

*Source: From the laboratories of Drs. N. Volkow and H. Schelbert*

Addiction is a lot like other diseases, such as heart disease. Both disrupt the normal, healthy functioning of the underlying organ, have serious harmful consequences, and are preventable and treatable, but if left untreated, can last a lifetime.

### **What is drug addiction?**

Addiction is defined as a chronic, relapsing brain disease that is characterized by compulsive drug seeking and use, despite harmful consequences.<sup>†</sup> It is considered a brain disease because drugs change the brain—they change its structure and how it works. These brain changes can be long-lasting, and can lead to the harmful behaviors seen in people who abuse drugs.

<sup>†</sup>The term *addiction* as used in this booklet may be regarded as equivalent to a severe *substance use disorder* as defined by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5, 2013)

## Why do people take drugs?

In general, people begin taking drugs for a variety of reasons:

- **To feel good.** Most abused drugs produce intense feelings of pleasure. This initial sensation of euphoria is followed by other effects, which differ with the type of drug used. For example, with stimulants such as cocaine, the "high" is followed by feelings of power, self-confidence, and increased energy. In contrast, the euphoria caused by opiates such as heroin is followed by feelings of relaxation and satisfaction.
- **To feel better.** Some people who suffer from social anxiety, stress-related disorders, and depression begin abusing drugs in an attempt to lessen feelings of distress. Stress can play a major role in beginning drug use, continuing drug abuse, or relapse in patients recovering from addiction.
- **To do better.** Some people feel pressure to chemically enhance or improve their cognitive or athletic performance, which can play a role in initial experimentation and continued abuse of drugs such as prescription stimulants or anabolic/androgenic steroids.
- **Curiosity and "because others are doing it."** In this respect adolescents are particularly vulnerable because of the strong influence of peer pressure. Teens are more likely than adults to engage in risky or daring behaviors to impress their friends and express their independence from parental and social rules.

## If taking drugs makes people feel good or better, what's the problem?

When they first use a drug, people may perceive what seem to be positive effects; they also may believe that they can control their use. However, drugs can quickly take over a person's life. Over time, if drug use continues, other pleasurable activities become less pleasurable, and taking the drug becomes necessary for the user just to feel "normal." They may then compulsively seek and take drugs even though it causes tremendous problems for themselves and their loved ones. Some people may start to feel the need to take higher or more frequent doses, even in the early stages of their drug use. These are the telltale signs of an addiction.

Even relatively moderate drug use poses dangers. Consider how a social drinker can become intoxicated, get behind the wheel of a car, and quickly turn a pleasurable activity into a tragedy that affects many lives.

## Is continued drug abuse a voluntary behavior?

The initial decision to take drugs is typically voluntary. However, with continued use, a person's ability to exert self-control can become seriously impaired; this impairment in self-control is the hallmark of addiction. Brain imaging studies of people with addiction show physical changes in areas of the brain that are critical to judgment, decision making, learning and memory, and behavior control.<sup>7</sup> Scientists believe that these changes alter the way the brain works and may help explain the compulsive and destructive behaviors of addiction.

## No single factor determines whether a person will become addicted to drugs.

### Why do some people become addicted to drugs, while others do not?

As with any other disease, vulnerability to addiction differs from person to person, and no single factor determines whether a person will become addicted to drugs. In general, the more *risk factors* a person has, the greater the chance that taking drugs will lead to abuse and addiction. *Protective factors*, on the other hand, reduce a person's risk of developing addiction. Risk and protective factors may be either environmental (such as conditions at home, at school, and in the neighborhood) or biological (for instance, a person's genes, their stage of development, and even their gender or ethnicity).

