chapter 9

Drugs

Key Terms

anabolic steriods

analgesic

confirmation

depressant

hallucinogen

microcrystalline tests

narcotic

physical dependence

psychological dependence

screening test

stimulant

Learning Objectives

After studying this chapter you should be able to:

- Compare and contrast psychological and physical dependence
- Name and classify the commonly abused drugs

- List and define the schedules of the Controlled Substances Act
- Describe the laboratory tests normally used to perform a routine drug identification analysis
- Explain the testing procedures used for forensic identification of marijuana
- Understand the proper collection and preservation of drug evidence

Pablo Escobar, Drug Lord

In 1989, *Forbes* magazine listed Pablo Escobar as the seventh richest man in the world. Escobar began his climb to wealth as a teenage car thief in the streets of Medellin, Colombia. He eventually moved into the cocaine-smuggling business. At the peak of his power in the mid-1980s, he was shipping as much as eleven tons of cocaine per flight in jetliners to the United States. Estimates are that the Medellin cartel controlled 80 percent of the world's cocaine market and was taking in about $25 billion annually. Escobar ruthlessly ruled by the gun: murdering, assassinating, and kidnapping. He was responsible for killing three presidential candidates in Colombia, as well as the storming of the Colombian Supreme Court, which resulted in the murder of half the justices. All the while, Escobar curried favor with the Colombian general public by cultivating a Robin Hood image and distributing money to the poor. In 1991, hoping to avoid extradition to the United States, Escobar turned himself in to the Colombian government and agreed to be sent to prison. However, the prison compound could easily be mistaken for a country club. There he continued his high-flying lifestyle, trafficking by telephone and even murdering a few associates. When the Colombian government attempted to move Escobar to another jail, he escaped, again fearing extradition to the United States. Pressured by the U.S. government, Colombia organized a task force dedicated to apprehending Escobar. The manhunt for

Escobar ended on December 2, 1993, when he was cornered on the roof of one of his hide-outs. A shootout ensued and Escobar was fatally wounded by a bullet behind his ear.

A *drug* can be defined as a natural or synthetic substance that is used to produce physiological or psychological effects in humans or other higher order animals. However, this colorless clinical definition does not really tell us what drugs are; in their modern context, drugs mean something different to each person. To some, drugs are a necessity for sustaining and prolonging life; to others, drugs provide an escape from the pressures of life; to still others, they are a means of ending it.

Considering the wide application and acceptance of drugs in our society, it was perhaps inevitable that a segment of our population would abuse them. During the 1960s, succeeding waves of hallucinogens, amphetamines, and barbiturates found their way out of laboratories, pharmacies, and medicine chests and into the streets. During this decade, marijuana became the most widely used illicit drug in the United States, and alcohol consumption continued to rise—today 90 million Americans drink alcohol regularly, and 10 million of these are hopelessly addicted or have severe problems in coping with their drinking habits. In the 1970s, heroin addiction emerged as a national problem, and today the United States is in the midst of an epidemic of cocaine abuse.

Drug abuse has grown from a problem generally associated with members of the lower end of the socioeconomic ladder to one that cuts across all social and ethnic classes of society. Today, approximately 23 million people in the United States use illicit drugs, including about a half million heroin addicts and nearly six million users of cocaine.

In the United States, more than 75 percent of the evidence evaluated in crime laboratories is drug related. The deluge of drug specimens has forced the expansion of existing crime laborato-

ries and the creation of new ones. For many concerned forensic scientists, the crime laboratory's preoccupation with drug evidence represents a serious distraction from time that could be devoted to evaluating evidence related to homicides and other types of serious crimes. However, the increasing caseloads associated with drug evidence have justified the expansion of forensic laboratory services. This expansion has increased the overall analytical capabilities of crime laboratories.

DRUG DEPENDENCE

In assessing the potential danger of drugs, society has become particularly conscious of their effects on human behavior. In fact, the first drugs to be regulated by law in the early years of the twentieth century were those deemed to have "habit-forming" properties. The early laws were aimed primarily at controlling opium and its derivatives, cocaine, and later marijuana. Today, it is known that the ability of a drug to induce dependence after repeated use is submerged in a complex array of physiological and social factors.

Dependence on drugs exists in numerous patterns and in all degrees of intensity, depending on the nature of the drug, the route of administration, the dose, the frequency of administration, and the individual's rate of metabolism. Furthermore, nondrug factors play an equally crucial role in determining the behavioral patterns associated with drug use. The personal characteristics of the user, his or her expectations about the drug experience, society's attitudes and possible responses, and the setting in which the drug is used are all major determinants of drug dependence.

The question of how to define and measure a drug's influence on the individual and its danger to society is difficult to assess. To this end, the nature and significance of drug dependence must be considered from two overlapping points of view: the interaction of the drug with the individ-

ual, and the drug's impact on society. It will be useful when discussing the nature of the drug experience to approach the problem from two distinctly different aspects of human behavior—**psychological dependence** and **physical dependence**.

The common denominator that characterizes all types of repeated drug use is the creation of a psychological dependence for continued use of the drug. It is important to discard the unrealistic image that all drug users are hopeless "addicts" who are social dropouts. Most users present quite a normal appearance and remain both socially and economically integrated in the life of the community.

The reasons why some people abstain from drugs while others become moderately or heavily involved are difficult if not impossible to delineate. Psychological needs arise from numerous personal and social factors that stem from the individual's desire to create a sense of well-being and to escape from reality. In some cases, the individual may be seeking relief from personal problems or stressful situations, or he or she may be trying to sustain a physical and emotional state that permits an improved level of performance. Whatever the reasons, the underlying psychological needs and the desire to fulfill them create a conditioned pattern of drug abuse.

The intensity of the psychological dependence associated with a drug's use is difficult to define and largely depends on the nature of the drug used. For drugs such as alcohol, heroin, amphetamines, barbiturates, and cocaine, there is a significant likelihood that continued use will result in a high degree of involvement. Other drugs, such as marijuana and codeine, appear to have a considerably lower potential for the development of psychological dependence. However, this does not imply that repeated abuse of drugs deemed to have a low potential for psychological dependency is safe or will always produce low psychological dependence. We have no precise way of measuring or predicting the impact of drug abuse on the individual. Even if a system could be

devised for controlling the many possible variables affecting a user's response, the unpredictability of the human personality would still have to be considered; the personal inadequacies of the drug user represent the underlying motivation for drug use.

Our general knowledge of alcohol consumption should warn us of the fallacy of generalizing when attempting to describe the danger of drug abuse. Obviously, not all alcohol drinkers are psychologically addicted to the drug; most are "social" drinkers who drink in reasonable amounts and on an irregular basis. Many people have progressed beyond this stage and consider alcohol a necessary crutch for dealing with life's stresses and anxieties. However, a wide range of behavioral patterns exists among alcohol abusers, and to a large extent the degree of psychological dependency must be determined on an individual basis. Likewise, it would be fallacious to generalize that all users of marijuana can at worst develop a low degree of dependency on the drug. A wide range of factors also influence marijuana's effect, and heavy users of the drug expose themselves to the danger of developing a high degree of psychological dependency.

Where emotional well-being is the primary motive leading to repeated and intensive use of a drug, certain drugs, when taken in sufficient dose and frequency, are capable of producing physiological changes that encourage their continued use. Once the user abstains from such a drug, severe physical illness follows. The desire to avoid this *withdrawal sickness* or *abstinence syndrome* ultimately causes physical dependence, or addiction. Hence, for the addict who is accustomed to receiving large doses of heroin, the thought of abstaining and encountering body chills, vomiting, stomach cramps, convulsions, insomnia, pain, and hallucinations is a powerful inducement for continued drug use.

Interestingly, some of the more widely abused drugs have little or no potential for creating physical dependence. Drugs such as marijuana, LSD, and cocaine create strong anxieties when

their repeated use is discontinued; however, no medical evidence attributes these discomforts to physiological reactions that accompany withdrawal sickness. On the other hand, use of alcohol, heroin, and barbiturates can result in development of physical dependency.

Physical dependency develops only when the drug user adheres to a regular schedule of drug intake; that is, the interval between doses must be short enough so that the effects of the drug never wear off completely. For example, the interval between injections of heroin for the drug addict probably does not exceed six to eight hours. Beyond this time the addict begins to experience the uncomfortable symptoms of withdrawal. Many users of heroin avoid taking the drug on a regular basis for fear of becoming physically addicted to its use. Similarly, the risk of developing physical dependence on alcohol becomes greatest when the consumption is characterized by a continuing pattern of daily use in large quantities.

