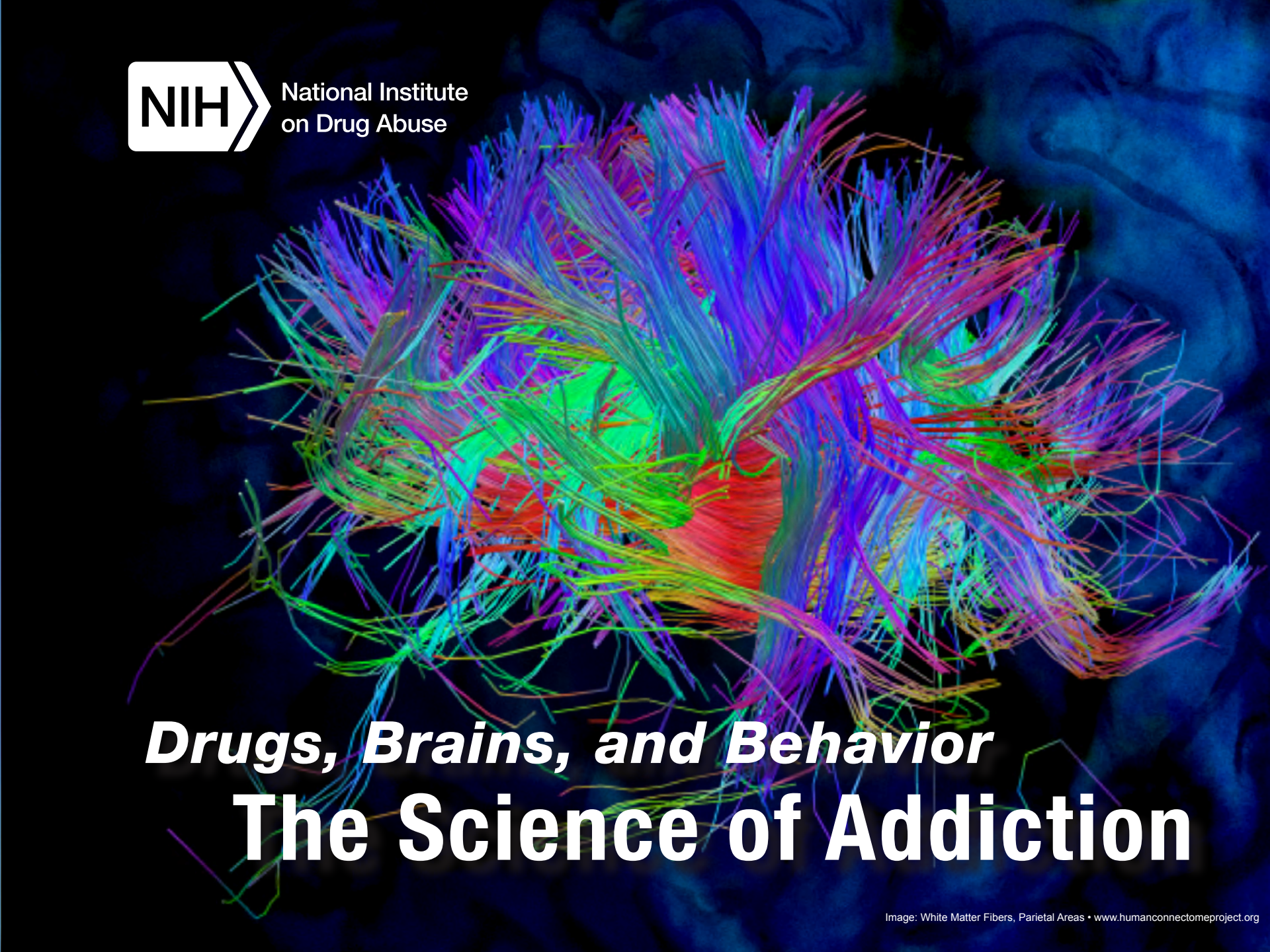
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Drugs, Brains, and Behavior
The Science of Addiction
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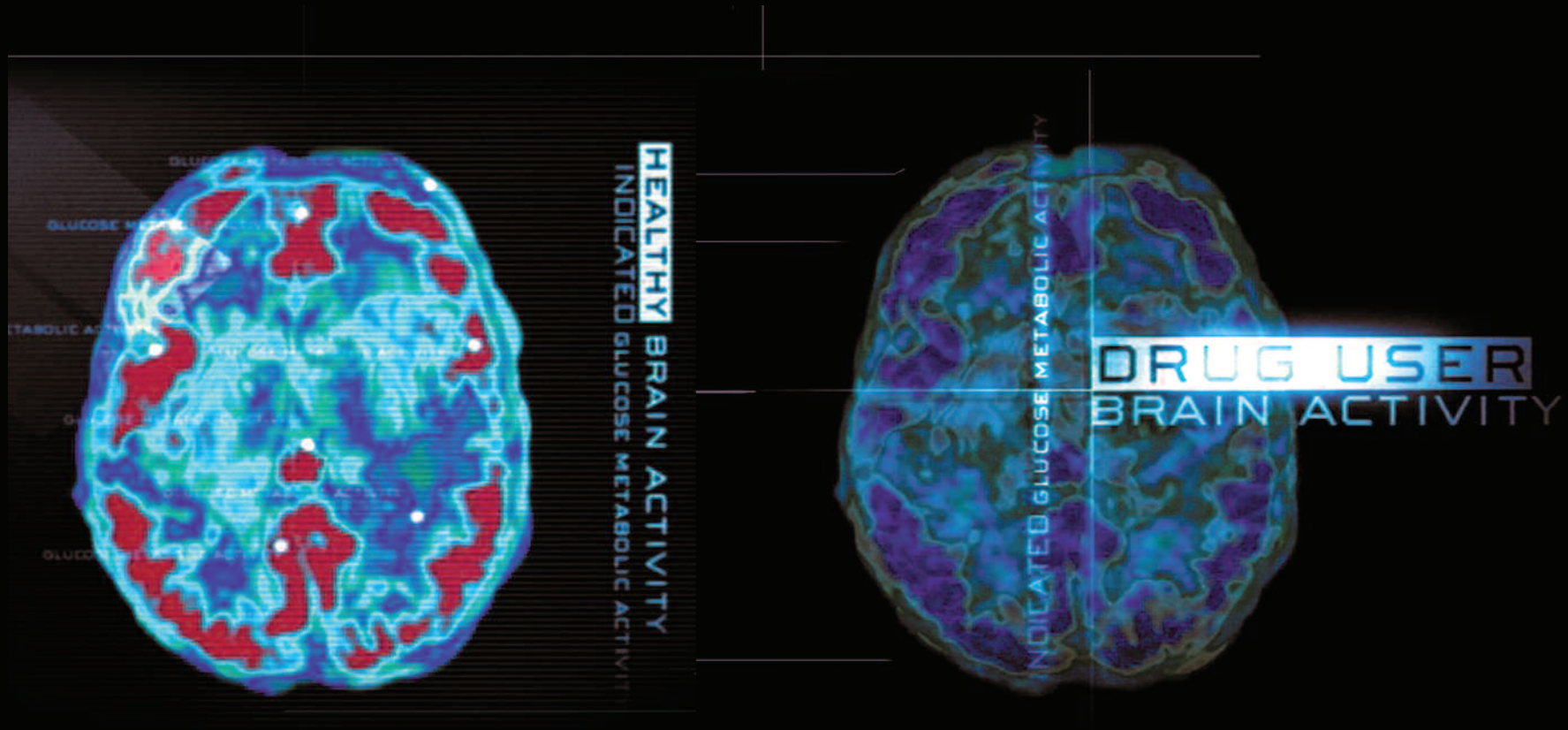


