Neurons

Instructor Manual

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This instructor resource module is designed to help facilitate a lesson about neurons. This module reviews the anatomy and physiology of neurons and glial cells. It covers the basics of within and between cell communication in neurons. General recommendations for implementing the lesson, as well as more specific recommendations for activities, discussion questions, and outside resources to support the learning in this module are included. PowerPoint slides that correlate with these recommendations are available at the Noba website.

Learning Objectives

Content Specific Learning Objectives:

- Differentiate the functional roles between the two main cell classes in the brain, neurons and glia.
- Describe how the forces of diffusion and electrostatic pressure work collectively to facilitate electrochemical communications.
- Define resting membrane potential, excitatory postsynaptic potentials, inhibitory postsynaptic

Relevant APA Learning Objectives (Version 2.0)

- Describe key concepts, principles, and overarching themes in psychology (1.1)
- Develop a working knowledge of psychology's content domains (1.2)

- Use scientific reasoning to interpret psychological phenomena (2.1)
- Demonstrate psychology information literacy (2.2)

Abstract

This module on the biological basis of behavior provides an overview of the basic structure of neurons and their means of communication. Neurons, cells in the central nervous system, receive information from our sensory systems (vision, audition, olfaction, gustation, and somatosensation) about the world around us; in turn, they plan and execute appropriate behavioral responses, including attending to a stimulus, learning new information, speaking, eating, mating, and evaluation of potential threats. The goal of this module is to become familiar with the anatomical structure of neurons and to understand how neurons communicate by electrochemical signals to process sensory information and produce complex behaviors through networks of neurons. Having a basic knowledge of the fundamental structure and function of neurons is a necessary foundation as you move forward in the field of psychology.

Class Design Recommendations

This topic can be taught in one long class period (60-90 minutes) or two short class periods (50-60 minutes each). It is preferable to teach this as a 2-class-period lesson because many students struggle with anatomy and physiology when taking a psychology course and extra time may be needed for analogies, examples, and clarifying comments. Class 1 should focus on the history of our understanding of neurons and glia, the structure and classifications of these cells in the brain, and the resting membrane potential. Class 2 should focus on action potentials and neurotransmission. Many animations of processes involved in neural communication are included in the PowerPoint, so time consideration should include the time required to play and explain these animations.

Topic Outline

- Introduction/Learning Objectives/Warmup
    - The Evolution of our Understanding of Neurons as Discreet Cells

- Begins over 100 years ago with Ramon y Cajal
- Through his use of the Golgi stain he could define discreet cells in the brain
- This discovery countered Gerlach's existing theory that the brain was an interconnected network
- This work paved the way for our current understanding of neurons

- Structure of the Neuron
  - Parts-Soma, dendrites, nucleus, axon, synapse, terminal button, dendritic spines, myelin sheath
  - Anatomy of the synapse-presynaptic and postsynaptic membranes, synaptic gap, synaptic vesicles, neurotransmitters, receptor sites, and ion channels
- Types of Cells in the Brain
  - Classification of neurons based on function-motor, sensory, interneurons
  - Classification of neurons based on structure-unipolar, multipolar, bipolar
  - Glial Cells
- Communication Within and Between Neurons
  - Resting Membrane Potential
  - Action Potential
  - Neurotransmission

Module Outline

- **Introduction:** It is difficult to begin to understand the function of the brain without understanding the function of the basic units of the brain, the neuron. Understanding how these discreet cells function alone and together to drive motor movements and to bring in sensory information is only the beginning of understanding human and animal behavior. Further, understanding cellular function gives us a better foundation for understanding what happens when things go wrong in the brain, like with strokes, seizures, tumors, and

traumatic brain injuries.

- **The Evolution of our Understanding of Neurons as Discreet Cells:**Begins over 100 years ago with Ramon y Cajal and his pursuit of visualizing brain cells. Through his use of the Golgi stain and newly developed compound microscope he could define discreet cells in the brain. This discovery countered Gerlach's existing theory that the brain was an interconnected network that did not recognize discreet cells. This work paved the way for our current understanding of neurons and how they communicate with each other. And helped us to identify synapses and conclude that chemical transfer was required between cells.
- **Structure of the Neuron:**Overview of the Anatomy of the Neuron: Soma-Cell body of a neuron that contains the nucleus and genetic information, and directs protein synthesis. Dendrites-Part of a neuron that extends away from the cell body and is the main input to the neuron. Nucleus-Contains the DNA for the cell. Axon-Part of the neuron that extends off the soma, splitting several times to connect with other neurons; main output of the neuron. Synapse-Junction between the presynaptic terminal button of one neuron and the dendrite, axon, or soma of another postsynaptic neuron. Terminal button-The part of the end of the axon that form synapses with postsynaptic dendrite, axon, or soma. Dendritic spines-Protrusions on the dendrite of a neuron that form synapses with terminal buttons of the presynaptic neuron. Myelin sheath-Substance around the axon of a neuron that serves as insulation to allow the action potential to conduct rapidly toward the terminal buttons.

