

■ **DRUGS**  
The Straight Facts

# LSD



**M. Foster Olive, Ph.D.**

Consulting Editor: David J. Triggle, Ph.D., University Professor  
School of Pharmacy and Pharmaceutical Sciences  
State University of New York at Buffalo



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## **DRUGS The Straight Facts**

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# The Use and Abuse of Drugs

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**The issues associated with drug use and abuse in contemporary** society are vexing, fraught with political agendas and ideals that often obscure information that teens need to know to have intelligent discussions about these very real problems. *Drugs: The Straight Facts* aims to provide this essential information through straightforward explanations of how an individual drug or group of drugs works in both therapeutic and non-therapeutic conditions, with historical information about the use and abuse of specific drugs, with discussion of drug policies in the United States, and with an ample list of further reading.

The series uses the word *drug* to describe psychoactive substances that are used for medicinal or nonmedicinal purposes. Included in this broad category are substances that are legal—and some that are illegal. It is worth noting that humans have used many of these substances for hundreds, if not thousands, of years. For example, traces of marijuana and cocaine have been found in Egyptian mummies; the use of peyote and *Amanita* fungi has long been a component of religious ceremonies worldwide; and alcohol production and consumption have been an integral part of the social and religious ceremonies of many human cultures. One can speculate about why early human societies chose to use such drugs. Perhaps anything that could provide relief from the harshness of life—anything that could make the poor conditions and fatigue associated with hard work easier to bear—was considered a welcome tonic. Life was likely to be, according to seventeenth century English philosopher Thomas Hobbes, “poor, nasty, brutish, and short.” One can also speculate about modern human societies’ continued use and abuse of drugs. Whatever the reasons, the consequences of sustained drug use are not insignificant—addiction, overdose, incarceration, and drug wars—and must be dealt with by an informed citizenry.

The problem that faces our society today is how to break the connection between our demand for drugs and the willingness of largely outside countries to supply this highly profitable

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trade. This is the same problem we have faced since narcotics and cocaine were outlawed by the Harrison Narcotic Act of 1914, and we have yet to defeat it despite current expenditures of approximately \$20 billion per year on “the war on drugs.” The first step in meeting any challenge is always an intelligent and informed citizenry. The purpose of this series is to educate our readers so that they can make informed decisions about issues related to drugs and drug abuse.

### **SUGGESTED ADDITIONAL READING**

Courtwright, David T. *Forces of Habit, Drugs and the Making of the Modern World*. Cambridge, Mass.: Harvard University Press, 2001. David T. Courtwright is professor of history at the University of North Florida.

Davenport-Hines, Richard. *The Pursuit of Oblivion: A Global History of Narcotics*. New York: Norton, 2002. The author is a professional historian and a member of the Royal Historical Society.

Huxley, Aldous. *Brave New World*. New York: Harper & Row, 1932. Huxley’s book, written in 1932, paints a picture of a cloned society devoted only to the pursuit of happiness.

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# 1

## Overview of Hallucinogens

*About 5 minutes after Paul put the LSD tab on his tongue, he sat down next to his stereo and cued up his CD player to play Pink Floyd's Dark Side of the Moon. He put on his headphones so he could turn up the music as loud as he wanted without disturbing any neighbors. While waiting for the effects of the LSD to kick in, he gazed at the artwork of the album cover, which depicted a single beam of white light striking a prism and then bursting into a rainbow of colors.*

*Within a few minutes, the album cover seemed to come to life, and Paul became fascinated with the geometric patterns of the artwork. The colored lines began to take on an emotional symbolism to him, with red symbolizing anger, blue symbolizing sadness, and yellow symbolizing frustration. When the music started, the rainbow of colors turned into a musical staff and notes burst into existence with each beat Paul heard through his headphones. Paul felt as if he were diving into the sea of colors, floating in a state of awe and wonder. When the lyrics of the first song began, Paul saw each word leap from the sea of colors in huge, bold, three-dimensional letters, only to disintegrate as the next word came along to replace it. Paul began to feel uneasy about his sense of floating, with increasing feelings of anxiety about sinking below the surface of the liquid spectrum. He tried desperately to cling to the huge block letters as they sprang from the multicolored water. But each new word the singer sang caused the previous word to disappear, and Paul fell back into the ocean of colors. It seemed like an eternity between the appearance and disappearance of each word. Paul continued this rollercoaster ride of clinging to the words for safety and the uneasiness*

