Investigating Atoms and Atomic Theory

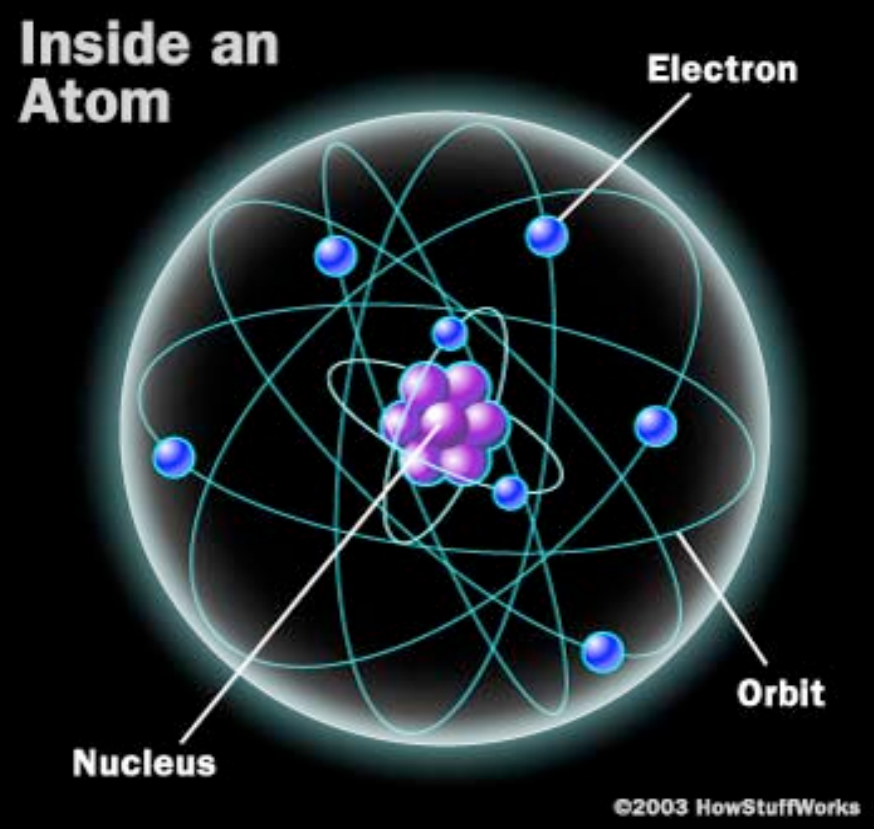
- Students should be able to:
  - Describe the particle theory of matter. PS.2a
  - Use the Bohr model to differentiate among the three basic particles in the atom (proton, neutron, and electron) and their charges, relative masses, and locations. PS.3
  - Compare the Bohr atomic model to the electron cloud model with respect to their ability to represent accurately the structure of the atom.PS.3

Lesson 1: Matter

A: The History of Atomic Theory

Atomic Models

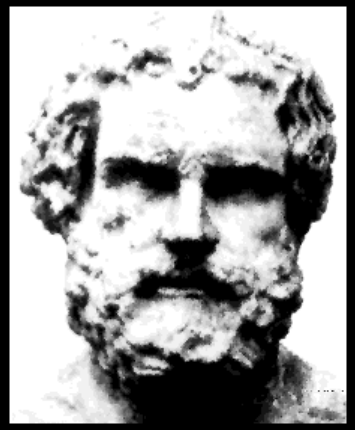
- This model of the atom may look familiar to you. This is the Bohr model. In this model, the nucleus is orbited by electrons, which are in different energy levels.
  - A model uses familiar ideas to explain unfamiliar facts observed in nature.
    - A model can be changed as new information is collected.

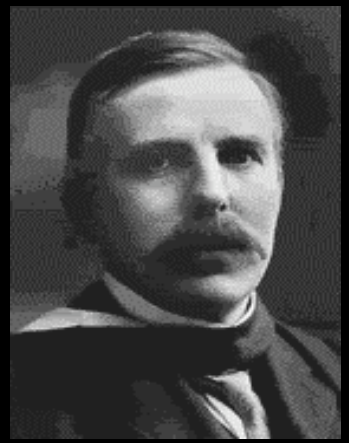


- The atomic model has changed throughout the centuries, starting in 400 BC, when it looked like a billiard ball →

Who are these men?

