How Addiction Affects the Brain:

The Neuroscience of Compulsive Behavior

SILVER RIDGE

A PREMIER PROGRAM BY PYRAMID HEALTHCARE

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Introduction

When scientists first began studying addiction in the 1930s, it was widely accepted that people who were addicted to drugs or alcohol were morally flawed and simply lacked willpower. This led to a widespread view in society that addiction was a moral failing, rather than the brain disease it's known to be today.

Incredible discoveries through scientific research have led to a much better understanding of addiction. As it turns out, addiction is the result of real and tangible changes in brain function that affect thought and behavior, and it's regarded by the medical community as a disease that can be systematically diagnosed and successfully treated.

Unfortunately, few people among the general population understand why and how addiction develops and how treatment works to end an addiction for the long-term. The stigma of addiction as a moral failing persists in many circles, making things more difficult for people who are addicted to drugs or alcohol.

In this eBook, we aim to help you understand the complex ways in which drug and alcohol abuse affect brain function and how these changes may lead to a compulsion to use drugs. Once you understand how addiction's compulsive behaviors develop, it's easier to see how treatment can help an individual successfully end even the most severe, long-term drug or alcohol addiction.

Neuroscience 101:

Neurons and Neurotransmitters

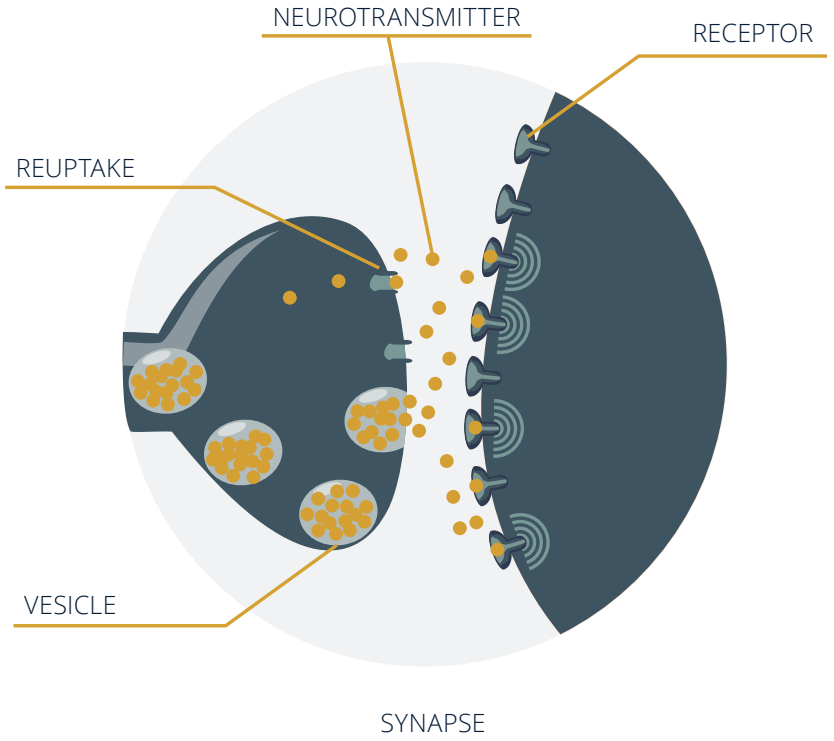
Your brain is a highly complex network of about one hundred billion neurons. Neurons are nerve cells that transmit information throughout the body by sending chemical and electrical messages back and forth thousands of times a minute, controlling everything we think, feel and do.

At the receiving end of a neuron, branched structures known as dendrites receive an electrical signal that is transported into the cell body, where it's processed. From the cell body, the signal travels into a long, slim nerve fiber known as the axon. The neuron terminates at the end of the axon.

Between neurons is a gap known as a synapse. When one neuron needs to relay an electrical message to an adjoining neuron, it manufactures chemical messengers known as neurotransmitters. The neuron stores these chemicals in little packets called vesicles. The electrical signal causes the vesicles to open up and release the neurotransmitters into the synapse.

The neurotransmitters travel across the synapse and, like a key in a lock, link up to specialized receptors on the receiving neuron. Once the message has been received by the receiving neuron, the neurotransmitter molecules disconnect from the receptors and move back into the synapse, where they re-enter the sending neuron through a special structure called a transporter. Once back in the sending neuron, the neurotransmitters become available again to send future messages. The process of neurotransmitters moving back into the sending neuron is known as "reuptake."

