Biology 12 **Human Biology - The Nervous System** **Name** _____

Main reference: Biology Concepts and Connects Sixth edition **Chapter 28**

Vocabulary

acetylcholine (ACh), acetylcholinesterase (AChE), action potential, "all-or-none" response, axomembrane, axon, axoplasm, calcium ion, cell body, central nervous system, dendrite, depolarization, effector, excitatory neurotransmitter, impulse, inhibitory neurotransmitter, interneuron, motor neuron, myelin sheath, myelinated nerve fibre, neuron, neurotransmitters, node of Ranvier, norepinephrine, peripheral nervous system, polarity, postsynaptic membrane, potassium gate, presynaptic membrane, contractile protein, receptor, reflex arc, refractory period, repolarization, resting potential, saltatory transmission, Schwann cell, sensory neuron, sodium gate, sodium-potassium pump, synapse, synaptic cleft, synaptic ending, synaptic vesicle, threshold value

It is expected that students will:

C11 Analyse the transmission of nerve impulses

C11.1 identify and give functions for each of the following: dendrite, cell body, axon, axoplasm, and axomembrane

C11.2 differentiate among sensory, motor, and interneurons with respect to structure and function

C11.3 explain the transmission of a nerve impulse through a neuron, using the following terms:

- – resting and action potential
- – depolarization and repolarization
- – refractory period
- – sodium and potassium gates
- – sodium-potassium pump
- – threshold value
- – "all-or-none" response
- – polarity

C11.4 relate the structure of a myelinated nerve fibre to the speed of impulse conduction, with reference to myelin sheath, Schwann cell, node of Ranvier, and saltatory transmission

C11.5 identify the major components of a synapse, including
- synaptic ending
- presynaptic and postsynaptic membranes
- synaptic cleft
- synaptic vesicle
- calcium ions and contractile proteins
- excitatory and inhibitory neurotransmitters (e.g., norepinephrine, acetylcholine – ACh)
- receptor
- acetylcholinesterase (AChE)

C11.6 explain the process by which impulses travel across a synapse

C11.7 describe how neurotransmitters are broken down in the synaptic cleft

C11.8 describe the structure of a reflex arc (receptor, sensory neuron, interneuron, motor neuron, and effector) and relate its structure to how it functions

This is a good website http://www.biologymad.com/NervousSystem/nervoussystemintro.htm

Pain. Is it all just in your mind? Professor Lorimer Moseley - University of South Australia 48 minutes
http://www.youtube.com/watch?v=-3NmTE-fJSo&feature=youtube_gdata_player

Brain Pacemakers Used To Treat Alzheimer's Disease
BEST OF SCIENCE | 30 JANUARY, 2013
http://pulse.me/s/hYoKy

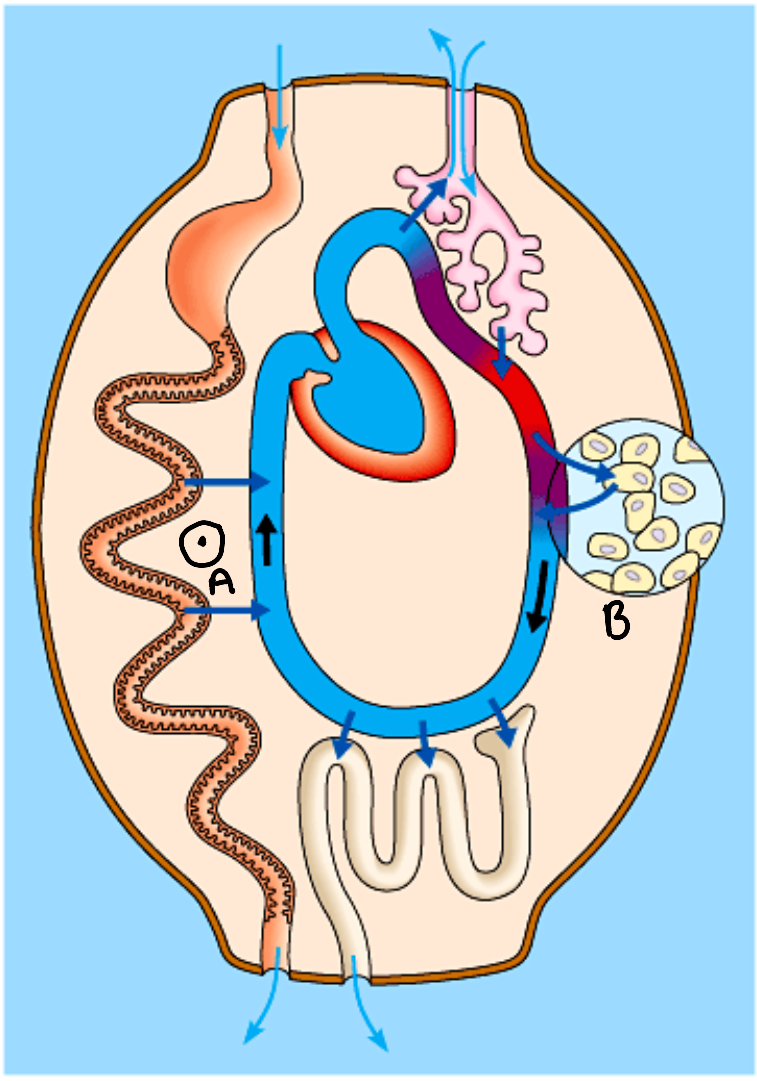
Elliot Krane – The mystery of chronic pain (it's only 8:10min)
I'm going to show this in class tomorrow since I'm going to be away at Playland! It's not too complicated, and he gets into neurotransmitters…
http://www.ted.com/talks/elliot_krane_the_mystery_of_chronic_pain?language=en#t-233674

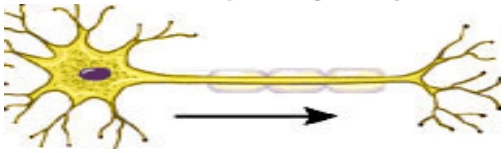
Jill Bolte Taylor – A Stroke of Insight (18:19min)
This one will be good when we discuss the brain next week! A brain scientist discusses her experience when she had a stroke… very interesting!
http://www.ted.com/talks/jill_bolte_taylor_s_powerful_stroke_of_insight?language=en

Introduction

If a cell at point 'A' needs to communicate with a cell at point 'B', what are two different ways that this can be done?

1. Via nerves (neurons)
2. The endocrine system via hormones (chemicals)



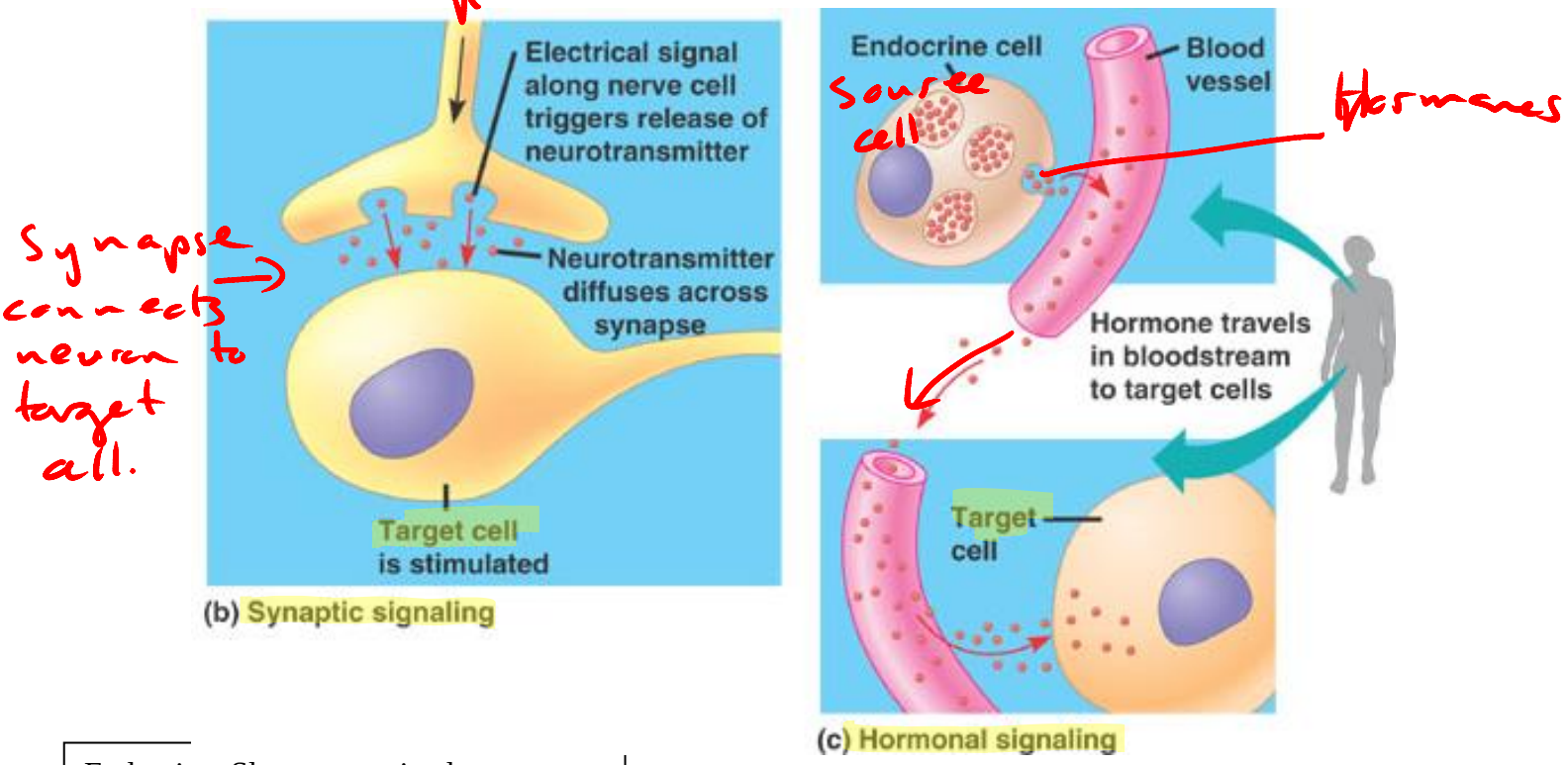


Both nervous and hormonal message systems use chemicals to communicate between cells. Use the diagrams to explain how these two systems compare.

Nervous system

neuron

Endocrine system.



Synapse connects neuron to target cell.

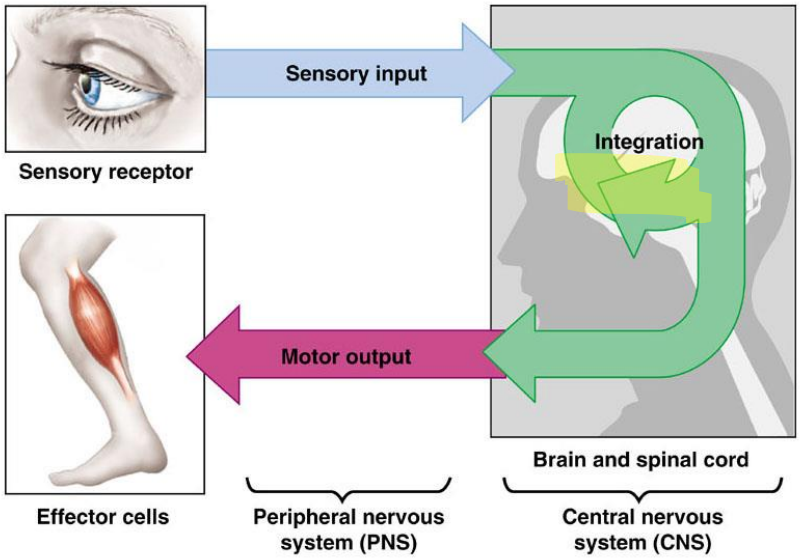
Endocrine: Slower, sustained responses
Nervous: Rapid coordination of body functions.

Target cells are either glands or muscle cells or another neuron.

These target cells receive messages via chemicals → neurotransmitters → hormones

Video: Fish Neurons Fire in Real-Time as It Stalks Prey
WIRED SCIENCE | 1 FEBRUARY, 2013
http://pulse.me/s/i4Yhf

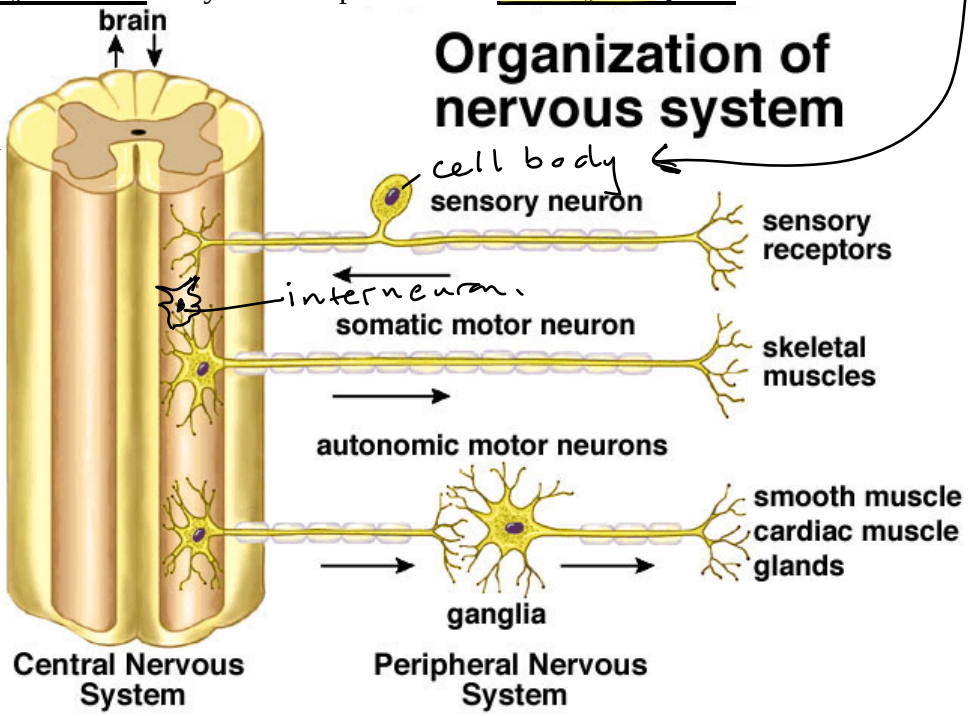
How is the nervous system organized?



Cell bodies form ganglia outside the spinal cord.

This diagram illustrates how **sensory neurons** carry nerve impulses from **sensory receptors** towards the central nervous system, and **motor neurons** carry impulses away from the CNS towards the **effectors** (muscles and glands).

