

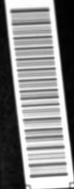
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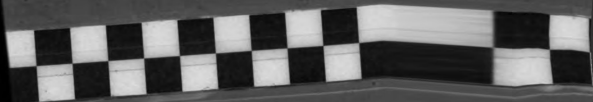
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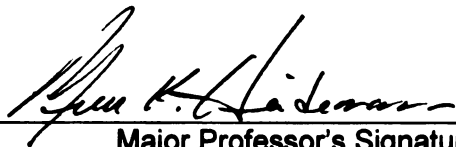
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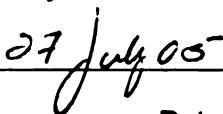
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**NERVES, SENSES, AND YOU: AN ACTIVITY BASED APPROACH TO THE
TEACHING OF SENSES AND THE NERVOUS SYSTEM**

By

Kenneth Carl Keyes

A THESIS

**Submitted to
Michigan State University
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ABSTRACT

NERVES, SENSES, AND YOU: AN ACTIVITY BASED APPROACH TO THE TEACHING OF SENSES AND THE NERVOUS SYSTEM

By

Kenneth Carl Keyes

Nerves, Senses, and You: An Activity Based Approach to the Teaching of Senses and the Nervous System is just what the title says. This thesis is an explanation of a hands-on activity integrated unit for the teaching of senses and the nervous system. The labs are centered around a PowerPoint® notes outline from which students fill in missing information on their outlines. The activities focus students learning of senses and how they provide input for the nervous system. The information students are given related to the nervous system includes; central and peripheral nervous systems, structures of the brain, structures and functions of the nerves and nerve impulses. The senses activities start with reaction verses a reflex, move to the sense of hearing, vision, taste, smell, balance and end with the sense of touch. Connections between the interactions of senses are developed through the laboratory activities. The assessments used consist of a pre and post test, pre and post lab questions, and an open ended individual post lab question. The desired outcomes are that students gain a better understanding of how senses and the nervous system function together. Students are given various types of learning styles to promote understanding of the information. These styles include; inquiry learning, cooperative activities, individual learning, and hands-on activities.

To my wife, Julia, for always believing I could accomplish this

To my children, Andrew and Amelia who are my inspiration

To my students past, present, and future

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INTRODUCTION:

Stimulus-Response that is the most basic function of the human nervous system, whether the stimulus comes from the autonomic nervous system, central nervous system, or peripheral nervous system. Given enough stimuli a response will occur and an action will be taken. Herein lays the problem I had with the nervous system unit of the Advanced Biology class at Webberville High School. Advanced Biology at Webberville High School is an Anatomy and Physiology class that uses hands-on activities and labs for most systems taught which meets the goals and objectives, but the Nervous System was a “book and paper” unit with a couple of labs and no additional hands on activities. The Nervous System relies on the senses for information. Therefore by adding activities with senses it was my goal to have better student involvement. I also expected a greater understanding of information and an improvement on assessments. There were two guiding principles for this unit as developed. First, the fundamental senses are very important in everything we do. Students need to understand that the decisions they make today will affect their senses now and in the future. Good choices in life will retain proper function of senses in the future. Second, students need to have a general knowledge about their own bodies and how they function. The students are learning about their own bodies and need to be engaged with the learning process. These are the reasons why I chose to redesign the unit as the topic for my M.S. degree project for Interdisciplinary Biological Science at Michigan State University. This unit connects well with the research performed at Michigan State University because

I was able to talk with professors, do internet searches, and develop lab activities and hands-on activities. All of this research I expected would better the unit for instruction of the Nervous System Unit at Webberville High School.

Teaching Considerations:

The first question I had to face was why should the nervous system and senses be taught? One answer came from an article by William Cameron and Eric Chulder (2003). They stated it is likely that most people will be affected directly or indirectly by a neurological disorder. For example, a young person may have a grandparent with Alzheimer's or Parkinson's disease. Many students have been diagnosed with learning disabilities, such as dyslexia or attention-deficit/hyperactivity disorder. A good working knowledge of the structure and function of the nervous system should help individuals to better understand and manage these disorders. That provided me sufficient rationale to improve the teaching of the nervous system unit. Why should I include the senses into the teaching of the nervous system unit? Kids each day have experiences using their senses and nervous system, but how do they perceive these experiences? Dr. Ingrid Waldron (2003) explained it as follows. "We enjoy the flavors of food we eat, and we identify the things we see easily, without even thinking about how we do it. But scientists have discovered that these sensory processes are amazingly complex and sophisticated." Because senses are complex and are the way the nervous system receives its information it is important to incorporate them into the teaching of this physiological system. There are two relevant state benchmarks that also indicate the need to teach the

senses and the nervous system. First, students will compare and contrast ways in which selected cells are specialized to carry out particular life functions. Specifically, students need to compare and contrast cells with different functions and determine how cells are specialized to perform specific tasks by relating cell structure to cell function. Second, students will describe technology used in the prevention, diagnosis, and treatment of diseases and explain its function in terms of human body processes.

The next question is: how best to teach this information. The main theories of learning are; Behaviorism, Constructivism, Cooperative Learning, and Individual Learning. In the end I decided to use a blend of them for this unit. The basic idea of behaviorism is that students learn as a result of a response that follows a specific stimulus. This idea fits very well in the teaching of the nervous system, because that reflects the nervous system itself. From behaviorism I moved on to constructivism. According to Ishii (2003), "The main tenet of constructivism learning is that people construct their own understanding of the world. And in turn their own knowledge." I used the ideas by Bruner, which are not new, as a starting point for using this learning theory. Bruner (1966) recommends four major aspects needed for instruction. They are; 1. a predisposition toward learning, 2. the body of knowledge must be structured so it is readily grasped by the learner, 3. present material in the most effective sequences, and 4. the pacing and nature of rewards and punishments. He also suggests that good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of

information. I then found specific ideas for the use of constructivism and a branch of it, conceptual change, in the classroom. Brooks and Brooks (1999) provide many guiding principles of constructivism that can be applied to the classroom, and I choose this one. "Another guiding principle is structuring learning around primary concepts. This refers to building lessons around main ideas or concepts, instead of exposing students to segmented and disjoint topics that may or may not relate to each other." Earnest (1996), suggests, "Use of multiple representations. In science and especially mathematics, multiple representations offer more avenues with which to connect to students' previous conceptions." The term "previous conceptions" is referencing the idea of conceptual change. Vasniadou (2002) suggests conceptual change as a process that enables students to synthesize models in their minds, beginning with their existing explanatory frameworks. This is thought to be a gradual process that can result in a progression of mental models. From the constructivist and conceptual change learning theories I built the unit incorporating many representations and constructing the unit with senses to provide the laboratory activities.

One of the key concepts in education today is the use of small groups, also known as collaborative learning or cooperative learning. Foote (1997) defines collaborative learning as the instructional use of small groups. The goal of these groups is to allow students to work together to maximize their own and others' learning. Cooke (1994) proposes another aspect of collaborative learning. Collaborative learning allows students and faculty to share the

responsibility for learning process. It also helps prepare students for workplaces that increasingly value self-motivated, self-confident, team-oriented employees. Nath (1996) indicates implemented correctly, cooperative learning results in many benefits to students, including increased academic achievement, greater self-esteem, and a greater acceptance of other students. She further states, group members can provide assistance to one another in a non-threatening environment, thereby encouraging other members to discuss the matter being studied. Based on the information from cooperative/collaborative learning, I developed laboratory activities for groups of two and the entire class.

Another buzzword in education is hands-on-learning. This is a very old idea as indicated by the Chinese proverb: I hear and I forget, I see and I remember, I do and I understand. Rutherford (1993, p 5) describes his view of hands-on science, "Hands-on quite literally means having students 'manipulate' the things they are studying- plants, rocks, insects, water, magnetic fields- and 'handle' scientific instruments – rulers, balances, test tubes, thermometers, microscopes, telescopes, cameras, meters, calculators. In a more general sense, it seems to mean learning by experience." He further states, "Hands-on and learning by experience are powerful ideas, and we know that engaging students actively and thoughtfully in their studies pays off in better learning." Another case for hands-on learning can be found in Penick and Yager (1993 p5) "There seems to be some evidence from exemplary programs that even poorly taught hands-on science is more interesting to students than the typical textbook based program." Hands-on science can be summarized by a quote from Haury

and Rillero (1994), "Students in a hands-on science program will remember the materials better, feel a sense of accomplishment when the task is completed, and be able to transfer that experience easier to other learning situations." I included a hands-on aspect to all of the laboratory activities.

In addition to incorporating hands-on learning, I wanted students to have inquiry learning about which Haury (1993) says: "A focus on inquiry always involves collection and interpretation of information in response to wondering and exploring." I added inquiry questions into the laboratory summary sections to have students move past the recall and repeat answers many cook book lab activities use to teach students.

I also incorporated a teaching method called the learning cycle approach. Abraham (1997) suggests that, "Instructional strategies utilized to teach science concepts are most effective when they consist of activities which serve three functions: (1) to introduce the concept, (2) to discuss the concept, and (3) to apply the concept. The learning cycle approach is an effective instructional strategy because it consists of activities focused on these functions, and uses laboratory activities to introduce rather than to verify concepts." Based on this concept I developed a demonstration using sound to introduce the sense of hearing.

The last strategy used in teaching this unit came from Wiggins and McTighe (1998) who suggest, "Require the students to answer the question, what of it? Many dictionaries offer as a core meaning of the word "understand" 'to know the importance or significance of something.' To grasp the importance of

an idea is key to understanding. Yet we rarely encourage students to step back and ask, of what value is this knowledge? How important is this idea? What does this idea enable us to do that is important?" This information fit with the guiding principle dealing with students making choices based on the knowledge they gain from studying senses and the nervous system. I had students answer the question "what did you learn from this lab" based on this idea.

Now that I had a framework for teaching the unit I needed some specific ways to present the information, particularly utilizing technology. In an article written by Steven Koenig (1997) Dr. Seymour Papert states, "The best teacher is someone who brings personal knowledge, warmth and empathy to a relationship with a learner. The effect of the new technologies is to provide better conditions for such teachers to work directly with their students." A specific teaching strategy from Park (1995) was: "Learners can be prompted by software to take notes or use the note taking capability of the built in word processor of the software. The software could provide the learner with an outline." From these ideas I developed a PowerPoint® note outline in which an outline was available for students to put on their palm pilots and type in the rest of the information.

The Senses

When considering the senses of taste and smell, research indicates that they are linked to memory (Hopkins, 2004).

"It's a familiar phenomenon: a single smell or sound has the power to conjure up entire scenes from the past. Now a British-led group of neuroscientists has come up with an explanation. The key, the researchers claim, is that memories relating to an event are scattered across the brain's sensory centers but marshaled by a region called the hippocampus. If one of the senses is stimulated to evoke a memory, other

memories featuring other senses are also triggered. Odor memory seems to be the most resistant to forgetting."

With this rationale I developed labs for taste and smell and had students for the smell lab write down what they thought about after detecting common odors. The next sense I wanted to cover was that of vision, in particular color vision and how it functions along with the problems colorblind individuals face. Waggoner (2003) indicates that being colorblind has a profound effect on a child's ability to participate in our educational system. Children not only have to learn their colors at an early age, but many color-enhanced instructional materials are used in teaching. It is important for teachers and parents understand the special needs of color deficient children, and what can be done to help them in their quest to learn. Further in the article Dr. Waggoner gives examples and explains the problems students who are colorblind have in specific detail.

The next sense I incorporated into this unit was hearing. Students constantly listen to music with high volumes. They need to understand how sound is perceived. Wood (2001) sums up a common sense concept of hearing by saying; hearing involves not only identifying the nature of a sound, but also pinpointing the location of its source. Therefore, an activity in one of the labs had students using their sense of hearing to determine the location of sounds, first using both ears and then only one.

The sensation of taste is closely related to smell and vision. Howard Hughes Medical Institute had two articles of importance related to this sense, Zuker (2000), in which Nicholas Ryba of NIDCR indicates that we now have the

means to really start to investigate how taste works, not just in the tongue, but also in the brain. Buck and Margolskee (2001) state: taste receptors are proteins located in the surface of taste bud cells which bind to specific chemicals. When the appropriate chemical activates a taste receptor, it causes a surge of molecular events that culminates in the brain's perception of taste information. From this research it was important that I incorporate the sense of taste into the unit on the nervous system.

Finally, in the article found on the *Science a GoGo* web page, (http://www.scienceagogo.com/news/20030212753data_trunc_sys.shtml), entitled "Grabbable Objects Grab Attention" it states, "Objects we typically associate with grasping automatically attract our visual attention, especially if these items are on a person's right-hand side. In the brain, there are two primary visual pathways, one for identifying objects (perception) and one to guide your arms and legs based on what you see (action)."

Lastly, a new way to assess student learning was incorporated into the unit. Sundberg (2002) states, "The only way an instructor can evaluate the effectiveness of an innovation on improving student learning is to plan and carry out a program of assessment." This is the reason I choose to administer a pretest and posttest to the students. It is also why each laboratory activity had a similar question at the end asking students what they learned from doing the activity. This question was individualized so each student wrote their own answer instead of having a group answer for this question. Now that the

answers of why, how, what, and how to assess have been answered, it is important to know something about the school and the class.

The Class Demographics

Webberville High School is part of the 7-12 building which currently houses 215 freshmen through seniors and 112 middle school students. The school is located approximately 15 miles east of East Lansing on Grand River Avenue. The class in which this unit was incorporated was Anatomy and Physiology. The class consisted of ten students (see Figure 1), five males and five females who were juniors or senior and have taken Biology and Chemistry, passing each with at least a seventy percent with departmental approval to take the class. Fig. 1 Class Photograph



The class picture is figure one. All students and parents signed the consent form (Appendix W) for the student data and photographs to be used in this thesis. Typically, there are approximately thirty students in Anatomy and Physiology, but because of scheduling conflicts and a new every other day eight block class schedule there were only the ten.

This unit is the second unit taught in the Anatomy and Physiology curriculum. It follows the introduction to the human body unit, which teaches terminology and the basic function of each of the eleven systems of the human body. It is taught second because the nervous system controls many of the

body's systems and their functions. The units which follow the nervous system are in order: skeletal, muscular, integumentary, digestion and nutrition, circulatory, respiratory, and endocrine and reproductive systems. The expected outcome for this unit is that students will understand how the nervous system functions through the inputs of the senses.

The basic concepts students were to master are the two basic divisions of the nervous system and how they are protected. The structures and functions of neurons and nerve impulses were the second group of concepts I wanted my students to understand. The next overall topic was a discussion of the details of the central and peripheral nervous systems. Students were expected to make the connection between the two systems and evaluate how the brain interprets stimuli from the peripheral nervous system and senses. This was followed by a study of the specific senses (see details in appendices E through P).

IMPLEMENTATION:

Nerves, Senses, and You: an Activity Based Approach to the Teaching of the Nervous System and Senses was designed to fit into fifteen 100 minute class periods. This should require six weeks, but due to the schedule at Webberville High School the unit in reality took seven weeks to accomplish because of days off and missed class periods. At Webberville High School classes meet Monday, Wednesday, and Friday one week and then Tuesday and Thursday the following week. The sequence of events for each day taught of the unit is shown in figure 2, which is based on detailed daily lesson plans in Appendix A.

Day Zero Pre-Test	Day One of the Week	Day Two of the Week	Day Three of the Week	Day Four of the Week	Day Five of the Week
Week One	Introduction to Nervous System	No Class	Notes & Lab on Reflex vs. Reaction	No Class	Notes & Lab Chemical Senses
Week Two	No Class	Labs on Chemical Senses (Taste)	No Class	Finish Labs Chemical Senses & Do Lab Reports	No Class
Week Three	Lab on Tasting Color Notes on Vision	No Class	Collect Lab. Notes on Structures of the Eye	No Class	Lab Activity on Vision Discuss Results
Week Four	No Class	Labs 2 & 3 on Vision Do and Discuss	No Class	Notes on Hearing Lab Demo and Lab	No Class
Week Five	Lab on Hearing Notes on Balance	No Class	Lab on Balance Notes: Sense of Touch	No Class	Lab Sense of Touch Collect All Lab Reports
Week Six	No Class	Review Information Nervous System & Senses	No Class	Post-Unit Evaluation Nervous System & Senses	No Class

Fig. 2 Basic Schedule of Unit

The day before the unit was started the students took the pre-test evaluation on the nervous system and senses to get a baseline of their knowledge for later analysis. All activities in Figure 2 that are bold and in italic are new to the unit. Basic concepts and terminology are introduced with PowerPoint® notes with the students having a 'skeletal' outline to fill in from it. The full version of the master copy of the notes is Appendix B, the student skeleton notes are Appendix C, and the full version of the PowerPoint® presentation is Appendix D. The laboratory activities corresponded to the notes and were performed at various stages of the unit. The full versions of all the labs are Appendices E through P.

In order to start the classes with student focusing on the topic or concept of the day I used scrolling power point slides with an introduction activity listed and what the class was going to accomplish that day or even that week. Examples of these are Appendix Q. The only material that was carried over from the previously taught unit was the use of review materials and some of the basic notes. The idea for the first lab, *Reflexes, Reaction, and Distraction*, came from the textbook we use, *Biology: the Dynamics of Life* (2004).



Fig. 3 Students Doing Reactions Lab

This lab is Appendix E and seen in figure 3. A student dropped a meter stick and another student determines reaction time based on the distance the meter stick

dropped. Next, the student was to count backwards from one hundred by fives with the lab partner dropping the meter stick without letting the student being tested know when this was going to happen. Variations and additions provided students with experiences related to reflexes and reactions. Students were asked to explain their results.

The lab activity *Can You Smell It?* (Appendix F) was developed from two sources; first, Neuroscience References for Kids online (<http://faculty.washington.edu/chudler/neurok.html>) and the second was Carolina Biological Supply Human Senses BioKit. Some people cannot detect odors at low concentrations, but the threshold for others is at much lower concentrations.

