Biology Magnets Module 0: Organic Molecules - Teacher and Student Guides

Teacher Information

This module uses magnets designed for teacher and student interaction to guide learning the parts of an atom. Contained in this guide are different lesson ideas that can last from 10 minutes each to an entire class period, depending upon teacher preference. Each lesson has both teacher-centered and student-centered activities. The student-centered activities are most effective if students are in small groups. It may be necessary to have multiple magnet sets for large classes. A student handout is provided which can be printed out and given to each student group to help guide their progress as they work with the magnets. If budget or white board space is limited, groups can alternate between using a set of magnets and doing other activities. Teachers can refer to the videos posted at the Biology Magnet web site at Biologymagnets.com for guided teaching instructions.

Magnet Care and Maintenance

Biology magnets are made to last for years. Periodically magnets will fall off or are knocked off the plastic. A piece of magnetic tape is included with each module, which should be able to replace around 10-12 magnets if necessary. Simply cut a new magnet and peel off the back to replace. Magnetic tape can be purchased from a hobby store to replace magnets lost over time. Laminate may peel off, especially on small pieces. Use transparent tape to re-attach laminate that comes loose, curling the tape over the back of the magnet. The machines used to cut Biology Magnets are not always perfectly accurate. Sometimes a bit of white or black outline on the edges occurs or a cut might be slightly off center. Use scissors to remove extra outline that is unnecessary if desired. Store magnets in the clasp envelopes in which they arrived for easy organization.

Organic Molecules Copyright and Licensing Information

Biology Magnets Module 1 Materials List

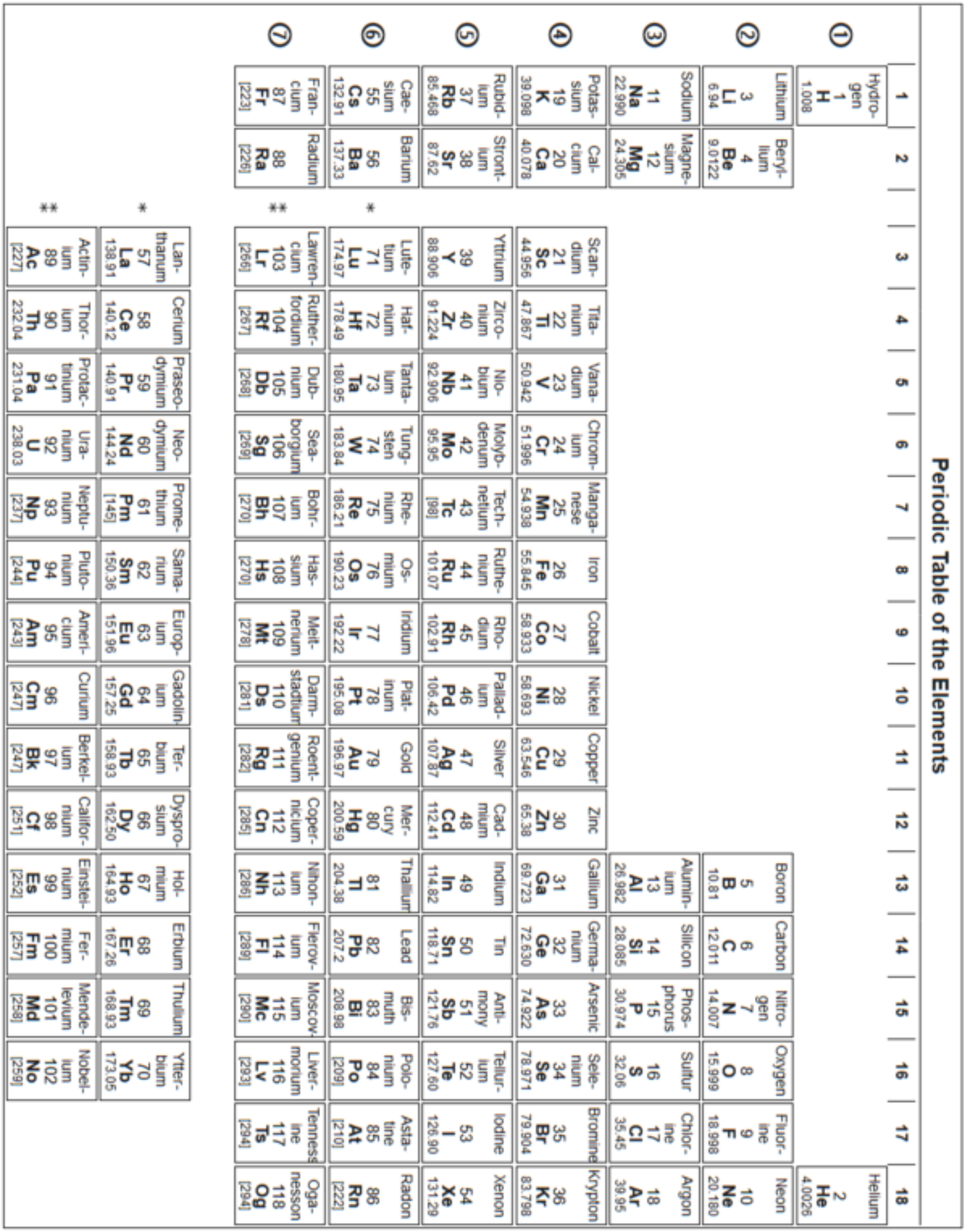
Magnet Name	Quantity	Picture
Proton	21	
Neutron	21	
Electron	21	
3” Magnetic Tape Strip	1	

