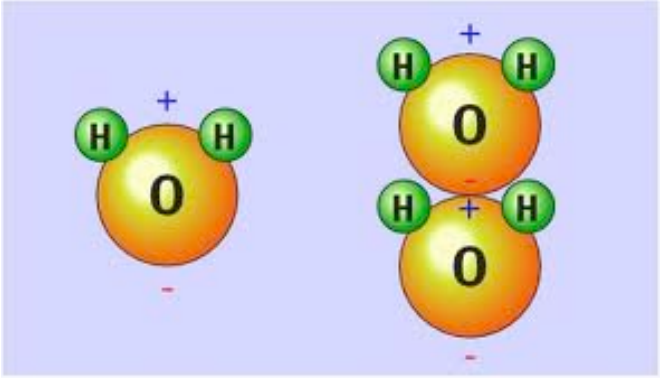
Water Polarity
Research #1

Like all matter, water is made up of atoms. Atoms attach together, or bond, to form molecules. Two hydrogen atoms bonded to an oxygen atom form a water molecule.

When electrons are not shared equally in a water molecule, the molecule is described as polar. Water molecules are polar. This means that while water molecules are neutral as a whole, one end of the water molecule tends to have a positive charge while the other has a negative charge. The oxygen end has a slight negative charge while the hydrogen end has a slight positive charge. Each end of a water molecule is attracted to the opposite charged end of another water molecule. Water's polarity is responsible for the "stickiness" or cohesion between the molecules. (see the illustration below)

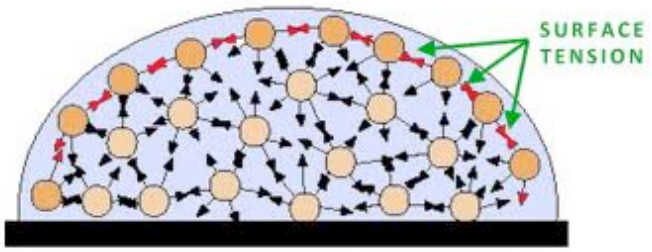


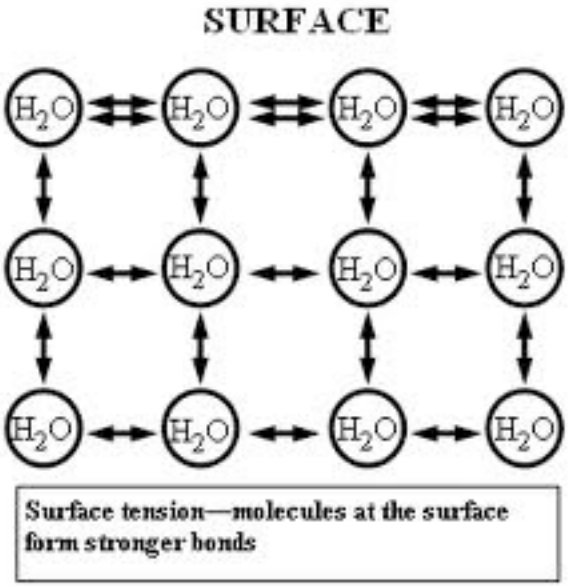
Water Polarity
Research #2

Whether you know it or not, you already have seen surface tension at work. Whenever you fill a glass of water too far, you may notice afterward that the level of the water in the glass is actually higher than the height of the glass. You may have also noticed that the water that you spilled has formed into pools that rise up off the counter. Both of these phenomena are due to surface tension of water.

In a sample of water, there are two types of molecules. Those that are on the outside, exterior, and those that are on the inside, interior. The interior molecules are attracted to all the molecules around them, while the exterior molecules are attracted to only the other surface molecules and to those below the surface. This makes it so that the energy state of the molecules on the interior is much lower than that of the molecules on the exterior. Because of this, the molecules try to maintain a minimum surface area, thus allowing more molecules to have a lower energy state. This is what creates what is referred to as surface tension. An illustration of this can be seen in to the right.

