Chapter 5:

The Periodic Table

The periodic table, unlike the tables you can purchase at IKEA, doesn't take hours to assemble with a tiny wrench.

5.1: Let's Arrange The Elements!

Most textbooks have a big section about the people who invented the periodic table. Because you don't really want to read a bunch of unnecessary stuff, and I don't want to write a bunch of unnecessary stuff, here's what you actually need to know:

1. When people were discovering the elements, people suspected that some of the elements had meaningful similarities to other elements.

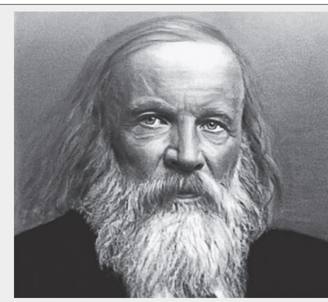
2. People screwed around with different organizational methods for quite a while, with varying degrees of success. Their names aren't important enough to memorize

3. In 1869, a guy named Dmitri Mendeleev arranged them in rows by increasing atomic mass. When set up in the right way, he found that elements in the same columns had similar properties.

Spotlight On Science: Dmitri Mendeleev

While Dmitri Mendeleev was married to his first wife, he started dating another woman. He eventually married this woman while still married to his first wife

Not cool, Mendeleev.

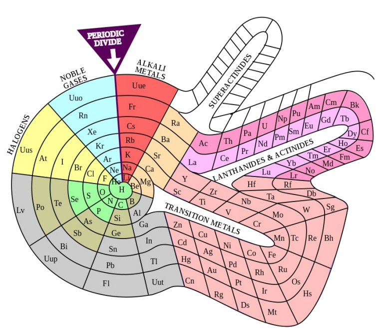


Ladies.

The interesting part about all of this is that Mendeleev's table had empty spaces in it for elements that didn't exist. When these elements were eventually discovered, everybody was like, “Go Mendeleev!”

His table is called the **periodic table** because the properties of the elements keep coming up in a periodic (i.e. regular) fashion as a new row is started. And now you're going to learn about it.

Or else.



Is it a unicorn duck?

Some people like to invent new periodic tables because they have a lot of time on their hands.

5.2: The Periodic Table We All Know And Love

Now that we've talked about some historical stuff, it's time to tell you stuff you'll actually need to know about the periodic table. By the way, the periodic table looks like this:[1]

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																		2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01												5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31												13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08		21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.63	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62		39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** [97.91]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.660	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	† La (below)	71 **Lu** 174.97	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [208.98]	85 **At** [209.99]	86 **Rn** [222.02]
87 **Fr** [223.02]	88 **Ra** [226.03]	‡ Ac (below)	103 **Lr** [262.11]	104 **Rf** [265.12]	105 **Db** [268.13]	106 **Sg** [271.13]	107 **Bh** [270]	108 **Hs** [277.15]	109 **Mt** [276.15]	110 **Ds** [281.16]	111 **Rg** [280.16]	112 **Cn** [285.17]	113 **Nh** [284.18]	114 **Fl** [289.19]	115 **Mc** [288.19]	116 **Lv** [293]	117 **Ts** [294]	118 **Og** [294]

†	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [144.91]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05
‡	89 **Ac** [227.03]	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** [237.05]	94 **Pu** [244.06]	95 **Am** [243.06]	96 **Cm** [247.07]	97 **Bk** [247.07]	98 **Cf** [251.08]	99 **Es** [252.08]	100 **Fm** [257.10]	101 **Md** [258.10]	102 **No** [259.10]

Periods in the periodic table are the left-to-right rows.[2] Elements in the same periods have electrons with similar energies, but not much else in common.

Groups or **families**[3] are the up-down columns. Elements within the same families have similar properties. This is because the number of outer electrons they is the same, and these electrons are the ones that are responsible for the chemical properties of stuff.

1 *This periodic table of the elements looks a lot like the one put up by Dr. Mark Winter at the University of Sheffield, available at www.webelements.com. If you're interested in learning more about the elements, his site is the best I've ever seen.*
2 *I always mix them up with columns for some reason. I also mix up horizontal and vertical, probably for the same reason.*
3 *They're the same thing.*

Metals, Nonmetals, and Metalloids

If you look at the periodic table on the last page, you can see all of the metals, nonmetals, and metalloids on the periodic table. Unfortunately, they all look the same in a black-and-white periodic table, so I've included a handy color-coded one here:

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01																		2 **He** 4.00
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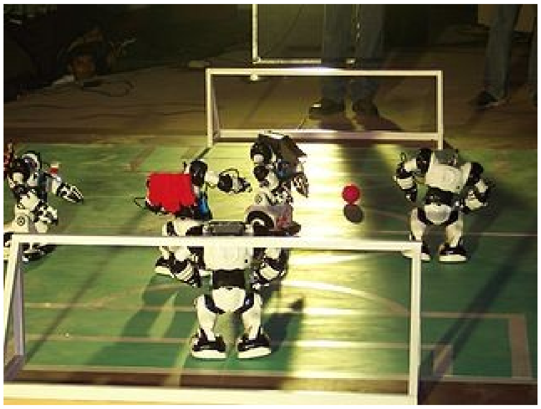
The elements in red are the metals. **Metallic elements** are shiny, conduct heat and electricity well, are malleable and ductile[4], and are generally solids at room temperature.[5] However, let's be honest: You already know what a metal is, right? I mean, if you found something in your pocket and pulled it out, you'd know whether it was a metal or not. If you can't remember the properties of metals, imagine an aluminum can or something.[6]

Nonmetals are the elements in blue. A lot of nonmetals are gases at room temperature, and the rest of them are brittle solids that neither conduct electricity well nor are particularly shiny. About the only nonmetals you're familiar with are charcoal and sulfur, so if you forget the properties of nonmetals, think of these.[7]

4 *"Malleable" means "able to be squished into sheets", while "ductile" means "able to be stretched into wires.*
5 *The exception is mercury, which is a liquid.*
6 *In some countries, aluminum is spelled "aluminium." This is a misspelling. Because I said so.*
7 *There are exceptions to these general descriptors. Carbon has several different forms with interesting and very unusual properties, including diamond, graphenes, and fullerenes. Find out more here: https://en.wikipedia.org/wiki/Allotropes_of_carbon.*

Metalloids, shown here in a very fashionable green, are elements that have properties between those of the metals and nonmetals. The property you'll find most interesting is that nonmetals are poor conductors at low temperatures or when low voltage electric current is applied, but when you either heated or exposed to high voltage, they become good conductors. This makes it possible to make electrical switches out of metalloids, which allow computers to work.[8] The metalloids usually look more like nonmetals than metals, with kind of a dull grey color.



The soccer-playing robots in this picture have computers in them that contain silicon chips. One day, robots like these will kill everybody you know.

5.3: The Groups of the Periodic Table

Here's where we get to the stuff you've been waiting for: The groups of the periodic table. Each group has its own properties, challenges, and uses. And you're going to love every single one of them. And that's no lie.[9]

Alkali metals (group 1): The alkali metals are all of the elements in group 1, with the exception of hydrogen. The alkali metals are all extremely reactive elements and blow up if you put them in water.[10] Generally speaking, alkali metals don't behave much like the metals you're familiar with because they're way too soft, melt at way too low temperatures, and the whole blowing up thing.

8 *On 9/2/16, it was shown that nanotubes made of carbon – a nonmetal – can be made to work as well as those of silicon. The reasons for this are complicated, but the unusual structure of carbon nanotubes cause a similar thing to happen in carbon as does in traditional silicon transistors. Just in case you were wondering.*

9 *Yes it is.*

10 *There are some cool videos of this on YouTube, so check it out.*

Elemental Fun: Sodium

You may have heard that having too much sodium in your diet will cause you to get heart disease, high blood pressure, and Acute Explosive Diarrhea Disorder (AEDD).[11] *Though these things are bad, it should be noted that dietary sodium isn't the same thing as elemental sodium. Compounds like sodium chloride (table salt) contain sodium atoms, but this is a very different from containing sodium metal (which would make you get all explodey).*

The sodium demon awakens!

Alkaline earth metals (group 2): The alkaline earth metals are more reactive than most metals, but less so than the alkali metals. Calcium, for example, reacts vigorously (but not explosively) in water, and magnesium burns with a brilliant white flame in oxygen. On the other hand, the low density of elements such as magnesium and beryllium make them useful in making light and strong products such as alloy wheels, laptop cases, and bicycles.

Transition metals (groups 3-12): The transition metals make up that great big part in the middle of the periodic table. Though there are a lot of transition metals out there, it's generally the case that transition metals behave like your stereotypical metal. They tend to be fairly unreactive, durable, strong, and good conductors of heat and electricity. The most familiar of the transition metals include iron (magnetic!), gold (expensive!), and copper (pennies!)[12]

Lanthanides and actinides (the two rows on the bottom of the periodic table): The two rows at the bottom of the periodic table consist of the lanthanides (the top row) and the actinides (the bottom row). The lanthanides are used for a bunch of stuff that are used in semiconductors and optics. The actinides are radioactive, and are good for medical purposes, nuclear power plants, and huge bombs. Most of the actinides are man-made, so don't expect to see them around much.

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The lanthanides are on the top row while the actinides are on the bottom row. Hence, the “La” and “Ac” on the first element in each group.