In this lesson, we'll learn about the men whose quests for knowledge about the fundamental nature of the universe helped define our views.

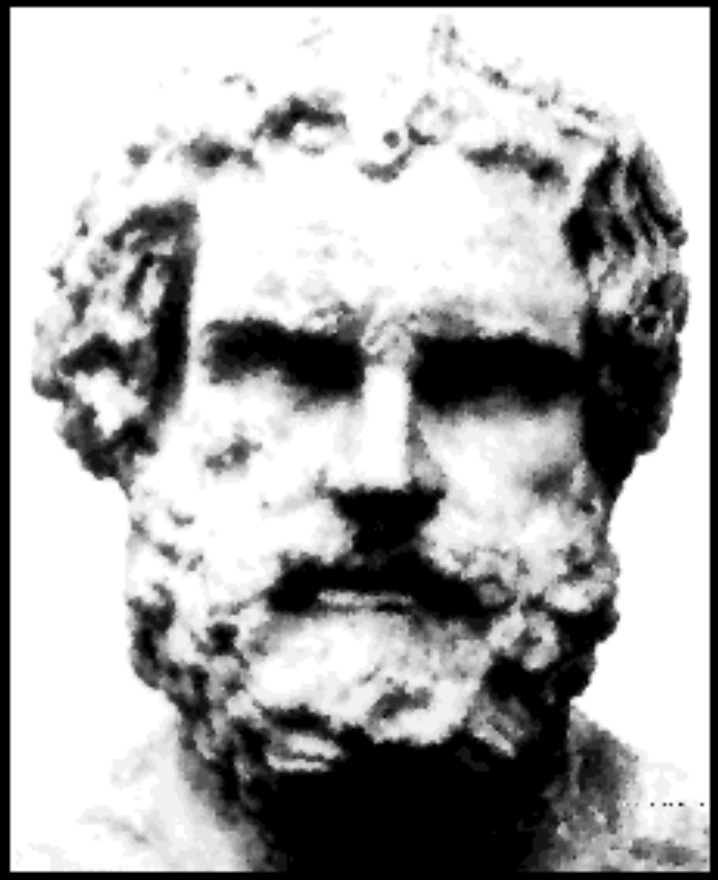




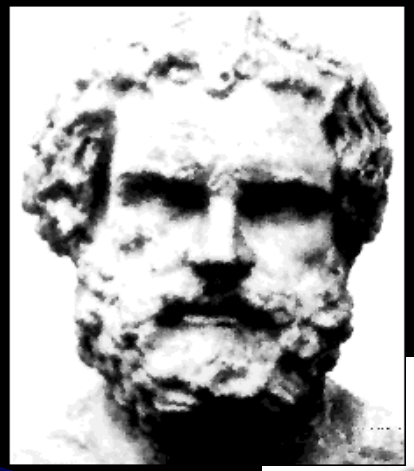
Democritus

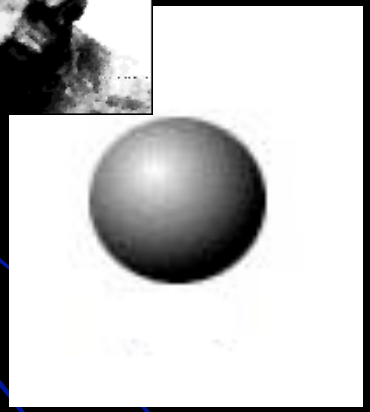
400 BC

- This is the Greek philosopher Democritus who began the search for a description of matter more than 2400 years ago.
  - He asked: Could matter be divided into smaller and smaller pieces forever, or was there a limit to the number of times a piece of matter could be divided?



