12 Nonmedical Drug Usage

This chapter provides a basic account of nonmedical cannabis drug consumption, mostly for recreational enjoyment, occasionally for religious or ritualistic purposes. An understanding of the nature of nonmedical usage to alter consciousness is needed to understand the context for employing *Cannabis sativa* for the authorized medical purposes documented in Chapter 13 and the recreational possibilities described in Chapter 15. There are hundreds of books providing instructions on the (usually illegal) preparation and use of cannabis products. Most of these masquerade as "educational" works and slyly provide disclaimers that laws should not be contravened. For a period in the late twentieth century, law enforcement authorities attempted to prohibit the sale and distribution of such volumes, but with an endless supply of articles now on the Web, this has proven futile. The fact is, despite the usually illegal status of cannabis, marijuana is being generated and used in huge quantities, and society in general has become quite knowledgeable about the subject. However, it is also true that a great deal of misinformation is in circulation.

RELIABILITY OF COUNTERCULTURE INFORMATION

Voluminous information on many aspects concerned with the nonmedical use of cannabis is available in drug counterculture/underground publications, both in print and on the Web. Such works typically advocate (explicitly or implicitly) the consumption of restricted (usually proscribed) drugs for recreational use and additionally often provide instructions for obtaining, preparing, or using such drugs. Most of these publications are authored anonymously or under pseudonyms. Particular publications may not be *illicit* (habitually, phrases like "Do not contravene any local laws!" are inserted, tongue-in-cheek); they may not entirely represent the *counterculture* (usually conceived of as representing a minority viewpoint); and they may not be *underground* (some jurisdictions are more permissive with respect to illicit drugs than others, and cannabis books that once could have led to prosecution are now being widely printed and circulated by the publishing industry). An appreciable proportion of the information in most of these publications is either invalid or seriously suspect. On the other hand, some of the content has been compiled as a result of careful observation, experimentation and/or inventiveness and is often mentioned in this book.

THE CANNABIS EXPERIENCE

Biphasic Effects

Cannabis and some of its constituent cannabinoids can generate "biphasic effects," a phrase that can mean "two phases" but in the case of cannabis refers to different responses: low doses produce symptoms or consequences opposite to those resulting from high doses. As noted by Ashton et al. (2005), many of the psychological effects of cannabis (particularly of THC) "are biphasic and bidirectional, depending on dose, mode of administration, environment, expectation, personality, degree of tolerance and other individual factors, as well as time-frame… Thus, acute effects in normal subjects can include euphoria or dysphoria, relaxation or anxiety, excitation followed by sedation, heightened perception followed by perceptual distortion, and increased motor activity followed by incoordination." The dual nature of cannabis was appreciated in ancient civilizations, particularly India and China. For example, the first century AD Chinese classic medical pharmacopeia *Ben Ts'ao* pointed out that cannabis was a benign treatment for numerous maladies, "but

when taken in excess it could cause seeing devils" (Mechoulam 1986; Mechoulam and Parker 2013a).

Sequence of Psychological Impacts

Iversen (2000) recognized four stages or phases of cannabis intoxication: "buzz," "high," "stoned," and "come-down." During the short initial "buzz," the user may feel lightheaded or slightly dizzy, and tingling may occur in the extremities or elsewhere. During the "high," there may be euphoria, exhilaration, and unrestrained behavior such as giggling, laughter, talkativeness, and other forms of sociability. When "stoned," the user usually feels calm, relaxed, and happy and may feel as if in a dreamlike state. After several hours, the come-down period occurs, marked by diminishment of the sensations. Iverson's analysis is debatably applicable to most people, especially to the effects of certain marijuana strains, but (in common with many drugs, including alcohol) conforms to a sort of bell curve of a gradually increasing, peak, and gradually decreasing set of reactions.

Pleasant Psychological Effects

Recreational usage of marijuana, for at least the majority of regular consumers, is employed for fun (Figure 12.1). It usually produces mild euphoria (a "high"), relaxation, decreased anxiety, and reduction of inhibitions. There are often accompanying decreases in abilities to judge time and focus intellectually and induction of sleepiness and incoordination, but these symptoms are expected in experienced users and may even be welcome. Some sensory perceptions frequently become more intense, and these may include those associated with hunger, sex, music, and other pleasurable activities. Marijuana is usually consumed in a group setting (it is said to increase sociability), which contributes to the enjoyment of the experience. "Social setting and expectations have a great effect on the perceived state of 'intoxication' induced by marijuana" (Yazulla 2008).

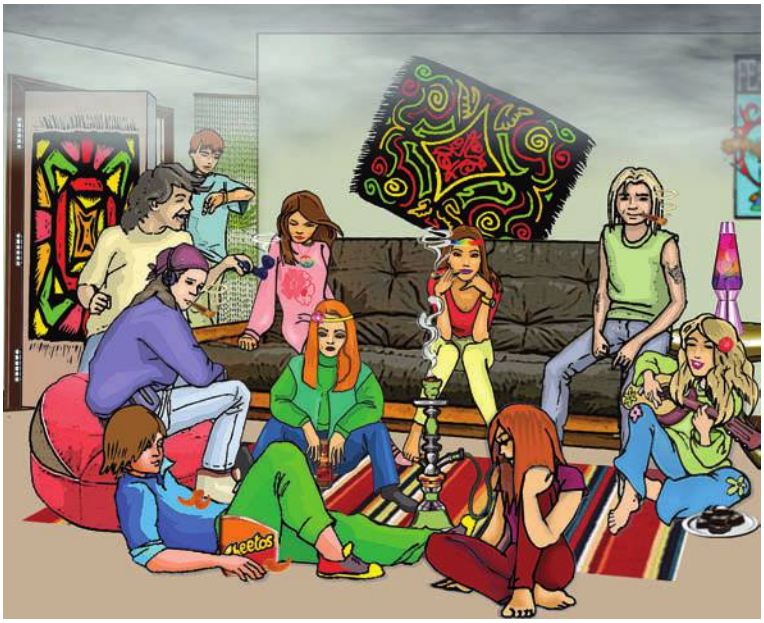

FIGURE 12.1 Social intoxicant usage of marijuana. Prepared by B. Brookes.

Unpleasant Psychological Symptoms

Because the drug is usually taken in an illegal setting, there may be anxiety or guilt associated with the possibility of being exposed. Most users today, however, have limited concerns for the legal status or possible harm related to marijuana and do not feel the shame and fear that are frequent with other illegal drugs. There is considerable variation in individual reaction, with personality playing a significant role, and some, particularly naïve users and those in stressful situations, can experience anxiety to the level of panic, paranoia, and psychosis (Gregg et al. 1976; Kalant 2001; Hall and Pacula 2003). Unpleasant psychological reactions occasionally occur and may include anxiety, depressed mood, dizziness, and panic attacks. Psychotic symptoms like delusions and hallucinations are rare but more likely at very high doses of THC. High doses can cause dysphoria (a profound state of unease or dissatisfaction), sensory distortion, and even hallucinations. As discussed in the next chapter, the particular constituents present in given samples of cannabis can result in different psychological effects.

Couchlock

"Couchlock" (also couch lock and couch-lock) refers to a state of extreme lethargy (literally to the point of being unable to rise from one's couch) resulting from smoking marijuana. "Zapped," "zonked," and "zombied" are occasionally terms also employed to indicate profound physical tiredness induced by marijuana. Couchlock has often been attributed to the sedative effect of the considerable cannabidiol (CBD) in indica strains but seems to result from a sedative interaction of THC and strains high in the terpene myrcene (Russo 2011a). As noted in Chapter 2, myrcene contributes to the sedative effect of *Humulus*, the sister genus of *Cannabis*.

Physiological Effects

Short-term noticeable physiological effects may include an increase in heart rate, a decrease in blood pressure when standing, dry mouth ("cotton mouth," "pasties"), lowering of body temperature, increased oxygen demand, reduced tear flow, reduced bowel movement, and delayed gastric emptying (Fišar 2009b).

"Red eye" (redeye, bloodshot eye, or conjunctival vasodilation) is another common effect of smoking marijuana (not to be confused with photographic redeye due to reflection of flash light from the retina). Red eye is redness of the sclera or white region of the eye (Figure 12.2) due to vasodilation of small vessels in the eye or occasionally simply from irritating marijuana smoke. Although red eye may result from smoking marijuana, the occurrence of pupil dilation, widely thought to occur, has been challenged (Weil et al. 1968; also see the next chapter).

FIGURE 12.2 Red eye caused by smoking marijuana. Photo by Psychonaught (released into the public domain).

HEALTH RISKS

Although cannabis is an enjoyable diversion for most, there are potential hazards associated with nonmedical usage of marijuana. Of course, purchasing material from criminals and exposure to prosecution are dangers that can indirectly be harmful psychologically and physically. There is no shortage of studies showing harmful psychological and physiological effects of marijuana, but, as pointed out in the next chapter, essentially only studies intended to demonstrate negative effects of marijuana consumption have been permitted until very recently, and research funding has been predicated on documenting the harmfulness of marijuana.

As pointed out in Chapter 13, a range of opinion exists in the medical community regarding just how hazardous consumption of marijuana is with respect to *causing* particular illnesses, just as there is a range of opinion with regard to how beneficial medical marijuana is with respect to *alleviating* particular illnesses. As also noted in Chapter 15, the official position of many national governments (particularly in North America) is (or at least has been until recently) that herbal marijuana is a dangerous "narcotic" with absolutely no valid medical value.

Health risks mentioned in the context of using medical marijuana are discussed in the next chapter. Except for the special hazards experienced by patients with weakened immune or cardiac systems (examined in the next chapter), the risks of using medical marijuana are essentially the same as for healthy people using recreational marijuana. The specific risks associated with smoking, hazardous contaminants, pathogens, pregnancy, and lactation are also discussed in the next chapter. The majority of medical associations have issued statements noting the potential harmfulness of marijuana and usually also indicating the need for research before it is accepted for medical usage. For example, the American Psychiatric Association (2013) revised *Diagnostic and Statistical Manual of Mental Disorders* warns that use of marijuana can progress to "marijuana use disorder," a condition requiring treatment. Kepp and Raich (2014) list the position statements on the use of medical marijuana of numerous medical organizations. While most such evaluations are rather negative, as detailed in the next chapter, there are quite promising therapeutic applications under examination and development. The following comments regarding health risks are pertinent to the recreational usage of marijuana.

Concern for Mental Status

There are many publications documenting mental health concerns associated with marijuana, including the possibilities of addiction and mental illness (Fernández-Artamendi et al. 2011; Zvolensky et al. 2011; Bostwick 2012; Greydanus et al. 2013; Karila et al. 2014; Lev-Ran et al. 2014; Rubino and Parolaro 2014; Volkow et al. 2014). Cannabis is extraordinarily attractive to adolescents (Figure 12.3), and the possible effects on the mental health of the young are the leading health concern associated with recreational marijuana. Moore et al. (2007) wrote "there is now sufficient evidence to warn young people that using cannabis could increase their risk of developing a psychotic illness later in life."

Possibly the most human characteristic is our advanced degree of cognition—the brain's ability to acquire, store, and later retrieve new information. Numerous studies have concluded that marijuana is not completely without serious risk for mental status. "Clearly, the chief psychoactive component in cannabis, THC, produces acute cognitive disturbances in humans and animals, more profoundly affecting short-term than long-term memory" (Mechoulam and Parker 2013a). Gilman et al. (2014) studied the brains of young recreational users ranging in age from 18 to 25 years and found "that in young, recreational marijuana users, structural abnormalities in gray matter density, volume, and shape of the nucleus accumbens and amygdala can be observed." Some reports have found that chronic marijuana use over several years produces quite significant cognitive impairments; others dispute the validity of these studies (Mechoulam and Parker 2013a). Jager (2012) stated, "Taken together, studies on long-term effects of cannabis on cognition have failed to find proof of

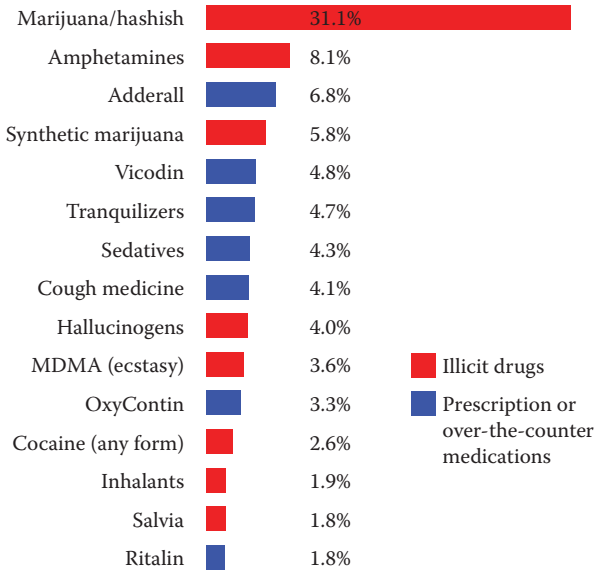

FIGURE 12.3 Annual use in 2014 (at least once) of recreational drugs by high school seniors (grade 12) in the United States. Sample size = 12,400. During the year, 38.7% of the students employed one of the illicit drugs shown at least once annually, 60.2% consumed alcohol at least once annually (37.4% at least once monthly), and 6.7% smoked tobacco daily. Based on information from the University of Michigan "Monitoring the Future" website (http://www.monitoringthefuture.org/), sponsored by the U.S. National Institute on Drug Abuse (NIDA).

gross abnormalities, but there is some evidence for mild cognitive impairments, particularly in the domain of memory and learning… The majority of recreational cannabis users does not experience serious adverse reactions and is able to regulate their use. However, a minority of frequent or long-term users will develop problems."

In a very extensive meta-analysis, Minozzi et al. (2010) stated, "We conclude that there is insufficient knowledge to determine the level of risk associated with cannabis use in relation to psychotic symptoms and that more information is needed on both the risks of cannabis use and the benefits of preventive interventions to support evidence-based approaches in this area." Radhakrishnan et al. (2014) concluded that there is danger of precipitating mental illness in those vulnerable to mental problems and risk of seriously aggravating mental conditions in those already suffering from mental problems. However, Zammit et al. (2008) were of the view that the degree of risk has not been clearly evaluated. A study by Phillips et al. (2002) suggested that marijuana use in a study group of patients at risk of developing psychosis did not increase that risk. Ksir and Hart (2016) reviewed studies of cannabis and psychosis and concluded that the research "suggests that cannabis does not in itself cause a psychosis disorder. Rather, the evidence leads us to conclude that both early use and heavy use of cannabis are more likely in individuals with a vulnerability to psychosis." Clearly, there is not a clear consensus on the potential serious harm that marijuana poses to human cognition.

Cannabis Dependence

"Addiction" as a term has become less popular in medicine; "dependence" is the preferred term for extreme, excessive harmful usage. Nevertheless, severe, chronic dependence is usually called addiction. "Abuse" can be employed to refer to a lesser degree of overuse.

The risk of addiction from cannabis is considerably lower than that of numerous prescribed and illegal agents (Grotenhermen and Russo 2002; Guzmán 2003). While the addictive potential of

cannabis is low compared to nicotine, alcohol, and some controlled drugs, there is general agreement that compulsive usage sometimes develops. "Physical dependence" on cannabis has not been demonstrated (Gordon et al. 2013), but psychological dependence on cannabis is often accepted as a genuine phenomenon (e.g., Norberg et al. 2012). Gardner (2014) stated, "It seems irrefutable that cannabis can be considered to be addictive at the human level."

The *Diagnostic and Statistical Manual of Mental Disorders*, published by the American Psychiatric Association headquartered in Washington, DC (fifth edition published in 2013), is the official analytical system for mental disorders in the United States. The *International Classification of Diseases* published by the World Health Organization (10th edition completed in 1992, 11th edition due in 2017) is the other major professional manual for mental disorders, although it covers all health conditions and is used mainly outside the United States. Both manuals accept "cannabis dependence" (cannabis use disorder) as a psychological condition requiring treatment. Budney et al. (2007) estimated that 9% of Americans who had ever used cannabis were psychologically dependent on it (cf. Crean et al. 2011). Degenhardt et al. (2013) estimated that on a worldwide basis, the figure is 20%.

The *International Classification of Diseases* (the standard diagnostic tool for epidemiology, health management, and clinical purposes; for details, see the World Health Organization's website at http://www.who.int/classifications/icd/en/) provides the following information: "Individuals who have cannabis dependence compulsively use the drug but do not usually develop physiological dependence, although frequently tolerance to the effects of cannabis has been reported by these individuals. Some users also reported withdrawal symptoms, although the symptoms have not usually been clinically significant. Frequently people with cannabis dependence use very potent cannabis over a period of months and sometimes years, and may spend significant time acquiring and using the substance. Cannabis dependence often interferes with family, work, school, or recreational activities. Individuals with cannabis dependence may also persist in using this drug although knowledge of physical or psychological problems may result."

The fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* lists 11 criteria for cannabis use disorder (cannabis dependence). These include cravings, giving up important life activities in order to use cannabis, continuing to use despite adverse physical or psychological problems caused or exacerbated by using, tolerance, withdrawal, and persistent unsuccessful efforts to quit. The validity of some of the criteria employed to define cannabis abuse has been disputed (e.g., Piontek et al. 2011). Clearly, there is subjective judgment associated with criteria based on personal choice to continue an activity that one judges to be pleasant, even if there are some unpleasant consequences. Some have argued that there is a "caffeine use disorder," as evidenced by the fact that some of the criteria for cannabis use disorder are analogous to those manifested by coffee addicts.

