



# The Biology of Addiction

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# Aboriginal populations in the Americas have utilized various psychogenic natural products for spiritual, medicinal, and recreational purposes.



- **Ayahuasca**: Used by Indigenous tribes in the Amazon basin, this brew is made from the Banisteriopsis caapi vine and other plants. It is known for its powerful hallucinogenic properties and is used in spiritual and healing ceremonies.
- **Peyote**: This small cactus, containing the psychoactive compound mescaline, has been used by Native American tribes in Mexico and the southwestern United States for religious rituals and healing. San Pedro Cactus is similar to peyote, this cactus contains mescaline and has been used by Indigenous peoples in the Andes for healing and spiritual purposes.
- **Psilocybin Mushrooms**: Various Indigenous groups in Mesoamerica have used these mushrooms, which contain the psychoactive compound psilocybin, in religious and healing ceremonies<sup>2</sup>.
- **Tobacco**: It has been used by many Indigenous cultures in the Americas for its stimulant and ceremonial properties<sup>2</sup>.

*These natural products have played significant roles in the cultural and spiritual lives of Indigenous peoples across the Americas.*

# What is addiction?

*Addiction is a chronic brain disease in which a person regularly finds and uses drugs, or regularly does something (such as gambling) despite the negative things that can happen. It is a brain disease because addiction can change how the brain works. Besides harming a person's health, it can change how someone thinks and feels. This may last a long time, lead to other harmful actions, and cause difficult relationships with family and friends. Without treatment and recovery, addiction may keep getting worse.*

\*Modified from ASAM Definition of Addiction

[www.asam.org/for-the-public/definition-of-addiction](http://www.asam.org/for-the-public/definition-of-addiction)

# EVOLUTIONARY PERSPECTIVE

The traits that make humans susceptible to addiction may have had benefits in ancestral environments.

## *Examples:*

- The ability to seek out and consume high-calorie foods was advantageous for survival (adaptive). However, in modern environments with easy access to addictive substances, these same traits can lead to harmful behaviors (maladaptive).
- Some addictive substances, like nicotine and opioids, are derived from plants that evolved these chemicals as defense mechanisms. We humans have co-evolved with these plants, leading to the development of both adaptive and maladaptive consumption of these natural products.

# Addiction is an illness that affects brain chemistry and brain structure of the patient

*“A common misperception is that addiction is a choice or moral problem, and all you have to do is stop. But nothing could be further from the truth,” says Dr. George Koob, director of NIH’s National Institute on Alcohol Abuse and Alcoholism. “The brain actually changes with addiction, and it takes a good deal of work to get it back to its normal state. The more drugs or alcohol you’ve taken, the more disruptive it is to the brain.”*

<https://newsinhealth.nih.gov/2015/10/biology-addiction>



*Addiction is an illness that affects brain chemistry and brain structure of the patient*