Total Quantity	**64**	

Lesson 0A – Atomic Nuclei (10-50 minutes)

Teacher Centered Activity (10-20 minutes): This lesson utilizes the protons and neutrons to build atomic nuclei. Use the periodic table of the elements to help teach this section (**Figure 0.A.1).**

Figure 0.A.1: Periodic Table of the Elements



Periodic Table of the Elements

	1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
①	Hydrogen 1 **H** 1.008																		Helium 2 **He** 4.0026
②	Lithium 3 **Li** 6.94	Beryllium 4 **Be** 9.0122												Boron 5 **B** 10.81	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
③	Sodium 11 **Na** 22.990	Magnesium 12 **Mg** 24.305												Aluminium 13 **Al** 26.982	Silicon 14 **Si** 28.085	Phosphorus 15 **P** 30.974	Sulfur 16 **S** 32.06	Chlorine 17 **Cl** 35.45	Argon 18 **Ar** 39.95
④	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** 65.38	Gallium 31 **Ga** 69.723	Germanium 32 **Ge** 72.630	Arsenic 33 **As** 74.922	Selenium 34 **Se** 78.971	Bromine 35 **Br** 79.904	Krypton 36 **Kr** 83.798
⑤	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** 95.95	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
⑥	Caesium 55 **Cs** 132.91	Barium 56 **Ba** 137.33	*	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]
⑦	Francium 87 **Fr** [223]	Radium 88 **Ra** [226]	**	Lawrencium 103 **Lr** [266]	Rutherfordium 104 **Rf** [267]	Dubnium 105 **Db** [268]	Seaborgium 106 **Sg** [269]	Bohrium 107 **Bh** [270]	Hassium 108 **Hs** [270]	Meitnerium 109 **Mt** [278]	Darmstadtium 110 **Ds** [281]	Roentgenium 111 **Rg** [282]	Copernicium 112 **Cn** [285]	Nihonium 113 **Nh** [286]	Flerovium 114 **Fl** [289]	Moscovium 115 **Mc** [290]	Livermorium 116 **Lv** [293]	Tennessine 117 **Ts** [294]	Oganesson 118 **Og** [294]
			*	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** 173.05		
			**	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]		

Start by showing students how to build the nuclei of various atoms. There are enough magnets in the kit to build any atomic nucleus with up to 21 protons and/or neutrons. It is recommended to start with smaller atoms and work your way up. Determine the number of neutrons in the average nucleus by rounding the atomic mass to the nearest whole

number and subtracting the atomic number from that. Some examples of various nuclei are shown in the figures below (**Figure 0.A.1-0.A.6**)

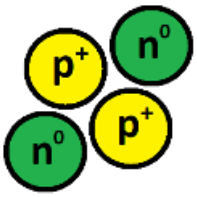
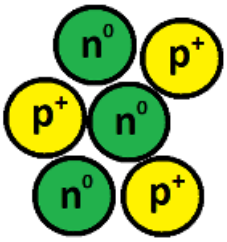
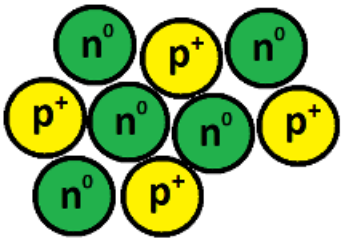
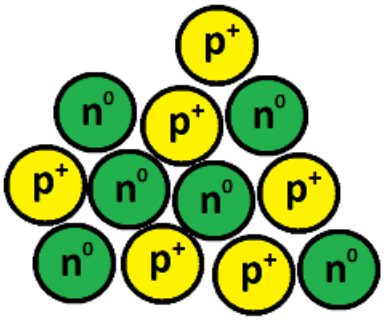
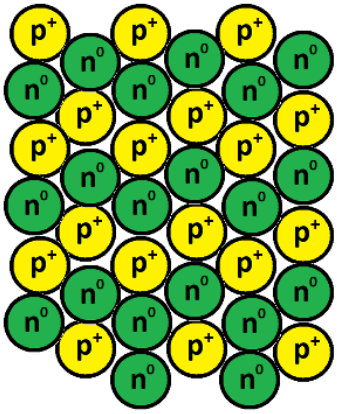
Figure 0.A.1: Hydrogen Nucleus	Figure 0.A.2: Helium Nucleus	Figure 0.A.3: Lithium Nucleus	Figure 0.A.4: Beryllium Nucleus
			

Figure 0.A.5: Carbon Nucleus	Figure 0.A.6: Argon Nucleus
	

Student Centered Activity (10-30 minutes): After teaching the structures, put students into small groups. A copy of the student guide for parts of the atom may be given to each group if necessary. Using the periodic table, have the students take turns building atomic nuclei for various atoms, starting from small to large. Allow the students to correct and help one another. Have one student build an atomic nucleus and then let the other members of the group figure out what atom it is. Then have one student place a number of protons on the board and have the other students try to figure out how many neutrons would go with it for a normal atom by using the periodic table.

Extra exercises:

Nuclei Quiz Race: Call out the name of an element and let the students build the nucleus as fast as they can. Eliminate the last one to finish then do another element. Continue until one group is left.

Research nucleons and quarks: Have the students research protons and neutrons and describe the subunits of which they are made. Students can use index cards and magnetic tape to make magnets that represent quarks and put them together to form protons and neutrons. Include the charge of each quark on the magnets (e.g. -1/3, +2/3) to show how the various combinations add up to the positive charge of protons and neutral charge of neutrons.

