The Young Scientist Program
Teaching Teams Manual
Division of Biology & Biomedical Sciences
Washington University in St. Louis

Anatomy of the Human Brain
Neuroscience Teaching Team

Introduction
In this module, students will learn the basics of brain anatomy through hands-on interactions with real preserved brains of various species.

Materials
Nitrile gloves
Black garbage bags (to cover during transport)
Plastic models of human brains
(2) Mouse preserved brains
(2) Preserved spinal cords
Two plastic trays
Trash can (glove disposal)
(4) Human cadaver brain models
(1) Sheep preserved brain
(2) Unlabeled preserved brains

Safety Concerns
The human cadaver brains are preserved in formaldehyde. **<u>Everyone MUST wear gloves.</u>** Formaldehyde is very toxic. Formaldehyde exposure can irritate the skin, throat, lungs, and eyes. If the solution gets on clothing, immediately remove it. If ingested, call 911 immediately.

The human cadaver brains are very delicate and must be treated with respect. They cannot be left unattended. A YSP volunteer must always accompany them. When not in use, return the brains to the bucket, make sure they are submerged in the preservation solution, and close the lid. When transporting, cover buckets with a black garbage bag to hide from view.

Methods/Protocol
1. Carefully place the human cadaver brains on the plastic trays. Hide from view, if possible.

2. Show students the plastic human model brains. Point out the different brain regions and what they do (see below). Students can GENTLY pick up the pieces and try to fit them back together in the skull.

3. Show students the preserved mouse and sheep brains. **Do NOT let them pick up the glass jars – only look!** Compare the size of the mouse and sheep brains to the plastic human models. How big is a mouse? How big is its brain? What is the relationship between overall size and brain size?

4. Show the human cadaver brains. Point out the different brain regions and what they do.

   Our specimens include three whole brains, two spinal cords (the long skinny dark thing), and a partial cross-section of another brain. One brain is preserved in latex – the tiny red strings are blood vessels!

5. Ask students if they want to touch it. If so, have them put on gloves. They can line up and **<u>GENTLY</u>** touch the brain, one at a time. "Pet it softly, like a cat". **The brains are very delicate – poking, squeezing, or rough handling is not allowed. Do NOT let students**

pick up or move the brains.

Very young children (under 3rd grade) should not touch the brains – only look!

Formaldehyde exposure via inhalation can cause headaches, dizziness, and fainting. Keep an eye on kids for these symptoms. Don't let students put their faces close to the specimens; keep a distance.

6. Immediately dispose of formaldehyde-contaminated gloves. Make sure they are thrown into the trash can. Do not let students leave the table with formaldehyde-contaminated gloves.

Brain Regions & Functions

Spinal Cord: connects the nerves all through the body to the brain, controls sensory and motor info

Cerebellum: coordination of motor activity, posture, equilibrium; monitors/corrects for errors in ongoing movement

Brain Stem: cardiovascular and respiratory control, circadian rhythms, motor controls

Frontal Lobe: planning responses to stimuli
Temporal Lobe: recognizing stimuli; auditory processing
Parietal Lobe: attending to stimuli, sensory
Occipital Lobe: vision

Corpus Callosum: major white matter tract that connects the two hemispheres (comprised of axons from neurons in either hemisphere that contact target neurons in the opposite hemisphere)

Olfactory Tracts: smell
Optic Tract: axons from eyes; crossing of axons = chiasm

Hippocampus: memory (damaged in Alzheimer's disease)

Hypothalamus: homeostatic, reproductive functions; visceral functions; regulate hunger and thirst

Thalamus: relay station to cortex from other parts of the brain; especially for sensory processing info

Basal Ganglia (Caudate, Putamen, and Global Pallidus): organization and guidance/gating of complex motor functions

Amygdala: processing of emotions

Lateral Ventricles: fluid-filled (cerebrospinal fluid) spices

Meninges: three protective tissue layers that surround/support the brain (dura, arachnoid, and pia mater)

