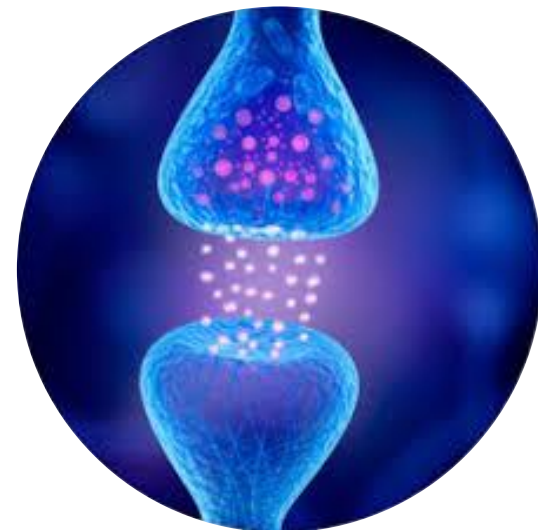




How Neurons and Brain Regions Communicate

Osher Course 10/19/2021

Natali Chanaday & Natalie Guzikowski

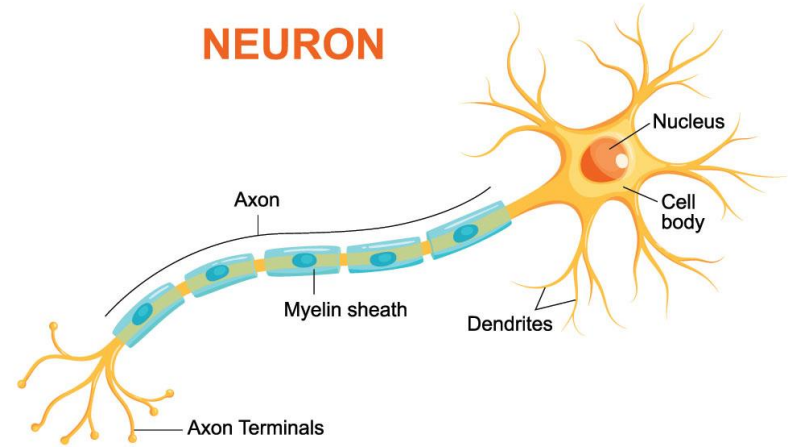


General Topic

- What are NEURONS?
- How do neurons COMMUNICATE with each other? → SYNAPSES
- Example:
 - how do neurons control the muscles to generate body movements
 - Rehabilitation using brain-machine-muscle interface

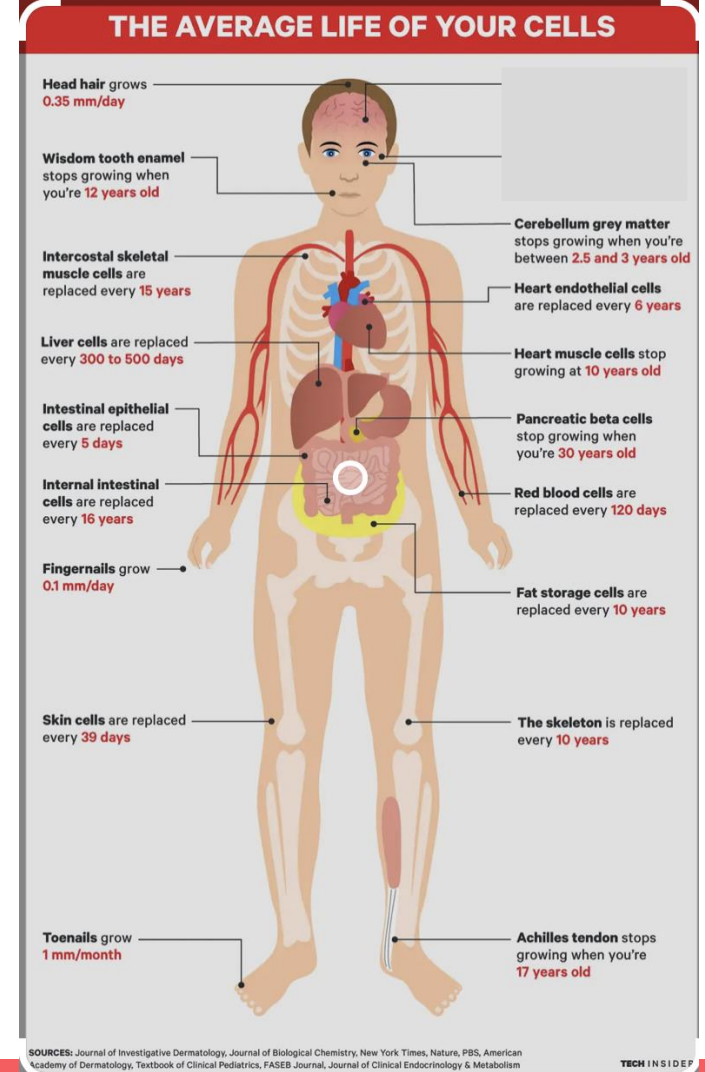
What is a neuron?