*of falling back into the colored sea for about four hours, until the effects of the LSD began to slowly wear off.*

**A hallucination is something that** we sense (i.e., hear, see, smell, feel, or taste) but that is not really present. Visualizing a doorway that changes into a portal to another galaxy, and seeing billions of galaxies swirling in concert as you float through this portal, or feeling as if your arms and legs have turned into tree limbs, are examples of hallucinations. Hallucinations are commonly experienced by people who suffer from mental disorders, such as schizophrenia. Many people with schizophrenia also commonly experience **auditory** hallucinations, hearing voices telling them to do things, when in fact the voices are not real but are rather a malfunction of the brain. These hallucinations are often frightening and disturbing to the person.

However, some people find certain types of hallucinations enjoyable and stimulating—and sometimes even life-changing spiritual or mystical experiences. These people may recreationally use mind-altering substances called **hallucinogens**, often called **hallucinogenic** or **psychedelic** drugs. Hallucinogens are powerful substances that can produce alterations in the senses or in such things as how body image or the passage of time are perceived. Although hallucinogens have been used for centuries in religious ceremonies by some cultures, the use of hallucinogens for recreational purposes in the United States did not become popular until the cultural revolution of the 1960s, and the use of these substances continues today.

Some hallucinogens, such as **lysergic acid diethylamide** (LSD, also known as **d-lysergic acid**), **phencyclidine (PCP)**, or **ketamine**, are purely synthetic chemicals. Many other hallucinogens are derived from plants. Examples of these include **psilocybin** (which is found in certain types of wild mushrooms, often called **magic mushrooms**); substances derived from plants found in South America, including **dimethyltryptamine (DMT)** and **5-methoxy-dimethyltryptamine (5-MeO-DMT)**;

and **mescaline**, which is derived from the peyote cactus found in the southwestern United States and northern Mexico.

### GENERAL PSYCHOLOGICAL EFFECTS OF HALLUCINOGENS

Each hallucinogen has a unique chemical structure, potency, and duration of psychological effects. LSD is one the most potent hallucinogens discovered so far, with less than one

## HALLUCINOGEN USE IN RELIGIOUS CEREMONIES

Although we commonly associate the rise of hallucinogen use with the “hippie” movement of the 1960s, archeological evidence suggests that hallucinogenic drugs have been used for centuries in religious or **shamanic** (spiritual healing) ceremonies. In this sense, hallucinogens are often referred to as **entheogens**, or mind-altering substances used to facilitate communication with the spiritual world, achieve spiritual enlightenment, or help in healing illnesses. Numerous cultures, including the ancient Egyptians, Greeks, Mayans, Incans, and Aztecs, have used naturally occurring hallucinogens such as the **peyote** cactus or hallucinogenic mushrooms. The decline of entheogens was due in part to the spread of religions such as Judaism, Christianity, and Islam, which frowned upon the use of hallucinogens. For example, the establishment of Christianity as the official religion of the Roman Empire led to the eradication of an entheogenic religious practice of ancient Greece called the Eleusinian Mysteries. Other examples include the witch hunts of the Early Modern period (about 1450–1750), where entheogen users in Western European countries such as Ireland, England, Scotland, Switzerland, and Germany were accused of devil worship, and the invasion of South America by the Spanish conquistadors, who destroyed many entheogenic religious

milligram needed to produce intense psychedelic effects. A typical LSD experience, or **trip**, lasts anywhere from 8 to 12 hours. In contrast, 10 milligrams or more of psilocybin or ketamine is needed to produce any significant hallucinatory experiences, and a trip on these hallucinogens typically lasts just a few hours. Mescaline is the least potent hallucinogen, requiring about 200 milligrams to produce any psychological effects; however, the effects of mescaline typically last 12 hours



**Figure 1.1** Many ancient Mexican and Native American peoples used plants such as the peyote cactus to induce hallucinations for spiritual purposes. (© Lindsay Hebbard/Corbis)

practices among the continent's natives. Despite the intolerance of entheogenic practices by mainstream religions, some cultural organizations such as the Native American Church and the União do Vegetal still strive to maintain their rights to use hallucinogens as part of their religious practices.

or more. These hallucinogens are usually taken orally, and are thus absorbed through the lining of the stomach or intestines before entering the bloodstream (and ultimately the brain); this process can take 30 to 90 minutes before producing any psychological effects. A few hallucinogens, such as ketamine or 5-MeO-DMT are sometimes smoked, and chemicals carried by smoke enter the bloodstream via the lungs rapidly; this means that the onset of the drug's effects occurs within seconds.

