Name _____ **Instructor** _____ **Lab Section**_____

Objectives: To gain an understanding of

- The organization of the human nervous system
- The structure and function of a reflex arc
- The structure and function of sensory receptors for light, sound, taste, smell and touch

Background material may be found in

- Chapter: 28.1 - 28.5, 28.12 - 28.16
- Chapter: 29 (all sections)

Biology: Concepts & Connections, 8th ed.

A property of all living organisms is the ability to detect and respond to environmental factors (stimuli) that are critical to survival and reproduction. The purpose of this lab is to investigate the structure and function of the human nervous system and to understand how the activities of the nervous and muscular systems are integrated to produce adaptive responses to various types of stimuli.

The human nervous system has three main functions:

1. **Sensory Input** – signals from sensory receptors, such as photoreceptors in the eye, are transmitted to the central nervous system (CNS)
2. **Integration** – organs of the CNS process/interpret information received from sensory systems and formulate a response
3. **Motor Output** – signals are sent from the CNS to **effector cells**, such as glands or muscles, which carry out a response

I. PARTS OF THE HUMAN NERVOUS SYSTEM

• THE CENTRAL NERVOUS SYSTEM (CNS)

The brain and spinal cord make up the **central nervous system.**

1. THE BRAIN

The brain is the enlarged, anterior end of the spinal cord which is protected by the skull. Since the detailed anatomy of the brain is exceedingly complex, we shall consider only four main regions: **cerebrum, hypothalamus, cerebellum,** and **medulla oblongata.**

Examine one of the models of the human brain and identify the following parts. Note the function of each part.

- ***CEREBRUM***

The cerebrum is the largest component of the mammalian brain and is divided into the **right and left cerebral hemispheres** by the **longitudinal fissure**. The outer portion of the cerebrum is the cortex, which is composed of **grey matter** (**cerebral cortex**). Intelligence, personality, self-will, some memory, and much of sensory perception are the functions of the cerebrum.

- ***HYPOTHALAMUS***

The hypothalamus forms the floor of the third **ventricle** of the brain and communicates with the thalamus, cerebrum, and brainstem. Collections of neurons controlling hunger, body temperature, water metabolism (thirst) and sex drive are present in the hypothalamus. The primary function of the hypothalamus is homeostasis. Most of these are homeostatic functions and are regulated via the release of hormones which affect the functions of the **pituitary gland**. The hypothalamus also has centers for pleasure, reproductive behavior, hostility and pain.

- ***CEREBELLUM***

The cerebellum is located posterior and inferior to the cerebrum and is divided into right and left lobes by a fissure. The cerebellum functions below the level of consciousness in coordinating equilibrium and motor activity.

- ***MEDULLA OBLONGATA***

The medulla oblongata is the most posterior portion of the brainstem. Nervous processes pass from the spinal cord through the medulla to higher brain regions. **Cardiac and ventilatory (breathing) control centers are present in the medulla oblongata**.

2. THE SPINAL CORD

The **spinal cord** is the part of the nervous system that extends from the posterior brain and is a region of the central nervous system that is partially responsible for local integration and reflex connections. It is protected by a series of hard bony segments which are **jointed (articulated)** into a **vertebral column (backbone).** Pairs of communication lines (**spinal nerves**) lead into and out from different levels of the spinal cord.

• THE PERIPHERAL NERVOUS SYSTEM (PNS)

All neurons outside of the spinal cord and brain comprise the peripheral nervous system. This integrated system of neurons consists of various nerve processes that connect the brain and spinal cord with receptor muscles and glands. **Sensory neurons** are the incoming communication pathways from sensory receptors and **motor neurons** form the outgoing pathways. The motor (efferent) neurons are subdivided into two categories:

1. **somatic nervous system**, which relays signals from the brain and spinal cord to the voluntary skeletal muscles and the
2. **autonomic nervous system**, which relays signals from the brain and spinal cord to the involuntary smooth muscles, cardiac muscle and glandular tissues. The autonomic nervous system regulates many physiological functions including: heart rate, contractility of the heart (how forcefully the heart beats), glandular secretions, blood vessel constriction and smooth muscle movement of the digestive system (peristalsis).

