children who live in a home with an alcoholic parent are four times more likely than children of nonalcoholic parents to develop alcoholism themselves.[36] Children of alcoholic parents are harmed in many other ways as well (see Table 5).

Table 5. Effects of Alcoholism on Children[37]

Children of alcoholics are more likely than children of nonalcoholic parents to

- suffer child abuse
- exhibit symptoms of depression and anxiety
- experience physical and mental health problems
- have difficulties in school
- display behavior problems
- experience higher healthcare costs

The interaction of genetic and environmental factors influences the probability that a young person will abuse alcohol. Children of alcoholic parents generally begin drinking at an earlier age than children of nonalcoholic parents.[12] Children who are restless and easily distracted at age 3 are twice as likely as their more focused counterparts to be diagnosed as alcoholic by age 21.[10]

The interaction of genetic and environmental factors influences the probability that a young person will abuse alcohol.

Parental drinking patterns and access to alcohol are associated with adolescents starting and continuing drinking.[26] Conversely, children who are warned about the negative consequences of drinking are less likely to begin.[2] Also, factors such as lack of parental support, monitoring, and communication contribute to alcohol abuse by adolescents. Children who are rejected or mistreated are much more likely

to develop problems with alcohol.

Many adolescents develop positive expectations about alcohol use, which factor into their decision about whether to begin drinking. These attitudes are influenced by positive depictions of alcohol use in movies, on television, and in advertisements. Our society has an ambivalent attitude toward alcohol consumption, sometimes restricting it and at other times promoting it. For example, television networks in the United States show advertisements for beer and wine but not for distilled liquor. This voluntary ban on television advertising of hard liquor could end. The positive messages about drinking do not escape the notice of our youngest citizens. A recent study examining 50 children's animated films for examples of tobacco and alcohol use found that 25 of the films (50 percent) depicted alcohol use. Furthermore, the characters drinking alcohol were as likely to be "good" characters as "bad" ones.[22]

As children grow older, their drinking or abstinence is influenced more by their peers and less by their parents. College students have been found to pattern their drinking after the amounts they *perceive* their peers to drink, not what their peers actually consume.[4, 5, 49] These students consistently overestimated the amount of alcohol consumed by their peers. This bias promotes heavier drinking habits. These studies also show that college students are less prone to heavy drinking after the spring term than the fall term. Presumably, they have experienced some of the negative consequences of alcohol abuse and temper their enthusiasm for drinking. Young people are also prone to model their drinking patterns after people they admire, such as athletes, actors, and musicians.[29]

Ultimately, each individual must decide whether to use alcohol or not. Students who understand the changes alcohol causes in their bodies and how these changes affect their health and behavior can make informed decisions about drinking. Providing that understanding is the first of the four objectives mentioned in the **introduction** to this curriculum supplement.

10 Consequences of Alcohol Abuse and Alcoholism

10.1 The costs to society

Biological (genetic) and psychosocial factors combine with environmental factors, such as the availability of alcohol, to increase the risk for developing drinking problems.

Approximately two-thirds of American adults drink alcohol at least once during the course of a year. Most people drink responsibly, but approximately 13.8 million Americans have problems related to either alcohol abuse or alcoholism.[23] The risk for developing alcohol-related problems is higher among those who begin drinking when they are young. Research shows that biological (genetic) and psychosocial factors combine with environmental factors, such as the availability of alcohol, to increase the risk for developing drinking problems.[55]

Alcohol abuse and alcoholism have a large economic impact on our society. In 1998, alcohol abuse and alcoholism cost an estimated $185 billion in lost productivity, illness, premature death, and healthcare expenditures. For 1995, these costs were estimated to be over $166 billion, and in 1992, they were $148 billion.[47] A large portion of these costs is borne, in various ways, by nonabusers (see Figure 14).[56] While 45 percent of the costs of alcohol abuse

fall on the abusers themselves and their families, 38 percent falls on government (in the form of lost or reduced tax revenue). Additional costs to nonabusers include, but are not limited to, the economic costs of the criminal justice system and higher insurance premiums, as well as the social costs of alcohol-related crimes and trauma. Some examples of the social costs of alcohol abuse and alcoholism are discussed in greater detail later.

