Assignment 2

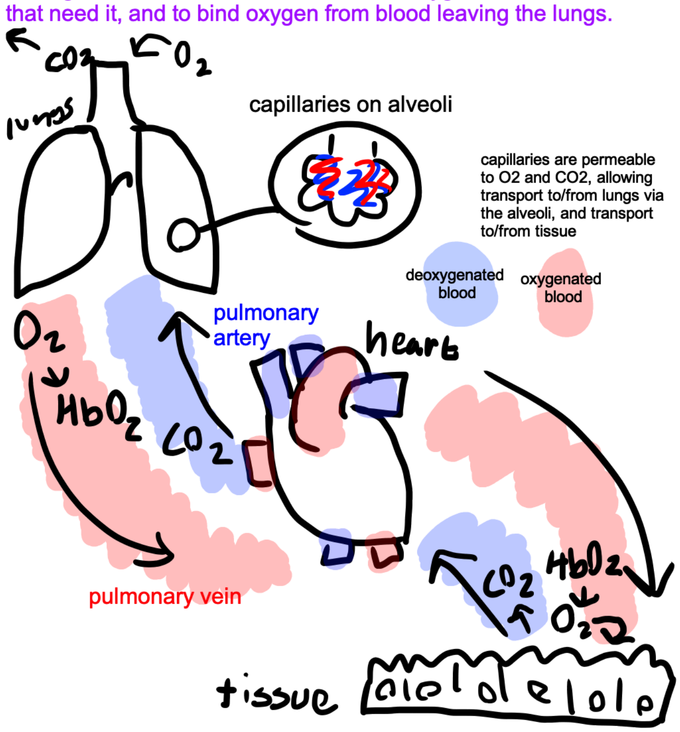
$$Hb + O_2 \rightleftharpoons HbO_2$$

(Hemoglobin) (oxyhemoglobin)

Chemical equilibrium: the point in a reversible chemical reaction where there is no net change in the amounts of reactants and products

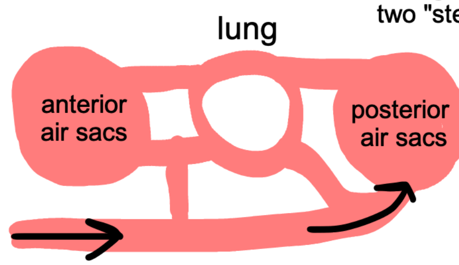
Le Chatelier's principle: If equilibrium is disrupted by a change in conditions, the position of equilibrium will shift to counteract the change

The oxyhemoglobin reaction is reversible, and the equilibrium will shift depending on the concentration of oxygen in different parts of the body and the bloodstream. This is vital, as hemoglobin needs to be able to release oxygen to the tissues that need it, and to bind oxygen from blood leaving the lungs.

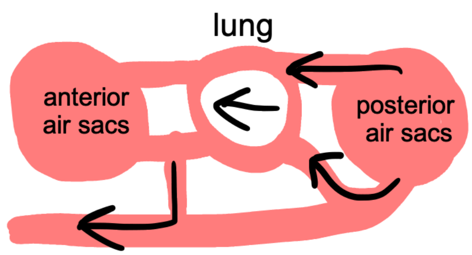


Avian Respiratory System

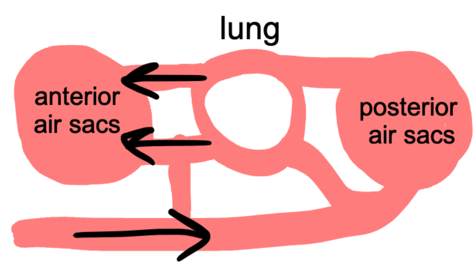
during avian inhalation and exhalation, two "steps are occuring simultaneously



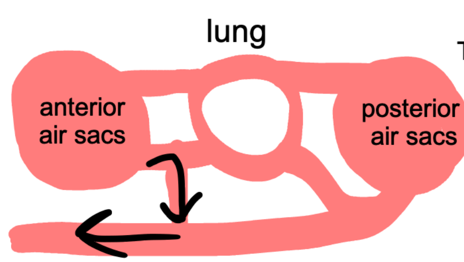
When inhalation occurs, the fresh air does not travel directly to the lung. instead, it is transported to the posterior air sacs



during exhalation, the air from the posterior air sacs moves into the lung, ensuring that very little of the previously inhaled air leaves the body before it is processed by the lungs



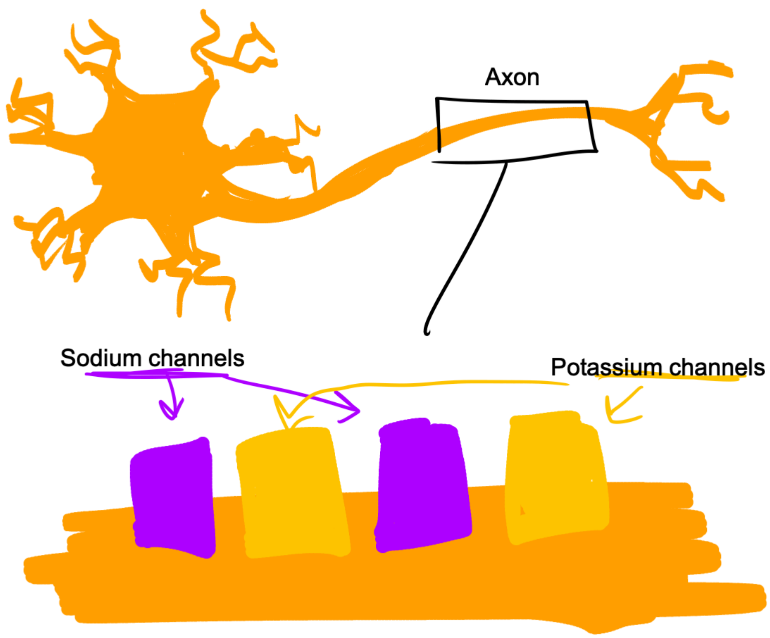
at the same time as the inhaled air moves to the posterior sacs, air processed by the lungs moves into the anterior air sacs, ready to be exhaled.



Finally, during exhalation, air from the anterior sacs leaves the body. Tidal mammalian respiratory systems do not have these air sacs, and the lungs canot be completely empty. The lungs always contain residual volume, and the fresh air inhaled is always diluted by exhalatory air. In contrast, almost all of the air that enters an avian lung is fresh.

A cell has a membrane potential of around -70 mV, meaning that the inside of the cell is electrically negative compared to the outside. Na+ has a positive charge, and is generally at a higher concentration outside of the cell than inside. This means that it can move up the concentration gradient inside of the cell, causing the cell to have a higher Na+ concentration, and to become more electrically positive, increasing the membrane potential. The concentration gradient will shift directions, and the cell will move ions in the opposite direction to regain its usual membrane potential.

Resting membrane potential refers to the difference in electrical potential inside and outside of the cell, whereas the equilibrium potential is the membrane potential that would be necessary to achieve electrochemical equilibrium inside and outside of the cell. These potentials may be the same, in cases where the concentration gradient and the electrical gradient are in balance.

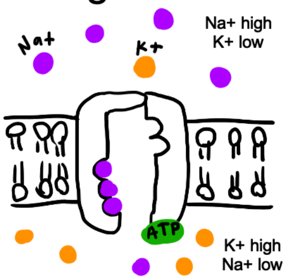


Sodium channels open when a threshold stimulus is recieved, allowing sodium ions to enter the axon and raise its membrane potential. They also allow sodium ions to leave the axon once the action potential has passed them and hyperpolarization has occured

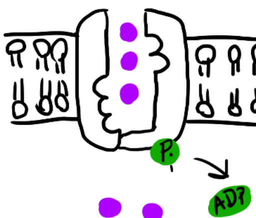
When sodium ions enter the axon and the membrane potential becomes positive, potassium channels open and allow potassium ions to leave the cell, hyperpolarizing it down to a negative membrane potential below the resting state

Phase:	At rest	During depolarization	During repolarization & hyperpolarization	During getting back to resting
Which channels are open in each of these four phases?	leak K+ channels	Na+ channels K+ channels	K+ channels	Na+ channels and leak K+ channels
Which ion has the greatest net flux? Na+ or K+	K+	Na+	K+	K+
Which direction is that ion moving? In or out of cell	out	in	out	out
Why is that ion moving in that direction? (Hint: use flux reasoning)	passive flow down the K+ concentration gradient	activation of Na+ gates and increased Na+ permeability	passive flow down the K+ concentration gradient and increased permeability via gated K+ channels	passive flow down the K+ concentration gradient

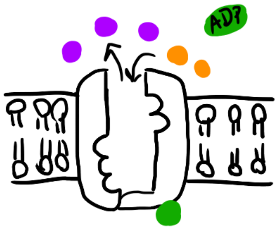
Assignment 3



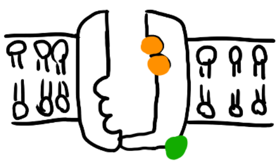
The cell needs to maintain a gradient of high Na+ outside of the cell, and high K+ inside of the cell. To do this, it uses a glycoprotein pump that binds Na+ and ATP inside of the cell.



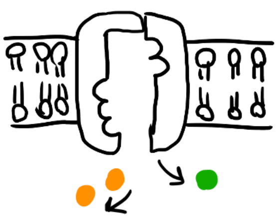
After 1 ATP and 3 Na+ bind to the protein, ATP is hydrolyzed, releasing ADP and causing a shape change. The pump is closed to the inside of the cell and open to the outside



Na+ ions are released outside of the cell, and K+ ions are able to bind to the protein for transport inside of the cell

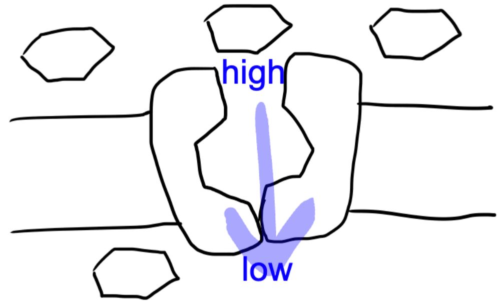


2 K+ ions bind to the interior of the pump.



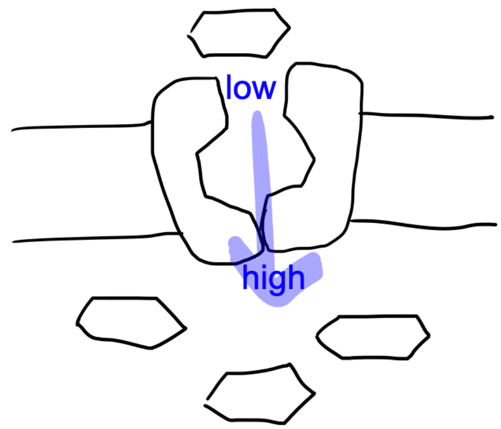
The pump is dephosphorylized, releasing Pi and the two K+ ions into the interior of the cell. The pump is returned to its original configuration and can perform the same process again

Passive transport



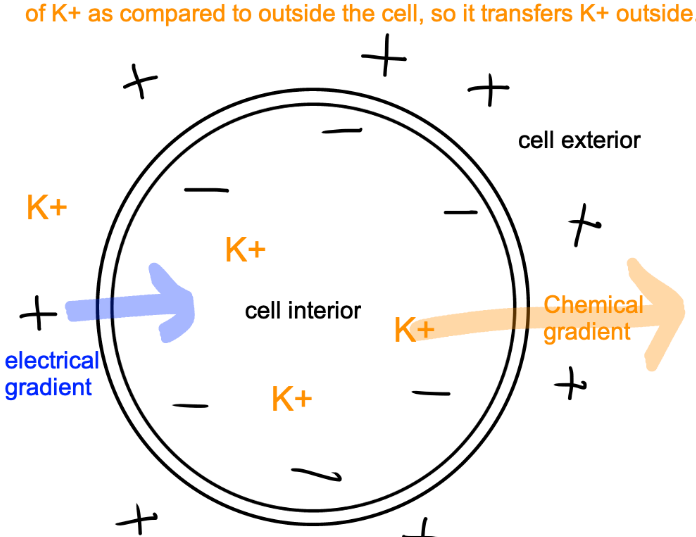
Passive transport occurs when a larger molecule is transported down the gradient. This requires no input of energy, and simply aids molecules that wouldn't normally be able to cross the membrane

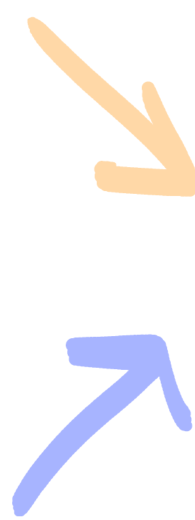
Secondary active transport



Secondary active transport can occur with the same molecules as passive transport. The difference is that transport occurs up the concentration gradient, and thus needs an input of energy for the protein to carry out the transport

The chemical gradient exists in ion concentrations inside and outside of the cell. For example, the cell has a high concentration of K+ as compared to outside the cell, so it transfers K+ outside.

