Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2006 Volume VI: Anatomy and Art: How We See and Understand

Making Connections: Exploring Our Brains through the Five Senses

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Introduction

I interact with an inquisitive group of tenth grade students at an urban magnet high school for health sciences, business, and technology. The students continually challenge me to provide engaging lessons that will grip their attention and at the same time assist them in the learning the concepts that are required by the state and district standards. I teach biology and I am very rarely at a loss for being able to relate the lesson to a real world application. The seminar topic of "Art and Anatomy" developed by the seminar leader William B. Stewart provides a wide range of real world applications that help to diversify the instructional methods used to teach human biology.

The unit is designed for biology courses that include a human biology section in their curriculum. The unit covers only the major anatomical structures associated with the central nervous system along with a brief introduction to the peripheral nervous system. This combination is used in order to allow for an investigation of the brain's relationship with the five senses (hearing, touching, seeing, smelling, tasting). The peripheral nervous system is briefly covered due to the integral role it serves in conducting the sensory information acquired by the sense organs to the central nervous system. However, due to time restrictions and the complexity of the partnership between these two divisions of the nervous system, the anatomy covered is basic. The unit can be easily modified to include a more advanced investigation of the anatomy associated with the nervous systems.

I always endeavor to design lessons with the intent of putting Howard Gardner's multiple intelligence theory into practice. The use of the five senses in this unit allows for each lesson to have the multiple intelligences theory direct the activities. In particular, Gardner's multiple intelligences identified as verbal-linguistic, logical-mathematical, visual-spatial, and tactile-kinesthetic intelligences are emphasized (Campbell, 2004). The variety of tasks that the students will need to complete in order to achieve the objective of each lesson will allow for the students to touch on these various intelligences. The current generations of students entering the classroom are conditioned to explore and learn concepts through multiple means due to their use of various electronic devices, video games, and their use of computers. The unit employs various multimedia sources as well as providing the students with multi sensory tasks this will help to cause the student to become proactive with the material presented.

Unit Objectives

1. The students will record observations and create drawings and models of anatomy using their five senses.

2. The students will describe the structures of a neuron and analyze each of their functions.

3. The students will compare and contrast the typical structural features of a general somatic cell to that of the specialized structures of the neuron.

4. The students will determine the path that an electrical nerve impulse takes as it conducts along one neuron and then transfers to neighboring neurons of various tissues and organs.

5. The students will distinguish between the central and peripheral nervous systems and describe the structure and function of the two main divisions of the central nervous system.

6. The students will identify the major anatomical structures of the brain and summarize their functions.

7. The students will construct a cerebrum representing the four major lobes of the brain.

8. The students will analyze how science and technology have improved our ability to understand our internal anatomy leading to an increase in the quality of health care that our society benefits from.

Unit Background

The Relationship of Art and Science

Science is often considered to be a subject that is dry and void of artistic expression. However, art is infused in the sciences when one considers the significant contributions that artists continually provide with two-dimensional and three-dimensional representations of the various organisms that inhabit the planet as well as representations of these organisms' habitats. These pieces of art provide essential visual aids that assist

scientists from various disciplines to learn from other scientists' discoveries and to either further their own investigations or make use of the material in a related but different direction.

Art and anatomy provide the prime example of the collaborative efforts that scientists and artists make together in creating masterpieces. The union of anatomy and art allowed for incredible works of art to be produced starting around the late 15th century (National Library of Medicine, 2004). At this point in medical history, scientists began to investigate the anatomy that existed beneath the skin in a more thorough manner. Human dissections were rare around the start of the Renaissance period due to the general population's disdain for such practices. The strong religious presence within the government at this time in history actually made provisions for human dissections, and allotted for a certain number of bodies to be given to medical schools. However, it was common for the schools never to receive the bodies due to the townspeople disrupting their delivery (Hilloowala, 1995).

The advent of the Renaissance provided an increased interest in human anatomy and the arts. At this critical point in history, influential members of society were willing to provide laws and funding to spark all the necessary elements needed to lead to the development of the partnership between the artist and scientist. This union provided masterpieces of art and science helping to advance the interest and the popularity of dissections to further scientific investigations of human health. The art work produced varied from a three-dimensional model to a two-dimensional illustration, served a key role for the instructor in the art and science classroom. The collaboration between artist and scientist even helped to educate the general public about their anatomy and the various ailments that were affecting their bodies (National Library of Medicine, 2004).

Many have the misconception that scientists have no artistic capability. Leonardo da Vinci is a prime example of a famous artist who is not necessarily thought of as also a brilliant scientist (National Library of Medicine, 2004). This unit is not only to teach students the important relationship of their senses with that of their brains, but to enlighten the students to the critical role art plays in science. Art is used frequently throughout the unit in order to develop the students' ability to recognize and understand the importance of recording observations using not only words but through the use of sketches and models. Sketches are one of the main tools that scientists use in recording their observations when studying an organism in the field or under a microscope. This unit will take the students on a journey beginning with observing and analyzing art representing the human form to becoming an artist through the creation of drawings and models that represent key anatomical structures found within the central nervous system.