- Neurons are **brain cells**
 - They are the messengers: cells that specialize in **transfer of information**
 - They are in the brain and also throughout the body, since they **communicate the brain with all the muscles and body organs**



What is a neuron?

- What makes neurons special
 - They **don't divide** – we have the same ones from birth until death!
 - They communicate via **electrical signals** – they are the only excitable cells in our body!
 - They are the biggest cells in your body – e.g. a motor neuron in the sciatic nerve can be more than a meter long (base of spinal cord → big toe)

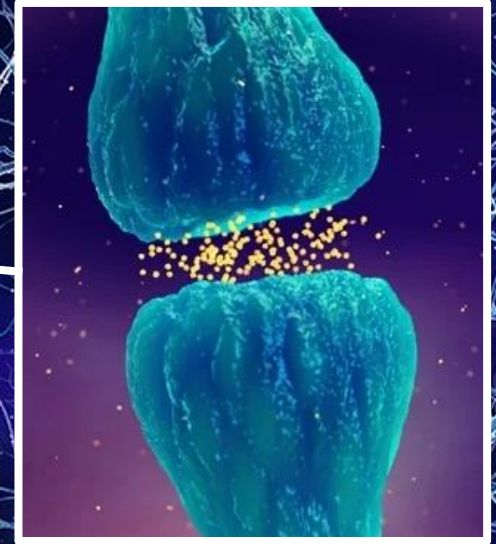


How Neurons talk to each other -
it's what makes us who we are!!

How do neurons communicate?