Cannabis Withdrawal Syndrome

A "cannabis withdrawal syndrome" is said to occur in frequent users shortly after they quit, the symptoms lasting a week or more (Budney and Hughes 2006). The fifth edition of *Diagnostic and Statistical Manual of Mental Disorders* lists seven symptoms of withdrawal: anger, anxiety, depression, loss of appetite, restlessness, sleep difficulties, and physical symptoms that cause significant discomfort, including chills, fever, headache, stomach pains, sweats, and tremors. Gorelick et al. (2012) noted that the symptoms are often vague. The very existence of the phenomenon of a withdrawal syndrome has not been universally accepted (Jager 2012). It could be argued that there is a "caffeine withdrawal syndrome," as evidenced by the fact that some of the symptoms from being denied coffee or other caffeine-laced beverages are the same as those described for cannabis withdrawal syndrome. However, several studies have found that ceasing usage of marijuana has at least temporary physiological effects (Allsop et al. 2012; Fratta and Fattore 2013).

Marijuana as a "Gateway Drug"

One of the most frequently cited dangers claimed to be associated with marijuana is that it is a "gateway drug," leading to the use of other more potent and addictive substances of abuse. Marijuana is just one of several drugs examined in "stepping-stone" or "stairway" models accounting for progression of usage of a sequence of more serious drugs (Tarter et al. 2012). Kepp and Raisch (2014) assert, "there is considerable evidence that marijuana is a gateway drug to other illicit drugs." Joy et al. (1999) noted that it is not surprising that most users of other illicit drugs have used marijuana first, simply because it is the most widely used illegal drug and therefore the first one most people encounter. But since most drug users employed alcohol and nicotine before using marijuana (and indeed mother's milk before that), it is hardly deductive logic to assume that preceding usage is causally linked to subsequent usage. Joy et al. (1999) pointed out that there is no conclusive evidence that marijuana is in fact a gateway drug. Morral et al. (2002) stated: "Strong associations between marijuana use and initiation of hard drugs are cited in support of the claim that marijuana use per se increases youths' risk of initiating hard drugs (the 'marijuana gateway' effect)… Marijuana gateway effects may exist. Our results demonstrate, however, that the phenomena used to motivate belief in such an effect are consistent with an alternative simple, plausible common-factor model. No gateway effect is required to explain them. The common-factor model has implications for evaluating marijuana control policies that differ significantly from those supported by the gateway model." Evaluation that marijuana is a gateway drug is difficult as there are various alternative explanations possible of observed correlations between marijuana usage and subsequent usage of other drugs (Hall and Lynskey 2005; Fergusson et al. 2006; Cleveland and Wiebe 2008). Melberg et al. (2010) suggested that there are "two distinct groups; a smaller group of 'troubled youths' for whom there is a statistically significant gateway effect that more than doubles the hazard of starting to use hard drugs and a larger fraction of youths for whom previous cannabis use has less impact."

Concern for Lung Function

Pletcher et al. (2012) conducted a large-scale study of the harm of smoking marijuana upon lung function, and concluded that "Occasional and low cumulative marijuana use was not associated with adverse effects on pulmonary function." However, in the main, the medical profession has a very negative view of how smoking marijuana influences breathing. The American Lung Association (2015) issued the following statement: "Smoke from marijuana combustion has been shown to contain many of the same toxins, irritants and carcinogens as tobacco smoke… Marijuana smokers tend to inhale more deeply and hold their breath longer than cigarette smokers, which leads to a greater exposure per breath to tar. Secondhand marijuana smoke contains many of the same toxins and carcinogens found in directly inhaled marijuana smoke, in similar amounts if not more. While there is no data on the health consequences of breathing secondhand marijuana smoke, there is concern that it could cause harmful health effects, especially among vulnerable children in the home. Additional research on the health effects of secondhand marijuana smoke is needed. Smoking marijuana clearly damages the human lung. Research shows that smoking marijuana causes chronic bronchitis and marijuana smoke has been shown to injure the cell linings of the large airways, which could explain why smoking marijuana leads to symptoms such as chronic cough, phlegm production, wheeze and acute bronchitis… Smoking marijuana hurts the lungs' first line of defense against infection by killing cells that help remove dust and germs as well as causing more mucus to be formed. In addition, it also suppresses the immune system. These effects could lead to an increased risk of lower respiratory tract infections among marijuana smokers, although there is no clear evidence of such actual infections being more common among marijuana smokers. However, frequent marijuana-only smokers have more healthcare visits for respiratory conditions compared to nonsmokers. Studies have shown that smoking marijuana may increase the risk of opportunistic infections among those who are HIV positive, although it does not seem to effect the development

of AIDS or lower white cell counts. Another potential threat to those with weakened immune systems is *Aspergillus*, a mold that can cause lung disorders. It can grow on marijuana, which if then smoked exposes the lungs to this fungus. However, it rarely causes problems in people with healthy immune systems." For additional information regarding the risks from *Aspergillus*, see the section "Microbiological Safety and Sterilization" in Chapter 14.

One of the least discussed risks associated with smoking marijuana is the unsanitary but widespread practice of sharing joints and bongs and the possibility of acquiring diseases such as hepatitis. It has been hypothesized that communal smoking could be one of the factors responsible for transmitting the human papilloma virus, linked to cancers of the throat and tongue (Zwenger 2009). Smoking marijuana has been alleged to have an inhibitory effect on the immune system, which could predispose users to infectious diseases. There are scattered case reports of *Aspergillus* infection in immunocompromised patients and even meningitis from passed joints. However, doses that are capable of producing immunosuppression in rodents are 50–100 times higher than usual human doses (Ethan Russo, personal communication).

Societal vs. Individual Health

Euphoric drugs can be used for good or evil, but the harm that can result is not limited to physical and/or psychological damage to the individual user (Figure 12.4). Opium use was once so widespread in China that a substantial portion of the population became nonproductive, and a burden on the state. The same situation prevails today for khat (*Catha edulis* L.) usage in some parts of the

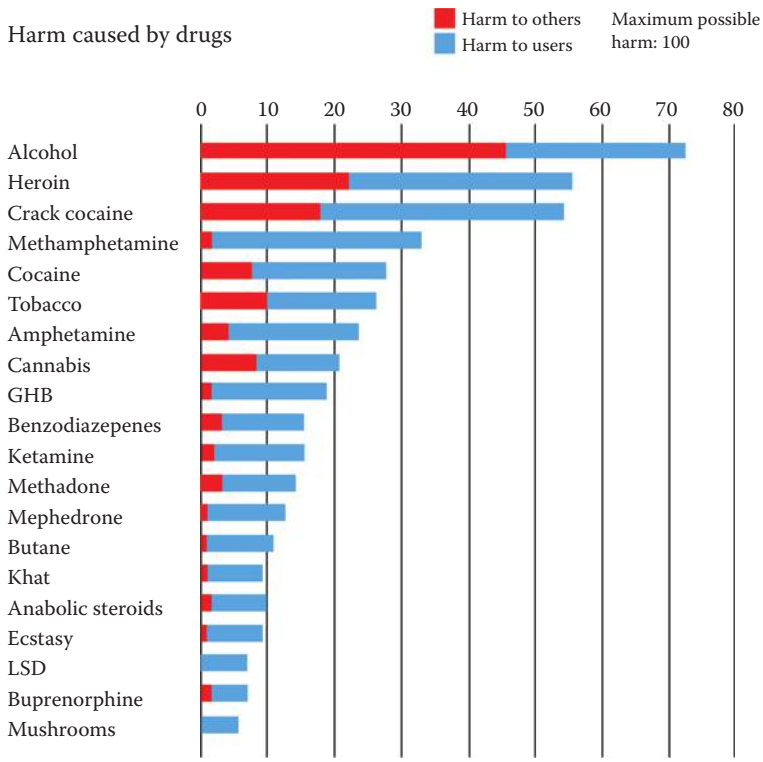

FIGURE 12.4 Ranking of harm to users and to society caused by drugs, in the United Kingdom, from Nutt, D.J., King, L.A., Phillips, L.D., *The Lancet*, 376, 1558–1565, 2010. Rankings are the opinion of drug-harm experts, using measures such as damages associated with health, drug dependency, economic costs, and crime. Figure downloaded by Tesseract2 (CC BY SA 3.0).

Middle East (Small 2004). Indeed, most proscribed illicit drugs harm not just the users but also are threats to the financial and physical welfare of many others. Alcohol and tobacco are obvious examples of legal (albeit controlled) harmful drugs that represent huge burdens on society. The same is true for sucrose (common table sugar) and other psychologically addictive foods that contribute to the obesity epidemic. The discussion of harmful effects of nonmedical uses of marijuana in this chapter is restricted to individual health, but it is well to remember that there are also potential effects on the collective welfare of society.

Driving Risks

Cannabis is a central nervous system depressant, and in some respects, the acute effects (i.e., at high dosages) resemble those of alcohol and other central nervous depressants. Cannabis can produce drowsiness, slower reactions, decreased memory (Figure 12.5), decreased attention, poorer psychomotor task performance, and poorer performance in driving. Asbridge et al. (2012) and Li et al. (2012) concluded that the risk of involvement in a motor vehicle accident increases approximately twofold after acute cannabis smoking. However, very experienced users seem able to compensate substantially, apparently tolerating the drug's actions well (Hart et al. 2001). Marijuana users operating vehicles seem to be less aggressive and more cautious than drunk drivers (Smiley 1999). (A joke that comes to mind: "A drunk driver will run a stop sign, a high driver will stop and wait for it to turn green.") Some of the impairment caused by cannabis is mitigated, since subjects appear to perceive that they are indeed impaired. Where they can compensate, they do, for example, by not overtaking, by slowing down, and by focusing their attention when they know a response will be required (Grotenhermen 2007). Experienced users appear able to develop physiological tolerance to the drug, substantially retaining driving ability (Grotenhermen and Müller-Vahl 2012). The combination of marijuana and alcohol or several illegal drugs is additive or synergistic, considerably increasing the risks associated with driving under the influence of drugs. Neavyn et al. (2014) recommended that users refrain from driving for 8 hours following a "high."

Hartman and Huestis (2013) reviewed the current literature on cannabis effects on driving and concluded, "drivers attempt to compensate by driving more slowly after smoking cannabis, but control deteriorates with increasing task complexity. Cannabis smoking increases lane weaving and impaired cognitive function. Critical-tracking tests, reaction times, divided-attention tasks, and lane-position variability all show cannabis-induced impairment. Despite purported tolerance in

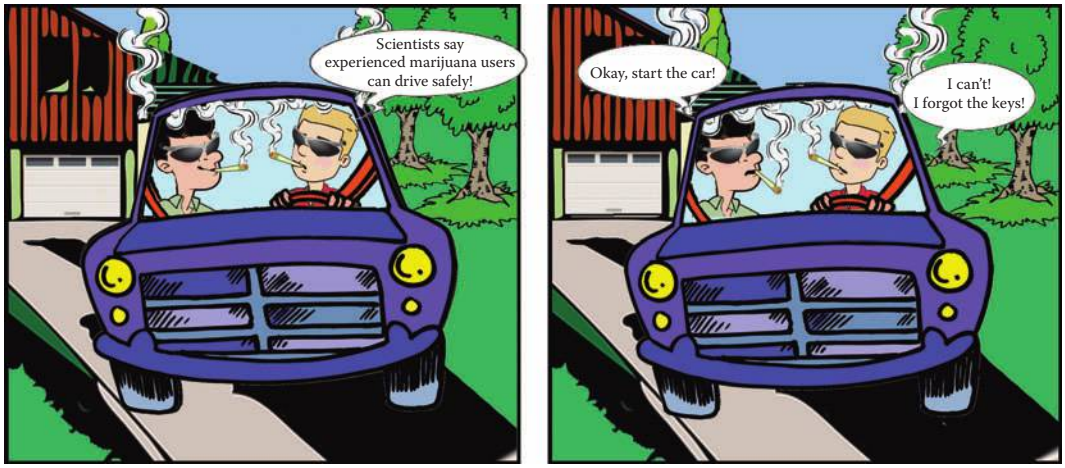

FIGURE 12.5 The perils of driving while stoned. Prepared by B. Brookes.

frequent smokers, complex tasks still show impairment. Combining cannabis with alcohol enhances impairment, especially lane weaving."

Similarly, Sewell et al. (2009) concluded: "Marijuana smokers tend to compensate effectively while driving by utilizing a variety of behavioral strategies. Combining marijuana with alcohol eliminates the ability to use such strategies effectively, however, and results in impairment even at doses which would be insignificant were they of either drug alone. Epidemiological studies have been inconclusive regarding whether cannabis use causes an increased risk of accidents; in contrast, unanimity exists that alcohol use increases crash risk. Furthermore, the risk from driving under the influence of both alcohol and cannabis is greater than the risk of driving under the influence of either alone."

Whitehill et al. (2014) noted (for the United States): "The issue of marijuana-impaired driving is particularly salient for young drivers, for whom the combination of inexperience and substance use elevates crash risk. Youth younger than 21 are at the highest risk of involvement in a fatal motor vehicle crash. They are also the age group most likely to use marijuana. Nationally, cannabis was involved in 12% of fatal crashes among 16–20 year olds. College students are a population at increased risk of substance-related risk behaviors, such as impaired driving… Marijuana is second only to alcohol for substances most abused by this population… Findings of previous studies suggest that male students are twice as likely as female students to drive while high on marijuana and 20% more likely to ride with a marijuana-using driver."

Risk of Contamination and Adulteration of Street Marijuana

The quality of cannabis drugs purchased in the illicit market is often uncertain, and this is one of the chief reasons that many grow and prepare their own supplies. Although sometimes a harmless substance is sold as marijuana, often the consumer is offered a product that is significantly more harmful that medical-grade forms of the drug.

Herbal marijuana may be contaminated as a result of negligent cultivation, preparation, or storage techniques. As discussed in Chapter 13, this can introduce dangerous fungi, aflatoxins (toxic fungal metabolites), other microbes (particularly bacteria), pesticide residues, and heavy metals. Law enforcement in some countries has employed Paraquat herbicide to control illicit marijuana, notably in Mexico (Figure 12.13b), and there has been concern that imported marijuana could be contaminated (Landrigan et al. 1983). However, according to Barceloux (2012), "the high combustion temperatures in marijuana cigarettes destroys Paraquat; therefore there is no significant risk of Paraquat-induced pulmonary fibrosis from cannabis smoking." Illicit growers sometimes have little concern about the health risks of their customers and can produce chemically contaminated marijuana. They may use banned plant growth regulators to force early flowering and production of bigger more compact buds, such as paclobutrazol, or daminozide (Alar) which degrades into the dangerous chemical hydrazine (Upton et al. 2013). So-called "growth enhancers" whose chemical nature is uncertain may also have been employed. Sullivan et al. (2013) examined how the presence in marijuana of three commonly employed pesticides, bifenthrin, diazinon, and permethrin, as well as the plant growth regulator paclobutrazol, produced contaminants in the resulting inhaled smoke. Recovered residues were as high as 70%, "suggesting that the potential of pesticide and chemical residue exposures to cannabis users is substantial and may pose a significant toxicological threat." Hair (from humans or pets), although not particularly hazardous, is commonly found on street marijuana, reflecting the sloppiness of many illicit marijuana producers and sellers.

Solvent extracts ("hash oil," discussed later) can be contaminated with dangerous chemical residues. "Synthetic" or "fake" marijuana, discussed in Chapter 13, and chemically synthesized analogues of THC are usually quite hazardous products.

Adulteration refers to the deliberate inclusion of inferior materials in a product in order to mislead the purchaser into thinking that the quantity or quality is superior. A chief motivation for this is to make the appearance more attractive and/or to increase the weight. Adding sand, chalk particles, or tiny glass shards can make marijuana appear to have more of the desirable glistening trichome

gland heads as well as increase the density. In the United Kingdom during the Victorian era, lead was a common adulterant, used for example to color cheese. Because street marijuana is sold by weight, some unscrupulous dealers have added lead particles to their offerings, resulting in poisoning consumers (Busse et al. 2008a,b). Especially dangerous is the practice of some dealers of adding dangerous drugs or plants to marijuana (McPartland 2008b; Upton et al. 2013).

Risk of Exposure to Indoor Grow-Op Environments

Martyny et al. (2013) examined the environmental dangers to law enforcement personnel of entering illegal indoor marijuana growing operations. They did not find hazardous levels of volatile organic compounds, carbon dioxide, carbon monoxide, and common chemicals utilized by illicit growers, primarily pesticides and fertilizers, and none of these showed high toxicity. Airborne fungal spores, however, were of significant concern, and it was noted that "removal of the marijuana plants could potentially expose responders to levels of exposure consistent with those associated with mold remediation processes and that respiratory protection is advisable."

