Chemistry

Chapter 2b

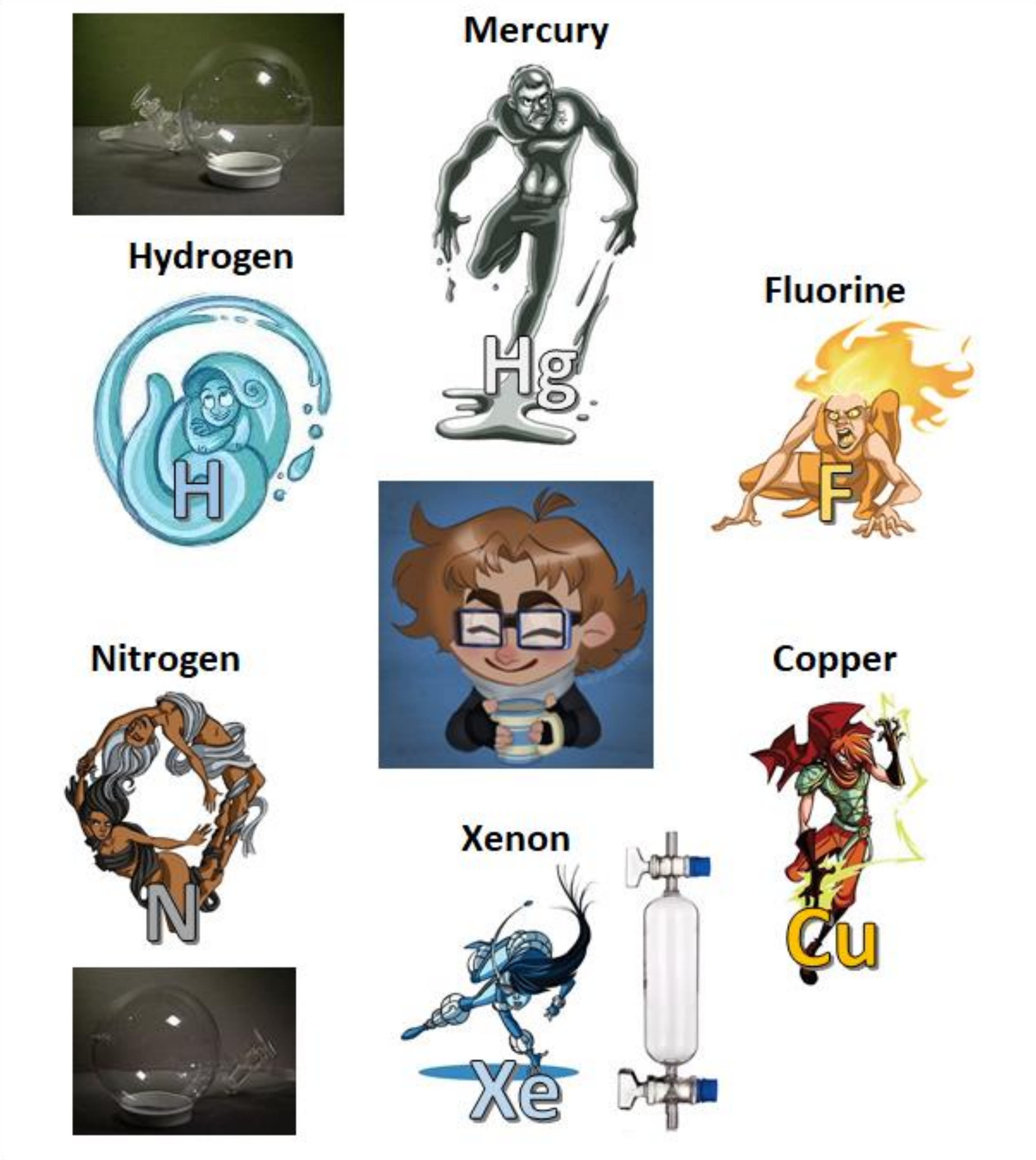
Periodic Elements

In a previous section we learned about elements as one of the important groups of substances. In this section we are going to look at them in more detail.

