Unit 1 – Nervous and Endocrine System

Outcome 1 – The Nervous System

Topic 1 – Neuron and Nerve signals

- Describe the general structure and function of a neuron and myelin sheath, explaining the formation and transmission of an action potential, including all-or-none response and intensity of response;
- Describe, using an example, the organization of neurons into nerves and the composition and function of reflex arcs; *e.g., the patellar reflex, the pupillary reflex*
- Describe the transmission of a signal across a synapse; and the main chemicals and transmitters involved, i.e., norepinephrine, acetylcholine and cholinesterase

Class 1 – Structure of the Neuron and the Reflex Arc
Class 2 – Resting Membrane Potential; Formation and Transmission of an action potential
Class 3 – Transmission of signal across a synapse

Topic 2 – Parts of the Nervous Systems

Identify the principal structures of the central and peripheral nervous systems and explain their functions in regulating the voluntary (somatic) and involuntary (autonomic) systems of the human organism; i.e., cerebral hemispheres and lobes, cerebellum, pons, medulla oblongata, hypothalamus, spinal cord, sympathetic and parasympathetic nervous systems, and the sensory-somatic nervous system

Class 1 – The Central nervous system (CNS)
Class 2 – The Peripheral nervous system (PNS)

Topic 3 –Sensory Organs

Explain ways that humans sense their environment and their spatial orientation in it; *e.g., olfactory receptors, proprioceptors, taste receptors, receptors in the skin.*

Topic 4 – The Human Eye

Describe the structure and function of the parts of the human eye; i.e., the cornea, lens, sclera, choroid, retina, rods and cones, fovea centralis, pupil, iris and optic nerve

Class 1 – Structure of the Eye
Class 2 – Getting light to the retina

Topic 5 – The Human Ear

Describe the structure and function of the parts of the human ear, including the pinna, auditory canal, tympanum, ossicles, cochlea, organ of Corti, auditory nerve, semicircular canals and Eustachian tube

Outcome 2 – The Endocrine System

Topic 1 – Endocrine Glands and Hormones

a. Identify the principal endocrine glands of humans; i.e., the hypothalamus/pituitary complex, thyroid, parathyroid, adrenal glands and islet cells of the pancreas

b. Describe the function of the hormones of the principal endocrine glands, i.e., thyroid stimulating hormone (TSH)/thyroxine, calcitonin/parathyroid hormone (PTH), adrenocorticotropic hormone (ACTH)/cortisol, glucagon/insulin, human growth hormone (hGH), antidiuretic hormone (ADH), epinephrine, aldosterone, and describe how they maintain homeostasis through feedback

Topic 2 – Role of hormones in Homeostasis

a. Explain the metabolic roles hormones may play in homeostasis; i.e., thyroxine in metabolism; insulin, glucagon and cortisol in blood sugar regulation; hGH in growth; ADH in water regulation; aldosterone in sodium ion regulation

b. Explain how the endocrine system allows humans to sense their internal environment and respond appropriately; *e.g., calcium balance, osmotic pressure of blood*

Topic 3 - Nervous and Endocrine System Working Together

Compare the endocrine and nervous control systems and explain how they act together; *e.g., stress and the adrenal gland*

Topic 4 – Hormone Imbalances

Describe, using an example, the physiological consequences of hormone imbalances; i.e., diabetes mellitus *(e.g., diabetes insipidus, gigantism, goitre, cretinism, Graves' disease).*

Topic 1 – The Neuron and Nerve Signals
Class 1 – Structure of the Neuron and the resting membrane potential
Pre Class Reading Assignment

1. Read pgs 408-410

2. Define the following terms
    a. Glial cell

    b. Neuron

    c. Axon

    d. Dendrite

    e. Myelin sheath

    f. Schwann cells

    g. nodes of Ranvier

    h. neurilemma

    i. sensory neurons

    j. sensory receptors

    k. interneurons

    l. motor neurons

    m. effectors

3. Differentiate between the peripheral nervous system (PNS) and central nervous system (CNS).

4. Differentiate between sensory nerves and motor nerves.

5. Briefly describe the **function** of the following parts of a neuron: dendrites, myelin sheath, Schwann cells, cell body, and axon.

6. What is the relationship between the speed of a nerve impulse and the size of the axon along which it travels?

7. What is the difference between ‘white matter’ and ‘grey matter’?

Topic 1 – The Neuron and Nerve Signals
Class 1 – Structure of the Neuron and the resting membrane potential
Notes

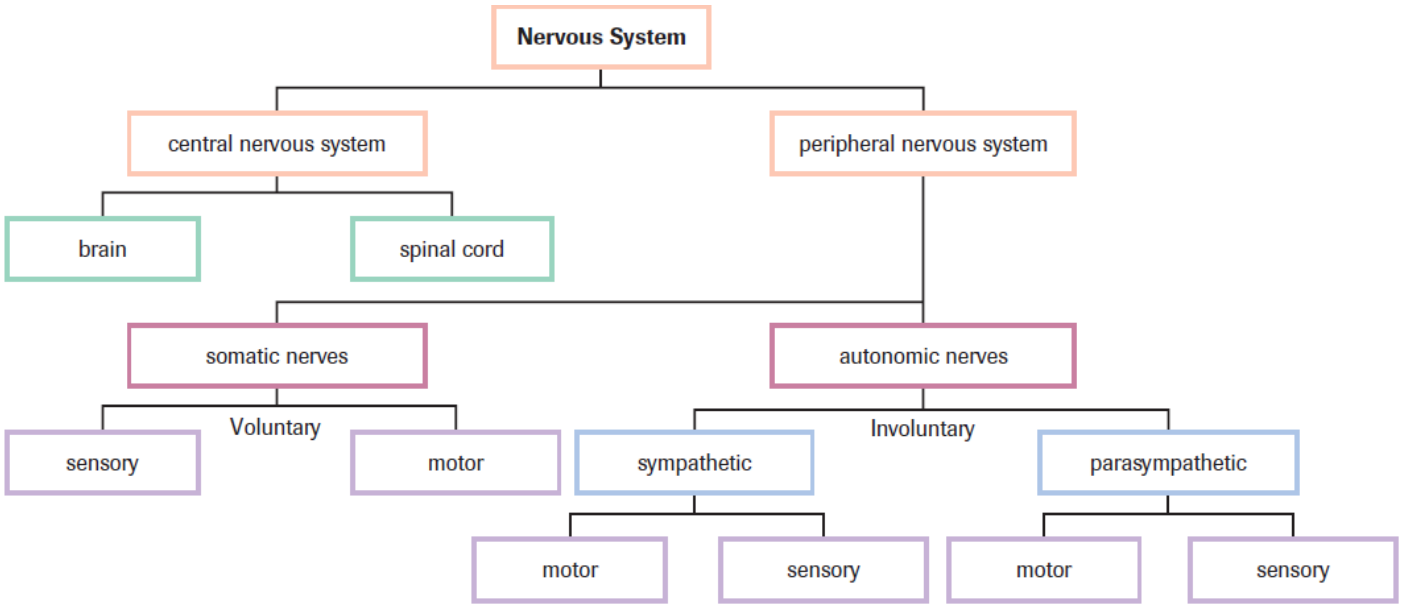


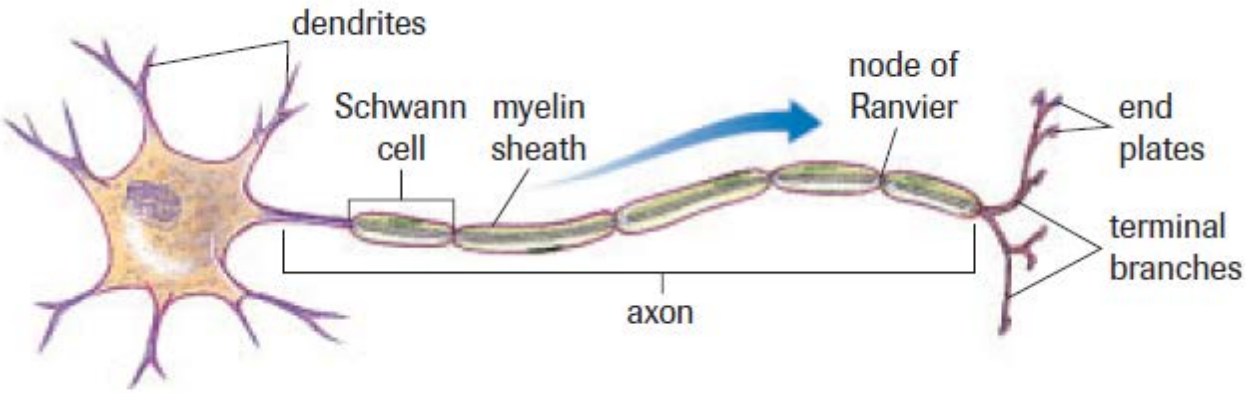
Figure 1
The main divisions of the nervous system

The Structure of a Neuron

- Neurons are the basic unit of the nervous system

- Neurons are **similar** to other cells in the body because they
  - are surrounded by a cell membrane.
  - have a nucleus that contains genes.
  - contain cytoplasm, mitochondria and other organelles.
  - carry out basic cellular processes such as protein synthesis and energy production

- Neurons are **different** than other cells b/c:
  - Have specialized extensions called dendrites and axons
  - Communicate with each other with an electrochemical process
  - contain specialized structures and chemicals

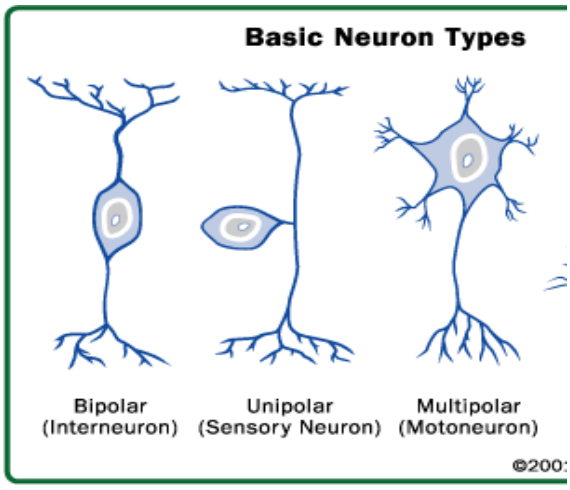


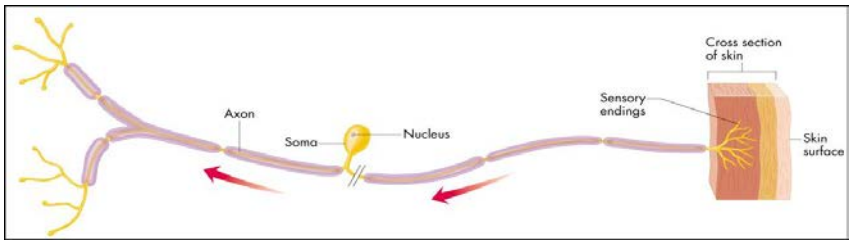
Parts of a Neuron

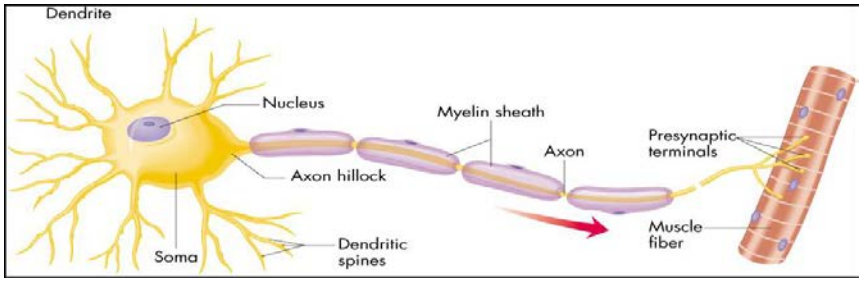
- Dendrites – projections of cell cytoplasm that carry signals towards the cell body
- Cell Body (soma) - holds all of the general parts of a cell as well as the nucleus, which is the control center
- Axon – extension of cytoplasm that carries signal (nerve impulse) away from dendrites and the cell body
- Schwann Cell – cells that produce the myelin sheath
  - A type of **Glial cell** (talked about later)
- Myelin Sheath – fatty covering over the axon
  - Prevents loss of charged ions
- Nodes of Ranvier – areas between sections of the myelin sheath
- Neurilemma - another membrane that surrounds and protects the axon.
  - Helps re-growth and repair.
- White matter - neurons that are both myelinated and have a neurilemma
  - all PNS and some CNS
- Gray matter - neurons in the brain and spinal cord that are not myelinated, nor have a neurilemma.