The water molecules attract one another due to the water's polar property. The hydrogen ends, which are positive in comparison to the negative ends of the oxygen cause water to "stick" together. This is why there is surface tension and takes a certain amount of energy to break these intermolecular bonds. Same goes for other liquids, even hydrophobic liquids such as oil. There are forces between the liquid that are responsible for the intermolecular forces found within the liquid. It will then take a certain amount of energy to break these forces, and the surface tension. Water is one liquid known to have a very high surface tension value and is difficult to overcome.





Water Polarity
Research #3

Surface tension of water can cause things to float which are more dense than water, allowing organisms to literally walk on water. An example of such organism is a spider, which can run across the surface of water, due to the intermolecular forces of the molecules, and the force of the spider which is distributed to it's eight legs. Surface tension also allows for the formation of droplets that we see in nature.

There are several other important concepts that are related to surface tension. The first of these is the idea of *cohesive forces* and *adhesive forces*. Put simply cohesive forces are those that hold the body of a liquid together with minimum surface area and adhesive forces are those that try to make a body of a liquid spread out. So if the cohesive forces are stronger then the adhesive forces, the body of water will maintain its shape, but if the opposite is true than the liquid will be spread out, maximizing its surface area.

Buffers
Research #1

Living cells require constant conditions to remain alive. Individual living cells that are not part of a larger organism rely on their surroundings to provide a constant flow of nutrients and oxygen and to maintain salt balance. Their environment must also be at a nearly constant temperature and pH. If any of these physical and chemical conditions are not held constant, the living conditions may vary above or below the optimum conditions necessary for life. Under these conditions the organisms may not grow or reproduce. If the conditions are varied even more, the organism's life may be threatened.

Fruit and vegetables provide a natural source of base to buffer the acid produced by other dietary components. An acid-yielding food is one that creates a lower, or more acidic, pH. Citrus fruits and tomatoes are acidic, but they have a basic results once arriving in the kidneys. For example, acidic and alkaline foods don't usually translate into acid- and alkaline-yielding foods. The distinction is subtle but significant.

Fruits and vegetables are rich in potassium salts, a natural buffer. Eating too few of these foods deprives us of potassium, a mineral that protects against hypertension and stroke. Today's diet can wreak havoc on our bodies because of heavily salted processed and fast foods, combined with a low intake of fruits and vegetables.

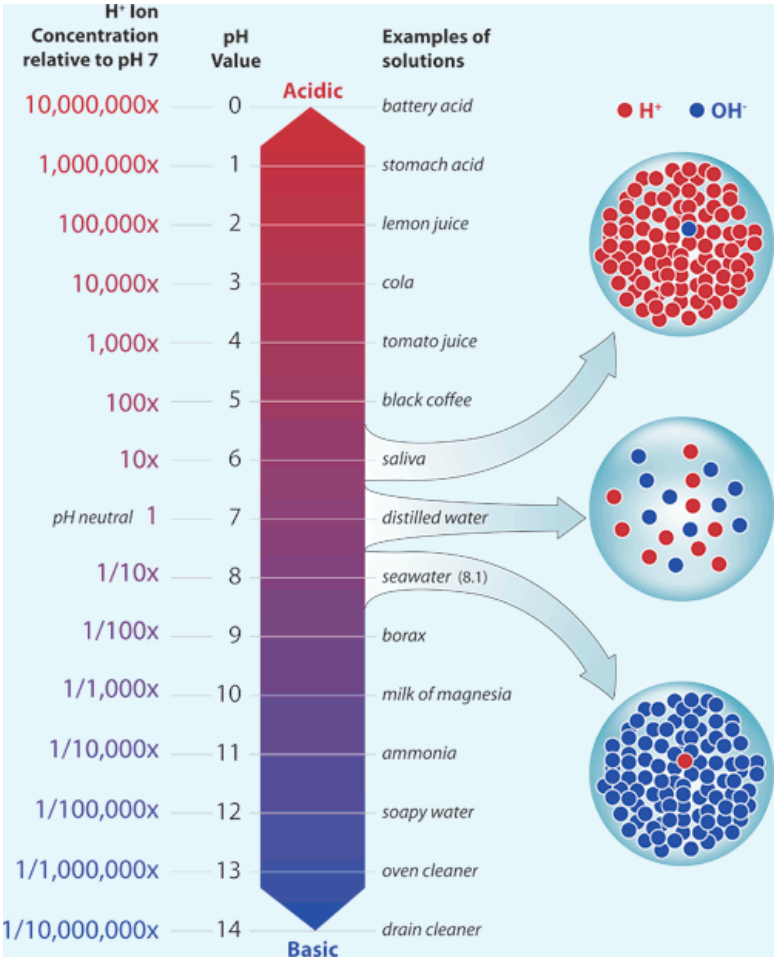
The buffers help to keep the pH in the normal range by "taking up" (combining with) the excess hydrogen or hydroxide ions. If something is wrong with the buffer system, an organism, such as you, can develop *acidosis* if the pH drops too low (blood becomes too acidic) or *alkalosis* if the pH gets too high (blood becomes too basic).

