Fascinating Education Script

Fascinating Biology Lessons

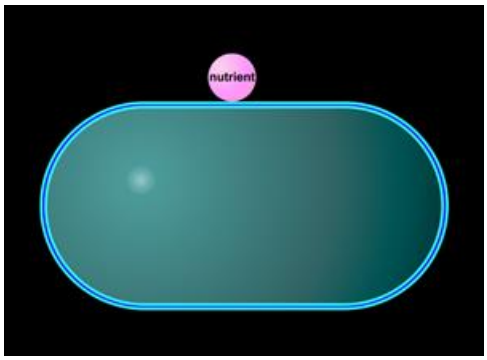
Lesson 4: Take in Nutrients

Slide 1: Introduction

Slide 2: Every cell takes in nutrients

Every cell has to take in nutrients to run its internal machinery. Nutrients may be polar or non-polar, and range in size from tiny ions to medium-sized vitamins to large carbohydrates, lipids, and proteins. How do you get nutrients to enter a cell? After all, why would a nutrient sitting outside a cell move into a cell? There must be some reason for something to move from one location to another, especially when it has to get through an obstacle like a cell membrane.

One thing that drives nutrients into a cell is simply a lower concentration of nutrients inside the cell. Entropy, the force in the universe that refuses to let things remain concentrated in one location, causes molecules to move from an area of high concentration, to an area of low concentration. The random movement of molecules that levels out a difference in concentration is called “diffusion.”



When I say a reason for moving, I don’t mean a purpose. Things don’t move to accomplish some purpose. They move because a force is pushing them to move. One such force is simply the difference in concentration, which causes molecules to move from an area where they ar highly concentrated to an area where they’re not. This type of movement is called “diffusion.”

The mechanism by which molecules diffuse through a solution was discovered by Robert Brown in 1827, and is thus called Brownian movement.

Slide 3: Robert Brown, botanist

Robert Brown was a botanist studying how microscopic pollen grains fertilize flowers. As he was viewing the pollen grains through a microscope, he noticed that as the pollen grains were floating on the surface of a water droplet, inside the pollen grains were very tiny particles jiggling every which way.

He hypothesized that the jiggling movement might be some type of life force needed to fertilize flowers.

Hypothesis:

jiggling inside pollen is due to a life force

Prediction from the hypothesis:

if the hypothesis were true, then there should be no movement inside dead pollen

Experiment to test the hypothesis:

look at dead pollen

To test this hypothesis, he said to himself, if this hypothesis were true, there should be no jiggling in dead pollen. So Brown decided to look for these jiggling particles inside pollen grains that were clearly dead, for example, pollen grains that had been suspended in alcohol for months on end. To his surprise, he still saw the jiggling particles.

He then looked at pollen grains that had been trapped in solidified sap for millions of years. Sure enough, when he placed the pollen grains in a droplet of water, the particles inside the pollen grains were still moving.

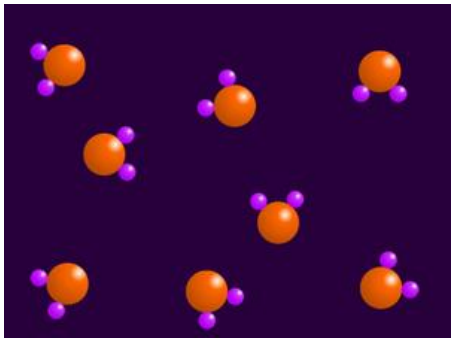
He even saw the movement in things that were *never* alive, like grains of powder; so, clearly, the movement had nothing to do with life.

Other hypotheses that Brown tested included turbulence in the water caused by differences in temperature, and turbulence caused by water molecules evaporating from the surface of the water droplet, but he was able to show that the jiggling movement inside the pollen grains was not due to these either.

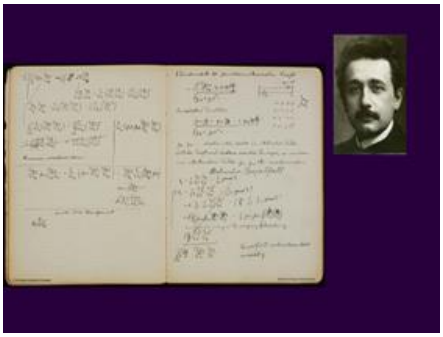
Slide 4: Brownian movement is random

It took another 50 years before scientists proposed that water molecules were in constant motion, and that the movement they were seeing was due to water molecules bumping into the particles.

This hypothesis, that Brownian movement was due to constantly moving water molecules, provided strong support for the idea that all matter was made up of molecules.



When in 1905, Einstein figured out the mathematics behind Brownian movement, scientists were able to make predictions about Brownian movement, and there was no longer any scientific reason for people to doubt the existence of atoms and molecules.



One of the things Einstein showed mathematically was that Brownian movement is random, completely unpredictable. In fact, atoms and molecules randomly knock into each other in every direction over a billion times a second.

If Brownian movement is random, why should atoms and molecules move across a cell membrane? What is the force driving them across the cell membrane?

Slide 5: The concentration gradient

The concentration gradient. If a drop of food coloring is squirted into a test tube of water, at first the food coloring spreads out in tiny swirls, but then turns a uniform color as individual molecules of the food coloring undergoing Brownian movement mix in between the water molecules. The mixing of molecules due to Brownian movement is simple diffusion.

Given the freedom to roam, molecules concentrated in one area will naturally drift away and diffuse into their surroundings until their concentration is equal everywhere. Why should that be? What's wrong with leaving things concentrated in one area?

Nature does not like things concentrated in one area, so she created a fundamental law based on pure chance, called the law of entropy, to prevent things from remaining concentrated in any one area.

