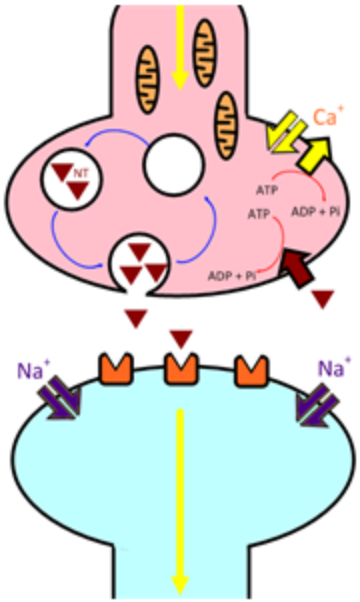
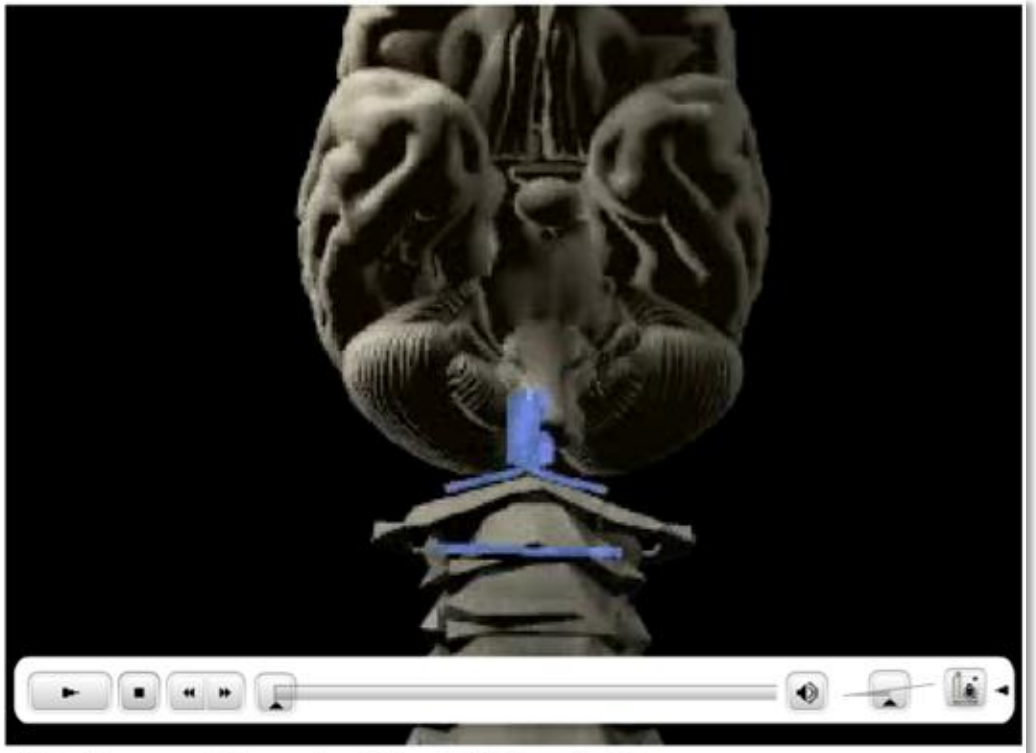


Nerves, Hormones and Homeostasis

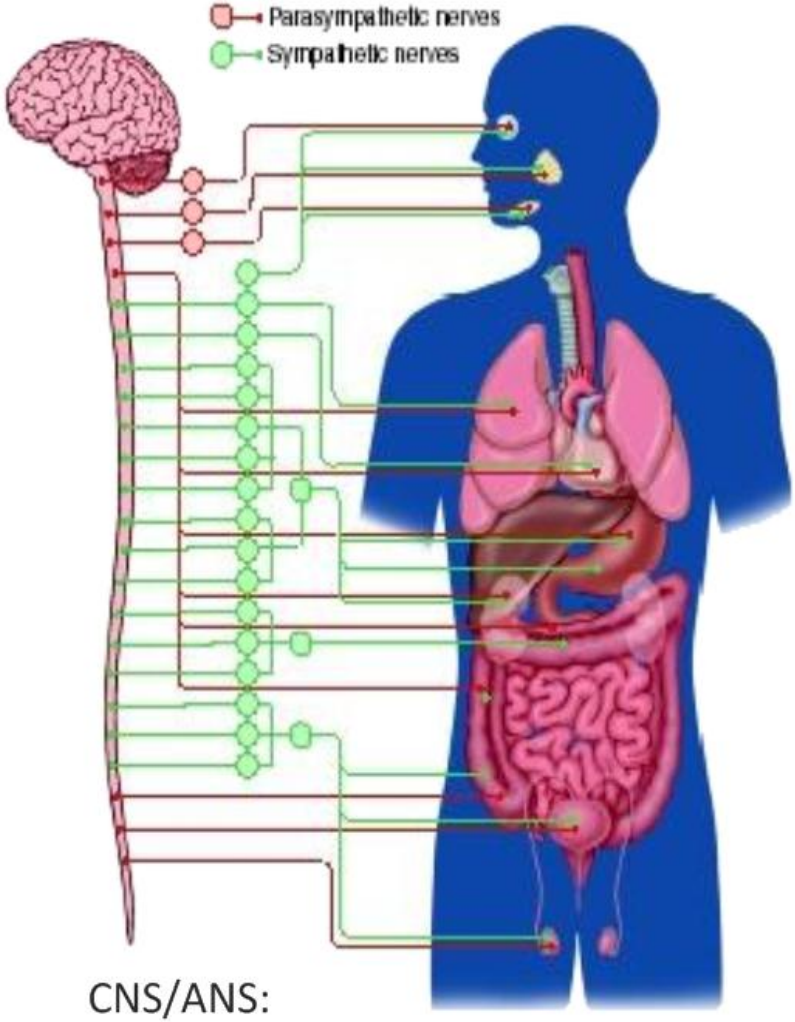
Stephen Taylor
Banding International School

Introduction to the nervous system:



http://www.youtube.com/watch?v=xRkPNwqm0mM

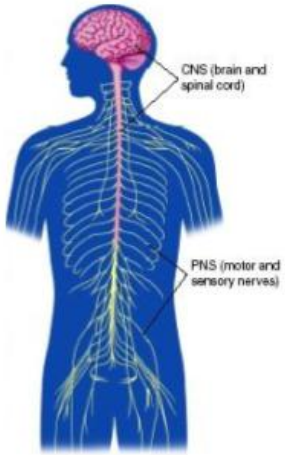
http://faculty.washington.edu/chudler/introb.html



CNS/ANS:

http://www.biologyreference.com/images/biol_03_img0336.jpg

The nervous system consists of the central nervous system and peripheral nerves



Nervous System

Central Nervous System

Brain

Spinal Cord

Peripheral Nervous System

Autonomic NS

homeostasis

involuntary control

Sympathetic

"fight or flight"

Parasympathetic

"rest and digest"

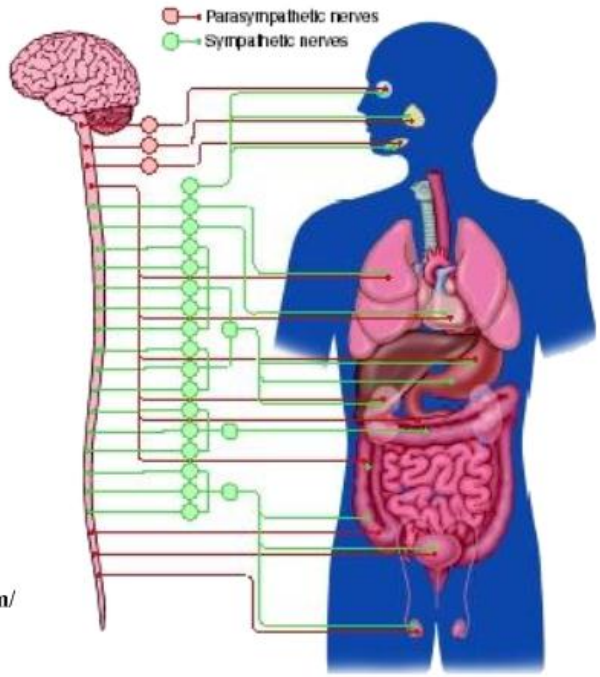
Enteric

controls digestive system

Somatic NS

-receives external stimuli

-voluntary control of muscle



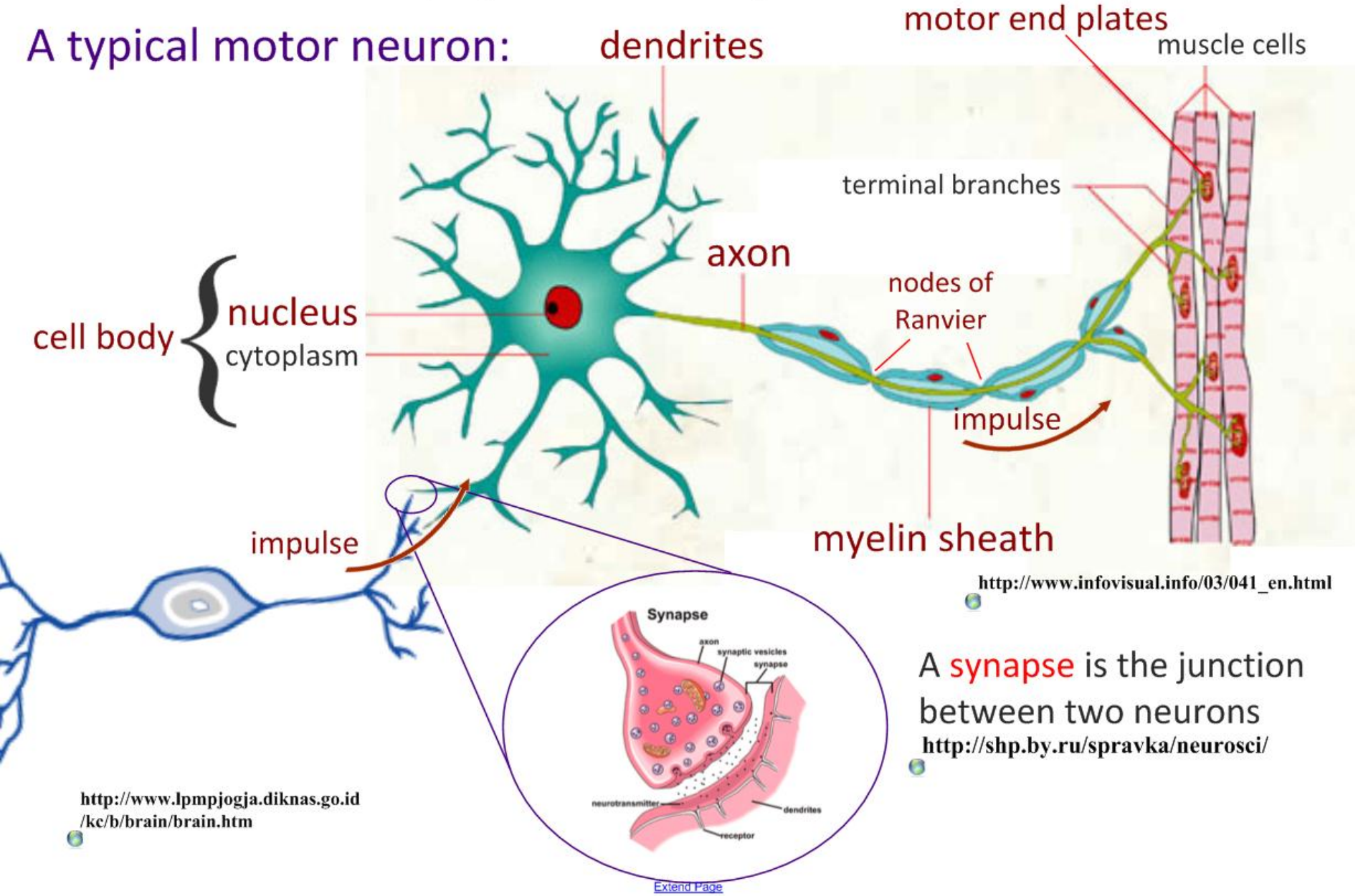
Brain:
http://faculty.washington.edu/chudler/gif/brainwig.gif