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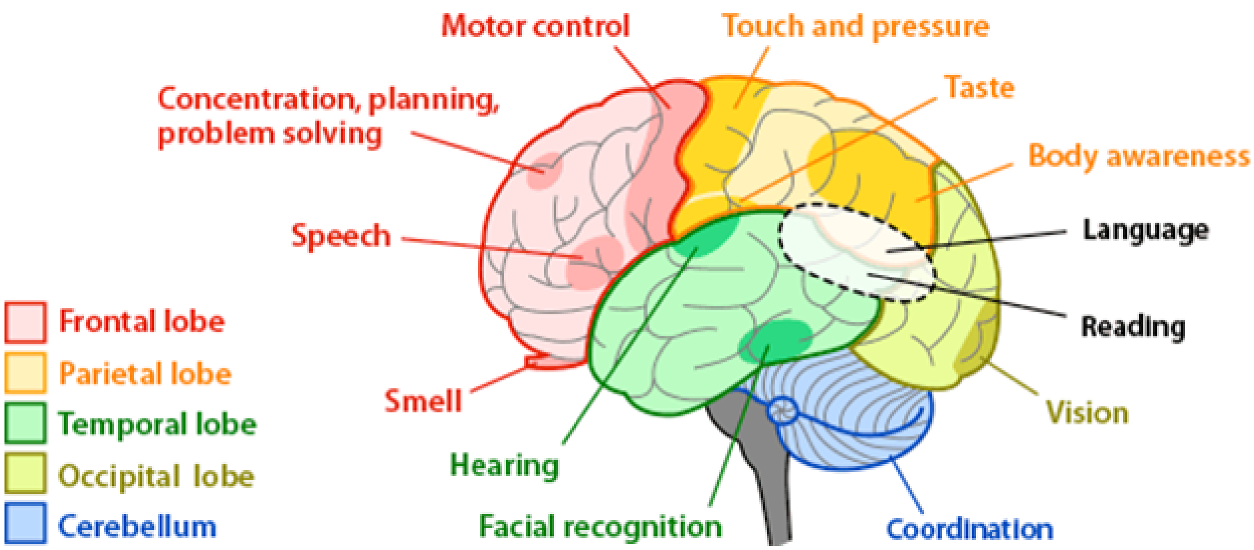

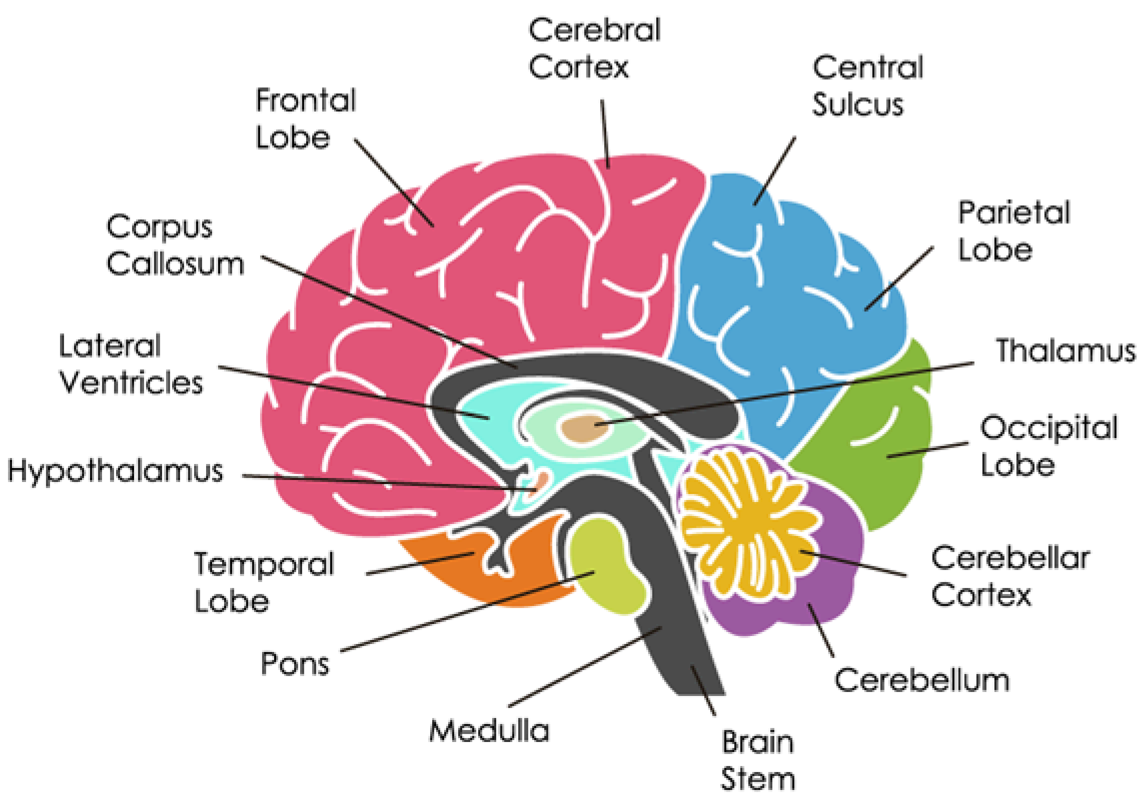

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Background Information
The adult human brain weighs about 1300-1400 g (about 3 lbs.). A newborn human brain weighs between 350 and 400 g. For comparison:

