Lecture 1 – 2020/2021 – Look at the end of this document for assignment #1!
Dr. Tim Revell

Welcome to Biology 1 On-Line!

Let me first introduce myself. My name is Tim Revell and I designed the biology 1 on-line course over 20 years ago and it has become better and better each year. I have probably already warned you about the difficulties of this course. I will leave it at that.

How did I get here? I started out as a community college student at Ventura Community College. After finishing my AA, I went on to U.C. Santa Cruz and received my Bachelor's degree in Biology. After that, I went to Cal State Fullerton and received my Master's degree in Biology. In 2001, while working full time at Mt. SAC, I started a Ph.D. program at Loma Linda University. To make a long story short and interesting, my research consisted of putting tiny backpacks with computers on them onto the backs of wild lizards so I could track their movements. I also studied the sleep patterns of these lizards and how various factors (such as rattlesnake interactions) may increase or decrease sleep. I finished my research and received my Ph.D. in 2005.

So lets talk about what Biology is and why it is important to study.

First of all, Biology is a science. A science is a body of information that is built around a foundation of scientific experiments (See Scientific Method Below). Specifically, biology is the scientific study of life (See Life Vs. Non-life down below)

Why it is important to study biology:

I think that this biology class will probably be the most important class you will ever take. This assumes that this class is the only biology class you will take. You might disagree with me, but here is my rationale:

Lots of classes are important to you for different reasons. You might become an accountant and so math might be important. You might become an artist and so, maybe a painting class is important. But things change in life. Lots of people switch jobs and professions. And, as long as you are alive, remaining alive and understanding how life works (and doesn't work) will ALWAYS be important. Staying alive should be the most important thing on your list of chores! Therefore, without a doubt in my mind, understanding Biology will always be relevant. Here are some related reasons why this class is so important:

1) Making decisions about your health: In this class, we will learn about how your body works and what you can do to keep it in good shape. Nearly every other class you will ever take will not teach you about how your body physically works.

2) Voting: Things are happening in the world that you may not even realize at this point. Your future (and especially the future of your children if you have any) is in

serious jeopardy. You need to be educated so that you can make wise decisions about voting (and if you don't vote, YOU NEED TO!)

3) The environment: I think the environment is the most important part of this whole class. The environment is everything around you and YOU NEED the environment (even though you don't know it). Many people do not respect the environment. As a result, the environment has become seriously damaged, mainly in just the last 50 years. Because of this damage, severe consequences have occurred that you might not be aware of. The world as your grandparents knew it is coming to an end. Many ecologists (biologists who study the environment) state that next to a total global nuclear war, the damage to the environment due to the human population growth and use of resources, is the most serious threat to the human race. We will talk more about the environment throughout this class.

4) Taking care of your current/future kids. Important stuff that you may not be thinking about at this time.

The Scientific Method:

Scientific Method - How Does Science Work? Science has specific rules. The rules are basically the following:

First- An observation is made

Second- A Hypothesis is formed about the observation. Often we work with many hypotheses (plural of hypothesis.)

Third - Experiments are done to evaluate the hypotheses.

Four - Conclusions are made. Often, new observations take place and start the cycle over and lead to further scientific studies.

Story Time. And yes, stories are fair game on quizzes and exams! When I was about seven, my cousin Kim and I were sent into Orange Julius to order food for the family. My cousin suggested we should order this drink called an Orange Julius. So we did and when we ordered the drink, the lady behind the counter said that if we finished drinking it before our order was ready, we would get another one for free. My cousin, who was older and much bigger than me, drank hers very quickly and then proceeded to cheer me on..."Come on Timmy! Come on Timmy! Hurry up and finish drinking it so we can get another one for free!" Well, I did finish it and I ran up to the counter to get another one for free and when I did, I got VERY sick and vomited all over the counter and all over the entire Orange Julius! Now applying the scientific method to this story. I made an observation: 1) I got sick and threw up. Step 2, I formulate a hypothesis. Maybe I threw up because I drank the Orange Julius too fast. BUT, there could be many other good hypotheses. It could be that I am not able to drink that much. It could be that my cousin got me too excited by cheering me on and that made me sick. Maybe I ate something bad earlier that day. Lots of things might have had an effect. After coming up with a list of hypotheses, you need to test each one (the third step) and from there, come up with conclusions.

Characteristics of Living Things

What is the difference between life and non-life?

Although many non-living things might have some of these characteristics, ALL living things have ALL OF THESE characteristics (well, most of the time!). There are always exceptions.

1) All living things can reproduce (even if your dog is spayed or neutered, it can still reproduce new cells such as skin cells).

2) All living things are made up of cells. 3) All living things can respond to their environment. 4) All living things are capable of evolving.

5) All living things must maintain homeostasis (this is an internal type of balance system). For example, your body temperature must stay close to 98.6 °F. There is a certain amount of water and salt in your body. You can lose some and gain some, but if you get too far out of balance, death results. This is true for all living things (although the exact temperature or amount of salt can differ from organism to organism).

6) All living things need to use energy in order to stay alive.

7) All living things inherit a genetic code.

8) All living things are organized. This also varies from organism to organism, but in general, cells are organized and function together in organized units such as tissues and tissues are organized into organs and organs are organized and work together to form organ systems and so forth. This organization continues into populations and communities in which individual organisms interact with each other. As you move up in organization, the complexity of the system also increases. This is a common theme in biology called **emergent properties**. This basically means that the whole is greater than the sum of the parts (the interaction of the parts generates greater complexity).