RISK TO DOGS

Man's best friend is in special danger from cannabis (Figure 12.6). The American Society for the Prevention of Cruelty to Animals Animal Poison Control Center reported that dogs account for 96% of their marijuana toxicity cases (Donaldson 2002). Ingestion of baked goods made with cannabis has resulted in sickness, even death of canines, which seem especially prone to being poisoned. Fitzgerald et al. (2013) reported that "The minimum lethal oral dose for dogs for THC is more than 3 g/kg. Although the drug has a high margin of safety, deaths have been seen after ingestion of food products containing the more concentrated medical-grade THC butter." (This report, based in part on a study of dogs dying from being tube-fed a large bolus of material causing aspiration and respiratory arrest, appears erroneous with respect to marijuana directly causing death in dogs. As CB_1 receptors are practically absent from the brain stem cardiorespiratory drive nuclei, true overdoses

FIGURE 12.6 Canine cannabis convention. Dogs are commonly poisoned by marijuana, especially edibles. Prepared by B. Brookes (a modification of the public domain "Dogs Playing Poker/A friend in need" by C. M. Coolidge).

have not been reported.) Meola et al. (2012) provided the following information: "Toxicosis in dogs can be caused by inhalation of the smoke, direct ingestion of the leaves, seeds, stems and flowers of the plant, ingestion of products laced with marijuana leaves, or ingestion of products made with concentrated THC or hashish oil. Clinical signs may be seen within 30–60 minutes after ingestion of marijuana. THC toxicosis in dogs can cause considerable morbidity. The most common reported clinical signs of marijuana toxicosis in dogs include central nervous system depression, ataxia [loss of control of bodily movements], mydriasis [pupil dilation], increased sensitivity to motion or sound, hyperesthesia [increased sensitivity to stimulation], especially ptyalism [excessive salivation], tremors, and the acute onset of urinary incontinence." A case of dermatitis in a dog resulting from moving into a residence that was previously used as a marijuana grow house was documented by Evans (1989).

THE GREAT DEBATE: IS CANNABIS RELATIVELY HARMFUL OR BENIGN?

Society has ferociously debated the merits of many scientific issues historically, such as biological evolution and vaccination, and such contentious debates continue to this day, exemplified by climate change and the comparative benefits of fad diets. Some debates are so esoteric and complex that they cannot be decided to the universal satisfaction of everyone (Figure 12.7), but in the fullness of time, disagreements concerning scientific facts can usually be settled. However, the debate concerning psychoactive cannabis (whether recreational or medicinal) is multifaceted, involving examination of not only its merits and risks in many independent respects but also human values concerning personal liberty and choice. It is easy to conclude when observing some debates (especially between politicians) that one or both parties are dishonest, foolish, deluded, prejudiced, and lacking in objectivity. As noted in this book, scientific methodology (at its best) controls these human weaknesses—but it is not possible to completely remove the human element from science, and particularly when scientific facts are not entirely clear, it is not surprising that there are very different perspectives. The following quotations representing such different perspectives of cannabis are intended simply to illustrate this phenomenon, *not* to summarize the best evidence or arguments, which are detailed

FIGURE 12.7 Left: "The School of Athens," representing philosophy, a fresco painted in 1509 in the Apostolic Palace in the Vatican by Raphael, considered to be his best painting. Right, detail, showing Plato (left) and Aristotle (right), considered to be among the greatest thinkers in history, and illustrating how the same reality can be viewed very differently by sincere, highly intelligent analysts. Photo credit: Web Gallery of Art; public domain.

elsewhere (especially in Chapter 13). As reflected by the predominance of negative views of the harmfulness of recreational marijuana, the *professional literature* is overwhelmingly dominated by those who regard marijuana as significantly harmful. A more balanced view (i.e., both for and against) is found in the media at large, but this book is most concerned with the views of informed individuals.

Representative Viewpoints That Cannabis Is Relatively Harmful

Hall and Degenhardt (2009) concluded, "The most probable adverse effects include a dependence syndrome, increased risk of motor vehicle crashes, impaired respiratory function, cardiovascular disease, and adverse effects of regular use on adolescent psychosocial development and mental health." Reece (2009) stated, "Chronic cannabis use is associated with psychiatric, respiratory, cardiovascular and bone effects. It also has oncogenic, teratogenic and mutagenic effects" (as discussed elsewhere, the contentions in the latter sentence are disputed). Hoch et al. (2015) concluded, "Various medical conditions can arise acutely after cannabis use, depending on the user's age, dose, frequency, mode and situation of use, and individual disposition; these include panic attacks, psychotic symptoms, deficient attention, impaired concentration, motor incoordination, and nausea. In particular, intense use of high doses of cannabis over many years, and the initiation of cannabis use in adolescence, can be associated with substance dependence, specific withdrawal symptoms, cognitive impairment, affective disorders, psychosis, anxiety disorders, and physical disease outside the brain (mainly respiratory and cardiovascular conditions)."

Hall (2014) concluded that chronic (long-term regular) recreational use is associated with the following hazards:

- Risk of developing a dependence syndrome (1 in 10 of all marijuana users, 1 in 6 of those starting in adolescence).
- Doubled risk of psychotic symptoms and disorders, especially with a personal or family history of psychotic disorders, and when use started in the mid-teens.
- Lower educational attainment by those beginning use as adolescents (causal link not established).
- Increased use of other illicit drugs by adolescent users (causal link not established).
- Intellectual impairment when use begins in adolescence and continues through young adulthood (reversibility of the impairment is unclear).
- Double the risk of schizophrenia or psychotic symptoms in adulthood when use begins in adolescence.
- Increased risk of chronic bronchitis.
- Probable increased risk of myocardial infarction from smoking in middle age.

Thompson and Koenen (2011) issued the following warning: "Predictable side effects of marijuana use include impaired judgment, cognitive impairment, impaired driving ability, hallucinations, early onset of psychosis in certain individuals, memory impairment, worsening of mood and anxiety disorders, and the risk of dependence. Individuals with major mental illnesses are especially vulnerable to the deleterious effects of cannabis. Smoking marijuana includes risks of rapid onset of intoxication as well as exposure to a variety of toxic and carcinogenic combustible products. Vaporization reduces exposure to some potential toxins such as carbon monoxide, but is unable to remove aluminum, ammonia, acetaldehyde, and other substances."

Hasin et al. (2015) concluded that in 2012–2013, 9.5% of U.S. adults (about 22 million) used marijuana in the past year, and nearly 3 of every 10 had a diagnosis of a marijuana use disorder. They also commented: "studies have shown that use or early use of marijuana is associated with increased risk for many outcomes, including cognitive decline, psychosocial impairments, vehicle crashes, emergency department visits, psychiatric symptoms, poor quality of life, use of other

drugs, a cannabis-withdrawal syndrome, and addiction risk. Further, marijuana use disorders (abuse or dependence) are associated with substantial comorbidity and disability and are consequently of substantial public health concern." (See Meier et al. 2015 for a discussion of the difficulties of concluding that marijuana use among teenagers leads to permanent damage.)

Zeisser et al. (2012) stated: "Chronic cannabis use, generally referred to as a pattern that entails weekly or more frequent use, has been associated with an increased likelihood of cannabis dependence, chronic bronchitis and impaired respiratory function, psychotic disorders and impaired cognitive functioning as well as psychosocial effects such as impaired educational attainment in adolescents, and an increased likelihood of using other illicit drugs. Individuals who use cannabis may also experience acute adverse effects such as anxiety and panic, and an increased risk of motor vehicle crashes."

Representative Viewpoints That Cannabis Is Relatively Benign

Van Ours and Williams (2012) concluded: "Widespread use reflects the common belief that cannabis is not a particularly harmful drug. The weight of evidence supports this belief…the harms associated with cannabis use are much less serious than those associated with 'hard' drugs such as cocaine or heroin and may even be smaller than those associated with alcohol and cigarettes. And while it is generally acknowledged that there are risks associated with long term heavy use of cannabis such as respiratory diseases, cancer and perhaps psychotic disorders, only a small fraction of those who ever use cannabis actually become long term heavy users…for those who are not long term heavy users of cannabis, the physical and mental health effects of their cannabis use are likely to be small." (See comments in the next chapter regarding cancer risk from smoking.)

Nathan (2013) stated: "I am a father who worries about my kids getting sidetracked by cannabis before their brains have a chance to develop. But I am also a physician who understands that the negative legal consequences of marijuana use are far worse than the medical consequences… Alcohol, tobacco, marijuana, caffeine and refined sugar are among the most commonly used, potentially habit-forming recreational substances. All are best left out of our daily diets. Only marijuana is illegal, though alcohol and tobacco are clearly more harmful. In several respects, even sugar poses more of a threat to our nation's health than pot… If you still believe that cannabis should be illegal, then you must logically support the criminalization of alcohol and tobacco, with vigorous prosecution and even imprisonment of producers and consumers. Does that sound ridiculous? Then you must conclude that the only rational approach to cannabis is to legalize, regulate and tax it."

Graham (2014) wrote: "For proponents of the legalization of marijuana…legalizing pot means the market will be regulated, governments will reap the tax revenue, and drastically fewer people will be mired in the violence of the drug war and the injustices of the legal system. If public health suffers a bit as use of the substance increases, so be it… But what if the rise in marijuana smoking prompted by legalization brings more than just tolerable negative side effects? What if it is actually good for public health? A growing body of research suggests that marijuana may replace alcohol or hard drugs in many people's lives. Other recent studies suggest that looser restrictions on weed decrease traffic fatalities and even the suicide rate. That means the rising tide of legalization may mean more than just an acceptable but unfortunate societal burden—it may be a boon to public health."

The New York Times Editorial Board (2014) concluded: "It took 13 years for the United States to come to its senses and end Prohibition, 13 years in which people kept drinking, otherwise law-abiding citizens became criminals and crime syndicates arose and flourished. It has been more than 40 years since Congress passed the current ban on marijuana, inflicting great harm on society just to prohibit a substance far less dangerous than alcohol. The federal government should repeal the ban on marijuana… There are no perfect answers to people's legitimate concerns about marijuana use. But neither are there such answers about tobacco or alcohol, and we believe that on every level—health effects, the impact on society and law-and-order issues—the balance falls squarely on the

side of national legalization. The social costs of the marijuana laws are vast. There were 658,000 arrests for marijuana possession in 2012, according to F.B.I. figures, compared with 256,000 for cocaine, heroin and their derivatives. Even worse, the result is racist, falling disproportionately on young black men, ruining their lives and creating new generations of career criminals. There is honest debate among scientists about the health effects of marijuana, but we believe that the evidence is overwhelming that addiction and dependence are relatively minor problems, especially compared with alcohol and tobacco. Moderate use of marijuana does not appear to pose a risk for otherwise healthy adults. Claims that marijuana is a gateway to more dangerous drugs are as fanciful as the 'Reefer Madness' images of murder, rape and suicide. There are legitimate concerns about marijuana on the development of adolescent brains. For that reason, we advocate the prohibition of sales to people under 21."

GLOBAL USAGE OF MARIJUANA

According to United Nations (2014): "In 2012, between 125 million and 227 million people were estimated to have used cannabis, corresponding to between 2.7 and 4.9 per cent of the population aged 15–64 years. West and Central Africa, North America, Oceania and, to a lesser extent, Western and Central Europe remain the regions with prevalence rates considerably higher than the global average. Over the past five years in North America, the largest cannabis herb market, prevalence rates have followed an upward trend." Cannabis users account for 80% of the illicit drug users in the world (Van Ours and Williams 2012). An analysis of consumption patterns and trends in Europe is provided by EMCDDA (2008, 2012). Estimates for the United States, the leader in usage, range up to 25% of the population. Marijuana has been claimed to be at least the fourth most valuable crop in America, outranked only by corn, soybeans, and hay (Small and Marcus 2002). As noted in Chapter 15, some authors claim that marijuana is the leading cash crop in the United States.

A BRIEF HISTORY OF NONMEDICAL PSYCHOTROPIC USAGE OF CANNABIS DRUGS

Natural drugs have been employed historically for three discernible purposes: spiritually or religiously, therapeutically, and recreationally as a euphoric. This chapter is mainly concerned with recreational and spiritual usage, and historical aspects related to medicinal usage are discussed in the next chapter. It is often difficult, perhaps impossible, to distinguish the three usages in ancient times because natural drugs were often utilized for more than one of these goals at the same time. The earliest recorded reference to euphoric use of *C. sativa* appears to date to about 5000 years ago, associated with Kurgan culture (the Kurgans were early people of the Caucasus region, known for elaborate burials mounds). A smoking cup with remnants of charred hemp seeds, associated with the Kurgans, who occupied Romania at that time, is suggestive of the flowering parts of *C. sativa* being combusted perhaps for euphoric ritualistic purposes. Kurgan incense burners have been hypothesized to have had the same function. It is speculative whether these early usages of cannabis actually were intended to produce intoxication, but it does seem that cannabis was used ritualistically in the Black Sea–Caucasus region (Sherratt 1991). The Scythians, noted next in this context, exemplify this tradition particularly well, and it seems that cannabis was also used for sacred purposes in Assyria, Babylon, and ancient Palestine (Rubin and Comitas 1975).

The ancient region of Scythia included a large area from the Ukraine to the borders of present-day India. The Scythians included nomadic Caucasoid tribes, wandering to the borders of modern Russia and China. Scythian culture thrived from the ninth to the third centuries BC. The fifth century BC Greek historian Herodotus described a Scythian funeral ceremony in which vapors from burning cannabis seeds (possibly entire fruiting heads, which could contain appreciable THC) were inhaled in small tents (Figure 12.8). Merlin (1972) provided Herodotus' account: "The Scythians then take this seed of hemp and, creeping under the mats, they throw it on the red-hot stones; and,

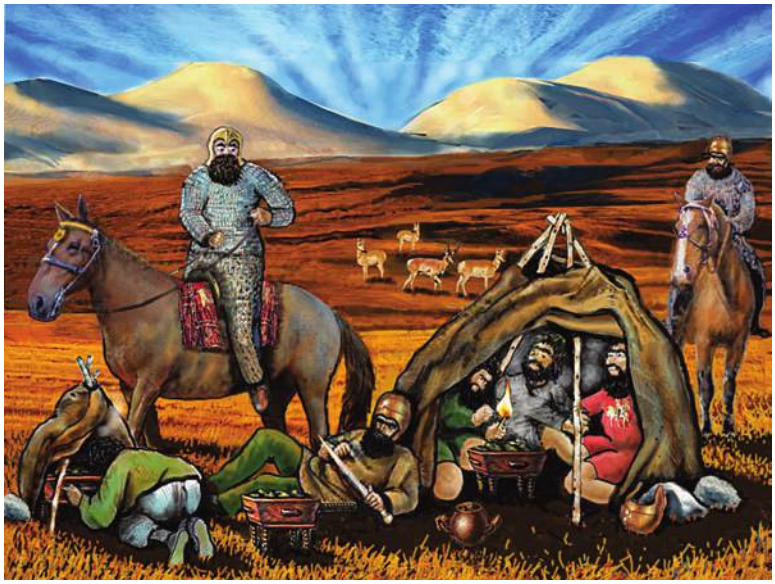

FIGURE 12.8 Artist's conception of a Scythian encampment, showing inhalation of smoke from cannabis being burned on braziers. The smaller tent shown is historically accurate; the larger tent is hypothesized. Prepared by B. Flahey.

being so thrown, it smolders and sends forth so much steam that no Greek vapor bath could surpass it. The Scythians howl in their joy at the vapor bath." Rudenko (1970) found archaeological evidence of a metal tripod censer with remnants of hemp seeds that Scythians of southern Central Asia had apparently employed during funeral rites. While the Scythian records have been interpreted as usage of marijuana to induce intoxication, this is uncertain. Plant materials are often burned ritualistically by various cultures without motivation to alter mental state. Nevertheless, in a rather reminiscent old practice in Poland, Russia, and Lithuania, hemp seeds were thrown on hot stones and the vapors inhaled in order to alleviate toothache (Benet 1975), suggesting relief of psychic stress as typically is induced by inebriants.

Practitioners of Buddhism and Shintoism historically often employed cordage or fabric made of hemp for ceremonial purposes (Olson 1997; Figure 12.11c), although this is not reflective of intoxicant usage. As late as the nineteenth century, there were cults and sects worshipping *C. sativa* in Africa (Benet 1975). Williams-Garcia (1975) described ritual usage of cannabis by an Indian tribal group in Mexico.

Touw (1981) reviewed evidence of shamanistic use in ancient China and suggested that the psychotropic properties of cannabis may have been known as early as five millennia ago there. Jiang et al. (2006) and Russo et al. (2008) documented a 2700-year-old grave, the Yanghai Tombs near Turpan, China, in which remains of apparently high-THC cannabis were detected, suggesting a possible ritualistic psychotropic purpose. (The DNA of this material was examined by Mukherjee et al. 2008, although the analysis is unclear with regard to relationships with modern varieties.)

Zoroastrianism, a monotheistic religion of Iran, was founded by the Prophet Zoroaster in ancient Persia approximately 3500 years ago and is still practiced by about three million devotees. Cannabis intoxication appears to have been a central activity in early Zoroastrian shamanic ecstasy (Mechoulam 1986).

Over the last millennium, cannabis consumption became more firmly entrenched in southern Asia from Afghanistan to India, than anywhere else in the world, both for medical and cultural purposes, some of which involved consumption of cannabis as an inebriant. Cannabis became

intimately associated with religions of southern Asia (Aldrich 1977), and its sacred use in India predates written records (Hasan 1975). Not surprisingly, highly domesticated drug land races were selected there.

