HAZELDEN’S CLINICAL INNOVATORS SERIES presents signature topics by industry leaders who define today’s (and tomorrow’s) standards of substance abuse treatment. Watch the video workshop, read the clinician’s manual, then take the posttest.* Staying current and maintaining credentials has never been more convenient.

Richard A. Rawson of UCLA has conducted research and developed treatment systems for substance abuse for more than two decades. The clinician’s manual builds on the content of the video, and it explains why methamphetamine is a highly addictive and dangerous drug, how its use is reaching epidemic levels across the United States, and what treatment strategies work effectively. In five concise chapters, Rawson covers the range of meth issues and clinical tools that you can use with clients. The thirty-question posttest is worth fifteen continuing education hours upon successful completion.

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The Neurobiology of Addiction

CLINICIAN'S MANUAL
The Neurobiology of Addiction
A New Perspective

CLINICIAN’S MANUAL

Carlton K. Erickson, Ph.D.
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Hazelden’s Clinical Innovators Series was designed with innovation in mind. The series features discussion of current topics by leading, cutting-edge experts in the field. Each topic in the series is composed of a DVD, a clinician’s manual, and a post-test offering continuing education hours.

The DVD should be viewed first. It allows the viewer to participate in a workshop led by an internationally recognized, highly trained speaker.

The clinician’s manual should be read after viewing the DVD. The manual is authored by the workshop speaker and expands on the material found in the DVD. As a NAADAC-approved provider, Hazelden offers continuing education hours for successful completion of the post-test based on the material, when applicable.

The Clinical Innovators Series is a professional development tool useful to practitioners such as chemical dependency counselors, psychologists, health care professionals, and clergy. It offers practical, new techniques that can be applied immediately.
Acknowledgments

The author wishes to thank Hazelden Publishing and those who were responsible for inviting me to aid in producing this contribution to its Clinical Innovator Series. I am aware of the excellent presentations in this series by acknowledged experts in the field and am humbled to be included among those experts. I am extremely thankful to Richard Solly for his help and expertise in putting this together. Doug Toft wrote the original draft of this manual and is to be commended for his devotion to plain talk and making sure that the accuracy of the science was not lost in the translation of my work. I also appreciate the work done by Jodie Carter and StoneArch, the video production company, in producing the excellent instructional DVD that accompanies this manual. Together this manual and DVD make a comprehensive package for the clinician on the subject of neurobiology and chemical dependency. Also, my thanks to Dave Spohn for the cover design and layout. All of these people have worked together to produce a work that I believe will bring understanding and assistance to clinicians in their work to help their clients in recovery. Finally, I thank my family for their understanding of the time it takes to complete an important project such as this.
I am trained as a pharmacologist, and my early work in this field included animal research to find out how alcohol intoxication occurs in the brain. Eventually I decided that I wanted to find out more about alcoholism in human beings. In the 1970s, one of the few ways that I could learn about this disease was to attend open Twelve Step meetings.

I listened to countless people tell their stories and soon befriended a man named John, an AA member for around forty years now. Later we began to work together, giving over 160 presentations across the country about the intersections between scientific research and the real-life experience of chemical dependence. As a result of these experiences, I developed a feeling for the human dimension of this disease while staying abreast of the emerging research. In addition, I attended a weeklong Professionals in Residence program at the Betty Ford Center where I observed something that amazed me as a pharmacologist: Alcoholics were getting better during treatment—usually without medication. I couldn't figure out why.

Today we know a lot about why people get better, and why people become dependent on alcohol or other drugs in the first place. This manual summarizes the latest scientific findings in both these areas, drawing heavily on neurobiology—how chemical dependence affects the brain. We’ll explore this area while focusing on perspectives and tools that you can use in your daily work.
This Manual in Brief

Early on, this manual defines several terms that are crucial to understanding the neurobiology of dependence and treatment. Traditional terminology based on the concept of “addiction” poses serious limits on our thinking and behavior. We can begin solving these problems by changing our language.

Next comes an overview of neurology basics—how neurons (nerve cells) send and receive messages. This will help you understand how chemical dependence affects neuron activity in a specific part of the brain called the mesolimbic dopamine system (MDS).

Both drinking and other drug use can disrupt the MDS, leading to the disease of dependence. Prolonged use and genetic vulnerability can lead to a constellation of changes called dysregulation. Clinicians need to understand how these changes in the brain will affect their work with clients.