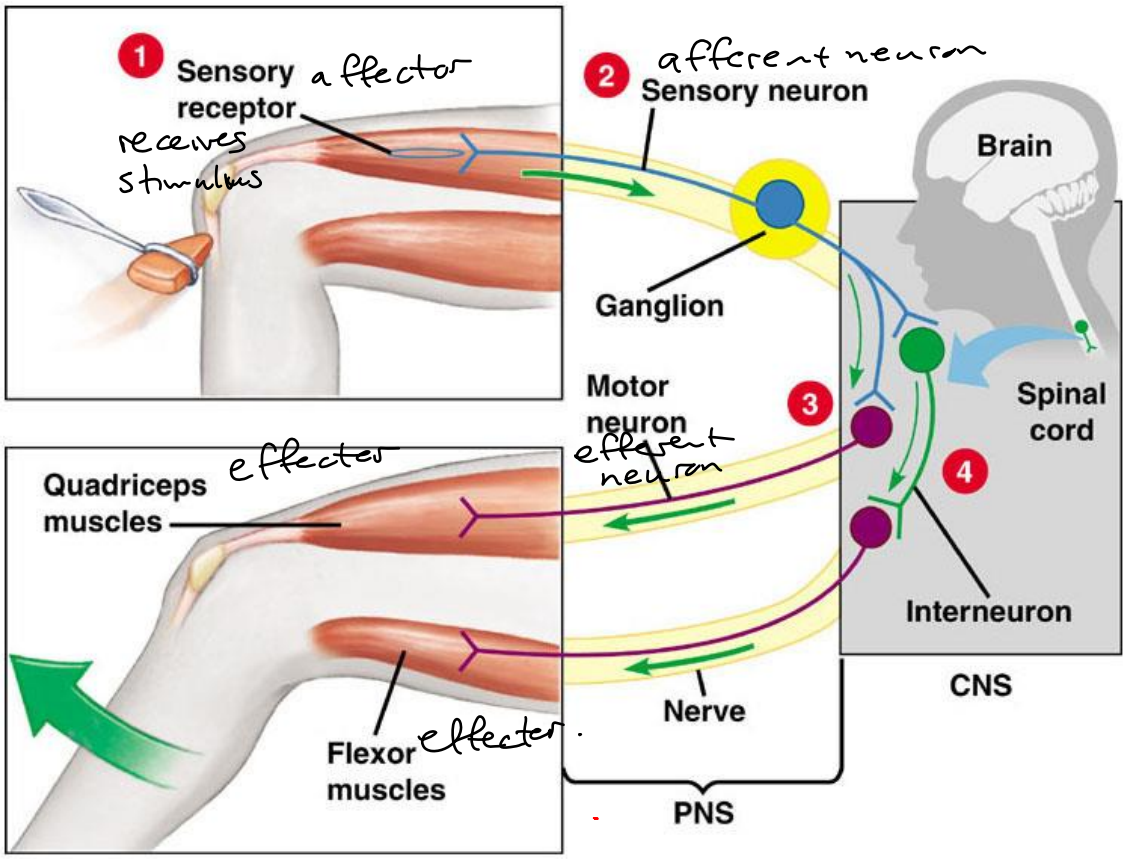
Notice that sensory and motor neurons look a bit different, and the cell body of each one is found in a slightly different location within the nervous system. Also notice that somatic and autonomic motor neurons are laid out a bit differently from each other.



Here is one of the simplest nerve pathways in the body.

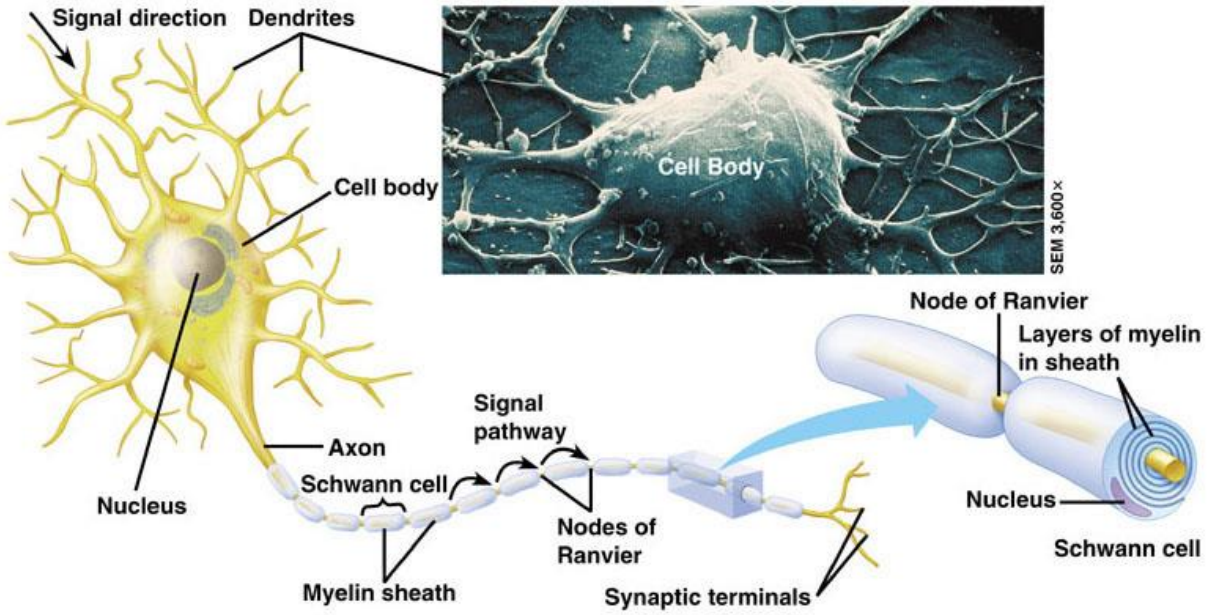
You can see that the Sensory neuron has its nucleus just outside of the central nervous system in the dorsal-root ganglion. The motor neuron has its nucleus within the CNS, near the ventral root. Neurons that are found completely within the CNS are referred to as interneuron.

From the diagram, can you see what the difference is between a 'neuron' and a 'nerve'?



Reflex Arc

C11.1 identify and give functions for each of the following: dendrite, cell body, axon, axoplasm, and axomembrane



Dendrite: Branched extensions that receive signals from other neurons.

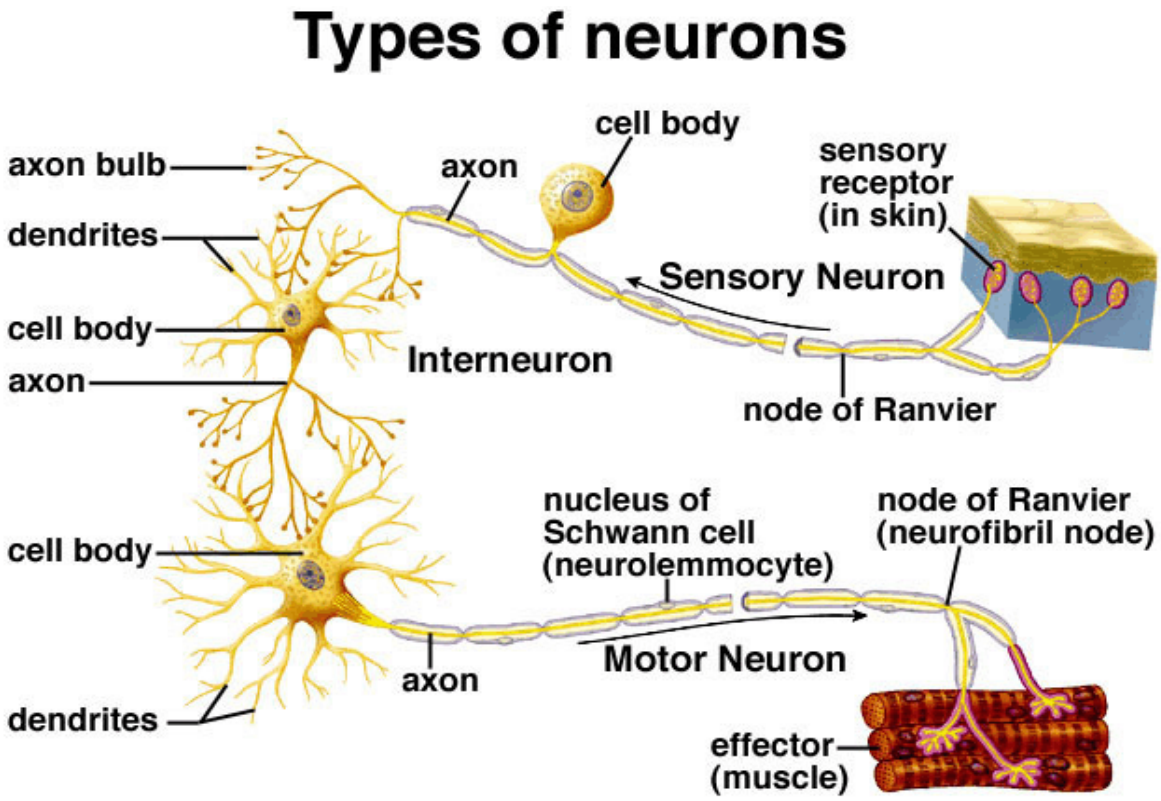
Cell body: Contains most of the neuron's organelles (including nucleus)

Axon: Extension that transmits signals to other cells.

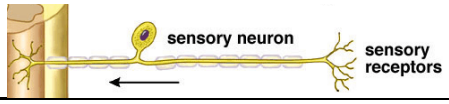
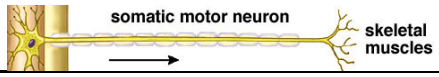
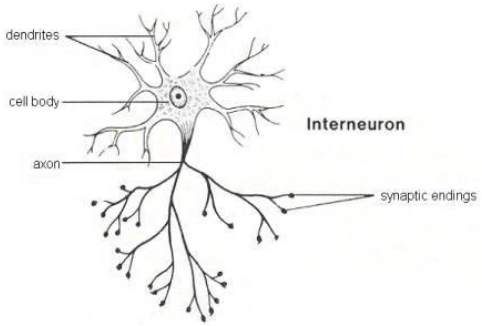
Axoplasm: ____cytoplasm in the axon containing the necessary ions for resting and action potential. _____

Axomembrane: cell membrane surrounding the axon of the neuron contains protein carriers to facilitate resting and action potential._____

C11.2 differentiate among sensory, motor, and interneurons with respect to structure and function



Complete the table

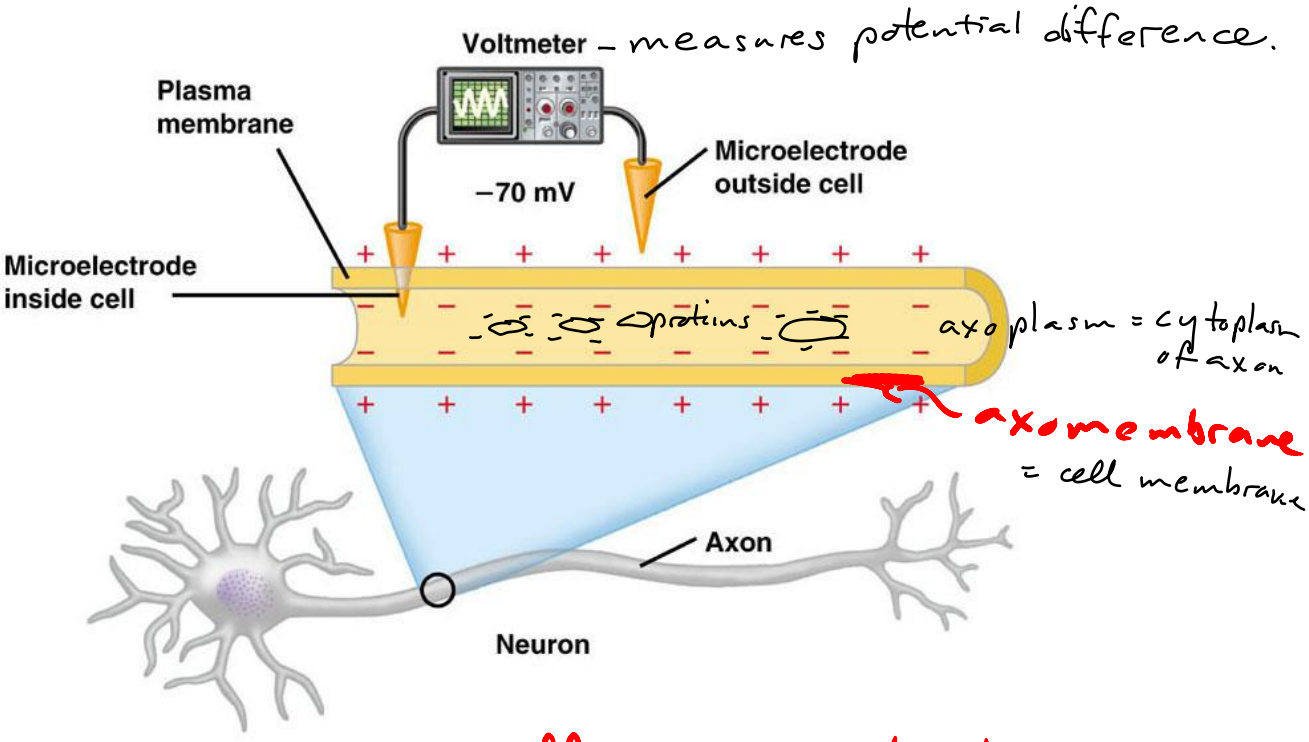
Neuron	Structure	Function
Sensory neuron 	**Long dendrite, short axon.** **Myelinated dendrite *and* axon.** **Cell body is just *outside* CNS.** **Cell body is like a bulb.**	**Carries nerve impulses from a receptor to the CNS.**
Motor neuron 	**Short dendrite, long axon.** **Myelinated axon.** **Cell body is just *inside* the CNS.** **Cell body has short dendrites attached to it.**	**Carries nerve impulses (messages) from the CNS to an effector (eg muscle).**
Interneuron 	**Short dendrites, long or short axon.** **Long axons are myelinated.**	**Carries nerve impulses within the CNS.**

C11.3 explain the transmission of a nerve impulse through a neuron, using the following terms:

- **resting and action potential**
- **depolarization and repolarization**
- **refractory period**
- **sodium and potassium gates**
- **sodium-potassium pump**
- **threshold value**
- **"all-or-none" response**
- **polarity**

BioFlix: How Neurons Work

Read page 566. ESSENTIAL READING and then write a brief note at the bottom of the next page.