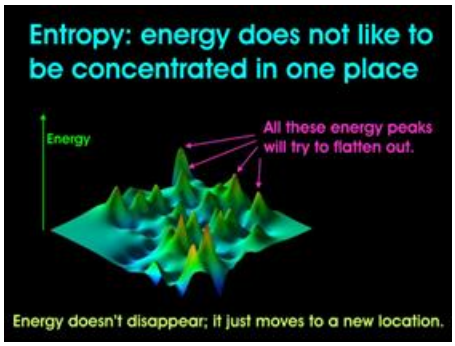
The law of entropy flattens out hills and valleys, whether they be actual hills and valleys on the surface of the earth, or simply areas of high molecular concentration, or even peaks of energy. The law of entropy says that, because of random movement, things always get more and more disorganized with time. Entropy, then, is a measure of disorder.

The law of entropy is only true, however, in a closed system where no energy is being added. For life on earth, the law of entropy does not apply because sunlight is continually adding energy to the earth, but for the sun and the earth together, the law of entropy does apply, because no energy is being added to that system.

Entropy is taking place all around you. A hot glass of coffee cools off, a cold glass of soda warms up, water runs downhill, and a drop of food coloring in water spreads out.

Peaks of high concentration contain energy called “potential” energy, and as the molecules spread out, they lose their potential energy by converting it into kinetic energy, or moving energy. In flattening out energy peaks and lifting up the energy valleys, the law of entropy is only redistributing energy. It is not destroying energy. Energy is never destroyed.

Don’t let the image of peaks and valleys mislead you into thinking that the reason areas of high concentration flatten out is because gravity or some other force is pushing the molecules from areas of high concentration to areas of low concentration. Diffusion is a totally random process. Molecules don’t know that they are in an area of high concentration.



Molecules in a single chamber are simply bouncing around every which way, and because there is no predictable direction to the movements, the molecules tend to wander around and mix until the concentration is equal everywhere inside the chamber.

Slide 6: Increasing the rate of diffusion

If the concentration gradient across a cell membrane helps molecules diffuse into a cell, what are some of the factors that increase the rate of diffusion?

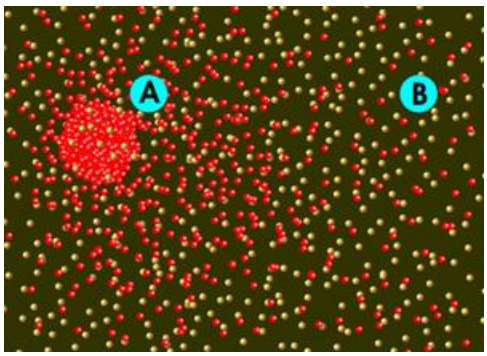
diffusion: random molecular movement

heat

concentration?

Since the mechanism of diffusion is random molecular movement, whatever increases random molecular movement should increase the rate of diffusion.

Random molecular movement is kinetic energy and the energy in kinetic energy is provided by heat.



Heat, then, is an important determinant of the rate of diffusion.

What about the concentration? Will a higher concentration make the molecules move faster?

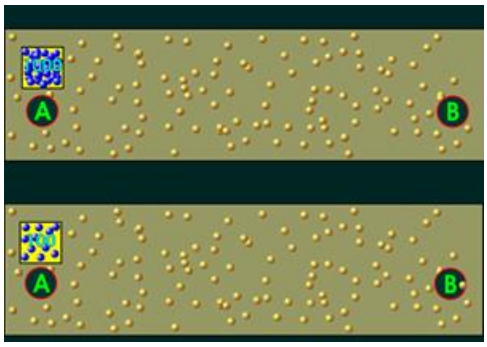
Here is a room full of air molecules.

A puff of perfume is released next to location A and within a few seconds, the perfume has spread to the other side the room to location B.

Will a higher concentration of perfume at point A cause the perfume to arrive at point B sooner?

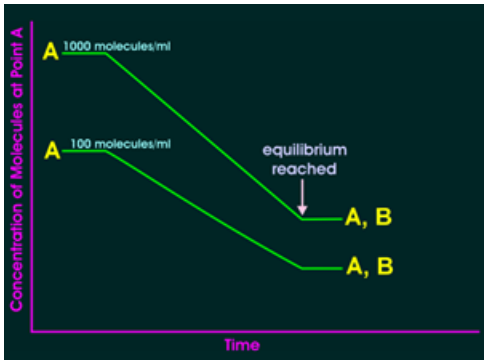
No. So long as the temperature remains constant, no matter how many perfume molecules per milliliter you release in a single puff, the time to reach equilibrium and equalize the difference in concentration remains the same. Why? Because in a gas, every molecule is so far apart from every other gas molecule that each gas molecule acts as if it were alone.

So long as these two samples of perfume are at the same temperature, the molecules in the more concentrated sample up top will diffuse to point B in the same time period as the less concentrated molecules below.



So while more perfume molecules will reach point B from the more concentrated puff of perfume, they do not arrive at point B faster. Thus, the time to reach equilibrium, where the concentration at point A equals the concentration at point B, will be the same regardless of the concentration of the initial puff.

These two green graph lines represent two concentrations of perfume at location A. The top graph line represents a 1 milliliter puff of perfume containing 1000 molecules of perfume, and the lower graph line a 1 milliliter puff of perfume containing 100 molecules of perfume.



Both samples take the same amount of time to reach equilibrium. However, because the upper sample contained more perfume molecules than the lower sample, more molecules from that sample were able to reach point B in that time period.

Slide 7: Barriers to diffusion across a cell membrane

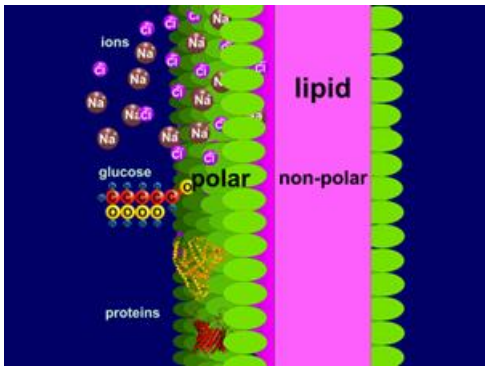
Diffusion explains how molecules move through the air or through water, but it doesn't explain how molecules get through a cell membrane. A cell membrane has three formidable barriers.