CNS/ANS:
http://www.biologyreference.com/images/biol_03_img0336.jpg

The nervous system is composed of neurons

These are cells that carry rapid electrical impulses

A typical motor neuron:



http://www.infovisual.info/03/041_en.html

http://www.lpmpjogja.diknas.go.id/kc/b/brain/brain.htm

A synapse is the junction between two neurons

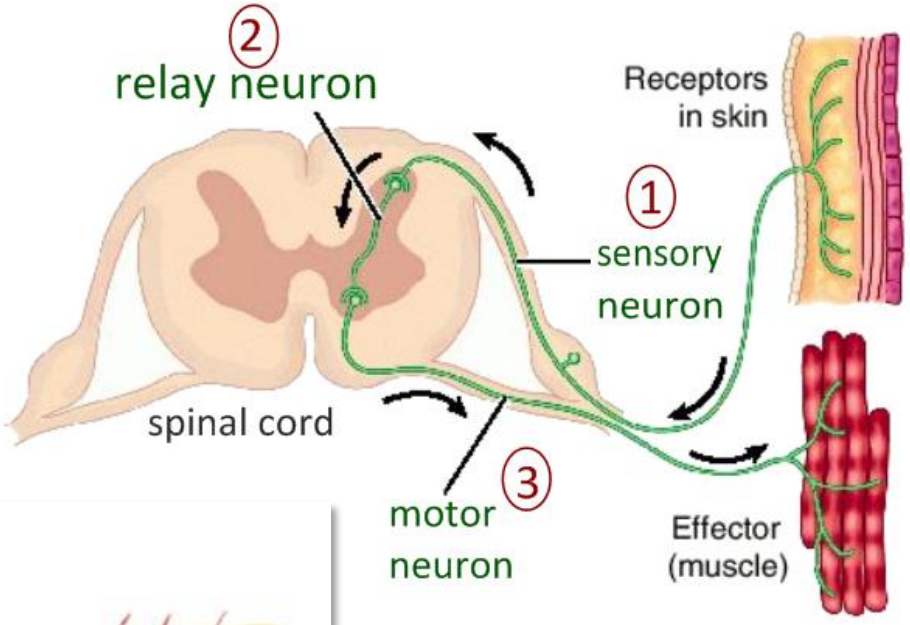
http://shp.by.ru/spravka/neurosci/

Extend Page

The reflex arc

Nerve impulse conduction:

① receptor to CNS: sensory neurons
② within CNS: relay neurons
③ CNS to effectors: motor neurons



http://medical-dictionary.thefreedictionary.com/ARC

Animation:

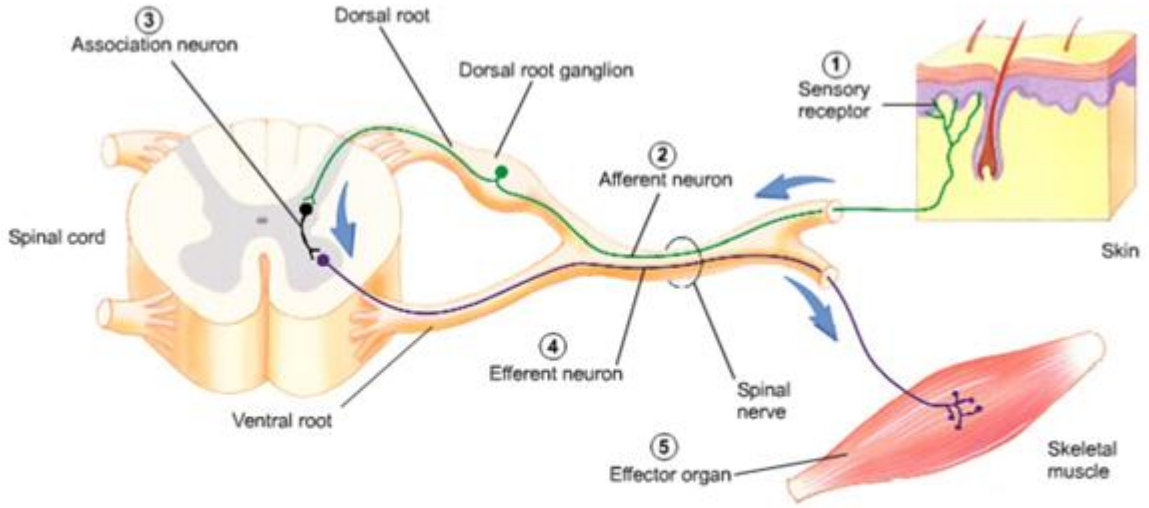
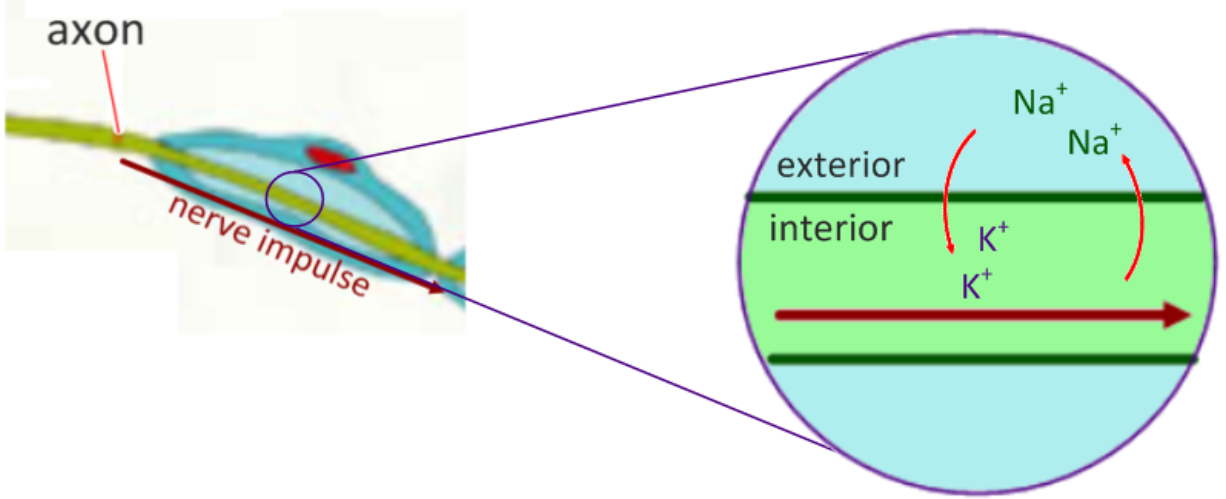


FIGURE 12.19 Reflex Arc

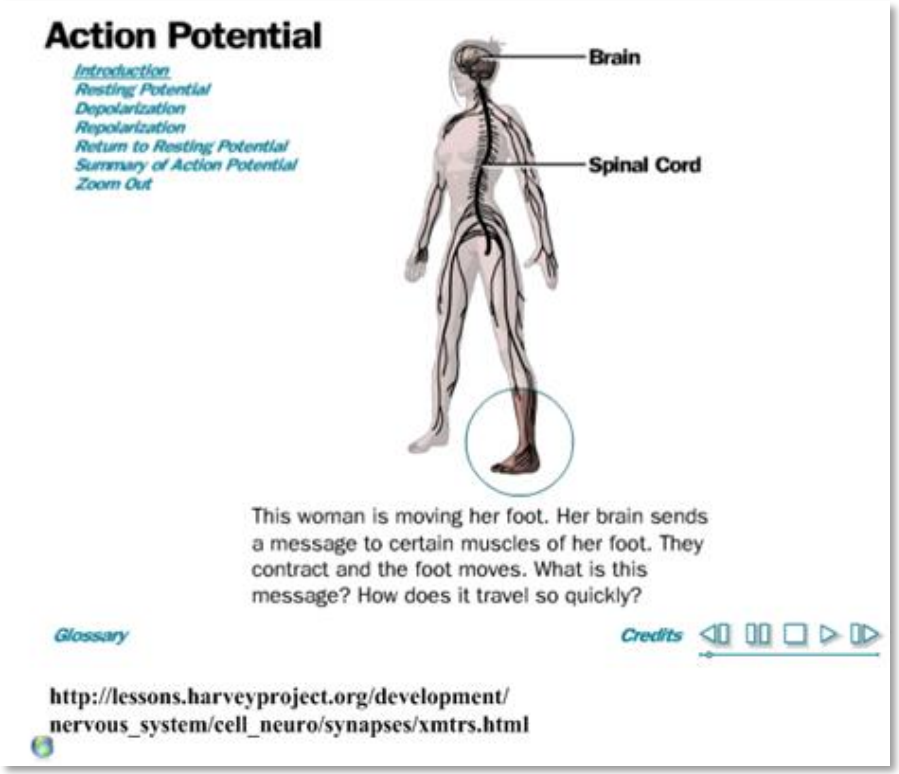
http://msjensen.cehd.umn.edu/1135/Links/Animations/Flash/0016-swf_reflex_arc.swf

Nerve impulses are conducted along the neuron

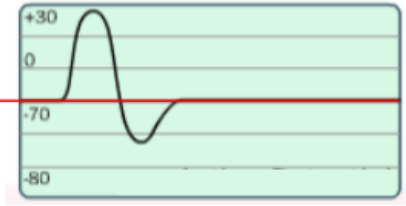


The nerve impulse is a result of a change in concentrations of sodium (Na^+) and potassium (K^+) ions across the membranes of the neuron.

These changes are called depolarisation and repolarisation.

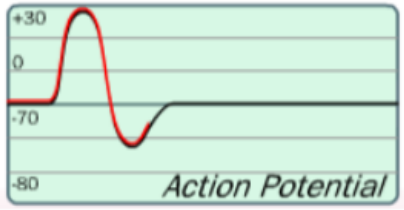


Resting potential



is the electrical potential across the plasma membrane of a cell that is not conducting an impulse.

Action potential



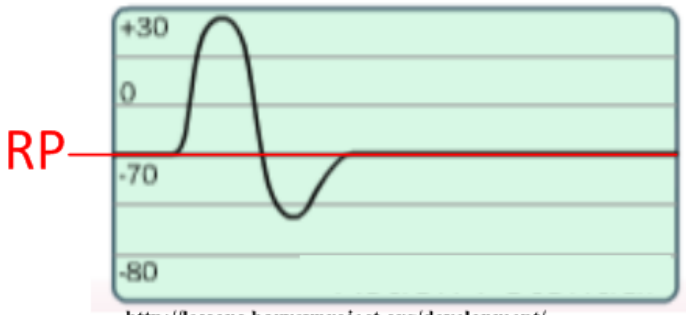
is the the reversal (depolarisation) and restoration (repolarisation) of the electrical potential across a plasma membrane as a nerve impulse passes along a neuron.

Resting Potential

is the electrical potential across the plasma membrane of a cell that is not conducting an impulse.

Resting potential is maintained by active transport (antiport):

Why is RP negative?

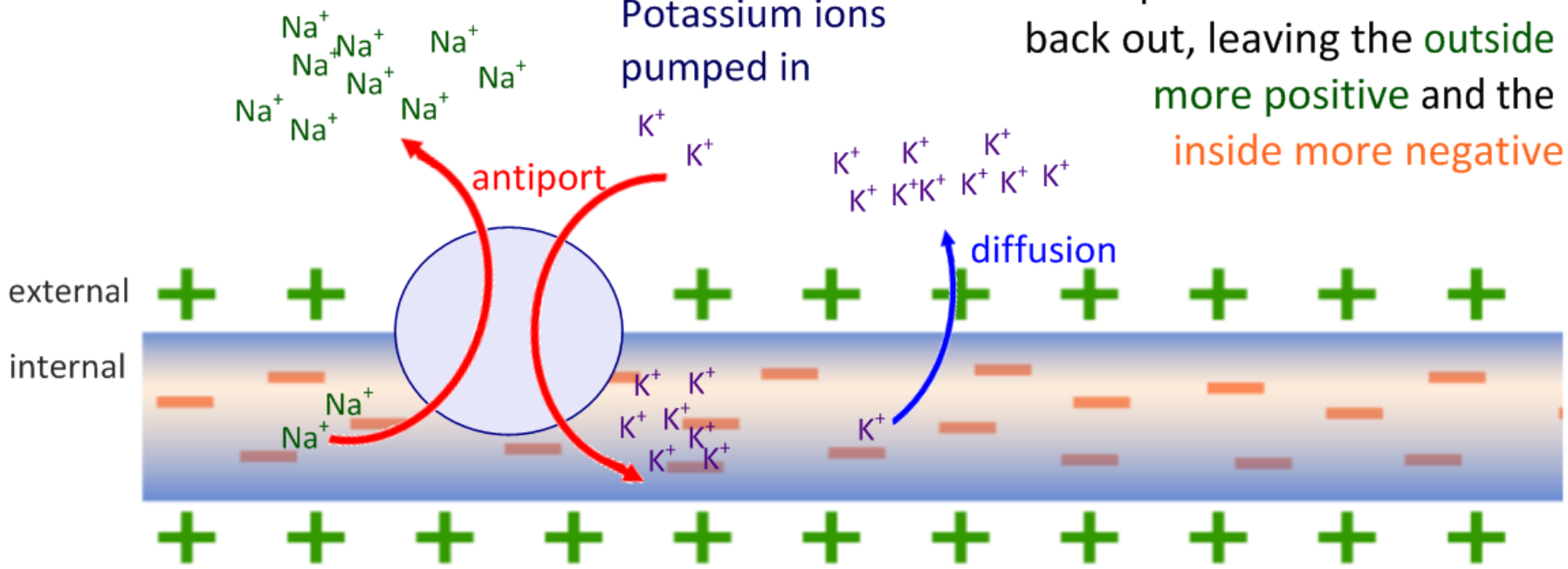


http://lessons.harveyproject.org/development/nervous_system/cell_neuro/synapses/xmtrs.html

Sodium ions pumped out

Potassium ions pumped in

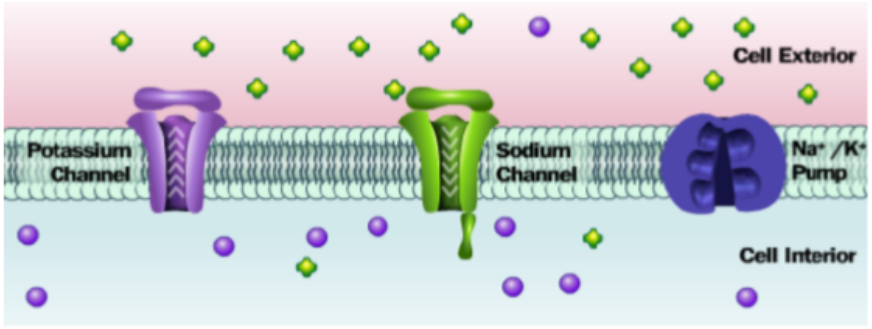
Some potassium ions diffuse back out, leaving the outside more positive and the inside more negative