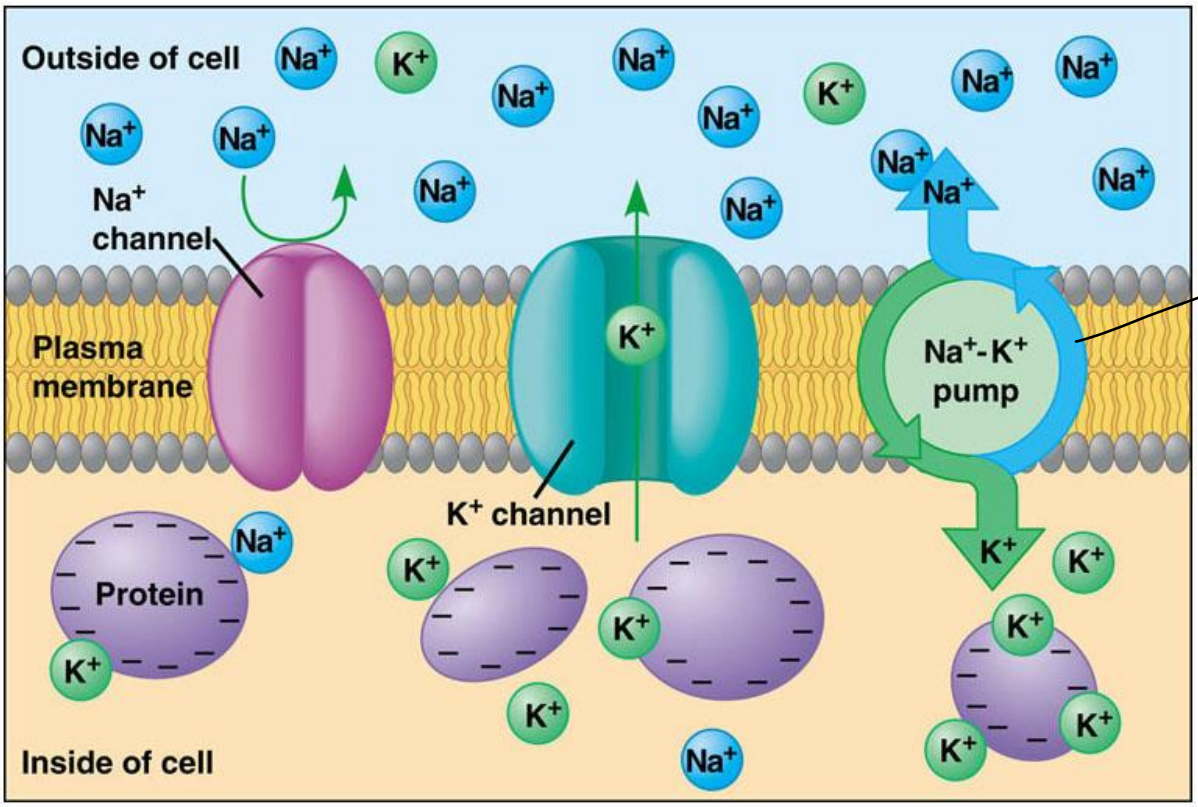


What is the 'resting potential'? The difference in electrical charge across the membrane when the neuron is at rest.

What do we mean when we say that the membrane of the neuron is 'polarized'?

The axoplasm is more negatively charged than the outer membrane.

How is the resting potential generated?



active transport by Na^+/K^+ pump ATP is used.

The inside of the membrane is negative relative to the outside. This results in a voltage (potential difference) of ± -65 mV.
The membrane is polarized.
The concentration of sodium ions is high outside the membrane; the concentration of potassium ions is high inside the membrane.
The sodium potassium gates are closed but leak slightly.
The sodium potassium active transport pump works to keep the concentration gradient - uses ATP

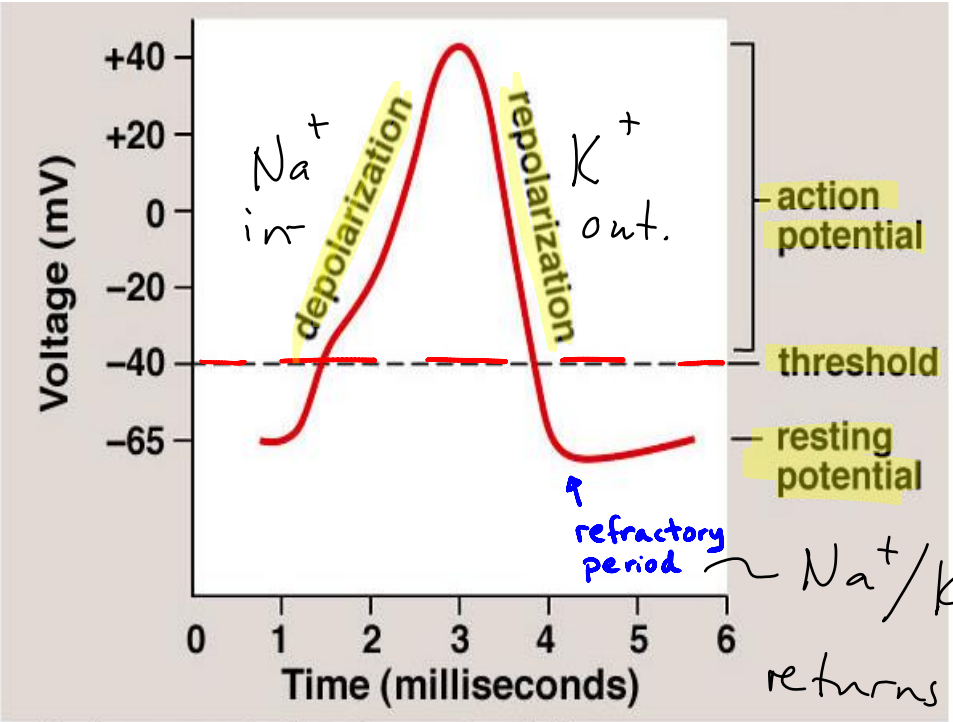
Now read page 566 and 567. *A nerve signal begins as a change in the membrane potential.*

What is an action potential?

Depolarisation of the membrane to transmit an impulse.

What causes an action potential?

Na^+ moving in and K^+ out. of neuron.



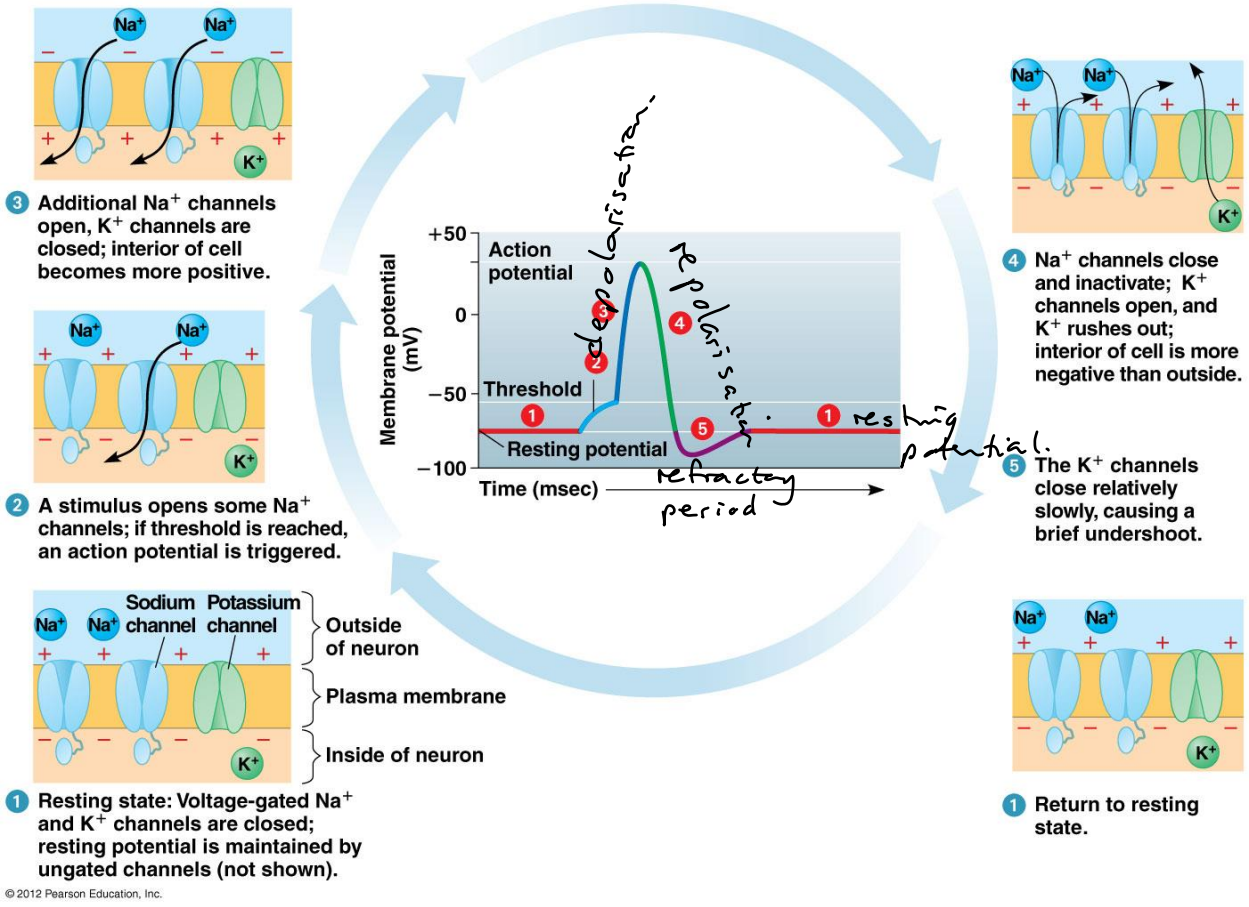
c. Enlargement of action potential

~ Na^+/K^+ pump returns Na^+ and K^+ to correct side of membrane.

Once the action potential happens at any spot on the neuron, it spreads like a wave down the whole neuron. This is what we call a '**nerve impulse**'.

http://www.youtube.com/watch?v=YP_P6bYvEjE resting and action potential

This diagram Fig. 28.4 illustrates the various stages in the action potential:



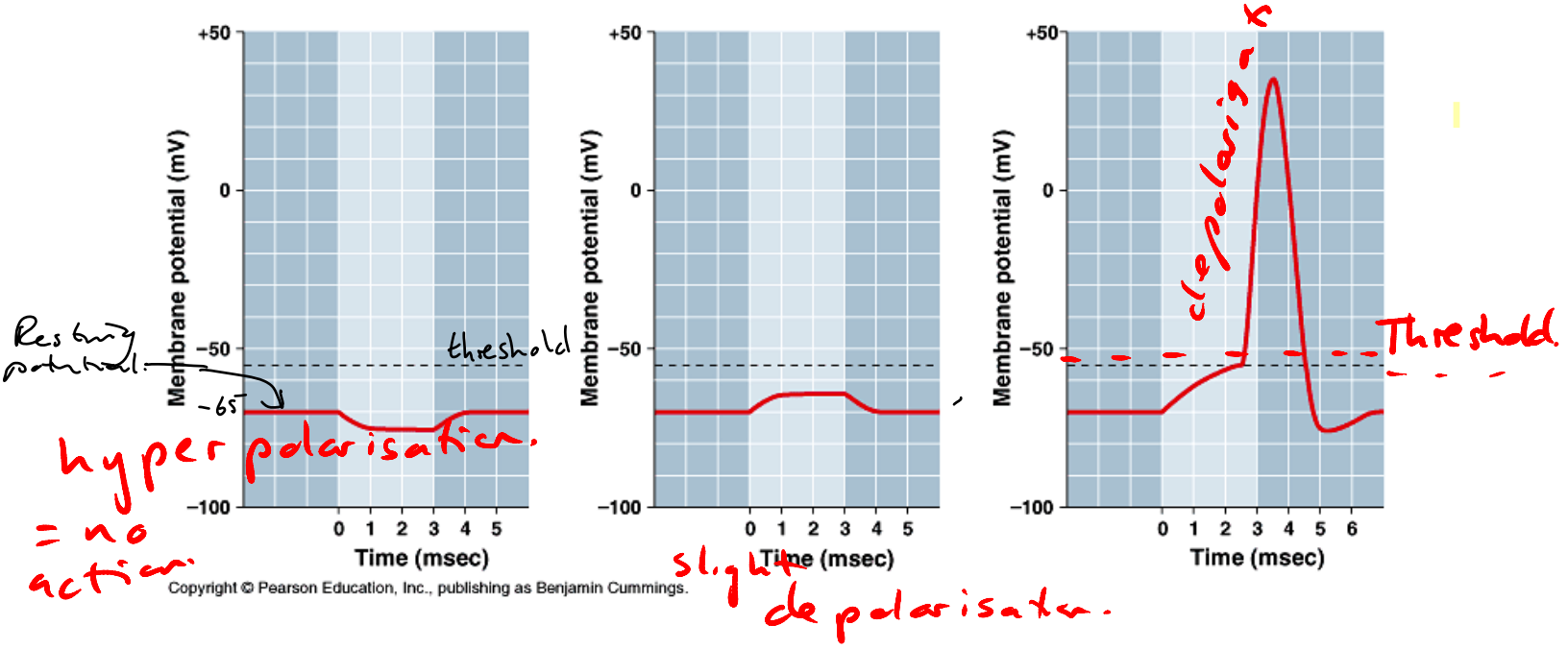
Describe the parts of the action potential:

An upswing to ± +40mV followed by a downswing of −65mV = an action potential.

There is an all or none response. This is the threshold depolarisation.

An action potential at one spot on membrane triggers another action potential right next to it. The action moves like a wave down neuron. At the end it passes the message to another neuron or effector.

What is meant by the *threshold* (all-or-none response)?



Resting potential

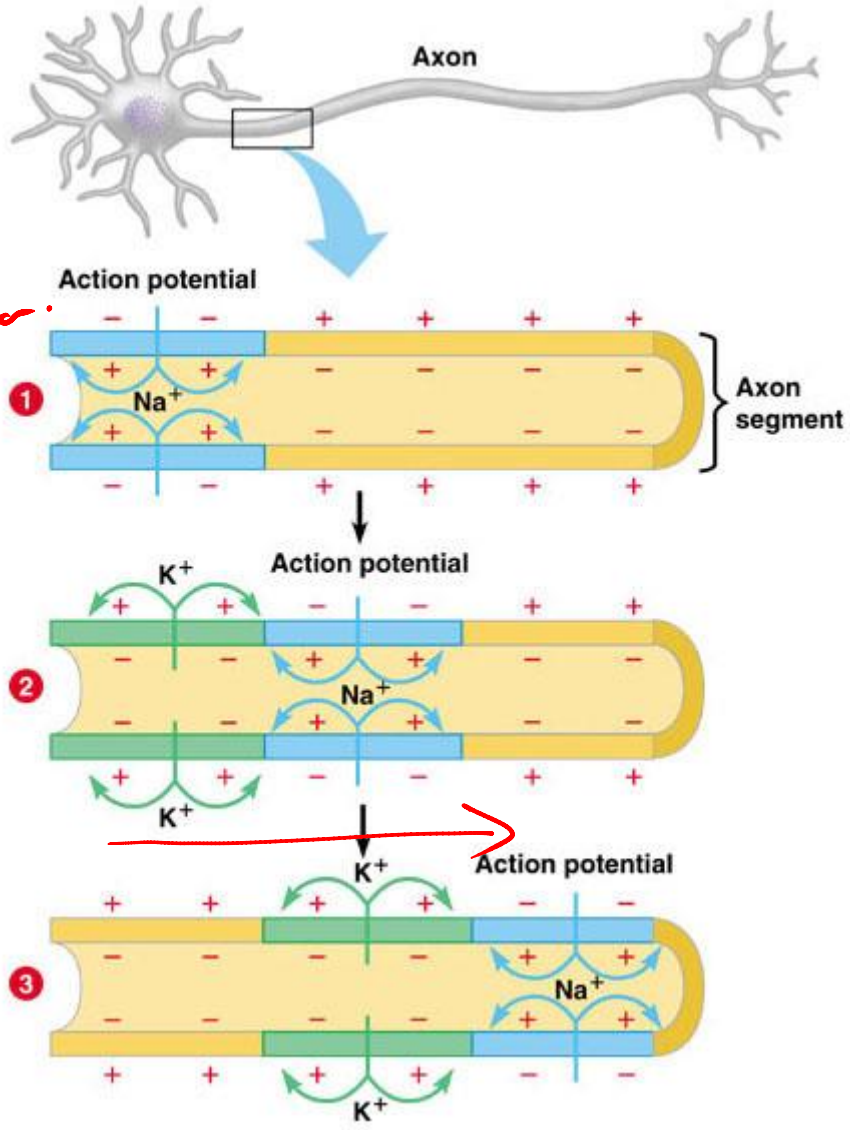
hyperpolarisation. = no action.

slight depolarisation.

depolarisation

An action potential will only begin in a particular neuron if the membrane is _____ depolarised _____ enough that it reaches the _____ Threshold _____ value. Once the membrane voltage reaches this value the action potential will occur, and will be _____ propagated _____ along the whole neuron.