The combination of anatomy and art is the perfect union to engage students in acquiring an understanding of the central nervous system. This unit covers the major anatomical features of the central and peripheral nervous systems with a greater emphasis on the anatomy of the brain. This unit utilizes the five senses (vision, taste, smell, touch, and hearing) in order to engage and to provide a reference point for the students as they are immersed in the abstract subject of anatomy.

Scientific Inquiry Fueled by Injuries and Diseases

Students are often intrigued with a description or a visual of the gore associated with an injury or a disease affecting human anatomy. This unit begins each lesson with a hypothetical situation where an individual has been afflicted by a certain disease or an injury that impairs one of the senses. My reasoning in using this approach is multi-faceted. First, this introduction feeds the students' innate desire to see how human anatomy can be disfigured and diseased, and will retain their attention and interest. This interest will motivate the students to recognize and develop their skills of scientific inquiry.

The desire to see parts of human anatomy that are typically unseen provides the students with opportunities to brainstorm as to the important role injuries and diseases play in the altering of human health. Scientists start with an observation of a certain natural phenomenon and then ask questions relating to their observations in order to explain and determine the cause of their observations. This process is the basis of the scientific method, the method with which scientists have made the advances in our knowledge of human anatomy and physiology. The increased understanding of the processes that underlie within human anatomy allows for scientists to develop cures for various injuries and diseases. Any increase in the awareness and understanding of a disease or an injury also provides critical information as to how to educate the general public in preventing an injury or a disease from taking place.

Science and technology play a key role in this unit as it is one of the main contributors of our current advancement in understanding human anatomy. The medical community is continually making advances in health care due to better medical imaging technology, surgical equipment, and precise medical tests. Although most technology is used to treat an injury or disease rather then prevention, one cannot ignore how the contribution of science and technology in medicine has increased the quality of life as well as the longevity of life.

Educational Theory

The intent of this unit is to integrate the majority of our activities with lessons surrounding the use of the senses in order to positively engage the students' limbic systems. If the students are feeling threatened by the material, they can develop a negative association with learning (Roberts, 2002). Current research in experiential education reveals a strong relationship with learning and engaging the limbic system. The limbic system is responsible for not only regulating some of the basic emotions such as pain and pleasure, but also the creation of memories (Grabowski, 2000). The hippocampus, a crucial structure within the limbic system assists in the creation of memories. Memory is solidified when paired with strong emotions connected to the activity (Roberts, 2002). The activities planned for this unit are attempts to employ several of Howard Gardner's multiple intelligences. The use of Gardner's multiple intelligences will help to provide the students with the ability to excel in a subject that can be abstract and difficult to process by providing a variety of means to initially explore the content and then to express their understanding of the content (Campbell, 2004).

The use of the five senses is essential in that it provides an activator for the students' prior knowledge and lays the foundation for exploring the brain anatomy. The anatomical features of the brain pair nicely with the senses due to its main function being the "processing center" for all of the information that the five senses receive (Hopson, 2006). The students will analyze their senses and the cascade of reactions that take place within the nervous system starting at the cellular level progressing to the macro level with the focus on the gross anatomy of the brain.

Teaching Strategies

Art will be infused throughout the unit. The unit will begin with an art activity that involves the students creating a piece of art work that they will later return to at the end of the unit. This piece of art work entails a "before and after" theme as the students reflect on the beginning of the unit and the knowledge they have acquired throughout the unit as to what their anatomy entails. These images will be collected and then referenced at the end of the unit. Students will observe various pieces of art work created at different points in history depicting the human form. The students will compare and contrast the depictions of the human form and brain storm as to why the images start as simplistic and become more complex with time.

The art activities focus on using a single sense or a combination of senses. Once the students have completed an activity, the students will analyze how their senses provided the necessary information to complete the art

activity in a daily journal. Each art activity used will allow the students to investigate how the central nervous system pairs with the structure and function associated with each of the five senses. The unit briefly touches upon how the sensory information is transported through the spinal cord and then processed in the brain. Due to the complexity of the mechanisms involved, the material covered will be brief and basic.

In addition, the art activities will focus on creating visual representations of the central nervous system to help provide the students with a better understanding of the anatomy. At the end of the unit, each of these artistic creations will be combined to provide the student with a giant visual concept map of how the central nervous system operates based on the information provided by the five senses. The objective is for the students to be able to distinguish how various parts of their anatomy assist in allowing for their five senses to exist. The students will distinguish the pathways being used that allow their senses and the brain to work together to facilitate their cognition of the world around them.

I know that through my own experiences as a student and now being a teacher that a variety of strategies should be used when planning a unit. I repeatedly attempt to connect new material I am teaching with the experiences students most likely have encountered in their world beyond the classroom. The technological age that we live in requires that students are provided with a multi-sensory environment that will engage them through various modes of instruction (Roberts, 2002). This type of environment can be created through the presence of computers and LCD projectors, items typically available in schools today. The unit also employs the use of basic art supplies in order to provide students with a more organic approach to their learning through the creation of different pieces of art depicting the anatomy.