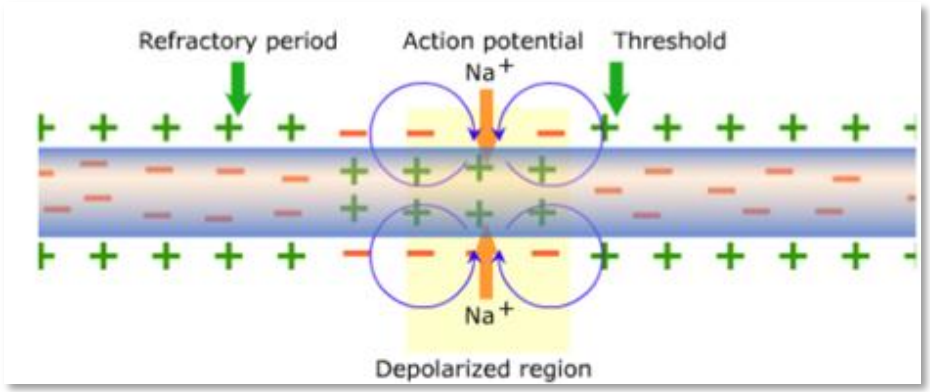


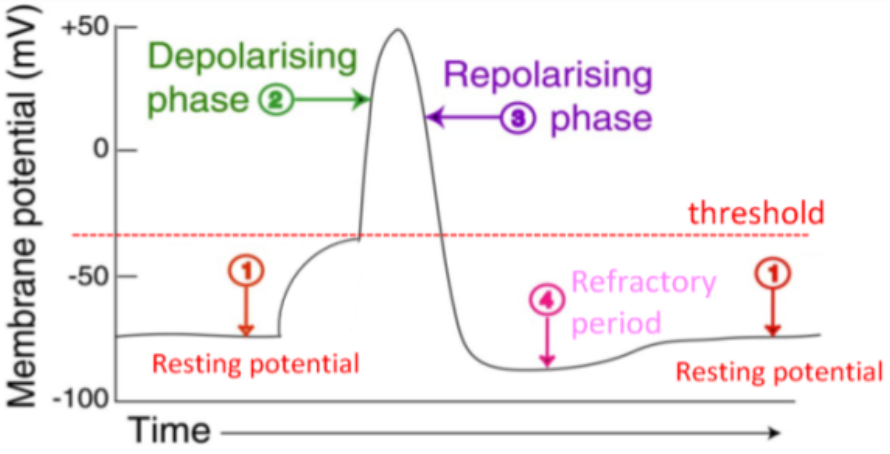
Adapted from http://www.blackwellpublishing.com/matthews/actionp.html

Action Potential

is the the reversal (depolarisation) and restoration (repolarisation) of the electrical potential across a plasma membrane as a nerve impulse passes along a neuron.







1. Resting potential is maintained by active transport: Na^+/K^+ pump pumps Na^+ out and K^+ in.

2. Arrival of an Action Potential (AP) causes depolarisation of adjacent sections of the neuron.
   - This causes local Na^+ diffusion and a current.
   - If the current is enough to rise above the threshold, voltage-gated Na^+ channels open and Na^+ rushes in. Internal potential is reversed - it is more positive than the outside (depolarisation).

3. K^+ channels are opened and K^+ diffuses out. Internal charge is negative again (repolarisation)

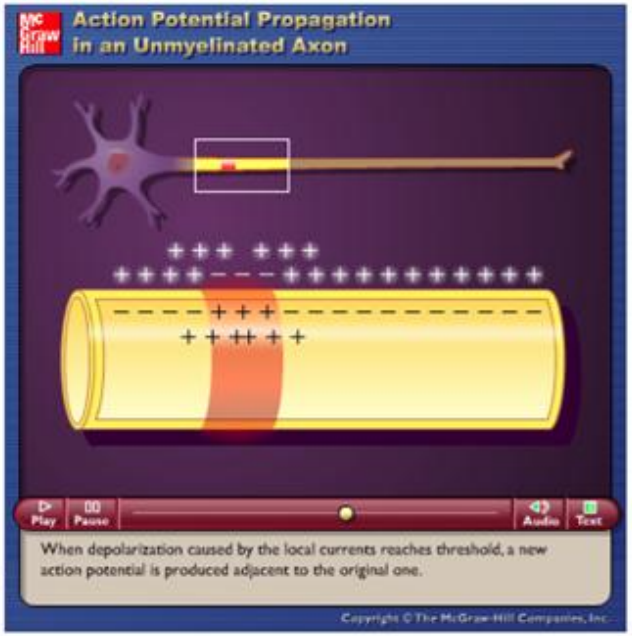
4. Refractory period is when the channels rest between openings. This ensures one-way impulse flow.
   Resting potential is then returned by active transport.

http://lessons.harveyproject.org/development/nervous_system/cell_neuro/synapses/xmtrs.html

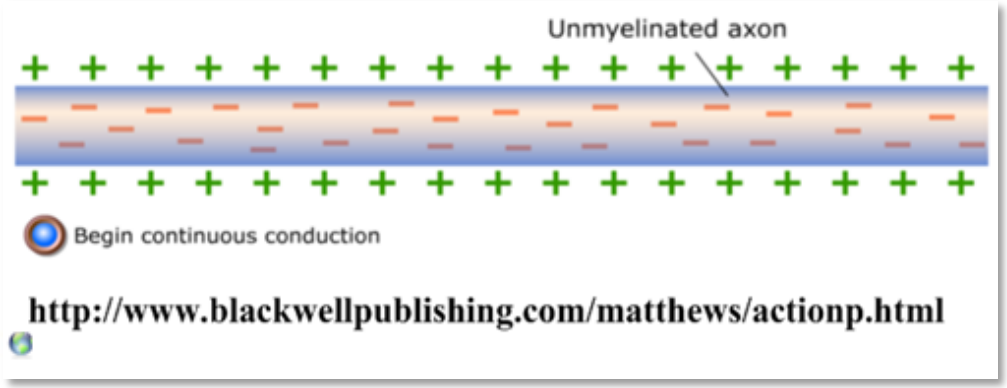
http://scienceblogs.com/clock/upload/2006/06/ActionPotential.jpg

http://www.blackwellpublishing.com/matthews/actionp.html

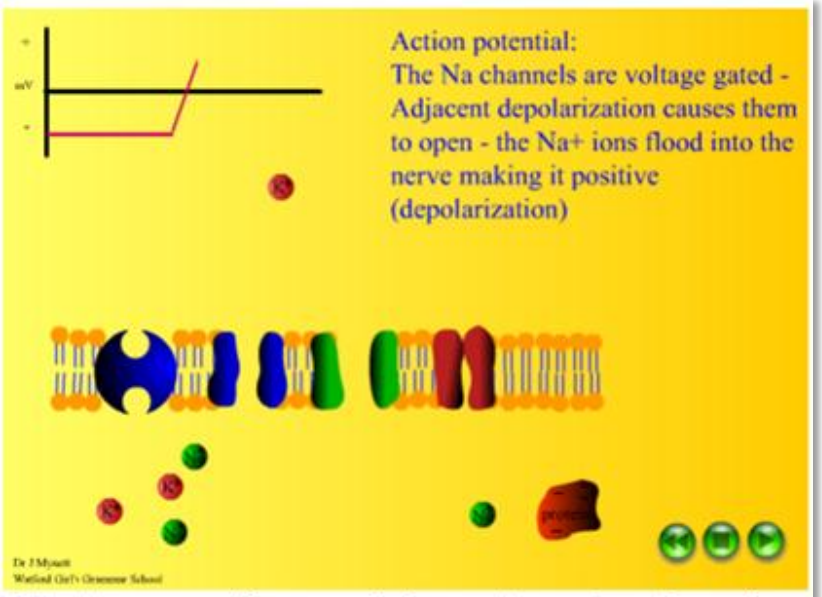
Action Potential Resources



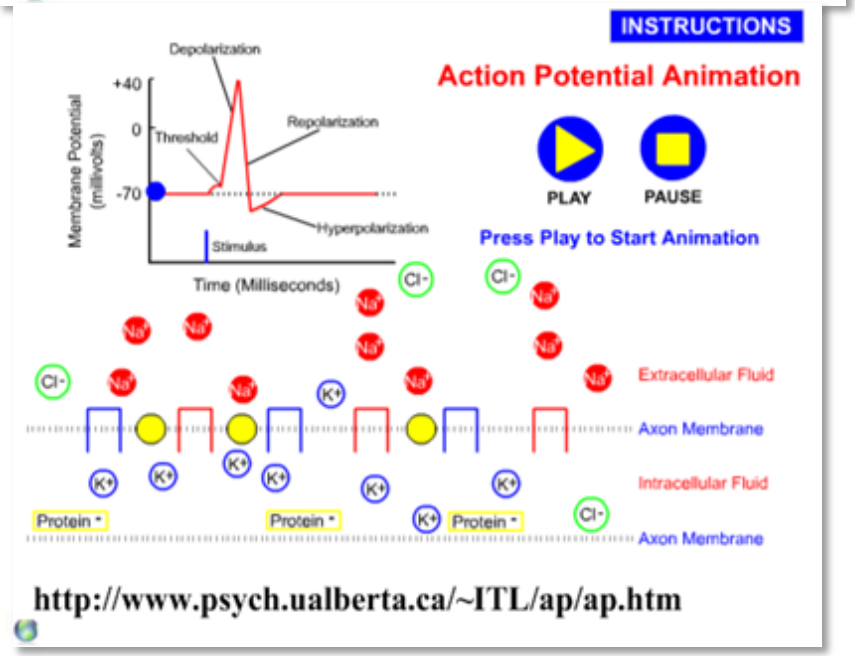
http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter45/animations.html#



http://www.blackwellpublishing.com/matthews/actionp.html



http://www.mrothery.co.uk/images/nerveimpulse.swf

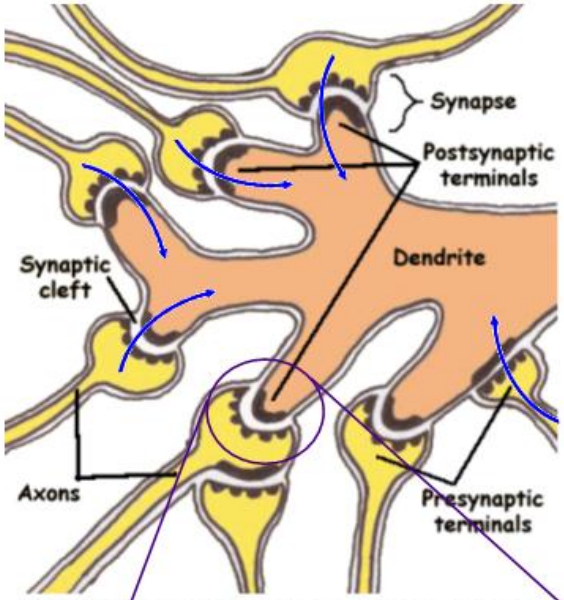


http://www.psych.ualberta.ca/~ITL/ap/ap.htm


http://www.mindhacks.com/blog/2005/09/synapse_wins_science.html

Synaptic Transmission

What happens when a nerve meets another nerve? This.