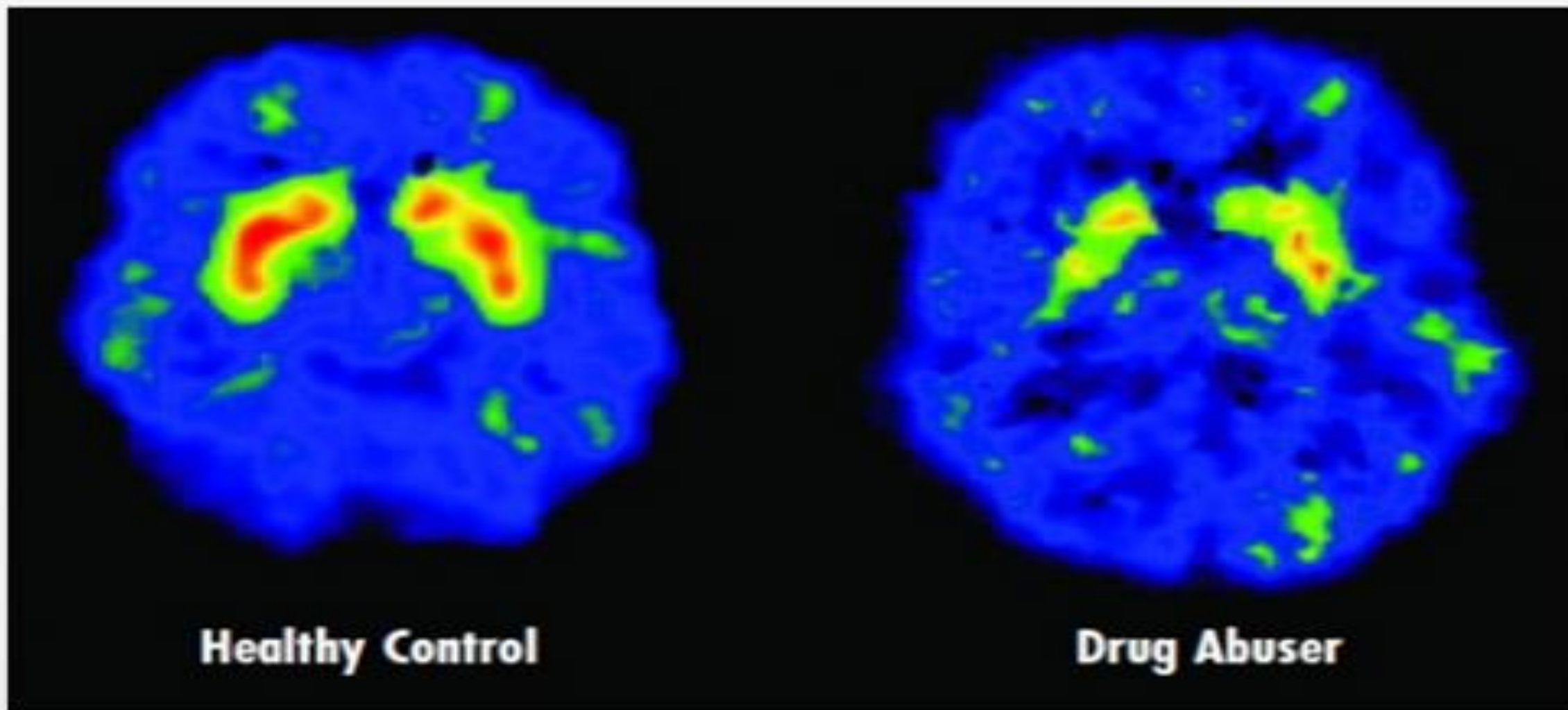
Scientists believe that these changes alter the way the brain works and may help explain the compulsive and destructive behaviors of addiction.

In 1954 Dr's Olds and Milner demonstrated on mice how substances can take over the brains "pleasure center".

# *Addiction is an illness that affects brain chemistry and brain structure of the patient*

- Brain imaging studies from people with substance use disorders show changes in areas of the brain that are critical to judgment, decision making, learning and memory, and behavior control.
- Beginning with CT scans, MRI's then moving to PET scans, the evidence of brain alteration related to substance use disorder became evident.