Brain Based Learning

This unit is built around the "principles of brain based learning" that Jay W. Roberts presented in his article on *Beyond Learning by Doing: The Brain Compatible Approach* in the Journal of Experiential Education (Roberts, 2002). Roberts' article focuses on the brain's programmed nature to look for relationships within new material to catalogue the information in a way that can be easily accessed (Roberts, 2002). Concept maps are key tools in allowing students to see the big picture of how foundational elements are the basis on which the new material is being built.

Romance Languages and Science

The student population I instruct in the New Haven district is very diverse. Many of my students speak a second language and some of these languages are romance languages. Students speak a romance language or those enrolled in a Latin class, can be instructed to look for the Latin cognates that are the roots of the majority of the vocabulary used in science. This can help students who are weak in their vocabulary acquisition to recognize the meaning that is woven in the root of new vocabulary words. The language of science is filled with Latin cognates and by understanding this relationship, the vocabulary can be presented in a less threatening manner, allowing the students a bit of familiarity with the new vocabulary. Students who do not have a romance language as a second language can still draw on their knowledge from a foreign language class. In particular, Latin provides a strong foundation.

Howard Gardner's Multiple Intelligences

Gardner's theory of multiple intelligences provides the basis for the unit to be grounded in an environment focused on using the senses. There are a variety of intelligences infused in the activities are influential in

determining the way in which students can excel in showcasing their talents (Campbell, 2004). Verbal-linguistic intelligence entails one's ability to understand and manipulate words in order to communicate in a variety of contexts such as reading, writing, and speaking (Campbell, 2004). Logical-mathematical intelligence revolves around the blending of science, logic, and mathematics (Campbell, 2004). This type of intelligence thrives off classrooms that include working with numbers, sequencing, the scientific method, Venn diagrams, questioning strategies, and analogies (Campbell, 2004). Tactile-kinesthetic intelligence revolves around the need for the student to manipulate what they are learning through touching objects as well as through the use of their entire body in activities. This type of intelligence thrives off activities that provide the student with the chance to learn the material by actually performing a task (Campbell, 2004). Visual-spatial intelligence entails a variety of areas such as the development of mental images, visually recognizing and discriminating between various objects and life forms, spatial reasoning, manipulating images, and projection (Campbell, 2004). This intelligence deals with much more then the creation of works of art that are original in their composition. This type of intelligence thrives off analyzing visual media such as graphs and diagrams, creating three-dimensional objects, and being able to depict negative space. The spatial orientation aspect of this intelligence includes not only artists but pilots and architects in their ability to successfully navigate themselves and objects through space (Campbell, 2004). The lessons in this unit may draw upon more than one intelligence as no individual is strictly one type of intelligence.

Nervous System Introduction

The unit will begin at the cellular level, in order to organize the information in a manner that allows students to activate prior knowledge. If this unit is used in an introductory biology course, the topic of cell function and structure should have already been presented due to this topic typically being covered earlier in the school year. This is an ideal time for a brief review of cell structure and function as these are key concepts that should appear on a midterm and final exam. Those students enrolled in an anatomy and physiology or an advanced biology course may need a refresher over the importance of the cell's structures and functions.

The central and peripheral nervous systems are the two main sections of the nervous system and they are the anatomical focal points covered in this unit. The main objective is for students to identify, describe, and analyze the nervous system anatomy involved in acquiring and processing information that is received through an individual's sense of hearing, seeing, smelling, touching, and tasting.

Central Nervous System

The central nervous system is composed of the brain and spinal cord. The brain acts as the main processor for all activities of the body. The spinal cord acts as a transport system carrying the electrical impulses away from or towards the brain to maintain a balance or homeostasis between the various organ systems of the body (Hopson, 2006).

Neurons and glia are the two types of cells that make up the tissues of the central nervous system. Glial or neuroglia do not participate in processing information but they are critically important in providing structural

and metabolic support for the neurons in the brain and also getting rid of dead cells within the brain (Grabowski, 2000). It is interesting to note that there are many more glial cells than there are neurons in the brain and they make up the majority of the brain's weight (Beatty, 1995). Students may benefit from knowing that the definition of glia is "glue." This can provide the students with a way in which to distinguish between the neuron and a glia cell (Grabowski, 2000).

Peripheral Nervous System

Neurons or part of neurons that reside in areas outside of the brain and spinal cord, comprise the peripheral nervous system. Afferent or sensory neurons work to transmit information from the body to the central nervous system. Efferent or motor neurons work to transmit information from the central nervous system to the rest of the body (Hopson, 2006). The sensory information that the afferent neurons send to the central nervous system cause the efferent neurons to send a signal from the central nervous system for muscle cells to contract and glandular cells to secrete hormones (Grabowski, 2000). Another way to help students to distinguish between these two types of neurons is to examine the definition of efferent which means "to carry outward" (Merriam-Webster,

1997). Students should be asked what exit and efferent both have in common. Their responses will be varied but they should make a connection between the connotation of the words and that both words start with the letter e.

