Science of Addiction (Updated)

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PREFACE

How Science Has Revolutionized the Understanding of Drug Addiction

For much of the past century, scientists studying drugs and drug use labored in the shadows of powerful myths and misconceptions about the nature of addiction. When scientists began to study addictive behavior in the 1930s, people addicted to drugs were thought to be morally flawed and lacking in willpower. Those views shaped society's responses to drug use, treating it as a moral failing rather than a health problem, which led to an emphasis on punishment rather than prevention and treatment.

Today, thanks to science, our views and our responses to addiction and the broader spectrum of substance use disorders have changed dramatically. Groundbreaking discoveries about the brain have revolutionized our understanding of compulsive drug use, enabling us to respond effectively to the problem.

As a result of scientific research, we know that addiction is a medical disorder that affects the brain and changes behavior. We have identified many of the biological and environmental risk factors and are beginning to search for the genetic variations that contribute to the development and progression of the disorder. Scientists use this knowledge to develop effective prevention and treatment approaches that reduce the toll drug use takes on individuals, families, and communities.

Despite these advances, we still do not fully understand why some people become addicted to drugs or how drugs change the brain to foster compulsive drug use. This booklet aims to fill that knowledge gap by providing scientific information about the disorder of drug addiction, including the many harmful consequences of drug use and the basic approaches that have been developed to prevent and treat substance use disorders.

At the National Institute on Drug Abuse (NIDA), we believe that increased understanding of the basics of addiction will empower people to make informed choices in their own lives, adopt science-based policies and programs that reduce drug use and addiction in their communities, and support scientific research that improves the Nation's well-being.

Nora D. Volkow, M.D.
Director, National Institute on Drug Abuse

INTRODUCTION

Why study

DRUG USE AND ADDICTION?

Use and misuse of alcohol, nicotine, and illicit drugs, and misuse of prescription drugs cost Americans more than $700 billion a year in increased health care costs, crime, and lost productivity.[1,2,3] Every year, illicit and prescription drugs and alcohol contribute to the death of more than 90,000 Americans, while tobacco is linked to an estimated 480,000 deaths per year.[4,5] (Hereafter, unless otherwise specified, *drugs* refers to all of these substances.)

People of all ages suffer the harmful consequences of drug use and addiction:

- **Teens** who use drugs may act out and may do poorly in school or drop out.[6] Using drugs when the brain is still developing may cause lasting brain changes and put the user at increased risk of dependence.[7]
- **Adults** who use drugs can have problems thinking clearly, remembering, and paying attention. They may develop poor social behaviors as a result of their drug use, and their work performance and personal relationships suffer.
- **Parents'** drug use can mean chaotic, stress-filled homes, as well as child abuse and neglect.[8] Such conditions harm the well-being and development of children in the home and may set the stage for drug use in the next generation.[9]
- **Babies** exposed to drugs in the womb may be born premature and underweight. This exposure can slow the child's ability to learn and affect behavior later in life.[10] They may also become dependent on opioids or other drugs used by the mother during pregnancy, a condition called neonatal abstinence syndrome (NAS).


Medical


Social


Economic


Criminal Justice

How does science provide solutions for drug use and addiction?

Scientists study the effects drugs have on the brain and behavior. They use this information to develop programs for preventing drug use and for helping people recover from addiction. Further research helps transfer these ideas into practice in the community.

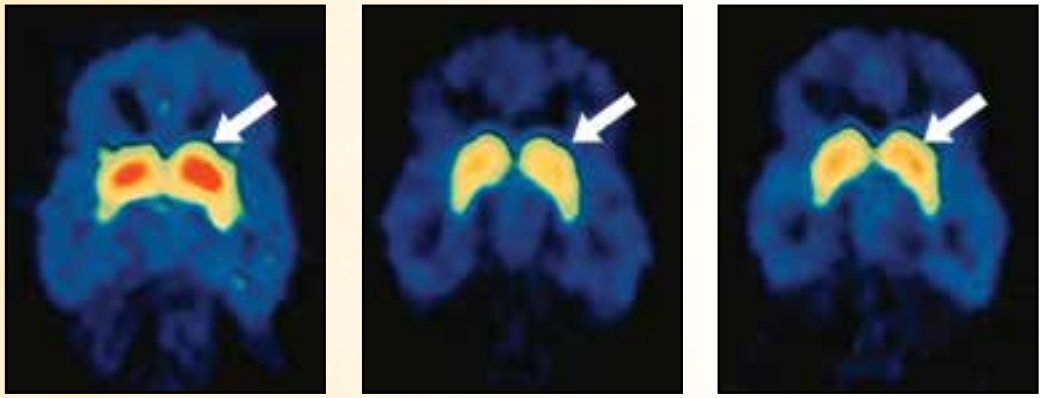
The consequences of drug use are vast and varied and affect people of all ages.

Drug Misuse and Addiction

What is DRUG ADDICTION?

Addiction is defined as a chronic, relapsing disorder characterized by compulsive drug seeking and use despite adverse consequences.[†] It is considered a brain disorder, because it involves functional changes to brain circuits involved in reward, stress, and self-control, and those changes may last a long time after a person has stopped taking drugs.[11]

Addiction is a lot like other diseases, such as heart disease. Both disrupt the normal, healthy functioning of an organ in the body, both have serious harmful effects, and both are, in many cases, preventable and treatable. If left untreated, they can last a lifetime and may lead to death.



Source: Facing Addiction in America: The Surgeon General's Report on Alcohol, Drugs, and Health

Modified with permission from Volkow et al. 1993

Note: These fMRI images compare the brain of an individual with a history of cocaine use disorder (middle and right) to the brain of an individual without a history of cocaine use (left). The person who has had a cocaine use disorder has lower levels of the D2 dopamine receptor (depicted in red) in the striatum one month (middle) and four months (right) after stopping cocaine use compared to the non-user. The level of dopamine receptors in the brain of the cocaine user are higher at the 4-month mark (right), but have not returned to the levels observed in the non-user (left).

Low dopamine D2 receptors may contribute to the loss of control in cocaine users.