    - Overview of the Anatomy of the Synapse: Presynaptic membrane-The space on the axon terminals where vesicles are delivered into the synapse. Postsynaptic membranes-The space on the postsynaptic dendrite, axon, or soma that contains receptors for neurotransmitter. Synaptic gap-Also, known as the synaptic cleft; the small space between the presynaptic terminal button and the postsynaptic dendritic spine, axon, or soma. Synaptic vesicles-neurotransmitters, receptor sites, and ion channels.

- **Types of Cells in the Brain**

    - Classification of neurons based on function

        - Motor-allow us to initiate movement and behavior
        - Sensory-Allow us to receive information about the world around us.
        - Interneurons-Process the sensory input from our environment into meaningful

representations, plan appropriate behavioral response, and connect to the motor neurons to execute these behavioral plans.

- Classification of neurons based on structure
    - Unipolar-Have only one process that radiates off from the cell body. Most often sensory neurons found in the spinal cord.
    - Multipolar-Have three or more dendrites.
    - Bipolar-Have two extensions radiating from cell body.
- Glial Cells
    - Oligodendroglia/Schwann cells-These cells provide myelin in the CNS and PNS. The oligodendroglia provide myelin in the CNS where each oligodendroglia provides several "pads" of myelin around multiple nearby axons. Schwann cells are found in the PNS and each cell wraps around one segment of the elongated nerves found in the periphery.
    - Microglia function much like the macrophage in the immune system. They are responsible for identifying and chewing up substances that come into the brain that don't belong there or cells that have died and need to be removed from the brain. So, they help identify if an infectious agent comes into the brain and they help clean up waste in the brain when cells die.
    - Astrocytes come from the Greek word for "star" because their shape resembles a star shape. Astrocytes function to support neurons by maintaining chemical balances in the brain, removing waste in the brain, and performing reparative functions in the brain. They also help in the formation of the brain-brain-barrier by creating tight junctions over the openings in the blood vessels.
- **Communication Within and Between Neurons**
    - Resting Membrane Potential
        - *Cell membrane*-The cell membrane is composed of a lipid bilayer of fat molecules and separates the cell from the surrounding extracellular fluid.
        - *Ion Channels*-There are proteins that pans the membrane, forming ion channels that allow particular ions to pass between the intracellular and extracellular fluid. These ions are in different concentrations inside the cell relative to the outside of the cell

and these ions have different electrical charges.

- *-70mV* – This is the resting membrane potential of the cell. It is created by a selective separation of ions across the cell membrane. The role of the ions in the resting membrane potential is explained in more detail on the next slide.
- *Separation of Ions* – Explain that that resting membrane potential is created by the separation of the ion's across the membrane.

- Anions are negatively charged and are unable to travel across the membrane through channels.
- Potassium is a positively charged ion found in abundance inside the cell.
- Chloride is a negatively charged ion found in abundance outside the cell.
- Sodium is a positively charged ion found in abundance outside the cell.
    - Pressures acting on ions-Identify that two forces act to maintain a steady state when the cell is at rest.
- Diffusion is the force on molecules to move from areas of high concentration to areas of low concentration.
- Electrostatic pressure is the force on two ions with similar charge to repel each other and the force of two ions with opposite charge to attract to another.
- Action Potential
    - Hodgkin and Huxley
        - Electrochemical Transduction
        - Giant Squid Axon
        - Nobel Prize 1963
- Characteristics of the Action Potential
    - All or nothing simply means that once an action potential begins, it will not diminish or stop in any way.
    - For an action potential to occur, the cell must experience a depolarization past the threshold of excitation (-50mV). These depolarizations occur through excitatory

postsynaptic potentials which will be explained more on the next slide.

- Once the action potential reaches the end of the terminal buttons, neurotransmitter is released into the synapse to pass the message on to the postsynaptic cell.