The peripheral nervous system is further sub-divided into the autonomic and somatic nervous systems. The autonomic nervous system relays electrical impulses from the central nervous system to internal organs such as the heart (Biggs, 2006). This system deals largely with the involuntary processes of our body such as our breathing and our heart rate. The autonomic system is further sub-divided into the sympathetic and parasympathetic nervous system. The somatic nervous system relays electrical impulses from sensory receptors located externally within the skin and skeletal muscles to the central nervous system and vice versa (Biggs, 2006). The somatic nervous system deals largely with voluntary actions however reflexes also fall under this system as well (Biggs, 2006). A prime example of this would be stepping on a nail and your knee jerking upward before you have yet to process the pain associated with stepping on a nail that went undetected.

Nerve Cells & Direction of Nerve Impulse

The basic structures of the neuron are dendrites, the cell body, and the axon. Dendrites are described as multiple branches that typically protrude from the cell body. These branches act as channels for incoming information from other neurons. The dendrites send this information as an electrical signal to the cell body where it is then sent to an additional process called the axon (Beatty, 1995). The nucleus and other organelles are located in the cell body or the soma of the neuron. The axon is one long continuous extension from the cell body. These basic components of the neuron can be found in various arrangements depending on the location of the neuron in the body (Beatty, 1995).

The axon sends information received from the cell body to the next neuron by the continuation of the electrical signal. Once this electrical signal reaches the terminal end of the axon, structures at this end of the axon called terminal buttons release chemicals called neurotransmitters (Hopson, 2006). The axons of sensory neurons can be found in a variety of places in the body such as muscles, the skin, the blood, and connective tissues (tendons and ligaments) (Grabowski, 2000).

The gap that exists between two neurons is called the synapse or the synaptic cleft. This is the point at which neurotransmitters are passed from one neuron's terminating axon to the dendrites of neighboring neurons. The synapse is the point of communication between two or more nerve cells and can also include other types of cells (Hopson, 2006). The mechanism behind the electrical impulse generated and then carried through the neuron is not covered in this unit due to the focus being on the gross anatomy of the brain.

The brain and spinal cord receive information from organs and tissues through the peripheral nervous system. Depending on the function of the neuron they are classified as receptors, interneurons, and effectors. The receptor and effector neurons are the two categories that are focused on in this unit. The motor neurons are effector neurons that can cause the contraction of voluntary muscles as well as the contraction of involuntary muscles found in blood vessels. These motor neurons also stimulate glandular cells to secrete hormones (Grabowski, 2000). The receptors of sensory neurons transmit their information through the dorsal root ganglion that then enters the central nervous system.

The brain stem, cerebrum, and the cerebellum are the three structures that compose the brain matter. The greatest portion of the brain resides within the cerebrum as it makes up the top outer layer of the brain. The cerebrum is the most recognizable anatomical structure of the brain being composed of large grooves and fissures. The cerebrum is divided into two main sections, the left and right cerebral hemispheres. The corpus callosum connects the left and right hemisphere through a thick band of axons that allow for communication to take place between the two hemispheres (Hopson, 2006). The left hemisphere is largely responsible for processing speech and language while the right hemisphere is responsible for processing reasoning and spatial information (Hopson, 2006).

The brain is then further subdivided into four lobes called the frontal lobe, occipital lobe, parietal lobe, and the temporal lobe (Hopson, 2006). The frontal lobe houses the brain's multiple processing centers for motor function, speech, and intellectual function (Johnson, 2004). The temporal lobe houses the brain's centers for smell and hearing. The occipital lobe houses the brain's centers for vision, and the parietal lobe houses the brain's centers for sensory function (Johnson, 2004). These are the major regions of the brain that the students will learn to identify and describe their function.

The cerebrum is responsible for the higher levels of functioning regarding the storage of memories, the ability to learn, and for intelligence. The cerebral cortex will be a key anatomical structure for the students to be able to identify as it is area that is easily identifiable composing the most superficial layer of the cerebrum composed of gray matter (Grabowski, 2000). This area serves a critical role in the brain's ability to process motor and sensory information. The cerebral cortex contains the largest surface area in the brain as it the outermost layer being only 2-4 millimeters thick (Hopson, 2006).

The cerebellum is another key brain structure as it serves to regulate the timing associated with skeletal muscles as they control our movement and aid posture and balance (Hopson, 2006). This structure will be highlighted throughout the unit as students perform various motor activities. It will also be mentioned that this brain structure must be intact and developed for individuals to be successful in various activities that athletes, musicians, and artists take part in.

The brain stem will not be covered in depth but its location and function will be briefly reviewed to acquaint the students with its importance. Its location is at the base of the brain connecting to the spinal cord. It serves a vital role in maintaining the internal

balance of the body's vital functions such as heart rate, sleep, breathing, temperature, and body temperature will be covered (Hopson, 2006). In addition, the brain stem acts as a relay station for sensory information intended for the cerebral cortex, and also for motor information intended for the head and body (Grabowski, 2000).

