


WHAT IS ADDICTION?

EXHIBIT GUIDE FOR TEACHERS

This exhibition is based on current scientific research on addiction. Researchers are analyzing addiction at many levels and from many scientific specialties: cell chemistry, genetics, neural pathways, changes in brain structure and function, people's compulsive activity, and addict's responses to treatment. Addiction is challenging to study because all these levels affect the others, and scientists from different disciplines use different methods. The exhibition illustrates some of the many methods used, including new technologies for looking into the brain.

Addiction has huge social and economic costs. If students are made aware of what is known about the science of addiction, they will understand that addiction is a complicated problem, not easily remedied, and that it is important to avoid addiction. We hope, too, that some of them may become interested in pursuing careers in research.

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ARIZONA SCIENCE CENTER
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Definition: What is Addiction?

Addiction can be viewed as a personal choice, a disease, or a social disorder. These differing viewpoints result in different approaches to research and treatment. Although addicts initially make a conscious choice to engage in a potentially addictive behavior, once someone is addicted, he or she has a problem he or she can no longer control. Just as patients with heart conditions have to exercise and watch their diets for the rest of their lives, an addict is personally responsible for staying addiction-free. To overcome one's addiction, however, social support is also necessary.

Addictions differ from habits and compulsions. **Habits** are activities that a person repeats, often unconsciously, that can be harmless or harmful. Habits usually can be broken, but if deeply entrenched they can become compulsions. **Compulsions** are repetitive behaviors performed irrationally and in a ritualistic manner, often in response to an irresistible impulse. Compulsions may limit the enjoyment of life but usually are not destructive. **Addictions**, by definition, are compulsions that escalate toward harmful social and/or physical consequences. Some behaviors that can be addictive are:

- alcohol abuse
- some eating disorders
- prescription drug abuse
- tobacco use
- impulsive sexual activity
- compulsive gambling
- compulsive spending
- abuse of opiates, psychomotor drugs, and analgesics

Research shows that there is a relationship between addiction to a substance and addiction to an activity. The two classes of addicts behave similarly. Drug addictions cause craving, tolerance, and withdrawal, and have a high likelihood of relapse. Pathological gamblers also experience craving, build up tolerance, feel the urge to increase betting, and experience symptoms of mild withdrawal when abstaining from gambling. When gamblers and cocaine addicts view videos that stimulate cravings for their respective addictions, the same pathways in the brain are activated. Brain scans show that the level of the stakes in a blackjack game affects levels of brain stimulation in gamblers, just as an alcoholic's brain reacts differently to images of soda and of whiskey. Another piece of evidence that points to commonality between addictive behaviors and drug addictions is that a drug that stops opiate users from getting high also inhibits the urge to gamble or steal.

The "Surprising Statistics" panels throughout the exhibition show students how much addictions cost society. Students may also be surprised by what scientists *don't* know about addiction.

Students may have noticed from news reports that some government policies focus on attacking the supply of illegal substances or the opportunities for addictive activities, while other policies focus on reducing demand, through education and treatment. Still other policies advocate a combined strategy that reduces both supply and demand.

Looking at the Brain

At this display, students learn about brain anatomy, advances in brain imaging, and the reward circuit in the brain that is responsible for feelings of pleasure. They can experience a simulated PET scan.

The reward circuit is stimulated by natural rewards, resulting in the production of dopamine, a brain chemical that makes us feel good. Addictive drugs and behaviors also affect the reward circuit, over-stimulating it and eventually desensitizing the brain's response to naturally pleasurable experiences.

Brain imaging is a relatively new tool that helps researchers study chemical activity in the brain. Imaging is usually done using ***functional Magnetic Resonance Imaging (fMRI)*** or ***Positron Emission Tomography (PET)*** scanning. To provide images of the brain's neural activity, fMRI examines blood oxygen levels. Changes in the concentration of levels in the blood are recorded by the fMRI and correspond to brain activity. Note that imaging is used as a research tool, not a diagnostic tool. Brain images cannot predict or detect addiction.