This diagram shows how the action potential spreads down the neuron: Fig 28.5
[Activity: Nerve Signals: Action Potentials (28.5)]



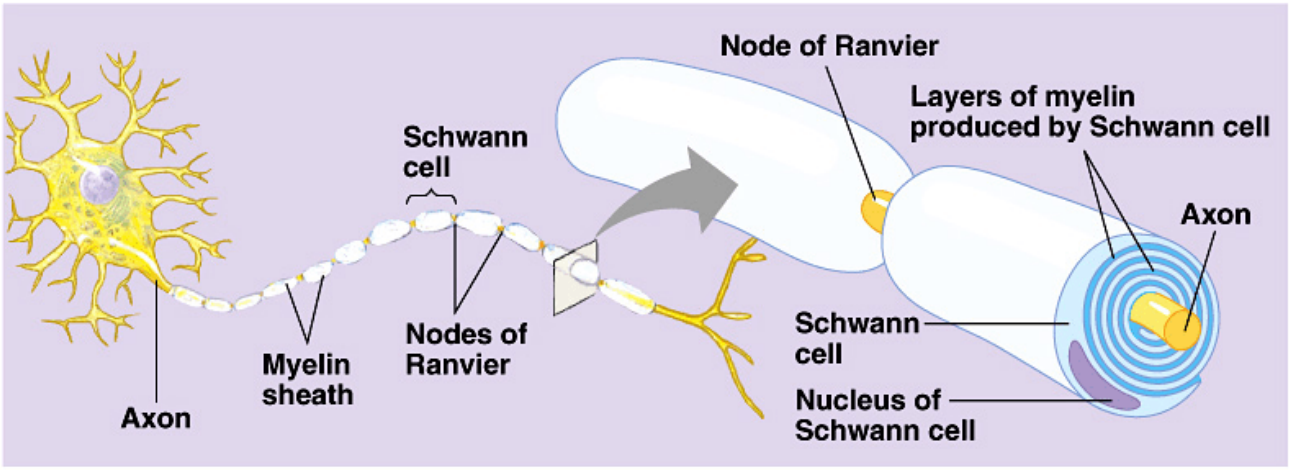
Describe the changes that occur in an axon segment as a nerve impulse passes from left to right.

3. Action potential continues along the neuron in one direction.

What prevents the action potential from travelling backwards? __

Where K^+ ions are leaving the axoplasm Na^+ channels are still inactivated and therefore an action potential cannot be generated in this region because sodium ions are on the wrong side of the membrane

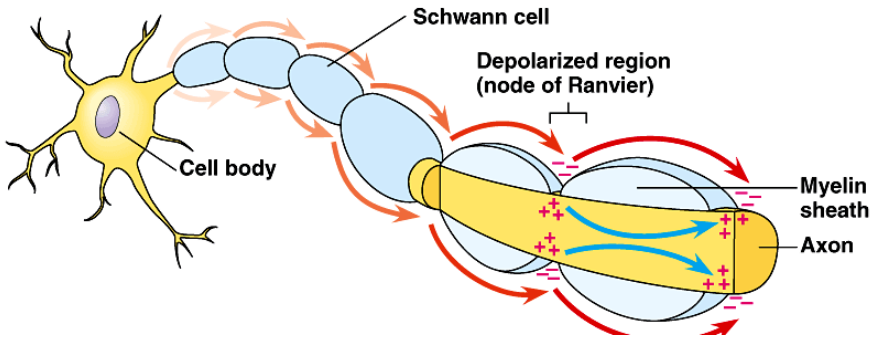
C11.4 relate the structure of a myelinated nerve fibre to the speed of impulse conduction, with reference to myelin sheath, Schwann cell, node of Ranvier, and saltatory transmission



Excellent visual for Schwann cell wrapping axon and other interesting information : http://www.siumed.edu/~dking2/ssb/neuron.htm#nodes

____Schwann cell membrane acts as an insulating layer, preventing action potentials in this region of the axon and dendrite. The space between the Schwann cells is called the Node of Ranvier and this is where the action potentials take place The action potential jumps from node to node as it propagates down the axon or dendrite. This is called SALTATORY CONDUCTION. This increases the speed of conduction by up to 400x. That is 200metres per second.

This diagram illustrates **saltatory conduction** (transmission) of a nerve impulse down a myelinated axon (or dendrite). Through this process the nerve impulse can travel up to _____ times faster than along an unmyelinated neuron.



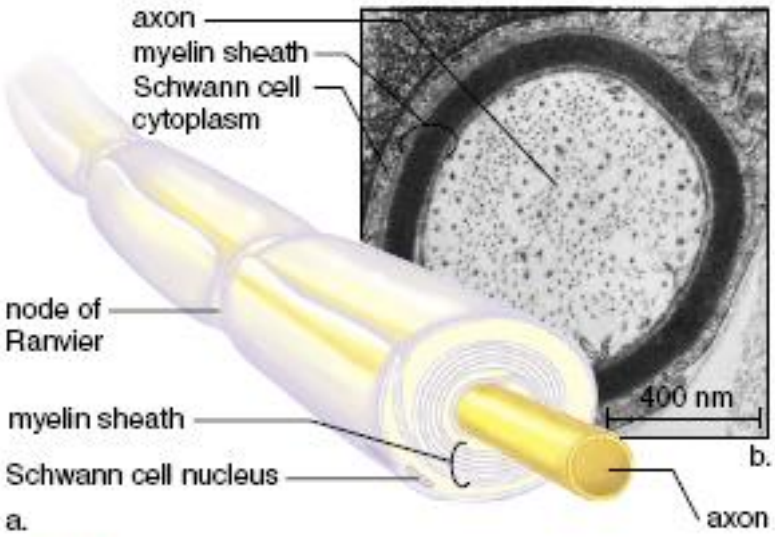


Figure 17.3 Myelin sheath.
a. A myelin sheath forms when Schwann cells wrap themselves around a nerve fiber. b. Electron micrograph of a cross section of an axon surrounded by a myelin sheath.

C11.5 identify the major components of a synapse, including
- synaptic ending
- presynaptic and postsynaptic membranes
- synaptic cleft
- synaptic vesicle
- calcium ions and contractile proteins
- excitatory and inhibitory neurotransmitters (e.g., norepinephrine, acetylcholine – ACh)
- receptor
- acetylcholinesterase (AChE)

C11.6 explain the process by which impulses travel across a synapse

C11.7 describe how neurotransmitters are broken down in the synaptic cleft

Activity: Neuron Communication (28.6)

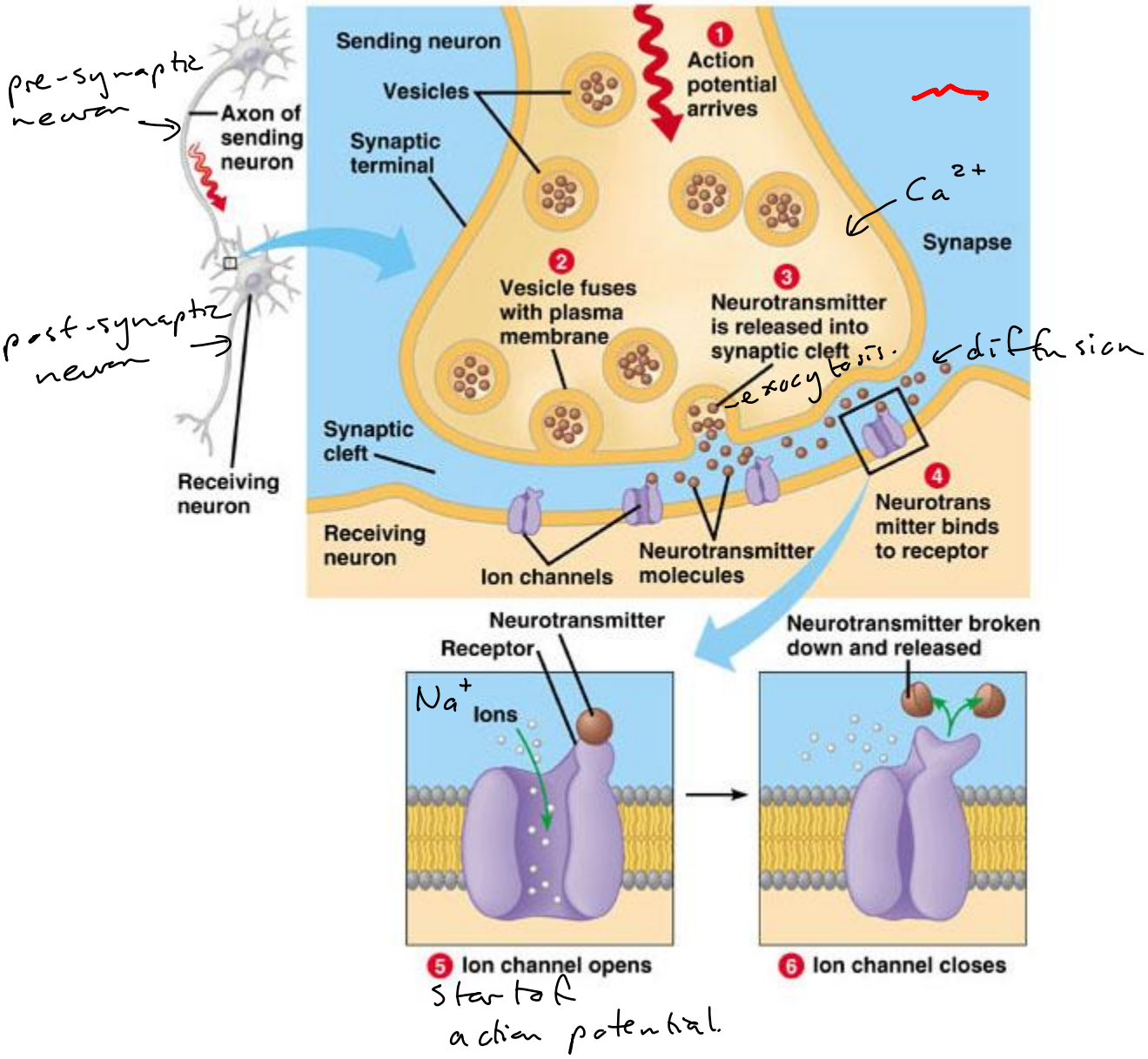
BioFlix: How Synapses Work
http://www.hhmi.org/biointeractive/molecular-mechanism-synaptic-function

Using Fig. 28.6 and the notes on page 569 describe the events that occur at a chemical synapse. Use the terms

1. Axon bulb
2. Synaptic vesicles containing neurotransmitter (eg. Acetylcholine)
3. Presynaptic membrane
4. Synaptic cleft
5. Postsynaptic membrane
6. Receptor proteins in postsynapatic membrane
7. Enzyme to break down the neurotransmitter (eg. Acetylcholinesterase)

1. **The action potential reaches the axon bulb.**
2. **Ca^{2+} ions diffuse into the axon bulb and cause synaptic vesicles to fuse with the presynaptic membrane and release their neurotransmitter into the synaptic cleft. (by exocytosis). Filaments in the axon bulb help to pull the vesicles over to the edge of the cell.**
3. **The neurotransmitter diffuses across the synaptic cleft and binds to receptor proteins on postsynaptic membrane (fit like "lock and key"). The receptor proteins open ions move in or out of the cell, depending on whether it is an excitatory or inhibitory synapse.**
4. **The postsynaptic membrane is either depolarized (excitatory synapse) or hyperpolarized (inhibitory synapse). Excitatory synapses open sodium ion channels, and inhibitory synapses open potassium ion channels.**
5. **If enough excitatory synapses occur in the second neuron and the threshold is reached in the postsynaptic cell, the action potential will be initiated in the second neuron, and travel down its axon.**

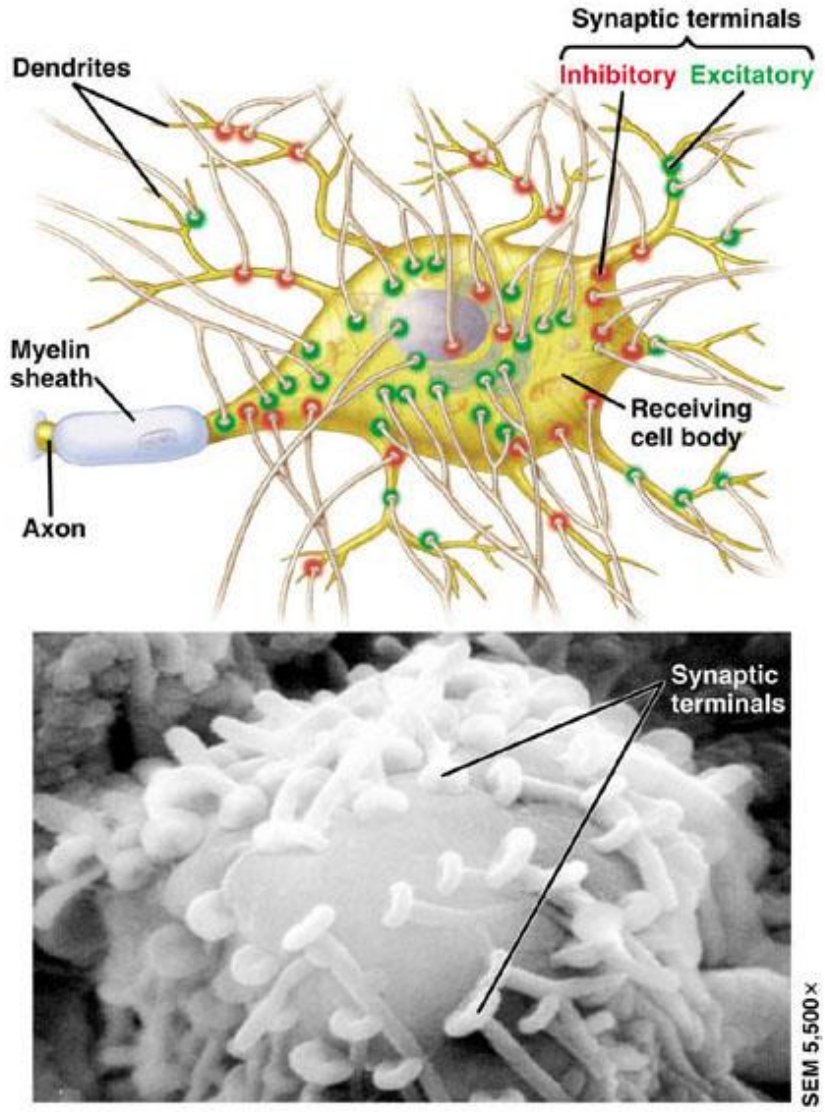
6. **An enzyme (eg acetylcholinerase) is released into the synaptic cleft breaks down the neurotransmitter to prevent continuous stimulation of the postsynaptic cell.**
7. **Note that the synapse can only go in one direction, because the presynaptic cell contains the neurotransmitter and the postsynaptic cell has the receptors.**



[BLAST Animation: Signal Transmission at Synapses (28.6)]