- How initiated – Explain how the flow of ion's into the cell can either raise the membrane potential toward the threshold of excitation or it can reduce the membrane potential away from the threshold of excitation (hyperpolarization).

  - IPSP's – are Inhibitory Post Synaptic Potentials. These potentials result when either positively charged ion's leave the cell or negatively charged ion's enter the cell.
  - EPSP's – are Excitatory Post Synaptic Potentials. These potentials result when either positively charged ion's enter the cell.

- Change in neuron potential during action potential –The action potential is dependent upon the exchange of the ions previously discussed (Na+ and K+) that lie on either side of the membrane.

  - Na+ channels open – Explain that when the cell reaches the threshold of excitation that sodium channels pop open.
  - Both diffusion and electrostatic pressure pushes Na+ into the cell - Explain that when sodium channels open, that sodium is under both diffusion and electrostatic pressure to rush across the membrane and into the cell. Therefore, sodium moves very quickly across the membrane through the ion channels.
  - As Na+ is rushing in, K+ channels open – Explain that as the charge on the inside of the cell is increasing due to the influx of Na+, that K+ channels will open to begin to let K+ back out of the cell.
  - At the peak of the action potential Na+ channels close – Indicate that when the cell reaches its highest charge, the sodium channels will close.
  - Diffusion and electrostatic pressure force K+ out – Explain that when the cell has become more positively charged on the inside of the cell that K+ will be under both diffusion and electrostatic pressure to now leave the cell.
  - Cell undergoes a brief hyperpolarization – Explain that as K+ leaves the cell, the charge on the inside of the cellbegins to move more negatively. The cell will actually move past its normal resting membrane potential for a brief period.

- Myelin speeds up the process – Myelin covers much of the axon, which saves time because the action potential doesn't need to occur at every little segment of the neuron.

- Action potentials occur at each Node of Ranvier – Point out that action potentials only need to occur at each segment of the axon that is bare. These spaces are called Nodes of Ranvier.
- Saltatory Conduction – When the action potential skips from Node of Ranvier to the next Node of Ranvier, it is called saltatory conduction.

- **Neurotransmission**

    - Video-Chemical Transmission
    - Neurotransmitter release – Explain that when the action potential arrives at the axon terminal, it results in the vesicles merging with the cell membrane and through exocytosis, they release neurotransmitter into the synapse.
    - Binds in lock and key fashion – Explain how neurotransmitter diffuses across the synapse and binds to receptor in a lock and key fashion.
    - Ionotropic/Metabotropic receptors – Explain that neurotransmitter binding allows ion channels to open up and ions can flow either into or out of the cell in response.
    - Results in IPSP's and EPSP's – Explain that the flow of ions results in IPSP's (hyperpolarizations) or EPSP's (depolarizations) in the receiving cell. Tie this back to the information on temporal and spatial summation and how it can result in an action potential in the receiving neuron.

        - Examples – Explain that IPSP's and EPSP's can occur through the flow of ion's after neurotransmitters bind to their receptors.

    - Glutamate – Explain that glutamate is an excitatory neurotransmitter so it results in EPSP's

        - Na+ enters cell – Explain that an EPSP can occur when Na+ enters the cell
        - Ca++ enters cell – Explain that an EPSP can occur when Ca++ enters the cell

    - GABA – Explain that GABA is an inhibitory neurotransmitter so it results in IPSP's

        - K+ leaves cell – Explain that inhibition can occur when K+ leaves the cell
        - Cl- enters cell – Explain that inhibition can occur when Cl- enters the cell

    - Termination of neurotransmission – Explain that once neurotransmitter is released in the synapse, it will continue to bind to receptors and pop off the receptor and bind again. This can be dangerous and lead to overexcitation. So, the brain has to have a

way to remove the neurotransmitter from the synapse.

- Enzymes – One method that is used to remove neurotransmitter from the synapse is through enzymes. Enzymes can find neurotransmitter in the synapse and break it down before it can bind to the receptors again.
- Reuptake – Another method used to remove transmitter is to have the neurotransmitter taken back up by the cell that released it. Once the neurotransmitter is back in the presynaptic cell, it can be broken down by enzymes or repackaged into vesicles to be used again.