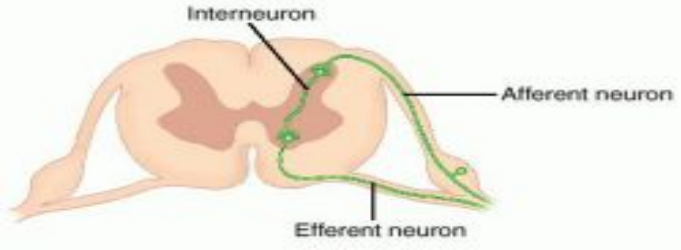
Types of Neurons:

- **Motor Neuron** – relay info to effectors (muscles, glands); cell body located in CNS; axons in PNS
- **Sensory Neuron** – relay info about environment to CNS (brain)
- **Interneuron** – connect neurons; only found in CNS









Watch the animation below before going on to Reflex Arc
http://bcs.whfreeman.com/thelifewire/content/chp46/46020.html

The Reflex Arc

- Reflexes are **involuntary** and often **unconscious**.
- Reflexes are fast b/c the brain does not have to process incoming info before reacting
- A **reflex arc** is the neural pathway that mediates a reflex action
- A reflex arc uses very few neurons to transmit messages
- **Steps in a reflex arc:**
  1. Receptors (heat, pain, cold) initiate an impulse in a sensory neuron
  2. Sensory neuron carries impulse to a interneuron in spinal cord
  3. Interneuron passes impulse to motor neuron which acts on a effector (muscle)
- http://www.sumanasinc.com/webcontent/anisamples/nonmajorsbiology/reflexarcs.html

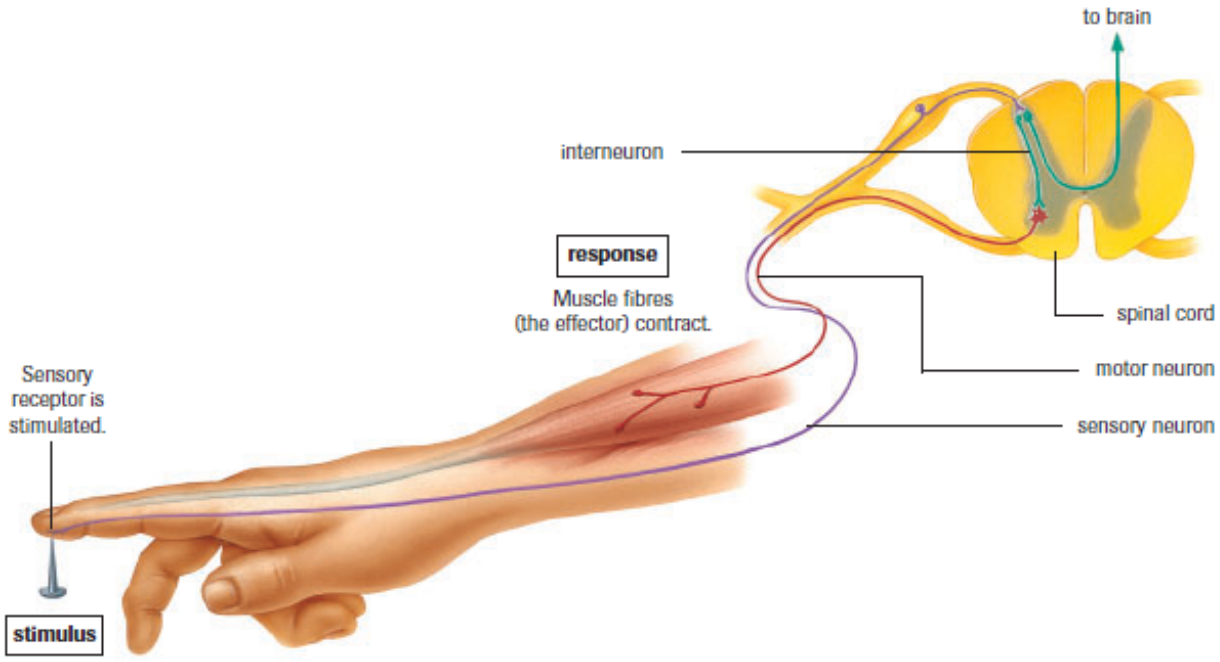
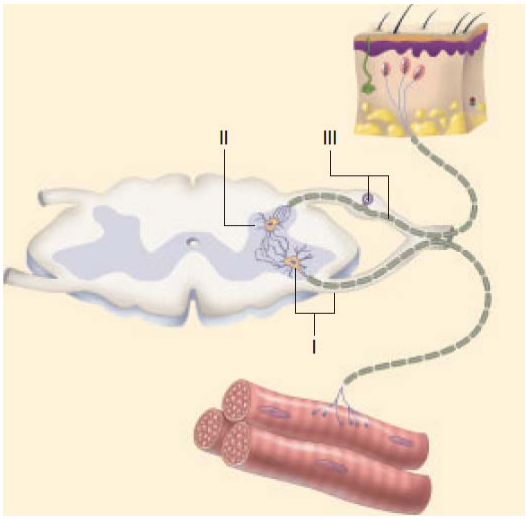


Figure 5
A reflex arc begins when the touch receptor in the finger senses the tack. Sensory information is relayed from the sensory neuron (purple) to the spinal cord. Interneurons in the spinal cord (green) receive the information from the sensory neuron and relay it to the motor neuron (red). The motor neuron activates the muscle cell (the effector), causing it to contract. The brain also receives sensory information from a sensory neuron, which registers as pain. This step is not part of the reflex arc.

Topic 1 - Class 1
Review Sheet

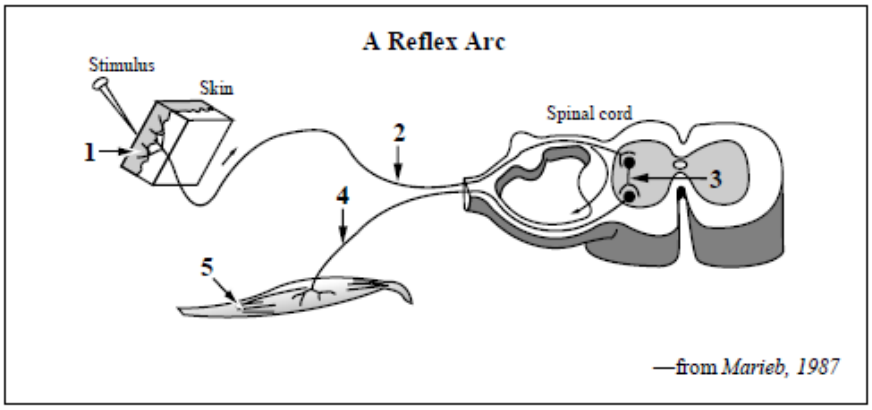


1. Name the essential components of a reflex arc and the function of each.

2. What would happen if neuron I in the figure was severed?

3. Number the following events of the reflex arc in the correct order.
   ____ Motor neuron activates the muscle cell to contract.
   ____Sensory information is received by interneurons in the spinal cord.
   ____Sensory information is relayed to the motor neuron.
   ____Sensory information is relayed from the sensory neuron to the spinal cord.
   ____Touch receptor is stimulated.

Use the following diagram to answer the next question.



—from *Marieb, 1987*

Numerical Response

1. Identify the structure, as numbered above, that performs each of the functions given below.

Structure:	_____	_____	_____	_____
Function:	**Transmits impulses to the central nervous system**	**Receives sensory stimulation**	**Carries out instructions from the central nervous system; is a muscle**	**Transmits impulses from the central nervous system to the effector**

The symptoms of untreated syphilis usually disappear within 12 weeks of the initial infection. However, new symptoms may appear many years later. These include damage to neurons of the central nervous system.

—from *Zabludoff, 1996*

The neurons damaged by syphilis are

A. interneurons
B. sensory neurons
C. somatic motor neurons
D. autonomic motor neurons

Research has shown that although interneurons in the spinal cord make proteins that inhibit regeneration of damaged axons, peripheral nerve axons can regenerate.

The structure that allows neurons of peripheral nerves to regenerate is the

A. axon
B. dendrite
C. neurilemma
D. node of Ranvier

Numerical Response

1. Another symptom of MS is an exaggerated pupillary light reflex. Some of the events that occur during this reflex are listed below.

1 Motor neuron depolarizes
2 Sensory neuron depolarizes
3 Interneuron depolarizes
4 Light receptors stimulated

The order in which the events listed above occur during a pupillary light reflex is _____, _____, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Topic 1 - Class 2
Resting Membrane Potential and Formation and Transmission of an action potential
Pre-Class Reading Assignment

1. Read pgs 415-419
2. Define the following terms
    a. Action potential
    b. Resting potential
    c. Facilitated diffusion
    d. Active transport
    e. Gated ion channel
    f. Sodium potassium pump
    g. Depolarization
    h. Repolarization
    i. Hyperpolarization
    j. Refractory period
    k. Salutatory conduction
    l. Threshold level
    m. All or none response

3. What is a polarized membrane?

4. What causes the inside of a neuron to become negatively charged?

5. Why does the polarity of a cell membrane reverse during an action potential?

6. Why do nerve impulses move faster along myelinated nerve fibres?

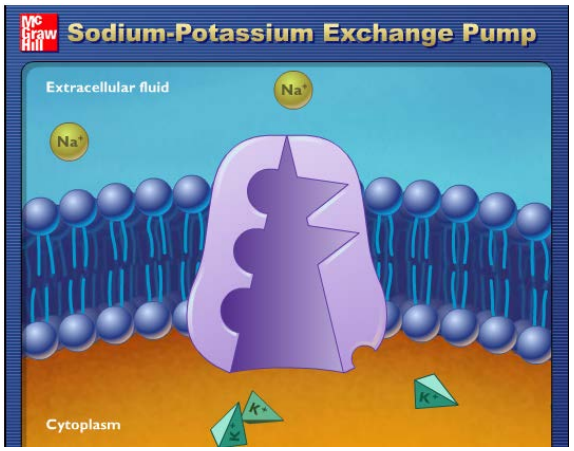
Topic 1 - Class 2
Resting Membrane Potential and Formation and Transmission of an action potential
Notes

Resting Membrane Potential

- Nerve cells are unique b/c they are **charged cells**.
- have a rich supply of + ive and – ive ions
  - Positive ions – sodium, potassium, calcium
  - Negative ions – chloride, proteins
- Nerve impulses are created by movement of ions across the cell membrane of the neuron
- A nerve impulse is called an **action potential**.
- Neuron at rest has more –ive ions inside the neuron than outside and more +ive ions outside than inside
- Charge separation across membrane is due to:
  - Action of sodium-potassium exchange pump
    - Pumps 3 Na^+ out and 2 K^+ in

      http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120068/bio03.swf::Sodium-Potassium%20Exchange%20Pump
  - Diffusion of potassium across membrane
    - Membrane is "leaky" to K^+ ions
  - Impermeability of membrane to –ive ions like chloride (Cl^-)

    http://bcs.whfreeman.com/thelifewire/content/chp44/4401s.swf



Resting Membrane Potential Animations

http://bcs.whfreeman.com/thelifewire/content/chp44/4402001.html

http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter14/animation__the_nerve_impulse.html

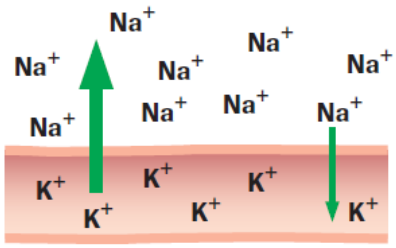


Figure 2
The K^+ concentration is higher inside the cell and the Na^+ concentration is higher outside the cell.

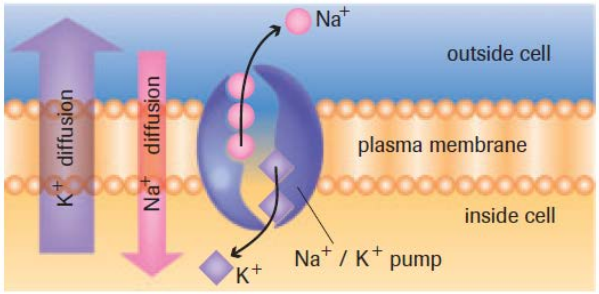


Figure 3
As potassium and sodium diffuse down their concentration gradients across the cell membrane through facilitated diffusion, the sodium-potassium pump actively transports them against the gradients.

Generating an Action Potential (neuron signal)

- A stimulus at the dendrites causes voltage-gated sodium gates to open and the neuron starts to be depolarized
- If the stimulus is strong enough, then sufficient Na+ will enter the neuron to cause an action potential
- Step by Step of Action Potential

1. Depolarization reaches **threshold level**
2. More voltage-gated Na^+ channels open allowing Na^+ to enter the cell increasing the **depolarization**
3. K^+ channels begin to open and allow K^+ out of the cell
4. Na^+ channels close
5. K^+ ions continue to leave cell returning the membrane to its original potential
6. K^+ channels close and Na^+ channels reset
7. Na-K pump returns ion concentrations to normal resting membrane potential concentrations

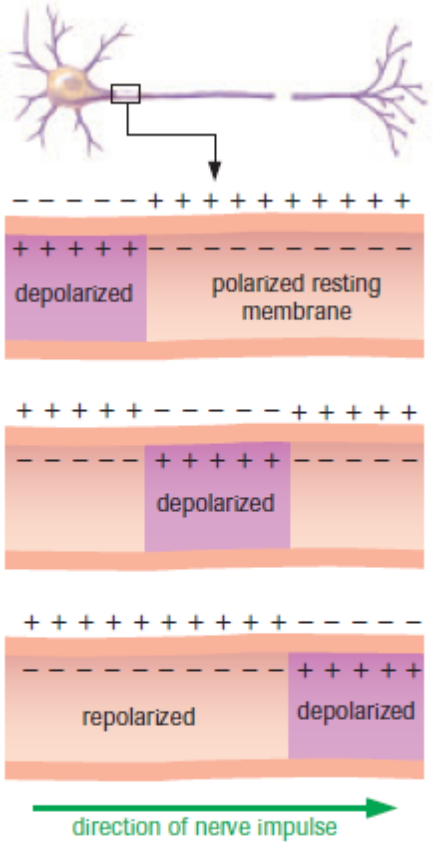
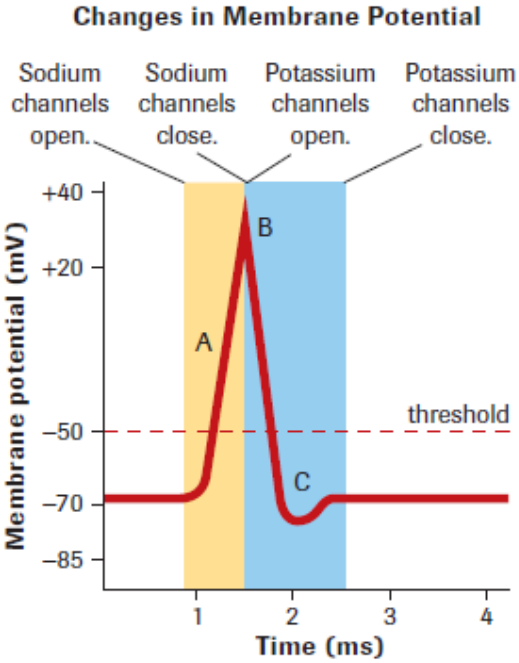


Figure 6
Successive action potentials along a section of axon cause a wave of depolarization along the cell membrane.



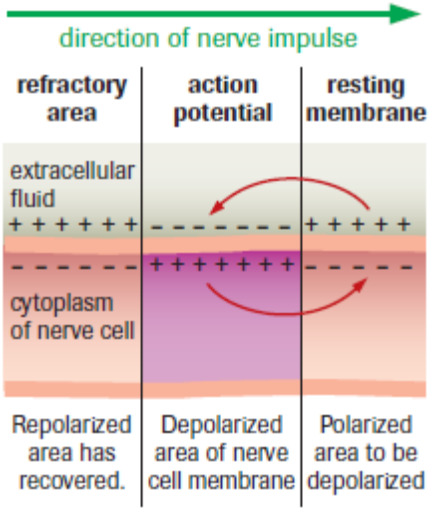


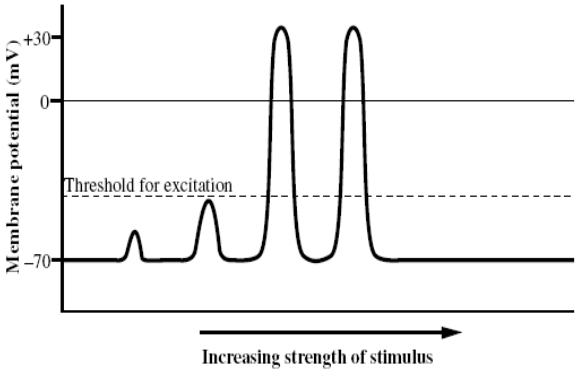
Figure 5
The movement of a nerve impulse. Red arrows indicate ions attracted to adjacent ions with opposite charges.

http://bcs.whfreeman.com/thelifewire/content/chp44/4402s.swf

Threshold Level and the All or none response

- Threshold level – min level of stimulus required to produce an action potential
- Aspects of the all-or-none law:
  - If the stimulus is too low there is no action potential (this is the "none" part)
  - If the stimulus is above a threshold the action potential is always the same size- it does not get larger for stronger stimuli
  - As the action potential travels along the axon it does not die out, but stays the same size

In an experiment, four stimuli of increasing strengths were applied to the membrane of an axon. The graph below illustrates the change measured in the membrane potential of the neuron for each stimulus.