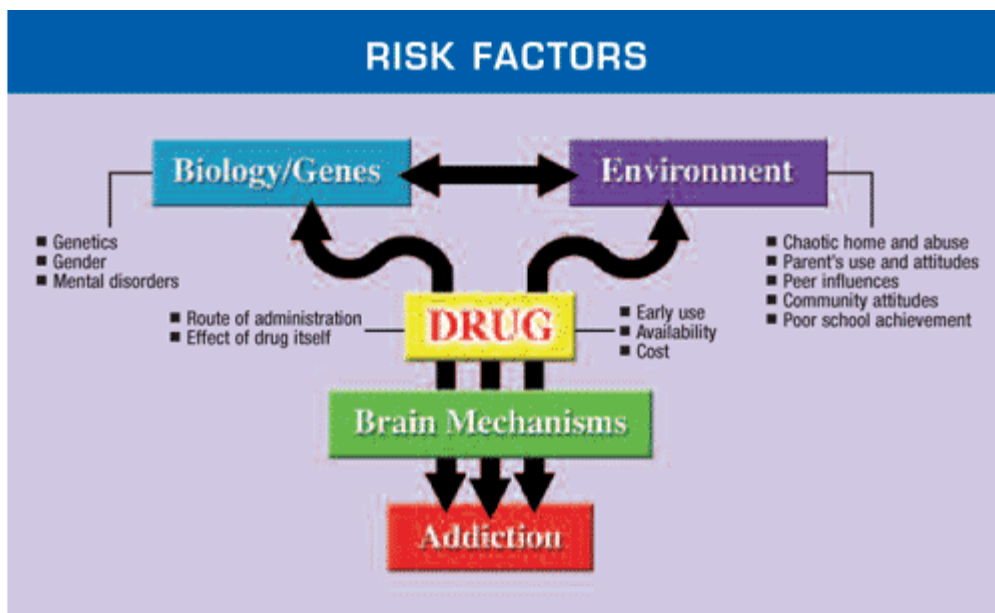
Risk and Protective Factors for Drug Abuse and Addiction	
Risk Factors	Protective Factors
Aggressive behavior in childhood	Good self-control
Lack of parental supervision	Parental monitoring and support
Poor social skills	Positive relationships
Drug experimentation	Academic Competence
Availability of drugs at school	School anti-drug policies
Community poverty	Neighborhood pride

## What environmental factors increase the risk of addiction?

- **Home and Family.** The influence of the home environment, especially during childhood, is a very important factor. Parents or older family members who abuse alcohol or drugs, or who engage in criminal behavior, can increase children's risks of developing their own drug problems.
- **Peer and School.** Friends and acquaintances can have an increasingly strong influence during adolescence. Drug-using peers can sway even those without risk factors to try drugs for the first time. Academic failure or poor social skills can put a child at further risk for using or becoming addicted to drugs.

## What biological factors increase risk of addiction?

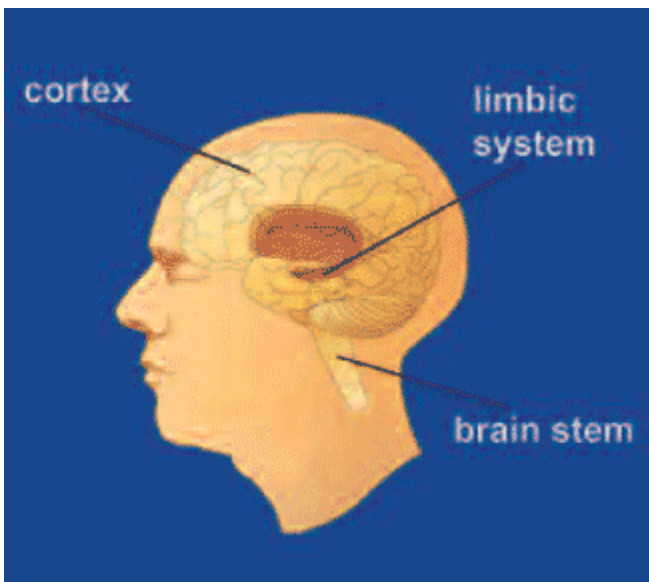
Scientists estimate that genetic factors account for between 40 and 60 percent of a person's vulnerability to addiction; this includes the effects of environmental factors on the function and expression of a person's genes. A person's stage of development and other medical conditions they may have are also factors. Adolescents and people with mental disorders are at greater risk of drug abuse and addiction than the general population.



# Drug Free- Human Brain

The human brain is the most complex organ in the body. This three-pound mass of gray and white matter sits at the center of all human activity—you need it to drive a car, to enjoy a meal, to breathe, to create an artistic masterpiece, and to enjoy everyday activities. In brief, the brain regulates your body's basic functions; enables you to interpret and respond to everything you experience; and shapes your thoughts, emotions, and behavior.

