

Neuroanatomy and Neurochemistry Lesson Plan for Brain Cap

Main objective

- Locate and identify the functions of the cerebellum, the brain stem, and the lobes of the cerebrum.

Optional objective

- Locate and identify the functions of some critical internal brain centers.

Or

- Identify the function of brain cells, including supporting glial cells and the main components of neurons. Describe how neurons use electrical impulses and chemical signals to help the brain communicate within and across brain regions and with the rest of the body.

National Science Education Standards Content Standards Grades 9 – 12

- Unifying concepts and processes
- Life sciences
- History and nature of science

Materials

- Preprinted or Blank Swim Caps (<http://www.allswim.com> - product #500513 for preprinted caps, #500512 for blank caps)
- Markers

1.1 To put the concept of distinct brain regions as responsible for distinct functions, start with a historical introduction of the practice of Phrenology

Phrenology is a theory which claims to be able to determine character and personality traits on the basis of the shape of the head, also known as “reading bumps”.

Phrenology was developed by German physician **Franz Joseph Gall** around 1800 and is now discredited as a **pseudoscience**, or fake science. Its principles were that the brain has a set of different **mental faculties**, each particular faculty being represented in a different part of the brain. These areas were said to be proportional to a given individual's personality, and that bumps in the overlying skull bone reflected these differences.

Gall believed he could feel the sizes of these brain regions by feeling the skull, thus predicting an individual's personality or even diagnosing the cause of abnormal behavior. Today, the basic premise that personality is determined by skull shape is considered to be false.

Phrenology has however received credit as a **protoscience** for having contributed to medical science the ideas that the brain is the home of the **mind** and that certain brain areas have **localized, specific functions**. **Gall was correct that areas of the brain direct specific behaviors.**

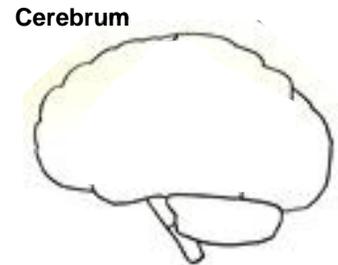


www.wikipedia.org/wiki/phrenology

1.2 Further engage the students in the activity and assess their current state of knowledge regarding the distinct functions of the brain. Make a list with the students in response to the following question: What are some of the functions of the brain? This activity is designed to get the students engaged in the day's lesson, and to recall the things that they may have already covered in class. Make a master list on the board or on a large sketch pad while the students write their list down in their lab notebooks. Include all suggestions from the students. Continue to make the list until several physiological and behavioral functions are covered.

1.3 Make your own Brain Cap. Now it is time to get out your swim caps. The swim caps are a great tool for discussing the structure and functions of the brain in a fun and interactive way.

- STEP 1: If your swim caps are not preprinted, instruct the students to draw the silhouettes of the cerebrum, cerebellum, and brain stem.
- STEP 2: Ask the students to locate which is the cerebrum, the cerebellum, and the brain stem and explain the general function of each structure. Label the cerebrum, cerebellum, and brain stem on the outside of the silhouette to save room for the remaining steps.



Step 2 in progress

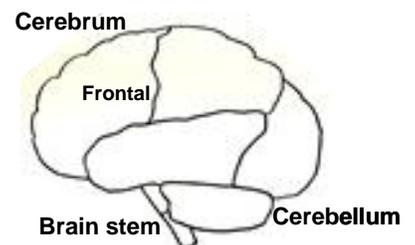
The cerebrum is comprised of the cerebral hemispheres: large, paired structures divided by the longitudinal fissure. The cerebrum controls all voluntary actions in the body and is composed of the cerebral cortex on the outside, and internally by the basal nuclei and the limbic system. Specific functions that the students should discuss at this point include movement, sensory processing, memory, emotion, and language.

