

# How Addiction Hijacks Our Reward System

by Wilkie A. Wilson and Cynthia M. Kuhn

From CEREBRUM: THE DANA FORUM ON BRAIN SCIENCE

Volume 7, Number 2, Spring 2005, Pages 53-66

The Dana Foundation, New York

CEREBRUM: THE DANA FORUM ON BRAIN SCIENCE (ISSN 1524-6205)

is published quarterly by The Dana Press. ©2005 The Dana Press

www.dana.org

---

## AUTHORS' BIOS:

Wilkie A. Wilson, Ph.D., is professor of pharmacology and cancer biology at Duke University Medical Center and a senior research scientist for the department of Veteran Affairs. He co-authored the recently revised and updated second edition of *Buzzed: The Straight Facts about the Most Used and Abused Drugs from Alcohol to Ecstasy* (W.W. Norton, 2003). He studies how drugs alter the way the brain acquires and stores information.

Cynthia M. Kuhn, Ph.D., is professor of pharmacology at Duke University Medical Center and head of its Pharmacological Sciences Training Program. She co-authored the recently revised and updated second edition of *Buzzed: The Straight Facts about the Most Used and Abused Drugs from Alcohol to Ecstasy* (W.W. Norton, 2003). Her chief research interest is in biologic factors that affect sensitivity to drugs of abuse in developing brains.

---

# How Addiction Hijacks Our Reward System

by Wilkie A. Wilson and Cynthia M. Kuhn

*People have been using addictive substances for centuries, but only very recently, by using the powerful tools of brain imaging, genetics, and genomics, have scientists begun to understand in detail how the brain becomes addicted. Neuropharmacologists Wilkie A. Wilson, Ph.D., and Cynthia M. Kuhn, Ph.D., explain, for example, that you cannot conclude you are addicted to something because you experience withdrawal symptoms. And calling our love of chocolate or football an "addiction" not only trivializes the devastation wrought by addiction, but misses the point that addiction involves a hijacking of the brain's circuitry, a reprogramming of the reward system, and lasting, sometimes permanent, brain changes. Any effective treatment must address both addiction's reorganization of the brain and the power of the addict's memories.*

The history of addiction stretches over thousands of years and reveals a persistent pattern: A chemical, often one with medicinal benefits, is discovered and found to be appealing for recreational use. Repeated use, however, leads to compulsive use and destructive consequences. Society then seeks to control use of the chemical. Many well known, problematic drugs have followed this pattern because they are derived from readily available and common plant products. Nicotine, cocaine, and many narcotics come from plants, and alcohol is produced by fermentation of many grains and fruits. These are products humans have known and used for millennia.

Things began to change in the 19th century. Until then, methods of delivering the active ingredients to the brain were relatively unsophisticated: swallowing and smoking. Swallowing drugs often produces only a slow rise in brain concentrations because plants must be digested and absorbed and the active ingredients must escape destruction in the liver. When people realized that smoking plant products worked better, that became a favored method of delivery. Then we invented even more effective ways of getting drugs to the brain, especially the hypodermic syringe and needle. Now, modern chemistry has enabled us to synthesize potent, highly addictive chemicals, such as amphetamines, that were never available naturally.

The ability to find new ways to become addicted has raced ahead of public understanding of the addiction process. For example, people often confuse a strong habit with an addiction, asserting that we can be addicted to chocolate, movies, or sports. Most people who are not addiction scientists or treatment professionals fail to understand what happens in the brain as addiction takes hold and how those brain changes may affect us. Yet one need not be an expert to understand how people become addicted, and the benefits of understanding are considerable—not least because to understand addiction is to understand the biological systems that govern our search for pleasure.

#### FROM MEDICINE TO DISEASE TO JAIL

First, though, it is worth looking more closely at how addictive substances and their use have made their way into virtually every culture, from the simplest agrarian society to the most advanced technological one, and have provoked rules and sanctions when their power and appeal seemed threatening.