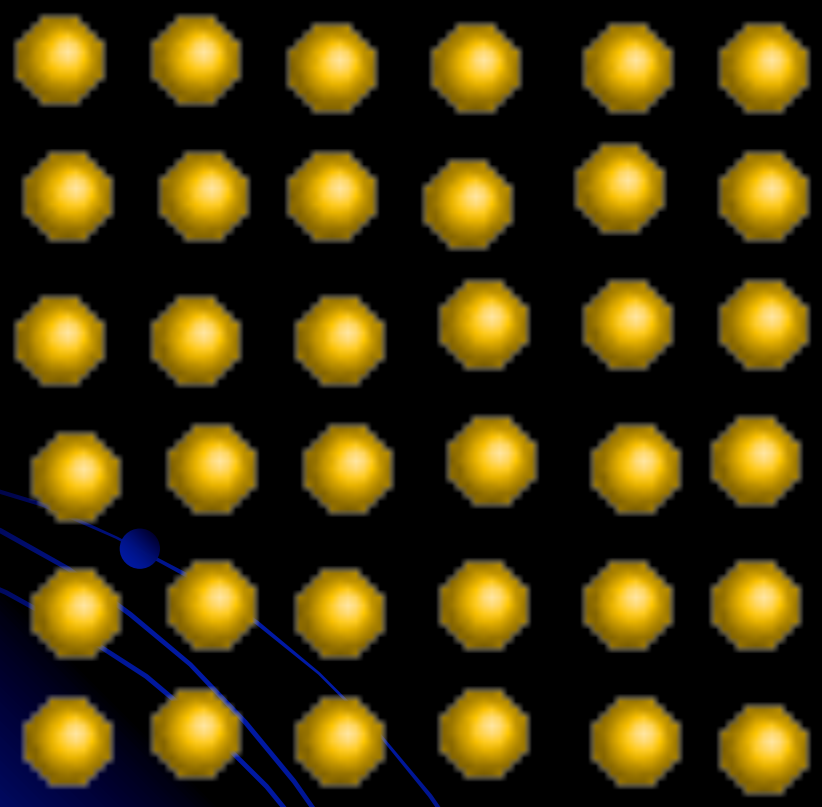
Atomos





- His theory: Matter could not be divided into smaller and smaller pieces forever, eventually the smallest possible piece would be obtained.
- This piece would be indivisible.
- He named the smallest piece of matter “atomos,” meaning “not to be cut.”

Atomos



- To Democritus, atoms were small, hard particles that were all made of the same material but were different shapes and sizes.
- Atoms were infinite in number, always moving and capable of joining together.

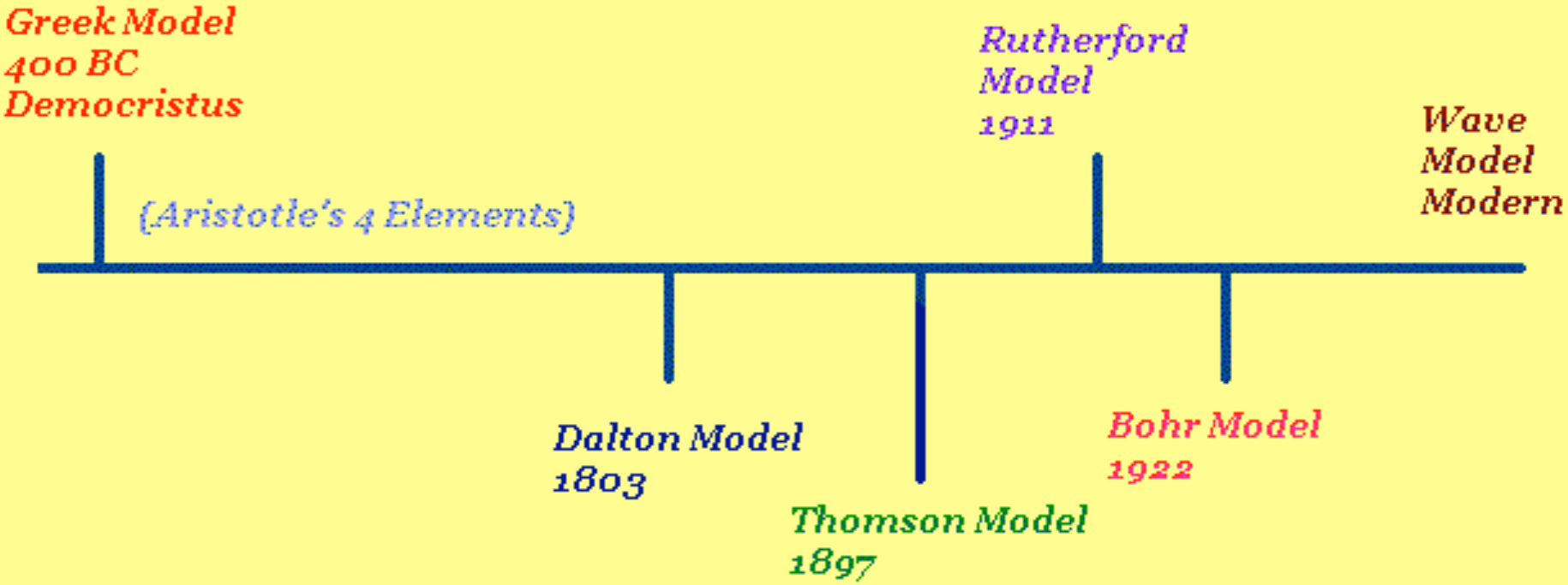
This theory was ignored and forgotten for more than *2000* years!