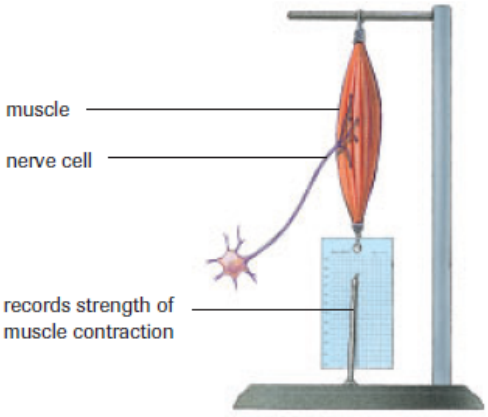


Table 1 Stimulus Strength and Force of Muscle Contraction

Strength of stimuli	Force of contraction
1 mV	–
2 mV	3 N
3 mV	3 N
10 mV	3 N

Figure 8
The threshold level for this neuron is 2 mV. Different neurons have different threshold levels.

How do we know the difference between different intensities of stimuli (light, heat, squeeze, etc)?

- The greater the stimuli
  - the more neurons that “fire” which the brain interprets as a more intense stimuli.
  - the greater the frequency of the impulses

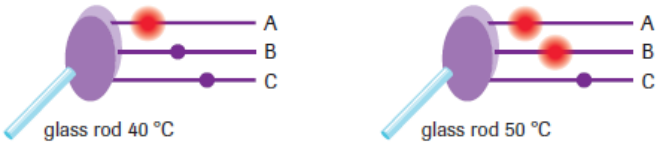


Figure 9
Neuron B has a higher threshold level than neuron A and will not fire until the glass rod is heated above 40 °C. The brain interprets both the number of neurons excited and the frequency of impulses.

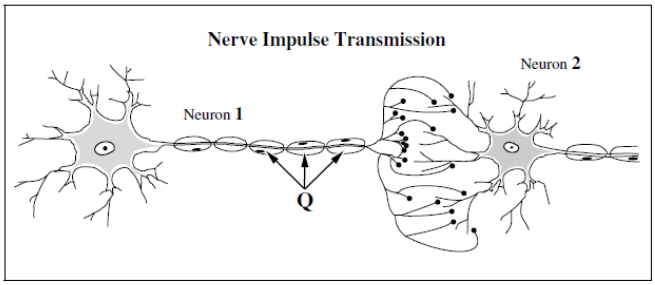
Topic 1 - Class 2
Resting Membrane Potential and Formation and Transmission of an action potential
Review Sheet

Movement of hair cells in normal ears opens tiny pores called ion channels in the nerve cell membrane. This process begins impulse transmission along the auditory nerve.

Nerve impulse transmission continues along the nerve cell membrane as

A. a wave of depolarization
B. a negative feedback loop
C. a diffusing wave of summation
D. the active transport of an electrical potential

Use the following information to answer the next question.



If the structures labelled **Q** were absent, what effect on neural transmission would be expected?

A. The axon would not release acetylcholine.
B. The axon would be not become depolarized.
C. The speed of transmission would be reduced.
D. Cholinesterase would not be secreted to deactivate acetylcholine.

Some people report they have a high pain tolerance. Explain this in terms of threshold levels.

What is the all-or-none response?

What changes take place along a nerve cell membrane as it moves from a resting potential to an action potential to a refractory period?

In Figure 14, which area(s) of the graph indicate(s) the opening of Na_ ion channels and the diffusion of Na_ ions into the nerve cells? Explain your answer.

In Figure 14, repolarization occurs in which areas? Explain your answer.

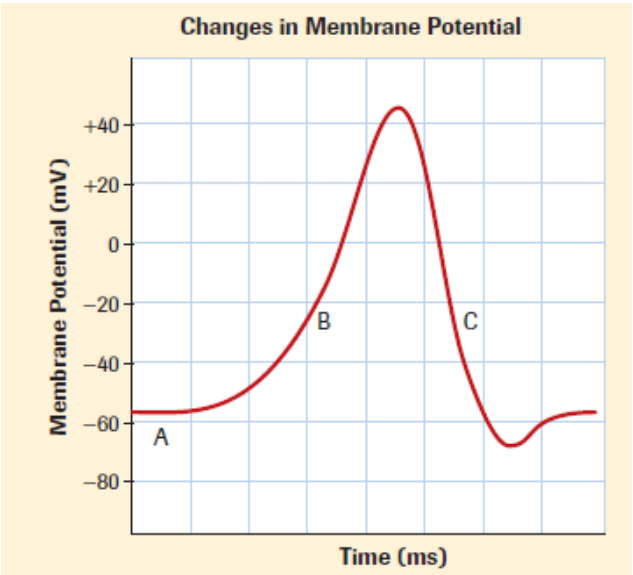
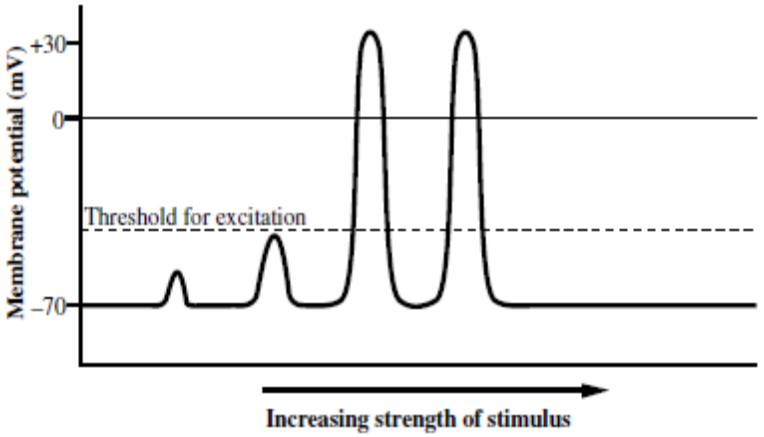


Figure 14
Action potential

Use the following information to answer the next question.

In an experiment, four stimuli of increasing strengths were applied to the membrane of an axon. The graph below illustrates the change measured in the membrane potential of the neuron for each stimulus.



Which of the following statements gives an accurate interpretation of the results of this experiment?

A. Most stimuli produce a nerve impulse.
B. A nerve impulse has a variety of strengths.
C. A stimulus must reach a threshold level to initiate a nerve impulse.
D. The greater the stimulus, the greater the strength of the nerve impulse produced.

Topic 1- Class 3
Transmission of a signal across a synapse
Pre-class Reading Assignment

1. Read pgs 420 – 422

2. Define the following terms

    a. Synapse

    b. Neurotransmitter

    c. Pre-synaptic neuron

    d. Post-synaptic neuron

    e. Inhibitory neurotransmitter

    f. Excitatory neurotransmitter

    g. Acetylcholine

    h. Cholinesterase

    i. Synaptic cleft

3. Explain the difference between excitatory and inhibitory neurotransmitters in terms of the effect they have on sodium and potassium channels and on the post-synaptic neuron.

4. What are 5 major neurotransmitters found in our bodies? Identify each as inhibitory, excitatory or both.

5. What diseases are associated with neurotransmitters? What is thought to be the cause of each?

Topic 1- Class 3
Transmission of a signal across a synapse
Notes

- When the action potential reaches the end of the axon (end plate) the signal needs to be relayed to the next neuron in the circuit, or to the effector (muscle, gland, etc)

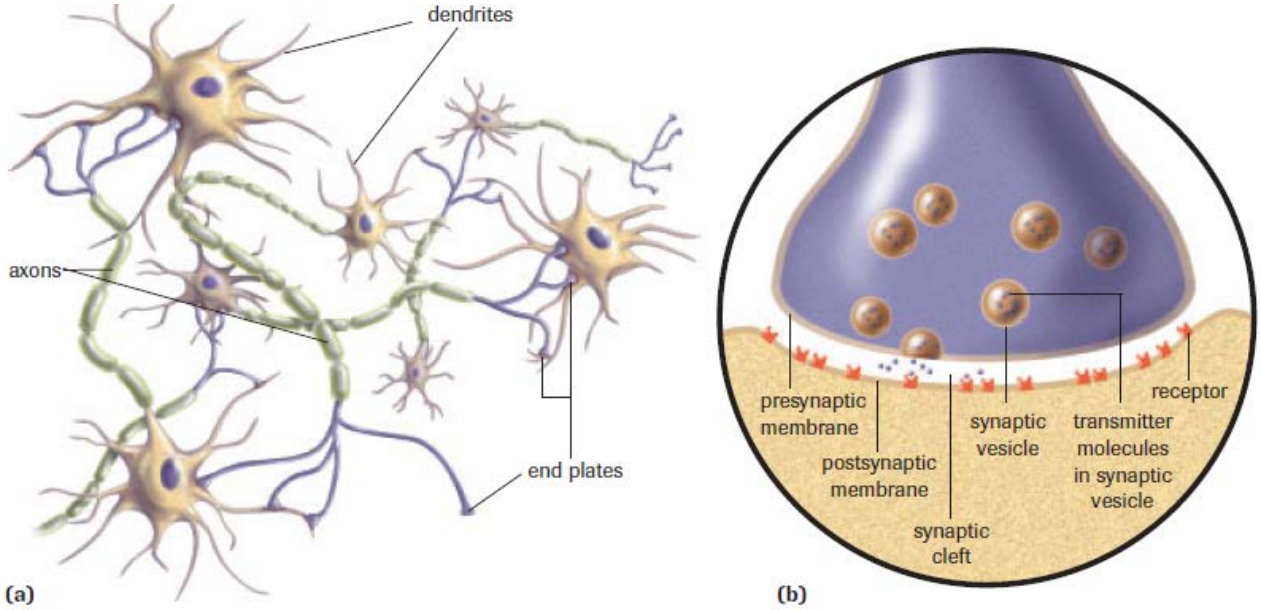


Figure 10
(a) The end plates of terminal branches synapse with the cell bodies and dendrites of many different neurons.
(b) Synaptic vesicles in the end plate of the presynaptic neuron release neurotransmitters into the synaptic cleft. The neurotransmitters attach themselves to receptors on the postsynaptic membrane, causing it to depolarize. The action potential continues along the postsynaptic neuron.

What Happens at the synapse?
- The nerve impulse arrives at the axon terminal opening Ca^{2+} ion gates
- Ca^{2+} ions entering neuron triggers release of neurotransmitters
- Neurotransmitter diffuses across synapse to post-synaptic neuron (or effectors)
- Post synaptic neuron gets depolarized (or hyperpolarized) by the neurotransmitter
- **Enzymes** break down the neurotransmitter

http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter14/animation__transmission_across_a_synapse.html

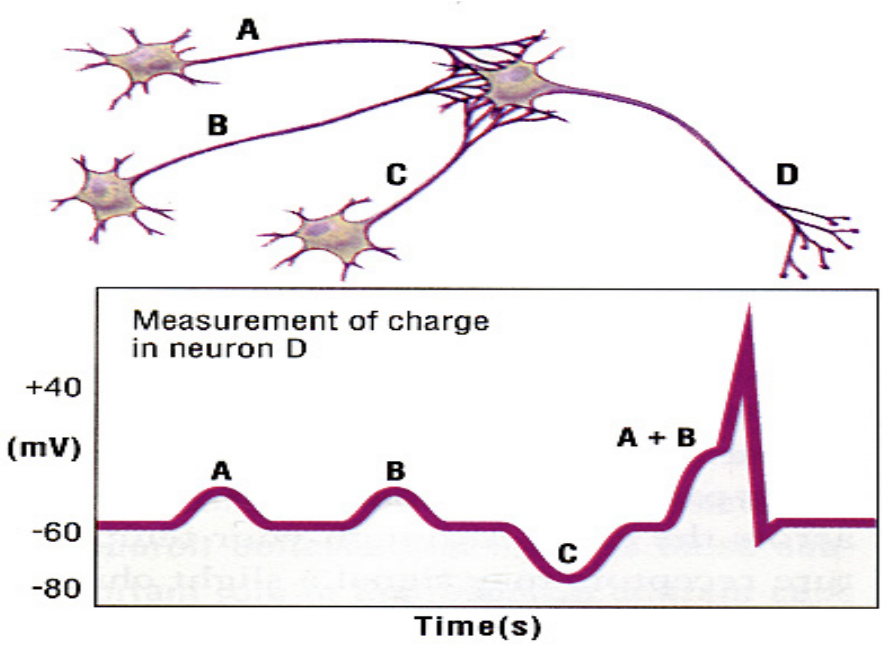
http://bcs.whfreeman.com/thelifewire/content/chp44/4403s.swf

Inhibitory vs Excitatory Neurontransmitters
- Depending on the receptor they join to, a neurotransmitter can be excitatory or inhibitory
- Excitatory open Na+ gates causeing an inrush of Na+ into the postsynaptic neuron.
    - This leads to **depolarization** of the post synaptic neuron
- Inhibitory opens K+ gates and cause K+ to leak out, therefore increasing polarity (more +ive membrane potential)
    - This leads to the postsynaptic neuron being **hyperpolarized**.
    - ***http://www.blackwellpublishing.com/matthews/neurotrans.html***

Summation

- Since most neurons have more than one presynaptic neuron acting on it, the sum of all the presynaptic neurons transmitters will determine the action of the postsynaptic neuron.

- This is called ***summation***.



