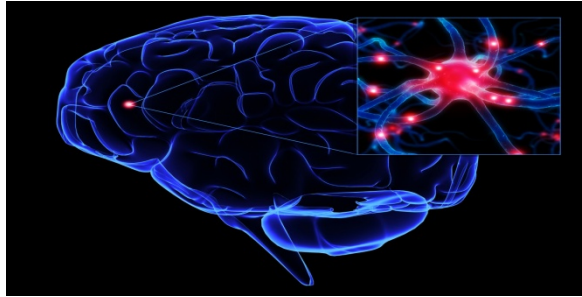


The Basics: from Neuron to Neuron to the Brain



Document Overview:

Description of Activity

Part I. Neuron

Part II. Action Potential

Part III. Neurotransmission

Part IV. Specific Neurotransmitters

Part V. Whole Brain

Part VI. Cerebral Cortex Areas

Terms

Observations worksheet

Minnesota State Science Standards:

7.4.1.1.1 Recognize that all cells do not look alike and that specialized cells in multicellular organisms are organized into tissues and organs that perform specialized functions.

7.4.1.1.2 Describe how the organs in the respiratory, circulatory, digestive, nervous, skin and urinary systems interact to serve the needs of vertebrate organisms.

7.4.3.2.2 Use internal and external anatomical structures to compare and infer relationships

9.1.3.1.1 Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs

9.1.3.1.2 Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts

9.1.3.4.3 Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results

9.1.3.4.6 Analyze the strengths and limitations of physical, conceptual, mathematical, and computer models used by scientists and engineers

9.4.1.1.1 Explain how cell processes are influenced by internal and external factors, such as pH and temperature, and how cells and organisms respond to changes in their environment to maintain homeostasis

9.4.1.1.2 Describe how the functions of individual organ systems are integrated to maintain homeostasis in an organism

9.4.1.2.5 Compare and contrast passive transport (including osmosis and facilitated transport) with active transport, such as endocytosis and exocytosis

9C.1.3.4.1 Use significant figures and an understanding of accuracy and precision in scientific measurements to determine and express the uncertainty of a result

Objective:

- Students will be able to describe the basic neuron.
- Students will be able to describe and simulate the action potential within one neuron.
- Students will be able to describe the neurotransmission between two neurons involving neurotransmitters.
- Students will be able to name several neurotransmitters and explain their basic functions within the nervous system.
- Students will research and describe what happens with Depression and it's relationship to neurotransmitters; and, watch and describe one new treatment of Depression.
- Students will dissect and describe a sheep brain.
- Students will be make their own model of a whole brain and describe the location and function of several areas of the cerebral cortex.

Type of Activity:

Model building, simulation, research, and dissection.

Duration:

Four to seven 45 minute class periods (depending on class needs and grade level)

- Part I – 1 class period
- Part II – 1 class period
- Part III – 1 class period
- Part IV – 1 class period
- Part V – 1-2 class periods
- Part VI – 1 class period

Connection to Nobel speakers:

Overall, this activity sets up the fundamental knowledge necessary to understand all of neuroscience. All of the speakers will utilize the basic concepts of the neuron and neurotransmission and their relationship to the brain and all of the body systems.

Speaker: Helen Mayberg, M.D., Professor of Psychiatry and Behavioral Sciences and Neurology, Dorothy C. Fuqua Chair of Psychiatric Neuroimaging and Therapeutics.

- Dr. Mayberg is known in particular for her work delineating abnormal brain function in patients with clinical depression using functional neuroimaging. This work led to the first pilot study of deep brain stimulation (DBS), a reversible method of selective modulation of a specific brain circuit, for patients with treatment-resistant depression

Recommended Prior Knowledge:

Students should have a basic understanding of all cells and their organelles, their structure and their function. Starting with Part I, the lessons builds from the smallest piece, the neuron, and ends with Part VI, the whole brain and the specific areas. Use each part as needed in your curriculum.

Concepts, Connections, and Terms addressed in the activity:

Part I, II, III, IV: neuron, dendrites, cell body, axon, synapse, synaptic cleft, pre & post synapse, neurotransmitters, action potential, GABA, etc.

Part IV: depression, dopamine, Deep Brain Stimulation, therapy, genes, cognition.

Part V & VI: lobes, sulci, gyri, cerebrum, hemispheres, sensory areas, motor areas, association areas, dura mater.