The brain is made up of many parts that all work together as a team. Different parts of the brain are responsible for coordinating and performing specific functions. Drugs can alter important brain areas that are necessary for life-sustaining functions and can drive the compulsive drug abuse that marks addiction. Brain areas affected by drug abuse include:



- **The brain stem**, which controls basic functions critical to life, such as heart rate, breathing, and sleeping.
- **The cerebral cortex**, which is divided into areas that control specific functions. Different areas process information from our senses, enabling us to see, feel, hear, and taste. The front part of the cortex, the frontal cortex or forebrain, is the thinking center of the brain; it powers our ability to think, plan, solve problems, and make decisions.
- **The limbic system**, which contains the brain's reward circuit. It links together a number of brain structures that control and regulate our ability to feel pleasure. Feeling pleasure motivates us to repeat behaviors that are critical to our existence. The limbic system is activated by healthy, life-sustaining activities such as eating and socializing—but it is also activated by drugs of abuse. In addition, the limbic system is responsible for our perception of other emotions, both positive and negative, which explains the mood-altering properties of many drugs.

# How do the parts of the brain communicate?

The brain is a communications center consisting of billions of neurons, or nerve cells. Networks of neurons pass messages back and forth among different structures within the brain, the spinal cord, and nerves in the rest of the body (the peripheral nervous system). These nerve networks coordinate and regulate everything we feel, think, and do.

- **Neuron to Neuron**

Each nerve cell in the brain sends and receives messages in the form of electrical and chemical signals. Once a cell receives and processes a message, it sends it on to other neurons.

- **Neurotransmitters - The Brain's Chemical Messengers**

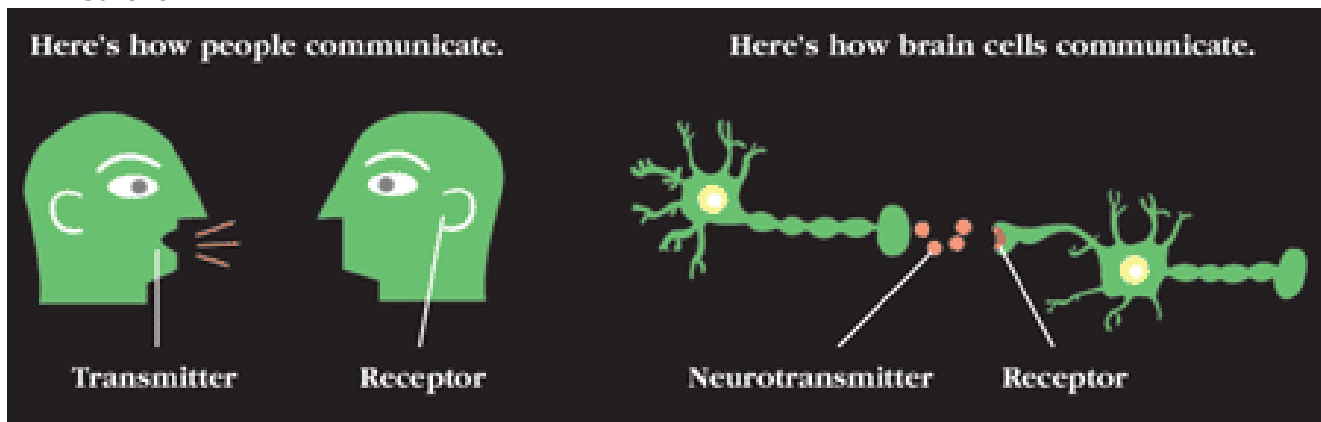
The messages are typically carried between neurons by chemicals called neurotransmitters.

- **Receptors - The Brain's Chemical Receivers**

The neurotransmitter attaches to a specialized site on the receiving neuron called a receptor. A neurotransmitter and its receptor operate like a “key and lock,” an exquisitely specific mechanism that ensures that each receptor will forward the appropriate message only after interacting with the right kind of neurotransmitter.

- **Transporters - The Brain's Chemical Recyclers**

Located on the neuron that releases the neurotransmitter, transporters recycle these neurotransmitters (that is, bring them back into the neuron that released them), thereby shutting off the signal between neurons.



Concept courtesy: B.K. Madras

To send a message, a brain cell (neuron) releases a chemical (neurotransmitter) into the space (synapse) between it and the next cell. The neurotransmitter crosses the synapse and attaches to proteins (receptors) on the receiving brain cell. This causes changes in the receiving cell—the message is delivered.