Difficult Terms

1 - Note on Difficult Terms in this Module
This module is unusual for the sheer volume of new and often difficult vocabulary words. It may be especially helpful for students to create study aids such as flashcards to help learn this new vocabulary. They may find it helpful if you define each term repeatedly when using it in lecture. We recommend openly addressing the potentially daunting amount of vocabulary and reassuring students that with effort and repetition they can learn it. The terms below represent only a portion of those which might be problematic.

Action potential
Diffusion
Electrostatic pressure
Excitatory postsynaptic potentials
Inhibitory postsynaptic potentials
Ion channels
Ionotropic receptor
Resting membrane potential
Sodium-potassium pump
Threshold of excitation

Lecture Frameworks

Overview: Begin the lecture by having students recall what they already know about neurons

and neuron function. Advance their knowledge by presenting an overview of both between and within cell communication. Give an overview of the anatomy of the neuron and synapse. Include information on ion flows during action potentials and the division of ions during the resting membrane potential. Extend the lecture to include neurotransmission and how synapses play a role in the excitation or inhibition of the receiving neuron. Conclude with how neurotransmission is stopped.

First Class (50-75 minutes)

Warmup Activity-Scaffolding Current Knowledge: The purpose of this activity is to get students to think about what they already know about the topic of neurons. This brainstorming will provide them with a framework to use to build their knowledge of neurons as the lectures progress. For a description of the activity, refer to the Activity/Demonstrations section below.

- (Optional) Here you may insert a discussion question on why it's important to study the cells of the brain.

Direct Instruction-Introduce Learning Objectives of the module

- Differentiate the functional roles between the two main cell classes in the brain, neurons and glia.
- Describe how the forces of diffusion and electrostatic pressure work collectively to facilitate electrochemical communication.
- Define resting membrane potential, excitatory postsynaptic potentials, inhibitory postsynaptic potentials, and action potentials.
- Explain the features of axonal and synaptic communication in neurons.

Direct Instruction - The Evolution of our Understanding of Neurons as Discreet Cells

- Explain how it begins over 100 years ago with Ramon y Cajal and his pursuit of visualizing brain cells.
- Through his use of the Golgi stain and newly developed compound microscope he could define discreet cells in the brain
- This discovery countered Gerlach's existing theory that the brain was an interconnected

network that did not recognize discreet cells.

- This work paved the way for our current understanding of neurons and how they communicate with each other.

    - Helped us to identify synapses and conclude that chemical transfer was required between cells.

Direct Instruction of the Structure of the Neuron

- Refer to the slides to show students the critical parts of the cell including soma, dendrites, nucleus, axon, synapse, terminal button, dendritic spines and myelin sheath.
- Refer to the slides to show students the critical parts of the synapse including the presynaptic membrane, postsynaptic membrane, synaptic gap, and synaptic vesicles.

Direct Instruction or Video - Types of Cells in the Brain

- Lecture on how cells can be categorized by function into motor, sensory and interneurons. Then the instructor can choose to either explain the role of each of these cells in the reflex arc, or the instructor can play the video linked in the PPT.

    - (Optional) Application – The instructor can choose to use the reflex activity contained in the Instructors Manual.

Direct Instruction of Classification of Neurons Based on Structure

- Describe classifications of cells based on structure including multipolar, unipolar and bipolar neurons.

    - Glial Cells: Describe glial cells and their roles in the brain, including oligodendroglia/ Shwann, microglia, and astrocytes.

Discussion

- This discussion is intended to get students to think about what would happen if just anything could reach the brain. Set up this discussion question by explaining what the blood-brain-barrier is building off of having just discussed how the astrocytes form tight junctions around the capillaries of the brain.

Direct Instruction - Communication Within and Between Neurons

- Resting Membrane Potential: Discuss the structure of the cell membrane and the role of the cell membrane in separating the ions that contribute to the resting membrane potential. Explain how diffusion and electrostatic pressure act on the ion's. Describe ion channels and their role in ionic movements across the membrane. Describe where the ion's are during resting membrane potentials.

    - Ask students to report where diffusion pressures are pushing potassium (outside cell), sodium (inside cell) and chloride (inside cell).

Classroom Assessment Technique (CAT) – The Muddiest Point: The purpose of this CAT is to determine where students are having difficulties. You will ask students to write down what they are still confused about and what they are struggling to understand. Collect the papers and look for common themes that can be addressed at the start of the next lecture. For a description of the activity, refer to the Activity/Demonstrations section below.

