Science-1A Lecture: Week-10, Friday, October 15, 2021

In the chemistry part of Science-1A, I like to give a lot of attention to biochemistry and environmental pollution since those are extremely relevant to the decisions we must make in our lives. Also, it is just plain extremely interesting. When I was 12 years old, I knew that we were just made from a bunch of chemicals, but it was a mystery how that bunch of chemicals makes a living organism different from just a bucket of chemicals. I was unaware that the structure of DNA, crucial to answering that puzzle, was just being discovered at that time.

The Atoms in Humans

The handout entitled "The Atoms in Our Bodies" is at
https://yosemitefoothills.com/Science-1A/Handouts/Week-09/AtomsInHumans.pdf .
It shows that we are mostly composed (by mass) of oxygen, carbon, hydrogen, and nitrogen, but lots of other atoms are necessary. Some like cobalt found in Vitamin B_{12} are essential even though only needed in extremely small quantities. Study that handout to learn more.

Metabolic Pathways and Enzymes

An enormous amount of biochemical research has revealed how living organisms make thousands of specialized chemicals to let us live and reproduce. It is a system perfected by evolution over millions of years starting with our microbe ancestors. The commonality between how all living creatures live is amazing, and the most startling way to appreciate that is through a chart called the "Metabolic Pathways Chart" which shows many pathways which are shared throughout the living world. Biochemistry students must study this and know all its details, but we get to just sit back and admire it. If you have any friends studying biochemistry or medicine, give them a virtual hug. They need it, but also let them tell you about the amazing things they are learning.

The chart is large and difficult to see in a normal image, but I have cropped off a portion of it for a starter. It is entitled "Lower Portion of Metabolic Pathways Chart" and found at
https://yosemitefoothills.com/Science-1A/Chapter_08-AtomsAndPeriodicProperties/MetabolicPathwaysChart-LowerPortion.png .

Blow up the lower left corner to show the pathway that ends with HEME. At the very bottom is a series of arrows leading from Porphobilinogen to HEME with a series of chemicals separated by arrows with 4-digit numbers. The chemical structures of each chemical is shown above their name and each set of numbers identifies an enzyme that reduces the energy barrier and allows the conversion to the next molecule to occur. If you study the molecular diagrams carefully, you can see the some COO– groups were clipped off to make Protoporphyrinogen which is part of chlorophyll, the key molecule in making sugars from sunlight energy. A bit more enzyme magic and HEME is produced that leads to hemoglobin used to carry oxygen from lungs to muscles in animals. This is how life works – thousands of enzymes altering thousands of molecules in slight ways to make an amazing cooperative feedback control system that can find and process food, defend itself, and reproduce.

In the middle below the picture of a runner, is an amazing set of molecules that form a **rotating** pump that is powered by hydrogen ion concentration differences. It produces molecules called ATP that provide conveniently-sized chunks of energy needed in hundreds of reactions. This chart is full of amazing stories.

A link to a full, interactive metabolic pathway chart is at
http://www.metabolic-pathway.com/fullMap.html .

None of these show the list of the thousands of enzymes that facilitate the conversion from one molecule to the next. Those were listed on the back of the chart I was given years ago. I think mine is the same sold by Sigma-Aldrich at
https://www.sigmaaldrich.com/catalog/product/sigma/m3907?lang=en&region=US
You might be sent a free one if you explain you are becoming a teacher. In any case, the price is not outrageous. What do you do with the chart? Admire it, and show it to others.

In Wednesday's lab, you learned a bit about the toxicity of mercury and snake bites. With this amazing metabolic pathways chart in mind, you can probably appreciate how snake or spider bite can mess up one enzyme and disrupt a key pathway leading to death. You can also appreciate that medicines that aim to affect one enzyme-mediated reaction can have side effects with totally-unrelated that use the same enzyme for a different purpose.

Metallic sodium burns in water and chlorine gas is poisonous. So why can we put NaCl on our food?

An old vaudeville show involved tossing sodium metal Na into water and showing how it bursts into flames. Every few years a railroad accident causes a tank car full of chlorine gas Cl_2 to derail in a town and the whole town is evacuated. Yet, we put table salt on our food which is sodium-chloride, NaCl.

This interesting paradox has a simple answer: metallic sodium and chlorine gas are highly reactive, but when reacted to make NaCl, they become sodium ions and chloride ions which have far less reactivity. The sodium has lost its outermost electron to the chlorine making both happy with filled outermost electron shells.

This is shown using chemical equations in the handout entitled "Metallic Sodium in Water Compared with Sodium Chloride in Water" at
https://yosemitefoothills.com/Science-1A/Handouts/Week-10/MetallicNaAndNaClInH2O.pdf .

In that handout, you need to know that a **mole** of stuff is like a dozen except that 1 mole is 6.022×10^{23} things while a dozen is only 12. When written as a unit, we just write mol, without the final "e".

The first equation, $\mathbf{2\,Na(s)+2\,H_2O(l)\Rightarrow 2\,Na^+OH^-(aq)+H_2(g)+364\,kJ}$, says that 2 mol of solid (s) sodium Na added to 2 mol of liquid (l) water H_2O react to produce 2 mol of aqueous (aq) sodium-hydroxide NaOH plus 1 mol of hydrogen gas (g) H_2 while releasing 364 kJ of energy. (Aqueous means dissolved in water.) Thus, the energy locked up in the metallic sodium atoms is released when they become ions in table salt leaving the sodium ions Na^+ with far less energy. Similarly, when a Cl_2 molecule is separated into two Cl^- ions, energy is released leaving the Cl^- ions with far less energy. (We will cover moles more thoroughly in week 12.)

With that introduction, I hope the above handout makes sense even though it is your first introduction to chemical equations.