Buffers
Research #2

The term *pH* symbolizes the hydrogen ion concentration in a solution. The pH scale goes from 1—14. A pH of 7 is neutral, meaning that the amount of hydrogen ions and hydroxide ions in a solution are equal. For example, water has a pH of 7 because when water breaks up, the split is equitable into one hydrogen ion for every hydroxide ion.

If a solution contains more hydrogen ions than hydroxide ions, it is said to be acidic, and the pH of the solution is less than 7. If a molecule releases hydrogen ions in water, it is an acid. The more hydrogen ions it releases, the stronger the acid, and the lower the pH value. The table below shows you the pH of some common substances and may visually help you to figure out the pH scale.

The situation is reversed for bases. If a solution contains more hydroxide ion than hydrogen ion, it is said to be basic, and its pH is higher than 7. Remember that bases dissociate (break apart) into hydroxide ions and a positive ion. The hydroxide ions can combine with H(+) to create water. Because the hydrogen ions are used, the number of hydrogen ions in the solution decreases, making the solution less acidic and therefore more basic. So, the more hydroxide ions a molecule releases (or the more hydrogen ions it takes in), the more basic it is.



Ailanthus
Research #1

The Ailanthus is now commonly known as *That Darn Weed*, because it grows everywhere and is nearly impossible to kill. Strangely enough, this tree was imported for use as an ornamental shade tree throughout the eastern United States. People actually paid for it! It is a Chinese species that grows very rapidly, thrives in almost all soils and climates, resists practically all insects and diseases, and tolerates soot and pollution better than any other tree, native or foreign.

Ailanthus grows rapidly, achieving its mature height of 90 feet and diameter of 3 feet in little more than a decade. It is hardy and grows in almost any soil and light conditions.

Ailanthus
Research #2

Ailanthus has been extremely successful in invading and dominating certain habitats since its introduction to the United States in 1784. A number of characteristics contribute to the invasiveness and success of Ailanthus. First, the versatility of its reproduction methods provides a decided advantage. The trees regularly produce large crops of winged seeds that are widely dispersed by the wind. Ailanthus can also spread rapidly by sprouting from stumps or from its wide-ranging lateral roots, particularly in openings or at the edges of forested areas. Another of its advantageous characteristics is the extremely rapid growth rate that enables it to outcompete many other species, especially when reproducing from root or stump sprouts.

Another contributor to the invasiveness and success of Ailanthus is the secondary chemical that provides competitive superiority through allelopathy. Many plants produce chemical compounds that have no apparent role in the life processes or plant structure. Much evidence now indicates that these chemicals play a defensive role for the Ailanthus, protecting the plant from herbivores by making the plant tissues toxic, perhaps, or by reducing tastefulness.

Another role that secondary chemicals play is the inhibition of one plant's growth by another through the production and release of chemicals into the environment. These chemicals have been shown to inhibit seed germination or plant growth.