Second Class (50-75 minutes)

Revisiting the Muddiest Point CAT: The purpose of this time is to refresh student's memories about what was covered in the first lecture and help them to understand things they are still confused about from the first lecture.Address common themes that you identified from the CAT activity at the end of lecture one by discussing those topics that seemed most confusing to the most students. You may also want to provide the students with additional background materials for anything that has been identified by a majority of the class.

Direct Instruction and Application – Communication Within and Between Neurons—Action Potential

- Describe how Hodgkin and Huxley used the Giant Squid Axon to study the action potential.
- Describe the characteristics of the Action Potential including all-or-none responses, how

action potentials are initiated, and how ion flows alter the potentials inside the cell. Explain the threshold of excitation.

- Describe how action potentials are initiated through EPSP's and IPSP's. How initiated – Explain how the flow of ion's into the cell can either raise the membrane potential toward the threshold of excitation or it can reduce the membrane potential away from the threshold of excitation (hyperpolarization).
- Application - Ask students what happens to diffusion and electrostatic pressures on each of the ion's at various stages of the action potential.
- Characteristics of the Action Potential
    - All or nothing simply means that once an action potential begins, it will not diminish or stop in any way.
    - For an action potential to occur, the cell must experience a depolarization past the threshold of excitation (-50mV). These depolarizations occur through excitatory postsynaptic potentials which will be explained more on the next slide.
    - Once the action potential reaches the end of the terminal buttons, neurotransmitter is released into the synapse to pass the message on to the postsynaptic cell.
- How Initiated
    - Explain how the flow of ion's into the cell can either raise the membrane potential toward the threshold of excitation or it can reduce the membrane potential away from the threshold of excitation (hyperpolarization).
    - IPSP's – are Inhibitory Post Synaptic Potentials. These potentials result when either positively charged ion's leave the cell or negatively charged ion's enter the cell.
    - EPSP's – are Excitatory Post Synaptic Potentials. These potentials result when either positively charged ion's enter the cell.
- Show the animation of temporal and spatial summation of EPSP's and IPSP's.

Colossal Neurons Activity: The purpose of this activity is to give students a visual and physical representation of neural communication. For a description of the activity, refer to the Activity/ Demonstrations section below.

Direct Instruction and Activity - Myelin

- Explain saltatory conduction and explain the benefits of having both slow and fast action

potentials.

- Activity – Activity showing the speed difference between myelinated and non-myelinated axons. For a description of the activity, refer to the Activity/Demonstrations section below.

Direct Instruction & Video - Neurotransmission

- Show video about how it was discovered that neurotransmission is chemical.
- Describe neurotransmitter release through the vesicles merging with the membrane. Describe how neurotransmitter binds in a lock and key fashion, and explain ionotropic and metabotropic receptors.
- Explain how EPSP's and IPSP's occur in the receiving cells through glutamate and GABA. Na+ enters cell – Explain that an EPSP can occur when Na+ enters the cell

Direct Instruction and Video - Termination of neurotransmission

- Explain that once neurotransmitter is released in the synapse, it will continue to bind to receptors and pop off the receptor and bind again. This can be dangerous and lead to overexcitation. So, the brain has to have a way to remove the neurotransmitter from the synapse. Explain enzymatic degradation and reuptake.
- Video – Summarize neurotransmission with video in PPT

Classroom Assessment Technique (CAT) – The Minute Paper: The purpose of this CAT is to assess learning during this lecture series. The *Minute Paper* tests how students are gaining knowledge, or not. The instructor ends class by asking students to write a brief response to the following questions: "What was the most important thing you learned during this class?" and "What important question remains unanswered?" For a description of the activity, refer to the Activity/Demonstrations section below.

Activities & Demonstrations

- **Warm Up Activity: Scaffolding Current Knowledge:**The purpose of this activity is to have students identify what they already know about neurons. They can use this knowledge to create a framework to build from with topics from the lecture.

- Time: 10 minutes
- Materials: Something that can be used to write down brainstorming ideas for everyone to see.
- Directions:

- **The Muddiest Point CAT:**The purpose of this CAT is to identify lecture content that was confusing to students.

  - Time: 1-2 minutes
  - Materials: Paper and pen
  - Directions:

    - Ask students to take 1-2 minutes to answer these questions.
    - What was the muddiest point about today's class?
    - Write down the concept you are still struggling to understand.

- **Neural Transmission Demonstration:** The purpose of this demonstration is to physically demonstrate time differences in neural communication based on how far the message has to travel.