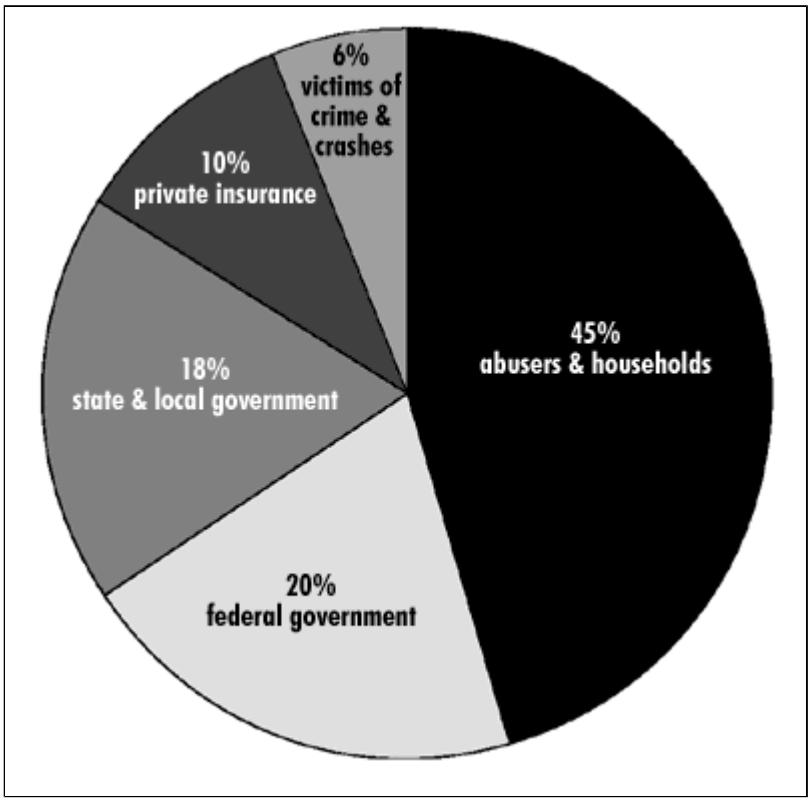

Figure 14. *Distribution of the cost of alcohol abuse in the United States in 1998.*

10.2 Drinking and driving

Although the proportion of crash fatalities attributable to drinking is declining, the problem is still serious, claiming about 15,000 lives annually in the United States. All states have laws stipulating driver BAC limits. Half the states have already established 0.08 as their *per se* level (meaning no other evidence of intoxication is required), while the other half currently have a limit of 0.10. Alcohol poses a more serious risk for younger drivers. They have less experience with driving and alcohol and consequently exhibit higher crash rates. Recognizing this fact, all states have laws aimed specifically at preventing underage drinking and driving. Important among these are the minimum legal drinking age of 21 and zero-tolerance laws for underage drinking and driving. In addition, some states have enacted graduated driver licensing (GDL) systems. These systems often feature a three-phase process where 16- and 17-year-old drivers first are required to be supervised at all times by an older driver. The second stage allows them to drive unsupervised during daytime hours. The third stage imposes few restrictions. Recent reports indicate that GDL programs are successful. Crashes involving 16-year-old drivers declined 25 percent in Michigan and 27 percent in North Carolina following implementation of GDL programs.[19, 52]

Some driving skills are more impaired than others for a given BAC. The brain must control eye movement,

briefly focusing on objects and tracking them. Low to moderate BACs (0.03–0.05) can interfere with the ability to track objects. Steering depends upon eye-to-hand reactions together with eye movements. Studies show that people have significant trouble steering a car with BACs beginning at 0.02.[42] Alcohol also interferes with the brain's information-processing ability. Another important aspect of driving is the ability of the driver to divide his or her attention. A driver must keep the car in its proper lane while at the same time paying attention to the local environment. Alcohol causes people to favor one activity over the other. Typically, alcohol-impaired drivers pay more attention to steering their car than they do to their local surroundings.