Scientists have identified dozens of neurotransmitters, and each individual neuron manufactures one or more of them. Each type of neurotransmitter produces particular effects, depending on what area of the brain it acts on.

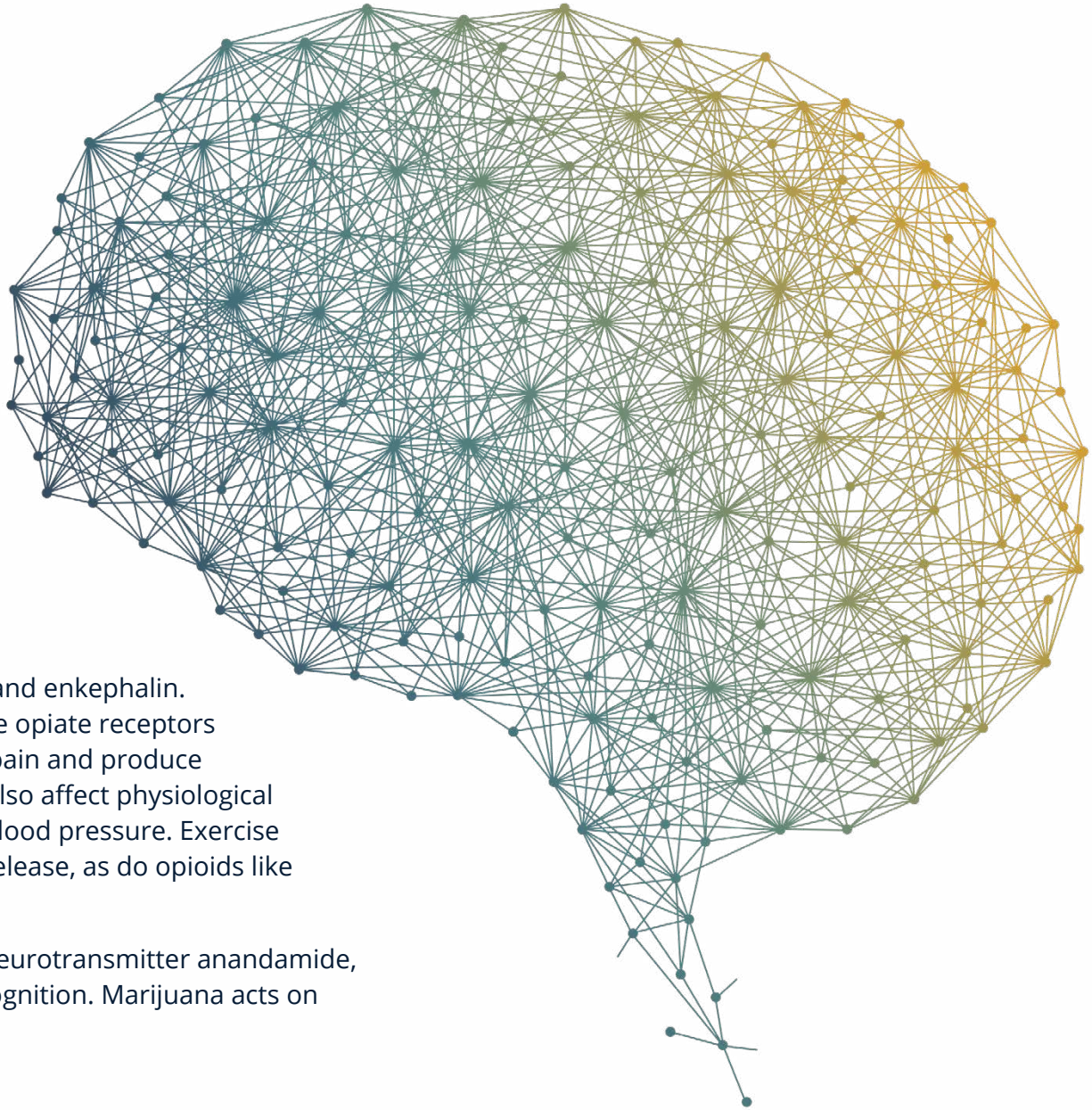


Neurotransmitters Affected by Drugs

A number of neurotransmitters are affected by drug use. Different drugs affect different neurotransmitters in different ways. They may increase the activity of some chemicals while inhibiting the activity of others. It's the way a drug interacts with neurotransmitters that creates its effects on mind and body. Drugs affect the function of a number of neurotransmitters.