## Decreased Dopamine Transporters in a Methamphetamine Abuser



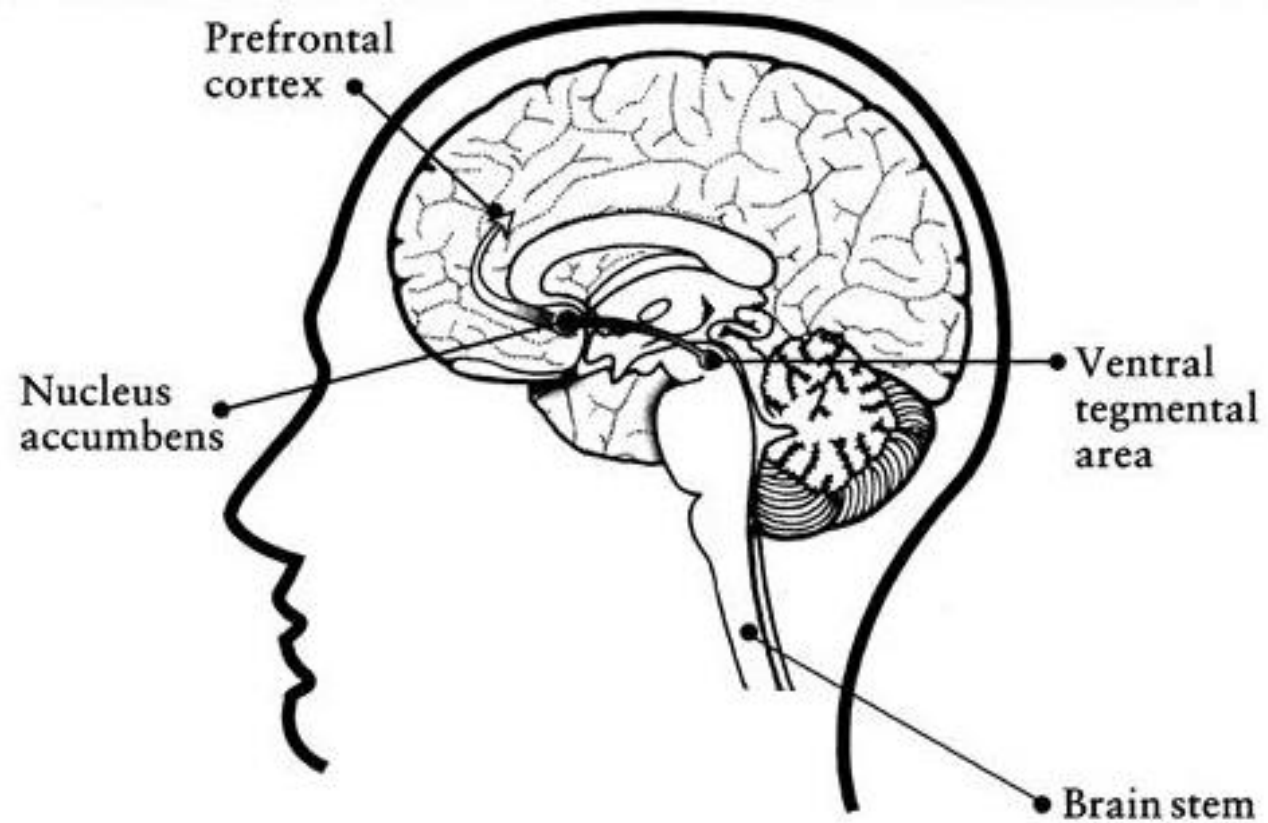
Methamphetamine abusers have significant reductions in dopamine transporters.  
*Source: Am J Psychiatry 158:377-382, 2001.*



# How does addiction affect the substance use disorder patient?

- It has a lot to do with brain chemistry.
- The human brain is wired to reward us when we do something pleasurable. Exercising, eating, and other behaviors that are directly linked to our survival trigger the release of a neurotransmitter called *dopamine*.
- This not only makes us feel good, but it encourages us to keep doing what we're doing. It teaches our brains to repeat the behavior.

# Brain Structures



# Structures of the Brain

These (4) areas are most affected and changed with addiction



## Prefrontal Cortex

*Intelligently regulates our thoughts, actions and emotions through extensive connections with other brain regions.*



## Nucleus Accumbens

*Mediating motivational and emotional processes, the limbic-motor interface, and the effects of certain psychoactive drugs.*



## Amygdala

*It's a major processing center for emotions. It also links your emotions to many other brain abilities, especially memories, learning and your senses.*



## Hippocampus

*Its main function is to keep your body in a stable state called homeostasis. It does its job by directly influencing your autonomic nervous system or by managing hormones.*

# Why do we have a reward system?

To ensure survival, if something beneficial the reward center of the brain complete the following actions, a release of Dopamine, and a memory of that action is created.