A PET scanner reads positron emissions given off by mildly radioactive substances injected into the patient's bloodstream prior to the scan. Different substances are injected depending on the target organ and type of diagnostics being done. For example, radioactive oxygen is used to check for Alzheimer's disease. A low-level radioactive sugar is used to study other kinds of brain activity.

Researchers continue to improve scanning technologies to produce more precise and faster imaging. FMRI is more convenient and less invasive than PET because radioactive substances do not need to be injected, scan times are shorter, and clearer images are produced. FMRI allows researchers to scan peoples' brains as they carry out certain tasks, such as looking at photos or doing mental calculations.

Students interested in this work may consider careers in:

- Cell Biology
- Computer Science
- Engineering
- Imaging Technology
- Medicine
- Neurology
- Neurochemistry
- Psychiatry
- Experimental Psychology
- Radiology

The Brain Changes Because of Addiction

At this display, students can compare models and images of brains in addicted and non-addicted states to observe the effects of addiction on neural pathways in the brain. They will also see a chart of other changes in the body associated with various drugs.

Currently, major research efforts are focused on understanding when addiction-induced brain changes become permanent. Sometimes brain cells can recover or compensate for damage, but some changes seem to be irreversible. Some researchers suggest this puts former addicts at an increased risk for neurological diseases such as Parkinson's disease.

Researchers have found that the part of addicts' brains that controls craving—the limbic system—can be powerfully activated by environmental cues (like the smell of a barroom) long after drug intake has ceased. At the same time, different cells in the brain that halt craving have become defective: they are slow to activate and are less dense. Research on cocaine users shows that they have problems making decisions. Brain imaging suggests that the parts of the brain involved in reason and judgment are not working normally.

At Brookhaven National Laboratory, scientists have found that former methamphetamine abusers can recover some brain function over time. PET scans show that the number of dopamine transporters (molecules produced by brain cells that remove dopamine from nerve synapses) can return to normal within a year of discontinuing methamphetamine use. But, although methamphetamine-induced brain alterations may be reversible, some functional and behavioral changes due to use of this drug are not.

Scientists have noted a difference between a drug user and an addict. Generally, repeated drug use is necessary to cause the changes in the brain that alter behavior, induce cravings, and cause addiction. First-time drug experiences may not be associated with feelings of pleasure. The user must make a repeated effort to feel the effects of illicit drugs. Thus, becoming addicted seems to involve the user's social setting in critical ways.

Students interested in this work may consider careers in:

- Cell Biology
- Molecular Neurobiology
- Neuropsychology
- Imaging Technology
- Neurochemistry

The Brain Chemistry of Addiction

At this display, students will learn more about the function of dopamine in the brain and the effects of addictive substances and behaviors on the brain's reward circuit.

Dopamine is a chemical messenger that helps to transmit signals between certain neurons in the brain. When dopamine is released into brain synapses (the spaces between the communicating neurons), it activates receptors, causing a sense of pleasure. Neurons release dopamine in areas clustered in three portions in the brain: the nucleus accumbens, ventral tegmental areas (the limbic system), and the frontal cortex.

An example is shown in the exhibit. Cocaine blocks the chemicals that normally remove dopamine from synapses after the neuron has been activated. If dopamine lingers in the synapses for longer than normal, it prolongs the stimulation of receptors and causes pleasurable effects. "Knockout mice" bred at the Howard Hughes Medical Institute by Marc Caron are born without the ability to remove dopamine, so scientists can study the effects of over-stimulation of dopamine receptors in the mice. They have found that as dopamine floods brain synapses in these mice, the mice become hyperactive. In time, this over-stimulation damages or destroys dopamine receptors, reducing their numbers. Soon increased amounts of a drug are required to stimulate the same amount of activity in the mice.

There are different types of dopamine receptors. Individuals may have different ratios of types of dopamine receptors, which could influence an individual's sensitivity to dopamine. These differences might affect their tendencies to develop addiction. Some people born with fewer dopamine receptors may be more prone to addictions because they cannot sense normal amounts of dopamine and consequently take large amounts of drugs to feel even a normal sense of pleasure.