Electrical signal is transformed into a chemical signal at **SYNAPSES**

Nerve impulses



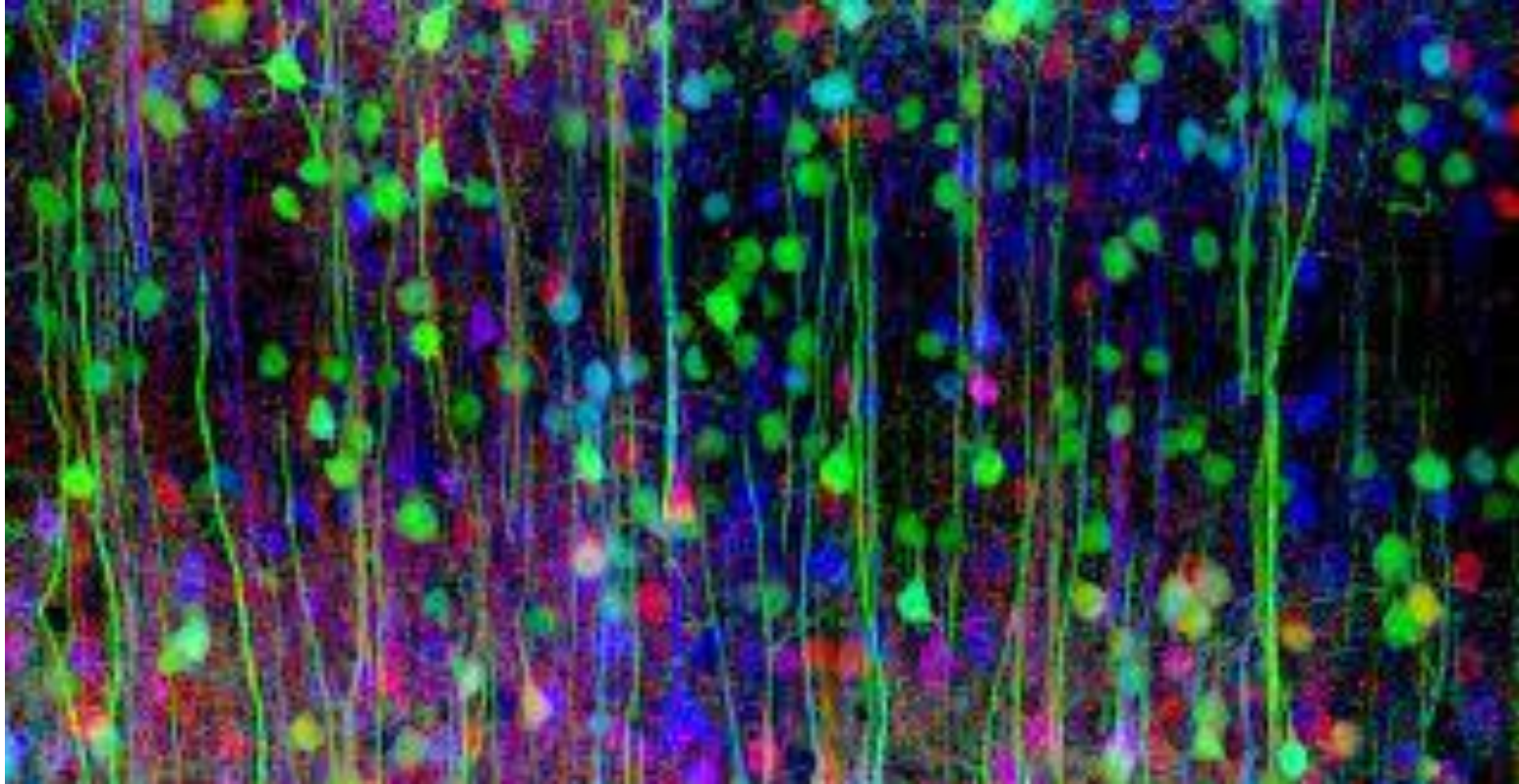
Information transfer in neuron networks

Muscle control

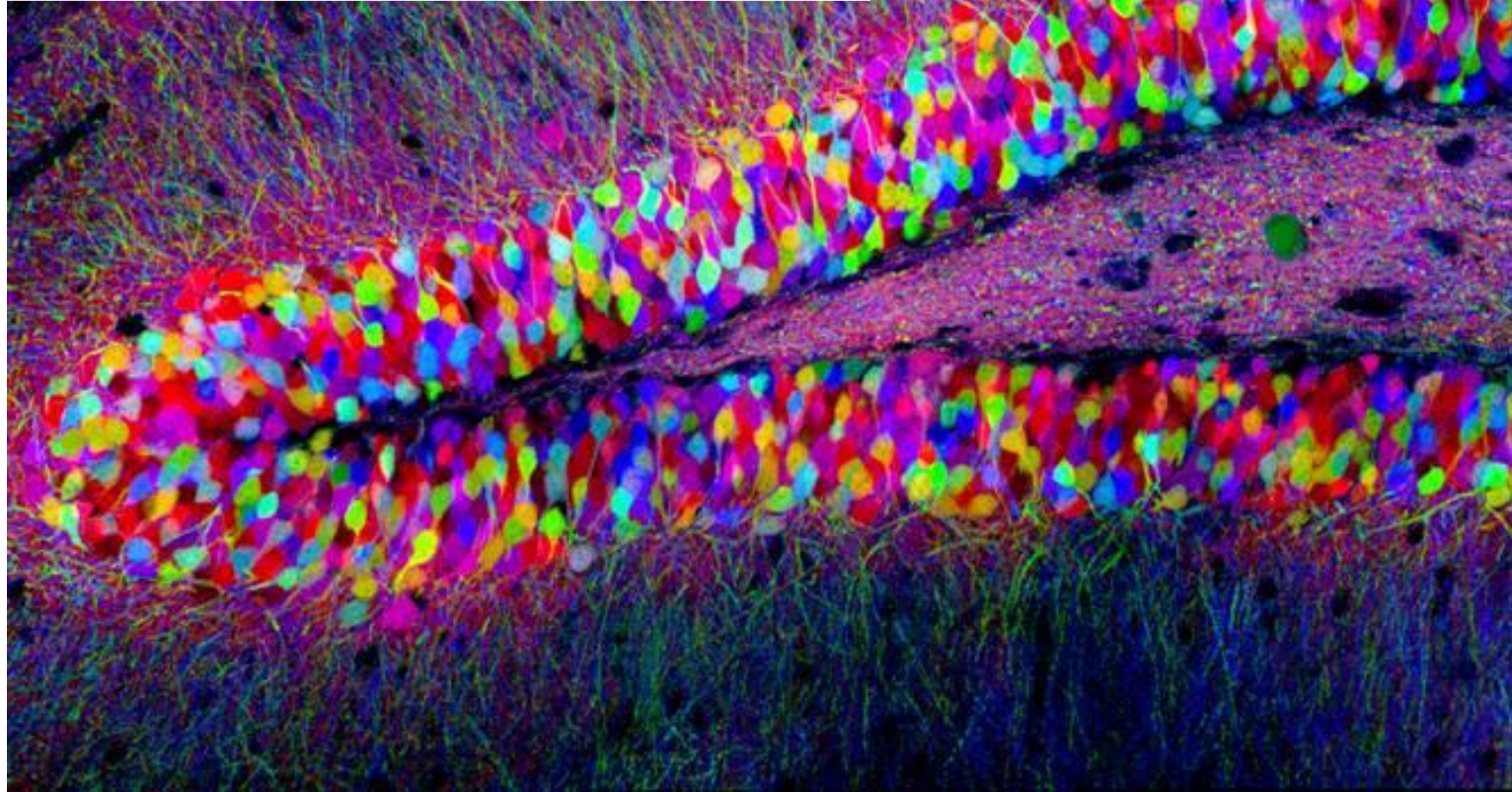
Learning and memory

Feeding, sleeping, feeling