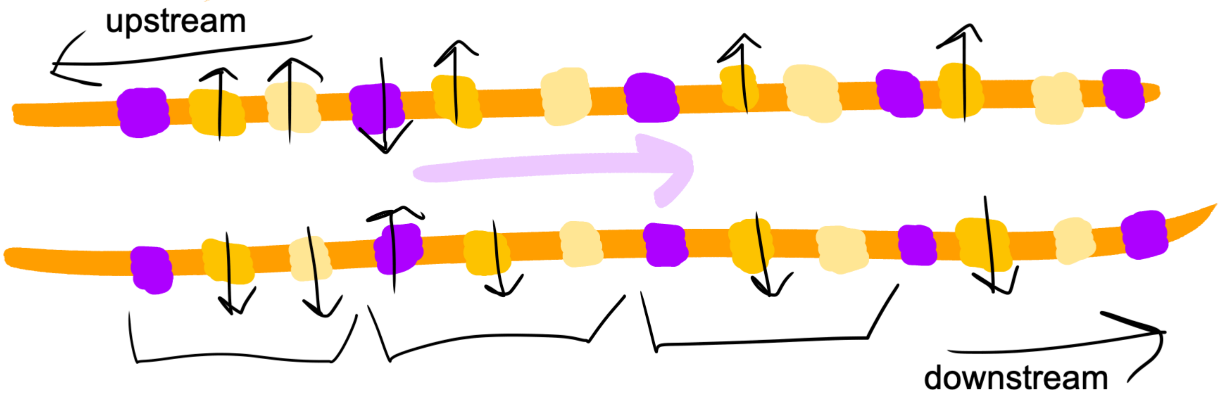




The electrochemical gradient is the combination of the chemical and electrical gradients, which move opposite of each other. The electrochemical gradient maintains equilibrium in the cell, by transporting ions into and out of it depending on each of its composite gradients.

The electrical gradient, however, is created by the charge of these ions. K+ flows back into the cell as the electrical gradient exists in the opposite direction of the chemical gradient, creating electrochemical equilibrium.

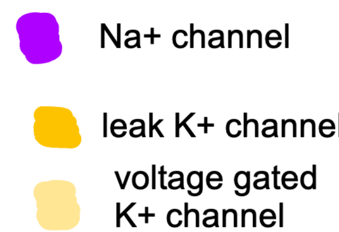
Axon with Action Potential



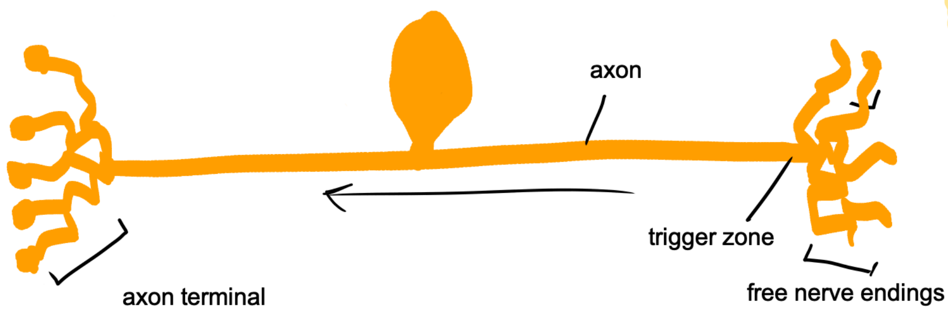
after the action potential has passed through a segment of the axon, Na+ channels deactivate, allowing the action potential to move forwards but not backwards. Voltage-gated K+ channels open to repolarize and hyperpolarize the axon to make up for the depolarization

at the point in the axon that the action potential is currently passing through, Na+ channels open in response to membrane depolarization. This causes depolarization to spread downstream in a current.

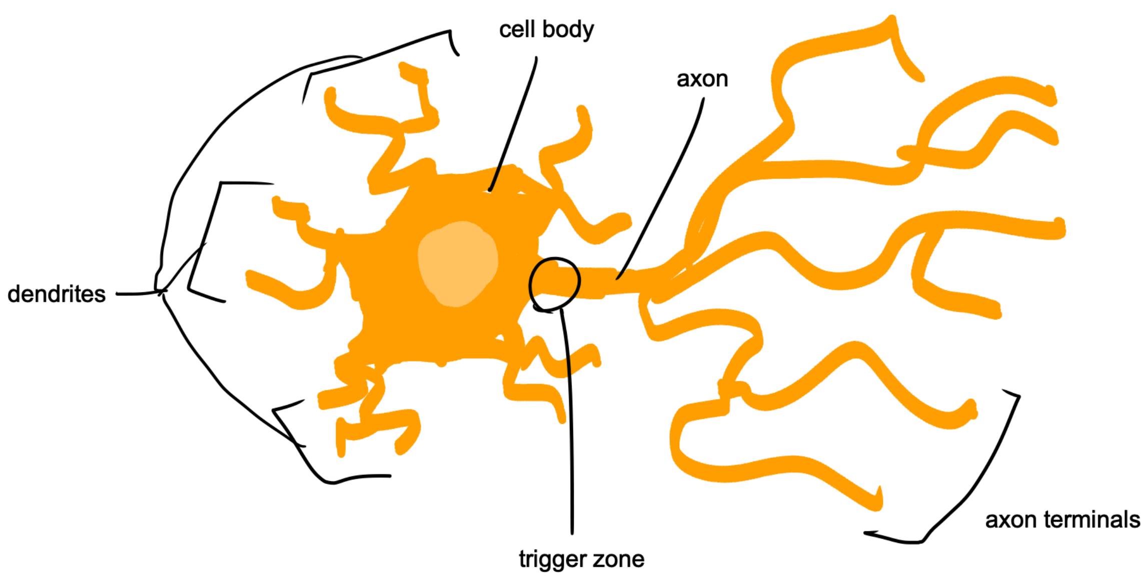
Downstream, only K+ leak channels are open, maintaining resting membrane potential levels. As the action potential travels downstream, a depolarizing current will open Na+ channels, propogating the action potential forward

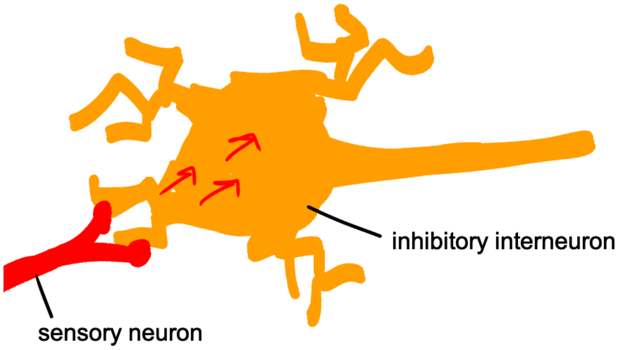


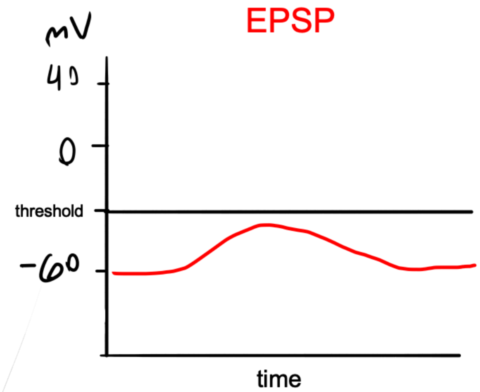
Sensory Neuron



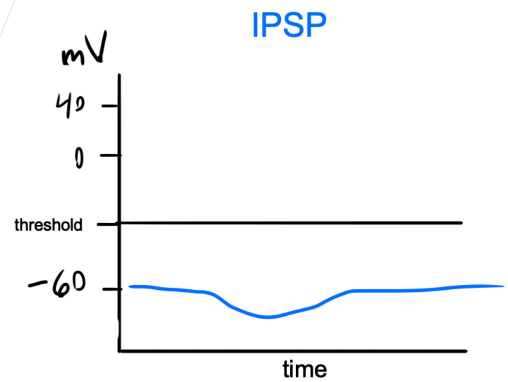
Interneuron

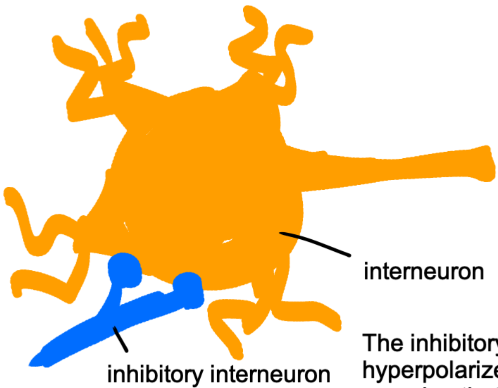




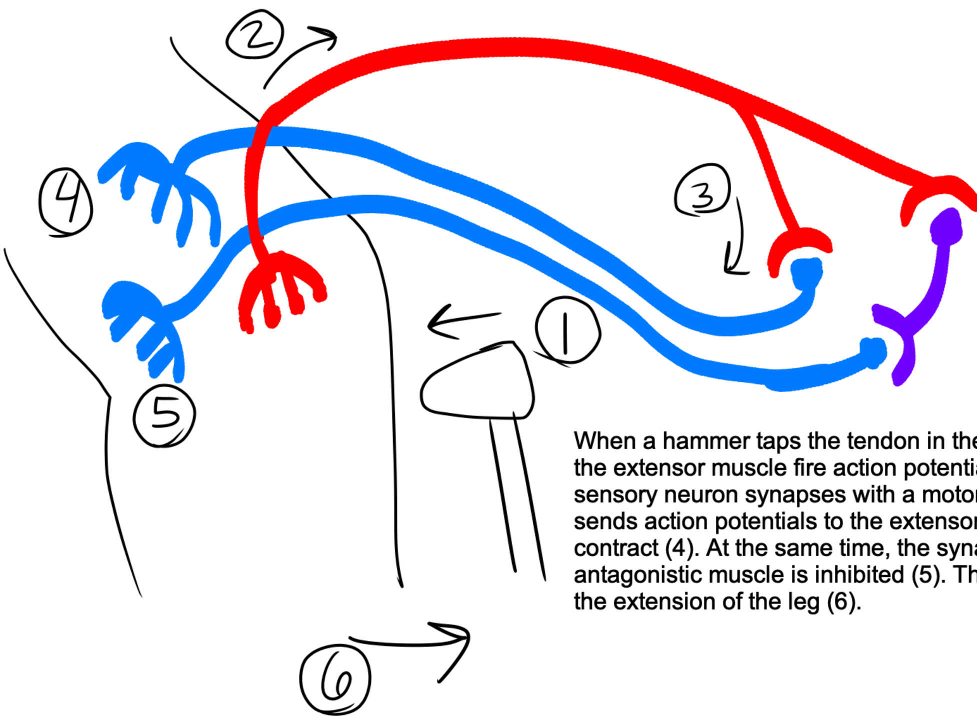


The sensory neuron releases a neurotransmitter that is intaken by the dendrites on an inhibitory neuron. This causes an EPSP in the interneuron. If enough of a potential is recieved simultaneously, an action potential may pass down the axon as a result