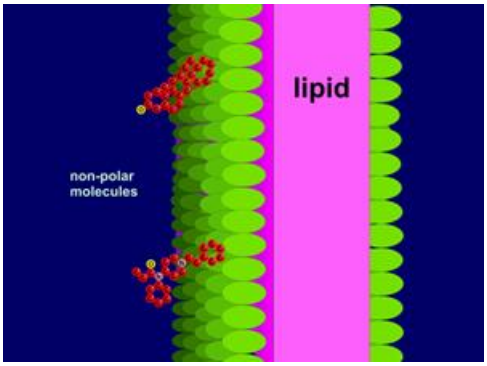
First off, the molecules making up the cell membrane are packed closely together, making it difficult for any molecule, especially a large molecule like a protein, to slip between the molecules of a cell membrane.

Second, the outside and inside layers of a cell membrane are composed of polar molecules which have an electrical charge. So if an ion or a polar molecule trying to get through a cell membrane happens to have the same electrical charge as the outer layer of the cell membrane, it's going to be repelled by the cell membrane.

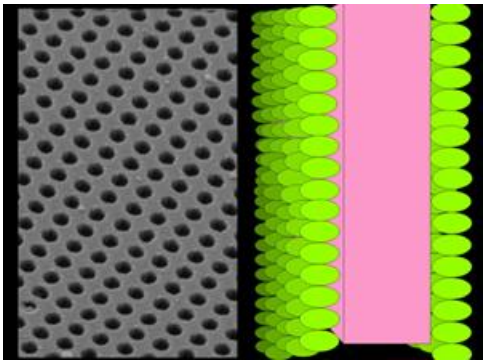
Third, the middle layer of a cell membrane is non-polar, posing a real barrier for polar molecules.

Non-polar molecules, on the other hand, have a much easier time passing through cell membranes because if they can get through the outer and inner polar layers of a cell membrane, they can readily slip through the non-polar, middle layer.



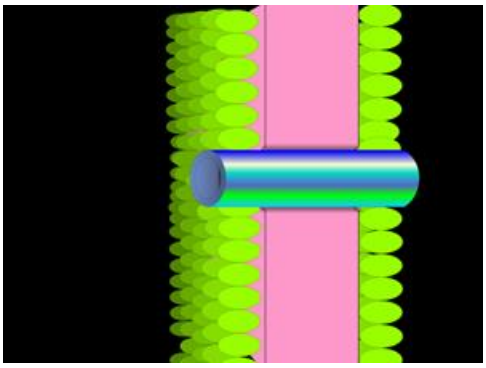


Slide 9: A cell needs a way to exclude molecules.



Mere diffusion is not efficient enough to get nutrients into a cell because unless the nutrient molecule is non-polar, its size and electrical charge may easily prevent it from diffusing across the cell membrane.

Moreover, if all it took was diffusion to get molecules into a cell, every molecule would be able to enter the cell, even molecules that might prove harmful to the cell.



Cells need some way to exclude molecules it doesn't want and some way to facilitate the entry of molecules it does want.

In other words, we need to make the cell membrane semipermeable. Any membrane that allows some atoms or molecules through but not others is called "semipermeable."

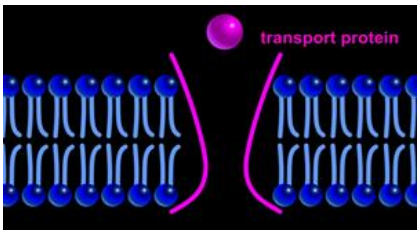
For example, is this membrane which we see through a high power microscope semipermeable? Yes. The holes only allow small molecules through, but not larger ones.

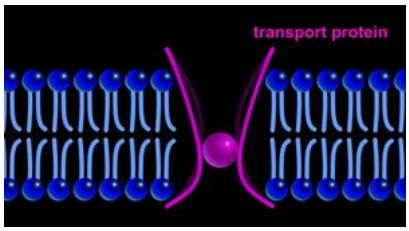
How do we design a cell membrane to allow those charged ions, polar molecules, and large molecules that we need to pass into and out of a cell while excluding those we don't need?

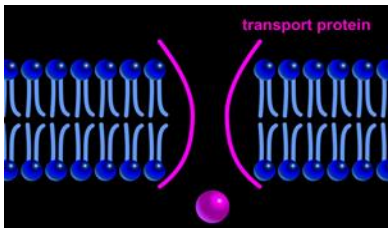
To allow ions and polar molecules through a cell membrane, Mother Nature punctured the cell membrane with thousands and thousands of tiny pores.

Each pore is lined with any one of thousands of different "transport proteins" that extend into and out of the cell. Each transport protein guards its pore by allowing only a few specific kinds of ions and molecules through.

When the ion or molecule touches the transport protein, the protein changes shape to escort the ion or molecule through the cell membrane. The transport protein uses none of its own energy to do this. It relies solely on the kinetic energy of the ion or molecule being transported.



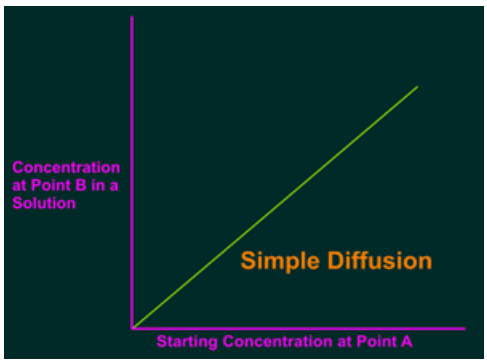




By using a transport protein to facilitate the movement of ions and polar molecules into the cell, cells are able to control the types of nutrients entering the cell.

Slide 9: Simple diffusion

This graph demonstrates that with simple diffusion, increasing the concentration of, say, potassium ions at point A in a solution, allows more of the ions to accumulate at some distant point B in the solution over time, even though increasing the concentration of potassium ions does not change the time it takes to reach equilibrium.

