

# All About the **PERIODIC TABLE**



**Georgia Beth**

The background of the page features a collage of chemistry-related images. At the top, a beaker contains a blue liquid. Below it, a test tube holds a red liquid. In the foreground, a test tube with a white and red substance is positioned diagonally over a portion of the periodic table. The periodic table shows elements such as Molybdenum (Mo), Technetium (Tc), Rhenium (Re), Osmium (Os), Rhodium (Rh), and Hassium (Hs).

## Table of Contents

The Basic Ingredients . . . . .	4
A Brief History of Atoms . . . . .	6
The Origins of the Periodic Table . . . .	10
Dissecting the Periodic Table . . . . .	18
Fundamental Building Blocks . . . . .	26
STEAM Challenge . . . . .	28
Glossary . . . . .	30
Index . . . . .	31
Career Advice . . . . .	32

# The Basic Ingredients

It's lunchtime, and you're hungry. You want something spicy and comforting. By combining a little of this and a little of that, you've made a delicious curry. If you had different ingredients, you might have made a sandwich or a burrito. It all depends on the foods you have and what you're hungry for!

Just like your lunch, everything in the world is made up of ingredients. **Elements** are the building blocks of everything in the universe. Hydrogen and oxygen combine to make water. Sodium and chlorine combine to make salt.

group	1	2	3	4	5	6	7	8	9
period	1	2	3	4	5	6	7	8	9
1	1 <b>H</b> Hydrogen 1.008								
2	3 <b>Li</b> Lithium 6.94	4 <b>Be</b> Beryllium 9.012							
3	11 <b>Na</b> Sodium 22.989	12 <b>Mg</b> Magnesium 24.305							
4	19 <b>K</b> Potassium 39.098	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.955	22 <b>Ti</b> Titanium 47.867	23 <b>V</b> Vanadium 50.941	24 <b>Cr</b> Chromium 51.995	25 <b>Mn</b> Manganese 54.938	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933
5	37 <b>Rb</b> Rubidium 85.467	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.905	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.905	42 <b>Mo</b> Molybdenum 95.95	43 <b>Tc</b> Technetium 98	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.905
6	55 <b>Cs</b> Cesium 132.905	56 <b>Ba</b> Barium 137.327	57 <b>La</b> Lanthanum 138.905	72 <b>Hf</b> Hafnium 178.486	73 <b>Ta</b> Tantalum 180.947	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.217
7	87 <b>Fr</b> Francium 223	88 <b>Ra</b> Radium 226.025	89 <b>Ac</b> Actinium 227	104 <b>Rf</b> Rutherfordium 261	105 <b>Db</b> Dubnium 270	106 <b>Sg</b> Seaborgium 269	107 <b>Bh</b> Bohrium 270	108 <b>Hs</b> Hassium 270	109 <b>Mt</b> Meitnerium 276
lanthanide series 6			58 <b>Ce</b> Cerium 140.116	59 <b>Pr</b> Praseodymium 140.907	60 <b>Nd</b> Neodymium 144.242	61 <b>Pm</b> Promethium 145	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.964	
actinide series 7			90 <b>Th</b> Thorium 232.037	91 <b>Pa</b> Protactinium 231.035	92 <b>U</b> Uranium 238.029	93 <b>Np</b> Neptunium 237	94 <b>Pu</b> Plutonium 244	95 <b>Am</b> Americium 243	



Hydrogen and helium are a bit like bread and butter—they are commonly found. Elements such as chromium and titanium are rarer. Everything from rocks to tomatoes exists because different elements combined in different ways.