Common Neurotransmitters

Table 1 Common Neurotransmitters

Neurotransmitter	Action	Secretion sites	Major effects
acetylcholine	excitatory to skeletal muscles; excitatory or inhibitory at other locations	neuromuscular functions; CNS, PNS	skeletal muscle contraction
norepinephrine	excitatory or inhibitory	CNS, PNS	wakefulness
dopamine	generally excitatory	CNS, PNS	voluntary movement and emotions
serotonin	generally inhibitory	CNS	sleep
GABA (gamma-aminobutyric acid)	inhibitory	CNS	motor behaviour

Read Drugs and the Synapse on pg 423-424

Answer Case study questions 1-8

Topic 1- Class 3
Transmission of a signal across a synapse
Review Sheet

1. Number these events in the correct order.
(**a**) ____ An action potential is stimulated at the postsynaptic membrane, and an impulse travels down the dendrite.
(**b**) ____ An enzyme destroys the neurotransmitter substance and clears out the synaptic cleft.
(**c**) ____ The impulse reaches the synapse from the axon.
(**d**) ____ The impulse stimulates synaptic vesicles to move to the presynaptic membrane.
(**e**) ____ The neurotransmitter substance diffuses across the cleft.
(**f**) ____ The neurotransmitter substance fits into receptor sites on the postsynaptic membrane.
(**g**) ____Synaptic vesicles dump neurotransmitter substance into the synaptic cleft.

Use the following information to answer the next three questions.

Serotonin is a naturally occurring neurotransmitter that plays an important role in a person's mood and emotions. A shortage of serotonin has been associated with phobias, schizophrenia, aggressive behaviour, depression, uncontrolled appetite, and migraine headaches. Synthetic drugs have been developed to enhance or hinder the performance of serotonin in the brain. Some of these drugs include:

I Prozac and Zoloft, which cause serotonin to remain in the brain for longer periods of time
II Drugs, such as Clozapine, that prevent serotonin from binding to post-synaptic membranes
III Diet drugs, such as Redux and Fenfluramine, that stimulate nerve cells to release more serotonin
IV Hallucinogens, such as LSD and Ecstasy, that react directly with serotonin receptors to produce the same effect as serotonin

—from *Lemonick, 1997*

The drugs numbered above that would act as competitive inhibitors to serotonin and the drugs that would slow down the rate of removal of serotonin from the synapse are, respectively,

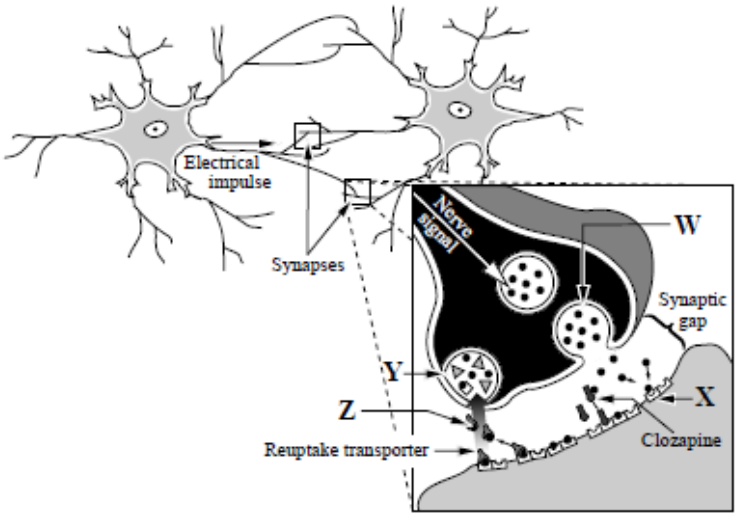
A. I and III
B. II and I
C. II and III
D. III and IV

If a person were suffering from clinical depression, which of the following drugs would **not** reduce the symptoms of depression?

A. LSD
B. Zoloft
C. Clozapine
D. Fenfluramine

Use the following additional information to answer the next question.

Two Neurons and a Synapse



The row below that identifies the structure that releases serotonin and the section of the neuron that this structure is found in is

Row	Released from structure	Found in the
A.	W	axon terminal
B.	X	dendrite
C.	Y	axon terminal
D.	Z	dendrite

Use the following information to answer the next question.

The disease myasthenia gravis causes a person to experience muscular weakness because of the failure of neuromuscular junctions to transmit signals from nerve fibres to muscle fibres. The weakness is due to a reduced sensitivity to acetylcholine, which is necessary to stimulate the muscle fibre. People suffering from this disease are often treated with neostigmine, an anticholinesterase drug, which can result in some normal muscular activity within minutes.

—from *Guyton and Hall, 1996*

Neostigmine is effective in treating this disease because it

A. binds with cholinesterase to form acetylcholine
B. binds with cholinesterase to increase acetycholine production
C. reduces the amount of active cholinesterase, thereby increasing the amount of acetylcholine available to stimulate muscle contraction
D. increases the amount of active cholinesterase, thereby increasing the amount of acetylcholine available to stimulate muscle contraction

Use the following information to answer the next question.

Observations About a Synapse and Synaptic Transmission

1. Only axon terminals release neurotransmitters.
2. A neurotransmitter diffuses from an axon terminal across the synapse to the dendrites or cell body.
3. Many transmissions across a synapse in a short time may cause fatigue of synaptic transmission.
4. Electron micrographs of a synapse show that there is no direct connection between the axon terminal of a presynaptic neuron and the dendrites or cell body of a postsynaptic neuron.

The assumption that axon terminals contain a limited amount of neurotransmitter could account for observation

A. 1
B. 2
C. 3
D. 4

Two symptoms of Parkinson's disease are lack of muscular coordination and tremors, both caused by inadequate amounts of dopamine. Symptoms of Alzheimer's disease include the deterioration of memory and mental abilities, possibly caused by a decrease in acetylcholine production.

Dopamine and acetylcholine are excitatory neurotransmitters in various parts of the brain.

For the neurotransmitters dopamine and acetylcholine, the releasing sites and the receptor sites are, respectively,

A. cell bodies and dendrites
B. dendrites and Schwann cells
C. axon terminals and dendrites
D. axon terminals and Schwann cells

What role do both dopamine and acetylcholine have when they function as excitatory neurotransmitters?

A. They make the presynaptic membrane more permeable to K^+ ions.
B. They make the presynaptic membrane more permeable to Na^+ ions.
C. They make the postsynaptic membrane more permeable to K^+ ions.
D. They make the postsynaptic membrane more permeable to Na^+ ions.

Topic 2 – Class 1
The Central Nervous System
Pre-Class Reading

1. Read pgs 426-431
2. Define the following terms
    a. Meninges

    b. Cerebrospinal fluid

    c. Dura mater

    d. Arachnoid mater

    e. *Pia mater*

    f. Cerebrum

    g. Corpus callosum

    h. Thalamus

    i. Hypothalamus

    j. Olfactory bulbs

    k. Cerebellum

    l. Pons

    m. Medulla oblongata

3. List the parts of the forebrain.

4. List the parts of the hindbrain.

Topic 2 – Class 1
The Central Nervous System
Notes

- The CNS is made up of the brain and the spinal cord

The Spinal Cord

- spinal cord carries sensory nerve messages from receptors to the brain and relays motor nerve messages from the brain to muscles, organs, and glands

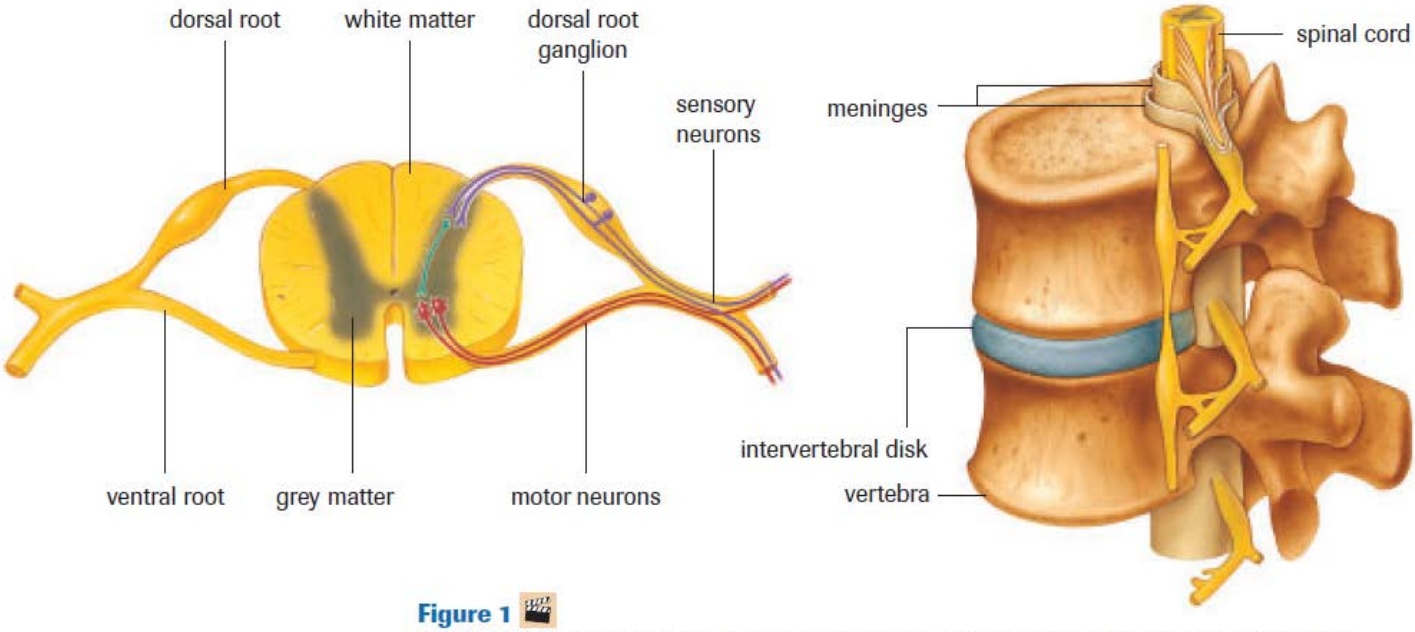
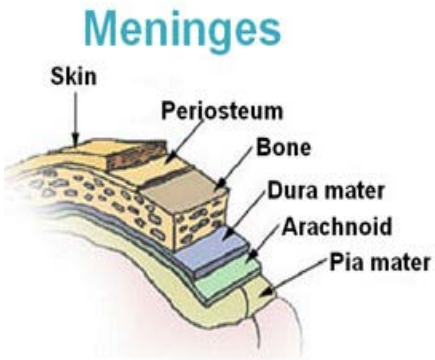
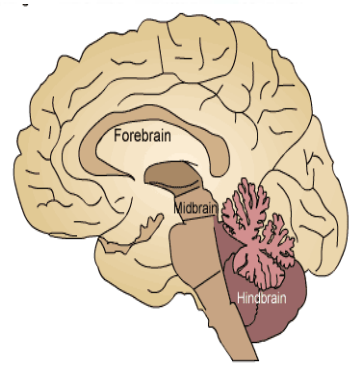


Figure 1
The spinal cord is protected by the vertebral column. Sensory nerves enter the spinal cord through the dorsal root, and motor nerves leave through the ventral root.

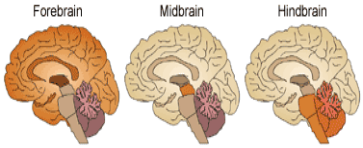
The Brain



- Enclosed within the skull
- Surrounded by 3 protective membranes known as **<u>meninges</u>**.
  - Outer layer – dura mater
  - Middle – arachnoid
  - Inner – pia mater
- Cerebrospinal fluid protects and nourishes brain and spinal cord and removes wastes.

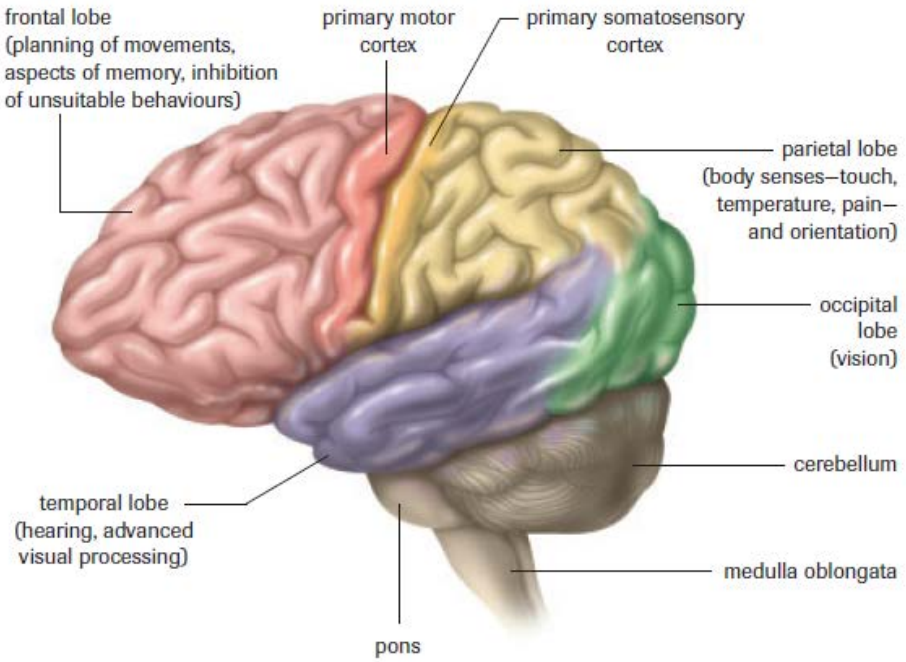


- Made up of three distinct regions
  - Forebrain
  - Midbrain
  - Hindbrain



Forebrain

- *Olfactory lobe* – receive information about smell.
- *Thalamus* – coordinates and interprets sensory info and sends it to the cerebrum
- *Hypothalamus* – links nervous and endocrine system via pituitary gland
- *Cerebrum* – forms the largest part of the forebrain
    - In humans, the forebrain is greatly enlarged and is comprised of many regions
    - is divided into left and right hemispheres.
        - **Corpus callosum** allows communication between the two sides
    - Each hemisphere can be further subdivided into four lobes: the frontal lobe, the temporal lobe, the occipital lobe, and the parietal lobe



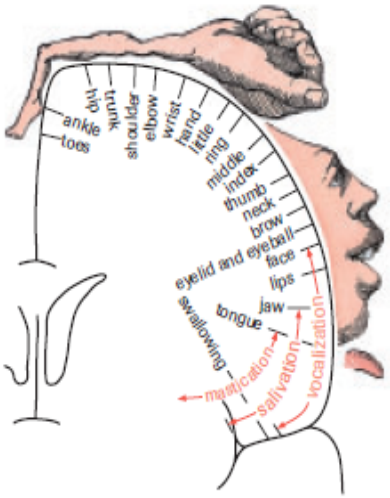


Figure 4
Regions of the body are drawn in proportion to the area of the motor cortex required to control the region.

