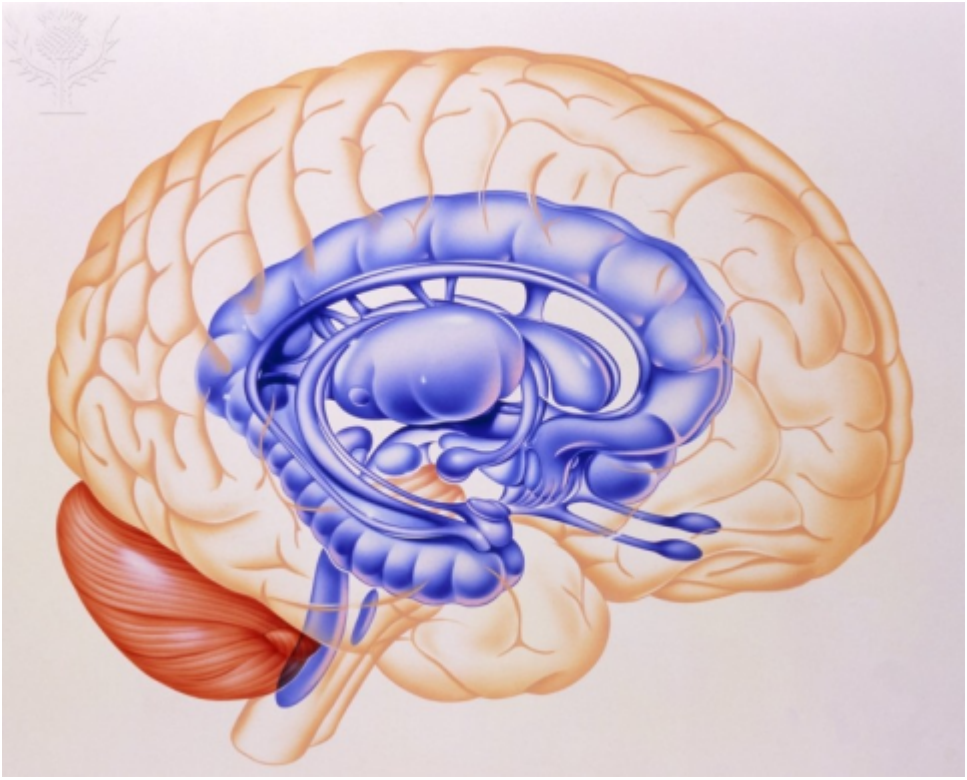
11.3.1

The Limbic System

The limbic system is probably the most primitive region of the cerebrum and hence is involved in some of the basic survival functions of the brain, namely; memory, reproduction and nutrition. This system is composed of several nuclei (clusters of cell bodies), the most conspicuous of which are the hippocampus, the cingulate gyrus and the amygdala. The image below highlights the components of the limbic system in blue. It is linked to the diencephalon and most of the output from the limbic system passes through the hypothalamus. As such it is closely tied to the autonomic nervous system. The limbic system functions as our emotional center, and yes, guys have a limbic system as well. As mentioned above, the limbic system also plays a role in the formation of memories. It is thought to play a role in remembering where food is found and the pleasure associated with eating. Additionally, it remembers the pleasure from sex as damage to this area results in voracious appetites for food and/or sex. The functions of two important structures of the limbic system, the hippocampus and the amygdala are explained below.



Limbic System (in blue). *© 2013 Encyclopædia Britannica, Inc. Downloaded from Image Quest Britannica; BYU-Idaho.*

Hippocampus

The hippocampus is involved in various processes of cognition and spatial memory, or the what, when, and where of memory. In addition, the hippocampus is very important in learning. In fact, neurologists have observed increases in

neuron numbers in response to training of a task which ultimately resulted in vast improvement in the learning of the task.

