A Matter of Matter

Grade Level: Fifth Grade (Chemistry and Science Biography)

Written by: Brian Selling, Cheyenne Mountain Charter Academy, Colorado Springs, CO

Length of Unit: Four lessons at 50 minutes per lesson; lessons may be reduced to eight 40-minute lessons if additional drill time is necessary (eight 25 minute classes with 15 minutes for additional drill and practice); dotted lines in each lesson procedures/activities indicate recommended break points if using as 40 minute lessons)

I. ABSTRACT

The purpose of this unit is for students to develop an understanding of the principles and inter-reactions of atoms, molecules, elements and compounds. This includes an understanding of the periodic table, as well as chemical and physical changes in matter. The students will also understand the cultural and scientific contributions of two scientists, Percy Lavon Julian and Earnest Everett Just.

II. OVERVIEW

A. Concept Objectives
   1. Students will recognize that patterns exist within and across systems. (Colorado State Standard (CSS), Science, 5.6G)
   2. Students will understand that materials made by chemically combining two or more substances may have different properties that differ from the original properties and that there are 103 known elements in nature. (CSS, Science, 5.2.A, 5.2.B)
   3. Students will understand the historical biographies of Julian and Just, recognizing that scientific contributions are made by individuals with diverse backgrounds, interests, talents, and motivations. (CSS, Science, 5.6.E)

B. Content from the *Core Knowledge Sequence* (page 129)
   1. Atoms, Molecules, and Compounds
      a. Basics of atomic structure: nucleus, protons (positive charge), neutrons (neutral), electrons (negative charge)
      b. Atoms are constantly in motion, electrons revolve around the nucleus in paths called shells (or energy levels)
      c. Atoms may join together to form molecules and compounds
      d. Common compounds and their formulas
         i. Water H_20
         ii. Salt NaCl
         iii. Carbon dioxide CO_2
   2. Elements
      a. Elements have atoms of only one kind, having the same number of protons. There are a little more than 100 different elements.
      b. The Periodic table: organizes elements with common properties
      c. Atomic symbol and number
      d. Some well known elements and their symbols
         i. Hydrogen H
         ii. Helium He
         iii. Carbon C
         iv. Nitrogen N

v. Oxygen O
vi. Sodium Na
vii. Aluminum Al
viii. Silicon Si
ix. Chlorine Cl
x. Iron Fe
xi. Copper Cu
xii. Silver Ag
xiii. Gold Au

e. Two important categories of elements: metals and non-metals
   i. Metals comprise about 2/3 of all elements.
   ii. Properties of metals: most are shiny, ductile, malleable, conductive

3. Chemical and Physical Change
   a. Chemical change changes what a molecule is made up of and results in a new substance with a new molecular structure. Examples of chemical change: rusting of iron, burning of wood, milk turning sour
   b. Physical change changes only the properties or appearance of the substance, but does not change what the substance is made up of. Examples of physical change: cutting wood or paper, breaking glass, freezing water
4. Science Biographies
   a. Percy Lavon Julian
   b. Earnest Just

C. Skill Objectives
1. Describe interrelationship of protons, neutrons, and electrons.
2. Describe how electrons revolve around neutrons.
3. Understand how atomic weight is determined.
4. Understand all atoms are in a constant state of movement, and how this movement relates to their state (solid, liquid, gaseous).
5. Understand how elements can be combined to form compounds.
6. Describe properties of metal and non-metal elements.
7. Describe well-known elements by symbol and properties.
8. Describe with examples how chemical changes in elements actually change the molecular structure of matter.
9. Describe with examples how physical changes to elements do not change the molecular structure of matter.
10. Describe Just and Julian's contributions to scientific thought, recognizing how their diverse backgrounds and interests allowed them to add to the body of scientific research.

III. BACKGROUND KNOWLEDGE

A. For Teachers
1. Hirsch, E.D. Jr., *What Your Fifth Grader Needs to Know*, Charlottesville, VA, Core Knowledge Foundation, 1993. ISBN 0-385-31464-7
2. Jones, Charyn, *Eyewitness Science-Chemistry,* New York, NY, DK Publishing, Inc., 1993. ISBN 1-56458-231-0
3. Moje, Steven W, *Cool Chemistry, Great Experiments with Simple Stuff,* New York, NY, Sterling Publishing Co, 1999. ISBN 0-8069-6349-2
4. Wick, Walter, *A Drop of Water,* New York, NY, Scholastic Press, 1997. ISBN0-590-22197-3

5. Brown, Mitchell C, Ernest Everett Just: Zoologist, Biologist, Physiologist, Research Scientist, *Princeton* [On-line]. Available URL: http://www.Princeton.edu/~mcbrown/display/just.html, 1995.
6. Unknown, Chemical Achievers, Percy Lavon Julian and Carl Djerassi, The *Chemical Heritage Foundation,* [On-line]. Available URL: http://www.chemheritage.org/EducationalServices/chemach/ppb/1d.html, 2000.
7. Unknown, The Periodic Table of Elements, U.S. Government [On-line]. Available URL: http://pearl1.lanl.gov/periodic/default.htm, 2002.

B. For Students
1. Students should have an understanding of basic states of matter-solid, liquid, gas (4^{th} grade, page 104).
2. Students should understand basic components of matter such as mass, volume, density and vacuum (4^{th} grade, page 104).
3. Students should have and understanding of what an atom is and how electrical charges impact atomic particles: proton (+), electron (-), neutron (N) (4^{th} grade, page 104).
4. Students should understand there are over 100 types of elements, and that elements consist of only one type of atom (4^{th} grade, page 105).
5. Students should understand solutions are developed by dissolving a substance into a liquid (which may not be visible to the naked eye) and how concentration and saturation can lead to development of crystals (4^{th} grade, page 105).