Students were to work in groups of two; one would randomly choose one of seven containers each having various concentrations of cologne per half liter of water. The blindfolded person was to indicate if they could



detect the odor when the tester wafted the odor once toward them as seen in figure 4. The tester would then repeat the process until all seven containers were used. The roles were reversed. The second part of this lab explored odor fatigue. A cotton swab with clove oil was placed under the student being tested and they were to inhale through the nose and out through the mouth until they experience odor fatigue and cannot detect the clove oil odor. At that point the second cotton swab with peppermint oil was

to be placed under their nose to determine if they could detect the peppermint oil. I also developed several containers with common odors in them. The examples were popcorn, Vic's vaporub, pizza sauce, apple extract, banana, vanilla, anis oil, peppermint oil, grape extract, and strawberry extract. Students were to take a container, close their eyes, remove the lid, and waft the odor toward their nose. They were to indicate what the odor was and then describe the first thought they had when smelling the odor.

Variations of the third lab can be found in almost every anatomy and physiology lab book. In *Can You Taste It?* (Appendix G) students evaluate their acuteness of taste by locating the four taste regions on the tongue, identifying their "sweet taste" threshold, and by determining if taste is related to vision and odor. The subject would stick out their tongue, closing their eyes and nose while the tester would "paint" their tongue with one of the four basic tastes which can be seen in figure 5. Secondly, section students used a



Fig. 5 *Can You Taste It "Bitter"*

stock sugar solution and diluted it to make the following test solutions; 20%, 10%, 5%, 2.5%, 1.25%, and 0%. The subject faced the tester with eyes closed and tongue out, while the tester randomly choose one of the solutions and painted the area of the subjects tongue they tasted sweet from the first part of the lab. The subject would indicate if they could or could not detect the sweet taste, then eat a low sodium saltine

cracker. This can be seen in figure 6. The last section of this lab had student examine the connections between taste, vision, smell and texture of food.

The students used small pieces of apple, carrot, kiwi, and onion on toothpicks. The tester then placed one of the four objects on the subjects



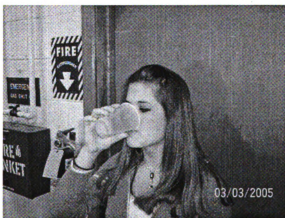
tongue for just a couple seconds and the subject would have to identify which one of the four foods was placed on their tongue.

Fig. 6 Can You Taste It Threshold

The next lab also addressed taste, but this time students saw what they tasted. *Tasting Color?* (Appendix H) was developed from neuroscience for kids (<http://faculty.washington.edu/chudler/neurok.html>) and a lab that Dr. Merle Heidemann uses. Students taste various types of soda pop with one simply

being colored soda water with sugar added. The other flavors I used were red pop, grape, lemon lime, orange.

The students tasted each sample and identified the flavor of each as seen in figure 7. In between each trial they



ate a quarter of a low sodium saltine,

Fig. 7 Tasting Color "Soda Pops"

which removed any residual flavor of the previous soda pop.

Students obtained three different half pieces of Fruit Stripe® gum. The subject closed their eyes and plugged their nose while the lab partner placed one of the half pieces of gum on their tongue as seen in figure 8. The subject was to chew the gum and identify the color of the gum using the sense of taste. The lab partner then recorded their observations along



Fig. 8 Tasting Color "Fruit Stripe Gum"

with the correct answer in the data table. The steps were repeated until all three flavors of gum were identified and the students reversed roles.

The fifth lab is called *How Well Do You See?* (Appendix I). Students placed a Snellen® eye chart at eye level on the wall and measured back twenty feet. They performed the basic eye tests with each eye. In the second section of this lab students performed a typical astigmatism test by looking at an astigmatism chart and comparing the intensity of blackness of the lines on the chart.

The next vision lab, *Seeing Close-Up* (Appendix J) was based on the Carolina Biological Supply Company, Human Senses BioKit. The activity introduces students to the optic nerve connection



Fig. 9 Seeing Close-Up "Blind Spot"

in the retina. In the first section of the lab students obtained a blind spot card and determined their blind spot as seen in figure 9. In the second portion of the lab students determined their near-point, to learn how close something can be to their eye and remain in focus. This lab was performed without students knowing about focal points or the optic nerve connection in the retina.

The sixth lab *Rods and Cones* (Appendix K) was designed to have students learn the functions and differences between the rods and cones in the human eye. In the first part of this lab students took copies of colorblind charts, looked at them, and wrote down the numbers they saw in the chart.



Fig. 10 *Rods and Cones* "Colorblindness"

One part of this lab was the result of watching ZOOM with my five year old. On the show the kids performed the lab which allowed them to determine their own location of motion, shape, and color vision. In the second section of the lab students made a semicircle on the floor with a meter long section of string and a protractor. The subject of the lab stood on the zero degree mark facing forward. The lab partner started on the left side of the circle holding a small colored shape at eye

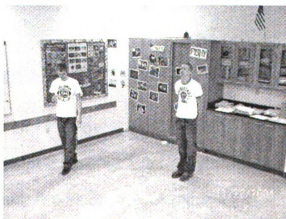


Fig. 11 *Rods and Cones* "M, S, C"

level and walked slowly around the semicircle. The subject was to indicate when they saw the motion, shape and color of the object. This can be seen in figure 11.

The next three activities related to the sense of hearing. The first activity is called, *Do Your Pennies Ring?* (Appendix L). It was a lab demonstration from Neuroscience Resources for Kids (<http://faculty.washington.edu/chudler/neurok.html>). Students listened to the sound pennies made when dropped on the lab table. Students used the data to determine the year the United States changed from solid copper pennies to pennies filled with zinc. This demonstration worked very well in introducing the concepts of hearing to the students.

The next activity, *Tuning In?* is a lab modified from Human Anatomy and Physiology Laboratory Manual by John W. Hole Jr. addressed types of inner ear deafness (Appendix M). Students activated a tuning fork and placed it on the top of their skull to hear the difference between bone and air transmission of sound. This is seen in figure 12.



Fig. 12 *Tuning In* "Introduction"

They also performed the Webber test by placing the base of an activated tuning fork in the center of their forehead. Students determined if the volume of the ringing tuning fork was the same in both ears as seen in figure 13.

Thirdly, the students performed the Rinne Test. The tester activated the tuning fork and placed the base on the mastoid process of the subject. The subject indicated when they no longer heard any sound and the tester moved the tuning fork seven to fifteen centimeters away from the outer ear.



The subject then indicated if they could detect the sound again. The process was reversed.

Fig. 13 *Tuning In* "Webber Test"

The last activity for hearing, *Can You Hear It?* was modified from a group of activities located on the Neuroscience Resources for Kids webpage (<http://faculty.washington.edu/chudler/neurok.html>) and activities performed in many laboratory books for Anatomy and Physiology (Appendix N). First, students determined the auditory acuity of the lab partners. Second, the ability of the subject to determine the distance a sound was produced was determined. The last section reinforced to students the need for two ears to determine the location from which sound is generated.

The next lab, *Balancing Act* was modified from Anatomy and Physiology Laboratory Manual by Jay M. Templin, it showed how a body determines its position based on muscle tension, examine the various ways a body balances, and compare dynamic and static equilibrium (Appendix O). In the first section of the lab students stood perfectly still for one minute, using legs, then one leg, and then the other. In the second section students performed proprioception tests.

In the last section of the lab students performed rotation tests. The subject sat cross-legged with their eyes open while the tester rotated the chair one revolution per second for ten seconds making sure the subject stopped at the same point they started. This lab helped students the concepts of balance and equilibrium based on the results they obtained.



Fig. 14 Balancing Act

The last lab performed *Can You Feel It?* (Appendix P) has three activities; the third can be found in most any lab book in print. The first two sections were modified from Neuroscience Resources for Kids webpage located at (<http://faculty.washington.edu/chudler/neurok.html>). The purpose of this lab was for students to evaluate comparative degrees of sensitivity on the skins surface and determine tactile detection threshold. In the first section, students had a blindfold placed on them then using only the sense of touch placed sets of sand paper in order of roughness. In the second section of the lab student used "Von Frey Hairs" to determine the threshold detection of skin receptors.



Fig. 15 Can You Feel It lab

An important assessment tool I gave for this unit was the summary questions at the end of each laboratory activity. These were posed to ensure that students were fully engaged in the activity. Most of the laboratory activities also had pre-lab questions to assess the level of knowledge the students gained from lecture and class discussion dealing with the topic of the lab. At the end of each laboratory activity there was an open ended question which basically said: "Describe and explain what you learned by doing this laboratory activity." I did administer a pre and post test evaluation of relevant knowledge (Appendix R). Also incorporated into this unit was a survey for students to indicate what they enjoyed and if the activities were helpful in learning and understanding the relevant concepts. A copy of the student activity survey is Appendix S.

RESULTS/EVALUATION

Pre/Post Test Comparison

The pre-test was the same instrument as the post test with a total of ten questions. The rubric used for scoring was a four point scale. Students earned a four if they used the correct terminology while demonstrating a full understanding of the relevant science. Three points were awarded to students who either used correct terminology or their understanding of the science was clear. Students earned two points if they had some basic understanding of the concept, but did not provide evidence of scientific understanding or used the terminology incorrectly. One point was awarded to students who had a rough idea of what the question was asking, but had no correct terminology or scientific understanding. No points were given for providing not answer, or for restating the question, or had no idea what they were writing about. The class average on the pre-test evaluation was 5.1 out of a possible 40 points, while the post-test evaluation average was 35.2 out of the same possible 40 points. This corresponds to an average before the unit of 12.75%, while the average after the unit 88%. This was a 75.25% increase in the average score for the class. An analysis of how each student performed on the pretest and posttest is Appendix S. A graph for a side by side comparison for each question for every student is Appendix T. The scores for each student for the pre and post test evaluation are located on the next page as shown in figure 16.

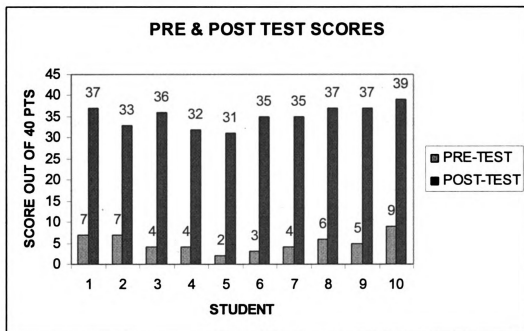


Fig. 16 Pre and Post Test Scores of Each Student

The paired t-Test results of this data have $t=-48.3$ with 9 degrees of freedom.

The probability of this result, assuming the null hypothesis, is 0.00. A complete breakdown of the data from the paired t-Test is in Table 1.

$t = -48.3$ Degrees of Freedom = 9	Group A Data (Pre-Test Scores)	Group B Data (Post-Test Scores)
# of Items	10	10
Mean	5.10	35.2
95% Confidence interval for Mean:	3.575 – 6.625	33.39 – 37.01
Standard Deviation	2.13	2.53
Hi Score	9	39
Low Score	2	31
Median	4.50	35.5
Average Absolute Deviation from Median	1.70	2.00

Table 1 Paired t-Test Results

It is obvious there was vast improvement in the scores of students between the pretest and the posttest. Because this class was half males and half females, I wanted to see if there was any difference in gender for the average of pretest and posttest scores. The following graph indicates the gender results between the pretest and posttest.

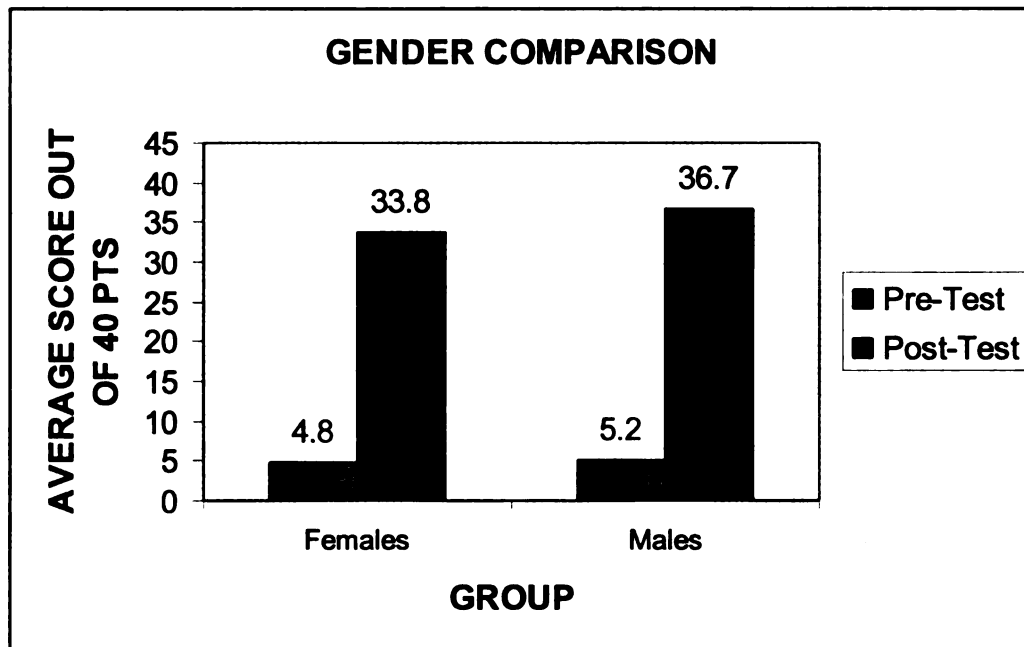


Fig. 17 Gender Comparison of Pre and Post Test

A quick analysis of the results of the difference in the average scores on the pretest and posttest based on gender shows that both groups knew approximately the same amount prior to the unit. The difference in average score on the post test is only 2.5 points greater for the males over the females and is not a great enough difference to indicate more learning by either group.

The results from individual questions were also analyzed. To determine whether the lab activities performed taught the students the desired outcomes. An analysis is shown in figure 18 on the next page.

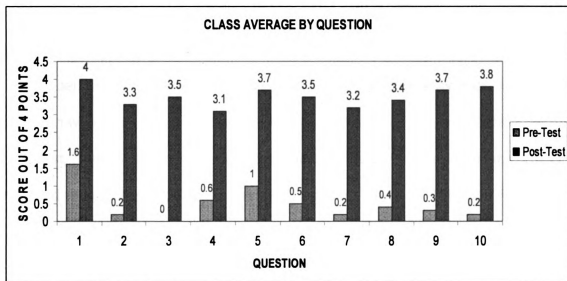


Fig. 18 Class Average by Question of Pre and Post Test

To interpret this data, it is important to know the main topic of each question.

Question one focused on the differences between a reflex and a reaction. The

second question was about how the brain interprets stimuli and perceives touch.

Question three connected the sense of smell and other sensory fatigue concepts,

such as hearing and touch. The connection between sense of taste, sense of

smell and vision was the main idea for question four. The specifics for color

vision were the focus of question five. Question six was on the concepts and

aspect of balance. The seventh question targeted structures and functions of the

cerebrum and how they are related to senses. The connection between

structure, function, and damage to the nerves was the focus of question eight.

Question nine addressed a specific response type of the nervous system, the

fight or flight response. Finally, question ten asked students to make a

connection between the senses of touch, pressure, and pain and how they are

interpreted in the brain. The assessment made from these graphs by question

was a great deal of learning occurred for each student. Each of the questions on the pre and post test corresponded to activities students performed in the unit. See Appendices E through P. The raw data shows students' average score by question went from .5 out of 4 points on the pre test to 3.52 out of 4 points on the post test. This indicates students accomplished the desired outcome and reached the goals set forth from the unit. See figure 18 and Appendix T.

The Survey of Student Attitudes

The student survey was evaluated based on the following rubric: 1; activity helped and was enjoyable, 2; activity helped, but was not enjoyable, 3; activity did not help, but was enjoyable, and 4; activity did not help and was not enjoyable. The average score for each activity is shown in figure 19. The answer for each activity by individual students is Appendix V.

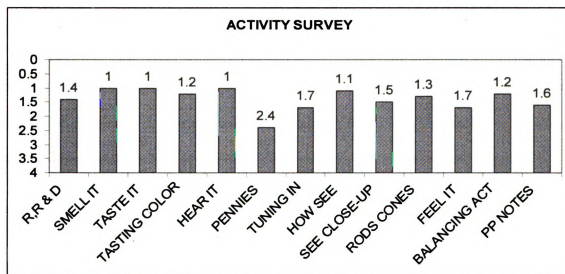


Fig. 19 Activity Survey Averages

The average score for each activity indicated that students thought that each activity, except ringing pennies, was helpful in understanding the topics and concepts. Also, the average indicates students basically enjoyed these activities.

Lab Assessment

Other subjective assessments used in this unit were located at the end of lab activities. These questions all had a similar theme: "Describe and explain what you learned by doing this lab about the concept presented in the lab." These open ended questions were scored on a credit, no credit basis. The students were asked answer the question honestly about what they had learned in order to receive credit.