We have two broad strategies for treating problems with alcohol and other drug use: psychosocial support and pharmacological treatments. You’ll find a chapter devoted to each strategy.

Finally, remember that neurobiology is one of the hottest areas of science and plenty of new developments are in store. Plan to continue learning about neurobiology for the rest of your career. This manual concludes with reminders about the nature of scientific research, suggestions for staying on top of the latest studies, and ways to understand and evaluate what you read and hear about neurobiology.

Why Clinicians Need to Understand Neurobiology

Continuing revelations about the human brain are transforming our approaches to medical treatment, education and training, and human development. People in treatment for chemical dependence will read about brain imaging and even about the functions of specific areas of the brain.
Popular publications such as the *New York Times*, *Time*, and *Newsweek* are already running feature stories about the amygdala (the “emotional” part of the brain), the “pleasure pathway,” and other aspects of neuroanatomy. Both clients and professionals will ask questions about how all this news affects your work and recovery itself.

This manual will help you provide the answers. Beyond getting grounded in Brain Science 101, you’ll learn how developments in neurobiology call for basic changes in the ways that we discuss, define, and treat chemical dependence.

As you’ll see, research in neurobiology validates the view of chemical dependence as a chronic, brain-based disease that can be arrested. We can translate these findings into increased funding for treatment and further research to improve our evidence-based practices.

**Using This Manual with the DVD**

To get an overview of neurobiology as it applies to chemical dependence and treatment, view the DVD first. Then turn to this manual for a detailed explanation of key concepts. To receive continuing education hours, complete and submit the post-test.
Critical Definitions

We’re confused about addiction.

According to one species of conventional wisdom, the answer to addiction problems is relatively straightforward. All we have to tell people is to increase their willpower and learn more about what drugs do. That would end drug problems in America—right?

The above point of view is grossly oversimplified, based on denial and misunderstanding, and widespread. Despite decades of research and the popular insights offered by groups such as Alcoholics Anonymous, Americans still have a confused and conflicted attitude toward problems with alcohol and other drug use.

This attitude was demonstrated in a video series produced by the Addiction Science Research and Education Center at the University of Texas at Austin. During one segment of this series, people coming out of Union Station in Washington, D.C., were stopped at random and asked: What do you know about alcoholism? Following is a sample of their responses:

Sometimes you don’t even know they’re alcoholics until they fall down or do something that’s silly, I guess.

Sometimes it’s really hard to tell. You have to watch over a period of time to see what the patterns are and to see what the irrational behaviors are.
Alcoholics tend to drink out of necessity because their body needs it.

It’s a disease, and there’s no cure.

There may be internal factors like genetics—biology. Then there could also be external factors—maybe family history and so on.

Addiction to alcohol is something that they can’t break free from. It is something that many of them may wish to break free from. But perhaps because of the chemical dependency—possibly also a spiritual deficiency of not depending on the power of God—they become addicted. They can’t quit.

I would tend to feel that it’s caused by a gene or some kind of chemical imbalance in the body that predisposes it. But I don’t think that’s ever been proven.

It’s one of the saddest, most prevalent, most deadly diseases in our country.

The same set of people were also asked another question: What do you know about drug addiction? Their responses included the following:

All you ever hear about is that they’re totally spaced out. They have no control and their mind is just not functioning right.

I’ve got an image of a drug addict as maybe a bum—someone who lives on the streets.

Low down, dirty, and just don’t care about nobody . . . They’d rob, kill, steal—whatever it takes, they’re going to get it.
Most people would say it’s somebody who lives on the street and doesn’t look like they have a lot of money. But I think a lot of people can be drug addicts. A lot of movie stars are drug addicts, I think.

You not having control—the drug having control over you—I think would be the key indicator.

Acting wacky or whatever . . . just acting crazy, I guess.

I would think that someone is hooked on drugs if they think about drugs 24/7. . . . They think about drugs even before they think about getting food—the basic necessities of life.

I see in the responses to these questions—especially the ones about the nature of addiction—a lot of prejudice, stigma, anger, and misunderstanding. Unfortunately, these ideas get translated into flawed public policies, including a lack of insurance coverage for medical treatment of the very problems that people described above.

There are reasons for this state of affairs. They center largely on our use of one word—addiction.