Why?

- The eminent philosophers of the time, Aristotle and Plato, had a more respected, (and ultimately wrong) theory.

Aristotle and Plato favored the *earth, fire, air and water* approach to the nature of matter. Their ideas held sway because of their eminence as philosophers. The *atomos* idea was buried for approximately 2000 years.

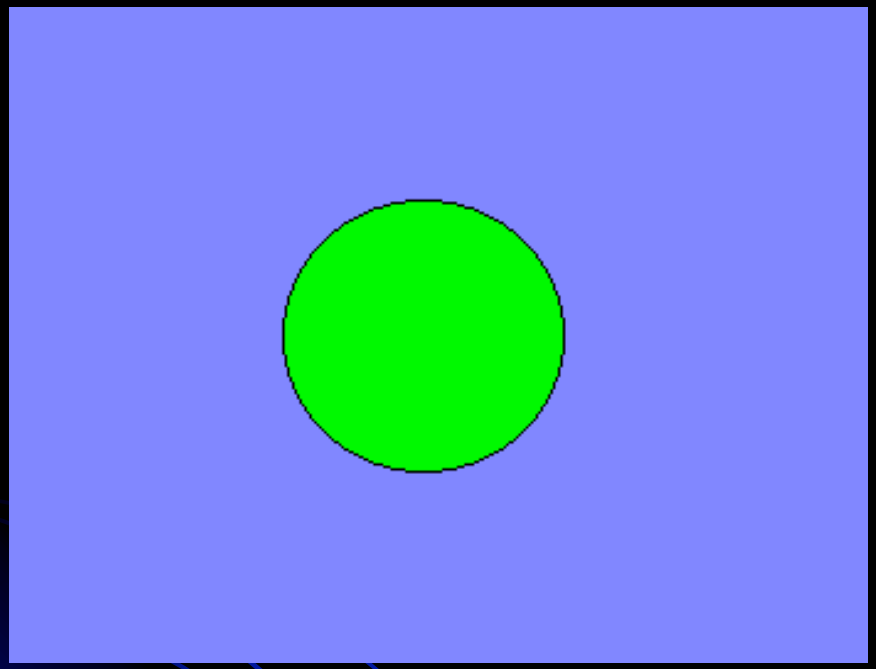
Timeline of Atomic Theory



Dalton's Model

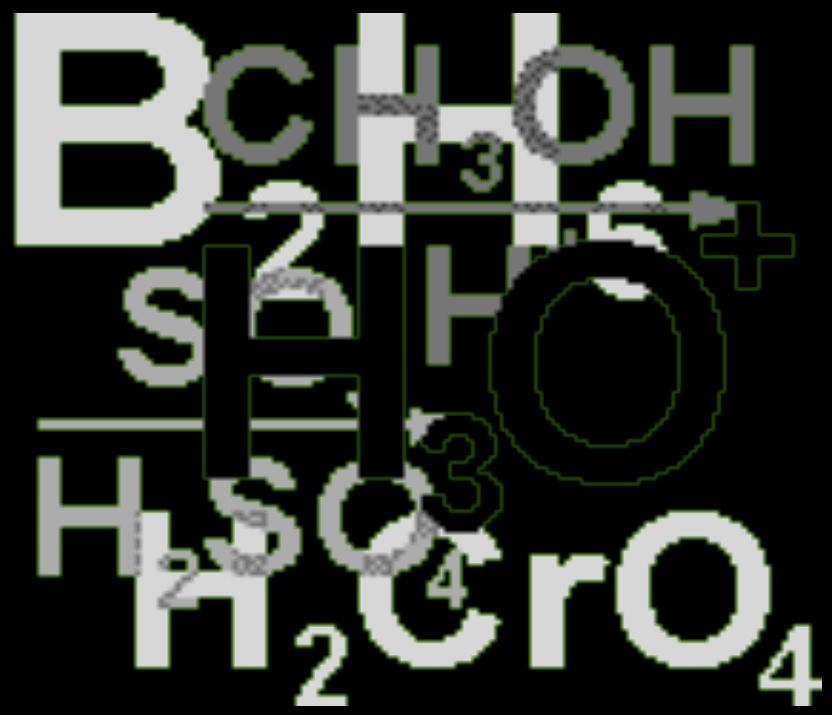
- In the early 1800s, the English Chemist John Dalton performed a number of experiments that eventually led to the acceptance of the idea of atoms.