• NEURONS (NERVE CELLS)

The basic unit of the nervous system is the **nerve cell** or **neuron**. The function of the neuron is to rapidly respond to chemical, electrical or mechanical stimuli and via an integration of inputs and propagation, to transmit information from one part of the body to another.

A NEURON IS COMPOSED OF:

- **cell body**, where the **nucleus and most of the organelles** are found
- **dendrites**, for **input** of a chemical signal (neurotransmitter) across a synapse **from another neuron**
- **axon**, the long cytoplasmic extension that allows the nerve cell to **convey the signal some distance** to another neuron
- **nerve cell terminals or synaptic knobs,** for **output** via a chemical signal (neurotransmitter) **to other neurons** across a synapse
- As your instructor will describe, some neurons are insulated by a lipid-based substance called **myelin** which allows for a more rapid propagation and transmission of electrical signals (action potentials) along these **myelinated neurons**. Myelinated neurons carry electrical signals about 50 times faster than non-myelinated neurons of the same size.

Draw a sketch of a neuron, label the axon, nucleus and dendrites. Now add a myelin sheath as described by your instructor.

II. REFLEXES

A reflex behavior is one which occurs without conscious effort. A simple reflex does not require intervention by the brain. A reflex involves the detection of a stimulus by one of many types of **sensory receptors** which generate an action potential (an electrical signal) in a **sensory (or afferent) neuron** that conveys the signal into the **spinal cord**. Sensory neurons synapse with and generate action potentials in **interneurons** found within the spinal cord. These interneurons synapse with and can affect the generation of action potentials in **motor (or efferent) neurons** which innervate **motor end organs** (muscles are an example) to cause an appropriate response.

- **THE REFLEX ARC**

Draw the cross section of the spinal cord and its associated reflex arc which your instructor presents.

PROCEDURE

1. TENDON REFLEXES: two tendon reflexes easily demonstrated are the patellar and Achilles reflexes. When these tendons are mechanically stimulated by tapping with a reflex hammer, the sensory neuron in the tendon transmits impulses over the reflex arc through the spinal cord back to a motor neuron that innervates the same muscle attached to the tendon that was stimulated. The muscle then contracts and tugs on the tendon causing movement of a bone in the foot or leg.

a. ACHILLES - have the subject rest one knee on a chair so that the leg is flexed (heel facing up). Tap the Achilles tendon at the ankle with the reflex hammer. **Which way does the foot move?_____** (Toward the knee is *flexion*, away from the knee is *extension*)

b. PATELLAR - have the subject sit on the table so that the legs hang free. Tap the patellar tendon sharply just below the patella (kneecap) with the reflex hammer. **Which way does the foot move?_____** ("kicking out" is *extension*, retraction backwards is *flexion*)

2. BLINK REFLEX

a. Using the rubber bulb, gently blow a jet of air from the side over the eyeball of your partner. **Can he or she inhibit the reflex?_____**

b. Feint toward your partner's eyes to make them blink. **Can this reflex be inhibited?_____**

c. How is the blink reflex helpful to the functioning of the eyes?

III. RECEPTORS (SENSES)

In this section you will examine the various receptors or sensory structures of the body. It should be emphasized that these receptors are not where feeling is actually experienced. Instead, they are merely receptive to stimulation (sensation) and transmit information to the central nervous system CNS where the perception of feeling is actually produced.

A. TOUCH (TACTILE) DISCRIMINATION

In this exercise you will attempt to determine the concentration of touch receptors in the skin of the four areas of the body listed in the next section.

PROCEDURE

1. Set the two points of the sliding micrometer (two-point discriminator) 4 to 5 cm apart.

2. Have your partner close his or her eyes and, beginning with the palm, lightly touch his or her palm with the two points simultaneously. Your partner should feel two distinct points.

3. With each successive touch, gradually reduce the distance between the two points, until you reach a distance at which the two points feel like a single point to your partner. **Record the distance below in the appropriate space**.

4. Use the same procedure for the other 3 areas of your partner's body.

PALM _____ **BACK OF HAND** _____

FINGERTIP _____ **BACK OF NECK** _____

QUESTIONS

1. According to your results, in which areas are touch receptors closest together?

2. Where are they least concentrated?

3. Why is this arrangement of receptors adaptive (helpful to survival) to humans?

B. TEMPERATURE JUDGEMENT

The purpose of this exercise is to illustrate the effect of previous experience on temperature judgment. You will first stimulate the cold receptors in one hand and the heat receptors in the other hand at the same time. You will then place both hands in room temperature water and compare how the room temperature water feels to each hand.