Fermenting alcohol probably began with agriculture itself, and, by Biblical times, there were prohibitions against misuse of alcohol. During the Middle Ages, the discovery of distillation yielded drinks that were as much as 50 percent alcohol (today's beer and wine range up to 15 percent alcohol). The enhanced potency, combined with wide availability and decreased social disapproval, caused use of alcohol to spread throughout Europe during the 17th century. The famous painting "Gin Lane" is emblematic of the rise of alcohol use and addiction in England during that time. Today's worries about binge drinking by college students are but the most recent iteration of an age-old concern.

Tobacco use followed a similar pattern. The leaves of the tobacco plant contain nicotine, which is both psychoactive and addictive. The plant is native to the Americas and its characteristics were probably known before the arrival of Europeans, although there are no written records by which to verify this. Tobacco first arrived in Europe in the early 16th century with returning Portuguese and Spanish explorers and soon was viewed as a miracle cure for everything from headaches to dysentery—so much so that it helped

drive further Portuguese and Spanish colonization in the Americas. As tobacco use spread rapidly, health concerns and public outcry followed. By 1573, the Catholic Church had forbidden smoking in churches. But modern chemical techniques and the Industrial Revolution led to mass production of a perfect nicotine delivery device, the cigarette. The cigarette delivers a single, small dose of inhaled nicotine that enters the brain almost immediately. In the United States, manufactured cigarettes first appeared during the 1860s, and, by 1884, James B. Duke was producing almost a billion cigarettes a year. Protests, such as those by the Women's Christian Temperance Union, soon followed, with complaints about addiction and other health concerns. The active prosecution of tobacco companies and increased legislation prohibiting smoking during the past decade are but the latest chapter in the history of tobacco use, addiction, and regulation.

We see the pattern again with cocaine and narcotics. Ancient records indicate that cocaine, from the coca plant, was used by natives in South America to enhance physical endurance. Extracts of the opium poppy were used in South East Asia to relieve pain. During the late 19th century, European scientists purified both cocaine and morphine. What followed was an explosion of patent medicine manufacturing and sales; entrepreneurs founded future drug company giants such as Merck, Parke Davis, and Squibb Chemical Company, all of which marketed cocaine and narcotics as medicines. These drugs became widely used, and eventually abused, in Europe and the United States. Sigmund Freud's personal research on cocaine helped to popularize the drug, and invention of the hypodermic syringe led to injectable analgesic and anesthetic drugs, increasing the potential for abuse. Public concern led to increased governmental regulation, which first took the form in the United States of the Pure Food and Drug Act of 1906 and the Harrison Narcotic Act in 1914. Today, the cycle of invention, popularity, demonizing, and regulation proceeds apace. Cultural acceptance of the benefits that psychoactive drugs can bring co-exist with condemnation of excess.

If there is a lesson, here, it is that addiction exerts a seemingly fundamental and enduring appeal and power for human beings. Why is this so?

#### WHAT IS AN ADDICTION?

Many people have a rather archaic view of the nature of addiction. Their misconceptions and confusion tend to revolve around three issues: What is the difference between addiction and a bad habit? What happens in the brain of an addict? What is involved in healing the addicted brain and the addicted person?

People often claim to be addicted to chocolate, coffee, football, or some other substance or behavior that brings pleasure. This is not likely. Addiction is an overwhelming compulsion, based in alteration of brain circuits that normally regulate our ability to guide our actions to achieve goals. It overrides our ordinary, unaffected judgment. Addiction leads to the continued use of a substance or continuation of a behavior despite extremely negative consequences. An addict will choose the drug or behavior over family, the normal activities of life, employment, and at times even basic survival. When we call our love of chocolate or football an addiction, we are speaking loosely or misconstruing the intensity of what can be a devastating disorder. It may help to consider, first, what is not an addiction.

