Brain Anatomy & Function, Cell Death, and Neurodegenerative Diseases

Presented to you by UM GIDAS

Brain Anatomy

Components of the Brain

The brain is divided into 3 main components. This includes the:

- Cerebrum
- Cerebellum
- And brain stem

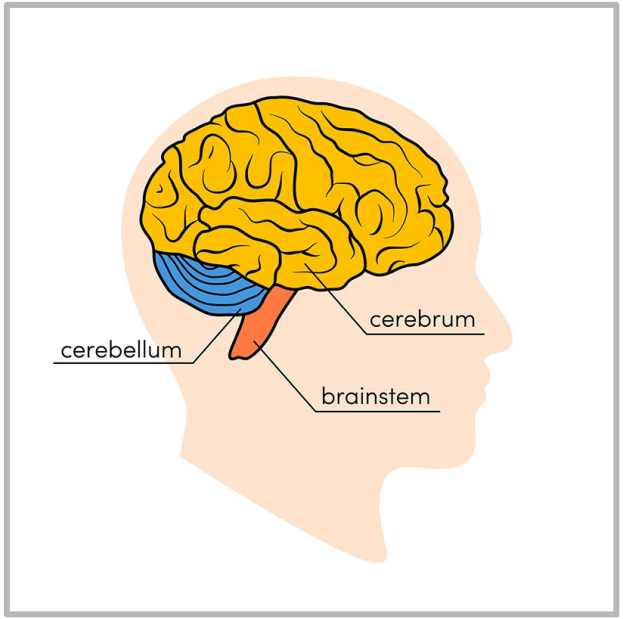

Photo Credit: Johns Hopkins Medicine

https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain

Lobes of the brain

The brain can also be divided into 4 lobes of the brain: the frontal lobe, parietal lobe, temporal lobe, and occipital lobe.

These different parts of the brain are responsible for different functions. We highly suggest you review this through the Mayfield Clinic website, as well as the Genes and Health Study Guide. Listed on the right are some general functions each lobe performs.

Frontal Lobe:

- Personality (think of Phineas Gage!), problem solving, planning, speech production, movement

Parietal Lobe:

- Understanding language (see Wernicke's area); touch, pain, temperature sensing; sense interpretation (sight, hearing, motor)

Occipital Lobe:

- Vision, sight processing

Temporal Lobe:

- Memory, hearing, information organization, language understanding

Language is complex! Be sure to review Broca's area and Wernicke's area.

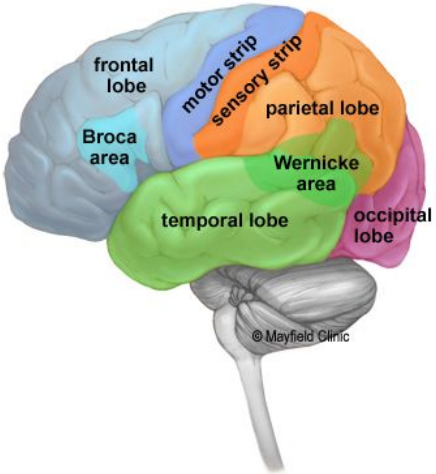

Photo credit: Mayfield Clinic

https://mayfieldclinic.com/pe-anatbrain.htm

Deeper Structures/Pathways

All these different parts of the brain are connected together! Signaling from neurons in one area can travel from one lobe to another, and sometimes even to structures deep in the brain.

Some important structures include the hypothalamus, pituitary gland, thalamus, basal ganglia, and limbic system (consisting of the hypothalamus, amygdala, and hippocampus).

Hypothalamus
- Regulates physiological processes such as temperature, hunger, thirst, and circadian rhythms.

Pituitary gland
- Known as the “master gland”, this gland controls the release of hormones that help regulate growth, metabolism, and more

Thalamus
- Relays sensory information, helping direct signals from sensory organs to the cerebral cortex for processing

Basal Ganglia
- Movement! This structure helps motor control, coordination, and voluntary movement.

Limbic System
- Involved in emotions, memory formation, and the regulation of very basic survival instincts (think fight or flight!)