Sense Organs

The eyes are the critical organs that contain nearly half of the body's sensory receptors. A large portion of the cerebral cortex is designated to processing all of the sensory information that these receptors receive (Grabowski, 2000). The eyes are complex structures and only two key photoreceptors will be reviewed concerning the anatomy of an eye. The ability for us to see in dim light is due to the action of rod cells. Cone cells provide us with the ability to see color and cones provide this capability only in bright light. Together these cells allow for our vision to function when various amounts of light are present.

The ears are the critical organs that allow for our ability to hear the various sounds of our environment. The external ear is the structure that is most familiar, but it is what is inside the ear or auditory canal that allows for our ability to hear. The ear canal leads to the eardrum or tympanic membrane. Take time to review with students the meaning of the Greek root word that tympanic is derived from. The Greek word "tympanon" means drum and this definition may be helpful for students to remember the function of the tympanic membrane (Hopson, 2006). Sound is made of up waves of energy. These waves cause the ear drum to vibrate allowing for a change in the air pressure in the middle ear. This pressure change causes small bones within the middle ear to vibrate the oval window which then transfers the vibrations to the inner ear. The cochlea is located in the inner ear where hair cells are located at the base of the base of the spiraling cochlea. These hair cells are mechanoreceptors that activate the auditory nerve by initiating an action potential that is relayed to the temporal lobe where the main auditory processing centers are located in the brain (Hopson, 2006).

The mouth and nose work together to provide our sense of taste. Gustation or the sense of taste deals directly with the tongue and the four zones on the tongue that are distinct to bitter, sweet, salty, and sour chemical stimuli (Grabowski, 2000). Olfaction or the sense of smell deals with taste as well providing the bulk of what we taste rather then the receptors located on the tongue. The olfactory receptors are stimulated by odorant molecules that may be inhaled into the nasal cavity or may enter the nasal cavity from the mouth (Grabowski, 2000). The sensitivity of olfaction is really the basis for the multitude of tastes we encounter in life. This is why a loss of smell means a loss of taste as well (Grabowski, 2000).

Classroom Activities

Lesson 1

This lesson is designed for visual-spatial intelligence and verbal-linguistic intelligence.

Goal

At the end of this unit, students will recognize the significance that science and technology have played in advancing our understanding human anatomy in the medical field as well as in art.

Objectives

1. Students will create a drawing representing how they think their bodies are connected to their brains.

2. Students will compare and contrast ancient cave art of human anatomy to modern art depicting human anatomy.

Teacher Materials (see appendix)

Student Materials

Pen/Pencil, Paper, Journal

Learning Activities

The unit will begin with a simple art activity. The students will be asked to simply draw the insides of their bodies. Using a pen and paper, they will represent how they think their brain is connected to the rest of their body. These drawings will be collected and shown to the students after the unit has been completed. This activity will allow the students to identify any misconceptions they had at the start of the unit concerning the anatomy associated with the nervous system. The students will then be introduced to the unit as an exploration of the anatomy involved that provides the sensory information associated with the five senses. The students will play a quick game of charades where they act out the five senses that we will be investigating in the unit (hearing, smelling, tasting, seeing, touching).

The unit will then continue with a discussion of the importance of diagrams when learning new material. The students will be asked to define what constitutes a diagram and could it be a piece of art work? The students should view photographs of anatomical figurines such as the "Medical Venus," an anatomical wax figurine that was created in the 18th century for medical students to study human anatomy (Hilloowala, 1995). This figurine is a classic example of art and science fused together to provide a teaching tool (National Library of Medicine, 2004).

Next, the students will briefly review a sampling of art history regarding the depiction of the human form. The students will first view images generated by ancient people groups (cave drawings) and end with the current modern day representations of human form. A good example of a cave drawing depicting a very simplistic human form can be found in the cave drawings found in France (1). The students will be asked to compare and contrast the earlier images with the modern ones. They will be asked what they think influenced the

images as they become more complex over time. The students should come to a conclusion that society's technological advancements have caused the evolution of how the human form has been depicted in art (Kelves, 1997).

Lesson 1 Closure

Next, the students will review the source of these changes in the depiction of human form by reviewing a history of medical imaging starting with the X-ray and ending with CT scans, ultrasounds, PET, and fMRI. The students will make conclusions as to how advancements in medical imaging have improved their health and their understanding of anatomy by writing a journal entry (Kelves, 1997).

Lesson 2

This lesson is designed for tactile-kinesthetic, visual-spatial intelligence, and logical-mathematical intelligences.

Goal

At the end of this unit, my students will distinguish between the two major divisions of the nervous system and relate how the two divisions work together in maintaining the homeostasis of the body. The students will also examine the part of the brain that is responsible for processing motor and sensory information.

Objectives

1. The students will distinguish between the central and peripheral nervous systems and describe the structure and function of the two main divisions of the central nervous system.