** see Terms at end

Materials:

- Part I
 - Neuron

- Pipe cleaners, Rope, Clay/playdough, Beads, Styrofoam, Wire , Yarn, Marbles, etc
- Part II
 - Action Potential
 - 3 pieces of 2-3 ft string
 - 1 piece of 10-15 ft string
 - 2 different, thin plastic containers (cool whip, sour cream, etc)
 - 6 ping pong or small plastic balls
 - 1 pool floaty or toilet paper/paper roll cardboard
- Part III
 - Neurotransmission
 - Original student built neuron model
- Part IV
 - Neurotransmitters
 - Student pages from G2C (Genes to Cognition) for depression
 - Computer access
- Part V
 - Dissection
 - Student pages from http://brainu.org/files/sg_sheep_brain_dissection.pdf
 - Sheep brain, cut in half with dura mater intact
 - Probe
 - Non-latex gloves
 - Dissecting tray/pan
 - Scissors/plastic knife/scalpel
- Part VI
 - Swim Caps
 - <http://www.allswim.com/product-p/500500.htm>
 - Markers
 - Brain map

Description of Activity:

Students will actively build a neuron, then demonstrate, on a class model, the action potential, and explain the reaction taking place, and, then make the connection between neurons and neurotransmitters on their own models. Then, students will research the different affects of different neurotransmitters, specifically what is happening when people have been diagnosed with depression. They will also do research on the various treatments of depression, that includes the work of one of the Nobel speakers, Dr. Helen Mayberg, and her ground-breaking work with Deep Brain Stimulation. The students will then dissect a whole sheep brain and discover the various areas of the brain that are known to be responsible for specific functions.

Lastly, the students will make a representative model of their own of the cerebral cortex areas on a swim cap.

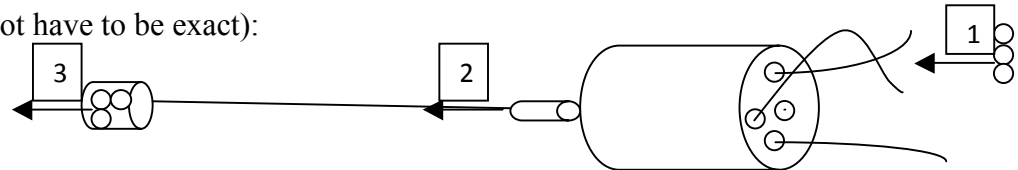
Procedure:

Part I Neuron (you need any materials available to you for building a neuron—beads, pipe cleaner, clay, etc)

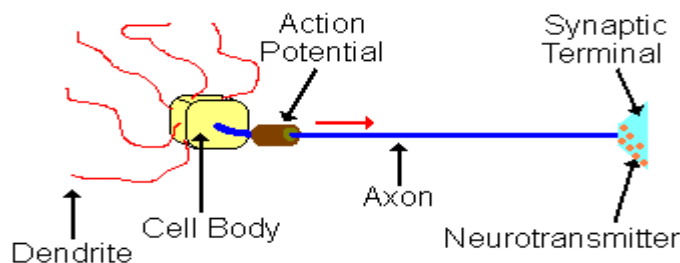
1. Go over a typical neuron and each of the parts: dendrites, cell body, axon, synaptic vesicles (draw on board or have picture where all students can see)
2. Have students, alone or in groups of 2-3, build a physical model using their resources
 - a. They need to be able identify each part individually

Part 2 Action Potential (you need 3 pieces of 2-3 ft pieces of string, 2 different thin plastic containers (cool whip or sour cream, etc) 1 piece of 10-15 ft rope, 6 ping pong balls, and one pool float (or toilet paper roll, etc)

1. Have students build class model (or teacher can build and reuse each year)
2. Put 4 holes in bottom of plastic container (not too big or rope will be hard to keep in) like such (does not have to be exact):



3. Attach 3 pieces of rope to 1 cool whip container through outermost holes in bottom (tie knots on other side so they do not come out) and have them protruding from back side of container
4. Put the 1 long piece of rope in other hole and have it protruding from front side of container
5. Attach pool floaty or toilet paper roll around rope and attach other plastic container through bottom end and tie on inside so that it does not fall off
 - a. Put 3 ping pong balls in that plastic end



6. Once built, have students review what each part represents (except floaty/tp roll) and have students pick up model and pull tight as it spreads out over room
 - a. 3 students can hold 3 other ping pong balls

