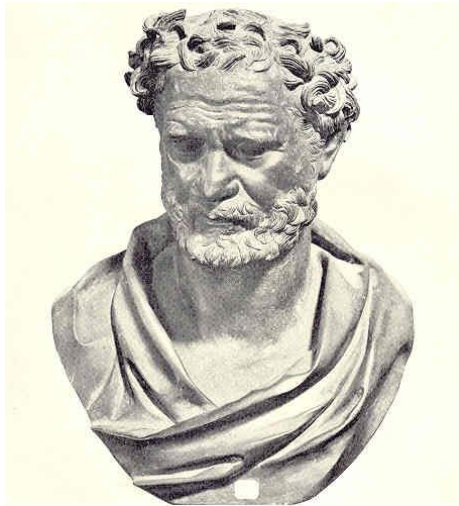


Lesson #4: History of the atom

Orally: *You will not be responsible for memorizing dates, but I'll give them in the notes so that you have a basic timeline for the evolution of the atomic model.*

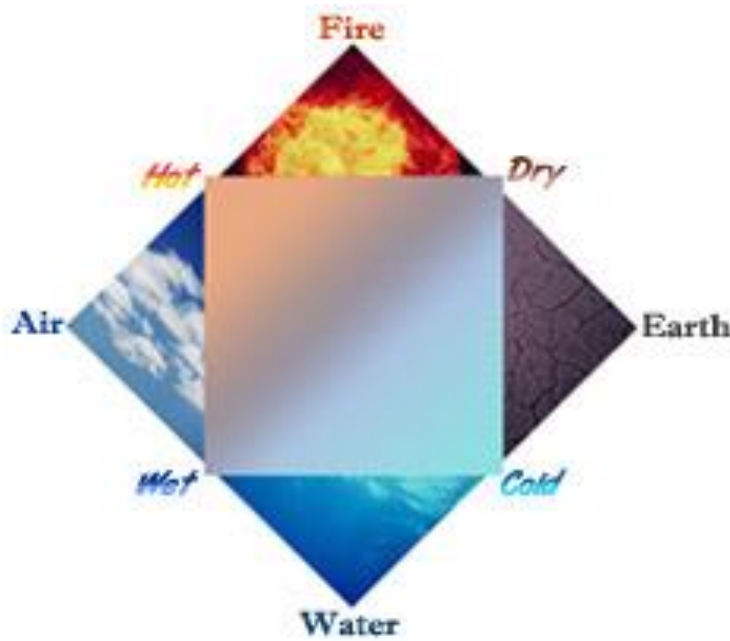
~ 430 BC Democritus



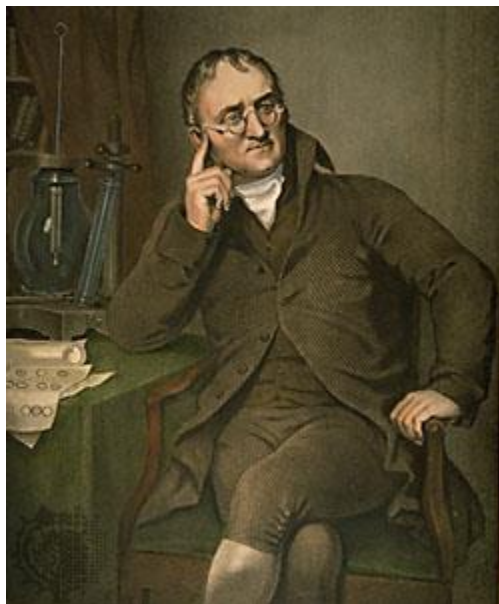
– philosopher who first proposed the concept of the atom (i.e., the smallest unit of matter). He also suggested that the difference in the matter we see is a direct result of the shape and size of the atoms.

Orally: *His thought process was that there must be a point where if you “chop” matter into smaller pieces that you would eventually get to the smallest unit of that substances that could no longer be divided.*

Orally: *In the 4th century BC, Aristotle refuted the idea that matter was made up of atoms and was a strong proponent of alchemy. Alchemy suggests that all matter was made up of some combination of Air, Water, Earth, and Fire. The properties of these “elements” could be reduced to moist, dry, heat, and cold. According to alchemists, it would have been possible to make gold* *providing these*
elements were *combined in the*
correct ratio.