"Drug addiction is a brain disease that can be treated."

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

PREFACE

How Science Has Revolutionized the Understanding of Drug Addiction

For much of the past century, scientists studying drug abuse 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 abuse, 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 other 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 disease that affects both the brain and behavior. We have identified many of the biological and environmental factors and are beginning to search for the genetic variations that contribute to the development and progression of the disease. Scientists use this knowledge to develop effective prevention and treatment approaches that reduce the toll drug abuse takes on individuals, families, and communities.

Despite these advances, many people today do not understand why 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 disease of drug addiction, including the many harmful consequences of drug abuse 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 abuse 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

MEDICAL

SOCIAL

ECONOMIC

CRIMINAL JUSTICE

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

INTRODUCTION

Why study drug abuse and addiction?

Abuse of and addiction to alcohol, nicotine, and illicit and 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 abuse and addiction.

- ***Babies*** exposed to drugs in the womb may be born premature and underweight. This exposure can slow the child's intellectual development and affect behavior later in life.[6]
- ***Adolescents*** who abuse drugs often act out, do poorly academically, and drop out of school. They are at risk for unplanned pregnancies, violence, and infectious diseases.
- ***Adults*** who abuse drugs often have problems thinking clearly, remembering, and paying attention. They often develop poor social behaviors as a result of their drug abuse, and their work performance and personal relationships suffer.
- ***Parents'*** drug abuse often means chaotic, stress-filled homes, as well as child abuse and neglect. Such conditions harm the well-being and development of children in the home and may set the stage for drug abuse in the next generation.

How does science provide solutions for drug abuse and addiction?

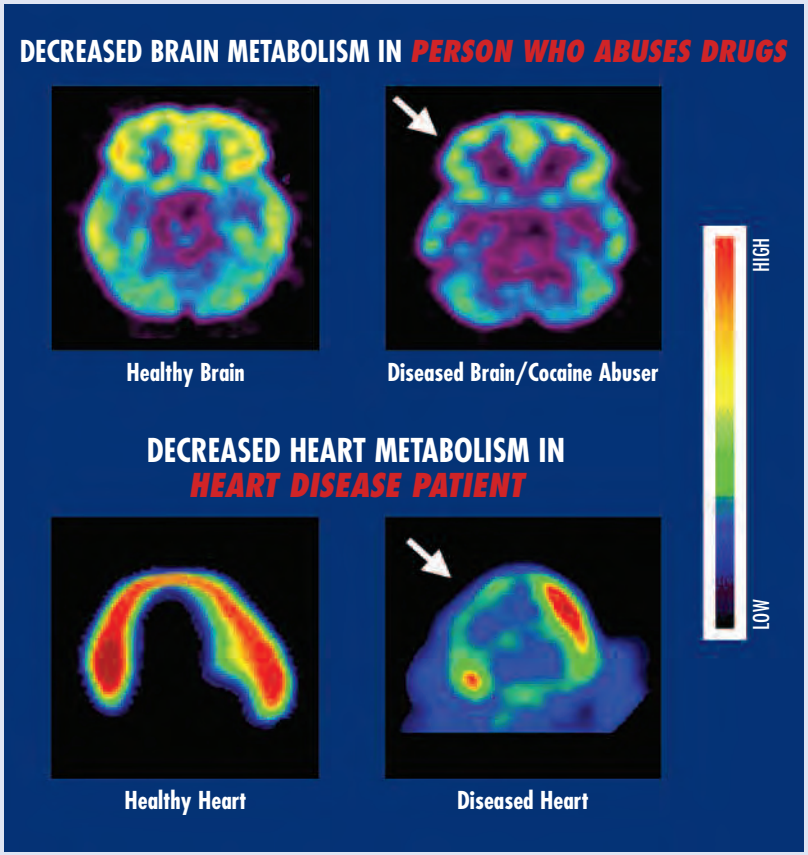
Scientists study the effects that drugs have on the brain and on people's behavior. They use this information to develop programs for preventing drug abuse and for helping people recover from addiction. Further research helps transfer these ideas into practice in our communities.