Despite their differing chemistries and durations of action, all hallucinogens tend to produce roughly similar psychological effects. In general, hallucinogens produce a sense of slowing of the passage of time. The perception of color, touch, or sound may seem more intense. Users may feel as if their body is not their own. Shapes and objects may appear to change or "morph." The person may give increased attention to geometric patterns found in ceiling tiles, windowpanes, flooring, furniture, architecture, or artwork. Users may also experience a sense of enlightenment and **euphoria** (a feeling of extreme pleasure and well-being). Another common effect is **synesthesia**, which is the "crossing over" of certain types of perception, such as "seeing" sounds or "hearing" colors.

Hallucinogens are sometimes taken to increase one's self-awareness, and some users believe that they can communicate with God or other higher powers while under the influence of these drugs. The experience after taking a hallucinogen can vary from person to person, and is often dependent on one's personality. For example, if one has a relatively extroverted personality, he or she may feel emboldened by the drug and become very active, whereas if someone is relatively introverted and inherently timid, he or she may feel frightened by the experience. Expectations about the drug and one's previous experience with it also influence the hallucinogenic experience. If one has had a negative or frightening experience in the past after taking a hallucinogen, he or she may be more likely to have the same type of negative experience when taking it again, or even be inclined to not take the drug at all. Finally,

the social setting in which the drug is taken can strongly influence the type of experience one has under the influence of a hallucinogen. Some people may prefer to be alone after taking the drug so they are less distracted by the presence of others and can concentrate more on their altered sensory perceptions, whereas other people may prefer to take the hallucinogen surrounded by friends.

Physical effects that are commonly produced by hallucinogens include dilation of the pupils, dizziness, nausea, and increases in heart rate, blood pressure, and body temperature. The intensity of these physical effects is dependent on dosage and an individual's biological makeup. For example, people with "weak" stomachs may experience nausea quite easily, whereas those with "strong" stomachs may not feel nauseous at all. The physical effects of hallucinogens are caused by the active hallucinogenic chemical itself, as well as other chemicals found within the drug. For example, magic mushrooms and peyote contain thousands of substances, many of which can contribute to the physical effects of the drug.

### **DANGEROUS EFFECTS OF HALLUCINOGENS**

Hallucinogens are not considered to be highly addictive in the same sense as drugs like cocaine, methamphetamine, heroin, nicotine, or alcohol. People rarely become physically dependent on hallucinogens, and seldom experience **withdrawal** symptoms after stopping their use. Also, hallucinogen users rarely go on hallucinogen "binges," taking them in large amounts over a period of several days.