Table 9–1 categorizes some of the more commonly abused drugs according to their effect on the body and summarizes their tendency to produce psychological dependency and to induce physical dependency with repeated use.

The social impact of drug dependence is directly related to the extent to which the user has become preoccupied with the drug. Here, the most important element is the extent to which drug use has become interwoven in the fabric of the user's life. The more frequently the drug satisfies the person's need, the greater the likelihood that he or she will become preoccupied with its use, with a consequent neglect of individual and social responsibilities. Personal health, economic relationships, and family obligations may all suffer as the drug-seeking behavior increases in frequency and intensity and dominates the individual's life. The extreme of drug dependence may lead to behavior that has serious implications for the public's safety, health, and welfare.

Drug dependence in its broadest sense involves much of the world's population. As a result, a complex array of individual, social, cultural, legal, and medical factors ultimately influence society's decision to prohibit or to impose strict controls on a drug's distribution and use. Invariably, society must weigh the beneficial aspects of the drug against the ultimate harm its abuse will do to the individual and to society as a whole. Obviously, many forms of drug dependence do not carry sufficient adverse social consequences to warrant their prohibition, as illustrated by the widespread use of such drug-containing substances as tobacco and coffee. Although heavy and prolonged use of these drugs may eventually damage body organs and injure an individual's health, there is no evidence that they result in antisocial behavior, even with prolonged or excessive use. Hence, society is willing to accept widespread use of these substances.

Table 9–1 The Potential of Some Commonly Abused Drugs to Produce Dependency with Regular Use

Drug	Psychological Dependence	Physical Dependence
Narcotics		
Morphine	High	Yes
Heroin	High	Yes
Methadone	High	Yes
Codeine	Low	Yes
Depressants		

Barbiturates (short-acting)	High	Yes
Barbiturates (long-acting)	Low	Yes
Alcohol	High	Yes
Methaqualone (Quaalude)	High	Yes
Meprobamate (Miltown, Equanil)	Moderate	Yes
Diazepam (Valium)	Moderate	Yes
Chlordiazepoxide (Librium)	Moderate	Yes
Stimulants		
Amphetamines	High	?
Cocaine	High	No
Caffeine	Low	No
Nicotine	High	Yes
Hallucinogens		
Marijuana	Low	No
LSD	Low	No
Phencyclidine (PCP)	High	No

We are certainly all aware of the disastrous failure in the United States to prohibit the use of alcohol during the 1920s and the current debate on whether marijuana should be legalized. Each of these issues emphasizes the delicate balance between individual desires and needs and soci-

ety's concern with the consequences of drug abuse; moreover, this balance is continuously subject to change and reevaluation.

NARCOTIC DRUGS

The term **narcotic** is derived from the Greek word *narkotikos*, which implies a state of lethargy or sluggishness. Pharmacologists actually classify narcotic drugs as substances that bring relief from pain and produce sleep. Unfortunately, "narcotic" has come to be popularly associated with any drug that is socially unacceptable. As a consequence of this incorrect usage, many drugs are improperly called narcotics. Furthermore, this confusion has produced legal definitions that are at variance with the pharmacological actions of many drugs. For example, until the early 1970s, most drug laws in the United States incorrectly designated marijuana as a narcotic; even now, many drug-control laws in the United States, including the federal law, classify cocaine as a narcotic drug. Pharmacologically, cocaine is actually a powerful central nervous system stimulant, possessing properties opposite to those normally associated with the depressant effects of a narcotic.

Narcotic drugs are **analgesics**—that is, they relieve pain by depressing the central nervous system. Regular use of a narcotic drug leads to physical dependence, with all its dire consequences. The source of most analgesic narcotics is opium, a gummy, milky juice exuded through a cut made in the unripe pod of the poppy (*Papaver somniferium*), a plant grown mostly in parts of Asia. Opium is brownish in color and has a morphine content ranging from 4 to 21 percent.

Although morphine is readily extracted from opium, for reasons that are not totally known, most addicts prefer to use one of its derivatives, *heroin*. Heroin is made rather simply by reacting morphine with acetic anhydride or acetyl chloride (see Figure 9–1). Heroin's high solubility in

water makes its street preparation for intravenous administration rather simple, for only by injection are heroin's effects almost instantaneously felt and with maximum sensitivity. To prepare the drug for injection, the addict frequently dissolves it in a small quantity of water in a spoon. The process can be speeded up by heating the spoon over a candle or several matches. The solution is then drawn into a syringe or eyedropper for injection beneath the skin. Figure 9–2 shows some of the paraphernalia typically associated with street administration of heroin. Besides being a powerful analgesic, heroin produces a "high" that is accompanied by drowsiness and a deep sense of well-being; however, the effect is short, generally lasting only three to four hours.

The content of a typical heroin bag is an excellent example of the uncertainty attached to buying illicit drugs. For many years into the 1960s and early 1970s, the average bag contained 15 to 20 percent heroin. Currently, the average purity of heroin obtained in the illicit U.S. market is approximately 35 percent. The addict rarely knows or cares what comprises the other 65 percent or so of the material. Traditionally, quinine has been the most common diluent of heroin. Like heroin, it has a bitter taste and was probably originally used to obscure the actual potency of a heroin preparation for those who wished to taste-test the material before buying it. Other diluents commonly added to heroin are starch, lactose, procaine (Novocain), and mannitol.

Codeine is also present in opium, but it is usually prepared synthetically from morphine. It is commonly used as a cough suppressant in prescription cough syrup. Codeine, only one-sixth as strong as morphine, is not an attractive street drug for addicts.

A number of narcotic drugs are not naturally derived from opium. However, because they have similar physiological effects on the body as the opium narcotics, they are commonly referred to as *opiates*. In 1995, the U.S. Food and Drug Administration approved for use the pain-killing drug *OxyContin*. The active ingredient in OxyContin is oxycodone, a synthetic closely related to

morphine and heroin in its chemical structure. OxyContin is an analgesic narcotic that has effects similar to those of heroin. It is prescribed to a million patients for treatment of chronic pain, with doctors writing close to seven million OxyContin prescriptions each year. The drug is compounded with a time-release formulation that the manufacturer initially believed would reduce the risk of abuse and addiction. This has not turned out to be the case. It is estimated that close to a quarter of a million individuals abuse the drug.

Because it is a legal drug that is diverted from legitimate sources, OxyContin is obtained very differently than illegal drugs. Pharmacy robberies, forged prescriptions, and theft from patients with a legitimate prescription are ways in which abusers access OxyContin. Some abusers visit numerous doctors and receive prescriptions even though their medical condition may not warrant it.

Methadone is another well-known synthetic opiate. In the 1960s, scientists discovered that a person receiving methadone periodically in oral doses of 80 to 120 milligrams a day would not get high if he or she then took heroin or morphine. Clearly, although methadone is a narcotic pharmacologically related to heroin, its administration appears to eliminate the addict's desire for heroin while producing minimal side effects. Critics of the controversial methadone maintenance programs claim that methadone use is just substituting one narcotic drug for another, and supporters argue that this is the only known treatment for keeping the addict off heroin and offering some hope for eventual abstention from narcotics.

Physicians are increasingly prescribing methadone for pain relief. Unfortunately, in recent years, the wide availability of the drug for legitimate medical purposes has led to greater quantities of the drug being diverted into the illicit market. Methadone is being abused increasingly and is causing an alarming number of overdoses and deaths.

HALLUCINOGENS

Hallucinogens are drugs that can cause marked alterations in mood, attitude, thought processes, and perceptions. Perhaps the most popular and controversial member of this class of drugs is marijuana.

Marijuana

Marijuana easily qualifies as the most widely used illicit drug in the United States today. For instance, more than 43 million Americans have tried marijuana, according to the latest surveys, and almost half that number may be regular users. Marijuana is a preparation derived from the plant *Cannabis*. Most botanists believe there is only one species of the plant, *Cannabis sativa L*. The marijuana preparation normally consists of crushed leaves mixed in varying proportions with the plant's flower, stem, and seed. See Figure 9–3. The plant secretes a sticky resin known as *hashish*. The resinous material can also be extracted from the plant by soaking in a solvent such as alcohol. On the illicit-drug market, hashish usually appears in the form of compressed vegetation containing a high percentage of resin. See Figure 9–4. A potent form of marijuana is known as *sinsemilla*. This is made from the unfertilized flowering tops of the female *Cannabis* plants, attained by removal of all male plants from the growing field at the first sign of their appearance. It follows that the production of sinsemilla requires a great deal of attention and care, and the plant is therefore cultivated on small plots.