  - Time: 10 minutes.
  - Materials and Resource: Retrieved from **https://www.cod.edu/programs/psychology/mistop/pdf...**
  - Directions:

- **Colossal Neurons Activity**: The purpose of this activity is to provide a visual and physical demonstration of neural communication.

  - Time: 20 minutes.
  - Source: Retrieved from **http://www.ncbi.nlm.nih.gov/pmc/articles/PMC385286...**

- Materials:
  - A very large space
  - Masking tape (or painter's tape if using a tile floor)
  - Styrofoam chips
  - Three to twelve lunch-size paper bags
  - Several large plastic cups
  - Sodium/potassium placards
  - Paper identification signs

- Directions:
  - Student assignments (students per neuron):
    - Sense Organ (1)
    - Receiving Dendrite (who holds a cup in his or her hands denoting the receptor sites) (1 - inter and motor neurons only)
    - Sodium (who carries placards and stands outside the neuron) (1 or more)
    - Potassium (who carries placards and stands inside the neuron) (1 or more)
    - (Optional) Sodium/Potassium Pump (who taps the sodium and potassium ions to make them return) (1)
    - Action Potential (who runs down the axon and taps the terminal button) (1) OR
    - Action Potential (who stands with others and lifts arms) (3 or more)
    - Terminal Button (who holds a bag of Styrofoam chips and throws the Styrofoam chips at the receiving dendrite) (1)
    - (Optional) Re-uptake Ducts (who picks up chips from the floor and fills a new bag/ vesicle) (1)
    - Crier (1 - motor neuron only)

- Procedure
  - On the floor, outline the shape of three neurons (sensory, inter, and motor) using the

masking tape. Adjust the size and length of each neuron according to the number of students who will be participating. Make sure that the synaptic clefts are far enough apart to challenge the students throwing the chips (eight to ten feet). Freshmen can get very competitive and will sometimes try to lean over or even step out of the neuron into the synaptic cleft. When roles have been assigned and students are in place, the "annoying little brother" played by the instructor, teaching assistant, or helper touches the sense organ (a bruise) who begins the neural transmission by turning to face the inside of the neuron. This unlocks the ion channels, allowing potassium to begin flowing out of the neuron, and sodium to begin flowing into the neuron (1:1 ratio). The sodium/potassium pump, who is straddling the edge of the neuron, then starts tapping the ions (one of each kind, in succession), so that they quickly return to their original positions in order to be ready for another signal from the sense organ.

  - Meanwhile, as soon as the sodium and potassium students trade places and the all-or-nothing threshold (as determined by the instructor) is reached, the action potential students will begin to raise their hands in succession, as if performing a "wave" similar to those seen in sports arenas, simulating the depolarization racing down the axon. The last action potential person taps the terminal button, who is holding a vesicle (paper bag) filled with neurotransmitters (Styrofoam chips); the vesicle opens, and the terminal button "releases" (throws) the neurotransmitters into the synaptic cleft. Alternatively, if there is only one student available for the role of action potential, that student should simply run down the axon and tap the terminal button. When a chip lands in the "receptor site" (cup) on the receiving dendrite of the next neuron (the inter-neuron), the receiving dendrite turns around, unlocking the gates, and the process repeats with the inter-neuron, ultimately causing the motor neuron to fire. If the synaptic cleft has been laid out with enough distance between the terminal button and the receiving dendrite, it can take several bags of chips to have one actually land in a receiving cup. When the last neuron's terminal button (motor neuron) is tapped by the action potential, the terminal button taps the crier, who shouts "Ouch," inspiring the "annoying little brother" to touch the bruise again.

- Research has shown that students participating in the demonstration score higher on exam questions associated with neural transmission (**http://www.ncbi.nlm.nih.gov/pmc/articles/PMC385286...**

- **Video: Types of Neurons and Reflex Arc**

  - Time: 4:35 minutes
  - Materials: Video Link on PPT (https://www.youtube.com/watch?v=M1E9Lm16cUs)

- Directions: This video walks the viewer through a detailed review of sensory, motor and interneurons and their role in the reflex arc.

- **Video: Neural Communication**
  - Time: 3:04 minutes
  - Materials: Video Link on PPT (https://www.youtube.com/watch?v=oLSmNcem2X0)
  - Directions: This video presents a visual animation of temporal and spatial summation in neurons.