While *Cannabis* has been extensively used as an inebriating and medicinal drug for thousands of years in southern Asia and subsequently in the Near East (Figure 12.9), parts of Africa, and other Old World areas, widespread drug use simply did not develop in temperate region countries, where by contrast fiber hemp was raised. After the French war in Egypt and Syria (1798–1801), returning Napoleonic soldiers brought back knowledge of cannabis usage to France. Similarly, British physicians returning from India also introduced the intoxicant use of cannabis drugs to their homeland (see Chapter 13). In due course, the recreational use of cannabis became popular in Europe among intellectuals, who assembled in small "hashish clubs" in the nineteenth century. Most infamous of these was the "Club des Hashischins" of Paris (Figure 12.10), established around 1835, with monthly meetings in a hotel. The participants experimented with hashish and other drugs and included such famous French literary figures as Honoré de Balzac, Charles Baudelaire, Alexandre Dumas, Théophile Gautier, and Victor Hugo.

The use of cannabis for recreational, spiritual, and medicinal purposes was probably imported into the Americas by African slaves as early as the sixteenth century, becoming established in early times among low-income rural groups in South America. By the late nineteenth century, recreational marijuana usage had migrated to Mexico and the southern United States, where it remained a stigmatized drug associated with the poor and underprivileged, particularly with Hispanics and Blacks.

The use of *Cannabis* as a recreational inebriant in sophisticated, largely urban settings began substantially in the latter half of the twentieth century. In the 1960s, "hippies" made pilgrimages to Asia in search of enlightenment and established what came to be known as the "hippie trail" or "hashish trail" extending across Eurasia. Up until then, drug preparations of *Cannabis* were used predominantly as a recreational intoxicant in poor countries and the lower socioeconomic classes of developed nations. In the late 1960s, marijuana became associated with the rise of a hedonistic, psychedelic ethos, first among college students in the United States (Abel 1980; Booth 2004) and

FIGURE 12.9 "Les fumeurs de kiff" (hashish smokers) by Gabriel Ferrier (1847–1914). Public domain photo (Salon de Paris 1887, no. 908).

FIGURE 12.10 Artist's conception of the notorious nineteenth century Parisian "Club des Hashischins." Prepared by B. Flahey.

eventually over much of the world, with the consequent development of a huge international illicit market.

Tarter et al. (2012) noted that in the United States, "Policies aimed at curtailing substance use have been largely guided by ideology and political expediency effected primarily through the criminal justice system. The Eighteenth Amendment of the U.S. Constitution and the Volstead Act banning manufacture, transport and selling of alcohol beverages between 1919 and 1933, for example, culminated a long struggle spearheaded by the Anti-Saloon League, Prohibition Party, and Woman's Christian Temperance Union. Similarly, the first Director of the Federal Bureau of Narcotics, Harry J. Anslinger, demonized marijuana for primarily political reasons, namely to bolster the visibility, prestige and budget of the Federal Bureau of Narcotics." Cultivation, commerce, and consumption of drug preparations of *Cannabis* were also proscribed in most other countries during the twentieth century, but cannabis continues to contribute substantially to the current illicit drug problems of the world.

MODERN SPIRITUAL USAGE OF CANNABIS

Despite the extensive historical usage of cannabis for ritualistic purposes described previously, there is limited employment of marijuana today for religious usage. Information on Indian, particularly Hindu, religious usage of cannabis is presented in Bey and Zug (2004). Hindu devotees of Shiva believe that cannabis pleases this god (Acharya et al. 2014). Some Sikh festivals employ cannabis. Sufism has long employed cannabis. Of all current religious traditions, Rastafarianism in Jamaica is most associated with the use of marijuana, attributing divine power to the drug (Beaubrun 1983). Some American cults (an example is shown in Figure 12.11a and b) have taken the position that their use of cannabis is exempt from drug laws, but their claims have been rejected by courts. It should be kept in mind that a considerable amount of spiritual usage of cannabis was once concerned with the ritualistic use of hemp, not marijuana, as illustrated in Figure 12.11c.

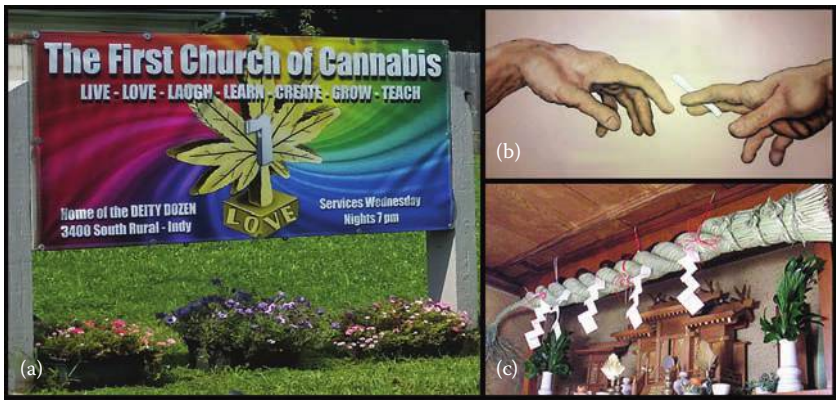

FIGURE 12.11 Recent examples of spiritual use of cannabis. (a) Entrance sign of the First Church of Cannabis, founded in Indianapolis in 2015. Photo by Ayjazz (CC BY SA 4.0). (b) Mural inside the church, painted in the style of "The Creation of Adam," showing a joint being passed between hands. Photo by Janulus 144 (CC BY SA 4.0). (c) Japanese Shinto shrine with ceremonial rope made of hemp. Photo by Kamidana (CC BY 3.0).

CANNABIPHOBIA AND THE CULTURAL WAR ON MARIJUANA

During the early part of the twentieth century, marijuana was savagely villainized as a drug leading to extreme physical and mental degeneration (Figure 12.12). In particular, the 1936 American cult film *Reefer Madness* propagandized the evils of marijuana (described as "the plant with its roots in hell") in such an exaggerated and alarmist fashion—portraying users as homicidally depraved raving lunatics—that today it seems ridiculous. Nevertheless, since the latter half of the twentieth century and lasting until the present, marijuana has been a principal target of the "war on drugs" as declared in the United States by the Nixon administration but waged throughout the Western World. The use of cannabis was widely claimed to be associated with sexual permissiveness, dropping out of productive society, and a breakdown of culture and conventional morals. Young marijuana users were accused of developing an "amotivational syndrome," causing them to become alienated and unproductive, and cannabis was said to be a "gateway" inducement to harder drugs. Law enforcement has dedicated huge efforts to eradicating illicit material (Figure 12.13) and prosecuting and jailing millions of users.

GROWING PUBLIC ACCEPTANCE OF MARIJUANA

Despite substantial continuing condemnation of the use of marijuana, much of the public in Western nations has become tolerant or sympathetic to it. As pointed out by Leggett (2006):

"A sizeable share of the population in the world has experimented with cannabis and not experienced dramatic negative repercussions. It is widely understood that, unlike other drugs, one cannot die of a cannabis overdose and few people develop cannabis habits that force them into street crime or prostitution. Cannabis is not associated with violent behavior in many countries and its role in accidents is vague in the public mind. The stereotypical 'stoner' character has become celebrated in the popular media as harmless and somewhat endearing. Claims of purported medical benefits of cannabis have created the impression that cannabis is not only virtually harmless but that it can actually be beneficial to health." (See Graham 2014 cited earlier as asking: what if marijuana is actually good for public health?) As pointed out in Chapter 15, in the United States, a majority of the population has recently shifted to favoring the decriminalization of marijuana.

FIGURE 12.12 Lurid, mid-twentieth century, American governmental propaganda posters (in the public domain) demonizing marijuana as a catalyst for sexual deviance and psychosis. Ironically, such exaggerated warnings undermined the credibility of subsequent health cautions. Also ironically, there is substantial evidence that marijuana can indeed decrease inhibition and increase libido and sexual pleasure (Stuart et al. 2014).

THE GENETIC "IMPROVEMENT" OF MARIJUANA DUE TO LAW ENFORCEMENT

Ironically, law enforcement pressure has had the unintended effects of (1) driving marijuana production indoors, where it is harder to locate, and (2) increasing potency. Cannabis quality and yield efficiency have been greatly improved by breeders and cultivators, especially in the Netherlands and North America, since the early 1970s. Breeding has generated strains that are more potent, more productive, faster maturing, hardier, and more attractive to consumers. Yields have also been increased dramatically by improved cultivation techniques. The cultivation of elite female clones and the use of indoor production techniques that hide plants from the authorities (typically in bedrooms, basements, attics, closets, garages, or sheds) have been perfected. Growers are able to harvest up to six crops annually, with much greater or faster growth in smaller spaces than achieved previously.

Breeding of superior intoxicating strains of *C. sativa* has largely been done in a clandestine fashion because of the illegality of marijuana. However, by no means have marijuana breeders regarded themselves as engaging in a shameful activity, and indeed, many are proud of their achievements, often exhibiting photos of their best plants and buds on the Internet (usually under a pseudonym). There are also competitions for the most impressive strains, particularly in the Netherlands. Best known of these is the annual *High Times* (magazine) "Cannabis Cup" in Amsterdam (Smith 2012; Figure 12.14). The breeding achievements of motivated amateur horticulturists can be remarkable.

FIGURE 12.13 Law enforcement activities by the U.S. government to control the illicit use of *C. sativa*. (a) A seizure of about a ton of hashish in Afghanistan. Photo by isafmedia (CC BY 2.0). (b) Helicopter spraying of Paraquat herbicide on a field of marijuana. (c) Burning seized marijuana. (d) Clandestine indoor cultivation. (Photos b–d provided by the U.S. Drug Enforcement Administration.)

FIGURE 12.14 Awards table at the 27th *High Times* Cannabis Cup ceremony in 2014 in Amsterdam (CC BY 2.0).

In the eighteenth century, "gooseberry clubs" became popular in Britain, with the goal of giving prizes for the heaviest gooseberries (the fruit of *Ribes* species). Previously, wild gooseberries weighed only about 7 g and were about the size of a small pea, but the breeding efforts produced fruits resembling small apples and weighing as much as 57 g (Small 2013a).

The authorities attempting to suppress marijuana cultivation have been faced with the daunting problem of limited international control over distribution of seeds and knowledge. The Netherlands has been uniquely responsible for much of this situation, as it has been substantially free to develop marijuana strains and knowledge and to disseminate both throughout the world via the Internet. The information revolution has spread technical knowledge globally, while Web blogs and chat groups provide tips about every aspect concerned with acquiring, growing, preparing, and using marijuana.

FORMAL BOTANICAL NOMENCLATURE AND "STRAINS" OF *CANNABIS SATIVA*

Terms used in botanical classification are dealt with in Chapter 18, but one technical point bears mention here in order to correctly refer to genetic variations of marijuana plants. Article 2.2 of the current nomenclatural code for cultivated plants (Brickell et al. 2009), a legalistic document that governs names for cultivated plants, forbids the use of the term "strain" as equivalent to "cultivar" for the purpose of formal recognition. Very few marijuana strains satisfy the descriptive requirements for cultivar recognition, although many marijuana cultivars (mostly grown for fiber or oilseed rather than cannabinoids) do and by convention are denoted in single quotes. However, *Cannabis* strains are conceptually identical to *Cannabis* cultivars. Snoeijer (2002) treated *Cannabis* strain names as equivalent to cultivar names.

THE EVOLUTION OF HIGH-THC STRAINS

High-THC forms of *Cannabis* were initially selected many centuries (possibly millennia) ago, and during these early times, fairly primitive techniques were employed to make intoxicant preparations. Particularly in recent decades, a considerable understanding of the biochemistry and genetic control of cannabinoid metabolism has been achieved, and strains are now being generated that are rich in given cannabinoids for potential medicinal applications. Sophisticated techniques for breeding strains have been developed, including the generation of all-female lines (Chapter 4). Technologies (described in this chapter) have been created to collect and concentrate the THC-rich heads of the glandular trichomes, and this development may have resulted in the selection of strains in which the THC-rich trichome heads separate readily so that they can be collected easily.

In previous chapters, information has been provided on some of the ways that the characteristics of high-THC strains have evolved. Strains have been chosen that differ in architecture (Chapter 6) and cannabinoid profile (as noted in Chapter 11). Geographical biotypes have been found with one or more rare cannabinoids in unusually high presence (Chapter 11), which is probably the result of genetic drift (change in population genetics occurring in small populations simply by haphazard survival of unusual plants). A variety of different essential oil profiles seem to have been selected in high-THC strains (Chapter 9). There also seems to have been selection for concentration and distribution of the secretory glands, with very large densities of the glands and larger glands present on the floral bracts of some strains (Chapter 11). In response to demand for very high levels of THC, there has been selection for congested female inflorescences (production of numerous, well-formed "buds" being a recent quality criterion; Chapter 11).

Chapter 6 provided information on the evolution of shoot architecture in the two groups of high-THC plants ("indica type" and "sativa type"), and Chapter 3 provided information on how the seeds of domesticated plants (including the high-THC groups) have been modified by comparison with wild plants. This information is not repeated here.

The two basic kinds of high-THC plants (sativa type, characterized by very high THC levels, and indica type, characterized by moderate amounts of THC supplemented by noneuphoric CBD) are

described next. They have become foundational breeding material for generating by hybridization a wide range of marijuana strains.

"SATIVA TYPE" AND "INDICA TYPE," THE TWO DOMESTICATED KINDS OF MARIJUANA PLANTS

Two discernibly different groups of high-THC cannabis plants were selected in Asia: "sativa type" and "indica type." The ancient distribution of these is shown in Figure 2.7, and in Figure 2.8, it is pointed out how the much more popular "sativa type" has been distributed in much of the world. In Figure 18.13, it is noted that the indica type probably arose from the sativa type and that extensive hybrids have been generated between the two kinds. The terms "indica" and "sativa" are widely employed, in the senses explained in this section, in innumerable books and websites providing instructions on how to (usually illegally) cultivate marijuana and more recently for medical marijuana.

Table 12.1 summarizes differences that have been alleged to distinguish the two kinds (no adequate statistically based study of differences has been published, and since hybrids between the two kinds dominate strains of marijuana currently grown, the two kinds are best considered as polar extremes connected by a continuous spectrum of intermediate forms). The two kinds are contrasted in Figures 12.15 through 12.17.

Strains of the sativa type tend to resemble European fiber cultivars, often being almost as tall although usually much more branched and tending to have relatively narrower leaflets. Sativa type strains characteristically have very high THC level in the cannabinoids and no or small amounts of

TABLE 12.1
Alleged Differences between the Two Basic Kinds of Domesticated Marijuana Plants

Group (Marijuana Trade Terminology)	Sativa Type	Indica Type
Early distribution area (see Figure 2.7)	Widespread (southern Asia)	Restricted (Afghanistan, Pakistan, northwestern India)
Seasonal adaptation	Relatively long (late-maturing), often in semi-tropical regions	Relatively short (early-maturing), adapted to relatively cool, arid regions
Height (under optimal growth conditions)	Relatively tall (2–4 m)	Relative short (1–2 m)
Habit	Diffusely branched (longer internodes); less dense, more elongated "buds"	Bushy (short internodes), often conical; very dense, more compact "buds"
Leaflet width	Leaflets narrow	Leaflets broad
Intensity of leaf color	Leaves lighter green	Leaves dark green
Length of season	Relatively late maturation	Relatively early maturation
Aroma (i.e., odor + "taste")	Relatively pleasant aroma (often described as "sweet")	Relatively poorer aroma (sometimes described as "sour" and "acrid")
Ease of detachment of heads from secretory glands (McPartland and Guy 2004a)	Variable	Easily detached
Presence of CBD	Little or no CBD	Substantial CBD
Alleged psychological effects	Relatively euphoric: a "cerebral high" promoting energy and creative thought (occasionally panic attacks in inexperienced users, or a drained feeling); recommended for daytime use	Relatively sedative: physically relaxing, producing lethargy ("couchlock"); recommended as a "nightcap" (cf. information regarding couchlock, in this chapter)

Note: Most of these differences are discussed in Clarke (1998a) and Clarke and Merlin (2013).

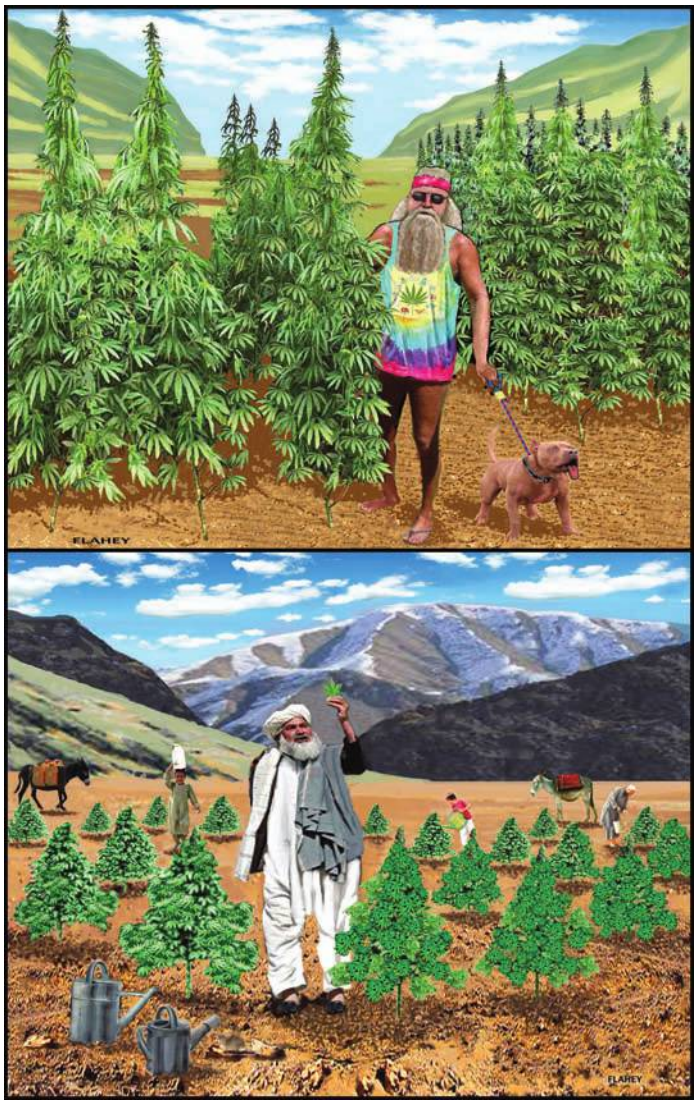

FIGURE 12.15 Contrast of the taller "sativa type" (above) and the shorter "indica type" (below) marijuana plants of *C. sativa*. Prepared by B. Flahey.