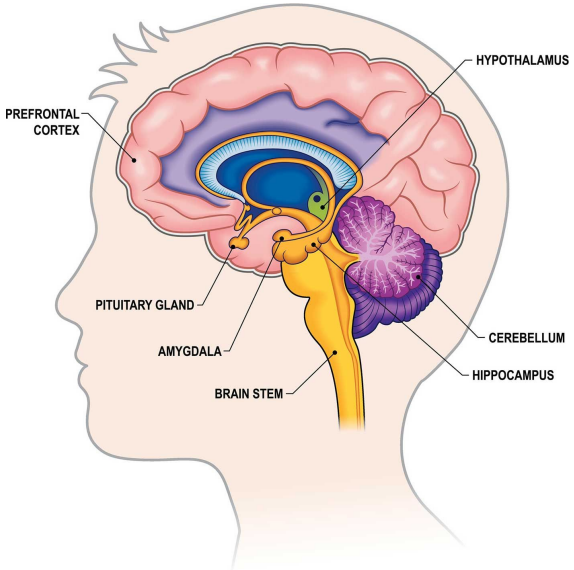

Photo Credit: Johns Hopkins Medicine

https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain

Memory

Memory consists of 3 phases:

- Encoding, storing, and retrieval/recall

Which lead to different parts of the working memory: short-term, long-term, skill-memory.

Short Term, Encoding

- Also known as the working memory. Most of this is done in the prefrontal cortex. It stores information for a temporary amount of time.

Long Term, Storing

- To store information from the short term memory, this type of memory needs to be processed by the hippocampus in the temporal lobe. This has unlimited content and also contains personal memories and facts & figures

Skill Memory, Retrieval

- This is processed in the cerebellum, which helps relay information to the basal ganglia. It has a lot of automatic learned memories (many of them related to movement, such as playing the piano, or muscle memory!)

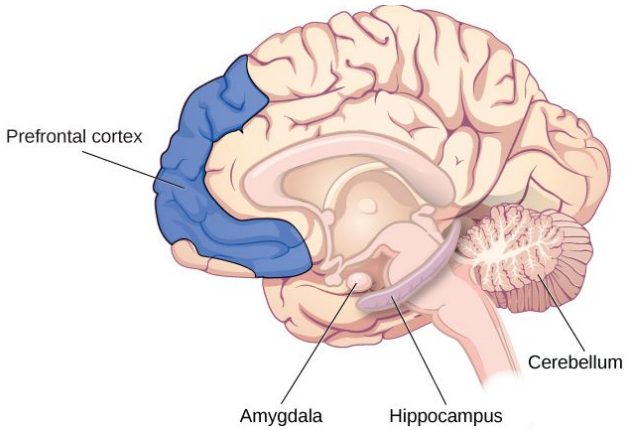

Photo credit: Lumen Learning

https://courses.lumenlearning.com/waymaker-psychology/chapter/parts-of-the-brain-involved-with-memory/

Cell Death

Cell Death Overview

While cell growth and synthesis is important, cell death is also very important! In the case of damaged or dying cells, our body uses cell death to keep our body healthy and functioning.

There are three main types of cell death: apoptosis, autophagy, necrosis.

As a brief summary,

- Apoptosis is a form of programmed cell death. Usually this means cells will naturally self-destruct or die.
- Autophagy is also a form of programmed cell death. It happens during times of stress or hunger. Our bodies does this to reuse cell parts– sort of like recycling!
- Necrosis is unprogrammed cell death that causes tissue death. This is usually due to trauma to a cell. Sometimes it could be because of the lack of blood flow or oxygen to certain parts of our body.

The main cell death the contest focuses on is apoptosis!

Apoptosis

Like mentioned before, apoptosis is a form of programmed cell death. Cells usually self-destruct or die naturally. It is usually healthy and expected for some cells to die like this.

In the cell division cycle (mitosis), typically apoptosis happens at the G1 phase, one of the very beginning stages of cell division. During this phase, the cell is preparing to divide by making sure it has the right mRNA and proteins for DNA replication. Therefore, this step is important as it will determine if the cell will commit to the cell cycle or leave it.

Problems with this type of cell death/programming could lead to the development of diseases such as Parkinson's disease or Alzheimer's disease, in which, too many nerve cells (neurons) die. This early neuron death could mean that the ability to think or move is impacted, leading to the many symptoms seem by these diseases.

