Neurons

- Around 100 billion Neuron cells in the brain
- Most important cells for brain function
- Sense changes in the environment
- Communicate it to other neurons

Glial Cells

- Around 1 trillion in the brain
- Contribute to brain function by insulating, and supporting the Neurons
- Derived from the greek word “Glue” which keeps the brain together and prevents it from flowing out of ears

*******The Neuron Doctrine*******

- Most cells are .01-.05 nano meters in diameter
- The compound microscope made it possible for new developments in Neuroscience
  - Scientists would cut the brain into thin slices by hardening them in Formaldehyde and then used a device called a **microtome** to cut them very thin
- **Histology** is the study of tissues
- Brain cells were all the same color so they started staining them
  - **Franz Nissl** stained the nuclei of all brain cells
    - also stumps around the bodies called **Nissl Bodies** and the stain is called a **Nissl Stain**
    - **Nissl Stain** distinguishes between Neurons and Glial cells and allows scientists to study **cytoarchitecture** - Arrangement of Neurons in different parts of the brain - which led scientists to understand that there are many different parts of the brain
  - **Camillo Golgi** discovered that by soaking the brain in **silver chromate solution**, Neurons became dark colored and were now distinguishable from the rest of the cell

Golgi Stains

- Revealed that the Nissl stain (which revealed the region of the neuron around the nucleus) was only a small part of the Neuron.
- Golgi stain revealed that neurons have two distinguishable parts.
  - A central region that contains the nucleus (**Soma**) and numerous tubes that go away from the nucleus (**Axons** and **Dendrites**)
  - **Axons** carry signals to other Neurons
  - **Dendrites** receive the signals for Neurons

Cajal

- Descendant of Golgi who argued with him
  - Golgi said that all Neurons are connected to each other just like arteries and veins. Cajal said that they are not connected with each other and must communicate with each other through contact, not continuity. **Cajals theory is called the Neuron Doctrine**

- Cajal was proven correct when the electron microscope was discovered and came to the conclusion that Neurons are independent and don't flow through each other.

The Neuron

- Inside of Neuron is separated from outside by the **Neuronal Membrane** - which gives the cell its 3-D shape

Soma

- Central part of the Neuron
  - Made up of **cytosol** - which is a watery fluid inside the cell - is a salty, potassium rich solution. The Soma is separated from the outside of the cell by the Neuronal membrane.

Organelles

- All the organelles within the cell - excluding the nucleus - are contained within the **Cytoplasm**

Nucleus

- Derived from nut
- Contained within a double membrane called the **Nuclear envelope**

- **Chromosomes** are in the nucleus
  - Contain the genetic material for DNA.
  - Each chromosome has a double strand of DNA

Gene Expression

- Genes are the segments of DNA
- The reading of DNA which creates a final product called **Proteins**- which gives Neurons all of their characteristics
- **Protein Synthesis** occurs in the cytoplasm - outside the nucleus.

MRNA

- Carries the genetic message from DNA (inside the nucleus) to the Proteins (IN the cytoplasm) and
- Consists of four different Nucleic Acids strung together

Transcription

- Process of creating MRNA that has genes to carry to the proteins, this MRNA will now be called the **transcript**

Promoter

- Region where RNA Polymerase (this is the enzyme that creates RNA) binds to start transcription.

Transcription factors

- Proteins that bind the polymerase to the promoters
- **Terminator** recognizes the end of RNA Polymerase for transcription
- **Introns -** region in the DNA that cant be used to code for protein.
- **Exons -** the sequence of DNA that is used for coding of proteins

RNA Splicing

- The introns are removed and the exons are fused together

- Alternatively Spliced proteins are when sometimes exons are removed with Introns and it will code a different protein altogether
- MRNA transcripts go through pores in the nuclear envelope and travel to sites of protein synthesis

Amino Acids

- Building blocks of protein
- There are 20 different kinds
- When amino acids are converted to build proteins, this is called **translation**

Central Dogma

- The whole process of DNA coding into proteins.
- Molecular Neurobiology is the study of genes to determine certain brain functions corresponding ti neuronal proteins

Rough ER

- Major site of protein synthesis
- RNA transcripts bind to the ribosomes and the ribosome translates the message to create a protein

Free ribosomes

- When attached by a thread, that is called **Polyribosomes**

Difference between rough er and free ribosomes is dependent on where the created protein will live

- Free ribosomes - proteins will reside in the cytosol
- Rough ER when the proteins will live in the membrane of the cell

Smooth ER

- Site where proteins are folded, giving there 3-D shape.
- Smooth ER regulates the concentration of calcium in the cell
- **Sarcoplasmic Retciulum -** smooth ER in muscle cells (Because it plays a huge roll in development of muscles)

Golgi apparatus

- Sorts proteins that are delivered to different parts of the Neuron

Mitochondria_

- Inner membrane is folded to be called **Cristae**
- **Matrix -** Space between the cristae
- Site of cellular respiration
- Inhales Pyruvic acid and oxygen which enters the **Krebs cycle** (Named after **Hans Krebs**) and produces energy that creates another phosphate - ADP becomes ATP.
- Exhales 17 ATP molecules per 1 m molecule of pyruvic acid
- The breakdown of ATP into ADP produces energy for the cell to pump substances across the membrane