[†]*The term addiction as used in this booklet is 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 take drugs for a few reasons:

- **To feel good.** Drugs can produce intense feelings of pleasure. This initial 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 opioids such as heroin is followed by feelings of relaxation and satisfaction.
- **To feel better.** Some people who suffer from social anxiety, stress, and depression start using drugs to try to feel less anxious. Stress can play a major role in starting and continuing drug use as well as relapse (return to drug use) in patients recovering from addiction.
- **To do better.** Some people feel pressure to improve their focus in school or at work or their abilities in sports. This can play a role in trying or continuing to use drugs, such as prescription stimulants or cocaine.
- **Curiosity and social pressure.** In this respect, teens are particularly at risk because peer pressure can be very strong. Teens are more likely than adults to act in risky or daring ways to impress their friends and show their independence from parents 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 they can control their use. But drugs can quickly take over a person's life. Over time, if drug use continues, other pleasurable activities become less pleasurable, and the person has to take the drug just to feel "normal." They have a hard time controlling their need to take drugs even though it causes many problems for themselves and their loved ones. Some people may start to feel the need to take more of a drug or take it more often, 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. Occasional drug use, such as misusing an opioid to get high, can have similarly disastrous effects, including overdose, and dangerously impaired driving.

Do people freely choose to

KEEP USING DRUGS?

The initial decision to take drugs is typically voluntary. But 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.[12] These changes help explain the compulsive nature of addiction.

Why do some people become addicted to drugs,

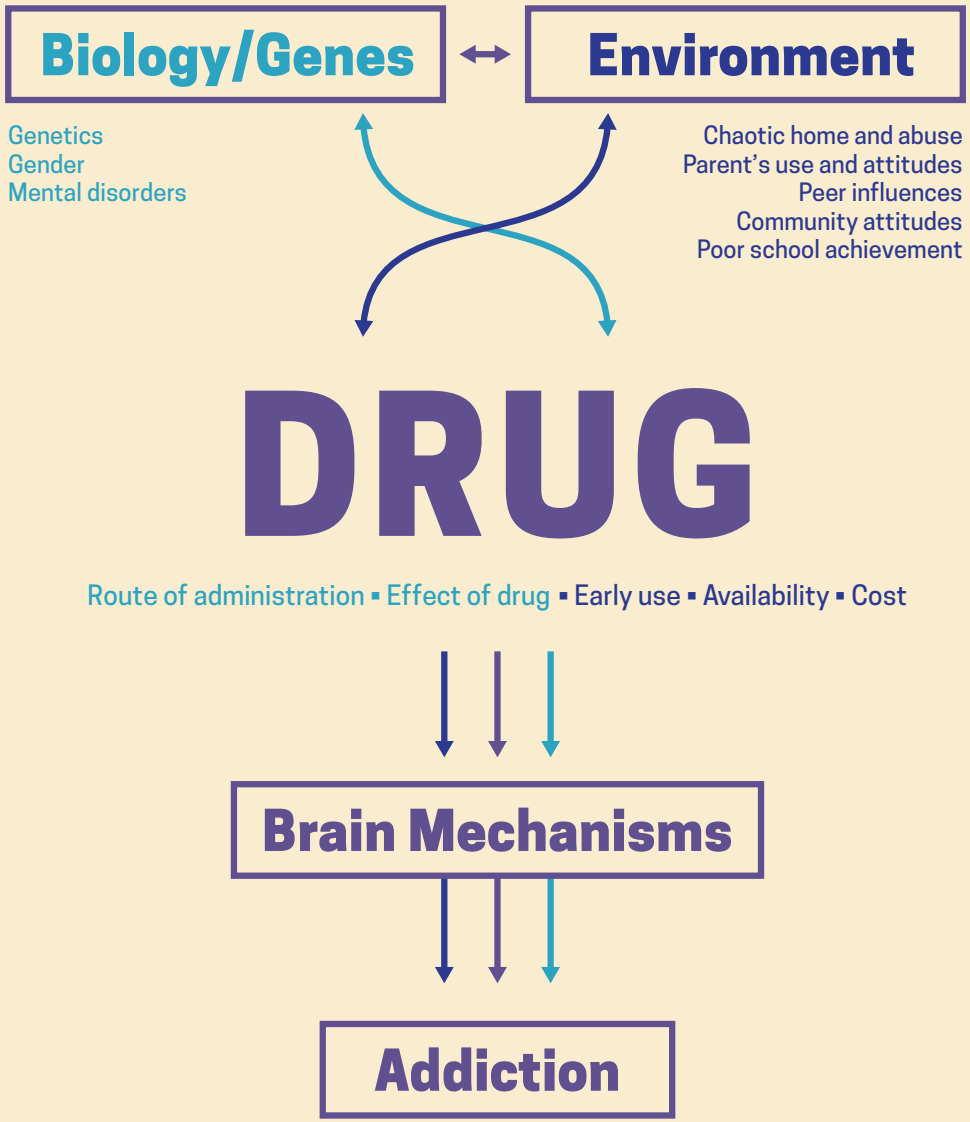
WHILE OTHERS DO NOT?

As with other diseases and disorders, the likelihood of developing an 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 drug use and addiction. *Protective factors,* on the other hand, reduce a person's risk. Risk and protective factors may be either environmental or biological.

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

Risk and Protective Factors for Drug Use, Misuse, and Addiction

RISK FACTORS	PROTECTIVE FACTORS
Aggressive behavior in childhood [13,14]	Good self control [15]
Lack of parental supervision [14,16]	Parental monitoring and support [16–18]
Poor social skills [13,17,18]	Positive relationships [17,19]
Drug experimentation [14,20,21]	Good grades [17,22]
Availability of drugs at school [21,23]	School anti-drug policies [17]
Community poverty [24,25]	Neighborhood resources [26]



Children's earliest interactions within the family are crucial to their healthy development and risk for drug use.

WHAT BIOLOGICAL FACTORS
increase the risk of addiction?

Biological factors that can affect a person's risk of addiction include their genes, stage of development, and even gender or ethnicity. Scientists estimate that genes, including the effects environmental factors have on a person's gene expression, called epigenetics, account for between 40 and 60 percent of a person's risk of addiction.[27] Also, teens and people with mental disorders are at greater risk of drug use and addiction than others.[28]

WHAT ENVIRONMENTAL FACTORS
increase the risk of addiction?