- b. 3 students can pick up the 3 short ropes (dendrites)
 - c. 1 student can be at cell body (1st plastic container)
 - d. 1 student at end of axon (synapse)
7. Action Potential:
- a. 3 students from elsewhere throw the ping pong balls to dendrites
 - b. Once “dendrites” catch all 3 ping pong balls, they can shake ropes to stimulate cell body
 - c. “Cell body” moves floaty down axon to “synapse”
 - d. Once synapse is stimulated, those 3 ping pong balls should roll out of plastic container
 - e. Discuss this floaty, the action potential, in as much detail as needed.
8. A very detailed movie clip on Action Potential to further demonstrate this phenomenon is available at http://brainu.org/files/movies/action_potential_cartoon.swf

Part III Neurotransmission (you need the students’ original neuron models)

1. Allow students to show their models and open up a discussion between the 2 neighboring groups (or class) about how information may be able to go from one neuron to another.
2. Summarize how neurotransmission occurs.
3. Show a neurotransmission animation on the computer. Let students watch it a couple of times.
 - a. http://brainu.org/files/movies/synapse_pc.swf
 - b. <http://www.youtube.com/watch?v=90cj4NX87Yk>
4. Explain the following concepts: synapses, presynaptic neuron, postsynaptic neuron, action potential, and neurotransmitter.
 - a. Lay out the 2 neurons on a large piece of paper and label synapse, presynaptic neuron, postsynaptic neuron
5. Give examples of neurotransmitters such as dopamine, Gama, and serotonin and explain their roles.
 - a. Have students decide what material they can use to represent a neurotransmitter.
 - b. Stimulate neurotransmission and the action potential from the presynaptic neuron to the postsynaptic neuron
 - c. Other questions to extend discussion and have them simulate:
 - i. what would happen if they had too much or too little neurotransmitter
 - ii. Have students place anything in between the 2 neurons
 - iii. Added neurons
 - iv. Too much space between neurons

Part IV Specific Neurotransmitters (you need access to a computer)

1. Go to www.g2conline.org
 - a. Go under “Teacher feature” in top right corner

- b. Click on “teacher pages” for **depression**
 - i. read teacher page—decide what parts (1, 2A, and/or 2B) you will use
 - ii. print off student pages needed
2. Students complete student pages from www.g2conline.org
3. Go to www.g2conline.org
 - a. Click on “Depression”
 - b. Click on the middle Brain Anatomy sphere on the TOP of the screen
 - i. Watch Dr. Helen Mayberg’s description the network of structures linked to depression
4. Watch this 4 minute clip from an actual patient as he goes through DBS and see the before and after results! http://blog.ted.com/2008/10/14/the_brain_and_t/

Part V Whole Brain (adapted from http://brainu.org/files/tg_sheep_brain_dissection.pdf)