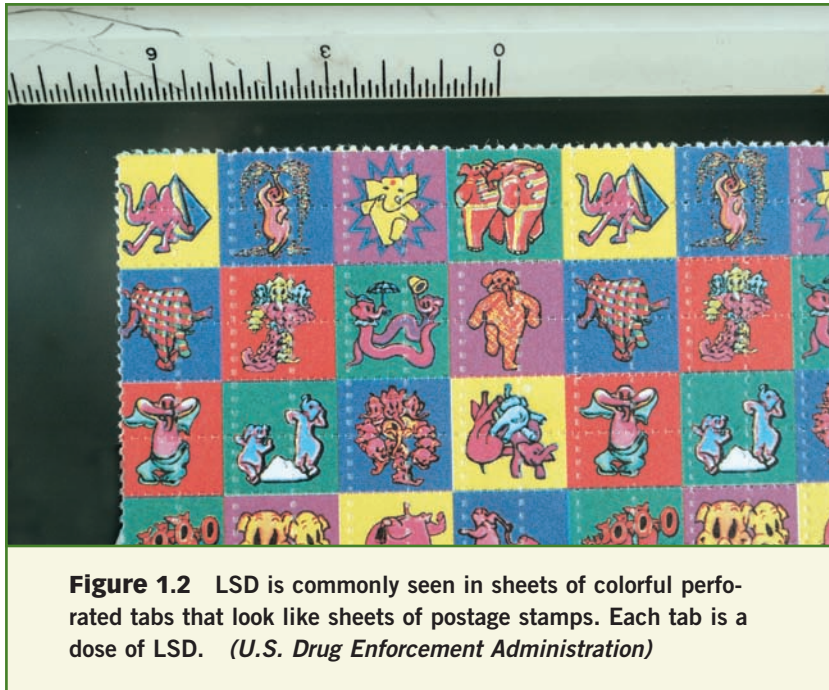
However, there are dangers associated with the use of hallucinogenic drugs. Sometimes users will experience a **bad trip**, characterized by frightening hallucinations and intense fear and anxiety that last for hours. People experiencing a bad trip can sometimes be calmed down by the consoling words of a friend, whereas other individuals experience such prolonged feelings of panic that they must be taken to a hospital and given tranquilizers. Bad trips are fairly unpredictable, which is

one of the greatest dangers of taking hallucinogens. Often the bad trip is triggered by a frightening image, but sometimes the anxiety and fear may grasp the person without any identifiable cause. Scientists are unsure what causes bad trips, but research thus far suggests that they are a result of interactions between the drug, an individual's personality, and the environment in which the drug is taken.

Bad trips can result in **flashbacks**, or sudden recurrences of images, memories, or “reliving” of a negative experience that occurred during a previous psychedelic experience. These flashbacks can occur weeks, months, or years after the drug is used and are sometimes persistent. They are like forgotten bad memories that creep into consciousness at unpredictable times and places. Scientists are unsure precisely what causes hallucinogen-induced flashbacks, just as they are unsure why combat veterans or victims of severe trauma often experience flashbacks. Some scientists speculate that flashbacks of any kind are a result of long-lasting changes in connections between nerve cells in the brain caused by the experience. Most scientists are confident that they are not a result of the drug remaining in the body for long periods of time. Some frequent users of hallucinogens may never experience a flashback, or a flashback may occur in an individual who has taken a hallucinogen only once. Occasionally, use of hallucinogens such as LSD can result in a complete psychotic breakdown that lasts for days or weeks. This state is characterized by a loss of touch with reality and mental problems such as **delusions** (false beliefs) and **paranoia**. Although these breakdowns are rare, they tend to occur in people with pre-existing psychiatric disorders such as schizophrenia.

### TRENDS IN HALLUCINOGEN USE

The popularity of hallucinogens such as LSD exploded in the 1960s and 1970s, and their use continues today, but only as a small fraction of people who use illegal drugs.<sup>1</sup> Males and



**Figure 1.2** LSD is commonly seen in sheets of colorful perforated tabs that look like sheets of postage stamps. Each tab is a dose of LSD. (*U.S. Drug Enforcement Administration*)

females use LSD in roughly equal proportions, and overall use of hallucinogens remained steady between 2001 and 2005. However, in the 1990s and early 2000s there was a dramatic spike in the number of people using a substance called 3,4-methylenedioxymethamphetamine (**MDMA**), also known as **ecstasy**. Ecstasy is chemically similar to methamphetamine and produces intense feelings of love and euphoria. It also produces enhancements in the perception of colors, sounds, and music, and for these reasons it is sometimes classified as a hallucinogen. LSD and ecstasy appear to be the most frequently used hallucinogens, according to a 2002 survey.<sup>2</sup>

### **HOW HALLUCINOGENS WORK IN THE BRAIN**

In the brain, **neurons** carry electrical signals along wire-like nerve fibers called **axons**. Axons can range from less than a millimeter in length to up to several centimeters. At the end of each axon is a mushroom-shaped nerve ending called a