- **Dopamine** is a feel-good brain chemical that produces a keen sense of pleasure. It's also involved in learning and memory. Dopamine is highly concentrated in the areas of the brain that affect motivation and feelings of pleasure and reward, and it plays an important role in the motivation to use drugs. One thing all psychoactive drugs have in common is that they cause a massive dopamine release in the pleasure center of the brain.
- **GABA**, or gamma-aminobutyric acid, is an inhibitive neurotransmitter, which means that it slows down neuronal activity to produce a sedative effect that reduces anxiety and promotes calmness. Drugs that enhance GABA activity include alcohol and benzodiazepines like Klonopin or Xanax.
- **Glutamate** is a stimulatory neurotransmitter, which means that it increases neuronal activity to produce feelings of alertness and excitability. Glutamate plays an important role in cognitive function, memory and learning. Its activity is enhanced by stimulant drugs like cocaine and Adderall, while depressants like alcohol decrease glutamate activity.

- **Serotonin** is a neurotransmitter involved in physiological processes like sensory and motor function, hormone secretion, memory and mood. Meth and the club drug MDMA elevate levels of serotonin, but repeated, prolonged use causes a decrease in reuptake, which ultimately results in lower-than-normal serotonin levels. This can cause depression, anxiety, memory problems and paranoia, according to the National Institute on Drug Abuse.[1]
- **Acetylcholine** is the most plentiful neurotransmitter in the body and is essential for memory, learning, arousal and concentration. It can either speed up or slow down nerve signals, and it's an important part of the brain's reward system.
- **Norepinephrine** is a neurotransmitter involved in functions like sensory processing, movement, memory and mood. Stimulant drugs like Adderall and cocaine raise levels of norepinephrine to increase alertness and improve mood.



- **Endogenous opioids** include endorphin and enkephalin. These neurotransmitters interact with the opiate receptors in the brain to reduce the perception of pain and produce sedation and a sense of euphoria. They also affect physiological functions like breathing, heart rate and blood pressure. Exercise and sex produce a powerful endorphin release, as do opioids like heroin and prescription painkillers.
- **Endogenous cannabinoids** include the neurotransmitter anandamide, which affects movement, memory and cognition. Marijuana acts on these neurotransmitters.

Some drugs affect just one neurotransmitter, while others can stimulate or inhibit more than one. To make matters more complicated, the disruption of one neurotransmitter can impact the activity of a number of others.

Brain Regions Involved in Addiction:

The Reward System

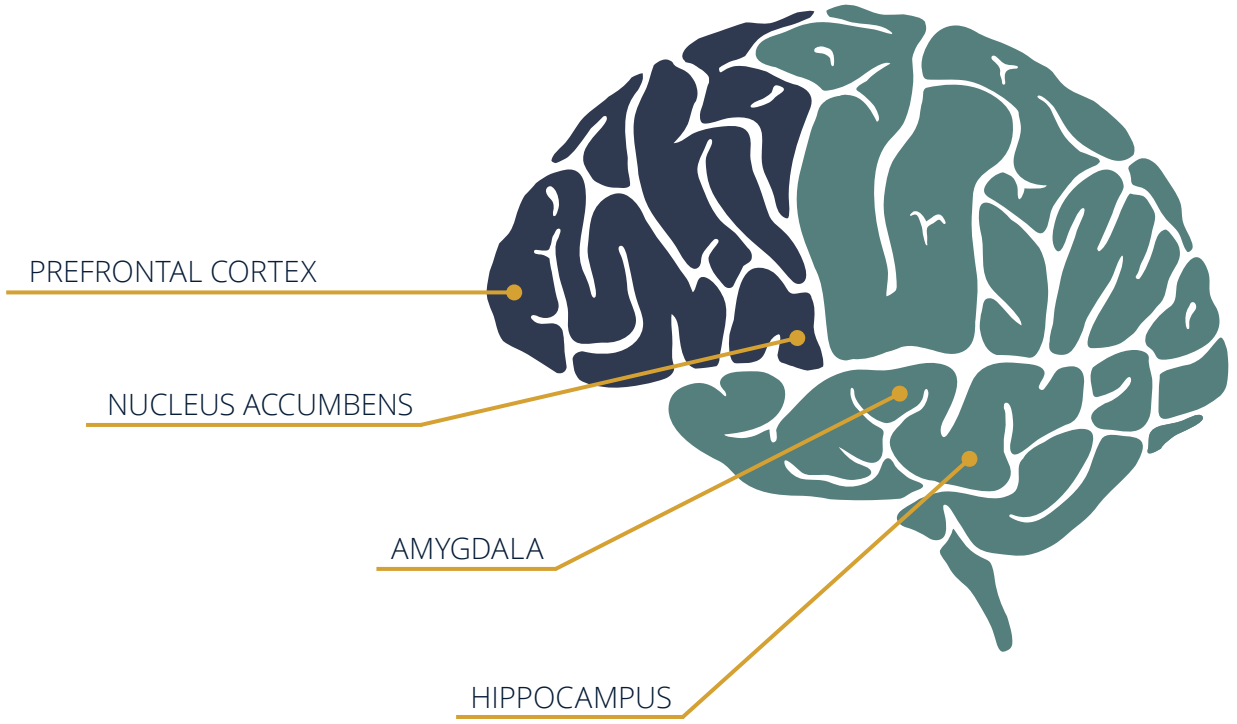
The reward system is a series of brain structures and neural pathways that are responsible for motivation, desire and cravings. It governs the positive emotions that come with pleasure, and it's where classical conditioning takes place—think Pavlov's dog, who salivated every time a bell rang because he associated the bell with food.

