Neurobiology in Brief

3 Basic Nerve Cells

Senses
- TASTE
- SMELL
- VISION
- HEARING
- TOUCH
  - Pressure
  - Temp.
  - Stretch
  - Pain

Muscles and Glands typically react to motor output.
3 Basic Nerve Cells

Type of Nerve Cell (Neurons):  
- SENSORY NEURON  
- INTERNEURON  
- MOTOR NEURON

BASIC FUNCTION:  
- PICKS UP INFO. FROM INSIDE AND OUTSIDE THE BODY  
- INTERPRETS INFO.  
- ACTS ON INFO.

Dendrites:  
- RECEIVING END OF A NEURON, TAKES IN INFO. AND STARTS THE MESSAGE

Axon:  
- CARRIES THE MESSAGE DOWN THE NEURON (LIKE AN ELECTRICAL CORD)

Terminal Ends:  
- THE END OF ONE NEURON, WHERE THE MESSAGE EITHER ENDS OR 'JUMPS' TO ANOTHER NEURON.

Synapse:  
- THE SPACE OR GAP BETWEEN 2 NEURONS - WHERE MESSAGE MUST 'JUMP'
HOW A MESSAGE TRAVELS

The brain is made up of billions of nerve cells, each containing three important parts: a central cell body; short fibers called DENDRITES that receive messages from other neurons and relay them to the cell body; and an AXON, a long single fiber that transmits messages from the cell body to the TERMINAL END of the neuron and to the dendrites of other neurons, or to body tissues such as muscles. Although most neurons contain all three parts, there is much diversity in the shapes and sizes of neurons as well as their axons and dendrites.

The transfer of a message from the axon of one nerve cell to the dendrites of another is known as neurotransmission. Although the terminal ends of axons and dendrites are located extremely close to each other, the transmission of a message from an axon to a dendrite does not occur through direct contact. Instead, communication between nerve cells occurs mainly through the release of chemical substances into the space, or SYNAPSE, between the axon and dendrites.

When neurons communicate, a message, traveling as an electrical impulse, moves down an axon and toward the synapse. There it triggers the release of molecules called neurotransmitters from the axon into the synapse. The neurotransmitters then diffuse across the synapse and bind to special RECEPTOR SITES located within the cell membranes of the dendrites of the adjacent nerve cell. This, in turn, stimulates or inhibits an electrical response in the receiving neuron's dendrites.

There are many different types of neurotransmitters, each of which has a precise role to play in the functioning of the brain. Generally, each neurotransmitter can only bind to a very specific matching receptor. Therefore, when a neurotransmitter couples to a receptor, it is like fitting a key to a lock. This coupling then starts a whole cascade of events at both the surface of the dendrite of the receiving nerve cell and inside the cell. In this manner, the message carried by the neurotransmitter is received and processed by the receiving nerve cell. Once this has occurred, the neurotransmitter is inactivated by being either broken down by an enzyme or reabsorbed back into the nerve cell that released it. The reabsorption (also known as re-uptake) requires the action of transporter molecules, which reside in the cell membranes of the axons that release the neurotransmitters. They pick up specific neurotransmitters from the synapse and carry them back across the cell membrane and into the axon. The neurotransmitters are then available for reuse.
The Brain

The brain consists of several large regions, each responsible for specific activities vital for living. (Figure below)

The cerebral cortex, which is divided into right and left hemispheres, encompasses about two-thirds of the brain mass and lies over and around most of the remaining structures of the brain. It is the most highly developed part of the human brain and is responsible for thinking, perceiving, and producing and understanding language. The cerebral cortex can be divided into areas with each having a specific function, such as vision, hearing, touch, movement, or smell. Other areas are critical for thinking and reasoning. Although many functions, such as touch, are found in both the right and left cerebral hemispheres, some functions are found predominantly in only one hemisphere.

For example, in most people, language abilities are localized in the left hemisphere. Even so, the cortex most often acts as a unit in processing for complex tasks, and dysfunction in any one area can affect the operation of the brain as a whole.

The brainstem is the part of the brain that connects the brain and the spinal cord. It controls basic functions such as heart rate, respiration, appetite and sleep.

The cerebellum, a prominent structure located above the brainstem, coordinates the brain's processes for skilled repetitive movements and for maintaining balance and posture. It has also been implicated in higher level cognitive functions that require complex motor activities.

The diencephalon, which is also located beneath the cerebral hemispheres, contains the thalamus and hypothalamus. The thalamus is involved in sensory perception and regulation of motor functions (i.e., movement). It connects areas of the cerebral cortex that are involved in sensory perception and motor control with other parts of the brain and spinal cord that also have a role in sensation and movement. The hypothalamus is a very small but important component of the diencephalon. It plays a major role in regulating hormone production, body temperature, and many other vital activities.

Limbic System / PLEASURE AND REWARD CENTER

On top of the brainstem and buried under the cortex, there is a set of more primitive brain structures called the limbic system. The limbic system structures are involved in many of our emotions and motivations, particularly those that are related to survival, such as fear, anger, and the pleasure derived from activities like eating and sex.

For a species to survive, its members must carry out such vital functions as eating, reproducing, and responding to aggression. Evolution has therefore developed certain areas in our brain whose role is to provide a pleasurable sensation as a “reward” for carrying out these vital functions.

These areas are interconnected with one another to form what is known as the limbic system or REWARD CIRCUIT.