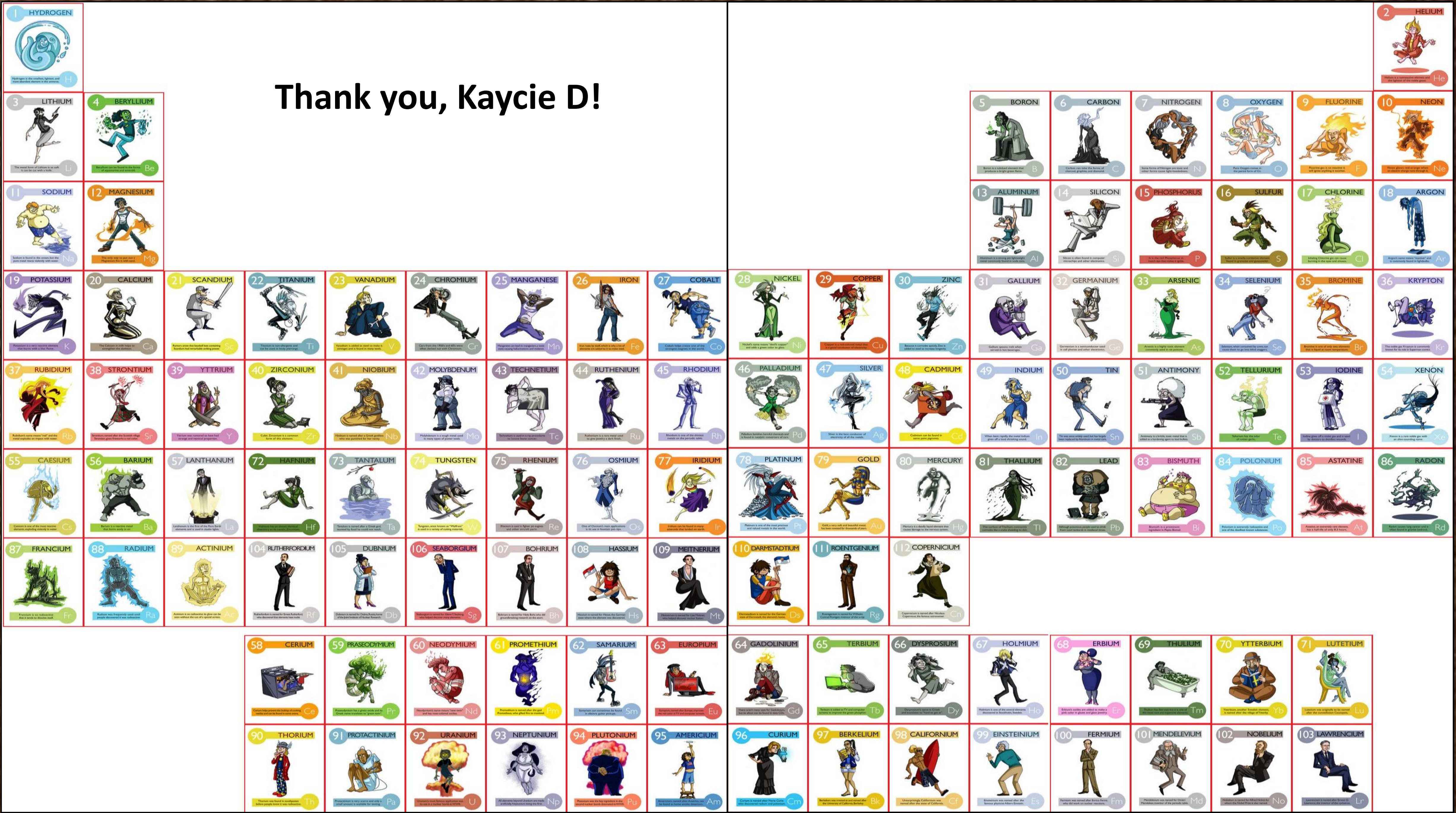
As we said in that previous section, each element has its own personality and appearance, but sometimes we might ***superficially*** see them as similar. Hydrogen, nitrogen, and xenon look very much the same. So do other elements, at least they ***look*** alike. Often, however, they are very different in how they act and what they do.

We should thank an artist named Kaycie D. She decided to learn about the elements and to create little doodles for each of them. She understood that each element is unique—they are all different. She gave them personality, so they stood out one from another.

We will use Kaycie’s art to help you see the elements as different from each other and each having its own personality. Otherwise it is too easy to see many of them as similar.



Thank you, Kaycie D!



So, what is an element? Once scientists were looking for the basic building blocks that make up the world. They used the word “element” to describe these things. At first their idea of an element was not very good. They thought that there should be hard things, and floaty things, and watery things, and burny things. So people talked about earth, air, water, and fire as the four elements.

Even then, people knew that wasn’t right. After all there were things that they knew weren’t made of earth, air, fire or water, so they had to think of fifth element that could account for those other things. Because they didn’t know what this fifth element would look like, they just called it ether and they used it as an excuse for anything that didn’t seem to fit their model of five elements.