Lesson 0B – Electron Configurations (10-50 minutes)

Teacher Centered Activity (10-20 minutes): Use the Biology magnets to build electron configurations for various atoms. Start by using the Bohr model. Have students draw the electron levels using a marker and placing the appropriate numbers of electrons in each level. Level 1 can hold 2 electrons, and level 2 and 3 can hold 8 (**Figure 0.B.1-6**).

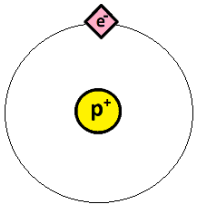
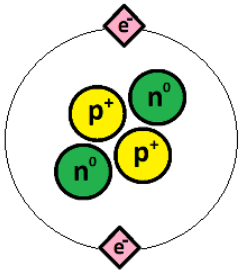
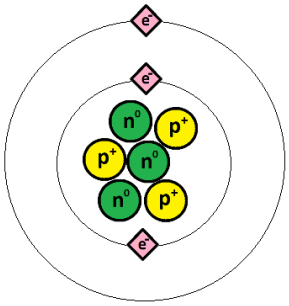
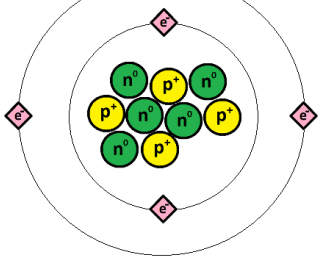
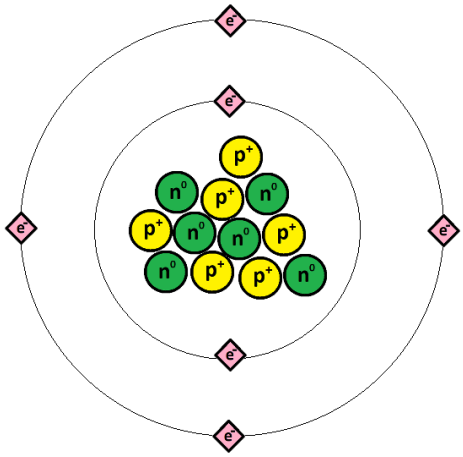
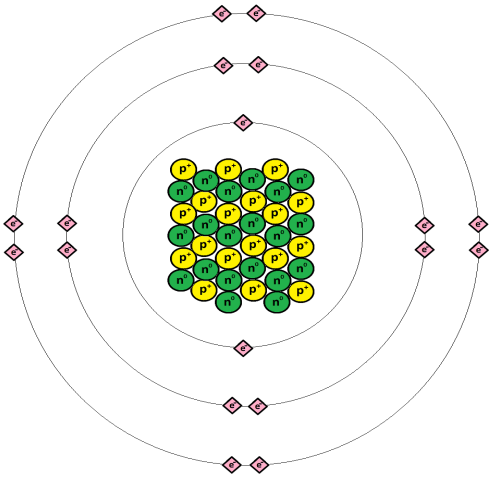
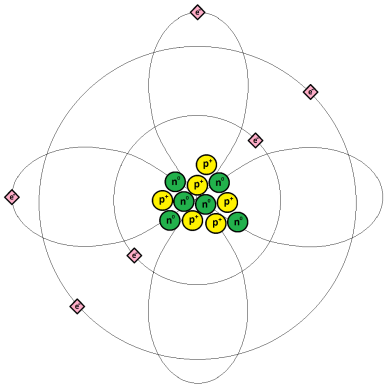
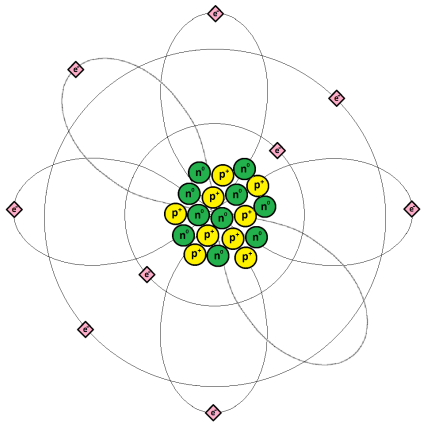
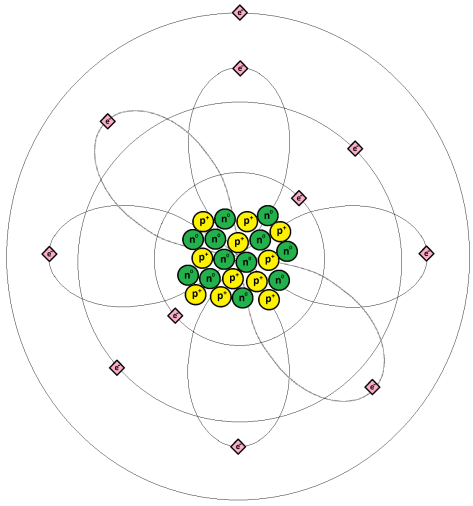
Figure 0.B.1: Hydrogen Atom Bohr Model	Figure 0.B.2: Helium Atom Bohr Model	Figure 0.B.3: Lithium Atom Bohr Model	Figure 0.B.4: Beryllium Atom Bohr Model
			

Figure 0.B.5: Carbon Atom Bohr Model	Figure 0.B.6: Argon Atom Bohr Model
	

Next, show the electron configuration using subshells, drawing the s and p orbitals and placing the electrons properly within each orbital. Have the students figure out the proper electron configuration notation for each atom, build the nucleus of the atom, then place the electrons in their proper orbitals. Have the students use markers to do a rough drawing of the electron orbitals in which they place the electrons. S orbitals are spherical, and p orbitals are shaped like a figure 8. Each successive electron level should be made larger than the previous to accurately model larger atoms. For example, carbon has 6 protons and 6 electrons and thus would be $1s^2\ 2s^2\ 2p^2$. Fluorine with 9 protons and 9 electrons would be $1s^2\ 2s^2\ 2p^5$. Sodium with 11 protons and 11 electrons would be $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(Figure O.B.7-9)**.