IV. RESOURCES

A. *What Your Fifth Grader Needs to Know* by E.D Hirsch
B. *Eyewitness Science-Chemistry* by Charyn Jones
C. *Cool Chemistry, Great Experiments with Simple Stuff* by Steven Moje
D. *A Drop of Water* by Walter Wick

V. LESSONS

Lesson One: Atoms, Molecules, and Compounds

A. *Daily Objectives*
1. Concept Objective
   a. Students will recognize that patterns exist within and across systems. (CSS, Science, 5.6G)
2. Lesson Content
   a. Basics of atomic structure: nucleus, protons (positive charge), neutrons (neutral), electrons (negative charge)
   b. Atoms are constantly in motion, electrons revolve around the nucleus in paths called shells (or energy levels)
   c. Atoms may join together to form molecules and compounds
   d. Common compounds and their formulas
      i. Water H_20
      ii. Salt NaCl
      iii. Carbon dioxide CO_2
3. Skill Objectives
   a. Describe interrelationship of protons, neutrons, and electrons.
   b. Describe how electrons revolve around neutrons.
   c. Understand all atoms are in a constant state of movement, and how this movement relates to their state (solid, liquid, gaseous).

B. *Materials*

1. Copies of periodic table for each student (available at http://pearl1.lanl.gov/periodic/default.htm)
2. Overhead transparency of periodic table
3. Copies of Appendices A and B for each student
4. One 8-16 oz. clear glass jar filled with room temperature tap water
5. Blue, green or purple water-based food coloring
6. Paper and pencils for students
7. Science folders-students need a place to keep all items from this unit

C. *Key Vocabulary*

1. Atom-the smallest particles of matter, which when combined with atoms of the same type form elements
2. Element-one or more atoms of the same type (gold, silver, lead, hydrogen)
3. Molecule-a collection of atoms from different elements that form a compound (Carbon Dioxide-CO_2, water-H_2O)
4. Proton-positive charged portion of an atoms nucleus; the number of protons in an atom is its atomic number
5. Neutron-neutrally charged portion of an atoms nucleus
6. Nucleus-center part of an atom consisting of protons and neutrons
7. Electron-negatively charged portion of an atom, which orbits the nucleus in a circular or elliptical path
8. Phase change-when matter changes from one phase to another-solid to liquid to gas; requires adding or removing of heat

D. *Procedures/Activities*

1. Begin with a description of the vastness of the universe-the millions of galaxies, systems, stars, and planets. Explain that these are all made up of matter-just like everything, including people on earth.
2. Bring the discussion down to earth size, then to Colorado Springs (or whatever city you live in), then to a person, then a cell, then a virus, then a molecule, and finally to an atom, made up of a proton, neutron, and electron. Draw a picture of an atom on the board or overhead (Appendix A). Explain that atoms are tiny particles that make up matter. There are over 100 types of matter, and they are called elements. Use drill to reinforce.
3. Pass out copies of the Periodic table of elements, placing one on a transparency on the overhead (or refer to a paper copy in your hand).
4. Explain to the students that you will cover the elements in greater detail in the next class, but that this is a list of all elements. Elements are substances that are made up of identical atoms.
5. Anything that takes up space is called matter. There are three phases of matter; solid, liquid, gas. Solid is the densest of the three, with a definite shape and volume. Liquid has a definite volume, but no defined shape. Gas, the least dense, has no definite volume or shape. In a gas, the atoms or molecules are not as close together as they are in the same substance in a liquid form, likewise for liquids when compared to solids. Use drill to reemphasize the principles of gas, liquids, or solids.
6. Explain that atoms are in a constant state of movement-electrons are always rotating around the nucleus. Further explain that as the state of a compound changes from solid to liquid to gaseous, the speed with which the electrons rotate around the nucleus likewise increases. Emphasize that heat plays the critical role in determining whether something is solid, liquid, or gaseous.

7. Explain phase changes of water (H_2O). At 32 degrees F (0 degrees C), water freezes. If warmed above that, it becomes liquid, then boils at 212 degrees F (100 degrees C) and turns to gas. Note that the addition or removal of heat is required to change any element or compound's state, or phase. Use drill to emphasize addition or removal of heat is necessary for a phase change to occur.
8. Explain how the atomic number on the periodic table refers to the number of protons, electrons, and neutrons in each atom (carbon has six of each, with an atomic number of 6). Explain these compounds are the same virtually across the entire universe. Show picture of Appendix A, explaining that the atomic number is the same as the number of protons, neutrons, and electrons. Draw a hydrogen atom with one each proton, neutron, and electron. Have students draw a carbon atom, with six protons, neutrons, and electrons on a sheet of paper. Use drill to emphasize the atomic number of an element is the same as the number of protons, neutrons, and electrons in each atom of the element. Mention that the weight of the atom is greater the higher the atomic number (as is logical), and that you will cover that in greater detail in the next lesson.

-------Break point if using as 40 minute lesson-25 minute lesson, 15 minute review)---Note-distribute Appendix B and complete to this point in the lesson

9. Explain that a group of the same kind or different atoms can create a molecule, though not all groups of atoms necessarily form molecules. Molecules are groups of atoms that have bonded together. Give examples-O_2 (oxygen), H_2O (water), CO_2 (carbon dioxide), and NaCl-salt. Explain that a molecule is in most cases a group of atoms from different elements and is also known as a compound, though in some cases, such as oxygen, it can be from the same element. Use drill to emphasize what a molecule is.
10. Show the students a clear jar of water. Leave it undisturbed at the front of the class. Explain that despite the fact it appears calm, the water is filled with billions of water molecules, all of which are rotating with electrons. Put one drop of blue water-based coloring in it. Explain to the students that the color will eventually mix completely with the water because of the motion of the electrons in the atoms and molecules. You will have to come back to the jar later as it slowly mixes itself.
11. Discuss matter and mass. Explain that some matter is denser than others, which results in heavier weights in the same volume. A word picture example is a bar of lead and an amount of water or air which takes up the same volume-the lead weighs more than the water, which weighs more than the air, due to the density of the substance, as well as the proximity of atoms and molecules based on the state of matter.
12. Refer back to the jar of water. The solution should be mixing throughout the glass, though the substance is probably not a uniform color. Remind the students that despite the fact the water appears calm, it is actually churning as a result of all the electrons rotating around the nucleus of the atoms.
13. Explain that heavier elements are denser-notice that the metals are generally heavier than the non-metals. Use drill to emphasize that metals are generally heavier than non-metals.
14. Refer back to the jar of water. The solution should be mixed throughout the glass, though the substance it probably not a uniform color. Remind the students that despite the fact the water appears calm, it is actually churning as a result of all the electrons rotating around the neutrons in the water molecules.
15. Distribute the vocabulary sheets (Appendix B) and allow students five minutes to complete. Then review the sheet ensuring students correct any errors.