How many neurons and synapses are there in the brain?



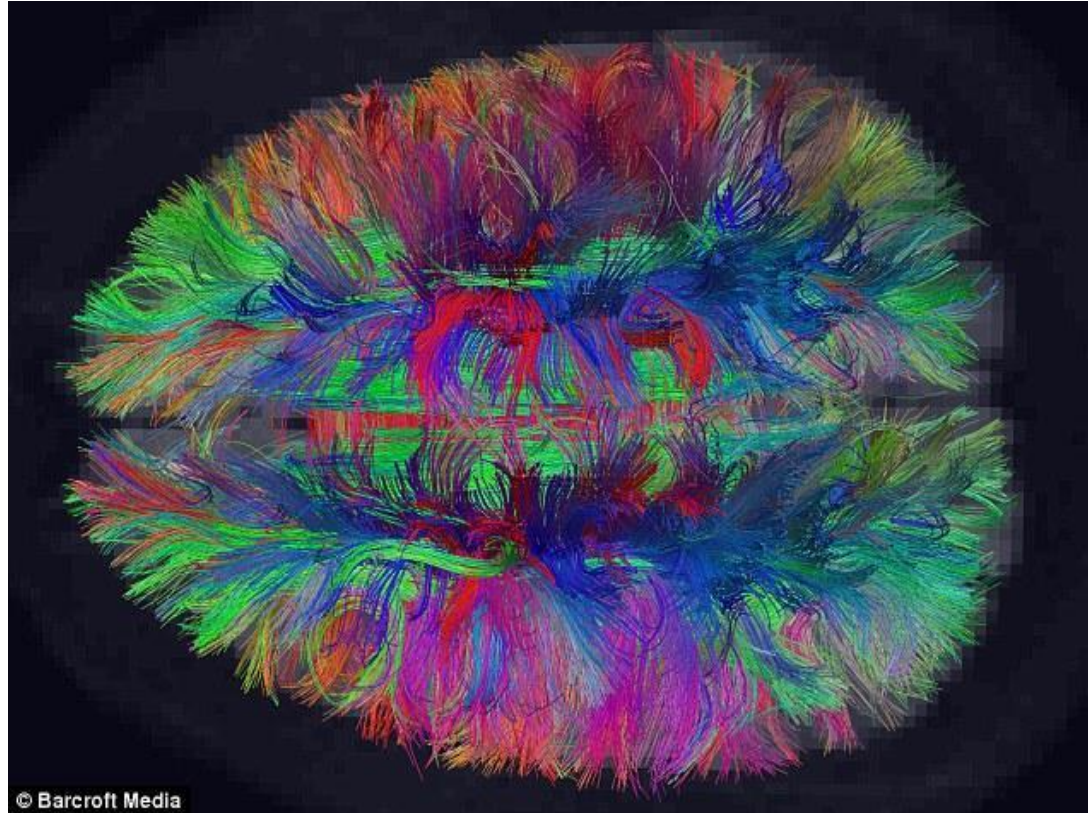
How many neurons and synapses are there in the brain?



How many neurons and synapses are there in the brain?

~86,000,000,000 neurons
in a human brain!!