Figure 0.B.7: Carbon Electron Configuration **$1s^2\ 2s^2\ 2p^2$**	**Figure 0.B.8: Fluorine Electron Configuration** **$1s^2\ 2s^2\ 2p^5$**	**Figure 0.B.9: Sodium Electron Configuration** **$1s^2\ 2s^2\ 2p^6\ 3s^1$**
		

Student Centered Activity (10-30 minutes): After teaching electron configurations, put students into small groups. A copy of the student guide for parts of the atom may be given to each group if necessary. Using the periodic table, have the students take turns building atomic nuclei for various atoms, starting from small to large, then add in the electron configurations. Start with Bohr models and then go to standard orbital configurations. Allow the students to correct and help one another.

Extra exercises:

D orbitals: Scandium, atomic number 21, has an electron in the 3d orbital. Have students research, draw the first d orbital, and then place the final electron. Students can make larger atoms and draw in the protons, neutrons, and electrons if necessary to fill other D orbitals.

Chemical Bonds: Have the students model chemical bonding using the magnets. Covalent bonding involves sharing electrons between two atoms, and ionic bonding involves the loss and gain of electrons by atoms. The H_2O molecule is a good example of covalent bonding and Li-F is a good example of ionic bonding.

Ions: Have the students create various ions by adding or removing electrons to the atom. Students can research ions online and demonstrate how the ion would be made starting with the uncharged atom.

Lesson 0C – Isotopes (15-80 minutes)

Teacher Centered Activity (10-20 minutes): Use the Biology magnets to build isotopes for various elements. Hydrogen has three different isotopes. Hydrogen-1 (protium), hydrogen-2 (deuterium), and hydrogen-3 (tritium). Each have one proton and 0, 1, and 2 neutrons respectively. Carbon comes in three isotopes as well, carbon-12, carbon-13, and carbon-14. Have students build the atoms and show the different isotopes by adding and/or removing neutrons. (**Figure 0.C.1-2**).

Figure 0.C.1: The Three Isotopes of Hydrogen – Protium, Deuterium, and Tritium

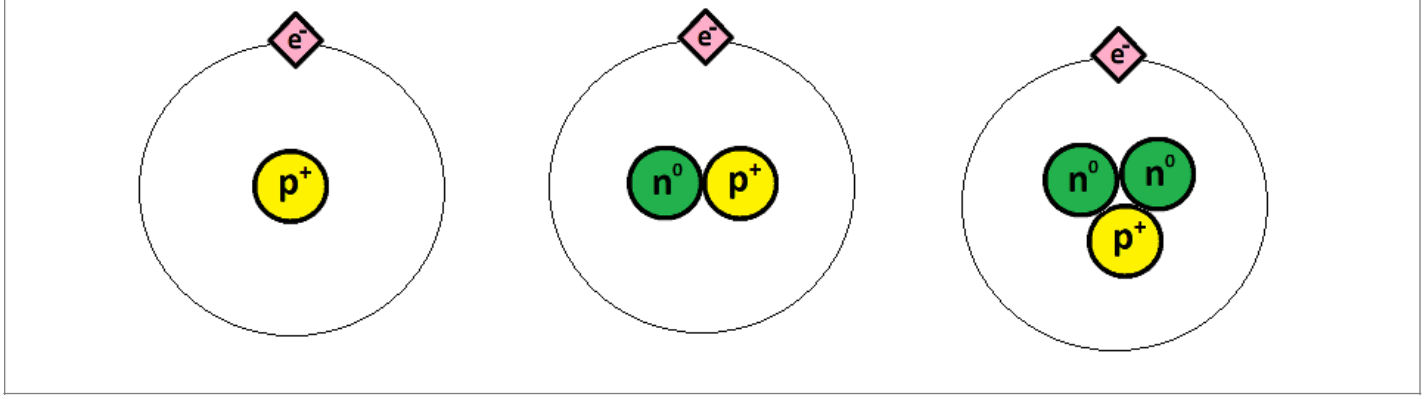
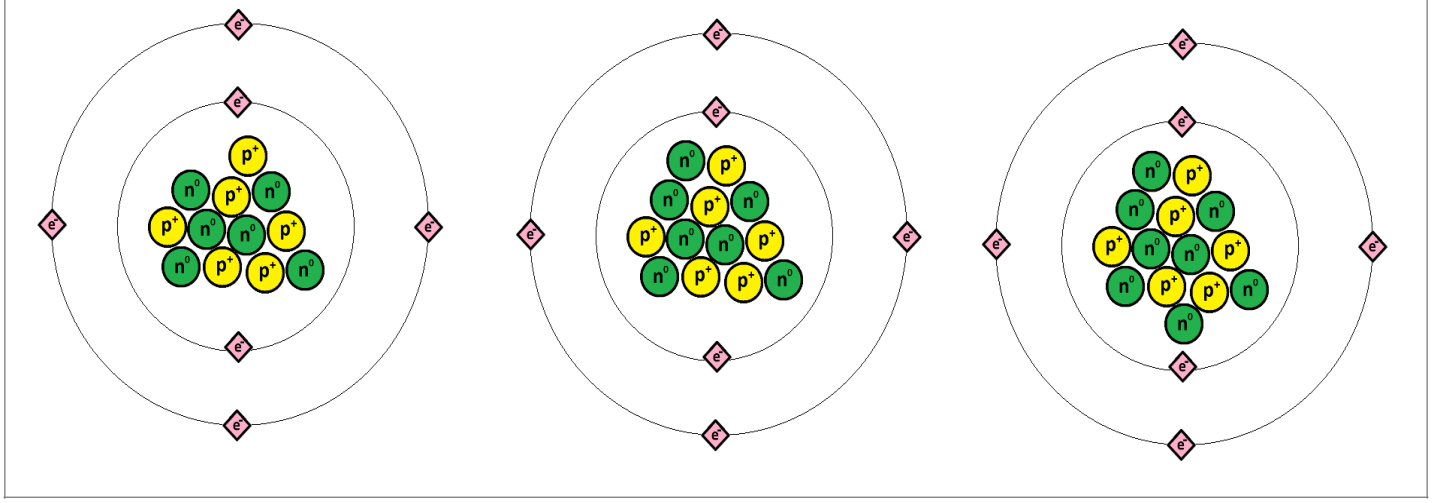