CBD. As pointed out in Chapter 18, usage of the term "sativa" to indicate extremely intoxicating (high-THC) plants is quite inconsistent with the tradition of employing the "epithet" (a word used in scientific names) taxonomically for nonintoxicant plants. Sativa type strains are extremely widespread in the illicit trade of Western nations.

Indica type strains tend to be short (about a meter in height) and compact under the often inhospitable conditions under which they are typically grown in Asia. They are often also highly branched, with large leaves and wide leaflets. The appearance is often reminiscent of a miniature, conical Christmas tree. Strains of this group characteristically have moderate levels of both THC and CBD in their cannabinoid profile. Like the sativa type, the indica type has historically been employed to produce hashish in southern Asia, particularly in Afghanistan and neighboring countries. Hashish is prepared by pooling collections from many plants, so individual plants may vary in proportions of cannabinoids (i.e., not all plants necessarily have moderate levels of both THC and CBD).

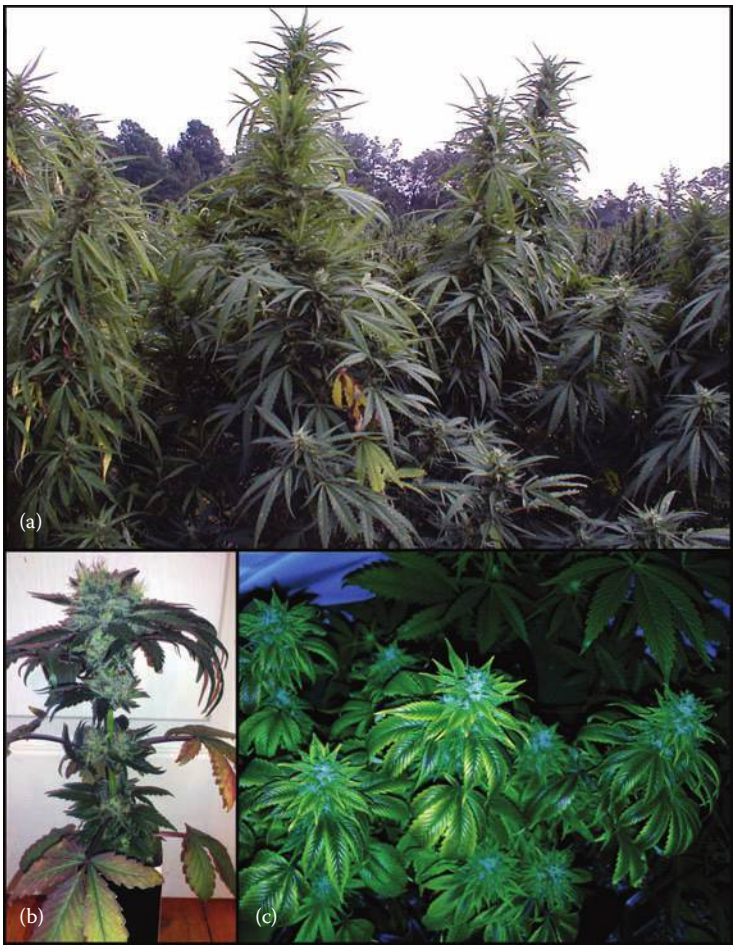

FIGURE 12.16 Contrast of the "sativa type" ([a]; note the tall stature and narrow leaflets) and the "indica type" ([b, c]; note limited stature and wide leaflets) marijuana plants of *C. sativa*. (a) Photographed at the U.S. Government marijuana production site at the University of Mississippi, Oxford (public domain photo). (b) Photo by Mr TM (CC BY 3.0). (c) Photo by otrs:2009060510011997 (CC BY 2.0).

FIGURE 12.17 A contrast of leaves of "sativa type" (left; narrow leaflets) and "indica type" (right; wide leaflets) marijuana plants. Photo by Transmitdistort (CC BY 3.0).

Clarke (1998a) and McPartland and Guy (2004a) interpreted indica type strains as having evolved in the cold, arid regions of Afghanistan and western Turkmenistan and explained their short height as an adaptation to the relatively short growing season. The relatively early-flowering nature of indica type strains is also an adaptation to a relatively short growing season.

Sativa type strains are very potent (higher in THC than most indica type strains) and hence more popular, although harder to grow indoors where room height is limited, because of their tallness. Hybrids between the two groups have proven to be well adapted to indoor cultivation and are progressively being marketed (Clarke and Watson 2006). Increasingly, strains with alleged percentages of each type are being sold.

There are varying descriptions in the literature about the contrasting psychological effects of indica type and sativa type strains (see, for example, Hazekamp and Fischedick 2012 and Smith 2012). These descriptions generally credit the high-THC sativa type with producing a more euphoric "high" and the lower-THC indica type with substantial CBD with producing a more subdued but attenuated (longer-lasting) experience, consistent not just with the lower THC content but more particularly with how CBD in marijuana substantially alters the effects of THC, as explained in Chapter 13. Erkelens and Hazekamp (2014) summarized the alleged effects as follows: "The sativa high is often characterized as uplifting and energetic. The effects are mostly cerebral (head-high), also described as spacey or hallucinogenic. This type gives a feeling of optimism and wellbeing, as well as providing a good measure of pain relief for certain symptoms… Sativa strains are generally considered a good choice for daytime smoking. In contrast, the indica high is most often described as a pleasant body buzz (body-high). Indica strains are primarily enjoyed for relaxation, stress relief, and for an overall sense of calm and serenity. They are supposedly effective for overall body pain relief, and often used in the treatment of insomnia; they are the late-evening choice of many smokers as an aid for uninterrupted sleep."

In Asia, strains of both kinds were often used to prepare hashish, but in most Western nations, they are predominantly employed to prepare marijuana. Traditional Asian hashish is typically rich in both the intoxicant THC and the noneuphoriant CBD, and indica type land races have been particularly selected for making hashish. By contrast, most high-THC sativa type cultivars have been selected just for THC, and indeed, most have limited or no CBD. An explanation for the presence of CBD in traditional hashish land races was offered by Clarke and Watson (2006): "Hashish cultivars are usually selected for resin quantity rather than potency, so the farmer chooses plants and saves seed by observing which one produces the most resin, unaware of whether it contains predominantly THC or CBD."

SELECTION FOR COLOR IN MARIJUANA STRAINS

The attraction that humans have for white or at least light shades of seeds was pointed out in Chapter 8. Another example of human preference for light hues is provided by the flowering parts of marijuana strains that have been selected by clandestine breeders in the last several decades. There appears to have been selection for strains developing whitish inflorescences (Figure 12.18). The immature stigmas of the female flowers are whitish, although becoming reddish or brown with age. High concentrations of female flowers in the inflorescence of marijuana strains is extremely desirable, since this increases potency, and because higher whiteness is reflective of more female flowers, selection for whiteness has been a simple way of selecting for higher potency and yield. The secretory glands responsible for producing THC are present in high density on the perigonal bracts, and these often glisten under strong light, also contributing to a whitish appearance of the female inflorescence. So-called "white strains" are very popular, as reflected by such names as White Diesel, White Fire, White Gold, White Haze, White Ice, White Label, White Queen, White Rhino, White Russian, White Skunk, White Widow, Early Pearl, Silver Haze, and X-Haze.

Humans are also fond of mutations that develop purplish foliage in domesticated plants, due to the prominence of anthocyanin pigments (e.g., Crimson King, a very popular variant of Norway

FIGURE 12.18 "Buds" of marijuana strains with notable development of white stigmas. Left: White Dwarf. Photo by Ankari80 (CC BY 3.0). Right: Photo by Psychonaught (released into the public domain).

maple; red (purple) cabbage). As is evident in Figure 12.19, when *C. sativa* is exposed to significant frost, it tends to become quite purple (or less green, since chlorophyll tends to degrade, revealing the anthocyanins), and sometimes, the same effect is noticed at high altitudes (perhaps related to high, damaging insolation), demonstrating a propensity for violet coloration. Often, purple coloration develops simply because of cultural conditions (Figure 12.19, right). Dewey (1913) found a purple-leaved mutation arising in Chinese hemp (a fiber biotype, not a marijuana strain), inbred for nine years in Kentucky, Minnesota, and Washington, DC. He named the inbred cultivar Kymington (based on Ky-Min-[Wash]-ington).

Purple coloration of the inflorescences of marijuana strains became quite attractive to consumers in the second half of the 1970s (Clarke and Merlin 2013; note Figure 12.20), many expressing the belief that such varieties are qualitatively superior. Examples of purplish strain names include Purple Bubba Kush, Purple Butter, Purple Cheese, Purple Diesel, Purple Dogg, Purple Erkle, Purple Haze, Purple Kush, Purple Maroc, Purple Monkey Balls, Purple Nepal, Purple Passion, Purple Pine, Purple Pineberry, Purple Power, Purple Pussy, Purple Snow, Purple Urkle, Purple Wreck, Grand Daddy Purple, Blackberry, Blueberry, Grape Ape, and Mendocino Purple. The development of purple coloration in foliage and/or stems occurs in some marijuana strains, likely reflecting past

FIGURE 12.19 Anthocyanin (purplish) coloration in *C. sativa*. Left: Purple color induced in foliage by exposure to frost in late autumn. Right: Purple color induced in the marijuana strain Bubba Kush by cultural conditions. Photo courtesy of Steve Naraine.

FIGURE 12.20 Marijuana strains of *C. sativa* illustrating selection of purple (anthocyanin) coloration under domestication. Left: A bud of Power to the Purple. Photo by Psychonaught, released into the public domain. Right: An inflorescence with numerous buds of Purple Haze. Photo by HansRoht (CC BY 3.0).

selection for expression of anthocyanin pigmentation, and this sometimes alarms illicit marijuana growers suspecting that their plants are diseased or haven't been cared for properly.

PLANT PRODUCTION

Information on outdoor cultivation of industrial hemp for fiber, oilseed, and essential oil is provided respectively in Chapters 7 through 9. Most illicit marijuana is also produced outdoors, although wind and rain can have detrimental effects on marijuana quality. For the most part, outdoor cultivation requirements for marijuana are similar to the requirements for industrial hempseed. Information on authorized indoor cultivation of medicinal marijuana is provided in the next chapter, where it is noted that over a hundred books, in addition to countless websites, provide detailed directions for the illicit cultivation of marijuana plants and consequent preparation of cannabis products. There is nothing fundamentally different in growing *C. sativa* for legitimate or illegitimate purposes, except for the needs for stealth and concealment when cultivating the plant illegally. Of course, this book is not intended to provide guidance on illegal cultivation.

DISTORTION OF BOTANICAL AND HORTICULTURAL TERMS BY THE MARIJUANA TRADE

Cannabis sativa is a plant and is most precisely described by the scientific terminology conventionally employed by biologists, agriculturists, and horticulturalists. For the past half-century, marijuana has been produced, traded, and employed mostly by people with limited knowledge, interest, and appreciation of "official" terminology and indeed who have often delighted in adopting terms that were unintelligible to conventional society. Unfortunately, some of these terms are ambiguous; i.e., they have one meaning scientifically and another meaning in the context of marijuana-specific street language. Frequently, technical botanical terms have been misinterpreted by the marijuana-using community (facetiously, one may ask why these intellectual lapses occurred). Sometimes, the differences in the meanings are subtle and require thought to understand exactly how a scientific term has been distorted. The terms in Table 12.2 especially often lead to misunderstanding.

TECHNOLOGIES FOR PREPARING CANNABIS DRUGS

Marijuana is consumed in a wide variety of forms, as discussed in this and the next chapter. These include several preparations that are smoked, edible formulations, skin patches, ointments, sprays, capsules, suppositories, and even sex lubricants for women. This chapter is concerned with formulations, apparatus,

TABLE 12.2
Examples of How "Marijuana Language" Has Distorted Correct Scientific Terminology

Term	Scientific Meaning	"Marijuana Language" Meaning
Bud	Meristem (growing point of a part of a plant, producing a stem, flower, or leaf; "eye" of tubers like potato)	Inflorescence (congested female flowering axis; see the discussion of why marijuana is not "flowers" in Chapter 1)
Indica	Part of the scientific name *Cannabis indica*, or the name *C. sativa* subsp. *indica*, conventionally employed to designate *all* cannabis plants that are rich in the intoxicating constituent THC	Employed to designate a distinctive class of intoxicating plants that have moderate levels of *both* THC and the nonintoxicating constituent CBD (see discussion of indica type in Chapter 18)
Pistil	Female portion of a flower (style + stigma + ovary)	Stigma (pollen-receptive part of a flower)
Pollen	Male fertilizing agent (functionally like animal sperm, although more complex)	Secretory heads of cannabis glands, collected by filtering techniques
Sativa	Part of the scientific name *C. sativa*, or the name *C. sativa* subsp. *sativa*, conventionally employed to designate all cannabis plants that are very low in the intoxicating constituent THC	Employed to designate intoxicating plants that have very high levels of THC and very low or no levels of the nonintoxicating constituent CBD (see Chapter 18)
Style	Transitional area of a female flower between the stigma (pollen receptive part) and ovary (seed-containing part); it is nonreceptive to pollen	Stigma (pollen receptive part of a female flower)
Trichomes	Small appendages on the surface of plants (includes "hairs"); in reference to cannabis, particularly the hairs tipped with resin-containing heads (i.e., both stalks and the resin-containing heads)	Resin-containing heads of cannabis stalked glandular trichomes

and methods used mainly for recreational purposes, while the next chapter is concerned with medical technologies, many of which are based on the same kinds of apparatus used for recreational marijuana.

Marijuana

"Manicured marijuana" is composed of flowering parts of the plant coupled with associated small leaves, prepared using intoxicant varieties. It is comparable in texture to smoking tobacco. Marijuana is conventionally prepared by (1) breaking up the dried flowering tops and eliminating all but the smallest twigs, (2) forcing the resulting material through a coarse screen, and (optionally) (3) crumbling. The result is a mixture of plant particles, including the tiny secretory trichome glands that contain most of the resin (some resin is smeared on plant particles during preparation). Up until the last two decades, in the Western world, marijuana often included a substantial content of seeds (which do not contain THC) and foliage (which contains limited THC, as illustrated in Figure 12.21, bottom). As a result, marijuana in the past usually contained no more than 5% THC, often less. Currently, marijuana rarely has seeds or larger leaves, and the THC content is at least 5%, sometimes as high as 25%. ElSohly et al. (2016) surveyed about 39,000 samples of cannabis confiscated by the American Drug Enforcement Administration between January 1, 1995 and December 31, 2014. The proportion of sinsemilla (seedless) samples increased, and (consistent with this) the potency of illicit cannabis plant material consistently rose from approximately 4% in 1995 to approximately 12% in 2014 (CBD content fell from approximately 0.28% in 2001 to <0.15% in 2014). Marijuana is sometimes referred to as "herbal-type" cannabis, in contrast to hashish, termed a "resin-type" form of cannabis.

The perigonal bracts subtending the female flowers are very rich in THC, and the market for marijuana has evolved toward the use of the unfertilized female inflorescences (which contain these bracts), i.e., the congested flowering branches, usually referred to as "buds," much less frequently termed "colas," illustrated in Figure 12.22a, b, and c. "Sinsemilla" is the most

FIGURE 12.21 Old-fashioned marijuana. Top: Sieving mature flowering tops with substantial amounts of foliage through a screen. Bottom: Grades of marijuana commonly encountered in the 1960s through the 1980s. Increasing quality is indicated by lesser content of twigs and seeds, which contain little or no THC. In the past, THC content of herbal marijuana rarely exceeded 5% dry weight.

frequent term, collectively referring to high-THC marijuana prepared mostly from the unfertilized female inflorescences. In the United Kingdom, sinsemilla is often called "skunk," a transfer of the word from the well-known strain Skunk #1. Similarly, "Kush" (part of the name of numerous marijuana strains) has become somewhat synonymous with high-grade marijuana in North America. Whole buds rather than those that are ground up are a favored commercial form of sinsemilla. Races with female marijuana plants have been selected to produce flowering heads with abundant flowers in tight heads. Buds have become much more popular as a sales item because they are usually a reliable indicator of high-grade marijuana (it is impossible to judge the quality of manicured marijuana without smoking it or measuring THC content). Contents of 10% to 20% THC are common in street grade bud. Rarely, 30% THC marijuana is found in illicitly sold material, although such high-potency material is claimed by some authorized medicinal marijuana suppliers (and can be achieved by careful trimming away of leaves). Buds are too large to smoke directly, so they are broken up into a tobacco-like consistency, often using a herb grinder (shown in Figure 12.22d).