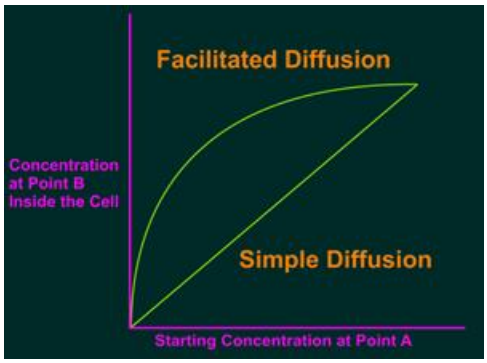


This graph line demonstrates the movement of potassium ions from point A outside the cell to point B inside the cell. Why does the graph line curve? What is this curved graph line telling us?

When the concentration of potassium ions outside the cell is low, the rate of accumulation inside the cell is much higher than simple diffusion. This is a good thing because when the concentration of potassium ions inside the cell is low, the cell wants potassium ions. By using its transport protein to facilitate the movement of potassium ions into the cell, the cell is able to bring potassium ions into the cell faster than simple diffusion even when the concentration of potassium ions outside the cell is quite low.

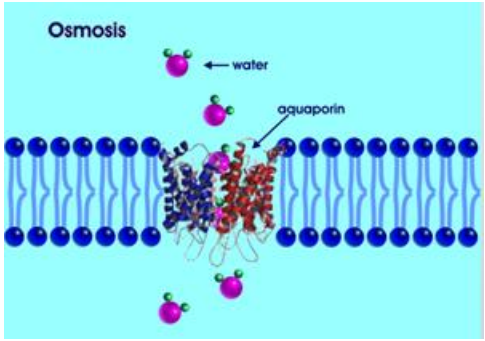
This type of diffusion is called facilitated diffusion. Like simple diffusion, facilitated diffusion requires no energy from the transport protein.

Why, though, does the rate of diffusion plateau and flatten out as the concentration of potassium outside the cell increases? Because as potassium's transport proteins become saturated with potassium ions, they can no longer increase the number of potassium ions being brought into the cell.



Slide 10: Aquaporin

Water molecules have their own membrane protein, called "aquaporin." Aquaporin creates a channel in the cell membrane for water, and *only* water, to pass through. No ions are allowed through the aquaporin pores. Because aquaporin only creates a channel for water molecules to pass through, aquaporin is known as a "channel protein."



No energy is expended when water molecules move through an aquaporin channel. Thus, aquaporin's channeling of water molecules through a cell membrane is like facilitated diffusion, because aquaporin creates an open channel for water molecules to move down a concentration gradient. The term for movement of water across a cell membrane is "osmosis."

It's thought that aquaporin also channels gases through cell membranes, which means that everything passing through cell membranes does so through a pore guarded by a protein embedded in the cell membrane.

Now why should every molecule and every ion have its own protein to get across the cell membrane? What do transport proteins do for the cell?

By forcing sodium ions, potassium ions, chloride ions, glucose molecules, and even water molecules to use a specific protein to enter the cell, the cell can regulate how much and when sodium, potassium, glucose, and water enter and exit the cell.

Slide 11: Active transport

For example, the concentration of extracellular calcium -- calcium outside the cell -- is about 10,000 times higher than intracellular calcium -- calcium inside the cell. The concentration of extracellular sodium is 14 times higher than intracellular sodium.

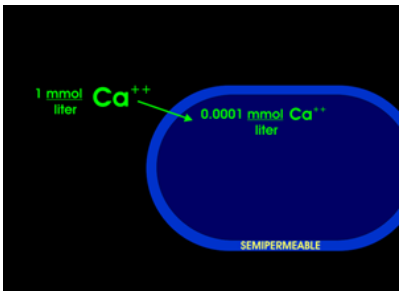
Conversely, the concentration of intracellular potassium is 35 times higher than the concentration of extracellular potassium.

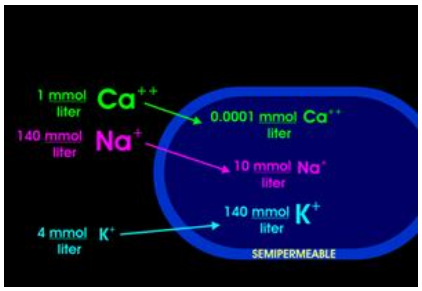
While calcium's chemical gradient of 10,000 to 1 is huge, its electrical gradient is even greater, because each calcium ion has an electrical charge of 2+.

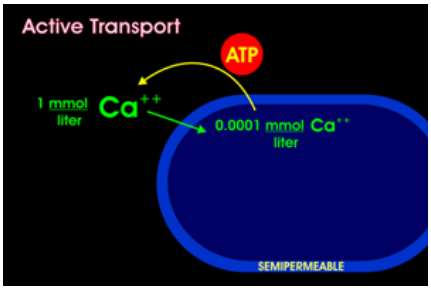
With such a large electrochemical gradient trying to force calcium <u>into</u> the cell, what would a transport protein need to continually pump calcium out of the cell?

Energy. Where is a transport protein going to get energy?

Like most chemical reactions, transport proteins use the energy molecule ATP. When a protein uses energy to move an ion or a molecule against a concentration gradient, it's called "active transport."





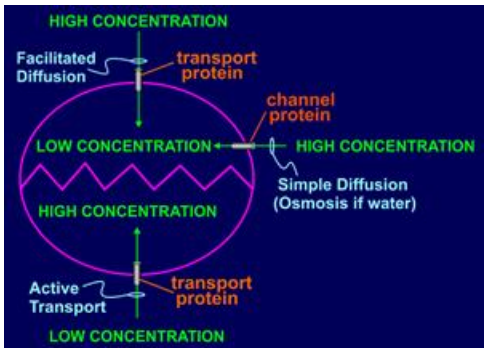


Slide 12: Three types of movement across a cell membrane

There are thus three types of movement across a cell membrane. The first is movement from an area of high concentration to an area of low concentration through a channel protein. Solutes move across the cell membrane, down a concentration gradient, as if there were no membrane at all.