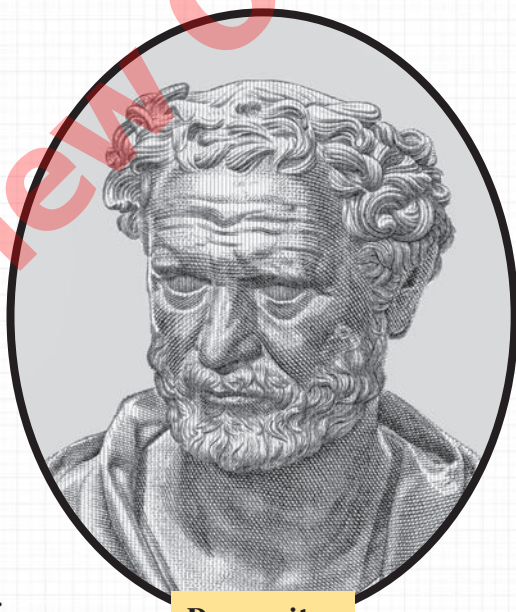
The periodic table of elements is a list of all the discovered elements in the universe. Every element is described in basic terms. And similar elements are grouped by the **properties** they share. The periodic table organizes all this information in one easy-to-read chart. It is a useful tool in the **chemistry** field. Today, the periodic table is used daily by scientists and students around the world.

																18 He Helium 4.002		
													13 B Boron 10.81	14 C Carbon 12.011	15 N Nitrogen 14.007	16 O Oxygen 15.999	17 F Fluorine 18.998	10 Ne Neon 20.179
												13 Al Aluminum 26.981	14 Si Silicon 28.085	15 P Phosphorus 30.973	16 S Sulfur 32.06	17 Cl Chlorine 32.06	18 Ar Argon 32.06	
10 Ni Nickel 58.693	11 Cu Copper 63.546	12 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798										
46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.293										
78 Pt Platinum 195.084	79 Au Gold 196.966	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222										
110 Ds Darmstadtium 281	111 Rg Roentgenium 281	112 Cn Copernicium 285	113 Nh Nihonium 286	114 Fl Flerovium 289	115 Mc Moscovium 289	116 Lv Livermorium 293	117 Ts Tennessine 293	118 Og Oganesson 294										
64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.045	71 Lu Lutetium 174.965											
96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californium 251	99 Es Einsteinium 252	100 Fm Fermium 257	101 Md Mendelevium 258	102 No Nobelium 259	103 Lr Lawrencium 262											

# A Brief History of Atoms

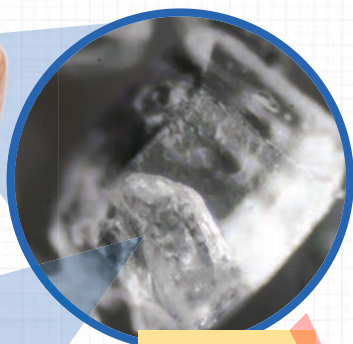
Before diving into the information presented in the periodic table, we have to go back in time—and start small. Throughout history, people have wondered what objects on Earth are made of. They have questioned how objects break down, too. For example, what would happen if you sliced an object into tinier and tinier parts? We know that smashing a rock can break it into smaller pieces. But how can a tomato be divided into pieces when, at some point in cutting it smaller and smaller, it turns into red mush? And are tomatoes and rocks made of the same things deep down, even though they look and behave differently?

In ancient Greece, philosophers had many theories about the world. They argued that the world is composed of tiny things that can't be cut into more pieces. They called those units **atoms**. The word *atom* means "indivisible" in Greek. Democritus, a philosopher, had a hypothesis. He argued that everything on Earth is composed of particles.

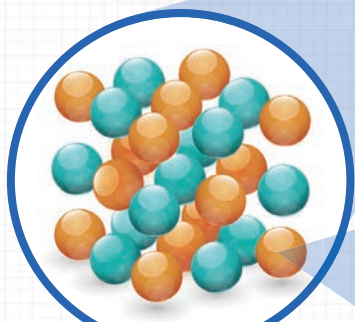


**Democritus**

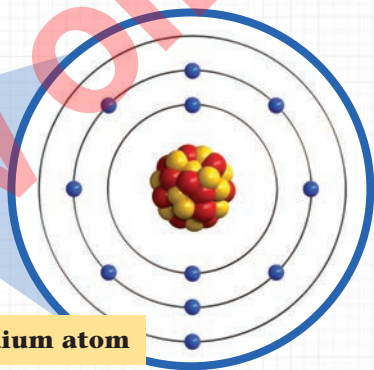
Eventually, scientists were able to test his idea. In fact, scientists advanced the theories of many early thinkers. Scientists discovered that atoms make up everything in the universe. They learned that atoms are smaller than cells, and they can only be seen by the most powerful electron microscopes. Scientists have been studying atoms in-depth for more than 200 years!