The cerebellum, Latin for “little brain”, is a smaller structure under the base at the back of the brain that plays an important role in motor control. The cerebellum does not initiate movement, but it contributes to balance, coordination, precision, and accurate timing. It may also be involved in attention and language, and in regulating fear and pleasure responses.

The brainstem extends from the base of the brain and is continuous with the spinal cord and plays an important role in the regulation of cardiac and respiratory function. It also regulates consciousness and sleep, and provides the main motor and sensory innervation to the face and neck through the cranial nerves.

- STEP 3: If your swim caps are not preprinted, instruct the students to draw the divisions between the lobes of the cerebrum that demarcate the frontal, parietal, occipital, and temporal cortices and describe their distinct functions. Label the frontal, parietal, occipital, and temporal cortices within each region.

The lobes are both functionally and anatomically distinct regions, in that they to a large extent separated by sulci, which are grooves or indentations in the brain. The raised regions between sulci are referred to as gyri and can also represent important structurally and functionally distinct brain regions. The two major sulci separate the frontal and parietal lobes (the central sulcus) and the parietal and temporal lobes (the lateral sulcus).

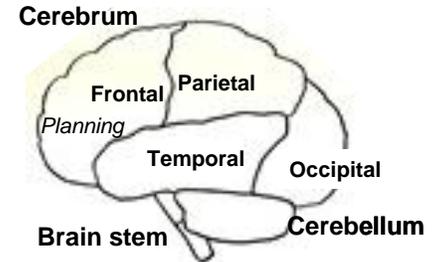


Step 3 in progress

The cerebral lobes are most often associated with their primary sensory and motor functions. The frontal lobe is involved in motor processing and execution, the parietal with somatosensation, the occipital with visual processing, and the temporal lobe with hearing. However, most of the cortex is

concerned with functions that go beyond the primary perception of sensation or primary control of movement. The frontal lobe is critical to higher order functioning related to personality, control of impulsivity, planning, and other executive functions, and also plays a major role in emotions and in the production of speech. The parietal lobe is critical to integrating processed information from all primary sensory areas, processing taste information, and in the comprehension of spoken language. The occipital lobe is crucial to our ability not only to see but to read, and the temporal lobe is critical to the sense of smell, and to learning, memory and emotions.

- **STEP 4:** Here comes the really fun part! After a lively discussion regarding the specific functions of each of the brain regions discussed, go through your lists you made at the beginning of the lesson and start identifying which region of the brain is responsible for that behavioral or physiological function. For example, if a student had said added to the list that the brain helps you to plan for the future, ask the class where that word belongs on the cap and why. There may be instances where a behavior can be placed in more than one lobe, and that's okay too! You will have limited space left available, so instruct students to pick just a few functions to add to each region.



Step 4 in progress

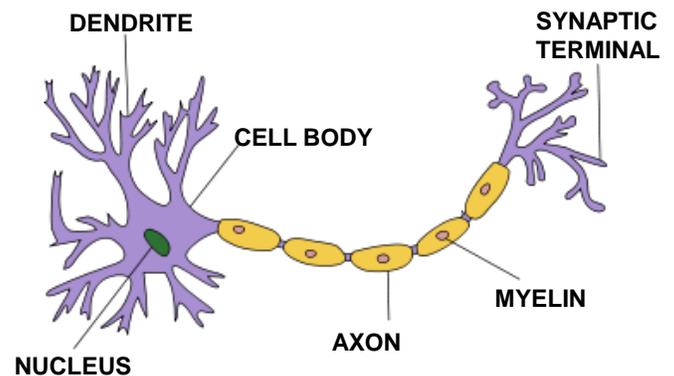
- **STEP 5:** Wear your caps around school!

Optional lessons

1.4 What do I do on the other side of the cap? I have two ideas. The first is to use the other side of the cap to draw and label a few brain cells (neurons and glia) and discuss how neurons communicate information within, between, and beyond brain regions to integrate neural signaling throughout the body. The second is to use the other side of the cap to draw and label the internal structures of the brain that are not observed by looking only at the outer cortices.