This is called simple diffusion, which requires no input of energy. If the molecules moving across the cell membrane are water molecules, the process is called osmosis, and the channel protein is aquaporin.

The second type of movement is also from an area of high concentration to an area of low concentration, but escorted through the cell membrane by a transport protein. The transport protein increases the rate of diffusion above that of simple diffusion, which is great when the cell needs a particular molecule.

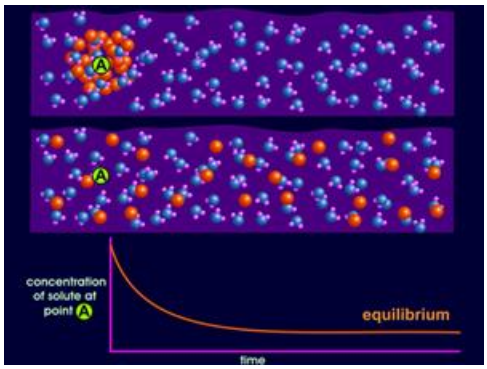


This is facilitated diffusion. Because facilitated diffusion moves ions and molecules down a concentration gradient, no ATP is needed to supply extra energy. As with simple diffusion, facilitated diffusion uses the energy of the ions and molecules.

The third type of movement is movement across a cell membrane from an area of low concentration, up a concentration gradient, to an area of high concentration with the help of a transport protein that uses ATP. That's active transport.

Slide 13: Equilibrium

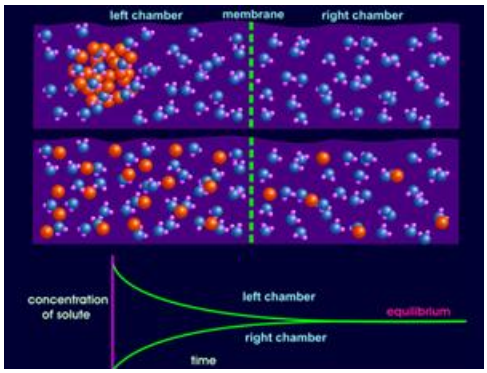
When a drop of food coloring is first dripped into water, the concentration of the food coloring at point A is quite high.



Eventually, though, the molecules of food coloring mix with the water and the concentration of food coloring is the same everywhere.

On a graph, the change in concentration at point A drops gradually until the concentration of food coloring is the same everywhere.

When the graph flattens out and the concentration remains constant, we say a state of *e*quilibrium has been reached. That's an okay definition when there's only one chamber.



Suppose though, you have two chambers, one on either side of a semipermeable membrane. When you first add a drop of food coloring into the left chamber, most of the molecules of food coloring remain to the left of the semipermeable membrane, and the concentration of solute in the left chamber is, at least initially, quite high.

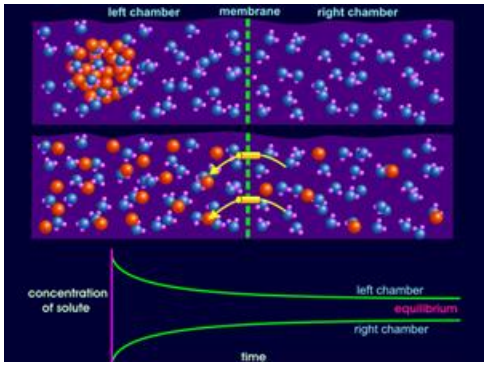
Because of the high concentration gradient between the two chambers, and because no membrane is a perfect barrier, molecules of food coloring do begin to move across the semipermeable membrane.

A graph would show an initial decline in the concentration of solute in the left chamber, and then a gradual flattening. Why the flattening?

First of all, the concentration gradient between the two chambers is dropping as molecules of food coloring leave the left chamber.

In addition, food coloring molecules that <u>had</u> moved to the right chamber are also slipping back over to the left chamber again. Eventually, the concentrations of food coloring on either side of the semipermeable membrane will be equal, and the two chambers will be at equilibrium with each other.

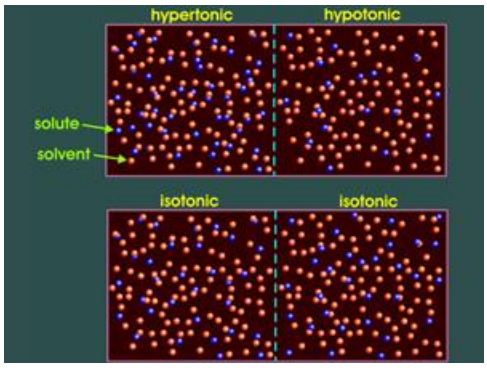
Now suppose we insert an active transport protein into the semipermeable membrane to actively pump molecules of food coloring from the right chamber back into the left chamber.



Now the concentrations of food coloring in the left and right chambers will level out at different concentrations. The two chambers will be at equilibrium with each other, even though they have different concentrations.

Equilibrium, then, does not mean that everything is equal everywhere. A state of equilibrium exists when the movement of molecules in one direction is matched by the movement of molecules in the opposite direction, even if it means one side remains more concentrated than the other. At equilibrium, then, you don't have to have the same concentration on either side of a semipermeable membrane, so long as the same number of molecules of solute are moving in either direction across the semipermeable membrane.

Slide 14: Hypertonic, hypotonic, and isotonic



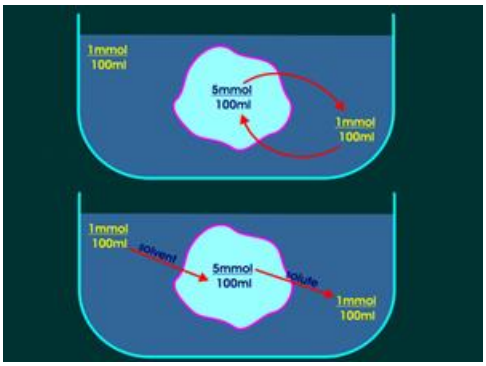
When comparing a solution on one side of a semipermeable membrane with a solution on the other side, instead of saying one solution is more concentrated than the other, we use the term "hypertonic" for the more concentrated solution, and "hypotonic" for the less concentrated solution. If both solutions have the same concentration, they are "isotonic."