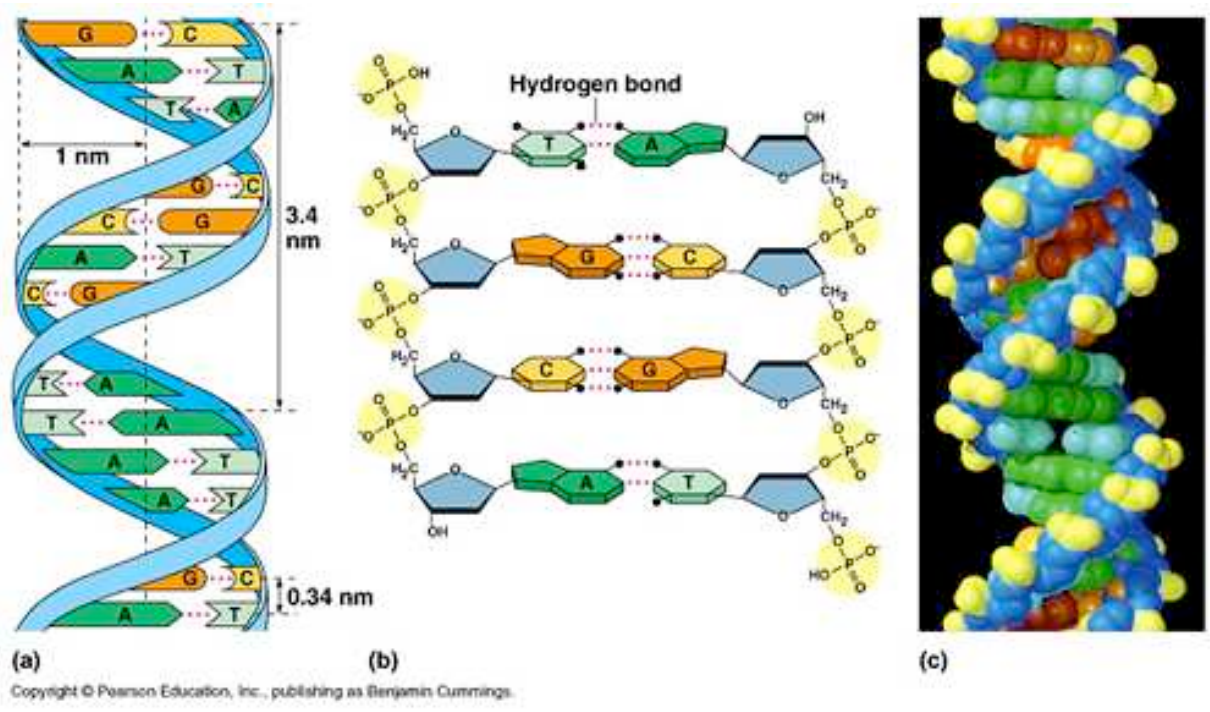
DNA
Research #1

DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA. Most DNA is located in the cell nucleus.

The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). Human DNA consists of about 3 billion bases, and more than 99 percent of those bases are the same in all people. The order, or sequence, of these bases determines the information available for building and maintaining an organism, similar to the way in which letters of the alphabet appear in a certain order to form words and sentences.

DNA bases pair up with each other, A with T and C with G, to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the ladder's rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.

An important property of DNA is that it can replicate, or make copies of itself. Each strand of DNA in the double helix can serve as a pattern for duplicating the sequence of bases. This is critical when cells divide because each new cell needs to have an exact copy of the DNA present in the old cell.



DNA
Research #2

Although DNA is an incredibly small molecule, in large quantities, it can be seen. Very pure DNA can be easily extracted from cells in a research laboratory, and somewhat less-pure DNA can be extracted with some simple techniques easily performed at home or in the classroom. One of the reasons fruits work so well is that they are soft and easy to pulverize.

There are three basic steps in DNA extraction. First, the cell must be lysed (broken open) to release the nucleus. Next, the nucleus must also be opened to release the DNA. Lastly, once the DNA is released, it must be precipitated out of solution.

Several reagents are required to complete the extraction procedure—salt, soap, and alcohol. Both the cell and nuclear membranes are composed primarily of lipids. In order for the cell to be lysed, the lipid walls must be broken down. The manual grinding and detergent solutions accomplish this. Soap molecules mix with fats or lipids, causing structures made of lipids to break apart. Alcohol is used to precipitate the DNA. In water, DNA is soluble. However, when it is in alcohol, it uncoils and precipitates
The addition of salt solution provides the DNA with a favorable environment by contributing positively charged atoms that neutralize the normal negative charge of the DNA, allowing the DNA to clump together.