Traditional Hashish

Hashish (Figure 12.23c) is a relatively pure preparation of the resinous secretions of intoxicant varieties of the plant. As traditionally made in Asia, it is prepared by a variety of methods (see

FIGURE 12.22 (a, b) Marijuana "buds" and their processing for smoking. (a) Buds (unfertilized, congested, female inflorescences, with large numbers of perigonal bracts rich in secretory glands), increasingly popular since the 1980s. THC content typically ranges between 10% and 20%. Achenes ("seeds"), which do not contain cannabinoids, are not present. Often, the buds are manicured (the small unifoliolate leaves present are trimmed away with scissors) to additionally increase THC content. (a) Bud of the strain Blue Dream. Photo by Psychonaught (released into the public domain). (b) Buds of the strains Platinum Bubba on top and Skywalker OG on bottom. Photo by Coaster420 (released into the public domain). (c) Portions of buds in a container, the kind of commercial product that is currently the most popular form of cannabis. Photo by Cannabis Culture (CC BY 2.0). (d) Herb grinder, a device composed of two separable halves with sharp teeth or pegs that shred contained material when the halves are rotated. Originally used to shred herbs and spices for culinary purposes, they are now more frequently employed to shred bud into finely ground bits that burn evenly. Photo (public domain) by Liquid Splitter.

Clarke 1998a, Hamayun and Shinwari 2004, and Figure 12.23a and b) but is always a mixture of resinous herbal material collected from the female inflorescences of *C. sativa*. It is predominantly prepared by filtering cannabis material through very fine fabric screens (such as silk) or sieves. Sieving requires the plants be dried first, and because applying artificial heat is usually too expensive, an arid climate is essential (such as provided in regions of Afghanistan, Lebanon, Morocco, and Pakistan). Additional treatments following collection of the powdery sieved particles vary depending on region, but usually the material is compressed, sometimes gently heated, resulting in a solidified, sticky mass, typically pressed or rolled to form hardened resinous cakes. Hashish in illicit markets typically has a THC content of 5% to 25% (levels as high as 45% have been reported). Texture or consistency varies from putty-like to brittle or dusty. Colors encountered include sandy, reddish, and black (often due to oxidation, reflective of aging or manner of handling). Green color is often due to the presence of unwanted plant material or collection when the plants were immature. Adulterants, such as oils or bulking agents, are sometimes introduced.

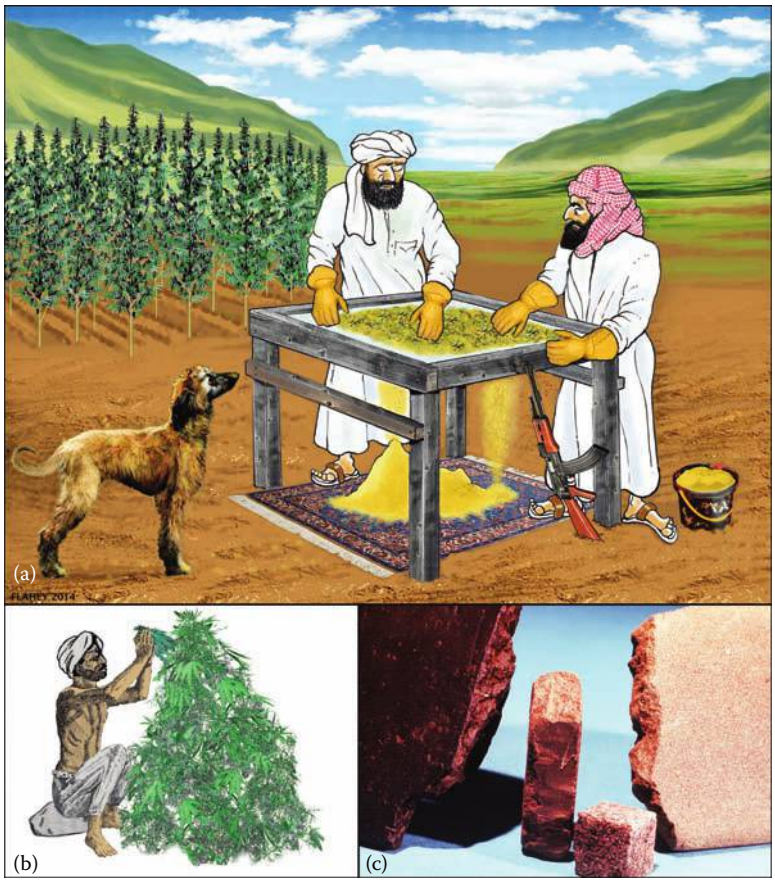

FIGURE 12.23 Traditional methods of preparing hashish (mostly encountered in Asia). (a) Preparation of hashish by sieving through a fine silk screen. Drawn by B. Flahey. (b) Preparation of hand-rubbed hashish ("charas"), as once practiced in Asia. Secretory glands and resin rich in THC accumulate on the hands during prolonged manual contact with the plant and are scraped off. Drawn by B. Brookes. (c) Confiscated bricks and cubes of compressed hashish. Such preparations are primarily an Asian product and are currently often made from indica type races with more or less equal amounts of THC and CBD. THC contents generally range from 5% to 15%, dry weight.

In contrast to filtering or sieving (to produce "sieved hashish"), an alternative method of preparing hashish in Asia is to rub the female inflorescences by hand so that the sticky resin glands and secretions stick to the hands (Figure 12.23b) and are scraped off (to produce "rubbed hashish"). Similarly in the past, people dressed in leather brushed against the sticky inflorescences until resin accumulated on their garments, subsequently scraping off the resin (Bouquet 1950). The hand-rubbing technique has been mostly abandoned because it is so labor-intensive, although Clarke (1998a) wrote that hand-rubbed charas is sold in Himalchal Pradesh, Kashmir, Chitral, and Nepal. Abel (1980) stated that in Nepal, workers ran naked through the cannabis fields, and the sticky resin was scraped from their bodies. Reports of this rather gross practice are probably apocryphal, indeed likely mythical (Ethan Russo, personal communication), as anyone working in a field of *C. sativa* quickly learns how abrasive the foliage can be to bare flesh. Hamayun and Shinwari (2004) is an excellent anthropological study of traditional methods of producing hashish.

The abandoned hand-rubbing technique requires that sticky resin accumulate on the plant's surfaces. Stickiness is due to the secretory glands releasing terpene and cannabinoid secretions over the outer surface of the glands. Probably the agitation from wind tends to break some gland heads,

which exude their resin. In very windy, dry, or cold environments, secretions tend to volatilize more readily, decreasing stickiness (terpenes volatilize readily, THC does not); by contrast, in hot, still environments (whether outdoors or under intense grow-lights), secretions appear to accumulate more readily, and the plant surfaces can become very sticky. It is unclear whether high-THC land races were selected that were particularly suitable for hashish preparation by the hand-rubbing technique, by virtue of tending to secrete resin readily rather than retaining it within the gland heads, but this seems plausible.

Traditional hashish is typically higher in THC content than traditional marijuana although buds can be higher in THC. Hashish is also more compact and retains THC levels longer (outer parts of a brick of hashish oxidize, but inner portions are relatively protected from oxygen and light). Hashish is more portable, transportable, and easier to conceal (both visually and with respect to odor). However, traditional hashish requires much more labor and land to produce than marijuana of equivalent psychoactive status. Its production is largely restricted to parts of Asia, and its export is mostly limited to Eurasia.

Solvent Extracts

Hashish in the illicit trade may be made by the use of solvents—often a fire and explosion hazard for preparers. There are several counterculture guides on the preparation of such cannabinoid extracts (e.g., Gold 1973; Starks 1990). The products range from liquid form (with substantial solvent remaining) through thick oil (most solvent removed) and viscous or hard consistency, depending on the extent of distillation (Figure 12.24). A variety of terms, most of them slang, are applied, the most common of which include hashish oil (hash oil), butane hash (when prepared with butane as a solvent), liquid hashish, honey oil, wax, dabs, shatter (referring to a glass-like consistency that often snaps or "shatters"), budder, and nug runs. (Note that the word "oil" in these phrases does not necessarily indicate liquid form but seems to have been adopted because of viscous consistency and/or stickiness. "Hashish oil" may be liquid, semisolid, or tar-like. "Waxes" have the consistency of a sticky wax.) Such products may have a THC content of 20%–50% (levels exceeding 60% are rarely reported). Solvent-prepared hashish is usually too strong to consume directly and is normally cut (diluted) using tobacco or marijuana. Given the lack of quality oversight in illegal operations, these formulations often contain toxic residues and may be particularly dangerous. Nevertheless, there is considerable home preparation of hash oil, often using nonbud material, material trimmed away from the buds ("trim"), or remains ("shake") after filtering the more potent fractions. Romano and Hazekamp (2013) analyzed the comparative value of employing naphtha, petroleum ether, ethanol, and olive oil as solvents in preparing cannabis oil and noted that olive oil was the safest and cheapest.

FIGURE 12.24 Home-prepared chemical extracts of *C. sativa* rich in THC. Left: "Hash oil." Photo (public domain) by Erik Fenderson. Right: "Butane honey oil." Photo by Vjiced (CC BY 3.0). Preparations (usually illicit) such as these are often dangerous because of the possible presence of toxic chemical impurities, very high THC content, and deliberate contamination with dangerous drugs.

Solvents are also used to extract cannabinoids by the medical cannabis industry, and reputable products are often available in the form of liquids (especially alcoholic) containing considerable dissolved cannabinoids, as discussed in the next chapter.

Advanced Nonsolvent Technologies for Preparing Concentrates of Gland Heads

New technologies, not employing solvents, have been created in Western countries to produce preparations, best termed "resin powder," which are rich in the THC-containing resin glands (or their heads). Such concentrates are commonly termed "pollen," "crystal," "bubble hash," and "kief" and are also known by a variety of other names. The Asian tradition of using filters is employed, but the millipore screens commonly used have much smaller openings (50–150 μm in diameter), and the techniques utilized produce a material that is very much richer in presence of secretory glands, very much lower in presence of other herbal material, and (usually) higher in THC, by comparison with conventional Asian hashish. Clarke (1998a) is widely considered to be the "gold standard" on the topic of preparing potent marijuana by such nonsolvent methods (especially see the chapter "High-Tech Hashish-Making"). Although remarkably ingenious systems have been devised to separate and collect the cannabinoid-rich trichome gland heads of *C. sativa*, similar systems have been employed to collect the gland heads of its relative, hop (*Humulus lupulus*), employed as a flavorant and medicinal (Bishop 1966; Rigby 2000).

Cannabis "resin powder" is produced by sieving high-THC parts of the cannabis plant through very fine-pored screens. Crude grades of cannabis resin powder are in fact the basis of most traditionally produced hashish (hashish, in essence, is cannabis resin powder that has been very strongly compressed into massed material). However, in the last two decades, techniques and apparatus have become available that produce cannabis resin powder of exceptional potency (sometimes with about 50% THC). To date, highly potent resin powder has been produced as "connoisseur," counterculture, illicit, or quasi-legal drug products that are very expensive and available in limited supply. Such high-THC material is generated (1) from bud, to produce very high THC "gourmet" material and (2) from the "nonbud" (i.e., usually discarded), low-THC parts of marijuana plants, in order to salvage a high-grade of cannabis drug. The expense of such high-THC preparations, due to the high cost of preparation, is the chief factor limiting their popularity. In the illicit trade, the very large wastage factors mean that high-quality marijuana is generally not used for producing cannabis resin powder. Rather, resin powder is produced as a salvage operation based on waste material that otherwise is simply discarded. Substantial amounts of high-grade marijuana must be sacrificed to produce cannabis resin powder. For example, starting with material of 12% THC, 1 kg of material would have to be sacrificed to produce just 1 g of resin powder of 30% THC content (i.e., 99.9% of the starting material is "wasted"). The attraction is that relatively little material needs to be smoked. However, because of the difficulty in smoking the very small amount of material required to become "high," it is occasionally diluted with regular marijuana or tobacco. The product is powdery in nature, hence adaptable to dispersion in marijuana for purposes of increasing the THC content of the latter. Because it is so expensive, deterioration is a major concern, but resin powder can be stored long-term under appropriate (very cold, dry, dark) conditions for later use.

The terms "pollen" and "crystal" are currently widely applied to cannabis resin powder. Uncompressed resin powder is often referred to as "kief" (sometimes "kif"). Very-high-quality compressed resin powder is often known as "bubble hash" (Figure 12.25), an expression reflecting the frequent occurring of bubbling when the preparations are burned for consumption. The technologies described in the following concentrate the resin glands into a fine powder, reminiscent of plant pollen, and hence the term "pollen" was taken up as also designating the concentrated resin glands. The term "pollen" is used almost exclusively in the illicit drug counterculture cannabis community but is inappropriate since it is incomprehensible to most people. Nevertheless, when searching for information on cannabis resin gland preparations, the term "pollen" needs to be considered. Searches for "crystal" often produce information for crystal meth (amphetamine).

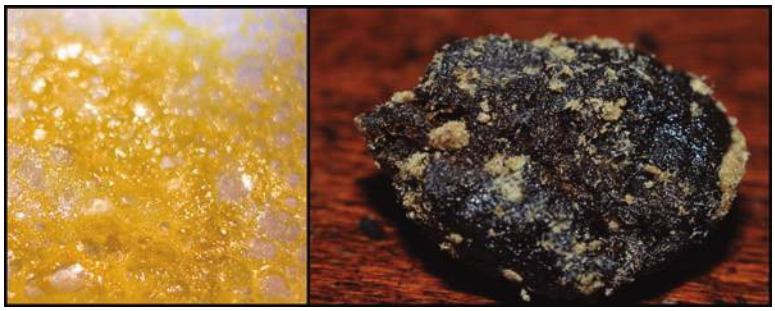

FIGURE 12.25 "Bubble hash," very potent forms of hashish (THC content has been claimed to sometimes exceed 50%) often prepared from resin powder. Photo at left by Andres Rodriguez, photo at right by J. Adams (both CC BY 2.0).

In the illicit drug counterculture, cannabis resin powder (which indeed is a powdery preparation) is compressed (e.g., by 5-ton hydraulic presses modified for the purpose), so that the preparation does have a superficial similarity to Asian hashish. Illicit drug counterculture publications use the term "hashish" to refer not only to traditional Asian styles of hashish but also to compressed cannabis resin powder, although the latter is different from traditional hashish. Clarke (1998a) refers to resin gland preparations produced by modern technologies as "high-tech hashish." When searching for information on cannabis resin powder, the term "hashish" needs to be employed.

Preparation of resin powder by modern techniques involves a combination of (1) very carefully regulated and limited application of force to separate secretory gland heads from the remainder of the plant materials and (2) the use of fine sieves (with very small pores). The sieves have holes 50–150 μm in diameter, the aperture size varied to separate the secretory glands from other plant materials. As noted in Clarke (1998a), marijuana varieties differ widely in gland size and so the filters used to produce resin powder should have pore sizes appropriate to the range of gland sizes. As noted in Small and Naraine (2016b), gland heads decrease in size with age, which can also affect the appropriate pore size required. Agitation and/or physical pressure is used to separate the glands and may be preceded by freezing to facilitate separation of intact glands. In "wet" techniques, dispersion in water is also employed, taking advantage of the principles that the cannabinoids are largely immiscible in water and differ in density from other parts of the plant. The result (potentially) is the production of a grade of material that is much richer in THC level than conventional marijuana. Portable handheld devices known as "kief boxes" are often used to transform small amounts of marijuana into a relatively crude grade of resin powder for personal use (Figure 12.26d).

The following are principal techniques employed to produce resin powder.

A. "Dry" technologies
   a. Vibration
      1. "Flat-screening": The simplest automated apparatus is a motor-driven shaker-sieve, preferably with both up-and-down as well as side-to-side motion. The material is placed in a container, the horizontal sieve forming the bottom of the container, and the container is kept in gentle motion for a limited period of time.
      2. "Drum-screening": Alternatively, a cylindrical container constructed of sieve material may hold the material, and the cylinder rotated, as in a conventional clothes dryer. Several designs are available. Drum-screening is considered to be preferable to flat-screening.