Marijuana and its related products have been in use legally and illegally for almost three thousand years. The first reference to the medical use of marijuana is in a pharmacy book written about 2737 B.C. by the Chinese emperor Shen Nung, who recommended it for "female weakness, gout, rheumatism, malaria, beriberi, constipation and absent-mindedness." In China, at that time

and even today, the marijuana or hemp plant was also a major source of fiber for the production of rope. Marijuana's mood-altering powers probably did not receive wide attention until about 1000 B.C., when it became an integral part of Hindu culture in India. After A.D. 500, marijuana began creeping westward, and references to it began to appear in Persian and Arabian literature.

The plant was probably brought to Europe by Napoleon's soldiers when they returned from Egypt in the early years of the nineteenth century. In Europe, the drug excited the interest of many physicians who foresaw its application for the treatment of a wide range of ailments. At this time, it also found some use as a painkiller and mild sedative. In later years, these applications were either forgotten or ignored.

Marijuana was first introduced into the United States around 1920. The weed was smuggled by Mexican laborers across the border into Texas. American soldiers also brought the plant in from the ports of Havana, Tampico, and Veracruz. Although its use was confined to a small segment of the population, its popularity quickly spread from the border and Gulf states into most of the major U.S. cities. By 1937, forty-six states and the federal government had laws prohibiting the use or possession of marijuana. Under most of these laws, marijuana was subject to the same rigorous penalties applicable to morphine, heroin, and cocaine and was often erroneously designated a "narcotic."

Marijuana is a weed that grows wild under most climatic conditions. The plant grows to a height of 5 to 15 feet and is characterized by an odd number of leaflets on each leaf. Normally, each leaf contains five to nine leaflets, all having serrated or saw-tooth edges, as shown in Figure 9–5.

In 1964 scientists isolated the chemical substance largely responsible for the hallucinogenic

properties of marijuana. This substance is known as *tetrahydrocannabinol*, or THC. Its discovery has allowed researchers to measure the potency of marijuana preparations and has permitted studies related to measuring the effect of marijuana's potency on individuals. The THC content of *Cannabis* varies in different parts of the plant, generally decreasing in the following sequence: resin, flowers, and leaves. Little THC is found in the stem, roots, or seeds. The potency and resulting effect of the drug fluctuate, depending on the relative proportion of these plant parts in the marijuana mixture.

The potency of marijuana depends on its form. Marijuana in the form of loose vegetation has an average THC content of about 3–4.5 percent. The more potent sinsemilla form averages about 6–12 percent in THC content, while hashish preparations average about 2–8 percent. Another form of hashish is known as *liquid hashish* or *hashish oil*. Hashish in this form is normally a viscous substance, dark green with a tarry consistency. Liquid hashish is produced by efficiently extracting the THC-rich resin from the marijuana plant with an appropriate solvent. Liquid hashish typically varies between 8 and 20 percent in THC content. Because of its extraordinary potency, one drop of the material can produce a "high." Ordinarily a drop is placed on a regular cigarette or on a marijuana cigarette before smoking.

Any study that relates to marijuana's effect on humans must consider the potency of the marijuana preparation. An interesting insight into the relationship between dosage level and marijuana's pharmacological effect was presented in the first report of the National Commission of Marijuana and Drug Abuse:

> At low, usual "social" doses the user may experience an increased sense of well-being; initial restlessness and hilarity followed by a dreamy, carefree state of relaxation; alteration of sensory perceptions including expansion of space and time;

> and a more vivid sense of touch, sight, smell, taste and sound; a feeling of hunger, especially a craving for sweets; and subtle changes in thought formation and expression. To an unknowing observer, an individual in this state of consciousness would not appear noticeably different from his normal state.
>
> At higher, moderate doses these same reactions are intensified but the changes in the individual would still be scarcely noticeable to an observer. … At very high doses, psychotomimetic phenomena may be experienced. These include distortion of body image, loss of personal identity, sensory and mental illusions, fantasies and hallucinations.[1]

No current evidence suggests that experimental or intermittent use causes physical or psychological harm. Marijuana does not cause physical dependency. However, the risk of harm lies instead in heavy, long-term use of the drug, particularly of the more potent preparations. Heavy users can develop a strong psychological dependence on the drug. Some effects of marijuana use include increased heart rate, dry mouth, reddened eyes, impaired motor skills and concentration, and frequently hunger and an increased desire for sweets. Long-term chronic marijuana use is associated with amotivational syndrome characterized by apathy; impairment of judgment, memory, and concentration; and loss of interest in personal appearance and the pursuit of conventional goals. Accumulating evidence suggests that marijuana has potential medical uses. Two promising areas of research are marijuana's reduction of excessive eye pressure in glaucoma and lessening of nausea caused by powerful anticancer drugs. Marijuana may also be useful as a muscle relaxant.

Other Hallucinogens

A substantial number of substances of widely varying chemical compositions have become part of the drug culture because of their hallucinogenic properties. These include lysergic acid diethylamide (LSD), mescaline, phencyclidine (PCP), psilocybin, and methylenedioxymethamphetamine, also known as MDMA or Ecstasy.

LSD is synthesized from lysergic acid, a substance derived from ergot, which is a type of fungus that attacks certain grasses and grains. Its hallucinogenic effects were first described by the Swiss chemist Albert Hofmann after he accidentally ingested some of the material in his laboratory in 1943. The drug is very potent; as little as 25 micrograms is enough to start vivid visual hallucinations that can last for about twelve hours. The drug also produces marked changes in mood, leading to laughing or crying at the slightest provocation. Feelings of anxiety and tension almost always accompany LSD use. Although physical dependence does not develop with continued use, the individual user may be prone to flashbacks and psychotic reactions even after use is discontinued.

In recent years, abuse of phencyclidine, commonly called PCP, has grown to alarming proportions. Because this drug can be synthesized by rather simple chemical processes, it is manufactured surreptitiously for the illicit market in so-called clandestine laboratories (see Figure 9–6). These laboratories range from large, sophisticated operations to small labs located in a bathroom. Small-time operators normally have little or no training in chemistry and employ “cookbook” methods to synthesize the drug. Some of the more knowledgeable and experienced operators have been able to achieve clandestine production levels that approach a commercial level of operation.

Phencyclidine is often mixed with other drugs, such as LSD or amphetamine, and is sold as a powder (“angel dust”), capsule, or tablet, or as a liquid sprayed on plant leaves. The drug is smoked, ingested, or sniffed. Following oral intake of moderate doses (1–6 milligrams), the user

first experiences feelings of strength and invulnerability, along with a dreamy sense of detachment. However, the user soon becomes unresponsive, confused, and agitated. Depression, irritability, feelings of isolation, audio and visual hallucinations, and sometimes paranoia accompany PCP use. Severe depression, tendencies toward violence, and suicide accompany long-term daily use of the drug. In some cases, the PCP user experiences sudden schizophrenic behavior days after the drug has been taken.

DEPRESSANTS

Alcohol (Ethyl Alcohol)

Many people overlook the fact that alcohol is a drug; its major behavioral effects derive from its **depressant** action on the central nervous system. In the United States, the alcohol industry annually produces more than one billion gallons of spirits, wine, and beer for which 90 million consumers pay nearly $40 billion. Unquestionably, these and other statistics support the fact that alcohol is the most widely used and abused drug.

The behavioral patterns of alcohol intoxication vary and depend in part on such factors as social setting, amount consumed, and the personal expectation of the individual with regard to alcohol. When alcohol enters the body's bloodstream, it quickly travels to the brain, where it suppresses the brain's control of thought processes and muscle coordination.