From *Reflexes, Reaction and Distraction* lab students' general answer was that reactions increase with practice, but decrease from distractions. One student wrote, "I learned that it is difficult for your brain to multitask. If there are distractions you can't focus as well as usual." The results of the open ended question on the *Can You Smell It* lab had the same basic answer on how the class learned the connection between odor and memory. "I learned that your nose is really sensitive" was the comment by one student as a result of the fatigue section of the lab. The class explained from the lab *Can You Taste It*, that taste is related to vision, odor and for some, texture. The student's comment that summarizes the rest of the class' responses is, "I learned that you can tell the kind of taste by the area of your mouth and texture. This was an interesting lab". The next lab, *Tasting Color* had a summary similar to the previous taste lab, which was taste can also be dependent on vision. One student wrote, "Taste is related to sight, if you see something that looks good it will probably taste good". This was a great transition to the next lab for students, *How Well Do You See*. Student's descriptions and explanations, for the vision labs, *Seeing Close-*

Up and Rods and Cones, can be summarized by this comment from a student. "I learned that my sight isn't that bad, one eye can be bad, but both eyes can be good together." The results from the hearing labs, *Tuning In* and *Can You Hear It*, all stated that hearing is better with the use of two ears for location and quality. One student simply wrote, "I learned that when you cover one ear you really can't tell where sound comes from." Students explained, from the lab on balance, *Balancing Act*, there are many different types of equilibrium and it is important to have good equilibrium. The other common quote was, "having your eyes open makes balance, much easier because you can focus on an object for a reference." For the last lab activity on the sense of touch, *Can You Feel It*, students found it interesting how the skin has different densities of touch receptors depending on the location. One student stated, "It was cool how student X could not detect two points on the back of his arm until they were 10 centimeters apart, but on the back of their neck they could detect two at 1.1 centimeters." For each lab there were specific questions to ensure students understanding of information. The students performed very well on these questions making connections between notes, reading, class discussions and the hands-on activities. I will end the results section with a quote from a student who showed the biggest improvement on their post test. "I thought it was fun doing these activities, I learned a lot of things I did not know about my senses."

DISCUSSION / CONCLUSION

The data for this study indicated that the unit was a success in student comprehension of the senses and nervous system information (See figures 16, 18, Table 1, and Appendices S and T). The data also implicated the unit did help with the problems of how this unit was previously taught. This is evident based on the scores for the posttest evaluation being much greater than those on the pretest. The unit was also successful in reaching the original goal, because students were involved with the learning process. The average score based on the activity survey was greater than 2 for each activity save one. That would indicate students enjoyed doing the activities and therefore learned more because it was meaningful to them.

The PowerPoint® notes worked well as an integration of technology. Students did not just simply listen to a lecture, they looked at the PowerPoint®, listened to me explain details and either wrote in the missing information or typed it using a palm® pilot (See figure 19). The lab activities as a whole succeeded because they were hands-on, students centered, interesting, and well organized. Specific examples of labs in which each of the activities worked well follow.

Reflex, Reaction, and Distraction worked well because students were able to design the last variable to be tested. They were able to choose the distracting activity. It also worked well because the desired objective was met by the students. This activity was very effective in allowing the students to explain the differences between a reflex and a reaction. Another lab that worked well by

students reaching the objectives was *Tuning In*. Students were put at ease to learn once they saw each other with tuning forks on their heads. They were able to focus on the types of deafness and their causes. This lab was also effective in teaching students the different ways inner ear deafness can be determined.

Another activity that worked entirely was the *How Well Do You See* lab.

Students were able to act in a different role as an eye doctor and check their lab partner's vision. This lab was very effective in showing students what it means to have 20/20 vision. Before performing this lab only one student understood that concept. The lab also functioned well in teaching students what can go wrong with vision if you have astigmatism. Again this had personal interest to students because it was their eyesight. They learned what vision testing numbers mean and meet the objectives set forth for the lab. *Seeing Close-Up* was also a successful activity in that students were able to learn about the optic nerve connection before being taught the specific details. They were also able to learn about near point discrimination. *Can You Feel It* allowed students to learn the densities of touch receptors is not the same for every section of the body. This was a discovery or inquiry lab activity because students were not given a great deal of information about touch before the lab, and the students reached the desired objective. The lab on balance called *Balancing Act* was also beneficial for the students' understanding of senses and the nervous system. They were able to observe all that is required for proper balance and how it was related to senses and the nervous system. By far the biggest success of a lab activity as a whole was the *Rods and Cones* lab. Students learned what colorblindness is

and how it affects one of their own in the class. They were able to also identify the general location of rods and cones by performing one of the activities. The last reason it was a big success was because of how much the students enjoyed doing this lab.

The labs that did not totally work did so for many reasons. The first lab in which one of the activities did not reach the desired outcome was the *Can You Smell It* lab. The students did not take enough time in doing the olfactory fatigue section and the results reflected this. As a whole the lab worked well in demonstrating to students the concepts of olfactory threshold and fatigue as well as how memories are linked to odors. In the future for this lab I will have students take more time on this section and focus their attention on another activity so they do not realize the amount of time needed to reach olfactory fatigue. The rest of that lab worked very well with students understanding how odor is so closely linked to memory. *Can You Taste It* was the next lab in which a section of it did not reach the desired outcome. This resulted from the kiwi being too ripe and the onion being too strong. Overall this lab helped the students understand the sense of taste and how it could detect where they would taste certain foods and how other senses are related to taste. It was also successful in that students were able to measure their threshold of sweetness and make comparisons with other students. Another taste lab that did not reach the desired outcome was *Tasting Color*. This was because I used soda water instead of seltzer water. Students were able to tell that something was different about the second orange soda pop. This lab reinforced to students how taste is

related to other senses such as vision. It also showed them that taste is perceived in the brain and not directly in the taste buds. In the future I will use seltzer water and food coloring for the 'fake' soda pop. The rest of the lab worked well because students were not able to determine the color of the gum being chewed with only the flavor. This section worked well in showing students how color can fool the sense of taste. The hearing labs also had problems. In the *Can You Hear It* lab, I used a clock that was too loud and students were not able to complete a portion of the lab. The rest of the lab was great in that students were able to determine the location of a sound generated using both ears. Once students only used one ear or the sound came from directly in front or behind them they were not able to determine where the sound was generated. This lab worked well in showing students how two ears are required for hearing and how hearing functions. In the future I will use a much quieter watch or clock for the first section of this lab. The activity that I determined to work well, but was not rated highly by student was the demo, *Do Your Pennies Ring*. This simply was a demonstration and students were not part of it. It did work in introducing students to the sense of hearing, but in the future I will divide up the pennies and have them perform the lab with a final combination of results for the entire class.

As a summative activity for the year in Anatomy and Physiology students attended Cedar Point®. This activity reinforced all most all of the units taught. One section of the activity had students performing various activities related to the senses and nervous system. Students were asked to ride Disaster Transport and describe how the ride was affecting their senses and nervous system.

Students also had to describe tastes based on the common four tastes they learned about in the unit. The last activity at Cedar Point related to the unit had students explain in detail how their senses and nervous system was affected throughout the day in relationship to odors, tastes, and balance.

In my opinion the entire unit was very successful, students were involved, interested and learned a great deal more than I expected. This is evident from the following quote made by a graduating senior at the end of the school year when discussing the unit. "I thought that this part of the class was helpful and I think I learned more in this than anything else."

When I have the opportunity to teach anatomy and physiology again I will be using this unit to instruct students in the senses and nervous system. I know that in the future the class sizes will increase and this unit will be easily scaled up to meet the needs of a larger class. I also plan to use similar data analysis from the pre and post test for the class to check and make sure students have learned as well as using pre and post tests for other units. I will also be looking at the data generated to check for any anomalies from this class because there were only ten students for analysis.

APPENDICES

APENDIX A

DAILY LESSON PLANS

DAILY LESSON PLANS

DAY ONE:

OBJECTIVE: The learner will explain the two basic divisions of the nervous system and the structures that protect the nervous system.

INTRODUCTION: Read the book section on introduction to the nervous system.

INSTRUCTION:

- Group Activity- What do you know about the nervous system? Brain Storm and Report (No Books)
- Outline Notes (Power Point®)
 - Nervous System Structures & Divisions
 - Protective Structures
- Re-Group as class and discuss Schedule for rest of unit

HOMEWORK: Book Page 950 #1-4

DAY TWO:

OBJECTIVE: The learner will explain the differences between a reflex and a reaction.

INTRODUCTION: Check & Collect Homework, Read Lab & Do Pre-Lab

INSTRUCTION:

- Outline Notes (Power Point®)
 - Reflex and Reaction
- Lab: *Reflexes, Reaction & Distraction*

HOMEWORK: Do Lab Summary Questions

DAY THREE:

OBJECTIVE: The learner will explain how the brain interprets the sensations from senses and describe the basics of chemical senses.

INTRODUCTION: Book Page 722 #1-4 (Modern Biology)

INSTRUCTION:

- Outline Notes (Power Point®)
 - Interpretations of Sensations
 - Chemical Senses (Taste & Smell)
- Lab: *Can You Smell It?*

HOMEWORK: Lab Summary Questions

DAY FOUR:

OBJECTIVE: The learner will perform various lab activities and from the results explain the chemical senses.

INTRODUCTION: Take a copy of the labs, read them, and do Pre-Lab

INSTRUCTION:

- Review Olfaction Lab
- Discuss Rest of Chemical Senses Labs
- Labs Time
 - Finish: *Can You Smell It?*
 - Start: *Can You Taste It?*

HOMEWORK: Do Lab Reports for Today' Activities

DAY FIVE:

OBJECTIVE: The learner will explain the sense of taste based on results from the labs performed on taste.

INTRODUCTION: Review Can You Taste It? And Do Pre-Lab

INSTRUCTIONS:

- Check & Collect *Can You Smell It?*
- Review Pre-Lab and Procedures for Taste Lab
- Lab: *Can You Taste It?*

HOMEWORK: Lab Report Summary Questions

DAY SIX:

OBJECTIVE: The learner will explain how vision is related to taste based on the results from the lab performed today.

INTRODUCTION: Take a copy of *Tasting Color* and READ It

INSTRUCTION:

- Check and Collect *Can You Taste It* Lab
- Lab: Tasting Color
- Outline Notes (Power Point®)
 - Vision & The Sense of Sight

HOMEWORK: Book Review Questions #1-7

DAY SEVEN:

OBJECTIVE: The learner will describe the sense of sight along with the structures and functions of the eye.

INTRODUCTION: Re-Read Book Section on Vision and the Eye

INSTRUCTION:

- Go through Homework & Collect
- Check and Collect Lab Reports
- Outline Notes (Power Point®)
 - Structures & Functions of the Eye

HOMEWORK: Read Vision Lab, *How Well Do You See* and do Pre-Lab

DAY EIGHT:

OBJECTIVE: The learner will perform a lab activity on vision and describe the sense of sight and how well they see.

INTRODUCTION: Discuss Pre-Lab & Do Diagram of the Eye

INSTRUCTION:

- Review Lab Procedures
- Outline Notes (Power Point®)
 - Finish Structures & Functions of the Eye
- Lab: *How Well Do You See?*
- Discuss Results & Do Lab Questions

HOMEWORK: Finish Lab Questions & Do Pre-Lab for *Seeing Close Up*

DAY NINE:

OBJECTIVE: The learner will explain how close up and color vision function based on the results of labs performed today.

INTRODUCTION: Check Pre-Lab Close Up & Do Pre-Lab *Rods & Cones*

INSTRUCTION:

- Go through Lab Procedures
- Labs
 - *Seeing Close-Up*
 - *Rods and Cones*
- Outline Notes (Power Point®)
 - Start Hearing Notes

HOMEWORK: Lab Questions *Seeing Close-Up & Rods and Cones*.

DAY TEN:

OBJECTIVE: The learner will explain the sense of hearing based on the results from the labs performed today.

INTRODUCTION: Collect Vision Labs & Do Pre-Lab *Tuning In?*

INSTRUCTION:

- Outline Notes (Power Point®)
 - Finish Hearing Notes
- Lab Demo: *Do Your Pennies Ring?*
- Lab: *Tuning In?*

HOMEWORK: Do Lab Summary Questions from *Tuning In?*

DAY ELEVEN:

OBJECTIVE: The learner will explain the acuteness of hearing and explain the basics required for balance.

INTRODUCTION: Pre-Lab question for *Can You Hear It?*

INSTRUCTION:

- Review Previous Labs on Hearing & Collect Them
- Lab: *Can You Hear It?*
- Outline Notes (Power Point®)
 - Notes on Balance

HOMEWORK: Lab Questions *Can You Hear It?*

DAY TWELVE:

OBJECTIVE: The learner will explain how balance occurs based on lab results and then describe the sense of touch.

INTRODUCTION: Pre-Lab Questions for *Balancing Act* Lab

INSTRUCTION:

- Collect Can You Hear It Lab
- Lab: Balancing Act
- Outline Notes (Power Point®)
 - Sense of Touch

HOMEWORK: Lab Questions: *Balancing Act*

DAY THIRTEEN:

OBJECTIVE: The learner will explain the sense of touch and how sensitive they are to it based on lab results.

INTRODUCTION: Pre-Lab Questions: *Can You Feel It?*

INSTRUCTION:

- Discuss Balance Lab Results and Collect
- Check Pre-Lab
- Lab: *Can You Feel It?*

HOMEWORK: Lab Questions: *Can You Feel It?*

DAY FOURTEEN:

OBJECTIVE: The learner will answer review questions over the information they have learned on the Nervous System and Senses.

INTRODUCTION: Take a copy of the Review & Start It

INSTRUCTION:

- Discuss *Can You Feel It* Lab and Collect it
- Discuss the Outcomes and Results of the Unit
- Students work on Review

HOMEWORK: Finish Review

DAY FIFTEEN:

OBJECTIVE: The learner will demonstrate the amount of knowledge they have gained dealing with the Nervous System and Sense.

INTRODUCTION: Question & Answer Time for Clarification

INSTRUCTION:

- Collect Review Materials
- Pass Out Post-Test Evaluation
- Students Take a Survey on Activities of Unit

HOMEWORK: Start Next Unit

APENDIX B

MASTER COPY OF NOTES

Nerves, Senses & You An: Activity Based Approach
Master Copy of Notes

- I. Introduction to the Nervous System.
 - A. Two major divisions according to structure.
 - B. Central Nervous System
 - 1. C.N.S.
 - 2. Includes brain and spinal cord
 - C. Peripheral Nervous System
 - 1. P.N.S.
 - 2. Consists of nerves and bundle of nerves that branch off from the brain and spinal cord.
 - D. Protection Equipment of the nervous system
 - 1. Bone for brain and spinal cord
 - 2. Meninges, protective layers around the brain and spinal cord
 - 3. Dura Mater, outer layer of the spinal cord made of connective tissue, blood vessels and nerves, one of the strongest tissues of the body
 - 4. Arachnoid Layer, elastic web-like middle layer
 - 5. Myelin, white sheath of protection on nerves made of Schwann cells.
 - 6. Cerebrospinal Fluid, shock absorber and nutrient carrier
- II. Neurons, Basic Units of Nervous System
 - A. Actual Nerve Cells that make up the nervous system
 - 1. Function is to conduct electrical messages from one area to another
 - 2. Structure of Neuron
 - a) Dendrite: Short and long branched extensions that receives impulses and conducts them toward cell body
 - b) Cell Body: Central section of the neuron that is also a receptor surface for stimuli
 - c) Axon: An extension of the neuron that carries impulses away from the cell body toward other neurons, muscles, or glands
 - B. Types of neurons, based on function
 - 1. Sensory Neuron, carries impulses from the senses of sight, hearing, taste, touch, and smell to the brain or spinal cord
 - 2. Interneurons, between the brain and spinal cord, they form links between other neurons and transmit impulses
 - 3. Motor Neurons relay impulses from the brain and spinal cord to body parts.
 - C. Nerve Impulse
 - 1. When a stimulus excites a neuron, depolarization occurs.
 - 2. Na^+ channels open and the sodium rushes into the cell causing the interior to be more positively charged than the outside.

3. This change in charge moves down the axon like a wave carrying the message.
 4. As the wave passes, gated channels and sodium/potassium pump return the neuron the resting state.
 5. An impulse can only move the complete length of the axon if the stimulation is strong enough, past threshold.
- D. Synapse is the junction between neurons. Neurotransmitters are chemicals used at the synapse to transmit the message
- E. White vs. Gray Matter
1. Axons that have a white insulating myelin sheath, like plastic on wires, are called white matter
 2. Axons without myelin are grayish and therefore called gray matter

III. Central Nervous System

- A. Coordinates all your body's activities made of brain and spinal cord.
- B. Brain, the control center has three main sections
1. Cerebrum
 - a) Divided into two halves, called hemispheres, by the longitudinal fissure.
 - (1) Right; verbal & nonverbal artistic abilities
 - (2) Left; reading, writing and analysis
 - b) The outer section is called the cerebral cortex that contains many grooves, which increase surface area.
 - c) The cerebrum controls; conscious activities, intelligence, memory, language, skeletal muscle movement, and senses.
 - d) Cerebral Lobes
 - (1) Corresponds to the cranial bones
 - (2) Frontal lobe, associated with personality, judgment, self-control, and movement of skeletal muscles.
 - (3) Parietal lobe, analyze senses, judgment for shape and texture, allows us to feel; temperature, pressure, and pain.
 - (4) Occipital lobe, sense of vision
 2. Cerebellum
 - a) Back of the brain below the occipital lobe
 - b) Controls balance, posture, and coordination
 - c) It is believed that after you learn a skill with the cerebrum, the cerebellum does it automatically.
 3. Brain Stem
 - a) Located between the cerebrum and the spinal cord, which causes all nerve fibers to pass through it.
 - b) Sections of the Brain Stem
 - (1) Medulla Oblongata, controls involuntary activities such as heart rate and breathing
 - (2) Pons, relay station for all parts of the brain.
 - (3) Midbrain, controls reflexes such as pupil size.

4. Other structures

- a) Thalamus, directs all incoming sensory impulses, except smell, to proper regions of the cerebral cortex
- b) Hypothalamus helps regulate body temperature and hunger as well as interacting with the pituitary gland to control the chemical homeostasis.
- c) Limbic System, regulates emotions and can be over activated making someone speechless with joy or fury
- d) Reticular Formation, filtering system for controlling incoming sensory impulses and without it you would go mad because every second 100 million messages bombard your brain.