## How do drugs work in the brain?

Drugs are chemicals that affect the brain by tapping into its communication system and interfering with the way neurons normally send, receive, and process information. Some drugs, such as marijuana and heroin, can activate neurons because their chemical structure mimics that of a natural neurotransmitter. This similarity in structure “fools” receptors and allows the drugs to attach onto and activate the neurons. Although these drugs mimic the brain’s own chemicals, they don’t activate neurons in the same way as a natural neurotransmitter, and they lead to abnormal messages being transmitted through the network.

Other drugs, such as amphetamine or cocaine, can cause the neurons to release abnormally large amounts of natural neurotransmitters or prevent the normal recycling of these brain chemicals. This disruption produces a greatly amplified message, ultimately disrupting communication channels.


## How do drugs work in the brain to produce pleasure?

Most drugs of abuse directly or indirectly target the brain’s reward system by flooding the circuit with dopamine. Dopamine is a neurotransmitter present in regions of the brain that regulate movement, emotion, motivation, and feelings of pleasure. When activated at normal levels, this system rewards our natural behaviors. Over stimulating the system with drugs, however, produces euphoric effects, which strongly reinforce the behavior of drug use—teaching the user to repeat it.

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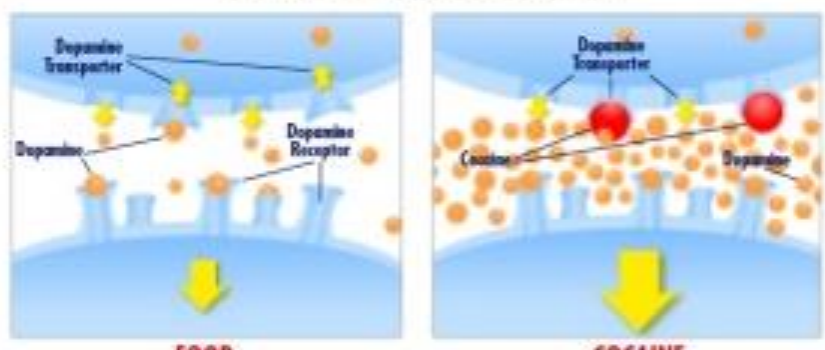
### DRUGS OF ABUSE TARGET THE BRAIN'S PLEASURE CENTER

**Brain reward (dopamine) pathways**



These brain circuits are important for natural rewards such as food, music, and sex.

**Drugs of abuse increase dopamine**



Typically, dopamine increases in response to natural rewards such as food. When cocaine is taken, dopamine increases are exaggerated, and communication is altered.



# How does stimulation of the brain's pleasure circuit teach us to keep taking drugs?

Our brains are wired to ensure that we will repeat life-sustaining activities by associating those activities with pleasure or reward. Whenever this reward circuit is activated, the brain notes that something important is happening that needs to be remembered, and teaches us to do it again and again without thinking about it. Because drugs of abuse stimulate the same circuit, we learn to abuse drugs in the same way.

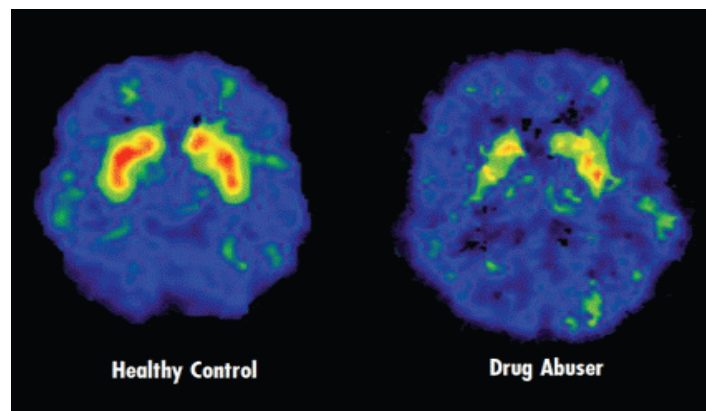
## Why are drugs more addictive than natural rewards?

When some drugs of abuse are taken, they can release 2 to 10 times the amount of dopamine that natural rewards such as eating and sex do.<sup>15</sup> In some cases, this occurs almost immediately (as when drugs are smoked or injected), and the effects can last much longer than those produced by natural rewards. The resulting effects on the brain's pleasure circuit dwarf those produced by naturally rewarding behaviors.<sup>16,17</sup> The effect of such a powerful reward strongly motivates people to take drugs again and again. This is why scientists sometimes say that drug abuse is something we learn to do very, very well.

