**Neurobiology**

**Dr. Nitin Gupta**

**Department of Biological Sciences and Bioengineering**

**IIT Kanpur**

**Week - 01**

**Lecture 1.5: Types of cells in the brain**

Hi everyone, welcome back to the online course on Neurobiology. In the last video, we looked at the different approaches and methods that are used to study the brain. And in this video, we are going to see what the brain is made of. So what are the different cell types that are present in the brain and how do they connect to each other. So let's dive in. There are two types of cells that are found in the brain or the nervous system in general.

The first kind is neurons, which are the more famous ones. And the second kind are called glia. These are somewhat less known compared to neurons and less studied, but they also play important roles. So we'll talk about neurons in the subsequent slides, but let's talk about glia first.

The glia themselves can be divided into two broad categories depending on the size. So microglia are the smaller ones and macroglia are the bigger glial cells. Microglia are typically involved in protective functions of the nervous system. So they become activated if there is some kind of an infection or injury or seizure in the brain and they protect the brain. And macroglia are further subdivided into different categories.

One type is oligodendrocytes. These cells provide insulation to the neurons or the axons of the neurons. So these oligodendrocytes basically wrap around the axons and create this insulation called the myelin sheath. Oligodendrocytes do this in the central nervous system, whereas a similar role is played by Schwann cells in the peripheral nervous system. So both of these cells, cell types oligodendrocytes and Schwann cells, which are both types of microglia, they provide insulation to the axons of neurons.

And the third kind of microglia are called astrocytes. These are actually the most abundant type of cells or glial cells in the brain and they play various supporting roles in the maintenance of neurons. And although traditionally glia have been thought to play these kinds of various supportive roles, but now it's the recent studies show that glia may also be involved in the function of the brain. They may be more directly involved in the various signals that are being processed by the brain. This is an active field of research now.

Now let's take a look at the basic architecture of a typical neuron. And this is the structure that you will see reported in textbooks or online websites mostly. We can divide the neuron into three broad parts. This part here is called the cell body. The cell body includes the nucleus, which contains the DNA, as well as some other cell organelles that are not shown here.

So cell body is the basic part of a neuron as it is in any other cell with the basic cell organelles. The main defining feature of a neuron are the various branches that come out of the cell body. And we can see that there are two types of branches that come out. So these branches in blue here, these are called the dendrites. These dendritic branches receive signal from other neurons.

And then they carry this signal to the cell body. And then from the cell body, the signal goes out through a long branch called the axon. So the one shown in red here, this branch is the axon. This conducts the signal out of the neuron to follow our neurons. And at the end of the axon, you can see there are small branches that can be called the axon terminals from where the signal is released out.

On the axon, as we discussed in the last slide, we can find an insulation. This insulation is made by the Schwann cells in the peripheral nervous system, or it is made of oligodendrocytes in the central nervous system. And this insulation helps in improving the conduction of signal along the axon. We'll talk about this later in the course. Based on the shape of the neurons, we can divide them into three broad classes called unipolar, bipolar, and multipolar.

Whether a neuron is unipolar or bipolar or multipolar depends on the number of branches that are coming out of the cell body. In the case of a unipolar neuron, there is a single branch that is connecting to the cell body here. So this is the cell body, and this is a single branch that is connected. And this branch later divides into the dendritic side and axonal side. So the neuron, of course, is receiving signal and giving out signal from the dendrite and giving out from the axon.

But these two parts of the neuron eventually combine into a single branch that is connected to the cell body. So that is a unipolar neuron. We can find some unipolar neurons in the cerebellum. The second kind of neuron is bipolar, where there are two branches that are connected to the cell body. So this is the cell body here, and you see there are two branches.

One branch can further subdivide, and this is the dendritic side. And the other branch is the axonal side. So this is a bipolar neuron. Signal comes from here and goes out from here. And the third kind of neuron are the multipolar neurons, where you have multiple branches connected to the cell body, as you can see here.

And this is the anatomy that we also saw on the last slide. This is the most prevalent type of neurons in the vertebrate brain. A lot of these branches that are connected to the cell body are the dendrites, and typically one axonal branch comes out. Most of the neurons in the brain, or many neurons in the peripheral nervous system, such as the motor neurons, are multipolar in nature. Although we talked about three types of neurons in the last slide, whenever we talk about types of something, we have to be careful in that this categorization is usually subjective in nature.

So whether there are really three types or four types or five types depends on our zoom level. For example, the category of multipolar neurons can be further subdivided into different categories. So all the three neurons shown in this slide are multipolar neurons, but if you see their morphology, it looks quite different from each other. The one on the left here is a pyramidal cell from the hippocampus. It's called a pyramidal cell because the cell body has a pyramidal shape.

At the top of the pyramid, you typically see a long branch, long dendritic branch that goes out, and then at the base of the pyramid there are a few other branches that act as dendrites, and then you have one axon at the bottom. This looks quite different from a motor neuron in the peripheral nervous system where the cell body is more spherical in nature and then all these branches are similarly attached to the cell body. And this looks quite different from a Purkinje cell in the cerebellum where you see the slightly different type of morphology of the dendritic branches. So all these branches still connect to the cell body, but they are connected near the same location, and then you have a smaller axon coming out of the base. So now that we understand the different types of neurons, let's think about how the neurons communicate with each other.

So we know that the neurons receive input in their dendrites and pass on the signal through their axon terminals. Now here we can see the axon terminal of one neuron, and it is passing on signal to the dendrite of another neuron, and the junction of these two neurons is called a synapse. So this synapse is the contact point where neurons communicate with each other. The neuron that is passing on the signal through its axon is called the presynaptic cell or the presynaptic neuron, and the neuron that is receiving the signal on its dendrite can be called the postsynaptic cell or the postsynaptic neuron. This communication of the signal can happen in different ways.

So the kind of synapse that we are looking here is called a chemical synapse, and in the synapses the signal is passed on in the form of these chemicals called neurotransmitters shown in red here. So these neurotransmitters are released from the axon terminal of the presynaptic neuron, and after these neurotransmitters are released into the synaptic region, they go and bind on the receptors that are present on the dendrites of the postsynaptic neuron, and then this postsynaptic neuron can be activated and then it passes on the signal to subsequent neurons or possibly to

muscles for causing some movement. So this is how the signal is passed on from one neuron to the other.