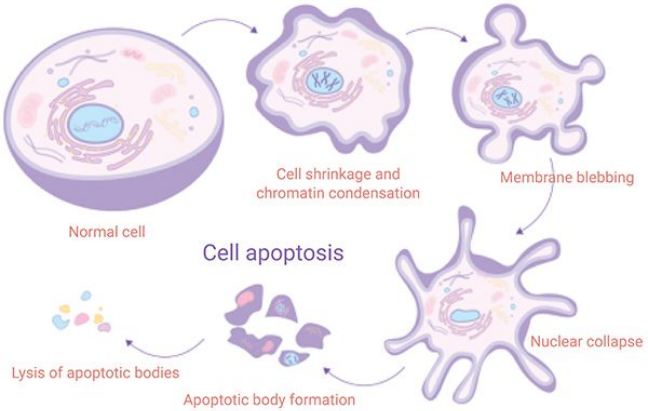

Photo Credit: MedChemExpress

https://www.medchemexpress.com/literature/cell-apoptosis-methods-for-the-detection-of-apoptosis.html

Neurodegenerative Diseases

Parkinson’s Disease

Parkinson’s Disease is when nerve cells die in the basal ganglia structure, located in the midbrain region. This region usually supplies dopamine to the basal ganglia.

This in turn, can cause symptoms that affect the motor system, such as tremor, rigidity, slowness of movement, balance problems, and difficulty with walking. In later stages, dementia is also common. Symptoms usually worsen over time.

Photo credit: American Parkinson Disease Association

https://www.apdaparkinson.org/what-is-parkinsons/symptoms/

Alzheimer's Disease

Alzheimer's disease is characterized by the loss of neurons and synapses in the cerebral cortex. The death of these nerve cells usually affect the temporal lobe and parietal lobe, as well as parts of the frontal cortex. Sometimes, degeneration may happen in the brainstem.

Some symptoms of this disease can include problems with language, mood swings, self-neglect, behavioral problems, and subtle problems with problem solving. Short term memory loss is usually the most noticeable first deficit.

Alzheimer's also makes up about 60-70% of dementia cases.

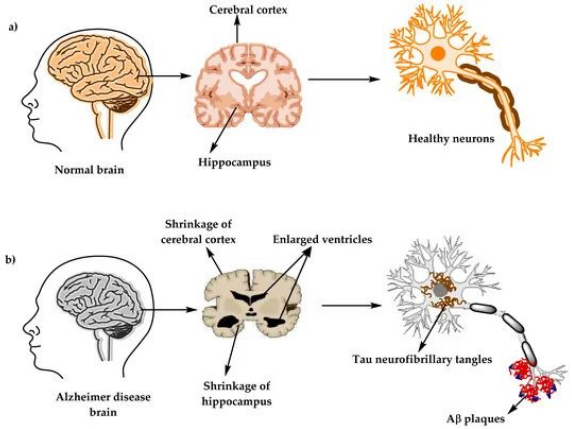

Photo Credit: MDPI

https://www.mdpi.com/1420-3049/25/24/5789

Multiple Sclerosis

Multiple Sclerosis (MS) is an autoimmune disease where the myelin sheaths of neurons are damaged. This usually means that neurons have a more difficult time transmitting signals.

This results in symptoms such as vision problems (loss or double), muscle weakness, or loss of sensation. It varies, however, but sensory problems seem to be most common.

The cause is usually thought to be the destruction of myelin by the immune system or the failure or myelin-producing cells.