One of the reasons that drugs of abuse can exert such powerful control over our behavior is that they act directly on the more primitive brainstem and limbic structures, which can override the cortex in controlling our behavior.
Pleasure Circuit / Dopamine

Pleasure is a very powerful biological force for survival. Life-sustaining activities, such as eating, activate a circuit of specialized nerve cells devoted to producing and regulating pleasure. One important set of these nerve cells, which uses a chemical neurotransmitter called **DOPAMINE**, sits at the very top of the brainstem in the ventral tegmental area (VTA). These dopamine-containing neurons relay messages about pleasure through their nerve fibers to nerve cells in a limbic system structure called the nucleus accumbens.

All drugs that are addicting can activate the brain's pleasure circuit. **Drug addiction is a biological, pathological process that alters the way in which the pleasure center, as well as other parts of the brain, functions.** Almost all drugs that change the way the brain works do so by affecting chemical neurotransmission.

Some drugs, like heroin and LSD, mimic the effects of a natural neurotransmitter. Others, like PCP, block receptors and thereby prevent neuronal messages from getting through. Still others, like cocaine, interfere with the molecules that are responsible for transporting neurotransmitters back into the neurons that released them. (Figure shown)

Finally, some drugs, such as methamphetamine, act by causing neurotransmitters to be released in greater amounts than normal.

EVERY DAY “HIGHS”
Full Stimulation of Pleasure Senses
Neurotransmitters
ex. Dopamine, Serotonin

Fasciculus Retroflexus

Prolonged drug use changes the brain in fundamental and long-lasting ways. These long-lasting changes are a major component of the addiction itself. It is as though there is a figurative "switch" in the brain that "flips" at some point during an individual's drug use. The point at which this "flip" occurs varies from individual to individual, but the effect of this change is the transformation of a drug abuser to a drug addict.

The **fasciculus retroflexus** is a slender little tract of 200 to 300 cells in the midbrain, and it is your center for **SELF CONTROL**. It helps you get up in the morning and go to work, take pride in your job, pay the rent and feed your kids. It allows you to control your behavior when you experience a craving, an urge, or a drive. It is part of what makes you human, and not just an animal. It is closely associated with the pleasure center in your brain.

Cocaine is neurotoxic to cells in this area of the brain. Under a microscope you can see that after exposure to cocaine the cells are coiled up, the axons degenerate, and the synaptic terminals disintegrate. The cells are dead.

Damage to this tract results in addiction and personality changes. When 50% to 80% of the cells in this tract are dead, you experience overwhelming cravings and you are addicted.

*It is not a matter of willpower anymore. Willpower has been destroyed. You don't care about feeding your kids or paying the rent; you don't care about the law. All you can think about is getting another hit, and you want it right now.*
What Cocaine does inside the nervous system

1) Inhibits the reuptake of dopamine
   (BLOCKS REUPTAKE PUMP)

2) Increases the availability of dopamine in the synapse
   (SEND OUT EXTRA DOPAMINE)

3) Increases dopamine’s action on the postsynaptic neurons
   (FIRES THE RECEPTOR SITES REPEATEDLY)

4) = mood elevation and euphoria

Cocaine’s effect is usually quite short, prompting the user to repeatedly administer cocaine to re-experience its intense subjective effects.

HOW A NATURALLY OCCURRING ‘HIGH’ WORKS

1- STRONG ELECTRICAL MESSAGE ARRIVES AT NERVE END
2- MAXIMAL AMOUNT OF DOPAMINE SENT INTO SYNAPSE
3- DOPAMINE FIRE RECEPTOR SITES
4- BRAIN FEELS STRONGEST MESSAGE OF PLEASURE

Dopamine gets ‘recycled’ back into presynaptic neuron

Things that will produce this:
MARRIAGE, BIRTH OF A CHILD, CHAMPIONSHIP, INHERITANCE, MAJOR ACCOMPLISHMENT ETC.
COCAINES AFFECT ON THE NERVOUS SYSTEM

1- BLOCKS REUPTAKE PUMP (RECYCLING BIN)
2- SENDS MANY MORE NEUROTRANSMITTERS INTO SYNAPSE

“There’s a party in the synapse”

NEUROTRANSMITTERS ARE ‘TRAPPED’ IN SYNAPSE = REFIRE THE RECEPTOR SITES

ADDITION - WHAT THEY USED TO THINK

ORIGINAL THEORY OF ADDICTION:

UP-REGULATION = Before advanced brain scans, they thought that more receptor sites were created in response to the amount of stimulus - therefore when the drug is not present receptor sites are left unfilled = understimulation = depression
ADDICTION - WHAT THEY USED TO THINK

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ADDICTION - WHAT THEY KNOW

CURRENT UNDERSTANDING OF ADDICTION:

DOWN REGULATION = Over time - due to amount of dopamine in synapse and repeated stimulation of receptor sites - the body actually reduces (or downsizes) the amount of receptor sites. Fewer receptor sites = Less ability to feel pleasure from everyday activities
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NERVOUS SYSTEM EXAM REVIEW

Know and be able to identify neuron anatomy ie:

- Axon, Cell Body, Dendrite, Terminal End, Receptor Site, Presynaptic Neuron, Neurotransmitters, Postsynaptic Neuron, Synapse

Know the three types of neurons and be able to explain the function of each.

Be able to explain how a message travels from one neuron to another.

Know what the ‘Limbic System’ is and where is it located.

Know where all drugs go to work in the nervous system.

Know and be able to explain how specific drugs (i.e. stimulants, depressants, narcotics) affect nerve transmission.

Know and be able to explain the theory of addiction.