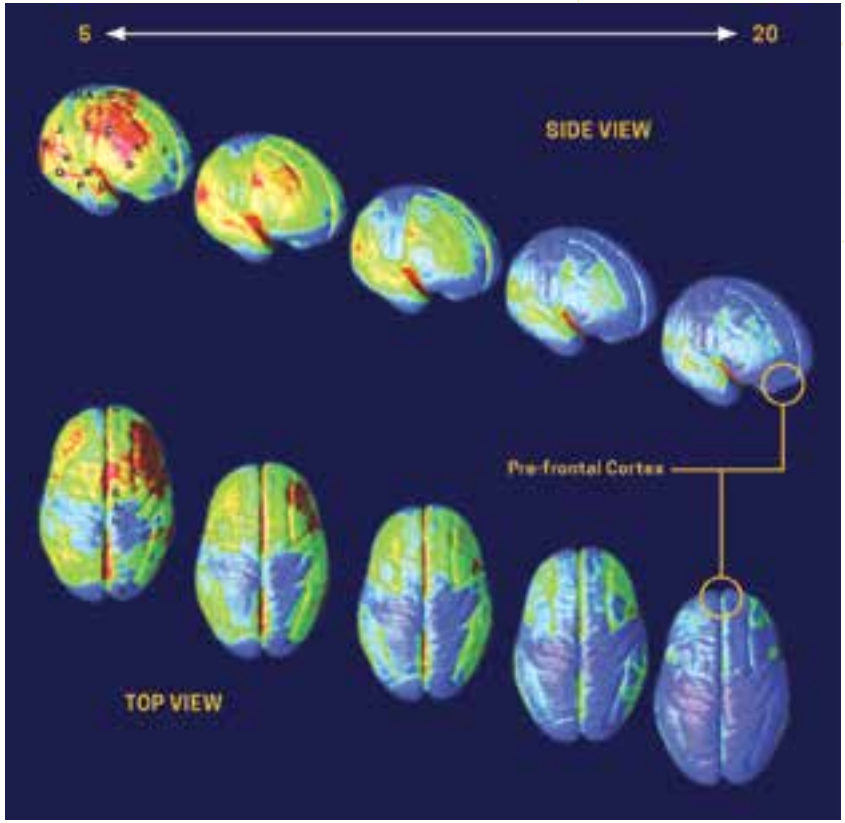
Environmental factors are those related to the family, school, and neighborhood. Factors that can increase a person's risk include the following:

- **Home and family.** The home environment, especially during childhood, is a very important factor. Parents or older family members who use drugs or misuse alcohol, or who break the law, can increase children's risk of future drug problems.[29]
- **Peers and school.** Friends and other peers can have an increasingly strong influence during the teen years. Teens who use drugs can sway even those without risk factors to try drugs for the first time. Struggling in school or having poor social skills can put a child at further risk for using or becoming addicted to drugs.[30]

What other factors increase the
RISK OF ADDICTION?

- **Early use.** Although taking drugs at any age can lead to addiction, research shows that the earlier a person begins to use drugs, the more likely he or she is to develop serious problems.[31] This may be due to the harmful effect that drugs can have on the developing brain.[32] It also may result from a mix of early social and biological risk factors, including lack of a stable home or family, exposure to physical or sexual abuse, genes, or mental illness. Still, the fact remains that early use is a strong indicator of problems ahead, including addiction.
- **How the drug is taken.** Smoking a drug or injecting it into a vein increases its addictive potential.[33,34] Both smoked and injected drugs enter the brain within seconds, producing a powerful rush of pleasure. However, this intense high can fade within a few minutes. Scientists believe this starkly felt contrast drives some people to repeated drug taking in an attempt to recapture the fleeting pleasurable state.

Images of Brain Development in Healthy Children and Teens (Ages 5–20)



Source: PNAS 101:8174–8179, 2004.

As the brain matures, experiences prune excess neural connections while strengthening those that are used more often. Many scientists think that this process contributes to the steady reduction in gray matter volume seen during adolescence (depicted as the yellow to blue transition in the figure). As environmental forces help determine which connections will wither and which will thrive, the brain circuits that emerge become more efficient. However, this is a process that can cut both ways because not all tasks are desirable. The environment is like an artist who creates a sculpture by chipping away excess marble; and just like bad artists can produce bad art, environments with negative factors (like drugs, malnutrition, bullying, or sleep deprivation) can lead to efficient but potentially harmful circuits that conspire against a person's well-being.

The brain continues to develop into adulthood and undergoes

DRAMATIC CHANGES DURING ADOLESCENCE

One of the brain areas still maturing during adolescence is the prefrontal cortex — the part of the brain that allows people to assess situations, make sound decisions, and keep emotions and desires under control. The fact that this critical part of a teen's brain is still a work in progress puts them at increased risk for making poor decisions, such as trying drugs or continuing to take them. Introducing drugs during this period of development may cause brain changes that have profound and long-lasting consequences.

Preventing Drug Misuse and Addiction: The Best Strategy

Why is adolescence a critical time for PREVENTING DRUG ADDICTION?

As noted previously, early use of drugs increases a person's chances of becoming addicted. Remember, drugs change the brain—and this can lead to addiction and other serious problems. So, preventing early use of drugs or alcohol may go a long way in reducing these risks.

Risk of drug use increases greatly during times of transition. For an adult, a divorce or loss of a job may increase the risk of drug use. For a teenager, risky times include moving, family divorce, or changing schools.[35] When children advance from elementary through middle school, they face new and challenging social, family, and academic situations. Often during this period, children are exposed to substances such as cigarettes and alcohol for the first time. When they enter high school, teens may encounter greater availability of drugs, drug use by older teens, and social activities where drugs are used.

A certain amount of risk-taking is a normal part of adolescent development. The desire to try new things and become more independent is healthy, but it may also increase teens' tendencies to experiment with drugs. The parts of the brain that control judgment and decision-making do not fully develop until people are in their early or mid-20s; this limits a teen's ability to accurately assess the risks of drug experimentation and makes young people more vulnerable to peer pressure.[36]

Because the brain is still developing, using drugs at this age has more potential to disrupt brain function in areas critical to motivation, memory, learning, judgment, and behavior control.[12] So, it's not surprising that teens who use alcohol and other drugs often have family and social problems, poor academic performance, health-related problems (including mental health conditions), and involvement with the juvenile justice system.

Can research-based programs prevent

DRUG ADDICTION IN YOUTH?

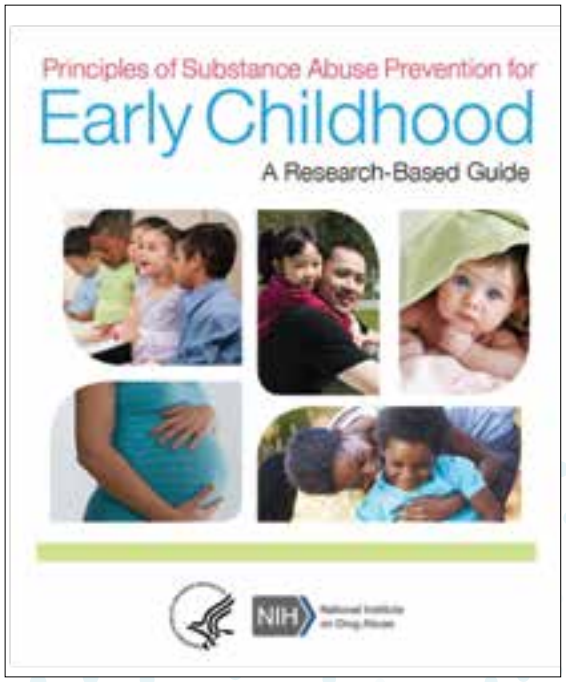
Yes. The term "research-based" or "evidence-based" means that these programs have been designed based on current scientific evidence, thoroughly tested, and shown to produce positive results. Scientists have developed a broad range of programs that positively alter the balance between risk and protective factors for drug use in families, schools, and communities. Studies have shown that research-based programs, such as described in NIDA's *Principles of Substance Abuse Prevention for Early Childhood: A Research-Based Guide* and *Preventing Drug Use among Children and Adolescents: A Research-Based Guide for Parents, Educators, and Community Leaders*, can significantly reduce early use of tobacco, alcohol, and other drugs.[37] Also, while many social and cultural factors affect drug use trends, when young people perceive drug use as harmful, they often reduce their level of use.[38]

How do research-based

PREVENTION PROGRAMS WORK?