C. Spinal Cord

- 1. Column of nerve tissue that starts in the medulla oblongata and runs down through the vertebral column
- 2. Made of 31 segments which give rise to spinal nerves.
- 3. Cross Section of the Spinal Cord
 - a) Core of Gray Matter, Posterior and Anterior horns
 - b) Meninges cover the core
 - c) Dura Mater makes up the outer layer
 - d) Cerebrospinal Fluid is located between the gray and white layer

IV. Peripheral Nervous System

A. Somatic Nervous System

- 1. Made up of 12 pairs of cranial nerves from the brains and 31 pairs of nerves from the spinal cord.
- 2. Nerves that control the voluntary movement of skeletal muscle
- 3. The nerves are actually bundles of neuron axons bound together by connective tissue.
- 4. Most nerves contain both sensory and motor axons.
- 5. Reflex
 - a) Reflex action is an involuntary and usually self protective movement
 - b) Rather than the nerve impulse proceeding to the cerebrum or cerebellum for interpretation, a reflex impulse travels to the spinal cord or brain stem where it causes an impulse to be sent directly back to the muscle.
 - c) The brain becomes aware of a reflex only after it has happened.
 - d) Reflex arc is the shortest pathway of a neural message

B. Autonomic Nervous System, nerves that control involuntary actions such as respiration and heart rate

- 1. Sympathetic, controls stimulations of internal organs during stress
- 2. Parasympathetic, controls internal organs during routine conditions.

C. Fight-or-Flight Response

1. When under extreme situations of fear or stress you either run or freeze
2. Your Heart and Breathing rates both increase

V. Brain Interpretation of Sensation

A. Phantom Pain: Receptors no longer present will continue to send impulses to the parietal lobe. These impulses are interpreted by the brain to produce phantom "pain" or "presence".

B. Intensity: A weak stimulus, like dim light, will affect a small number of receptors, but a stronger stimulus, bright light, will stimulate many more. The brain "counts" the impulses and projects the sensation based on the stimuli.

C. Contrast: The effect of a previous or simultaneous sensation on a current situation. If on a hot day you jump into a swimming pool, the water will feel quite cool at first. This is because the brain compares the new sensation of the pool to the previous one of the hot air.

D. After-Image: An image remaining in the consciousness even after the stimulus has stopped. A good example is a flash of a camera staying visible after the flash occurs.

E. Sensory Adaptation

1. When receptors are subjected to continuous stimulation, many of them undergo and adjustment.
2. As the receptors adapt, impulses leave them at decreasing rates, until finally the receptors may completely fail to send signals.
3. Once receptors have adapted, impulses can be triggered only if the strength of the stimulus is changed.
4. This is experienced when a person enters a room where there is a strong odor. At first the scent seems intense, but it becomes less and less noticeable as the smell receptors adapt.
5. Another example is the wearing of jewelry, the skin receptors for touch and pressure adapt quickly to continuing stimulus.
6. Odor Fatigue
 - a) If the person remains in the room for a minute or more, he or she may become totally adapted to the odor and quite unaware of its presence.
 - b) However, if the person leaves the room and then reenters it, the receptors will probably be stimulated once again.

VI. Sensory Receptors

A. Chemo receptors,

1. Detect to chemicals of specific substances dissolved in fluid
2. Are the senses of taste and smell

B. Nociceptors:

1. Pain receptors that detect tissue damage
2. Localized in extremities not in brain

3. Detect chemical, electrical, mechanical or thermal stimulus if strong enough
- C. Thermo receptors detect temperature and temperature changes
 1. Heat: 25° to 45° C
 2. Cold: 10° to 20° C
- D. Mechanoreceptors:
 1. Receptors responsible for sensations of touch and pressure
 2. Pressure receptors are deeper in your skin than touch receptors.
- E. Photoreceptors:
 1. Detect visible and ultraviolet light
 2. Located in the eyes
- F. Sense Organs, are a second group of sense receptors that are highly complex
- VII. Somatic Senses
 - A. Exteroceptive- senses associated with changes occurring at body surface
 - B. Proprioceptive- senses associated with changes occurring in muscles, tendons and body position
 - C. Visceroceptive- senses associated with organ changes, O₂ and CO₂ concentration
- VIII. Chemical Senses
 - A. Sense of Smell (Olfaction)
 1. Olfactory receptors are connected to the olfactory bulbs in the brain.
 2. Olfactory nerve connects these receptors
 3. Certain odors can cause a memory to reoccur.
 4. Chemoreceptors for smell are located high in the nasal passage as well as being covered with mucus, therefore normal breathing does little stimulation, in order to "smell" we must sniff in larger amounts of air.
 5. Humans have 10 millions olfactory receptors in patches, bloodhounds have 200 million.
 - B. Sense of Taste (Gustation)
 1. Taste receptors are part of the sensory organs called taste buds
 2. You have about 10,000 taste buds scattered over the tongue, roof of the mouth and throat.
 3. Taste buds contain receptors for one or more of the four basics or general taste classes; sweet, sour, salty, and bitter.
 4. Most flavors are a combination of the four basic tastes, plus sensory input from olfactory receptors in the nose.
 5. Some foods we eat have chemicals that are released when we chew the food and "float" up to the nose to be detected.
 6. Taste does occur in the brain; therefore the sense of smell can be fooled.
- IX. Sensing Light (Sight)
 - A. The Eye

1. Structure

a) Outer;

(1) Sclera, dense fibrous tissue (white of the eye), protects the eyeball

(2) Cornea, focuses light

b) Middle;

(1) Choroid (pigmented tissue), prevents light scattering

2. Iris, controls incoming light

3. Ciliary body, aids in focusing

c) Inner;

(1) Retina, absorbs, converts light

(2) Fovea, increases visual acuity

(3) Start of Optic Nerve, transmits signals to brain

d) Other Components;

(1) Lens, finely focuses light on photoreceptors

(2) Aqueous Humor, transmits light, maintains pressure

(3) Vitreous Humor, transmits light, supports lens and eye

e) Rods,

(1) Detect light intensity

(2) Detect very dim light

f) Cones,

(1) Colors; Red, Green, Blue

(2) Receptor cells adapted for sharp vision and bright light

(3) Detect bright light

(4) Contribute to sharp daytime vision and color perception

B. Visual Field

1. The part of the outside world that a person actually sees.

C. Depth Perception

1. The ability to judge how far away an object is.

X. Hearing

A. The Ear

1. Outer ear

a) Pinna

(1) Sound gathering trumpet

(2) Cartilage, flap of skin

b) Sound waves enter here

c) Channels sound waves inward through the auditory canal

2. Middle ear

a) Tympanic membrane

(1) Commonly called the Eardrum

(2) Sound waves cause it to vibrate

- b) Malleus
 - (1) Commonly called the Hammer
 - (2) Receives impulses from the tympanic membrane
- c) Incus
 - (1) Commonly called the Anvil
 - (2) Connects the malleus to the stapes
- d) Stapes
 - (1) Commonly called the Stirrup
 - (2) Transmit their motion to the oval window
- e) Eustachian Tube
 - (1) Opening in the middle ear
 - (2) Runs from middle ear to the throat
 - (3) Permits air pressure in middle ear to be equalized with pressure from the outside

3. Inner Ear

- a) Oval Window
 - (1) Elastic membrane over the entrance of the cochlea
 - (2) Amplified original vibration
- b) Cochlea & Semicircular Canals
 - (1) Tightly wound inner ear section filled with tiny little hairs
 - (2) Snail shaped organ
 - (3) Helps maintain balance
 - (4) Filled with a thick fluid
 - (5) Translates vibrations into nerve impulses so we can detect sounds

B. Hearing starts with acoustical receptors which are vibration-sensitive mechanoreceptors deep within the ear

C. The sense of hearing

- 1. Relies on mechanoreceptors called hair cells
- 2. Hair cells are attached to membranes within the cochlea of the inner ear.

D. Pressure waves generated by sound

- 1. Cause the membrane vibrations that bend hair cells
- 2. Results in action potential of neurons of the auditory nerve
- 3. Action potential travels to the brain as a nerve impulse

XI. Balance

A. Sense of "Natural Position"

B. The brain compares displacement of body parts and trunk from the baseline location called the "equilibrium position."

C. This sense relies on input from receptors in the eyes, skin, and joints.

D. Balance also relies on Vestibular Apparatus is the closed system of fluid filled canals and sacs in the inner ear

- 1. Semicircular canals

- a) Three canals that are positioned at right angles to each other which correspond to the three planes of space.
 - b) They detect rotational head movement, acceleration, and deceleration.
- 2. Utricles and Saccules
 - a) Contain otolith organs in which hair cells are embedded in a jellylike membrane
 - b) Detect changes in head's orientation relative to gravity, as well as straight-line acceleration and deceleration.
- E. Proprioception- is the ability to determine location of limbs on muscle tension

XII. Sense of Touch

- A. Skin Mechanoreceptors
 - 1. Highly specialized nerve endings linked to collagen fibers
 - 2. Adapt at different rates
 - a) Some only fire when stimuli is changing producing sensations of touch, movement and vibration
 - b) Others produce sensations of pressure
- B. Types of skin receptors
 - 1. Tactile (Meissner's) corpuscle = light touch
 - 2. Tactile (Merkle's) corpuscles = touch
 - 3. Free nerve ending = pain
 - 4. Lamellated (Pacinian) corpuscle = deep pressure
 - 5. Ruffini corpuscle = warmth
- C. Not all areas of the skin have the same distribution of skin receptors

APENDIX C

STUDENT 'SKELETON' COPY OF NOTES

Nerves, Senses & You An: Activity Based Approach
Student 'Skeleton' Copy of Notes

Anatomy & Physiology
Nerves, Senses, & You Notes

Name _____
Date _____ Block _____

- I. Introduction to the Nervous System.
 - A. Two major divisions according
 - 1.
 2. Includes
 - B. Central Nervous System
 - 1.
 2. Includes
 - C. Peripheral Nervous System
 - 1.
 2. Consists of nerves and bundle of nerves that branch off
 - D. Protection Equipment of the nervous system
 1. Bone for
 2. Meninges, protective layers around the brain and
 3. Dura Mater, outer layer of the spinal cord made of connective tissue, blood vessels and nerves,

4. Arachnoid Layer, elastic web-like
5. Myelin, white sheath of protection on nerves
6. Cerebrospinal Fluid,

II. Neurons, Basic Units of Nervous System

A. Actual Nerve Cells

1. Function is to conduct electrical messages from
2. Structure of Neuron
 - a) Dendrite: Short and long branched extensions that
 - b) Cell Body: Central section of the neuron that is also a
 - c) Axon: An extension of the neuron that carries impulses away from the cell

B. Types of neurons, based on function

- 1. Sensory Neuron, carries impulses from the senses of**
- 2. Interneurons, between the brain and spinal cord, they form links between**
- 3. Motor Neurons relay impulses from the brain and spinal cord**

C. Nerve Impulse

- 1. When a stimulus excites a neuron,**
- 2. Na^+ channels open and the sodium rushes into the cell causing the interior to**
- 3. This change in charge moves down the axon like a**
- 4. As the wave passes, gated channels and sodium/potassium pump return**

5. An impulse can only move the complete length of the axon if the stimulation is

D. Synapse is the junction

Neurotransmitters are chemicals used at the synapse

E. White vs. Gray Matter

1. Axons that have a white insulating myelin sheath, like plastic on wires,

2. Axons without myelin are grayish and therefore

III. Central Nervous System

A. Coordinates all your body's activities made of

B. Brain, the control center has

1. Cerebrum

a) Divided into two halves, called hemispheres, by

(1) Right;

(2) Left;

b) The outer section is called the cerebral cortex that contains many grooves,

c) The cerebrum controls; conscious activities, intelligence, memory, language, skeletal muscle movement,

d) Cerebral Lobes

(1) Corresponds to

(2) Frontal lobe, associated with personality, judgment, self-control,

(3) Parietal lobe, analyze senses, judgment for shape and texture, allows us to feel;

(4) Occipital lobe, sense of

2. Cerebellum

a) Back of the brain below the

b) Controls balance, posture, and

c) It is believed that after you learn a skill with the cerebrum, the

3. Brain Stem

a) Located between the cerebrum and the spinal cord, which causes all nerve fibers

b) Sections of the Brain Stem
(1) Medulla Oblongata, controls involuntary activities such as

(2) Pons, relay station for all

(3) Midbrain, controls reflexes such

4. Other structures

a) Thalamus, directs all incoming sensory impulses, except smell, to proper

b) Hypothalamus helps regulate body temperature and hunger as well as interacting with the pituitary gland to

c) Limbic System, regulates emotions and can be over activated making someone

d) Reticular Formation, filtering system for controlling incoming sensory impulses and without it you would go mad because every

C. Spinal Cord

1. Column of nerve tissue that starts in the medulla oblongata and runs down through

2. Made of 31 segments which give rise to

3. Cross Section of the Spinal Cord

a) Core of Gray Matter,

b) Meninges cover the

c) Dura Mater makes up the

d) Cerebrospinal Fluid is located between

IV. Peripheral Nervous System

A. Somatic Nervous System

1. Made up of 12 pairs of cranial nerves from the brains and 31 pairs of nerves from

2. Nerves that control the voluntary movement of

3. The nerves are actually bundles of neuron axons

4. Most nerves contain both
5. Reflex
 - a) Reflex action is an involuntary and usually
 - b) Rather than the nerve impulse proceeding to the cerebrum or cerebellum for interpretation, a reflex impulse travels to the spinal cord or brain stem where it causes an impulse
 - c) The brain becomes aware of a reflex
 - d) Reflex arc is the shortest pathway of

B. Autonomic Nervous System, nerves that control involuntary actions such as

1. Sympathetic, controls stimulations of internal

2. Parasympathetic, controls internal organs during

C. Fight-or-Flight Response

1. When under extreme situations of fear or stress you either

2. Your Heart and Breathing rates

V. Brain Interpretation of Sensation

A. Phantom Pain: Receptors no longer present will continue to send impulses to the parietal lobe.

B. Intensity: A weak stimulus, like dim light, will affect a small number of receptors, but a stronger stimulus, bright light, will stimulate many more.

C. Contrast: The effect of a previous or simultaneous sensation on a current situation. If on a hot day you jump into a swimming pool, the water will feel quite cool at first.

D. After-Image: An image remaining in the consciousness even after the stimulus has stopped.

E. Sensory Adaptation

1. When receptors are subjected to continuous stimulation,

2. As the receptors adapt, impulses leave them at decreasing rates, until finally the

3. Once receptors have adapted, impulses can be triggered only if

4. This is experienced when a person enters a room where there is a strong odor. At first the scent seems intense, but

5. Another example is the wearing of jewelry, the skin receptors for

6. Odor Fatigue

a) If the person remains in the room for a minute or more, he or she may become totally

b) However, if the person leaves the room and then reenters it, the receptors

VI. Sensory Receptors

A. Chemo receptors,

1. Detect to chemicals of specific substances

2. Are the senses of

B. Nociceptors:

1. Pain receptors that

2. Localized in extremities

3. Detect chemical, electrical, mechanical or thermal stimulus if

- C. Thermo receptors detect
 - 1. Heat:
 - 2. Cold:
- D. Mechanoreceptors:
 - 1. Receptors responsible for sensations of
 - 2. Pressure receptors are
- E. Photoreceptors:
 - 1. Detect
 - 2. Located in
- F. Sense Organs, are a second group of sense receptors that

VII. Somatic Senses

- A. Exteroceptive- senses associated with changes
- B. Proprioceptive- senses associated with changes occurring
- C. Visceroceptive- senses associated with organ

VIII. Chemical Senses

A. Sense of Smell

- 1. Olfactory receptors are connected to the**
- 2. Olfactory nerve connects**
- 3. Certain odors can**
- 4. Chemoreceptors for smell are located high in the nasal passage as well as being covered with mucus, therefore normal breathing does**
- 5. Humans have 10 millions olfactory receptors in**

B. Sense of Taste

- 1. Taste receptors are part of the sensory organs called**
- 2. You have about 10,000 taste buds scattered over the**

3. Taste buds contain receptors for one or more of the four basics or
4. Most flavors are a combination of the four basic tastes,
5. Some foods we eat have chemicals that are released when we chew the food and
6. Taste does occur in the brain; therefore

IX. Sensing Light (Sight)

A. The Eye

1. Structure
 - a) Outer;

(1) Sclera, dense fibrous tissue

(2) Cornea,

- b) Middle;
 - (1) Choroid, prevents light scattering
 - (2) Iris, controls incoming light
 - (3) Lens, aids in focusing
- c) Inner;
 - (1) Retina, absorbs,
 - (2) Macula, increases visual acuity
 - (3) Start of Optic Nerve,
- d) Other Components;
 - (1) Crystalline Lens, finely focuses light on
 - (2) Aqueous Humor,
 - (3) Vitreous Humor, transmits light,

e) Rods,
(1) Detect

(2) Detect very

f) Cones,
(1) Colors;

(2) Receptor cells

(3) Detect

(4) Contribute to sharp

B. Visual Field

1. The part of the outside world that

C. Depth Perception

1. The ability to judge how

X. Hearing

A. The Ear

1.

a) Pinna

(1) Sound

(2) Cartilage,

b) Sound waves

c) Channels sound waves
inward

2. Middle ear

a) Tympanic membrane
(1) Commonly called

(2) Sound waves

b) Malleus
(1) Commonly called

(2) Receives impulses

c) Incus
(1) Commonly called

(2) Connects the

- d) Stapes
 - (1) Commonly called
 - (2) Transmit their
- e) Eustachian Tube
 - (1) Opening
 - (2) Runs form
 - (3) Permits air pressure in middle

3. Inner Ear

- a) Oval Window
 - (1) Elastic membrane over the
 - (2) Amplified
- b) Cochlea & Semicircular Canals
 - (1) Tightly wound inner ear section

(2) Snail

(3) Helps

(4) Filled with

(5) Translates vibrations into
nerve

B. Hearing starts with acoustical
receptors which are

C. The sense of hearing

1. Relies on

2. Hair cells are attached to

D. Pressure waves

1. Cause the membrane

2. Results in action potential

3. Action potential travels

XI. Balance

A. Sense of

B. The brain compares displacement of body parts and trunk from the baseline

C. This sense relies on input from

D. Balance also relies on Vestibular Apparatus is the closed system of

1. Semicircular canals

a) Three canals that are positioned at right angles to

b) They detect rotational

2. Utricles and Sacculles

a) Contain otolith organs in which hair cells

b) Detect changes in head's orientation relative

E. Proprioception- is the ability to determine

XII. Sense of Touch

A. Skin Mechanoreceptors

1. Highly specialized nerve endings
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a) Some only fire when stimuli is changing

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B. Types of skin receptors

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3. Free nerve ending =
4. Lamellated (Pacinian) corpuscle =
5. Ruffini corpuscle =

C. Not all areas of the skin have

APENDIX D

POWERPOINT® SLIDE PRESENTATION OF NOTES

Nerves, Senses, & You. An Activity Based Approach



Fig. 20 Slide 1

Nerves, Senses, & You...