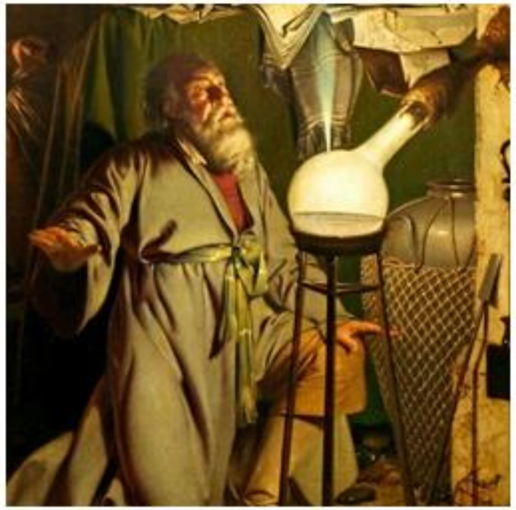
This was the model in Greek and Roman teachings. In China they had a very similar model. They had earth, water, fire, wood, and metal. For the Chinese each of these elements has a color as well and they still use these colors today.

Of course all these models were wrong, but you can see people were searching for a definition of the basic building blocks of all things on earth: elements.

So, long after the Roman Empire, people were still looking for elements. They had some elements, but they didn't understand what they had any better. They could separate gold and mercury, silver and tin, lead and copper, but they didn't know that these metals were elements and different from bronze, steel, and brass which are ***not*** elements. If you look at them, it's hard to tell the difference. We can understand why then hadn't really worked it out yet.

Then in 1669 there was a man who conducted an odd experiment. Well, it seems odd to us, but back then people were trying to figure out how to do very odd things with chemicals. They knew that gold was yellow. They assumed that anything yellow probably contained gold. When you pee, it's yellow. The question was how to get the gold out of the pee.

The scientists, they called them philosophers back then, was Hennig Brand. He took a lot of pee and boiled it down into a black powder and a red ooze. When he heated them some more, they lit on fire and created a bright light. He didn't know what he had, but we would recognize it today as the red powder on matches. Hennig just knew that it made light, so he named it ***phos phoros*** (light bringing). Today we call this element phosphorus.



The next big step was taken by Antoine Lavoisier. Up to that time, people like Hennig were not sure how chemicals worked and they were trying to break the chemicals up and destroy the parts they didn't want. If I can get rid of the wet part of pee, I'll have gold, right? Lavoisier wasn't sure that was quite right.

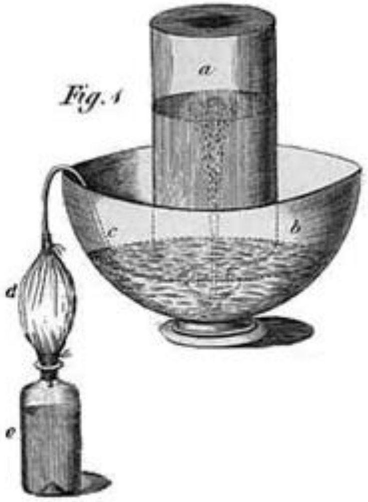
Lavoisier spent time working with chemicals during reactions in sealed containers. He measured everything before and after and he saw that the ***mass*** of the ***reactants*** was the same as the mass of the ***products***.

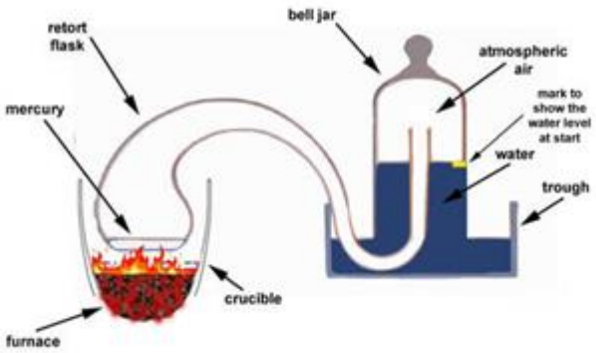
- Mass is the measure of how much stuff there is.
- Reactants are the things that were there in the beginning and react.
- Things made by the reaction are called products.

By putting everything in a sealed container, he was able to prove that nothing was being lost or created. It was still there…it just looked different.

Lavoisier used this understanding to look at experiments others had done. Joseph Priestly had discovered an element that made acids. He called it ***oxys gen*** (acid maker) or oxygen. Lavoisier figured out that oxygen in the air was being used when things burned. He also figured out that "fixed air", a strange thing that would sometimes occur was created when things burned. We now call this carbon dioxide.

Lavoisier's experiments changed things forever. People quit trying to destroy and create parts of chemicals and they began seeing them combining and pulling apart.