These prevention programs work to boost protective factors and eliminate or reduce risk factors for drug use. The programs are designed for various ages and can be used in individual or group settings, such as the school and home. There are three types of programs:

- **Universal programs** address risk and protective factors common to all children in a given setting, such as a school or community.
- **Selective programs** are for groups of children and teens who have specific factors that put them at increased risk of drug use.
- **Indicated programs** are designed for youth who have already started using drugs.

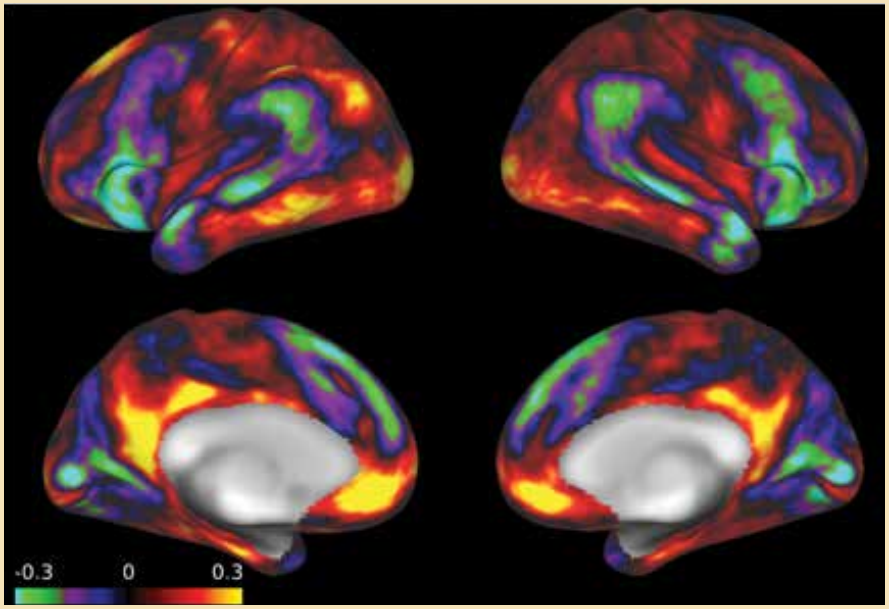


National drug use surveys indicate some children are already using drugs by age 12 or 13.

Prevention is the best strategy.

Young Brains Under Study

Using cutting-edge imaging technology, scientists from the NIDA's Adolescent Brain Cognitive Development (ABCD) Study will look at how childhood experiences, including use of any drugs, interact with each other and with a child's changing biology to affect brain development and social, behavioral, academic, health, and other outcomes. As the only study of its kind, the ABCD study will yield critical insights into the foundational aspects of adolescence that shape a person's future.



These brain images show the reward-related circuity in the cortical and subcortical regions of the brain that tend to be more active when a child is successful at achieving a reward. While all of the images show the regions of the brain that are active to reward, the regions in yellow and red are the most active.

Courtesy of the ABCD Study. Adapted from Casey et al., 2018 https://doi.org/10.1016/j.dcn.2018.03.001

Economics of Prevention

Benefit-per-dollar cost ratios for evidence-based interventions range from small returns per dollar invested to more than $65 every dollar invested.[39]

Drugs and the Brain

Introducing the

HUMAN BRAIN

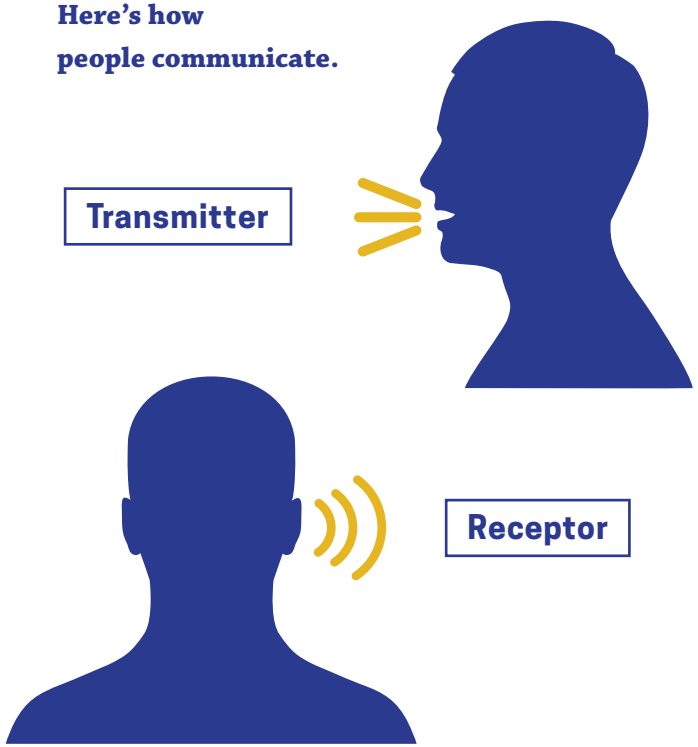
The human brain is the most complex organ in the body. This three-pound mass of gray and white matter sits at the center of all human activity — you need it to drive a car, to enjoy a meal, to breathe, to create an artistic masterpiece, and to enjoy everyday activities. The brain regulates your body's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

How does the

BRAIN WORK?

The brain is often likened to an incredibly complex and intricate computer. Instead of electrical circuits on the silicon chips that control our electronic devices, the brain consists of billions of cells, called *neurons,* which are organized into circuits and networks. Each neuron acts as a switch controlling the flow of information. If a neuron receives enough signals from other neurons connected to it, it "fires," sending its own signal on to other neurons in the circuit.

Here's how people communicate.