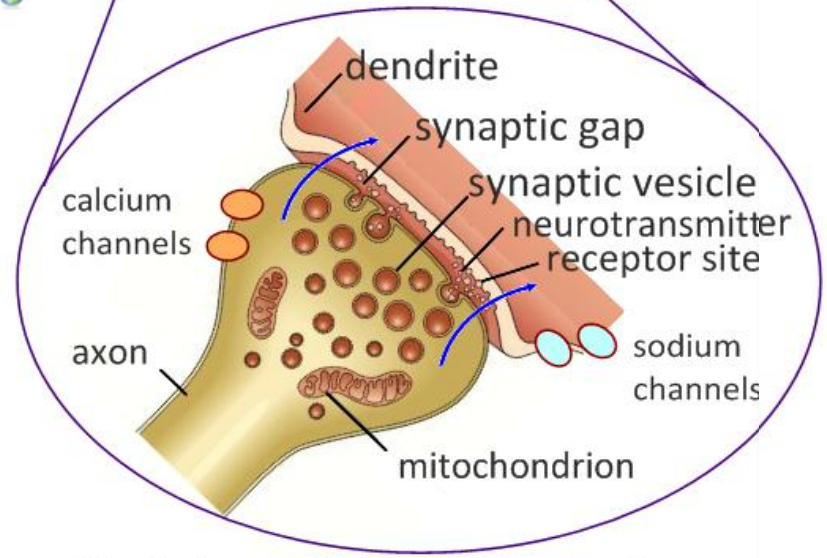


http://www.mult-sclerosis.org/synapse.gif

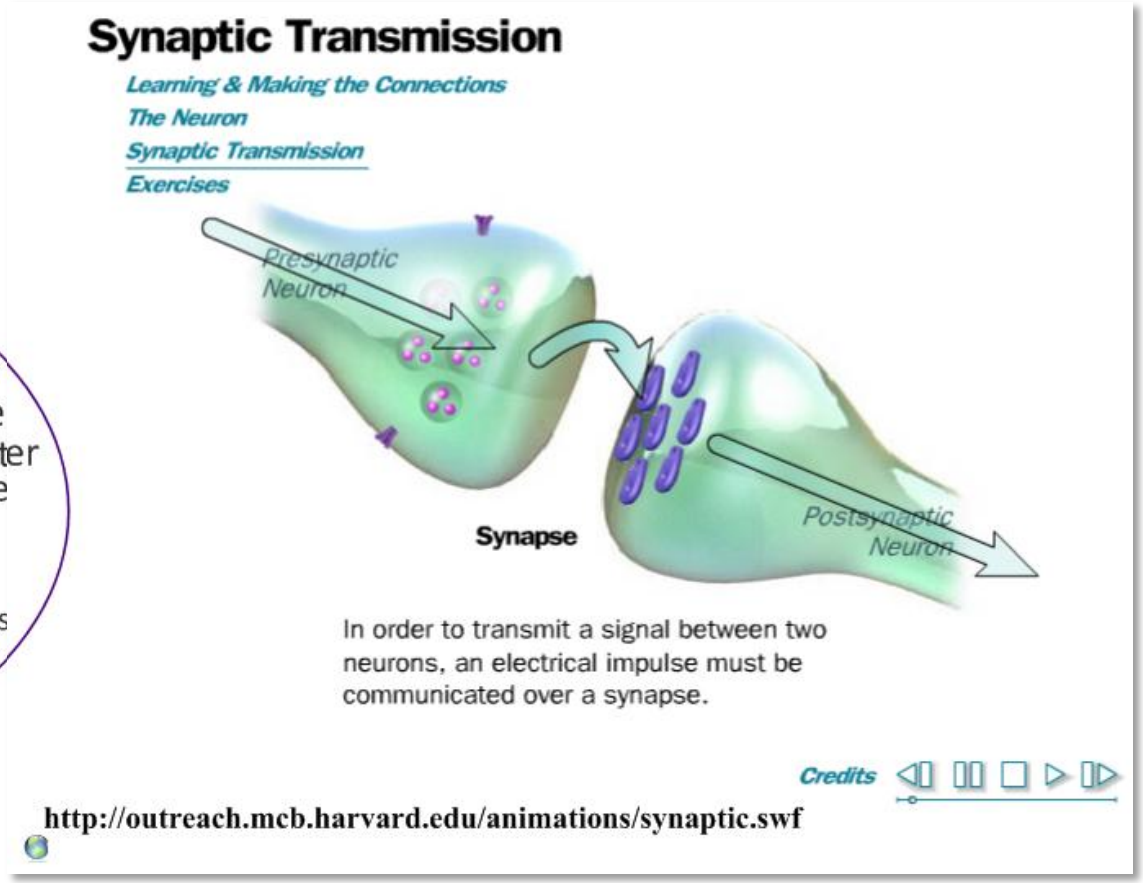
At the dendritic end of the nerve cell, each dendrite collects the nerve impulse from the terminal end of a different nerve cell. The impulse needs to 'jump' across a small gap - the synapse - by synaptic transmission.

The electrical impulse is converted to a chemical neurotransmitter.

Work thorough the tutorial below:
How does synaptic transmission work?

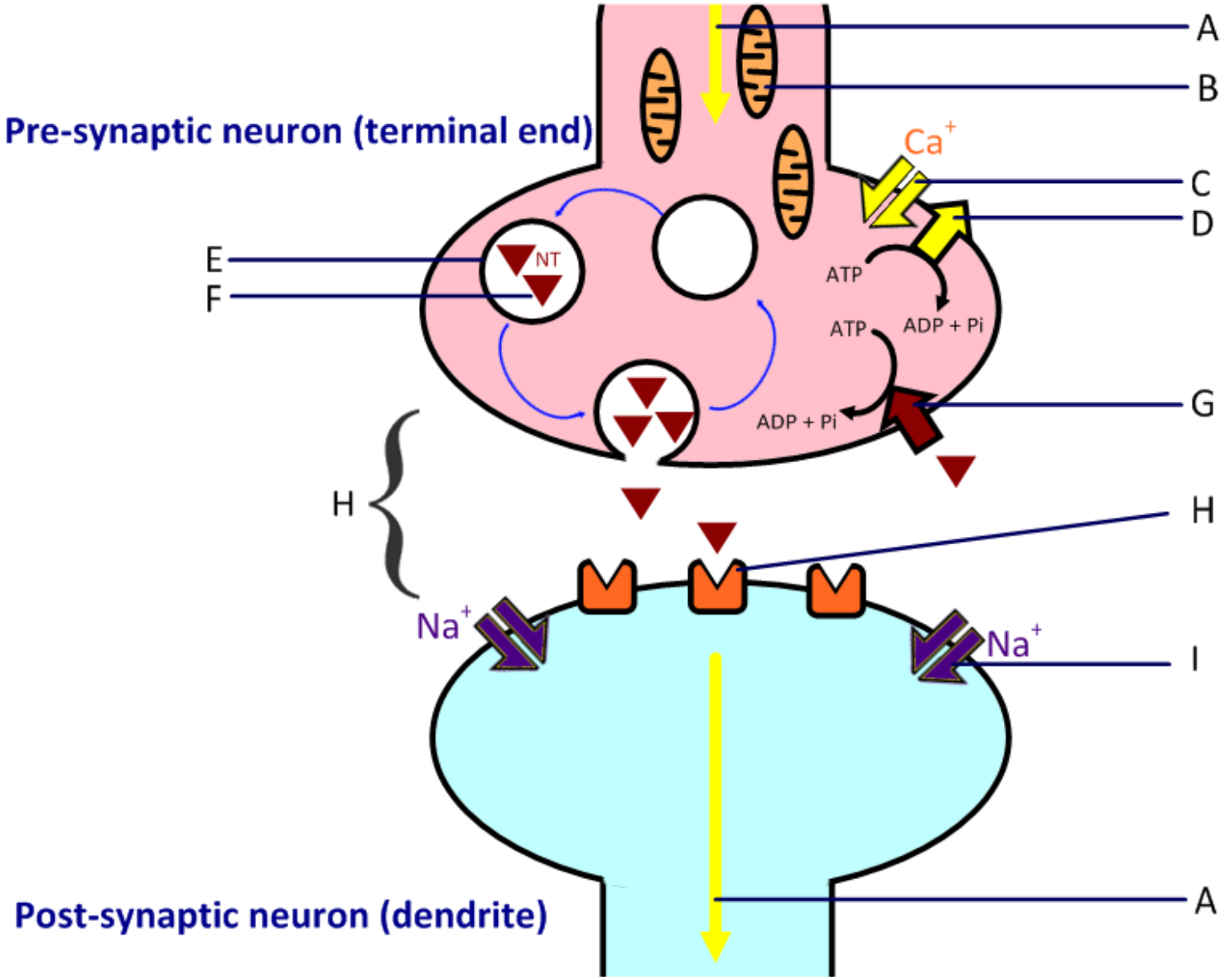


http://universe-review.ca/I10-40-synapse.jpg

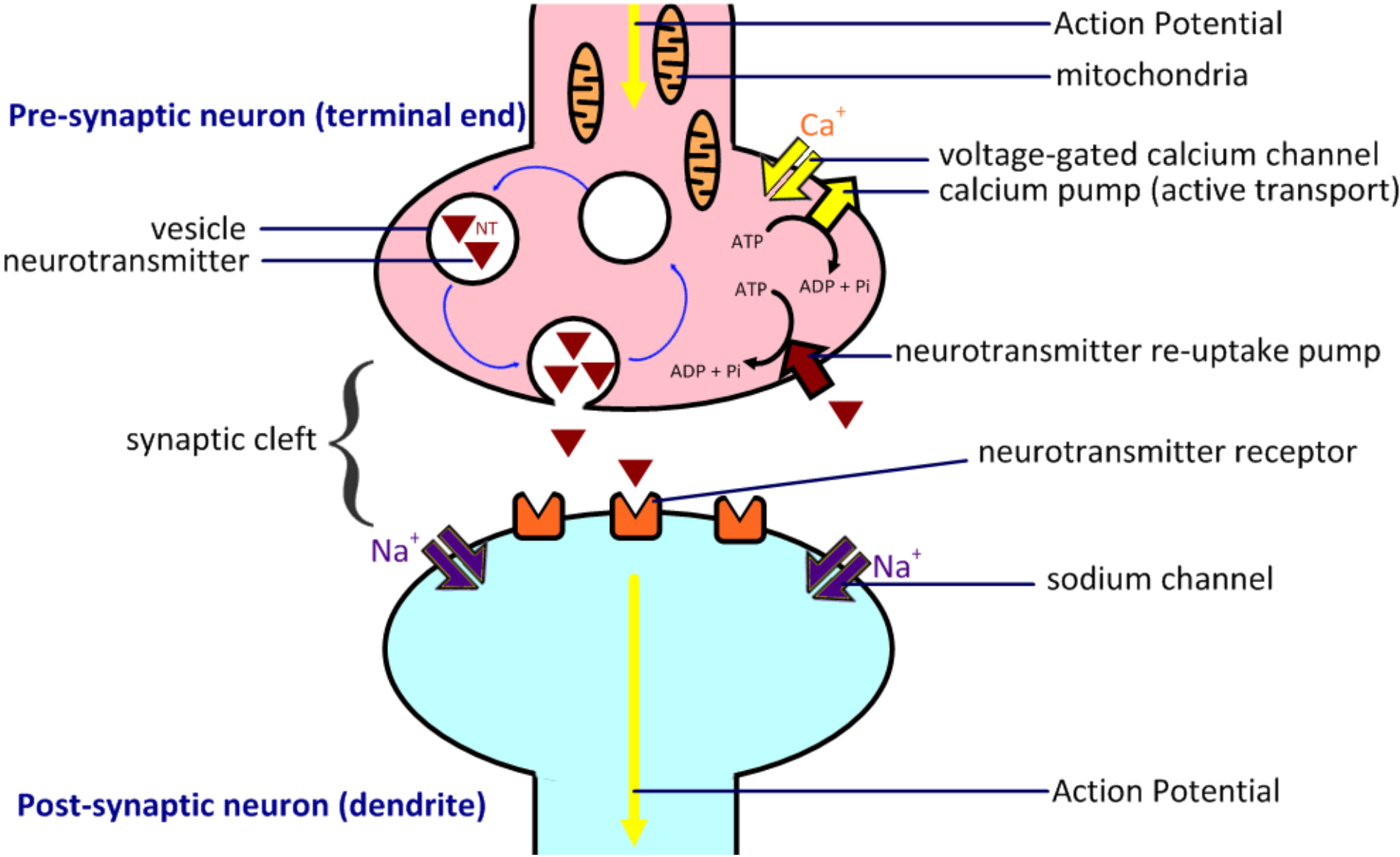


http://outreach.mcb.harvard.edu/animations/synaptic.swf

Label this diagram of a synapse



Label this diagram of a synapse

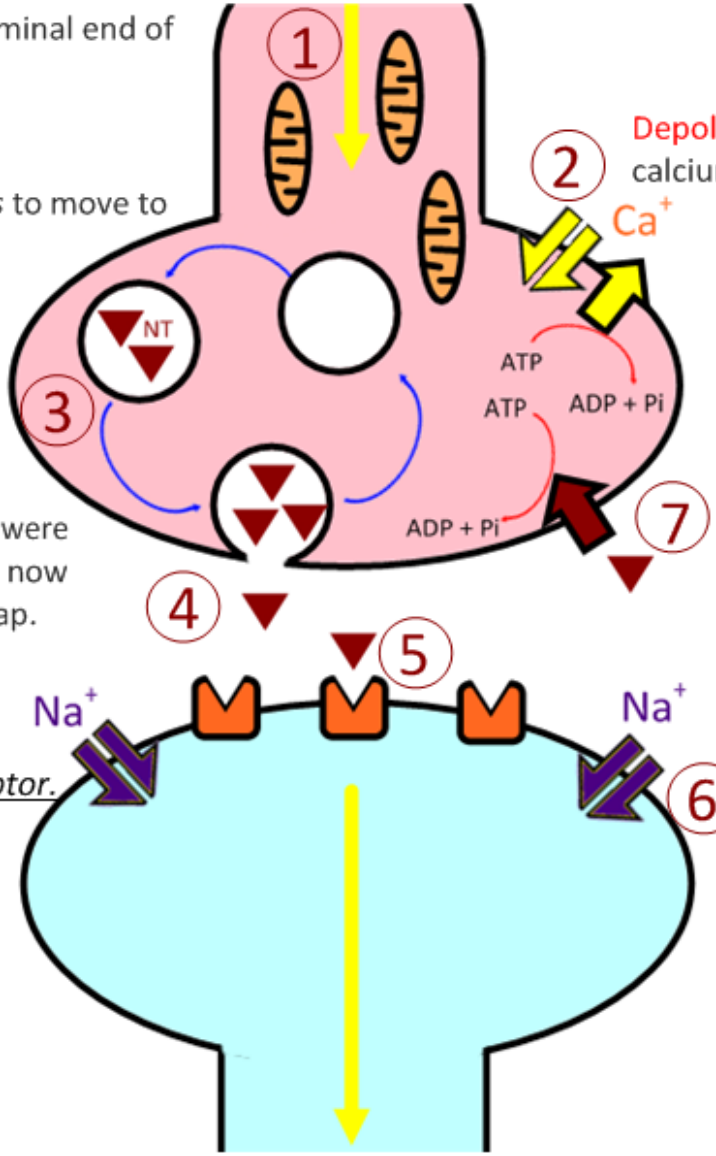


Summary of Synaptic Transmission

1. Nerve impulse reaches terminal end of pre-synaptic neuron.

2. Depolarisation causes voltage-gated calcium channels to open. Ca^{2+} rushes in.

3. Ca^{2+} causes *synaptic vesicles* to move to the membrane and fuse.



4. Neurotransmitters (NTs)that were stored in the synaptic vesicle now diffuse across the synaptic gap.

5. NTs bind with post-synaptic receptors.
NTs are specific to the receptor.

6. Sodium channels open, causing Na^+ to enter, leading to depolarisation of the post-synaptic neuron.
An action potential is initiated.