At the molecular level, scientists are studying the structure, regulation, and working of specific chemicals that stimulate cell functioning. The regulation of dopamine (and, consequently, of euphoria) may be a key to central nervous system functioning. Susan Amara's team at the Oregon Health Sciences Institute, however, has found that cocaine may affect processes other than dopamine uptake by cells. Clearly, the effects of psychotropic drugs are complex; researchers need to understand this complexity in order to develop more effective antagonist medications.

Students interested in this work may consider careers in:

- Biochemistry
- Molecular Neurobiology
- Physiological Psychology
- Psychopharmacology

Contributors to Craving and Addiction

This display presents research on visual and environmental cues that can trigger craving.

Having a craving is not a strange or unusual event. We all experience cravings at certain times – the craving to scratch an itch, the craving to finish off that pint of ice cream, the craving to turn off the alarm and go back to sleep. Cravings happen when something in your environment signals a very high intensity reward. An addict's experience with taking drugs at various times and places makes those times and places strong signals for the very high intensity effect of drugs. Just as your craving for a chocolate dessert increases as the meal progresses – as the dessert moves from the words on the restaurant menu to the cake itself right under your nose – so the addict's craving increases as the time and place of drug consumption get closer and closer. The difference between the non-addict and the addict is one of degree, not of kind.

Somehow, in the addict's mind, originally neutral environmental factors— like a particular place— will trigger physical, mental, and behavioral reactions associated with the addiction. The "cues" now reinforce the addiction. Behavior researchers are trying to understand the relation between the environment and the craving response. Some brain research suggests that this is a complicated challenge since the "GO" response (craving) seems to involve different areas in the brain than the "STOP" response. Once addicted, someone's craving circuits are sensitized while their inhibition circuits seem to be weakened, so both systems may need to be addressed in treatment. However, if brain cells are damaged, the addiction may be harder to reprogram or unlearn.

The intensity of cravings has been directly linked to glucose metabolism rates in the brain using PET scans. This is a breakthrough for scientists who can now analyze PET scans to measure objectively the affects of potential treatments for dampening cravings.

People treating addicts try to reduce the power of environmental cues to induce addictive responses. The cigarette smoker will never be able to totally avoid the presence or availability of cigarettes. Therefore, the smoker must learn to break the connection between smoking and all the cues that signal smoking – i.e., the sight or smell of someone else smoking, a cigarette advertisement, the availability of cigarettes, etc.

Researchers at the National Institute on Drug Abuse's Division of Intramural Research are trying to understand the role of craving in relapse. They have discovered that cocaine craving caused by environmental cues affects parts of the brain associated with memory and learning, so cue-induced cravings have an emotional component, too.

Students interested in this work may consider careers in:

- Counseling
- Experimental Psychology
- Psychiatry

Addictive Behaviors

What price do addicts pay for their addiction? Psychologists studying *behavioral economics* have tried to determine how dysfunctional behavioral patterns become established, how they persist, and how they can be changed. To do so, behavioral economists study people's responses to the level of risk associated with various rewards.

This display illustrates research on patterns of preferences for different kinds of "payoffs" (rewards that come sooner or later, smaller or larger) and their connection to compulsive, repetitive behavior.

Our bodies are designed to reward us for doing things that increase our chances of survival. That is why life-sustaining activities such as eating give us pleasure. Other pleasures less connected to survival come from our awareness of a longer-term payoff. For example, someone may feel satisfaction from playing an instrument well (joy from the music, social recognition, etc.) after many hours of less pleasurable practice.

In this research framework, addicts are characterized as choosing short-term rewards, like an immediate high, over long-term ones, like the potential for a long and healthy life. They "live in the present." However, research shows that actions today affect actions tomorrow, making it harder to change one's pattern of choices over time. Furthermore, addicts who develop tolerance choose rewards differently from those who do not.

Like humans, animals such as pigeons and rats seem to prefer immediate, smaller rewards to bigger, delayed rewards. The more often they are allowed to choose this way, the more consistently they opt for the short term. If, however, a cost is attached to the temptations, the value of the smaller-sooner reward to them goes down. Attaching these costs is difficult in the case of addictions, particularly if addicts must evaluate costs for themselves—that is, they must show "self-control."