No matter how much you like some drug or activity and how much you choose to involve yourself with it, you are not addicted if you can stop it when the consequences

become negative for you. Coffee is an ideal example with which to illustrate this because it contains a powerful drug, caffeine, that can have significant effects on our behavior. Most of us like to drink coffee, but if your doctor told you that the heart attack you just had was precipitated by caffeine and that you would likely have another if you did not stop drinking coffee, what would you do? Most people would miss the buzz, but not so much that they would continue to drink coffee, knowing it would likely kill them. They would stop cold, right then and there.

Yet people say they are addicted to coffee because they feel bad when they do not use it. This reflects common confusion about two important biological processes: tolerance and withdrawal. Most people, when they abruptly stop drinking coffee, begin to suffer some negative effects within about 24 hours: a nagging headache and general feelings of sleepiness and lethargy. Their experience, however, does not signify addiction. They are suffering from the processes of tolerance and withdrawal. Tolerance occurs when the brain reacts to repeated drug exposure by adapting its own chemistry to offset the effect of the drug—it adjusts itself to tolerate the drug. For example, if the drug inhibits or blocks the activity of a particular brain receptor for a neurotransmitter, the brain will attempt to counteract that inhibition by making more of that particular receptor or by increasing the effectiveness of the receptors that remain. On the other hand, if a drug enhances the activity of a receptor, the brain may make less of the receptor, thus adapting to its over-stimulation. Both conditions represent the process of tolerance, and, in either case, withdrawing the drug quickly leaves the brain with an imbalance because the brain is now dependent on the drug. This is true not only for addictive drugs; many neuroactive drugs from caffeine to antidepressants to sedatives (and even non-neuroactive drugs) cause the adaptation we call tolerance.

In the case of coffee, the caffeine inhibits the receptors for the neurotransmitter adenosine. When we regularly use caffeine, the brain senses that its adenosine receptors are not working up to par, and it responds by increasing their function, which affects brain cells, blood vessels, and other tissues. Two major functions of adenosine in the brain are to regulate blood flow to the brain and to inhibit the neuronal circuits that control alertness. When the coffee drinker stops his intake of caffeine, he goes into withdrawal, as the receptors for adenosine become less inhibited. With more adenosine receptors functioning, his brain experiences abnormal levels of blood flow in the arteries around it, and he gets a headache. At the same time, the brain centers that keep him alert are suppressed by the excess functioning of adenosine, so he feels sleepy and lethargic.

Now the former coffee drinker is in caffeine withdrawal, feeling miserable, and wanting a cup of coffee because he is sleepy and has a headache. Is he addicted? No, he is tolerant to the caffeine because his brain chemistry has adapted to it and its proper function is dependent on its presence. This will quickly pass, because caffeine withdrawal symptoms usually disappear after a few days, and, unless he is a very unusual person, he will be able to stop using caffeine and hope to avoid another heart attack. His craving is not overwhelming; for example, it does not override his decision to protect himself from another heart attack.

The relationship between withdrawal and addiction may confuse people because most genuine addicts do experience withdrawal of some sort when they quit, and most scientists think that avoiding withdrawal is one reason addicts keep using the substance to which they are addicted. Alcohol is a good example of how tolerance and withdrawal

contribute to addiction. If a person drinks heavily for a long time, his brain will adapt to the sedative effects of the alcohol. The compensation that happens is like the caffeine example above, only with a different neurotransmitter. Alcohol activates receptors in the brain for the neurotransmitter GABA, which normally inhibits brain activity. After long-term alcohol exposure (weeks to months or years), the brain compensates by diminishing the ability of these receptors to function. The alcoholic is now tolerant to the alcohol, just as the coffee drinker was tolerant to caffeine.

If the alcoholic abruptly stops drinking, the neuronal circuits in the brain will suffer from excess excitation, because the opposing inhibitory functions have been diminished. The consequences of acute alcohol withdrawal can be lethal, because the hyperexcitability of the brain can cause epileptic seizures as well as instability of blood pressure and heart functions. Fortunately, however, other sedative drugs can be substituted for the alcohol to keep the brain stable, and withdrawal can proceed over a few days.