I. DRUG ABUSE AND ADDICTION

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.† 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.

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.



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

†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.

Courtesy: Vivian Felsen

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

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.[7] Scientists believe that these changes alter the way the brain works and may help explain the compulsive and destructive behaviors of addiction.

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

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*

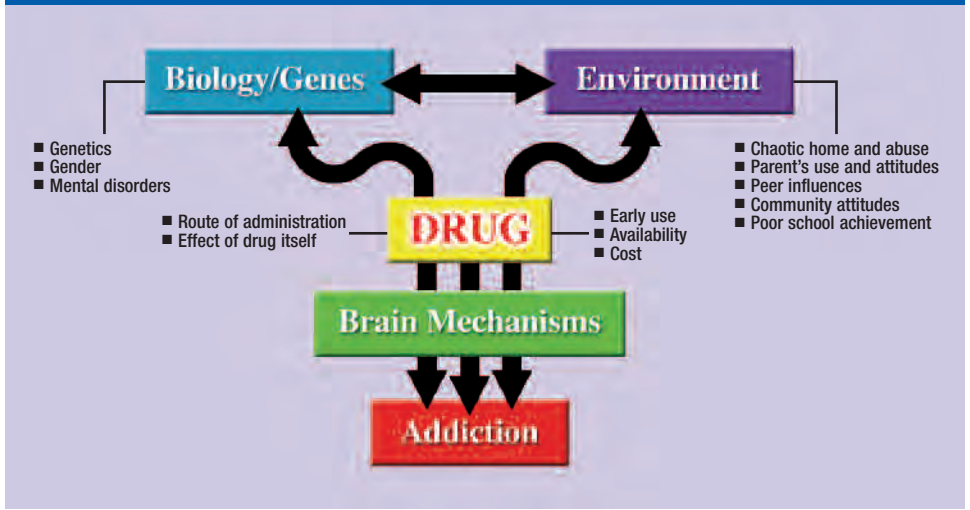
Children's earliest interactions within the family are crucial to their healthy development and risk for drug abuse.

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).

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.

RISK FACTORS



What biological factors increase the risk of addiction?

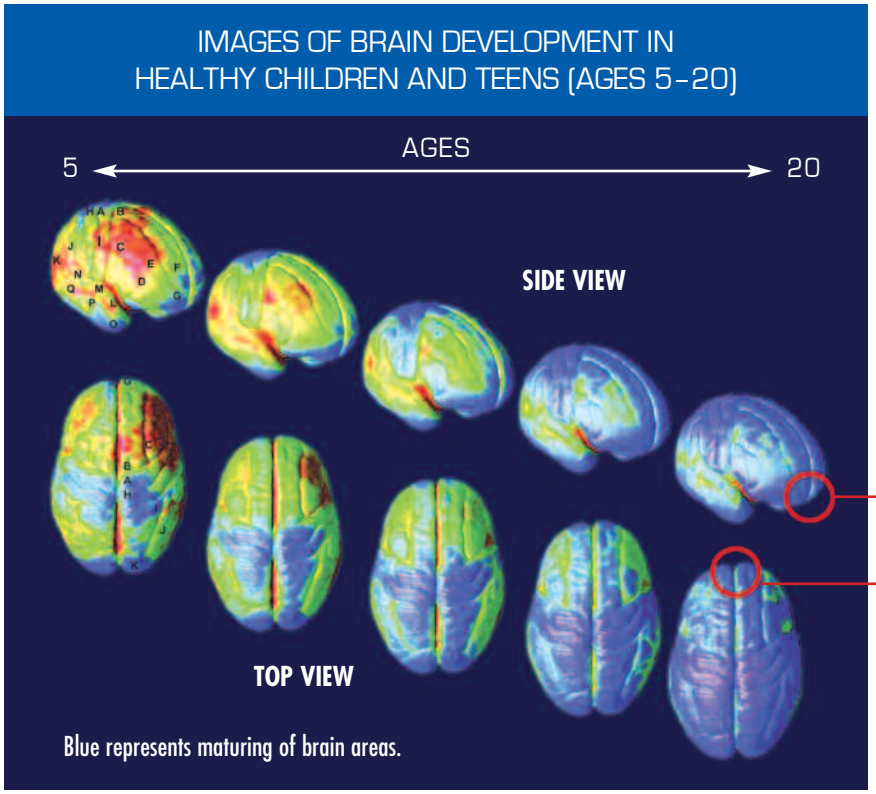
Scientists estimate that genetic factors account for between 40 and 60 percent of a person's vulnerability to addiction; this includes the effects of environmental factors on the function and expression of a person's genes. A person's stage of development and other medical conditions they may have are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

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.[8] This may reflect the harmful effect that drugs can have on the developing brain; it also may result from a mix of early social and biological vulnerability factors, including unstable family relationships, exposure to physical or sexual abuse, genetic susceptibility, or mental illness. Still, the fact remains that early use is a strong indicator of problems ahead, including addiction.

- ***Method of Administration.*** Smoking a drug or injecting it into a vein increases its addictive potential.[9,10] 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, taking the abuser down to lower, more normal levels. Scientists believe this starkly felt contrast drives some people to repeated drug taking in an attempt to recapture the fleeting pleasurable state.

Addiction is a developmental disease—it typically begins in childhood or adolescence.



Source: PNAS 101:8174–8179, 2004.

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 enables us to assess situations, make sound decisions, and keep our emotions and desires under control.[11] The fact that this critical part of an adolescent'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). Also, introducing drugs during this period of development may cause brain changes that have profound and long-lasting consequences.

II. PREVENTING DRUG ABUSE: THE BEST STRATEGY

Why is adolescence a critical time for preventing drug addiction?