Low doses of alcohol tend to inhibit the mental processes of judgment, memory, and concentration. The drinker's personality becomes expansive, and he or she exudes confidence. When taken in moderate doses, alcohol reduces coordination substantially, inhibits orderly thought processes and speech patterns, and slows reaction times. Under these conditions, the ability to walk or drive becomes noticeably impaired. In the next chapter, we examine in greater detail the

relationship between alcohol blood levels and driving ability. Higher doses of alcohol may cause the user to become highly irritable and emotional; displays of anger and crying are not uncommon. Extremely high doses may cause an individual to lapse into unconsciousness or even a comatose state that may precede a fatal depression of circulatory and respiratory functions.

Barbiturates

Barbiturates are commonly referred to as “downers” because they relax, create a feeling of well-being, and produce sleep. Like alcohol, barbiturates suppress the vital functions of the central nervous system. Collectively, barbiturates can be described as derivatives of barbituric acid, which was first synthesized by a German chemist, Adolf Von Bayer, more than a hundred years ago. Twenty-five barbiturate derivatives are currently used in medical practice in the United States; however, five—amobarbital, secobarbital, phenobarbital, pentobarbital, and butabarbital—tend to be used for most medical applications. Slang terms for “barbs” usually stem from the color of the capsule or tablet (for example, “yellow jackets,” “blue devils,” and “reds”).

Normally, barbiturate users take these drugs orally. The average sedative dose is about 10–70 milligrams. When taken in this fashion, the drug enters the blood through the walls of the small intestine. Some barbiturates, such as phenobarbital, are absorbed more slowly than others and are therefore classified as long-acting barbiturates. Undoubtedly, the slow action of phenobarbital accounts for its low incidence of abuse. Apparently, barbiturate abusers prefer the faster-acting ones—secobarbital, pentobarbital, and amobarbital. When taken in prescribed amounts, barbiturates are relatively safe, but in instances of extensive and prolonged use, physical dependence can develop. Since the early 1970s, a nonbarbiturate depressant, methaqualone (Quaalude), has appeared on the illicit-drug scene. Methaqualone is a powerful sedative and muscle relaxant that

possesses many of the depressant properties of barbiturates.

Tranquilizers

In the past forty-five years, the use of tranquilizers has grown dramatically. Although tranquilizers can be considered depressants, they differ from barbiturates in the extent of their actions on the central nervous system. Generally, these drugs produce a relaxing tranquility without impairing high-thinking faculties or inducing sleep. Antipsychotics such as reserpine and chlorpromazine have been used to reduce the anxieties and tensions of mental patients.

A group of antianxiety drugs is commonly prescribed to deal with the everyday tensions of many healthy people. These drugs include meprobamate (Miltown), chlordiazepoxide (Librium), and diazepam (Valium). Medical evidence shows that these drugs produce psychological and physical dependency with repeated and high levels of usage. For this reason, widespread prescribing of tranquilizers as a means of overcoming the pressures and tensions of life has worried many who fear the creation of a legalized drug culture.

"Glue Sniffing"

Since the early 1960s, the practice of sniffing materials containing volatile solvents (airplane glue or model cement, for example) has grown in popularity. Within recent years, another dimension has been added to the problem with the increasing number of incidents involving the sniffing of aerosol gas propellants such as freon. All materials used in sniffing contain volatile or gaseous substances that are primarily central nervous system depressants.

Although toluene seems to be the most popular solvent to sniff, others can produce comparable physiological effects. These chemicals include naphtha, methyl ethyl ketone, gasoline, and trichloroethylene.

The usual immediate effects of sniffing are a feeling of exhilaration and euphoria combined with slurred speech, impaired judgment, and double vision. Finally, the user may experience drowsiness and stupor, with these depressant effects slowly wearing off as the user returns to a normal state. Most experts believe that users become physiologically dependent on the effects achieved by sniffing. There is, however, little evidence to suggest that solvent inhalation is addictive. But sniffers expose themselves to the danger of liver, heart, and brain damage from the chemicals they have inhaled. Even worse, sniffing of some solvents, particularly halogenated hydrocarbons, is accompanied by a significant risk of death.

STIMULANTS

Amphetamines

Amphetamines are a group of synthetic drugs that stimulate the central nervous system. They are commonly referred to in the terminology of the drug culture as “uppers” or “speed.” Ordinary therapeutic doses of 5–20 milligrams per day, taken orally, provide a feeling of well-being and increased alertness that is followed by a decrease in fatigue and a loss of appetite. However, these apparent benefits of the drug are accompanied by restlessness and instability or apprehension, and once the **stimulant** effect wears off, depression may set in.

In the United States, the most serious form of amphetamine abuse stems from the intravenous injection of amphetamine or its chemical derivative, methamphetamine (see Figure 9–7). The desire for a more intense amphetamine experience is the primary motive for this route of administration. The initial sensation of a “flash” or “rush,” followed by an intense feeling of pleasure, constitutes the principal appeal of the intravenous route for the “speed freak.” During a “speed binge,” the individual may inject 500–1,000 milligrams of amphetamines every two to three

hours. Users have reported experiencing a euphoria that produces hyperactivity, with a feeling of clarity of vision as well as hallucinations. As the effect of the amphetamines wears off, the individual lapses into a period of exhaustion and may sleep continuously for one or two days. Following this, the user often experiences a prolonged period of severe depression, lasting from days to weeks.

A new smokable form of methamphetamine known as “ice” is reportedly in heavy demand in some areas of the United States. Ice is prepared by slow evaporation of a methamphetamine solution to produce large, crystal-clear “rocks.” Like crack cocaine (discussed next), ice is smoked and produces effects similar to those of crack cocaine, but the effects last for a longer period of time. Once the effects of ice wear off, users often become depressed and may sleep for days. Chronic users exhibit violent destructive behavior and acute psychosis similar to paranoid schizophrenia. Repeated use of amphetamines leads to a strong psychological dependency, which encourages their continued administration.

Cocaine

Between 1884 and 1887, Sigmund Freud created something of a sensation in European medical circles by describing his experiments with a new drug. He reported a substance of seemingly limitless potential as a source of “exhilaration and lasting euphoria” that permitted “intensive mental or physical work [to be] performed without fatigue… . It is as though the need for food and sleep was completely banished.”

The object of Freud’s enthusiasm was cocaine, a drug stimulant extracted from the leaves of *Erythroxylon coca*, a plant grown in tropical Asia and the Andes mountains of South America (see Figure 9–8). At one time, cocaine had wide medical application as a local painkiller or anes-

thetic. However, this function has now been largely replaced by other drugs, primarily procaine and lidocaine. Cocaine is also a powerful stimulant to the central nervous system, and its effects resemble those caused by the amphetamines—namely, increased alertness and vigor, accompanied by the suppression of hunger, fatigue, and boredom. Most commonly, cocaine is sniffed or "snorted" and is absorbed into the body through the mucous membranes of the nose.

One form of cocaine that has gained widespread popularity in the drug culture is known as *crack*. The process used to make crack is simple. Ordinary cocaine is mixed with baking soda and water into a solution that is then heated in a pot. This material is then dried and broken into tiny chunks that dealers sell as crack rocks. Crack is freebase cocaine and is sufficiently volatile to be smoked, usually in glass pipes. Crack, like cocaine that is snorted, produces a feeling of euphoria by stimulating a pleasure center in the base of the brain, in an area connected to nerves that are responsible for emotions. Cocaine stimulates this pleasure center to a far greater degree than it would ever normally be stimulated. The result is euphoria—a feeling of increased energy, of being mentally more alert, of feeling really good. The faster the cocaine level rises in the brain, the greater the euphoria, and the surest way to obtain a fast rise in the brain's cocaine level is to smoke crack. Inhaling the cocaine vapor gets a large wallop of the drug to the brain in less than fifteen seconds—about as fast as injecting it and much faster than snorting it. The dark side of crack, however, is that the euphoria fades quickly as cocaine levels drop, leaving the user feeling depressed, anxious, pleasureless. The desire to return to a euphoric feeling is so intense that crack users quickly develop a habit for the drug that is almost impossible to overcome. Only a small percentage of crack abusers will ever be cured of this drug habit.

In the United States, cocaine abuse is on the rise. Cocaine generates confidence and produces increased alertness, giving a false illusion that one is doing well at an assigned task. However,

some regular users of cocaine report accompanying feelings of restlessness, irritability, and anxiety. Cocaine used chronically or at high doses can have toxic effects. Cocaine-related deaths are a result of cardiac arrest or seizures followed by respiratory arrest. Many people are apparently using cocaine to improve their ability to work and to keep going when tired. While there is no evidence of physical dependency accompanying cocaine's repeated use, abstention from cocaine after prolonged use brings on severe bouts of mental depression, which produce a very strong compulsion to resume using the drug. In fact, laboratory experiments with animals have demonstrated that of all the commonly abused drugs, cocaine produces the strongest psychological compulsions for continued use.