The brain is made up of many parts with interconnected circuits that all work together as a team. Different brain circuits are responsible for coordinating and performing specific functions. Networks of neurons send signals back and forth to each other and among different parts of the brain, the spinal cord, and nerves in the rest of the body (the peripheral nervous system).

To send a message, a neuron releases a *neurotransmitter* into the gap (or *synapse)* between it and the next cell. The neurotransmitter crosses the synapse and attaches to receptors on the receiving neuron, like a key into a lock. This causes changes in the receiving cell. Other molecules called *transporters* recycle neurotransmitters (that is, bring them back into the neuron that released them), thereby limiting or shutting off the signal between neurons.

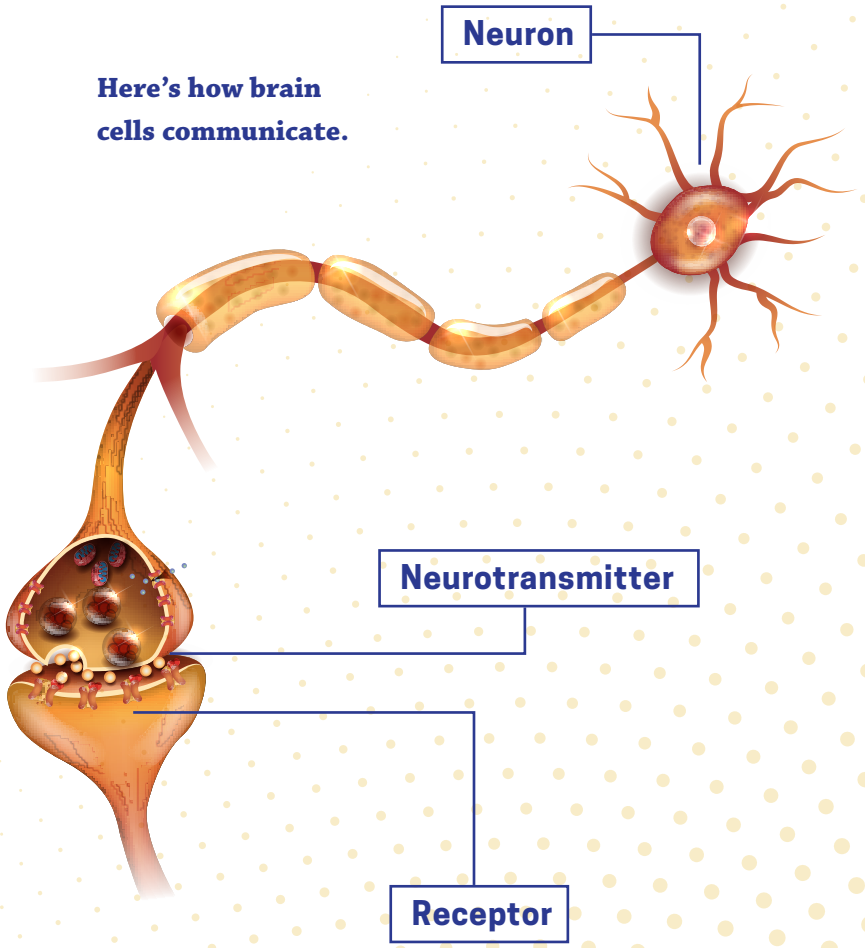
How do drugs

WORK IN THE BRAIN?

Drugs interfere with the way neurons send, receive, and process signals via neurotransmitters. Some drugs, such as marijuana and heroin, can activate neurons because their chemical structure mimics that of a natural neurotransmitter in the body. This 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 sent 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 by interfering with transporters. This too amplifies or disrupts the normal communication between neurons.

Here's how brain cells communicate.



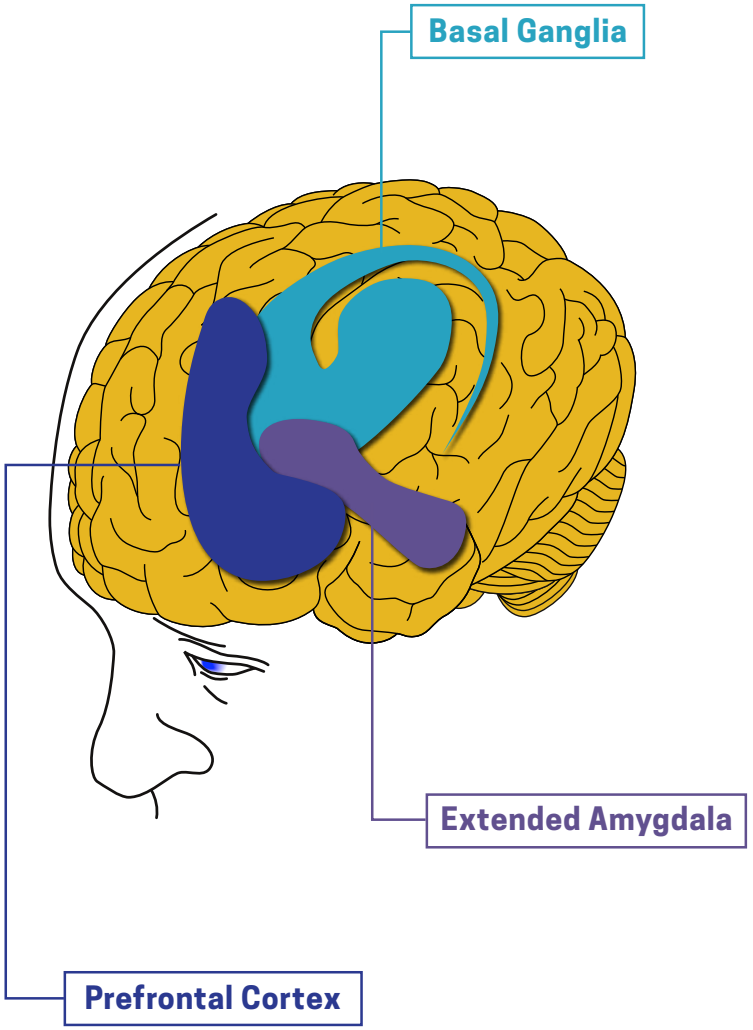
What parts of the brain are

AFFECTED BY DRUG USE?