I. Introduction to the Nervous System.

A. Two major divisions according to structure.

B. Central Nervous System

1. C.N.S.
2. Includes brain and spinal cord

C. Peripheral Nervous System

1. P.N.S.
2. Consists of nerves and bundle of nerves that branch off from the brain and spinal cord.

Fig. 21 Slide 2

Nerves, Senses, & You...

D. Protection Equipment of the nervous system

1. Bone for brain and spinal cord
2. Meninges, protective layers around the brain and spinal cord
3. Dura Mater, outer layer of the spinal cord made of connective tissue, blood vessels and nerves, one of the strongest tissues of the body
4. Arachnoid Layer, elastic web-like middle layer
5. Myelin, white sheath of protection on nerves made of Schwann cells.
6. Cerebrospinal Fluid, shock absorber and nutrient carrier

Fig. 22 Slide 3

Nerves, Senses, & You...

II. Neurons, Basic Units of Nervous System

A. Actual Nerve Cells that make up the nervous system

1. Function is to conduct electrical messages from one area to another
2. Structure of Neuron
 - a) Dendrite: Short and long branched extensions that receives impulses and conducts them toward cell body
 - b) Cell Body: Central section of the neuron that is also a receptor surface for stimuli
 - c) Axon: An extension of the neuron that carries impulses away from the cell body toward other neurons, muscles, or glands

Fig. 23 Slide 4

Nerves, Senses, & You...

B. Types of neurons, based on function

1. Sensory Neuron, carries impulses from the senses of sight, hearing, taste, touch, and smell to the brain or spinal cord
2. Interneurons, between the brain and spinal cord, they form links between other neurons and transmit impulses
3. Motor Neurons, relay impulses from the brain and spinal cord to body parts.

Fig. 24 Slide 5

Nerves, Senses, & You...

C. Nerve Impulse

1. When a stimulus excites a neuron, depolarization occurs.
2. Na^+ channels open and the sodium rushes into the cell causing the interior to be more positively charged than the outside.
3. This change in charge moves down the axon like a wave carrying the message.
4. As the wave passes, gated channels and sodium/potassium pump return the neuron to the resting state.
5. An impulse can only move the complete length of the axon if the stimulation is strong enough, past threshold.

Fig. 25 Slide 6

Nerves, Senses, & You...

- D. Synapse is the junction between neurons.
Neurotransmitters are chemicals used at the synapse to transmit the message
- E. White vs. Gray Matter
 - 1. Axons that have a white insulating myelin sheath, like plastic on wires, are called white matter
 - 2. Axons without myelin are grayish and therefore called gray matter

III. Central Nervous System

- A. Coordinates all your body's activities made of brain and spinal cord.

Fig. 26 Slide 7

Nerves, Senses, & You...

- B. Brain, the control center has three main sections
 - 1. Cerebrum
 - a) Divided into two halves, called hemispheres, by the longitudinal fissure.
 - (1) Right; verbal & nonverbal artistic abilities
 - (2) Left; reading, writing and analysis
 - b) The outer section is called the cerebral cortex that contains many grooves, which increase surface area.
 - c) The cerebrum controls; conscious activities, intelligence, memory, language, skeletal muscle movement, and senses.

Fig. 27 Slide 8

Nerves, Senses, & You...

D. Cerebral Lobes

- (1) Corresponds to the cranial bones
- (2) Frontal lobe, associated with personality, judgment, self-control, and movement of skeletal muscles.
- (3) Parietal lobe, analyze senses, judgment for shape and texture, allows us to feel; temperature, pressure, and pain.
- (4) Occipital lobe, sense of vision

2. Cerebellum

- a) Back of the brain below the occipital lobe
- b) Controls balance, posture, and coordination
- c) It is believed that after you learn a skill with the cerebrum, the cerebellum does it automatically.

Fig. 28 Slide 9

Nerves, Senses, & You...

3. Brain Stem

- a) Located between the cerebrum and the spinal cord, which causes all nerve fibers to pass through it.
- b) Sections of the Brain Stem
 - (1) Medulla Oblongata, controls involuntary activities such as heart rate and breathing
 - (2) Pons, relay station for all parts of the brain.
 - (3) Midbrain, controls reflexes such as pupil size.

Fig. 29 Slide 10

Nerves, Senses, & You...

4. Other structures

- a) Thalamus, directs all incoming sensory impulses, except smell, to proper regions of the cerebral cortex
- b) Hypothalamus, helps regulate body temperature and hunger as well as interacting with the pituitary gland to control the chemical homeostasis.
- c) Limbic System, regulates emotions and can be over activated making someone speechless with joy or fury
- d) Reticular Formation, filtering system for controlling incoming sensory impulses and without it you would go mad because every second 100 million messages bombard you brain.

Fig. 30 Slide 11

Nerves, Senses, & You...

C. Spinal Cord

- 1. Column of nerve tissue that starts in the medulla oblongata and runs down through the vertebral column
- 2. Made of 31 segments which give rise to spinal nerves.
- 3. Cross Section of the Spinal Cord
 - a) Core of Gray Matter, Posterior and Anterior horns
 - b) Meninges cover the core
 - c) Dura Mater makes up the outer layer
 - d) Cerebrospinal Fluid is located between the gray and white layer

Fig. 31 Slide 12

Nerves, Senses, & You...

IV. Peripheral Nervous System

A. Somatic Nervous System

1. Made up of 12 pairs of cranial nerves from the brains and 31 pairs of nerves from the spinal cord.
2. Nerves that control the voluntary movement of skeletal muscle
3. The nerves are actually bundles of neuron axons bound together by connective tissue.
4. Most nerves contain both sensory and motor axons.

Fig. 32 Slide 13

Nerves, Senses, & You...

5. Reflex

- a) Reflex action is an involuntary and usually self protective movement
- b) Rather than the nerve impulse proceeding to the cerebrum or cerebellum for interpretation, a reflex impulse travels to the spinal cord or brain stem where it causes an impulse to be sent directly back to the muscle.
- c) The brain becomes aware of a reflex only after it has happened.
- d) Reflex arc is the shortest pathway of a neural message

Fig. 33 Slide 14

Nerves, Senses, & You...

- B. Autonomic Nervous System, nerves that control involuntary actions such as respiration and heart rate
 - 1. Sympathetic, controls stimulations of internal organs during stress
 - 2. Parasympathetic, controls internal organs during routine conditions.
- C. Fight-or-Flight Response
 - 1. When under extreme situations of fear or stress you either run or freeze
 - 2. Your Heart and Breathing rates both increase

Fig. 34 Slide 15

Nerves, Senses, & You...

V. Brain Interpretation of Sensation

- A. Phantom Pain: Receptors no longer present will continue to send impulses to the parietal lobe. These impulses are interpreted by the brain to produce phantom "pain" or "presence".
- B. Intensity: A weak stimulus, like dim light, will affect a small number of receptors, but a stronger stimulus, bright light, will stimulate many more. The brain "counts" the impulses and projects the sensation based on the stimuli.

Fig. 35 Slide 16

Nerves, Senses, & You...

- C. Contrast: The effect of a previous or simultaneous sensation on a current situation. If on a hot day you jump into a swimming pool, the water will feel quite cool at first. This is because the brain compares the new sensation of the pool to the previous one of the hot air.
- D. After-Image: An image remaining in the consciousness even after the stimulus has stopped. A good example is a flash of a camera staying visible after the flash occurs.

Fig. 36 Slide 17

Nerves, Senses, & You...

E. Sensory Adaptation

1. When receptors are subjected to continuous stimulation, many of them undergo an adjustment.
2. As the receptors adapt, impulses leave them at decreasing rates, until finally the receptors may completely fail to send signals.
3. Once receptors have adapted, impulses can be triggered only if the strength of the stimulus is changed.
4. This is experienced when a person enters a room where there is a strong odor. At first the scent seems intense, but it becomes less and less noticeable as the smell receptors adapt.

Fig. 37 Slide 18

Nerves, Senses, & You...

5. Another example is the wearing of jewelry, the skin receptors for touch and pressure adapt quickly to continuing stimulus.

6. Odor Fatigue.

- a. If the person remains in the room for a minute or more, he or she may become totally adapted to the odor and quite unaware of its presence.
- b. However, if the person leaves the room and then reenters it, the receptors will probably be stimulated once again.

Fig. 38 Slide 19

Nerves, Senses, & You...

VI. Sensory Receptors

A. Chemo receptors,

1. Detect chemicals of specific substances dissolved in fluid
2. Are the senses of taste and smell

B. Nociceptors:

1. Pain receptors that detect tissue damage
2. Localized in extremities not in brain
3. Detect chemical, electrical, mechanical or thermal stimulus if strong enough

C. Thermo receptors detect temperature and temperature changes

1. Heat: 25° to 45° C
2. Cold: 10° to 20° C

Fig. 39 Slide 20

Nerves, Senses, & You...

D. Mechanoreceptors:

1. Receptors responsible for sensations of touch and pressure
2. Pressure receptors are deeper in your skin than touch receptors.

E. Photoreceptors:

1. Detect visible and ultraviolet light
2. Located in the eyes

F. Sense Organs, are a second group of sense receptors that are highly complex

Fig. 35 Slide 21

Nerves, Senses, & You...

VII. Somatic Senses

- A. Exteroceptive- senses associated with changes occurring at body surface
- B. Proprioceptive- senses associated with changes occurring in muscles, tendons and body position
- C. Visceroceptive- senses associated with organ changes, O₂ and CO₂ concentration

Fig. 41 Slide 22

Nerves, Senses, & You...

VIII. Chemical Senses

A. Sense of Smell (Olfaction)

1. Olfactory receptors are connected to the olfactory bulbs in the brain.
2. Olfactory nerve connects these receptors
3. Certain odors can cause a memory to reoccur.
4. Chemoreceptors for smell are located high in the nasal passage as well as being covered with mucus, therefore normal breathing does little stimulation, in order to "smell" we must sniff in larger amounts of air.
5. Humans have 10 millions olfactory receptors in patches, bloodhounds have 200 million.

Fig. 42 Slide 23

Nerves, Senses, & You...

B. Sense of Taste (Gustation)

1. Taste receptors are part of the sensory organs called taste buds
2. You have about 10,000 taste buds scattered over the tongue, roof of the mouth and throat.
3. Taste buds contain receptors for one or more of the four basics or general taste classes; sweet, sour, salty, bitter.
4. Most flavors are a combination of the four basic tastes, plus sensory input from olfactory receptors in the nose.
5. Some foods we eat have chemicals that are released when we chew the food and "float" up to the nose to be detected.
6. Taste does occur in the brain; therefore the sense of smell can be fooled.

Fig. 38 Slide 24

Nerve, Senses, & You...

IX. Sensing Light (sight)

A. The Eye

1. Structure

a) Outer;

1. Sclera, dense fibrous tissue (white of the eye), protects eyeball
2. Cornea, focuses light

b) Middle;

1. Coroid, (pigmented tissue) prevents light scattering
2. Iris, controls incoming light
3. Ciliary body, aids in focusing

c) Inner;

1. Retina, absorbs, converts light
2. Fovea, increases visual acuity
3. Start of Optic Nerve, transmits signals to brain

Fig. 44 Slide 25

Nerve, Senses, & You...

d) Other Components;

1. Lens, finely focuses light on photoreceptors
2. Aqueous Humor, transmits light, maintains pressure
3. Vitreous Humor, transmits light, supports lens and eye

e) Rods;

1. Detect light intensity
2. Detect very dim light

Fig. 45 Slide 26

Nerve, Senses, & You...

f) Cones;

1. Colors; red, green, blue
2. receptor cells adapted for sharp vision and bright light
3. detect bright light
4. contribute to sharp daytime vision and bright light

B. Visual Field

- The part of the outside world that a person actually sees.

C. Depth Perception

- The ability to judge how far away an object is.

Fig. 46 Slide 27

Nerve, Senses, & You...

X. Hearing

A. The Ear

1. Outer ear
 - a) Pinna
 - 1) Sound gathering trumpet
 - 2) Cartilage, flap of skin
 - b) Sound waves enter here
 - c) Channels sound waves inward through the auditory canal

Fig. 47 Slide 28

Nerve, Senses, & You...

2. Middle ear

- a) Tympanic membrane
 - 1) Commonly called the eardrum
 - 2) Sound waves cause it to vibrate
- b) Malleus
 - 1) Commonly called hammer
 - 2) Receives impulses from the tympanic membrane
- c) Incus
 - 1) Commonly called anvil
 - 2) Connects the malleus to the stapes
- d) Stapes
 - 1) Commonly called stirrup
 - 2) Transmits their motion to the oval window

Fig. 48 Slide 29

Nerve, Senses, & You...

- e) Eustachian Tube
 - 1) Opening in the middle ear
 - 2) Runs from middle ear to the throat
 - 3) Permits air pressure in middle ear to be equalized with pressure from the outside
- 3. Inner Ear
 - a) Oval Window
 - 1) Elastic membrane over the entrance of the cochlea
 - 2) Amplified original vibration
 - b) Cochlea & Semicircular Canals
 - 1) Tightly wound inner ear section filled with tiny little hairs

Fig. 49 Slide 30

Nerve, Senses, & You...

- 2) Snail shaped organ
- 3) Helps maintain balance
- 4) Filled with a thick fluid
- 5) Translates vibrations into nerve impulses so we can detect sounds

B. Hearing starts with acoustical receptors which are vibration-sensitive mechanoreceptors deep within the ear

C. The sense of hearing

1. Relies on mechanoreceptors called hair cells
2. Hair cells are attached to membranes within the cochlea of the inner ear.

Fig. 50 Slide 31

Nerve, Senses, & You...

D. Pressure waves generated by sound

1. Cause the membrane vibrations that bend hair cells
2. Results in action potential of neurons of the auditory nerve
3. Action potential travels to the brain as a nerve impulse

XI. Balance

A. Sense of "Natural Position"

B. The brain compares displacement of body parts and trunk from the baseline location called the "equilibrium position."

C. This sense relies on input from receptors in the eyes, skin, and joints.

Fig. 51 Slide 32

Nerve, Senses, & You...

D. Balance also relies on Vestibular Apparatus is the closed system of fluid filled canals and sacs in the inner ear

1. Semicircular canals

- a) Three canals that are positioned at right angles to each other which correspond to the three planes of space.
- b) They detect rotational head movement, acceleration, and deceleration.

Fig. 52 Slide 33

Nerve, Senses, & You...

2. Utricles and Saccules

- a) Contain otolith organs in which hair cells are embedded in a jellylike membrane
- b) Detect changes in head's orientation relative to gravity, as well as straight-line acceleration and deceleration.

E. Proprioception- is the ability to determine location of limbs on muscle tension

Fig. 53 Slide 34

Nerve, Senses, & You...

XII. Sense of Touch

A. Skin Mechanoreceptors

1. Highly specialized nerve endings linked to collagen fibers
2. Adapt at different rates
 - a) Some only fire when stimuli is changing producing sensations of touch, movement and vibration
 - b) Others produce sensations of pressure

Fig. 54 Slide 35

Nerve, Senses, & You...

B. Types of skin receptors

1. Tactile (Meissner's) corpuscle = light touch
2. Tactile (Merkle's) corpuscles = touch
3. Free nerve ending = pain
4. Lamellated (Pacini) corpuscle = deep pressure
5. Ruffini corpuscle = warmth

C. Not all areas of the skin have the same distribution of skin receptors

Fig. 55 Slide 36

APENDIX E

REFLEXES, REACTION, AND DISTRACTION LAB ACTIVITY

Reflexes, Reaction, and Distraction:

Equipment:

Meter stick

Objective:

Observe reflex/reaction time and then how distraction stimulus affects reaction time.

Procedure:

1. Observe knee-jerk reflex.
2. Do Pre-Laboratory questions.
3. In groups of two, pick one person to be the participant and the other to be the recorder.
4. The participant should sit with proper posture facing their lab partner.
5. The lab partner should hold the meter stick level to the participant's hand, so that the increments increase up.
6. The participant should tell the lab partner to drop the meter stick. As soon as the lab partner drops the meter stick the participant should catch it between their thumb and fingers.
7. Measure the distance the meter stick falls before you catch it.
8. Repeat step five for a total of ten trials and record the data in the table.
9. Variation 1: Repeat steps 3-6, this time have your lab partner drop the meter stick **WITHOUT** you telling them when to drop it.
10. Variation 2: Repeat steps 3-6, this time do an activity that makes you distracted from the meter stick. Examples are singing the alphabet song, counting backwards from 50 by 1's. This variation also has the participant **NOT** telling the lab partner to drop the meter stick.
11. Trade places and repeat above.
12. Do summary questions.

Pre-Laboratory Questions:

1. What is a reflex? _____

2. What is reaction time? _____

3. Are we testing reflexes or reaction time? Explain. _____

Data Table:

Trail #	Basic Drop Distance	Variation #1 Distance	Variation #2 Distance
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Average			

Summary Questions:

1. Did you decrease the distance for your reaction time after continued practice? Why?

2. Explain how your reaction time changed when you did not instruct the your lab partner to drop the meter stick. Why did this happen?