Who Is an “Addict”?
Addiction is an unscientific term that is applied widely and indiscriminately. Look at all our “addictions”: There’s “addiction” to alcohol, heroin, cocaine, nicotine, marijuana, prescription drugs, and club drugs. Okay, nothing too unusual here. But then there’s also “addiction” to gambling, sex, the Internet, work, chocolate, exercise, people, and food. Beyond these is “addiction” to cell phones and BlackBerries (sometimes called “crackberries” when used compulsively), sugar, ice cream, television, Disneyland, and shoes. On top of all this is our cultural “addiction” to oil, big government, and debt. Our daily conversations contain the unstated assumption that almost anything can be addicting.
Do some people get “addicted” to gambling, Internet use, or sugar in the same way that other people need alcohol or other drugs? We don’t know the answer to this question yet. Some new research based on functional magnetic resonance imaging (fMRI) indicates that pathological gambling is linked to reduced activity in the reward system of the brain. In regard to Internet “addiction,” there are no solid studies yet. With sugar, there is too much anecdotal evidence to ignore; someday scientists may find the mechanism of dependence on sugar.

Not surprisingly, the public discourse on alcohol and other drug use—which includes the general public, treatment professionals, researchers, and policymakers—is still marked by disagreement over core issues. For example, what is alcoholism? Is it merely drinking too much, too often, and for too long? Is it a disease, a disorder, or a mental illness? Is it synonymous with alcohol abuse or something entirely different? Is alcoholism largely driven by genetics or is it preventable? Is it a consciously chosen behavior that can be treated with behavioral methods?

These questions still provoke wide disagreement. Millions of people are still unsure about whom to label as “addicts” and whether these people are “bad” or “mad.”

Going Beyond “Addiction”

One of the most fundamental problems with addiction is that the term fails to distinguish between voluntary behavior and involuntary behavior. Alcoholics Anonymous, for example, opens its arms to anyone with a self-declared drinking problem, from mild abuse to severe dependence. Members of AA routinely describe themselves as alcoholics. However, many researchers and government agencies (including
the National Institute on Alcohol Abuse and Alcoholism) separate alcohol dependence from alcohol abuse and equate alcoholism with the brain disease of dependence.

The word *addiction* tends to stigmatize people who want help. And because the term fails to draw a clear distinction between abuse and dependence, it perpetuates the myth that problems with drug use stem from moral weakness or a lack of willpower. This perception erects barriers to funding treatment and research. It also contributes to perpetuating a lack of parity in insurance coverage for drug-related disorders as compared to “real diseases,” such as cancer and Parkinson’s disease.

The imprecision of *addiction* leads to other terms that are not supported by research or have conflicting definitions, including

- alcoholic
- addictive personality
- binge drinking
- heavy drinking
- moderate drinking
- problem drinking
- social drinking

In addition, there is the problematic term *substance*, as in *substance abuse* and *substance dependence*. The word *substance* can include everything from dust to broccoli. Speaking about substances also makes it harder for us to clarify the relationships between chemical dependence and behaviors such as compulsive gambling and sexual activity.

There is a solution. All this addiction-based language can be replaced with terms based on widely used, evidence-based diagnostic manuals, such as the fourth edition, text revision, of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR) from the American Psychiatric
Association and the *International Classification of Diseases, Tenth Edition* (ICD-10) from the World Health Organization. This is especially true in scientific and clinical contexts.

We can start by maintaining a fundamental distinction between abuse and dependence. Many policymakers and members of the general public don’t understand this distinction, leading to a cascading series of negative consequences—ranging from a lack of funding for treatment and research to illness and premature death for people who are never diagnosed correctly. Thus, it is critical to understand that all drug overuse is *not* “addiction.”

**Abuse**

As defined in DSM-IV and ICD-10, *abuse* refers to intentional overuse of a drug in cases of celebration, anxiety, despair, self-medication, or ignorance. Drug abuse thus describes a voluntary behavior—not a brain-based disease (see the section on Dependence on the next page). From this perspective, speaking of alcohol and other drug *misuse, overuse,* or *nondependent use* is a possible improvement over the term abuse.

According to the diagnostic criteria in DSM-IV, an abuser can experience withdrawal, blackouts, and other consequences traditionally associated with alcoholism or addiction. However, these alone are not enough to warrant a diagnosis of dependence. Drinking or drugging “too much, too often” does not automatically mean that someone’s drug use has the characteristics of dependence, which is a disease state.