Table 1 The Lobes of the Cerebrum

Lobe	Function
frontal lobe	• Motor areas control movement of voluntary muscles (e.g., walking and speech). • Association areas are linked to intellectual activities and personality.
temporal lobe	• Sensory areas are associated with vision and hearing. • Association areas are linked to memory and interpretation of sensory information.
parietal lobe	• Sensory areas are associated with touch and temperature awareness. • Association areas have been linked to emotions and interpreting speech.
occipital lobe	• Sensory areas are associated with vision. • Association areas interpret visual information.

Midbrain

- Less developed than forebrain
- Contains four spheres of grey matter
- Acts as relay center for some eye and ear reflexes

Hindbrain

- 3 major sections
  - ***Cerebellum*** – coordinates skeletal muscle movement (limb movement, balance and muscle tone)
  - ***Pons*** – means 'bridge'. Passes info between two sections of cerebellum and between cerebellum and medulla
  - ***Medulla oblongata*** – controls **autonomic nervous system**
    - controls involuntary muscle action. Breathing movements, the diameter of the blood vessels, and heart rate are but a few

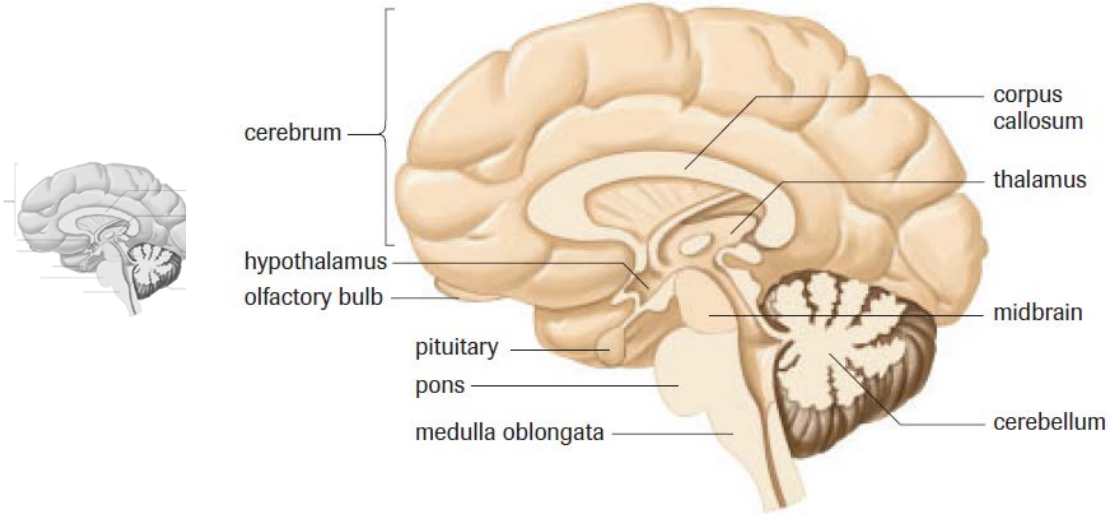


Table 2 Function of the Main Structures of the Central Nervous System

Structure	Function
meninges	• protective membranes that surround the brain and spinal cord
cerebrospinal fluid	• circulates between the innermost and middle membranes of the brain and spinal cord • acts as a transport medium and shock absorber (cushion)
cerebrum	• the largest and most highly developed part of the human brain • stores sensory information and initiates voluntary motor activities
cerebral cortex	• the outer layer of the cerebral hemispheres
corpus callosum	• a nerve tract that allows communication between the two cerebral hemispheres
cerebellum	• the region of the brain that coordinates muscle movement
hypothalamus	• maintains the body's internal equilibrium
pons	• the region of the brain that acts as a relay station by sending nerve messages between the cerebellum and the medulla
medulla oblongata	• the hindbrain region that joins the spinal cord to the cerebellum • the site of autonomic nerve control

Topic 2 – Class 1
The Central Nervous System
Review Sheet

Use the following information to answer the first two questions.

> A group of psychologists wondered if inhaling pure oxygen could enhance a person's mental capacity. They tested forty-five students.
>
> These students breathed through a face mask for one minute. They were either given pure oxygen or normal air, but they did not know which. Those receiving pure oxygen could recall twice as many words as those receiving normal air.
>
> —from *Mihill, 1996*

The part of the brain that is directly responsible for the recall of previously learned words is the

A. cerebrum
B. cerebellum
C. pituitary gland
D. medulla oblongata

The part of the brain that controls the unconscious rate of breathing is the

A. cerebrum
B. cerebellum
C. pituitary gland
D. medulla oblongata

> Many predatory birds such as eagles have two foveas in each eye. The fovea in predatory birds is similar in structure and function to the fovea in humans. In addition, these birds have strong powers of near and far accommodation.
>
> —from *Curtis, 1983*

If an eagle's brain were similar in structure to a human brain, impulses that begin in the retina of the eagle's eye would travel first to the

A. frontal lobe
B. parietal lobe
C. occipital lobe
D. temporal lobe

> Mercury poisoning causes neurological damage, which leads to a deterioration of short-term memory and an inability to coordinate muscle movements.

The areas of the brain affected by mercury poisoning as indicated by the above symptoms are, respectively, the

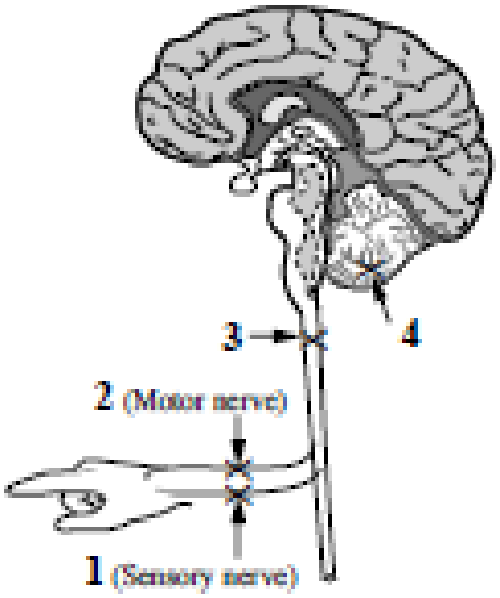
A. cerebrum and medulla
B. cerebellum and cerebrum
C. cerebrum and cerebellum
D. hypothalamus and cerebellum

Use the following information to answer the next three questions.

A man was injured in an automobile accident. There appeared to be damage to his back, his arm, and his head.

A doctor examined the man, noted some symptoms, and hypothesized that nerve damage had occurred.

Some Possible Locations of Nerve Damage



Which of the following rows correlates possible observations about the accident victim with locations of nerve damage?

Row	Possible Observations	Locations of Nerve Damage
A.	The man could not move his wrist and could not feel sensations from his hand.	1 and 2
B.	The man could move his wrist normally but could not feel sensations from his hand.	1 and 4
C.	The man could not move his wrist but could feel sensations from his hand.	2 and 3
D.	The man could move his wrist normally and could feel sensations in his hand.	2 and 4

If, following the accident, the man exhibited a marked changed in personality, the doctor would suspect damage to the

A. medulla
B. cerebrum
C. cerebellum
D. hypothalamus

The structure that allows neurons of peripheral nerves to regenerate is the

A. axon
B. dendrite
C. neurilemma
D. node of Ranvier

Topic 2 - Class 2
Peripheral Nervous System
Pre-class Reading

1. Read pgs 433-435

2. Define the following terms
    a. Sympathetic nervous system

    b. Parasympathetic nervous system

    c. Vagus nerve

3. Fill in the chart below with the similarities and differences between the sensory-somatic and autonomic nervous systems

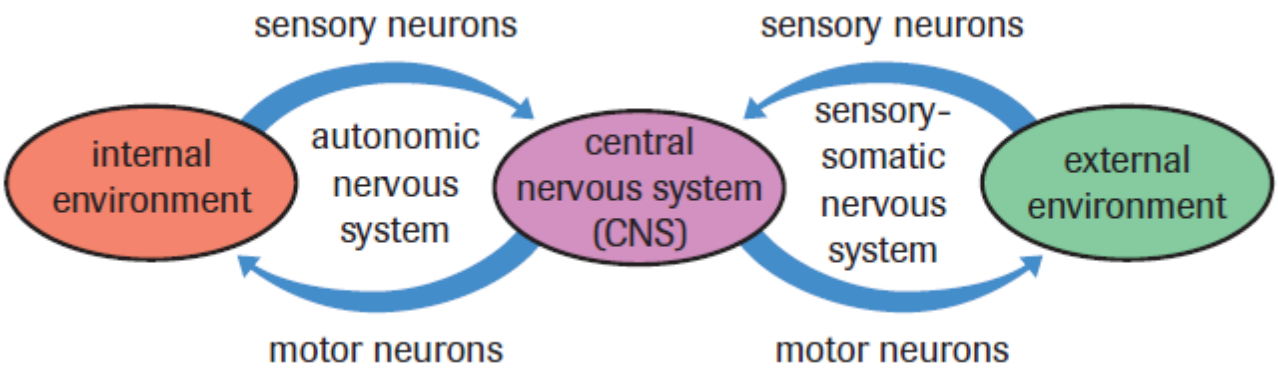
Similarities	**Differences**

4. State the two divisions of the autonomic nervous system and compare their structures and functions.

5. What are the functions of the vagus nerve?

Topic 2 - Class 2
Peripheral Nervous System
Notes

- peripheral nervous system is composed of two divisions
    - the **sensory-somatic** system – responds to **external** stimuli
    - the **autonomic** nervous system – responds to **internal** stimuli
- Both systems are composed
    - sensory neurons, which run from stimulus receptors to the central nervous system (CNS)
    - motor neurons, which run from the CNS to muscles or organs that take action



The sensory-somatic nervous system

- under **voluntary** (somatic) control because you can, for the most part, control the movement of your muscles
- **reflex arcs**, which are involuntary, also fall under the sensory-somatic nervous system
- All our conscious awareness of our surroundings and all our actions to cope with them operate through the sensory-somatic nervous system
- system is composed of 12 pairs of **cranial** nerves (nerves that originate in the brain) and 31 pairs of **spinal** nerves
- cranial nerves control vision, hearing and balance, taste and smell, facial and tongue movements, and muscles of the head and neck among other things.
- The spinal nerves control the skeletal muscles for the rest of the body.

The autonomic nervous system

- brings information about the body's internal environment to the CNS and carries signals back to regulate the internal environment

- controls smooth muscle, cardiac muscle, the internal organs, and glands

- control is **involuntary**

- made up of two distinct, and often opposing, units, the **sympathetic** nervous system and **parasympathetic** nervous system

- sympathetic system prepares the body for **stress**

- parasympathetic system reverses the effects of the sympathetic nervous system and **restores the body to normal**

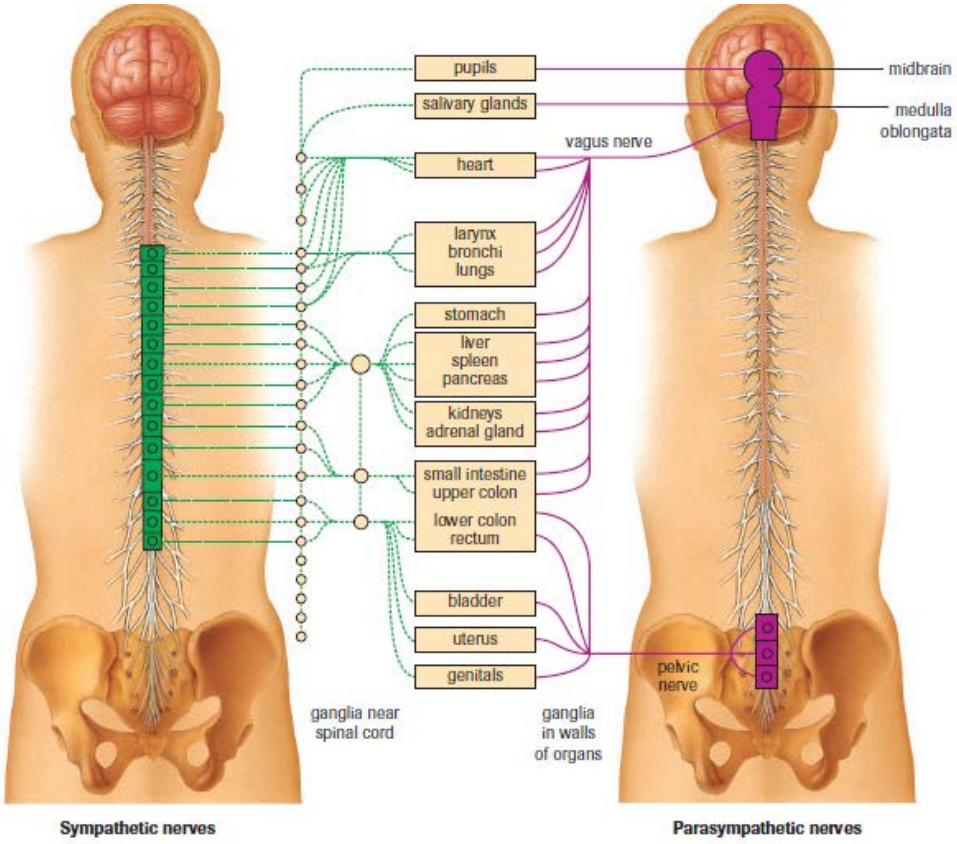
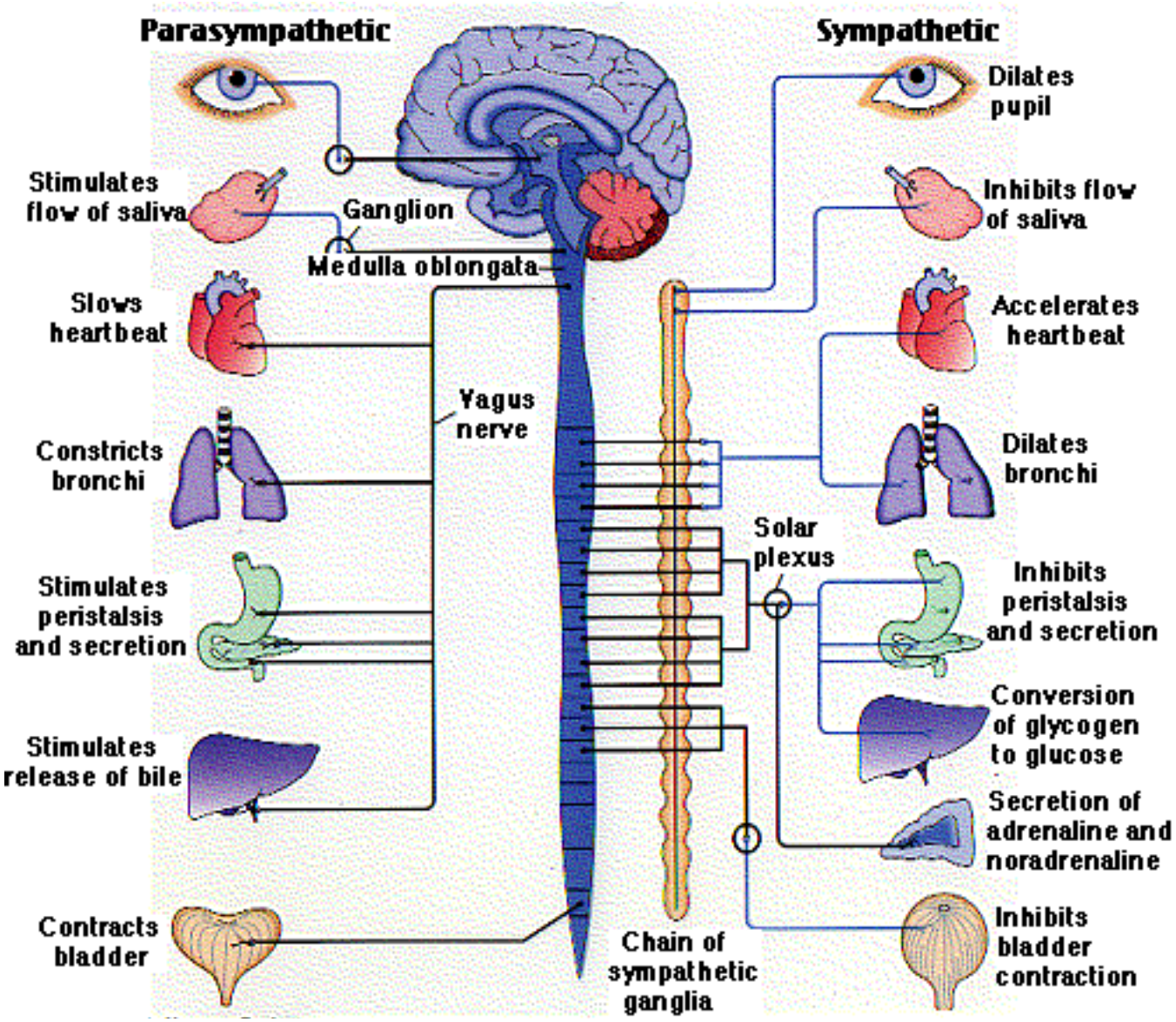