Research suggests that helping the addict commit to the rewards of longer chains of events is needed in order to balance the short-term payoffs of the addiction. So, if the focus is on choosing to be a safe driver instead of choosing to drink one more shot of whiskey, the alcoholic has more incentive to refrain from drinking. Social support is essential in the prevention and cure of addiction; the more isolated the addict, the less support he or she has for keeping the larger picture in mind.

Students interested in this work may consider careers in:

- Epidemiology
- Psychiatry
- Public Health
- Medicine
- Experimental and Clinical Psychology

Treatment for Addiction

This display explains various approaches to the treatment of addiction.

Research has shown that while overcoming an addiction is hard and relapses are common, it is possible to recover, but a recovered addict will always have to work to avoid relapse. A combination of therapy and aversive medication (anti-craving drugs) appears to be most helpful.

Certain medications, like Naltrexone or Methadone, help reduce cravings and compulsive behavior. Therapeutic programs target the addict's social isolation, help him or her develop better decision-making skills, and introduce stress reduction techniques. Groups like Alcoholics Anonymous, Narcotics Anonymous, and Gamblers Anonymous encourage their members to rely on support groups that provide recovering addicts with a needed sense of community.

Central to effective treatment of addiction is reprogramming or "extinguishing" the environmental cues associated with craving. Researchers have found that relapse in 75% of addicts can be attributed to these triggers. In some experiments, addicts are given the trigger without the "high" that followed it in the past. The power of triggering then decreases over time.

Researchers are studying different kinds of treatment, such as school- or workplace-based interventions and therapeutic communities, to see what makes them more or less effective. Unfortunately, relatively little systematic research has been done on which therapies work best for which types of people or types of addiction.

Some research looks closely at people's interactional styles, for instance, among family members, and how they may contribute to a person's addiction. Analyzing videotaped therapeutic sessions, researchers have shown, for instance, that couples may unwittingly reinforce one spouse's drinking problem by the kind of language, body movement, and timing of their interactions. Family therapy often addresses interaction patterns among the family members and tries to help members of the addict's family become aware of their effect on each other.

Students interested in this work may consider careers in:

- Counseling
- Psychiatry
- Social Work
- Experimental or Clinical Psychology
- Public Health

Risk and Prevention

At this display, students can take self-assessment tests to determine if they are at risk for an addiction.

Tests like these are useful as research tools to gauge a person's level of addiction. The self-assessment tests presented here are derived from clinical practice about factors involved in addiction. Criteria identified here may shift as researchers learn more about the components of addiction.

A person who is addicted to one substance is relatively more likely to become addicted to something else or to be suffering from related psychiatric disorders like depression or trauma. Researchers are addressing the common problem of "co-morbidity" by looking at interventions that address multiple problems simultaneously.

Students will also read about a large-scale research program that is looking for genetic markers for many addictions. Studying family genetic histories has shown that certain families are predisposed to problems such as alcoholism. For instance, 30% of males with an addicted parent will become alcoholics, as will 15% of females. It has also been possible to breed rats in the lab with an increased likelihood of drug addiction. However, patterns of addiction in families can occur for many reasons.

Although susceptibility to addiction may be partially genetic, a person's environment also affects his or her risk of addiction. Some studies, for instance, explore the concept of "gateway" drugs or behavior; the premise is that young people begin participating in addictions at one level but go on to further experimentation. Gateway substances such as nicotine and alcohol increase young people's likelihood of experimenting with illegal drugs, according to a study from the Center on Addiction and Substance Abuse at Columbia. Marijuana is also considered a gateway drug.

Students interested in this work may consider careers in:

- Counseling
- Epidemiology
- Psychiatry
- Education
- Clinical Psychology
- Public Health

Additional Resources

ATOD-TV Teacher's Guide, University of Missouri-Columbia School of Medicine. Contact: Continuing Education, Missouri Institute of Mental Health, 5400 Arsenal, St. Louis, MO 63139. (314) 644-8803.

Mind Over Matter, National Institute on Drug Abuse and National Institutes of Health and www.sarasquest.org. Contact: National Clearinghouse for Alcohol and Drug Information, P.O. Box 2345, Rockville, MD 20847. 1-800-729-6686.