Dalton's Theory



- He deduced that all elements are composed of atoms. Atoms are indivisible and indestructible particles.
- Atoms of the same element are exactly alike.
- Atoms of different elements are different.
- Compounds are formed by the joining of atoms of two or more elements.

- *This theory became one of the* ***<u>foundations of modern chemistry.</u>***

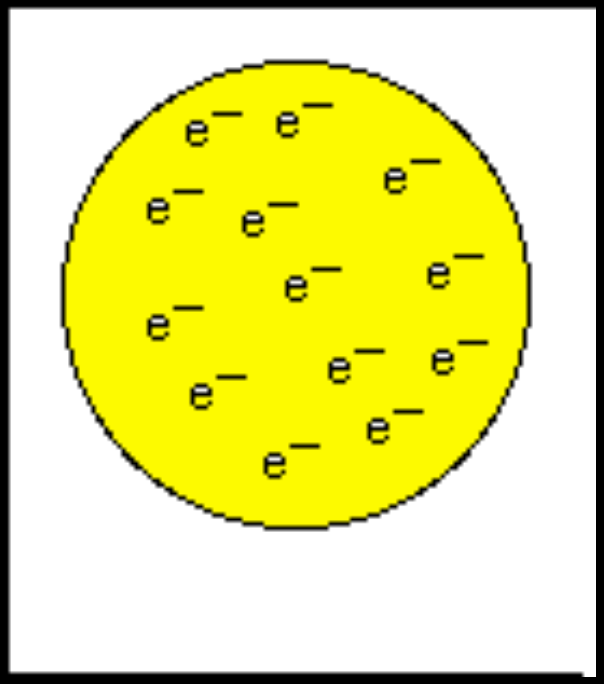


Thomson's Plum Pudding Model

- In 1897, the English scientist J.J. Thomson provided the first hint that an atom is made of even smaller particles.

Thomson Model

- He proposed a model of the atom that is sometimes called the "Plum Pudding" model.
- Atoms were made from a positively charged substance with negatively charged electrons scattered about, like raisins in a pudding.