- **Video: Nerve Impulse**
  - Time: 4:14 minutes
  - Materials: Video Link on PPT (https://www.youtube.com/watch?v=fHRC8SlLcH0)
  - Directions: This video provides a visual animation of the nerve impulse.

- **Video: Neurotransmission**
  - Time: 3:11minutes
  - Materials: Video Link on PPT (https://www.youtube.com/watch?v=RyfJwisRxvs)
  - Directions: This video provides the student with a background in how neurotransmission was discovered. From the greatest discoveries series (Discovery). Neurotransmission, the communication of a signal between neurons, used to be thought as an electrical process rather than a chemical one. Here the experiment that developed the truth.
- **Video: The Brain-Lesson Two-How Neurotransmission Works**
  - Time: 1:35 minutes
  - Materials: Video Link on PPT (https://www.youtube.com/watch?v=p5zFgT4aofA)
  - Directions: Use this video to provide a quick review of the lesson on neurons.

- **CAT – The Minute Paper:**The purpose of this CAT is to test where students are gaining

knowledge or not.

- Time: 1-2 Minutes
- Materials: Paper and pen
- Directions
  - Ask students to take 1-2 minutes to answer these questions.
  - What was the most important thing you learned during this class?
  - What important question remains unanswered?"

Additional Activities

Neurons. (2014). Classroom demonstration of neural transmission. Retrieved from **https://www.apa.org/ed/precollege/undergrad/ptacc/...**

- This teaching exercise is designed to help psychology teachers explain how neurons work. It allows student to act out neural communication.

Simon-Dack, S. L. (2012). Interactive teaching activities for introductory biopsychology. Office of Teaching Resources in Psychology. Retrieved from **http://teachpsych.org/resources/Documents/otrp/res...**

- Published by the Society for the Teaching of Psychology, this is a group of classroom activities that support building a model neuron, acting out action potentials, and acting out saltatory conduction.

(n.d.). Activity #8 Reflexes. Mythbusters: The explosive exhibition. Retrieved from **http://www.mythbusterstheexhibition.com/assets/doc...**

- Published by Mythbusters, this experiment allows students to measure the speed of a reflex. It outlines the reflex arc and promotes critical thinking about how reflexes work and what may impact their speed.

Discussion Points

- Based on what you know about neurons, predict parts of the process of cell communication that can be used as targets for drug interventions.
    - Students may predict that neurotransmitters can target synthesis of neurotransmitters, storage of neurotransmitters, release of neurotransmitters, binding of neurotransmitters and the processes of ending neurotransmission.
- How might nutrition impact neural communication in the brain? Why?
    - Students may predict that the basic makeup of food may contain important substances to support or detract from neurotransmission. For instance, since sodium is used in neurotransmission, consuming some salt may be important. Same thing with potassium and calcium.
- Which is more reliable, communication within or between neurons?
    - Communication within neurons is considered more reliable because, once an action potential begins, it cannot be altered. That is not true about between neuron communication.

Outside Resources

Video Series: Neurobiology/Biopsychology - Tutorial animations of action potentials, resting membrane potentials, and synaptic transmission.
http://www.sumanasinc.com/webcontent/animations/neurobiology.html

Video: An animation and an explanation of an action potential
https://youtu.be/OZG8M_ldA1M

Video: An animation of neurotransmitter actions at the synapse
http://www.youtube.com/watch?v=90cj4NX87Yk

Video: An interactive animation that allows students to observe the results of

manipulations to excitatory and inhibitory post-synaptic potentials. Also includes animations and explanations of transmission and neural circuits.
https://apps.childrenshospital.org/clinical/animation/neuron/

Video: Another animation of an action potential
http://www.youtube.com/watch?v=-SHBnExxub8&list=PL968773A54EF13D21

Video: Another animation of neurotransmitter actions at the synapse
http://www.youtube.com/watch?v=LT3VKAr4roo&list=PL968773A54EF13D21

Video: Domino Action Potential: This hands-on activity helps students grasp the complex process of the action potential, as well as become familiar with the characteristics of transmission (e.g., all-or-none response, refractory period).
https://www.youtube.com/watch?v=xzvZ11EutBY

Video: For perspective on techniques in neuroscience to look inside the brain
https://www.youtube.com/watch?v=s4smjT1qwZU

Video: The Behaving Brain is the third program in the DISCOVERING PSYCHOLOGY series. This program looks at the structure and composition of the human brain: how neurons function, how information is collected and transmitted, and how chemical reactions relate to thought and behavior.
http://www.learner.org/series/discoveringpsychology/03/e03expand.html