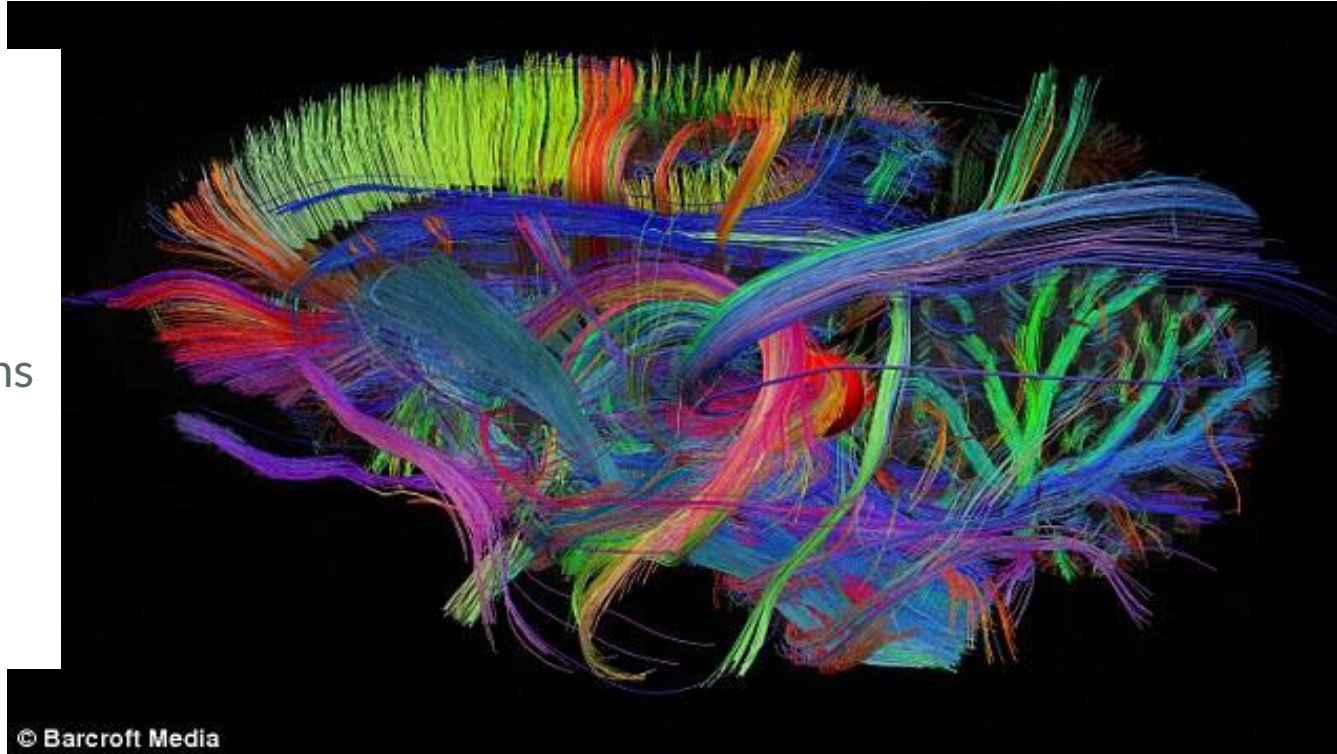
Each neuron makes hundreds
or thousands of synapses →
can we even count how many
synapses we have?



How many neurons and synapses are there in the brain?

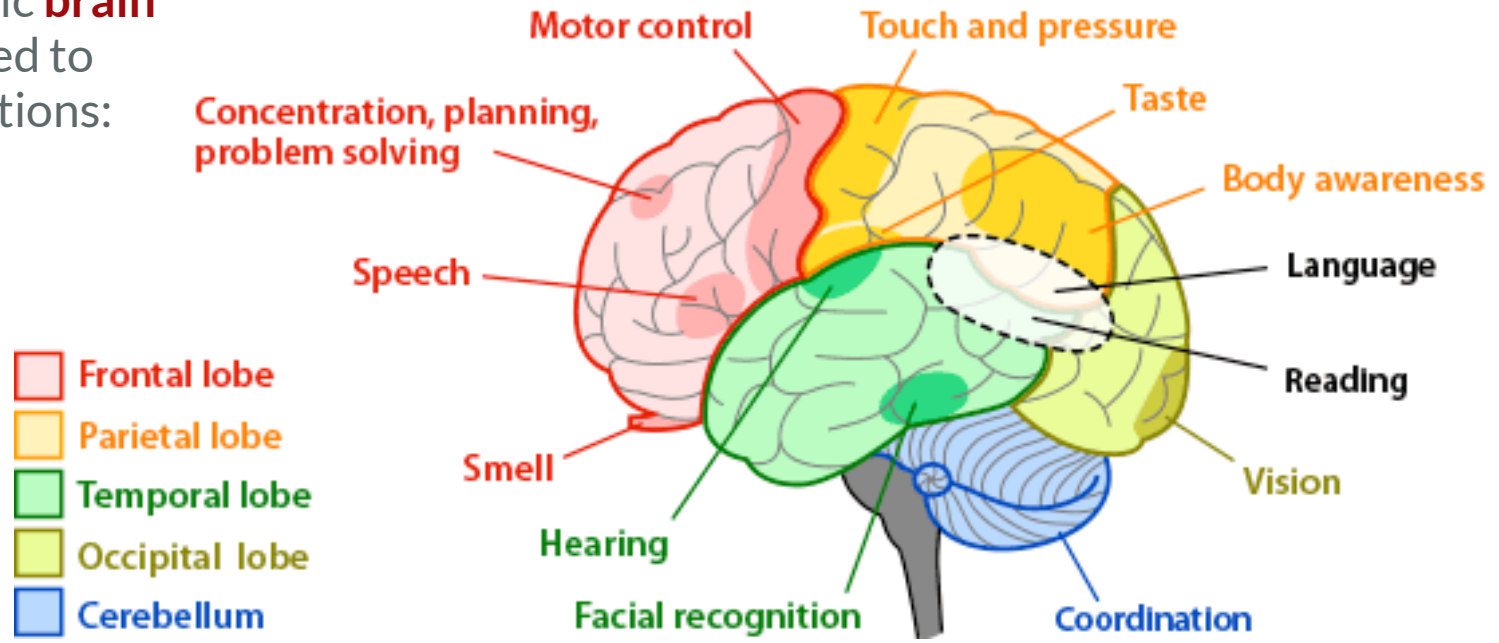
Then... how do all these neurons organize and work together?