The United States spends millions of dollars annually in attempting to control cultivation of the coca leaf in various South American countries and to prevent cocaine trafficking into the United States. Three-quarters of the cocaine smuggled into the United States is refined in clandestine laboratories in Colombia. The profits are astronomical. Peruvian farmers may be paid $200 for enough coca leaves to make one pound of cocaine. The refined cocaine is worth $1,000 when it leaves Colombia and sells at retail in the United States for up to $20,000.

CLUB DRUGS

The term *club drugs* refers to synthetic drugs that are used at nightclubs, bars, and raves (all-night dance parties). Substances that are often used as club drugs include, but are not limited to, MDMA (Ecstasy), GHB (gamma hydroxybutyrate), Rohypnol ("Roofies"), ketamine, and methamphetamine. These drugs have become popular at the dance scene to stimulate the rave experience. A high incidence of use has been found among teens and young adults.

The rave scene supports this type of drug use. Tablets can be easily hidden in various contain-

ers, such as Pez dispensers and other items not usually thought of as drug paraphernalia. The rave scene is often depicted as a room filled with people jumping and bouncing in unison for hours to loud rhythmic, trancelike music. The stimulatory effects of some of the club drugs allow for the users to be active for hours.

GHB and Rohypnol are central nervous system depressants that are often connected with drug-facilitated sexual assault, rape, and robbery. Effects accompanying the use of GHB include dizziness, sedation, headache, and nausea. Recreational users have reported euphoria, relaxation, disinhibition, and increased libido. Rohypnol causes muscle relaxation, loss of consciousness, and an inability to remember what happened during the hours after ingesting the drug. This is particularly a concern in a sexual assault because victims are physically unable to resist the attack. Unsuspecting victims become drowsy or dizzy. Effects are even stronger when the drug is combined with alcohol because the user experiences memory loss, blackouts, and disinhibition. Law enforcement agencies have warned multitudes of partygoers that drugs such as Rohypnol and GHB are odorless, colorless, and tasteless and so will remain undetected when slipped into a drink.

Methylenedioxymethamphetamine, also known as MDMA or Ecstasy, is the most popular drug at rave club scenes. Ecstasy is a synthetic, mind-altering drug that exhibits many hallucinogenic and amphetamine-like effects. Ecstasy was originally patented as an appetite suppressant and was later discovered to induce feelings of happiness and relaxation. Recreational drug users find that Ecstasy enhances self-awareness and decreases inhibitions. However, seizures, muscle breakdown, stroke, kidney failure, and cardiovascular system failure often accompany chronic use of Ecstasy. In addition, chronic use of Ecstasy leads to serious damage to the areas of the brain responsible for thought and memory. Ecstasy increases the heart rate and blood pressure; produces muscle tension, teeth grinding, and nausea; and causes psychological difficulties such as

confusion, severe anxiety, and paranoia episodes. The drug can cause significant increases in body temperature from the combination of the drug's stimulant effect with the often hot, crowded atmosphere of a rave club.

Ketamine is primarily used in veterinary medicine as an animal anesthetic. When used by humans, the drug can cause euphoria and feelings of unreality accompanied by visual hallucinations. Ketamine can also cause impaired motor function, high blood pressure, amnesia, and mild respiratory depression.

ANABOLIC STEROIDS

Anabolic steroids are synthetic compounds that are chemically related to the male sex hormone testosterone. Testosterone has two different effects on the body. It promotes the development of secondary male characteristics (androgen effects), and it accelerates muscle growth (anabolic effects). Efforts to promote muscle growth and to minimize the hormone's androgenic effects have led to the synthesis of numerous anabolic steroids. However, a steroid free of the accompanying harmful side effects of an androgen drug has not yet been developed.

Incidence of steroid abuse first received widespread public attention when both amateur and professional athletes were discovered using these substances to enhance their performance. Interestingly, current research on male athletes given anabolic steroids has generally found little or, at best, marginal evidence of enhanced strength or performance. While the full extent of anabolic steroid abuse by the general public is not fully known, the U.S. government is sufficiently concerned to regulate the availability of these drugs to the general population and to severely punish individuals for illegal possession and distribution of anabolic steroids. In 1991, anabolic steroids were classified as controlled dangerous substances, and the Drug Enforcement Administration

was given enforcement power to prevent their illegal use and distribution.

Anabolic steroids are usually taken by individuals who are unfamiliar with the harmful medical side effects. Liver cancer and other liver malfunctions have been linked to steroid use. These drugs also cause masculinizing effects in females, infertility, and diminished sex drive in males. For teenagers, anabolic steroids result in premature halting of bone growth. Anabolic steroids can also cause unpredictable effects on mood and personality, leading to unprovoked acts of anger and destructive behavior. Depression is also a frequent side effect of anabolic steroid abuse.

DRUG-CONTROL LAWS

Although the previous sections have attempted to classify drugs according to their physiological effects on the body, for practical purposes of law enforcement, the legal community requires a thorough knowledge of drug classification and definitions as they are delineated by drug laws. The medical and legal definitions or classifications of a drug often bear little resemblance. The provisions of drug laws are of particular interest to the criminalist, for they may impose specific analytical requirements on drug analysis. For example, the severity of a penalty associated with the manufacture, distribution, possession, and use of a drug may depend on the weight of the drug or its concentration in a mixture. In such cases, the chemist's report must contain all information that is needed to properly charge a suspect under the provisions of the existing law.

The provisions of any drug-control law are an outgrowth of national and local law enforcement requirements and customs, as well as the result of moral and political philosophies. These factors have produced a wide spectrum of national and local drug-control laws. Although their detailed discussion is beyond the intended scope of this book, a brief description of the U.S. federal law known as the Controlled Substances Act will illustrate a legal drug classification system

that has been created to prevent and control drug abuse. Many states have modeled their own drug-control laws after this act, an important step in establishing uniform drug-control laws throughout the United States.

Controlled Substances Act

The federal law establishes five schedules of classification (as outlined next) for controlled dangerous substances on the basis of a drug's potential for abuse, potential for physical and psychological dependence, and medical value. This classification system is extremely flexible in that the U.S. attorney general has the authority to add, delete, or reschedule a drug as more information becomes available. In addition, controlled dangerous substances listed in schedules I and II are subject to manufacturing quotas set by the attorney general. For example, eight billion doses of amphetamines were manufactured in the United States in 1971. In 1972, production quotas reduced amphetamine production approximately 80 percent below 1971 levels.

The criminal penalties for unauthorized manufacture, sale, or possession of controlled dangerous substances are related to the schedules as well. The most severe penalties are associated with drugs listed in schedules I and II. For example, for drugs included in schedules I and II, a first offense is punishable by up to 20 years in prison and/or a fine of up to $1 million for an individual or up to $5 million for other than individuals. Table 9–2 summarizes the control mechanisms and penalties for each schedule of the Controlled Substances Act.

Table 9–2 Control Mechanisms of the Controlled Substances Act

Schedule	Registration	Record Keeping	Manufacture	Distribution Re-	Dispensing Limits

			ing Quotas		**strictions**	
I	Required	Separate	Yes		Order forms	Research use only
II	Required	Separate	Yes		Order forms	Rx: written; no refills
III	Required	Readily retrievable	No *but*	Some drugs limited by schedule II quotas	Records required	Rx: written or oral; with medical authorization, refills up to 5 times in 6 months
IV	Required	Readily retrievable	No *but*	Some drugs limited by schedule II quotas	Records required	Rx: written or oral; with medical authorization, refills up to 5 times in 6 months
V	Required	Readily	No		Records re-	Over-the-

	retrievable	*but*	Some drugs limited by schedule II quotas	quired	counter (Rx drugs limited to MD's order)

Source: Drug Enforcement Administration, Washington, D.C.