~ 1800 John Dalton -



⊙ Hydrogen

○ Oxygen

① Azote

● Carbon

⊕ Sulphur

⊙ Phosphorus

⊛ Magnesia

Orally: Note contribution of using symbols to represent atoms.

1. **All matter is composed of atoms.**

The billiard-ball model of the atom (i.e., all atoms are tiny spheres).

2. **All atoms of a given element are identical; atoms of different elements have different properties.**

Orally: Dalton characterized elements according to their atomic weight; however, when isotopes of elements (which we will discuss later) were discovered in the late 1800s this concept changed.

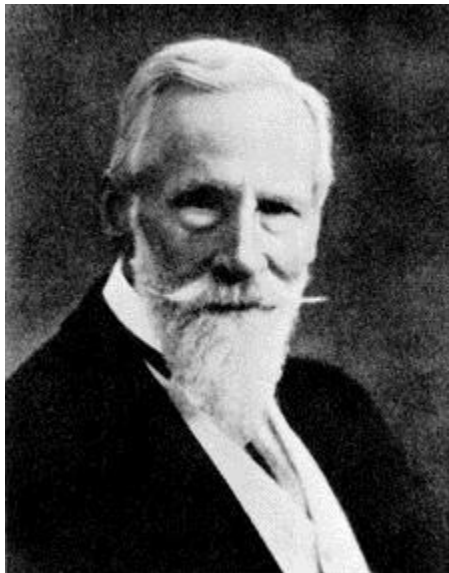
3. **Chemical reactions involve the combination of atoms, not the destruction of atoms.**

Orally: While Dalton's theory implied that atoms bonded together, it would be more than 100 years before scientists began to explain the concept of chemical bonding.

4. **When elements react to form compounds, they react in defined, whole-number ratios.**

Orally: The experiments that Dalton and others performed showed that reactions are not random events; they proceed according to precise and well-defined formulas. I like to think of this as the baking principle. If you follow the recipe, you should be able to predict how many cookies you can make (size dependent of course).

~ 1880 Sir William Crookes

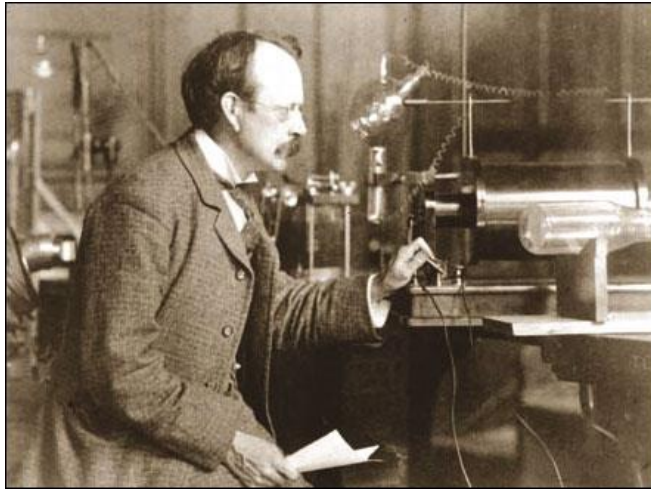


- Invented the Crookes tube: A sealed glass tube with electrodes at either end. When a high voltage current was passed through it, electrons would be accelerated from the cathode to the anode. **Orally:** The Crookes tube was used later by J.J. Thomson in the discovery of the electron.

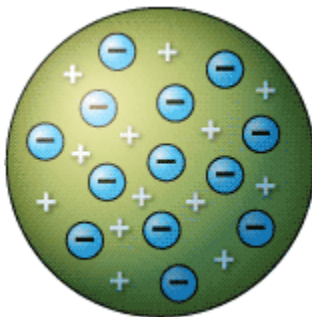
http://www.youtube.com/watch?v=LV8DL8Oz_Mk (Crookes tube with magnet)

<http://www.youtube.com/watch?v=QDwk5s-QrLY> (Crookes tube with Maltese cross)

~1890 J.J. Thomson:



- Did cathode ray tube (CRT) experiments and discovered the electron (he called them corpuscles) and the proton (H^+).
- Developed the plum-pudding (also called raisin- bun or muffin) model of the atom. Electrons are embedded in a “pudding” of positively charge protons which would perfectly balance the negatively charged electrons. **Orally:** *These experiments were highly significant b/c they showed that atoms were not the smallest units of matter.*
- He determined the electron had a mass to charge ratio 1/1840 times that of a hydrogen ion (i.e., a proton). **Orally:** *In other words, the charge on each electron balances one proton, but the electrons are far less massive.*



~1910 R.A. Millikan



– determined the charge on a single electron in the famous oil drop experiment.
<http://www.youtube.com/watch?v=XMfYHag7Liw> (Oil drop Exp.)