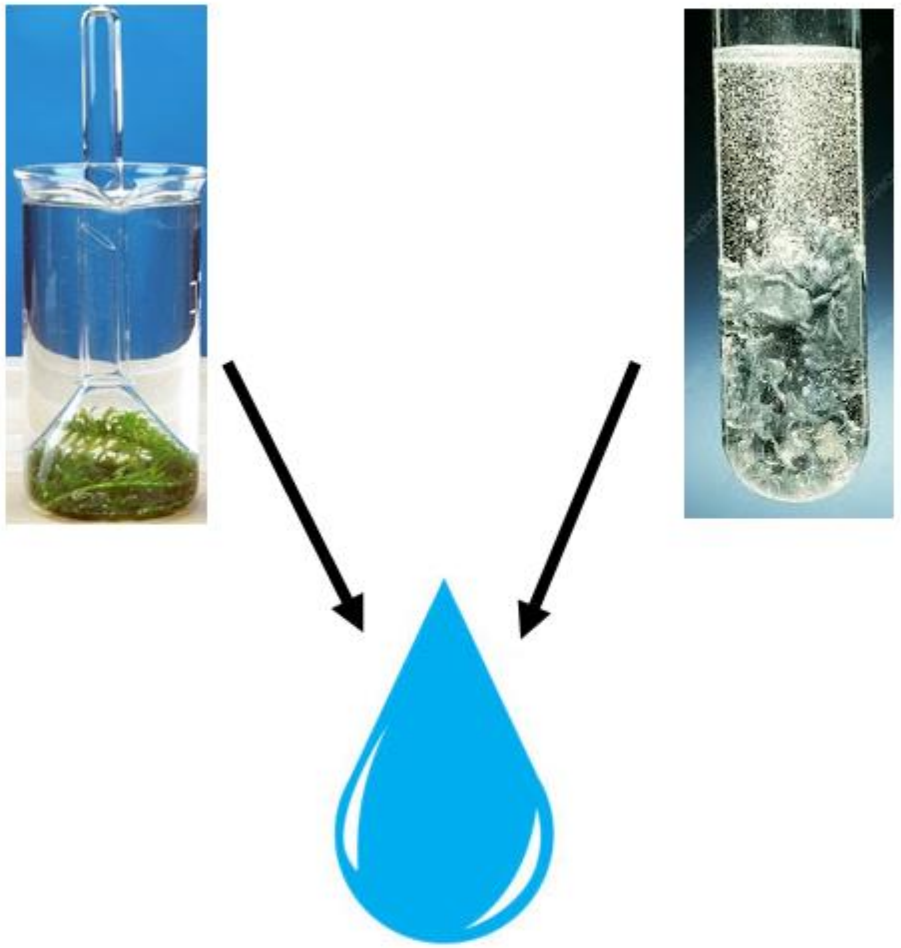




After Lavoisier, chemists could work with two chemicals and see how they combined. Then they could break them apart again and again, trying to find the purest form of the elements that make it up. When Priestly discovered oxygen he was using plants to separate an “air” which he later named oxygen. In another experiment, Boyle used an acid to eat a metal and create bubbles of a “flammable air”. Both Priestly and Boyle believed they were looking at substances that contained a kind of fire. They didn’t know what they had.

Lavoisier’s experiments showed that Priestly’s oxygen was being eaten up as a reactant to make fire. Once he knew that, he showed that Boyles flammable air was combining with the oxygen to make water. He renamed flammable are ***hydro gen*** (water maker) or hydrogen. Even though he still didn’t understand what an atom was or how atoms and elements were related, he now could lay out experiments to purify elements and show how they combined.

For many years after Lavoisier, people continued to use his methods to purify various elements and figure out how they reacted and what they did.



Over the next hundred years people began to discover new elements and name them. As they compared them with each other certain patterns began to stand out. One of the patterns seemed to be a repeating set of similar chemical properties. One example was a group of elements called alkali metals that really, REALLY don’t like water. If you put these metals into water, they will explode with increasing ferocity. Like a bomb. Somehow, they were all related.

John Newland saw the pattern, but he couldn’t really fit it into a useful model. You can see his group B contains all the alkali metals. Still, his model had problems like multiple elements in the same box and metals associated with non-metals. It just didn’t make sense.

Then Dmitri Mendeleev arranged the chart a little differently. He still had problems, but we could now see that things were definitely falling into fixed patterns. More importantly, while Newland tried to fit everything into a nice neat chart, Mendeleev left several blanks. He knew that he didn’t have all the elements yet, but we could see where something was missing. For example he new that there had to be some light-weight strong metal like aluminum but heavier. He new there had to be something unreactive like tin or lead, but somewhere between them in mass.