1.4.1 There are two main categories of brain cells: neurons and glia

Neurons are information messengers. They use electrical impulses and chemical signals to transmit information within different areas of the brain and between the brain and the rest of the nervous system. They are comprised of a few key parts, including the cell body (or soma), axons, dendrites, synaptic terminals, and myelin. The cell body contains the nucleus that contains genetic information to control the cell's activities, and it also contains cytoplasm and organelles. The axon uses an electrical impulse to transmit messages starting from the cell body to the end of the axon, called the synaptic terminal. The synaptic terminal is a specialized area that makes close contact with another cell. The synaptic terminal contains chemicals that can be released on demand once the electrical impulse arrives, to communicate with the target cell across the synapse. Myelin covers and protects the axon and helps to speed the transmission of information. Dendrites are extensions off of the cell body which can receive the chemicals released from the synaptic terminal of a neighboring neuron. There are three classes of neurons:



www.wikipedia.org/wiki/Neuron

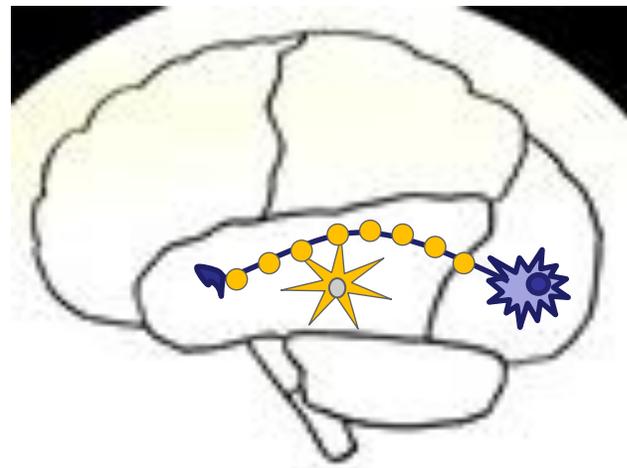
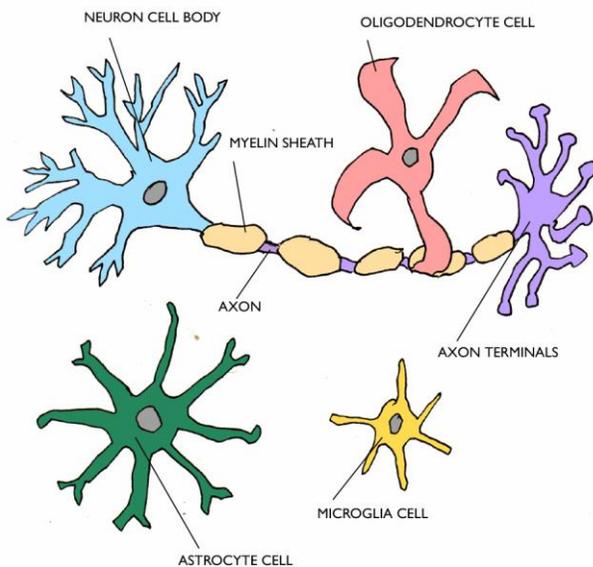
1. Sensory neurons: Carry information from the sense organs (i.e. eyes and ears) to the brain
2. Motor neurons: Have long axons and carry information from the central nervous system to the muscles and glands of the body.
3. Interneurons: Have short axons and send information between sensory and motor neurons.

- STEP 1: Have the students draw the outlines of the lobes of the brain as they were drawn on the opposite side, before any labeling occurred. Then have the students decide which region of the brain they want to communicate to another region of the brain or body. You can even ask them to describe a scenario associated with this. For example, a student could imagine that the brain receives visual information that a tiger is walking down the street and communicates the emotion of fear. Instruct the student to draw the cell body of a neuron in the area that wants to send the information, and to extend the axon to the region of the brain which should receive it. In this example, the student may draw the cell body of the neuron in the occipital lobe and project the axon to the temporal or frontal lobe. Then instruct the student to add the other components of the neuron that are mentioned above.