Drug abuse is a problem with major costs to society, even though we know much about how to prevent it. Abuse tends to decline as people experience adverse consequences from their alcohol or other drug use. Other solutions include
education, punishment, raising the legal drinking age, and taking steps to reduce the supply of illicit drugs.

In short, abuse is an “I-can-stop-using-when-it-gets-bad-enough” condition. And since abuse is a voluntary and conscious behavior, abusers are clearly culpable for what they do while under the influence of drugs.

**Dependence**

Chemical *dependence* is a chronic, progressive, brain-based disease. The main symptom of dependence is impaired control over drug use, which leads to compulsive drug use in spite of adverse consequences. Current research indicates that this is caused by dysfunction in a specific part of the brain called the “pleasure pathway.” (More about this in chapter 3.)

There are two major types of impaired control over the use of drugs, and either can occur in severe dependence. One is an inability to abstain from using a drug. The other occurs after a person has started using and becomes intoxicated. In either case, the disease of dependence is present when people repeatedly promise to limit or end their drug use—and break those promises every time.

DSM-IV lists multiple criteria* for distinguishing abuse from dependence:

**Chemical (Drug) Abuse**

I. A maladaptive pattern of drug use leading to impairment or distress, presenting as one or more of the following in a twelve-month period:

1. recurrent use leading to failure to fulfill major obligations
2. recurrent use which is physically hazardous

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* These criteria are adapted with permission from the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, Text Revision (Copyright 2000), American Psychiatric Association.
3. recurrent drug-related legal problems
4. continued use despite social or interpersonal problems

II. The symptoms have never met the criteria for chemical dependence.

**Chemical (Drug) Dependence**

I. A maladaptive pattern of drug use, leading to impairment or distress, presenting as three or more of the following in a twelve-month period:

1. tolerance to the drug’s actions
2. withdrawal
3. the drug is used more than intended
4. there is an inability to control drug use
5. effort is expended to obtain the drug
6. important activities are replaced by drug use
7. drug use continues despite knowledge of a persistent physical or psychological problem

II. Two types of dependence can occur:

A. with physiological dependence (including either items 1 or 2), or

B. without physiological dependence (including neither items 1 nor 2).

Note that the presence of *physiological* dependence (an old term that explains how withdrawal occurs) or tolerance is not enough to warrant a diagnosis of chemical dependence. This evidence-based definition of *dependence* is unique and at odds with the official lexicon of some prominent organizations, including professional organizations and self-help groups. For example, the American Pain Society and American Medical Association officially define *addiction* as impaired control over use, using the term in a way that is
nearly identical to the term dependence as I define it here.

It makes sense that Alcoholics Anonymous and other Twelve Step groups are filled with people who abuse drugs and people who are dependent on them. For understandable reasons, AA opens its doors to both sets of people without requiring a diagnosis first.

I believe that many people benefit from Twelve Step groups and that some owe their very lives to the principles of the program. Yet my training and experience tell me that some people are helped by Twelve Step groups and others who attend meetings are not helped as much. The reason is that the former do not have a brain disease while the latter do have this pathology. Thus, maintaining a clear distinction between abuse and dependence is critical to an understanding of how these drug overuse states can be overcome. In the future, we expect major changes to this terminology that may resolve this issue.

I work at the University of Texas at Austin, where on any night of the week I can walk downtown to Sixth Street and see students crowded into bars for the purpose of getting “hammered.” Are all these students dependent on alcohol? Of course not! Based on current research, we can now understand that most of them are alcohol abusers whose drug use will decrease or end after they leave college, get older, and assume the responsibilities of work and family. One can safely estimate that only 10 to 15 percent of heavy-drinking students will actually go on to become dependent. These are the people whose relationship to alcohol or other drugs is uncontrollable until they receive treatment.

Chemical dependence—like diabetes, cancer, and Parkinson’s—fully meets the requirements imposed by any reasonable definition of the term disease. And like other
diseases, dependence occurs in mild, moderate, and severe forms (the last being the hardest to treat).