3. Explain what happened to your reaction time for trial #3. Why did this occur?

4. Explain what other factors would change, either increase or decrease, reaction time?

5. Describe and explain what you learned by doing this laboratory activity.

APENDIX F

CAN YOU SMELL IT LAB ACTIVITY

Can You Smell It?

Equipment:

- Threshold Odorants
- Odorants in Containers
- Timer or Clock with Secondhand
- Oil of Peppermint
- Oil of Clove
- Swabs
- Blindfold (optional)

Objective:

The student will determine threshold for olfactory sensation, experience olfactory fatigue, and identify common odors.

Procedure:

1. Read Lab Carefully!
2. Observe proper “wafting” technique.
3. Answer Pre-lab questions.

Part A: Olfactory Threshold

1. Obtain a set of threshold odorant containers.
2. The subject of the lab should have their eyes closed or be blindfolded.
3. The tester should remove the cap from a randomly picked container and carefully hand the container to the subject.
4. The subject should waft the odor toward their nose and indicate if they can detect the odor, then return the container to the tester who replaces the cap.
5. Mark on data table A for that container if they could or could not detect the odor.
6. Repeat steps 3 - 5 for the rest of the threshold containers.
7. Switch jobs and repeat the lab.

Part B: Olfactory Fatigue

1. The tester should place two drops of clove oil on a swab.
2. The subject of the lab should hold the swab under one nostril while closing the other, inhaling through the nose repeatedly while exhaling through the mouth.

3. While the subject is inhaling the clove oil, they should place two drops of peppermint oil on a swab.
4. Once the subject can no longer detect the clove oil odor from olfactory fatigue the tester should hand them the peppermint swab to be inhaled.
5. Record in data table B if the subject could detect the peppermint oil after olfactory fatigue of clove oil.
6. Switch jobs and repeat.

Part C: Odor Identification

1. Obtain a set of odor identification containers.
2. The subject should have their eyes closed or be blindfolded for this test.
3. The tester should hand a randomly chosen odorant container to the subject.
4. The subject should remove the lid away from their nose so they do not “smell” it yet, and then waft the odor toward them. Replacing the cap when done.
5. The tester should not look at or try to smell the odor until it is their turn.
6. The subject should indicate what they “smell” and their first thought.
7. Record what they indicate in data table C.
8. Repeat this for all the containers the change roles and repeat the process.

Pre-Lab Questions:

1. Describe what has to occur physically and anatomically in order for you to “smell”.

2. Explain why wafting is an important technique in detecting odors.

3. Describe your favorite odors and explain why you enjoy them.

Data Table A: Threshold

Container	Control Plan Water	1 drop per 500 ml	2 drops per 500 ml	3 drops per 500 ml	4 drops per 500 ml	5 drops per 500 ml	6 drops per 500 ml
Odor Detected Y/N							

Data Table B: Fatigue

Time for Clove Oil Fatigue	
Detection of Peppermint Oil Y/N	

Data Table C: Common Odors

Odor Container ↓	“Smell Detected”	First Thought
# 1		
# 2		
# 3		
# 4		
# 5		
#6		

Summary Questions:

1. Describe your threshold for odor detection and explain why you believe it is at this level.

2. Describe what occurred for part B of the lab activity for fatigue.

3. Describe the variation for part B for the entire class, what differences were evident?

4. Describe the correlation between odor and memory based on the results for part C.

5. Describe what you have learned about olfactory sensation based on this lab activity.

APENDIX G

CAN YOU TASTE IT LAB ACTIVITY

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Can You Taste It?

Equipment:

- 4 Swab & 4 Liquids per Person
- One piece of Apple, Carrot, Kiwi & Onion
- Toothpicks
- Sugar Solutions
- Low Sodium Salty Crackers

Objective:

The student will evaluate their acuteness of taste by: locating the four taste regions on the tongue, identifying their “sweet taste” threshold, and by determining if taste is related to vision and odor.

Procedure:

1. Read the Entire Lab Carefully!
2. For each activity, subject’s eyes should be closed and nose plugged.
3. Do Pre-lab questions.
4. Wash Your Hands. Because we are doing a lab that deals with placing things in others mouths we must be sanitary!!!
5. This lab works best with two people per lab group.

Part A: Mapping the Four Basic Tastes

1. Obtain four cups: label them Sweet, Sour, Salty, Bitter, and put the respective liquids in them.
2. Have four swaps per person in lab group.
3. Subject should sit with eyes closed and nose plugged.
4. Tester will use a moistened swap soak with one of the liquids and paint the subject’s tongue.
5. The subject will identify the taste and the location on their tongue that they sensed that taste. Example: tip, sides, back, middle.
6. Mark it on the diagram and repeat with the other three liquids.
7. **Remember Do not re-dip the swap after it has gone into anyone’s mouth.**
8. Switch roles and repeat steps 3 –6
9. Answer the summary questions dealing with part A of the lab activity.

Part B: Threshold of "Sweet Taste"

1. Obtain 6 cups and label them as follows. 20%, 10%, 5%, 2.5% 1.25% 0%.
2. In the 20 % cup add 10 ml of "stock sugar solution"
3. Place 10 ml of water in each of the other cups.
4. In the 10% cup add 10 ml of "stock sugar solution".
5. Remove 10 ml of solution from the 10% cup and add it to the 5% cup.
6. Remove 10 ml of solution from the 5% cup and add it to the 2.5% cup.
7. Remove 10 ml of solution from the 2.5 % cup and add it to the 1.25% cup.
8. Place two swabs in each solution.
9. Once a swab has been removed from a solution and placed into a person's mouth it is NEVER TO RETURN TO THE CUP!!!!
10. Have the subject face you with eyes closed and tongue out.
11. Randomly pick solutions and place the swab on the location of their tongue they tasted sweet from part A.
12. They are to indicate if they taste sweet or not.
13. After each swap have them eat $\frac{1}{4}$ of a low sodium saltine to cleanse the palate.
14. Repeat steps 10-13 until all the solutions have been tested.
15. Trade jobs and repeat steps 9-14.

Part C: Tasting or Seeing and Smelling Food

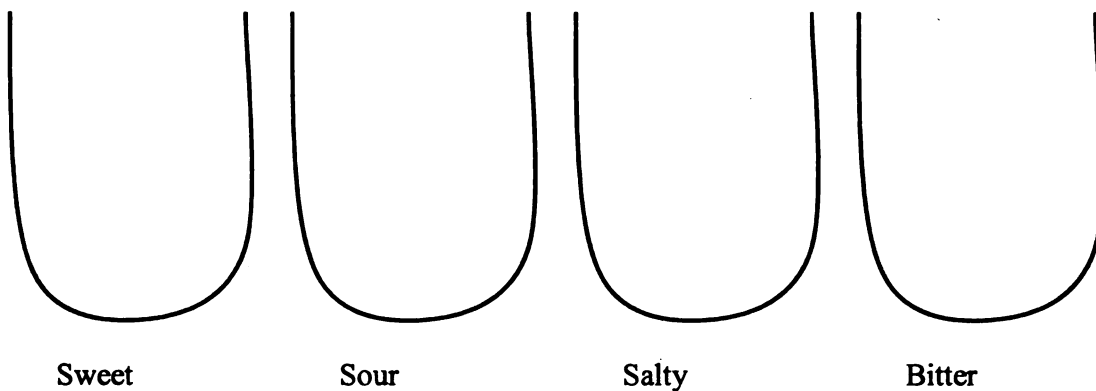
1. Obtain one piece of each food for each person in the lab group.
2. The subject will sit facing the tester with their eyes closed and nose plugged.
3. EYES AND NOSE MUST REMAIN CLOSED!
4. The tester will place one of the test foods on the subject's tongue and then remove it without the subject chewing it.
5. The subject will identify what food was placed on their tongue.
6. The tester will write down what the subject guessed.
7. Repeat steps 3-6 for the other test foods.
8. Change jobs and repeat steps 1-7

Pre-Lab Questions:

1. Describe the structure of a taste bud. _____

2. Describe the taste you prefer when eating and why. _____

Diagram Part A: Mapping Taste on Your Tongue



Data Table Part B: Sweet Thing:

	20%	10%	5%	2.5%	1.25%	0%
Taste? Y/N						

Data Table Part C: Tasty Vision

Substance	Guess	Actual
1		
2		
3		
4		

Summary Questions:

1. What area(s) of your tongue was most/least sensitive to each of the four basic tastes?

2. Describe some foods that have a combination of two or more of the basic tastes.

3. Explain where your threshold for tasting sweet is and why it is that hi a percent.

4. Describe the sensation you had with each of the four substances placed on you tongue for part C of this lab only using your sense of taste.

5. Describe how taste, smell and vision are related. _____

6. Explain the factors from this lab affect the sense of taste and the intensity of taste.

7. Explain and describe what you learned from doing this laboratory activity.

APENDIX H

TASTING COLOR LAB ACTIVITY

Tasting Color?

Equipment:

- Five flavored pops
- Cups
- Fruit Stripe Gum
- Low Sodium Salty Crackers

Objective:

The student will determine if vision is related to taste by performing laboratory activities.

Procedure:

6. Read the Entire Lab Carefully!
7. Wash Your Hands. Because we are doing a lab that deals with placing things in others mouths we must be sanitary!!!
8. This lab works best with two people per lab group.

Part A: Pop To It

1. Obtain 5 cups for each individual in the lab group and label them 1-5.
2. Pour 15 ml of each pop into each cup and return to lab station.
3. Start with cup #1 and taste the pop in it, record the color and what you believe to be the flavor in data table A. Each ¼ of a low sodium salty cracker.
4. Repeat step with each of the other 4 cups.
5. Dispose of cups into the trash and clean lab area.

Part B: Fruity Fun Gum

1. Obtain a ½ piece of three different colors of fruit strip gum for each lab subject.
2. Have your lab partner who is to be the subject of the first trial close their eyes and plug their nose before beginning.
3. Place one of the ½ pieces of gum in their tongue and have them chew the gum and identify the color and flavor of the gum only using the sense of taste.
4. Record their observation along with the correct answer in data table B.
5. Place the chewed piece of gum directly into the trash and eat a ¼ of a salty.
6. Repeat steps 3-5 with the other two pieces of fruit strip gum.
7. Trade jobs and repeat steps 2-6.
8. Clean lab area and do summary questions.

Data Table A: Colored Pop

Cup →	1	2	3	4	5
Color					
Flavor					

Data Table B: Colored Gum

Gum	Actual Color	Actual Flavor	Guess Color	Guess Flavor
1				
2				
3				

Summary Questions:

1. Does what you see influence what you taste? Explain. _____

2. Were you able to identify each of the colored soda pop flavors? Which one was the easiest? Which was the toughest? Explain.

3. Did color influence your decision for identification of the colored pop flavors? Explain

4. Where you able to identify the color and flavor of the fruit strip gum? What were the reasons for this?

5. Was it easier to identify the flavors of the color pop or the fruit strip gum? Explain.

6. Teacher directed discussion question.

7. Describe what you learned about the sense of taste from this lab activity.

APENDIX I

HOW WELL DO YOU SEE LAB ACTIVITY

How Well Do You See:

Equipment:

- 👁️ Eye Chart (Snellen Type)
- 👁️ Astigmatism Chart
- 👁️ Tape Measure
- 👁️ Masking Tape

Objective:

Students will determine if they have any sight problems and check their vision.

Procedure:

1. READ lab carefully.
2. Do Pre-Lab questions.

Part A: Visual Acuity

1. Place the eye chart on the wall at approximately “eye” level.
2. Measure back 20 feet with the tape measure and mark the floor with masking tape
3. If you wear glasses remove them for the first trial
4. With both eyes open cover one eye and read as many lines down as possible.
5. Cover the other eye and repeat the process.
6. If you wear glasses repeat steps 4 –5.
7. Repeat test using both eyes without then with glasses if you wear them.
8. Record results in the data table A, based on the sequence of 70, 60, 50, 40, 30, 20, 10, 7, 4 from the top down.

Part B: Astigmatism

1. Obtain the astigmatism test chart.
2. Look at the center of the test chart.
3. If all the peripheral lines have equal intensity of blackness, astigmatism is not present.
4. Cover each eye and repeat steps 2 &3.
5. If you wear glasses repeat steps 2-4.
6. Record you results in data table B.
7. Answer summary questions.

Pre-Laboratory Questions:

1. Explain what is meant by 20/20 vision. _____

2. Describe the physiology that causes astigmatism. _____

3. Explain and Diagram what occurs with the light rays as they enter a normal eye and one that has astigmatism.

Your Diagrams:

Data Table A: Visual Acuity

Eye	Sight Ratio without Glasses	Sight Ration with Glasses
Right	20/	20/
Left	20/	20/
Both	20/	20/

Data Table B: Astigmatism

Eye	Present	Absent
Right		
Left		

Summary Questions:

1. Did you or anyone in your lab group show any signs of astigmatism? If so, what lines were different in darkness?

2. Was it easier to do the astigmatism test with both eyes or a single eye? Why?

3. How does your vision compare between left, right and both eyes for part A? Why?

4. Based on the result for your lab group, explain which way it was easier to see the eye chart and why it was easier this way.

5. If you can read correctly at 20 feet the line designated for 20 feet, you have “normal” vision of 20/20. How does your vision compare with and without glasses?

6. Explain and describe what you learned from doing this laboratory activity.

APENDIX J

SEEING CLOSE UP LAB ACTIVITY

Seeing Close-Up

Equipment:

- 👁️ Blind Spot Dot/+ Chart
- 👁️ Index Card with Typed Capital Letter
- 👁️ Ruler

Objective:

Students will locate their blind spot and how close they are able to focus on an object.

Procedure:

1. Read the laboratory activity carefully.
2. Close your left eye and hold your left arm out in front of you with a pencil in it.
3. Hold your right arm with your index finger up out to the side and slowly move it toward your left.
4. Look only at the pencil in your left hand.
5. Record what happens in Summary questions.
6. Do Pre-Lab questions.

Part A: Blind-Spot

1. Obtain a Blind Spot card
2. Holding the Dot/+ sign card so the dot is on the outside close one eye and stare at the plus sign.
3. Slowly move the card forward and back from your eye, remember only look at the plus sign!
4. When the dot disappears measure and record the distance in the data table.
5. Cover the other eye and repeat steps 2-4.

Part B: Near-Point Determination

1. Hold an index card with a typed capital letter in the center.
2. Close one eye, and move the card toward your eye until the image becomes blurry and then away until the letter is sharp again.
3. Measure and record the distance in the data table.
4. Close the other eye and repeat steps 1-3

Pre-Laboratory Questions:

1. Explain what causes a blind spot in vision. _____

2. Explain what happens to the lens of your eye as you look at distance object and then at those object up close. _____

3. Describe how an eye focuses on an object at various distances. _____

Data Table:

Eye	Distance of Blind Spot	Distance of Near-Point
Right		
Left		

Summary Questions:

1. Describe what occurred when you were observing your right hand moving toward your left in the first activity for this lab.

2. How do the distances between your left and right eyes compare for blind spot determination? What does this mean?

3. How do the distances compare between your left and right eye for near point determination? What does this mean?

4. Is there any similarity between blind spot distance and near-point for either or your eyes when you tested them?

5. Explain why it is important to have two eyes for vision. _____

6. If excellent refraction is 7.6 cm and very poor is 152.4, how is your near point vision?

7. Explain what you learned about vision from doing these laboratory activities.

APENDIX K

RODS AND CONES LAB ACTIVITY

Rods and Cones:

Equipment:

- 👁 Colorblindness Charts
- 👁 Set of Colored Paper Shapes
- 👁 Meter Stick
- 👁 String
- 👁 Protractor
- 👁 Masking Tape
- 👁 Pen

Objective:

Students will study the functions and differences of rods and cones in the human eyes.

Procedure:

1. Read lab carefully!
2. Do Pre-Lab questions.

Part A: Colorblindness

1. Obtain a color blindness test page
2. Look at the patterns of dots and write down the numbers you see in the data table for part A.
3. Compare what you see to your lab partners.

Part B: Motion, Shape, and Color

1. Use the meter stick and string to make a 1 to 1 ½ -meter long section of string.
2. Use the string to make a ½ circle on the floor. (See Diagram 1)
3. The lab partner should hold one of the shapes and SLOWLY walk the ½ circle for the left eye.
4. The participant should stand at the X of the circle (see diagram 1) facing forward, NOT TURNING THEIR HEAD!!!!
5. When the participant sees movement they say, "Stop, Movement. The recorder should put a piece of masking tape labeled motion with the participant's name.
6. The lab partner should then continue to SLOWLY walk the half circle until the participant sees shape.

7. When the participant sees shape they should say, "Stop, Shape" and correctly name the shape.
8. If they do this then the recorder should place a piece of masking tape labeled shape with the participant's name.
9. The lab partner should then continue slowly walking the half circle until the participant says, "Stop, Color" and correctly names the color.
10. The recorder should place a piece of tape with color and the participants name on the half circle at this point.
11. Repeat steps 3-10 with the other eye.
12. Use the two-meter string and protractor to determine the participants vision areas.
Record results data into table.
13. Repeat lab with each participant
14. Do calculations and summary questions.

Pre-Laboratory Questions:

1. Explain the function and location of rods. _____

2. Explain the function and location of cones. _____

3. Describe peripheral vision and when it is useful. _____

4. Describe Red/Green colorblindness. _____

Data Table A: Colorblindness

A	E
B	F
C	G
D	

Data Table B: Motion, Shape, and Color

	Left Eye	Right Eye	Vision Area in Degrees
Movement			
Shape			
Color			

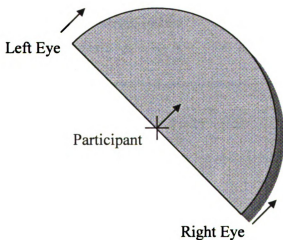


Diagram 1:

Summary Questions:

1. Describe what you say in the color chart and how your results compare with others in your lab group.

2. How do the areas of motion, shape and color compare?

3. How does your degree of vision compare for your left and right eye?

4. What is the relationship between the location of rods and cones and the vision areas? you determined using this activity?