Step 1 in progress

Glial cells are often thought of as the support cells of the nervous system, but our understanding that they actually also play a prominent role in electrical and chemical communication in the brain and spinal cord is increasing. What is well understood is the role that glial cells play in protecting the brain from harmful chemicals or organisms (astrocytes, microglia) and in helping neurons transmit their electrical impulses and chemical signals (astrocytes, oligodendrocytes). Oligodendrocytes have a starfish-like appearance, and wrap their “feet” around the axons of neurons. This in effect provides insulation to the axon and increases the speed at which electrical impulses get sent down the axon from the cell body to the synaptic terminal. The feet of the oligodendrocytes are the myelin that cover of the axon.



Steps 1 and 2 without labels

www.societyofamateurneurologists.org

- STEP 2: Have the students draw in the rest of the oligodendrocyte that is connected to the myelin around their axon.
- STEP 3: Students can continue to “connect” the brain cap with neurons and glia as room and neatness permit!

1.4.2 Mid-sagittal view of the brain

The most common way to view some of the key internal structures of the brain either in dissection or in images is to look at a mid-sagittal section of the brain. Imagine dividing the brain in half between its left and right hemispheres. Important brain regions that can now be seen include the pons, medulla, midbrain, hypothalamus, thalamus, lateral ventricle, corpus callosum, and anterior cingulate.

Medulla – The medulla is the lower half of the brainstem, and contains the cardiac, respiratory, vomiting, and vasomotor centers and deals with autonomic, involuntary functions.

Pons – The pons is located above, or superior to, the medulla. The pons contains axons sending signals from the cerebrum to the cerebellum and to the brain stem/spinal cord. It also contains centers regulating sleep, respiration, swallowing, and the relay of sensory information coming in to the cerebrum.

Midbrain – The midbrain is an ancient sensory processing center, and in humans is involved in reflexive responses to visual and auditory stimuli. It is also involved in alertness and temperature regulation.

Thalamus – The thalamus is situated between the midbrain and the cerebrum. It acts as a major relay point for sensory and motor signals to the cerebral cortex, along with regulation of consciousness, sleep, and alertness.

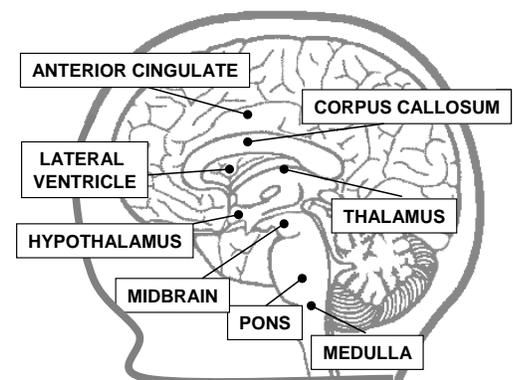
Hypothalamus – The hypothalamus is located below the thalamus and contains a number of small centers involved in the regulation of hormone release, appetite, thirst, body temperature, emotions, and circadian cycles.

Lateral ventricle – The lateral ventricles are part of the ventricular system, the brain's own circulatory system which synthesizes and circulates cerebral spinal fluid throughout the nervous system.

Corpus callosum – The corpus callosum is a wide band of neural fibers (fibers = bundles of axons) connecting the left and right hemispheres. Its primary role is to support interhemispheric communication.

Anterior cingulate – The anterior cingulate is a bilateral structure deep in the cerebrum that covered the corpus callosum in the right and left hemispheres. It plays several roles, including in reward and emotion, decision making, and autonomic functions.

- STEP 1: Draw the internal structures of the brain as they appear in a mid-sagittal section.
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- STEP 2: Label the internal structures described above.



BRAIN CAP IMAGES MADE BY ACTUAL STUDENTS COMING SOON!