Drugs can alter important brain areas that are necessary for life-sustaining functions and can drive the compulsive drug use that marks addiction. Brain areas affected by drug use include:

- *The basal ganglia,* which play an important role in positive forms of motivation, including the pleasurable effects of healthy activities like eating, socializing, and sex, and are also involved in the formation of habits and routines. These areas form a key node of what is sometimes called the brain's "reward circuit." Drugs over-activate this circuit, producing the euphoria of the drug high; but with repeated exposure, the circuit adapts to the presence of the drug, diminishing its sensitivity and making it hard to feel pleasure from anything besides the drug.
- *The extended amygdala* plays a role in stressful feelings like anxiety, irritability, and unease, which characterize withdrawal after the drug high fades and thus motivates the person to seek the drug again. This circuit becomes increasingly sensitive with increased drug use. Over time, a person with substance use disorder uses drugs to get temporary relief from this discomfort rather than to get high.
- *The prefrontal cortex* powers the ability to think, plan, solve problems, make decisions, and exert self-control over impulses. This is also the last part of the brain to mature, making teens most vulnerable. Shifting balance between this circuit and the reward and stress circuits of the basal ganglia and extended amygdala make a person with a substance use disorder seek the drug compulsively with reduced impulse control.

Some drugs like opioids also affect other parts of the brain, such as the brain stem, which controls basic functions critical to life, such as heart rate, breathing, and sleeping explaining why overdoses can cause depressed breathing and death.



Source: Facing Addiction in America: The Surgeon General's Report on Alcohol, Drugs, and Health

How do
DRUGS PRODUCE PLEASURE?

Pleasure or euphoria — the high from drugs — is still poorly understood, but probably involves surges of chemical signaling compounds including the body's natural opioids (endorphins) and other neurotransmitters in parts of the basal ganglia (the reward circuit). When some drugs are taken, they can cause surges of these neurotransmitters much greater than the smaller bursts naturally produced in association with healthy rewards like eating, music, creative pursuits, or social interaction.

It was once thought that surges of the neurotransmitter *dopamine* produced by drugs directly caused the euphoria, but scientists now think dopamine has more to do with getting us to repeat pleasurable activities (reinforcement) than with producing pleasure directly.

Simple activities in everyday life can produce small bursts of neurotransmitters in the brain bringing pleasurable feelings. Drugs can hijack that process.

How does
DOPAMINE REINFORCE DRUG USE?

Our brains are wired to increase the odds that we will repeat pleasurable activities. The neurotransmitter dopamine is central to this. Whenever the reward circuit is activated by a healthy, pleasurable experience, a burst of dopamine signals that something important is happening that needs to be remembered. This dopamine signal causes changes in neural connectivity that make it easier to repeat the activity again and again without thinking about it, leading to the formation of habits.

Just as drugs produce intense euphoria, they also produce much larger surges of dopamine, powerfully reinforcing the connection between consumption of the drug, the resulting pleasure, and all the external cues linked to the experience. Large surges of dopamine "teach" the brain to seek drugs at the expense of other, healthier goals and activities.

Cues in a person's daily routine or environment that have become linked with drug use because of changes to the reward circuit can trigger uncontrollable cravings whenever the person is exposed to these cues, even if the drug itself is not available. This learned "reflex" can last a long time, even in people who haven't used drugs in many years. For example, people who have been drug free for a decade can experience cravings when returning to an old neighborhood or house where they used drugs. Like riding a bike, the brain remembers.

Why are drugs more addictive than

NATURAL REWARDS?

For the brain, the difference between normal rewards and drug rewards can be likened to 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 of someone who misuses drugs adjusts by producing fewer neurotransmitters in the reward circuit, or by reducing the number of receptors that can receive signals. As a result, the person's ability to experience pleasure from naturally rewarding (i.e., reinforcing) activities is also reduced.

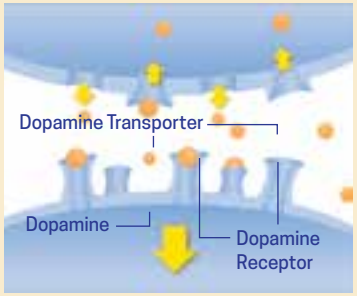
This is why a person who misuses drugs eventually feels flat, without motivation, lifeless, and/or depressed, and is unable to enjoy things that were previously pleasurable. Now, the person needs to keep taking drugs to experience even a normal level of reward — which only makes the problem worse, like a vicious cycle. Also, the person will often need to take larger amounts of the drug to produce the familiar high — an effect known as *tolerance*.

Some drugs target the brain's pleasure center

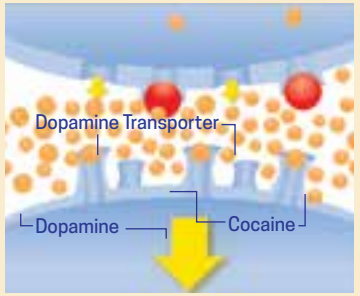
Brain reward (dopamine pathways)

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

How drugs can increase dopamine



While eating food



While using cocaine

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

Long-term drug use impairs brain functioning.

For more information on drugs and the brain, order NIDA's Teaching Packets or the *Mind Matters* series at *www.drugabuse.gov/parent-teacher.html*. These items and others are available to the public free of charge.

Addiction and Health

What are the other health
CONSEQUENCES OF DRUG ADDICTION?

People with addiction often have one or more associated health issues, which could include lung or heart disease, stroke, cancer, or mental health conditions. Imaging scans, chest X-rays, and blood tests can show the damaging effects of long-term drug use throughout the body.

For example, it is now well-known that tobacco smoke can cause many cancers, methamphetamine can cause severe dental problems, known as "meth mouth," and that opioids can lead to overdose and death. In addition, some drugs, such as inhalants, may damage or destroy nerve cells, either in the brain or the peripheral nervous system (the nervous system outside the brain and spinal cord).

Drug use can also increase the risk of contracting infections. Human immunodeficiency virus (HIV) and hepatitis C (a serious liver disease) infection can occur from sharing injection equipment and from impaired judgment leading to unsafe sexual activity.[40,41] Infection of the heart and its valves (endocarditis) and skin infection (cellulitis) can occur after exposure to bacteria by injection drug use.[42]

Does drug use cause
MENTAL DISORDERS OR VICE VERSA?

Drug use and mental illness often co-exist. In some cases, mental disorders such as anxiety, depression, or schizophrenia may come before addiction; in other cases, drug use may trigger or worsen those mental health conditions, particularly in people with specific vulnerabilities.[43,44]

Some people with disorders like anxiety or depression may use drugs in an attempt to alleviate psychiatric symptoms, which may exacerbate their mental disorder in the long run, as well as increase the risk of developing addiction.[43,44] Treatment for all conditions should happen concurrently.

Addiction and HIV/AIDS are intertwined health conditions.

How can addiction

HARM OTHER PEOPLE?