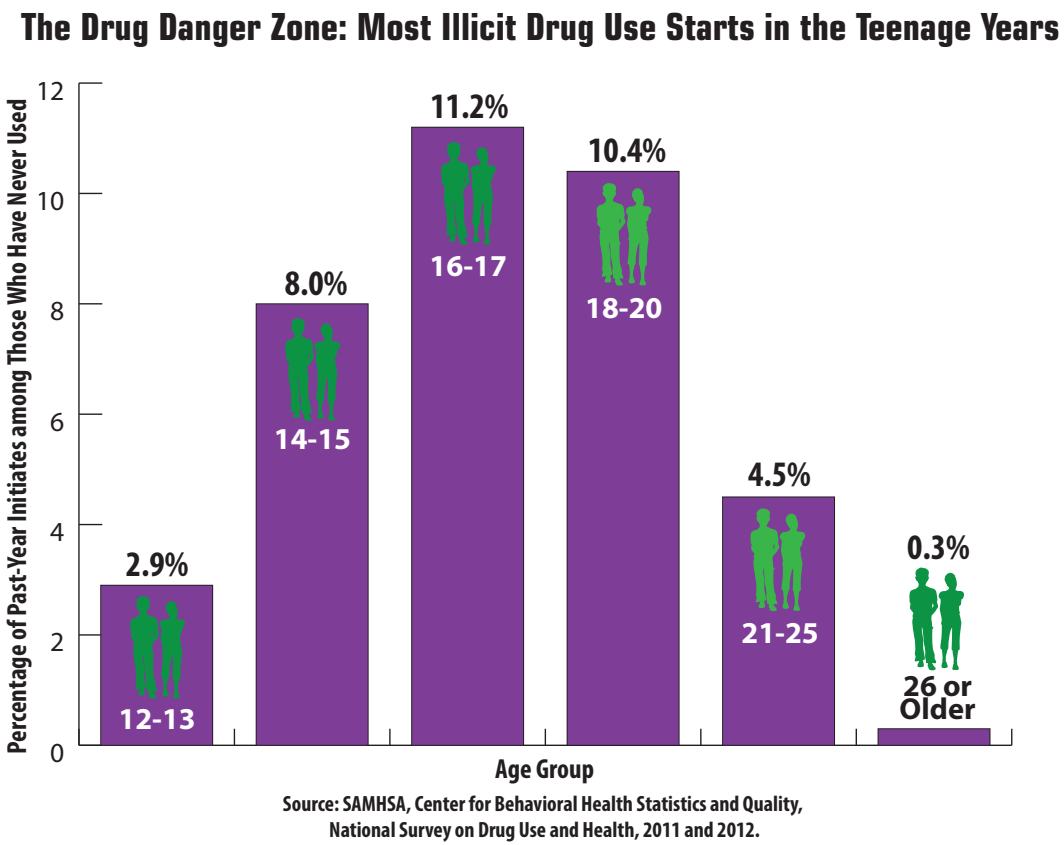
As noted previously, early use of drugs increases a person's chances of developing addiction. Remember, drugs change brains—and this can lead to addiction and other serious problems. So, preventing early use of drugs or alcohol may go a long way in reducing these risks. If we can prevent young people from experimenting with drugs, we can prevent drug addiction.

Risk of drug abuse increases greatly during times of transition. For an adult, a divorce or loss of a job may lead to drug abuse; for a teenager, risky times include moving or changing schools.[12] In early adolescence, when children advance from elementary through middle school, they face new and challenging social and academic situations. Often during this period, children are exposed to abusable 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.

At the same time, many behaviors that are a normal aspect of their development, such as the desire to try new things or take greater risks, may increase teen tendencies to experiment with drugs. Some teens may give in to the urging of drug-using friends to share the experience with them. Others may think that taking drugs (such as steroids) will improve their appearance or their athletic performance or that abusing substances such as alcohol or MDMA (ecstasy or "Molly") will ease their anxiety in social situations. A growing number of teens are abusing prescription ADHD stimulants such as Adderall® to help them study or lose weight. Teens' still-developing judgment and decision-making skills may limit their ability to accurately assess the risks of all of these forms of drug use.

Using abusable substances at this age can disrupt brain function in areas critical to motivation, memory, learning, judgment, and behavior control.[7] So, it is 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), and involvement with the juvenile justice system.

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



Can research-based programs prevent drug addiction in youth?

Yes. The term "research-based" means that these programs have been rationally designed based on current scientific evidence, rigorously 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 abuse in families, schools, and communities. Studies have shown that research-based programs, such as those described in NIDA's *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 illicit drugs.[13]

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 designed for individual or group settings, such as the school and home. There are three types of programs:

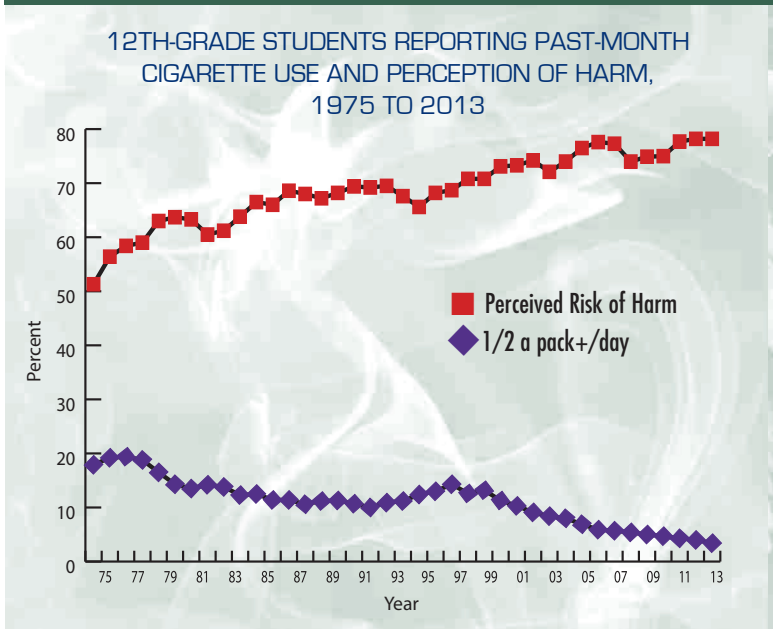
- ***Universal programs*** address risk and protective factors common to all children in a given setting, such as a school or community.
- ***Selective programs*** target groups of children and teens who have factors that put them at increased risk of drug use.
- ***Indicated programs*** are designed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

