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Human Physiology, 10am
Extra Credit assignment
(Altered to gear toward fellow Massage Therapists)

Bodywork: A Sensorimotor Re-education

Understanding the Central Nervous System and its Role in Therapeutic Massage

“It is the business of body work to constructively modify the harmful acquired reflexes and the vicious circles that they generate... by giving the subject new sensations in his flesh and a new feelings in his mind, so that these sensations and feelings can begin to redirect his musculature in new movement patterns in exactly the same way that older sensations and feelings build up the existing patterns. It is not the muscles themselves that must be changed, but the internal “sense of effort” which Guides them.”

-Jobs Body: A Hand Book for Bodywork” by Deane Juhan

Introduction

To often as Massage Therapists we see only the muscle knot that lies in front of us on our table, and maybe sometimes the muscle, connective tissue, and skin we have to work through to get at it. But in today’s discussion we are going to explore the **Nervous System**, particularly the Central Nervous System, that had a significant role in developing the pesky-painful knot, and will be the key to fixing it.

Nervous System: The Central Nervous System

Over view

The **Nervous System** is the most complex organ system in the body, not only is it the main communication system, through electrical signals (versus hormonal signals in the endocrine system), but it monitors the internal and external environments, integrates that sensory information, coordinates voluntary and involuntary responses and thus; *maintains Homeostasis!!*

It consists of a complex network of nerves and nerve centers including the brain, spinal cord, nerves, ganglia and stimulus receptors. For studying purposes we break this system into many branches, but it is important to remember that all these branches work together as a whole. The first Divisions are the **Central Nervous System (CNS)** (the brain and the Spinal Cord) and the **Peripheral Nervous System (PNS)** (all the neural tissue outside the CNS). Since our goal here to is to understand the how our body *Integrates* sensory information we will be focusing on the Central Nervous System.

The Central Nervous System; consists of the *Brain* and *Spinal Cord* (which is located centrally in the body. *Easy to remember right?*), it receives the incoming information (afferent signals), processes and integrates that information, decides what to do about it, and sends out a signal (efferent) to the body to give a response.

Protection

We now have a slight grasp at how important the functions are of this system. But the brain and spinal cord is a squishy-squishy thing, it is made of soft tissue the consistency of jello and it must be protected! Particularly because importantly neural cells are stuck in G0 phase of the cell cycle; it does not multiply: SO IT MUST BE PROTECTED! There is many structures to keep it safe.

- Bones: Bones provide a ridged armor: the Skull or Cranium protects the brain and the vertebral column surrounds the spinal cord.
- Cerebrospinal fluid (CSF): Is a clear watery fluid that bathes the CNS and Acts as a shock

absorber. (so that the squishy brain and spinal cord doesn't slam into the bones when you trip) Not only does it surround the CNS, it fills cavities located within the brain and spinal cord called ventricles. (Want to learn more about CSF? Take a CranialSacral Bodywork Course!)

- **Meninges:** Between this hard tissue and soft tissue is three layers of connective tissue membranes, *the dura mater*, *the arachnoid master*, and the *pia mater*. These layers surround the brain and spinal cord, providing a physical stability, (Also delivers all important oxygen and nutrients)
- **Blood Brain Barrier:** To protect the brain from bacteria, infections and other things in the blood that can harm the brain, the endothelial cells in the capillaries have tight junctions that prevent the harmful stuff from crossing into the CNS. The CNS still needs some supplies from the blood; Small hydrophobic molecules like Oxygen and Carbon Dioxide still diffuse in and out. Glucose is actively transport in.
- **Myelination** discussed later.