Introductory Chemistry

Living things are made up of parts. If you take apart the parts, you get more parts. Eventually, you get down to the very tiniest of parts (which, by the way, also have parts). Anything that takes up space and has mass (which is like weight) is called matter. In biology, a good place to start when talking about matter is with atoms (which are very, very, very small).

An Atom is made up of protons, neutrons and electrons. Protons have a +1 charge, electrons have a -1 charge, and neutrons are neutral and have no charge. The protons and neutrons are located in the center of the atom (a region called the nucleus). The electrons spin around the nucleus. The electrons are located in different distances from the nucleus. These distances are called energy levels and the space in which the electrons are held are called orbitals. Each orbital can hold two electrons in it. A total of 2 electrons can be held at the first energy level because there is one orbital. Eight electrons can be held in the second and third energy level because there are four orbitals in each. Different atoms have different numbers of protons, electrons and neutrons. **For the most part, it is the protons and electrons that we need to pay attention to.**

Here is a picture of a hydrogen atom and a helium atom: (Fig 1.1a)

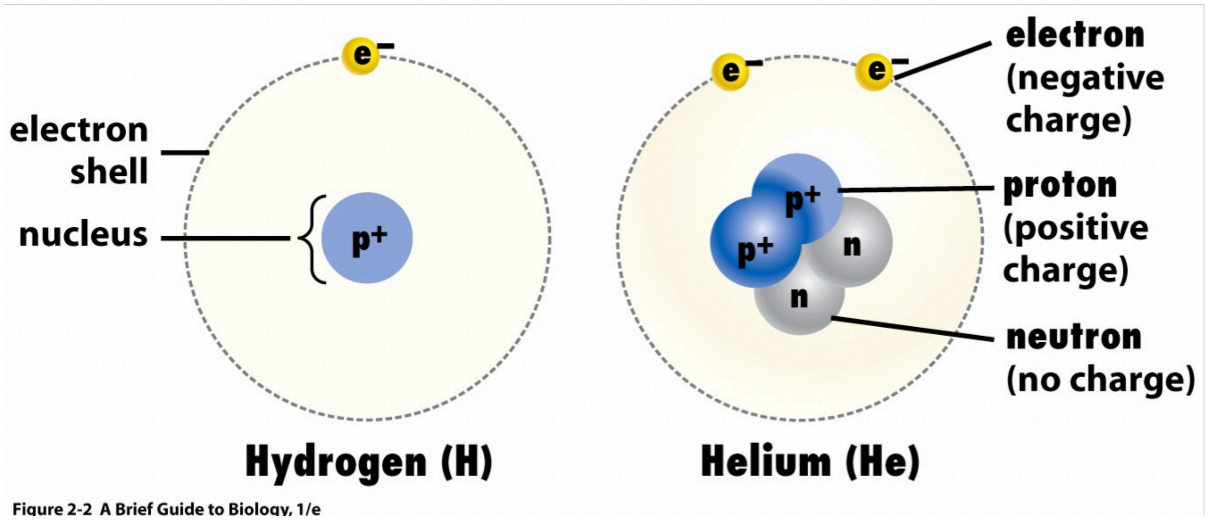


Figure 1.1a

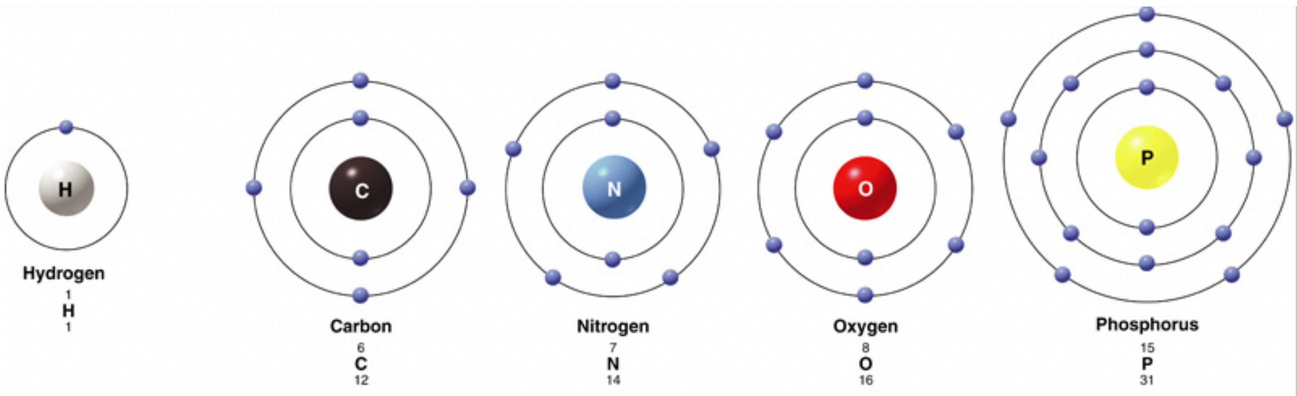
In a balanced, normal atom, the number of protons is equal to the number of electrons (we will see in a minute that this can change). So, in the picture above, the hydrogen atom has 1 proton and can attract 1 electron (one positive thing can attract one negative thing). In the picture below, more protons can attract more electrons. As electrons are added, they are added in such a way as to fill up the

lower energy level first. In other words, before an electron can be placed in the second energy level, the first energy level must be filled first.