Table 1 Some Effects of the Autonomic Nervous System

Organ	Sympathetic	Parasympathetic
heart	increases heart rate	decreases heart rate
digestive tract	decreases peristalsis	increases peristalsis
liver	increases the release of glucose	stores glucose
eyes	dilates pupils	constricts pupils
bladder	relaxes sphincter	contracts sphincter
skin	increases blood flow	decreases blood flow
adrenal gland	causes release of epinephrine	no effect


Parasympathetic
Sympathetic
Dilates pupil
Stimulates flow of saliva
Ganglion
Medulla oblongata
Inhibits flow of saliva
Slows heartbeat
Accelerates heartbeat
Vagus nerve
Constricts bronchi
Dilates bronchi
Solar plexus
Stimulates peristalsis and secretion
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Stimulates release of bile
Secretion of adrenaline and noradrenaline
Contracts bladder
Chain of sympathetic ganglia
Inhibits bladder contraction

Topic 2 - Class 2
Peripheral Nervous System
Review Sheet

1. Many prescription drugs affect the autonomic nervous system. Table 2 describes the action of four different drugs.

Table 2 Drug Actions

Drug	Action
pilocarpine	produces effects similar to the parasympathetic nervous system
resperine	inhibits the activity of the sympathetic nervous system
ephedrine	stimulates the release of norepinephrine from postganglionic nerves
neostigmine	blocks the action of cholinesterase at synapses

(a) Which drug should not be taken by someone who has high blood pressure? Give reasons for your answer.

(b) A patient who has taken too much neostigmine is admitted to hospital. What symptoms would be displayed?

2. Jogging will cause heart rate to change because of

A. increased sympathetic and decreased parasympathetic impulses
B. decreased sympathetic and increased parasympathetic impulses
C. increased sympathetic and decreased central nervous system impulses
D. decreased sympathetic and increased central nervous system impulses

3. Returning involuntary body functions to normal after a period of stress is the function of which division of the nervous system?

A. Central **B.** Somatic **C.** Sympathetic **D.** Parasympathetic

Topic 3
The Senses
Pre-Class Reading Assign

1. Read pgs 446-448

2. Define the following terms
    a. Stimulus

    b. Sensory receptor

    c. Sensory adaptation

3. Identify a sensory receptor for each of the following stimuli: chemical energy, mechanical energy, heat, light energy, and sound energy.

4. Do sensory receptors identify all environmental stimuli? Give examples to back up your answer.

5. Explain why you are less able to taste food when you have a cold.

Topic 3
The Senses
Notes

- A **stimulus** is a form of **energy**.

- We sense our environment using a varitey of **sensory receptors**.

    - Convert one form of energy into the **electrical energy** of an **action potential**.

    - Are highly modified ends of sensory neurons.

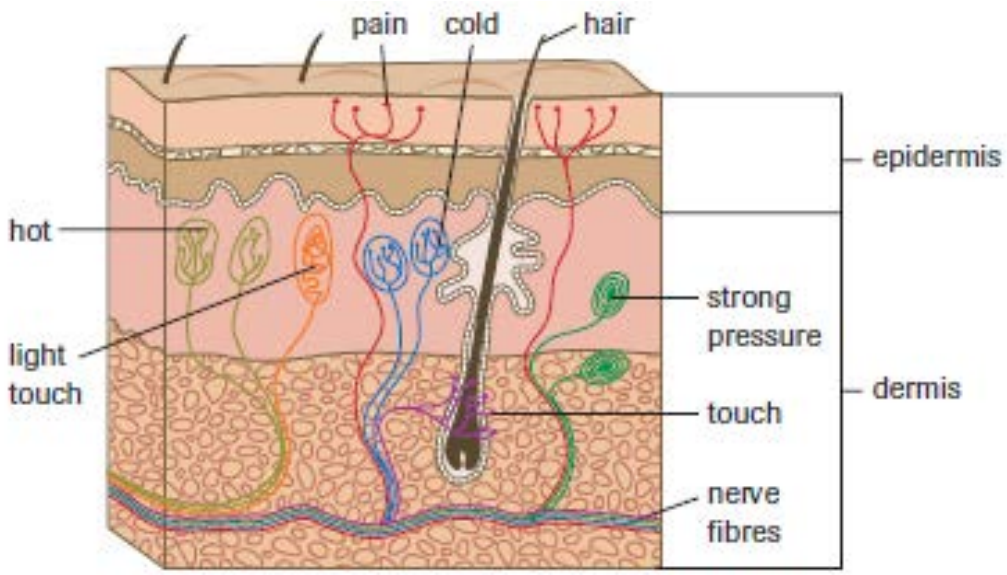
    - Often grouped within sensory organs (eye, ear, tongue, nose).

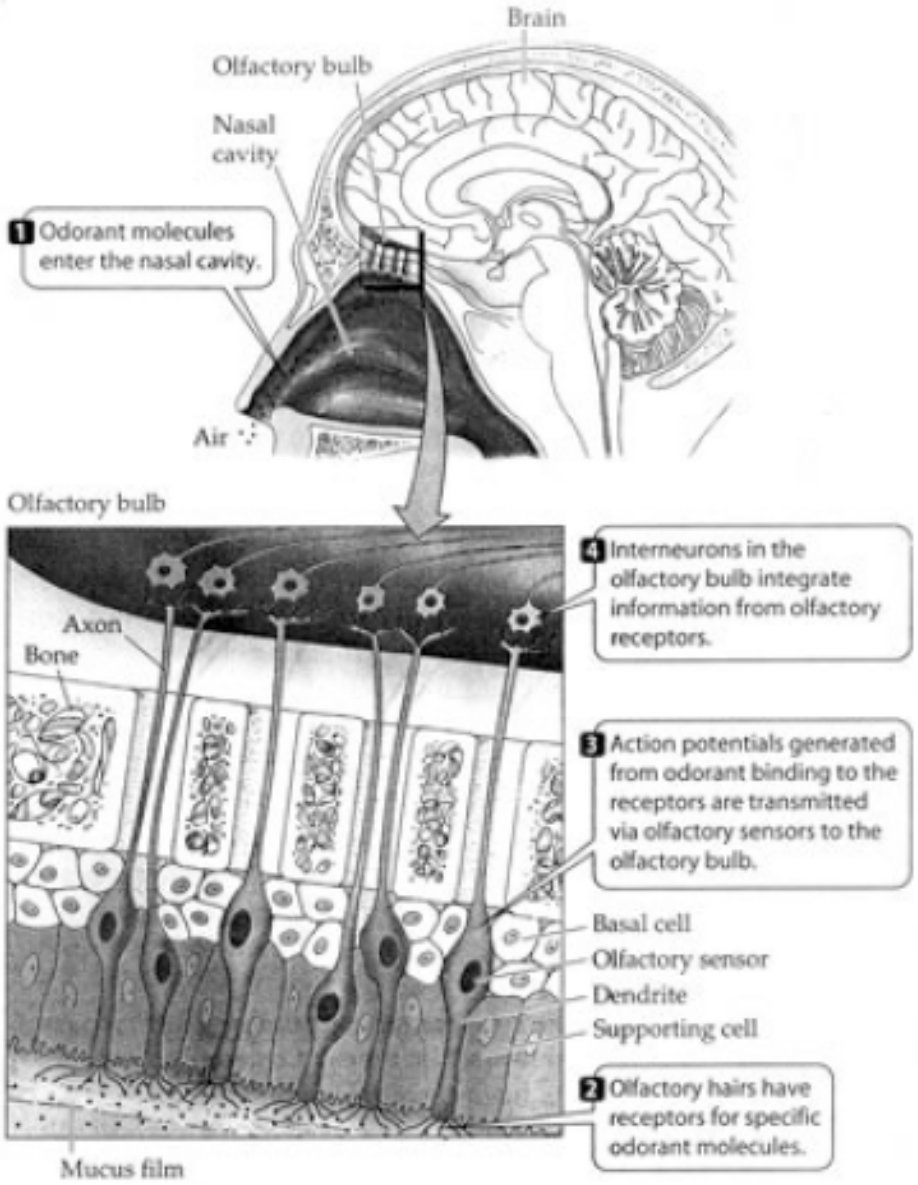
Table 1 The Body's Sensory Receptors

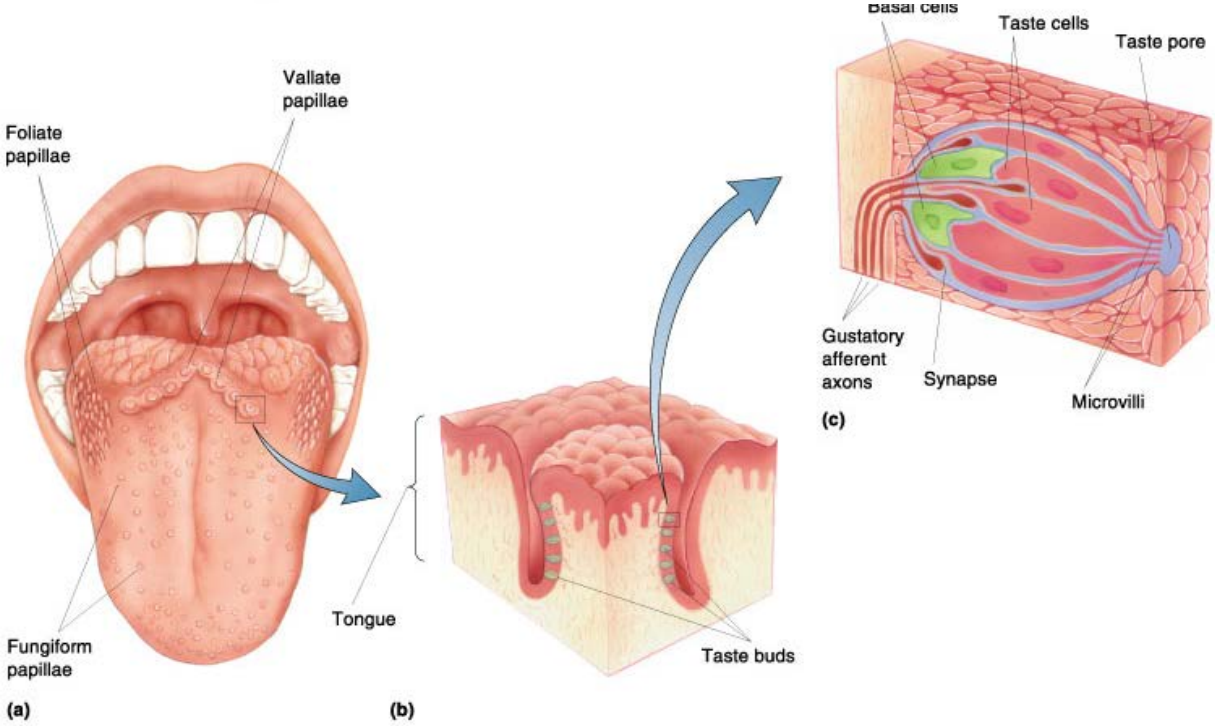
Receptor Type	Stimulus	Information provided
taste	chemical	presence of specific chemicals (identified by taste buds)
smell	chemical	presence of chemicals (detected by olfactory cells)
pressure	mechanical	movement of the skin or changes in the body surface
proprioceptor	mechanical	movement of the limbs
balance	mechanical	body movement
audio	sound	sound waves
visual	light	changes in light intensity, movement, and colour
thermoreceptor	temperature changes	flow of heat

http://www.bbc.co.uk/science/humanbody/body/factfiles/smell/smell_ani_f5.swf

http://www.sumanasinc.com/webcontent/animations/content/skinreceptors.html




Brain
Olfactory bulb
Nasal cavity
1 Odorant molecules enter the nasal cavity.
Air
Olfactory bulb
Axon
Bone
4 Interneurons in the olfactory bulb integrate information from olfactory receptors.
3 Action potentials generated from odorant binding to the receptors are transmitted via olfactory sensors to the olfactory bulb.
Basal cell
Olfactory sensor
Dendrite
Supporting cell
2 Olfactory hairs have receptors for specific odorant molecules.
Mucus film