Elephant brain ~ 6,000 g
Chimpanzee brain = 420 g
Rhesus monkey brain = 95 g
Beagle dog brain = 72 g
Cat brain = 30 g
Rat brain = 2g

It is estimated that there are 100 billion (100,000,000,000) neurons in the human brain. To get an idea of how many 100 billion is, think of this:

Assume that you were going to count all 100 billion cells at a rate of 1 cell per second. How long would it take you to count all 100 billion cells? My calculations say it would take about 3,171 years!!! Do the math yourself. (Here is a hint on the math: there are 60 seconds in a minute; 60 minutes in an hour; 24 hours in a day; 365 days in a year). By the way, my calculations did NOT take "leap years" into account. Actually, it would probably take a lot longer than 3,171 years since it takes more than 1 second to say the large numbers.

Here is another way to think of 100 billion:

Assume the cell body of one neuron is 10 microns wide (this is just an assumption since neurons come in many different sizes. However, 10 microns is small; smaller than the period at the end of this sentence). Ok...if you were able to line up all 100 billion neurons in a straight line, how long would your line be? Check my math!!

1 neuron 10 microns wide
10 neurons = 100 microns wide
100 neurons = 1000 microns wide 1 mm wide
1,000 neurons = 10 mm wide = 1 cm wide
100,000 neurons 100 cm wide = 1 m wide
100,000,000 neurons 1000 m 1 km
10,000,000,000 neurons = 100 km
100,000,000,000 neurons = 1000 km (about 600 miles)

While all the neurons lined up side by side would stretch 1000 km, the line would be only 10 microns wide...invisible to the naked eye!!!

To get an idea of how small a neuron is, let's do some more math:

The dot on top of this "i" is about 0.5 mm (500 microns or 0.02 in) in diameter. Therefore, if you assume a neuron is 10 microns in diameter, you could squeeze in 50 neurons side-by-side across the dot. However, you could squeeze in only 5 large (100) micron diameter) neurons.

If you assume the average person is 150 pounds and the average brain weighs 3 lbs. then the brain is 2% of the total body weight.

The average spinal cord is 45 cm long in men and 43 cm long in women. The spinal cord weighs about 35 g.

Information travels at different speeds within different types of neurons. Transmission can be as slow as 0.5 meters/sec or as fast as 120 meters/sec. Traveling at 120 meters/sec is the same as going 268 miles/hr!!!

Discussion Questions

1. What is the brain made out of? (cells, tissues, 3 lbs.)

2. What is the main kind of cell? (neuron)
    a. Point out dendrites, axons, cell body, etc. with help of pictures.
    b. How many neurons are in the brain? (100 billion, 30,000 could fit on a pinhead)

3. How do neurons talk to each other?
    a. How information gets from head to toe (pictures)
        i. Different speeds in different types of neurons (0.5 m/s 120 m/s or 268 mph)
    b. Axons/dendrites, axons can be really long, run from toe to spinal cord...
    c. Synapses (pictures)
    d. Nervous System
        i. CNS = Brain + Spinal Cord (inside the skeleton)
        ii. PNS = nerves to rest of body (outside the skeleton)
        iii. Sensory nerves - info from body to brain
        iv. Motor nerves = info from brain to body

4. What does the brain look like?
    a. Is it one big mush or divided into different segments?
    b. Take out model brain, ask students what they notice about it
    c. Which end is front/back? (hold it up to someone's head, show where eyes would be)
    d. Point out how wrinkly it is. Why? (takes up less space when folded up)
    e. Different regions for different functions
        i. Point out various functional regions
        ii. Right versus left hemispheres
        iii. 4 lobes (frontal, parietal, occipital, temporal)
        iv. Where do they think the part of brain that processes visual information would be? (optic nerve, optic chiasm, visual cortex...)
        v. Cerebellum, involved in movement and coordinating movement
        vi. Any other regions... (hippocampus - forming memories, thalamus – gating movements)

5. Spinal cord
    a. Main pathway connecting brain and PNS

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6. Nervous system injury
    a. Stroke can damage different parts of the brain
    b. Spinal cord injury, paralysis
    c. fMRI to visualize brain activity
    d. fMRI images from injured/diseased brains