Understanding how neurons form connections creating **brain circuits** is fundamental to understanding how does the brain work



How many neurons and synapses are there in the brain?

There are specific **brain circuits** dedicated to specialized functions:



Example of neuron circuit:
encoding of muscle movement

How a thought becomes movement

- Picking up a cup of coffee



How a thought becomes movement

The French philosopher René Descartes (1596–1650) and the **mind-body problem**

How do I know I have a foot and where it is, even though I'm not touching or seeing it?

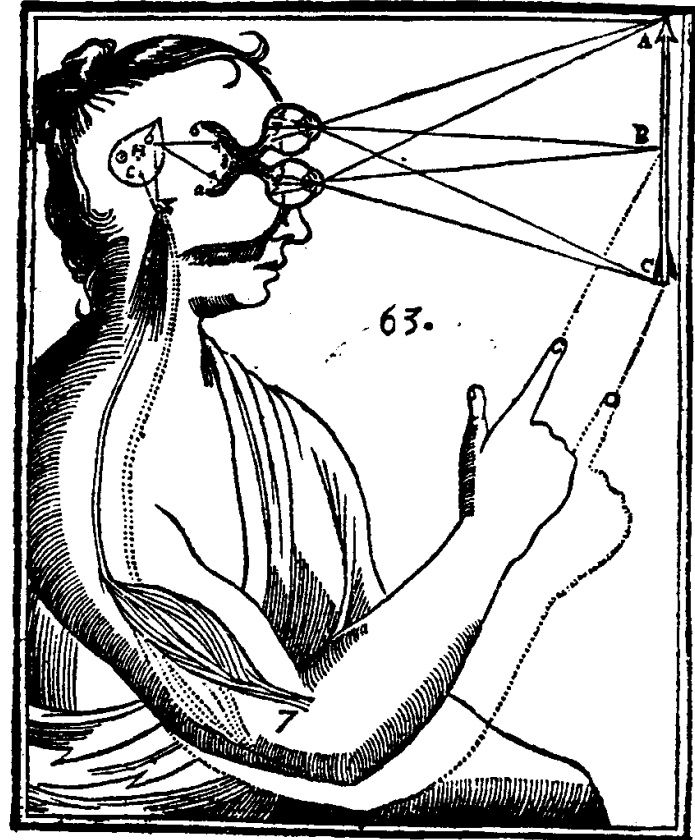


How a thought becomes movement

The French philosopher René Descartes and the **mind-body problem**

How do I know I have a foot and where it is, even though I'm not touching or seeing it?

When I drop my cup of coffee, how does my brain coordinate the vision (what I see) and the movement of my arm?