Vallate papillae
Foliate papillae
Fungiform papillae
Tongue
Taste buds
(a)
(b)
Basal cells
Taste cells
Taste pore
Gustatory afferent axons
Synapse
Microvilli
(c)

Topic 4 – Class 1
Parts of the Eye
Pre-Class Reading Assign

1. Read pgs 449-451

2. Define the following terms
    a. Sclera

    b. Cornea

    c. Aqueous humour

    d. Choroid layer

    e. Iris

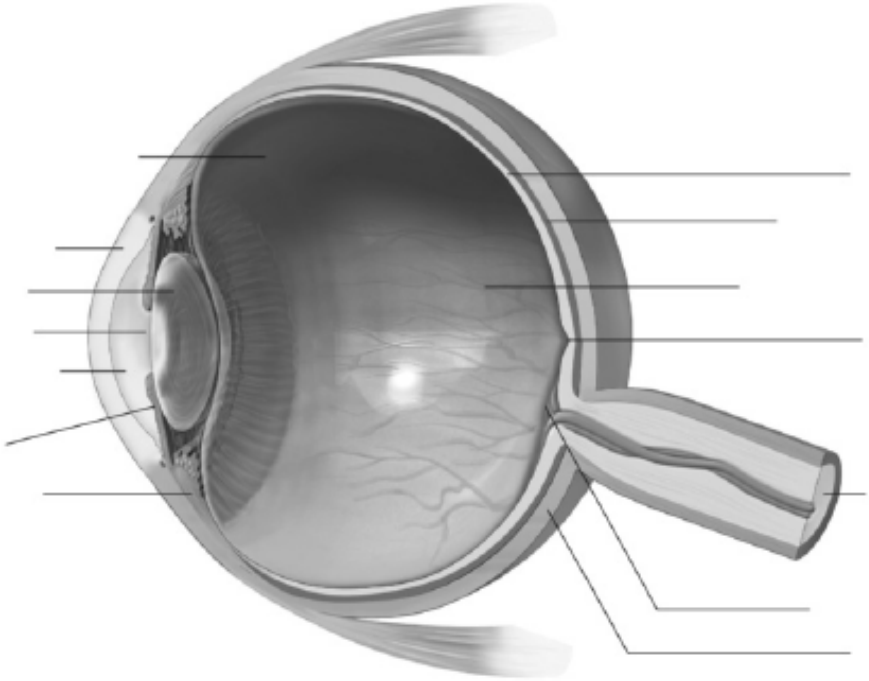
    f. Retina

    g. Rods

    h. Cones

    i. Fovea centralis

3. Label the following diagram of the eye



4. List the three layers of the eye and describe the function of each layer.

5. Compare rods and cones in terms of location, structure, and function.

Topic 4 – Class 1
Parts of the Eye
Notes

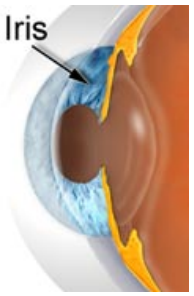
Parts of the eye

Outer Layer

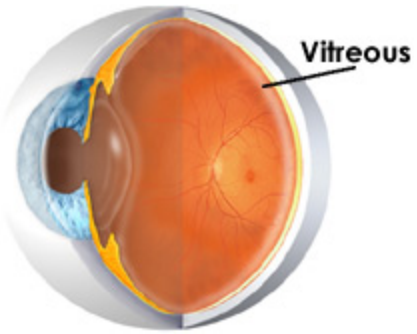
- Cornea –
  - transparent, dome-shaped window covering the front of the eye
  - providing **2/3** of the eye's focusing power
- Sclera –
  - The **"white"** of the eye
  - Protective layer and maintains eye shape

Middle Layer

- Aqueous humor –
  - thin, watery fluid that fills the space between the cornea and the iris
  - **nourishes** the cornea and the lens
  - gives the front of the eye its form and shape.
- Choroid –
  - composed of layers of blood vessels that nourish the **retina**
- Iris
  - **colored** part of the eye
  - controls **light** levels inside the eye
  - embedded with tiny **muscles** that **dilate (widen)** and **constrict (narrow)** the pupil size.

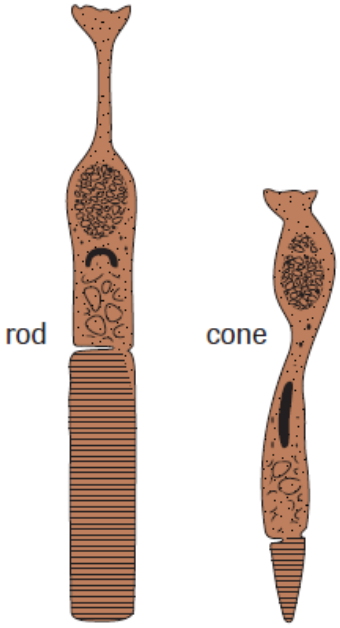


- Pupil
  - opening in the center of the **iris**
- Lens
  - located just behind the **iris**
  - focus light onto the **retina**
  - can change shape to change the area of focus
- Vitreous humor
  - thick, transparent substance that fills the center of the eye
  - comprises about 2/3 of the eye's volume



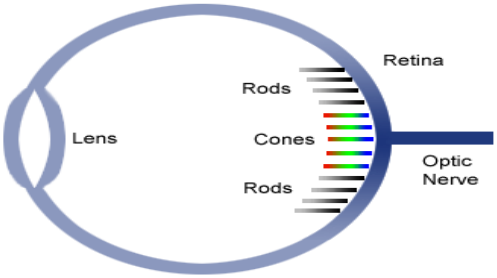
Inner Layer

- Retina
  - multi-layered sensory tissue that lines the back of the eye
  - contains millions of photoreceptors that capture light rays and convert them into electrical impulses
  - impulses travel along the optic nerve to the brain where they are turned into images
    - specifically to the **occipital** lobe
  - two types of photoreceptors in the retina: **rods and cones**



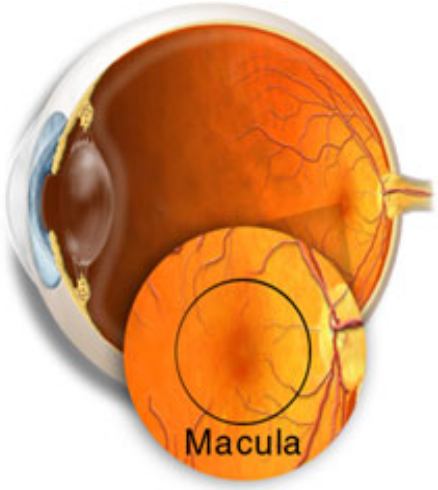
- Rods
  - got their names because of their **shape**.
  - many more rods than cones, although cones do the bulk of the work in every day light
  - rods only respond in **black and white**
  - .located in all parts of the eye except the **fovea**.

- Cones
  - cones are more responsible for acute (detailed) vision, and are also responsive to colors
  - cones are mostly located on the **fovea**.



- Macula
  - located roughly in the center of the retina
  - small and highly sensitive part of the **retina** responsible for detailed central vision

- Fovea
  - Very center of the **macula**
  - Most sensitive area of the retina
  - Contains only **cones**



- Optic Nerve
  - transmits electrical impulses from the retina to the brain
  - connects to the back of the eye near the **<u>macula</u>**
  - sensory receptor cells of retina are absent from the optic nerve.
    - Because of this, everyone has a normal blind spot. This is not normally noticeable because the vision of both eyes overlaps

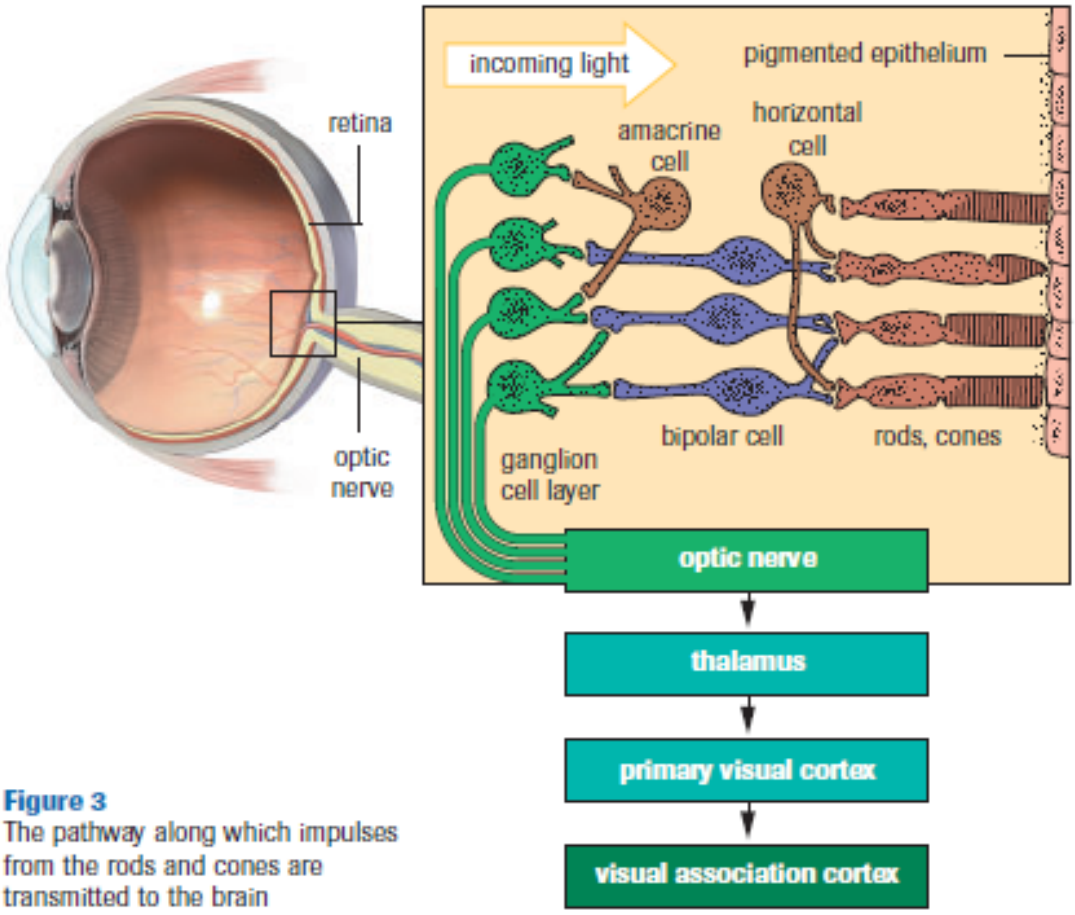


Figure 3
The pathway along which impulses from the rods and cones are transmitted to the brain

Chemistry of Vision

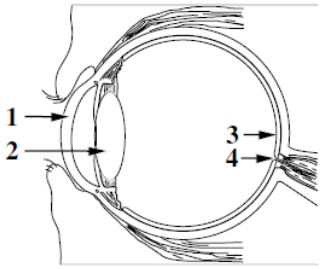
- Rods and cones contain a compound called **<u>rhodopsin</u>**
  - There are 3 types of cones that detect diff colors and contain different types of rhodopsin
- When light strikes the rods and cones, rhodopsin is broken down into smaller compounds
- These chemicals start a pathway that ends up in the membrane becoming more permeable to Na^+
- This leads to an action potential that sends an impulse to the brain

  http://www.sinauer.com/neuroscience4e/animations11.1.html

Topic 4 – Class 1
Parts of the Eye
Review Sheet

Use the following information to answer the next question.

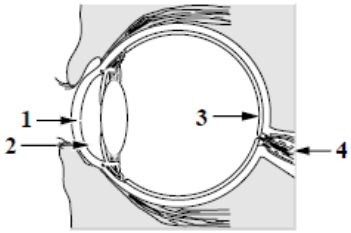
The Human Eye



An area of the eye where sensory reception of light is most acute and an area where there is no such sensory reception are labelled, **respectively**,

A. 1 and 2
B. 2 and 3
C. 3 and 4
D. 4 and 1

Many scientists believe that sleep cycles are influenced by the hormone melatonin. Two scientists have shown that the retinas in hamsters are involved in maintaining a 24-hour cycle. Their research shows that impulses sent from the retina to the brain after exposure to light influence the secretions of melatonin. Melatonin is normally produced in greater amounts at night when the eyes are exposed to less light. In humans, melatonin produces drowsiness.



—from *Raloff, 1996*

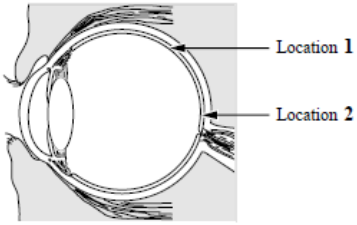
Melatonin secretion decreases when light stimulates receptors found in the structure labelled

A. 1
B. 2
C. 3
D. 4

Erectile dysfunction is defined as the inability to maintain an erection adequate enough to achieve a satisfactory sexual experience. When erectile dysfunction is related to inadequate blood flow to the penis, the medication Viagra can be prescribed.

A side effect of Viagra is that it sometimes results in temporary difficulties in distinguishing between the colours of blue and green. For this reason, pilots have been banned from using the drug within six hours of a flight.