In the picture below, look at an **oxygen** atom and a **nitrogen** atom (Fig 1.2a). The oxygen has eight protons and eight electrons (2 in the first energy level and 6 in the second energy level). There are also neutrons (not pictured), but they are generally not important in how the atom functions so we don't need to worry about them at the moment. Notice that the nitrogen atom has seven protons and seven electrons.

These first three atoms are very common in living things. Also important and very common are **Carbon, Sodium, Chlorine** and **Phosphorous** (especially carbon). You should make sure to remember how many protons and electrons each one of these has (and where the electrons are).

You should also be able to draw any of these atoms. Figure 1.2a shows the most common atoms in living organisms.



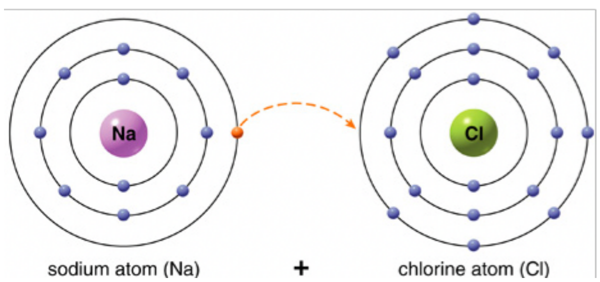


Figure 1.2a

I should mention that these models of atoms are inaccurate in how they place atoms in a particular spot. In reality, we believe that the atoms move around the nucleus in sort of a “cloud” of probability as to where the atom might be during specific times. We won’t worry about this, however, and we will just stick with the oversimplified models above.

Ions

Ions are atoms that have gained or lost electrons. Notice in Fig 1.3a that the only difference between the sodium atom and the sodium ion is that the sodium atom is

missing an electron. When this electron is lost (in a minute, you will find out what causes that to happen) the sodium atom becomes a sodium ion. Because the sodium ion has 1 more proton than electrons, we symbolize it as Na+, implying that it has an electrical charge.

Chlorine atoms can also form ions. In Fig 1.3a you can see that when a Sodium atom (Na) loses its electron, it moves over to the chlorine atom which then turns into a Chloride ion. When the sodium loses an electron (and becomes a sodium ion) and when the chlorine atoms gains an electron (and becomes a chloride ion), they become attracted to each other (because one is positively charged and one is negatively charged). When they stick together, they form an ionic bond. This then becomes NaCl which is a molecule better known as table salt.