         With these kinds of devices, it is critical to limit the degree and period of agitation so that primarily the larger secretory gland-heads are separated. These are the first to separate. If agitation is too strong or continued for too long a period, the result is that additional plant materials pass through the pores of the sieve material, and the THC

FIGURE 12.26 Top: recent commercially available extraction systems for preparation of purified, high-THC concentrates of secretory glands starting with herbal material (leaves and flowers). (a) The "Pollinator" is a dry sifting machine. Herbal material is placed in the revolving drum, which is perforated with 150 μm holes. Resin glands are expelled through the holes and collect in the box containing the drum. (b) The "Bubbleator" is constructed like a small washing machine. Frozen herbal material is placed, along with ice water, in a series of bags that are perforated with holes of decreasing size that permit the resin glands to be expelled. These in turn are placed in the device, which agitates the bags for a period, and then the separated resin glands are purified by additional sieving, and dried. This device takes advantage of the insolubility of the resin in water and the brittleness of the glands when frozen. (c) The "Ice-O-Lator" is a similar but simpler apparatus, in which an agitating device is placed on top of a bucket. Detailed operating instructions are available at various websites. These devices may be considered to be illegal drug paraphernalia in some countries. Photographs courtesy of Mila and Chimed Jansen of the Pollinator Company. Bottom: (d) "Kief box" ("pollen box"). This is a small box fitted with a fine screen through which bud is gently sifted, allowing mostly secretory trichome gland heads to fall through the screen onto a collection plate. (e) Cannabis resin powder. Photo by Mjpression (CC BY 3.0).

level of the resulting resin powder is decreased. Moreover, by freezing the starting material just prior to sieving, the stalked glands become much more easily detached, facilitating separation of high-grade resin powder (illustrated in Figure 12.26d). The most widely advertised, sold, and used apparatus in the dry technology category is the Pollinator (Figure 12.26a), a device inspired by a clothes dryer.

b. Sonication (ultrasonic vibration)

Ultrasonic vibrators are an alternative to the use of motor-driven shakers. Commercial sonicator models, employing a liquid bath, are widely used to clean by shaking dirt off objects. Because the marijuana used as starting material must not contact liquid, the liquid either is simply not placed in the bath chamber or is first placed in a water-tight container. The resin powder collects at the base of the container or bath chamber. Commercially available devices specifically employing sonication for the production of cannabis resin powder do not seem to be available.

B. "Wet" technologies

Wet technologies exploit the fact that mature secretory glands are heavier than water (as well as the fact that the resin in the gland is basically not dissolvable in water), while most plant parts are lighter than water. When mixed with water, cannabis powder resin can thus be substantially separated. The principal marketed devices also utilize freezing to make the secretory glands more separable, combining this with filters and agitation.

The Bubbleator (Figure 12.26b) resembles a miniature washing machine. Bags made up of very fine-pored material ("bubble bags") are employed (a coarse-pored one with the material is placed inside a second bag with finer pores), and by varying the pore size of the bags and repeating the sifting process, it is possible to separate a series of resin powders of different THC levels.

The Ice-o-lator (Figure 12.26c) is one of the principal devices used. Material is placed in a bucket of cold (4°C) water to harden the resin glands and make them more easily separated. Agitation by a motor-driven mixer results in the resin glands separating. The denser resin glands sink while the less dense remaining parts of the plant float on the surface. A course screen (e.g., with hole size 187 μm) is used to skim off the floating materials, and a fine screen (e.g., with hole size 62 μm) is used to separate the resin glands from any finer particulate material that has sunk. Resin powder prepared with this apparatus is sometimes termed "iceolator hash" or "water hash."

Water Extracts ("Teas")

The word "tea" in common usage corresponds to two kinds of liquid extract in technical pharmacological literature. An "infusion" is a liquid solution extracting a compound of interest, prepared by soaking or steeping, usually in water. An infusion is usually made by pouring boiling water over herbaceous material and allowing this to steep (it can also be made by adding concentrated extracts to water). A "decoction" is an extract obtained by boiling in water (the strained liquor is called the decoction). In pharmacy, a decoction may be contrasted with an infusion, where there is merely steeping. Decoctions are often made using hard components such as roots and bark that are resistant to boiling. Both infusions and decoction are employed to prepare cannabis teas.

When cannabis is smoked, vaporized, or baked, the heat is sufficient to convert essentially 100% of the nonpsychoactive THC acid (THCA) to the psychoactive THC. When cannabis is placed in boiling water, only a small percentage of the THCA is converted to THC, so that cannabis tea is a comparatively less psychoactive way of consumption (unless one likes to drink a lot). Moreover, the amount of THC that can be dissolved in water is very low: Hazekamp et al. (2007) found that when pure THC is placed in boiling water, only 17% was solubilized. However, it is well known that THC is soluble in fats like milk, so adding some form of milk to the water greatly increases the THC dissolved. As noted later, in India, beverages prepared with cannabis often have milk added to extract the THC. Hazekamp et al. (2007) observed that if milk is added to cannabis tea, it stores well for several days, but if not added, most of the THC precipitates in only one day, so that the tea loses its potency.

In Jamaica, cannabis tea is used as a remedy for cold, fever, and stress (Hazekamp et al. 2007). In Europe (and occasionally in North America), packages of foliage of *C. sativa* are available (usually illegally) for preparing cannabis tea. The Office of Medicinal Cannabis of the Netherlands (http://www.cannabisbureau.nl/en/) provides the following instructions for preparing cannabis tea using marijuana:

- Boil 500 mL of water in a pan with the lid on.
- Add 0.5 g (about two teaspoons or one measuring scoop) of medicinal cannabis.
- Turn down the heat and let the tea simmer gently for 15 minutes with the lid still on the pan.
- Take the tea off the stove and pour it through a sieve.
- Keep the tea in a thermos flask if you plan to drink it the same day.

If you want to make tea for several days, use 1 g (about four teaspoons or two measuring scoops) of medicinal cannabis for 1 L of water. Then, after preparing the tea as described previously, add a package or teaspoon of coffee creamer powder to the warm tea. This will keep the active substances in the tea from sticking to the inside of the teapot or cup, reducing its effectiveness. Let the tea cool down and store it in the fridge. It will store for several days. You may reheat the refrigerated tea and can add sugar, syrup, or honey to improve its taste.

TECHNOLOGIES FOR SMOKING AND VAPING CANNABIS DRUGS

Representative traditional and novel methods of inhaling cannabis are discussed in the following presentation (in some jurisdictions, the materials illustrated are illicit). Regardless of smoking method, the very undesirable health effects of smoking are discussed in the next chapter, with emphasis on the relative desirability of inhalation modes that reduce the intake of toxins.

Joints and Blunts

"Joints" (marijuana cigarettes; Figure 12.27a), also referred to as "reefers," "spliffs," "doobies," and by numerous other slang names, as indicated in Abel (1982), are the most widely employed method of smoking. Occasionally, "blunts" (marijuana cigars; Figure 12.27b) are prepared, although these are much too large for a single dosage. In Europe, cigarettes are frequently fashioned by combining tobacco with 0.1–0.3 g of marijuana, often using high-potency material since the tobacco occupies much of the cigarette; in North America, tobacco is infrequently employed and joints tend to be smaller. In the past in North America, marijuana was of lower potency, and up to 0.5 g was placed in a joint. The word "spliff" is sometimes used for a joint prepared with both cannabis and tobacco, but in the West Indies, where the term originated, and in North America, it normally designates a joint made only with marijuana.

FIGURE 12.27 Variations of marijuana cigarettes. (a) Hand-rolled marijuana cigarettes ("joints") and a regular tobacco cigarette for scale. Twisting the ends is common because marijuana lacks the packing qualities of tobacco. Note the smaller amounts that are typically smoked by comparison with tobacco. (b) A marijuana cigar ("blunt"), often prepared by replacing the tobacco in a conventional cigar with marijuana. Photo by iTopher (CC BY 2.0). (c) An unrolled joint with a rolled up piece of cardboard stock employed at the base so that the marijuana can be completely smoked. Photo by Erik Fenderson (released into the public domain). (d) A rolled up piece of cardboard as shown in (c). Photo by Erik Fenderson (released into the public domain).

Roach clips are devices employed to hold the lit butt of a joint, in order to avoid finger burns and stains. They may be as simple as a paper clip or tweezers. Roach clips are considered passé today in North America; an alternative technique is to use a piece of rolled-up business card (Figure 12.27c and d) inside the base of a joint so that it can be smoked completely.

Simple (Nonfiltering) Pipes

An impressive array of smoking devices are employed for marijuana. Very crude instruments suffice, for example, the "chillum" (Figure 12.28a), a simple, clay pipe employed in India and Jamaica. (While elementary in design, traditional usage requires an assistant to light the marijuana, while the other inhales the smoke through a wet cloth wrapped around the mouthpiece to cool the smoke and prevent inhalation of embers.) Often, makeshift crude instruments are fashioned out of all kinds of objects, such as hollowed-out apples (Figure 12.28b) and beer cans. Sebsi pipes (Figure 12.29),

(a) (b)

FIGURE 12.28 Examples of simple marijuana pipes. (a) Earthen chillums displayed for sale in the city of Jorhat, India. Photo by Anupom sarmah (CC BY SA 4.0). (b) Apple pipe. Photo by Payman (CC BY SA 3.0).

FIGURE 12.29 Drawing of a sebsi pipe being smoked in North Africa. (Courtesy of Ebers, G., *Egypt: Descriptive, Historical, and Picturesque, Vol. 1*, Cassell & Company, New York, 1878. Public domain.)

FIGURE 12.30 Artistic glass pipes employed for smoking marijuana. (a) A store in San Francisco-Haight & Ashbury-specializing in cannabis pipes. Photo by David Ohmer (CC BY 2.0). (b) Display of marijuana pipes. Photo by Charlie Gaddie (CC BY 2.0). (c) A general-purpose drug pipe. Photo (public domain) from the U.S. Drug Enforcement Administration. (d) A "spoon pipe" (so-named for its resemblance to a spoon). Photo by Todd Blaisdell (CC BY ND 2.0). (e) Note the ventilation hole ("carb," "choke," "shottie," "shot hole," "rush hole") in the bowl of this pipe, intended for thumb control; like the carburetor of a car, this serves to regulate burning and airflow by controlling access to air. Photo by TheChanel (CC BY 2.0).

which are popular in North Africa, especially in Morocco, are long-stemmed and have a small metal or ceramic bowl, both features that cool the smoke.

Multicolored handblown glass pipes have become quite popular (Figure 12.30) and are often works of art, sometimes designed to change color as the pipes heat up.

Water Pipes

Based mostly on tobacco, different cultures have created complex devices to cool smoke by passing it through a water chamber (Figure 12.31a). These are known as water pipes, hookahs, hubble bubbles, nargils, and by other names. Such instruments modified specifically for cannabis consumption are known as "bongs." Most bongs have a carb (explained in Figure 12.30e) to clear smoke from the portion of the chamber above the water, but some bongs have a removable stem called a "slide," that has the same purpose. Today, a variety of instruments, often quite artistically designed and occasionally costing as much as thousands of dollars, are marketed. Often, instruments are constructed from household materials by individuals for personal use (Stone 2010). A "Rasta chalice" (tracing to Rastafarian religious use of marijuana) can be as simple as a hollowed out coconut with two holes, a smoking bowl inserted in one of the holes, its tube extending into the water placed in the coconut, and a drawtube inserted in the other hole. "Ice catchers" (ice bongs; Figure 12.32) incorporate indents in the instrument so that ice can be supported in the air flow column to cool the smoke (in addition to the water through which the smoke is bubbled). In past centuries, extraordinarily crafted hookahs were often

FIGURE 12.31 Hookahs for cooling smoke. (a) Diagram showing how marijuana smoke is cooled by a water pipe. Prepared by Christopher Thomas (CC BY 3.0). (b) A king of Nepal with a hookah (created in 1840 by an unknown Indian artist; public domain photo). Credit: The San Diego Museum of Art, Edwin Binney 3rd Collection Accession Number: 1990.177. (c) Ali-Pasha and his hookah. He was an eighteenth century Muslim Albanian ruler who served as a pasha for the Ottoman Empire. Photo by Dimitris Siskopoulos, of a mural in the Ali Pasha Museum, Epirus, Greece (CC BY 2.0).

prized possessions of Asian potentates (Figure 12.31b and c). As detailed in the next chapter, while water filtration reduces the amount of some harmful constituents, nevertheless, significant toxic compounds are inhaled when water pipes are employed to smoke cannabis. Some hookahs are designed to not only pass smoke through water but also through charcoal. However, waterpipes, even when fitted with solid filters, are ineffective at improving the THC/tar ratio in smoke (Gieringer 2001).

Vaporizers

Vaporizers are instruments designed to vaporize materials for inhalation. Unlike "smoking" (inhalation of "smoke"—a combination of vapors and combusted particles, invariably including hundreds of dangerous chemicals), the heat produced is sufficient to produce steam or vapor but ignition

FIGURE 12.32 An ice bong, for cooling smoke. Photo by Taschenkrebs, released into the public domain.

or burning does not occur. Commercial vaporizers specifically for inhaling the cannabinoids are available, particularly the popular "Volcano" series (Figure 12.33b). Personally constructed vaporizers have been made (Figure 12.33a). "Electronic cigarettes" (e-pen vaporizers, as shown in Figure 12.33c) are instruments usually designed to vaporize nicotine for inhalation but are also commonly employed for cannabis. Forms of cannabis used for vaporization are usually quite concentrated—resin or oil. E-pen vaporizers are increasing rapidly in popularity and could well become the most common instruments used for cannabis consumption. As detailed in the next chapter, vaporizers considerably reduce but do not entirely eliminate the intake of toxins experienced by smoking. Jensen et al. (2015) noted that E-cigarette liquids are typically solutions of propylene glycol, which can degrade to produce alarming levels of formaldehyde during vaping.

Dabbing

"Dabbing" refers to a practice, largely conducted by a subculture of marijuana users, usually young, who employ cannabis concentrates (so concentrated that a "dab" suffices) to become very high very quickly. The technique was developed partly to efficiently use concentrates, which are easily ignited and wasted, and partly to get high rapidly. "Blasting dabs" is done by heating on a hot surface (Figure 12.34, right), often as simple as a real nail, or a similar structure termed a "nail" (often made of titanium, sometimes quartz or glass), and inhaling the vapor. Frequently, specialized instruments are available (Figure 12.34, left), as well as special gear such as "dab tools" (utensils for smoking concentrates) are employed. Blow torches (often specially designed) are typically used to heat nails or glass bongs (electronic nails have been developed to eliminate the need for fire). Some dabbing pipes look like traditional meth or crack cocaine pipes, and dabbing using torches has led to the practice being termed "the crack of pot." Like those who drink to become very drunk quickly, the intense highs desired by "dabbers" may be a sign of addiction or maladjustment (Loflin and Earleywine 2014). Because concentrates produced illicitly are often unsafe, and it is very easy to overdose, dabbing is dangerous (Gieringer 2015), especially for novices.

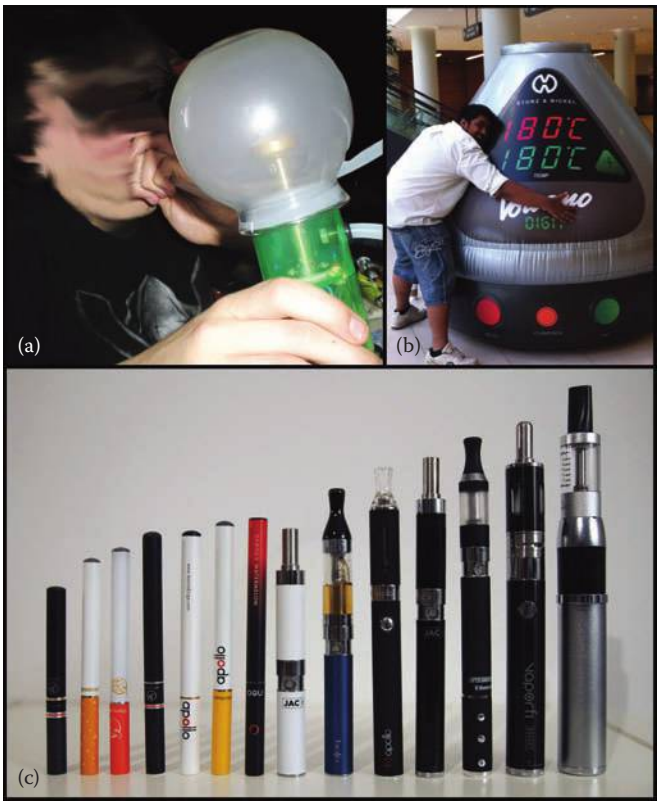

FIGURE 12.33 Vaporizers. (a) A vaporizer constructed for smoking cannabis. Photo (self-portrait) by Patrick Morris (CC BY 2.0; face obscured). (b) An exhibit of the popular Volcano vaporizer at a medical marijuana sales event in Toronto in 2013. Photo courtesy of Steve Naraine. (c) Different types of electronic cigarettes, adaptable for smoking cannabis resin and oil. Photo by Vaping 360.com (CC BY 2.0).

FIGURE 12.34 Dabbing of cannabis. Left: A dab rig. Photo by Steven Schwartz (CC BY 2.0). Right: Dabbing hash oil. Concentrated cannabis resin on the end of a metal poker is being applied to the cup of a glass "nail," which replaces the bowl of a bong. This nail has been heated using a butane torch, and applied resin will be almost instantaneously vaporized. The THC-rich vapor that results will be drawn through the hollow stem (seen in the center of the nail) into an attached smoking device (like a bong) and inhaled. Photo by DJ Colonel Corn (face obscured; CC BY SA 3.0).

EDIBLE CANNABIS

Marijuana can be ingested as food, often termed "edibles" (Wolkowicz 2012), such as illustrated in Figure 12.35. Eating cannabis to alter consciousness has a long history. India traditionally produced "bhang"—chopped, macerated cannabis leaves most often consumed as a beverage (typically with added milk), sometimes with other psychoactive ingredients added. To this day, preparing bhang is still practiced in India, where "bhang shops" can be found (Figure 12.36). "Majoon" is another traditional Indian marijuana foliage-based confection prepared with various foods and spices, some of which may also be psychotropic.