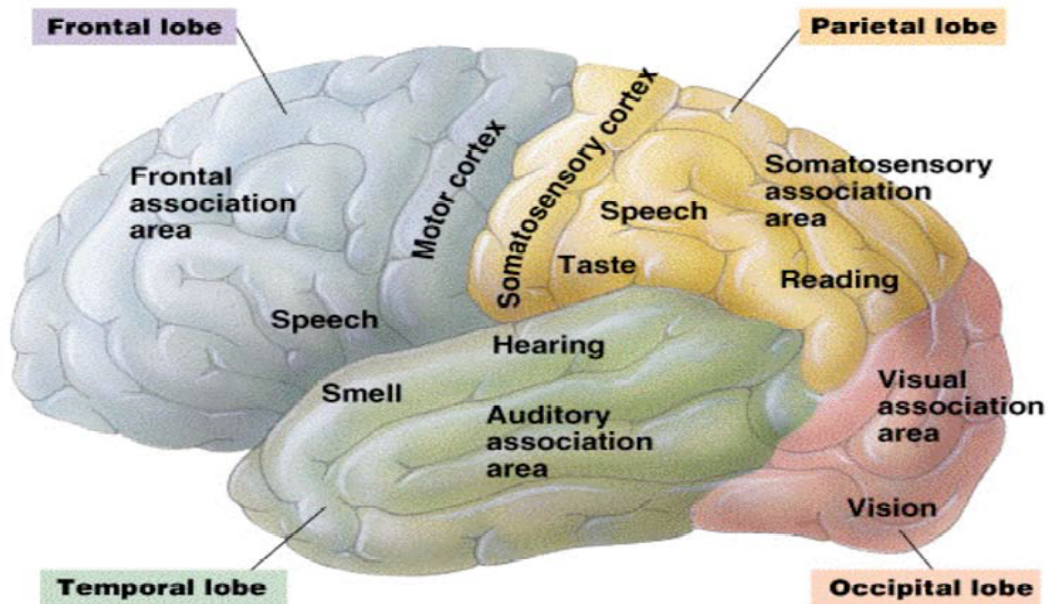
1. Print off student pages from http://brainu.org/files/sg_sheep_brain_dissection.pdf (at end of document as well)
 - a. Depending on dissection style or preference, students can either go through pages on their own or teacher can use the following steps to facilitate throughout the dissection
2. Engage students in a discussion about dissections
 - a. Dissections provide students with additional ways of learning through touch, supplemental to looking at pictures.
 - b. Ask students why scientists might dissect a body even if they already know the parts and how they are connected.
 - c. Develop appreciation and understanding of how scientists can learn about causes of death, effects of disease, and differences of organs and tissues among individuals and species.
 - d. Ask students where they think dissection materials come from.
 - i. People must designate before they die that they want to donate their body to science. Animal bodies and organs are obtained from slaughterhouses or from companies who breed animals for science experiments.
3. Organize students to work in groups of 2 or 3, and have them get their supplies (1/2 sheep brain, non-latex gloves, scissors, plastic knife, dissecting probe/wood splint, and tray).
 - a. Direct students to put a glove on their non-writing hand so that they can still write observations or assign one person to act as the designated recorder.
 - b. Encourage students to discuss their scientific observations with their group. While the group discusses their observations, they can also write them down on their lab guide or in their notebook.
 - c. Allow students time to share their observations with the class.
 - d. Ask students to write 2-3 questions about the brain or its structures that pique their interest during the observation phase.
4. Review with students the terms used to define anatomical directional relationships (dorsal, ventral, rostral, caudal, lateral, medial).
 - a. Ask each group to determine which half of the brain they have (right or left).