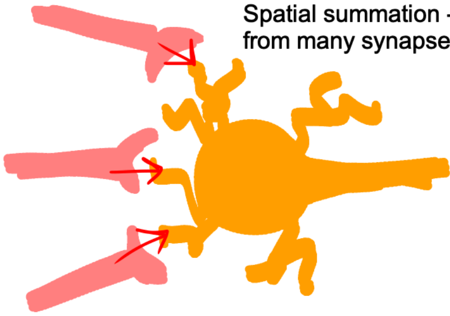


The inhibitory interneuron releases a neurotransmitter that hyperpolarizes the interneuron, causing an IPSP and ensuring that any excitatory signals are cancelled out

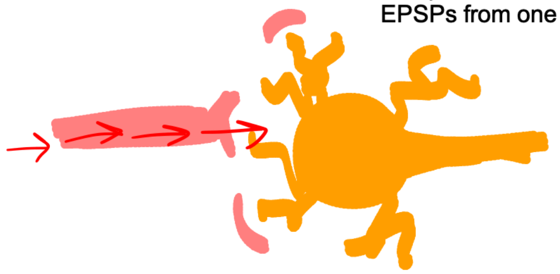


When a hammer taps the tendon in the knee (1), receptors in the extensor muscle fire action potentials in response (2). The sensory neuron synapses with a motor neuron (3) which then sends action potentials to the extensor muscle, causing it to contract (4). At the same time, the synapse pathway to the antagonistic muscle is inhibited (5). These combined result in the extension of the leg (6).

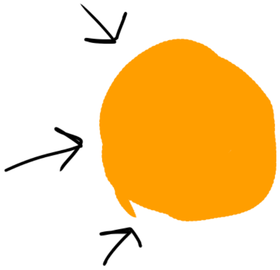
Spatial summation - EPSPs from many synapses at once



Temporal summation - Many EPSPs from one synapse

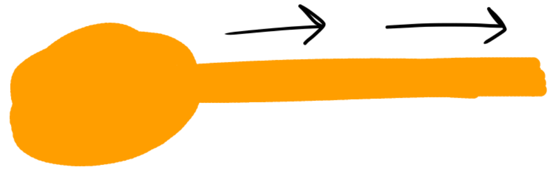


Graded Potential

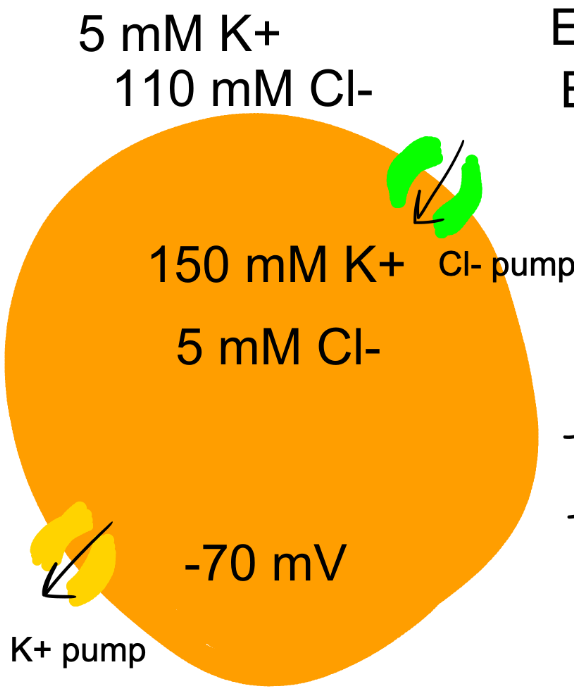


-variable in strength
-due to de- or hyper- polarization
-can be added together
-short distance, loses strength over distance

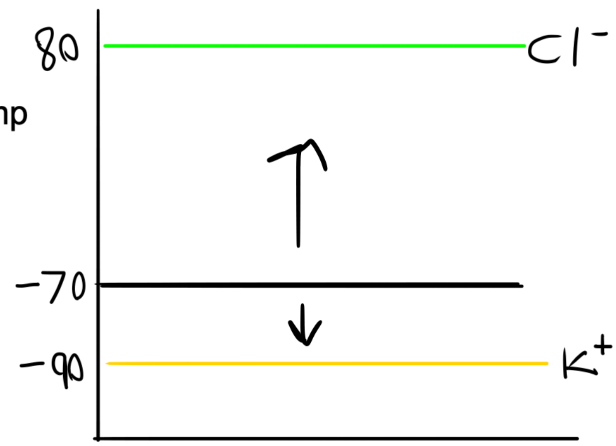
Action Potential



-consistently strong
-due to depolarization
-can't be added together
-long distance, doesnt lose strength



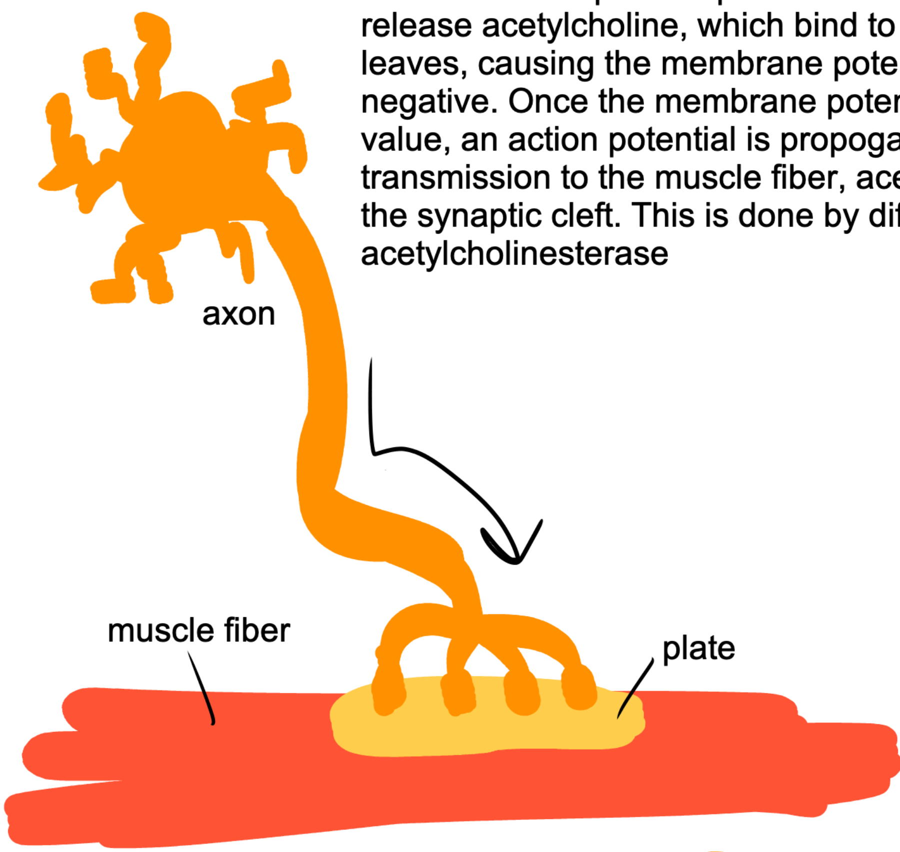
E[K+] = -90 mV
E[Cl-] = 82.5 mV

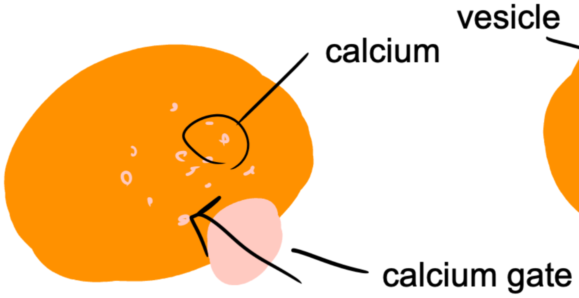


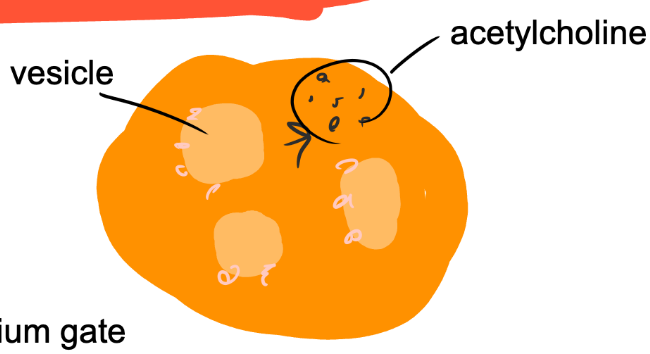
The equilibrium potential of Cl- and K+ as compared to the resting potential dictates that K+ is moving into the cell, and Cl- is moving out of it, according to the electrochemical gradient. While the concentration gradient alone would cause Cl- to enter the cell, the electrical potential of the membrane activates pumps that move Cl- outside of the cell

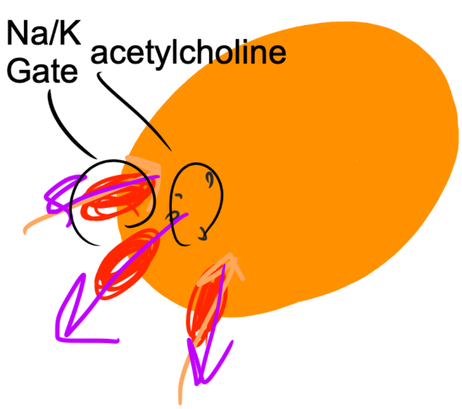
Assignment 5

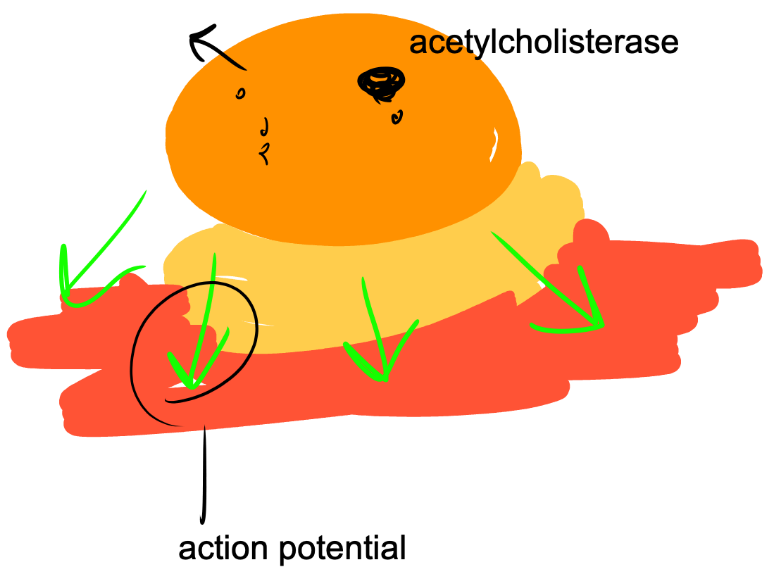
An action potential travels down the axon to the axon terminal, which opens its calcium ion channels and allows calcium to diffuse into it. Upon the presence of calcium, synaptic vesicles release acetylcholine, which bind to Na/K channels. Sodium leaves, causing the membrane potential to become less negative. Once the membrane potential reaches the threshold value, an action potential is propogated. In order to stop the transmission to the muscle fiber, acetylcholine is removed from the synaptic cleft. This is done by diffusion or by acetylcholinesterase