Video: You can grow new brain cells. Here\\\'s how. -Can we, as adults, grow new neurons? Neuroscientist Sandrine Thuret says that we can, and she offers research and practical advice on how we can help our brains better perform neurogenesis—improving mood, increasing memory formation and preventing the decline associated with aging along the way.
https://www.youtube.com/watch?v=B_tjKYvEziI

Web: For more information on the Nobel Prize shared by Ramón y Cajal and Golgi
http://www.nobelprize.org/nobel_prizes/medicine/laureates/1906/

Evidence-Based Teaching

Holloway, S. R. (2013). Three colossal neurons: A new approach to an old classroom

demonstration. *The Journal of Undergraduate Neuroscience Education, 12*(1), A1-A3. Retrieved from http://0-search.proquest.com.skyline.ucdenver.edu/docview/1543434957?accountid=14506

- This article describes how to have students participate in a demonstration of neuron function that is scientifically proven to improve an understanding of cell communication both in individual cells and in neural networks. This demonstration can be used in classes as small as 15 and as large as 200.

Larkin, M. (2002). Eric clearinghouse on disabilities and gifted education. Using scaffolded instruction to optimize learning. http://www.vtaide.com/png/ERIC/Scaffolding.htm

- Supports beginning the presentation with what the students already know so that they can build on their current knowledge.

Cacciopo, J. T. (2013). Psychological science in the 21st Century. *Teaching of Psychology, 40,* 304-309. doi:10.1177/0098628313501041

- This article reviews current trends in psychology, focusing on the burgeoning field of neuroscience. It supports the importance of giving students basic terminology to use in the future when exposed to the neuroscience field and its research.

Links to ToPIX Materials

Activities & Demonstrations: Free Neuroscience Course
http://topix.teachpsych.org/w/page/19981022/Neuroscience%20in%20the%20Classroom

Activities & Demonstrations: Got Neurons? How to Teach Neuroscience Mnemonically
http://topix.teachpsych.org/w/page/19981022/Neuroscience%20in%20the%20Classroom

Activities & Demonstrations: Mouse Party (how drugs affect the brain)
http://topix.teachpsych.org/w/page/19981021/Neuroscience

Audio: Elliot Krane TED Talk How Do Nerves Work?
http://topix.teachpsych.org/w/page/19981021/Neuroscience

Videos: Biopsychology Collection
http://topix.teachpsych.org/w/page/19981021/Neuroscience

Videos: The Behaving Brain
http://topix.teachpsych.org/w/page/19981021/Neuroscience

Videos: The Responsive Brain
http://topix.teachpsych.org/w/page/19981021/Neuroscience

Teaching Topics

Teaching The Most Important Course
https://nobaproject.com/documents/1_Teaching_The_Most_Important_Course.pdf

Content Coverage
https://nobaproject.com/documents/2_Content_Coverage.pdf

Motivating Students
https://nobaproject.com/documents/3_Motivating_Students_Tips.pdf

Engaging Large Classes
https://nobaproject.com/documents/4_Engaging_Large_Classes.pdf

Assessment Learning
https://nobaproject.com/documents/5_Assessment_Learning.pdf

Teaching Biological Psychology
https://nobaproject.com/documents/6_Teaching_Bio_Psych.pdf

PowerPoint Presentation

This module has an associated PowerPoint presentation. Download it at

https://nobaproject.com//images/shared/supplement_editions/000/000/258/Neurons.pptx?1478800882.

About Noba

The Diener Education Fund (DEF) is a non-profit organization founded with the mission of re-inventing higher education to serve the changing needs of students and professors. The initial focus of the DEF is on making information, especially of the type found in textbooks, widely available to people of all backgrounds. This mission is embodied in the Noba project.

Noba is an open and free online platform that provides high-quality, flexibly structured textbooks and educational materials. The goals of Noba are three-fold:

- To reduce financial burden on students by providing access to free educational content
- To provide instructors with a platform to customize educational content to better suit their curriculum
- To present material written by a collection of experts and authorities in the field

The Diener Education Fund is co-founded by Drs. Ed and Carol Diener. Ed is the Joseph Smiley Distinguished Professor of Psychology (Emeritus) at the University of Illinois. Carol Diener is the former director of the Mental Health Worker and the Juvenile Justice Programs at the University of Illinois. Both Ed and Carol are award- winning university teachers.

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