Beyond the harmful consequences for the person with the addiction, drug use can cause serious health problems for others. Some of the more severe consequences of addiction are:

- **Negative effects of drug use while pregnant or breastfeeding** A mother's substance or medication use during pregnancy can cause her baby to go into withdrawal after it's born, which is called neonatal abstinence syndrome (NAS). Symptoms will differ depending on the substance used, but may include tremors, problems with sleeping and feeding, and even seizures.[45] Some drug-exposed children will have developmental problems with behavior, attention, and thinking. Ongoing research is exploring if these effects on the brain and behavior extend into the teen years, causing continued developmental problems. In addition, some substances can make their way into a mother's breast milk. Scientists are still learning about long-term effects on a child who is exposed to drugs through breastfeeding.

THE IMPACT OF ADDICTION CAN BE

FAR-REACHING

- Heart disease
- Stroke
- Cancer
- HIV/AIDS
- Hepatitis B and C
- Endocarditis
- Cellulitis
- Lung disease
- Mental health conditions

- **Negative effects of secondhand smoke**
  Secondhand tobacco smoke exposes bystanders to at least 250 chemicals that are known to be harmful, particularly to children.[46] Involuntary exposure to secondhand smoke increases the risks of heart disease and lung cancer in people who have never smoked.[5] Additionally, the known health risks of secondhand exposure to tobacco smoke raise questions about whether secondhand exposure to marijuana smoke poses similar risks. At this point, little research on this question has been conducted. However, a study found that some nonsmoking participants exposed for an hour to high-THC marijuana in an unventilated room reported mild effects of the drug, and another study showed positive urine tests in the hours directly following exposure.[47,48] If you inhale secondhand marijuana smoke, it's unlikely you would fail a drug test, but it is possible.

- **Increased spread of infectious diseases**
  Injection of drugs accounts for 1 in 10 of cases of HIV. Injection drug use is also a major factor in the spread of hepatitis C,[49] and can be the cause of endocarditis and cellulitis. Injection drug use is not the only way that drug use contributes to the spread of infectious diseases. Drugs that are misused can cause intoxication, which hinders judgment and increases the chance of risky sexual behaviors.
- **Increased risk of motor vehicle accidents**
  Use of illicit drugs or misuse of prescription drugs can make driving a car unsafe—just like driving after drinking alcohol. Drugged driving puts the driver, passengers, and others who share the road at risk. In 2016, almost 12 million people ages 16 or older reported driving under the influence of illicit drugs, including marijuana.[50] After alcohol, marijuana is the drug most often linked to impaired driving. Research studies have shown negative effects of marijuana on drivers, including an increase in lane weaving, poor reaction time, and altered attention to the road.

Treatment and Recovery

Can addiction be

TREATED SUCCESSFULLY?

Yes, addiction is a treatable disorder. Research on the science of addiction and the treatment of substance use disorders has led to the development of research-based methods that help people to stop using drugs and resume productive lives, also known as being in *recovery*.

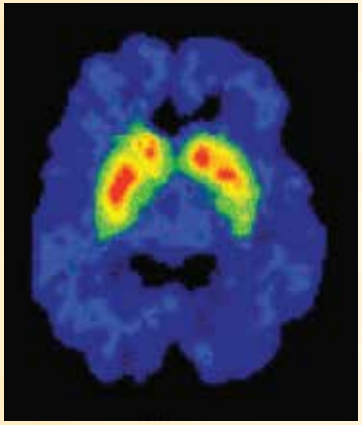
Can addiction be

CURED?

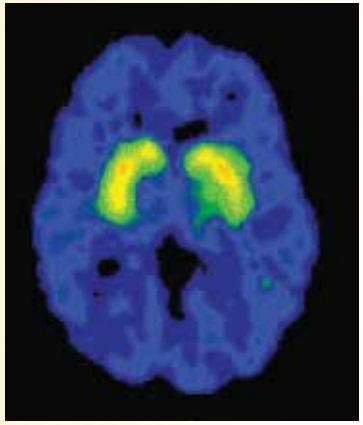
Like other chronic diseases such as heart disease or asthma, treatment for drug addiction usually isn't a cure. But addiction *can* be managed successfully. Treatment enables people to counteract addiction's disruptive effects on their brain and behavior and regain control of their lives.

Brain Recovery with Prolonged Abstinence

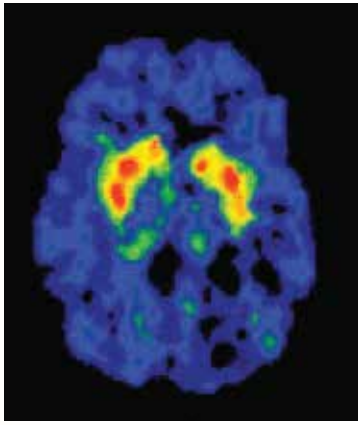
Healthy Person



Meth User: 1 month abstinence



Meth User: 14 months abstinence



These images showing the density of dopamine transporters in the brain illustrate the brain's remarkable ability to recover, at least in part, after a long abstinence from drugs — in this case, methamphetamine.[51]

Source: The Journal of Neuroscience, 21(23):9414-9418. 2001

Does relapse to drug use mean

TREATMENT HAS FAILED?

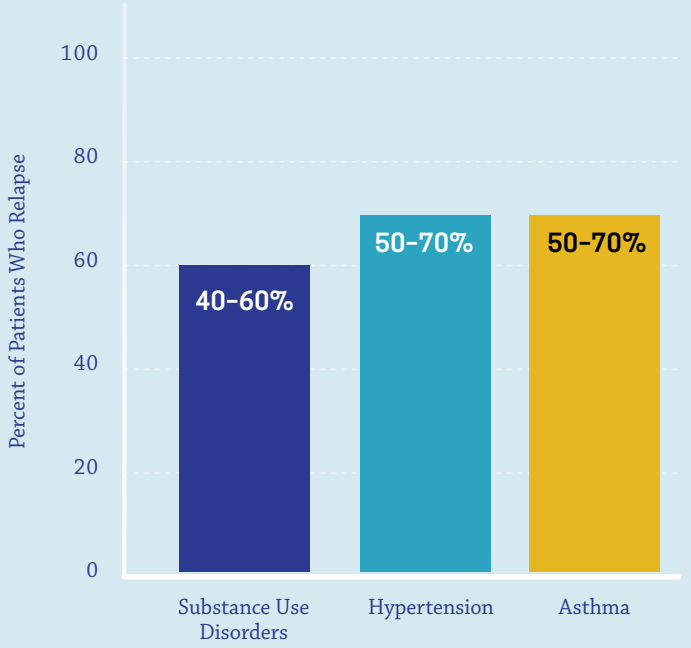
No. The chronic nature of addiction means that for some people *relapse,* or a return to drug use after an attempt to stop, can be part of the process, but newer treatments are designed to help with relapse prevention. Relapse rates for drug use are similar to rates for other chronic medical illnesses. If people stop following their medical treatment plan, they are likely to relapse.