Many addictive drugs like alcohol produce tolerance, and addicts experience withdrawal when they try to stop using them. This withdrawal can range from mild or at most moderate discomfort for a drug like marijuana, to extreme discomfort from opiates, to lethal brain instability from sedative agents like alcohol, barbiturates, and benzodiazepines (such as Valium and Ativan). Still, the key point remains: withdrawal discomfort ends in a matter of days to weeks as the brain chemistry normalizes, and this discomfort alone does not signify addiction.

Are habits addictions? This is a tough question, because such habits range from mild and innocuous—such as twirling your hair when you are thinking about something—to dangerous, for example, overeating and gambling. Mild habits can be difficult to stop, but if we can stop when we must, we are not addicted. More dangerous habits or compulsions may be different. In fact, as we discuss later, modern neurobiology suggests that there are some strong similarities between drug addictions and compulsive habits.

## THE ADDICTED BRAIN

Scientists now think that the brain changes associated with genuine addiction long outlast the withdrawal phase for any drug. Addiction is characterized by profound craving for a drug (or behavior) that so dominates the life of an addict that virtually nothing can stop the person from engaging in the addictive activity. Addicts will give up anything and everything in their lives for the object of their addiction. They will lose all their money for cocaine, give up loved ones to feed their craving for alcohol, and sometimes give up their lives. The perplexing questions for neuroscientists who study addiction are how the brain learns to crave something so fiercely and how to reverse that craving.

With new imaging techniques, we can watch the brain function in real time, and we now know that addictive drugs cause the activation of a specific set of neural circuits, called the brain reward system. This system controls much of our motivated behavior, but most people are hardly familiar with it. Our brain's reward system motivates us to behave in ways such as eating and having sex that tend to help us survive as individuals and as a species. This system organizes the behaviors that are life-sustaining, provides some tools necessary to take the desired actions, and then rewards us with pleasure when we do. Research shows that almost any normal activity we find pleasurable—from hearing great music to seeing a beautiful face—can activate the reward system. When this happens, not

only are we stimulated, but these circuits enable our brains to encode and remember the circumstances that led to the pleasure, so that we can repeat the behavior and go back to the reward in the future.

A critical component of this system is the chemical dopamine, which is released from neurons in the reward system circuits and functions as neurotransmitter. Through a combination of biochemical, electrophysiological, and imaging experiments, scientists have learned that all addictive drugs increase the release of dopamine in the brain. Some increase dopamine much more than any natural stimuli.

Let us imagine a simplified scenario that illustrates the power of a functioning reward system and our understanding of the role of dopamine. You are at a cocktail party, talking with friends. From time to time, you glance about the room to see who is coming and going, and then you notice an extremely attractive person has entered the room. That person now has your attention. The person is attractive enough that you begin to focus on him or her, and pay less attention to the ongoing conversations among your friends.

At this point, you have experienced two effects of activating the reward system: attention and focus on the potential reward. Attention is the first of the reward system tools, giving you the ability to recognize a potentially rewarding possibility, be it your grandmother's chocolate cake or this beautiful person. Next, you focused on the person, tending to ignore other aspects of your environment. The dopamine system is active at this point because it is part of the brain circuits that mediate attention; it helps us ignore peripheral stimuli and focus more on whatever we perceive as our task. Finally, in this first stage, perhaps you felt a little rush as the person indicates a mutual interest.

Now things get interesting, as your reward system tells you that there is a possibility of a significant rewarding interaction with this person. This is the point where our understanding of what dopamine does has become more sophisticated in the last 10 years. We once held the simplistic view of dopamine as the "pleasure chemical"; when you did something that felt good, the increase in dopamine was the reason. Experimental psychologists now make clear distinctions between "wanting" something and "liking" something, and dopamine seems to be important for the "wanting" but not necessary for the "liking." This distinction seems to hold in every species in which it has been tested, from rodents to man. "Wanting" turns a set of neutral sensory stimuli (a face, a scent) into a stimulus that is relevant, or has "incentive salience." In other words, in our scenario above, activation of dopamine neurons helps signal that the person who enters the room is somebody interesting.