Import–Export			**Manufacturer/Distributor Reports to Drug Enforcement Administration**	**Criminal Penalties for Individual Trafficking (First Offense)**
Narcotic	**Nonnarcotic**	**Security**		
Permit	Permit	Vault/safe	Yes	0–20 years/$1 million
Permit	Permit	Vault/safe	Yes	0–20 years/$1 million
Permit	Declaration	Secure storage area	Yes, narcotic No, nonnarcotic	0–5 years/$250,000
Permit	Declaration	Secure storage area	Manufacturer only, narcotic No, nonnarcotic	0–3 years/$250,000

Permit to import; declaration to export	Declaration	Secure storage area	Manufacturer only, narcotic No, nonnarcotic	0–1 year/$100,000

Schedule I. Schedule I drugs are deemed to have a high potential for abuse, have no currently accepted medical use in the United States, and/or lack accepted safety for use in treatment under medical supervision. Drugs controlled under this schedule include heroin, marijuana, methaqualone, and LSD.

Schedule II. Schedule II drugs have a high potential for abuse, a currently accepted medical use or a medical use with severe restrictions, and a potential for severe psychological or physical dependence. Schedule II drugs include opium and its derivatives not listed in schedule I, cocaine, methadone, phencyclidine (PCP), most amphetamine preparations, and most barbiturate preparations containing amobarbital, secobarbital, and pentobarbital. Dronabinol, the synthetic equivalent of the active ingredient in marijuana, has been placed in schedule II in recognition of its growing medical uses in treating glaucoma and chemotherapy patients.

Schedule III. Schedule III drugs have less potential for abuse than those in schedules I and II, a currently accepted medical use in the United States, and a potential for low or moderate physical dependence or high psychological dependence. Schedule III controls, among other substances, all barbiturate preparations (except phenobarbital) not covered under schedule II and certain codeine preparations. Anabolic steroids were added to this schedule in 1991.

Schedule IV. Schedule IV drugs have a low potential for abuse relative to schedule III drugs and have a current medical use in the United States; their abuse may lead to limited dependence relative to schedule III drugs. Drugs controlled in this schedule include propoxyphene

(Darvon); phenobarbital; and tranquilizers such as meprobamate (Miltown), diazepam (Valium), and chlordiazepoxide (Librium).

Schedule V. Schedule V drugs must show low abuse potential, have medical use in the United States, and have less potential for producing dependence than schedule IV drugs. Schedule V controls certain opiate drug mixtures that contain nonnarcotic medicinal ingredients.

The Controlled Substances Act also stipulates that an offense involving a controlled substance analog, a chemical substance substantially similar in chemical structure to a controlled substance, shall trigger penalties as if it were a controlled substance listed in schedule I. This section is designed to combat the proliferation of so-called "designer drugs." Designer drugs are substances that are chemically related to some controlled drugs and are pharmacologically very potent. These substances are manufactured by skilled individuals in clandestine laboratories, with the knowledge that their products will not be covered by the schedules of the Controlled Substances Act. For instance, fentanyl is a powerful narcotic that is commercially marketed for medical use and is also listed as a controlled dangerous substance. This drug is about 100 times as potent as morphine. Currently, a number of substances chemically related to fentanyl have been synthesized by underground chemists and sold on the street. The first such substance encountered was sold under the street name "China White." These drugs have been responsible for more than a hundred overdose deaths in California and nearly twenty deaths in western Pennsylvania. As designer drugs, such as China White, are identified and linked to drug abuse, they are placed in appropriate schedules.

The Controlled Substances Act also reflects an effort to decrease the prevalence of clandestine drug laboratories designed to manufacture controlled substances. The act regulates the manu-

facture and distribution of precursors, the chemical compounds used by clandestine drug laboratories to synthesize drugs of abuse. Targeted precursor chemicals are listed in the definition section of the Controlled Substances Act. Severe penalties are provided for a person who possesses a listed precursor chemical with the intent to manufacture a controlled substance or who possesses or distributes a listed chemical knowing, or having reasonable cause to believe, that the listed chemical will be used to manufacture a controlled substance. In addition, precursors to PCP, amphetamines, and methamphetamines are enumerated specifically in schedule II, making them subject to regulation in the same manner as other schedule II substances.

DRUG IDENTIFICATION

One only has to look into the evidence vaults of crime laboratories to appreciate the assortment of drug specimens that confront the criminalist. The presence of a huge array of powders, tablets, capsules, vegetable matter, liquids, pipes, cigarettes, cookers, and syringes is testimony to the vitality and sophistication of the illicit-drug market. If outward appearance is not evidence enough of the difficult analytical chore facing the forensic chemist, consider the complexity of the drug preparations themselves. Usually these contain active drug ingredients of unknown origin and identity, as well as additives—for example, sugar, starch, and quinine—that dilute their potency and stretch their value on the illicit-drug market. Do not forget that illicit-drug dealers are not hampered by governmental regulations that ensure the quality and consistency of a product.

When a forensic chemist picks up a drug specimen for analysis, he or she can expect to find just about anything, so all contingencies must be prepared for. The analysis must leave no room for error, because its results will have a direct bearing on the process of determining the guilt or innocence of a defendant. There is no middle ground in drug identification—either the specimen

is a specific drug or it is not—and once a positive conclusion is drawn, the chemist must be prepared to support and defend the validity of the results in a court of law.

The challenge or difficulty of forensic drug identification comes in selecting analytical procedures that will ensure a specific identification of a drug. Presented with a substance of unknown origin and composition, the forensic chemist must develop a plan of action that will ultimately yield the drug's identity. This plan, or scheme of analysis, is divided into two phases. First, faced with the prospect that the unknown substance may be any one of a thousand or more commonly encountered drugs, the analyst must employ **screening tests** to reduce these possibilities to a small and manageable number. This objective is often accomplished by subjecting the material to a series of color tests that produce characteristic colors for the more commonly encountered illicit drugs. Even if these tests produce negative results, their value lies in having excluded certain drugs from further consideration.

Once the number of possibilities has been substantially reduced, the second phase of the analysis must be devoted to pinpointing and confirming the drug's identity. In an era in which crime laboratories receive voluminous quantities of drug evidence, it is impractical to subject a drug to all the chemical and instrumental tests available. Indeed, it is more realistic to look on these techniques as constituting a large analytical arsenal. The chemist, aided by training and experience, must choose tests that will most conveniently furnish the identity of a particular drug.

Forensic chemists often use a specific test (such as infrared spectrophotometry or mass spectrometry) to identify a drug substance to the exclusion of all other known chemical substances. A single test that identifies a substance is known as a **confirmation**. The analytical scheme sometimes consists of a series of nonspecific or presumptive tests. Each test in itself is insufficient to prove the drug's identity; however, the proper analytical scheme encompasses a combination of

test results that characterize one and only one chemical substance—the drug under investigation. Furthermore, experimental evidence must confirm that the probability of any other substance responding in an identical manner to the scheme selected is so small as to be beyond any reasonable scientific certainty.

Forensic chemists normally rely on several tests for a routine drug-identification scheme: color tests, microcrystalline tests, chromatography, spectrophotometry, and mass spectrometry.

Color Tests

Many drugs yield characteristic colors when brought into contact with specific chemical reagents. Not only do these tests provide a useful indicator of a drug's presence, but they are also used by investigators in the field to examine materials suspected of containing a drug (see Figure 9–9).[2] However, color tests are useful for screening purposes only and are never taken as conclusive identification of unknown drugs.

Five primary color test reagents are as follows:

1. *Marquis* (2 percent formaldehyde in sulfuric acid). The reagent turns purple in the presence of heroin and morphine and most opium derivatives. Marquis also becomes orange-brown when mixed with amphetamines and methamphetamines.
2. *Dillie-Koppanyi* (1 percent cobalt acetate in methanol is first added to the suspect material, followed by 5 percent isopropylamine in methanol). This is a valuable screening test for barbiturates, in whose presence the reagent turns violet-blue in color.
3. *Duquenois-Levine* (solution A is a mixture of 2 percent vanillin and 1 percent acetaldehyde in ethyl alcohol; solution B is concentrated hydrochloric acid; solution C is chloroform). This is a valuable color test for marijuana, performed by adding solutions A, B, and C, respectively,

to the suspect vegetation. A positive result is shown by a purple color in the chloroform layer.

4. *Van Urk* (1 percent solution of p-dimethylaminobenzaldehyde in 10 percent concentrated hydrochloric acid and ethyl alcohol). The reagent turns blue-purple in the presence of LSD. However, owing to the extremely small quantities of LSD in illicit preparations, this test is difficult to conduct under field conditions.