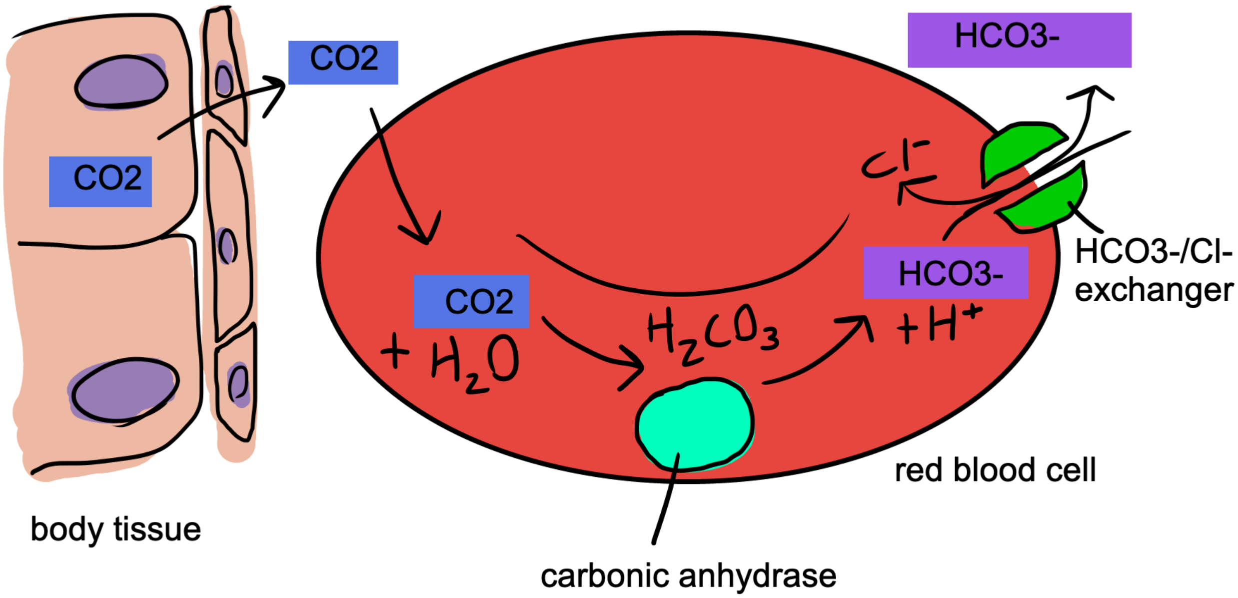


Assignment 5

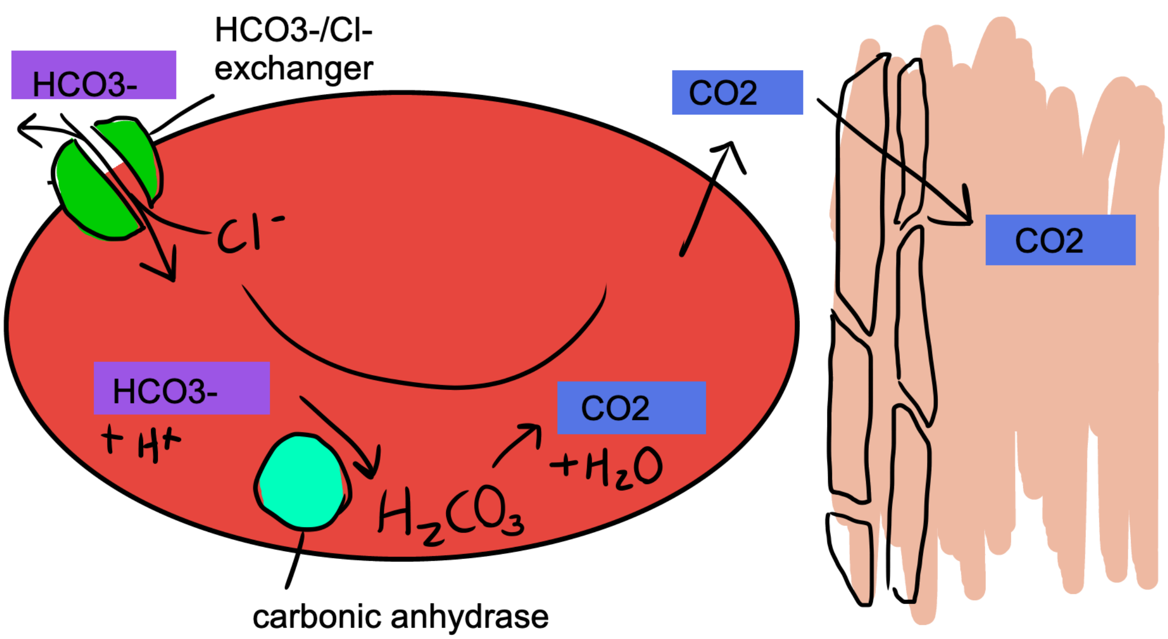
carbonic anhydrase catalyzes the conversion of CO2 to H2CO3

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

As the reaction produces bicarbonate (HCO3-) in the capillaries and red blood cells, bicarbonate is transported to the blood plasma in exchange for Cl- ions. Le Chataliers principle dictates that the reaction will shift to maintain equilibrium, so as bicarbonate is transported out of the RBCs, the reaction will continuously proceed forward in order to maintain the equilibrium concentration of bicarbonate.

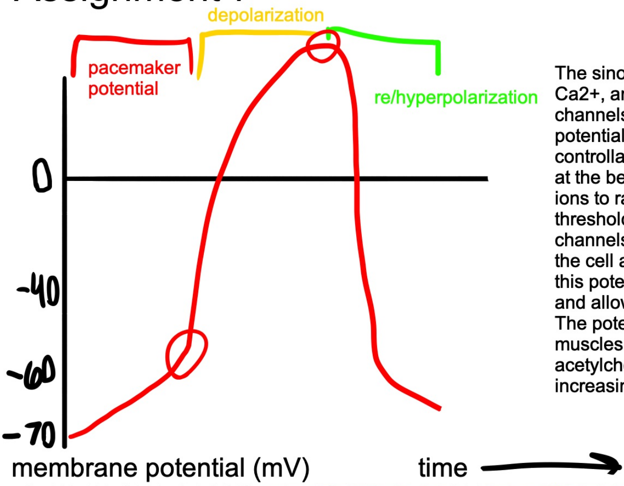


Carbon dioxide diffuses from the body tissue into the blood, entering the red blood cells. Inside the red blood cells, carbonic anhydrase catalyzes a reaction turning carbon dioxide into bicarbonate ions. The bicarbonate ions then leave the blood cell via a bicarbonate/chloride exchanger.



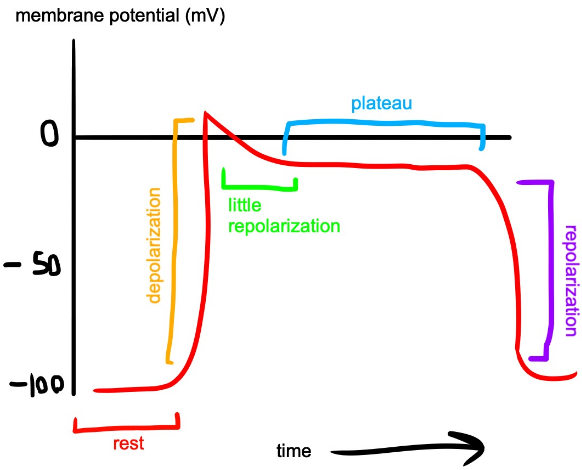
Bicarbonate enters the RBC via the HCO3-/Cl- exchanger, and is turned into carbon dioxide via the carbonic anhydrase catalyzed reaction. The carbon dioxide is then free to diffuse out of the cell and into the alveoulus, where it is exhaled

Assignment 7

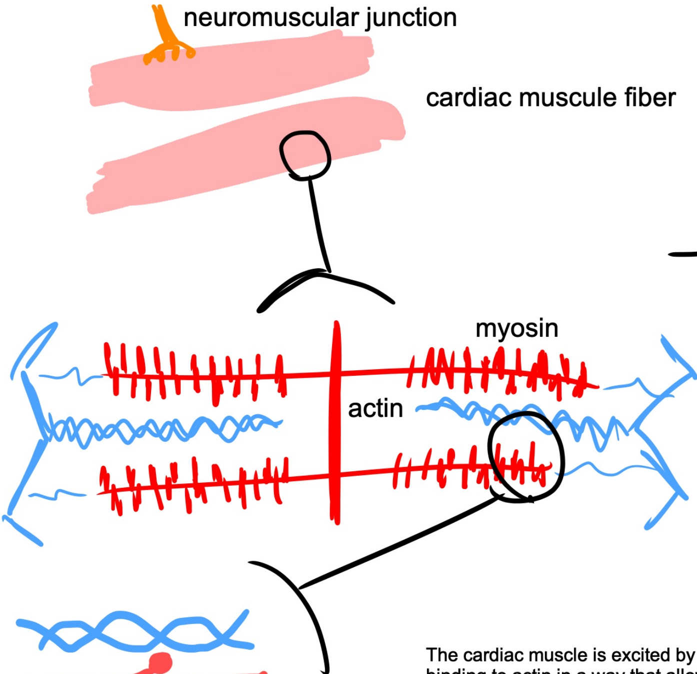


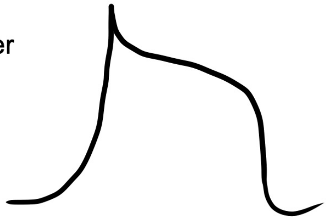
The sinoatrial node maintains the heart rate using Na+, Ca2+, and K+ channels. In particular, the Ca2+ channels and "funny" Na+ channels enable the potential to be continuously generated at a controllable rate. The Na+ channels are open at the beginning of the cycle, bringing in Na+ ions to raise the membrane potential to the threshold value. When this happens, Ca2+ channels open as Na+ channels close, depolarizing the cell and generating an action potential. Once this potential reaches its peak, K+ channels open and allow K+ ions to enter the cell, repolarizing it. The potential causes the contraction of the pacemaker muscles. Neurotransmitters, namely norepinephrine and acetylcholine, can affect the permeability of the channels, increasing or decreasing the heart rate.