Studies using animals that were receiving sweet food treats or having sex usually show that dopamine activity increases not as a result of getting the reward, but in anticipation of a reward. Sophisticated mathematical models of this neuronal activity have led some of these scientists to view the dopamine system as an "error detector" that determines whether things are going as predicted. So if a monkey (or rat or person) is anticipating an expected reward (a kind glance from the person in the above scenario, perhaps), dopamine neurons fire in anticipation of this, and shut down their firing if it is not forthcoming.

The reward system also has the ability to encode cues to help you repeat the experience. You will remember the room where you met this person, the clothes, the food being served, the odor of cologne or perfume, a spoken phrase, and much more. Assuming that things go well, the next time you encounter one of these cues, you will not

only remember the encounter, but feel a little craving to repeat it. When a person experiences a positive, pleasurable outcome from an action or event, the release of dopamine and other chemicals alters the brain circuitry, providing tools and encouragement to repeat the event. The memory circuitry stores cues to the rewarding stimulus, so previously neutral cues (a perfume, a line of white powder) become salient. Our brains map the environment in which we experience the rewarding activity by recording the physical space, the people involved, the smells—in fact, all of the sensory experience. In addicts, cues that normally would have no particular importance to survival or pleasure—such as a line of white powder, a cigarette, or a bottle of brown liquid—activate this same reward system.

But cues alone are not enough; action is necessary to get a reward. The brain's reward system is organized to engage the areas of the brain that control our ability to take action. The executive area of the brain, located in the prefrontal cortex, enables us to plan and execute complex activities, as well as control our impulses. Humans have a much larger prefrontal cortex and so a greater capacity for planning and executing complex activities than lower animals do, even the nearest primates. When we experience a rewarding event, the executive center of the brain is engaged. It remembers the actions used to achieve the reward and creates the capacity to repeat the experience. Thus, not only does a pleasurable experience result in pleasant memories, but also the executive center of the brain provides motivation, rationalization, and the activation of other brain areas necessary to have the experience again. And each time the experience is repeated all of these brain changes—memories and executive function tasks—become stronger and more ingrained. These planning centers are an important target of dopamine action.

## THE HIJACKED BRAIN

Everything we know about addictive drugs suggests that they work through precisely these mechanisms. All addictive drugs activate the reward system by directly raising the levels of dopamine. Although each addictive drug also has its own unique effects, which is why alcohol feels different from cocaine or heroin, stimulation of the dopamine component of the reward system seems to be a common denominator. When addictive drugs enter the brain they artificially simulate a highly rewarding environment. The feelings provided by the drugs activate the “wanting” system just the way a cute person or tasty food would, and the dopamine released influences memory and executive function circuitry to encourage the person to repeat the experience. With every use, the enabling circuits become stronger and more compelling, creating an addiction. Recent imaging studies of the brains of addicts while they were anticipating a fix show that the planning and executive function areas of the prefrontal cortex become highly activated as the addicts plan for the upcoming drug reward.

As an interesting aside: A new area of study is the mathematical modeling of the reward by economists. It should not be a surprise that the mathematical models that predict our consumption of cards, food, and perfume could be applied to more basic reward phenomena, and a group of mathematicians have shown that these models predict a wide range of normal human behaviors. The field of “behavioral economics” has become one of the most exciting forefronts of neuroscience research. Some scientists have proposed that addiction hijacks the normal reward circuitry and so disrupts the normally perfectly quantifiable relationships between reward and behavior.