Neurotransmitters have a variety of functions and act differently in different brain structures within the reward system, including:

- **The nucleus accumbens.** The nucleus accumbens, a cluster of nerve cells located beneath the cerebral cortex, is known as the brain's pleasure center. When you engage in enjoyable activities, dopamine floods the nucleus accumbens, producing feelings of pleasure.
- **The hippocampus.** The hippocampus is the memory center of the brain and plays an important role in the forming of memories associated with drug-seeking behavior. It also coordinates emotion-based responses to internal and external events.
- **The amygdala.** The amygdala creates a conditioned response to certain stimuli. The conditioned response includes cravings when these stimuli—a person, place, thing or emotion—are present. Drug-induced changes in the amygdala contribute to anxiety and other negative symptoms when the drug is withheld, and these negative symptoms contribute to the drive to keep using the drug.

- **The prefrontal cortex.** The prefrontal cortex of the brain is involved in planning and executing tasks. It's also associated with awareness and self-control. Dysfunction in the prefrontal cortex leads to decreased sensitivity to normal, non-drug pleasures and a decrease in the ability to stop engaging in dysfunctional behaviors.

When you engage in heavy substance abuse, the various brain regions involved in the reward system communicate with one another in a way that can lead to addiction, characterized by compulsive drug-seeking behaviors.



The Addicted Brain

The brain's reward circuit has an important, powerful role in sustaining life. It associates the life-giving activities—such as eating food and having sex to procreate—with pleasure and reward. Pleasure and reward are powerful motivators designed to ensure we continue seeking out these activities.

The brain registers all pleasure in the same way, according to Harvard Medical School.[2] A delicious meal, a big, unexpected check in the mail or a sexual encounter all produce a dopamine release in the nucleus accumbens, resulting in pleasurable feelings. When these normal pleasures occur, the brain maintains the amount of the neurotransmitters involved within certain limits.

But drugs provide a shortcut to feelings of pleasure by flooding the nucleus accumbens with two to 10 times more dopamine than is natural, resulting in pleasure that's far greater than the pleasure we naturally feel. The dopamine interacts with the neurotransmitter glutamate, and together, they take over the brain's system of reward-related learning.

The Process of Developing an Addiction

When you take drugs, the hippocampus records a memory of the intense pleasure they produce, and the amygdala creates a conditioned response to environmental cues that are present at the time of use. These environmental stimuli, which can be people, places, situations or emotions, become powerful triggers for intense cravings once the addiction develops.

Repeated substance abuse leads to communication between the neurons in the nucleus accumbens (pleasure center) and the prefrontal cortex (planning and execution). This communication results in an ironclad association between liking the effects of the drug and wanting the drug. It makes us want those effects, and it motivates us to seek out the source of the pleasure again and again.

With heavy, prolonged substance abuse, the brain adapts by producing less dopamine or reducing dopamine receptors and adjusting the activity of other neurotransmitters. These adjustments make the effect of the drug itself less pleasurable over time, but the memory of the desired effects—and the powerful need to recreate it—persist.