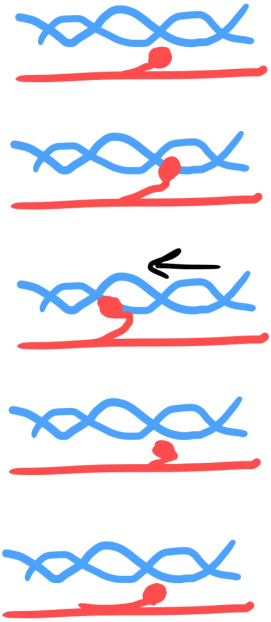
Phase:	During pacemaker potential	During depolarization	During repolarization & hyperpolarization
Which channels are open in each of these three phases?	Na+	Na+, Ca++	Na+, K+
Which ion has the greatest net flux? Na+ or K+ or Ca++	Na+	Ca++	K+
Which direction is that ion moving? In or out of cell	in	in	out
Why is that ion moving in that direction? (Hint: use flux reasoning)	to produce the threshold value for a potential to be generated	to depolarize the cell	to repolarize the cell and return it to pre-potential levels so it can restart the process



Phase:	At rest	During depolarization	During little repolarization	During plateau	During repolarization
Which channels are open in each of these four phases?	K+	Na+, K+	K+	K+, C++	K+
Which ion has the greatest net flux? Na+ or K+ or Ca++	K+	Na+	K+	K+ = C++	K+
Which direction is that ion moving? In or out of cell	In	Out	In	both	out
Why is that ion moving in that direction? (Hint: use flux reasoning)	maintain negative resting potential	depolarize the cell to create the action potential	voltag gated channels open due to positive potential	K+ and C++ flux are equal	cell must return to resting state

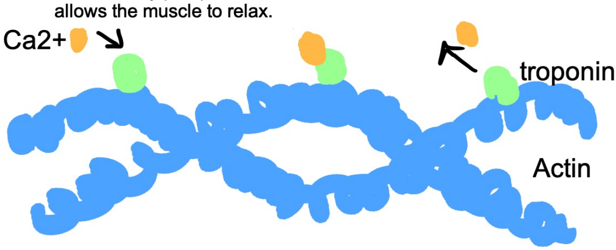




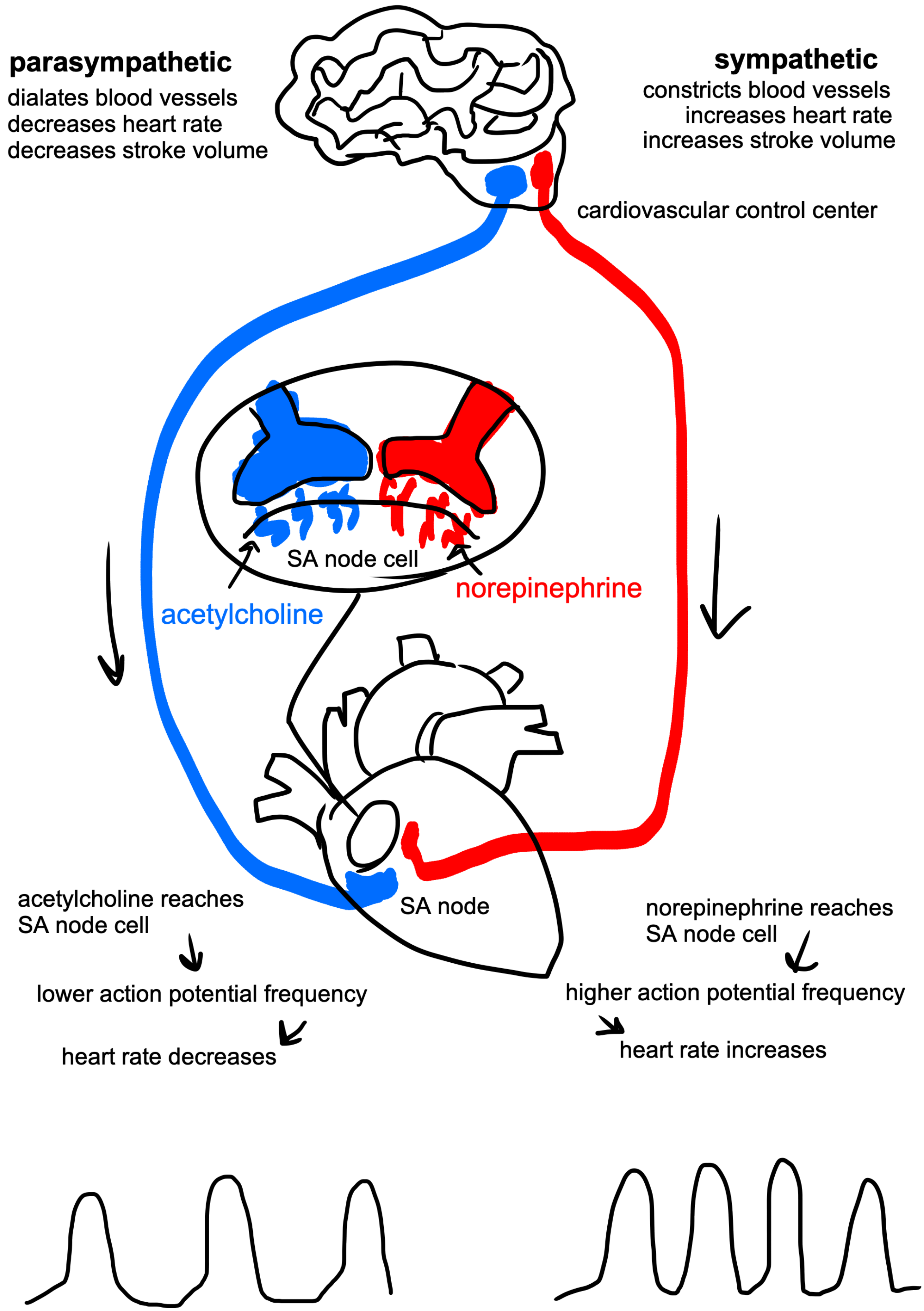


cross bridge cycling

The cardiac muscle is excited by a neuron and Ca2+ is released, binding to actin in a way that allows the myosin heads to bind to it as well. The release of Pi from the myosin head causes the actin to move, eventually releasing the myosin head and resulting in a muscle contraction. This occurs cyclicly, allowing the heart to continuously pump blood, until the actin releases the Ca2+ and allows the muscle to relax.



Assignment 8



Assignment 8

Blood flow rate is determined primarily by two factors: the difference in blood pressure (gradient) and the diameter of the blood vessels (resistance).

$$MAP = HR \times SV \times TPR$$

mean arterial pressure

stroke volume (amount of blood pumped with each beat)

heart rate (beats per minute)

aka CO (cardiac output)

total peripheral resistance (flow resistance in the blood vessels)

HR changes → change in frequency of movement of blood through arteries

SV changes → change in amount of blood per beat

TPR changes → change in resistance to blood movement

→ change in pressure in the arteries

blood pressure drops

↓

decreased activity in baroreceptors

↓

signal to cardiovascular control center

→ stimulated sympathetic motor neurons → SA node

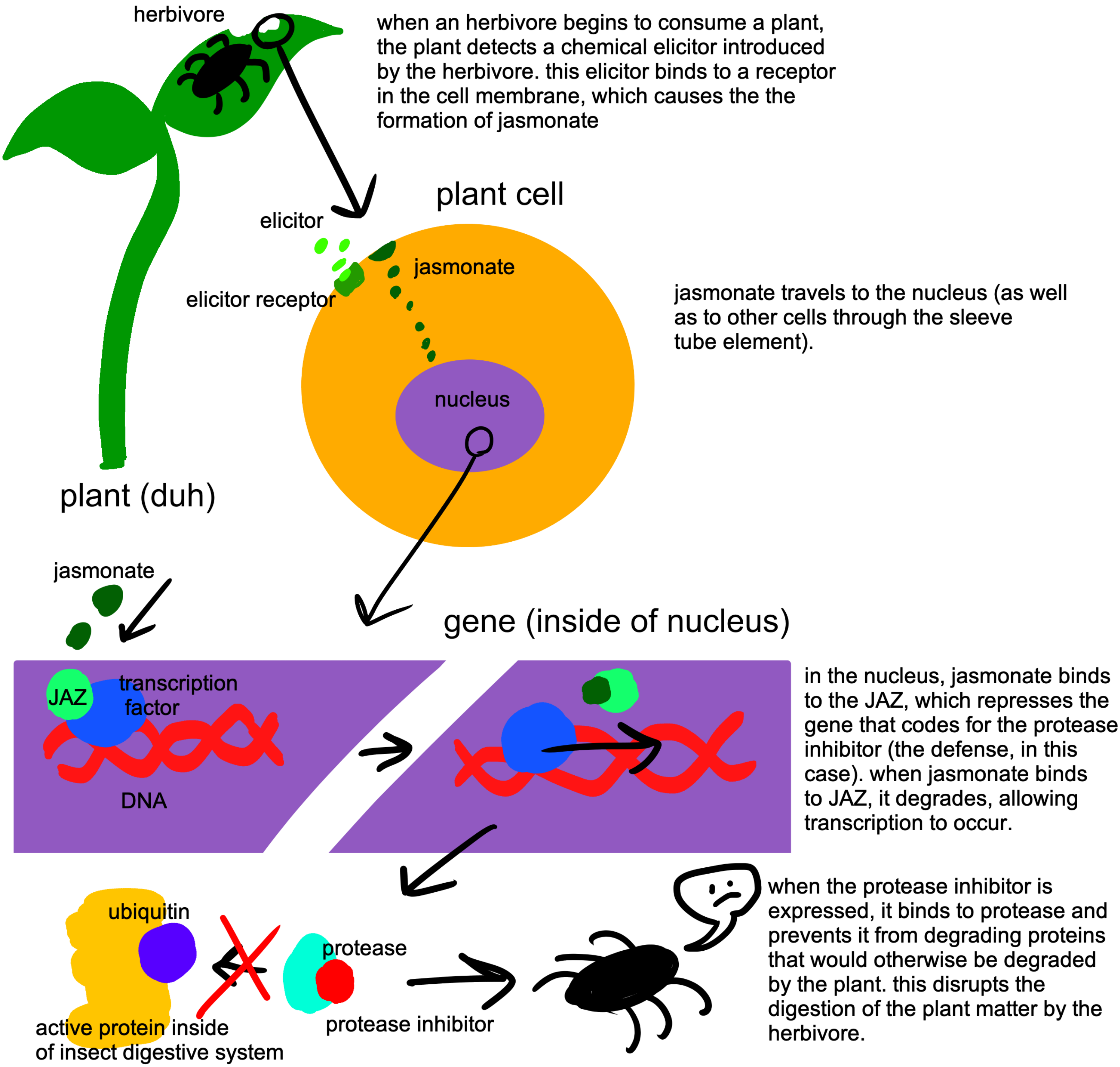
→ reduced activity in parasympathetic motor neurons → SA node

SA node → smooth muscles on arterioles constrict → blood pressure increases

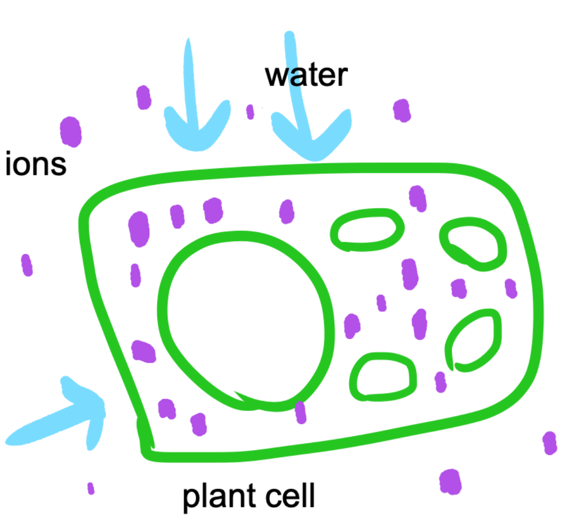
SA node → ventricular muscle cells → heart rate increases

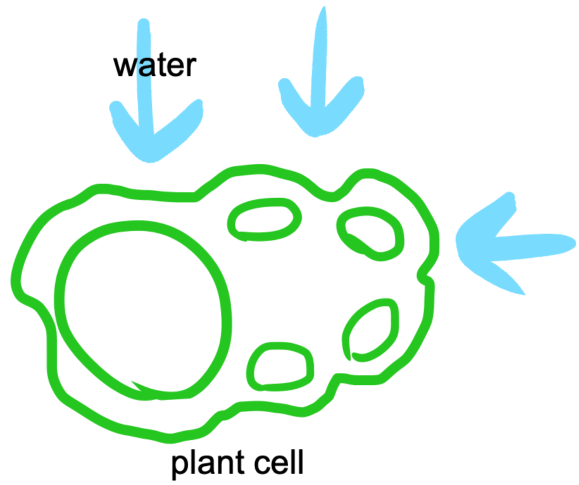
Assignment 10

Constitutive defenses are expressed at all times, while induced defenses are activated by the occurance of an attack or other stimulus.