5. *Scott Test* (solution A is 2 percent cobalt thiocyanate dissolved in water and glycerine [1:1]; solution B is concentrated hydrochloric acid; solution C is chloroform). This is a color test for cocaine. A powder containing cocaine turns solution A blue. Upon addition of B, the blue color is transformed to a clear pink color. Upon addition of C, if cocaine is present, the blue color reappears in the chloroform layer.

Microcrystalline Tests

A technique considerably more specific than color tests is the **microcrystalline test**. A drop of a chemical reagent is added to a small quantity of the drug on a microscopic slide. After a short time, a chemical reaction ensues, producing a crystalline precipitate. The size and shape of the crystals, under microscope examination, are highly characteristic of the drug. Crystal tests for cocaine are illustrated in Figure 9–10.

Over the years, analysts have developed hundreds of crystal tests to characterize the most commonly abused drugs. These tests are rapid and often do not require the isolation of a drug from its diluents; however, because diluents can sometimes alter or modify the shape of the crystal, the examiner must develop experience in interpreting the results of the test.

Most color and crystal tests are largely empirical—that is, scientists do not fully understand why they produce the results that they do. From the forensic chemist's point of view, this is not

important. When the tests are properly chosen and are used in proper combination, their results constitute an analytical scheme that is characteristic for one and only one drug.

Chromatography

Thin-layer and gas chromatography are especially well suited to the needs of the drug analyst, because they separate drugs from their diluents while providing for their tentative identification. The basic principles of these techniques have already been described in Chapter 5.

Because chromatography requires a comparison of either R_f or retention-time values between questioned and known drugs, the analyst must have some clue to the identity of the illicit material before using these techniques. Hence, in a typical drug analysis, chromatography accompanies and complements color and crystal tests.

Spectrophotometry

Selective absorption of UV and IR light by drugs provides a valuable technique for characterizing drugs. The ultraviolet spectrum is not conclusive for positive identification of a drug, because other materials may very well produce an indistinguishable spectrum. Nevertheless, UV spectrophotometry is often a useful technique for establishing the *probable* identity of a drug. For example, if an unknown substance yields a UV spectrum that resembles that of amphetamine (see Figure 9–11), thousands of substances are immediately eliminated from consideration, and the analyst can begin to identify the material from a relatively small number of possibilities. A comprehensive collection of UV drug spectra provides a ready index that can rapidly be searched in order to tentatively identify a drug or, failing that, at least to exclude certain drugs from consideration.

Infrared spectrophotometry is one of the few analytical techniques that can specifically iden-

tify a substance. The pattern of an infrared spectrum is unique for each compound and can thus serve as a "fingerprint" of the compound. The combination of preliminary screening tests with a final verification by infrared spectrophotometry offers an ideal approach to drug identification. Unfortunately, the technique does present some problems because the substance to be identified must be as pure as possible. This requirement often necessitates lengthy purification steps to prepare the sample for IR analysis. The IR spectra of heroin and secobarbital were shown in Figure 5–19.

Mass Spectrometry

The technique of chromatography is particularly suited for analyzing illicit drugs, because it can readily separate a drug from other substances that may be present in the drug preparation. Chromatography does, however, have the drawback of not being able to provide a specific identification of the material under investigation. This deficiency has been overcome by linking the gas chromatograph to a mass spectrometer (see the discussion on pp. 150–154) to yield a very powerful combination known as *gas chromatography/mass spectrometry* (GC/MS). As a sample emerges from the gas chromatograph, it immediately enters the mass spectrometer. Here, the sample is exposed to high-energy electrons, which cause the sample molecules to fragment or break apart. With few exceptions, no two substances fragment in the same fashion; hence, this fragmentation pattern serves as a "fingerprint" of a chemical substance. The fragmentation patterns of heroin and cocaine were shown in Figure 5–21.

With data obtained from a GC/MS determination, a forensic analyst can, with one instrument, separate the components of a complex drug mixture and then unequivocally identify each substance present in the mixture (see Figure 5–20).

The Identification of Marijuana

Enforcement of laws prohibiting the sale and use of marijuana accounts for a high percentage of drug arrests in the United States. Any trial or hearing involving a seizure of marijuana requires identification of the material before the issue of guilt or innocence can be decided.

Unlike most other drugs received by the crime laboratory, marijuana (*Cannabis sativa L.*) possesses botanical features that impart identifiable characteristics. Because most marijuana specimens consist of small leaf fragments, their identification must be partially based on botanical features observed under the microscope by a trained expert. This approach is further augmented with a chemical test that will independently confirm the findings of the botanical examination.

The identification of marijuana by microscopic methods depends largely on observing short hairs shaped like "bear claws" on the upper side of the leaf (see the SEM photo in Figure 7–12). These hairs are known as *cystolithic hairs*. Further verification of the identity of marijuana is confirmed by the presence of longer, nonglandular hairs on the opposite side of the leaf.

The Duquenois-Levine color test, described earlier in this chapter, is a highly but not totally specific test for marijuana. However, when used in combination with a botanical examination, the results constitute a specific identification of marijuana. In addition, the analyst may be unable to obtain a microscopic identification of the marijuana leaf, as in the case of hashish or hashish oil. Here, the color test has to be supplemented by another examination, preferably thin-layer chromatography. This method involves separating chemical constituents found in the suspect resin on a thin-layer plate. The separated components are compared on the same plate to those obtained from a known marijuana extract, as shown in Figure 5–10. In this manner, a positive TLC comparison, used in conjunction with the Duquenois-Levine color test, constitutes a specific identifi-

cation for marijuana.

COLLECTION AND PRESERVATION OF DRUG EVIDENCE

Preparation of drug evidence for submission to the crime laboratory is normally a relatively simple task, accomplished with minimal precautions in the field. The field investigator has the responsibility of ensuring that the evidence is properly packaged and labeled for delivery to the laboratory. Considering the countless forms and varieties of drug evidence seized, it is not practical to prescribe any single packaging procedure for fulfilling these requirements. Generally, common sense is the best guide in such situations, keeping in mind that the package must prevent the loss and/or cross-contamination of the contents. Often, the original container in which the drug was seized will suffice to meet these requirements. Specimens suspected of containing volatile solvents, such as those involved in glue-sniffing cases, must be packaged in an airtight container to prevent evaporation of the solvent.

All packages must be marked with sufficient information to ensure identification by the officer in future legal proceedings and to establish the chain of custody.

To aid the drug analyst, the investigator should supply any background information that may relate to a drug's identity. Analysis time can be markedly reduced when this information is at the disposal of the chemist. For the same reason, the results of drug-screening tests used in the field must also be transmitted to the laboratory. However, although these tests may indicate the presence of a drug and may help the officer establish probable cause to search and arrest a suspect, they do not offer conclusive evidence of a drug's identity.

Chapter Summary

A drug can be defined as a natural or synthetic substance that is used to produce physiological or psychological effects in humans or other higher-order animals.

Narcotic drugs are analgesics, meaning they relieve pain by depressing the central nervous system. Regular use of a narcotic drug leads to physical dependence. The most common source of narcotic drugs is opium. Morphine is readily extracted from opium and is used to synthesize heroin. Opiates, which include methadone and OxyContin (oxycodone), are not derived from opium or morphine, but they have the same physiological effects on the body as do opium narcotics. Another class of drugs is hallucinogens; marijuana is the most well-known member of this class. Hallucinogens cause marked changes in mood, attitude, thought processes, and perceptions. Marijuana is the most controversial drug in this class because its long-term effects on health are still largely unknown. Other hallucinogens include LSD, mescaline, PCP, psilocybin, and MDMA (Ecstasy).

Depressants are another class of drugs. These include alcohol (ethanol), barbiturates, tranquilizers, and various substances that can be sniffed, such as airplane glue and model cement. Stimulants include amphetamines, sometimes known as “uppers” or “speed,” and cocaine, which in its free-base form is known as *crack*. The term *club drugs* refers to synthetic drugs that are used at nightclubs, bars, and raves (all-night dance parties). Substances that are often used as club drugs include, but are not limited to, MDMA (Ecstasy), GHB (gamma hydroxybutyrate), Rohypnol (“Roofies”), ketamine, and methamphetamine. Yet another category of drugs is anabolic steroids, which are synthetic compounds that are chemically related to the male sex hormone testosterone. Anabolic steroids are often abused by individuals who want to accelerate muscle growth. Federal law establishes five schedules of classification for controlled dangerous substances on the basis of a drug’s potential for abuse, potential for physical and psychological dependence, and medical

value.

