Exploring the Periodic Table

By the end of the nineteenth century, most scientists agreed on the existence of atoms and, thanks to the work of a physicist named J. J. Thomson, knew that these structures contained particles called electrons. Thomson proposed that the atom is a sphere filled with positively charged matter that contains negatively charged electrons embedded in it like plums in a pudding, he was not correct on this model but it was a start!

With more data, today's "nuclear model" of the atom, first proposed by physicist Ernest Rutherford, is very different from Thomson's model. In it, the nucleus, which carries all of the positive charge and 99.9 percent of the atom's mass, is at the center of the atom. Orbiting at a distance of up to 100,000 times the diameter of the nucleus are the electrons. These tiny particles are anything but inconsequential, however. We now know that their arrangement and behavior is responsible for each element's unique set of chemical characteristics.

At first glance, the periodic table--that chart that appears on the walls of science classrooms everywhere--appears to be an oddly shaped collection of chemical information about the elements. A closer look, however, reveals the source of the table's name: The elements are arranged "periodically;" that is, according to properties that repeat in regular, predictable patterns. This periodic arrangement of the elements makes the table very useful, in that if you know the location of an element in the table, you can predict its properties.

The more than 100 elements that make up the periodic table are organized in a series of 18 columns and 7 rows. Each column is called a group, or family. Each row is called a period. Elements in the same group have similar physical characteristics. For example, all of the elements in group 1 (at the far left) react easily with other elements. Unlike the elements in a group, however, the elements in a period do not share properties. Rather, the properties of the elements change as you move from left to right across the row. But to understand why the table is organized as it is, it's helpful to understand the structure of atoms.

An atom is the smallest particle of an element. An atom of any given element is made up of a certain number of protons, an equal number of electrons, and approximately the same number of neutrons. (The exception is hydrogen, which can have zero neutrons.) Protons and neutrons form the nucleus of an atom, and electrons swarm around the nucleus. This swarming isn't completely haphazard, though. Electrons inhabit various energy levels, or shells. The electron configuration shown in the periodic table indicates how many electrons are found in each shell, from innermost to outermost. For example, the electron configuration for calcium is 2,8,8,2.

Electron configuration depends upon the energy state and magnetic spin of each electron, and these qualities. The first shell, can hold no more than two electrons. The second shell can

1. What do all atoms contain?
2. Where is most of an atom's mass located?
3. Why are tiny electrons so important?
4. What does being arranged “periodically” mean?
5. Why is this useful?
6. What is each column called?
7. What is each row called?
8. What is similar about each group but not each row?
9. What is every atom made of and what are the proportions of each?
10. How are electrons configured?

hold no more than eight electrons. The first shells fill first, and if full, additional electrons are found in the next higher shell--which is generally in the adjacent outer shell. Sometimes, the shells can fill out of order because of varying energy states. This explains why, for example, the electron configuration for calcium can be 2,8,8,2 even though the third shell can hold up to 18 electrons.

Elements are arranged in the periodic table according to atomic number, from left to right, top to bottom. The atomic number of an element is equal to the number of protons found in an atom of that element. For example, an atom of carbon has 6 protons in its nucleus; its atomic number is 6. The elements are also arranged according to atomic mass. The mass of a single proton is equal to 1, while the mass of a neutron is very close to 1. An atom's atomic mass, then, is close in number to the sum of its protons and neutrons. An atom of carbon, with 6 protons and, on average, 6 neutrons in its nucleus, has an atomic mass of 12.0107. With the lighter elements, the atomic mass is about double the element's atomic number. As you move up to the heavier elements, the number of neutrons relative to protons increases, causing the mass to be increasingly more than double the atomic number.

When Dmitri Mendeleyev first devised the modern periodic table in 1869, he organized it such that elements with similar characteristics fell into the same columns. Doing so naturally created rows within the table. What scientists later found out was that these rows represented something very significant. They discovered that the elements in each successive row contained an additional electron shell. For example, the atoms of hydrogen and helium in the first row each had one electron shell; atoms of elements listed in the second row had two electron shells, and so on to elements in the final row, whose atoms each have seven shells.

From this, scientists learned what caused elements to have different characteristics. Each element's physical characteristics are determined, in large part, by the number of electrons in the outermost shell of its atoms. As with the number of protons, the number of electrons increases by one as you move across the table from left to right, top to bottom. Atoms of elements in the left-hand column have one electron in their outer shell, while atoms of elements in the right-hand column have eight electrons in their outer shell. How does this determine an element's characteristics? Single electrons in an outer shell can easily be taken away from the atom with the application of very little energy. This makes atoms of elements in the left-hand column very reactive (and good conductors of heat and electricity). It is very difficult, on the other hand, to add or remove electrons from an atom that has eight electrons in its outer shell. The atoms of these elements, found in the column to the far right, are non-reactive.