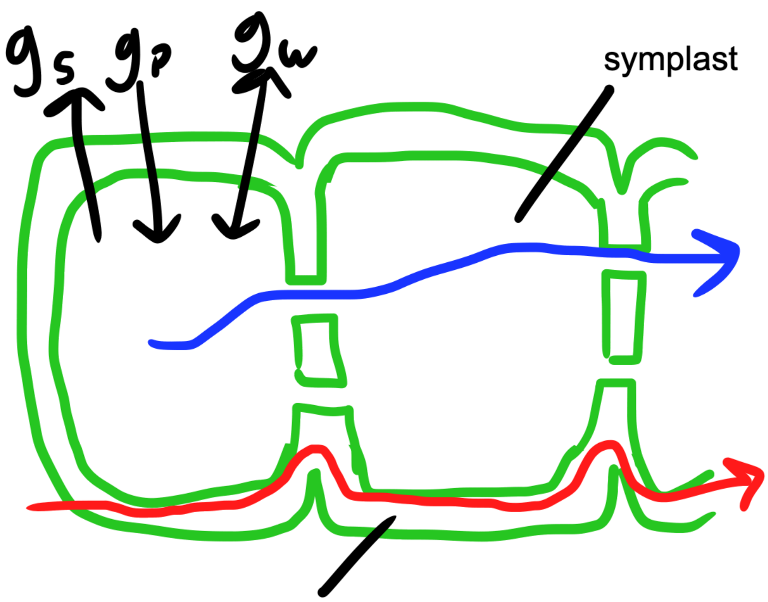
Assignment 11





The ion concentration of this cell is high, higher than that outside of the cell. The cell has a low solute potential ,and water enters the cell.

The water volume of this cell is low, causing the water pressure inside of it to be low as well. The cell has a low pressure potential, and water enters the cell.



$\Psi_s = -$ (large, negative)

$\Psi_p = +$ (small, positive)

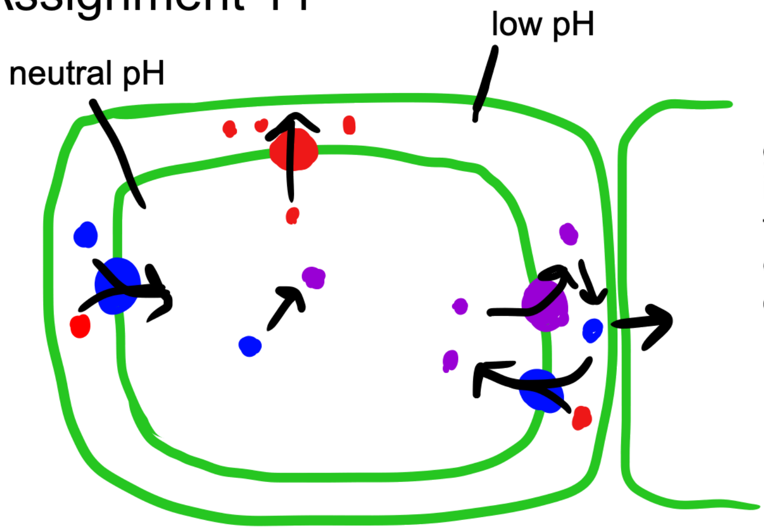
the solute gradient has water moving into of the cell
the pressure gradient has water moving into the cell
the water gradient is balanced, allowing water to move in and out of the cell when needed

apoplast

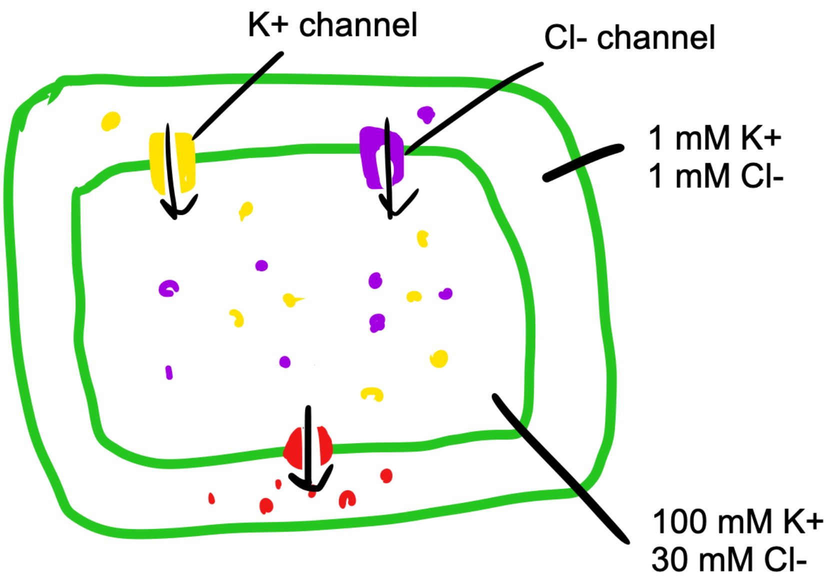
$\Psi_s = +$ (small, positive)

$\Psi_p = -$ (large, negative)

Assignment 11



H+ channels generate a H+ gradient by maintaining a low pH in the cell wall and a neutral pH in the cytoplasm. Auxin enters and exits the cell membrane as a result of these H+ pumps.

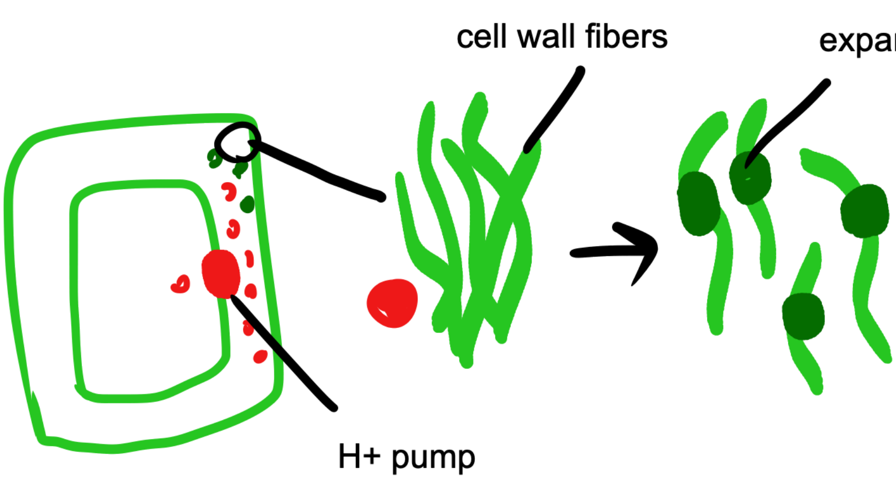


Em = -125 mV

E(K+) = -123 mV

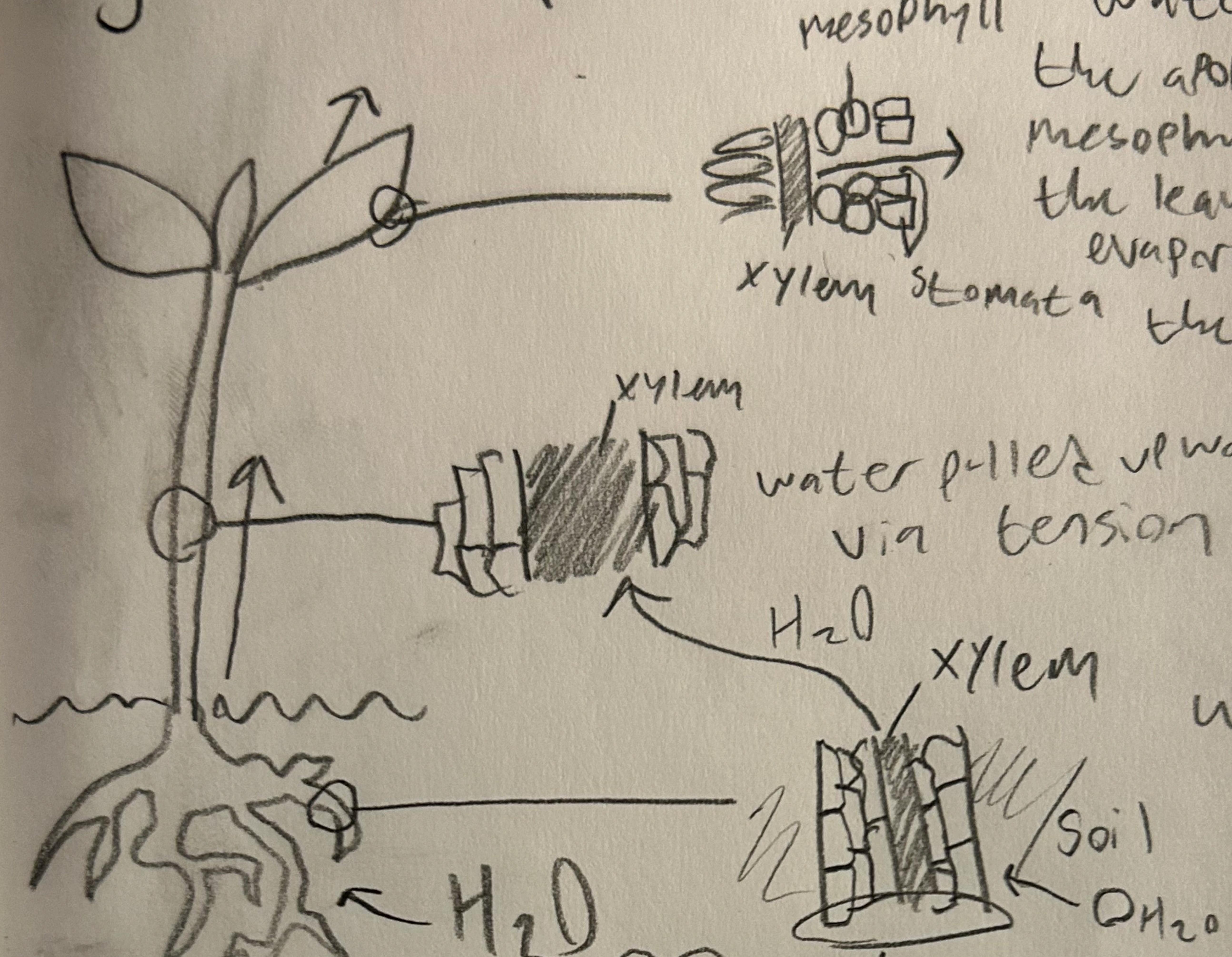
E(Cl-) = 90.8 mV

The H+ pump establishes a negative membrane potential by pumping positive ions out of the cell membrane. Because of this, K+ will be able to move into the membrane through passive transport, as the electrical potential is in its favor, even if the concentration potential isn't. Cl-, however, will require active transport to move into the very negative cytoplasm.