The terms hypotonic, hypertonic, and isotonic can only be used to compare two solutions. A single solution cannot be hypotonic or hypertonic; it can only be hypotonic or hypertonic to another solution.

Here, for example, is a cell containing 5 millimoles of solute per 100 milliliters of water surrounded by fluid containing 1 millimole of solute per 100 milliliters of water. What happens?

There are two ways to look at this situation and both come to the same conclusion. The first way is mathematical.

Entropy wants to equalize the intracellular and extracellular concentrations. Mathematically, there are two ways to do this: either lower the numerator inside the cell, or raise the denominator inside the cell. Because the semipermeable cell membrane obstructs the movement of solutes, it's very difficult to lower the solute level in the numerator.



However, the denominator, water, is freely mobile. So water moves into the cell, lowering the concentration of solute inside the cell. Water flows from the hypotonic extracellular fluid into the hypertonic intracellular space.

The other way to view this situation is to look at the concentration gradients, because molecules will flow down their concentration gradients.

The concentration gradient for the solute slants toward the outside of the cell, because there are more molecules of solute per milliliter of solution inside the cell than outside the cell.

The concentration gradient for the solvent slants toward the inside of the cell, because outside the cell there are more water molecules per milliliter of solution than inside the cell. Again, the semipermeable membrane obstructs the solute from flowing down its concentration gradient, but does allow the solvent to flow down its concentration gradient into the cell.

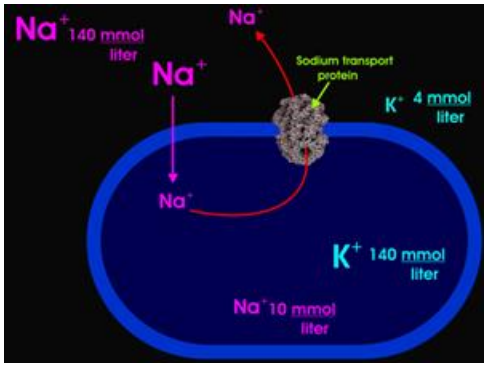
The rule is this: when a semi-permeable membrane separates a hypertonic solution from a hypotonic solution, water always flows from the hyp*o*tonic solution into the hyp*er*tonic solution. The easy way to remember this is, "water chases salt."

One final note: When trying to decide which way water molecules will move, the only thing you need to concern yourself with is the concentration of solutes on either side of the semipermeable membrane, not the volume of the solutions. Even if you have a huge volume of solution on one side of a semipermeable membrane containing a lot more individual water molecules, it doesn't matter.

The only thing that matters is the concentration of the two solutions on either side of the semipermeable membrane. Water will flow from the hypotonic side to the hypertonic side. Period. And don't forget, hypertonic doesn't care how many different solutes are dissolved in solution, only the final concentration after totaling up all the solutes.

Slide 15: Osmosis

All body fluids contain sodium ions. In humans the concentration of sodium ions in the extracellular fluids surrounding cells is about 140 mmoles per liter of water. Intracellularly, the sodium ion concentration is only 10 mmoles per liter of water. This large concentration gradient is more than meets the eye, because the gradient is not only chemical involving sodium atoms, but electrical, too, because each sodium atom carries a positive electrical charge.



The law of entropy wants to level out this electrochemical gradient. If the law of entropy had its way, sodium ions would move into the cell, or water would move out of the cell, or both. How, then, do cells maintain this electrochemical gradient?

One way cells maintain this electrochemical gradient is for the sodium transport protein embedded within the cell membrane to pump out any sodium ions that do leak into the cell. Since the pumping would be up the concentration gradient, this would be active transport.

The electrical gradient is much less of a problem, because the positive electrical charge outside the cell is offset by an equally positive charge inside the cell. How so? Inside the cell is a high concentration of positive potassium ions.

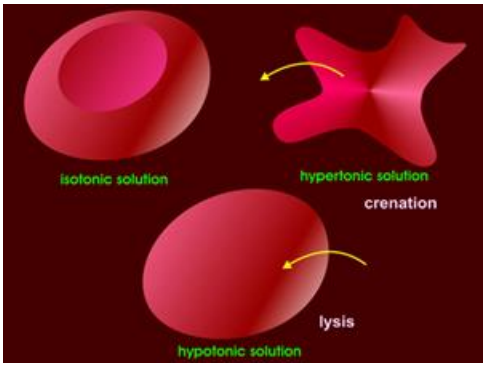
Also, by having a high concentration of potassium ions inside the cell, the interior of the cell is now isotonic to the exterior of the cell, because the total solutes per liter inside the cell equals the solutes per liter outside the cell. Water no longer has a reason to move into or out of the cell.

So while water molecules may wander back and forth across the cell membrane, the number of water molecules entering the cell is matched by the number of water molecules exiting the cell. In other words, intra and extracellular water are at a state of equilibrium.

One last point. The sodium transport protein that pumps sodium out of the cell also pumps potassium into the cell, so it's really called the sodium-potassium pump. Remember, the sodium-potassium pump uses ATP because it's pumping against a concentration gradient as active transport. The sodium-potassium pump is so widespread and so busy that it's estimated that a quarter of the total energy used by the body is used to run the sodium-potassium pump.

Slide 16: Osmosis and red blood cells

This is a red blood cell. Red blood cells contain hemoglobin to carry oxygen from our lungs to all the cells of our body, and carbon dioxide back from the cells to our lungs. When placed in an isotonic solution, red blood cells are round with a shallow depression in the middle.