Cellular Transport
Research #1

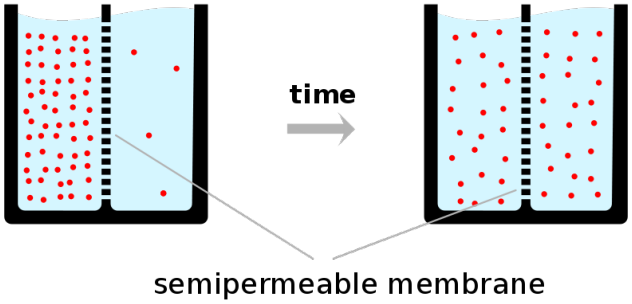


Figure 1

Diffusion and osmosis are both very similar properties, however diffusion is the movement of particles from an area of high concentration to an area of low concentration, and osmosis is the movement of water from high concentration to low concentration. Diffusion is shown in Figure 1 because the particles (dots) are moving from an area of many particles close together to an area with very few particles. If the water had moved instead from right (high concentration of water) to left (low concentration of water), this would have been osmosis.

There are several factors that can influence the rate of osmosis or diffusion. One of these factors is temperature. Temperature is often described as the amount of the energy of molecules. More energy means a higher temperature, thus particles move faster. If the temperature of the water in Figure 1 is high, that means the solute particles and water molecules would move faster and would thus diffuse faster. The opposite is true for colder temperatures. Other factors that can influence the rate of osmosis or diffusion include the concentration of solute, type of membrane, diffusion distance, and pressure.

Cellular Transport
Research #2

A hard, calcium shell surrounds eggs. Underneath the tough exterior is a selectively permeable membrane that protects the nutritious fluid inside the egg. By soaking eggs in vinegar, the acidic solution dissolves the calcium-based shell leaving only the thin, flexible membrane surrounding the egg and its yolk. The vinegar solution is an isotonic solution, meaning the amount of solutes inside the egg and the amount of solutes outside the egg is equal. Only water is small enough to pass through the membrane so it enters and exits the egg at equal rates, causing the mass of the egg to remain the same. However, if the egg is submerged in water, which is a hypotonic solution, the egg would gain mass. This is because more water enters the egg since there are more solutes and less water inside the egg. Thus, water moves from an area of higher concentration outside the egg, to an area of lower concentration, inside the egg. The opposite is true of a hypertonic solution, such as honey. Honey contains a higher concentration of solutes like sugar and less water, compared to an egg. Thus water moves from an area of higher concentration inside the egg to an area of lower concentration outside the egg, causing the egg to lose mass.

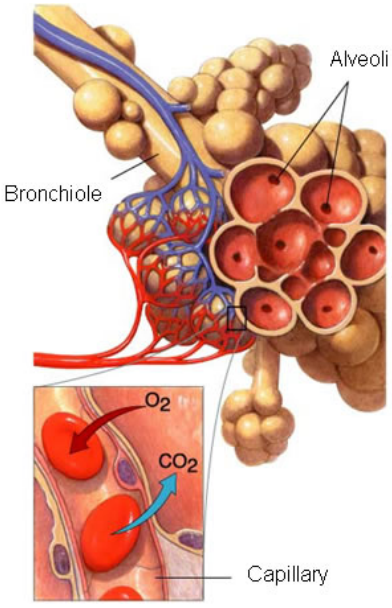
Respiration
Research #1

The two major functions of the respiratory system are to provide oxygen to the body, via the lungs, and to remove carbon dioxide from the body, via the lungs. Oxygen is needed for the process of cellular respiration, in which all of our cells break down food (glucose) to obtain energy. A waste product of this process is carbon dioxide, which we exhale. A buildup of excess carbon dioxide can be dangerous to the body and thus it needs to be exhaled as quickly as possible.

When a person begins to exercise, the body uses the energy stored in the muscles. Therefore, the first few minutes of exercise (depending on the person) do not cause an increase in respiration rate. After this energy source is depleted, the body begins to increase respiration rate, to take in more oxygen so that cells can go through cellular respiration and create energy. The amount the respiration rate increases depends on the type of exercise. Short bursts of high intensity exercise cause a dramatic increase in respiration rate, and a sustained rapid respiration rate because of the excessive demand for energy on the muscles. Long, endurance training causes a slower rise in respiration and an increase in respiration rate only slightly higher than resting. Exercises like weightlifting cause a sudden rise in respiration rate to a moderate-high level, and then a fairly fast drop back to normal resting respiration rate.

