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How Addiction Lights Up Our Brains:

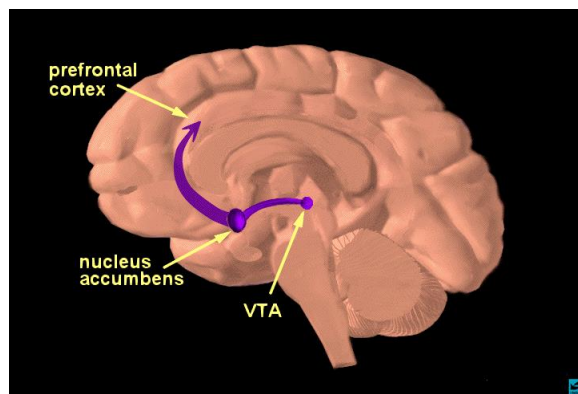
Reviewing how the Neurotransmitters Dopamine and Glutamate affect Addiction

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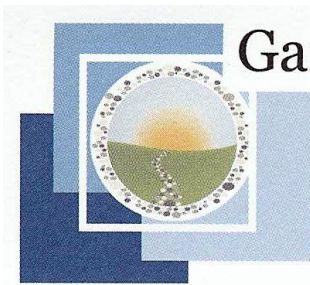
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When we eat great lasagna, get a warm hug or compliment, use a drug or addictive behavior, or even anticipate one of these: *our brain lights up!* What happens in the brain when we experience pleasure—including the pleasure induced by addictive behavior? Briefly, three core areas of the brain and two neurotransmitters play a role in eliciting the pleasure or the “high”. Addictions to alcohol, drugs, gambling and problematic behaviors, interrupt the normal balance of the brain and neurotransmitters. They can have lasting negative effects on the addicted person, but with recovery and abstinence the brain can re-set itself so that they can again find joy and fulfillment in things other than the addictive behaviors. Each day we are learning more and more about how the neurotransmitters in our brain affect our behavior. The way it “lights up our brain” can be quite complex, but for simplicity sake, this article will look at just two neurotransmitters and three parts of the brain.

Three areas of the brain affected by addiction are the *Ventral Tegmental Area (VTA)*, the *prefrontal cortex*, and the *Nucleus Accumbens (NA)*. (See illustration) The VTA and NA are



parts of the midbrain. They are the ancient survival areas of the brain that store information at the subconscious level. The midbrain is responsible for survival and moment-to-moment living. It does *not* think or make decisions; it is a life-or-death processing station for signals detected through the five senses. It primarily focuses on the "eat, kill, and sex" survival mechanism. Most importantly, it is the “pleasure center” of our brains. The midbrain holds involuntary memories that are activated by our senses, which are woven together into perceptions. Ordinarily, the prefrontal cortex keeps the midbrain in check. However, with addiction, the midbrain becomes more powerful than the prefrontal cortex at guiding behaviors. Addictive chemicals or behaviors stimulate the unconscious survival centers in the midbrain. With addiction, the communication between the prefrontal cortex and the midbrain is impaired. The addicted person reacts to what feels good at the moment without any concern for the consequences.



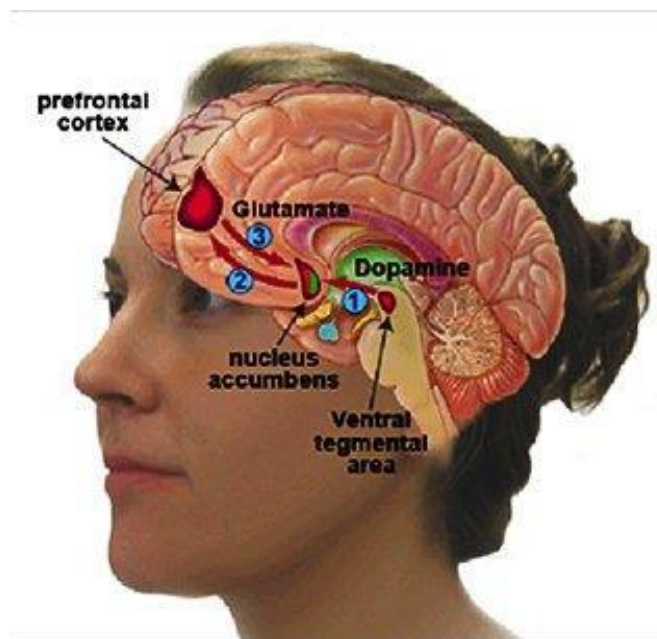
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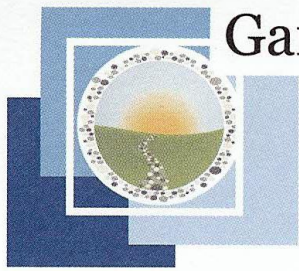
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Therefore, in addiction, a new survival hierarchy is created, instead of eat, kill and sex, the *hierarchy starts with the addiction or the drug first* and then is followed by eat, kill and sex.