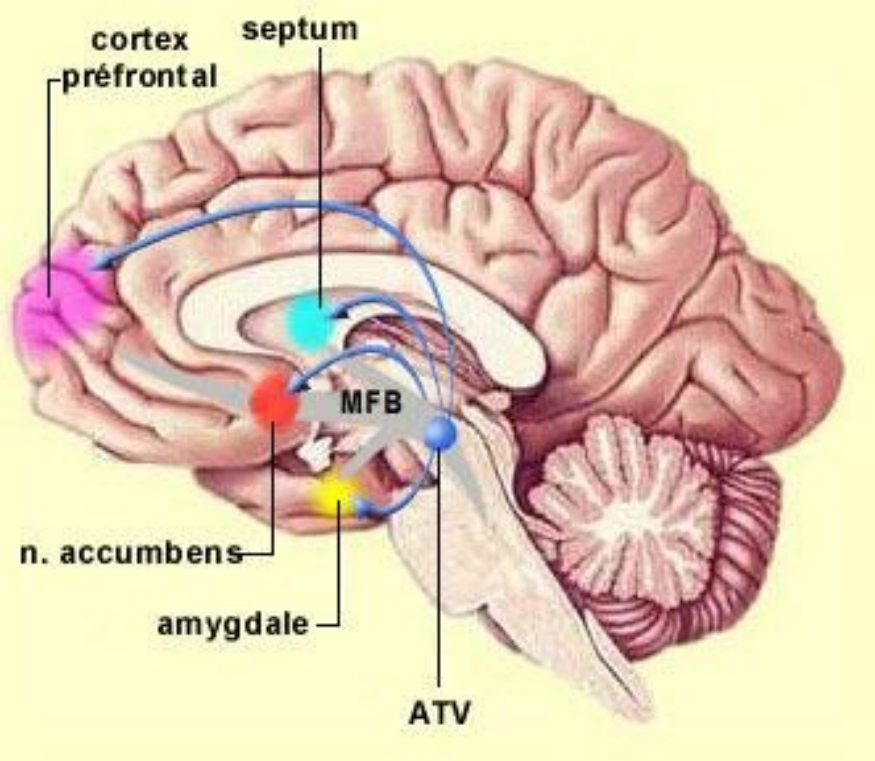
Amygdala

The amygdala is also involved in many cognitive processes and memory but in contrast to the hippocampus the amygdala functions in episodic and autobiographical types of memories. In addition, the amygdala is important in maintaining attention. In fact, if you have gotten this far in your reading you are probably not amygdala challenged. A function that appears to be specific to the amygdala is social processing, in particular facial recognition and the evaluation of first impressions. The amygdala is also involved in "fear conditioning". Stimuli that we might regard as frightening trigger the amygdala to help us form a fear memory. If similar stimuli occur in the future, the amygdala will help us recall the memory and experience fear again.

The Reward Center

Because addictions are becoming such a problem in modern society we have added the following section to describe the physiology of addiction.

The reward pathway consists of five brain structures: the nucleus accumbens, the ventral tegmental area (also called area tegmental ventral or ATV in the picture below), the amygdala, the septal nuclei (septum), and the medial forebrain bundle (MFB).



Reward Centers of the Brain. *Downloaded from Wikimedia Commons Dec 2013; Author: lecerveau.mcgill.ca; Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported*

The Nucleus Accumbens

The nucleus accumbens is a collection of neurons that play major roles in reward, pleasure, laughter, addiction, aggression, fear, and the placebo effect. In short, the nucleus accumbens is very important for motivation and pleasure. This structure has also been linked to addiction and depression as damage to the nucleus accumbens results in lack of motivation and loss of addictive behaviors. The nucleus accumbens uses dopamine and serotonin as the preferred

neurotransmitters. In response to dopamine secretion the nucleus accumbens elicits feelings of pleasure while serotonin release has a calming influence. The surge of these neurotransmitters during addictive behaviors triggers the neural activity that is correlated with the sensation of reward. Studies have shown that when individuals crave a substance, their neural activity increases in anticipation of the future pleasure.

The Ventral Tegmental Area

The ventral tegmental area is a collection of cell bodies that release the neurotransmitter dopamine (dopaminergic) in response to rewards. It is important in cognition, motivation and intense love emotions. The neurons project to numerous areas of the brain, in particular the nucleus accumbens. Neurons in the ventral tegmental area respond to novelty, unexpected rewards and rewards that are predictive (rewards that the brain has previously learned are rewarding). Under resting conditions the dopaminergic neurons are phasic, with release of dopamine occurring at predictable consistent rates. However, when a stimulus is received the neurons send multiple action potentials to the nucleus accumbens which results in the increased release of dopamine. The artificial release of dopamine by the ventral tegmental neurons can occur in response to heroin, cocaine, alcohol, opiates, marijuana, nicotine and amphetamines. The effect of these drugs is to prolong the action of dopamine on the nucleus accumbens. Repeated use of drugs results in functional changes within the reward circuitry induced by both molecular and cellular adaptations. In response to the functional changes, the body adapts to the increase in dopamine release so that normal release of dopamine is not sufficient to reward the brain. In response, the body enters a state where the drugs become necessary to restore the normal homeostatic state. In animal studies, even after the final stages of withdrawal have passed, an organism will "re-enter" the addictive state if the exposed again to the drug.