7. Enzymes in the synaptic gap then break down the NT.
The products of this break down are taken up by the pre-synaptic neuron by active transport (hence the large number of mitochondria)

The nerve impulse is then propagated along the post-synaptic neuron.

Draw and label a diagram of a motor-neuron, showing the direction of nerve impulse propagation.

(3 marks)

Draw and label a diagram of a motor-neuron, showing the direction of nerve impulse propagation.

(3 marks)

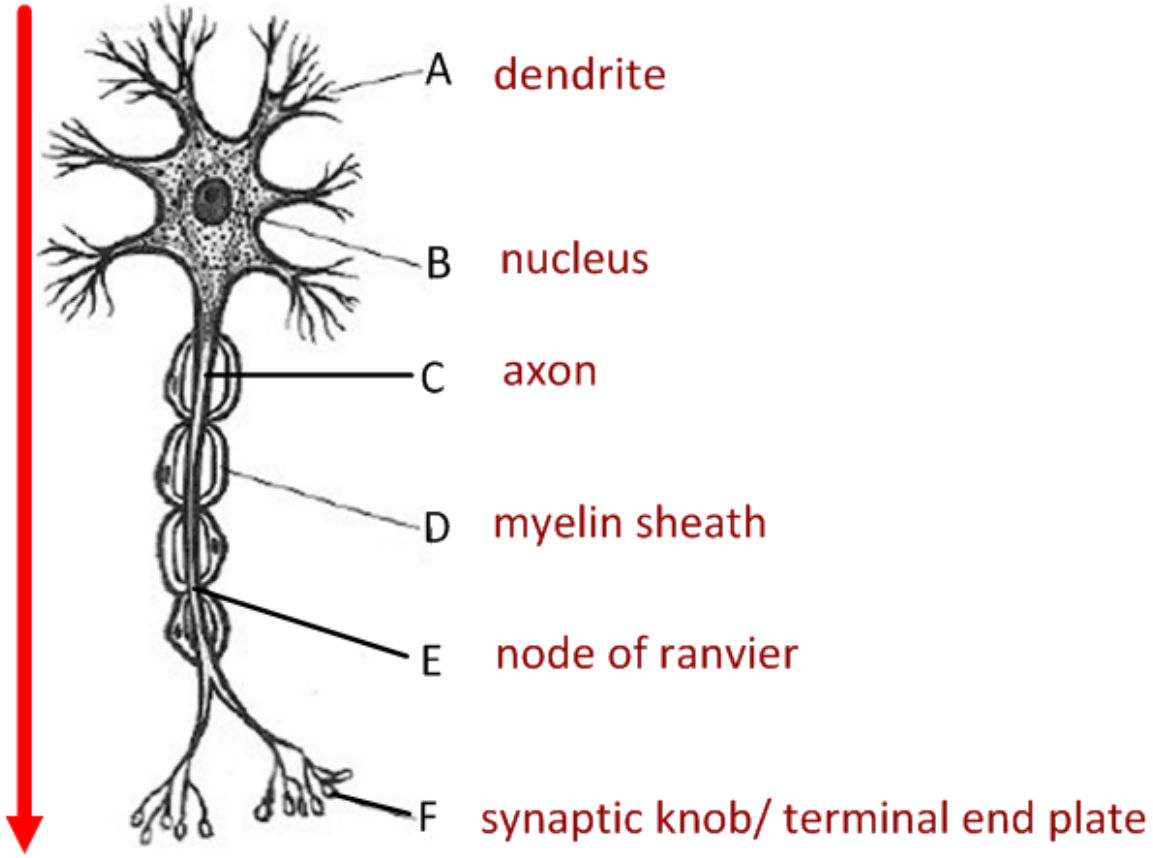


Image: QuestionBank CDRom

arrow in correct direction;
Award [1] for any <u>two of the following</u> structures clearly drawn and correctly labelled, up to [2 max].
nucleus;
cell body;
axon;
dendrites;
myelin sheath;
node of Ranvier;
synaptic knob; 3 max

Explain how a nerve impulse passes along a non-myelinated neuron.

(8 marks)

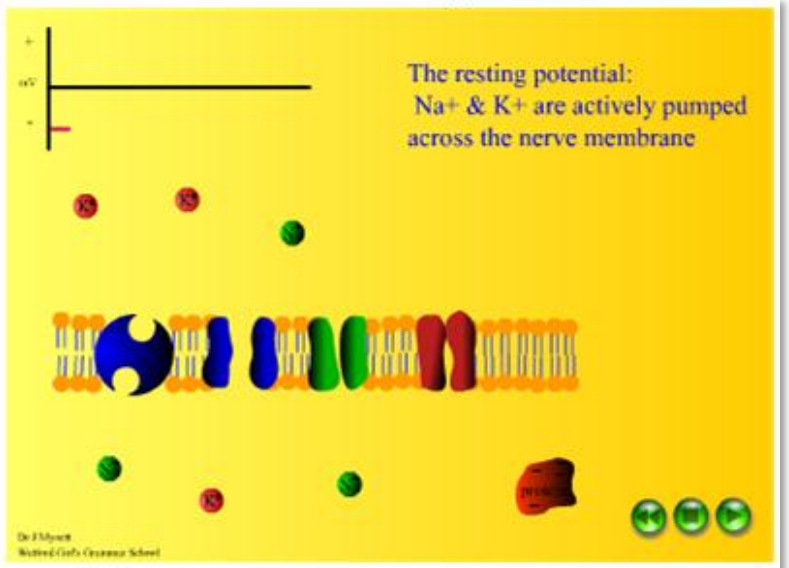
Explain how a nerve impulse passes along a non-myelinated neuron.

(8 marks)

Action potential activates v**oltage-gated sodium-channels**;
sodium ions (+) rush in to **axon**;
Potential increases;
If it increases beyond **threshold**, more sodium channels open;
Axon **depolarises**, stimulating adjacent sections;
Potassium channels open, **potassium (+) rushes out**;
Potential is reduced (repolarisation);
Refractory period ensures **one-way conduction** of action potential;
sodium-potassium pump returns axon section to resting potential.

Answer from QuestionBank CD Rom

Narrate this animation with the correct answer to the question:

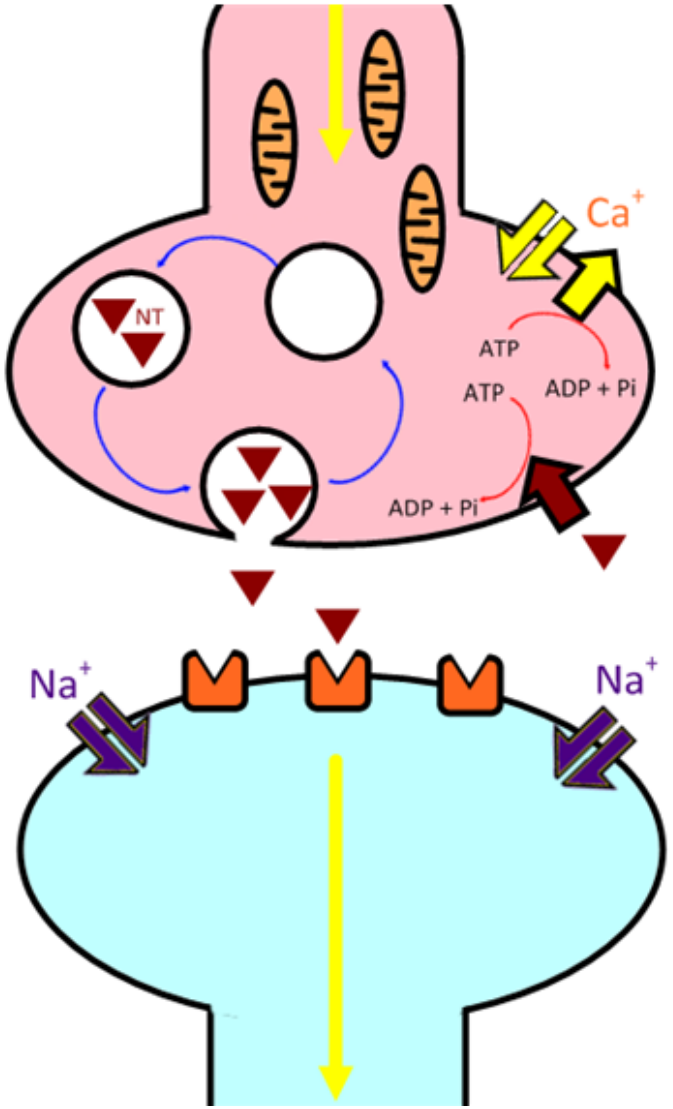


http://www.mrothery.co.uk/images/nerveimpulse.swf

Explain the principles of synaptic transmission. (8 marks)

Explain the principles of synaptic transmission.

(8 marks)



nerve impulse (AP) travels to end of **presynaptic neuron**;
triggers influx of $^{Ca_{2+}}$;
causes **synaptic vesicles** to fuse with membrane;
release **neurotransmitter** molecules into **synaptic cleft**;
(neurotransmitter) crosses / **diffuses** across channel;
(neurotransmitter) **binds to receptors** on next / postsynaptic neuron;
causes **ion channels to open** on post-synaptic neuron;
e.g. Na^+ diffuse into postsynaptic neuron;
can inhibit/excite;
by hyperpolarizing/depolarizing;
neurotransmitter degraded;
Ca^{2+} pumped back into the synaptic cleft by **active transport**;
acetylcholine / GABA / dopamine / serotonin / other examples of neurotransmitter; 8 max

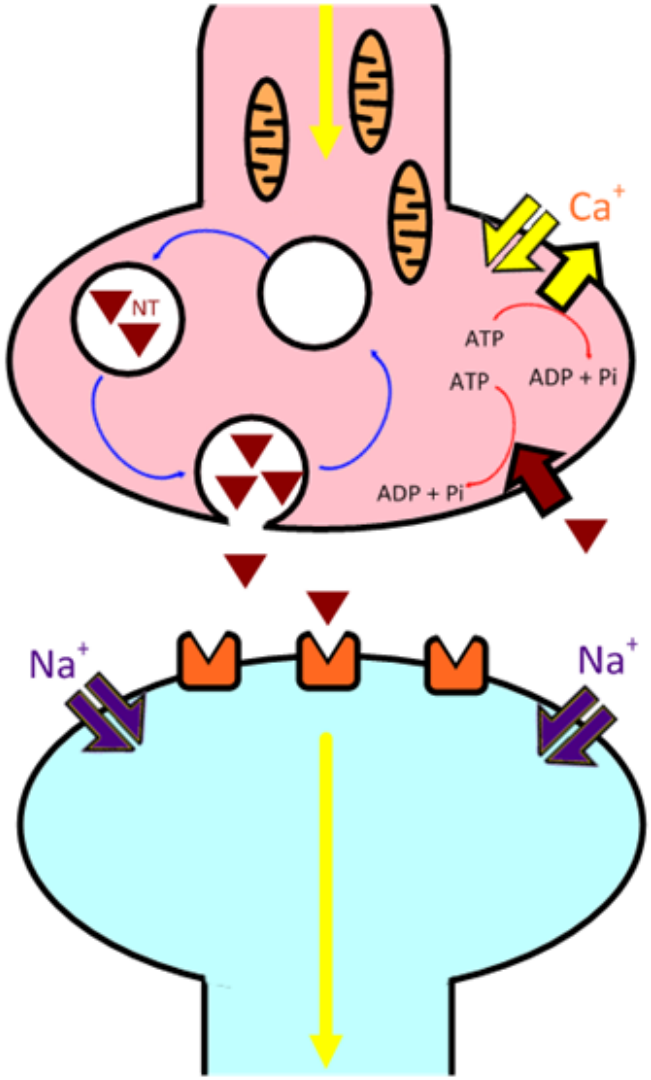
Answer from QuestionBank CDRom

Outline the use of four methods of membrane transport in nerves and synapses.

(8 marks)

Outline the use of four methods of membrane transport in nerves and synapses.