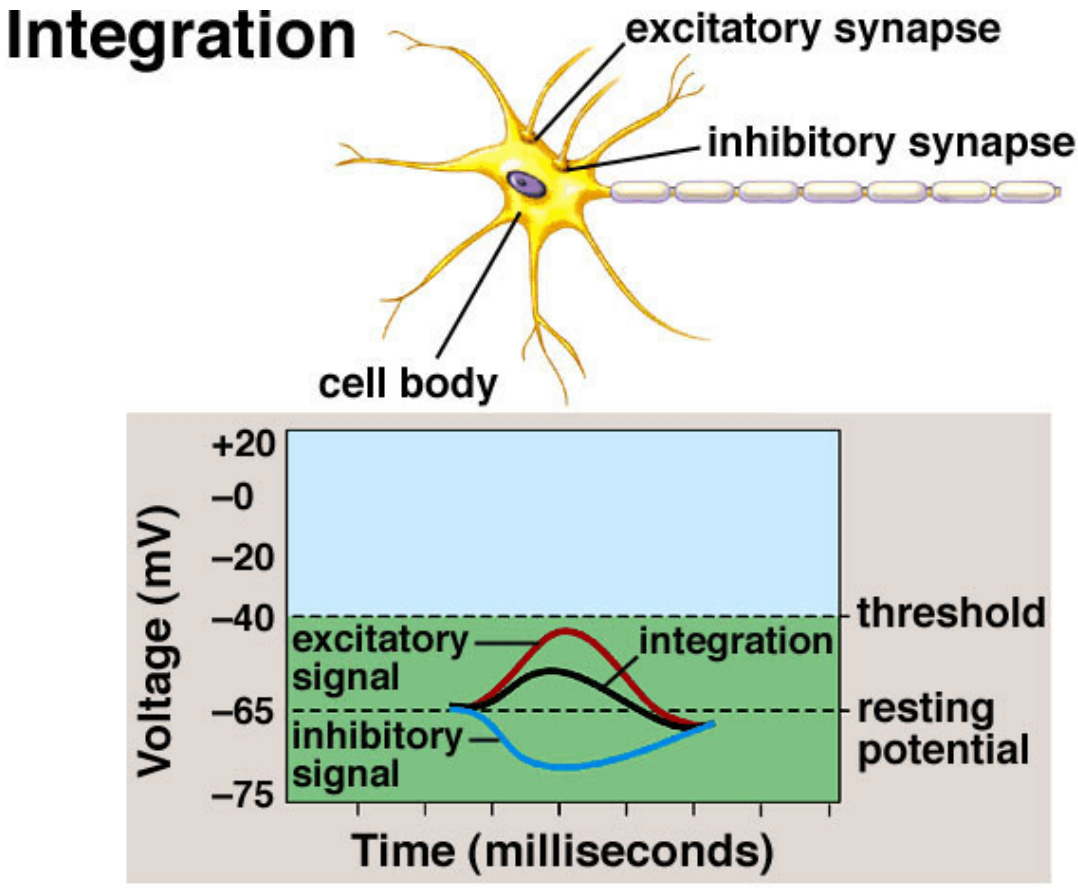
What is the difference between an **excitatory** synapse and an **inhibitory** synapse?

Fig. 28.7



_____Excitatory allow an action potential by opening the sodium gates and Inhibitory prevent an action potential by allowing potassium ions to leave the axoplasm. _

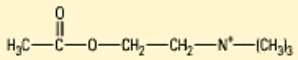
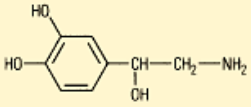
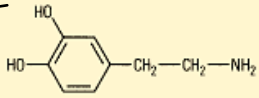
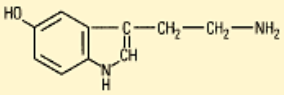
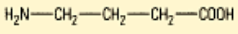
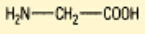
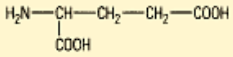
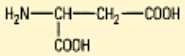
Integration: What determines whether or not the *post-synaptic cell* will develop an action potential?



A synapse which _____hyperpolarises _____ the membrane will lead to inhibition of the neuron, because it pushes the membrane potential _____below the threshold value. Conversely, a synapse which ___depolarises_____ the membrane will lead to excitation of the neuron, because it pushes the membrane potential _____above _____ the threshold value. An excitatory synapse opens ____sodium _____ gates, whereas an inhibitory synapse opens ____potassium_____ gates.

http://www.youtube.com/watch ?v=LT3VKAr4roo&NR=1 neuron synapse
There are many different neurotransmitters throughout the nervous system. They can be excitatory or inhibitory depending on where in the nervous system they are found.
Refer to 28.8 in textbook

Table 48.1 The Major Known Neurotransmitters

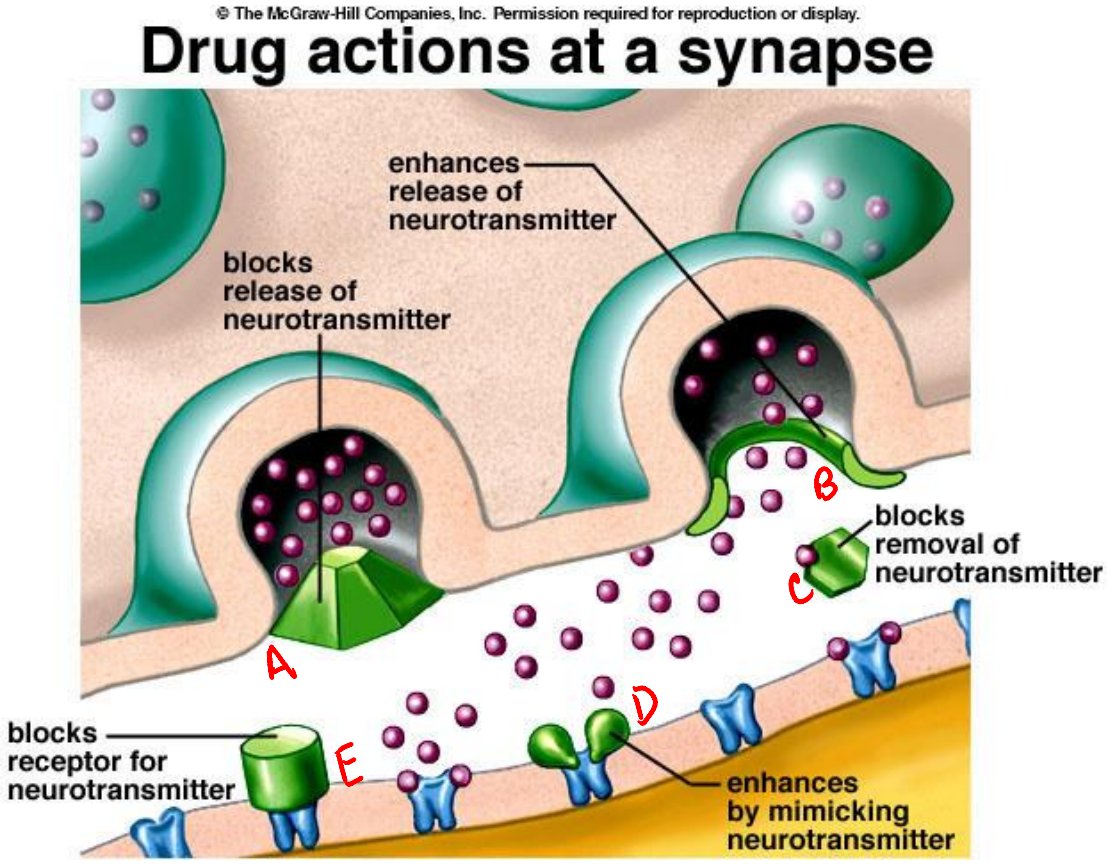
Neurotransmitter	Structure	Functional Class	Secretion Sites
Acetylcholine		Excitatory to vertebrate skeletal muscles; excitatory or inhibitory at other sites	CNS; PNS; vertebrate neuromuscular junction
Biogenic Amines			
Norepinephrine (adrenalin, epinephrine)		Excitatory or inhibitory	CNS; PNS
Dopamine		Generally excitatory; may be inhibitory at some sites	CNS; PNS
Serotonin		Generally inhibitory	CNS
Amino Acids			
GABA (gamma aminobutyric acid)		Inhibitory	CNS; invertebrate neuromuscular junction
Glycine		Inhibitory	CNS
Glutamate		Excitatory	CNS; invertebrate neuromuscular junction
Aspartate		Excitatory	CNS
Neuropeptides			
Substance P	Arg—Pro—Lys—Pro—Gln—Gln—Phe—Phe—Gly—Leu—Met	Excitatory	CNS; PNS
Met-enkephalin (an endorphin)	Tyr—Gly—Gly—Phe—Met	Generally inhibitory	CNS

Glutamate is the brains main excitatory receptor present in over 50% of nervous tissue and GABA is the brains main inhibitory receptor. Glutamate receptors are responsible for the glutamate-mediated postsynaptic excitation of neural cells, and are important for neural communication, memory formation, learning, andregulation.

http://www.5min.com/Video/The-Link-Between-Dopamine-and-Drug-Addiction-297703220 neurotransmitters and drug addiction

http://thebrain.mcgill.ca/flash/i/i_03/i_03_m/i_03_m_par/i_03_m_par_ecstasy.html#drogues ecstacy
Mouse party http://learn.genetics.utah.edu/content/addiction/mouse/

Many drugs have their effect at the synapse. The effect they have depends on whether it is an excitatory or inhibitory synapse, and on the drug itself.



If the neurotransmitter is an excitatory one, what effect will each of the drugs have at this synapse?

A: ____inhibits the action of the neurotransmitter - no excitation _____

C: ___keeps the neurotransmitter on the receptor protein – encourages excitation _____

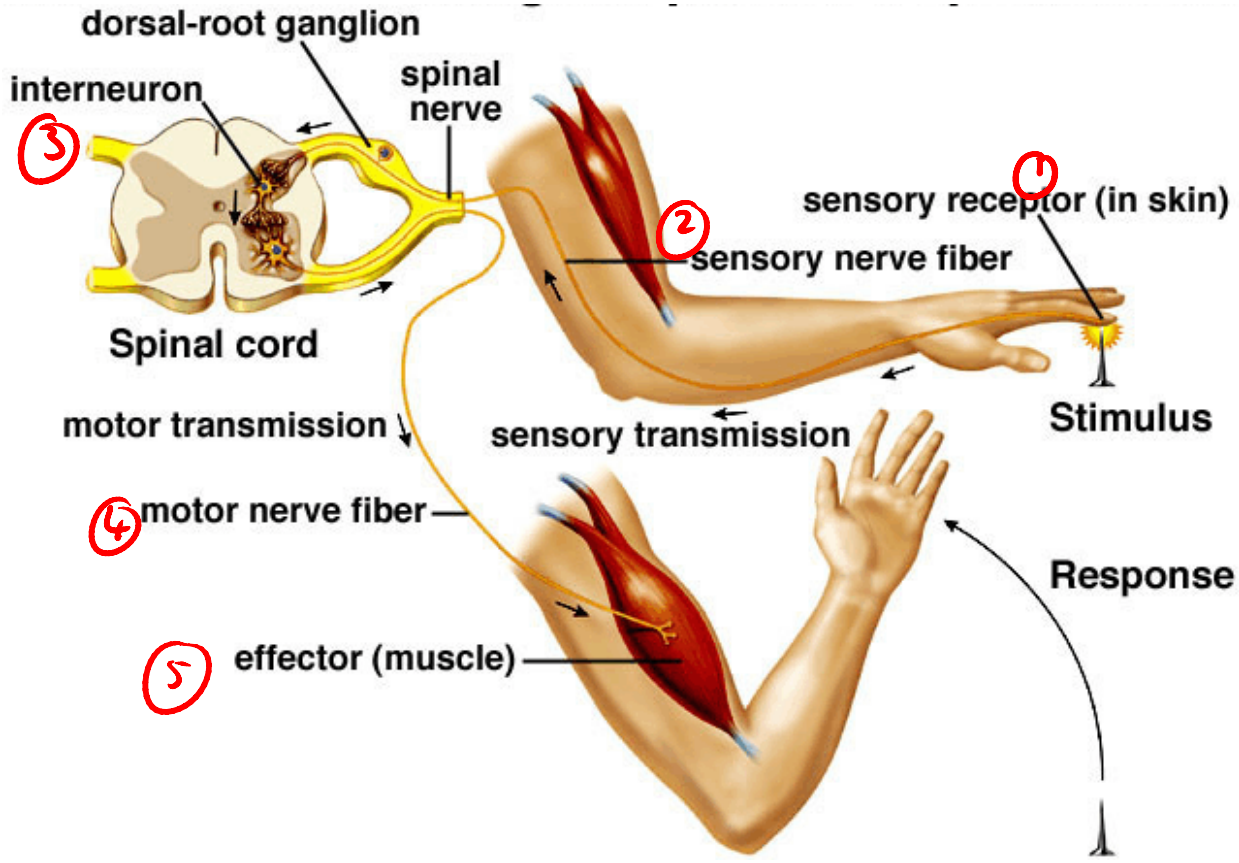
E: _Blocks excitation -neurotransmitter not effective _____

If the neurotransmitter is an inhibitory one, what effect will each of the drugs have at this synapse?

B: _____more inhibition _____

D: ____ more inhibition _____ E: _____less inhibition _____

C11.8 describe the structure of a reflex arc (receptor, sensory neuron, interneuron, motor neuron, and effector) and relate its structure to how it functions



What is a reflex arc?

_____ A neural pathway that provides an automatic involuntary response to a stimulus. _____

What are the five components of a reflex arc?