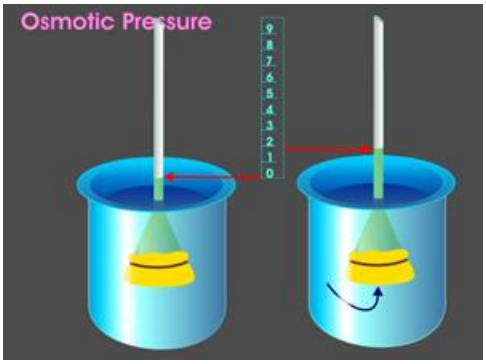


What would happen to the red blood cell if it were suddenly placed in a hypertonic salt solution? The semipermeable cell membrane blocks the movement of sodium ions, but not water. Water chases salt, so water leaves the red blood cell, a process called osmosis.

The red blood cell shrinks and shrivels up, called "crenation." What would happen to the red blood cell if it were placed in a hypotonic solution? Now water chases salt by moving from the solution into the red blood cell.

This time osmosis causes the red blood cell to swell. The additional intracellular water exerts pressure against the walls of the red blood cell and distends them. The raised intracellular pressure caused by osmosis is called "osmotic pressure." If osmotic pressure rises too high, it can burst the cell wide open, called "lysis" of the cell.

Slide 17: Osmotic pressure



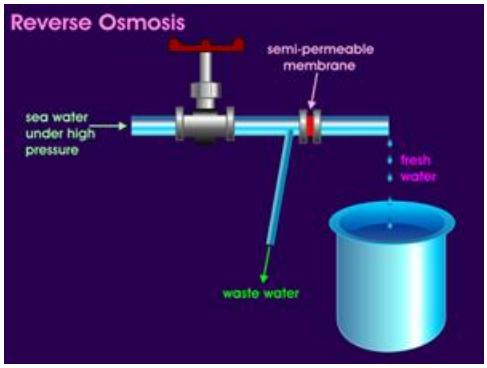
Here is beaker of water. Inside this inverted funnel is a hypertonic solution. The yellow membrane over the mouth of the funnel is semipermeable, so very little solute can escape the funnel. What happens?

The water in the beaker is hypotonic to the solution inside the funnel. Water chases salt, so water enters the funnel by osmosis from the beaker.

We can measure the osmotic pressure in the funnel by simply measuring the difference in the height of the two columns.

Slide 18: A semi-permeable membrane acts like a filter.

Do you see how osmosis across a semipermeable membrane can be used to obtain fresh water from sea water? Pump in sea water under high pressure against a semipermeable membrane acts like a filter, allowing only fresh water through the membrane. As the solutes and other debris collect on the sea water side of the semi-permeable membrane, they are removed through a side pipe as waste water. A highly salty solution like this is called brine.

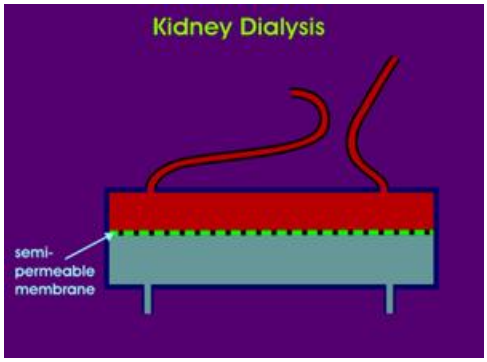


Since water is passing through the semipermeable membrane from the hypertonic to the hypotonic side, which is the opposite direction of typical osmosis, this process is called "reverse osmosis." Reverse osmosis is used by water treatment plants to clean dirty water, and by desalination plants to convert salt water to fresh water.

Doctors are faced with a similar problem in patients who, for one reason or another, suffer kidney failure. Toxins building up in the blood stream need to be removed within a week or so, or else the patient will lapse into a coma and die.

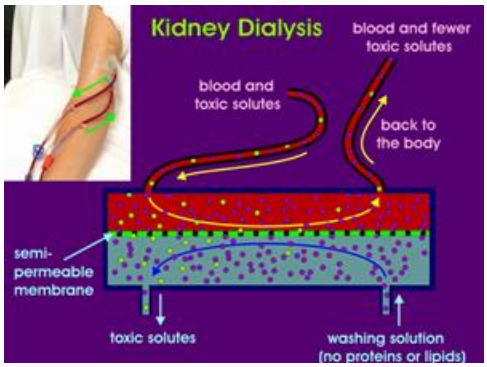
Slide 19: Dialysis

To remove toxins dissolved in the blood, we need a dialysis machine. Here's how the machine works.



Inside the machine is a semipermeable membrane. The holes in the semi-permeable membrane are too small for proteins in the blood, or the red or white blood cells, to pass through, but the water phase of the blood can pass through.

By placing a tube into an artery, blood is diverted into the upper chamber of the dialysis machine.



From below, a washing solution is fed into the chamber over to the right. The washing solution is the water phase of normal blood, and contains all the small molecules contained in normal blood. So the only difference between the water phases of upper chamber and the lower chamber is the presence of kidney toxins in the upper chamber.

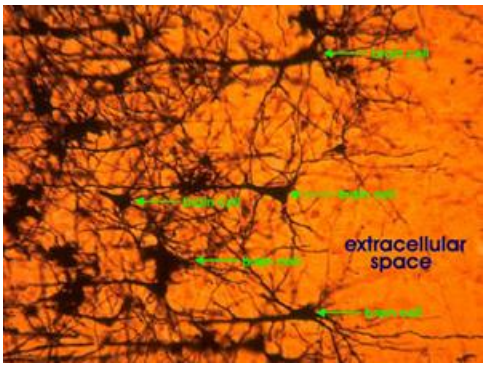
The blood in the upper chamber, and the washing fluid in the lower chamber, move through the dialysis machine in opposite directions. Because the upper chamber and the lower chamber have the same concentration of ions and molecules needed by the body, there is no net movement of these molecules. They are already at equilibrium from the beginning of dialysis.

The toxins, however, are solely in the upper chamber at the beginning of dialysis. As they diffuse across the semipermeable membrane, the blood is partially cleansed of these toxins, and returned to the patient through a large vein.