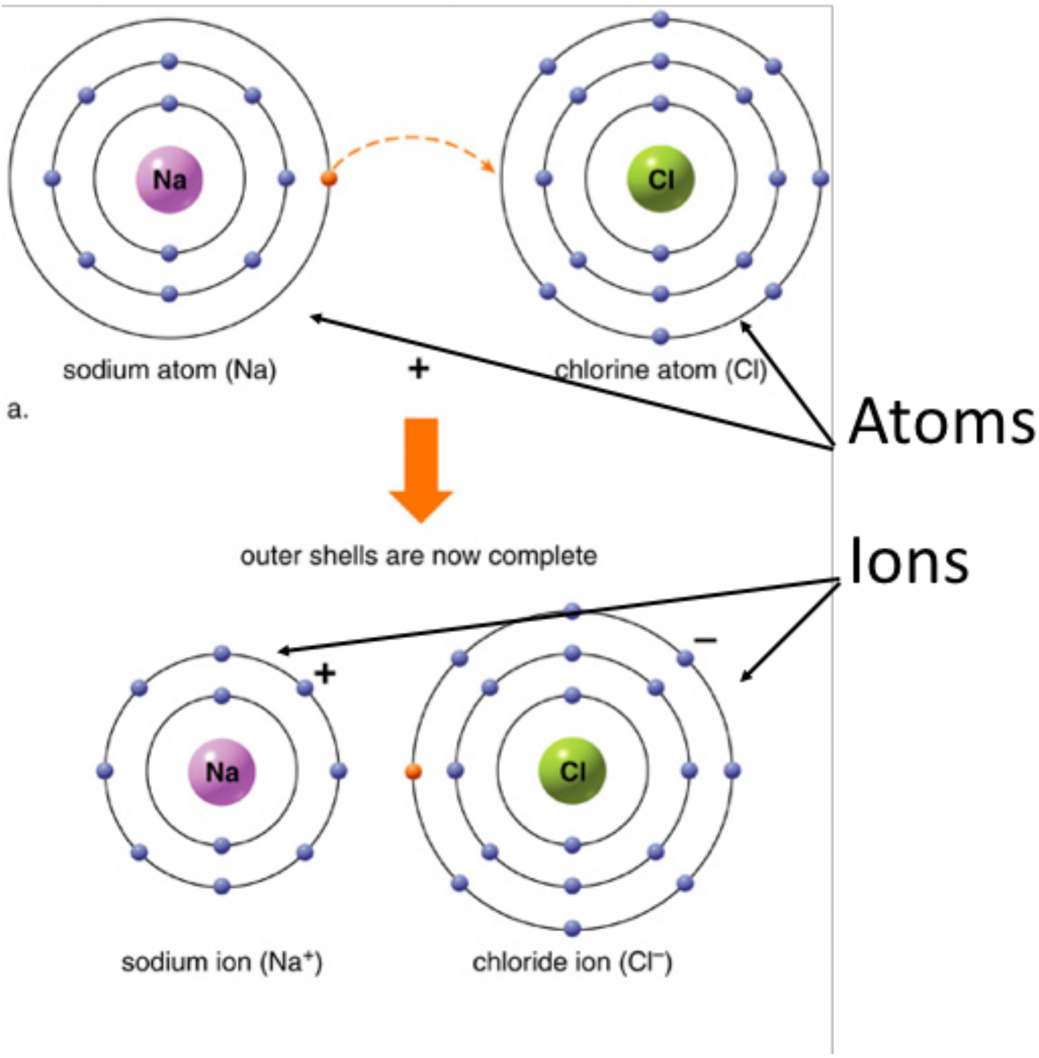


Figure 1.3a

It just so happens that all atoms are most stable when their outer electron shell is either filled with electrons or is empty. If I attached a wing onto each side of my car and then drove really fast down the road, I might be able to actually fly (for a very short distance). But if I attach a wing to ONLY ONE SIDE of my car then it would be very unbalanced and I would generate lift on only one side. The atom kind of works that way. There are two main ways that an atom can reach this balance. One is that the two atoms can share electrons (a covalent bond...see below).

The other is that one atom can "steal" an electron away from another atom. This makes both atoms turn into ions (again, ions are atoms that have either gained or lost electrons). In the picture above, you should notice that the Chlorine has stripped the Sodium of one of its electrons:

Now, the Sodium will have +1 positive charge and the chloride ion will have a -1 negative charge (because it now has 18 electrons and 17 protons). Because the Na+ is positive and the Chloride (Cl-) is negative, the two are attracted to each other and form an ionic bond.

Isotopes

Isotopes are atoms that differ in the number of neutrons they have. For example, carbon comes in several different isotopes. Two of the most important ones are carbon-12 (with 6 protons and 6 neutrons) and carbon-14 (with 6 protons and 8 neutrons). Here is a picture of three different isotopes of hydrogen (Fig 1.4a). You do not need to remember these specifically, as long as you know what an isotope is:

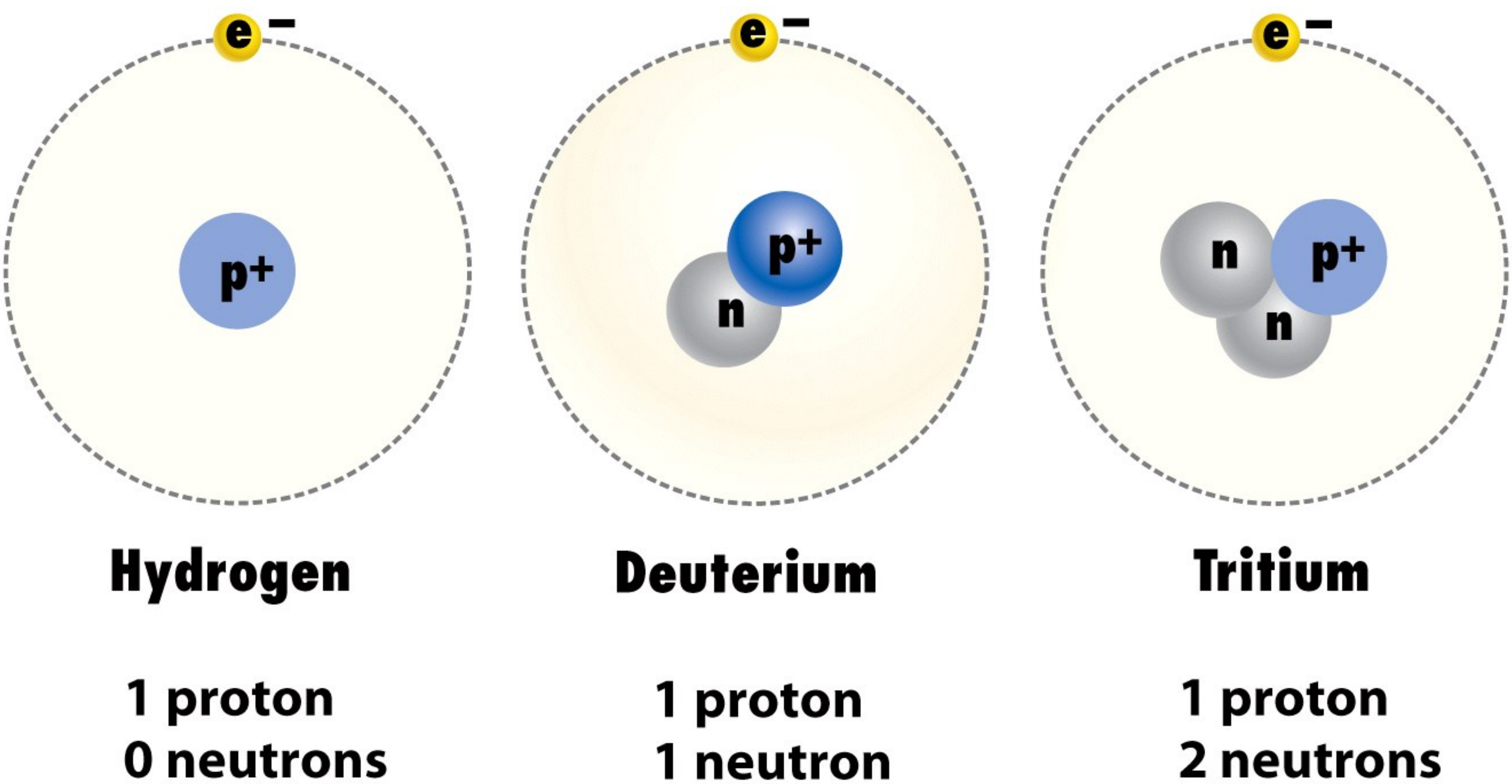


Figure 1.4a

Individual atoms are often unstable by themselves. In order for an atom to be "balanced", an atom's outer electron shell (or valence shell) must be filled with electrons. This can be achieved in several ways. An atom can gain or lose electrons (which forms the ions we just talked about). Or, two or more atoms can share electrons. When two atoms are connected, they become a molecule. Chemical bonds hold the two atoms together. In this class, chemical bonds can be divided into four basic types:

1) **Ionic bonds** - these form between ions (see example above)

2) **Covalent Bonds**- bonds that form when two atoms share electrons 3) **Hydrogen Bonds**- weak bonds that form when a molecule has slightly positive and/or

negative regions.

