Neurobiology

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Week - 01

Lecture 01: Historical Perspectives

Hi everyone, welcome to Neurobiology. In this course, we are going to look at what the brain is made of, what are the components at the cellular and molecular level and how these components come together as circuits to result in our perceptions, our memories and so on. There are no prerequisites for this course. Anyone who has an interest in learning about the brain is welcome to take these classes. So let's get started. What we are seeing on the screen here is a picture of a human brain.

This jelly-like structure has a volume of about 1.5 litres and weighs about 1.5 kgs, which might be actually less than the weight of the laptop that some of you might be using to view this on. But in many respects, the human brain is more powerful than the laptops.

So how does the brain do it? The key to this lies in the organization on how the brain is composed from the fundamental units. If we look at it from outside, we can see these three types of structures, which are labeled cerebrum on top here, then cerebellum, this darker structure here and then this stem-like structure, which is called the brain stem. But what about inside? Is it similar to other organs? How other organs are organized? Or is the brain fundamentally different from other structures, from other organs in some ways? So this is what we'll try to understand in this course. But one thing I should point out is that the brain is often recognized as the most complex organization of matter in the universe. And as a result, it's not surprising that we know much less about the brain than about other organs of the body.

So this makes it both a challenging as well as an exciting organ of the body to look at. Can you guess what is being shown on the screen here? So this is actually the pictorial representation of

brain from 17th century Egypt. And the reason I'm showing it to you here is to make the point that people have been thinking about the brain for thousands of years. And it's quite interesting to see how the understanding of brain has evolved over time before we arrived at the current understanding. One of the first people to comment about the brain was Alcmaeon of Croton.

He was an ancient Greek who lived around the 500 BC period. And he did some experiments by cutting the nerves of animals and then seeing their effects. And based on these observations, he came to the conclusions that the brain is the seat of mind, which seems like a reasonable conclusion now. But he also concluded that eyes contain fire and water, or that sleep occurs when blood vessels are filled with blood. And these latter two we now know make no sense.

And that also raises questions about his crude methods that led to the first conclusion. Then after him, about 100 years later, Hippocrates, who is also known as the father of modern medicine, you might have heard of the Hippocratic oath that doctors take when they graduate. So based on his understanding of the anatomy of the body, he was also in agreement that brain is the seat of intelligence. But not everyone thought that intelligence comes from the brain. In fact, one of the most famous Greek philosophers, Aristotle, who lived around 350 BC and was a disciple of Pluto, who was a disciple of Socrates.

So Aristotle thought that the intelligence comes from the heart. It's not the brain, but the heart. And then what about the brain? Then what does the brain do? So he thought that brain is just a cooling mechanism for the heart. You know, the brain is sitting up there and radiating the heat out and keeping the heart cool. And he thought that that very nicely explains why humans are more rational than other animals.

Because of course, they have bigger brains to cool their hot tempers. So that's what he thought. And even in today's world, we can see some resonation of this kind of idea. When we use terms like memorizing by heart, or heartfelt things, we are somehow implicating the heart in these kinds of cognitive functions. After the Greeks, another person who did some remarkable work on the brain was Claude Galen.

Galen lived around 150 AD in the Roman Empire. He was a surgeon by profession. So he was used to doing surgeries. And as part of his work, he did surgeries on animals and probably

correlated the deficits that he saw in the behavior of the animals with the damages that were there in the brain or the nervous system. And based on that, he was able to conclude that his spinal nerves controlled different muscles in the body.

And he even could infer that cerebellum controls muscles, whereas cerebrum seemed more involved in processing the senses. And this is in the right direction. And it's quite remarkable that he was able to draw these kinds of conclusions at that time. But did not get everything right again. So he also concluded that brain functions by the movement of animal spirits through the ventricles.

If you look at the cross section of a brain, you will see some holes as seen here. These are the ventricles. And I guess he cannot be blamed for drawing these conclusions because at that time, all you could see in the brain was this dense jelly like structure and within that there were these holes that were filled with some kind of fluid. So he thought that the movement of this fluid, which he was calling animal spirits, is what controlled the muscles and the senses. In ancient India also, people thought about the brain.

One of the first descriptions is found in Charak Samhita, which is a book composed by Charak. Some of you might be familiar with him. He is also known as the founder of the Indian medicine or Ayurveda and lived around 200 BC. So in one of his writings, Charak wrote that if the head is affected, stiffness of the carotid regions, that is the neck regions, facial paralysis, rolling of eyeballs, mental confusion, cramps, loss of movement and these various other problems arise. So basically he was also able to infer in the control of these various functions of the body.