**Long-term drug abuse impairs brain functioning.**

## What happens to your brain if you keep taking drugs?

For the brain, the difference between normal rewards and drug rewards can be described as the difference between someone whispering into your ear and someone shouting into a microphone. Just as we turn down the volume on a radio that is too loud, the brain adjusts to the overwhelming surges in dopamine (and other neurotransmitters) by producing less dopamine or by reducing the number of receptors that can receive signals. As a result, dopamine's impact on the reward circuit of the brain of someone who abuses drugs can become abnormally low, and that person's ability to experience *any* pleasure is reduced. This is why a person who abuses drugs eventually feels flat, lifeless, and depressed, and is unable to enjoy things that were previously pleasurable. Now, the person needs to keep taking drugs again and again just to try and bring his or her dopamine function back up to normal—which only makes the problem worse, like a vicious cycle. Also, the person will often need to take larger amounts of the drug to produce the familiar dopamine high—an effect known as tolerance.



## How does long-term drug taking affect brain circuits?

We know that the same sort of mechanisms involved in the development of tolerance can eventually lead to profound changes in neurons and brain circuits, with the potential to severely compromise the long-term health of the brain. For example, glutamate is another neurotransmitter that influences the reward circuit and the ability to learn. When the optimal concentration of glutamate is altered by drug abuse, the brain attempts to compensate for this change, which can cause impairment in cognitive function. Similarly, long-term drug abuse can trigger adaptations in habit or non-conscious memory systems. Conditioning is one example of this type of learning, in which cues in a person's daily routine or environment become associated with the drug experience and can trigger uncontrollable cravings whenever the person is exposed to these cues, even if the drug itself is not available. This learned "reflex" is extremely durable and can affect a person who once used drugs even after many years of abstinence.

## What other brain changes occur with abuse?

Chronic exposure to drugs of abuse disrupts the way critical brain structures interact to control and inhibit behaviors related to drug use. Just as continued abuse may lead to tolerance or the need for higher drug dosages to produce an effect, it may also lead to addiction, which can drive a user to seek out and take drugs compulsively. Drug addiction erodes a person's self-control and ability to make sound decisions, while producing intense impulses to take drugs.

## What are the medical consequences of drug addiction?

People who suffer from addiction often have one or more accompanying medical issues, which may include lung or cardiovascular disease, stroke, cancer, and mental disorders. Imaging scans, chest X-rays, and blood tests show the damaging effects of long-term drug abuse throughout the body. For example, research has shown that tobacco smoke causes cancer of the mouth, throat, larynx, blood, lungs, stomach, pancreas, kidney, bladder, and cervix.<sup>19</sup> In addition, some drugs of abuse, such as inhalants, are toxic to nerve cells and may damage or destroy them either in the brain or the peripheral nervous system.

1 OUT OF 3 U.S. AIDS DEATHS ARE  
RELATED TO DRUG ABUSE



## Addiction and HIV/AIDS are intertwined epidemics.

### How can addiction harm other people?

Beyond the harmful consequences for the person with the addiction, drug abuse can cause serious health problems for others. Three of the more devastating and troubling consequences of addiction are:

- **Negative effects of prenatal drug exposure on infants and children.**

A mother's abuse of heroin or prescription opioids during pregnancy can cause a withdrawal syndrome (called neonatal abstinence syndrome, or NAS) in her infant. It is also likely that some drug-exposed children will need educational support in the classroom to help them overcome what may be subtle deficits in developmental areas such as behavior, attention, and thinking. Ongoing research is investigating whether the effects of prenatal drug exposure on the brain and behavior extend into adolescence to cause developmental problems during that time period.

- **Negative effects of secondhand smoke.**

Secondhand tobacco smoke, also called environmental tobacco smoke (ETS), is a significant source of exposure to a large number of substances known to be hazardous to human health, particularly to children. According to the Surgeon General's 2006 Report, [\*The Health Consequences of Involuntary Exposure to Tobacco Smoke\*](#), involuntary exposure to secondhand smoke increases the risks of heart disease and lung cancer in people who have never smoked by 25–30 percent and 20–30 percent, respectively.<sup>20</sup>

- **Increased spread of infectious diseases.**

Injection of drugs such as heroin, cocaine, and methamphetamine currently accounts for about 12 percent of new AIDS cases.<sup>21</sup> Injection drug use is also a major factor in the spread of hepatitis C, a serious, potentially fatal liver disease. Injection drug use is not the only way that drug abuse contributes to the spread of infectious diseases. All drugs of abuse cause some form of intoxication, which interferes with judgment and increases the likelihood of risky sexual behaviors. This, in turn, contributes to the spread of HIV/AIDS, hepatitis B and C, and other sexually transmitted diseases.