(8 marks)



Active transport

- sodium-potassium pump resets resting potential in the axon following nerve impulse
- re-uptake of neurotransmitters to the pre-synaptic neuron following synaptic tranmission
- removal of Ca^{2+} from pre-synaptic neuron following synaptic transmission

Simple diffusion

- diffusion of NT across synaptic cleft
- diffusion of K^{+} ions out of axon in resting potential

Facilitated diffusion

- opening of voltage-gated Na^{+} and K^{+} channels in action potential
- opening of voltage-gated Ca^{2+} channels at pre-synaptic terminal
- Na^{+} channels activated at post-synaptic terminal to propagate AP

Vesicle transport

- influx of Ca^{2+} activates vesicles of neurotransmitters
- exocytosis of NT from pre-synaptic neuron to synaptic cleft

The Endocrine System

A stimulus is received and processed.

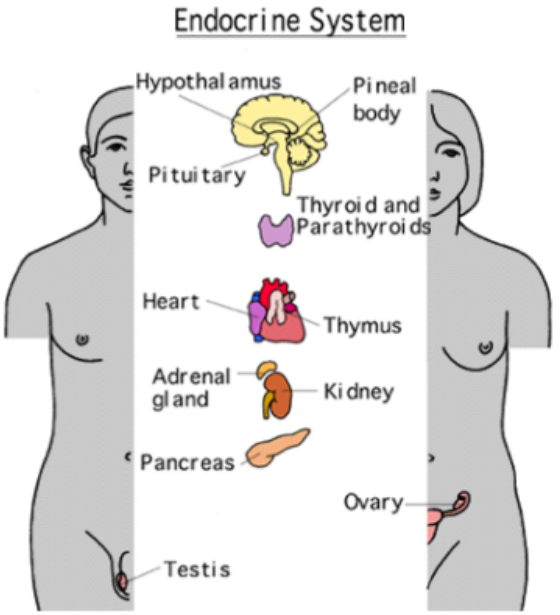
Hormones are secreted into the blood, via ducts.

They are carried to the target tissue - the place of action.

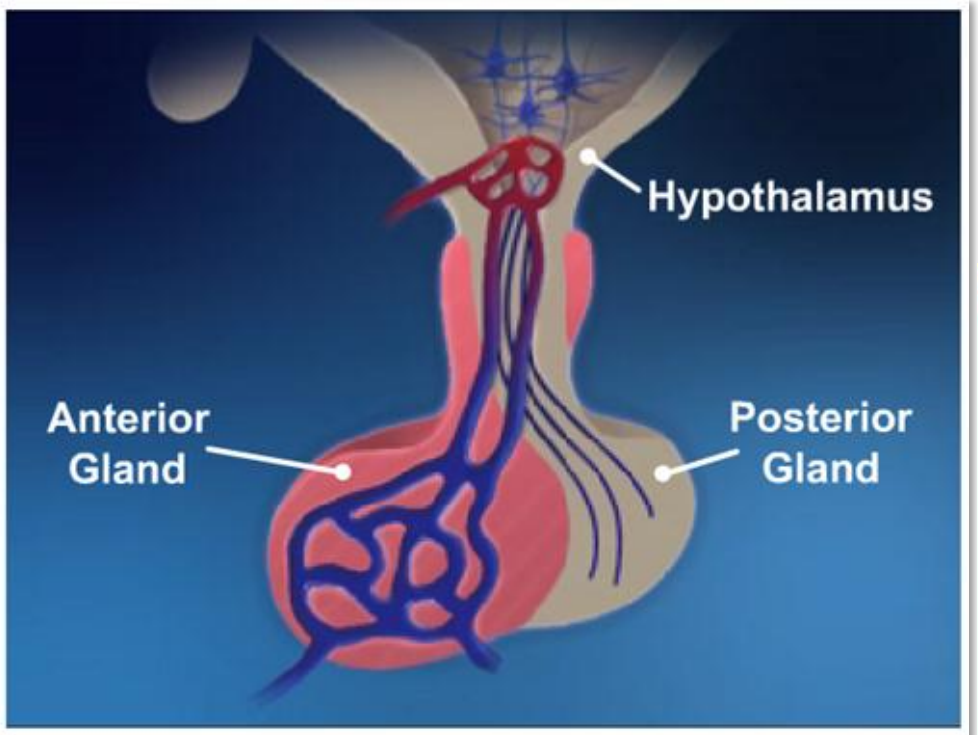
The action of the hormone changes conditions of the tissue.

This change is monitored through feedback.

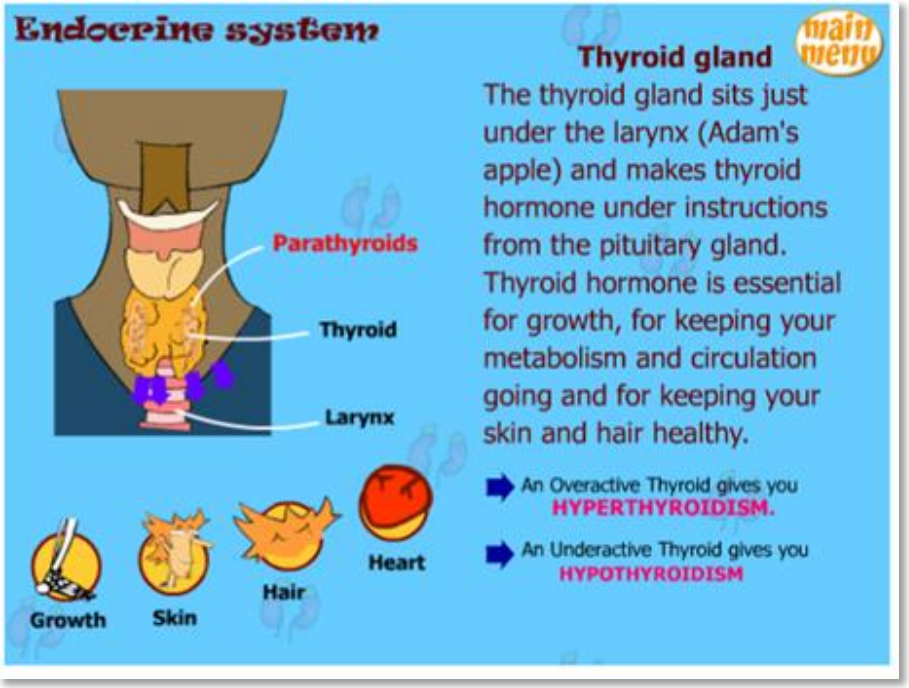
Most hormonal change results in negative feedback.



http://www.umm.edu/endocrin/images/endocrine.gif



http://www.delmarlearning.com/companions/content/1401837182/Animations/Endocrine%20System.swf



http://www.e-learningforkids.org/Courses/Liquid_Animation/Body_Parts/Endocrine_System/endocrine_object.swf

Hormones in IB Biology

What do they all do?

insulin
glucagon

adrenaline

testosterone

FSH
LH
oestrogen
progesterone

HCG
oxytocin

Hormones in IB Biology

What do they all do?

insulin	converts glucose to glycogen
glucagon	converts glycogen glucose
adrenaline	"Fight or flight" increases heart rate
testosterone	sperm production, male body development
FSH	stimulates oocyte development
LH	develops endometrium
oestrogen	stimulates ovulation (release of the egg)
progesterone	maintains endometrium
HCG	maintains high levels of oestrogen and progesterone in pregnancy
oxytocin	causes contraction of the uterus during childbirth

Homeostasis: maintaining the internal environment of the body within safe limits

blood tissue fluids

Water balance (osmoregulation)

around 90% of blood volume

dehydration with water loss

kidneys & hormones (excretion)

Blood glucose concentration

80mg dl^{-1} - 110mg dl^{-1}

pancreas & liver

insulin & glucagon

CO_2 concentration

10-13 kPa

kidneys (excretion)

circulation (breathing & heart rate)

Blood pH

pH 7.35 - 7.45

buffering agents

kidneys (excretion)

circulation (breathing & heart rate)

Body temperature (thermoregulation)

36°C - 38°C

Vasodilation and Sweating (hot)

or vasoconstriction and shivering (cold)

http://en.wikipedia.org/wiki/Blood

http://en.wikipedia.org/wiki/Dehydration

Yeah, yeah, I know...

Do this!

Homeostasis

works by monitoring levels of variables and making corrections by negative feedback mechanisms.

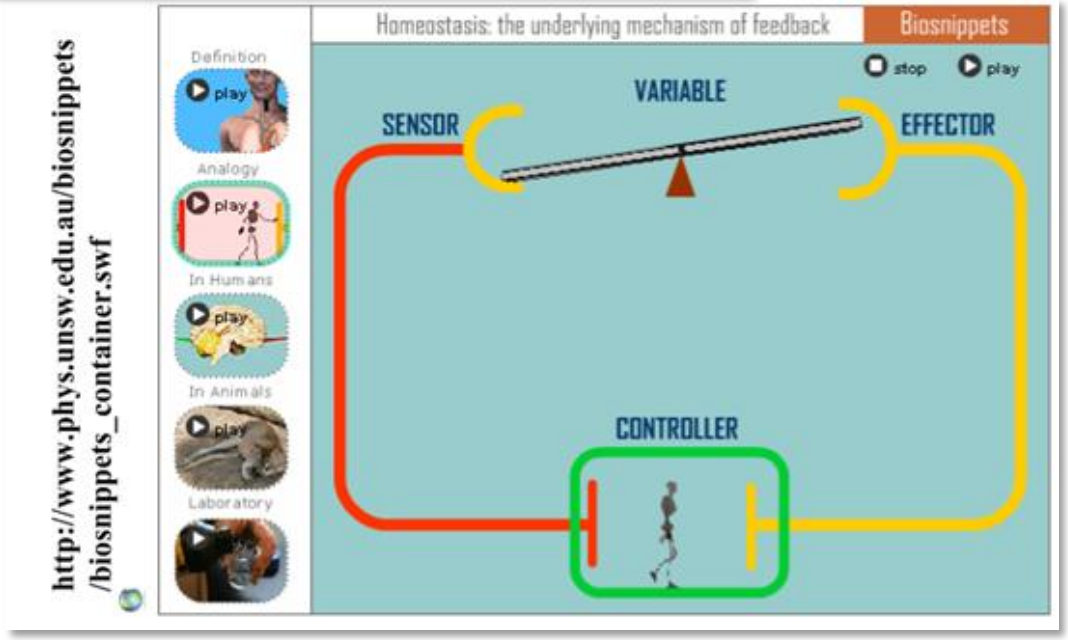
http://www.think-bank.com/iwb/flash/homeostasis.swf

Too hot? Get cooler!

How do you know?

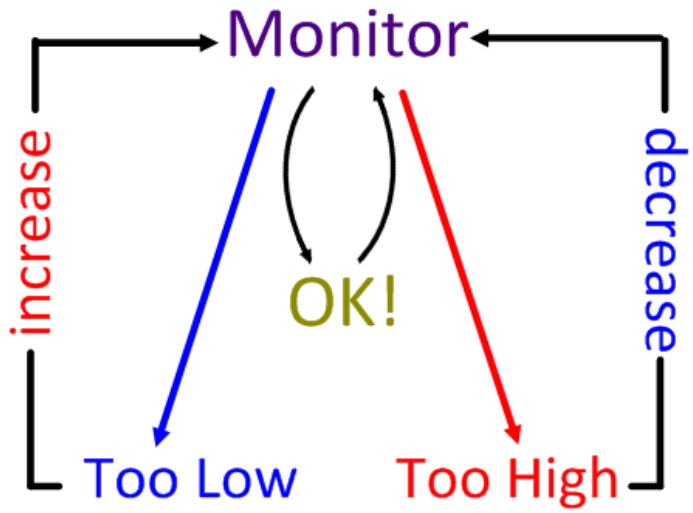
Stimulus - Receptor - Coordinator

Effector → Check again!



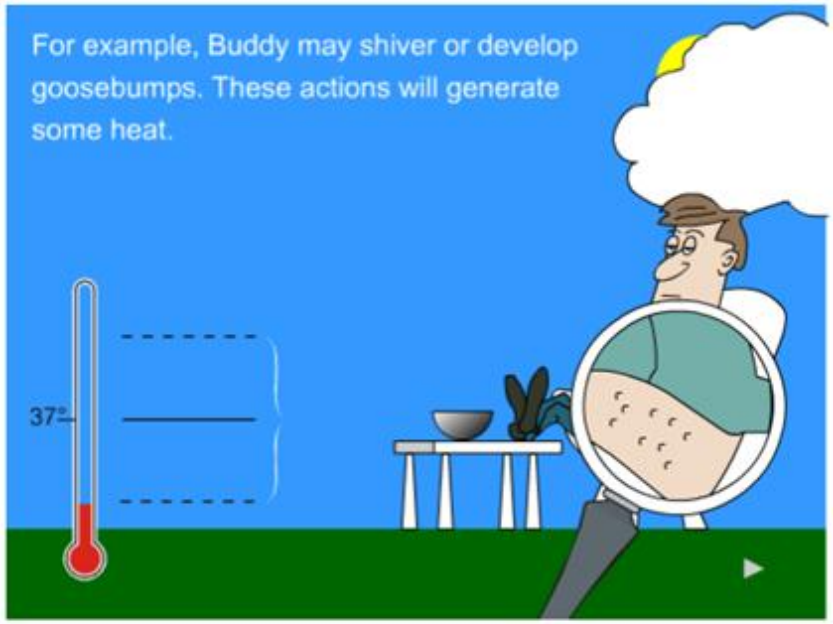
http://www.phys.unsw.edu.au/biosnippets/biosnippets_container.swf

Feedback loops:



Thermoregulation

Human core body temperature needs to remain at around 37°C.