4) **van der Waal interactions** – Even non-polar covalent bonds will occasionally have slightly positive and negative regions every now and then. This results in very weak bonds (similar to those of hydrogen bonds) called van der Waal interactions. We won't talk about these very much.

Covalent Bonds

One way that atoms can become balanced is to share electrons. For example, take a look at a hydrogen atom. It has 1 proton and therefore can attract one electron in the first energy level. But for the atom to be stable, it would need to have two electrons in the first energy level (because remember, the atom is most stable when the outer energy shell is either full of electrons or completely empty). So, if TWO hydrogen atoms were to get together (each needs one electron and each has one electron) they could each share their electron (Figure 1.5a). This would mean that some of the time the two electrons would be around one hydrogen and other times they would be around the other hydrogen. This forms a covalent bond. This is a very strong chemical bond and you will pretty much see this every day for the rest of your life. Well, at least this semester.

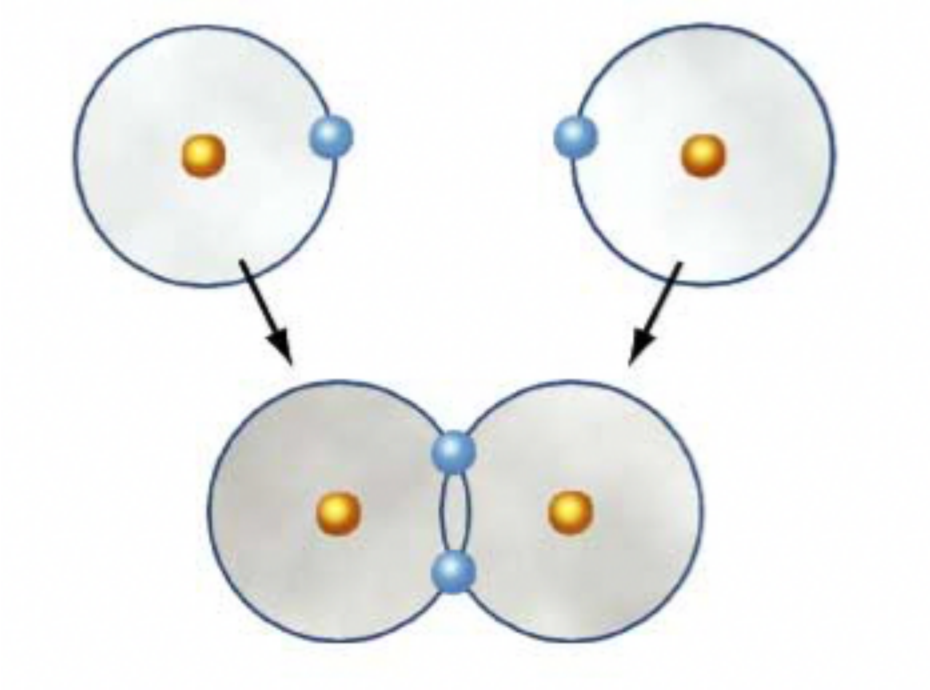


Figure 1.5a

Now, let’s look at another covalent bond. Let’s look at Oxygen. An oxygen atom has 8 protons and 8 electrons. In the first energy level, oxygen fills the entire shell with 2 electrons. That leaves six electrons left that are placed in the second energy level. But

the second energy level can hold a total of eight. So, how many covalent bonds can oxygen form?

Oxygen can form 2 covalent bonds. It can form them with many different atoms. In this case, I'm showing you an oxygen atom that is forming one covalent bond with one hydrogen atom and another covalent bond with another hydrogen atom. What molecule is formed from one oxygen atom and two hydrogen atoms? Water (Figure 1.6a)!

