Science Unit:	***The Electron: Conductivity and Chemistry***
Lesson 2:	***Particle Model of Matter***

School Year:	2011/2012
Developed for:	Trafalgar Elementary School, Vancouver School District
Developed by:	James Day (scientist); Kathryn Coulter-Boisvert and Christy Shea (teachers)
Grade level:	Presented to grades 6 and 7; appropriate for grades 5 – 7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes
Notes:	This lesson assumes that students have had some exposure to the periodic table of the elements; at the very least, students should understand that it lists information about all the known elements. This lesson also assumes that 30 students are participating in the activity. Only slight modifications will be required for classes of a different size.

Objectives

1. Discover the existence of the quantum world and learn about the atomic constituents.
2. Learn to read the periodic table of the elements.
3. Build both a mental and physical model of the atom.
4. Identify the ways in which the electron, a charged particle, can be influenced to move.
5. Realize the important role that the electron plays in electricity and chemistry.

Background Information

Over 2000 years ago, in ancient Greece, Democritus suggested that matter is made up of particles too small to be seen individually. His idea implied that if you cut a substance into subsequently smaller and smaller pieces, you would eventually reach the smallest possible piece of that substance. These "smallest possible pieces" were called particles—the building blocks of matter. More recently, scientists have added to Democritus' idea and have developed a working theory called the particle model of matter.

There are four main concepts associated with the particle model of matter: (1) all matter is composed of tiny particles; (2) these particles are always in motion; (3) there exists empty space between these particles; and (4) adding heat to the particles makes them move faster. This lesson focuses primarily on the first concept: that matter is composed of tiny particles.

Vocabulary

<u>Atom:</u>	The basic unit of matter that consists of a dense central nucleus surrounded by a cloud of negatively charged electrons.
<u>Element:</u>	A pure chemical substance consisting of only one type of atom.
<u>Molecule:</u>	A group of atoms bonded together, representing the smallest fundamental unit of a chemical compound.
<u>(atomic) nucleus:</u>	The dense region at the center of an atom, consisting of protons and neutrons.

Proton:	A subatomic particle (typically given the symbol *p*+) with a positive electric charge, equal and opposite to that of the electron. One or more protons are present in the nucleus of each atom, along with neutrons.
Neutron:	A subatomic particle (typically given the symbol *n*) with no net electric charge. Neutrons are just very slightly more massive than protons.
Electron:	A subatomic particle (typically given the symbol *e*−) with a negative electric charge, equal and opposite to that of the proton. It has no known components or substructure, and is considered to be an elementary particle. An electron has a mass that is nearly 2000 times less than the proton.
electromagnetic field:	A physical quantity associated with each point of space (and time) that describes the electromagnetic forces acting upon the motions of a charged particle. This field can be viewed as the combination of separate electric and magnetic fields. The electric field is produced by stationary charges, and the magnetic field by moving charges (currents). The way in which charges and currents interact with the electromagnetic field are well understood.

Materials

- handout of the periodic table of the elements
- activity sheet Jelly bean model of the atom
- thirty plastic bags filled with jelly beans (one for each of the elements listed below)

In the Classroom

The teacher should participate in the discussion.

Introductory Discussion

1. Begin by having the students brainstorm over the following questions: What is matter made up of? (Consider drawing an analogy to help convey the concept of the particle model of matter; e.g., a LEGO tower and simple blocks of LEGO.) What makes one substance different from another? How are these questions answered? (Again, consider using an analogy to help convey the concept of particle accelerators; e.g., two cars crashing.) Be sure to carefully define the words: atom, element, molecule, atomic nucleus, proton, neutron, and electron.

2. Review the importance of keeping a scientific notebook. Then, distribute to each student a copy of the periodic table of the elements – have the students glue or tape this periodic table into their scientific notebooks.