Sensory receptor – affector

Sensory neuron – afferent neuron

Interneuron

Motor neuron – efferent neuron

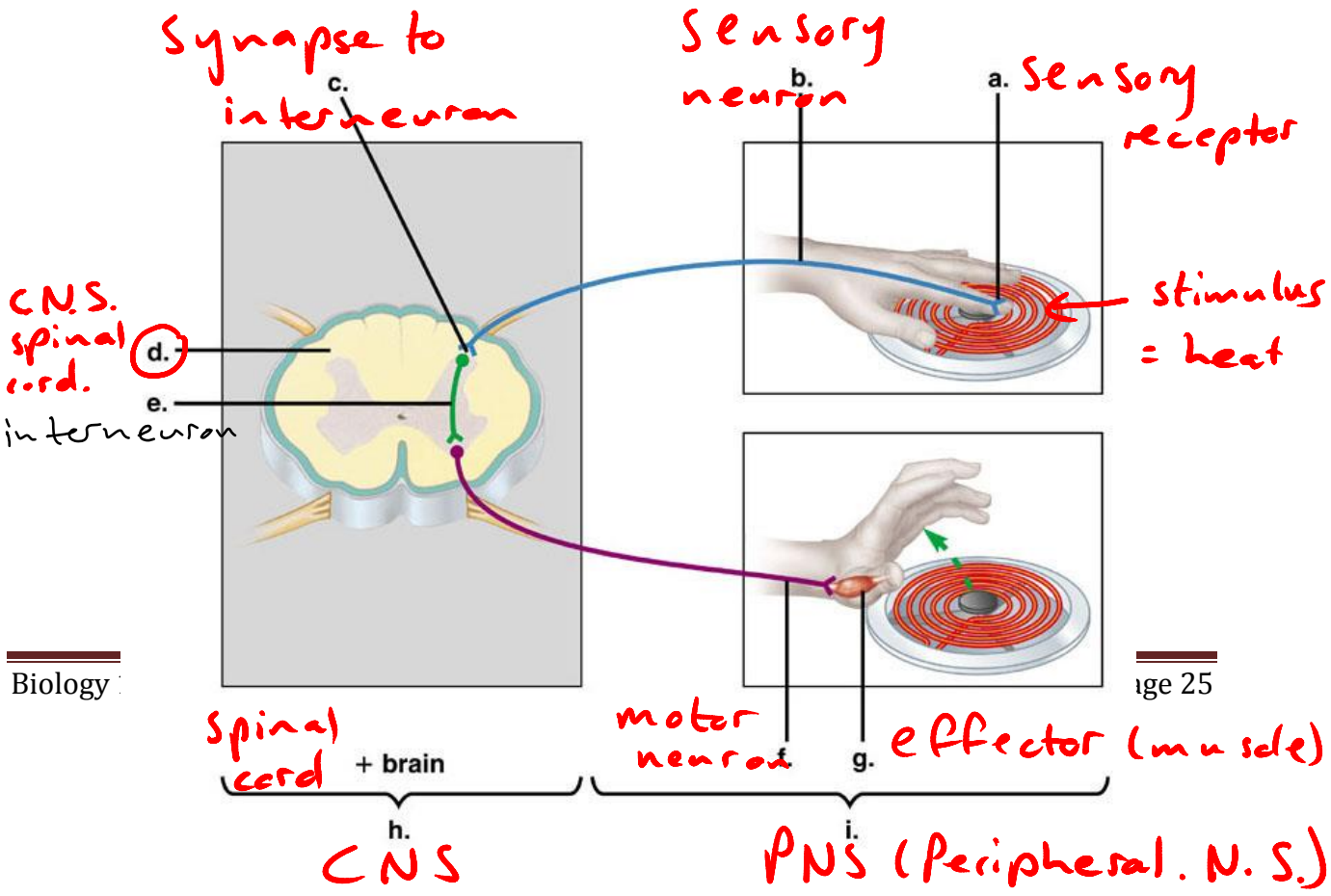
Muscle or gland - Effector

Is it necessary for the brain to be involved in a reflex arc? Explain.

The brain is not involved initially, but at the same time as an impulse is transmitted along the motor neuron, another impulse is transmitted along an interneuron to notify the brain. The brain will be involved in making an integrated decision.

–

Label the following diagram illustrating a simple reflex arc:



The Nervous System Part 2

David Anderson: Your brain is more than a bag of chemicals Ted talk

Vocabulary

adrenal medulla, adrenalin, autonomic nervous system, central nervous system, cerebellum, cerebrum, corpus callosum, effector, hypothalamus, interneuron, medulla oblongata, meninges, neuroendocrine control centre, norepinephrine, parasympathetic division, peripheral nervous system, pituitary gland, somatic nervous system, sympathetic division, thalamus

It is expected that students will:

C12 Analyse the functional inter-relationships of the divisions of the nervous system

C12.1 compare the locations and functions of the central and peripheral nervous systems
C12.2 identify and give functions for each of the following parts of the brain:
- medulla oblongata
- cerebrum
- thalamus
- cerebellum
- hypothalamus
- pituitary gland
- corpus callosum
- meninges

C12.3 explain how the hypothalamus and pituitary gland interact as the neuroendocrine control centre
C12.4 differentiate between the functions of the autonomic and somatic nervous systems
C12.5 describe the inter-related functions of the sympathetic and parasympathetic divisions of the autonomic nervous system, with reference to
- effect on body functions including heart rate, breathing rate, pupil size, digestion
- neurotransmitters involved
- overall response ("fight or flight" or relaxed state)

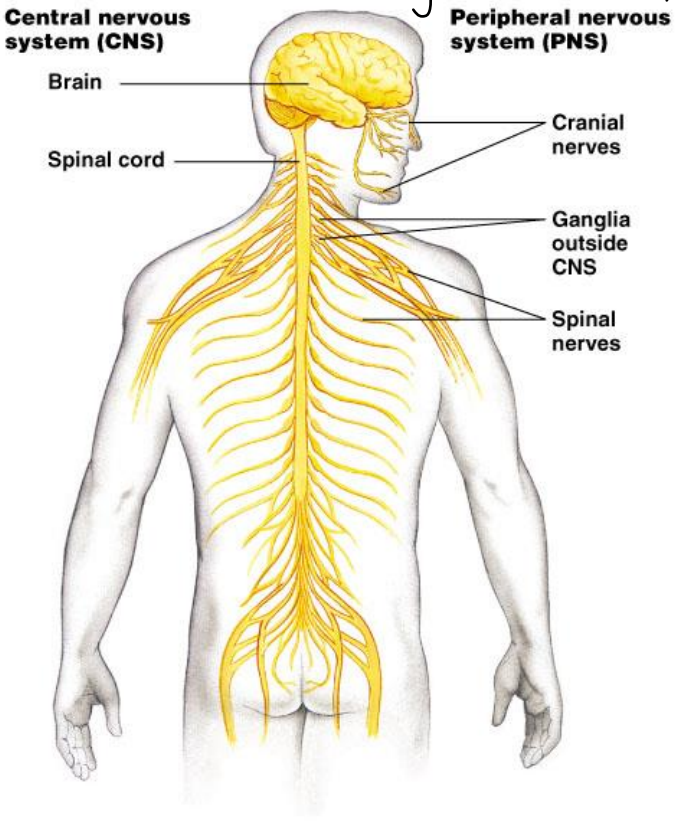
C12.6 identify the source gland for adrenalin (adrenal medulla) and explain its role in the "fight or flight" response

http://www.youtube.com/watch?v=OI_865LGTeU&feature=related Pinky and the brain

C12.1 compare the locations and functions of the central and peripheral nervous systems

location: CNS:
made up of interneurons + support cells (glial cells)
PNS = outside of brain + spinal cord +
made up of sensory + motor neurons

functions: CNS: to receive sensory impulses + integrate sensory info. and decide an appropriate response
+ send motor response.
PNS. ① Receive environmental stimuli from receptors + conduct sensory info to CNS.
② Carry nerve impulses from CNS to effectors or motor neurons.



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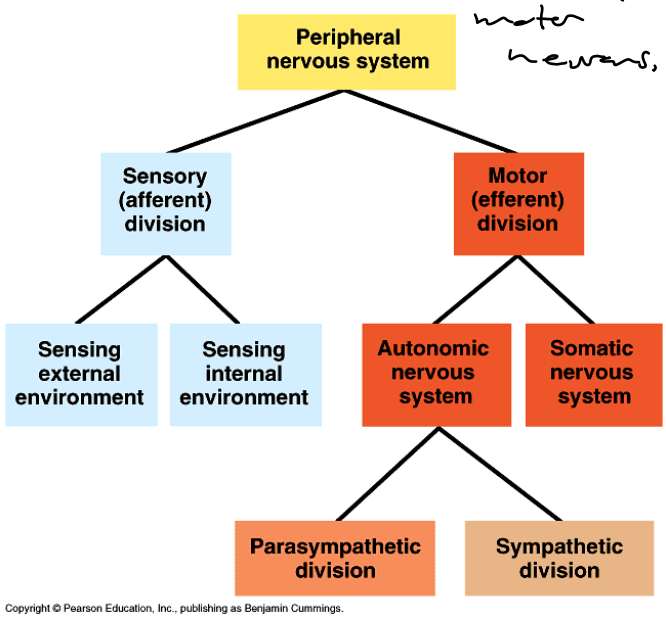

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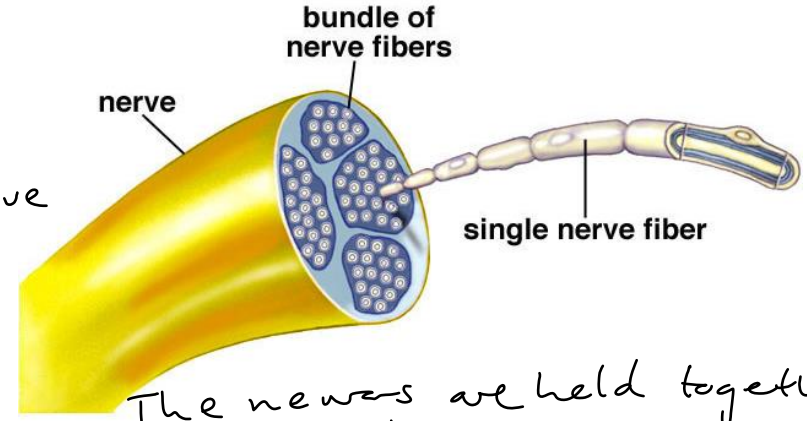
What is a 'nerve'?

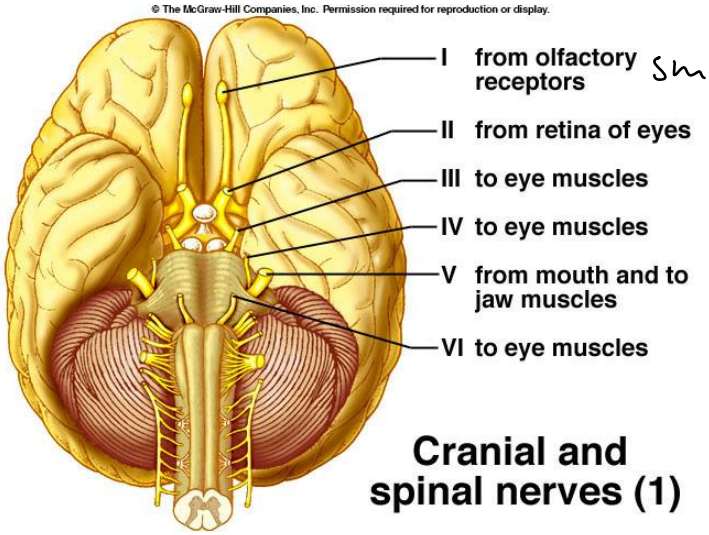
= a bundle of neurons (nerve fibres) The fibre is the axon of the neuron outside the CNS.



The neurons are held together by connective tissue.

What are *cranial* nerves?

Sensory or motor neurons attached to the brain.



smell

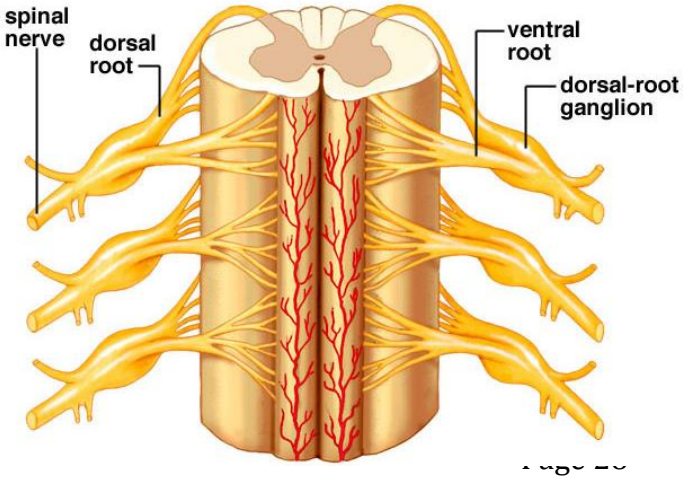
What are *spinal* nerves?

Sensory + motor neurons attached to spinal cord.

Can you identify all of the structures in this diagram on the model of spinal cord and explain it to a friend?

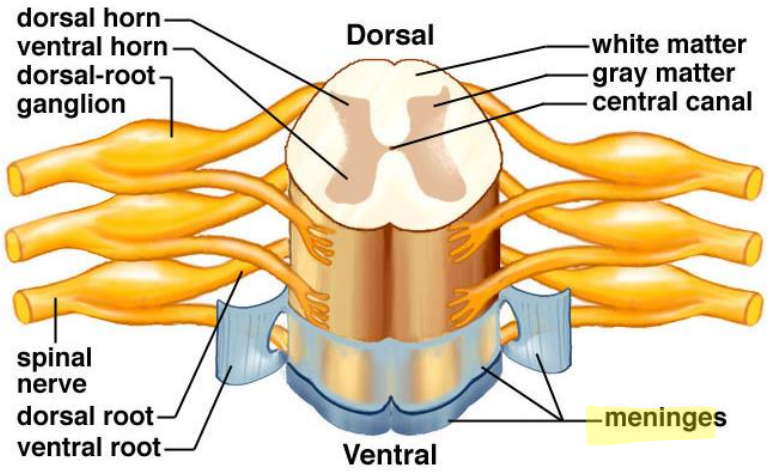
What is the *dorsal root ganglion*?

Accumulation of sensory neuron cell bodies.



What are the *meninges?*

http://faculty.une.edu/com/fwillard/Meninges/pages/mening03.htm



Continuous membranes surrounding the brain + spinal cord.

Cerebrospinal fluid flows between the 3 layers.

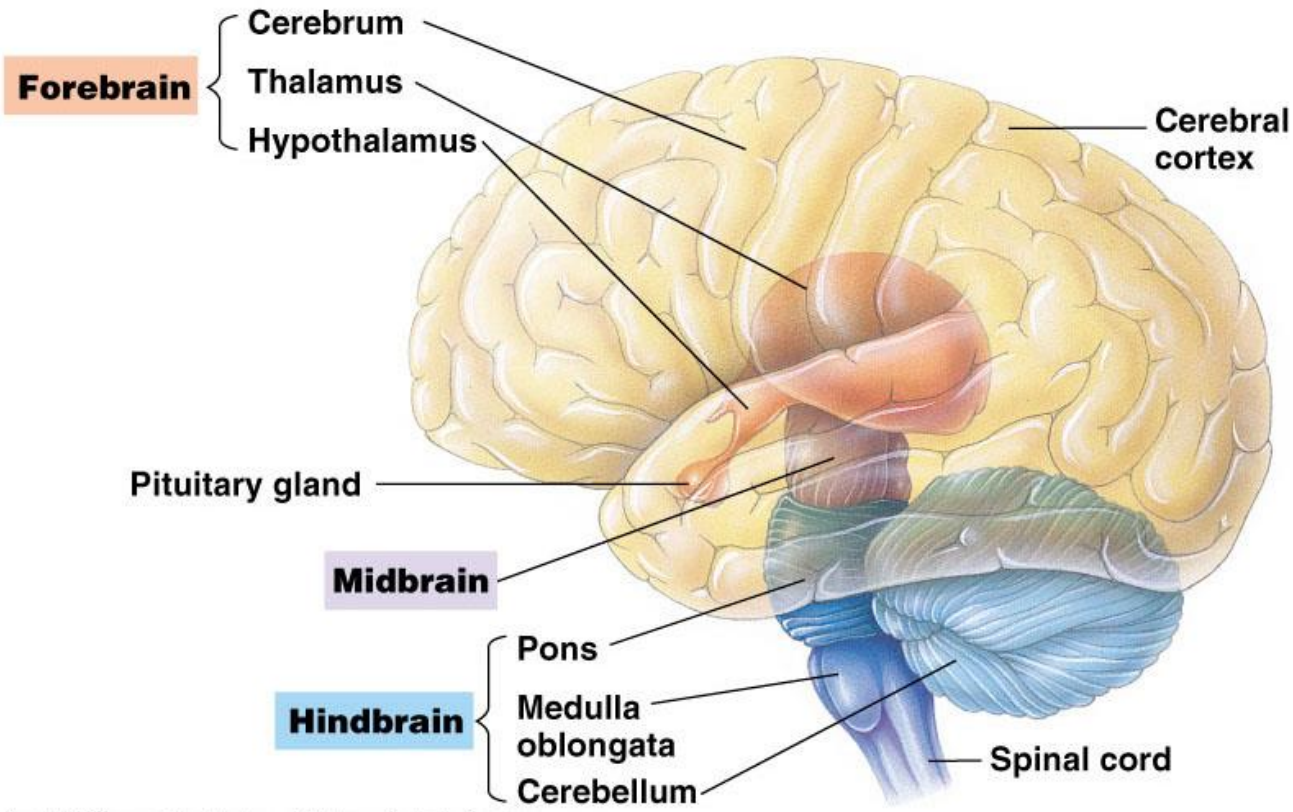
- Duramater
- Arachnoid mater
- Pia mater.