11. How are elements arranged?

12. What is atomic number vs. atomic mass? Use carbon as your example.

13. What did scientists discover about the rows of the periodic table?

14. What determines an element's physical characteristics?

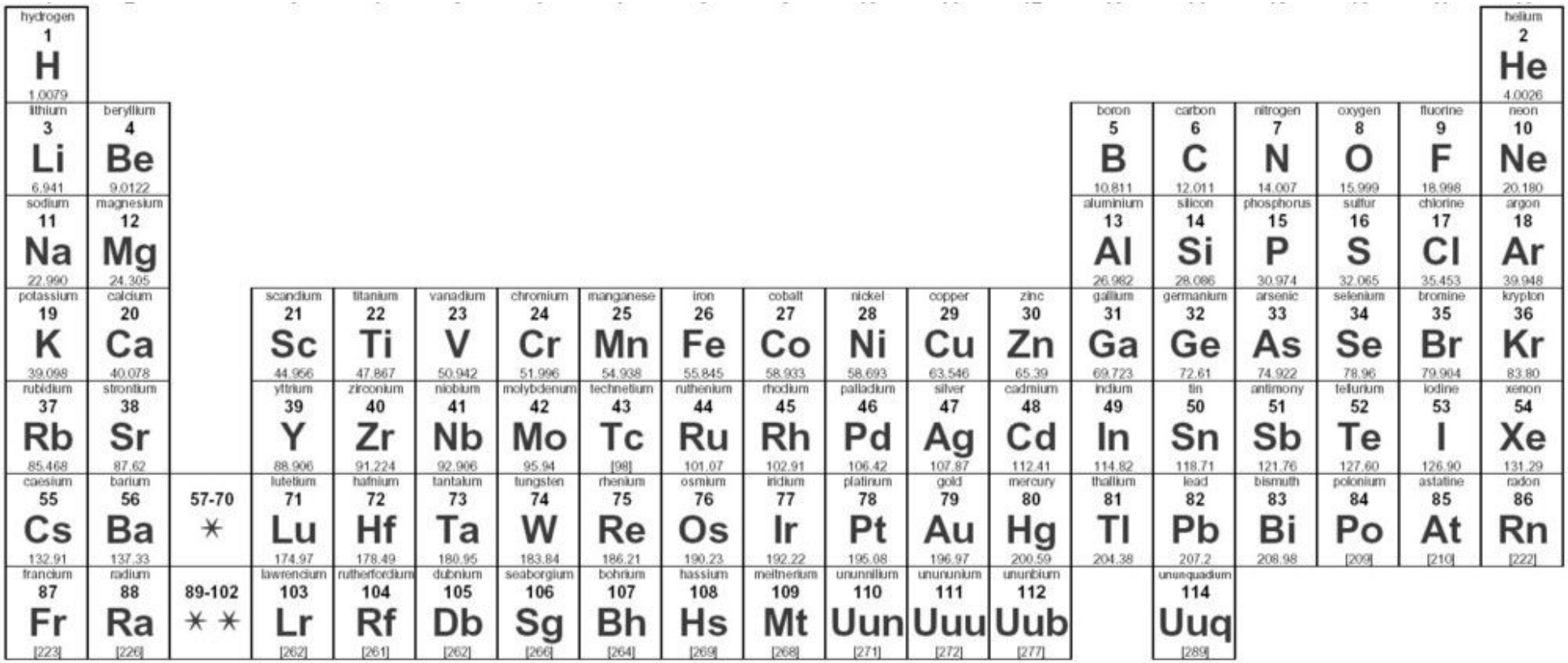
15. How does moving from left to right/top to bottom affect the number of electrons in the outer shell?