## Hunt and Gather

*Since the dawn of time humans have sought FOOD. Each of us remember a great restaurant, or a special family meal. We all know how “good” it feels to enjoy that meal.*



## Procreation

*The continuation of the human race requires procreation, so in general sex releases dopamine and a memory of that feeling is collected.*



## Escape/Success

*In earlier times, escaping a situation that could leave the person injured or worse released dopamine and created a memory of what and how was done. It is more common today, for some success to replace that process.*



## Creature Comforts

*A dwelling that is “warm and dry”, a comfortable chair and bed, Great movies or TV shows, special times with family and friends all release dopamine and create a memory.*

# What substances can cause this change in the brain?

*We are exposed to billions of chemicals each day, but only a small fraction can lead to this path of addiction.*

X

## **Opiates**

(morphine, heroin, oxycodone, hydrocodone fentanyl)

X

## **Stimulants**

(Cocaine, amphetamine, methamphetamine, methylphenidate)

X

## **Tobacco Products**

(nicotine)

X

## **Alcohol**

(ethanol)

X

## **Marijuana**

(cannabinoids)



# What substances can cause this change in the brain?

We are exposed to billions of chemicals each day,  
but only a small fraction can lead to this path of  
addiction

## **PCP**

(phencyclidine or “angel dust”, ketamine)

## **Sedative/Hypnotics**

(barbiturates, benzodiazepines)

## **Psilocybin**

(magic mushrooms)

## **MDMA**

(ecstasy)

# How substances hijack the brains reward center



- The reward system is one of the most ancestral parts of the brain that developed to get humans to learn, work and reproduce.
- The brain's reward pathway is a network that releases dopamine, a feel-good hormone responsible for the pleasure and satisfaction you feel after eating a good meal, buying a nice outfit or having sex.
- When you perform an action that stimulates dopamine release, a feedback loop is created that drives you to repeat it so you can keep feeling good. This creates a vicious cycle
- Drugs such as caffeine, nicotine, cocaine and opioids make your brain release **10 times more dopamine** than regular pleasurable activities. Once the reward system experiences that dopamine rush, it keeps wanting more, creating a feedback loop that encourages you to use drugs to experience the flood of pleasure throughout your body.

# How substances hijack the brains reward center



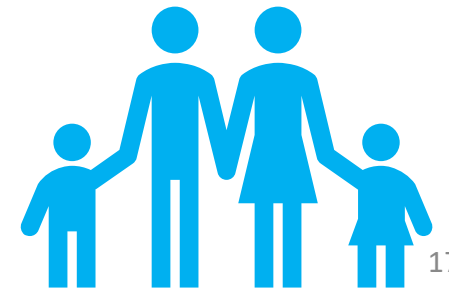
- When you continuously abuse drugs, you get to a point where the same quantity of the drug doesn't produce the same dopamine rush as when you first started using. This condition, known as tolerance and then worsening to **DEPENDENCE** is another type of feedback loop in addiction.
- When your brain lowers its dopamine production, your reward system prompts you to use more drugs to obtain earlier levels of pleasure. Thus, if you initially got a dopamine rush from drinking a glass of wine, you'd have to double or triple the quantity to get the same pleasurable feeling.
- Drugs change the way your reward system perceives pleasure. When you stop using, your brain stops producing dopamine in response to non-drug activities that used to give you pleasure. This causes negative changes in how you think, feel and behave. These psychological withdrawal symptoms can lead to [anxiety](#), [anger](#) and [depression](#). The easiest way to stop experiencing this negative feedback loop is by continuing to use drugs.