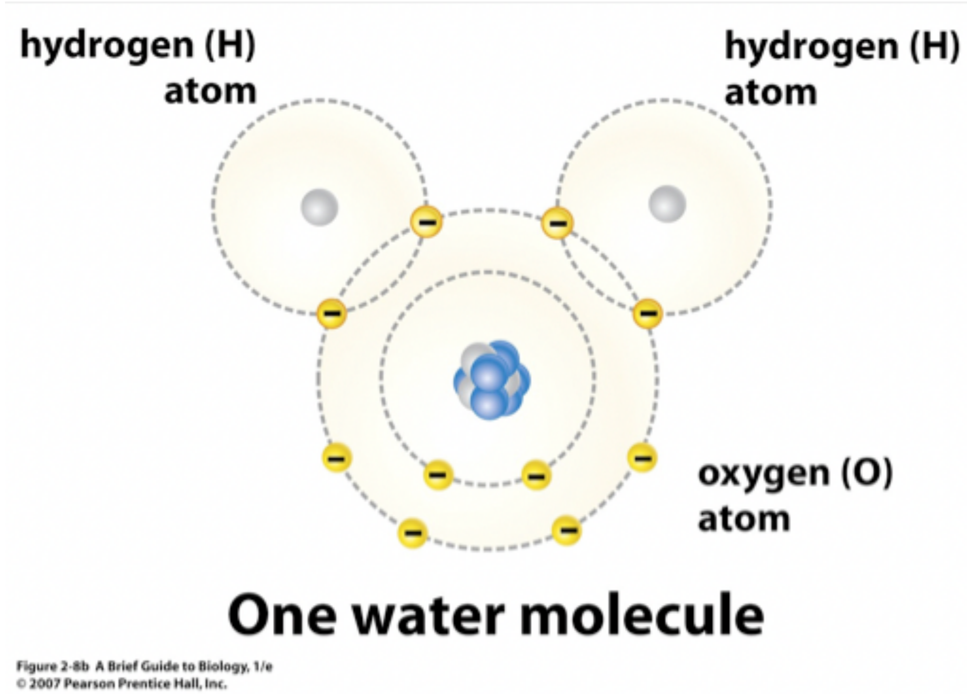


Figure 1.6a

Hydrogen Bonds

Now remember that a COVALENT bond forms when two or more atoms share electrons. Well, sometimes they don't share the electrons equally. Instead, one of the atoms pulls the electrons with more force. It's kind of like a tug-of-war match between Arnold Schwarzerneger and a little kid. Now also remember that the electrons are negative. So, if one atom (the "Arnold atom") pulls the electrons slightly more towards it, then it will become slightly negative. And the other atom (the little kid) will become slightly positive. This type of covalent bond (when electrons are shared unequally) is called a polar covalent bond. Figure 1.7a is an example of several water molecules. The arrow shows that the molecule has a slightly positive and slightly negative region. Notice that the hydrogen bond is between the two adjacent water molecules. That is because the slightly positive regions of one water molecule are attracted to the slightly negative regions of another water molecule. I say slightly negative because it is not a full +1 or -1 charge; in order for that to occur it would have to pick up or lose one or more electrons (which would make it an ion). Hydrogen bonds can form between other molecules; water is just one very good example!

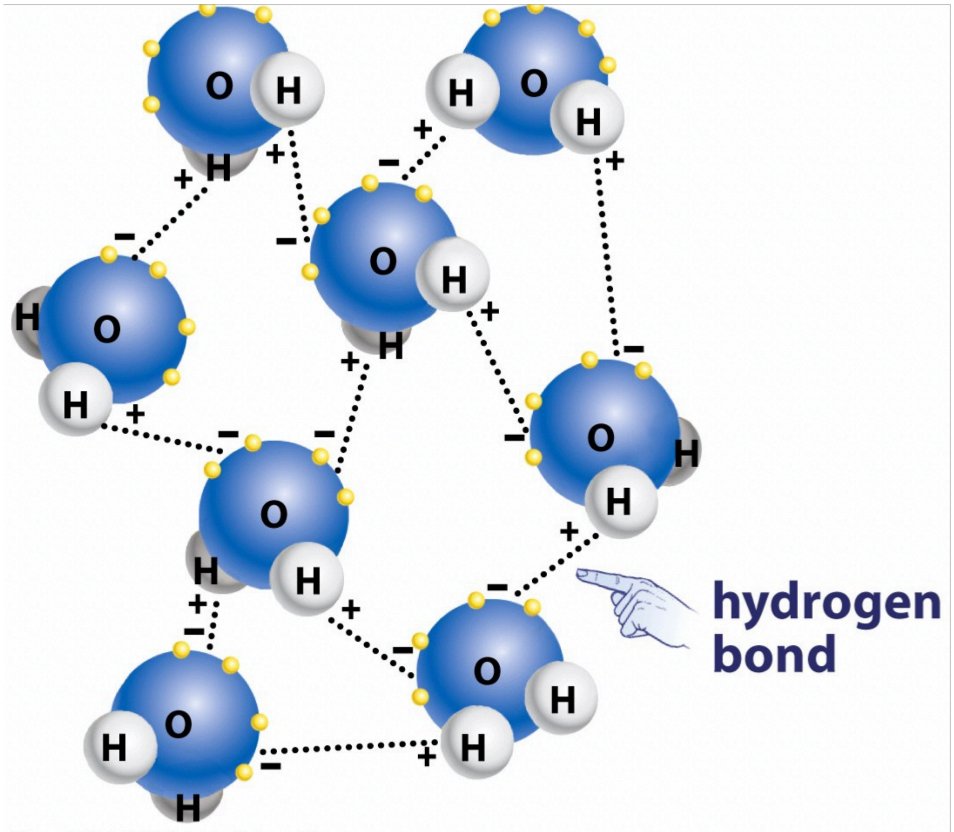


Figure 1.7a

ACIDS AND BASES

By now, you should realize that the way molecules behave depends largely upon their electrical charges. **Acids and bases** can have drastic effects on the overall electrical composition of a solution. Therefore, acids and bases can greatly affect the way molecules behave. This will be VERY important a little later on in the course....BUT FOR NOW:

An Acid is a chemical that ADDS **Hydrogen ions** (H+) to a solution.

A Base is a chemical that REMOVES Hydrogen ions from a solution. Many bases REMOVE hydrogen ions because they actually ADD **Hydroxide ions** to the solution (OH-). A hydroxide ion is a water molecule missing one of the hydrogens but is keeping the electrons it would share with that hydrogen. These Hydroxide ions combine with the H+ and form water.