3. Provide a concise introduction to the periodic table of the elements. In particular, highlight the element name and symbol, the atomic number, and the atomic mass of each element. Notice that mercury [Hg] is used as an example on the handout. In the interest of collecting some formative feedback, have the students explain the information given for, say, aluminum. In this case, they should be able to list the symbol as “Al”, identify that the nucleus contains 13 protons, that aluminum has 13 electrons, and that there are 27-13=14 neutrons in its nucleus.

4. Briefly describe the jelly bean atom model activity. (Time and technology permitting, spend 10 minutes with the 'Build an Atom' PhET, listed in the references below. This is best done if the classroom is equipped with a computer and an associated projector, so that all students can easily watch the teacher build an atom, as an example for the activity to follow.)

5. Highlight that students should focus on drawing some conclusions about the different atoms created by different groups (size and mass of atom, number of neutrons present, etc.), and that they should be recording their results (e.g., a sketch of their atom) in the scientific notebook.

Activity Title: Jelly bean model of the atom

Purpose of Activity: By using colored candies to represent subatomic particles (protons, neutrons, and electrons), students make their own model of an atom. (The Bohr model of the atom is used here, as contemporary models of the atom require accounting for quantum mechanical effects---a concept far too complex for this age. The Bohr model does, however, serve as an excellent first understanding of how atoms are structured.) This activity will help with student understanding of the subatomic constituents of an atom, as well as nuclear notation of the periodic table.

Methods and Instructions:
Set-up prior to experiment: Have thirty bags of jelly beans prepared. Use (for example) red jelly beans as protons, green jelly beans as neutrons, and yellow jelly beans as electrons. The table below outlines the contents of each bag (these particular elements were chosen so that the "Extension of Lesson Plan" is also possible). Label each bag with only the element symbol and let the students use the periodic table to find the element name and other relevant information.

It is strongly recommended that the bags contain more than the minimum numbers listed below for two reasons. First, having more jelly beans than required forces students to think about whether or not they have actually used the correct number of jelly beans in their model. Second, the students will likely be eating the jelly beans after the activity, and things will seem "more fair" if all bags contain roughly the same number of jelly beans.

Element (name, # of bags)	Minimum# **red** per bag	Minimum # **green** per bag	Minimum # **yellow** per bag
H (hydrogen, 11 in total)	1	0	1
He (helium, 1 in total)	2	2	2
C (carbon, 3 in total)	6	6	6
N (nitrogen, 3 in total)	7	7	7
O (oxygen, 9 in total)	8	8	8
Ne (neon, 1 in total)	10	10	10
Na (sodium, 1 in total)	11	12	11
Cl (chlorine, 1 in total)	17	18	17

Students will work individually for this activity, but should be encouraged to exchange ideas with or solicit help from their peers. [This activity was originally done for 60 students at once, all working in pairs.]

1. Randomly assign one of the above elements to each student.

2. Define the colour scheme to the students. For example: protons are red jelly beans; neutrons are green jelly beans, and electrons are yellow jelly beans.

3. Ask students to arrange their jelly beans on the blank Bohr model of the atom activity sheet. Let the students know that they have *at least* enough jelly beans to make their element, but that they might have more than required. They need to think about where and how many jelly beans of each colour to place on the activity sheet.

4. When a student thinks they have completed their model correctly, the teacher should check that it has been done correctly.

5. If the model was built correctly, the student should transfer the jelly bean model of their element as a picture into their scientific notebook. Encourage the students to look at some of the pictures/models made by their peers. Ask students what they can conclude about atomic sizes and masses; i.e., in general, both increase as we move across and down the periodic table of the elements (from top left to bottom right).

6. Once the sketches are complete, the jelly beans may be shared and eaten.

Closure Discussion

1. Review atomic constituents. Ask students whether or not they think protons, neutrons, and electrons are “fundamental particles”. (We think that electrons are, but don't know for sure. we know that protons and neutrons are not – they are made up of quarks.)

2. Highlight the importance of the periodic table – it allowed scientists to make predictions about the existence of elements that had yet to be discovered!