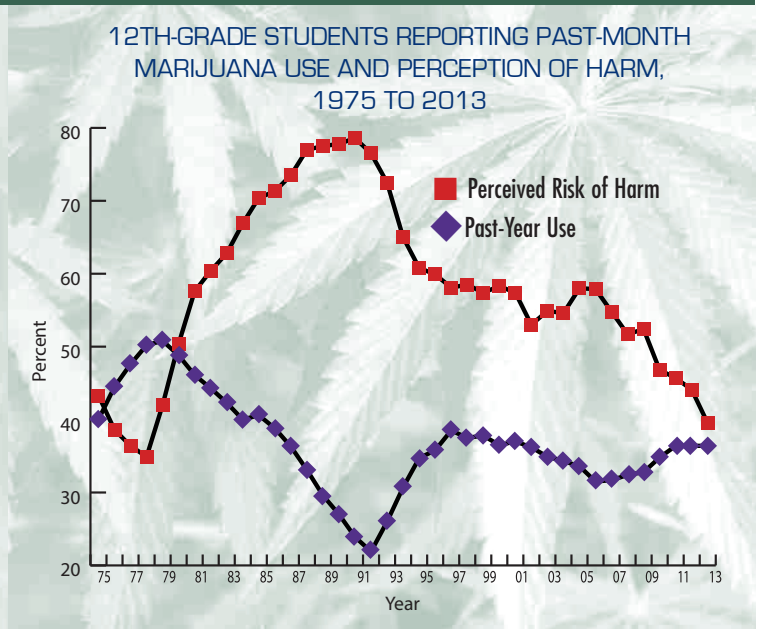
Are all prevention programs effective in reducing drug abuse?

When research-based substance use prevention programs are properly implemented by schools and communities, use of alcohol, tobacco, and illegal drugs is reduced. Such programs help teachers, parents, and health care professionals shape youths' perceptions about the risks of substance use. While many social and cultural factors affect drug use trends, when young people perceive drug use as harmful, they reduce their level of use.[14]

Prevention is the best strategy

DRUG USE DECREASES WHEN DRUGS ARE PERCEIVED AS HARMFUL, AND VICE VERSA





Cigarette smoking among teens is at its lowest point since NIDA began tracking it in 1975. But marijuana use has increased over the past several years as perception of its risks has declined.

Source: 2013 Monitoring the Future survey. University of Michigan, with funding from the National Institute on Drug Abuse.

For more information on prevention, see NIDA's most recent edition of *Preventing Drug Use among Children and Adolescents: A Research-Based Guide for Parents, Educators, and Community Leaders* at www.drugabuse.gov/Prevention/Prevopen.html.

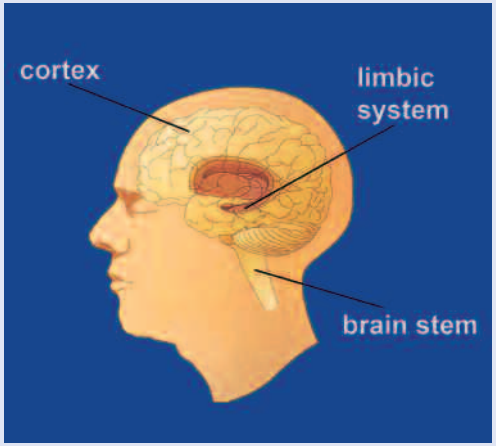
III. DRUGS AND THE BRAIN

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. 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?

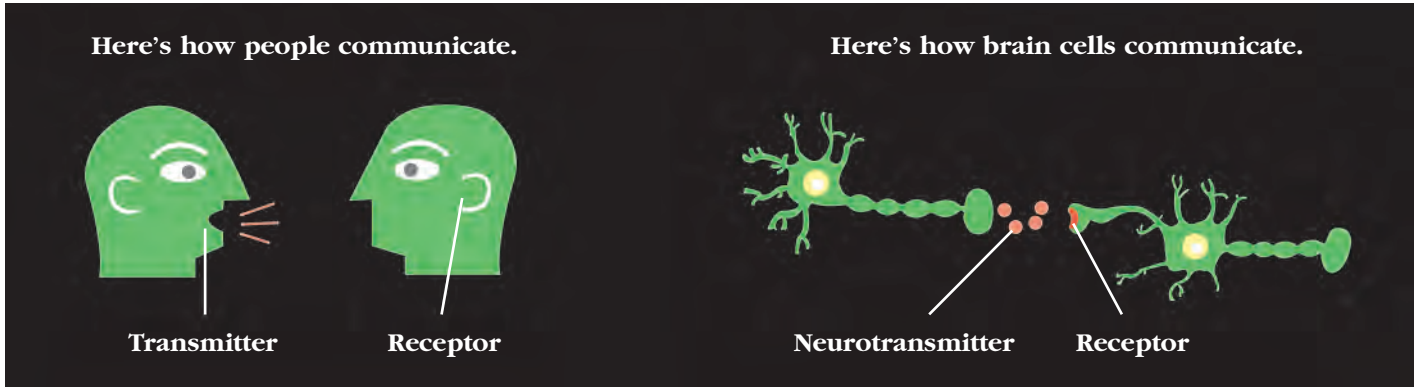
The brain is a communications center consisting of billions of neurons, or nerve cells. Networks of neurons pass messages back and forth among different structures within the brain, the spinal cord, and nerves in the rest of the body (the peripheral nervous system). These nerve networks coordinate and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



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.