**salt crystal**



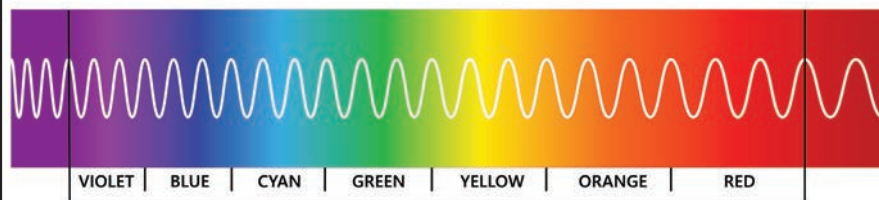
**sodium chloride molecule**



**sodium atom**

### **FUN FACT**

Democritus proposed many theories during his life. He was the first person in recorded history to attempt to explain how colors work. He thought colors were caused by the position of atoms. In his theory, black was caused by bumpy and uneven atoms. White was caused by even and smooth atoms. Today, scientists know that colors are different wavelengths of light.



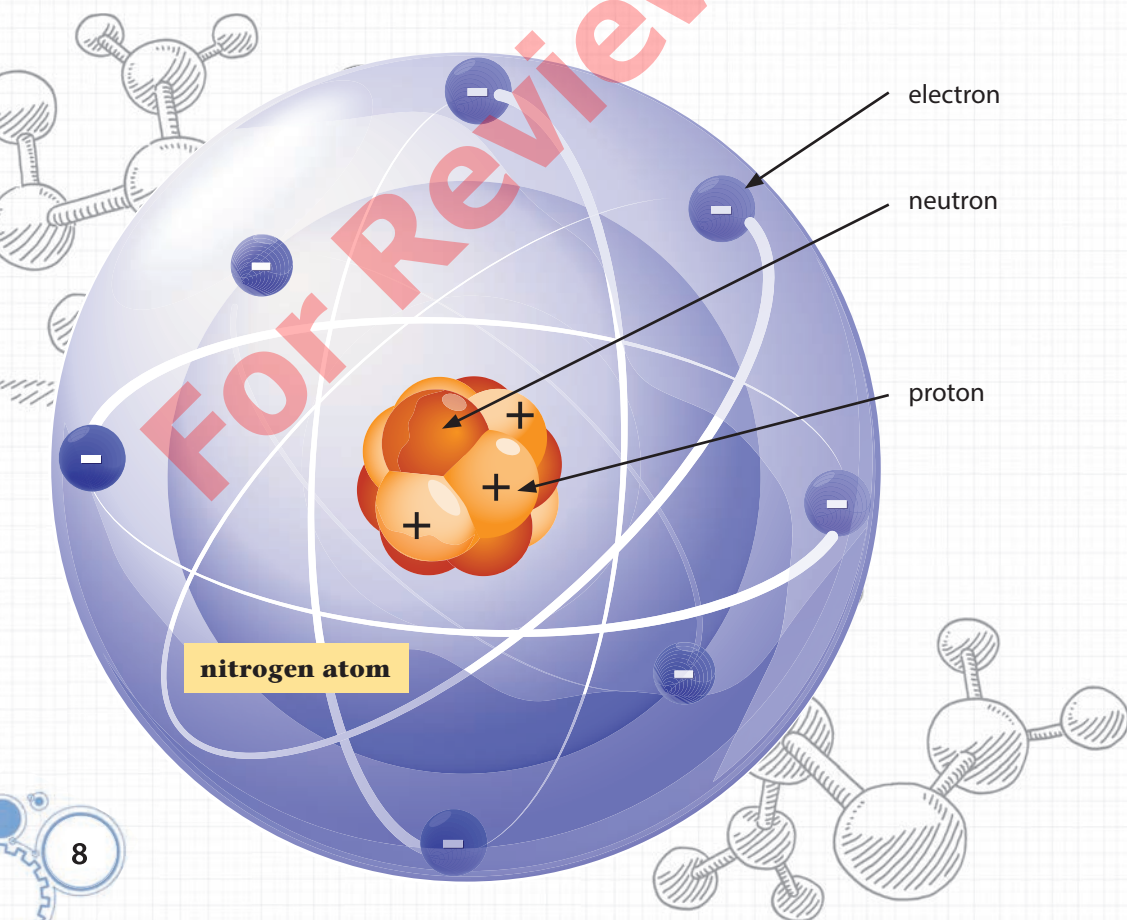
**VISIBLE SPECTRUM**



# Subatomic Particles

Modern scientists learned that atoms can be divided into smaller particles. These are **subatomic** particles. There are three types. The first and second types are **protons** and **neutrons**. They are found in the nucleus of an atom. **Electrons** are the third type. These move around protons and neutrons.

Each type of particle is different. First, protons are heavy and have positive charges. The number of protons is an atom's defining trait. Adding or subtracting protons changes the way atoms behave. Neutrons are similar in size and mass to protons but don't have any charge. Electrons are tiny and lightweight. Each one has a negative charge equal in strength to the proton's positive charge.



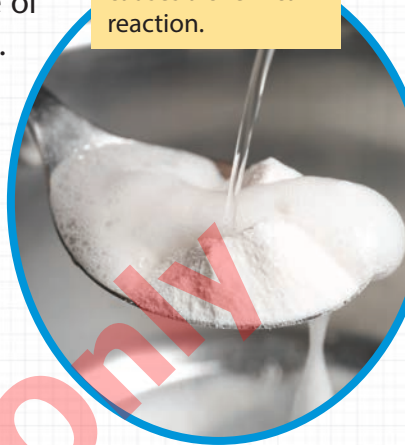
## Making Molecules

Atoms combine in different ways to form new molecules. Some molecules are made of two atoms. Others are made of thousands.

Through chemical reactions, atoms combine into new molecules. When this happens, no atoms are created or destroyed. Molecules that combine are called *reactants*. The bonds between atoms break, and new bonds form. The new molecules are called *products*.

Each different type of atom is a unique element. Some atoms can form molecules by themselves. Atoms of different elements can combine to form more complex molecules.