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11 *See if you can guess which of these I made up.*

12 *Yes, I know that pennies have been thin coatings of copper over zinc cores for the past 30+ years. But zinc is a transition metal too. So there.*

Boron's family (group 13): Aluminum is the most popular of the elements in this group, as it's good for making everything from soda cans to, well, just about everything you can imagine a metal being used for. Between aluminum and iron (which is in steel), you can pretty much make whatever you want. Oddly, though aluminum is the third most abundant element in the earth's crust, it's never found as a pure element.[13]

Carbon's family (group 14): These elements don't have much in common with each other, given that carbon is a nonmetal, silicon and germanium are metalloids, and tin and lead are metals. Though they don't have many similarities except for the number of outer electrons they have, these elements are all pretty handy. Carbon is present in organic compounds and, by extension, everything alive; silicon is used to make computer chips; tin is used in solder and to make bronze and pewter; lead is used in vast quantities to make car batteries.

The Science Behind Tin Foil Hats

For many years, lunatics have known that if you wear a hat made of "tin foil" (it's actually aluminum), you can keep government mind control rays from damaging your brain. As it turns out, this actually makes a very tiny bit of sense, because surrounding something in metal will keep electromagnetic waves from reaching the object. However, the basic premise behind the tin foil hat is flawed, as you'd need to surround the entire head in foil to get the proper effect. And this can only really be accomplished by severing the head and wrapping it like a hunk of old cheese. Which is what the government wants you to do.

Wear it proudly.

Nitrogen's family (group 15): Nitrogen's family, like carbon's family, contains elements that are metals, nonmetals, and metalloids. Nitrogen and phosphorus are both notable elements in this group, as they're present in all living things. Not surprisingly, since they're present in everything that's alive, they're used in vast quantities as fertilizers (nitrogen as ammonium salts, and phosphate as phosphate salts).

A Really Crappy War

From 1864-1866, Spain waged war on Peru and Chile to gain control over the Chincha Islands, which consisted mostly of huge piles of bird crap. This guano (as bird crap is called) is an excellent fertilizer because of its high concentrations of nitrogen, phosphorus, and potassium. Incidentally, the Spanish lost.

This guy, shown standing in his own crap, was responsible for a whole war.

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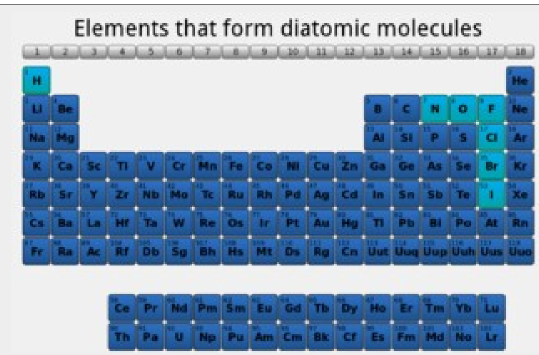
13 *The top of the Washington Monument in Washington, DC is a 23 cm tall pyramid of aluminum. Why not a more awesome metal? Actually, at the time, aluminum was considered pretty awesome and was as expensive as silver. Who would've thought that less than 50 years later it would be used to make beer cans?*

Oxygen's family (group 16): Oxygen's family contains both nonmetals (oxygen, sulfur, selenium) and metalloids (tellurium, polonium). The most commonly used of these is oxygen, which we breathe and which is required for combustion to take place. Oxygen is also present in ozone (O_3), which helps protect the earth from ultraviolet radiation. Sulfur is used to make sulfuric acid (H_2SO_4), which is a common industrial chemical used to manufacture fertilizers (as ammonium sulfate) and is an important ingredient in lead-acid car batteries.

Halogens (group 17): The halogens are all highly reactive oxidizing elements – the "oxidizing" part of this sentence refers to the fact that they pull electrons away from other elements whenever possible. Not surprisingly, elements this reactive are good at killing things because pulling electrons off of living things doesn't exactly help them survive. Fortunately for us, the ability of something to kill other things is a handy feature if you want to kill bacteria in water purification or medical environments. Fluorine and chlorine are both gases, while bromine is a liquid, and iodine and astatine are solids.[14]

The Diatomic Elements

There are seven elements in the periodic table that are naturally diatomic – that is to say, they naturally occur as two atoms of the element bonded to one another. These include hydrogen (H_2), nitrogen (N_2), oxygen (O_2), fluorine (F_2), chlorine (Cl_2), bromine (Br_2), and iodine (I_2). To remember these seven elements, remember that they look like the "big seven and the weirdo" on the periodic table.[15]



See, it's totally a seven! And a weirdo!