Why is calling dependence (and even “addiction”) a disease so controversial? It appears that labeling a person with chemical dependence as “being diseased” is the same (in some people’s minds) as releasing the person from the responsibility for his or her behavior. We seem to have a human desire to punish people whose behavior makes us angry or fearful. In actuality, saying that a drug overuser has a disease does not absolve anyone from responsibility for bad behavior. Overusers are still responsible for getting into treatment and staying in treatment. But the point is that they are not capable of changing their drug overuse behavior without help. Also, for complete understanding of the disease of chemical dependence, proper differentiation between dependence and drug abuse (which is not a disease) must be understood. Some people have a hard time understanding that a percentage of drug overusers do not have a disease.

There are no agreed-upon criteria that define a medical disease (that is, you will not find such a definition in a medical textbook). Rather, a belief that a pathological state is a medical disease comes about by consensus. Thus, physicians and people who are in recovery through the Twelve Steps have less of a problem understanding “disease” (the American Medical Association declared alcoholism to be a disease as early as 1967). Some psychologists and philosophers, however, continually debate about whether people “did it to themselves” and about the degree of involvement of volition (choice making) in drinking and drugging. Many people I have debated with on this issue appear to be thinking only about volitional drug abuse, while I was talking about chemical dependence. It is difficult to agree when arguing apples and oranges.
Lewis (1991) compared several characteristics of nine different diseases and found that all the diseases had common characteristics: a clear biological basis; unique, identifiable signs and symptoms; predictable course and outcome; and a cause beyond the patient’s control. One of the diseases, alcoholism, had all of these characteristics, leading Lewis to conclude that all nine diseases had equal medical significance. McLellan and coworkers broadened this idea in 2000, when they concluded, “genetic heritability, personal choice, and environmental factors are comparably involved in the cause and course of . . . chemical dependence, type II diabetes, hypertension, and asthma.”

Remember, treating chemical dependence as a disease does not release people from responsibility for their behavior. However, our notion of culpability for people with chemical dependence needs to be adjusted and clarified. As we know from experience, it does not work to take people who are dependent on alcohol or other drugs and throw them in jail while saying: There, that’ll teach ya—now sober up. The only option for these people—and for any nation that wants to reduce the social toll of chemical dependence—is to improve access to treatment.

In summary, dependence is an “I-can’t-stop-using-unless-I-get-help” disease. Since dependence (not abuse) is an involuntary behavior, the only way for a person to break the cycle of compulsive use and broken promises is treatment. When chemically dependent people are convinced that they have a no-fault, brain-based disease, they may find it easier to enter treatment.

Recovery

Recovery is a commonly used term with widely varying definitions. This manual uses a working definition of recovery formulated by a group of researchers and treatment
professionals that convened at the Betty Ford Institute, a newly formed research and education entity, in September 2006. That group defined recovery as “a voluntarily maintained lifestyle” characterized by the following:

- **Sobriety**—abstinence from alcohol and all other nonprescribed drugs. *Early* sobriety means that a person has at least one month but less than one year of abstinence. *Sustained* sobriety is one to five years of abstinence. *Stable* sobriety is five years or more of abstinence.

- **Personal health**—improved quality of personal life as defined and measured by scores on the physical health, psychological health, and spirituality domains of the Quality of Life Scale of the World Health Organization.

- **Citizenship**—improved quality of social function as defined and measured by scores on the social function, environment, and independent living domains of the Quality of Life Scale of the World Health Organization.

This definition can help health insurers and treatment professionals understand recovery as a clearly defined and measurable process. The definition is only preliminary as of this date and needs validation by more scientific research before it can be fully accepted by scientists, treatment centers, and the recovering community.

**Other Key Terms**

*Craving* is a sense of longing that leads to behaviors associated with seeking alcohol or another drug.

*Euphoria* is a sense of well-being, ranging from mild to strong, that is associated with alcohol or other drug use. By itself, euphoria is not a defining feature of dependence, and
drugs produce differing levels of euphoria. For example, nicotine has a high dependence liability and yet produces only mild euphoria. Cocaine also has a high dependence liability and produces high euphoria. Marijuana produces a moderate euphoria but has a low dependence liability.

**Withdrawal** includes signs and symptoms associated with drug cessation. People with chemical dependence can experience withdrawal when they stop using many drugs, including alcohol, heroin, and nicotine. Finally, a person’s experience of craving, euphoria, or withdrawal—either in isolation or in combination—does not mean that this person is dependent on a drug.