Faced with the prospect that the unknown substance may be any one of a thousand or more commonly encountered drugs, the analyst must employ screening tests to reduce these possibilities to a small and manageable number. This objective is often accomplished by subjecting the material to a series of color tests that produce characteristic colors for the more commonly encountered illicit drugs. Once this preliminary analysis is completed, a confirmation is pursued. Forensic chemists use a specific test to identify a drug substance to the exclusion of all other known chemical substances. Typically infrared spectrophotometry or mass spectrometry is used to specifically identify a drug substance.

Review Questions

1. True or False: Underlying emotional factors are the primary motives leading to the repeated use of a drug. _____
2. Drugs such as alcohol, heroin, amphetamines, barbiturates, and cocaine can lead to a (high, low) degree of psychological dependence with repeated use.
3. The development of (psychological, physical) dependence on a drug is shown by withdrawal symptoms such as convulsions when the user stops taking the drug.
4. True or False: Abuse of barbiturates can lead to physical dependency. _____
5. True or False: Repeated use of LSD leads to physical dependency. _____
6. Physical dependency develops only when the drug user adheres to a _____ schedule of drug intake.
7. Narcotic drugs are _____ that _____ the central nervous system.

8. _____ is a gummy, milky juice exuded through a cut made in the unripe pod of the opium poppy.

9. The primary constituent of opium is _____.

10. _____ is a chemical derivative of morphine made by reacting morphine with acetic anhydride.

11. A legally manufactured drug that is chemically related to heroin and heavily abused is _____.

12. True or False: Methadone is classified as a narcotic drug, even though it is not derived from opium or morphine. _____

13. Drugs that cause marked alterations in mood, attitude, thought processes, and perceptions, are called _____.

14. _____ is the sticky resin extracted from the marijuana plant.

15. The active ingredient of marijuana largely responsible for its hallucinogenic properties is _____.

16. True or False: The potency of a marijuana preparation depends on the proportion of the various plant parts in the mixture. _____

17. The marijuana preparation with the highest THC content is _____.

18. LSD is a chemical derivative of _____, a chemical obtained from the ergot fungus that grows on certain grasses and grains.

19. The drug phencyclidine is often manufactured for the illicit-drug market in _____ laboratories.

20. Alcohol (stimulates, depresses) the central nervous system.

21. _____ are called “downers” because they depress the central nervous system.

22. Phenobarbital is an example of a (short-, long-) acting barbiturate.

23. _____ is a powerful sedative and muscle relaxant that possesses many of the depressant properties of barbiturates.

24. _____ are drugs used to relieve anxiety and tension without inducing sleep.

25. True or False: Glue sniffing stimulates the central nervous system. _____

26. _____ are a group of synthetic drugs that stimulate the central nervous system.

27. The most severe form of amphetamine abuse stems from its (oral, intravenous) administration.

28. An increasing percentage of amphetamines available on the illicit-drug market originate from _____ drug laboratories.

29. _____ is extracted from the leaf of the coca plant.

30. Traditionally, cocaine is _____ into the nostrils.

31. True or False: Cocaine is a powerful central nervous system depressant. _____

32. The two drugs usually associated with drug-facilitated sexual assaults are _____ and _____.

33. _____ steroids are designed to promote muscle growth but have harmful side effects.

34. The federal drug-control law is known as _____.

35. Federal law establishes _____ schedules of classification for the control of dangerous drugs.

36. Drugs that have no accepted medical use are placed in schedule _____.

37. Librium and Valium are listed in schedule _____.

38. True or False: Color tests are used to identify drugs conclusively. _____

39. The _____ color test reagent turns purple in the presence of heroin.

40. The _____ color test reagent turns orange-brown in the presence of amphetamines.

41. The Duquenois-Levine test is a valuable color test for _____.

42. The _____ test is a widely used color test for cocaine.

43. _____ tests tentatively identify drugs by the size and shape of crystals formed when the drug is mixed with specific reagents.

44. _____ provides a means of separating drugs from their diluents while making a tentative identification.

45. The pattern of an _____ absorption spectrum is unique for each drug and thus is a specific test for identification.

46. The gas chromatograph, in combination with the _____, can separate the components of a drug mixture and then unequivocally identify each substance present in the mixture.

47. Microscopic identification of marijuana largely depends on observing short hairs on the leaf known as _____ hairs.

48. All packages containing drugs must be marked for identification by the police officer before being sent to the laboratory in order to maintain the _____.

Further References

Bono, J. P., “Criminalistics—Introduction to Controlled Substances,” in S. B. Karch, ed., *Drug Abuse Handbook.* Boca Raton, Fla.: Taylor & Francis, 1998.

Christian, D. R., Jr., “Analysis of Controlled Substances,” in S. H. James and J. J. Nordby, eds., *Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd ed.* Boca Raton, Fla.: Taylor & Francis, 2005.

Siegel, J. A., “Forensic Identification of Controlled Substances,” in R. Saferstein, ed., *Forensic Science Handbook*, vol. 2, 2nd ed. Upper Saddle River, N.J.: Prentice Hall, 2005.

Smith, F., and J. A. Siegel, eds., *Handbook of Forensic Drug Analysis.* Boca Raton, Fla.: Taylor & Francis, 2005.

Psychological Dependence

Conditioned use of a drug caused by underlying emotional needs.

Physical Dependence

Physiological need for a drug that has been brought about by its regular use. Dependence is characterized by withdrawal sickness when administration of the drug is abruptly stopped.

Narcotic

An analgesic or pain-killing substance that depresses vital body functions such as blood pressure, pulse rate, and breathing rate. Regular administration of narcotics produces physical dependence.

Analgesic

A drug or substance that lessens or eliminates pain.

Hallucinogen

A substance that induces changes in mood, attitude, thought processes, and perceptions.

Depressant

A substance that depresses the functions of the central nervous system. Depressants calm irritability and anxiety and may induce sleep.

Stimulant

A substance taken to increase alertness or activity.

Anabolic Steroids

Steroids that promote muscle growth.

Screening Test

A test that is nonspecific and preliminary in nature.

Confirmation

A single test that specifically identifies a substance.

Microcrystalline Tests

Tests to identify specific substances by the color and morphology of the crystals formed when the substance is mixed with specific reagents.

(a)

(b)

Figure 9–1 The opium poppy and its derivatives. Shown are the poppy plant, crude and smoking opium, codeine, heroin, and morphine. *Courtesy Pearson Education/PH College*

Figure 9–2 Heroin paraphernalia. *Courtesy Drug Enforcement Administration*

Figure 9–3 Several rolled marijuana cigarettes lie on a pile of crushed dried marijuana leaves next to a tobacco cigarette. *Courtesy U.S. Department of Justice, Drug Enforcement Administration*

Figure 9–4 Blocks of hashish in front of leaves and flowering tops of the marijuana plant. *Courtesy James King-Holmes, Photo Researchers, Inc.*

Figure 9–5 The marijuana leaf. *Courtesy Drug Enforcement Administration*

Figure 9–6 Scene from a clandestine drug laboratory. *Courtesy Drug Enforcement Administration*

Figure 9–7 Granular amphetamine beside a razor blade. *Courtesy Cordelia Molloy, Photo Researchers, Inc.*

Figure 9–8 Coca leaves and illicit forms of cocaine. *Courtesy Drug Enforcement Administration*

Figure 9–9 A field color test kit for cocaine. The suspect drug is placed in the plastic pouch. Tubes containing chemicals are broken open and the color of the chemical reaction is observed. *Courtesy Tri-Tech, Inc., Southport, N.C., www.tritechusa.com*

Figure 9–10 (a) A photomicrograph of a cocaine crystal formed in platinum chloride (400×). (b) A photomicrograph of a methamphetamine crystal formed in gold chloride (400×). *Courtesy David P. Blackburn, San Bernardino County Sheriff's Department, San Bernardino, Calif.*

Figure 9–11 Ultraviolet spectrum of amphetamine.

[1] *Marijuana—A Signal of Misunderstanding* (Washington, D.C.: U.S. Government Printing Of-

fice, 1972), p. 56.

[2] Field-color test kits for drugs can be purchased from various commercial manufacturers.