Humans are not well equipped to chew and digest herbal marijuana, which is not tasty. Consuming hashish is preferable in that less needs to be consumed, but depending on how it was prepared, there may be problems of toxicity and dosage. It is preferable to extract the cannabinoids as a solution and employ the solution as one would use culinary spices. There are numerous books and Internet sources detailing how to prepare foods "enriched" with cannabinoids. Cannabis is frequently consumed in baked goods in Western culture, classically brownies, but also cakes, cookies, and fudge. The slower onset and longer duration of the effects of eating rather than inhaling cannabinoids are discussed in the next chapter. THC content of commercial edible products has proven to be erratic in some jurisdictions, and edibles not properly stored are a hazard for young children.

As noted previously, THC is mostly insoluble in water, although marijuana is nevertheless sometimes made into a "tea" or other type of beverage such as sodas. THC dissolves readily in alcohol, so an alcoholic infusion of marijuana can be a route to getting THC into food. Tinctures are typically made by placing marijuana in glass jars with alcoholic beverages such as vodka for six to eight weeks to allow the cannabinoids to dissolve. A much faster mode of preparation is described in the next paragraph.

THC is fat-soluble, and by infusing it into a fat like butter, milk, or olive oil, cannabis can be incorporated into a wide range of edible products. Finely ground marijuana can be cooked with oil or butter (Figure 12.37), dissolving the cannabinoids in these fats. Cannabis butter ("cannabutter,"

FIGURE 12.35 Confiscated edible marijuana products, including "Allmy Joy," "Munchy Way," "Pot Tarts," "Stony Rancher," "Rasta Reece's," "Buddafingers," "Double Puff Oeo," "Keef Kat," "Budtella," "Puff-A-Mint Pattie," "Puffsi," "Bong's Root Beer," and "Toka Cola." Photos (public domain) from the U.S. Drug Enforcement Administration.

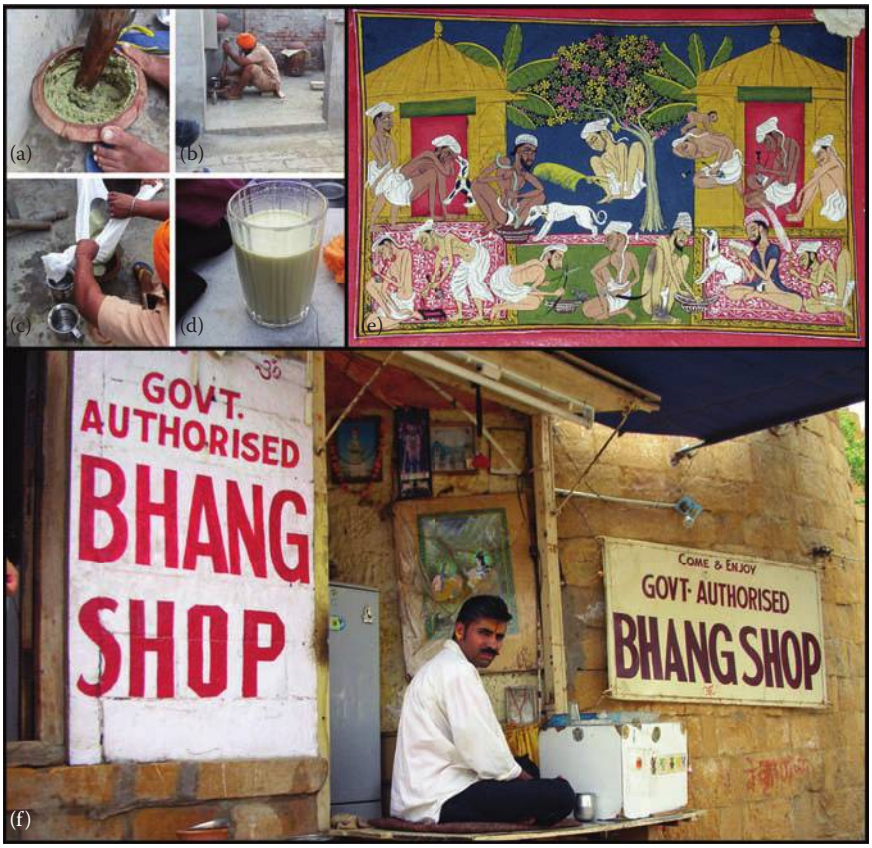

FIGURE 12.36 Bhang. (a–d) Preparing bhang in Punjab, India. (a, b) Macerating herbal cannabis with other ingredients. (c) Filtering macerated ingredients through cloth. (d) A glass of bhang. Photos by Marcusprasad (CC BY SA 4.0). (e) "Bhang eaters before two huts," dated ca. 1790. Credit: Edwin Binney 3rd Collection Accession Number: 1990.642, The San Diego Museum (public domain). (f) A bhang shop in Jaisalmer, Rajasthan, India. Photo by Tom Maisey (CC BY 2.0).

FIGURE 12.37 Examples of marijuana culinary arts. Left: Preparation of "cannabutter," a widely employed ingredient of edible cannabis. Photo by Realclark, released into the public domain. Right: Preparing marijuana brownies by cooking cannabis-infused butter with chocolate. Photo by Antoine (CC BY SA 3.0).

FIGURE 12.38 Scenes of THC-infused ice cream available in California. Photos courtesy of Cannabis Creamery (https://www.facebook.com/pages/Cannabis-Creamery/704824732895521?sk=info&tab=page_info).

"butteruana") can be quite green when prepared by combining macerated marijuana with butter because of the presence of extracted chlorophyll. "Recommendations range from 1/8 to 1/2 ounce [3.5–14 g] of marijuana per 1/4 cup [59 ml] of oil or butter. Cooking times range from 20 to 45 minutes. Shorter cooking times should release fewer flavonoids and minimize the grassy taste" (Earleywine 2010). The cannabinoid-infused butter or oil can be employed in many recipes, including ice cream (Figure 12.38).

As discussed in detail in Chapter 8, hempseed and hempseed oil are widely incorporated in edible products. Often outlets marketing cannabis products sell hempseed foods lacking THC as well as foods laced with THC, and sometimes, the THC-free products are there simply to augment sales because many people purchasing psychotropic foods are sympathetic to anything manufactured with cannabis.

PREFERRED MODES OF MARIJUANA CONSUMPTION

Based on a sample of over 4000 Americans at least 18 years of age who reported consumption of marijuana in 2014, Schauer et al. (2016) reported that: "Overall, 7.2% of respondents reported current marijuana use; 34.5% reported never use. Among current users, 10.5% reported medicinal-only use, 53.4% reported recreational-only use, and 36.1% reported both. Use of bowl or pipe (49.5%) and joint (49.2%) predominated among current marijuana users, with lesser use of bong, water pipe, or hookah (21.7%); blunts (20.3%); edibles/drinks (16.1%); and vaporizers (7.6%); 92.1% of the sample reported combusted-only marijuana use." Smoking, as pointed out in the next chapter, is deleterious to health, and likely, the noncombustion consumption of cannabis as edibles and by convenient e-pens will increase in the future.

FIGURE 12.39 Illicit, dangerous marijuana-like (noncannabinoid) preparations. Left: Anti-synthetic cannabinoid poster. Credit: Hawkes Bay District Health Board, New Zealand. Right: "Spice" and "K2," the principal marketed "fake marijuana" products. Photo (public domain) by U.S. Drug Enforcement Administration.

FAKE MARIJUANA

In recent years, "designer drug" mixtures of shredded plant material laced with chemical additives have been marketed as "legal marijuana" alternatives, under such names as Spice, K2, fake weed, Yucatan Fire, Skunk, and Moon Rocks (Dresen et al. 2010; Vardakou et al. 2010; Ashton 2012; Rosenbaum et al. 2012; Seelly et al. 2012; Thomas et al. 2014a; Figure 12.39). Well over 100 products are being marketed (Zawilska and Wojcieszak 2014), sometimes with, often not with chemicals related to the cannabinoids. Frequently with labels such as "not for human consumption" or "for aromatherapy only," the intent has been to provide a marijuana substitute that evaded current laws. These preparations have proven to be quite attractive to youth. Most jurisdictions have made these marijuana mimics illegal, as they have often resulted in sickness. Synthetic cannabinoids are sometimes used in such products (see the discussion of prescription "cannabimimetic" substances in the next chapter). Synthetic cannabinoids in samples of Spice products have sometimes shown an affinity for the CB_1 receptor (discussed in the next chapter) that is four to five times greater than natural THC (Vandrey et al. 2012). A wide variety of cheap toxic compounds has also been employed in fake marijuana.

It needs to be pointed out that by no means are all synthetic cannabinoids deleterious. Some are useful as research and therapeutic tools (Chiurchiù et al. 2015).

ETHICAL PERSPECTIVES OF DECRIMINALIZATION AND LEGALIZATION OF RECREATIONAL MARIJUANA

There are endless publications arguing the merits for and against decriminalization or legalization of recreational marijuana from an ethical perspective. This book is not intended to take a position on the issue, but some of the arguments and considerations that are commonly raised are presented in the next paragraphs.

The following statement regarding the U.S. marijuana prohibition is representative of the viewpoint that recreational marijuana should be legalized: "Our marijuana laws are clearly doing more harm than good… Law enforcement agencies today spend many billions of taxpayer dollars annually trying to enforce this unenforceable prohibition. The roughly 750,000 arrests they make each year for possession of small amounts of marijuana represent more than 40% of all drug arrests. Regulating and taxing marijuana would simultaneously save taxpayers billions of dollars in

enforcement and incarceration costs, while providing many billions of dollars in revenue annually. It also would reduce the crime, violence and corruption associated with drug markets, and the violations of civil liberties and human rights that occur when large numbers of otherwise law-abiding citizens are subject to arrest. Police could focus on serious crime instead. The racial inequities that are part and parcel of marijuana enforcement policies cannot be ignored. African-Americans are no more likely than other Americans to use marijuana but they are three, five or even 10 times more likely—depending on the city—to be arrested for possessing marijuana… Who most benefits from keeping marijuana illegal? The greatest beneficiaries are the major criminal organizations in Mexico and elsewhere that earn billions of dollars annually from this illicit trade—and who would rapidly lose their competitive advantage if marijuana were a legal commodity…. Like many parents and grandparents, I am worried about young people getting into trouble with marijuana and other drugs. The best solution, however, is honest and effective drug education" (Soros 2010).

The following statement is representative of the viewpoint that marijuana should not be legalized: "Marijuana is the most commonly abused illegal drug in the U.S. and around the world. Those who support its legalization, for medical or for general use, fail to recognize that the greatest costs of marijuana are not related to its prohibition; they are the costs resulting from marijuana use itself… Rapidly accumulating new research shows that marijuana use is associated with increases in a range of serious mental and physical problems. Lack of public understanding on this relationship is undermining prevention efforts and adversely affecting the nation's youth and their families. Drug-impaired driving will also increase if marijuana is legalized… Since legalization of marijuana for medical or general use would increase marijuana use rather than reduce it and would lead to increased rates of addiction to marijuana among youth and adults, legalizing marijuana is not a smart public health or public safety strategy for any state or for our nation" (DuPont 2010).

CURIOSITIES OF SCIENCE, TECHNOLOGY, AND HUMAN BEHAVIOR

- London's hosting of the 2012 Summer Olympic and Paralympic Games was associated with the construction of Britain's largest piece of public art, officially named "The ArcelorMittal Orbit." Located in Olympic Park in Stratford, London, it is 114.5 m tall (the Eiffel Tower is 324 m in height). The construction is eerily reminiscent of a hookah (Figure 12.40).
- Between the eleventh and thirteenth centuries, in the Middle East, a sect known as the Assassins—followers of Hasan-ibn-Sabah—dominated the Middle East through a reign of terror. Italian traveler Marco Polo (1254?–1324?) reported that the Assassins used a drug to rouse themselves to bloody deeds. In the nineteenth century, several European writers claimed that the word "Assassin" was derived from the word "hashish" and that this was the drug used by the Assassins. Thereafter, *Cannabis* was frequently associated with violence in many anti-marijuana stories, although marijuana is well known to induce sleepiness rather than hyperactivity and aggression.
- Intercouple violence in a marriage has been found to be less when one spouse is a marijuana smoker and even less when both partners are users (Smith et al. 2014).
- In the 1890s, several women's temperance societies recommended the recreational use of hashish instead of alcohol, in the belief that liquor led to wife-beating, while hashish just made people sleepy.
- The recreational use of cannabis in the United States is so widespread that about 10% of paper currency has been found to be contaminated with cannabinoid residues (Lavins et al. 2004).
- President Bill Clinton is famous for saying "When I was in England I experimented with marijuana a time or two, and I didn't like it. I didn't inhale." Clinton is believed to have had hemp beer ("Hempen Gold beer" manufactured by the Frederick Brewing Company

FIGURE 12.40 A giant hookah? Known as the ArcelorMittal Orbit, this huge sculpture and observation tower is located in London, England. Photo by BaldBoris (CC BY SA 2.0).

of Frederick, Maryland) served on February 15, 1999, on Air Force One, the presidential jet. Beer, of course, is usually flavored principally by hemp's cousin, hop. According to one reporter, the president "tasted but didn't swallow." President Barack Obama replied when asked if he had smoked marijuana, "I inhaled frequently…that was the point" (https://www.youtube.com/watch?v=cpBzQI_7ez8).

- "420" (4:20, 4/20, pronounced four-twenty) is a code reference to marijuana consumption, a term dating to the early 1970s in California. It has been suggested that the expression traces to 4:20 p.m., a time when school is over and students are free. Celebrations to advocate the legalization of marijuana (Figure 12.41) and other events based on marijuana are commonly scheduled for 4:20 during the day and on April 20 (i.e., fourth month, 20th day). The Colorado Department of Transportation replaced the frequently stolen Mile Marker 420 sign on I-70 east of Denver with one reading 419.99 to stop the thievery. The occasional expression "8:40" (twice 4:20) means that by 8:40 p.m., one has become twice as high as normally achieved at 4:20 p.m.
- The number "13" associated with the 13th letter of the alphabet, M, is occasionally used as code for "marijuana." For example, 13 on a motorcycle gang member's biker jacket sometimes stands for marijuana.
- In the eighteenth century, the term "sawbuck" was slang for a sawhorse, made by joining pieces of wood into an "X" shape to support boards at their ends while they were being cut. The first U.S. $10 bill bore the Roman numeral X, and consequently "sawbuck"

FIGURE 12.41 A four-twenty event in Boulder, Colorado, 4:20 p.m., April 20, 2010. Photo by Zach Dischner (CC BY 2.0).

became slang for the $10 bill, while "buck" became a reference to the dollar. In the mid-1900s, "sawbuck" became street slang, apparently originating in Chicago, for a 10-dollar bag of marijuana. Since the 1980s, the term has referred to a 10-dollar package of any street drug.

- Oxford Dictionaries declared "vape" to be its 2014 word of the year, including the verb ("inhale and exhale the vapor produced by an electronic cigarette or similar device") and noun ("an electronic cigarette or similar device; an act of inhaling and exhaling the vapor produced by an electronic cigarette or similar device"). Lake Superior State University (in northern Michigan), on the last day of 2014, issued its 41st annual "List of Words Banished from the Queen's English for Misuse, Overuse and General Uselessness," and "vape" was one of the 13 words included. Although "vape pens" are predominantly used for tobacco, they are increasingly being adapted for marijuana.
- "Budtender" (based on a combination of bud and bartender) refers to a worker who sells and is knowledgeable about the cannabis products in a medical marijuana dispensary or recreational marijuana shop. The qualifications of such personnel are suspect, and they have been referred to as "quasimedical vendors" (Kleiman 2015).
- In assessing the effects of smoking recreational marijuana, many researchers employ the unit "joint-year," where one joint-year equals smoking one joint/day for one year.
- "Bogarting" is a slang verb meaning to selfishly keep something completely for oneself, especially applied to joints (a Bogart is a person who hogs a joint). The term is based on actor Humphrey Bogart, who habitually kept a cigarette in his mouth.
- In the context of cannabis, a "hotbox" is a sealed room or vehicle in which the exhaled smoke from several pot smokers accumulates, so that the secondhand smoke reinforces the effects of the original smoke. The method was originally employed to avoid detection, but became a social activity. A "Jamaican hotbox" uses a bathroom in which the shower is turned on hot, so that steam also fills the room. It has been shown that the secondhand smoke in a hotbox can have appreciable intoxicating effect (Herrmann et al. 2015).
- Detecting illicit drugs (including cannabis) in urine has become a multibillion dollar industry, and in parallel, "fake urine" ("synthetic urine") businesses have developed to assist users of illegal drugs to pass these tests. (Of course, the simplest way most people avoid detection is to obtain clean urine from someone who is not using illicit substances and is a match for sex and age.) Typically costing $30.00 to $100.00, some of the products offered are claimed to be heatable to body temperature and sometimes are accompanied by portable warmers (since many labs check this to ensure genuineness). The "Whizzinator" is a prosthetic urine-delivery device that has been employed to simulate actually urinating into a collection bottle for "observed tests." The best formulations can be difficult to detect, closely simulating pH, creatinine, and the specific gravity of normal urine. Indeed, there is a sort of chemical warfare between the makers of fake urine, who keep improving their product, and detection laboratories, who are constantly seeking new ways to detect artificial urine. In some jurisdictions, such cheating is subject to specific criminal penalties.