2. The students will identify the major anatomical structures of the brain and summarize their functions.

3. The students will construct a cerebrum representing the four major lobes of the brain.

Teacher Materials (see appendix)

Student Materials

Pen/Pencil, Journal, Biology Text book

Learning Activities

The brain is the key anatomical structure that the students will be investigating as they relate the information their senses provide. The brain is the processor of all of the information that is taken in by the body via the five senses. The cerebral cortex is being created at the beginning of the unit so that this three-dimensional model can serve as a reference point for the students as they explore their five senses and the areas of the brain that process this sensory information.

First, the students will be introduced to basic features of the central nervous system anatomy mentioned in the nervous system section of the unit. The students will record this information in their journals. The students will be provided with a view of a homunculus cartoon based on Wilder Penfield's map depicting the areas of the body that the motor cortex is responsible for (Beatty, 1995). This cartoon provides an excellent visual aid for the students to use by providing a foundation for where in the brain certain functions take place. Although,

Penfield's cartoon dealt with the motor cortex, knowledge of the somatosensory cortex was increased due to Penfield's experimentation with electrodes on the brains of epileptics (Afifi, 1998).

There are two homunculus cartoons, one represents the motor cortex and the other represents the somatosensory cortex. Provide the students with a copy of each in order for the students to analyze the similarities and differences between the two. The students will examine each cartoon and then create their own cartoon representations of the somatosensory cortex by drawing various parts of the body based on the proportions in their homunculus examples. They can then cut these drawings out and glue them to toothpicks. These tooth pick creations will be used to stick in their clay cerebral cortexes in order to identify the regions of the somatosensory cortex devoted to finger tips, the mouth, etc. The students should note that the mouth and finger tips are the most sensitive spots on our bodies and have the most areas devoted to them on the cortex. A great website to visit concerning Penfield's contributions is offered through PBS (3).

Before the students are provided with modeling clay, they will be given time to explore the brain through an interactive website that provides a three-dimensional image of the brain (6). A plastic model of the brain can also be made available to the students to examine. This exploration will provide them with a familiarity of the parts of the brain that are more interactive then an illustration in the textbook. The website mentioned above, can be used with each of the five senses and the anatomy associated with each of the senses. This art activity is a tactile activity focusing on the student's sense of touch as they mold pieces of clay to represent the lobes of the brain along with fissures found within the gray matter of the cerebral cortex. The clay provided will have different textures (smooth and sandy). The students will be given four colors to represent the frontal, parietal, temporal, and occipital lobes of the brain. The class should decide which colors will represent each lobe and each student should follow this key. It is crucial that every student uses this color key, in order for there to be no confusion as the use the class as we go through the unit and make references to our clay cerebral cortexes. This model provides a visual aid to refer to as the class discusses the somatosensory and motor cortex areas of the brain after each lesson.

The students will diagram the major structures of the brain (the four lobes, longitudinal fissure, and corpus callosum) and then create a clay model of the cerebral cortex placed on a piece of cardboard. The students should start by creating a core to hold the outer shell of the cerebral cortex. This can be done by rolling a piece of newspaper into the shape of an ostrich egg or an oval grapefruit. Masking tape should be wrapped around the shaped paper in order to keep it steady and then the core should be taped to the piece of cardboard. Then the students can begin molding their four lobes making sure to include the longitudinal fissure and the central sulcus. These two fissures are critical in allowing the students to locate the somatosensory cortex on the postcentral gyrus of the parietal lobe and the motor cortex in the precentral gyrus on the frontal lobe (Grabowski, 2000). The brain stem will not be created in order to allow for the cerebral cortex to stay flat on the card board.

The students should decide which senses were used to complete this art activity and record how they came to their conclusion in their journals. The students will then refer to the homunculus cartoons they were given at the beginning of class and determine where they should place a toothpick to represent the amount of space on the somatosensory cortex that is devoted to processing sensory receptors in the fingers. The students should also identify the frontal lobe as it is the main processor for motor function and mark it with a toothpick.

Closure Lesson 2

Students will discuss the importance of wearing helmets while riding a bicycle and review a case study of a student who hit the back of their head after falling from their bike while not wearing a helmet. The student

describes having vision problems after the accident. Students will hypothesize as to why this injury affected the student's vision even though the student's eyes were not damaged.

Lesson 3

This lesson is designed for visual-spatial, tactile-kinesthetic, and logical-mathematical intelligences.

Goal

At the end of this unit, students will be able to identify a neuron and describe its structure and function in allowing communication between the two major divisions within the nervous system. The students will also identify the two major divisions of the nervous system and relate how the two divisions work together in maintaining the homeostasis of the body.

Objectives

1. The students will describe the structures of a neuron and analyze each of their functions.

2. The students will determine the path that an electrical nerve impulse takes as it conducts along one neuron and then transfers to neighboring neurons of various tissues and organs.

3. The students will make conclusions as to how their five senses have allowed for the creation of art.

Teaching Materials (see appendix)

Student Materials

Biology text book, Journal, Pen/Pencil

Learning Activities

At this point in the unit, the students will be asked to name the five senses (touch, sight, hearing, smell, taste) that they acted in playing charades. They will be asked to decide in groups which of the five senses they feel are the most important and to explain why, recording their conclusions in their journals. The students will then brainstorm which of the five senses they could conduct a scientific investigation on using the resources available to them in our classroom. Then the students will be asked to determine which sense is most important to them when producing a piece of art work and to explain why.