PROCEDURE

1. At the side counter are three plastic trays. One is filled with hot water, the one in the center with room temperature water, and the other is filled with cold water.

2. Start by placing your left hand in the pan on your left and your right hand in the pan on the right. Let them soak in the water for one minute or so, until each is acclimated to the water.

3. Then, remove both hands at once and quickly place them in the center plastic tub, noting how each hand feels as you do so.

QUESTIONS

1. What did the "hot hand" feel like when you placed it into the room temperature water? How did this compare to the feeling of the "cold hand?"

2. Based on your results, is the sensation of temperature relative or absolute? Relate this to your feeling of temperature when you come into a cold room from an even colder outside temperature.

C. SMELL (OLFACTION) AND SENSORY ADAPTATION

Have you ever noticed how a scent that you are exposed to continually seems to disappear over time? (Think of working in a room with a strong odor. After a while, you don't notice the odor. But, if you leave the room for a period and return, it once again seems strong.) You are experiencing **sensory adaptation**, a term that refers to a decrease in the intensity of a sensation during continuous exposure to a certain stimulus. Sensory neurons that are exposed repeatedly to the same stimulus "get used to" that stimulus and fire fewer action potentials. Sensory adaptation, while present in many different types of receptors, is particularly noticeable with the sense of smell.

PROCEDURE

1. Obtain four vials of scents (camphor, vanilla, spearmint, and clove) and take them back to your bench.

2. Open one vial at a time and hold it directly under one nostril, while blocking the other nostril. **Note the time.**

3. Breathe normally and focus on the sensation of the scent. Is the intensity decreasing or remaining the same? Did the sensation of the scent eventually subside? If so, note the time in the table below. This is the time required for your nose to adapt to that odor. If you never adapted to a particular odor, note that in the table.

Scents	Adaptation Observed? (yes or no)	Time required for Adaptation
Vanilla		
Spearmint		
Clove		
Camphor		

QUESTION

1. What is the evolutionary significance of olfactory sensory adaptation? In other words, why is it useful to us that we do not continually notice background stimuli?

D. HEARING (HOW WE HEAR)

- **SOUND TRANSMISSION - OBSERVE THE MODEL OF THE EAR CANAL AND INNER EAR.**

The fact that much of what we hear is transmitted to our ears through the bones of our skull can be demonstrated by the following experiment.

PROCEDURE

1. Plug both ear openings with clean cotton.

2. Gently strike a tuning fork. Hold the vibrating tuning fork on the tip of your chin as demonstrated by your instructor. **Can you hear the sound?** Try pressing the vibrating fork on different parts of your head, including your jawbone.

QUESTIONS

1. In what region(s) does the tuning fork sound the loudest? Where does it sound the softest?

2. How is this related to your recorded voice never sounding quite the way you think you sound?

- **SOUND DISCRIMINATION**

PROCEDURE

l. Seat your laboratory partner and have them close both of their eyes.

2. Strike a tuning fork. Ask the subject to give the exact location of the sound in relation to the head. Record the results in the space below.

BELOW THE HEAD _____ BEHIND THE HEAD _____

ABOVE THE HEAD _____ IN FRONT OF THE SUBJECT _____

TO THE SIDES OF THE SUBJECT _____

QUESTION

Explain why the subject missed some of these sound locations.

E. VISION

Examine the model of the human eye and note the positions of the cornea, lens, retina and optic nerve.

- **VISUAL ACUITY**

Visual acuity refers to the ability of the eye to focus on an object and produce a sharp image on the retina. Defects in visual acuity include **nearsightedness (myopia)** and **farsightedness (hyperopia)**. Visual acuity can be measured with an eye chart that contains rows of letters that decrease in size from top to bottom. The rows are marked with the distance from the chart that a "normal" person can see when standing still and reading the letters**.** For example, the largest letter E can be read by a "normal" person standing 200 feet from the chart. A person who can only read this letter at 20 ft from the chart is said to have 20/200 vision. "Normal" vision is said to be 20/20.