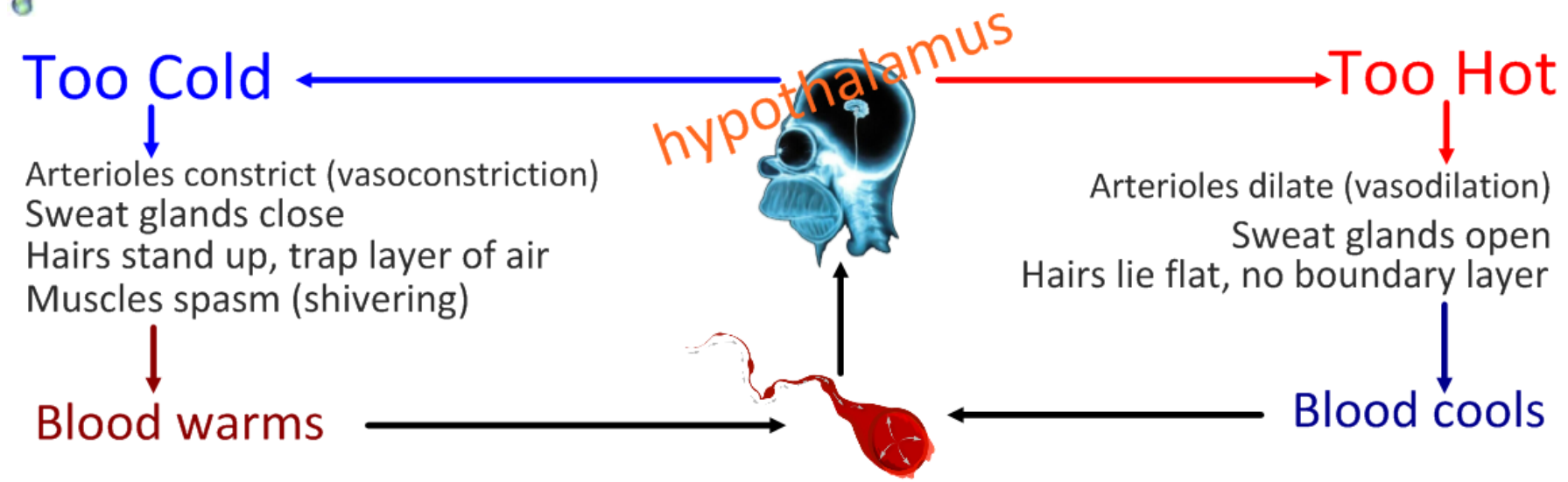


http://www.distance.mun.ca/media/samples/homeostasis/04_audio.swf

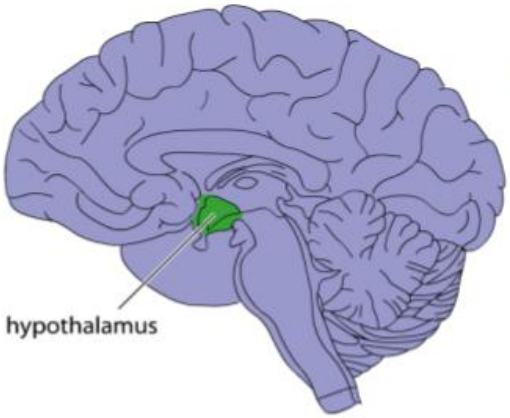
Hypothermia occurs when the body's core temperature drops too low for metabolic reactions to occur. Death below 32°C.

Hyperthermia (heat stroke) occurs when the body's core temperature gets too high and tissues are damaged. Above 40°C is deadly.

A lot of heat is generated in the liver and carried around the body in the blood. Heat is lost through the skin - the larger the SA:Vol ratio, the faster the rate of heat loss.

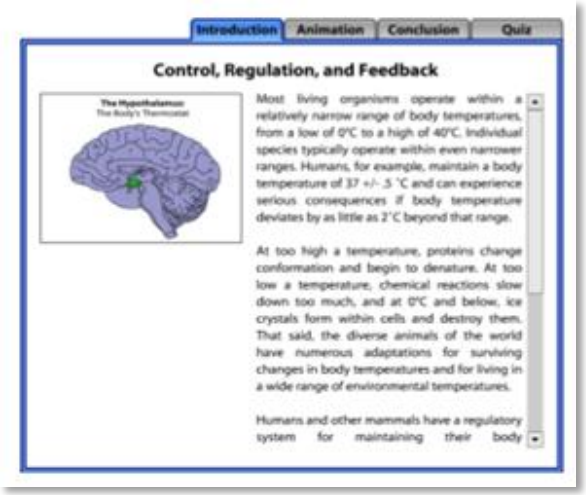


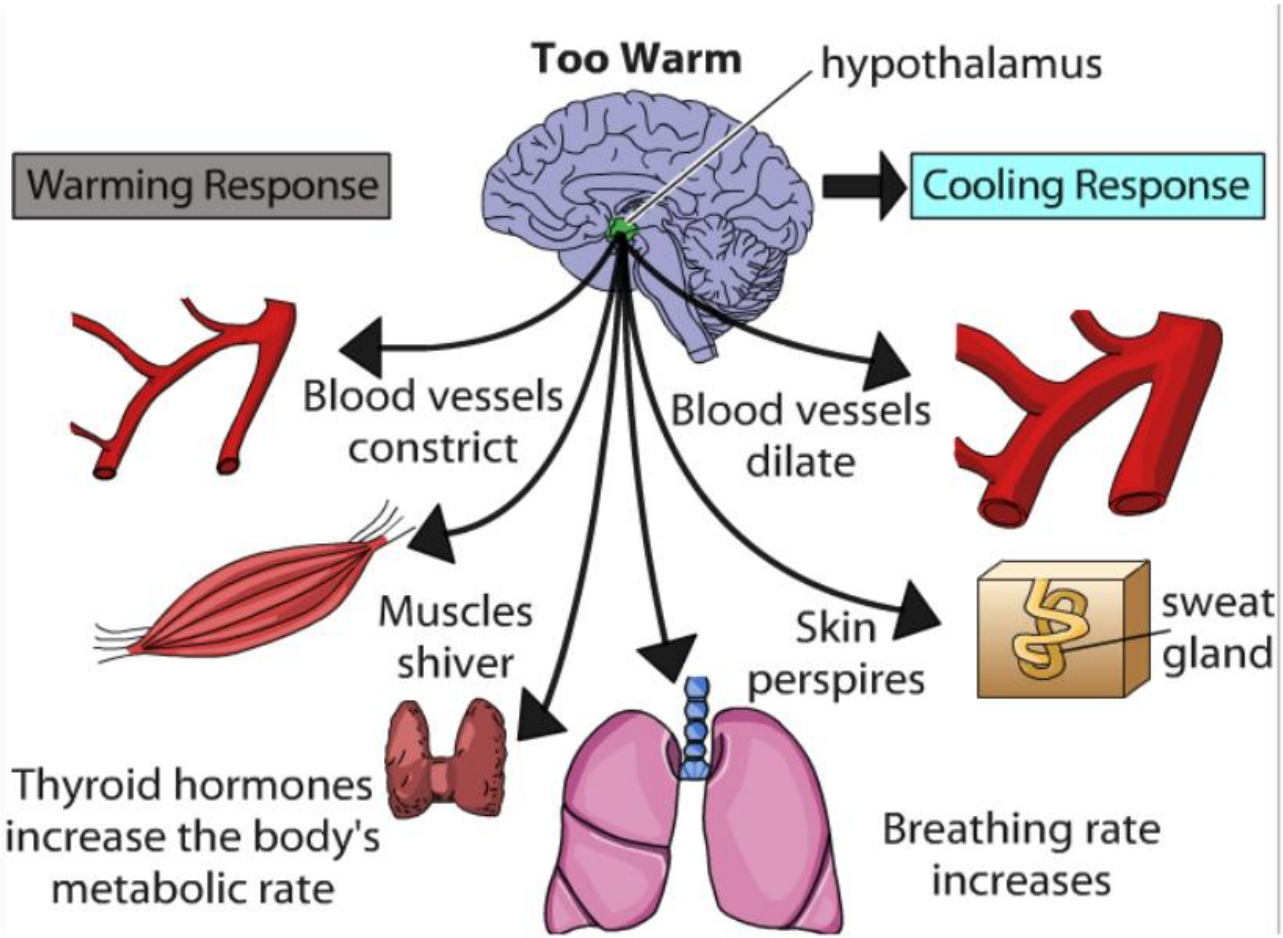
The Hypothalamus:
The Body's Thermostat



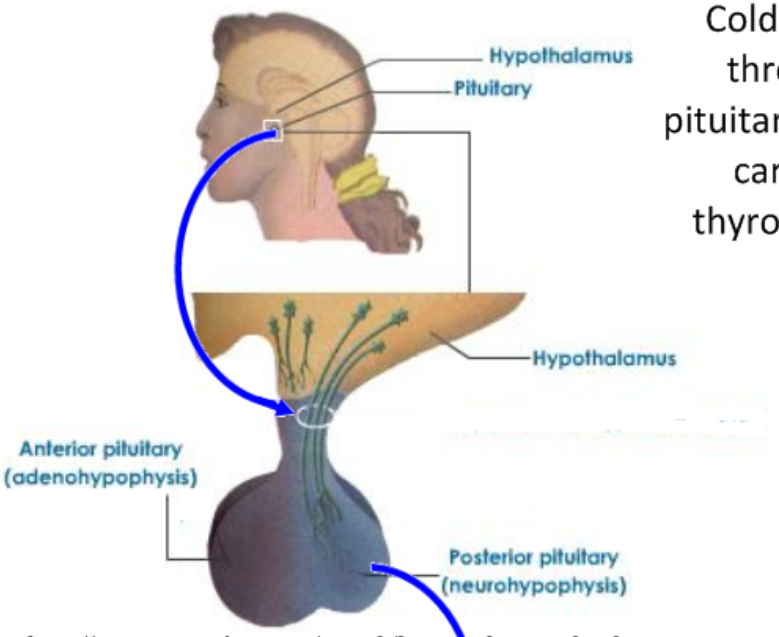
Find out more:

http://bcs.whfreeman.com/thelifewire/content/chp41/4101s.swf

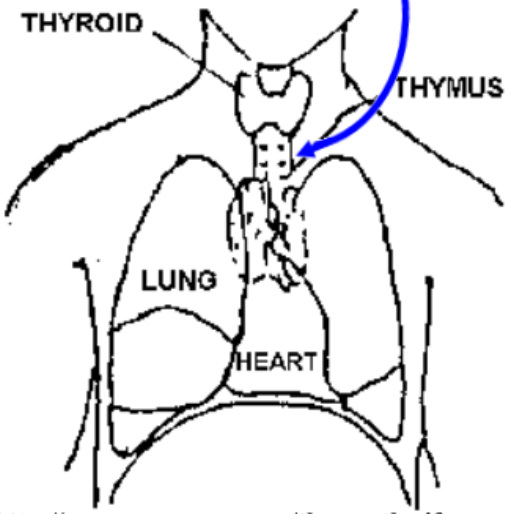




The hypothalamus and pituitary link the nervous and endocrine systems:



http://www.tutorvista.com/search/hypothalamus-gland



http://www.space-age.com/thymusth.gif

Cold temperature changes are detected by cells in the skin and relayed through the hypothalamus. The hypothalamus relays the signal to the pituitary, which acts to release thyroid stimulating hormone (TSH). TSH is carried in the blood and acts upon the thyroid, causing the release of thyroid hormone. This is carried through the blood, acting on almost all cells, leading to increased heat production through metabolism.

stimulus:

sensory neurons:

relay:

effector:

hormone 1:

gland:

target cells:

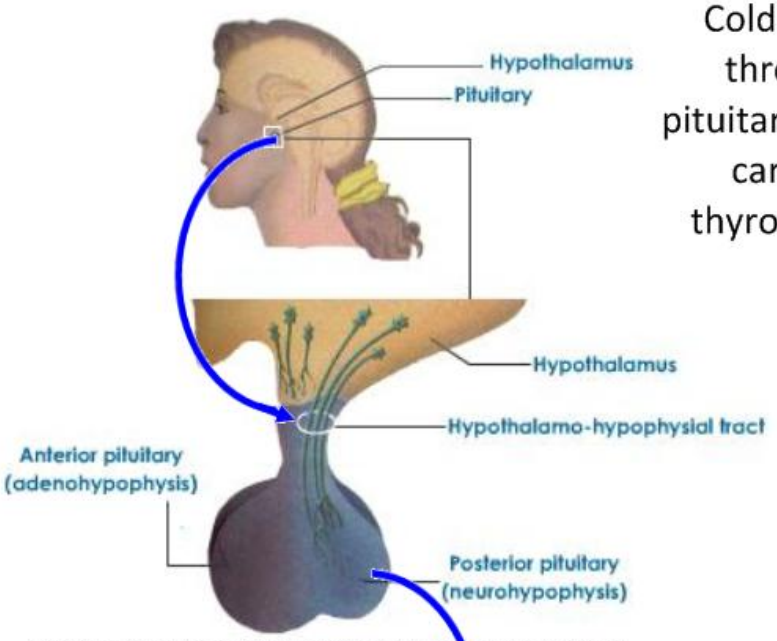
effect:

target cells:

effect:

How is this an example of negative feedback control?