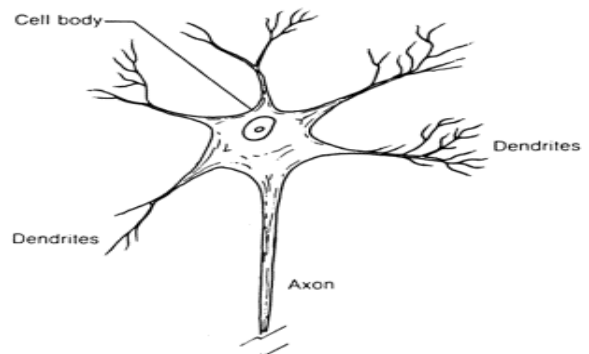
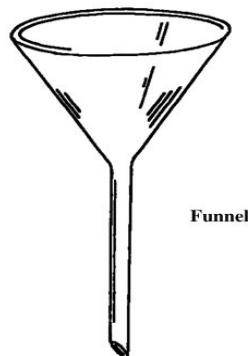
Dissection of the Central Nervous System

This should be a review, but for many of us it has been quite a bit of time since our certification examinations, so lets be clear about the anatomy. To bare in mind that the Nervous System is essentially an electrical system, and the charges we see circulating in the system are caused by **Ions** (atoms or molecules with a positive or negative charge due to the gain or loss of an electron), changes in **membrane potential, concentration and graded potentials, and action potentials**. Which we will be discussing later on.

Cells

Neurons- (nerve cells): this is the main cell type we think about when we are discussing the Nervous System. They are responsible for the actual transmission of information and processing. These are the cells that are largely unrepairable. Lets compare the structure of a neuron to a funnel since they both...eh..funnel.

- **Dendrites** -like the rim of the funnel, it is where information is usually collected into the cell
- **Soma (cell body)**- is like the cup of the funnel, this is where the nucleus is and most metabolic processes take place.
- **Axon**- like the tube of the funnel dirrectis the contents to its destination. The beginning is the *axon hillock* this is where an action potential starts, and the *axon terminal* is where the substance or information flows to its destination. At this site **Synapse** occurs.



Glial Cells: 75%-90% of cells in the CNS!! these cells provide a supportive framework for neural cells, “glial” literally meaning “glue” in Latin. There are 5 types but we will focus in on 2 types since it is very important to signal conduction. *astrocytes, ependymal cells, microglia, Schwann cells, and oligodendrocytes.*

- *Shwann Cells and Oligodendrocytes:* These cells form an insulation of **myelin** by wrapping themselves around the axon. Oligodendrocytes are found in the CNS, Schwann in the PNS. Myelination helps conduct a signal faster, and protect the axon from damage. *Nodes of Ranvier*, or places between the myelination where action potentials are propagated by voltage channels.

Tissue

- Gray matter-40% of the CNS. consists primarily of cells bodies, dendrites, and axon terminals. This is the site of synaptic communication and neural integration.
- White Matter- consists of mostly myelinated axons. (*myelin is white in color*)

Organs

Before we really talk about these organs it is important to note that our bodies are highly-highly organized; specific stimulus from specific regions of the body travel up specific pathways to specific regions of the brain to be processed and responses are sent from those specific regions of the brain to specific regions/organs/effectors along another specific pathway. (Very specific right?)

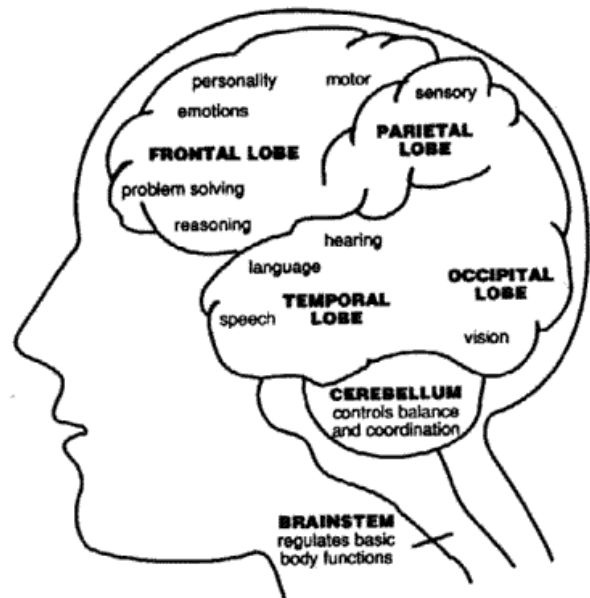
Wanna see exactly where these things are located? Check out these youtube videos:

<http://www.youtube.com/watch?v=Li5nMsXg1Lk> (the entertaining one)

<http://www.youtube.com/watch?v=HVGIfcP3ATI&feature=related> (the purely educational one)

Brain- *If you have a brain you know what this is.* Now lets break it up into regions.

- **Cerebrum:** Conscious thought, intellectual functions, memory and complex involuntary motor patterns, language. (*Cerebral hemispheres (2)*- remember that each controls opposite side of the body. *Frontal Lobe. Parietal Lobe, Temporal lobe, Occipital lobe*)
- **Diencephalon:** Provides switching and relay center needed to integrate the conscious and uncscious sensory and mother pathways (*Epithalmus- pineal gland, choroid plexus. Thalamus. Hypothalmus*)
- **Brain stem:**
 - *Midbrain*- processes visual and auditory information and generatres involuntary somatic motor responses
 - *Pons* - connects the cerebellum to the brain stem and is involved with somatic visceral motor contron
 - *medulla oblongata* – here the brain connects to the spinal cord. Relays sensory information, importantly to the thalamus, and regulates autonomic functions.
- **Cerebellum:** (also known as “little brain” or “small brain”) Over sees the body's postural muscles and programs and fine-tunes voluntary and involuntary movement. Also very important to bodywork; of the cerebellum Deane Juhan writes:



<http://e-ducation.net/moreimages/brain.gif>

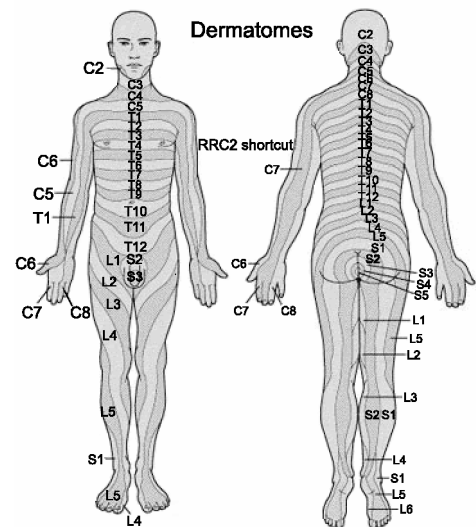
“It is here where all of the disparate neural threads we have been taking up one by one are ultimately woven together into one fabric, where sensory experience, cognitive reflection and musculature response are thoroughly homogenized and translated into highly individualized bodies and lives.

This is not to say that the bodyworker cannot be effective until he can get his hands on the cerebellum... on the contrary, this highest level of integration is one of the bodyworkers most valuable tools, even if he cant touch it; if acquired reflex responses, muscle tone, posture, and manner of movement are being altered by the practitioners manipulations, the we can be all but certain that activities in the cerebellum are altering as well.”

-”Jobs Body: A Hand Book for Bodywork” by Deane Juhan

Spinal Cord- *If you have a spine you know what this is! If you are a Massage Therapist you better know what this is!* This one is not quite as complex as the brain and even though we usually think of the brain doing all the thinking, a lot of integration happens here too. Why pass a signal up higher when you can take care of the problem yourself anyway? Here is the Highlights:

- **31 pairs of spinal nerves** branch off in regular intervals between vertebrae, they are named for the vertebrae it is next to. (*wait a minute? Can you explain why there is a C8 nerve then?*)
- Remember the difference between gray and white matter? (*Why would more Gray matter be found in the center?*)
- Remember we spoke of specific pathways for specific types of stimulus, specific directions, and specific regions. Think of the Spinal Cord like a very intricate braid of these pathways. As they branch off and “braid in” they create structures we call horns, roots and ganglia.
- **Dermatomes.** You are probably very aware of this concept even if you don’t recognize the name. A dermatome is an area of skin that is mainly supplied by a single spinal nerve. Check out the illustration to see how this spreads across the skin in segmented layers. (*Let’s link some of your knowledge of different modalities of massage with this image. Overlay and compare the differences and similarities to what you know about; Oriental Energy Meridians, Indian Energy Meridians/Ayurvedics, zoning/reflexology, and of the more physiological pain patterns, trigger points, referred pain sites and more. Now compare with Cutaneous Distrubution of spinal nerves. Don't know what that is? Look it up!)*)



http://www.emeraldinsight.com/content_images/fig/0250160209003.png

Integrated CNF Functions

Reflexes

Remember how we said the CNS and PNS work together as a whole. Lets look at some ways they interact. A **reflex** is an automatic motor response to a specific stimulus. This makes maintaining

homeostasis easier by making rapid adjustments in organs and organs systems. A reflex involves a sensory fiber delivering a signal from the PNS to the CNS and then motor commands being sent to the effecting organ. We call this wiring of a single reflex a **reflex arc**. A reflex response usually removes or opposes the original stimulus, a simple example of this is placing your hand accidentally on a hot stove top, an automatic reflex is to pull your hand off it and yo don't really have to think about it. Reflexes can be *spinal* or *cranial*, *somatic* or *autonomic*, *innate* or *conditioned*, *monosynaptic*, or *polysynaptic*.

- An example of a reflex is the **Stretch Reflex** and its sensory receptor is called *muscle spindles*.
>We play with this reflex a whole lot!

Voluntary Motor Control

Voluntary control of muscles involves many regions of the CNS. Review the parts of the brain for specifics.

Language

Human are very unique in the way we communicate with others. We speak, write, sing and communicate in many different types of languages. Most people have 2 areas in the left hemispher devoted to language. *Wernick's area* which has to do with language comprehension in the temporal lobe and *Broca's area* which deals with language expression. in the parietal love.

Sleep

Because we love this one, we will include it. Sleep is a necessary process. It is a time for out body to repair itself, dreaming itself can even help us retain memories, and even allow us to face things and fears from out subconscious mind. But just because our body is asleep that doesn't mean out minds are. With **electroencephalograms (EEGs)** we can measure brain waves and identify levels of sleep. Many parts of the CNS are involved in maintaining our normal sleep wake cycle and the involved areas shift as we fall deeper and deeper into sleep. *Slow-wave-sleep* is induced in the forebrain,while *REM* or dream sleep activity originates in the pones. The precise mechanisms are not well understood.

Emotions and Motivation

Emotions involve many areas of the brain including the cerebral cortex, limbic system, and hypothalmus. Emotions are generally triggered by sensory input or memories. Emotions are not just all in our mind, (or even heart) an emotional response's can trigger strong physiological changes, changes in heart rate, digestion, tears and laughter. Our emotions can effect our actions by motivating us one way or another.

Touch is a very powerful sensation and sometimes with massage therapy we can trigger an “**Emotional Release**”, powerful memories or experiences can be locked away in a neural pathway attached to our skin receptors, when triggered me might cry or laugh or remember a traumatic even we had long forgotten. It is important as a Therapist to understand that this is a very natural mechanism in our body, you have not done anything wrong. When this does happen:

1. Don't Pry! You might be tempted to find out what emotion is being felt so you can find a way to help the client cope. Don't!, If they want to share that is fine.
2. Take care of their physical needs, if they need a tissue of a glass of water, get it.
3. Explain to them what is happening, that an “Emotional Release” is common. Bring them back at ease, if you feel it is appropriate share a brief experience of your own “emotional release”. Help them recognize and pass the emotion
4. If you can get back to your session great! If not listen to the clients needs, emotions can be strong and they might need to end the session and have some time to themselves.