We measure how acidic or how basic a solution is by using a pH scale. It ranges from a scale of 1 to 14. The **pH scale** is an INVERSE measure of how many H+ ions are in a solution. This means that something with a pH of 1 or 2 is very acidic and has lots of H+ floating around. If a solution has a pH of 13 or 14, it is very basic and does not have many hydrogen ions floating around in the solution. A pH of 7 is considered neutral. Stomach acid and battery acid are very acidic. Oven cleaner is very basic. Water is considered neutral with a pH around 7. Figure 1.8a below shows the pH scale and several examples of acids and bases.

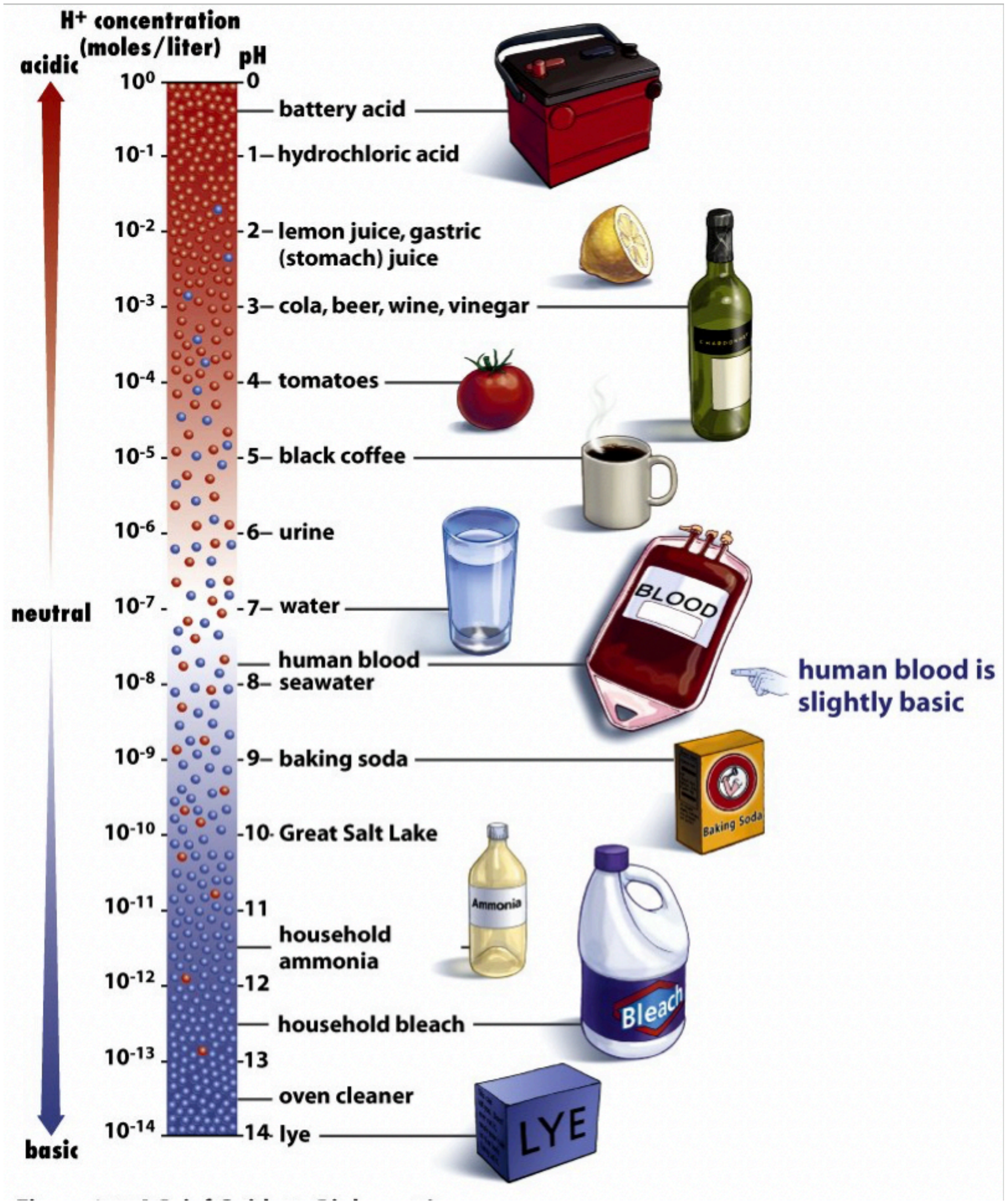


Figure 1.8a

The Importance of Water

Water is a very, very important molecule in all living things. Nearly all of its important properties are linked to its structure.

Cohesion:

Because water is made up of polar covalent bonds, it ends up having a slightly negative oxygen region and a slightly positive hydrogen region. This means that one water molecule can stick to another water molecule. The bonds that hold two water molecules together are very weak and are called hydrogen bonds (make sure you are not confusing this type of bond with a covalent bond which is strong). The property of anything sticking to itself is called cohesion.

Adhesion:

Water, with its slightly negative and positive regions, can also form hydrogen bonds with other polar molecules and ions (such as glucose and $Na+$). When something is adhesive (like tape) it sticks to other things.