PROCEDURE

1. **Stand at the red tape** (which is 20 feet from the chart) cover your left eye and read the smallest set of letters possible.

2. Now cover your right eye and repeat. **Record your results**.

RIGHT EYE 20/_____ **RIGHT EYE WITH GLASSES (IF ANY) 20/_____**

LEFT EYE 20/ _____ **LEFT EYE WITH GLASSES (IF ANY) 20/_____**

QUESTIONS

1. How would you rank your visual acuity (below normal / normal / above normal)?

2. Nearsightedness (myopia) is typically due to an individual having an abnormally elongated eyeball. The lens of the eye cannot flatten sufficiently to focus far objects onto the retina, thus the image is in focus short of reaching the retina. **Explain how glasses (corrective lenses) can correct this problem.**

- **ASTIGMATISM**

A defect in the curvature of either the cornea or lens produces an **astigmatism** in that eye. The presence of an astigmatism can be detected through the use of a chart containing radial spokes. If one has an astigmatism then some of the spokes appear sharply focused and dark while other spokes appear lighter and less focused.

PROCEDURE

Stand 20 feet from the astigmatism chart and cover one eye. **Focus on the semicircle at the base of the radiating lines**.

QUESTIONS

1. Are any of the lines darker and more sharply focused than any others? (yes/no)

right eye _____ **left eye _____**

2. If you have astigmatism, describe how it affects your eyesight. If you don't, ask someone who does have an astigmatism how it effects their eyesight, then describe it below.

- **NEAR-POINT ACCOMMODATION TEST**

When viewing far objects the lens becomes flattened. When viewing near objects the lens becomes more round in shape. The eye **accommodates** for distance. The elasticity of the lens and thus its ability to accommodate for near vision decreases with age (**presbyopia**). Lens elasticity can be tested for by measuring the near point of vision, the closest an object can be brought to the eyes and still be in focus.

PROCEDURE

1. Hold a pencil at arm's length with the eraser tip up and close your right eye. Focus on a letter on the pencil.
2. Focus on the letter of the pencil and slowly bring it closer to your left eye until it goes out of focus.
3. Using a small plastic ruler, have your partner measure the closest distance at which the letter on the pencil was still in focus.
4. Repeat with the right eye (close the left eye this time).

RIGHT EYE NEAR POINT _____CM **LEFT EYE NEAR POINT _____CM**

AVERAGE NEAR POINT BASED ON AGE:

CM:	**9**	**10**	**13**	**18**	**50**	**83**
AGE:	**10**	**20**	**30**	**40**	**50**	**60**

QUESTION

What is the estimated "age" of your right eye? _____ Your left eye? _____

- **LOCATION OF THE BLIND SPOT**

PROCEDURE

1. From your lab tray, obtain a card on which has been marked an **"X" and a dot.**
2. Hold the card up in front of your face, with the dot to your left and the "X" to your right.
3. **Shut your left eye and look *only* at the left dot with your right eye.**
4. Move the card **slowly** in and out about 6 to 12 inches away from your face.
5. At one point, while you are looking at the dot with your right eye, the "X" will seem to disappear
6. **If you have any difficulty locating the blind spot, notify your instructor.**

QUESTION

Why don't you normally notice the blind spot? When using the card to locate it, what did you see in place of the "X" when it appeared to disappear?

- **SUPERIMPOSED IMAGES**

For the most part, each of your two eyes sees the same image, but from a slightly different angle. Your brain integrates these two images together to greatly improve your depth perception (the ability to accurately locate objects in three dimensional space). That your brain superimposes the two images from your eyes is demonstrated in the following exercise.

PROCEDURE

1. Obtain a paper tube from your lab tray. Hold it up to your right eye and focus on some object in the room.

2. Bring your left hand along the side of the tube in front of your left eye.

3. Move your left hand toward, then away from your left eye until you "see" a hole in your hand.

QUESTION

Explain your results.

- **LIGHT-SENSITIVE PIGMENTS.**

Photoreceptor cells (**rods and cones**) within the **retina** of the eye contain light-sensitive pigments that change conformation (shape) when struck by light. This conformational change induces a nerve impulse that is relayed to the brain via the optic nerves. The brain interprets these impulses as light. The eye's light-sensitive pigments require time to regenerate (go back to their original conformation) and thus the photoreceptor cell cannot be re-stimulated until this regeneration occurs.