**“Addictions” as Obsessive-Compulsive Disorders**

When people who are dependent on alcohol or other drugs enter treatment, we often see that they turn to another substance or activity—such as smoking, work, or gambling—in a compulsive way. Based on continuing research and clinical experience, we may eventually come to see chemical dependence as a sophisticated obsessive-compulsive disorder (OCD). This viewpoint reinforces the idea that dependence, like OCD, is a brain-based disease that can be treated with medication. Moreover, from a political standpoint, it may be actually desirable to separate impulse control disorders (such as gambling) from the stigma associated with “addictions.” In the near future we may find that the most evidence-based use of language is to stop saying “addicted” altogether and start saying “obsessed” or “obsessive compulsive.”

In any case, the core problem in chemical dependence does not lie in the bottle, the syringe, or the glass plate. As the next two chapters explain, the problem lies in brain chemistry that’s gone awry, leading to compulsive use and
impaired control, and the chemicals are only a trigger for the disease. Thus, dependence is a disease process that can only be arrested with the intensive intervention provided by modern treatment methods.
Research about chemical dependence has a major lesson for us: A drug only causes chemical dependence when a person is ready for it—that is, neurochemically vulnerable. Put in more colloquial terms: It’s not the drug, sweetheart—it’s the brain. Another way of saying this is that a person must “have what it takes” to become dependent. A drug on its own is not capable of producing dependence unless several other factors (genetics, plus other unknown triggers) are in place. Chapter 3 explains this point in more detail, but to understand it, you’ll need the overview of basic neurobiology offered in this chapter. (Also see the appendix for suggestions on how to explain neurotransmission to patients.)

**Neurons Are the Functional Units of the Nervous System**

The body is made up of billions of cells. Cells are the basic unit of all living things. Even single-celled organisms such as bacteria can perform the basic functions needed to sustain life. These basic functions include gathering energy from food, reproducing, and producing waste material.

Plants, animals, and human beings are multicellular creatures. The human body includes billions of cells that specialize in certain functions. For example, some cells become part of muscle tissue and aid movement. Other cells
make up organs, glands, blood, veins, arteries, and bones.

The nervous system specializes in receiving, processing, and sending messages. To serve its three functions, the nervous system includes vast circuits of delicate cells that are elaborately interconnected. In fact, the brain, spinal cord, and nerves throughout the body are all made up of one kind of cell. These are nerve cells, also called neurons. The brain includes billions of neurons. So does the spinal cord and all the nerves that fan out from the spinal cord to glands, organs, and muscles. A single neuron can be connected to thousands of other neurons through axons and dendrites.

Neurons allow the brain to learn, reason, and remember. Through the activity of neurons, the body responds and adjusts to changes in the environment. These changes, called stimuli, set off impulses in the sense organs: the eye, ear, organs of taste and smell, and sensory receptors located in the skin, joints, muscles, and other parts of the body.

**Neurons Send and Receive Neurotransmitters**

Every time the body feels something—including the effects of a drug—millions of neurons are firing messages to and from one another. Those messages consist of chemicals and electrical impulses.

Each neuron may have thousands of branches that connect it to other neurons. The branches are called dendrites and axons. Dendrites carry messages toward the cell body; axons carry messages away from the cell body to another neuron. Axons extend for as long as four feet in humans. In some animals, axons are even longer.

At first, scientists thought that axons and dendrites simply ran through the body continuously, like wires. Then they discovered a space between each axon and dendrite. We call this space a synaptic gap or synapse. A synapse is the space between the axon of one neuron and the dendrite
of the next neuron in a nerve pathway. That gap is extremely small: about one-millionth of an inch. Note the synapse in diagram 1.

Researchers originally thought that electrical impulses jumped these gaps, as electricity jumps across the gap in a spark plug. Now we know this is not true. Chemicals—not electrical impulses—travel across the gaps. These chemicals are called neurotransmitters. Today, about sixty neurotransmitters have been characterized in the brain. Undoubtedly, there are many more waiting to be discovered.

The body synthesizes neurotransmitters. Some of the chemical building blocks for neurotransmitters, such as amino acids, come from food. But simply increasing certain foods or food supplements will usually not increase brain neurotransmitters, because the process of brain neurotransmitter function is very intricate, complex, and controlled.

Neurons have places to store neurotransmitters. These storage areas, called vesicles, are located close to the ending of each axon. (See diagram 2.) Neurons synthesize some neurotransmitters right in the vesicles. Other neurotransmitters
are synthesized in the body of the cell and transferred to the vesicles.