The hypothalamus and pituitary link the nervous and endocrine systems:



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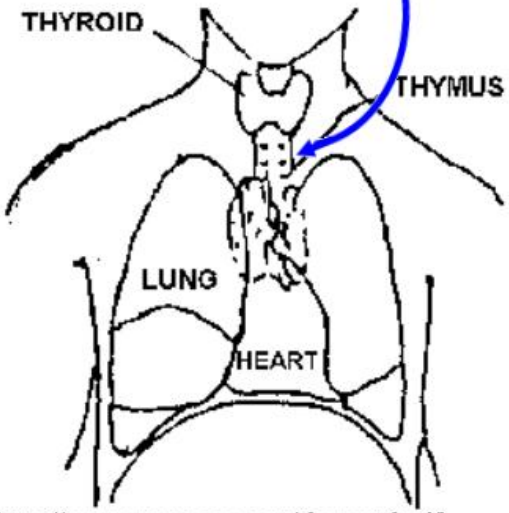

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stimulus: cold

sensory neurons: cold receptor cells

relay: hypothalamus

effector: pituitary

hormone 1: TSH

gland: pituitary

target cells: thyroid gland

effect: release thyroid hormone

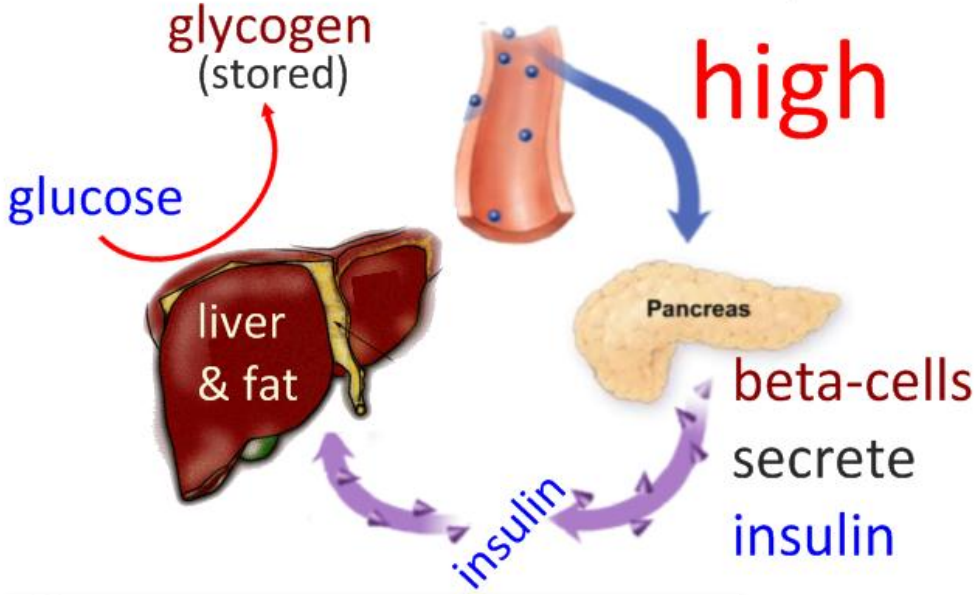
target cells: all cells

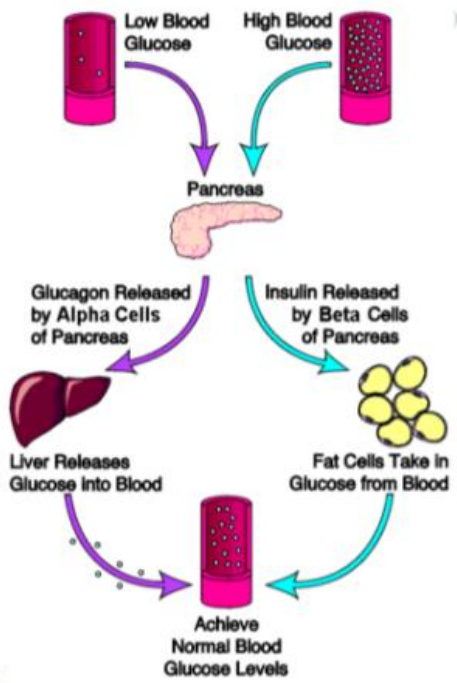
effect: increase metabolism, get warmer

How is this an example of negative feedback control?

Blood Glucose

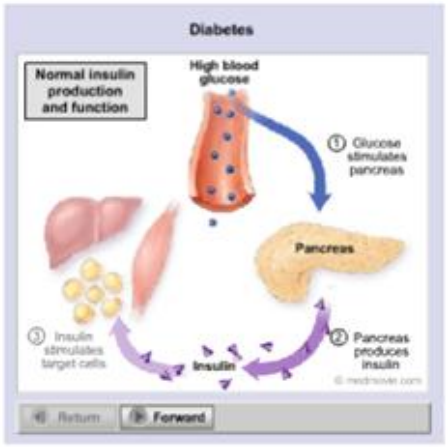
is maintained through the actions of the pancreas and liver





http://www.endocrineweb.com/images/sugar.gif

From:



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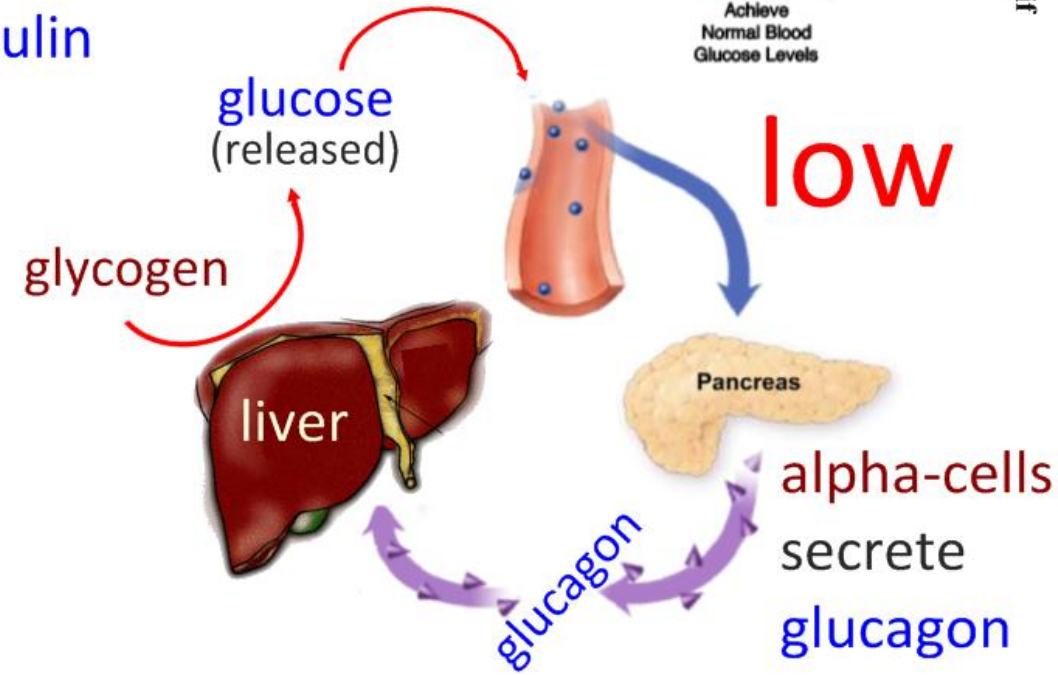


Explain the control of blood glucose.

(8 marks)

Explain the control of blood glucose.

(8 marks)

Pancreatic cells monitor blood glucose;
Absorption of glucose from digestion in the intestine increases blood sugar/ fasting reduces blood sugar;
Glucoregulation is an example of negative feedback;
Uses hormones insulin and glucagon;

If blood glucose is too high

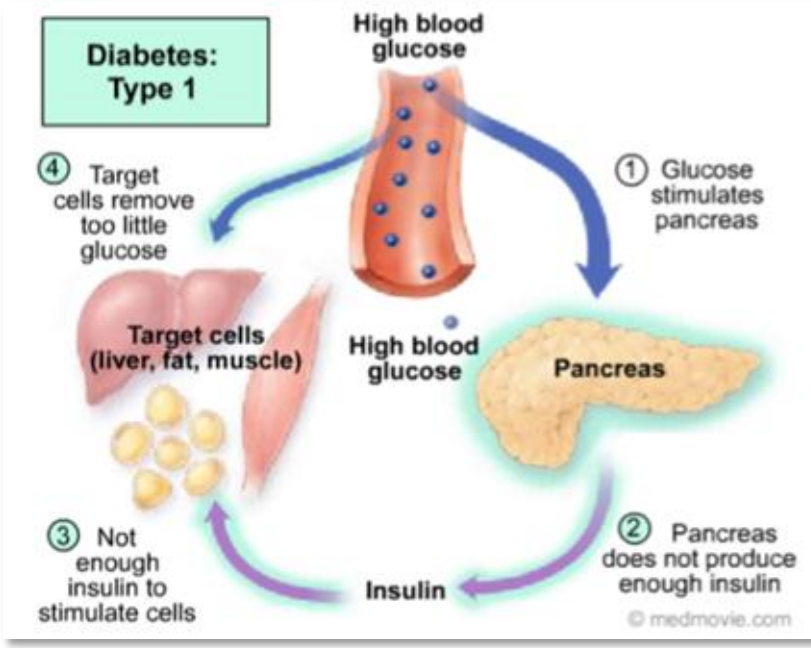
β-cells of pancreas produce insulin;
insulin stimulates uptake of glucose to cells, e.g. muscle;
insulin stimulates liver/ fat cells to store glucose as glycogen;
leading to decrease in blood glucose;

If blood glucose is too low

α-cells of pancreas produce glucagon;
glucagon stimulates liver to break glycogen into glucose;
leads to increased blood sugar;

Diabetes: reduced ability to control blood glucose through insulin

Type I: Early Onset

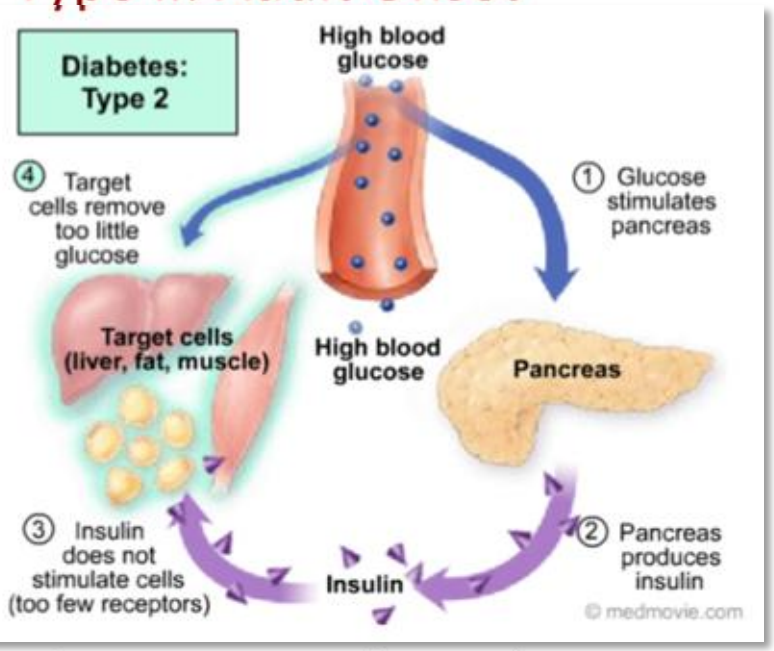


Hereditary, weak relationship

Trigger needed, e.g. illness

- Beta cells destroyed
- insulin production stops

Type II: Adult Onset

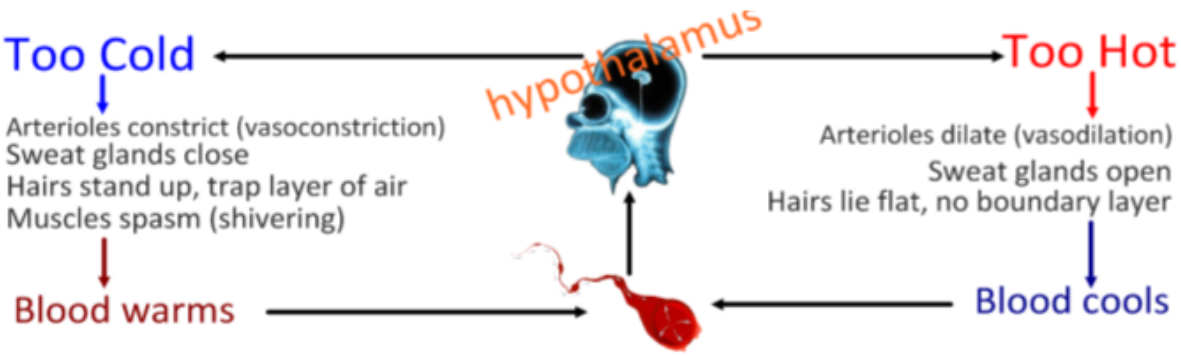


Hereditary, strong relationship

Related to obesity & poor diet

- Fewer insulin receptors in liver
- less sensitivity to insulin
  (insulin does not work as well)

http://www.medmovie.com/mmdatabase/MediaPlayer.aspx?ClientID=65&TopicID=670



For more resources and animations visit:

http://sciencevideos.wordpress.com