Figure 0.C.2: The Three Isotopes of Carbon – Carbon-12, Carbon-13, and Carbon-14



Student Centered Activity (10-30 minutes): After teaching isotopes, put students into small groups. A copy of the student guide for parts of the atom may be given to each group if necessary. Using the periodic table, have the students take turns building isotopes for various atoms, adding or removing neutrons to represent the various isotopes. Teachers can provide a table or have students research online which isotopes are common for various elements.

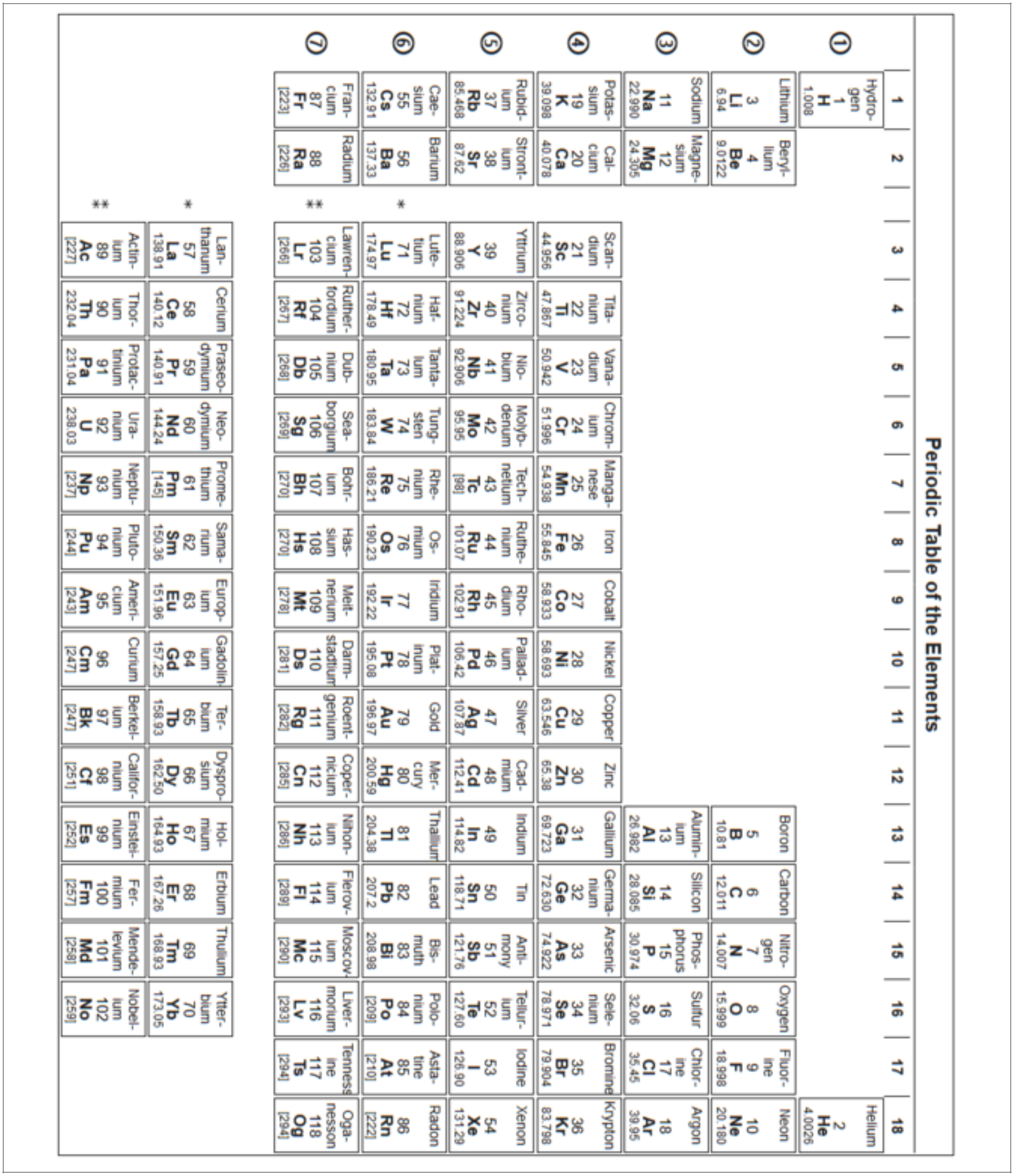
Extra exercise:

Radioactive Isotopes: Some isotopes are radioactive. Students can research which isotopes are radioactive and can model how they decay. For example, carbon-14 will decay into nitrogen-14 when a neutron becomes a proton and emits an electron. Students can use the Biology Magnets to demonstrate this decay.