The Human Eye



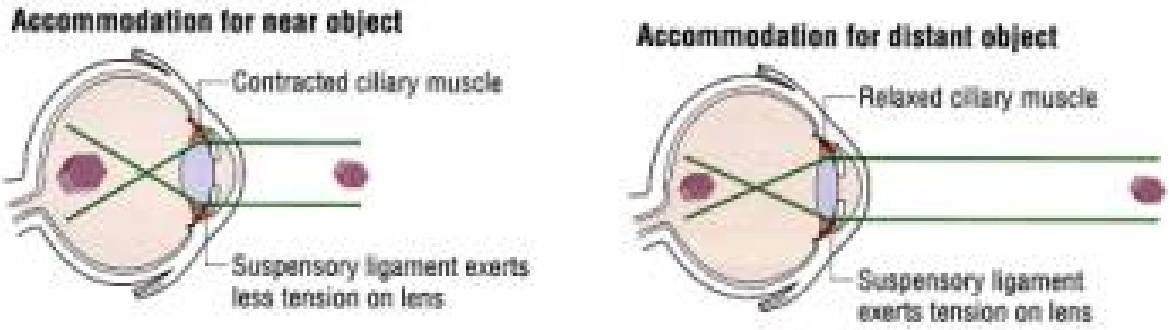
The cells in the eye that are affected by Viagra and the primary location of these cells, as labelled above, are, respectively,

A. rod cells and location 1
B. rod cells and location 2
C. cone cells and location 1
D. cone cells and location 2

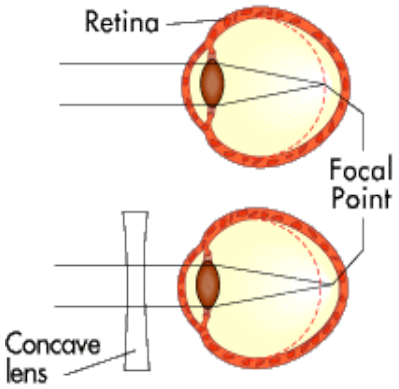
Topic 4 – Class 2
Getting light to the Retina
Pre-Class Reading Assignment

1. Read pgs. 452-455

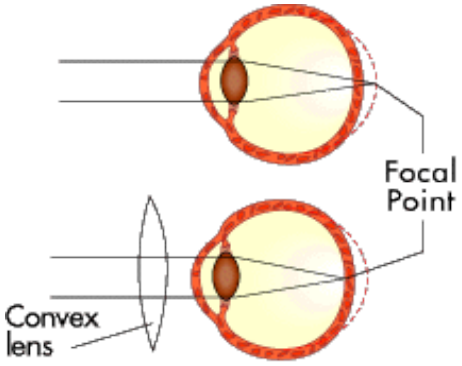
- When light rays reach an angulated surface of a different material, it causes the light rays to bend.
    - This is called **refraction**.
- The cornea, aqueous humor, lens and vitreous humor all bend light to focus is perfectly on the retina
- Pupil size and lens shape changes with distance.
    - For far objects the lens is stretched flat
    - For close objects it bulges out.
    - http://www.nelson.com/ABbio20-30/teacher/protect/otr/Bio2030OTR/attachments/i_AnimationSimulation/accommodation.html
- The time it takes to adjust varies according to age and genetics!

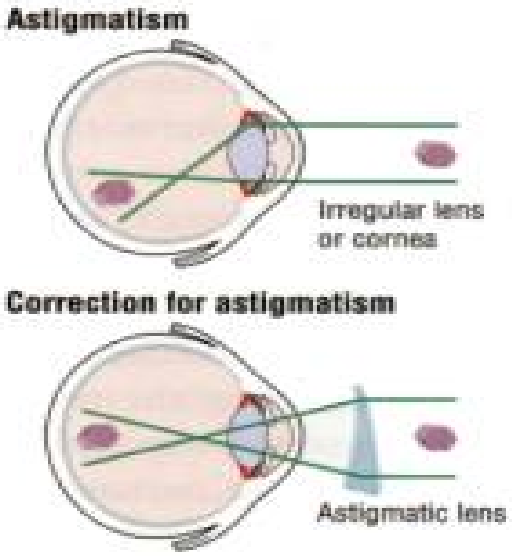


Nearsightedness (**myopia**)
- a person is able to see **near** objects well and has difficulty seeing objects that are **far away**
- Light rays become focused **in front** of the retina
- caused by an eyeball that is too long, or a lens system that has too much power to focus corrected with a concave lens



Farsightedness (**hyperopia**)
- a person is able to see **distant** objects well and has difficulty seeing objects that are **near**
- Light rays become focused **behind** the retina
- caused by an eyeball that is too short, or by a lens system that has too little focusing power with a convex lens





Astigmatism

- caused by an irregularly shaped lens or cornea.

Glaucoma

- Glaucoma involves damage to the optic nerve most often caused by high pressure inside the eye due to a build-up of excess fluid

Color Blindness

- Color blindness occurs when there is a problem with the color-sensing granules (pigments) in cones.
- Most color blindness is due to a X-linked recessive disorder

Macular degeneration

Topic 4 – Class 2
Getting light to the Retina
Review Assignment

Topic 5 – The Ear
Class 1
Pre class reading assignment

1. Read pgs 456-460
2. Define the following terms
    a. pinna

    b. auditory canal

    c. tympanic membrane

    d. ossicles

    e. oval window

    f. eustachian tube

    g. vestibule

    h. semicircular canals

    i. cochlea

3. Go to the following website and follow the instructions on the screen
   http://www.wisc-online.com/objects/index_tj.asp?objID=AP1502

4. What function do the tympanic membrane, ossicles, and oval window serve in sound transmission?

5. Categorize the following structures of the inner ear according to whether their functions relate to balance or hearing: organ of Corti, cochlea, vestibule, saccule, ampulla, semicircular canals, oval window, and round window.

6. Briefly outline how the external ear, middle ear, and inner ear contribute to hearing.

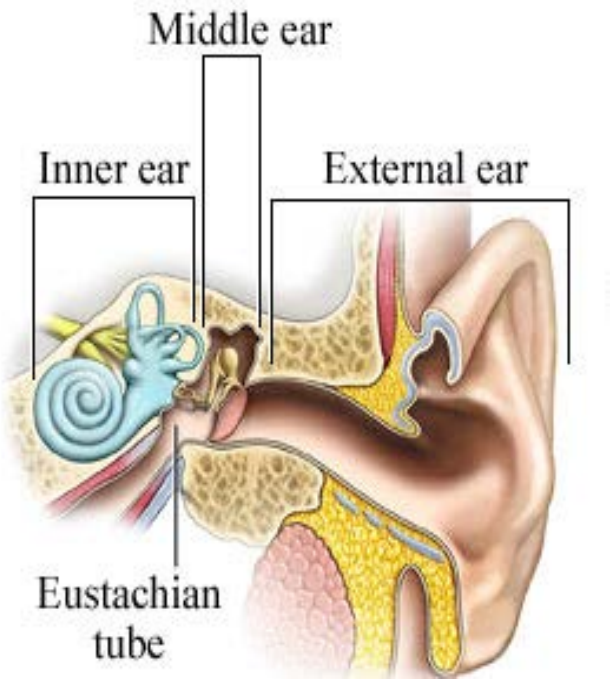
7. Describe how the semicircular canals provide information about body movement.

Topic 5 – The Ear
Class 1
Notes

- Associated with 2 basic functions
    - **Hearing**
    - **Equilibrium**
- Sensory cells for both functions are located in the **inner ear**
    - Consist of tiny hairs called cilia that respond to movement and generate a nerve impulse

Structure of the ear

- Divided into 3 sections:
    - Outer Ear
    - Middle Ear
    - Inner Ear



Outer (External) Ear

- Pinna
    - Acts like a funnel, collecting sound from a large area and channeling it into a small canal
- Auditory canal
    - Carries sound to the eardrum (tympanic membrane)
    - Has specialized sweat glands that produce ear wax

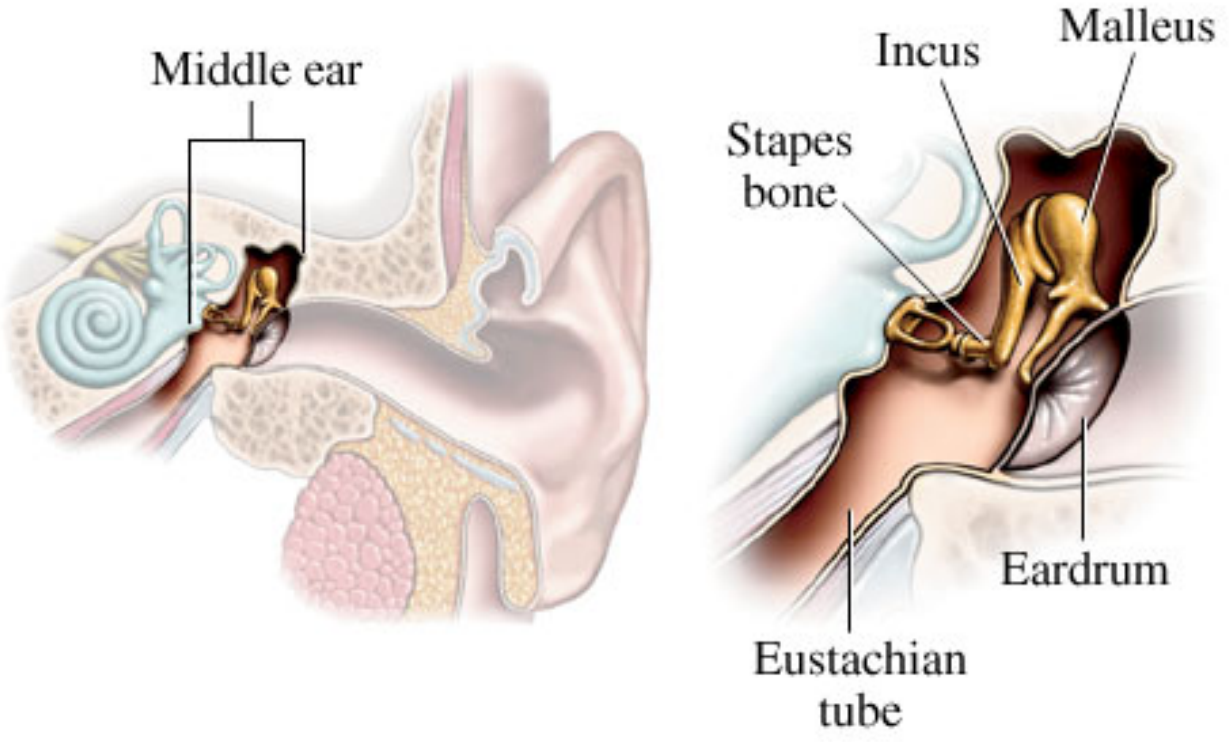
Middle Ear

- Tympanic Membrane
  - thin membrane that separates the outer ear from the middle ear
  - Also called the ear drum

- Ossicles
  - 3 small bones: **malleus** (hammer), **incus** (anvil), **stapes** (stirrup)

- Oval Window
  - Small membrane which receives sound waves from the stapes
  - 3.2 mm^2 whereas the tympanic membrane is 64mm^2

- Eustachian Tube
  - Extends from middle ear to the air in mouth and nose
  - 40mm in length and 3mm in diameter
  - Allows for equalization of air pressure (scuba diving, plane)



Inner Ear - encased in the hardest bone of the body

- Vestibule
  - houses two small sacs, the utricle and saccule, which establish head position

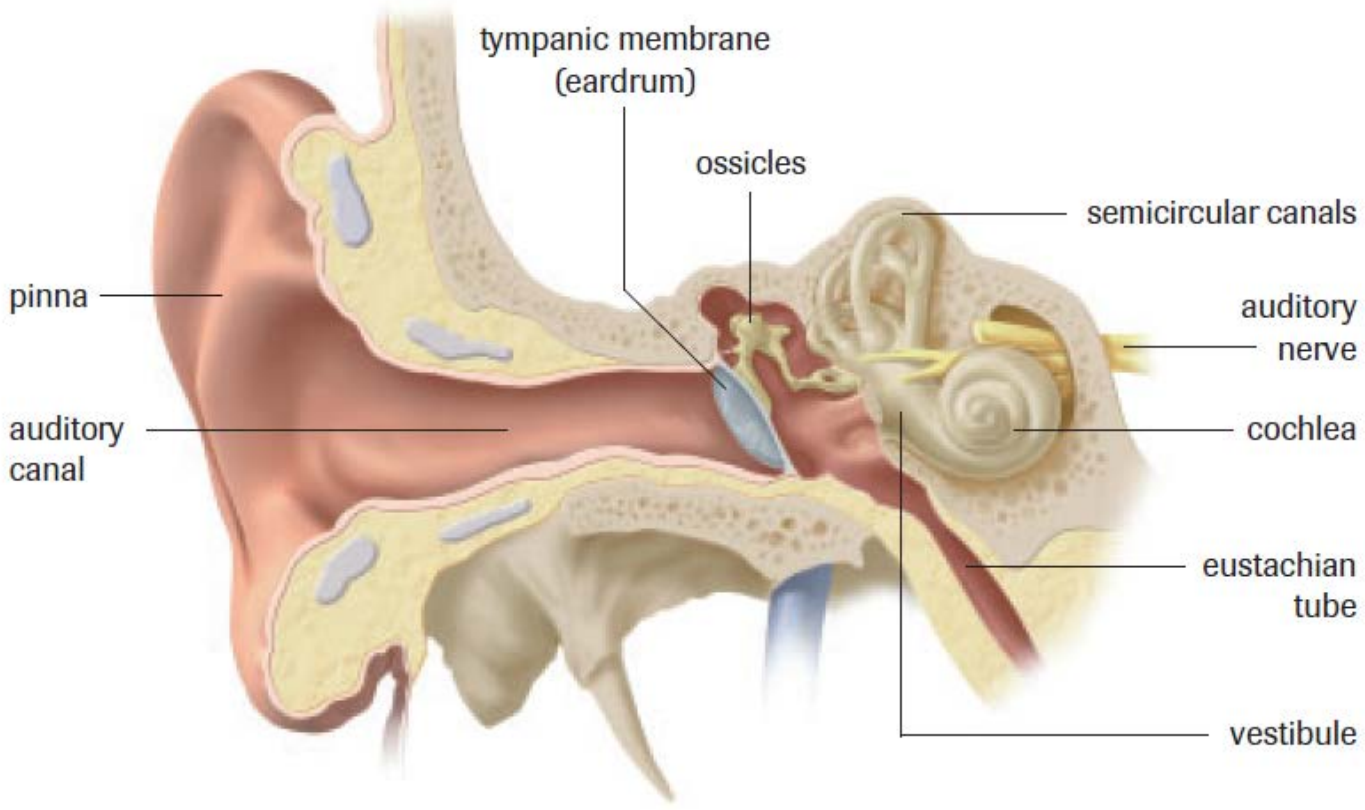
- Semicircular canals
  - Arranged at different angles and filled with fluid

  - Helps determine body movement

- Cochlea – shaped like a snail shell

  - Contain specialized hairs that transmit sound waves to nerve impulses **via the auditory nerve**

    - The hairs are a type of **mechanoreceptor** that detect changes in movement



The Ear and Hearing

- sound energy must be converted into an electrical impulse before our brain can make sense of it

- How sound creates hearing

  1. Sound waves enter auditory canal and vibrate tympanic membrane

  2. Tympanic membrane vibrates ossicles

  3. Ossicles vibrate oval window

  4. Oval window produces waves in fluid in cochlea

  5. Waves move tiny hairs which produce nerve impulses that travel to brain

  http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120108/bio_e.swf
  http://www.sumanasinc.com/webcontent/anisamples/neurobiology/soundtransduction.html

The Ear and Equilibrium

Hearing Loss

Topic 5 – The Ear
Review Sheet