E. *Assessment/Evaluation*
   1. Verify correct completion of carbon atom drawing.
   2. Verify completion of vocabulary Worksheet (Appendix B).

Lesson Two: Elements

A. *Daily Objectives*
   1. Concept Objective
      a. Students will recognize that patterns exist within and across systems. (CSS, Science, 5.6G)
   2. Lesson Content
      a. Elements have atoms of only one kind, having the same number of protons.
      b. There are a little more than 100 different elements.
      c. The Periodic table: organizes elements with common properties
      d. Atomic symbol and number
      e. Some well known elements and their symbols

i.	Hydrogen	H
ii.	Helium	He
iii.	Carbon	C
iv.	Nitrogen	N
v.	Oxygen	O
vi.	Sodium	Na
vii.	Aluminum	Al
viii.	Silicon	Si
ix.	Chlorine	Cl
x.	Iron	Fe
xi.	Copper	Cu
xii.	Silver	Ag
xiii.	Gold	Au

      f. Two important categories of elements: metals and non-metals
         i. Metals comprise about 2/3 of all elements.
         ii. Properties of metals: most are shiny, ductile, malleable, conductive
   3. Skill Objectives
      a. Describe atomic makeup of elements and compounds.
      b. Describe how the periodic table organizes elements and the meaning of the atomic number and weight.
      c. Understand properties of metal elements and how they differ from non-metal elements.
      d. Describe chemical symbols for some well-known elements.
      e. Identify that there are more than 100 known elements.

B. *Materials*
   1. Three toothpicks for each student
   2. Three paperclips for each student
   3. Three pieces foam packing (peanuts)
   4. Paper and pencils for students
   5. Science folders-students need a place to keep all items from this unit
   6. Copies of periodic table for each student (available at http://pearl1.lanl.gov/periodic/default.htm)
   7. Appendix B from previous lesson for each student
   8. Appendix C for each student

9. Appendix D for each student

C. *Key Vocabulary*
   1. Ductile-ability to stretch material out into long thin wire-like strands
   2. Malleable-the ability to hammer material (such as lead, gold, or silver) into a shape
   3. Conductive-material that transmits electrical energy well

D. *Procedures/Activities*
   1. Ensure students have their copy of the periodic table of elements from the previous lesson. Distribute additional copies if they have misplaced it. Distribute copies of the class worksheets, Appendices C and D to the students. Ensure students have partially completed Appendix B from the previous lesson. Give each student three toothpicks, three paperclips, and three pieces of Styrofoam popcorn.
   2. Review previous lesson material of atoms and molecules. Drill students on properties of gases, liquids, and solids, what is necessary for a phase change (addition or removal of heat), and that the atomic number of an element represents the number of protons, electrons, and neutrons in each atom. Reinforce to students that elements are pieces of matter that contain only one kind of atom. Tell students the paperclips, toothpicks, and Styrofoam padding each represents one kind of atom.
   3. Hold up three toothpicks. Ask the class, "If each were an atom, would this be an atom, molecule, element, or compound?" Explain that the toothpicks are representative of an element-each toothpick represents a single atom of the same type.
   4. Hold up one toothpick, one paperclip, and one piece of Styrofoam. Repeat question from 3 above. Answer is a compound or molecule, as they have dissimilar atoms in the same mass. Remind students a molecule is not necessarily a compound, as two oxygen atoms together form a molecule of oxygen but are not considered a compound, as they do not share dissimilar atoms. Repeat the above several times until all students respond properly to teacher prompts to show atoms, molecules, and compounds. Note that compounds and molecules would be any combination of paperclips, Styrofoam, and toothpicks, as long as there are at least two different objects, an element would be two or more of the same object, and an atom would be a single item. Then tell the students to hold up an atom, then a molecule, then a compound. Ensure students are holding up appropriate items of their choice to represent the item the teacher has called for.
   5. Refer to the Periodic table of elements. Remind students that the atomic number in each element refers to the number of protons, neutrons, and electrons in each atom of the element. Require students to repeat the correct number of protons/electrons/neutrons when the teacher asks how many for various elements.
   6. Explain that two thirds of all elements are metals. Properties of metals include the fact they are shiny, ductile (can be pulled into strings or wires), malleable (can be pounded into shape), and conductive (allow electricity to transfer through it easily). Metals have distinct chemical properties. They react to acids to create salts and with oxygen to form oxides. The other one third of the elements are non-metallic, half of which are gases, and have opposite reactions to acid and oxygen. Non-metallic elements normally don't react to acids, and when burned in air form oxides which produces acids with water. Use drill to reinforce the definition of ductile, malleable, and conductive properties of metals.