Nueronal Membrane

• Barrier to enclose the cytoplasm inside the neuron

- 5 nanometers thick
- Protein of neuronal membrane is different depending on if it is the soma, dendrites, or axons

Cytoskeleton

- Gives neuron its shape,
- Made of microtubules, microfilaments, and neurofilaments

Microtubules

- Run longitudinally down neurites
- The wall is composed of smaller strands that are made of protein **tubulin**
- Small proteins to create long strand is called **polymerization** which creates a **Polymer**
- **MAP's** are proteins that regular the production of microtubules
- Changes in the MAP called **Tau** is a cause for Alzheimers and dementia

Microfilaments

- Same thickness as cell membrane
- Changes the shape of the cell
- Made of **Actin Filaments** which play a role in muscle contraction
- Looks like a spider web

Neurofilaments

- Really called intermediate filaments in the body, in the brain they are called neurofilaments
- Resemble bone and ligaments of Skeleton

Axon

- Transfers information in the nervous system
- **Axon Hillock** is the beginning of the Axon
- There is no rough ER or free ribosomes, meaning that they get all of their proteins from the soma
- **Axon collaterals** - the branching of the Axons
- **Recurring collaterals** - when axon branches return to communicate with the same cell that gave rise to the Axon
- The thicker the axon, the faster the impulses travel

Axon terminal

- The end of the axon is called the **Axon Terminal** or **terminal Bouton**
- Site where axon comes in contact with other neurons and passes along information to them
- Point of contact is called **synapse**
- When an axon branches and the branches form synapses, these branches are called **terminal arbor**
- Innervation is when the cell innervates by making synaptic contact with another cell

Cytoplasm of Axon terminal

- Microtubules do not extend into the terminal
- Contains synaptic vesicles
- Inside is loaded with layer of proteins
- Numerous mitochondria - which means there is a lot of energy

Synapse

- Presynaptic and postsynaptic

- Presyanptic consists of axon terminal
- Postsynaptic consists of dendrite

- **Synaptic cleft**
  - Space between the pre and postsynaptic membranes
  - Transfer of information is called **Synaptic Transmission**
  - Signals are converted from electrical impulses to chemical signals
  - Chemical signal is called a **neurotransmitter**

Axoplasmic transport

- Movement of material down the axon
- **Wallerian degeneration** - When an axon cant exist without the soma
  - Named after **Augustus Waller**
- **Paul weiss** discovered that tying a thread around axon, material accumulates down axon closest to soma
- **Bernice Grafstein** discovered fast axoplasmic transport
- Legs of axoplasmic transport are from a protein called **kinesin** and the process is filed by ATP
- Kinesin moves material from the soma to the terminal - this direction is called **anterograde transport**
- Material moving down the other way is called **retrograde transport**
- Legs from retrograde are made of proteins called **dynien**

Dendrites

- Derived form greek word for tree
- Each branch of dendrite is called a **dendritic branch**
- The shapes and sizes of dendrites classify different groups of neurons

Dendritic spines

- Discovered by **Cajal**
- **William Greenough -** discovered that dendritic spines can be altered through environment during early development
- **Oswald Steward** discovered that polyribosomes are right under dendritic spines - which shows that proteins get created in some neurons which is crucial for the brain

Neurites

- Axons and dendrites are called neurites
- A single neurite is called unipolar
- Three or more is multipolar - most are multipolar

- **Stellate cells/Pyramidal cells -** Star shaped cells/pyramid shaped
  - Both are in cerebral Cortex
  - All pyramid cells are spiny
- **Primary sensory neurons** are senses in surfaces of body (Skin, eyes)
- Motor neurons are axons that form synapses with muscles
  - Motor neurons release acetylcholine
  - Classified as **cholinergic -** they have a specific type of neurotransmitter
  - Interneurons only communicate with other neurons

Golgi Type 1 Neurons

- Have axons that go from one part of the brain to the other
- Pyramidal cells are Golgi type 1

Golgi type 2 Neurons

- Only in vicinity of cell
- Stellate cells are Golgi type 2

Astrocytes

- Most numerous Glial cells
- Regulates chemical content of extracellular space
- Neurotransmitter that triggers electrical and biochemical events in glial cells
- Controls extracellular concentration that can interfere with neuronal function
- Regulates potassium ion concentration

Myelinating Glia

- Shwann cells and oligodendrological cells
- Provide layers that insulate the axon

Myelin sheath

- Discovered by **Alan Peters**
- Spirals around the axon
- Short length that is exposed is the **node of ranvier**
- Speeds the nerve impulses down the axon

Oligodendrological cells

- Only in the CNS
- Deliver Myelin to several axons

Schwann cells

- Are in the PNS
- Deliver myelin to only 1 axon

Ependymal cells

- Direct cell migration during development

Microglia

- Function as phagocytes