It was not until 16th century that we started to understand the organization of the brain. Some of the most fundamental work in this direction was done by Andreas Vesalius. He was a physician who lived in Europe in the 16th century and what he did was he took human cadavers or dead bodies and did very detailed dissections on them and then drew detailed anatomical images for different parts of the body including the brain. So you can see one of the images of the brain here and this is probably the first time that we could see the brain not just as a mushy gel but we could really see different parts of the brain. He could also see various nerves and probably could see these nerves going to different parts of the body and so he concluded that the brain functions through these various nerves.

Later another great scientist in Europe, Leonardo da Vinci, built upon Vesalius' work and then he took these images and drew detailed 3D drawings like the one shown here and based on this type of anatomical work we started to understand the organization of the brain. Understanding the parts is essential before we can understand how the brain functions. As we started to learn about the organization or the anatomy of the brain, we could see that it is a part of the body. It is connected to different organs within the body through the nerves. So it was basically becoming clear that it is a physical structure and also at the same time it was becoming clear that brain is what controls various senses and also various cognitive functions in the body.

And then naturally this question began to emerge that what is the relationship between the brain or the body since brain is part of the body. So what is the relationship between the body and the mind? Now mind has been a term that has been used frequently for describing the cognitive functions, the thinking, the memories. So these are associated with the mind and this idea also relates to the idea of the soul that has been there in various cultures which is thought of as a non-physical entity that somehow keeps track of our emotions or our memories or our memories within this life or even previous lives and so on. So a lot of the cognitive functions have been assigned to the mind which is often thought of as a non-physical entity. But now we were learning more and more about the brain, a physical entity controlling some cognitive functions.

So what is the relationship between the body and the mind? What do you think? Now broadly there have been two kinds of ideas. The first idea is called dualism which is that the brain and the mind are two very different entities. The brain is physical and the mind is non-physical and they somehow interact but these are two different things. And the other idea is monism which says that the mind is not different from the body or the brain rather it is just a feature or a functionality of the brain or the body. Historically the idea of dualism has been more favoured in the past and one of the most famous proponents of dualism was this French scientist and philosopher René Descartes.

Some of you are probably familiar with his name. He is the one after whom the Cartesian geometry is named. So he was also a mathematician in addition to being a scientist and a philosopher. He is also the one who gave the famous quotation, I think therefore I am. So he was a well-known philosopher of his time and he had done also quite a bit of remarkable work on the brain.

So here is an illustration that Descartes drew to explain what happens when someone sees an arrow and then points a finger towards it. So here is the arrow in this diagram and he drew detailed image of how the rays of light would travel and go to the eyes and inverse images of the arrow would form in the two eyes and then from there it was already known that from the previous anatomical work that optic nerves carry the information from the eyes to the brain. So this information would go to the brain and then after the brain he also drew how the information would come out in the nerves and would activate the muscles and that would ultimately lead to pointing of the finger towards the arrow. So he got all of this quite right. Now let us see what he thought about what is happening inside the brain.

So he thought that the information from the optic nerves goes to a part of the brain, the pineal gland. Then he thought that the pineal gland as Galen had also thought earlier that the activity in the brain happens by the movement of a fluid in the ventricles or the cavities or the holes that are there in the brain. So Descartes also thought that is what is happening. But how is the decision to point the finger is being made? And that is where Descartes thought that this kind of decision making, intelligent decision making cannot happen by inert material or this physical entity of the brain. This must be made by the mind which must be separate from the brain.

And then how does the mind instruct the brain? So he thought that this instruction happens, the mind interacts with the brain at the pineal gland. And why did he narrow down to pineal gland? That is because he thought that this interaction of the mind must happen at a single place in the brain. It should not happen at two or three places. And if you look at the structure of the brain, you find that every brain is symmetric and it has left and right halves. And most parts of the brain are present in two copies, the left copy and the right copy.

But pineal gland appears to be a single structure in the middle of the brain. Although now we know that that was a mistaken assumption. Pineal gland also is composed of a left half and a right half. But just because it is in the middle of the brain, the two halves appear fused and so they appear like a single structure. So as you can see, people have thought about the brain for thousands of years and the theories have gotten refined over time.

And as people have learned more and more about the anatomy of the brain and its connection with the rest of the body, people have made more reasonable hypotheses about how the brain might function. But the theories are limited by what we can see. And till 16th or 17th century, we

were limited to seeing the brain by what we could see with the naked eyes. And we could not see much more than these coarse structures and the ventricles and the fluid in them. And therefore, these kinds of ideas that the brain functions by the movement of fluid in the ventricles persisted for some time.

And the next set of discoveries became possible after the invention of the microscope, which is what we would see in the next video. Thank you.