# Is biology the only reason for substance use?

Several risk factors can make someone more likely to become addicted to drugs. These include things like:

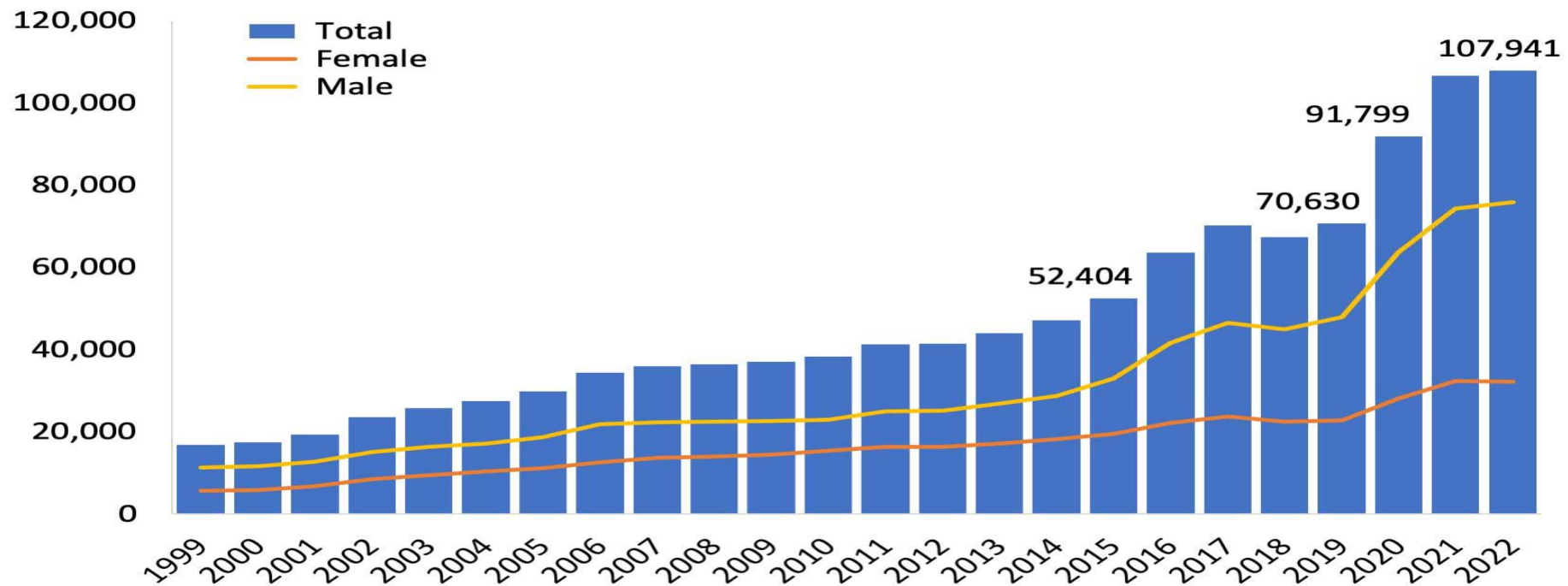
- Having a mental health disorder
- Coming from a family with a history of addiction
- Having friends or family members who use drugs
- Exposure to trauma or stress
- Easy access to drugs

Not everyone who uses drugs will become addicted, but it's essential to be aware of the risks. If you or someone you know is struggling with addiction, help is available.



# Why is treatment so important?

Figure 1. National Drug Overdose Deaths\*, Number Among All Ages, by Sex, 1999-2022



\*Includes deaths with underlying causes of unintentional drug poisoning (X40–X44), suicide drug poisoning (X60–X64), homicide drug poisoning (X85), or drug poisoning of undetermined intent (Y10–Y14), as coded in the International Classification of Diseases, 10th Revision. Source: Centers for Disease Control and Prevention, National Center for Health Statistics. Multiple Cause of Death 1999-2022 on CDC WONDER Online Database, released 4/2024.