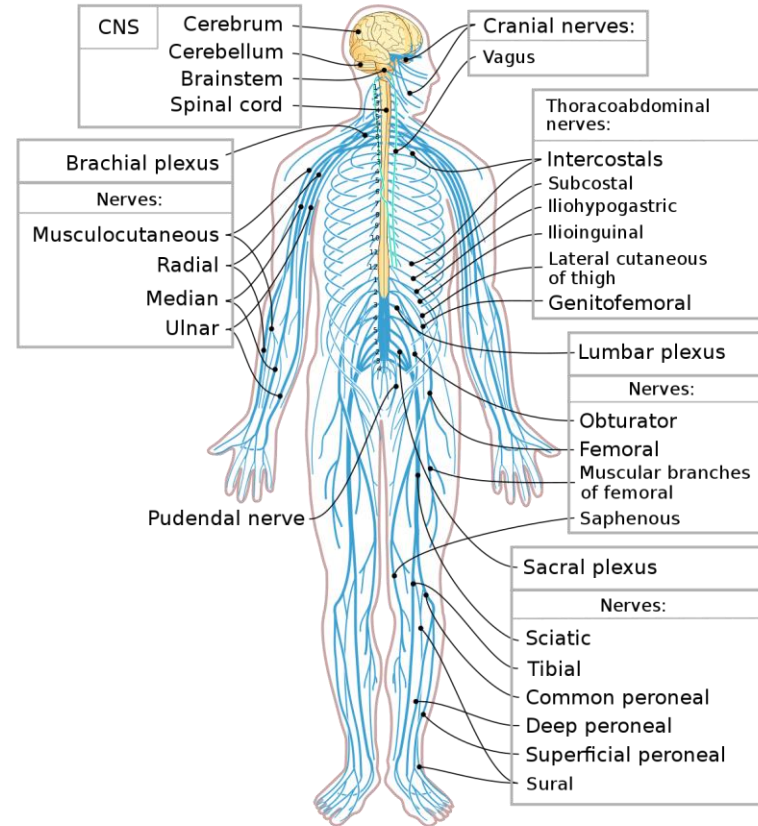


How a thought becomes movement

This is done by **motor neurons**!

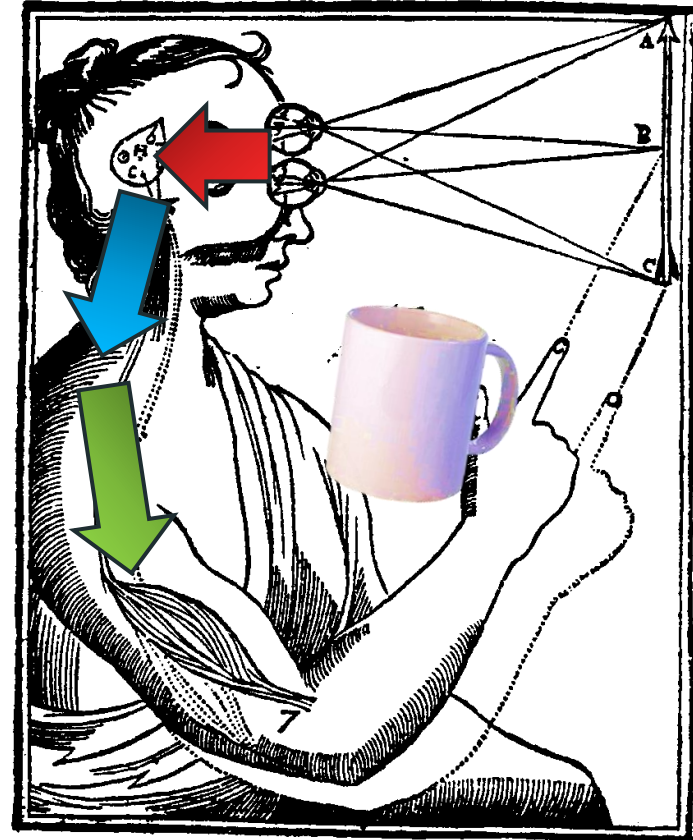
Neurons from the brain send an electrical signal to neurons in the spinal chord: the motor neurons.

Motor neurons are huge! They can send a nerve up to a meter long and contact muscles in your hands or feet, and regulate muscle contraction via electrical and chemical signals.



How a thought becomes movement

- Picking up a cup of coffee
 1. Neurons in the retina of the eye send the visual signal to the brain
 2. The brain sends the signal to the spinal cord
 3. The motor neuron send the signal to the muscle
 4. Pick up your coffe and have a wonderful morning!