Learning and Memory We will discuss at the conclusion

The Signal

Lets follow an outgoing or efferent signal. The Brain has already integrated a stimulus and has decided some sort of response to that stimulus. It has traveled down the PNS and is about to enter the last neuron before entering the effecting organ. Bare in mind that we are mainly dealing with an ions, these ions are changing the permeability of the cell membrane, it does this by opening or closing channels in the membrane, allowing different ions to enter the cell then normal.

A **synapse** is a site where intercellulare communication occurs. Here we are looking at a synapse of 2 neurons the *presynaptic neuron* had the signal and is releasing a **Neurotransmitter** (specific ligand or chemical) from its axon terminal into the space between the 2 cells, the *synaptic Cleft*. The *Postsynaptic neuron* has a receptor for that neurotransmitter on its dendrites and when it receives that signal it causes it to open an ion channel altering the permeability of the cell. The neurotransmitter once it's job is done will be released; reabsorbed by the presynaptic neuron to be recycled, or broken down by an enzyme or diffuse out of the synapse or any combination of the three.

Ions flow into the cell through the open channel, this causes a **Graded Potential** a small change in membrane potential that decreases as you get farther from the source location (very similar to the concept of diffusion). The graded potential diffuses throughout the cell until it reaches the axon hillock.

The Resting Membrane Potential is balanced by leaks and pumps and is maintained at -70mV when the cell is not being disturbed. A graded potential can be *depolarizing* (make it more positive) and if it is strong enough and bring the membrane potential to threshold stimulus level of -55mV it will cause and action Potential to fire. This involves the **Voltage Gated Na⁺** to open fully and allow Na⁺ to flow into the cell at a fast rate and continue to depolarize the cell until the cell reaches a +30mV.

At this point another part of the Voltage Gated Na⁺ channel closes down and stops the flow of Na⁺ into the cell, and **Voltage Gated K⁺ channel** which allows K⁺ to flow out of the cell in a tempt to *Repolarize* it. As the cell reaches membrane potential once more the Voltage Gated Na⁺ Channels are reset but because the Voltage Gated K⁺ Channel is much slower to close it is still pumping out K⁺ causing the cell to *Hyper-Polorize*. Eventually the K⁺channel closes and the leaks and pumps brings the cell back to Resting potential.

It is important to remember that while the repolarization is going on another action potential can not be propagated because the Voltage Gated Na⁺ channel is not reset, and during Hyper-polarization it would take an extra strong stimulus to set an Action Potential off. We call these *Absolute Refractory period* and *relative refractory period*. Because of this a signal is pushed in one direction down and axon as the action potentials activate the voltage gates by it and ripple down the line.

When an Action Potential reaches the axon terminal it causes the opening of a Ca⁺ channel, calcium pours into the cell and then forces vesicle of Neurotransmitters to be poured into the synaptic cleft and continue the signal on, or in this example cause the effector organ to do something.

Conclusion

As we repeat and reinforce these synapses that we make in the CNS, we are literally programing our minds and thus our bodies. But that doesn't mean we cannot get ride of unproductive or harmful synapses. We have a certain amount of **plasticity**, ability to alter our anatomy and function in response to changes activity patterns; because existing synapses can be altered for long periods of time, and new synapses can occur. *This is what we do as massage therapists on the CNS level, we help discard old harmful synapses and replace them with healthy ones, we literally help rewire bodies!*

On a conscience level massage makes a client more aware of how they use their body, . This can really help the individual take responsibility for their body; you come to see your whole self. Your body is not just a vehicle for your mind and soul, it is an extension of it, all interconnected and wrapped up in each other, each part irreversibly connected to each other. This self awareness alone can help you treat yourself better, change your habits, and increase the quality of your life.