-------Break point if using as 40 minute lesson-25 minute lesson, 15 minute review)---

7. Review common elements and their symbols, atomic numbers, and weights. Tell the students the atomic weight is the number of grams that 6.02 X 10 (23rd power) atoms of the element weigh, also known as a mole. Ask the students to repeat what a mole is. Thus, Carbon, with an atomic number of six and an atomic weight of 12, has six protons, six neutrons, and six electrons, and one mole of carbon weighs 12 grams. Review well known elements, their atomic numbers and weights below: Note the logic of the original table, developed in 1869 by Russian scientist Dmitri Mendeleyev, lists the elements in order of atomic mass which shows regularly (or periodically) repeating properties. Note that the atomic weight is either exactly or generally twice the atomic number, which refers to the number of protons, electrons, and neutrons in a given element. This is the periodic or repeating pattern indicated above. Drill the students on this principle, using atomic numbers and weights as examples, requiring students to respond with the correct atomic weight and/or number, as well as to who Dmitri Mendeleyev was.

Name	Symbol	Atomic #	Atomic Weight
Hydrogen	H	1	1
Helium	He	2	4
Carbon	C	6	12
Nitrogen	N	7	14
Oxygen	O	8	16
Sodium	Na	11	23
Aluminum	Al	13	27
Silicon	Si	14	28
Chlorine	Cl	17	35.5
Iron	Fe	26	56
Copper	Cu	29	63.5
Silver	Ag	47	108
Gold	Au	79	197

8. Review Appendix C to ensure students have completed their exercise and notes question correctly.
9. Have students take home Appendix D and complete.

E. *Assessment/Evaluation*
1. Verify students understand difference between atoms, molecules, compounds, and elements in the toothpick exercise.
2. Ensure students complete the classroom vocabulary and note exercise accurately.
3. Completion of Appendix D.

Lesson Three: Chemical and Physical Change of Matter

A. *Daily Objectives*
1. Concept Objectives
   a. Students will understand that materials made by chemically combining two or more substances may have different properties that differ from the original properties and that there are more than 100 known elements in nature. (CSS, Science, 5.2.A, 5.2.B)
2. Lesson Content
   a. Chemical change changes what a molecule is made up of and results in a new substance with a new molecular structure. Examples of chemical change: rusting of iron, burning of wood, milk turning sour
   b. Physical change changes only the properties or appearance of the substance, but does not change what the substance is made up of.

Examples of physical change: cutting wood or paper, breaking glass, freezing water

3. Skill Objectives
   a. Describe with examples how chemical changes in elements actually change the molecular structure of matter.
   b. Describe with examples how physical changes to elements do not change the molecular structure of matter.

B. *Materials*
1. One Bunsen burner*
2. One teaspoon iron filings*
3. One teaspoon yellow sulfur*
4. One small magnet*
5. One test tube*
6. Test tube clamp stand*
7. Glove to handle hot test tube
8. Eye protection for all*
9. One piece of charcoal or piece of wood, burned black
10. One piece of wood 2" X 4" (12 inches long)-available at most hardware stores
11. One small bag of sawdust or a hand saw with which to make a small cut in the 2" X 4"
12. Paper and pencils for students
13. Science folders-students need a place to keep all items from this unit
14. Copies of periodic table for each student (available at
15. http://pearl1.lanl.gov/periodic/default.htm)
16. Small (8-16 oz) jar of clear water

* These items are available at most hardware or teacher supply stores.

C. *Key Vocabulary*
1. Ionic Bonds-when two elements (typically a metal and non metal) are combined and trade electrons to become a completely different compound; the loss or gain of electrons also changes the properties of the elements; example-Sodium Chloride-salt
2. Covalent bonds-when two elements combine and share their electron rather than losing or gaining as in the ionic bond-example is water-H_2O, where each hydrogen atom shares its single electron with the one in oxygen
3. Noble gases-elements which do not give up or share their electrons with other elements, and generally do not react at all with other elements
4. Chemical reaction-process where elements react to exposure to other elements in the process of changing their molecular makeup

D. *Procedures/Activities*
1. Distribute Appendix E. Begin with a review of previous material, specifically targeting phase changes, principles of atoms, elements, and compounds, definition of gases, liquids and solids, and atomic weights and numbers. Drill students on atomic numbers and weights to ensure all understand the repeating or periodic nature of the table. Ensure students understand that when matter changes from a solid to a liquid and then a gas it is because of the addition or deletion of heat (energy). Use drill to reinforce whether heat is added or taken away to create a solid, liquid, or gas.
2. Explain that an ion is an atom or group of atoms with an electrical charge. When different atoms with electrical charges are combined, they form ionic bonds. Essentially, one of the elements loses some or all of their electrons to the other, changing the chemical makeup of the compound. These are normally created

from elements that are far apart in the periodic chart (sodium [Na] and chloride [Cl] combine make salt-NaCl). Explain that metals tend to form ionic bonds. Use drill to reinforce that ionic bonds are the result of loss or gains of electrons, and that metals are most commonly the source of ionic bonds.

3. Explain that covalent bonds are created when two elements combine and share their electron rather than losing or gaining as in the ionic bond-example is water-H_2O, where each hydrogen atom shares its single electron with the one in oxygen. Explain that non-metals typically form covalent bonds. Use drill to reinforce that covalent bonds are the sharing of electrons, and is most commonly associated with non-metal elements.
4. Using the piece of unburned wood, either show the students the sawdust or, if capable of doing so, use the saw to make a few small cuts in the wood. Ask the students if you have changed the molecular structure of the wood. When they say no, ask them if this is an example of a physical or chemical change. Reinforce that cutting the wood or melting of ice is a physical change in the compound-the molecular structure has not changed. Show them the burned wood or charcoal. Remind them this was once wood just like the unburned wood. Ask them if this is an example of a chemical or physical change in wood. Reinforce that a chemical change in the molecular structure of the elements or compounds in known as a chemical reaction. Repeat with drills to emphasize this point. Query with such questions as to how the wood has changed after burning. When burned, some carbon in the wood was changed into CO_2 (Carbon dioxide) and CO (carbon monoxide) through the generation of heat (energy). It now weighs less, as it has lost matter to the atmosphere. The very structure of the wood was changed, with the burned portion becoming cracked and brittle. Ask the students if you would build a house from unburned or burned wood. Use drill to reinforce what constitutes a change in chemical or physical structure of elements and compounds. Use examples in the drill such as the burning of gasoline, boiling of water, hammering of metal, cutting of stone, etc.
5. Describe to students the Noble Gasses, which have the effect of not reacting with other elements. Explain that the Noble Gases (Helium, Neon, Argon, Krypton, Xenon, and Radon) do not readily give up their electrons and thus don't normally react with other elements. They are non-reactive and do not form compounds easily. Drill students to reinforce Noble Gases don't normally form ionic or covalent bonds.