Lesson 0A – Atomic Nuclei – Student Handout

Student Centered Activity: This lesson utilizes the protons and neutrons to build atomic nuclei. Use the periodic table of the elements to help you with this section (**Figure 0.A.1).**

Figure 0.A.1: Periodic Table of the Elements



Start by building the nuclei of various atoms. There are enough magnets in the kit to build any atomic nucleus with up to 21 protons and/or neutrons. It is recommended to start with smaller atoms and work your way up. Determine the number of neutrons in the average nucleus by rounding the atomic mass to the nearest whole number and subtracting the atomic number from that. Some examples of various nuclei are shown in the figures below (**Figure 0.A.1-0.A.6**). Build some atomic nuclei that are not shown below as examples, and ask your teacher if they are correct.

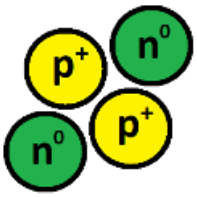
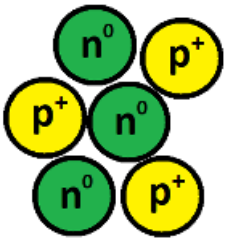
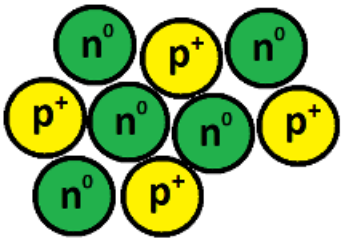
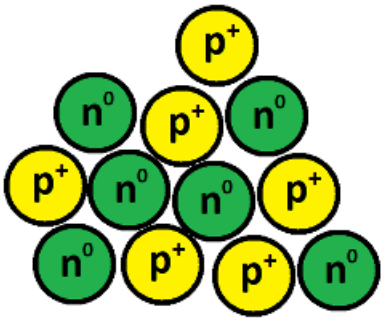
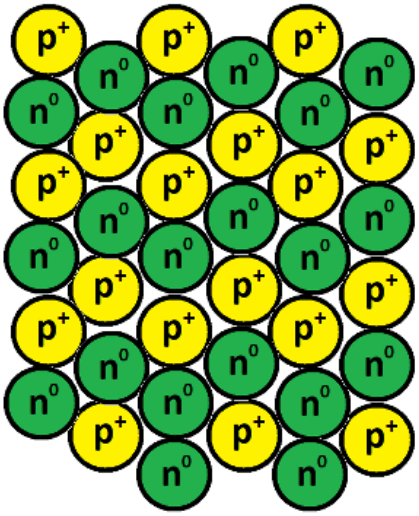
Figure 0.A.1: Hydrogen Nucleus	Figure 0.A.2: Helium Nucleus	Figure 0.A.3: Lithium Nucleus	Figure 0.A.4: Beryllium Nucleus
			

Figure 0.A.5: Carbon Nucleus	Figure 0.A.6: Argon Nucleus
	

Extra exercise:

Research nucleons and quarks: Research protons and neutrons and describe the subunits of which they are made. If available, use index cards and magnetic tape to make magnets that represent quarks and put them together to form protons and neutrons. Include the charge of each quark on the magnets (e.g. -1/3, +2/3) to show how the various combinations add up to the positive charge of protons and neutral charge of neutrons.

Lesson 0B – Electron Configurations – Student Handout

Student Centered Activity: Use the Biology magnets to build electron configurations for various atoms. Start by using the Bohr model. Have students draw the electron levels using a marker and placing the appropriate numbers of electrons in each level. Level 1 can hold 2 electrons, level 2 can hold 8 (**Figure 0.B.1-6**).

