Module:
Biological foundations of mental health

Week 1
Introduction to brain anatomy

Topic 2
Neuroanatomy, neural systems and brain function – Part 1 of 3

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Lecture transcript

Slide 1
Hello. My name is John Pizzey. I'm an anatomist here at King's College London, and in this lecture, I'll be telling you about the ways in which the nervous system is put together, some of the classifications that we use to divide it up. We'll also look at some of the component parts and how they're connected.

Slide 2
By the end of the lecture, you should be able to recognise some of the two main ways in which we divide the nervous system up. We divide it up by function, and we can divide it up by the anatomy of the parts of the central nervous system. We'll be speaking about the differences between the central nervous system and the peripheral nervous system as we go along. We'll also be looking at the ways in which these parts are wired together-- not in great detail, but in general terms so that you can appreciate how we can derive a large huge amount of complex circuitry and computing power from the ways in which we wire up the different component parts.

Slide 3
To start with, let's think about what the starting material is. We have about 100 billion neurons in the adult human brain. Now, this equates to up to 100,000 trillion synapses. That's a vast amount of potential given that each of these is effectively a binary unit that contributes to the computing power of the brain.

But that is only a part of the story. The greatest complexity comes, not so much from these big numbers, but from some of their properties that we'll look at now.

Slide 4
The first is convergence. This is the ability of many different cells to send their inputs to one target cell. That is, the single cell receiving the inputs is receiving it from multiple sources. In fact, the average neuron in the human brain receives 10,000 different inputs-- not necessarily from 10,000 different cells, but there will be 10,000 different synapses on it.

Slide 5
The other side of the coin from convergence is divergence, and here, this is the ability of a single cell to project to multiple cells. Here again, we're looking at large numbers, maybe up to 1,000 different axon terminals from one single neuron. So we have the ability of the cell to receive multiple signals as well as to send out multiple signals. This creates what we know as neural networks.

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Slide 6
Now, these neural networks are not the same as neural networks that you might be familiar with in computing terms, but they're genuinely networks of neuronal origin, and this is the key to the complexity of the nervous system.

This means that a cell here can target a cell here in multiple different ways, going from the front of the brain via the back of the brain or directly in a more sensible route, if you like, a shorter route. But it can recruit different cells along the way.

Slide 7
If we think of this in terms of a tube map, now, how many different ways could we get, for example, from Bayswater to Arsenal, over here. There's clearly a quickest way, maybe this route, but there are alternatives, via this route for example. But in addition to these two we could take a very extreme route out via North West London coming back in again, maybe going down to South London and then arriving at Arsenal. So we have multiple ways of which we can get from one station to another, not necessarily the quickest way but how many different ways could we do it? Now of if you think of this in terms of the nervous system you can see, you can start to appreciate, how you can build up a great amount of complexity within the system. So I don't know how many ways you can get from Bayswater to Arsenal, if you can work it out, well done, but if you think of that multiplied by how many ways could you get from any one station on the London tube map to another you would soon realise you are dealing with very big numbers indeed. Now if you apply this to the nervous system, where each of these stations, each station, is effectively a single neuron and each station instead of recieving just one or two or three lines coming in you're now dealing with a hundred thousand lines coming in, 300 billion neurons, 300 billion stations, a hundred thousand lines coming in and a thousand lines going out you can see that you can genreate huge possibilities for the routes in which circuits can be made and it has been estimated that there are more possibilities for routing through the brain than there are atoms in the known universe.

Slide 7
Let's look now at some of the ways the nervous system can be divided up. What you can see here is one of the commonest ways, in which the nervous system is divided into the central nervous system and the peripheral nervous system. For now what I want you to look at is the fact the central nervous system is typically divided into the brain and spinal cord.

Now this has limitations we'll come to later. The peripheral nervous system includes the autonomic, which is the component that we are not aware of-- maintaining our heart rate, maintaining our breathing rate, maintaining gut peristalsis for example-- and the somatic nervous system, things we are consciously aware of-- things like movement, things like feeling temperature or fine touch or vibration. But this scheme, although you will see it a lot, has serious limitations.

Slide 8
First of all, let's have a look at the autonomic nervous system. Now, you might be familiar with this as often described as being divided into the parasympathetic component, and its complement, the sympathetic component. These are often referred to as 'rest and digest' or 'fight and flight' divisions. I would encourage you not to think along those lines as there are too many exceptions to these rules.

For example, the parasympathetic nervous system via the action of one of the cranial nerves-- in fact, the third cranial nerve, the ocular motor nerve-- is responsible for constriction of the pupil in bright light. The complement via the sympathetic nervous system is to dilate the pupil in dim light. It's not really related to 'rest and digest' or 'fight and flight.' And there are a large number of exceptions to these.

But generally, they do work in opposite ways. They work against each other. Dilation or constriction is a common feature of the two nervous systems.

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But the important point here is that although they send peripheral branches, they're not restricted to the periphery alone. So in the brain, there will be pathways that are wholly concerned with either parasympathetic or sympathetic function. Therefore, the earlier description of the parasympathetic and sympathetic nervous system not being related to the brain is probably not ideal.

Slide 10

I would think of the nervous system as being divided up into central nervous system where we have this definition whereby a neuron is a member of the central nervous system if it's wholly contained within the brain or spinal cord. So this means it might be within the brain, within the spinal cord, or travel between the brain and spinal cord.

But no part of it-- not the cell body, not the dendrites, not the axons-- project outside of those two structures. If any part of it does, then it's a peripheral nervous system neuron. And that's the way I would suggest you think about these terms.

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