-------Break point if using as 40 minute lesson-25 minute lesson, 15 minute review)---

6. Have students put their safety glasses on and gather around a table. The teacher demonstrates mixing of elements and the change in molecular structure. Place some iron filings and sulfur in a small dish. Use the magnet to draw out the iron filings. Explain that the metal (iron) is attracted to the magnet, while the sulfur is not. This is a common trait of metal and non-metal elements. Replace the metal filings in the sulfur and mix both in a small amount of water. While they will mix (the sulfur will dissolve) explain that there is no immediate chemical reaction. The mix is still not a compound-it is a mixture of water, sulfur and iron filings, each of which has retained its molecular structure and has not been absorbed by the other. It is neither a covalent or ionic bond at this time. It would be simple to strain the filings from the water and distill the sulfur out later. Repeat as necessary to drill the students that this is not an example of a chemical reaction or a bond.
7. Place the solution in a test tube and heat over the Bunsen burner. Explain that the heat (or energy) in this example is allowing the iron filing atoms to donate

electrons to the sulfur atoms, forming an ionic bond. Review ionic and covalent bonds in a drill to ensure students understand the difference between donation and sharing of electrons. In this exercise, heat is providing the energy to make the ionic bonds between the atoms of the elements iron and sulfur to create a compound-Ferrous sulfide. When the water is boiled off, remove the tube from the burner and knock out the small piece of ferrous sulfide. Show the students the ferrous sulfide is no longer magnetic, even though it still looks like metal-the iron lost its magnetic properties when it donated electrons to the sulfur. The compound ferrous sulfide is a combination of iron (FE) and sulfur (S), with the chemical equation of FeS.

8. Use drill to review the entire unit to date. Review phase changes, definitions of a solid, liquid, and gas, protons, neutrons, electrons, elements, compounds, periodic tables, chemical reactions, ionic and covalent bonds.

E. *Assessment/Evaluation*

1. Complete Appendix E, Take Home Study Sheet (Lesson Three).

Lesson Four: Scientific Biographies

A. *Daily Objectives*

1. Concept Objective(s)
   a. Students will understand the historical biographies of Percy Julian and Ernest Just, recognizing that scientific contributions are made by individuals with diverse backgrounds, interests, talents, and motivations. (CSS, Science, 5.6.E)
2. Lesson Content
   a. Percy Lavon Julian
   b. Ernest Just
3. Skill Objective
   a. Describe the backgrounds and contributions of Drs. Julian and Just, specifically identifying what challenges they overcame and their contributions to science.

B. *Materials*

1. Appendix F for each student
2. Paper and pencils for students
3. Science folders-students need a place to keep all items from this unit

C. *Key Vocabulary*

1. Cytoplasm-living substance surrounding the nucleus of an egg
2. Ectoplasm-outer part of the cytoplasm
3. Steroids-cortical (affecting the mind and spinal column/growth) hormones of the
4. adrenal glands
5. Synthesis-to distill or create one substance from another

D. *Procedures/Activities*

1. Distribute Appendix F to students. Begin the class with a review of previous lessons. Ensure students understand phase changes, principles of atoms, elements, and compounds, definition of gases, liquids and solids, and atomic weights and numbers. Drill students on atomic numbers and weights to ensure all understand the repeating or periodic nature of the table. Ensure students understand that when matter changes from a solid to a liquid and then a gas it is because of the addition or deletion of heat (energy). Use drill to reinforce whether heat is added or taken away to create a solid, liquid, or gas. Review chemical and physical changes in matter, ensuring students understand chemical

changes refer to molecular changes while physical changes refer to phase changes. Review definitions of noble gases, ionic and covalent bonds.

2. Tell students that science is filled with great men and women's contributions. No one scientist has given everything to the body of knowledge known as scientific theories. Many of the world's great scientists were self-taught while others had to overcome great hardship and barriers in the pursuit of education. The things that separated these great scientists from the rest of the people of the world were two things-an inquisitive mind and the drive and perseverance to pursue their scientific careers. Ask the students if any of them could become well known research scientists when they grow up. Who is curious? Who is willing to work hard in things that interest them? Who is not willing to give up at the first sign of difficulty? Have the students raise their hands in the affirmative to these questions and explain that they all have the ability to become research scientists if they so choose.
3. Begin with Professor (Dr.) Percy Lavon Julian. Born in 1899 (died 1975) in Montgomery, Alabama. His father was a railway mail clerk and his grandparents were slaves. He faced prejudice because he was African-American in every aspect of his life, especially his education. He decided to attend De Pauw University and only made it through by supporting himself by digging ditches and waiting tables during meals at a fraternity house. He did these jobs and studied very hard at the same time, and managed to graduate. He worked at Fisk University for two years, then attended Harvard University for a Masters in organic chemistry. Following another teaching job at West Virginia State College, he went to the University of Vienna, where he earned his doctorate in the chemistry of plants in 1931.
4. He returned to the US and became a professor at Howard University, and then moved back to De Pauw as Professor in 1933. He and a partner, Josepf Pikl, whom he helped immigrate to the US in 1931, then synthesized an alkaloid called physostigmine, used to treat glaucoma. This was very important as untreated glaucoma caused the blindness of many people every year.
5. He worked on synthesizing hormones from soybeans. While applying for a job in 1936 in Wisconsin, he was noticed by a senior executive of the Glidden Company in Chicago. The Institute of Paper Chemistry in Wisconsin couldn't hire Julian because these was a law in the town of Appleton, Wisconsin, that prohibited African Americans from staying the night in the town, and Appleton was where the company was located. W.J O'Brien from Glidden of Chicago hired him instead. While with Glidden, Julian synthesized Reichsteins Substance S, which is very similar to cortisone. Hydrocortisone is still widely and inexpensively produced from this substance, which is a very important drug in the treatment of a variety of illnesses and injuries.
6. Julian's work in the development of artificial or synthesized hormones laid the foundation for other scientists to pursue study in a variety of areas. One of the outgrowths of Julian's work was the development of the oral contraceptive, otherwise known as the birth control pill, by Carl Djerassi in 1951. Other compounds were also developed that today treat a wide variety of human and animal illnesses and injuries.
7. Julian overcame racism and poor educational opportunities to become one of the 20th centuries' most prolific research scientists in the area of synthesized hormones. Throughout his life he encouraged other African-Americans to pursue educational opportunities. He always placed a high value on his position both as