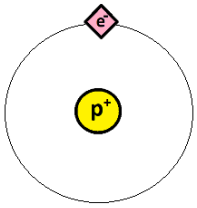
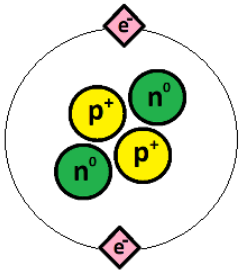
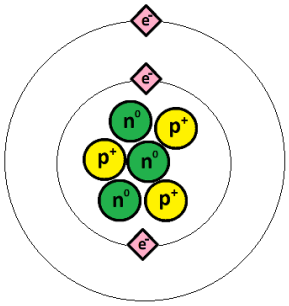
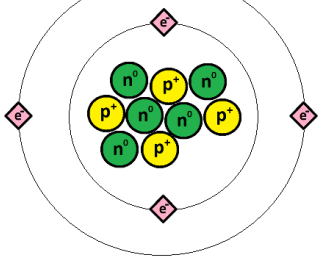
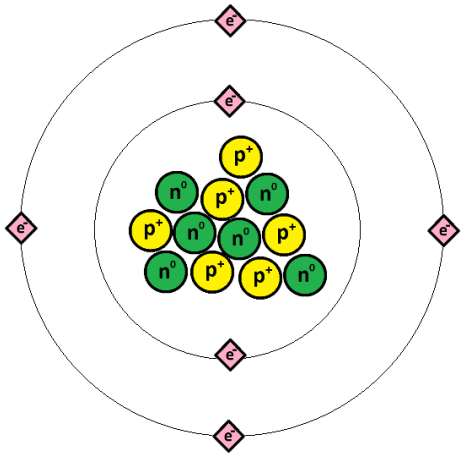
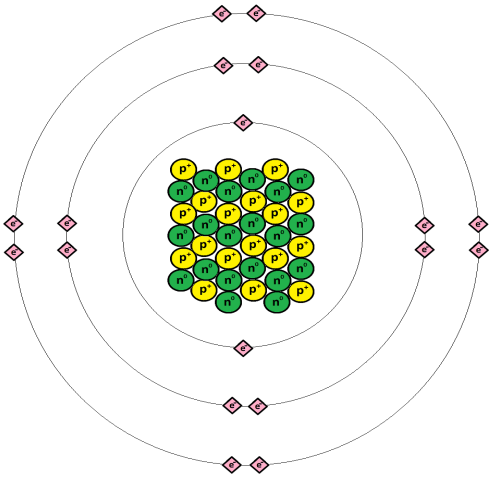
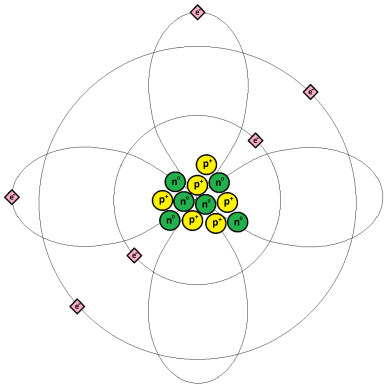
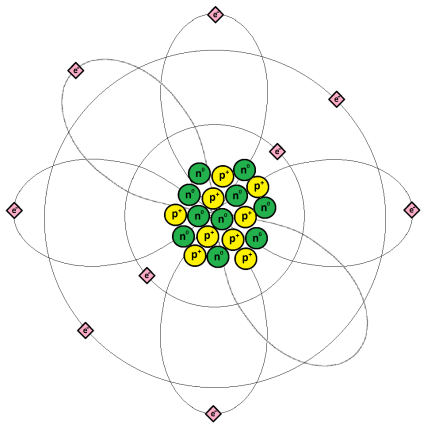
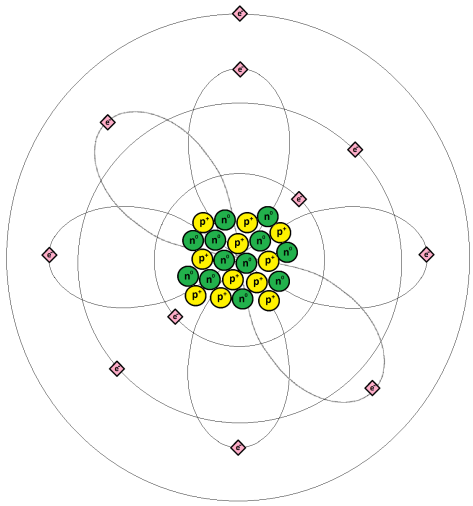
Figure 0.B.1: Hydrogen Atom Bohr Model	Figure 0.B.2: Helium Atom Bohr Model	Figure 0.B.3: Lithium Atom Bohr Model	Figure 0.B.4: Beryllium Atom Bohr Model
			

Figure 0.B.5: Carbon Atom Bohr Model	Figure 0.B.6: Argon Atom Bohr Model
	

Next, show the electron configuration using subshells, drawing the s and p orbitals and placing the electrons properly within each orbital. Figure out the proper electron configuration notation for each atom, build the nucleus of the atom, then place the electrons in their proper orbitals. Use markers to do a rough drawing of the electron orbitals in which they place the electrons. S orbitals are spherical, and p orbitals are shaped like a figure 8. Each successive electron level should be made larger than the previous to accurately model larger atoms. For example, carbon has 6 protons and 6 electrons and thus would be $1s^2\ 2s^2\ 2p^2$. Fluorine with 9 protons and 9 electrons would be $1s^2\ 2s^2\ 2p^5$. Sodium with 11 protons and 11 electrons would be $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(Figure O.B.7-9)**. Make several atoms with electron configurations other than the ones shown in the examples below.

Figure 0.B.7: Carbon Electron Configuration **$1s^2\ 2s^2\ 2p^2$**	**Figure 0.B.8: Fluorine Electron Configuration** **$1s^2\ 2s^2\ 2p^5$**	**Figure 0.B.9: Sodium Electron Configuration** **$1s^2\ 2s^2\ 2p^6\ 3s^1$**
		

Extra exercises:

D orbitals: Scandium, atomic number 21, has an electron in the 3d orbital. Research, draw the first d orbital, and then place the final electron. Make larger atoms and draw in the protons, neutrons, and electrons if necessary to fill other D orbitals.

Chemical Bonds: Model chemical bonding using the magnets. Covalent bonding involves sharing electrons between two atoms, and ionic bonding involves the loss and gain of electrons by atoms. The H_2O molecule is a good example of covalent bonding and Li-F is a good example of ionic bonding.