Amygdala

As already stated the amygdala neurons are involved in the formation and storage of memories associated with emotional events. Studies have shown that the greater the emotional arousal that occurs with a learning event the greater the retention. The amygdala is also associated with social interactions. Loss of function of the amygdala is associated with loss of fear and the loss of the ability to discriminate between animate and inanimate objects. It is interesting to note that homosexual men have more female-like patterns in the amygdala than heterosexual men and homosexual females show more male-like patterns in the amygdala when compared to heterosexual women. The amygdala is involved in the processing of personal space. The amygdala is also associated with sexual and aggressive behavior.

The Septal Nuclei

The septal nuclei are very similar in function to the nucleus accumbens, both playing a role in the reward and reinforcement pathways. The septal nuclei differ from other areas in that the signals sent to the amygdala from the septal nuclei are inhibitory. For example, activation of the amygdala can result in sexual behavior and the desire for physical contact. This activation of the amygdala can then be modified by the septal nuclei through inhibitory signals to allow the person to decipher what is appropriate and what is not. Some researchers suggest that this modulation is essential in forming closer more long-lasting emotional bonds between partners.

The Medial Forebrain Bundle

The medial forebrain bundle serves to carry information between the ventral tegmentum and the nucleus accumbens. It is no wonder that humans report that stimulation of this area of the brain is intensely pleasurable.

Together, these five structures are called the reward system and are very important for driving our feelings of motivation, reward and behavior. These feelings include those that are necessary for the survival of the person such as food, sexual contact, and protection. The reward pathway is a natural and important component of our enjoyment in life. However, addictions occur when the reward system is abused.

An **addiction**, by definition, is the continued use of a mood or behavior altering substance despite adverse

consequences. They result from the motivated repetition of the same thougths and behaviors unitil they become habitual. Addictions can include, but are not limited to, drug abuse, sexual addiction, gambling, overeating and even exercise addiction. **Dependence** upon addictions occurs when the body learns to adjust to the substance by incorporating it into the body's normal function. This adjustment creates conditions of tolerance and withdrawal. **Tolerance** refers to the body's ability to adapt to the substance which then requires increasing amounts of the substance to achieve the original effect. **Withdrawal** refers to the symptoms, both physical and psychological, experienced when the substance use is discontinued or even reduced. Withdrawal symptoms include anxiety, irritability, intense cravings, nausea, headaches tremors and hallucinations.

The "addictiveness" of a substance is often determined by one of four factors:

1. The substance is a highly stimulating version of a natural product (for example; high-calorie foods)
2. The substance is available in limitless supply
3. The substance comes in lots of varieties (novelty)
4. The substance causes us to binge without realizing it is triggering brain changes

Very addictive substances usually meet 2 or more of the categories (high-calorie foods, exercise) or even all 4 categories (internet porn). All addictions have a common theme; they induce physiological changes in certain structures of the brain. So why do addictive patterns occur? Addictions arise because of the *misuse* of the normal reward pathways of the brain.

Internet Pornography

Now that we have a basic understanding of the reward pathway, we can attempt to explain why some substances can become so incredibly addictive. As previously stated, it is important to understand that the reward circuitry is important even necessary for survival. At the forefront of the reward system is the neurotransmitter dopamine. In brief, the purpose of dopamine is to motivate, thus, the bigger the dose, the bigger the motivation and the more desire to do something. For example, chocolate and ice cream are great motivators for dopamine release, broccoli, by comparison, is not. Not surprisingly, sexual activity causes large surges of dopamine. Dopamine surges increase with novelty. Internet pornography is especially enticing because endless novelty is just clicks away (points 2 and 3 of "addictiveness"). The brain will eventually adapt, and require access to a super-stimulating reward to maintain normal homeostasis. This adaptation is what leads to addiction.