The level of addiction to a drug can vary immensely, depending on the characteristics of the particular drug. If a person uses a drug such as cocaine or amphetamine, which produce a profound dopamine release, the addict's reward system experiences surges of activation. With repeated use, the circuitry adapts (perhaps becomes tolerant) to dopamine, and normal pleasures, such as sex, become less pleasurable compared with the drug.

In alcoholics, using neuroimaging we can actually see decreases in the brain's receptors for dopamine. Since it is hard to study human addicts before their addiction, we have a bit of a "chicken and egg" problem with this finding; we do not know which came first, the low receptors or the addiction. We do know from a recent rat study that raising the level of dopamine receptors by a sophisticated molecular strategy (transfection with a virus) caused rats to decrease their alcohol intake.

Some addictive drugs, such as nicotine, might seem rather innocuous, because they do not produce a profound "buzz" or euphoria. How can nicotine be as addictive as it is? We know that nicotine is a reliable dopamine-releasing agent, although the amount of dopamine released is small with each use. People smoke or chew quite frequently, however, providing the brain a large number of exposures to the drug, allowing the reward system to modify the brain to crave the drug and take action to get it. The powerfully addicting effects of nicotine demonstrate that the conscious "liking" of the drug experience is not the most important effect of addictive drugs. Most smokers describe nicotine as relaxing, or anxiety reducing, but not as particularly pleasurable.

This dissociation between liking the drug experience and taking drugs is described by most addicts. Many addicts will say that their initial experiences with addictive drugs were the best they ever had, and they have spent the remainder of their addiction seeking out a similar high. Addicts do report that when they stop, they go through a period when they are unable to experience pleasure from normally pleasurable activities; this is called "anhedonia." But the result of the addiction is more than simply missing pleasure, as bad as that is. In an established addiction, the brain's executive centers have become programmed to take all action necessary to acquire the drug. The person begins to crave the drug and feel compelled to take whatever action—spend money, rob a mini-market, steal from his parents—is necessary to get the drug and the high levels of dopamine that come with it. After awhile, seeking out the drug can become an automatic behavior that the addict does not even enjoy.

And yet, the reasons that addicts keep using drugs are more complicated than activation of the reward system by dopamine. We think that long-lasting changes in the production of certain brain molecules are at work. Until recently, researchers patiently focused on single molecules, one at a time, to evaluate their potential role in addiction. Using this approach, we learned how to identify molecules that changed as an addiction developed and remained altered for a long time after drug use stopped, in concert with the long-lasting cravings that people experienced. Some of the molecules identified, such as the dopamine receptors, were expected, but others were not. For example, growth factors that produce long-lasting structural changes in the brain may also contribute to the changes in brain function associated with addiction.

Scientists now know that the best way to produce long-lasting changes in the brain is to regulate the production of proteins by activating or silencing their genes. With the new ability to track changes simultaneously in thousands of brain molecules, we have

started looking for patterns of change in genes. Some of the single molecules targeted earlier, such as proteins like CREB and delta fos B, themselves coordinate production of families of genes. Furthermore, these families change over different time frames. CREB is important during the early phases of cocaine use, but becomes much less important once addiction is long established. The fos family of proteins is the opposite: many more are changed after long-term exposure to cocaine.

These changes do not go away quickly. The biological memories of the drug can be as profound and long-lasting as any other kinds of memories, and cues can activate the executive system to initiate drug-seeking years after the most recent previous exposure. So addiction is far more than seeking pleasure by choice. Nor is it just the unwillingness to avoid withdrawal symptoms. It is a hijacking of the brain circuitry that controls behavior, so that the addict's behavior is fully directed to drug seeking and use. With repeated drug use, the reward system of the brain becomes subservient to the need for the drug. Brain changes have occurred that will probably influence the addict for life, regardless of whether or not he continues to use the drug.