When we smell the roses, have a great meal or an intimate encounter, the neurotransmitter *dopamine* is released in the VTA and NA which are located in the midbrain area between our ears. This dopamine is sent to the NA, which “measures” the degree of pleasure of the dopamine. If the level of dopamine is high, the pleasure experienced will be high. When stimulated by dopamine, the NA secretes another neurotransmitter, *glutamate*, which stimulates the prefrontal cortex. This part of the brain remembers what led up to this pleasurable experience or “high”. Our prefrontal cortex at our forehead “lights up” when these neurotransmitters are secreted and we delighted and pleased. Since glutamate is the most abundant excitatory neurotransmitter, it instructs our cortex to remember pleasant experiences or tastes and screams: “Remember this Baby!” That is, glutamate locks the pleasurable experience into the memory centers of our brains. In simple words, the brain is learning and remembering our great and not so great experiences.

Now enter an addictive behavior or addictive use of a chemical. Again, the VTA releases dopamine and stimulates the NA to perceive and judge the *degree of pleasure* and in turn secretes glutamate. Dopamine could be symbolized as a green hose filled with excitatory dopamine that floods the NA (step 1 in the figure below) and then glutamate is released in the brain. Remember glutamate is the neurotransmitter that helps lock the drug or addictive “high” into memory. Glutamate can be thought of as a red hose that floods the prefrontal cortex imprinting very powerful memories. When glutamate stimulates the cortex, it responds “Oh baby, I remember this one!” In addition, the excess glutamate in the cortex loops back in a harmful cycle between the prefrontal cortex and the NA (steps 2 and 3 in figure below), triggering drug seeking behaviors at the expense of naturally rewarding behaviors. This cycle is depicted in the following figure.





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We already know that pleasurable things cause the brain to produce dopamine. But drugs and addictive behaviors release *far more* dopamine than the brain was ever meant to handle. Drugs fool the brain into feeling great at first, and then the drug is viewed as necessary for survival; even before proceeding with the normal hierarchical response of survival: eating, killing and sex.

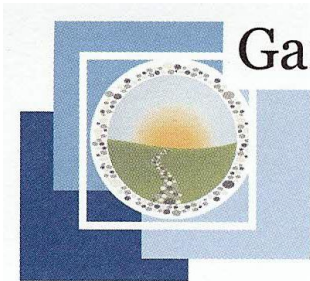
Even the “expectation” of a reward like a hug or a drug can trigger dopamine release in the VTA. The brain is out of balance and mind-altering substances slowly rob the cortex of so-called “synaptic plasticity”. When this happens the neurotransmitters do not communicate well with each other. The loss of this synaptic plasticity triggers many addictive urges. Because the synapses are damaged, the addicted person has problems resisting these urges and may relapse.

Now for the addict, the drug IS survival. Even chain smoking and the use of caffeine can trigger the harmful dopamine \leftrightarrow glutamate cycle that can feed the addiction. After the dopamine is sent up to the NA, glutamate, another neurotransmitter locks the drug or addictive experience into memory. And if this isn't bad enough, drugs wipe out the dopamine \leftrightarrow glutamate connection and balance. This detrimental cycle becomes stronger and stronger with repeated addictive behavior creating “super-duper memories” which can last for many years after abstinence and leave the addict vulnerable to relapse.