Noble gases (group 18): The noble gases don't react with stuff. You can put all kinds of crazy reactive stuff into contact with them, and they just don't like to react. The only time you can get them to react is if you put huge amounts of energy into them, and even then the compounds they make aren't stable. For this reason, the noble gases are often used in situations when you don't want chemical reactions to take place. Argon, for example, is used in glove boxes when scientists are working with air-sensitive materials, because these materials won't react with it. Other uses for these elements are in "neon" signs, which zap tubes filled with these gases with electricity to make light via the whole spectrum thing we learned about in the last chapter.[16]

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14 *We really know very little about astatine because it is a highly unstable element. As yet, it's not used for anything, though it may turn out to be medically useful.*

15 *Astatine is probably also diatomic, but since nobody ever really runs into astatine in real-life, I omit it here.*

16 *It's important to note that there are actually a lot of different lights that work in this way. Helium tubes give off light with a peach color, while the color of neon is red, argon is light purple, krypton is white, and xenon is pale blue.*

Hydrogen (element 1): Hydrogen is a real weirdo among the elements of the periodic table. It's in the same column of the periodic table as the alkali metals, but is neither a metal nor as reactive as the rest of the group. It's fairly unreactive in air, except when you add energy to it – which causes it to explode. Hydrogen can either gain or lose electrons when it reacts, which is behavior the other elements find deeply confusing. In other words, hydrogen doesn't really fit anywhere in the periodic table, so we just kind of cram it into the top left corner because it would look bad if we left it off entirely.

The LZ-129 Hindenburg *was a German airship that was made lighter-than-air by filling it with explosive hydrogen gas. Given the fact that it later caught fire and killed a lot of the people in it, this was probably a bad idea. But then again, it's hard to feel too awful for people flying in a giant swastika-covered balloon.*

The Lost Elements

You may have noticed that nobody ever really talks about the elements from lawrencium (element 103) onward. This isn't because we hate these elements or anything – it's just that we don't know much about them because they aren't stable enough to study. Consider element 117, Tennessine. Given that only a very few atoms of this element have ever been formed and that they have a half-life of less than 0.08 sec, it's not really possible to figure out whether it acts like the other halogens.

<u>The Main Ideas in Chapter 4</u>:

- Dmitri Mendeleev came up with the first really good periodic table.
- Elements in each period (row) of the periodic table have electrons with similar energies, while elements in each family/group (column) of the periodic table have similar properties.
- Metals, nonmetals, and metalloids are things you should know about.
- You should also probably learn the different groups of the periodic table.
- It's a bad idea to fill balloons full of hydrogen.

Image Credits:

- Mendeleev: By unknown / неизвестен (here / здесь) [Public domain], via Wikimedia Commons. Because of an argument with Svante Arrhenius, Mendeleev never got the Nobel Prize in chemistry. It wasn't over his wife, though.

- Duck periodic table: Mardeg at en.wikipedia [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0) or GFDL (http://www.gnu.org/copyleft/fdl.html)], via Wikimedia Commons. There are a ton of different periodic tables out there, with the most common alternate one cramming the lanthanides and actinides between group 2 and 3. This usually isn't done, however, because doing so makes the periodic table too wide to remain readable in a textbook. Seriously.

- Killer robot soccer: By sanchom [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons. The first RoboCup soccer games were held in 1997. If you look at YouTube, you can see that even after 20 years, these robots still totally suck at soccer.

- Sodium demon: By Jurii (http://images-of-elements.com/sodium.php) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons. The liquid that this blob of sodium floats in is paraffin, which, unlike air, won't react with sodium. As a result, when you pull sodium out of a bottle, it's usually pretty slimy and gross.

- Tin foil hat guy: By Drvec (talk)Drvec at en.wikipedia [Public domain], from Wikimedia Commons. There are some data that suggest tin foil hats may actually make it *easier* for the government to read your mind. Check it out here: http://www.theatlantic.com/health/archive/2012/09/tin-foil-hats-actually-make-it-easier-for-the-government-to-track-your-thoughts/262998/.

- Swallow-tail gull: By suecan1 (swallow tailed gull Uploaded by Snowmanradio) [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons. The courtship ritual of the swallow-tail gull includes puking by the male. This officially makes the swallow-tail gull the most disgusting bird alive.

- Diatomic periodic table: See https://commons.wikimedia.org/wiki/File:Diatomic_molecules_periodic_table.png for author [GPL (http://www.gnu.org/licenses/gpl.html) or CC0], via Wikimedia Commons. “Big seven and the weirdo” is, incidentally, the only thing I still remember from my own high school chemistry class. Which should tell you about the general level of chemistry education in the mid-1980s.

- Hindenburg: By U.S. Department of the Navy. Bureau of Aeronautics. Naval Aircraft Factory, Philadelphia, Pennsylvania (USA). [Public domain], via Wikimedia Commons. The big tower on top of the Empire State Building was originally intended to be part of a zeppelin airport. However, since the building itself made winds in the area unpredictable, they couldn't do it. Which, clearly, is for the best.