The students should come up with vision as their most important sense, though answers may vary from class to class. The students should review the importance of the rods and cones found under the sense organs section. The students will be given a case study where a student with a very poor diet of only sugar cookies and hot dogs has started to experience problems with their ability to see at night. In small groups, students will discuss what part of the eye they think is being affected by the student's inability to see at night time. Once they have come to a consensus, the student's will be asked if they think there is relationship with the diet of the student and their vision problem. The students may be given a hint by being asked what have they heard about eating vegetables and eye sight. Once they have come to a conclusion, they will read about night blindness or nyctalopia and how a deficiency in vitamin A leads to rod cell destruction (Grabowski, 2000).

The class will review the familiar structure of a somatic animal cell and review the various organelles and their

function. The students will then view a diagram of a neuron from their text book and compare and contrast the differences they see between a neuron and a somatic cell. They will record this in their journal. After this discussion, students will draw neurons using the diagram in the student's textbook. The students will be provided with an index card to draw their neuron diagram. The students will then be told they will lose their sense of vision in this art activity. The students will then be blind folded to take away their vision. After they have completed their drawings, the students will remove their blindfolds and then discuss how the other four senses were enhanced in order to compensate for the loss of their vision's sensory input information. They will write in their journal, their experience of having lost their vision. Then the students will draw the neuron from their textbook using their eyes and then label the key parts of the neuron. They should color their diagram of the neuron and cut them out. The students will take each of their neurons and tape them inside the giant outline of a brain that is at the front of the room. The students should then locate on their clay cerebral cortex the occipital lobe and mark it with a toothpick as the location for the visual association area of the brain. The students should place a toothpick in the somatosensory cortex to represent the amount of area that is devoted to processing the sensory receptors of the eyes.

Lesson 3 Closure

The class will discuss how the brain is composed of billions of neurons (Johnson, 2004). The students will record in their journal how the brain filled with neurons created by the class shows the relationship between the neuron and the brain.

Lesson 4

This activity is designed for tactile-kinesthetic, logical mathematical, and visual-spatial intelligences. This lesson focuses on the sense of hearing. First, an introduction to the main structures of the ear and the ear functions in sending nerve impulses to the auditory centers located in the temporal lobe of the brain. The students should identify the temporal lobe on their clay cerebral cortices and mark it with a tooth pick. The students will then break into small groups in order to play a game that highlights hearing. The students will play a variation of Marco Polo where one individual is blindfolded and has to pinpoint the location of students who will make noises at various locations around the room. Before the game starts, the student will be informed of the various locations that the student making sound can choose to stand at. The students will take turns acting as noise makers and as the person identifying the origin of the sound. After one round is complete, the students will analyze what variables aided in their ability to determine the location of the sound. The students can brainstorm variables that may want to test during another round of Marco Polo. The students should journal concerning the variables they would want to test. The students will then be asked to rate how much time they spend listening to their iPods and how loud they typically have the volume on their iPods as well as other entertainment systems they encounter in their daily life (video games, concerts, car audio systems, etc). The students will then read an article describing noise and hearing loss (see appendix). Students should then consider what changes they can make in their life concerning noise levels and the damage that may have already taken place with the delicate hair cells in their inner ear at the base of the cochlea (Grabowski, 2000).

Lesson 5

This activity is designed for tactile-kinesthetic and logical-mathematical. This lesson focuses on the sense of taste and smell and how these two senses work together to provide taste. Students will take part in an activity, where they are blind folded and they are required to try to determine the mystery substance using their sense of smell. The same event will take place but the focus will be on taste and the students will be

asked to plug their nose as they are sampling some of the mystery substances blindfolded. The students will be asked to compare and contrast how their sense of taste changed when they plugged their nose. They will record their observations and conclusions in their journals. The students will then locate the temporal lobe for smell and the parietal lobe for taste on their clay cerebral cortices and mark each region of the lobe that contains processing centers for these senses. The students should also represent the nose and tongue on their somatosensory cortices.

The students would then be given a case study where a student has a horrible cold with their symptoms being described as being completely congested and being unable to breathe through their nose. The student has lost their appetite because everything is "tasteless." Students should hypothesize as to why the student complains of not being able to taste any of the foods they eat. The answer is that the olfactory receptors located in the nose are not able to be stimulated by the odors of the food in the mouth (Grabowski, 2000). The tongue's receptors located in the taste buds are still intact but are only capable of distinguishing simple chemical forms of taste such as sweet, salty, bitter, and sour (Grabowski, 2000). The nose through olfaction provides the majority of what we taste through the odors of the food in the mouth entering the nasal cavity and stimulating olfactory receptor cells (Grabowski, 2000).