**Neurotransmission Occurs in Three Basic Stages**

In many ways, neurons act like computers. That is, they receive messages, process the messages, and send out the results as new messages to other cells. In the case of neurons, the message consists of chemicals that interact with the outer surface of the cell membrane of the next neuron. This chemical interaction with the next neuron’s cell membrane causes chemical changes within the receiving neuron. The changes are the result of how the chemical messages interact with the receiving cell’s binding sites, known as receptors.

One name for the constant exchange of chemical messages between neurons is *neurotransmission*. Neurotransmission involves three basic steps:

1. **The sending neuron releases a neurotransmitter (see diagram 2).**
   
   A resting neuron has a negative charge. That is, there are
more negative ions inside the axon than outside the axon. (Ions are molecules with an electric charge.) In contrast, the fluid outside the axon has a positive charge. Because the outside and inside of the axon have different charges, the axon is said to be polarized.

When a neuron is excited or fires, several events take place to create an electrical impulse. Sodium ions, which have a positive charge, enter the axon. This depolarizes the axon—that is, it changes the electrical charge inside the axon from negative to positive. This change starts at one end of the axon and continues all the way to the other end. In response to this electrical impulse (called an action potential), the vesicles swarm to the edge of the axon and release neurotransmitters into the synapse.

After the neurotransmitters are released, potassium ions flow out of the axon. Potassium ions have a positive charge, so their absence restores the negative charge inside the axon. The neuron is again polarized and at rest, waiting to fire another impulse.

2. **The neurotransmitter binds to a receptor on the receiving neuron** (see diagram 2).

   Neurotransmitters float across the synapse until they contact the dendrites of the next neuron. On each dendrite, neurotransmitters find molecules that are set to receive them. These molecules are called receptors.

   Neurotransmitters are recognized by specific receptors, and these receptors “grab” onto them, a process called binding. (The neuron that originally released the neurotransmitter is the “sending” neuron; the neuron that binds the neurotransmitter is the “receiving” neuron.)

3. **The neurotransmitter changes the function of the receiving neuron.**

   Binding causes a set of chemical reactions within the
receiving neuron. Those reactions start up a similar kind of impulse that was fired in the sending neuron, although some reactions are reduced or modified by the receiving neuron’s receptors. In this way, the original impulse is enhanced or inhibited through the sending neuron—and through the rest of the neurons in a nerve pathway. Many neurons contribute to the message received at the final destination, which is a muscle, gland, or organ. The result is a change in the way the person thinks, feels, or behaves.

**Two Key Implications**

In summary, neurotransmission is all about how nerve cells “talk” to each other. In the brain of a person who’s chemically dependent, something about the “conversation” or neurotransmission has gone awry.

Knowing about the steps of neurotransmission allows us to pose precise questions about the nature of chemical dependence. Instead of simply asking what causes the disease of chemical dependence, we can ask: How does drug use affect the release of specific neurotransmitters across the synaptic gap? And how do drugs affect the ways that neurotransmitters bind to receptors? These questions are the key to understanding that chemical dependence occurs because of a problem (dysregulation) at the cell (neuron) level.

There are many possible answers to these questions, and they are complex. However, neuroscience has two basic implications for clinicians and other treatment professionals. First, dysregulation of neurotransmitters is the core problem in dependence. Second, the symptoms of dysregulation, including impaired control over
drug use, can be overcome with treatment. It is here that the technical findings of neurobiology merge with a larger system of values. That is, treatment is based on the idea that the vast network of neurons in the brain—which creates our uniquely human capacities to learn and to love—is a wonder of nature that deserves to be protected.
HAZELDEN’S CLINICAL INNOVATORS SERIES presents signature topics by industry leaders who define today’s (and tomorrow’s) standards of substance abuse treatment. Watch the video workshop, read the clinician’s manual, then take the posttest.* Staying current and maintaining credentials has never been more convenient.

Richard A. Rawson of UCLA has conducted research and developed treatment systems for substance abuse for more than two decades. The clinician’s manual builds on the content of the video, and it explains why methamphetamine is a highly addictive and dangerous drug, how its use is reaching epidemic levels across the United States, and what treatment strategies work effectively. In five concise chapters, Rawson covers the range of meth issues and clinical tools that you can use with clients. The thirty-question posttest is worth fifteen continuing education hours upon successful completion.

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