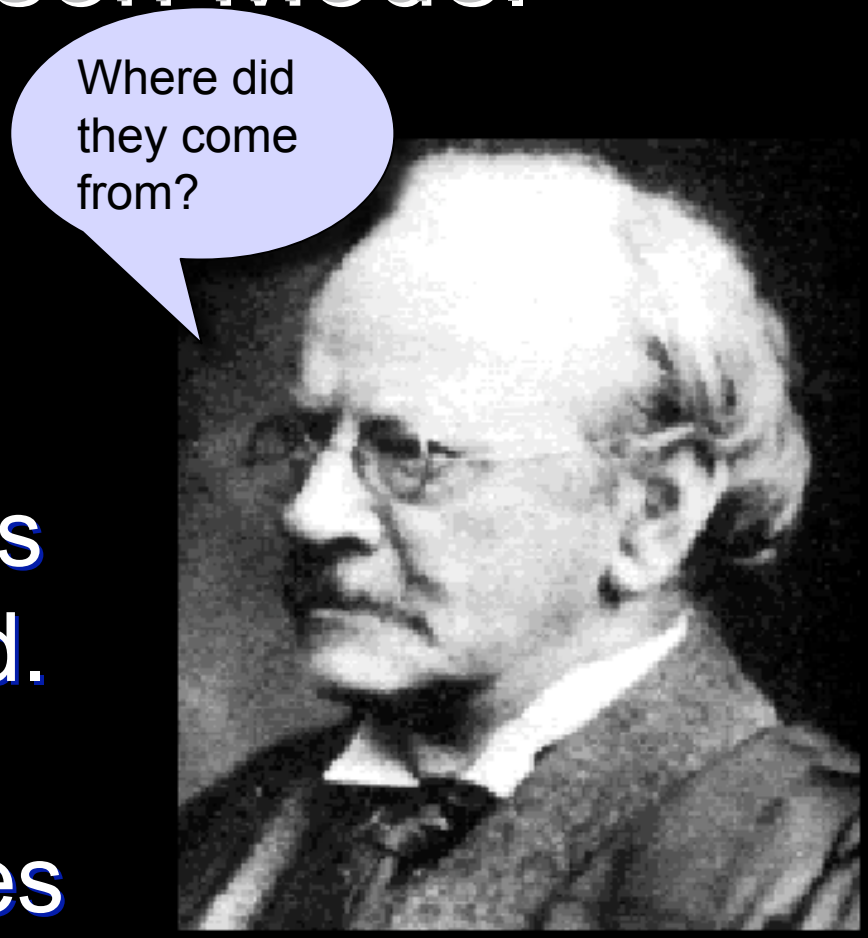
Thomson Model

- Thomson studied the passage of an electric current through a gas.

- As the current passed through the gas, it gave off rays of negatively charged particles.

Thomson Model

- This surprised Thomson, because the atoms of the gas were uncharged. Where had the negative charges come from?



Thomson concluded that the negative charges came from *within* the atom.

A particle smaller than an atom had to exist.

The atom was divisible!

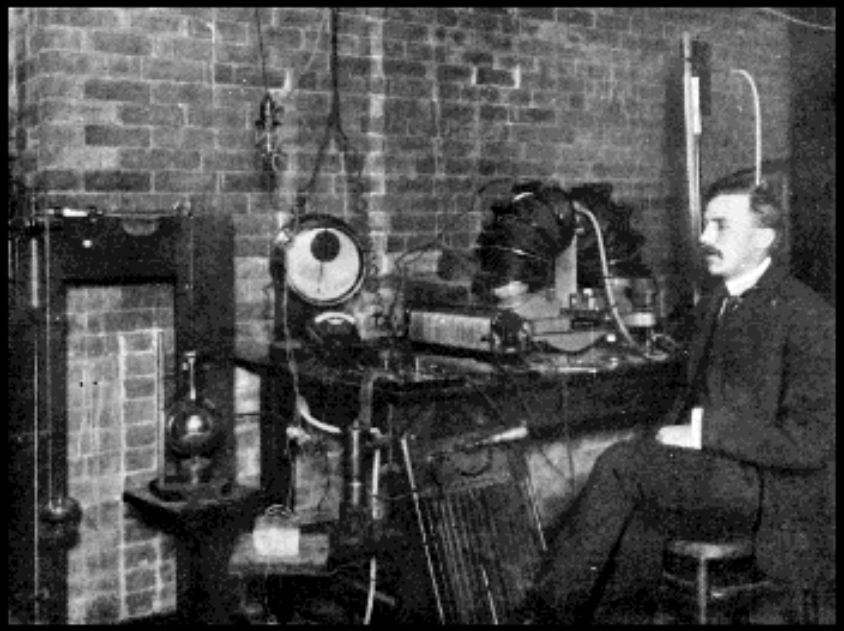
Thomson called the negatively charged "corpuscles," today known as electrons.

Since the gas was known to be neutral, having no charge, he reasoned that there must be positively charged particles in the atom.

But he could never find them.