The result is a conditioned response, which comes in the form of intense cravings when you encounter a learned environmental cue. For example, if you use drugs to relax when you're feeling stressed or you use with a particular person, both stress and being around that particular person will trigger intense cravings for the drug. These cravings, and the resulting repeated drug use, ultimately lead to compulsion, or the need to take the drug no matter what.

Characteristics of Addiction and Its Effects on Thought and Behavior

Addiction is characterized by compulsive drug use despite the negative consequences of using. Addiction takes over normal brain processes, changing the physical structures and chemical functions of the brain.

These brain changes in turn cause changes in your thought and behavior patterns so that even though your life may be falling apart around you, you'll continue to seek out and use the drug. Your brain's natural reward circuitry has been hijacked by drugs, and the cravings for the drug become more and more powerful—and more important than the actual pleasure you get from using the drug.[3]

By the time you realize that the thrill of using drugs is gone, long-lasting changes have already occurred in key regions of the brain, which is now hardwired to habitually crave the drug. When you're exposed to anything that the brain associates with using, you'll feel miserable if you don't get it. But you'll expend a great deal of energy doing everything in your power to obtain it—including things you wouldn't have done before the addiction.

Factors in the Development of Addiction

The number of people who develop long-term addictions as a result of drug use is actually somewhat small. Whether or not an addiction develops depends on a number of factors, including environmental, psychological and biological circumstances. Also at work are the speed with which a drug produces a dopamine release, the intensity of the release, and how reliable the drug is at producing the release.

The mechanism of taking the drug is another influence on whether an addiction develops. Smoking or injecting a drug produces a faster, stronger dopamine release than swallowing it as a pill, and this can speed up the process of developing an addiction.

The brain changes that lead to addiction are so powerful that even years after you stop using, environmental cues, or triggers, can produce intense cravings for the drug.

ENVIRONMENTAL

PSYCHOLOGICAL

BIOLOGICAL

The Dependent Brain

Addiction and dependence aren't the same thing. Dependence is a physical reliance on drugs or alcohol, characterized by withdrawal symptoms that set in when you stop using.

As you continue to use drugs, your brain adapts by changing the activity of neurotransmitters to compensate for their presence. For example, alcohol initially stimulates the activity of GABA (relaxation) and reduces the activity of glutamate (excitement). But repeated, heavy alcohol use causes the brain to reduce the activity of GABA and increase the activity of glutamate in order to compensate for the effects of the alcohol. The result is tolerance, which occurs when you need increasingly larger doses of the drug to get the desired effects.

But as you use larger and larger doses, your brain continues to adapt. At some point, your brain may begin to need the drug in order to operate "normally." Then, when you stop using, normal neurotransmitter function rebounds. These swift shifts in chemical function produce physical and mental withdrawal symptoms, which can range in intensity from mild to severe. In some cases, such as with alcohol and benzodiazepines, withdrawal can be dangerous or fatal.

Treating Dependence:

The First Step in Addiction Recovery

Ending an addiction first requires quitting using drugs or alcohol. But if dependence has developed, quitting will produce withdrawal symptoms, including intense cravings, that can make it extremely difficult to maintain abstinence. Most people who try to withdraw on their own will go back to using very quickly, if only to make the discomfort stop.

Medical detox is the first order of business in treating an addiction. Medical detox is supervised by medical and mental health professionals who administer medications as needed to reduce the severity of symptoms, help prevent dangerous symptoms from setting in and help to normalize brain function.

Medical detox by itself is not addiction treatment and does very little to address the complexities of the addiction. Most people who don't follow detox with treatment will relapse, most of them very quickly. Conversely, most people who engage in addiction treatment successfully recover for the long-term.

Treating Addiction:

A Holistic Approach Is Essential

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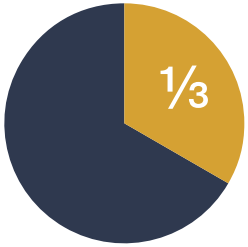
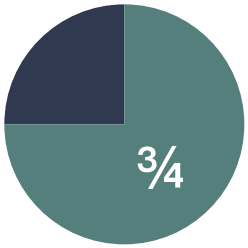


OF THE GENERAL POPULATION

AND NEARLY



OF YOUNG ADULTS

BELIEVE THAT ENDING AN ADDICTION IS LARGELY A MATTER OF EXERCISING WILLPOWER

According to a 2008 survey by the Substance Abuse and Mental Health Services Administration, more than a third of the general population and nearly three-quarters of young adults believe that ending an addiction is largely a matter of exercising willpower.[4] But an enormous body of research shows that this simply isn't true. The National Institute on Drug Abuse stresses that willpower and good intentions are rarely enough to end and addiction for the long-term.[5] Professional help is almost always needed.