What's the reason blood is not completely cleansed of toxic molecules? First of all, not all the toxic molecules leave the blood and enter the washing solution. Moreover, some of the toxic molecules that do cross the semipermeable membrane into the washing solution cross back over into the blood again, as the blood and washing solution try to reach equilibrium with each other.

Slide 20: Extreme water intoxication

Here is a woman in a coma. In 2008, a woman just like her lapsed into a coma and eventually died after rapidly drinking over 2 gallons of water. She did it to try to win money to buy her children Christmas presents. A radio station was offering money to whomever could drink the most water without going to the bathroom. Why did she die? What happened to all the water she drank?



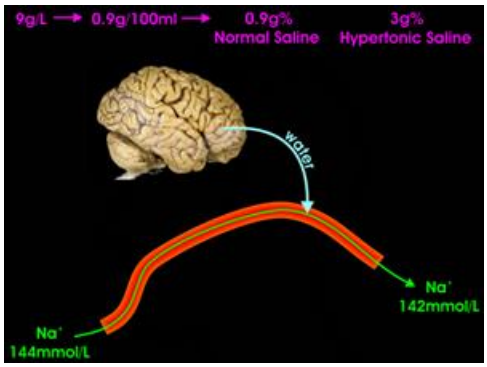
The water entered her bloodstream and then all the extracellular fluid surrounding every cell of her body. As the extracellular fluid outside her brain cells became more and more hypotonic, the water began moving into her brain cells. Her brain cells swelled, causing the whole brain to swell.

There is only so much room inside the skull. When the swelling brain met the rigid skull bone, pressure inside her skull began to rise. Eventually the pressure rose so high that it killed all her brain cells and she died.

If you were the doctor in the emergency room before she lapsed into a coma, what would you do?

You would administer intravenous hypertonic salt water. As her blood becomes hypertonic, which is anything above 140mmol per liter, the extra water inside her brain cells would leave the brain cells by osmosis and return to the blood, giving the brain some elbow room inside the skull. Hypertonic salt solutions suck water out of the brain.

What is a hypertonic salt solution? A hypertonic salt solution is anything more concentrated than an isotonic salt solution.



Normal saline is the term used in medicine for an isotonic salt solution. When administered intravenously, normal saline doesn't make red blood swell or shrink. It's isotonic.

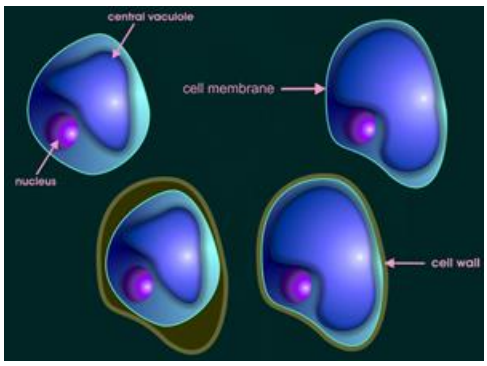
Normal saline has a salt concentration of 9 grams of salt per liter of water, which is 0.9 grams per 100 ml of water, or 0.9%.

A 3% saline solution, however is hypertonic and will raise the sodium concentration in the blood from 140 to around 144mEq per liter.

Slide 21: Plant turgidity

Not all cells mind high osmotic pressure. This wilted plant needs that extra water pressure inside its cells to reestablish its turgor, its stiffness.

When you water a plant, the water enters a central vacuole inside each plant cell.



As the central vacuole fills up with water, it greatly increases osmotic pressure inside the cell. You see the increased osmotic pressure as the plant straightening up.

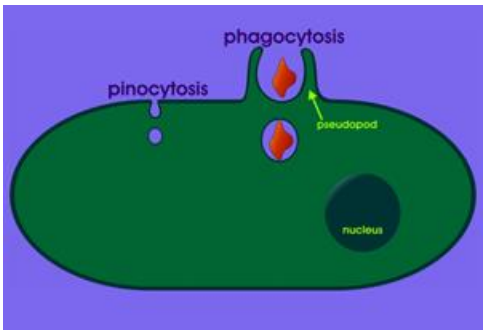
Why doesn't the high osmotic pressure burst, or lyse the plant cells?

Because each plant cell is surrounded by a rigid wall of cellulose.

When the plant isn't watered for a while, the cell membrane pulls away from the cell wall and the plant droops again.

Here are some examples of cell walls in plants. Note the cell wall around each plant cell, unlike the animal cells in the middle pane.

Slide 22: Pinocytosis



Cells can also take in water by indenting a small pouch of its cell membrane and pinching off a droplet of water. This process is called "pinocytosis."

If the cell detects a bit of food, it can extend two arms, called "pseudopods", to encircle the bit of food and bring it into the cell for digestion. This process is called "phagocytosis."

Slide 23: What you know so far

1. All molecules are in continuous random movement, called "Brownian movement."

2. The law of entropy says that in a closed system, any concentration of energy will eventually flatten out. So molecules concentrated in one area slowly spread out by Brownian movement until their concentration is equal everywhere, in a process called "diffusion."

3. A cell membrane can speed up diffusion through the cell membrane using proteins embedded in the cell membrane. This is called "facilitated diffusion."

Slide 24: What you know so far

4. Other proteins in the cell membrane, called "transport proteins," simply transport molecules through the cell membrane. Aquaporin is a transport protein for water molecules. The term for diffusion of water across a cell membrane is "osmosis."

5. Osmosis and facilitated diffusion require no energy, but transport of molecules up a concentration gradient, called "active transport," does.

6. When the movement of molecules across a cell membrane is the same in either direction, the solutions on either side of the membrane are said to be “in equilibrium.” Equilibrium does not mean that the concentration is the same on each side of the membrane.

Slide 25: What you know so far

7. A less concentrated solution is “hypotonic” to a more concentrated solution, and the more concentrated solution is “hypertonic” to the less concentrated solution.

8. Water flowing into a cell from a hypotonic solution outside the cell raises intracellular pressure. Because the process occurs by osmosis, the intracellular pressure is called “osmotic pressure.”

9. A cell membrane can gulp water by pinching off a droplet of water, called “pinocytosis.”