Neuroanatomy 2

[00:00:01.52] Now we're going to review major divisions of the brain. First the brain stem and the mid-brain. The brain stem can be divided into two sections, the pons and the medulla.

[00:00:12.66] All three of these regions handle very basic functions like breathing, heart rate, digestion, and temperature regulation. They also house the pathways from the rest of the brain, to the spinal cord, onto the body, from the body to the spinal cord, and then back to the brain. With the exception of sensory and motor information both directions from the face and head. That information enters directly into the brain stem via cranial nerves, which bypass the spinal cord entirely. Which is why people who are paralyzed, because of a spinal cord injury, retain the use of their face and head and parts of their neck function.

[00:00:57.61] Because the brainstem handles very basic functions, damage to this region is often fatal or at least very debilitating.

[00:01:08.06] The thalamus and hypothalamus are located near the middle of the brain. The thalamus acts as a sensory relay. Almost all sensory information, traveling from the body to the brain, passes through the thalamus before it travels on to its final destination in the cortex. The exception to this is smell information, which travels to its cortical destination and then to the thalamus.

[00:01:33.31] The hypothalamus handles autonomic nervous system functions. Fight or flight and feed or breed. Damage to these regions can cause mild to severe impairments, depending on the location and extent of the damage, but it's not usually fatal.

[00:01:50.88] The cortex is what we usually think of when we think about the brain. We can divide it up first into very large regions which are marked on this map. The frontal lobe, marked in purple, handles executive functions. These are higher level thinking processes that we think of as being conscious. Language, decision making, thinking about the future, our personalities, all of these things happen in the frontal lobe.

[00:02:21.06] At the most posterior section of the frontal lobe, next to the central sulcus which is marked on this map, is the primary motor cortex. We'll come back and talk about that in more detail later. Know that all motor commands originate in the frontal lobe. Although other regions of the brain are involved in motor systems, all of the commands originate in the frontal lobe.

[00:02:46.98] The parietal lobe handles somatic sensory information. That is to say touch information, pain information, proprioception information, which is the location of your body in space. Anything that is coming in from your body goes to the parietal lobe. The parietal lobe also handles sensory integration, which means taking multiple senses and putting them together to form a coherent multi-sensory picture of the world.

[00:03:16.07] The occipital lobe handles visual processing. It takes up about 20% of your cortex just for processing vision. That's all it does. The temporal lobe handles memory and some language function. Not visible on this view, located medial to the temporal lobe, is an area of cortex called the Insula. It's called that because it's insulated from the outside. The Insula handles some pain information and some emotion.

[00:03:47.39] Also marked on this picture is an area called the limbic lobe. Now many people, including me, don't consider the limbic system to be a lobe because it involves a lot of non cortical regions. The area marked here is cortex. It's the parahippocampal, entorhinal, and singulate cortex, and it handles a lot of emotional processing as well as reward functions.

[00:04:14.63] Now while we think of the cortex as being the wrinkly outer surface of the brain, it's not actually defined by the presence of wrinkles. Cortex is defined by the presence of these layers of neurons. In neocortex, which the most of human cortex is neocortex, there are six layers of neurons. There are some areas of the human cortex that have fewer than six layers of neurons. These are called paleocortex. Other species have a mix of neocortex and paleocortex or only paleocortex.

[00:04:48.82] Some neurons remain only in the local area of the cortex and do processing on whatever that area of the brain's function is. Some neurons pass information between different areas of cortex. And some neurons enter or exit the cortex taking away commands to the body or bringing in sensory information.

[00:05:11.30] Now because the cortex is defined by the presence of these layers, in order to increase the number of neurons and therefore increase processing power we have to increase the surface area of the brain. We accomplished this by having sulci or grooves, and gyri or the lumps of the grooves. Wrinkling the brain increases the available surface area without having our heads be giant like balloons. These gyri and sulci are all in the same positions in all typically developing humans.

[00:05:43.73] So when we talk about the central focus position, it is in the same location in all typically developing adult human beings. We can count on finding the functions of the brain in the same locations on the same gyri by every single time. Besides dividing the brain up into the lobes, we can also divided up into smaller divisions of cortex.

[00:06:07.86] On the left, we have the same picture of the lobes that I showed you before. On the right, we have one way of dividing the brain up into smaller regions. These are called Brodmann areas. It's one of the oldest ways of dividing the brain up into smaller regions. They were defined partially by the functions associated with those regions, and partly by the cellular anatomy. Which is to say that the cells in one Brodmann area how they look and how they communicate with each other, are different from those in the areas next to them.

[00:06:42.58] Finally, I want to mention the basal ganglia, which is a group of known cortical regions. They are composed of neurons, but they are not cortex because they don't have layers of cells, that are involved in motor control. The basal ganglia is very important for refining motor movements. For making them precise and controlled as the person wants them to be. We're going to come back and cover the basal ganglia in more detail later.

[00:07:12.87] As we continue discussing neuroanatomy in more detail, through the rest of this course, I want you to consider what parts of the brain and body might be targets for neural engineering. For this we need to consider the goals of the device, the deficit that we're trying to treat, and the needs of the specific user. One of the most common things that we're looking to interact with in neural engineering is motor systems. We primarily talk about skeletal muscles, which are controlled by the somatic nervous system. Muscles that you move voluntarily. Less discussed and less research, but no less important are smoother internal organ muscles. Which are controlled by the autonomic nervous system subconsciously by a different pathways. The information doesn't travel the same way through the brain stem and spinal cord for controlling autonomic nervous system targets as it does for somatic nervous system targets.

[00:08:08.56] How could we generate a movement? By the body, or by an external device? With a prosthetic or an orthotic Without using the original pathways. We could route around an injury to control the user's own body. We could control a prosthetic or an orthotic. Or we could hook up to a computer or a wheelchair using motor commands from the user's own brain.

[00:08:33.25] Vision, hearing, touch, and proprioception, or the sense of where your body is in space, are the top sensory priorities for engineering. Every sense has a specific region of the brain responsible for receiving input and for processing that input. And every sense has cells that are responsible for receiving information from the environment. Some of these are neurons and some of them aren't. All of these are targets for neural engineering.

[00:09:03.28] How can we create perceptions, in the brain, in the absence of any kind of sensory stimulation in the environment? As we continue through the rest of the course, think about what functions in the brain we might want to access or replicate as we develop targets for neural engineering.