5. Explain what vision would be like after a drug has destroyed all in the retina and how it would have changed the lab results.

6. Explain and describe what you learned from doing this laboratory activity.

APENDIX L

DO YOUR PENNIES RING LAB DEMONSTRATION

Do Your Pennies Ring?

Equipment:

20 or more pennies from 1960's to Present

Objective:

The learner will appraise the sound generated from pennies dropped on a table to determine the make-up of those pennies compared to others dropped.

Background Information & Procedure:

The U.S. government changed the metal make-up of pennies from 100% copper to copper-plated zinc. The question is, "When did they do this?" Pennies that are old have a "full", "ringing" sound to them, while the pennies that are copper-plated have a "tinny", "dull" sound to them. As the instructor drops the pennies LISTEN CAREFULLY and decide if it is an older penny or new one. If you think it is an older penny with a full ring place an "O" in the correct year on the data table, if on the other hand you think it is a newer penny with a dull tinny sound, place an "N" in the correct year on the data table. Do not shout the answer out; let others decide for themselves! Then listen as the instructor drops a penny from Canada. Answer the summary questions.

Data Table:

<u>1960</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>	<u>1965</u>	<u>1966</u>	<u>1967</u>	<u>1968</u>	<u>1969</u>
<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986</u>	<u>1987</u>	<u>1988</u>	<u>1989</u>
<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>	<u>1994</u>	<u>1995</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>	<u>1999</u>
<u>2000</u>	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>				

Summary Questions:

1. Based on your observation when do you believe pennies started being made of copper-plated zinc instead of 100% copper? Why?

2. How do your results compare with the rest of the class? Are there any discrepancies?

3. Based on the sound produced from an old penny that is 100% copper and a new penny that is copper-plated zinc, describe the make-up of a penny from Canada.

4. Describe what you learned from this demonstration activity.

Going Further Question:

Did Canada ever change the make-up of their pennies?

APENDIX M

TUNING IN? LAB ACTIVITY

Tuning In?

Equipment:

- 🔊 Tuning Forks
- 🔊 Ear Plugs

Objective:

The students will evaluate the quality of their hearing by performing various tests.

Procedure:

1. Read Laboratory Carefully!!!
2. Activate the tuning fork and touch the base to the top of your skull.
3. Repeat step 2 this time with one ear plugged then the other, then both.

Part A: Webber Test

1. The subject should be seated facing the tester.
2. The tester should activate the tuning fork and place the base of the tuning fork in center of the subject's forehead.
3. In the data table record if hearing was the same in both ear or better in one.

Part B: Rinne Test

1. Have the subject of the lab activity plug one ear.
2. The tester should activate the tuning fork and place the base of the fork on the subject's mastoid process of the temporal bone, this is the protrusion located right behind the ear.
3. When the subject can no longer hear the tuning fork, immediately place the vibrating end of the fork 7 to 15 centimeters away from the outer ear.
4. The subject should indicate if they can hear the tuning fork again. Record this in the data table. Y for yes subject can hear the tuning fork again, N for no cannot.
5. The tester should then activate the tuning fork again and this time placing it 7 to 15 centimeters from the outer ear of the subject.
6. When the subject says they cannot hear the vibrations, the tester should immediately place the base of the tuning fork on the mastoid process of the temporal bone.
7. Record if the subject could hear the vibrations of the tuning fork in the data table.
8. Have the subject un-plug one ear and plug the other and repeat steps 1 to 7.
9. Change jobs from subject to tester and repeat steps 1-8.

Data Table:

Ear	Webber Test Same in Both Ears Or Louder in One	Rinne Test Start on Mastoid Process (Y/N)	Rinne Test End on Mastoid Process (Y/N)
Right			
Left			

Summary Questions:

1. Explain, which is superior in conduction of sound waves, air or bone. Why?

2. Describe if the Webber and Rinne Tests supported or refuted each other. _____

3. In a person with middle-ear deafness the inner ear bonds are often partially fused and do not move properly when sound waves traveling though the air hit the ear drum. Such an individual will not be able to hear sound when the tuning fork handle is removed from the mastoid process or reheard when it is applied. Based on this information defend if anyone in the lab group has any inner ear deafness.

4. Explain and describe what you have learned about the sense of hearing from this lab.

APENDIX N

CAN YOU HEAR IT? LAB ACTIVITY

Can You Hear It?

Equipment:

- 🔊 Ticking Watches or Clocks
- 🔊 Tape Measure
- 🔊 Ear Plugs
- 🔊 Pencils (Tap together for sound)
- 🔊 Blindfold
- 🔊 Masking Tape

Objective:

The learner will evaluate the sharpness of their hearing by performing various tests.

Procedure:

1. BE COMPLETELY SILENT WHEN DOING THIS LAB!!!!
2. Read Laboratory Activity Carefully!!

Part A: Auditory Acuity

1. The test subject should sit with one ear plugged.
2. The tester should hold a ticking clock several feet away at the side of the unplugged ear.
3. The tester should move the watch toward the subject's head, *very slowly*.
4. The subject should signal when they can first hear the ticking watch.
5. The tester should stop the watch and mark that location with tape.
6. Measure the distance from the tape to the subject's ear.
7. Repeat steps 4-6 four more times to insure accurate results of distance.
8. Now reverse the process by starting close to the subject's ear and move away.
9. Switch ears and repeat steps 2-8.
10. Change jobs and repeat steps 1-9.

Part B: Distance Determination

1. Use the masking tape to make an "X" on the floor.
2. Measure distances in a straight line in increments of 1 meter, up to 10 meters, from the X and label each one with its distance from X.
3. Place the blindfolded subject on the X.
4. The tester should stand at one of the points and say the subject's name.

5. The subject must tell the tester at which line they are standing.
6. Repeat steps 4 & 5 from various locations from the subject.
7. Have the subject plug their right ear and repeat steps 4-6.
8. Have the subject now plug their left ear and repeat steps 4-6.

Part C: Location Determination

1. Place an "X" out of masking tape in the center of a room
2. Measure out a five-meter piece of string.
3. Use the string and make a circle from the "X".
4. Place the blindfolded subject on the "X".
5. Place people at all the 'clock' positions. It is important to have someone directly in front and someone directly behind the subject.
6. Each person should have two pencils to produce the same sound.
7. Have random people tap the pencils together and have the subject point to where the sound was generated without turning their head.

Data Table A:

Trial	Left Ear Clock Toward	Right Ear Clock Toward	Left Ear Clock Away	Right Ear Clock Away
1				
2				
3				
4				
5				
Average				

Summary Questions:

1. Describe what occurs with the human ear in order to hear a sound. _____

2. Explain why it is better to have two ears for hearing rather than one. _____

3. Describe when it was easier to determine distance of sound and why it was easier.

4. Describe the sensation when doing the location determination laboratory activity.

5. Explain and describe what you have learned about hearing from doing this lab.

APENDIX O

BALANCING ACT? LAB ACTIVITY

Balancing Act?

Equipment:

- ✦ Stopwatch (Clock w/ Second Hand)
- ✦ Pencil
- ✦ Meter Stick
- ✦ Chair that Rotates
- ✦ Blindfold (Optional)

Objective:

The student will evaluate how a body determines its position based on muscle tension, examine the various ways a body balances, and compare dynamic and static equilibrium.

Procedure:

1. Read Lab Carefully!
2. Do Pre-Lab Questions.
3. Obtain materials for laboratory activities.

Part A: Balance Test

1. Have the subject of the test either put on the blindfold or have their eyes closed.
2. The subject should stand perfectly stationary for one minute.
3. The subject should then stand perfectly stationary on one leg for one minute.
4. Repeat step 3 on the other leg for one minute.
5. Maintaining balance indicates healthy function for maintaining static equilibrium.
6. Record what occurred in data table A.
7. Change jobs and repeat steps 1-6.

Part B: Proprioception Tests

1. The subject of the lab should be seated with a blindfold on and their heel of their right foot on the left foot toes.
2. The subject needs to bring the index finger from an extended arm position to the nose and touch just the tip of their nose.
3. Repeat with the other arm.
4. Record what occurred in data table B-1.
5. The subject should now sit with their eyes open and have their hands on their knees facing the tester.
6. The tester should hold a pencil 1 meter from the subject.

7. The subject should raise their right hand from their right knee vertically and move it forward to touch the pencil tip.
8. Continue this cycle 10 times at the rate of once each second.
9. Repeat steps 5-8 with the test subject's eyes closed or a blindfold used.
10. Record the results in data table B-2.

Part C: Rotation Tests

1. The subject should sit cross-legged with eyes open in the rotating chair.
2. The tester will turn the subject at the rate of once revolution per second.
3. The tester will stop the subject after 10 revolutions, making sure the subject stops at the same starting position.
4. The tester will then hold a pencil at the same position as in the Proprioception test. Ask the subject to point to the tip of the pencil.
5. The subject should continue this cycle for 10 times at one per second; after each touch make sure that the hand is returned to the knee.
6. The subject should now be blindfolded and then the tester, by feel, should show the subject where the tip of the pencil is located. **KEEP THE LOCATION OF PENCIL TIP CONSTANT.**
7. Revolve the subject once per second for ten revolutions. Stop the subject at the starting position.
8. Immediately ask the subject to point to the perceived location of the pencil tip. **DO NOT** let the subject touch the pencil.
9. Repeat the motion to the pencil tip 10 times making sure the hand returns to the knee each time.
10. Record the results in data table C.
11. Repeat steps 1-10 revolve the subject the other direction.
12. Change jobs and repeat steps 1-11.

Pre-Lab Questions:

1. Explain what must occur for a person to maintain their balance when sitting, standing, walking and jogging/running.

2. Explain what has occurred when a person wakes up and can not “feel” their arm because of its position.

3. Describe when it is the easiest to maintain balance. _____

Data Table A: Balancing Act

Standing	Both Legs	Left Leg	Right Leg
Stationary Y/N Explain			

Data Table B-1: Proprioception

Index Finger ⇔	Left	Right
Touch Nose Y/N Explain		

Data Table B-2: Proprioception

Indicate if the subject was able to touch the pencil tip Y/N

Trial ⇄ Eyes ↓	1	2	3	4	5	6	7	8	9	10
Open										
Closed										

Data Table C: Rotation

Indicate if the subject was able to touch the pencil tip Y/N

Trial ⇄ Eyes ↓	1	2	3	4	5	6	7	8	9	10
Open										
Closed										

Summary Questions:

1. Describe what occurred in part A of the laboratory activity, sway or stationary?
What does this state about your static equilibrium?

2. Describe what occurred in part B for touching your nose in regards to proprioceptors.

3. Explain how well your proprioceptors functioned in part B of the laboratory activity.

4. Describe what occurred with proprioception once the blindfold was applied.

5. Explain the result of spinning on proprioception and describe what it “felt” like.

6. Based on the data for part C, describe your ability to maintain of dynamic equilibrium.

7. Give real world examples of when a problem with dynamic equilibrium is considered a good thing and when it is considered a bad thing.

8. Explain what you learned about equilibrium from doing these laboratory activities.

APENDIX P

CAN YOU FEEL IT? LAB ACTIVITY

Can You Feel It?

Equipment:

- ☛ 5-10 grades of sandpaper
- ☛ Calipers
- ☛ Von Frey Hairs (Monofilament Fishing Line on Popsicle Sticks)
- ☛ Blindfold & Toothpicks (optional)

Objective:

The students will evaluate comparative degrees of sensitivity on skin surface to touch and determine tactile detection threshold.

Procedure:

1. Read Lab Carefully.
2. Do Pre-Lab questions.
3. This laboratory activity works best with lab groups of two.

Part A: Rough Going

1. Obtain a set of sand paper squares and a blindfold
2. Have the subject of the lab activity put on the blindfold.
3. The tester of the lab group should place the sand paper squares in a pile.
4. The subject should place the sand paper in order of roughness using only their sense of touch.
5. Check to see if the subject was able to accomplish the task.
6. Change jobs and repeat steps 2-5.

Part B: Detection Threshold

1. Obtain a set of Von Frey Hairs and a blindfold
2. Have the lab subject place the blindfold on and sit quietly.
3. The lab tester should pick one of the Von Frey Hairs at random.
4. The tester should touch the Von Frey Hair to the lab subjects back of the hand until the hair bends.
5. Ask the person if they feel anything. Record if they did or didn't in data table B.
6. At random do not touch a Von Frey Hair and ask.
7. Repeat Steps 3-5 using all the Von Frey Hairs for three trials.
8. Switch jobs and repeat steps 2-7.

Part C: Touching Two Point

1. You will be measuring two-point discrimination in 4 locations on your lab partner.
2. The ones that everyone will be doing are back of the left hand/wrist, the back of the neck and tip of the right index finger.
3. The fourth location is one that you pick, remember NO BAHTING SUIT AREAS! Make good choices!!
4. Obtain a Caliper and Blindfold
5. If the caliper does not have points on it that touch attach toothpicks with tape so they make a point where the ends touch at zero. If the points touch go to step 6.
6. Remember you are LIGHTLY TOUCHING; no pressure is applied to the caliper!
7. Have the subject of the test put on the blindfold or close their eyes.
8. Using the caliper start with then 2.5 cm apart and lightly touch the back of the subjects left hand/wrist ask them if they feel two or one point of touch. If they say one, move the calipers farther apart until they say two.
9. Slowly move the calipers closer together until the subject says they feel one point of touch. You will want to use only one point every now and then to make sure the subject isn't cheating.
10. Record the distance the subject says they feel one in data table C for out to in.
11. Repeat steps 8-10 for two more trials.
12. Then start with the caliper points touching and move them apart until the subject says they feel two points of touch. Again using one every now and then.
13. When the subject says they feel two, record the measurement in data table C for in to out column.
14. Repeat steps 12-13 for two more trials.
15. Repeat steps 7-14 for the other areas.
16. Trade jobs and repeat steps 7-15.

Data Table B: Von Very Hairs

Lb Test	2 lb	4 lb	6 lb	8 lb	10 lb	12 lb
Trial #1 Y/N						
Trial #2 Y/N						
Trial #3 Y/N						

Data Table C: Two Point Discrimination

Outside to In	Back of Left Hand/Wrist	Back of the Neck	Tip of Right Index Finger	Your Choice of Location
Trial #1				
Trial #2				
Trial #3				
Average				
Inside to Out	Hand/Wrist	Neck	R Index Finger	Your Choice
Trial #1				
Trial #2				
Trial #3				
Average				

Summary Questions:

1. Explain the difference between the senses of touch, pressure and pain. _____

2. What other senses did you use when doing these lab activities? _____

3. Explain if it was easy or difficult to organize the sand paper into the proper order. Then explain what factors about you made it this way.

4. Based on your results of the Von Frey Hairs do you have a good detection threshold?

5. Explain what would happen if you used the Von Frey Hairs on your back. _____

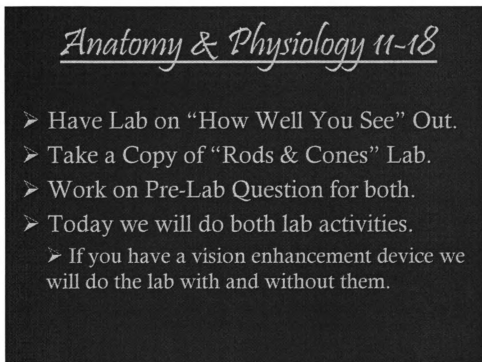
6. Based on your data which area has the most touch receptors? Which has the least?

7. Explain the reason why these areas have the most and least number of receptors.

8. Explain what you learned about the sense of touch from doing these lab activities.

APENDIX Q

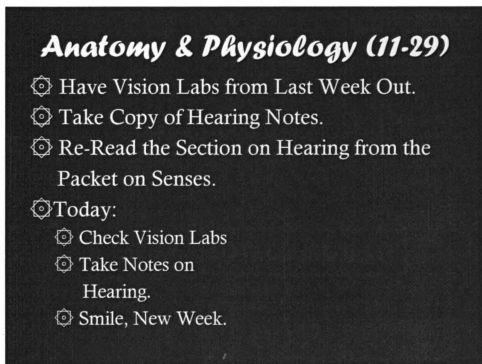
EXAMPLES OF SCROLLING INTRODUCTION SLIDES



Anatomy & Physiology 11-18

- Have Lab on “How Well You See” Out.
- Take a Copy of “Rods & Cones” Lab.
- Work on Pre-Lab Question for both.
- Today we will do both lab activities.
 - If you have a vision enhancement device we will do the lab with and without them.

Fig. 65 Introduction Slide Example 1



Anatomy & Physiology (11-29)

- ⊗ Have Vision Labs from Last Week Out.
- ⊗ Take Copy of Hearing Notes.
- ⊗ Re-Read the Section on Hearing from the Packet on Senses.
- ⊗ Today:
 - ⊗ Check Vision Labs
 - ⊗ Take Notes on Hearing.
 - ⊗ Smile, New Week.