**synaptic terminal.** When the electrical signal traveling down the axon reaches the synaptic terminal, it causes chemical messengers called **neurotransmitters** to be released and secreted onto nearby neurons. This junction between a synaptic terminal and a nearby neuron is called a **synapse**. There are billions of synapses in the brain, and each neuron can have as many as 10,000 different synapses on it. After neurotransmitters are released, they diffuse away from the synaptic terminal into the synapse and encounter proteins called **receptors** on the surface of nearby neurons. Receptors are specific proteins that

### SLANG TERMS FOR LSD

The most common slang term for LSD is “acid,” because one of its chemical names is d-lysergic acid. Sometimes users will even shorten these terms to one letter, such as “L” or “A.” However, there are a host of other slang terms for LSD, including “sugar” and “cubes” (when the drug is sold as small white crystal cubes similar in shape to sugar cubes). LSD is most often sold in perforated tabs (like a sheet of postage stamps), and so it has been given nicknames such as “blotter acid,” “paper acid,” “tabs,” “dots,” “microdots,” “stamps,” or “panes” (like window panes). Individual tabs, also called “hits” since they contain enough LSD to produce a vivid psychedelic experience, often have designs printed on them, such as images of comic book or cartoon characters, political symbols, or animals. Thus, some people may refer to specific LSD tabs by what is printed on them, calling them “elephants,” or “strawberries.” Other slang names for LSD include “animal,” “barrels,” “big D,” “battery acid,” “black star,” “blue heaven,” “blue moons,” “blue mist,” “boomers,” “California sunshine,” “domes,” “frogs,” “mind blow,” “orange sunshine,” “orange barrels,” “snowmen,” “white lightning,” or “yellow sunshine.” Sometimes LSD users take the drug in combination with other hallucinogens like ecstasy, which is commonly referred to as “candy flipping.”

are designed to recognize specific neurotransmitters. When activated by neurotransmitters, these receptors can cause the nerve cell on which they reside to either become activated (so it passes along the electrical signal) or inhibited (so it does not pass the signal along).

Mescaline, LSD, and psilocybin produce their effects on the brain by mimicking the actions of the neurotransmitter **serotonin**. This alters how neurons communicate with each other. More specifically, these hallucinogens stimulate a subclass of serotonin receptors called 5-HT<sub>2</sub> receptors. PCP and ketamine act by inhibiting the function of the **N-methyl-D-aspartate receptor**, which is normally stimulated by the neurotransmitter **glutamate**. Scientists are unsure precisely why either stimulating 5-HT<sub>2</sub> receptors or inhibiting the function of NMDA receptors results in hallucinations, but it likely has to do with how these receptors regulate the functions of neurons located in regions of the brain that control sensation, perception, and cognition.

### WHERE DO HALLUCINOGENS ACT IN THE BRAIN?

The brain has numerous regions that are each specialized for particular functions. So the effect of a particular drug on a person's thinking or behavior may depend partly on which region of the brain it acts upon.

Given that hallucinogens primarily affect perception, it is thought that they primarily act in regions of the brain such as the **sensory cortex** and **visual cortex**. They are also thought to act on a region of the brain involved in the perception of sound known as the auditory cortex. Finally, since hallucinogens increase one's thoughts about religion, one's purpose in life, and self-awareness, it is believed that they also act in the **frontal cortex**, where a great deal of cognition occurs. Sophisticated brain imaging techniques ("brain scans") such as functional magnetic resonance imaging (fMRI) have enabled scientists to pinpoint precisely what regions of the brain are activated by drugs such as cocaine,

## SALVIA—THE NEXT NEW HALLUCINOGEN?

A recent legal battle has begun over a hallucinogenic plant called *Salvia divinorum*, which translated from Latin means “sage of the seers.” Salvia (also known by nicknames such as “Sally D,” “magic mint,” “Ska Maria Pastora,” “shepherdess’ herb,” and “yerba de Maria”) is a member of the sage family of plants that grows in the Sierra Mazatec region of Mexico. Salvia has been cultivated and used by shamans for centuries, and its widespread use throughout Mexico is thought to have been suppressed by the Spanish Conquest. However, the use of salvia has gained popularity, particularly amongst young people, in recent years as a legal way to have a psychedelic experience.