an educator and scientist, and was always cognizant of his responsibilities as a citizen.

-------Break point if using as 40 minute lesson-25 minute lesson, 15 minute review)---

8. If class begins at this point, ensure students have Appendix F from previous class session. Begin the class with a review of previous lessons. Ensure students understand phase changes, principles of atoms, elements, and compounds, definition of gases, liquids and solids, and atomic weights and numbers. Drill students on atomic numbers and weights to ensure all understand the repeating or periodic nature of the table. Ensure students understand that when matter changes from a solid to a liquid and then a gas it is because of the addition or deletion of heat (energy). Use drill to reinforce whether heat is added or taken away to create a solid, liquid, or gas. Review chemical and physical changes in matter, ensuring students understand chemical changes refer to molecular changes while physical changes refer to phase changes. Review definitions of noble gases, ionic and covalent bonds.
9. If class continues from item seven above, begin discussion of Ernest Just. Born in 1883 in Charlestown, South Carolina, as an African-American he faced limited educational opportunities as an African-American in the Reconstruction-era South. He worked his way to New York City in 1900 on a steamship. He arrived there as a 17 year-old young man with two pairs of shoes and $5. Eventually he went to the Kimball School in New Hampshire, which accepted African-Americans without charging tuition. He did very well (finished the four year program in three years) and went on to Dartmouth College, where he fell in love with biology. He graduated from Dartmouth in 1907, the only member of his class to graduate Magna Cum Laude.
10. Following graduation from Dartmouth, he worked at Howard University as a professor starting in 1907. He began summer research in 1909 at the Marine Biological Laboratory in Woods Hole, Massachusetts. In 1916 he earned a PhD from the University of Chicago in experimental embryology, with his dissertation on the mechanics of fertilization.
11. Professor Just displayed a lifelong desire to pursue "pure science." This focus on science for the sake of learning, as opposed to monetary profit, made him stand out from many of his peers. His primary focus remained fertilization. Dr. Just was the first scientist who understood the importance of the cytoplasm and ectoplasm (outer area of the cell nucleus and outer area of the cytoplasm, respectively). He discovered factors outside of the fertilized egg had much to do with embryonic development. Previously, scientists focused on the nucleus of the egg, assuming exogenous factors were irrelevant to the development of an embryo.
12. Professor Just faced racism and difficulty in acceptance by the scientific community throughout his life. Despite the barriers he faced, he continuously encouraged African Americans to pursue careers in science. His lifetime achievements were recognized in Europe during his life and in America following his death in 1941. Dean Miller, his biographer, stated his genius enriched the blood of mankind regardless of race.

E. *Assessment/Evaluation*

1. Complete Appendix F in class. Go over with students and correct all errors.

VI. CULMINATING ACTIVITY

A. Demonstration experiment showing chemical change of sulfur and iron filings, creating ferrous sulfide, which loses magnetic properties.

B. Completion of unit exam (Appendix G) with 80% accuracy.

VII. HANDOUTS/WORKSHEETS

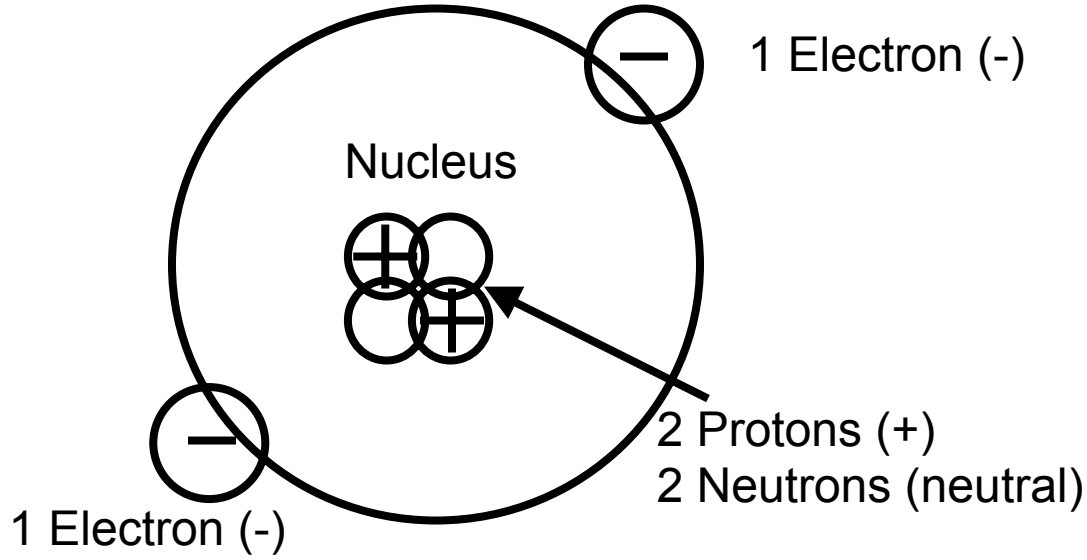
A. Appendix A: Pictures of Atoms Student Handout-Lesson One
B. Appendix B: Vocabulary Work sheet (Lesson One-Three)
C. Appendix C: Class Worksheet/Notes Page (Lesson Two)
D. Appendix D: Take Home Quiz/Study Sheet (Lesson Two)
E. Appendix E: Take Home Study Sheet (Lesson Three)
F. Appendix F: Notes Sheet for Scientific Biographies (Lesson Four)
G. Appendix G: Unit Exam
H. Appendix H: Answer Keys to Homework and Exam