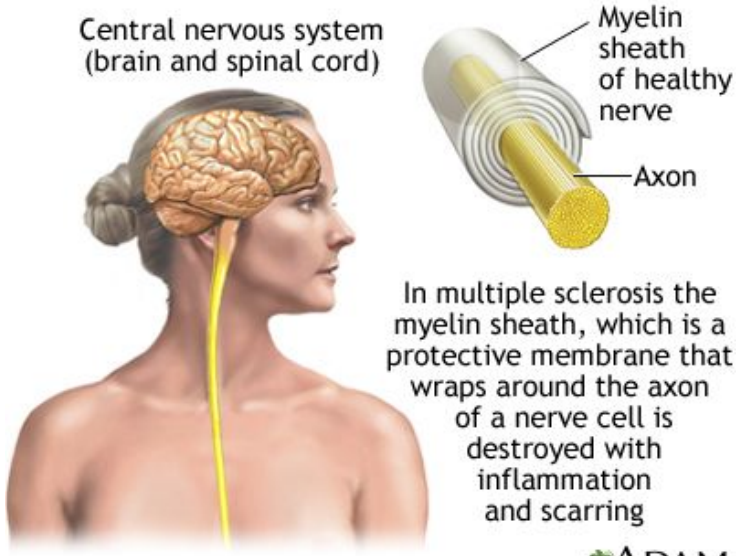

Photo Credit: Medline Plus

https://medlineplus.gov/ency/article/000737.htm

Frontotemporal dementia

Frontotemporal Dementia (FTD) is dementia where the frontal and temporal lobes are degenerated. Usually, this is due to damage to the neurons in the frontal and temporal lobe (loss of neurons). This causes the lobes to shrink.

Common symptoms may include change to personality and social behaviors, deficits in emotional responses (eg. lack of empathy), trouble with language, and frequent mood changes.

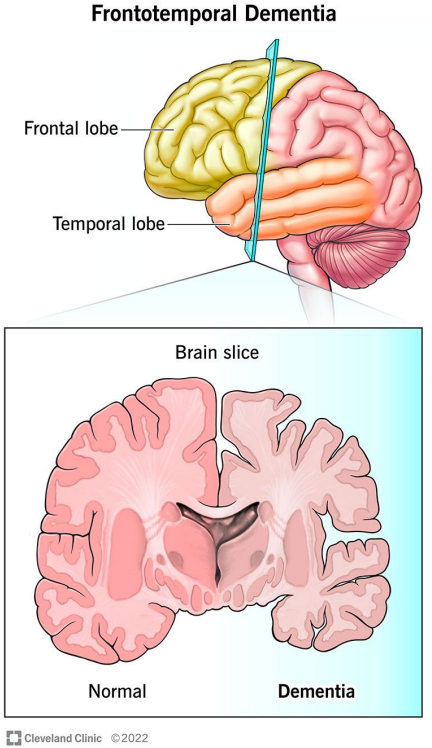

Photo Credit: Cleveland Clinic

https://my.clevelandclinic.org/health/diseases/21075-frontotemporal-dementia

Amyotrophic Lateral Sclerosis (ALS)

Amyotrophic Lateral Sclerosis (ALS) is a disease where there is a loss of motor neurons that usually control voluntary movement. It involves neurons in the brain and spinal cord. The disease itself can also be classified by a many different factors, including which part of the body is affected first, the age, the influence of genes, how the disease progresses.

As a result, symptoms include stiff muscles, muscle twitches, weakness, muscle atrophy, and difficulty speaking or swallowing. As the disease progresses and more motor neurons are lost, it affects the abilities to eat, speak, move, and finally, the ability to breathe. Generally, sensory neurons and autonomic nerves are unaffected.

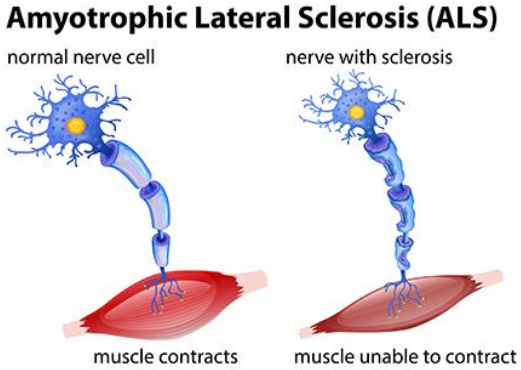

Photo Credit: OHSU

https://www.ohsu.edu/brain-institute/als-amyotrophic-lateral-sclerosis

Questions?

Email genesandhealthcontestinfo@gmail.com

Other Helpful Resources

- Brain Stuff
  - https://mayfieldclinic.com/pe-anatbrain.htm
  - https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-know-your-brain
- Cell Death
  - https://my.clevelandclinic.org/health/articles/cell-death
- Neurodegenerative Diseases
  - https://www.physio-pedia.com/Neurodegenerative_Disease