How we can cure complete paralysis using brain-machine-muscle interfaces

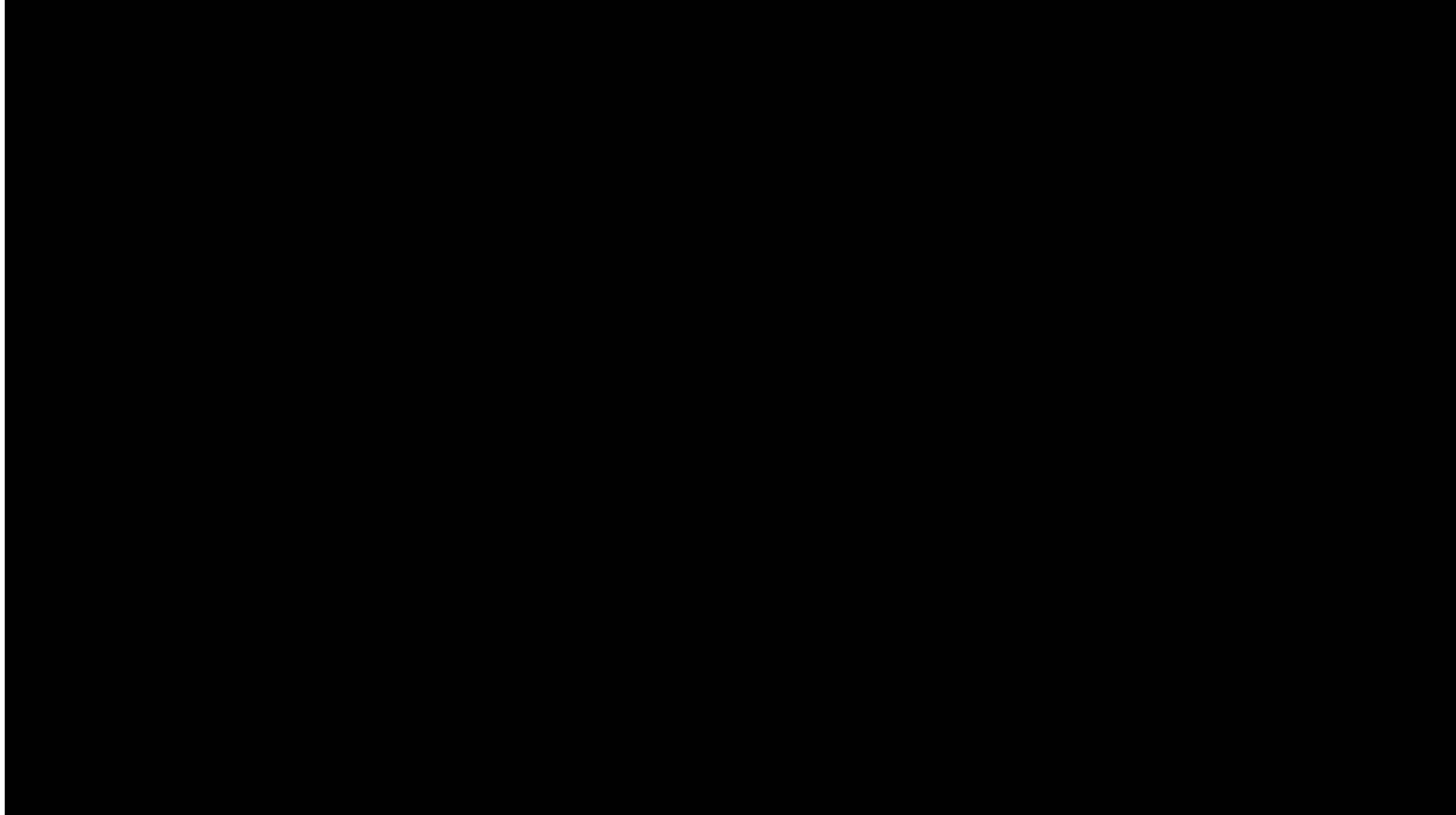
- Walk Again Project:

“Over the past decade, neuroscientists at the **Duke University Center for Neuroengineering (DUCN)** have developed the field of brain-machine interface (BMI) into one of the most exciting—and promising—areas of basic and applied research in modern neuroscience.”

“The **Walk Again Project™**, an **international consortium of leading research centers around the world** represents a new paradigm for scientific collaboration among the world’s academic institutions, bringing together a global network of scientific and technological experts, distributed among all the continents, to achieve a key **humanitarian goal**.”

“The project’s central goal is to **develop and implement the first BMI capable of restoring full mobility to patients suffering from a severe degree of paralysis**.”

<https://www.walkagainproject.org/>



Conclusions

- What are NEURONS? → Cells that transfer information
- How do neurons COMMUNICATE with each other? → SYNAPSES
- Example:
 - Muscle control and Rehabilitation using brain-machine-muscle interface
 - If we understand how neurons communicate, then we can design interventions to treat or cure neurological diseases, and that is why brain research is so important!
 - Research is MULTIDISCIPLINARY: people from different professions and diverse backgrounds come together, and this is how amazing discoveries start!