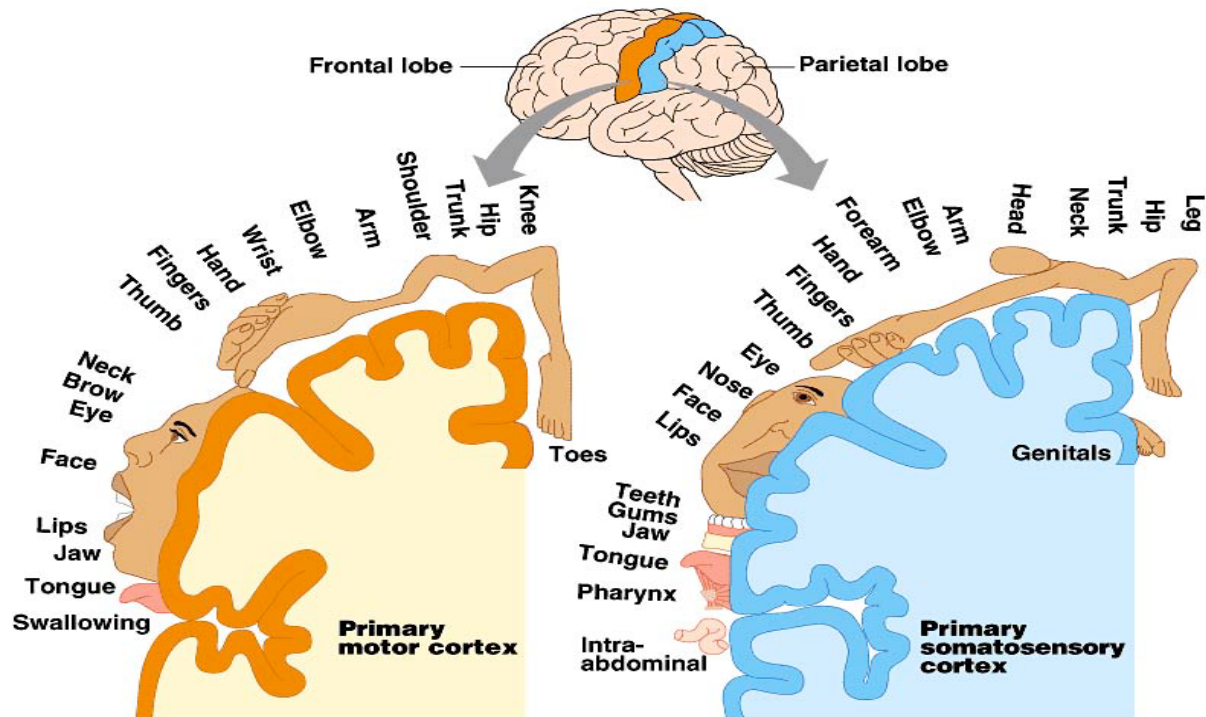
5. Direct students to put a glove on their writing hand and remove the dura mater. Tell students to try tugging on the dura mater.
 - a. Ask students what their experience was with the dura mater.
 - b. Ask why the brain benefits from having a dura mater (“tough mother” in Latin).
6. Tell students to cut through the brain with the plastic knife about 1 inch from the rostral end.
 - a. Ask students what they think was located on or at the indented area.
7. Tell students to poke the cut surface with the probing stick.
8. Ask students how the dark surface compares to the light surface.
 - a. Explain that the light surface is tough because it contains bundles of axons that are covered with fatty material (myelin, white matter) and the dark material is softer because it consists of dendrites and cell bodies (gray matter).
 - b. Review parts and functions of a neuron.
9. Show and help students remove the hippocampus.
10. Allow time for students to complete the Comparing Sheep Brains to Human Brains portion of the lab packet.
 - a. Let students answer the 2-3 questions they developed before the dissection.
11. Ask students to scrape the gray matter away from the white matter on the piece of cerebral cortex they cut off. If students scrape carefully along the white matter, they can get axon fibers to pull or peel away. Sometimes these can be traced over long distances.
12. Direct students to gently scrape the edge of the wood stick over the surface of the cerebrum to remove the thin meninges and expose the brain’s ridges and folds (gyri and sulci).
13. Students complete student pages from http://brainu.org/files/sg_sheep_brain_dissection.pdf
14. Refer to <http://faculty.washington.edu/chudler/what.html> for extra brain statistics
15. See terms at end of document

Part VI Cerebral Cortex Areas (adapted from <http://www.explorebiology.com/documents/08LabBrainAnatomy.pdf>)

1. Obtain neutral colored swim cap and eight different colored permanent markers including black
2. Review areas of brain (via either sheep brain, book, brain maps, etc)
3. Using a Sharpie, mark the major external features that you have identified on the swimming cap.
 - a. Outline the cerebral hemispheres
 - b. Cerebellum
 - c. Central sulci
 - d. Lateral sulci
4. REMEMBER: Mark BOTH sides. Make sure to REVERSE the orientation for the other side.
5. Identify and mark the following lobes:
 - a. Frontal lobe: in front of the central sulcus and above the lateral sulcus
 - b. Temporal lobe: below the lateral sulcus
 - c. Parietal lobe: behind the central sulcus

- d. Occipital lobe: the extreme back of the brain
6. Find the following and mark the areas on your brain caps:
 - a. Somatosensory cortex: perception of touch from surface of body
 - i. strip behind the central sulcus (post-central gyrus) in parietal lobe
 - b. Primary motor cortex: final output from brain to spinal cord for voluntary control of muscular movement
 - i. strip in front of central sulcus (pre-central gyrus) in frontal lobe
 - c. Premotor cortex: planning of movement
 - i. area in front of primary motor cortex in frontal lobe
 - d. Primary visual cortex: perception of vision, first input from eyes
 - i. hindmost part of occipital lobe
 - ii. surrounding areas of occipital lobe are concerned with analysis of vision.
 - e. Primary auditory cortex: input from ears
 - i. upper surface of temporal lobe
 - f. Motor speech: Broca's area
 - i. lower region of frontal lobe *on left side only*
 - g. Sensory speech: Wernicke's area
 - i. region of temporal and parietal lobe *on left side only*
7. Depending on needs and grade level, fill out chart of functions to accompany swim cap
8. Study and wear swim cap





Assessment:

Teacher note: much of this activity is going to use formative assessment as students are guided through building and modeling neurons, neuron-neuron transmission, and finally dissecting the sheep brain. Any type of summative assessment can be used as needed.