Now back to a question we posed earlier: "How are dangerous habits related to addiction?" Researchers are discovering that behaviors such as promiscuous sex, gambling, and overeating have some commonality with drug addiction, and you can probably imagine why. Nature did not create the brain reward circuit to help us get high on cocaine; this system evolved to help us eat and reproduce, behaviors that are complex but necessary to life. Recent brain imaging studies show that some of the changes that happen in the drug-addicted brain—for example, a decrease in the receptors for the neurochemical dopamine—are also seen in the brains of extreme overeaters. Other researchers are exploring this phenomenon in connection with other types of behaviors.

#### TREATING THE ADDICTED BRAIN AND ADDICTED PERSON

How can we help control or reverse addictions? We do not yet have tools to erase the long-lasting brain changes that underlie addiction. The best pharmacological tools that we have now use a simple but effective strategy: an alternative drug is used to stimulate the brain on a low and steady level. This can fend off withdrawal, while providing a mild, almost subliminal, stimulation to the reward system, allowing the brain circuitry to readapt over time from the intense stimulation of daily use of addictive drugs to the very slight stimulation by steady, low levels of the medication. As the brain adapts back toward normality, an addict may gradually decrease the substitute drug until he becomes drug free. The narcotic drugs methadone and buprenorphine are safe and effective examples of such drugs. A recently approved drug called acamprosate uses a similar approach to treating alcoholism by providing a very mild sedative action that resembles alcohol. Is this just a chemical "crutch" that maintains the same brain changes caused by addiction? Perhaps, but by providing a minimal action it allows considerable normalization of brain function. Furthermore, these drugs allow people to reconnect with their families, hold jobs, and be productive members of society.

Why not use a drug that blocks the effects of all addictive drugs, an abstinence-based approach that appeals to some people? The problem with such a drug is that it would also prevent all the normal rewards through which people need to find satisfaction in living. If you invented the perfect reward-blocking drug, nobody would take it at the cost of losing the pleasures of life. Another approach may be found in a new drug called

rimonabant, which blocks the actions of the cannabinoid receptor, the brain receptor that the active ingredients in marijuana act upon. There is a tremendous amount of excitement right now about this new drug, and successful trials in weight reduction and smoking cessation have raised hopes that this drug might prevent certain addictive behaviors, and also block the effects of alcohol and narcotics. Recent experiments with “knockout” mice that lack the cannabinoid receptor show that these animals do not drink alcohol, and they will not self-administer narcotics. This is consistent with older studies that have hinted that there is some common thread in the addiction pathway for these three drugs. What is philosophically more appealing about rimonabant is that the effects of drugs are prevented, not mimicked. Time will tell, but its effectiveness against several problems suggests that neuropharmacologists are on the right track.

There will never be a simple pill to regulate such a complicated disease as addiction. The most important contribution that anyone dealing with addicted individuals can make is to recognize that reversing addiction is not just a matter of giving up something pleasurable but of accepting that addicted individuals have undergone a formidable reorganization of their brains. Treating an addict requires dealing with every aspect of this reorganization.

Acute withdrawal is the first problem that any addict faces after he stops using, and this process plays an important role in maintaining drug-taking behavior. The withdrawal can be a day or two, or many days, even weeks, depending on the particular drug, how long the addict has been using, and how much he has been taking. We must recognize that the executive system in the brain of an addict is programmed to initiate drug seeking in response to cues, so it is critical to help the addict avoid those cues. This usually means removing the addict from the environment where he became addicted. The addict will also have to relearn impulse control; his executive system will have to be retrained to inhibit the impulses toward drug use as they occur.

Finally, we should recognize that addiction is one of the most powerful memories we can have. These memories are imbedded in the brain; we do not forget an addiction any more easily than we forget our first love. People often receive drug treatment more than once, and still relapse. Relapses are unfortunately common in treating addiction, but the same thing happens in treating cancer and we still keep trying for a cure. We must take the same attitude toward addictive diseases and offer extensive as well as intensive treatment. But, most of all, we must offer understanding, which comes from knowing that addiction lies at the very core of our brains.

-----

[END OF ARTICLE]