Combining vinegar with baking soda causes a chemical reaction.



## TECHNOLOGY

### New Compounds

Some chemists use elements to develop new **compounds**. In the last 200 years, they have discovered nearly 15 million compounds! Some of these compounds can also be found organically. In June 2023, astronomers using the James Webb Space Telescope detected a compound for the first time. It is called *methyl cation* (MEH-thul CAT-eye-on). It was found in a nebula about 1,350 light years away from Earth!

### Orion Nebula





# STEAM CHALLENGE

## Define the Problem

The periodic table has been a source of inspiration for art, accessories, and decor. A children's furniture and decor company is working on a line of science-themed items for budding scientists. They have asked you to create a mobile inspired by the periodic table. It needs to be hangable in a nursery or in a young child's room.



**Constraints:** You may only use the materials provided to you.



**Criteria:** Your mobile must include representations of at least three different elements from the periodic table. It must be able to hang and remain intact. It must be visually appealing so customers will want to buy it and babies or young children will enjoy looking at it.



# CAREER ADVICE

from Smithsonian

## Do you dream of studying chemistry?

Here are some tips to keep in mind  
for the future.

"Understanding chemistry helps us understand the world around us. Everything from salt on our food, to clouds in the sky, to volcanic eruptions, involves chemistry."

– Benjamin Andrews, Geologist and Associate Curator of Rocks and Ores, National Museum of Natural History

"The periodic table helps make sense of the building blocks that make up everything around us."

– Gabriela Farfan, Research Geologist,  
National Museum of Natural History