1. Discuss within a group the structure and function of neurons; how neurons communicate and how neuronal communication can be altered
2. have students present their physical models to the class
3. evaluate student reports
4. have students make and then evaluate concept maps on neurons, neurotransmission
5. have students make swim caps (part VI) based on knowledge gleaned from dissecting sheep brains (part V)

Extensions:

- Have students build a neural circuit that includes a sensory input and a motor output.
 - how can circuit be modified?

- Have students do research on how drugs, such as cocaine, nicotine, alcohol, and/or caffeine affect neurotransmitters and neurotransmission
- Create brochure about depression (symptoms, causes, treatments, etc)
- Make a concept map that includes everything in lesson

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Terms — important vocabulary that strengthen the lesson. Select terms according to the needs and abilities of your students.

- anterior – towards the head
- brainstem – the major route by which the forebrain sends information to and receives information from the spinal cord and peripheral nerves; controls respiration and regulation of heart rhythms
- caudal or posterior – towards the tail
- cerebellum – a structure located above or dorsal to the brainstem that helps control movement, balance, and muscle coordination
- cerebral hemispheres – the two halves of the cerebrum; the left hemisphere is specialized for speech, writing, language, and calculations; the right hemisphere is specialized for spatial abilities, face recognition in vision, and some aspects of music perception and production
- cerebrum or cerebral cortex – brain tissue seen from the side, top, front, and back that appears as tightly packed fat ridges and narrow folds; the outer cerebrum is responsible for all forms of conscious experience including perception, emotion, thought, and planning; *cortex* means bark in Greek - the bark of the cork tree looks a lot like the cerebral cortex of the brain
- corpus callosum – a large bundle of nerve fibers (myelinated axons) that link the right and left hemispheres of the brain
- dorsal – towards the back
- dura mater – tough, leathery outermost layer of the membranes surrounding and protecting the brain; lines the inside of the skull and drapes loosely around the spinal cord; Latin for ‘toughmother’
- frontal lobe – front region of the cerebrum concerned with cognitive processes that include planning, inhibition of instincts and drives, and declarative memory
- gyrus (pl = gyri) - the ridges or bumps of folded cortex
- hippocampus – c-shape band of fibers located within the brain responsible for formation of declarative memory, transfer of short-term to long-term memories, and has nerve fiber connection to the amygdala for emotional processing
- lateral – towards the outside
- medial – towards the middle

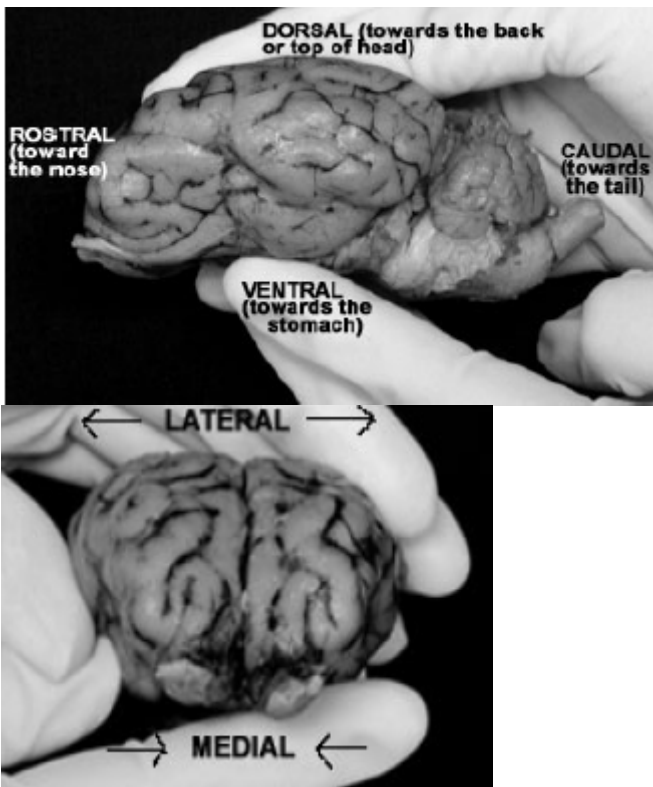
- meninges – three membranes (the dura mater and two other thin membranes) that cover and protect the brain and spinal cord against shocks, knocks, and vibrations; blood vessels run through the thin membranes before entering the brain
- myelin – compact fatty material that surrounds axons of many neurons; acts as an insulator to speed action potential movement down axons
- occipital lobe – located in the caudal region of the cerebrum; receives sensory information from the eyes
- olfactory bulb – anterior part of the brain concerned with the sense of smell
- optic nerve – nerve that connects the retina to the brain
- parietal lobe – located around the dorsal and medial region of the cerebrum that processes higher sensory and language functions
- pituitary gland – gland at the base of the brain that makes and releases growth, reproductive, and other hormones into the blood stream
- rostral or anterior – towards the front or nose
- spinal cord – bundle of nerve fibers, located inside the backbone, that connects the brain to different sensory and motor parts of the body
- sulcus (pl = sulci) – the valleys or spaces between the folds or gyri of the brain
- temporal lobe – located near the temples and ear region of the cerebrum concerned with smell, taste, hearing, visual associations, some aspects of memory, and a person's sense of self
- ventral – towards the stomach
- ventricles – fluid-filled cavities inside the brain