The leaves of the salvia plant contain a psychedelic chemical called **salvinorin**. When eaten or smoked, the plant produces an intense dreamlike state similar to LSD or mescaline; first-time users, however, often find the salvia experience unpleasant, or obtain no psychological effects at all. If smoked, the effects of salvia peak within a few minutes or so and last for up to 20 minutes; however, if salvia is eaten, the onset of effect is more delayed and the effects last for up to an hour or two, and the psychological effects may not be as intense as if it were smoked. The leaves of the salvia plant contain other psychoactive chemicals such as salvinorins B and G; divinorins A, D, and E; and salvincins A and B. The precise roles these chemicals play in the psychological effects of salvia are not yet known.

Some of the effects of salvia are similar to those produced by LSD. When salvia reaches its peak effects, users become easily distracted, less willing to socialize, and have altered perceptions of color and time. They may also become fascinated with geometric patterns, feel as if they are floating, experience intense feelings of spirituality and understanding, and feel as if they can communicate with higher powers. They



**Figure 1.3** *Salvia divinorum*. (© Edward Kinsman / Photo Resarchers, Inc.)

may even experience full blown hallucinations and out-of-body experiences. Also, like users of LSD, salvia users rarely report any type of hangover effect and they seldom become addicted, but they do sometimes experience bad trips and flashbacks.

Salvia is currently legal in most of the United States, and is sold in some tobacco shops as well as on the Internet. However, the Drug Enforcement Agency has salvia on its “watch list” and is considering making it a controlled substance. Several states have placed their own restrictions on the salvia plant. For example, in Louisiana it is illegal to purchase or distribute salvia if it is intended for human consumption. States such as Missouri and Delaware have classified salvia as a Schedule I controlled substance, making it illegal to possess or distribute. Currently, other states such as New York and Alaska are considering similar classification. Salvia has been banned or restricted in several other countries including Australia, Belgium, Italy, and Sweden.

**Table 1.1** Regions of the Brain

REGION	FUNCTION
frontal cortex	involved in planning, thinking, memory, and decision making
motor cortex	controls movement of the face, arms, and legs
sensory cortex	involved in perception of touch
visual cortex	processes sight and vision
cerebellum	controls motor coordination, balance
brainstem	controls basic bodily functions like chewing, swallowing, heart rate, and breathing
hypothalamus	controls metabolism, sleep, eating, and drinking
limbic system*	controls emotions, memory, and motivation
*Note: The limbic system is made up of several brain structures such as the <b>hippocampus</b> , <b>amygdala</b> , and <b>basal forebrain</b> .	

heroin, and methamphetamine. However, because advanced brain imaging techniques are very expensive, and because hallucinogens are not considered addictive or a major public health problem, the funding for research on hallucinogens using brain imaging has not been given a high priority by the U.S. government. Brain scans are more frequently used to determine the long-term effects of chronic drug or alcohol use on the normal functioning of the brain.