Respiration
Research #2

Although two different systems, the respiratory and circulatory systems are often discussed together. The respiratory system is responsible for inhaling oxygen for the body's cells to use for cellular respiration and exhaling carbon dioxide from the body. But the respiratory system depends on the circulatory system to help transport these gases throughout the body. The circulatory system is responsible for transporting blood, waste, and nutrients to and from all parts of the body. The red blood cells have a special protein, hemoglobin, which bonds to both oxygen and carbon dioxide. Thus, red blood cells are the carriers of these gases and are responsible for gas exchange in the lungs and in the cells of the body.



Because these two systems are so intertwined, an increase in respiration rate will often coincide with an increase in heart rate. As the body exercises, cells need more oxygen to create energy in cellular respiration. Thus the body needs to breathe in more oxygen and breathe out more carbon dioxide, so respiration rate increases. However the only way to get cells oxygen at a faster rate is to move the blood to the cells faster. Thus the heart must then pump blood faster throughout the body to move the red blood cells, causing heart rate to increase. As the demand for oxygen subsides, both respiration rate and heart rate decrease.

Two-Point Discrimination Test
Research #1

Our skin provides us with protection as well as information about our external environment. We can identify several distinct types of sensations, such as tapping, vibration, pressure, pain, and temperature. Based on what we use our different body parts, our bodies have evolved to have the right amount of each kind of receptor in the appropriate places. For example, the mechanoreceptors in our skin that sense pressure are found more densely in places like our fingertips or our faces because we use these parts to feel things. Mechanoreceptors are found farther apart (less dense) in other places like our backs because we do not really use these areas to feel things. However the other receptors in our skin that sense things like temperature, vibration, or pain are found in different densities throughout our body.

However our receptors are not perfect. Sometimes our receptors become acclimated to a specific environment. For example, if you stuck your hand in ice water, the thermoreceptors would sense the temperature of the water. After a while, they would become used to it. Then if you stuck your hand in warm water, it would feel extremely hot. This is because your receptors had become accustomed to one environment and the drastic change in environments caused the receptors to overreact. There are a number of conditions that can cause our receptors to not respond correctly, including different environments, traumas, and other chemicals released by the brain inhibiting the receptors.

Enzymes
Research #1

Enzymes are catalysts, meaning they speed up the rate of chemical reactions. Without them, everything would take an extremely long time. Different organisms have different enzymes based on their different functions. For example, pineapples contain an enzyme called bromelain, which breaks down proteins. This is why labels on Jell-O boxes contain warn against using fresh pineapple, kiwi, ginger, guava, papaya, and figs. All of these fruits contain enzymes that break down protein. Jell-O or gelatin, is made of protein, so using these fruits with their enzymes causes the enzymes to break down the protein, preventing the Jell-O from setting, or becoming a solid.

An easy way around this problem is to use canned pineapple or other fruit. Canned fruit is heated before it is sealed in the can. The heating process causes the enzymes in the fruit to denature or unfold. When the fruit cools back down, the enzyme re-folds incorrectly causing it to no longer function. As a result when canned fruit is mixed with Jell-O, the Jell-O becomes a solid.

Besides temperature, there are several other factors that can affect the activity of an enzyme in positive and negative ways. Like high temperatures, pH can negatively impact an enzyme. Enzymes have specific pHs at which the function best. Pepsin, an enzyme that breaks down protein, works best in the very acidic environment of our stomachs. However, amylase, an enzyme that breaks down carbohydrates in our small intestine, would not function in such an acidic environment. In fact, it denatures. Most enzymes can only function at a pH around 7 and denature in acidic or basic environments. Inhibitors, like their name suggest, cause an enzyme to slow down or stop working. They work by binding to the active site of an enzyme, preventing the enzyme from attaching to substrates to break them down. The opposite of inhibitors, are activators. Activators, usually hormones, can help trigger an enzyme to work faster.