Concept courtesy: B.K. Madras

Most drugs of abuse target the brain's reward system by flooding it with dopamine.

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. Overstimulating the system with drugs, however, produces euphoric effects, which strongly reinforce the behavior of drug use—teaching the user to repeat it.

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

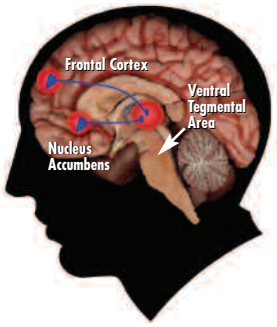
Our brains are wired to ensure that we will repeat life-sustaining activities by associating those activities with pleasure or reward. Whenever this reward circuit is activated, the brain notes that something important is happening that needs to be remembered, and teaches us to do it again and again 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.[15] 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.[16,17] 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.

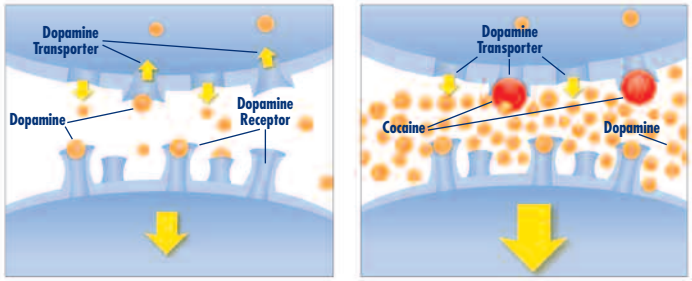
DRUGS OF ABUSE TARGET THE BRAIN'S PLEASURE CENTER

Brain reward (dopamine) pathways



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

Drugs of abuse increase dopamine



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 altered.

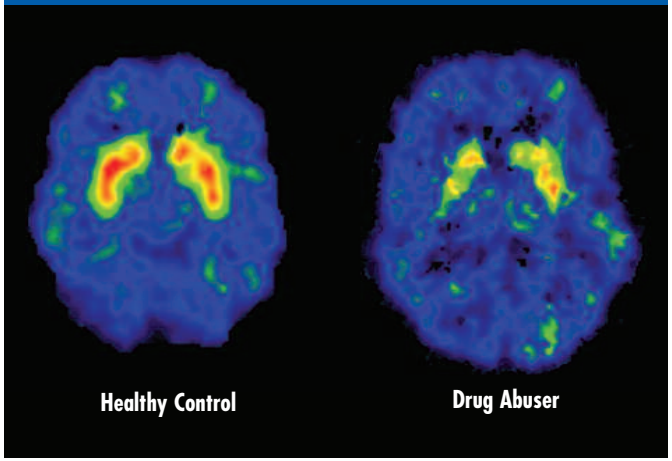
Long-term drug abuse impairs brain functioning.

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.

DECREASED DOPAMINE TRANSPORTERS IN A METHAMPHETAMINE ABUSER[18]



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 drug 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.

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

IV. ADDICTION AND HEALTH

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.[19] 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.

THE IMPACT OF ADDICTION CAN BE FAR-REACHING

- Cardiovascular disease
- Stroke
- Cancer
- HIV/AIDS
- Hepatitis B and C
- Lung disease
- Mental disorders

Does drug abuse cause mental disorders, or vice versa?

Drug abuse and mental illness often co-exist. In some cases, mental disorders such as anxiety, depression, or schizophrenia may precede addiction; in other cases, drug abuse may trigger or exacerbate those mental disorders, particularly in people with specific vulnerabilities.

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.[20]
- ***Increased spread of infectious diseases***
  Injection of drugs such as heroin, cocaine, and methamphetamine currently accounts for about 12 percent of new AIDS cases.[21] 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.

1 OUT OF 3 U.S. AIDS DEATHS ARE RELATED TO DRUG ABUSE[22]

Tobacco use is responsible for an estimated 5 million deaths worldwide each year.[23]

What are some effects of specific abused substances?

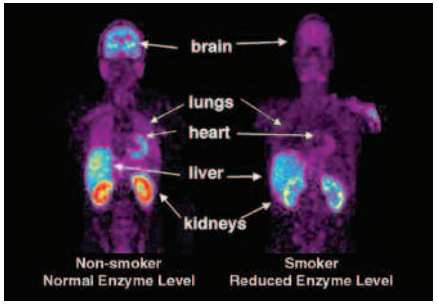
- ***Nicotine*** is an addictive stimulant found in cigarettes and other forms of tobacco. Tobacco smoke increases a user's risk of cancer, emphysema, bronchial disorders, and cardiovascular disease. The mortality rate associated with tobacco addiction is staggering. Tobacco use killed approximately 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.[24]

- ***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).

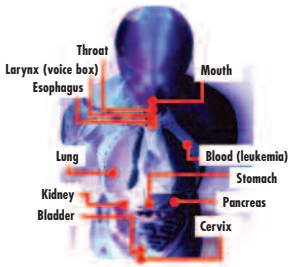
- ***Marijuana*** is the most commonly abused illegal substance. This drug impairs short-term memory and learning, the ability to focus attention, and coordination. It also increases heart rate, can harm the lungs, and can increase the risk of psychosis in those with an underlying vulnerability.

TOBACCO SMOKE AFFECTS THE WHOLE BODY

Monoamine Oxidase B[25]



Smoking causes cancer throughout the body.[26]



- ***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.

Nearly half of high school seniors report having used marijuana, and 6.5 percent are daily marijuana users.[14]

- ***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 (www.drugabuse.gov) to view the popular Research Reports (www.drugabuse.gov/ResearchReports/ResearchIndex.html), DrugFacts fact sheets and other publications.