It takes time for brain function to become hijacked by drugs and for you to develop the dysfunctional thought and behavior patterns that result. By the same token, it takes time to re-learn healthy ways of thinking and behaving and develop new lifestyle habits that support long-term recovery.

High-quality treatment programs are central to this process, and staying in treatment for an adequate amount of time is essential for success. Treatment lasting less than 90 days is of limited effectiveness.[6]

Addiction is widely understood to be a complex and chronic brain disease, and as such, it almost always has complex, underlying causes that must also be addressed in order to successfully recover. The same goes for other chronic diseases like diabetes and heart disease. Common underlying issues behind addiction include chronic stress, a history of trauma and underlying mental illnesses like anxiety and depression. In these cases, drug and alcohol abuse is typically used as a way to cope, but they almost always make things much worse.

Treating addiction requires a multi-faceted approach, utilizing a variety of both traditional and complementary therapies that help individuals to:

- Address the complex underlying issues that led to the substance abuse and addiction
- Identify and treat any co-occurring mental illnesses
- Identify dysfunctional thought and behavior patterns and re-learn healthy ways of thinking and behaving
- Develop essential skills for coping with stress, cravings and other triggers for relapse
- Find their own intrinsic motivation for wanting to recover
- Identify purpose and meaning in a life without drugs or alcohol
- Identify an ideal future and set goals to achieve it
- Develop healthy lifestyle habits that support a life in recovery
- Learn how to relax and have fun without needing drugs or alcohol to do it
- Repair damaged relationships and improve the functioning of the family system

Therapies Used in Addiction Treatment

Cognitive-behavioral therapy is the most successful and widely used therapy for treating addiction. It helps individuals develop essential coping skills and strategies for dealing with stress, cravings and other triggers. CBT helps people identify situations that can lead to relapse and learn to either cope with or avoid them.

CBT also improves self-awareness and self-confidence and helps people change long-held habits. According to the National Institute on Drug Abuse, the skills and strategies people learn through CBT help them stay in recovery once treatment is complete.[7]

CBT is just one of many treatment therapies used in a high-quality, holistic treatment program.

Pharmacotherapy, or the use of medications, is another important aspect of treatment for many addicted individuals. One study of medications that act on the GABA system found that a number of drugs, including gabapentin and clomethiazole, are safe and effective for helping individuals maintain alcohol abstinence.[8] Medications like methadone and buprenorphine can help normalize brain function, reduce cravings and promote long-term abstinence for those addicted to opioids like heroin and prescription painkillers.

Complementary therapies like art therapy, restorative yoga and nature therapy also play an important role in treatment and recovery. Complementary therapies help individuals express complex emotions, synthesize difficult experiences and look at a variety of issues from different angles.

No single treatment therapy is right for every addicted individual.[9] A personalized treatment plan that includes a variety of therapies hand-picked to address a complex collection of unique issues is crucial for successful recovery.

Successful treatment must address an individual's multiple needs. A high-quality treatment program will provide resources for a wide range of needs, such as educational and vocational assistance, legal help or medical and mental health services.

ART THERAPY

RESTORATIVE YOGA

NATURE THERAPY


Addiction Treatment
Works

Addiction treatment has helped countless people put an end to their drug and alcohol abuse while improving their lives on many fronts. If you're addicted and find you can't stop on your own, treatment can help you, too. For the best possible outcomes of treatment, choose a holistic treatment program that offers individualized treatment plans and utilizes a variety of research-based therapies. Research shows that the majority of people who engage fully with their treatment plan enjoy successful recovery and a higher quality of life for the long haul.

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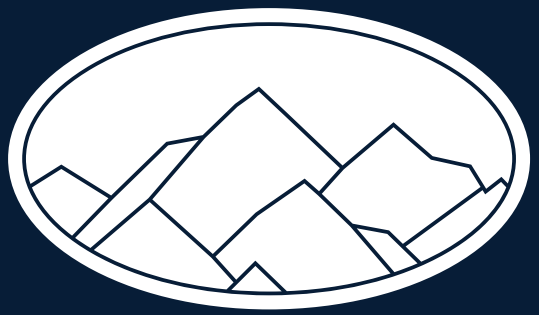

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