Treatment of chronic diseases involves changing deeply rooted behaviors, and relapse doesn't mean treatment has failed. When a person recovering from an addiction relapses, it indicates that the person needs to speak with their doctor to resume treatment, modify it, or try another treatment.[52]

Source: JAMA, 284:1689-1695, 2000

Relapse rates for people treated for substance use disorders are compared with those for people treated for high blood pressure and asthma. Relapse is common and similar across these illnesses. Therefore, substance use disorders should be treated like any other chronic illness. Relapse serves as a sign for resumed, modified, or new treatment.

Comparison of Relapse Rates Between Substance Use Disorders and Other Chronic Illnesses



While relapse is a normal part of recovery, for some drugs, it can be very dangerous — even deadly. If a person uses as much of the drug as they did before quitting, they can easily overdose because their bodies are no longer adapted to their previous level of drug exposure. An overdose happens when the person uses enough of a drug to produce uncomfortable feelings, life-threatening symptoms, or death.

What are the principles of

EFFECTIVE TREATMENT?

Research shows that when treating addictions to opioids (prescription pain relievers or drugs like heroin or fentanyl), medication should be the first line of treatment, usually combined with some form of behavioral therapy or counseling. Medications are also available to help treat addiction to alcohol and nicotine.

Additionally, medications are used to help people detoxify from drugs, although detoxification is not the same as treatment and is not sufficient to help a person recover. Detoxification alone without subsequent treatment generally leads to resumption of drug use.

For people with addictions to drugs like stimulants or cannabis, no medications are currently available to assist in treatment, so treatment consists of behavioral therapies. Treatment should be tailored to address each patient's drug use patterns and drug-related medical, mental, and social problems.

Discoveries in science lead to breakthroughs in drug use treatment.

What medications and devices help

TREAT DRUG ADDICTION?

Different types of medications and devices may be useful at different stages of treatment to help a patient stop using drugs, stay in treatment, and avoid relapse.

- **Treating withdrawal.** When patients first stop using drugs, they can experience various physical and emotional symptoms, including restlessness or sleeplessness, as well as depression, anxiety, and other mental health conditions. Certain treatment medications and devices reduce these symptoms, which makes it easier to stop the drug use.
- **Staying in treatment.** Some treatment medications and mobile applications are used to help the brain adapt gradually to the absence of the drug. These treatments act slowly to help prevent drug cravings and have a calming effect on body systems. They can help patients focus on counseling and other psychotherapies related to their drug treatment.
- **Preventing relapse.** Science has taught us that stress cues linked to the drug use (such as people, places, things, and moods), and contact with drugs are the most common triggers for relapse. Scientists have been developing therapies to interfere with these triggers to help patients stay in recovery.

COMMON MEDICATIONS USED TO TREAT DRUG ADDICTION AND WITHDRAWAL

Opioid

- Methadone
- Buprenorphine
- Extended-release naltrexone
- Lofexidine

Nicotine

- Nicotine replacement therapies (available as a patch, inhaler, or gum)
- Bupropion
- Varenicline

Alcohol

- Naltrexone
- Disulfiram
- Acamprosate

How do behavioral therapies

TREAT DRUG ADDICTION?

Behavioral therapies help people in drug addiction treatment modify their attitudes and behaviors related to drug use. As a result, patients are able to handle stressful situations and various triggers that might cause another relapse. Behavioral therapies can also enhance the effectiveness of medications and help people remain in treatment longer.

- **Cognitive-behavioral therapy** seeks to help patients recognize, avoid, and cope with the situations in which they're most likely to use drugs.
- **Contingency management** uses positive reinforcement such as providing rewards or privileges for remaining drug-free, for attending and participating in counseling sessions, or for taking treatment medications as prescribed.
- **Motivational enhancement therapy** uses strategies to make the most of people's readiness to change their behavior and enter treatment.
- **Family therapy** helps people (especially young people) with drug use problems, as well as their families, address influences on drug use patterns and improve overall family functioning.
- **Twelve-step facilitation (TSF)** is an individual therapy typically delivered in 12 weekly session to prepare people to become engaged in 12-step mutual support programs. 12-step programs, like Alcoholic Anonymous, are not medical treatments, but provide social and complementary support to those treatments. TSF follows the 12-step themes of acceptance, surrender, and active involvement in recovery.

How do quality treatment programs help patients

RECOVER FROM ADDICTION?

Stopping drug use is just one part of a long and complex recovery process. When people enter treatment, addiction has often caused serious consequences in their lives, possibly disrupting their health and how they function in their family lives, at work, and in the community.

Because addiction can affect so many aspects of a person's life, treatment should address the needs of the whole person to be successful. Counselors may select from a menu of services that meet the specific medical, mental, social, occupational, family, and legal needs of their patients to help in their recovery.

For more information on drug treatment, see *Principles of Drug Addiction Treatment: A Research-Based Guide,* and *Principles of Adolescent Substance Use Disorder Treatment: A Research-Based Guide.*

Treatment must address the whole person.

Advancing Addiction Science and Practical Solutions

Leading the Search for

SCIENTIFIC SOLUTIONS

To address all aspects of drug use and its harmful consequences, NIDA's research program ranges from basic studies of the addicted brain and behavior to clinical strategies and health services research. NIDA's research program develops prevention and treatment approaches and ensures they work in real-world settings. As part of this goal, NIDA is committed to research that addresses the vulnerabilities and health differences that exist among ethnic minorities or that stem from gender differences.

Bringing Science to

REAL WORLD SETTINGS

- **Clinical Trials Network (CTN):** CTN "road tests" research-based drug use treatments in community treatment programs around the country.
- **Criminal Justice Drug Abuse Treatment Studies (CJ-DATS):** Led by NIDA, CJ-DATS is a network of research centers, in partnership with criminal justice professionals, drug use treatment providers, and federal agencies, responsible for developing integrated treatment approaches for criminal justice offenders and testing them at multiple sites throughout the Nation.
- **Juvenile Justice Translational Research on Interventions in the Legal System (JJ-TRIALS):** JJ-TRIALS is a seven-site cooperative research program designed to identify and test strategies for improving the delivery of research-based substance use and HIV prevention and treatment services for justice-involved youth.
- **The Adolescent Brain Cognitive Development (ABCD) Study:** ABCD is the largest long-term study of brain development and child health in the United States. The study is following more than 11,000 healthy children ages nine to 10 and follow them into early adulthood to observe brain growth.

Drugs, Brains, and Behavior: The Science of Addiction.
(2018, July). NIH Publication No. 18-DA-5605.
National Institute on Drug Abuse; National Institutes of Health;
U.S. Department of Health and Human Services.

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