His model left holes that he predicted would be filled and they were. That is the hallmark of good science when your model can be shown right by experimentation.

Today we have filled in all the gaps in the chart. We call it the ***periodic table***. We have also come to understand it better and why the elements have these strange relationships. The shapes of chart was weird. Now it looks even weirder, but there are good reasons why it looks this way. What's really interesting is that we are still adding new elements.

In the beginning we didn't understand what an element was. Then we learned to separate them from each other and to see what they did. Then we created this model that helps us understand where more might be. Now, people are making all new elements.

See the red arrow? That is where we are creating bigger elements all the time. Right now there are only eight elements left before we create something very different. People are still discovering new elements.

Because the scientists figured out these patterns, we now have a model to understand the elements. One of the best tools in this model is the ***group***. A group is the line of elements up and down the periodic table. All the elements within a group react in the same way. Later we will talk about shy this is, but for now it is still interesting to learn about a group.

Remember the alkali metals we met earlier? That is the first group and they are all very reactive, almost explosive. There is a great video about them on YouTube. A group of scientists put each of these metals into water to show how reactive they are. They get worse and worse until it really is like a bomb going off.

https://www.youtube.com/watch?v=m55kgyApYrY

Just like the alkali metals, the last group has a special name. These are the halogens. These are also very reactive, but they are less explosive. Instead each of them serves as a poison. We use them in various ways to clean our homes, food, and hospitals. We use them to kill viruses and bacteria. We even use them to kill each other.

As you learn about the elements you will learn the ***properties*** of the elements and the groups. Properties are the personality traits of the element or family that separate it from the others.

Alkali Metals

Halogens

There are lots of other groups, each with their own “family trait” of properties. One of the most important groups is called the Noble Gases. These are very stable and absolutely ***hate*** to join with other elements. These elements are very important because they are so very stable. All the other elements want to be like them.

One group that has always been very important to humans are the precious metals. Copper, silver, and gold have been used for a long time to make coins. We also know that they don’t ruse or corrode so they make good electrical conductors. They are soft enough to be pulled into great wires. We tend to use copper wires, but silver and gold wires are used in some computer pieces and in space.

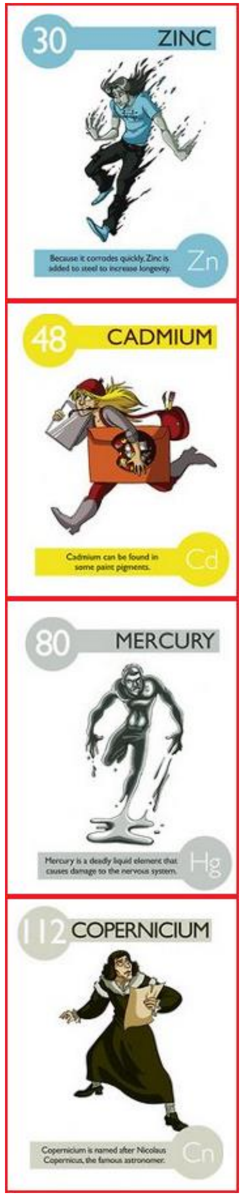
All the groups have a similar story, but let’s tell just one more. This group doesn’t have a famous name, but they are still a family. Zinc, Cadmium, Mercury and Copernicum are great at mixing with other metals. We call these mixtures ***alloys***. Zinc alloys are great for building things and protecting other metals. Cadmimum can make things easier to melt like wiring solder. Mercury forms a whole bunch of amalgams with many different metals. Even though Capernium is new, it has the same properties.

So, as we move forward, you will learn the groups and the elements by their groups and properties.

Noble Gases

Precious Metals

Group XII



Finally, there are some elements that are more or less important for different jobs. One of the most important jobs is biology, because that is what keeps you alive. These elements are the most used in your body and in other living things. These eleven elements account for 99.7% of your body mass. Sometimes you do get a bit of gold or helium in your body, but it is very rare. I guess Hennig was wrong.

It would be a good idea to be very familiar with these elements because they are so important to the chemistry you will learn. There is a special field called ***organic chemistry*** where people study chains of carbon atoms. Nitrogen, oxygen, hydrogen, sulfur, phosphorus, and chlorine are mixed into thousands of different chemicals based on those carbon chains. The four metals, sodium, magnesium, calcium, and potassium are the easiest to combine into useful salts.

You may not be able to ignore the rest of the periodic table, but I would definitely focus on learning these elements first.

Elements of Biology