Rutherford's Gold Foil Experiment

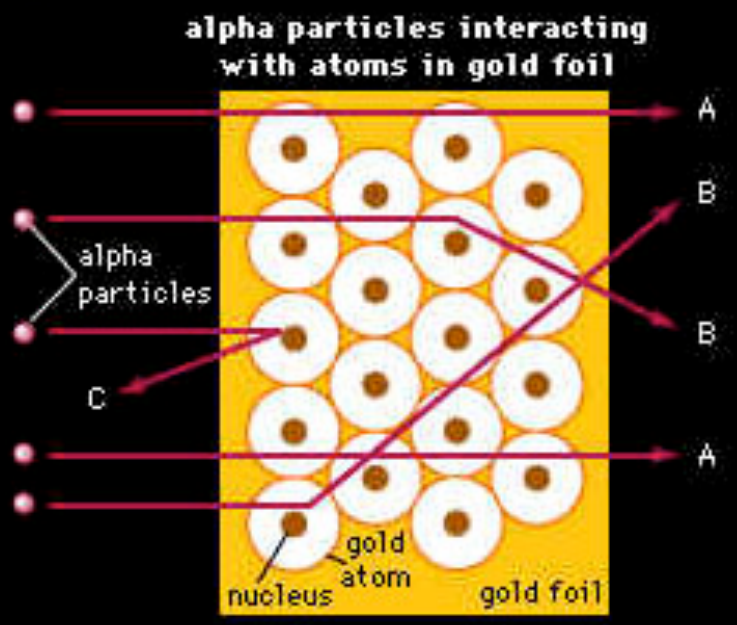
- In 1908, the English physicist Ernest Rutherford was hard at work on an experiment that seemed to have little to do with unraveling the mysteries of the <u>atomic structure.</u>