Observations

1. Write down 5 physical characteristics of your sheep brain? (for example: how the brain feels, color of the brain)

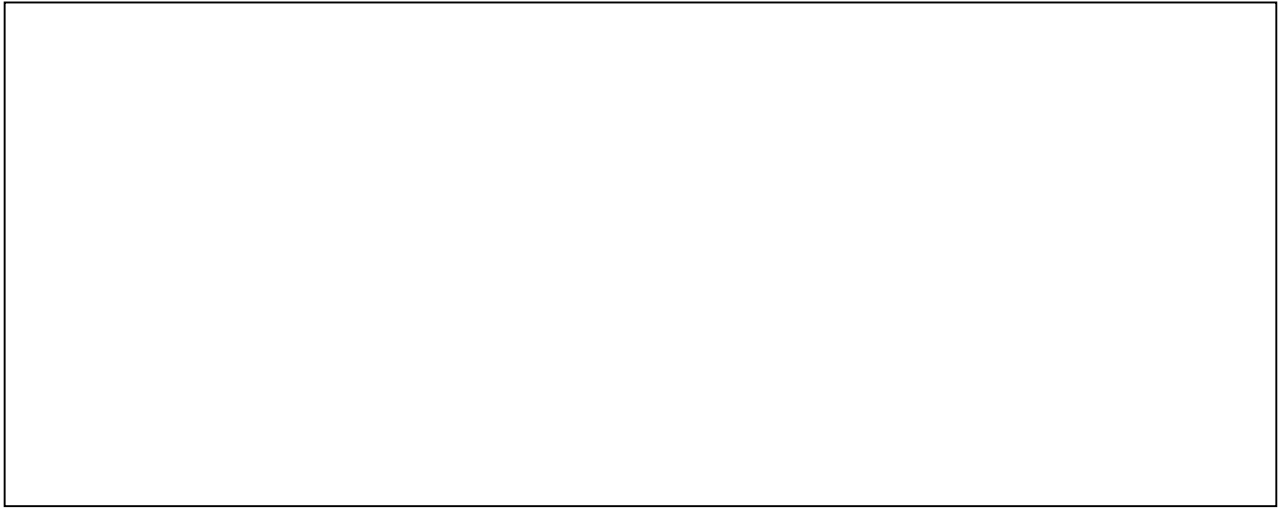
- a. _____
- b. _____
- c. _____
- d. _____
- e. _____

2. When talking about the brain, use the following terms:



lateral = toward the side
medial = toward the middle

3. Draw the LATERAL (outer side) view of your sheep brain; include the cerebellum and brainstem. Label the different lobes. You can peel the covering halfway back.



4. Looking at your drawing, find the different lobes of the brain on your sheep brain. List one or more functions of each lobe.

- Frontal Lobe _____
- Parietal Lobe _____
- Temporal Lobe _____
- Occipital Lobe _____

5. Draw the MEDIAL (inner side) view of the sheep brain. Label 3-5 brain parts that you see.



6. Look at your sheep brain and find out whether you have the right or left half (hemisphere).

I have the _____ half (hemisphere).

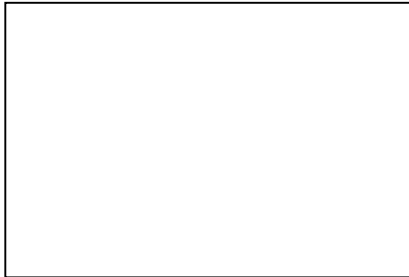
7. Find another group that has the half that is opposite to yours and put both halves together. Write about how big or small the whole brain is. (ex. The whole sheep brain is as small as an apple.)