V. TREATMENT AND RECOVERY

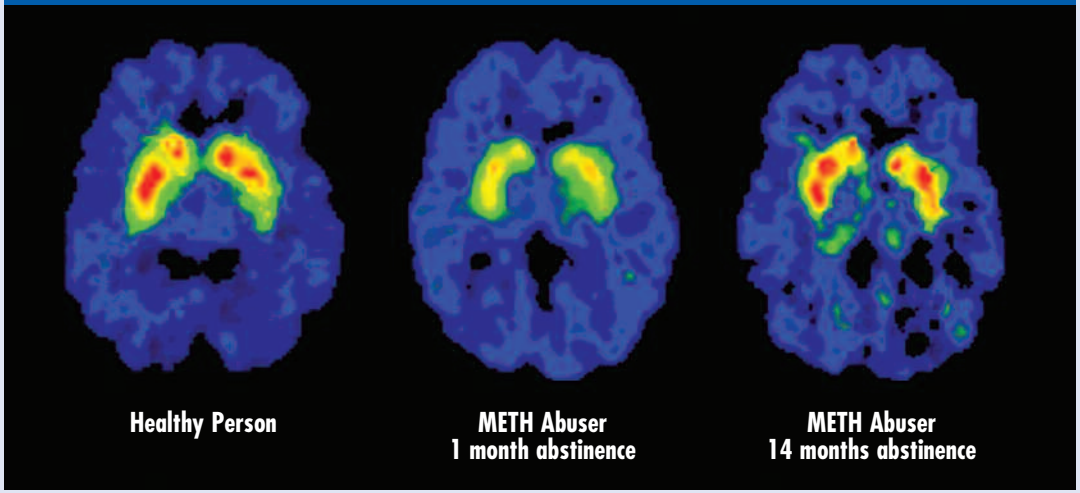
Can addiction be treated successfully?

YES. Addiction is a treatable disease. Research in the science of addiction and the treatment of substance use disorders has led to the development of evidence-based interventions that help people stop abusing drugs and resume productive lives.

Can addiction be cured?

Not always—but like other chronic diseases, addiction can be managed successfully. Treatment enables people to counteract addiction's powerful disruptive effects on their brain and behavior and regain control of their lives.

BRAIN RECOVERY WITH PROLONGED ABSTINENCE



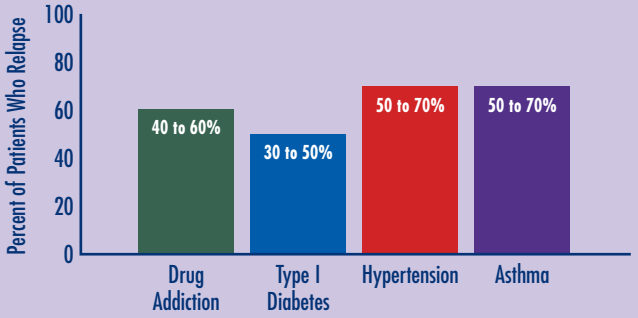
These images showing the density of dopamine transporters in a brain area called the striatum illustrate the brain's remarkable potential to recover, at least partially, after a long abstinence from drugs—in this case, methamphetamine.[27]

Addiction need not be a life sentence.

Does relapse to drug abuse mean treatment has failed?

No. The chronic nature of the disease means that relapsing to drug abuse at some point is not only possible, but likely. Relapse rates (i.e., how often symptoms recur) for people with addiction and other substance use disorders are similar to relapse rates for other well-understood chronic medical illnesses such as diabetes, hypertension, and asthma, which also have both physiological and behavioral components. Treatment of chronic diseases involves changing deeply imbedded behaviors, and relapse does not mean treatment has failed. For a person recovering from addiction, lapsing back to drug use indicates that treatment needs to be reinstated or adjusted or that another treatment should be tried.[28]

COMPARISON OF RELAPSE RATES BETWEEN DRUG ADDICTION AND OTHER CHRONIC ILLNESSES



Relapse rates for people treated for substance use disorders are compared with those for people with diabetes, hypertension, or asthma. Relapse is common and similar across these illnesses (as is adherence/non-adherence to medication). Thus, drug addiction should be treated like any other chronic illness; relapse serves as a trigger for renewed intervention.

Source: JAMA, 284:1689-1695, 2000

What are the principles of effective substance use disorder treatment?

Research shows that combining treatment medications (where available) with behavioral therapy is the best way to ensure success for most patients. Treatment approaches must be tailored to address each patient's drug use patterns and drug-related medical, psychiatric, and social problems.

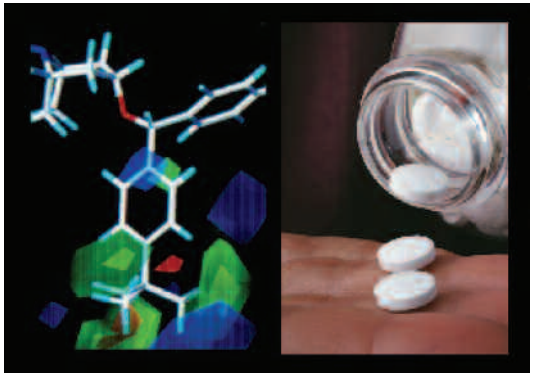
How can medications help treat drug addiction?

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

- ***Treating Withdrawal.*** When patients first stop using drugs, they can experience a variety of physical and emotional symptoms, including depression, anxiety, and other mood disorders, as well as

restlessness or sleeplessness. Certain treatment medications are designed to reduce these symptoms, which makes it easier to stop the drug use.

- ***Staying in Treatment.*** Some treatment medications are used to help the brain adapt gradually to the absence of the abused drug. These medications act slowly to stave off 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.



Discoveries in science lead to advances in drug abuse treatment.