Fig. 66 Introduction Slide Example 2

APENDIX R

PRE & POST-TEST EVALUATION OF INFORMATION

Pre & Post - Test Evaluation of Information

1. Explain how a reflex is different from a reaction. _____

2. Describe somatic sensory fatigue and give an example. _____

3. Describe olfactory fatigue and explain how it is difference from other sensory fatigue.

4. Explain how one can taste odors and colors. _____

5. Describe the differences between a colorblind and non-colorblind individual.

6. Explain the factors that affect balance. _____

7. Explain what you would experience if there was damage to your cerebral lobes.

8. Describe what would occur if someone lost the white matter around the nerves.

9. Explain what occurs in a fight or flight response of the nervous system. _____

10. Explain why someone who has lost a limb or digit will have phantom pain. ____

APPENDIX S

INDIVIDUAL STUDENT PRE AND POST TEST RESULT

INDIVIDUAL STUDENT PRE AND POST TEST RESULT

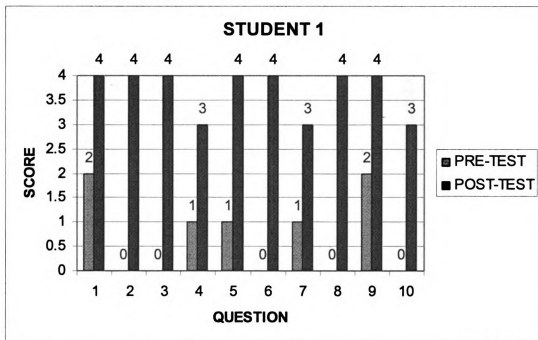


Fig. 67 Student 1 Pre-Post Test Results

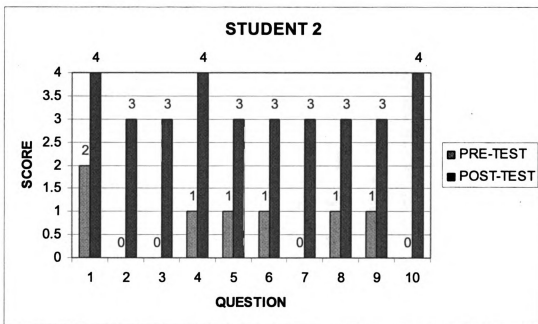


Fig. 68 Student 2 Pre-Post Test Results

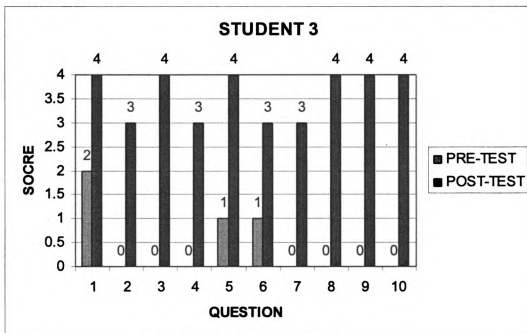


Fig. 69 Student 3 Pre-Post Test Results

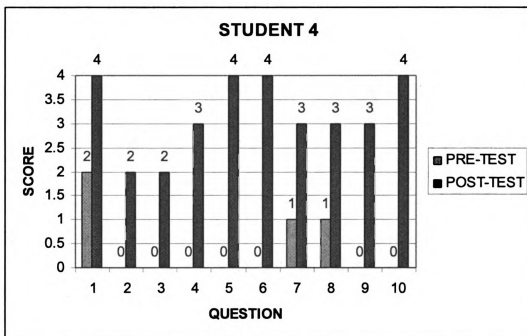


Fig. 70 Student 4 Pre-Post Test Results

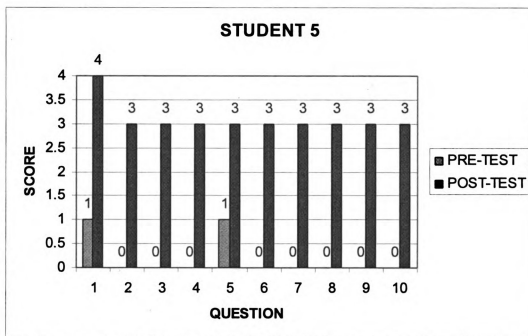


Fig. 71 Student 5 Pre-Post Test

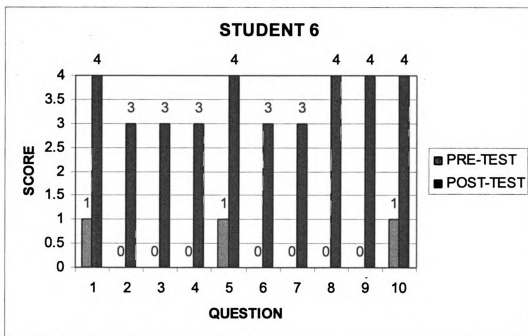


Fig. 72 Student 6 Pre-Post Test Results

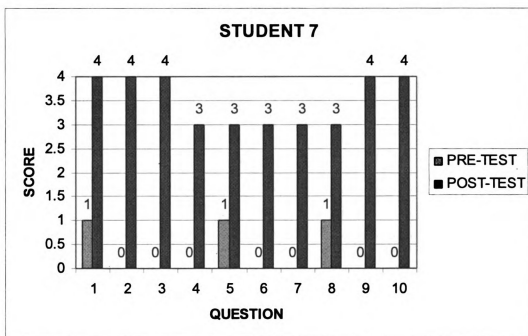


Fig. 73 Student 7 Pre-Post Test Results

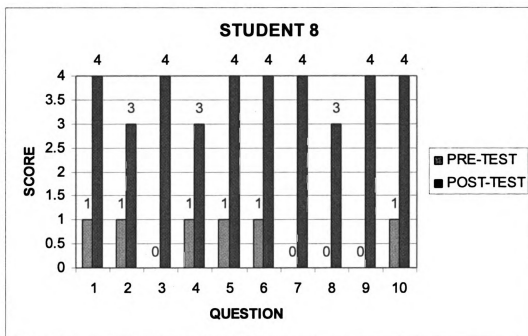


Fig. 74 Student 8 Pre-Post Test Results

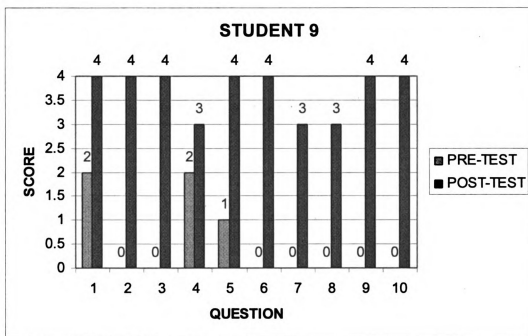


Fig. 75 Student 9 Pre-Post Test Results

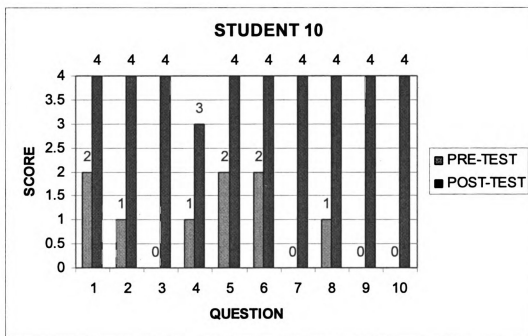


Fig. 76 Student 10 Pre-Post Test Results

APPENDIX T

PRE-POST TEST RESULTS BY QUESTION

PRE-POST TEST GRAPHS BY QUESTION

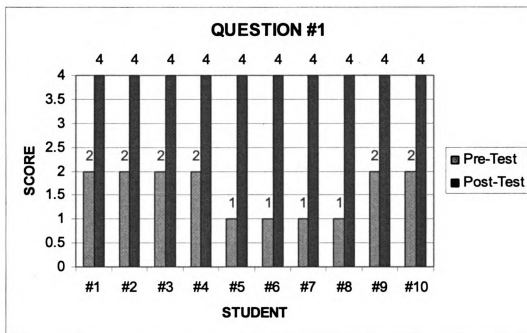


Fig. 77 Question 1 Pre-Post Test Results

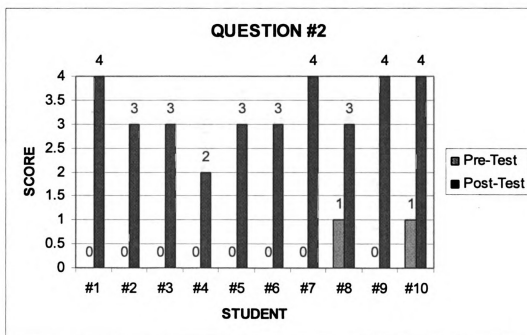


Fig. 78 Question 2 Pre-Post Test Results

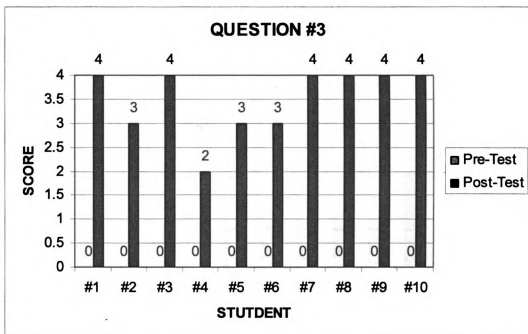


Fig. 79 Question 3 Pre-Post Test Results

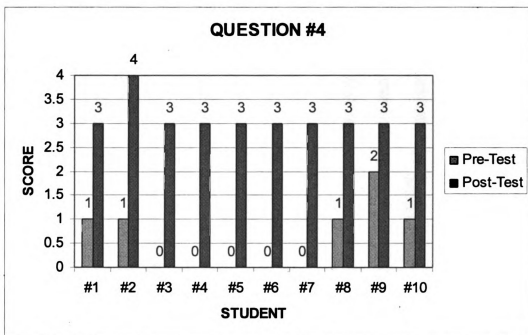


Fig. 80 Question 4 Pre-Post Test Results

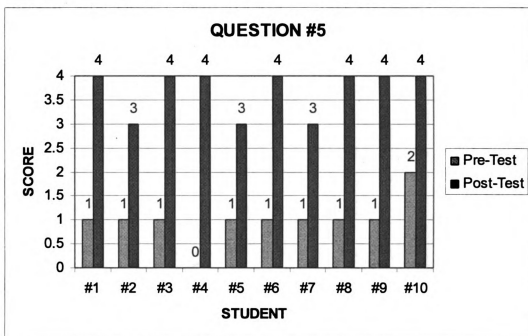


Fig. 81 Question 5 Pre-Post Test Results

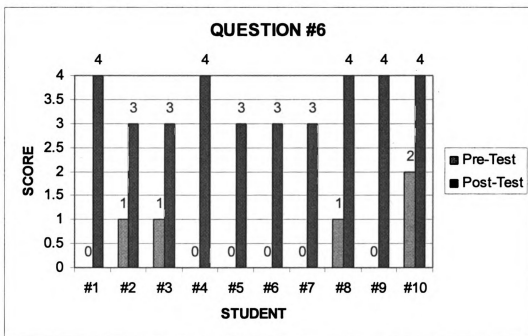


Fig. 82 Question 6 Pre-Post Test Results

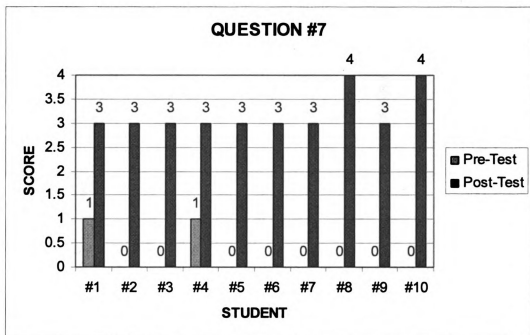


Fig. 83 Question 7 Pre-Post Test Results

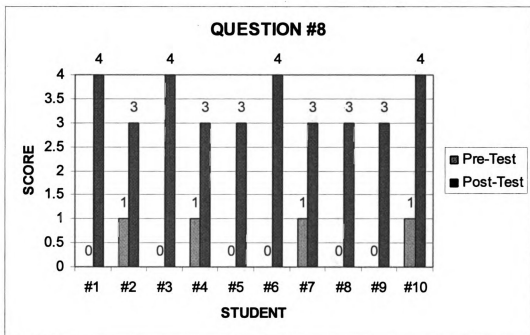


Fig. 84 Question 8 Pre-Post Test Results

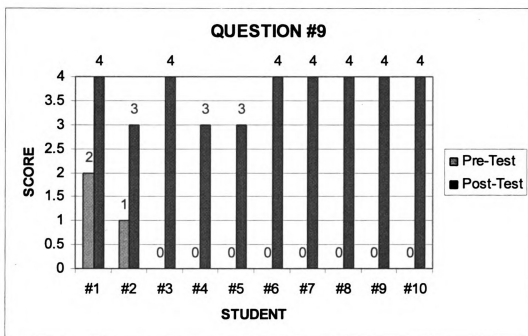


Fig. 85 Question 9 Pre-Post Test Results

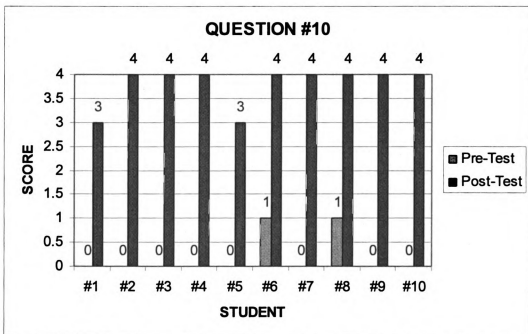


Fig. 86 Question 10 Pre-Post Test Results

APENDIX U

STUDENT ACTIVITY SURVEY

Nerves Senses & You; An Activity Based Approach Activity Survey

Please rate each of the following activities from the Senses & NS Unit

RATING SYSTEM:

1 helped, enjoyable; 2 helped, not enjoyable;

3 did not help, enjoyable; 4 did not help, not enjoyable

A. Reflexes, Reaction, and Distraction	1	2	3	4
B. Can You Smell It?	1	2	3	4
C. Can You Taste It?	1	2	3	4
D. Tasting Color?	1	2	3	4
E. Can You Hear It?	1	2	3	4
F. Do Your Pennies Ring?	1	2	3	4
G. Tuning In?	1	2	3	4
H. How Well Do You See?	1	2	3	4
I. Seeing Close Up	1	2	3	4
J. Rods & Cones	1	2	3	4
K. Can You Feel It?	1	2	3	4
L. Balancing Act?	1	2	3	4
M. Notes on PowerPoint	1	2	3	4

What are your thoughts on the presentation and instruction done on this unit?

APPENDIX V

STUDENTS' ACTIVITY SURVEY RESULTS

ACTIVITY ↓ STUDENT →	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Reflexes, Reaction & Distraction	1	1	1	2	3	1	1	1	1	2
Can You Smell It?	1	1	1	1	1	1	1	1	1	1
Can You Taste It?	1	1	1	1	1	1	1	1	1	1
Tasting Color	1	1	1	1	3	1	1	1	1	1
Can You Hear It?	1	1	1	1	1	1	1	1	1	1
Do Your Pennies Ring?	4	1	1	3	4	1	1	1	4	4
Tuning In?	4	1	1	1	3	1	1	1	3	1
How Well Do You See?	1	2	1	1	1	1	1	1	1	1
Seeing Close-Up	1	2	1	1	1	2	1	1	4	1
Rods & Cones	1	1	1	1	3	1	1	1	2	1
Can You Feel It?	1	4	2	2	3	1	1	1	1	1
Balancing Act	1	1	1	1	3	1	1	1	1	1
Power Point Notes	1	2	2	1	1	2	1	2	2	2

Table 2 Activity Survey Results by Student

APPENDIX W

CONCENT FORM

Parent/Student Consent Form

Re: Collection of Data for Master's Thesis

Anatomy & Physiology Unit: Nerves, Senses, and You an Activity Based Approach to the Teaching of Senses and the Nervous System

Dear Parents/Guardians and Students:

For the past three years I have been working on my Masters of Biology Education at Michigan State University through the Division of Science and Math Education. An important requirement for obtaining this degree is to write and submit a thesis explaining the implementation of effectiveness of a unit taught during a class. This past summer I redesigned a unit for Anatomy & Physiology. It is titled, "Nerves, Senses, and You an Activity Based Approach". In order to evaluate the effectiveness of this unit, I will be collecting data on pre and post tests, surveys on the students' reflections and opinions, questions from laboratory activities, homework and other assignments. With your permission, I would like to include your student's classroom data in my thesis. I would also like to use your student's picture as they perform the activities for this unit. **At no time will your student's name be attached to any of the work or associated with pictures included in the thesis, all information will remain confidential. Privacy for your student will be protected to the maximum extent allowable by law.**

There is no penalty for denying permission to use this data. Your decision will not affect your student's grade in any way. The requirements for the course will remain the same for all students whether their work is used in my thesis or not. At any time during the course, you may request that your student's work not be included in the data analysis. This unit will begin in October and conclude in approximately 4 to 6 weeks.

Please complete the back side of this form and return it to me by September 14, 2004. If there are any questions about this unit, please contact me at Webberville High School, (517) 521-3447 ext 117 or by email at keyesk@webbervilleschools.org.

If there are any questions about this study, please contact the Responsible Project Investigator- Dr. Merle Heidemann, DSME, 118 N. Kedzie, MSU, East Lansing, MI 48824, phone at (517) 432-2152 ext. 107, or email heidema2@msu.edu. If you have any question or concerns regarding your student's rights as a study participant, please contact Peter Vasilenko, M.D., Chair of the University Committee on Research Involving Human Subjects (UCRIHS) at (517) 355-2180, email ucrihs@msu.edu, or mail to Olds Hall, East Lansing, MI 48824.

Thank you,
Mr. Kenneth C. Keyes
High School Science Teacher
Webberville High School

Please read the following carefully and mark all that apply:

DATA USE:

➤ **Student Section:**

_____ I **voluntarily agree** to participate in this study. Mr. Keyes will not use my name and any student information will remain confidential

_____ I **do not agree** to participate in this study. There is no penalty for choosing to withhold my data.

➤ **Parent/Guardian Section:**

_____ I **grant permission** for Mr. Keyes to use my student's data in his thesis research. All data from my student used by Mr. Keyes will remain confidential.

_____ I **do not grant permission** for Mr. Keyes to use my student's data at any time during his thesis research. There is no penalty for choosing to withhold data.

PHOTOGRAPHY USE:

_____ I **grant permission** for Mr. Keyes to use my student's photograph during his Anatomy & Physiology Nervous System Unit for Thesis research. Their picture will remain confidential.

_____ I **do not grant permission** for Mr. Keyes to use my student's photograph at any time during his Thesis research.

Student's name _____

Student's signature _____ Date _____

Parent/Guardian name _____

Parent/Guardian signature _____ Date _____

GENERAL REFERENCES

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