As the cell vacuoule increases in volume, the whole cell expands. To account for this, auxin stimulates H+ pumps to become more active, lowering the pH in the cell wall. This activates expansins, which disrupt the hydrogen bonds between cell wall fibers, loosening the cell wall

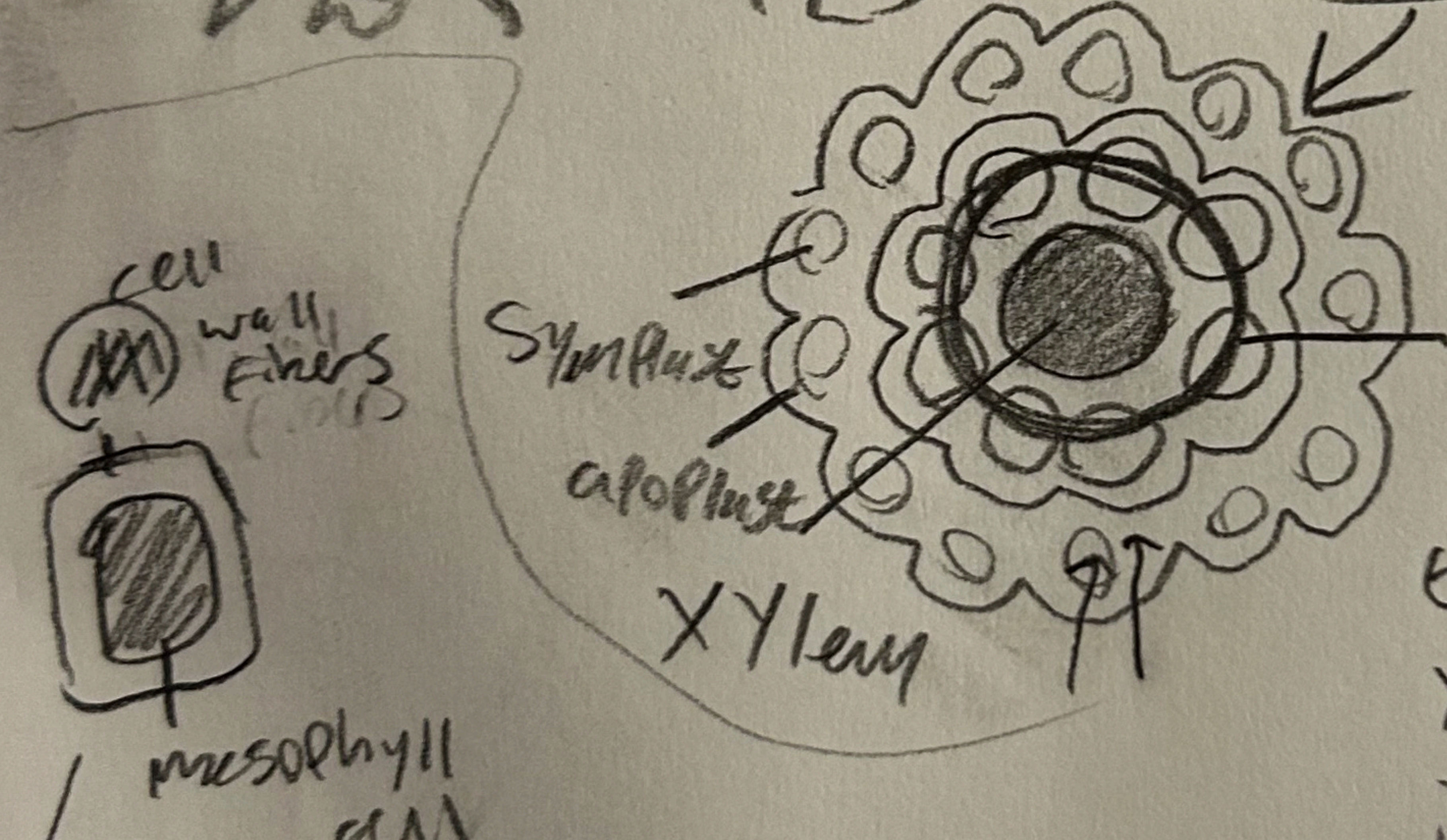
Assignment 14



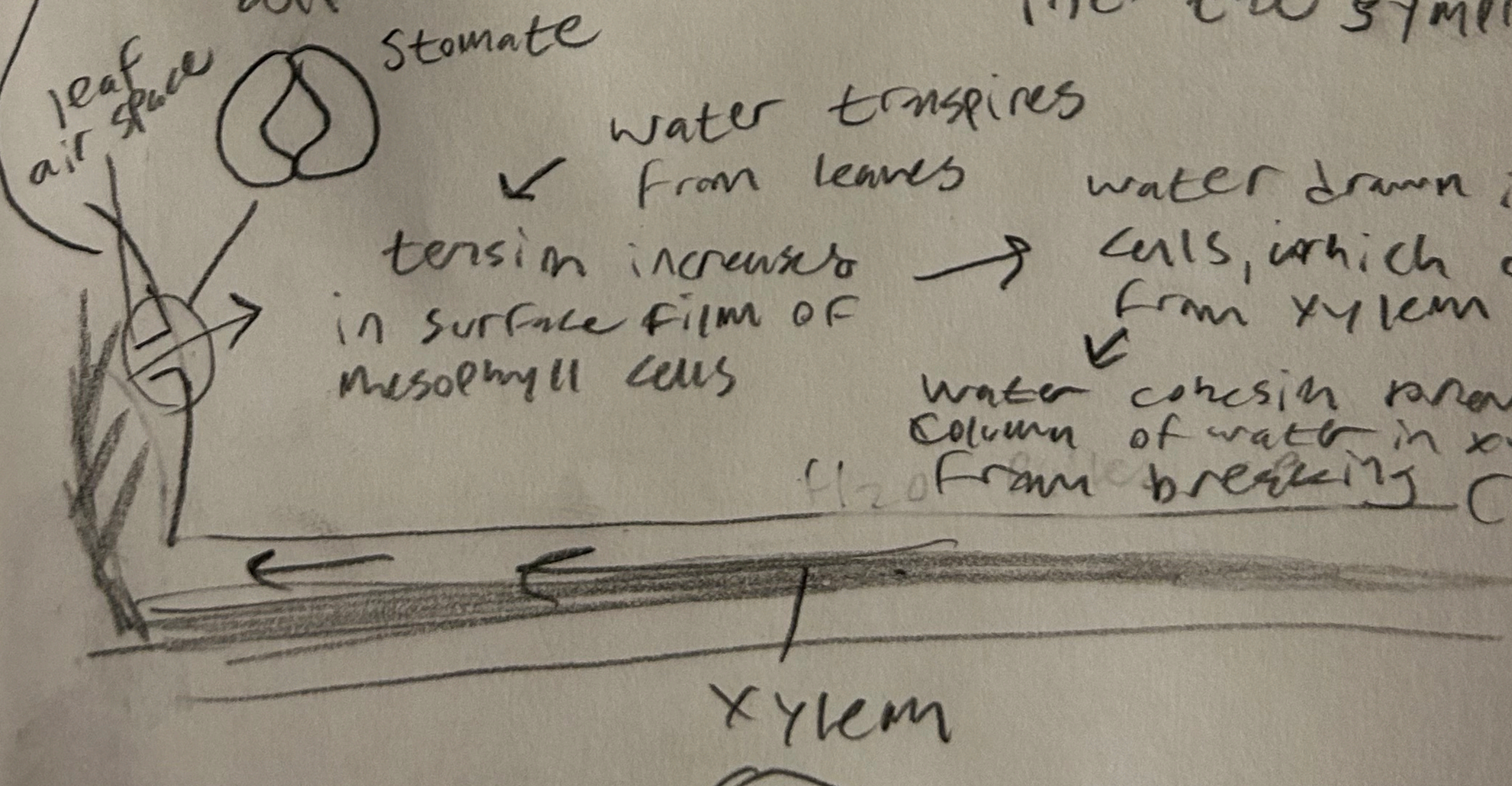
water enters the apoplast of mesophyll cells in the leaves, then evaporates, leaving the stomata.

water pulled upward in xylem via tension

water enters the root via osmosis, as well as the xylem



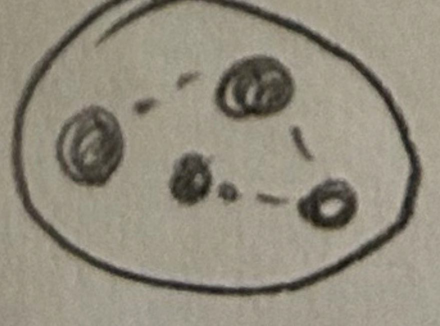
Casparian strip prevents apoplast transport around the xylem, forcing water into the symplast



water transpires from leaves

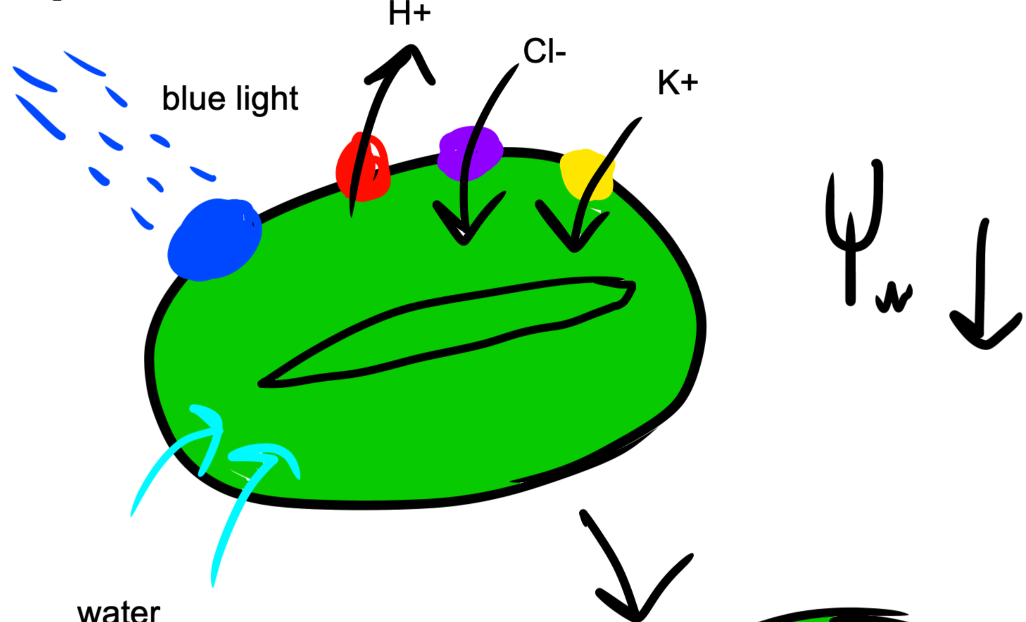
tension increases in surface film of mesophyll cells → water drawn in from cells, which draw from xylem

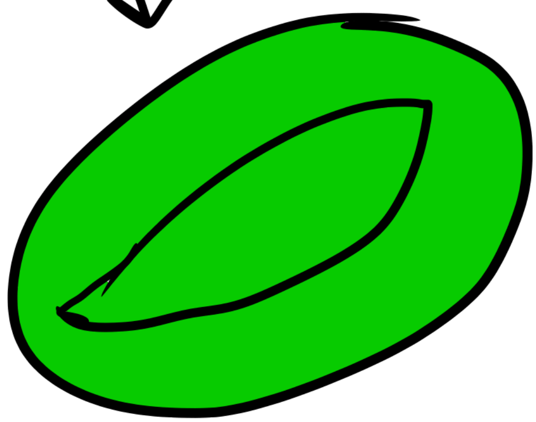
water cohesion prevents column of water in xylem from breaking (H-bonds)