High Specific Heat:

Although the hydrogen bonds are weak, there are so many of them that water is constantly breaking and forming new hydrogen bonds. This makes individual water molecules move around nearly all the time. If you want to increase the temperature of water, you need to make the molecules move faster (temperature is a measure of the average movement of molecules whereas heat is a measure of the total amount of movement of the molecules). Because of the many hydrogen bonds constantly breaking and reforming, water strongly resists temperature change. This is called having a high specific heat. When something has a high specific heat, it takes a lot of energy to increase the temperature. Likewise, it requires the loss of a lot of energy for water to decrease in temperature. If you were going to buy a house, where would it be cheaper, Huntington Beach or Victorville? The reason that a house in a place like Huntington Beach is so expensive has everything to do with the High Specific Heat of the Pacific Ocean (well, it has a lot to do with it).

Surface Tension:

Water also has a high surface tension. A high surface tension results because the water molecules below the surface are attracted to one another whereas those on the surface

ARE NOT attracted to the air. Therefore, water molecules (at the surface) create an almost solid surface. If you dive in a pool INCORRECTLY ("belly flop") you will notice this high surface tension very quickly! If you dive in correctly, you can enter with very little effort because you have less hydrogen bonds to break relative to the "belly flop". This property also allows some animals to walk on the surface of water (Figure 1.9a):

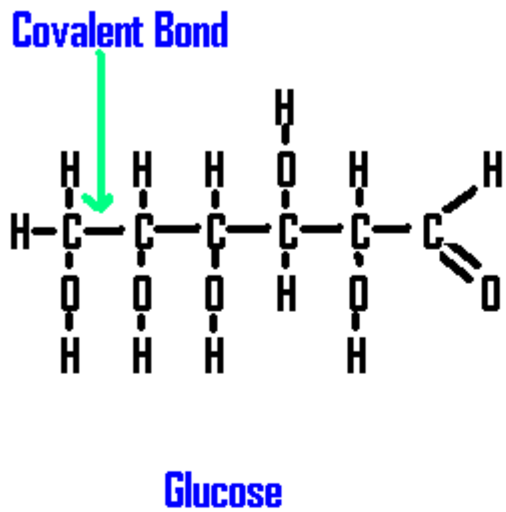
Figure 1.9a

Density when Frozen:

When things cool down, the molecules normally get closer together. When they heat up, the molecules move apart. This is true for water, for the most part. As water heats up, it expands and eventually turns into a gas. As it cools down, the molecules get closer together and the water becomes denser. At about 4 degrees Celsius, water is at its densest. As it gets colder than that, it starts to EXPAND again. This is a very unusual property. This means that as water starts to turn into ice, it becomes less dense and starts to float. This is very important in lakes and the ocean and means that life can still persist below a frozen body of water.

Methods of Drawing Molecules

So far, we have drawn each atom showing all of its electrons and where they are located. But this is going to take too much time when we start getting into the much larger molecules. So, we have ways of cheating. The picture below is a common way in which molecules are drawn. Each line between the carbon and hydrogen (or carbon and carbon or carbon and oxygen) is a covalent bond. Next to this is an even easier way to represent this molecule (Figure 1.10a). In this case, I just tell you how many of each atom can be found.



$C_6H_{12}O_6$

Figure 1.10a

Coming Up....(but you need to know at least this part for this coming quiz!)...

Smaller molecules are used to make larger molecules (or macromolecules). The smaller units are often called **monomers**. **Monomers** are hooked together to form larger molecules called **polymers**. There are four large kinds of molecules that we talk about in biology. They are:

Carbohydrates – such as glucose and starch.

Proteins-these include structural proteins such as keratin (found in hair and fingernails), and enzymes (such as lactase and sucrase) which are used to build and break down other molecules.

Lipids – such as fats and steroids **Nucleic Acids** – such as DNA and RNA that are used in the genetic codes of all living organisms.

PLC#1

Make a short video introducing yourself to the class. Directions will be explained in the module during week 1.

Make sure you know these questions and words as well:

1) An atom with a total of 6 protons and 6 electrons would be a/an:

A) Carbon atom

B) Nitrogen Atom

C) Hydrogen Atom

D) Hydrogen Ion

E) Phosphorus Atom

2) An atom with 5 electrons in the second energy level can form how many covalent bonds?

A) 1

B) 2

C) 3

D) 4

E) 5

3) Which of the following would have the highest pH?

A) Water

B) Stomach Acid

C) Oven Cleaner

D) Blood

E) Urine

4) Which of the following is the highest (or largest) level of organization from the list provided (Use your textbook or internet)?

A) Organelle

B) Organ System

C) Community

D) Organism

E) Tissue

5) Which of the following is the most common atom found in the human body (Use your textbook or internet)?

A) Oxygen

B) Hydrogen

C) Carbon

D) Nitrogen

E) Sodium

6) What is a free radical and why are they bad (Use your textbook or internet)?

7) What do the term hydrophilic and hydrophobic mean?

8) What is the pH of lye, hydrochloric acid, cola, and blood?

9) What causes acid rain (Use your textbook or internet)?

10) What is the difference between a lump of coal and a diamond (Use your textbook or internet)?

11) What is the difference between a monomer and a polymer?

Words that you may be asked to define or use in fill-in-the blank types of questions. Make sure you look these up:

Atom, Ion, Isotope, Covalent Bonds, Ionic Bonds, Hydrogen Bonds, Adhesion, Cohesion, Homeostasis, Emergent Properties, Specific Heat, Surface Tension, Acid, Base, pH, Free Radical, Hyrdophilic, Hydrophobic, Monomer, Polymer, Lipid, Carbohydrate, Protein, Nucleic Acid. H+, OH-, Polar, Non-Polar,