Lesson 6

This activity is designed for visual-spatial intelligence and tactile-kinesthetic intelligences. The closing activity will be to create a jumbo concept map using their clay cerebral cortices. The goal is to have the students recognize the connections between all of the activities and how their five senses activated certain portions of their brain and how the spinal cord acted as a channel to send this sensory information to the brain. The students will analyze how the five senses have allowed for human populations to increase their chances of survival through the adaptation and natural selection to take place in the human population.

Appendix

Implementing District Standards

There are two key standards that will be covered in this exploration of the five senses and the central nervous system.

The New Haven district requires that students are able to answer the question of how science and technology in society affect the quality of life that we currently benefit from. The unit will be infused with images provided from a variety of biotechnological sources that health sciences rely on in their scientific inquiry of maintaining human health. The students will compare the simplistic two-dimensional hand drawn images to the sophisticated three-dimensional computer generated images of human internal anatomy.

The students will be able to come to conclusions as to how technological advances have increased the longevity of human life and in turn increased the size of human populations over the past century. The unit will also have a significant e-learning component that will allow the students to use technology (computer software programs, web sites) that provide the general public and health science careers with a three-dimensional interactive study of anatomy.

The district standard regarding the scientific inquiry will be covered in this unit as the students determine ways in which injury and disease have been and are continually being used in the advancement of medicine. The students will read a few case studies dealing with the injury and disease of various sense organs and record observations, ask questions regarding to the case study. They will then develop a hypothesis as to what anatomy has been damaged and determine how they could possibly develop an experiment to test their hypothesis of what anatomy is damaged.

The other district standard that will be covered concerns the students' ability to describe how natural selection has taken place in increasing an organism's ability to survive in their environment based on the adaptations in their structure and behavior. The students will analyze their five senses and make conclusions as to how the physiology and anatomy of the central nervous system combined with the five senses provides the human species with increased chances of survival.

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Johnson, G., & Raven P. (2004). *Biology* . New York: Holt, Rinehart and Winston. High school level biology textbook with excellent diagrams of neurons along with tactile activities.

Kelves, B. (1997). *Naked to the Bone: Medical Imaging in the Twentieth Century.* New Brunswick, N.J.: Rutgers Univ. Press. Historical review of how medical imaging has transformed the way in which we depict our anatomy in art.

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Student Reading List

Biggs, A., & Hagins, W.C. (2007). *Biology* . New York: Glencoe/McGraw-Hill. High school biology textbook with excellent diagrams of nerve impulse in relation to neuron structure.

Hopson, J. L., & Prostlethwait, J. H. (2006). *Modern Biology* . New York: Holt, Rinehart & Winston. High school biology textbook with colored diagrams of the lobes of the brain and overview of the different types of sensory receptors.

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Kelves, B. (1997). *Naked to the Bone: Medical Imaging in the Twentieth Century.* New Brunswick, N.J.: Rutgers Univ. Press. High-level reading that provides an overview of how art depicting anatomy has advanced with the age of medical imaging.

McCracken, T., & Walker, R. (1999). *The New Atlas of Human Anatomy.* New York: Barnes & Noble Pub. Over-sized book of anatomical diagrams based on the Visible Human Project, anatomy software program also provided.

Web Sites

1. http://www.culture.gouv.fr/culture/arcnat/lascaux/en/index.html. Ancient cave drawings of human form specifically the drawing entitled "the shaft of the dead man."

Gallery of art depicting anatomy historically, look for ancient rock drawing entitled "Aboriginal x-ray style drawing."

2. http://www.pbs.org/wnet/brain/3d/. Interactive three-dimensional brain.

3. http://www.netanatomy.com/. Describes how to study a cross section of a certain piece anatomy and provides images of various human anatomy subgroups.

4. http://www.nlm.nih.gov/research/visible/visible_human.html. Visible Human Project home page provides various anatomical images created from frozen cross sections of human tissue dissections.

5. http://www.visibleproductions.com/home.html. Go to showcase, click on "view rotatables/dissections," click of image of cerebral cortex, students can interact with brain and the lobes and their functions are labeled.

6. http://www.asha.org/public/hearing/disorders/noise.htm. Describes cause of hearing loss, provides links to additional websites.

7. Howard Hughes Medical Inst. (2006). *Seeing, Hearing and Smelling The World.* Retrieved April 9, 2006 from the World Wide Web: http://www.hhmi.org/senses/. Website provides various activities and articles explaining the mechanisms behind our senses.

Classroom Materials

Lesson 1: LCD Projector (optional), Ancient Cave Art Drawings (see art web sites #1, #2) Modern Art Drawings (see art web site #2), Colored Pencils/Markers (optional)

Lesson 2: Modeling Clay or Play Dough (4 different colors, 2 colors with sand added), Sand, Cardboard cut in the size of a sheet of paper, Markers, Glue, Toothpicks, Copies of homunculus cartoons , Tape , Diagram from textbook of somatosensory cortex and lobes of brain , Newspaper, Masking tape

Lesson 3: LCD Projector (optional) , Diagram of Neuron from Biology text book , Markers, Colored Pencils, Scissors, Paper , Tape/Glue , Butcher Paper or Large piece of poster board with the outline of a brain, Blind folds (optional, may have students close their eyes)