C12.2 identify and give functions for each of the following parts of the brain:

- **medulla oblongata**
- **cerebrum**
- **thalamus**
- **cerebellum**
- **hypothalamus**
- **pituitary gland**
- **corpus callosum**
- **meninges**

http://faculty.une.edu/com/fwillard/external/index.htm

http://faculty.une.edu/com/fwillard/saggitals/pages/00046mod.htm



https://www.youtube.com/watch?v=_e60_4ZV0zs Blood brain barrier

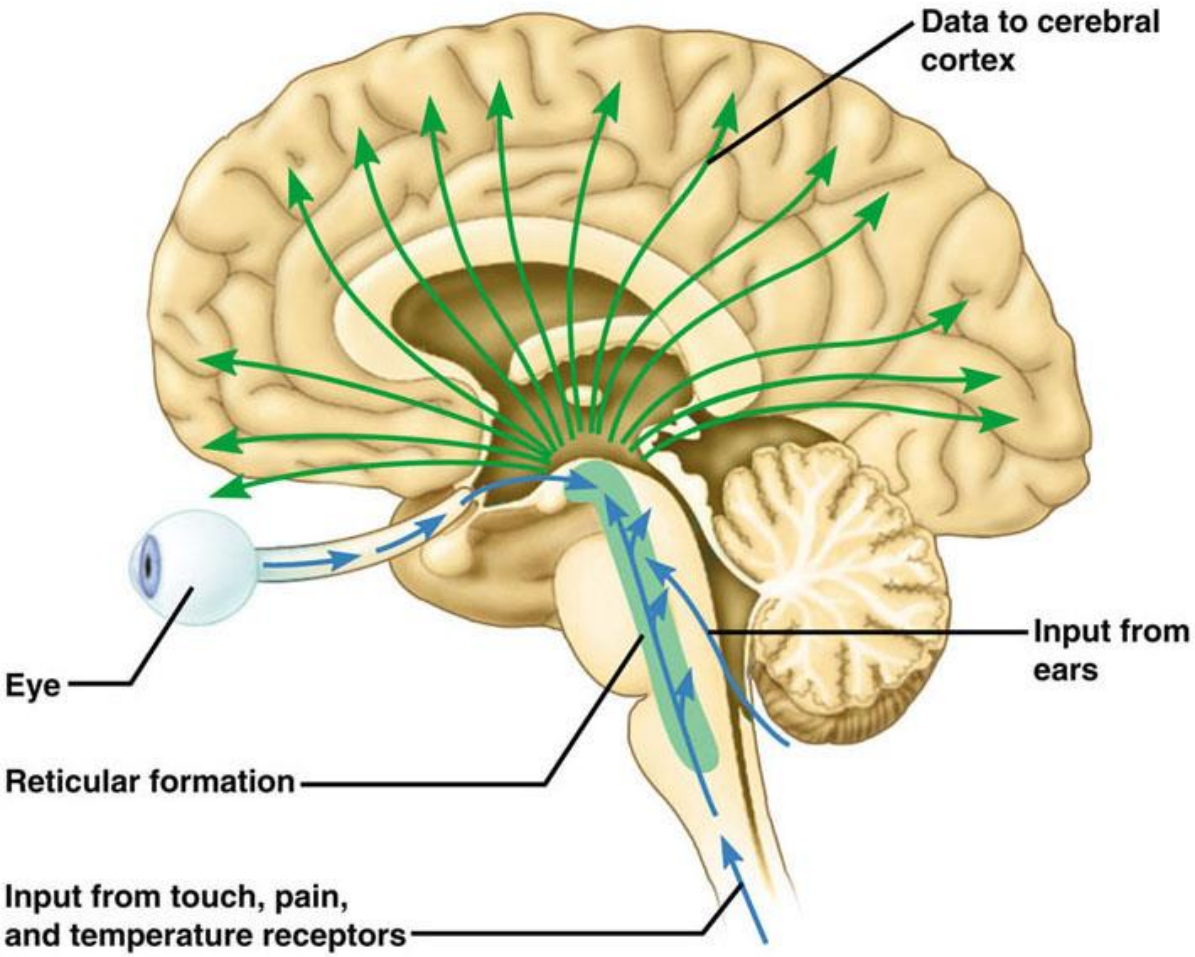
https://www.youtube.com/watch?v=86NDMfxU4ZU Development of the embryonic brain

MP3 Tutor: The Human Brain (28.15)

Medulla oblongata
controls autonomic, homeostatic functions including: breathing, heart and blood vessel activity, swallowing, digestion and vomiting

Cerebrum (cerebral cortex)
integrating centre for memory, learning, emotions, and other highly complex functions of the central nervous system; initiation of somatic motor responses (sketetal muscle contractions)

Thalamus the "main input center for sensory information going to the cerebrum and the main output center for motor information leaving the cerebrum. Incoming information from all the senses is sorted in the thalamus and sent to the appropriate cerebral centers for further processing. The thalamus also receives input from the cerebrum and other parts of the brain that regulate emotion and arousal."



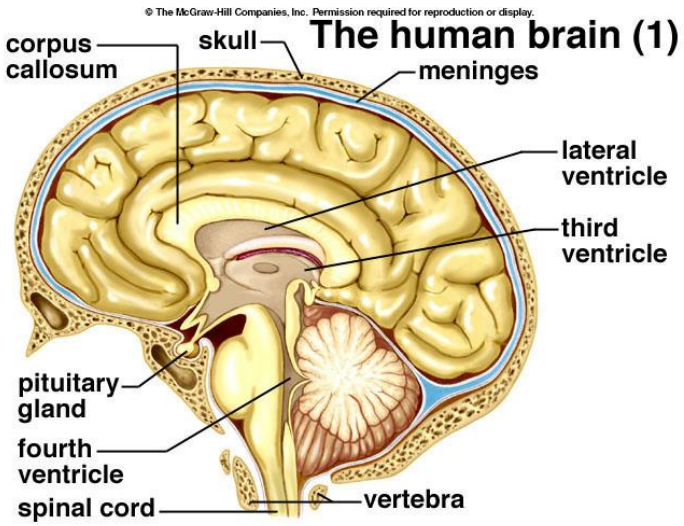
Bi

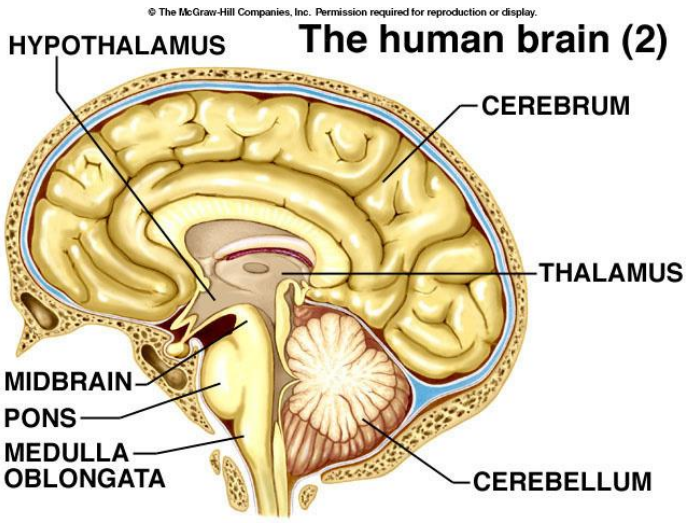
Arbor vitae.

Cerebellum unconscious coordination of movement and balance, including hand-eye coordination

Hypothalamus maintenance of homeostasis, particularly in coordinating of endocrine and nervous systems (neuroendocrine control center - ; secretes hormones of the posterior pituitary and releasing factors, which regulate the anterior pituitary - involved in osmoregulation, contractions of uterus, control of sexual cycles, milk production, control of thyroid gland, etc.)

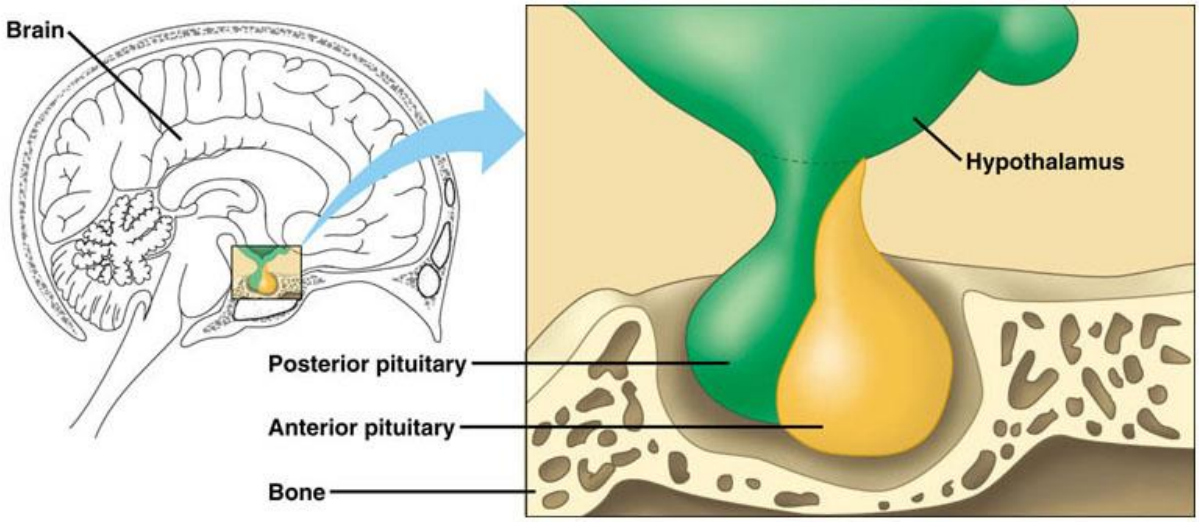
Corpus callosum a thick band of nerve fibres that connect the right and left cerebral hemispheres and enable the hemispheres to process information together





C12.3 explain how the hypothalamus and pituitary gland interact as the neuroendocrine control centre

This diagram shows where the hypothalamus and pituitary gland are located in your head:

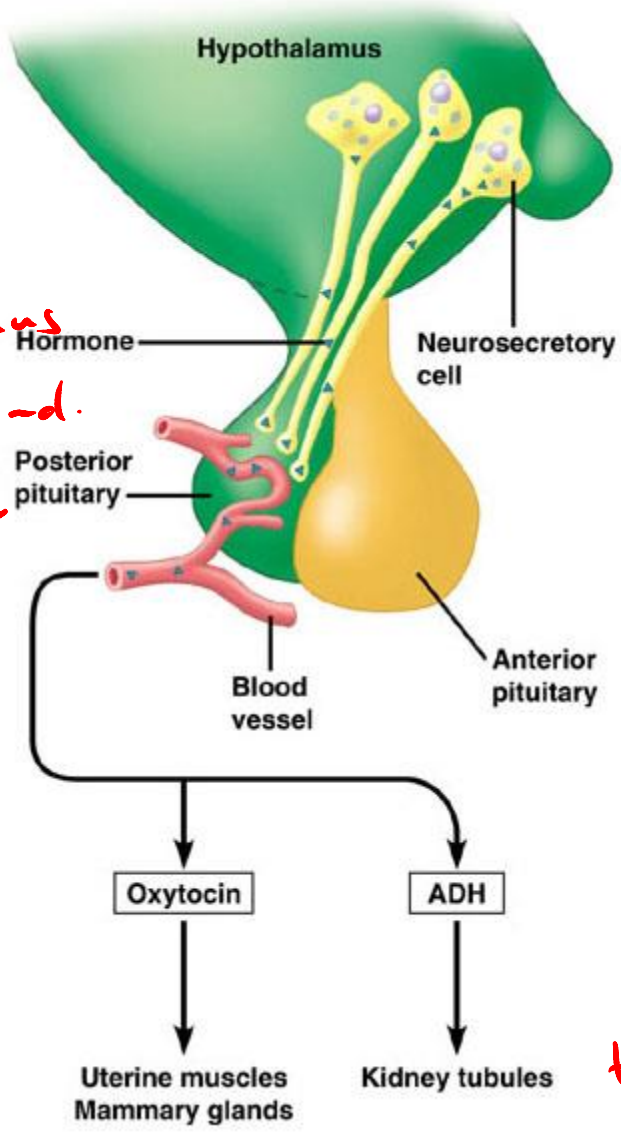


Posterior pituitary is composed of nervous tissue and is an extension of the hypothalamus. It stores and secretes two hormones made in the hypothalamus.

The Anterior Pituitary is composed of endocrine cells that synthesize and secrete hormones directly into the bloodstream.

The hypothalamus exerts control over the anterior pituitary by secreting Releasing hormones – which stimulate the pituitary to secrete hormones and Inhibiting hormones - which induce the pituitary to stop secreting hormones.

How do the hypothalamus and the posterior pituitary work together?



Produced in hypothalamus = source gland.