Coverings of the Brain

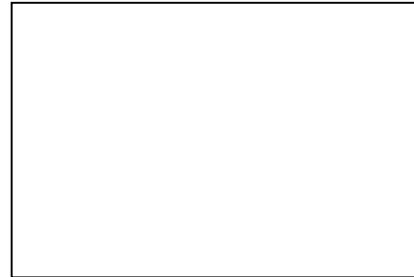
1. The dura mater (*tough mother*) is a protective covering of the brain. Does your sheep brain have a dura mater? _____ (Hint: it looks white or purplish.)
2. To take the dura mater off, locate the ROSTRAL end of your sheep brain. Using your thumb and index finger, peel the dura mater back towards the CAUDAL side. You might have to use the scissors to snip part of the dura mater at the ROSTRAL end. Remove the dura mater.
3. Try pulling the dura mater apart. What do you notice? Does it rip like a piece of paper?

First Dissection -- Exploring the Neuron and its Parts

1. Your teacher will draw a neuron on the board. Identify the parts of the neuron.
2. Place your sheep brain with the cut side (MEDIAL) down. Using the plastic knife, cut the brain about 1 inch from the rostral end (where the dent is located).



Box A - draw the inside of the
cutoff piece



Box B - draw a picture of a
neuron & label its parts

3. Draw the inside surface view of the brain in Box A above.
 - a. What do you notice about the cut surface?
 - b. Using the probe stick, poke the dark area. How does it feel?
 - c. Using the probe stick, poke the light area. How does it feel?
 - d. What do you think the dark and light areas are?

Second Dissection

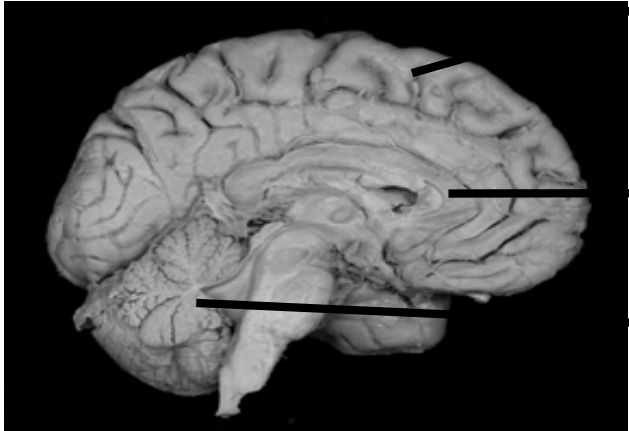
What is the part of the brain that stores short-term memories called? _____

To find this brain part, slide your thumb along the outside (LATERAL) of the brain stem until it disappears under the cerebrum. Keep wiggling your thumb and dig it gently under the cortex until you can't push it in anymore. Pull back the cerebrum so that you break the brain into two pieces. The memory center is the white C-shaped band of fibers and the grey matter inside them right around the area where the brain broke apart. Try to pull it out.

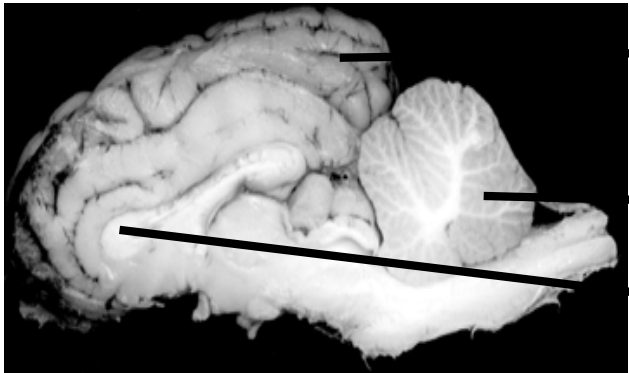
1. What do you notice about it?
2. What kinds of things does a sheep need to remember?

Comparing Sheep Brains to Human Brains

MEDIAL View of the Human Brain



MEDIAL View of the Sheep Brain



1. Label the brain parts in both the human and sheep brain pictures.
2. How are these brains similar?
3. Why might both brains be similar?
4. How are they different?
5. Why would they be different?