VIII. BIBLIOGRAPHY

A. Hirsch, E.D. Jr., *What Your Fifth Grader Needs to Know*, Charlottesville, VA, Core Knowledge Foundation, 1993. ISBN 0-385-31464-7
B. Jones, Charyn, *Eyewitness Science-Chemistry,* New York, NY, DK Publishing, Inc., 1993. ISBN 1-56458-231-0
C. Moje, Steven W, *Cool Chemistry, Great Experiments with Simple Stuff,* New York, NY, Sterling Publishing Co, 1999. ISBN 0-8069-6349-2
D. Wick, Walter, *A Drop of Water,* New York, NY, Scholastic Press, 1997. ISBN 0-590-22197-3
E. Brown, Mitchell C, Ernest Everett Just: Zoologist, Biologist, Physiologist, Research Scientist, *Princeton* [On-line]. Available URL: http://www.Princeton.edu/~mcbrown/display/just.html, 1995.
F. Unknown, Chemical Achievers, Percy Lavon Julian and Carl Djerassi, The *Chemical Heritage Foundation,*[On-line]. Available URL: http://www.chemheritage.org/EducationalServices/chemach/ppb/1d.html, 2000.
G. Unknown, The Periodic Table of Elements, U.S. Government [On-line]. Available URL: http://pearl1.lanl.gov/periodic/default.htm, 2002.

Appendix A-Pictures of Atoms Student Handout-Lesson One

HELIUM
Atomic Symbol: He
Atomic Number: 2



What would a carbon atom look like? Draw it below. (Hint-it has an atomic number of 6.)

Appendix B-Vocabulary Work sheet (Lesson One-Three)

Name_____ Date_____

1. Atom_____

2. Electron_____

3. Proton_____

4. Nucleus of an atom_____

5. Phase Change_____

6. Matter_____

7. Gas_____

8. Liquid_____

9. Solid_____

10. Molecule_____

----------LESSON TWO----------

11. Ductile_____

12. Malleable_____

13. Conductive_____

----------LESSON THREE----------

14. Ionic Bond_____

15. Covalent Bond_____

16. Chemical Reaction_____

17. Noble Gases_____

Appendix C-Class Worksheet/Notes Page (Lesson Two)

Name_____ Date_____

1. Name three types of matter._____

2. What are the three stages of matter?_____

3. Is joy a form of matter? Why or why not?

4. What characteristic of a substance determines if it is a solid, liquid, or gas?_____

5. Give three examples of gases._____

6. Give three examples of liquids._____

7. What is the difference between a compound and an element?

8. What is the relationship between the atomic number and the atomic weight of the known elements as listed on the Periodic Table?

Appendix D-Take Home Quiz/Study Sheet (Lesson Two)

NAME_____ DATE_____

Match the definition with the word.

1. Gold_____
2. Compound_____
3. Molecule_____
4. Iron_____
5. Element_____
6. Atomic Number_____
7. Periodic Table_____
8. Atomic Symbol_____
9. Oxygen_____

a. a scientific tool that organizes elements

b. O

c. formed when two or more elements come together

d. Au

e. the number of protons in an element's nucleus

f. molecules of a substance are changed and a new substance is formed

g. a symbol developed by chemists that represents the type of atom

h. two or more atoms joined together

i. Fe

j. a substance that cannot be broken down into a simpler substance

10. For what is Dmitri Mendeleev famous?

11. What is the chemical formula for:

Salt?_____ Water?_____ Carbon Dioxide?_____

Appendix E-Take Home Study Sheet (Lesson Three)

NAME_____ DATE_____

1. Describe a physical change of matter and give an example.

2. Describe a chemical change of matter and give an example.

3. What is needed for a chemical change to occur? (Hint-one or two word answer)

4. What is an ionic bond?

5. What is a covalent bond?

6. A metal-sodium (Na) and non-metal-chlorine (Cl) combine. In the reaction, the sodium atom gives a single electron to the chlorine atom, thus creating an _____ bond.

A. Covalent
B. Ionic
C. Chemical reaction
D. Strong
E. Weak

7. The event described in question 6 above creates sodium chloride (NaCl). Another name for sodium chloride is_____

A. Sugar
B. Cinnamon
C. Salt
D. Starch
E. Floor Wax

8. When hydrogen and oxygen atoms combine, the hydrogen atoms share their single electrons with one electron from the oxygen. This is an example of a _____ bond

A. Covalent
B. Ionic
C. Chemical reaction
D. Strong
E. Weak

Appendix F-Notes Sheet for Scientific Biographies (Lesson Four)

Name_____ Date_____

Percy Lavon Julian

Born_____ at _____

Area of study_____

Obstacles faced and overcome:

His major contributions to science:

==========

Ernest Everett Just

Born_____ at _____

Area of study_____

Obstacles faced and overcome:

His major contributions to science:

Appendix G-Unit Exam

NAME_____ DATE_____

Match the definition with the word.