Ions: Create various ions by adding or removing electrons to the atom. Research ions online and demonstrate how the ion would be made, starting with the uncharged atom.

Lesson 0C – Isotopes – Student Handout

Student Centered Activity: Use the Biology magnets to build isotopes for various elements. Hydrogen has three different isotopes. Hydrogen-1 (protium), hydrogen-2 (deuterium), and hydrogen-3 (tritium). Each have one proton and 0, 1, and 2 neutrons respectively. Carbon comes in three isotopes as well, carbon-12, carbon-13, and carbon-14. Build the atoms and show the different isotopes by adding and/or removing neutrons. (**Figure 0.C.1-2**). Research on the internet or use instructions from your teacher to build isotopes for other elements not shown below.

Figure 0.C.1: The Three Isotopes of Hydrogen – Protium, Deuterium, and Tritium

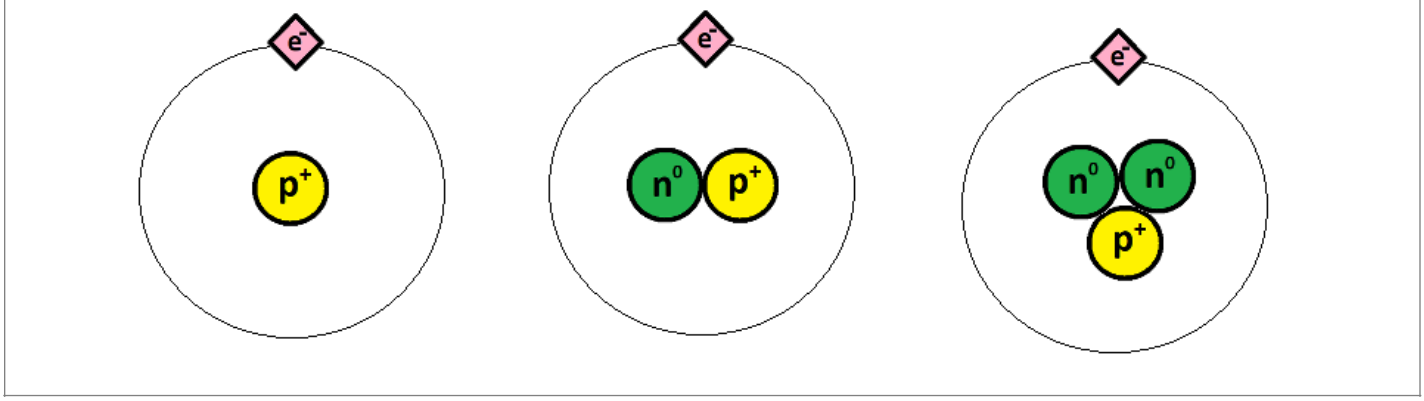
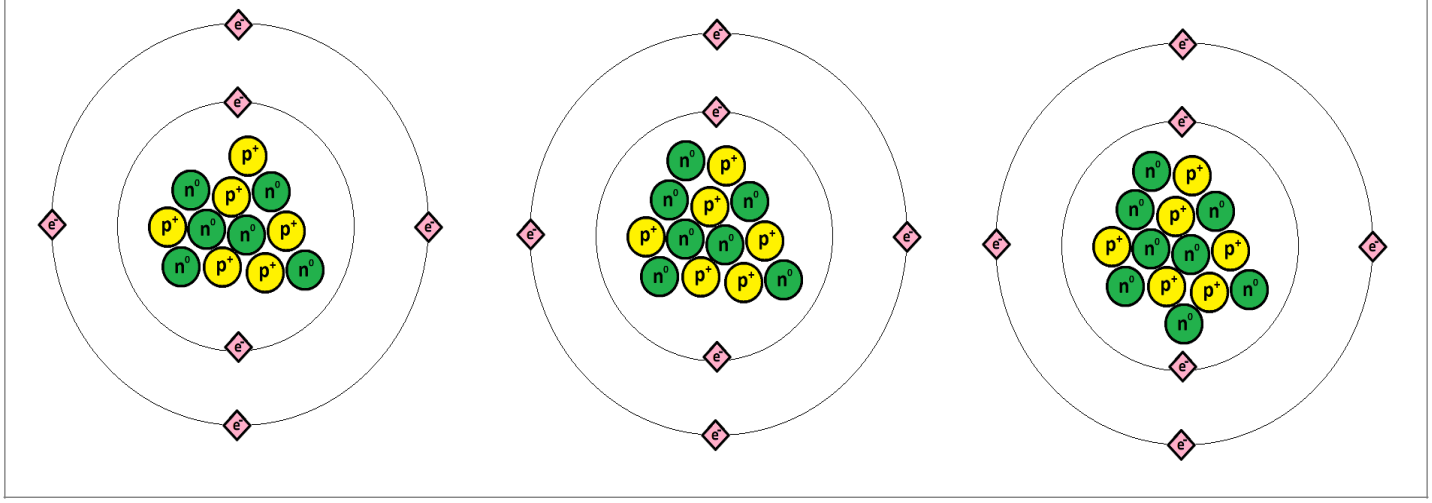


Figure 0.C.2: The Three Isotopes of Carbon – Carbon-12, Carbon-13, and Carbon-14



Extra exercise:

Radioactive Isotopes: Some isotopes are radioactive. Research which isotopes are radioactive and model how they decay. For example, carbon-14 will decay into nitrogen-14 when a neutron becomes a proton and emits an electron. Use the Biology Magnets to demonstrate this decay.