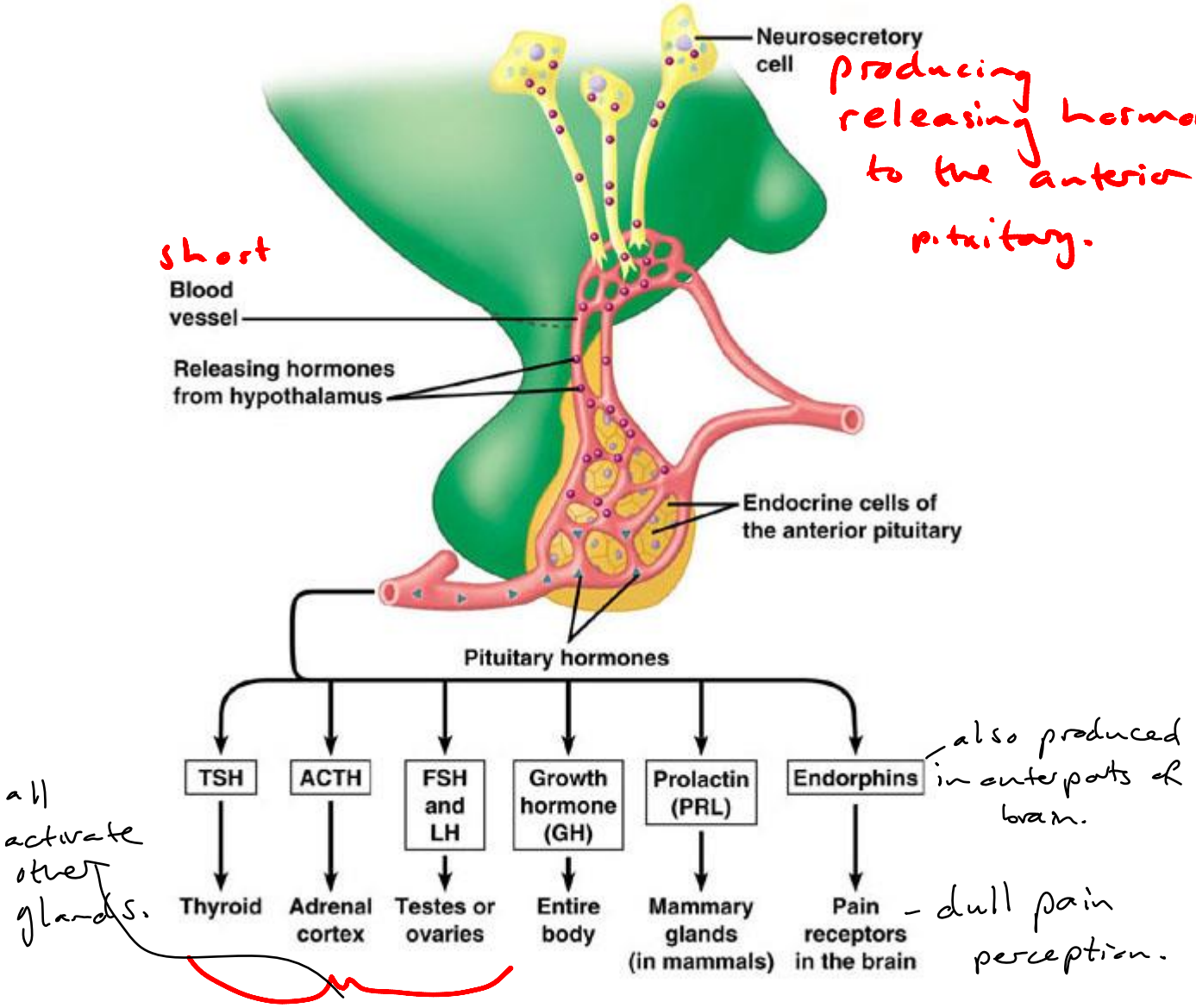
stores Oxytocin + ADH.

target cells.

ADH = Antidiuretic hormone - changes the permeability of the collecting duct so that water is reabsorbed. (less urine). In response to thirst, dehydration, low blood volume.

Oxytocin :- is secreted during labor & responds to positive feedback.

How do the hypothalamus and the anterior pituitary work together?



TSH = Thyroid stimulating hormone stimulates thyroid gland to produce metabolic hormones

ACTH = Adrenocorticotropic hormone = adrenal cortex.

FSH = Follicle stimulating - ♀ dev. of ovum to ♂ sperm.

LH = Luteinizing Hormone - ♀ maintains corpus luteum

♂ stimulates testosterone production.

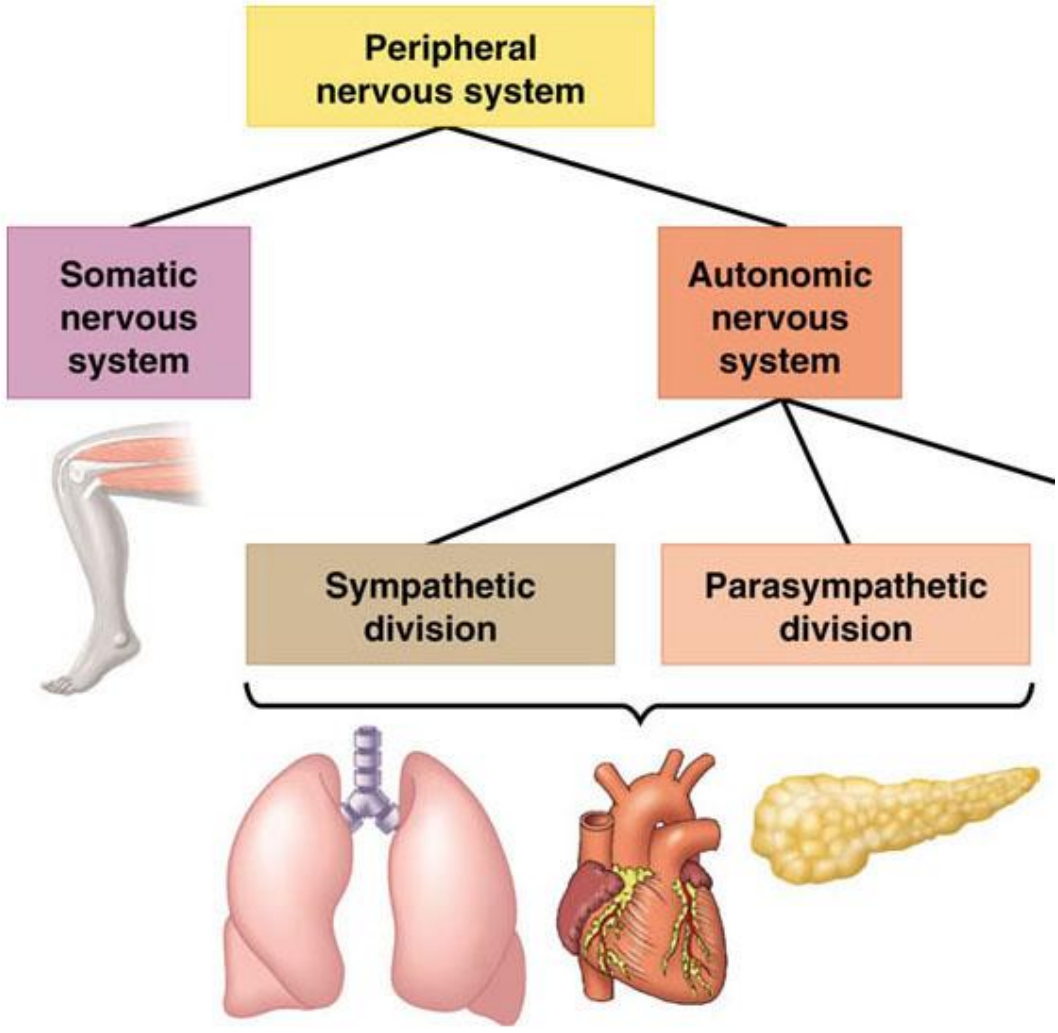
C12.4 differentiate between the functions of the autonomic and somatic nervous systems

The Autonomic Nervous System – part of the motor division of the peripheral nervous system

Involves involuntary control of muscles + glands eg. heart, smooth muscle of digestion, resp, ...

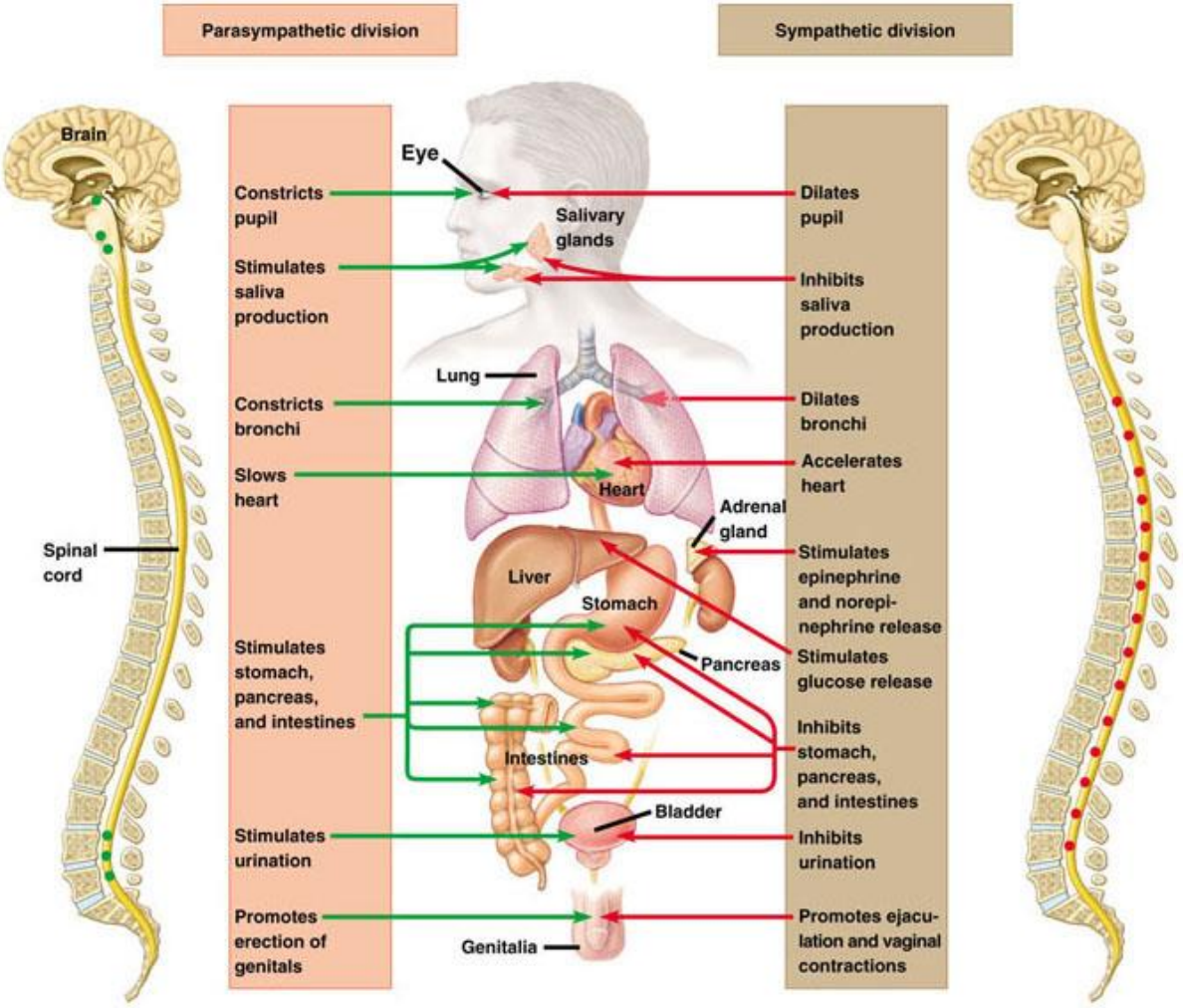
The Somatic Nervous System – part of the motor division of the peripheral nervous system

Voluntary instruction to muscles + glands.



C12.5 describe the inter-related functions of the sympathetic and parasympathetic divisions of the autonomic nervous system, with reference to

- **effect on body functions including heart rate, breathing rate, pupil size, digestion**
- **neurotransmitters involved**
- **overall response ("fight or flight" or relaxed state)**



Which of the two divisions is responsible for the 'fight or flight' (emergency) response?

Sympathetic

Which of the two divisions is responsible for the 'return to normal' (relaxed) response?

Parasympathetic.

How do the sympathetic and parasympathetic divisions affect:

Heart rate? S = ↑

P =

Breathing rate?

Pupil size?

Digestion?

adrenalin

Which of the two divisions uses *norepinephrine* as a neurotransmitter, the sympathetic division or the parasympathetic division?

Sympathetic

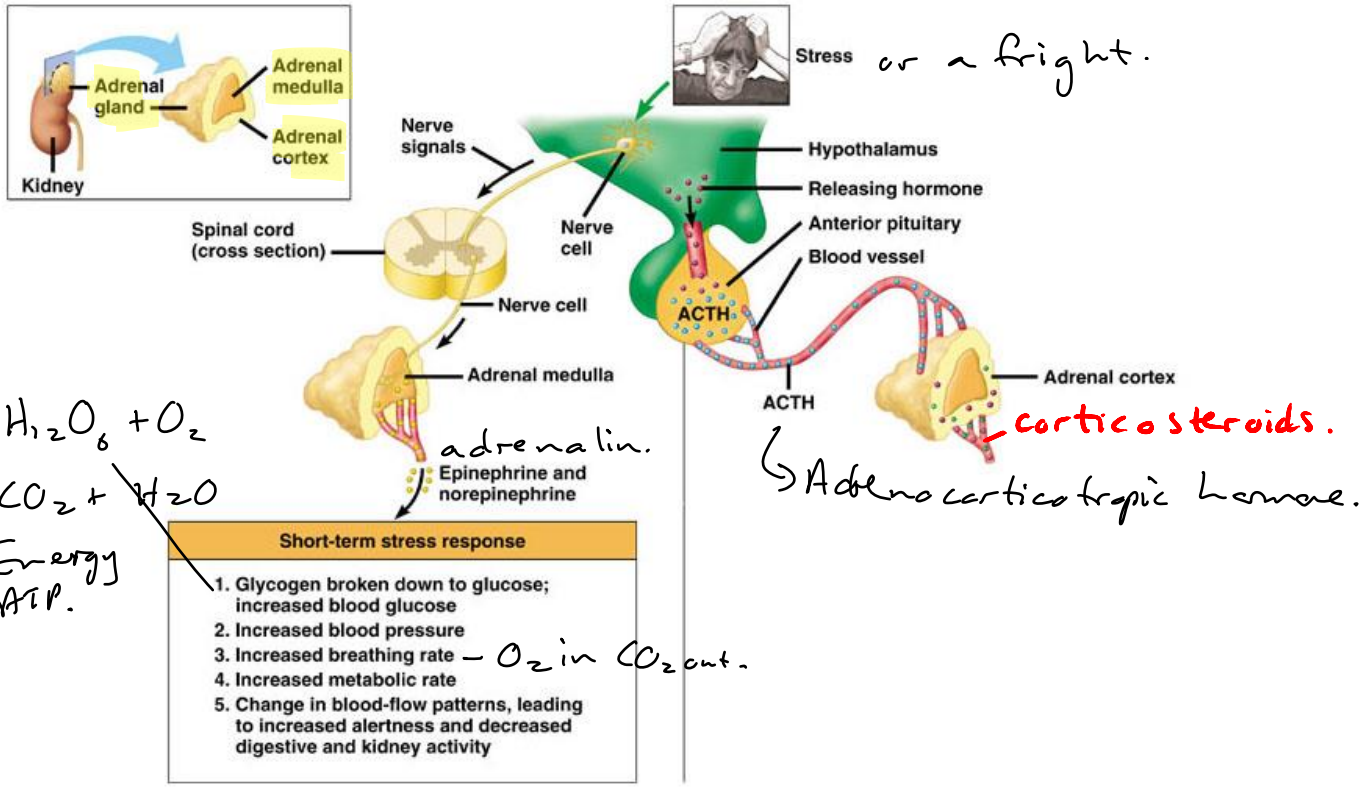
Which of the two divisions uses *acetylcholine* as a neurotransmitter, the sympathetic division or the parasympathetic division?

Parasympathetic.

C12.6 identify the source gland for adrenalin (adrenal medulla) and explain its role in the "fight or flight" response

The Adrenal Gland

This gland is actually two endocrine glands in one. The two hormones you are responsible for are epinephrine (adrenalin) from the adrenal medulla (N3) and aldosterone from the adrenal cortex



a) What is the source gland for *adrenalin* (*epinephrine*)?

Adrenal medulla

b) Describe the role of adrenalin in the '*fight or flight*' response. How does adrenalin work together with the sympathetic nervous system?

Breath faster, pupils dilate, increased heart rate, increased Thyroxin release, increase blood flow to muscles, increase [glucose].