- **Nicotine** is an addictive stimulant found in cigarettes and other forms of tobacco. Tobacco smoke increases a user's risk of cancer, emphysema, bronchial disorders, and cardiovascular disease. The mortality rate associated with tobacco addiction is staggering. Tobacco use killed approximately 100 million people during the 20th century, and, if current smoking trends continue, the cumulative death toll for this century has been projected to reach 1 billion.<sup>24</sup>
- **Alcohol** consumption can damage the brain and most body organs. Areas of the brain that are especially vulnerable to alcohol-related damage are the cerebral cortex (largely responsible for our higher brain functions, including problem solving and decision making), the hippocampus (important for memory and learning), and the cerebellum (important for movement coordination).
- **Marijuana** is the most commonly abused illegal substance. This drug impairs short-term memory and learning, the ability to focus attention, and coordination. It also increases heart rate, can harm the lungs, and can increase the risk of psychosis in those with an underlying vulnerability.
- **Prescription medications**, including opioid pain relievers (such as OxyContin® and Vicodin®), anti-anxiety sedatives (such as Valium® and Xanax®), and ADHD stimulants (such as Adderall® and Ritalin®), are commonly misused to self-treat for medical problems or abused for purposes of getting high or (especially with stimulants) improving performance. However, misuse or abuse of these drugs (that is, taking them other than exactly as instructed by a doctor and for the purposes prescribed) can lead to addiction and even, in some cases, death. Opioid pain relievers, for instance, are frequently abused by being crushed and injected or snorted, greatly raising the risk of addiction and overdose. Unfortunately, there is a common misperception that because medications are prescribed by physicians, they are safe even when used illegally or by another person than they were prescribed for.
- **Inhalants** are volatile substances found in many household products, such as oven cleaners, gasoline, spray paints, and other aerosols, that induce mind-altering effects; they are frequently the first drugs tried by children or young teens. Inhalants are extremely toxic and can damage the heart, kidneys, lungs, and brain. Even a healthy person can suffer heart failure and death within minutes of a single session of prolonged sniffing of an inhalant.

- **Cocaine** is a short-acting stimulant, which can lead users to take the drug many times in a single session (known as a “binge”). Cocaine use can lead to severe medical consequences related to the heart and the respiratory, nervous, and digestive systems.
- **Amphetamines**, including methamphetamine, are powerful stimulants that can produce feelings of euphoria and alertness. Methamphetamine’s effects are particularly long-lasting and harmful to the brain. Amphetamines can cause high body temperature and can lead to serious heart problems and seizures.
- **MDMA (Ecstasy or "Molly")** produces both stimulant and mind-altering effects. It can increase body temperature, heart rate, blood pressure, and heart-wall stress. MDMA may also be toxic to nerve cells.
- **LSD** is one of the most potent hallucinogenic, or perception-altering, drugs. Its effects are unpredictable, and abusers may see vivid colors and images, hear sounds, and feel sensations that seem real but do not exist. Users also may have traumatic experiences and emotions that can last for many hours.
- **Heroin** is a powerful opioid drug that produces euphoria and feelings of relaxation. It slows respiration, and its use is linked to an increased risk of serious infectious diseases, especially when taken intravenously. People who become addicted to opioid pain relievers sometimes switch to heroin instead, because it produces similar effects and may be cheaper or easier to obtain.
- **Steroids**, which can also be prescribed for certain medical conditions, are abused to increase muscle mass and to improve athletic performance or physical appearance. Serious consequences of abuse can include severe acne, heart disease, liver problems, stroke, infectious diseases, depression, and suicide.
- **Drug combinations.** A particularly dangerous and common practice is the combining of two or more drugs. The practice ranges from the co-administration of legal drugs, like alcohol and nicotine, to the dangerous mixing of prescription drugs, to the deadly combination of heroin or cocaine with fentanyl (an opioid pain medication). Whatever the context, it is critical to realize that because of drug–drug interactions, such practices often pose significantly higher risks than the already harmful individual drugs.

**For more information on the nature and extent of common drugs of abuse and their health consequences,**

Go to NIDA's Web site to view the popular [Research Reports](#), [DrugFacts](#), and [other publications](#).