Figure 15. *The Breathalyzer is used by law enforcement personnel to measure BACs.*

Some statistics about alcohol and driving compiled by the U.S. Department of Transportation include the following[39]:

- Alcohol was involved in 39 percent of fatal crashes and in 7 percent of all crashes in 1997.
- About 3 in every 10 Americans will be involved in an alcohol-related crash at some time in their lives.
- In 1997, the age group of drivers with the highest rates for fatal crashes while intoxicated was 21–24 years old (26.3 percent), followed by ages 25–34 (23.8 percent) and 35–44 (22.1 percent).
- Relatively few problem drinkers (about 7 percent of all drivers) account for over 66 percent of all alcohol-related fatal crashes.
- One-third of all pedestrians 16 years of age or older killed in traffic crashes in 1997 were intoxicated.
- In 1997, an estimated 846 lives were saved by minimum-drinking-age laws.

10.3 Drinking and risky behavior

The perception of risk, risk taking, acting on impulse, and sensation-seeking behaviors are all affected by alcohol use.

The perception of risk, risk taking, acting on impulse, and sensation-seeking behaviors are all affected by alcohol use. Among males, higher levels of drinking lead to increased risk-taking behaviors.[14] One study revealed that among a group of adults who came to the emergency room for alcohol-related injuries, three-fourths admitted to not using seat belts.[8] Adolescents who drink are more likely to report that they engage in risky behaviors such as swimming alone or taking someone else's medication.[60]

The association between alcohol use and risky behavior applies to sexual behaviors, as well. The consequences of such behaviors can include rape, transmission of diseases, unwanted pregnancies, and birth defects. Surveys of young people show an association between alcohol use and engaging in risky sexual behaviors.[53] Among boys, 17 percent said that they were less likely to use condoms when having sex after drinking. Alcohol use also correlates with increased risk of forced sexual activity. In one study of Massachusetts teenagers, 44 percent said they were more likely to engage in sexual intercourse if they had been drinking.[53]

Sometimes risky behavior associated with drinking may be inadvertent. For example, mixing alcohol with some medicines can produce serious and even fatal consequences. Anyone taking prescription and/or over-the-counter medications should carefully read the labels and check with a pharmacist, physician, or other health professional to be aware of possible adverse reactions if the drug is mixed with alcohol.

10.4 Drinking and pregnancy

Pregnant women who drink expose their unborn children to alcohol through the **placenta**. That exposure can lead to **fetal alcohol syndrome (FAS)**, which is characterized by a variety of developmental problems, some of which can be severe (see Table 6, below, and ***The immune system***). FAS is estimated to be the most common preventable cause of mental retardation in children. Although not completely understood, the severity of the signs and symptoms seems to be related to the amount, frequency, and timing of alcohol consumption by the mother during pregnancy.

Table 6. Characteristics of Fetal Alcohol Syndrome

growth deficiency either before or after birth
distinctive abnormal facial features
central nervous system disorders, including: • cognitive deficits • developmental delays • behavioral impairments • structural abnormalities

Diagnosis of FAS has been greatly improved by discoveries in alcohol research. Still, because there is no simple laboratory test to detect FAS, it is difficult to estimate its incidence with great accuracy. Complicating this situation are studies that indicate that some physicians are reluctant to make the diagnosis even when it does exist. Presumably, they don't want the child burdened with the stigma associated with FAS, and they recognize that the disorder has limited treatment options. Nevertheless, early and accurate diagnosis and referrals of these children and their parents/caregivers for appropriate medical, social, and educational services is effective.

On the basis of a study in Washington State, it has been estimated that the minimum rate of FAS in the general population is 3.1 per 1,000 live births, or 0.31 percent.[15] Among heavy drinkers, the rate is 4.3 percent, which translates to more than 2,000 cases per year in the United States.[54] The incidence of FAS varies among different racial and ethnic groups. For example, data from the Centers for Disease Control and Prevention indicate that the incidence of FAS is seven times greater among African Americans than European Americans. Some Native American groups have a 30-fold greater incidence of FAS than the general population.[13] Since some populations are disproportionately affected by FAS, it is important that researchers, healthcare providers, and educators from these populations be involved in obtaining knowledge about and treatments for this serious disorder.