All addictions lead to the same major brain changes:

1. **Desensitization:** the neurotransmitter dopamine declines and the dopamine receptors are down regulated. This creates a less sensitive area for natural dopamine release and leaves the individual craving for activities that result in high dopamine release. The addict will tend to neglect interests and/or behaviors that were once of high personal value.
2. **Sensitization:** The newly wired brain and reward pathway will start to turn on in response to any addiction-related stimuli or even thoughts.
3. **Hypofrontality:** The frontal lobe centers, those associated with understanding consequences, begin to weaken. The result is a reduced response to the ability to foresee consequences of actions.
4. **Dysfunctional stress circuits:** This means that stress, which before the addiction was easily managed, can now trigger relapses when the individual comes under stress.

In addition to dopamine, another protein called DeltaFosB serves to modulate many of the activities of the reward circuitry. Continued over-consumption of natural rewards (sex, sugar, high-fat, exercise) causes DeltaFosB to accumulate in the reward circuitry. DeltaFosB is also a protein that motivates, but unlike dopamine, the simple purpose of DeltaFosB is to "take while the taking is good". In other words, it is a primitive binge mechanism already in place for natural rewards. Think of our ancestors who didn't have complete access to fruit. This circuitry allowed them to identify and consume the fruit before it was lost. This would be a very beneficial reward when there was very little to be had, however, when there is plenty it makes addictions to things like junk food and internet pornography extremely easy.

Perhaps Dr. Gary Wilson put it best when he said; "nerve cells that fire together, wire together." This re-wiring and overproduction of the neurotransmitter dopamine and the protein DeltaFosB strengthen connections between the nerve cells and make it easier for those particular neurons to communicate. Habitual viewing of internet pornography results in addiction-related brain changes. Thus, just as water flows down the path of least resistance, so do the impulses, and ultimately our thoughts and desires. Thus, normal everyday pleasures are viewed as boring because they do not stimulate those pathways, but anything associated with the pornography addiction results in hypersensitivity.

Heavy pornography use can also result in tolerance unless the user moves into new directions in search of more intense experiences to produce a more powerful chemical response. Therefore, the more intense the event, for example adding masturbation, the stronger the response, which results in an increased brain re-wiring.

What makes Internet pornography unique and so addictive?

1. **It affords extreme novelty:** Internet pornography allows for hundreds of "new" scenes per session. Novelty is highly stimulating. Today's pornography is even more addictive than pornographic magazines of the past. With Internet pornography, one can escalate both with new scenes and with new types of pornography. It's quite common for a user to move to ever more extreme and degrading forms of pornography.
2. **Limitless exposure:** Unlike food and drugs, in which there is a physical limit to consumption, there are no physical limitations to Internet pornography consumption. The user can simply click and begin the process all over again.
3. **Lack of Aversion mechanism:** An aversion system is activated when you don't like the symptoms, for example, eating too much is associated with pain so typically you stop bingeing in response to the pain (aversion system). Internet pornography doesn't have any immediate side effects to activate the natural aversion system. However, long term side effects include:

    a. Distress about escalation to more extreme pornography

    b. Frequent masturbation

    c. Uncharacteristic, worsening social anxiety or lack of confidence

    d. Morphing pornography tastes that don't match sexual orientation

    e. Inability to concentrate, and extreme restlessness

    f. Depression and anxiety

Many of these symptoms arise from the changes in dopamine levels and dopamine receptors.

Is there hope for the internet pornography addict?

Fortunately the brain, including the reward center, is very plastic in its ability to restore order. The first step in addiction recovery is the re-balance of the brain. This begins with stopping all sexual stimulation, including pornography, masturbation, fantasies, chat rooms, erotic stories or surfing on the internet. Other triggers must be carefully watched, these include boredom, loneliness, anger, stress and being overly tired. The pathways must be rebuilt to respond to natural stimulants. Additionaly, intense shame and guilt are more likely to thwart recovery than facilitate it.

The Church of Jesus Christ of Latter Day Saints provides many resources for learning how to prevent or recover from a pornography addiction and other addictions by focusing on the power of Christ’s Atonement. Here is the link to their websites:

- https://books.byui.edu/-hAkt
- https://books.byui.edu/-wAWS