Orally:

- *Henri Becquerel (1896)*



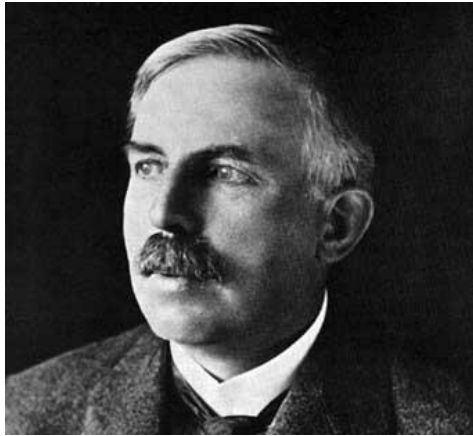
- *Is credited with the discovery of radioactivity.
(Working with Uranium laced minerals.)*

- *Madame Curie (1898)*



- *Separated radium and Polonium and
studied their radioactive properties.
She coined the term radioactivity.*

~1910 Earnest Rutherford



– He discovered that the vast majority of the mass of the atom was located in a centrally located, positively charged nucleus in his famous gold foil experiment.

Orally: *This experiment would not have been possible without the work of Becquerel and Curie.*

<http://www.youtube.com/watch?v=CznmkQvNzeI> (Gold foil Exp.)

- Rutherford also predicted the existence of neutrons because the mass to charge ratio of the nucleus was not consistent with what was known about the mass to charge ratio of protons.

~1930 J. Chadwick – discovered the neutron. **Orally:** *J. Curie (daughter of Madame Curie is thought to have discovered both the positron and the neutron but failed to identify the significance of the data).*



Assignment: Hebden Workbook pg.142 #3, 4, 7-10, 12.

Atomic Structure Timeline

Obtained from Mr. Lee Buescher at http://www2.watertown.k12.wi.us/pages/teachers_Resources.cfm

Early theories of the structure of matter were not based upon experiments. As scientists began to study the relationship between several physical phenomenon such as electricity, and magnetism they began to develop different models about atomic structure.

		Year Scientist(s) Discovery
Greek era	<u>Democritus</u>	"by convention bitter, by convention sweet, but in reality atoms and void"
1704	<u>Isaac Newton</u>	Proposed a mechanical universe with small solid masses in motion.
1803	<u>John Dalton</u>	Proposed an " atomic theory" with spherical solid atoms based upon measurable properties of mass.
1832	<u>Michael Faraday</u>	Studied the effect of electricity on solutions, coined term "electrolysis" as a splitting of molecules with electricity, developed laws of electrolysis. Faraday himself was not a proponent of atomism.
1859	J. Plucker	Built one of the first gas discharge tubes ("cathode ray tube").
1869	<u>Dmitri Mendeleev</u>	Arranged elements into 7 groups with similar properties. He discovered that the properties of elements "were periodic functions of the their atomic weights". This became known as the Periodic Law.
1873	<u>James Clerk Maxwell</u>	Proposed electric and magnetic fields filled the void.
1874	<u>G.J. Stoney</u>	Proposed that electricity was made of discrete negative particles he called <u>electrons</u> ". (Link to info on electrons)
1879	<u>Sir William Crookes</u>	Discovered cathode rays had the following properties: travel in straight lines from the cathode; cause glass to fluoresce; impart a negative charge to objects they strike; are deflected by electric fields and magnets to suggest a negative charge; cause pinwheels in their path to spin indicating they have mass.
1886	E. Goldstein	Used a CRT to study "canal rays" which had electrical and magnetic properties opposite of an electron.
1895	<u>Wilhelm Roentgen</u>	Using a CRT he observed that nearby chemicals glowed. Further experiments found very penetrating rays coming from the CRT that were