An additional unestimated number of children are born each year who were exposed to alcohol *in utero* but do not have the full syndrome. Their condition is termed **fetal alcohol effects** (**FAE**). They show one or more birth abnormalities associated with alcohol exposure.

These may be either physical or neurodevelopmental.

Figure 16. *Pregnant women should not drink alcohol.*

The deficits associated with FAS are lifelong. Although the distinctive facial features of FAS become less apparent after puberty, the intellectual impairments remain, and emotional, behavioral, and social problems often get worse. In one study, adolescents and adults with FAS were found to have arithmetic skills at the second- to fourth-grade levels.[54] Children with FAS are often described as hyperactive with short attention spans. They display a number of behavioral problems including poor judgment, failure to consider the consequences of their actions, and failure to appropriately respond to social cues.

A high BAC can destroy nerve cells in the developing rat brain.

The timing of alcohol exposure during pregnancy is critical to the development of FAS and FAE. By using animal studies to explore the relationship between alcohol exposure and FAS, researchers are able to control not only the timing and dose of alcohol during pregnancy, but also the genetic background and environment of the test animals. A high BAC can destroy nerve cells in the developing rat brain.[27] The timing of this nerve-destroying alcohol exposure in rats corresponds to the brain growth spurt in humans, called **synaptogenesis**, when brain cells form most of their interconnections. In humans, synaptogenesis lasts from about the sixth month of pregnancy to a child's second birthday. In rats, this period occurs for a short period after the pup is born. The scientists exposed newborn rat pups to a BAC of 0.20 (about twice the BAC defined as legally intoxicated in humans). This high BAC was maintained for four hours or longer. A one-time exposure of four hours was sufficient to cause brain cells to die off at a rate nearly 30 times greater than normal.[27] Although it is difficult to translate these results from rats to humans, the uncertainties involved led the authors to advise expectant mothers to avoid alcohol entirely during their pregnancies.

10.5 Drinking and violence

It has long been observed that there is an association between alcohol use and aggressive or violent behavior. Clearly, violence occurs in the absence of alcohol, and drinking alcohol alone is not sufficient to cause violence. However, numerous studies have found that alcohol is involved with about half of perpetrators of violence and their victims. This relationship holds across cultures and for various types of violence. In the United States, alcohol use is a significant factor in[47]

- 68 percent of manslaughter cases
- 62 percent of assault offenders
- 54 percent of murders
- 48 percent of robberies
- 44 percent of burgerlies

The mechanism by which alcohol contributes to

aggressive behaviors is not completely understood. Alcohol may interfere with the brain's mechanisms for restraining impulsive behaviors. Individuals who are intoxicated may misread social cues, overreact to situations, and not be able to accurately anticipate the consequences of their actions. In addition, alcohol consumption can lead to increased vulnerability in potential victims. Intoxicated people are often less able to defend themselves against a violent attack than are people who are sober. For example, a survey of students in grades 8 and 10 across the United States showed that alcohol use correlates significantly to risky behavior and victimization. This association was strongest among eighth-grade males.[61]

Individuals who are intoxicated may misread social cues, overreact to situations, and not be able to accurately anticipate the consequences of their actions.

One experimental approach to studying the relationship of alcohol to aggressive behavior is to have a test subject administer an electric shock to an unseen "opponent" as part of a competitive task, such as one involving learning and reaction time. Unknown to the test subject, a computer plays the role of the opponent. The test subject performs the task while sober and after alcohol consumption. Such studies show that test subjects administer stronger electric shocks with increasing alcohol consumption. These same studies also reveal that test subjects do not display aggressive behavior unless they feel threatened or provoked.[8] Once again, these results show that alcohol alone is associated with, but not sufficient to account for, aggressive behavior.

The relationship between alcohol and violence is complex. Alcohol seems to influence aggressive behaviors in some individuals but not others, and only in certain social or cultural situations. Although our knowledge of the causes of violence is limited, research suggests that some violence may be treatable through behavioral therapies. Studies also show that successful alcoholism treatments have the added benefit of reducing violent behaviors.