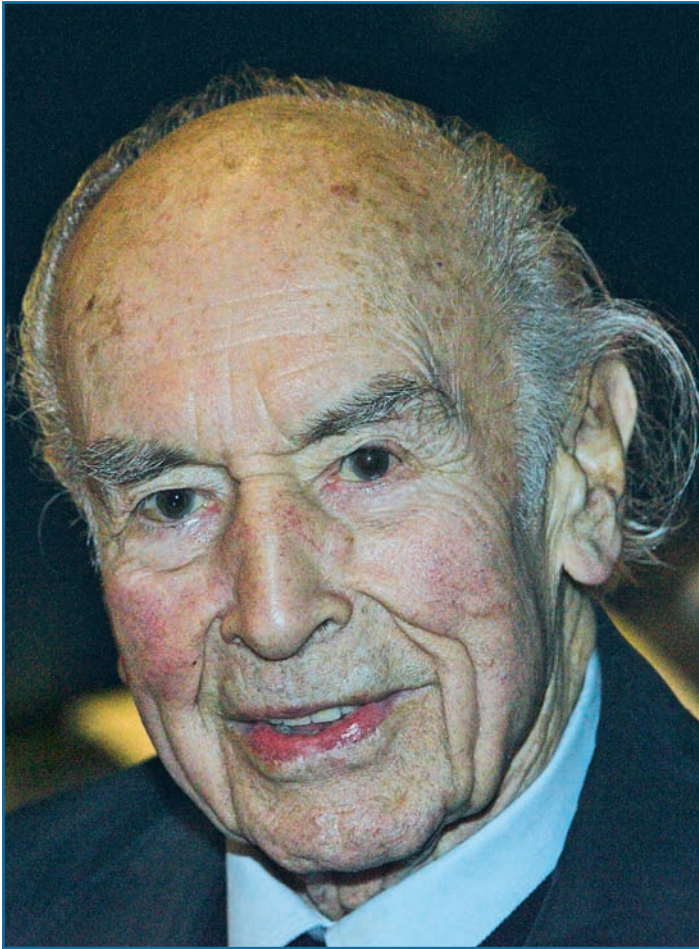
# History of LSD

*I lay down and sank into a not unpleasant intoxicated-like condition ... I perceived an uninterrupted stream of fantastic pictures, extraordinary shapes with intense, kaleidoscopic play of colors. After some two hours this condition faded away.<sup>1</sup>*

—Dr. Albert Hofmann, discoverer of LSD

## THE DISCOVERY OF LSD

LSD was discovered in November 1938 by a Swiss chemist named Dr. Albert Hofmann. Hofmann was born in Baden, Switzerland, in 1906, and studied the chemistry of plants and animals at the University of Zurich. After receiving his doctorate, Hofmann became a chemist at Sandoz Laboratories (now Novartis), located in Basel, Switzerland, where he performed research on isolating medically useful derivatives of a type of fungus called **ergot** (scientific name *Claviceps purpurea*), which grows on crops such as rye and other grains that are used to make bread. Previously, scientists at Rockefeller University in New York had identified a chemical from the ergot fungus called lysergic acid, and Hofmann believed that derivatives of this chemical could have potential use in the treatment of migraines and ailments of the respiratory and circulatory systems. In one series of experiments, Hofmann mixed lysergic acid with a chemical called diethylamide to form lysergic acid diethylamine (the German name was *lyserg saeure diathylamid*, which was given the abbreviation LSD). Since Hofmann was attempting to synthesize a large number of lysergic acid derivatives, he called this one



**Figure 2.1** Dr. Albert Hofmann. (© AP Images)

LSD-25, since it was the twenty-fifth compound synthesized in his set of experiments.

Following the synthesis of LSD-25, Hofmann and his colleagues administered the substance to laboratory animals but found that it showed none of the desired effects they were looking for (i.e., increased circulation and respiration) so further research on LSD-25 was abandoned. However, in 1943,

Hofmann resumed work on his LSD derivatives. One day while attempting to make a crystallized form of LSD-25, he accidentally contaminated himself and absorbed some of the chemical through his skin on his fingertips. Soon he began to feel dizzy and restless, so he decided to go home to rest and recover. It was there Hofmann had a vivid hallucinogenic experience.

Although Hofmann is often credited with discovering LSD and its hallucinogenic properties, it is likely that many people throughout Europe actually experienced similar hallucinations prior to the twentieth century. There are many reports of outbreaks of **ergotism**, or poisoning from the ergot fungus, as a result of eating bread or other products made from rye or grains contaminated with ergot, dating as far back as the Middle Ages.<sup>2</sup> Some of the poisonings were characterized by swelling of the hands, limbs, and feet and accompanied by severe burning pain in the arms, hands, legs, and feet, whereas in other instances of ergotism people suffered from **delirium**, hallucinations, muscle spasms, and diarrhea. It is believed that many thousands of people died from ergotism in European countries such as France, Germany, and England, and recorded history shows that such poisonings occurred as early as the tenth century A.D.

### **HOFMANN'S SECOND LSD EXPERIENCE— "BICYCLE DAY"**

After a five-year hiatus from his research on LSD, Albert Hofmann returned to research on the drug in April 1943 by intentionally taking 250 micrograms (one-quarter of a milligram) of LSD. Within an hour, Hofmann found himself unable to speak clearly, and asked his laboratory assistant to help him return to his home on his bicycle. As he rode home with the help of his assistant, his hallucinations and perceptual distortions worsened, and by the time he reached home he summoned his physician as well as a neighbor to bring some milk to help relieve his symptoms. Hofmann's hallucinations had become so intense and bizarre that he believed he was possessed by a demon, his neighbor was a



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