1. Chemical Change_____
2. Compound_____
3. Molecule_____
4. Atomic Symbol_____
5. Element_____
6. Ionic Bond_____

a. when two elements combine and one gives the other some electrons
b. a substance made up of one or more identical atoms
c. formed when two or more elements come together
d. molecules of a substance are changed and a new one is formed
e. two or more atoms joined together
f. a symbol developed by chemists that represents the type of atom

7. Some great scientists overcame barriers in their education and careers. We studied Professors Julian and Just in class. Choose one and briefly describe what he overcame and how he contributed to science.

8. Define atom.

9. Define atomic weight and number from the periodic table. What is the relationship between the two?

10. Define gas.

11. What determines if a substance is a solid, liquid, or gas? Explain.

12. Using complete sentences, give an example of a chemical change.

13. What is necessary for a chemical change to occur?_____

Extra Credit (three points each, partial credit awarded):

What is the chemical formula for:
Salt?_____ Water?_____ Carbon Dioxide?_____

What is the atomic symbol and weight and number of the following elements?
Helium_____ Hydrogen_____
Nitrogen_____ Carbon_____

Appendix H-Answer Keys to Homework and Exam

Answer Key to Appendix A

A picture showing a nucleus consisting of six each protons and neutrons and six electrons

Answer Key to Appendix B

1. Smallest piece of a substance that still has the properties of that substance
2. Negatively charged particle inside of an atom
3. Positively charged particle inside an atom
4. Center of an atom, neutrally charged (both correct)
5. When matter changes from solid, liquid, or gas to another state due to addition or loss of heat.
6. Anything that takes up space-what everything is made up of
7. Least dense form of matter-no definite shape or volume
8. Less dense matter than a solid, definite volume, no definite shape
9. Densest state of matter, definite shape and volume.
10. A collection of atoms of different elements that form a compound.
11. Ductile-ability to stretch material out into long thin wire-like strands.
12. Malleable-the ability to hammer material (such as lead, gold, or silver) into a shape.
13. Conductive-material that transmits electrical energy well.
14. When two elements combine, one gives up electrons to the other, creating a new substance with different properties than the two (or more) original elements.
15. When two elements combine, they share electrons rather than one giving up an electron to another.
16. Process whereby one or more elements reacts at the molecular level with another element. Energy is required for the reaction to occur-energy either applied through heat or from within the element itself.
17. Noble gases (Helium, Neon, Argon, Krypton, Xenon, and Radon) do not readily give up their electrons and thus don't react with other elements. They do not form ionic or covalent bonds.

Answer Key to Appendix C

1. Rocks, water, dirt, wood, air, etc. etc. etc.
2. Solid, liquid, gas
3. No-it does not take up any space or volume.
4. The temperature of the element
5. Helium, oxygen, air, nitrogen, radon, gasoline vapors, smoke, all at room temperature (assumed)
6. Water, gasoline, kerosene, orange juice, milk, all at room temperature (assumed)
7. An element has atoms of all the same kind-a compound has atoms of different elements.
8. The atomic weight is approximately twice the atomic number (number of electrons and protons).

Answer Key to Appendix D

1. D 4. I 7. A
2. C 5. J 8. G
3. H 6. E 9. B

10. Discovered the Periodic Law and developed the first periodic table of the elements in 1869 (date not critical), which ordered the known elements by atomic weight and number of protons/electrons/neutrons.
11. NaCl, H_2O, CO_2

Answer Key to Appendix E

1. Physical change of matter is where the molecular structure remains the same. Example is ice melting to liquid water.
2. Chemical change of matter where the molecular makeup is changed. Example is the burning of wood or gasoline. Matter is changed to CO_2, CO, etc.
3. Energy (or heat)
4. When different atoms with electrical charges are combined, they form ionic bonds. Essentially, one of the elements loses some or all of their electrons to the other, changing the chemical makeup of the compound. These are normally created from elements that are far apart in the periodic chart (sodium (Na) and chloride (Cl) combine make salt-NaCl). Metals tend to form ionic bonds.

Appendix H-Answer Keys to Homework and Exam (page 2)

5. Covalent bonds are created when two elements combine and share their electron rather than losing or gaining as in the ionic bond-example is water-H2O, where each hydrogen atom shares its single electron with the one in oxygen. Non-metals typically form covalent bonds.
6. B
7. C
8. A

Answer Key to Appendix F

1. Percy Lavon Julian. Born 1899, Montgomery, AL
Area of study-Synthesis of human hormones from plants
Overcame racism and worked his way through school, eventually earning a doctorate.
Major contribution to science-synthesized hydorcortizone and laid the foundation for others to continue research into the field of synthesizing hormones from plants. His research allowed others to synthesize human hormones in the development of the birth control pill and many other medicines.
2. Ernest Everett Just. Born 1883, Charleston, SC
Area of Study-Zoology and Biology-Fertilization and development of embryos
Overcame racism and worked his way through school, being the only graduate of Dartmouth with Magna Cum Laude in 1907.
Major contribution to science-study of importance of the environment on the development of the embryo, with specific focus on the cytoplasm and ectoplasm of the egg. He conducted "pure scientific research", not trying to gain financially from his efforts. He also encouraged other African Americans to pursue a career in science and was held in high esteem in Europe during his life and in America after his death in 1941.

Answer Key to Appendix G

1. D 4. F
2. C 5. B
3. E 6. A

7.Famous scientists-refer to lesson four procedures to determine student accuracy
8. Smallest piece of a substance that still has the properties of that substance
9. Atomic weight is the weight of one mole. It is usually twice the atomic number, which is the number of protons and electrons in the element's atom.
10. Least dense form of matter-no definite shape or volume
11. Temperature of object and its relevant melting/evaporation temperatures.
12. Wood burning, vinegar and baking soda, formation of metal salts, oxidation
13. A reaction between two or more elements-also, heat/energy acceptable.

Extra Credit: Salt-NaCl, Water-H20, Carbon Dioxide-CO2
Helium-He (number-2, weight-4), Nitrogen-N (7,14), Hydrogen (1,1), Carbon (6,12)