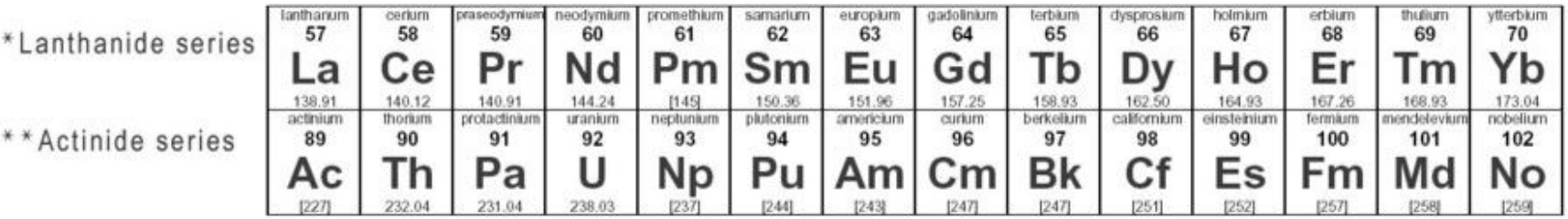
16. How does the number of electrons determine an element's **characteristics**?

17. What is a major difference between having 1 electron vs. 8 in the outer shell?

Part II: Exploring the Periodic Table

1. Go to the following website http://tinyurl.com/k4r7l38
2. Click launch
3. Click on the "interactive" table tab
4. On the following page, shade in each group on the periodic table like the interactive table and make a legend with each group name.
5. In data table 1 (on the page after the periodic table) find the element(s) from each of the following groups and fill in the information.


hydrogen 1 H 1.0079
helium 2 He 4.0026
lithium 3 Li 6.941
beryllium 4 Be 9.0122
boron 5 B 10.811
carbon 6 C 12.011
nitrogen 7 N 14.007
oxygen 8 O 15.999
fluorine 9 F 18.998
neon 10 Ne 20.180
sodium 11 Na 22.990
magnesium 12 Mg 24.305
aluminium 13 Al 26.982
silicon 14 Si 28.086
phosphorus 15 P 30.974
sulfur 16 S 32.065
chlorine 17 Cl 35.453
argon 18 Ar 39.948
potassium 19 K 39.098
calcium 20 Ca 40.078
scandium 21 Sc 44.956
titanium 22 Ti 47.867
vanadium 23 V 50.942
chromium 24 Cr 51.996
manganese 25 Mn 54.938
iron 26 Fe 55.845
cobalt 27 Co 58.933
nickel 28 Ni 58.693
copper 29 Cu 63.546
zinc 30 Zn 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 ✶
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
astatine 85 At [210]
radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 ✶ ✶
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]


*Lanthanide series
**Actinide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
samarium 62 Sm 150.36
europium 63 Eu 151.96
gadolinium 64 Gd 157.25
terbium 65 Tb 158.93
dysprosium 66 Dy 162.50
holmium 67 Ho 164.93
erbium 68 Er 167.26
thulium 69 Tm 168.93
ytterbium 70 Yb 173.04
actinium 89 Ac [227]
thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]

Data Table 1

Group	Element Info	Group	Element Info
Alkali Metals	**Lithium (Li)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Draw Configuration: Electron Configuration:_____	Non-Metals	**Nitrogen (N)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Draw Configuration: Electron Configuration:_____
Trans-ition Metals	**Copper (Cu)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Electron Configuration:_____	Other Metals	**Tin (Sn)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Electron Configuration: _____
Metal-loids	**Silicon(Li)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Electron Configuration:_____	Alkaline Earth Metals	**Barium (Ba)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Electron Configuration: _____
Halo-gens	**Chlorine (Cl)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Draw Configuration: Electron Configuration:_____	Noble Gases	**Neon (Ne)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Draw Configuration: Electron Configuration:_____
Rare Earth Ele-ments	**Berkelium (Bk)** Atomic Number: _____ Atomic Mass: _____ Protons: _____ Neutrons: _____ Electron Configuration: _____		

Part III: Exploring the Periodic Table

1. On the same page as part II, click on the “mystery elements” tab.
2. Click on each question mark and read the information about the mystery element and fill in data table 2

Data Table 2

Clue	Element	What was important in figuring it out?
Atomic Number: 2		
Atomic Number: 3		
Atomic Number: 9		
Atomic Mass: 12.01		
Atomic Mass: 26.98		
Atomic Mass: 65.409		
Electron Configuration: 2,6		
Electron Configuration: 2,8,8		
Electron Configuration: 2,8,8,2		
Physical Characteristic: explodes when mixed with water; atomic mass: 22.99		
Physical Characteristic: Heaviest of the inert elements		
Physical Characteristic: Does not conduct heat well and is about twice as heavy as oxygen		

Adapted from:
http://www.pbslearningmedia.org/resource/phy03.sci.phys.matter.lp_pertable/the-periodic-table-of-the-elements/