		not deflected by a magnetic field. He named them "X-rays".
1896	<u>Henri Becquerel</u>	While studying the effect of x-rays on photographic film, he discovered some chemicals spontaneously decompose and give off very penetrating rays.
1897	<u>J.J. Thomson</u>	Used a <u>CRT</u> to experimentally determine the charge to mass ratio (<u>e/m</u>) of an electron = 1.759×10^8 coulombs/gram.
1897	<u>J.J. Thomson</u>	Studied "canal rays" and found they were associated with the proton H^+ .
1898	<u>Rutherford</u>	Studied radiations emitted from uranium and thorium and named them <i>alpha</i> and <i>beta</i> .
1898	<u>Marie Sklodowska Curie</u>	Studied uranium and thorium and called their spontaneous decay process "radioactivity". She and her husband Pierre also discovered the radioactive elements polonium and radium.
1900	<u>Soddy</u>	Observed spontaneous disintegration of radioactive elements into variants he called "isotopes" or totally new elements, discovered "half-life", made initial calculations on energy released during decay.
1900	<u>Max Planck</u>	used the idea of quanta (discrete units of energy) to explain hot glowing matter.
1903	<u>Nagaoka</u>	Postulated a "Saturnian" model of the atom with flat rings of electrons revolving around a positively charged particle.
1904	Abegg	Discovered that inert gases had a stable electron configuration which lead to their chemical inactivity.
1905	<u>Albert Einstein</u>	Published the famous equation <u>$E=mc^2$</u>
1906	<u>Hans Geiger</u>	Developed an electrical device to "click" when hit with alpha particles.
1909	<u>R.A. Millikan</u>	Oil drop experiment determined the charge ($e=1.602 \times 10^{-19}$ coulomb) and the mass ($m = 9.11 \times 10^{-28}$ gram) of an electron.
1911	<u>Ernest Rutherford</u>	Using alpha particles as atomic bullets, probed the atoms in a piece of thin (0.00006 cm) <u>gold foil</u> . He established that the nucleus was: very dense, very small and positively charged. He also assumed that the electrons were located outside the nucleus.
1914	<u>H.G.J. Moseley</u>	Using x-ray tubes, determined the charges on the nuclei of most atoms. He wrote "The atomic number of an element is equal to the number of

		protons in the nucleus". This work was used to reorganize the periodic table based upon atomic number instead of atomic mass.
1919	Aston	Discovered the existence of isotopes through the use of a mass spectrograph.
1922	<u>Niels Bohr</u>	Developed an explanation of atomic structure that underlies regularities of the periodic table of elements. His atomic model had atoms built up of successive orbital shells of electrons.
1923	<u>de Broglie</u>	Discovered that electrons had a dual nature-similar to both particles and waves. Particle/wave duality. Supported Einstein.
1927	<u>Heisenberg</u>	Described atoms by means of formula connected to the frequencies of spectral lines. Proposed Principle of Indeterminacy - you can not know both the position and velocity of a particle.
1929	<u>Cockcroft / Walton</u>	Built an early linear accelerator and bombarded lithium with protons to produce <i>alpha particles</i>
1930	<u>Schrodinger</u>	Viewed electrons as continuous clouds and introduced "wave mechanics" as a mathematical model of the atom.
1930	<u>Paul Dirac</u>	Proposed <i>anti-particles</i> . Anderson discovered the anti-electron (positron) in 1932 and Segre/Chamberlain detected the anti-proton in 1955..
1932	<u>James Chadwick</u>	Using alpha particles discovered a neutral atomic particle with a mass close to a proton. Thus was discovered the neutron.
1938	<u>Lise Meitner, Hahn, Strassman</u>	Conducted experiments verifying that heavy elements capture neutrons and form unstable products which undergo fission. This process ejects more neutrons continuing the fission chain reaction.
1941 - 51	<u>Glenn Seaborg</u>	Synthesized 6 transuranium elements and suggested a change in the layout of the periodic table.
1942	<u>Enrico Fermi</u>	Conducted the first controlled chain reaction releasing energy from the atoms nucleus.
1950's -	<u>New findings/particles</u>	Follow this link to current theories about atomic structure.

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