In addiction, the green dopamine and red glutamate neurotransmitters flood the craving brain. Addictive behaviors like gambling, eating, and the use of drugs “increase the reward threshold for these behaviors and desensitize the brain to rewards obtained from normal biological cues. This helps explain why addiction seeking behavior can take over a person's life and can cause them to abandon their friends, families, jobs and even engage in illegal behaviors to obtain the drug.” (NeuroScience) The harmful dopamine \leftrightarrow glutamate imbalance deadens the pleasure obtained from normal rewards such as food, water, and intimacy. The addict is only able to feel *pleasure*, or perhaps only feel *normal*, when using the drug or engaging in the addictive behavior. The inability of the addict to feel pleasure can result in the depression associated with the withdrawal syndrome. To avoid the withdrawal, the addicted person continues engaging in the addictive behavior.

Some still question whether or not alcohol and chemical dependency are a choice or a disease. The disease model is supported by the following observation. If an alcoholic is offered a drink and told that if they drink it they will be shot and killed, they may not drink it at that moment, yet they may still *crave* it in their brain. The NeuroScience article continues, “Drugs increase the activity of the reward pathway by increasing dopamine transmission. Thus addiction is truly a disease of the brain. Increased dopamine over-stimulates the normally calm, balanced NA into eliciting rapid dopamine and glutamate reactive and strengthening mechanisms.” The normal “green hose \leftrightarrow red hose” cycle is altered and maintained through repeated use of the alcohol or the addictive behavior. Furthermore, as noted earlier, addiction affects the prefrontal cortex, the area of the brain that is used in decision making. Those who recognize addiction as a disease admit that the behaviors of addicts may be seen as frustrating and sometimes amoral, but they are *symptoms of the addiction* and not the causes of the addiction.

The disease model of addiction was formulated over 100 years ago. In a wonderful new DVD lecture, Dr. Kevin McCauley explains that in order for a disease to exist there must be a defect in an organ, and as a result, there must



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be symptoms of this defective organ. For example, if someone breaks a leg, the femur is broken resulting in pain and trouble walking. A diabetic has problems with insulin release from the pancreas which can cause blindness and bad circulation. Similarly in addiction, the affected organ is the midbrain, the defect is stress, and the symptoms are loss of control, craving, and persistent use despite adverse consequences. Dr. McCauley proposes that addiction is, "Pleasure Unwoven" because there is a defect in the reward process of the brain.

Drugs and addictive behavior fool the brain into feeling great at first, and then the drug/behavior is viewed as *necessary for survival*. Remember dopamine is the chemical of pleasure. It tells us when a reward is better than expected. If it is less than expected, less dopamine is released. Again, addiction impairs the brain and the balance between the "green dopamine and the red glutamate hoses" filled with neurotransmitters. If the brain is out of balance, emotional attachments and decision making are invisible to the addict. When the frontal cortex fails, the addicted person's prior commitment to quit, memory of past use, love of family, and knowledge of punishment are all invisible to them. This involves denial and a damaged brain. The craving disease process is an intense, emotional experience.

We know the most about the effects of alcohol and drugs on the brain. Other addictions like gambling, sex, food, co-dependency, internet games and other addictive behaviors also "light up the brain". Just ask the person who is repeatedly getting high on it! Abstinence from the chemical or behavior allows the brain to recover and return a balance between the green dopamine \leftrightarrow red glutamate neurotransmitters. Stress and life pressures test this balance and can cause cravings. Even the expectation of a reward from a hug or a drug can trigger the dopamine release. The brain is out of balance and mind-altering substances slowly rob the cortex of its synaptic plasticity or flexibility. When this happens the green \leftrightarrow red neurotransmitters do not communicate well with each other. The loss of this synaptic plasticity triggers many addictive urges. Because the synapses are damaged, the addicted person has problems resisting these urges and may relapse.

Involvement with healthy, supportive people who have had similar experiences helps speed up the recovery process. People with addictive backgrounds must expand their lives much beyond one or two things that bring them pleasure. Treatment for addiction involves much more than just abstinence. Multiple healthy behaviors, psychotherapy and supportive people in programs like 12 step groups decrease stress and cravings. With treatment, the brain's pleasure centers can re-set themselves and balance the green dopamine \leftrightarrow red glutamate neurotransmitters. Addicted persons can recover and live full, happy, productive and serene lives.

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