3. Time permitting, emphasize that chemistry is almost entirely the result of what electrons do. (See Extension of Lesson Plan)

4. Introduce the upcoming lesson on how batteries work.

References

1. <http://en.wikipedia.org/wiki/Scientific_method> 'Periodic Table' entry on Wikipedia [Provides an excellent description of the periodic table of the elements, with a detailed explanation of the table's organizational structure.].

2. <http://phet.colorado.edu/en/simulation/build-an-atom> 'Build an Atom' PhET (*Ph*ysic *E*ducation *T*echnology) from the University of Boulder, Colorado. One of many from a suite of research-based interactive computer simulation for teaching and learning physics, chemistry, math, and other sciences. [Small, simple program that allows the user to drag and drop protons/neutrons/electrons into an atom, thereby building an atom. This is the virtual analog to the hands-on activity described in this lesson.]

3. <http://www.exo.net/~emuller/activities/M%20and%20M%20Atom%20Model.pdf> M&M® model of the Atom. [.pdf document.] Accessed 12 January 2012.

Extension of Lesson Plan

1. Show how chemistry happens by sharing or exchange of electrons. The choice of elements in the table above allows for creating the following covalently bonded molecules: H_2, O_2, N_2, O_3, H_2O, CO, CO_2, NH_3, CH_4. Also possible is the ionically bonded NaCl and the inert gases Ne and He. For more information of this extension, see Lesson 6, Material Classification, in this science unit (The Electron: Conductivity and Chemistry).

The Periodic Table of the Elements

Element name → Mercury
Atomic # → 80
Symbol → **Hg**
Avg. Mass → 200.59

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 **H** 1.01																		Helium 2 **He** 4.00
Lithium 3 **Li** 6.94	Beryllium 4 **Be** 9.01												Boron 5 **B** 10.81	Carbon 6 **C** 12.01	Nitrogen 7 **N** 14.01	Oxygen 8 **O** 16.00	Fluorine 9 **F** 19.00	Neon 10 **Ne** 20.18
Sodium 11 **Na** 22.99	Magnesium 12 **Mg** 24.31												Aluminum 13 **Al** 26.98	Silicon 14 **Si** 28.09	Phosphorus 15 **P** 30.97	Sulfur 16 **S** 32.07	Chlorine 17 **Cl** 35.45	Argon 18 **Ar** 39.95
Potassium 19 **K** 39.10	Calcium 20 **Ca** 40.08		Scandium 21 **Sc** 44.96	Titanium 22 **Ti** 47.88	Vanadium 23 **V** 50.94	Chromium 24 **Cr** 52.00	Manganese 25 **Mn** 54.94	Iron 26 **Fe** 55.85	Cobalt 27 **Co** 58.93	Nickel 28 **Ni** 58.69	Copper 29 **Cu** 63.55	Zinc 30 **Zn** 65.39	Gallium 31 **Ga** 69.72	Germanium 32 **Ge** 72.61	Arsenic 33 **As** 74.92	Selenium 34 **Se** 78.96	Bromine 35 **Br** 79.90	Krypton 36 **Kr** 83.80
Rubidium 37 **Rb** 85.47	Strontium 38 **Sr** 87.62		Yttrium 39 **Y** 88.91	Zirconium 40 **Zr** 91.22	Niobium 41 **Nb** 92.91	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
Cesium 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** 207.20	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** (267)	Dubnium 105 **Db** (268)	Seaborgium 106 **Sg** (271)	Bohrium 107 **Bh** (272)	Hassium 108 **Hs** (270)	Meitnerium 109 **Mt** (276)	Darmstadtium 110 **Ds** (281)	Roentgenium 111 **Rg** (280)	Copernicium 112 **Cn** (285)	Ununtrium 113 **Uut** (284)	Ununquadium 114 **Uuq** (289)	Ununpentium 115 **Uup** (288)	Ununhexium 116 **Uuh** (293)	Unnunseptium 117 **Uus** (294?)	Ununoctium 118 **Uuo** (294)

*lanthanides	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** 151.97	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
**actinides	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)

Jelly bean model of the atom