# What is the “hidden” sequela of substance use disorder?

Addiction is a progressive disease, which means it gets worse over time. As someone continues to abuse drugs or alcohol, they will experience more and more negative consequences. These can include things like:

- Relationship problems
- Job loss
- Financial difficulties
- Health problems
- Legal trouble



# So why is substance use disorder so hard to treat?

- In a “nutshell”, those substances listed earlier in this presentation “hijack” the rewards center of the brain, in doing so the substance becomes the only source of any substantial dopamine release.
- Food, sex, success, or being warm and dry take a “backseat” to use of the substance, since none of them provide any close to same “reward” as do the chosen substance.
- With each use, there is an increase in tolerance, so it requires more and more of the chosen substance to elicit any dopamine response. Soon it takes what most would consider an exorbitant amount of the chosen substance to elicit even the smallest dopamine response.
- With this, the chosen substance becomes the **ONLY NEED** for the addicted person, who becomes dependent.

# So why is substance use disorder so hard to treat?



It would be easy to think that if the patient just stopped using then everything would go back to “normal”. Unfortunately, it may not be that easy.

- There can be significant risks in abruptly stopping alcohol, benzodiazepines, and opiates.
  - Besides the uncomfortable withdrawal symptoms, there is a risk of death in sudden discontinuation of these substances.
  - Most of us have heard of Delirium Tremors (DT’s) secondary to alcohol withdrawal (this is a risk in benzodiazepine withdrawal as well). This can be a life-threatening event.
  - The Food and Drug Administration (FDA) has issued a warning to all health care providers identifying risk of harm from sudden discontinuation of opioids.
    - Those risks include
      - serious withdrawal symptoms
      - Uncontrolled pain
      - Psychological distress
      - Suicide

# So why is substance use disorder so hard to treat?



*One of the most significant hurdles preventing the treatment of many substance use disorders is withdrawal. Many people who have never had a substance abuse problem don't understand that "quitting cold turkey" isn't a viable option.*

*Aside from feeling awful, withdrawal can cause many other issues, making it nearly impossible for a person to function. Recovering from a substance use disorder takes time, commitment, and, most importantly, support.*

# So why is substance use disorder so hard to treat?



- Alcohol withdrawal has long been known as a potential life-threatening event, with treatment protocols generally standardized utilizing evidence based objective scales such as Clinical Institute Withdrawal Assessment for Alcohol (CIWA) and Alcohol Use Disorders Identification **Test** (AUDIT) screenings
- Withdrawal from opiates is often thought of as very uncomfortable, but until recently not thought of as life threatening. However, recent research describes with more powerful opiates, and increased tolerance the risk of dehydration along with electrolyte imbalances have shown that the risk of death is substantial with opiate withdrawal as well
- The symptoms of opioid withdrawal are severe and intense – it is difficult for someone who has not experienced opioid withdrawal to understand how uncomfortable it can be. People describe opioid withdrawal as “the worst I have ever felt in my whole life.” Sometimes they use words like “horrible” or “terrible.”
  - These symptoms are so awful that they can drive people to do things they would typically never do just to make them disappear.



# Treatment options for substance use disorder.

- Treatment can occur in several different places or settings depending on the medication used, the patient's situation and other factors.
- Four broad treatment settings should be considered:
  - ASAM Level 1 (outpatient),
  - ASAM Level 2 (intensive outpatient or partial hospitalization), and
  - ASAM Levels 3 and 4 (residential addiction treatment or hospital settings)

# What does treatment “look like”?

## Development of a treatment plan



- After the assessment, the clinician will discuss all recommended treatment options with the patient. Every patient situation is different, so choosing the best options is a shared decision between the patient and the clinician.
- Treatment Planning
  - The treatment plan should include:
    - Visit schedule to meet with clinicians
    - Medications (if used) frequency and dose
    - Patient commitment to cooperate with treatment
    - Risks of relapse and other safety concerns
- Patient Participation
- Support from Family and Friends