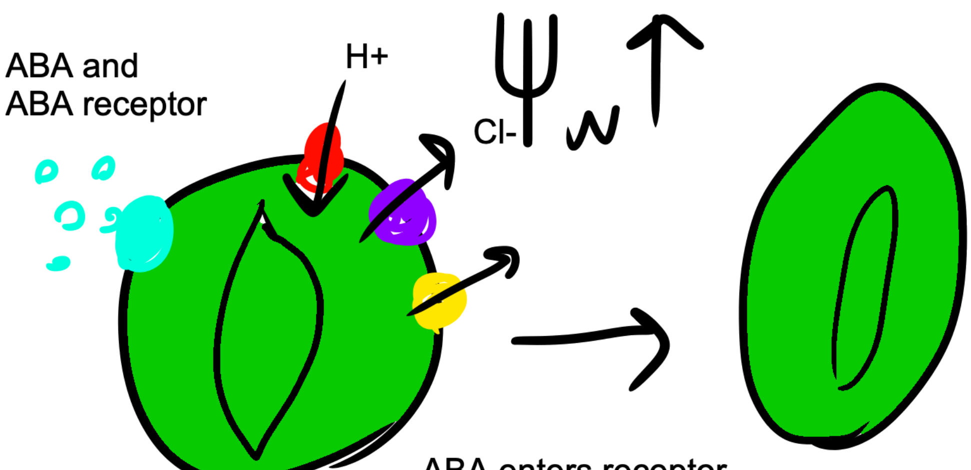
H-bonds = cohesion

Assignment 15





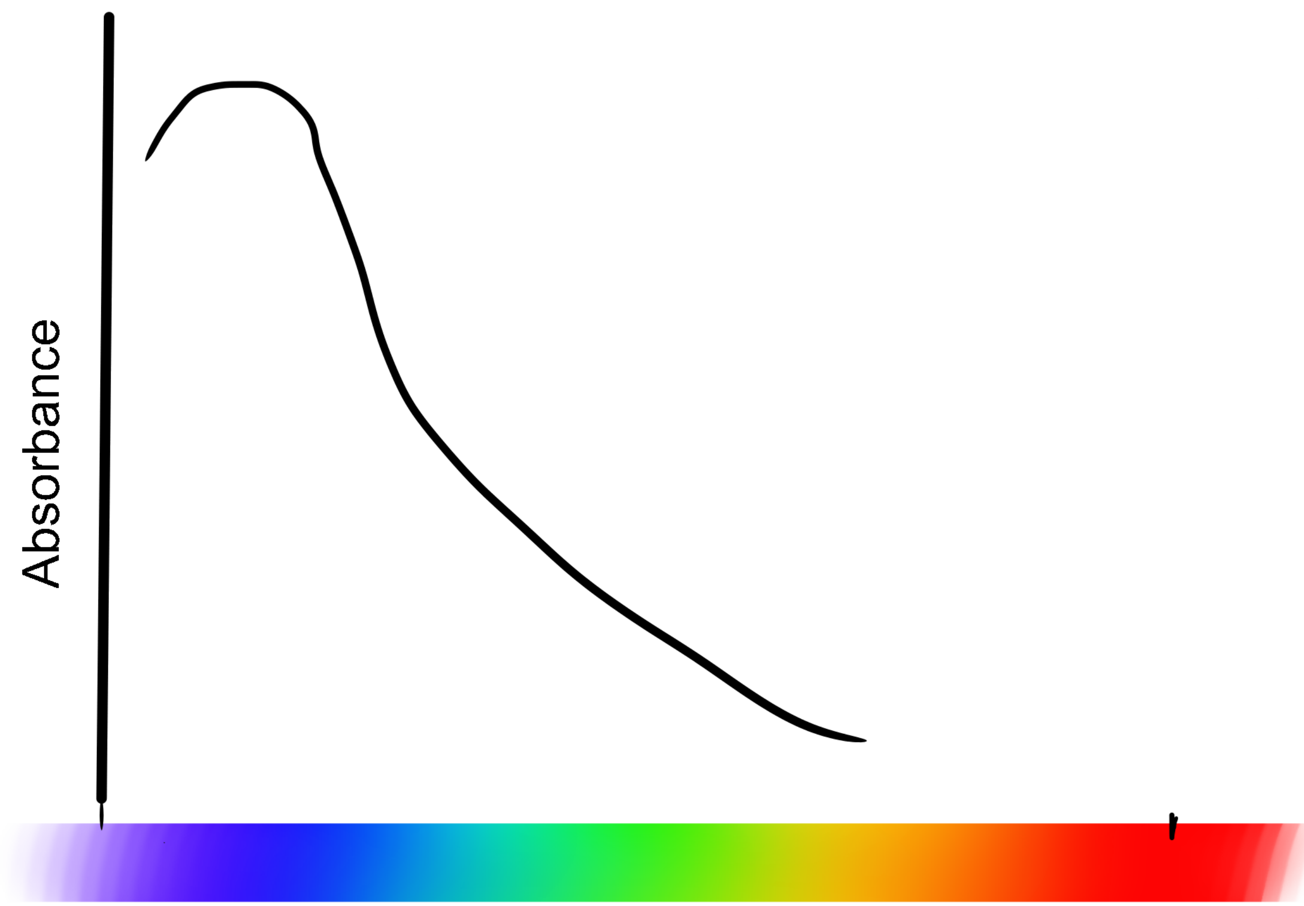
-Blue light enters PHOT
-H+ transported out
-Cell is depolarized
-K+ and Cl- channels open
-K+ and Cl- transported in
-Solute concentration rises, water potential drops
-Water enters cell
-cell becomes turgid



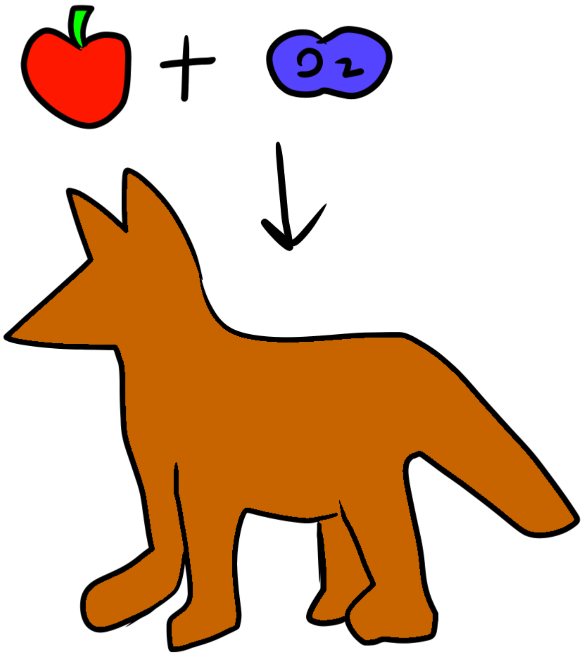
-ABA enters receptor
-H+ enters cell
-Cell hyperpolarizes
-Cl- and K+ leave cell
-solute concentration drops, water potential rises
-water leaves cell, cell becomes flaccid

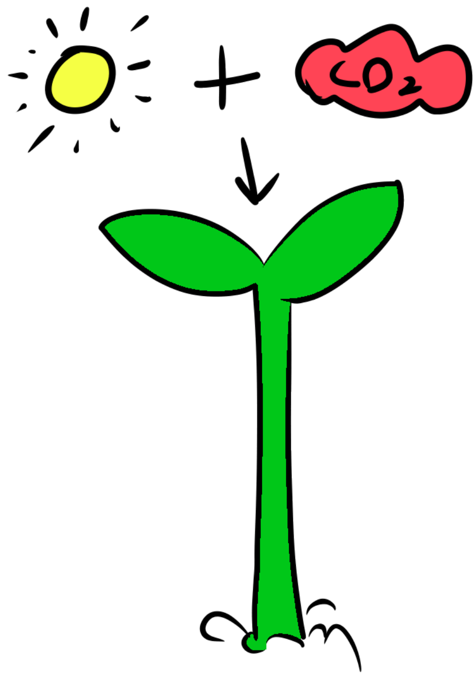
Assignment 15

Guard cells utilize receptors that activate proton pumps, either to pump H+ into or out of the cell. This de- or hyperpolarizes the cell, activating ion pumps that change the solute concentration and therefore the water potential. This allows the cell to become turgid or flaccid.



Assignment 16





Animals gain mass via food, mainly solid matter, that is broken down into compounds that the animal can use to build mass, particularly when there is an excess of nutritious food. Plants, however, gain mass using carbon dioxide primarily, with sunlight being used as an energy source to allow the carbon dioxide to be converted into useable matter.

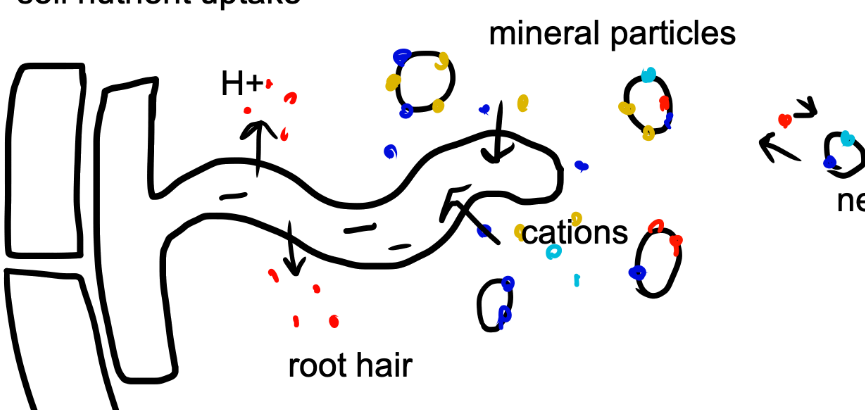
photosynthesis

glucose

combined into an amino acid → joined to make a protein

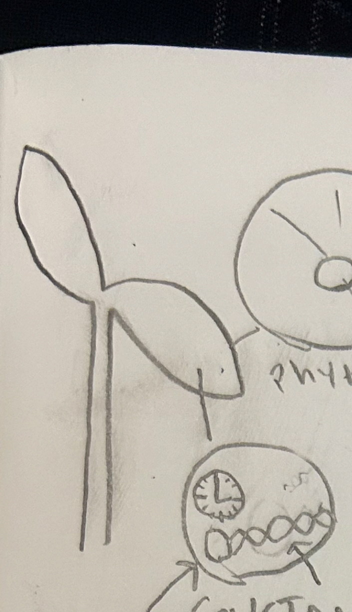
nitrates

soil nutrient uptake



Cations in soil are bound to negative particles such as clay. In order to draw these cations off of the particles and into the symplast, the root hair releases H+, which bind more strongly to the negative particles. Essentially, H+ swaps places with the cations, which can then be drawn into the symplast of the root.

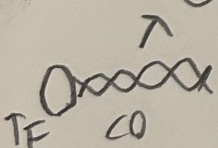
Constans Produces Constans Protein



Zinc-finger trans. factor (circadian rhythm) rises in late afternoon, degrades fast

long day → PR → PFR → CO protein stabilizes

short day → no PFR → CO protein degrades via ubiquitin



CO Prot. → degrades by ubiquitin (no PFR) → no Promotion of Flowering Locus T → no florigen → no flowering

The expression of organ structures in a flower is dependent on the combination of genes A B and C, with the overlap allowing for gene efficiency.