PROCEDURE & QUESTIONS

1. Look at a bright light for 5 seconds and then look at a white piece of paper. Continue to stare at the paper for 15-20 seconds. Describe what you observed.

2. Provide an explanation for why the image of the light bulb eventually turned dark.

- **COLOR VISION**

Color vision depends on three different sets of cones (photoreceptor cells that distinguish between colors; the wavelength of light), that detect either red, green or blue light. All other colors are interpreted by the brain as a mixture of these colors. Color discrimination is impaired if one or more systems of cones becomes defective or if one system of cones is "bleached" by the continued viewing of a colored object.

PROCEDURE & QUESTIONS

(THE COLORED SQUARES ARE FOUND ON YOUR LAB TRAYS)

1. **Continuously stare at the red square** that has been placed on a black background **for one minute**. Then quickly place a piece of white paper over the red square. **What color does the white paper appear to be?**

2. Repeat the experiment using the **blue square**. **What color does the white paper appear to be?**

3. Repeat the experiment using the **green square. What color does the white paper appear to be?**

4. Provide an explanation for your results. With regard to the electromagnetic spectrum, **what is white light?**

- **COLOR BLINDNESS**

Color blindness is an inherited disorder in which one or more sets of cones are defective. The most common defects occur in either the red or green cones (as we know from our lab on genetics, red-green color blindness is a sex-linked inherited trait). Individuals that suffer from red-green color blindness have difficulty distinguishing between red and green colors.

PROCEDURE: **Using the test booklets provided and the score sheet below, have your partner test you for color blindness. Using plates 5-14, determine which colored number stands out the most to you. Circle that number on your score sheet. When you are finished, add up the number of circles in each column to determine if your vision is normal or Red-Green color defective. You do not need to complete the *Classification Series* table.**

Score Sheet

No. _____

Name _____ Age _____ M/F _____ Date _____

Examiner _____

Screening Series

Plate No.	Normal	R-G Defect
5	3	8
6	2	9
7	4	invisible
8	7	4
9	8	7
10	4	3
11	2	4
12	7	5
13	8	invisible
14	3	6
Total		

Classification Series

Plate No.	Protan	Deutan
15	8	3
16	5	7
17	4	8
18	9	4
19	3	5
Total		

Result : Normal
Protan
Deutan
Others

NB: 1) Nos. 1–4 are demonstration plates.
2) Encircle the number read by the subject.
3) When two numbers are identified, encircle either of the two that is better read.
4) Obtain the sum of the circles in each column and if normal response is 8 or more, the subject is determined as normal.
5) Classify as protan or deutan according to the greater number of the circles in those columns.

[Standard Pseudoisochromatic Plates. IGAKU-SHOIN]

QUESTIONS

1. Are you or your partner color blind?

2. The gene that determines red-green color blindness is located on the X chromosome.
- Given what you know about human genetics, is color blindness predicted to be more common in women or in men? Explain.

F. BALANCE

Several systems contribute to your sense of balance. **Proprioceptors** (special types of sensory receptors) in your muscles and joints provide information regarding the position your body in space. Your eyes tell you if you are standing still or moving relative to stationary objects in view. Additionally, structures in the inner ear collectively called the **vestibular apparatus** provide information regarding the position, rotation and acceleration of the head.

PROCEDURE & QUESTIONS

In the following test be sure that your partner is standing close enough to prevent you from falling if you should lose your balance.

1. Stand upright and look straight ahead. Bend your right leg and hold your ankle with your right hand. Balance for 30 seconds.
Rank the ease with which you accomplished this task using one of the following terms; easy, challenging, difficult, or impossible.

2. Switch feet (bend and hold your left ankle) and assume the same position, but close both eyes. Balance for 30 seconds.
Rank the ease with which you accomplished this task.

3. Switch feet again and assume the same position. Close both eyes and then tilt your head backwards. Balance for 30 seconds. **Rank the ease with which you accomplished this task.**

- Are your results consistent with the notion that balance is dependent on multiple sensory systems? Explain why or why not.

Clean-up:

_____ Meter stick, blind spot card, colored squares and color vision book remain on student table.

_____ Used cotton balls go into the trash.

_____ Return all supplies to correct trays on the back counter.