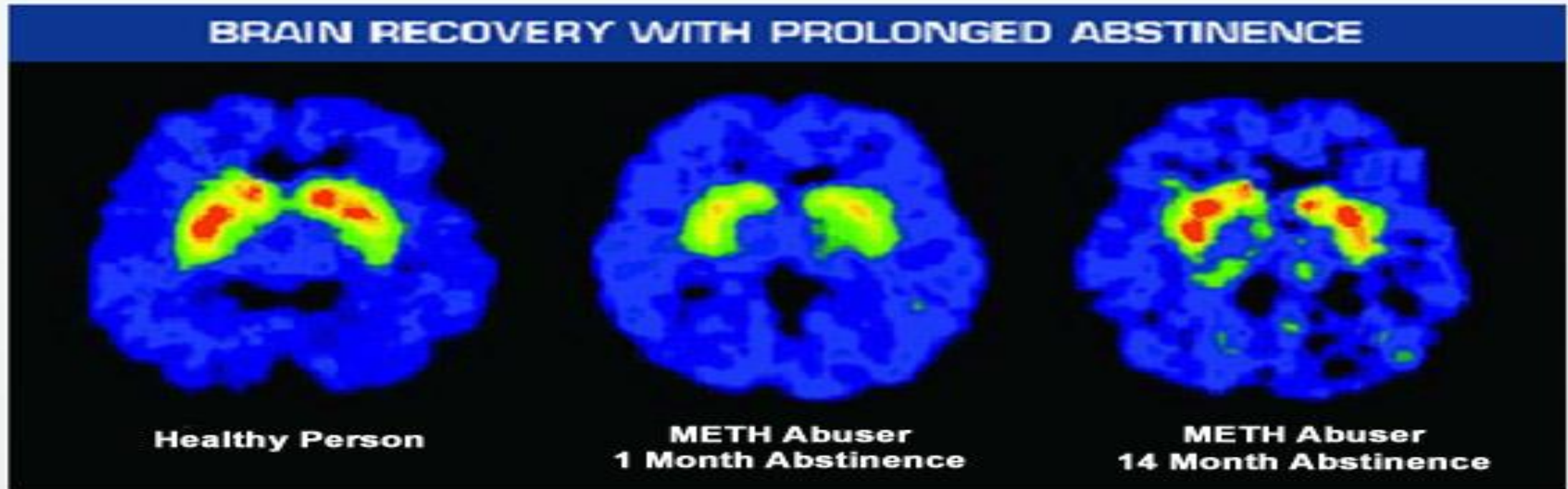
# Treating Addiction with Science.



*Fortunately, addiction is a treatable disease. There are a number of effective treatment options available, including:*

- **Medications** – Many medications can be used to help people addicted to drugs or alcohol. These can help reduce cravings, manage withdrawal symptoms, and improve the chances of long-term recovery.
- **Therapy** – Therapy can be an important part of addiction treatment. It can help people identify the underlying causes of their addiction and develop healthy coping skills.
- **Self-help groups** – Self-help groups like Alcoholics Anonymous or Narcotics Anonymous can be a valuable resource for people in recovery. These groups provide support and accountability, which can help people stay on track with their sobriety.

# What does treatment “look like”?



*Source: The Journal of Neuroscience, 21(23):9414-9418. 2001*

These images of the dopamine transporter show the brains' remarkable potential to recover, at least partially, after a long abstinence from drugs - in this case, methamphetamine.<sup>26</sup>

# Final Thoughts

- Addictive substances have been around longer than the United States.
- Treatment has and continues to evolve rapidly
  - Unfortunately, the stigma of addiction remains although in recent years we have seen a decrease in the stigma among both health care professionals as well as with the public.
  - With an increasing understanding of substance use disorder as a chronic biological illness, that requires treatment (possibly for life) just as diabetes and hypertension we hope to see a continued reduction of stigma.

# Questions??

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