- ***Preventing Relapse.*** Science has taught us that stress, cues linked to the drug experience (such as people, places, things, and moods), and exposure to drugs are the most common triggers for relapse. Medications are being developed to interfere with these triggers to help patients sustain recovery.

How do behavioral therapies treat drug addiction?

Behavioral treatments help engage people in substance use disorder treatment, modifying their attitudes and behaviors related to drug use and increasing their life skills to handle stressful circumstances and environmental cues that may trigger intense craving for drugs and prompt another cycle of compulsive use. Behavioral therapies can also enhance the effectiveness of medications and help people remain in treatment longer.

MEDICATIONS USED TO TREAT DRUG ADDICTION

- **Tobacco Addiction**
  - **Nicotine replacement therapies** (available as a patch, inhaler, or gum)
  - **Bupropion**
  - **Varenicline**
- **Opioid Addiction**
  - **Methadone**
  - **Buprenorphine**
  - **Naltrexone**
- **Alcohol and Drug Addiction**
  - **Naltrexone**
  - **Disulfiram**
  - **Acamprosate**

Treatment must address the whole person.

- ***Cognitive Behavioral Therapy*** seeks to help patients recognize, avoid, and cope with the situations in which they are most likely to abuse 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 evoke rapid and internally motivated behavior change to stop drug use and facilitate treatment entry.
- ***Family Therapy (especially for youth)*** approaches a person's drug problems in the context of family interactions and dynamics that may contribute to drug use and other risky behaviors.

How do the best treatment programs help patients recover from the pervasive effects of addiction?

Gaining the ability to stop abusing drugs is just one part of a long and complex recovery process. When people enter treatment for a substance use disorder, addiction has often taken over their lives. The compulsion to get drugs, take drugs, and experience the effects of drugs has dominated their every waking moment, and abusing drugs has taken the place of all the things they used to enjoy doing. It has disrupted how they function in their family lives, at work, and in the community, and has made them more likely to suffer from other serious illnesses. Because addiction can affect so many aspects of a person's life, treatment must address the needs of the whole person to be successful. This is why the best programs incorporate a variety of rehabilitative services into their comprehensive treatment regimens. Treatment counselors may select from a menu of services for meeting the specific medical, psychological, social, vocational, and legal needs of their patients to foster their recovery from addiction.

For more information on substance use disorder treatment, see *Principles of Drug Addiction Treatment: A Research-Based Guide* (www.drugabuse.gov/PODAT/PODATIndex.html) and *Principles of Adolescent Substance Use Disorder Treatment: A Research-Based Guide* (www.drugabuse.gov/publications/principles-adolescent-substance-use-disorder-treatment-research-based-guide).

VI. ADVANCING ADDICTION SCIENCE AND PRACTICAL SOLUTIONS

Leading the Search for Scientific Solutions

To address all aspects of drug abuse and its harmful consequences, NIDA's research program ranges from basic studies of the addicted brain and behavior to health services research. NIDA's research program develops prevention and treatment approaches and ensures they work in real-world settings. In this context, NIDA is strongly committed to developing a research portfolio that addresses the special vulnerabilities and health disparities that exist among ethnic minorities or that derive from gender differences.

Bringing Science to Real-World Settings

- ***Clinical Trials Network (CTN)***
  CTN "road tests" research-based drug abuse 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 abuse 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 evidence-based substance abuse and HIV prevention and treatment services for justice-involved youth.

Sharing Free Information With the Public

NIDA further increases the impact of its research on the problems of addiction by sharing free information about its findings with professional audiences and the general public. Special initiatives target students and teachers as well as designated populations and ethnic groups.

NIDA's Special Initiatives for Students, Teachers, and Parents

Heads Up: Real News About Drugs and Your Body—A drug education series created by NIDA and SCHOLASTIC INC. for students in grades 6 to 12.
headsup.scholastic.com

NIDA for Teens: The Science Behind Drug Abuse—An interactive Web site geared specifically to teens, with age-appropriate facts on drugs.
www.teens.drugabuse.gov

Drug Facts Chat Day—A Web chat between NIDA scientists and teens, held through school computer labs once a year during National Drug Facts Week (below).
www.drugabuse.gov/chat

National Drug Facts Week—A week-long observance that encourages community-based events and dialogue between teens and scientists during National Drug Facts Week (below).
www.drugfactsweek.drugabuse.gov/

Special Initiative for Clinicians

NIDAMED

NIDAMED—Tools and resources to increase awareness of the impact of substance use on patients' overall health and help clinicians and those in training identify patient drug use early and prevent it from escalating to abuse or addiction.

Publications on Prevention and Treatment Principles

Preventing Drug Use among Children and Adolescents: A Research-Based Guide for Parents, Educators, and Community Leaders—NIDA's research-based guide for preventing drug abuse among children and adolescents provides 16 principles derived from effective drug-prevention research and includes answers to questions on risk and protective factors as well as on community planning and implementation.

Principles of Drug Addiction Treatment: A Research-Based Guide—This guide summarizes the 13 principles of effective treatment, answers common questions, and describes types of treatment, providing examples of scientifically based and tested treatment components.

Principles of Adolescent Substance Use Disorder Treatment: A Research-Based Guide—This guide discusses the urgency of treating addictions and other substance use disorders in teenagers, answers common questions about how young people are treated for drug problems, and describes effective treatment approaches supported by scientific evidence.

Principles of Drug Abuse Treatment for Criminal Justice Populations: A Research-Based Guide—NIDA's research-based guide for treating people with addiction who are involved with the criminal justice system provides 13 essential treatment principles, and includes answers to frequently asked questions and resource information.

For more information:
All NIDA publications are available at www.drugabuse.gov. Some publications are also available in print, free of charge. To order print copies call the DRUGPubs Research Dissemination Center at 1–877–NIH–NIDA or go to drugpubs.drugabuse.gov. Watch NIDA videos (NIDA TV) at: www.drugabuse.gov/nida-tv.

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