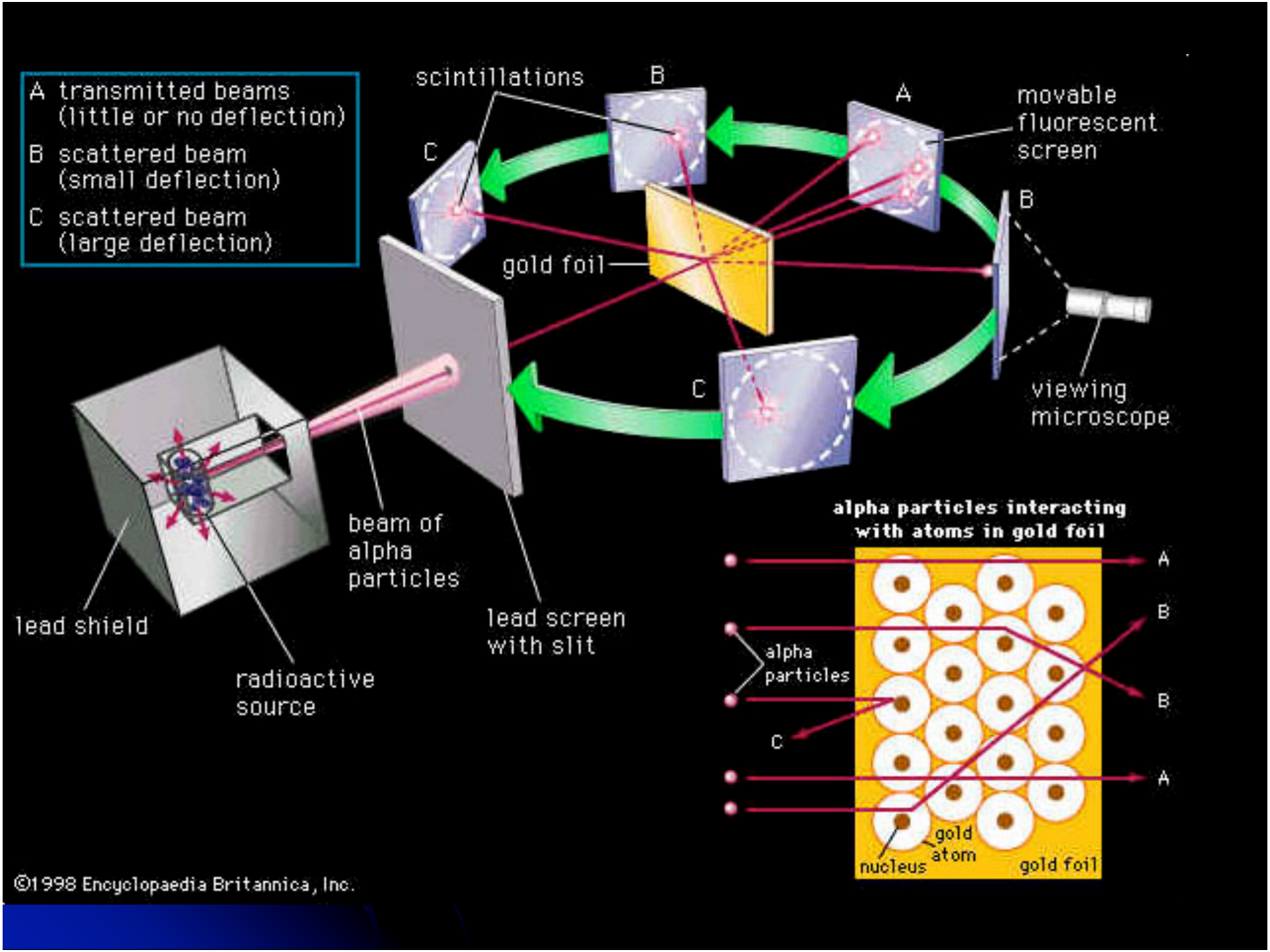


- Rutherford's experiment Involved firing a stream of tiny <u>positively charged</u> particles at a thin sheet of <u>gold foil</u> (2000 atoms thick)

- Most of the positively charged “bullets” passed right through the gold atoms in the sheet of gold foil without changing course at all.

- Some of the positively charged “bullets,” however, did bounce away from the gold sheet as if they had hit something solid. He knew that positive charges repel positive charges.




A transmitted beams (little or no deflection)
B scattered beam (small deflection)
C scattered beam (large deflection)
scintillations
B
A
movable fluorescent screen
C
B
gold foil
C
viewing microscope
beam of alpha particles
lead shield
lead screen with slit
radioactive source
alpha particles interacting with atoms in gold foil
A
B
alpha particles
B
C
A
gold atom
nucleus
gold foil
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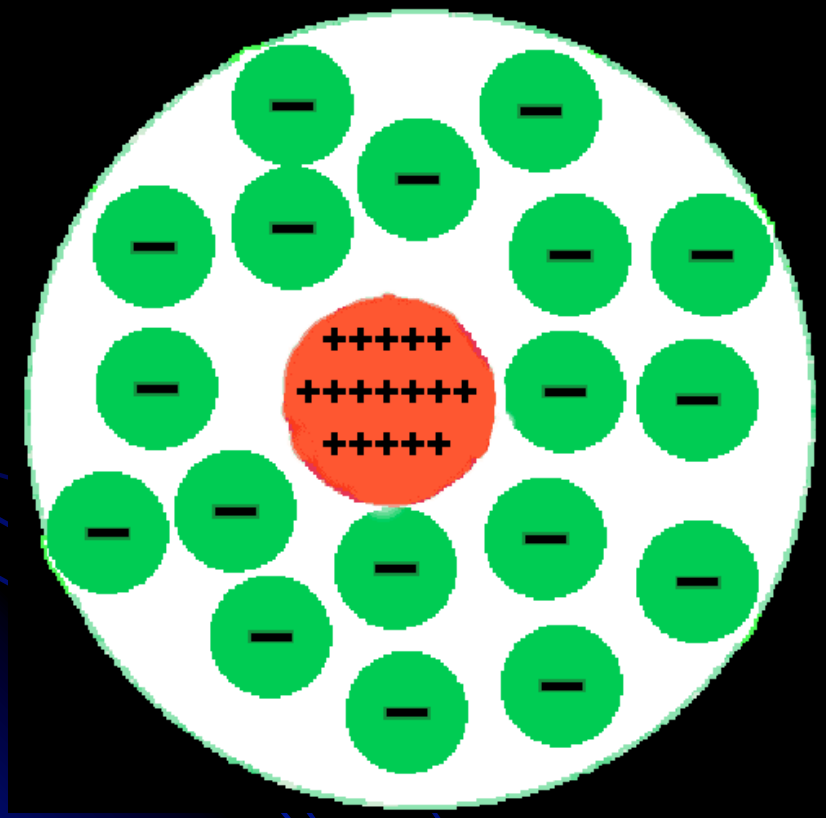
- http://chemmovies.unl.edu/ChemAnime/RUTHERFD/RUTHERFD.html

- This could only mean that the gold atoms in the sheet were mostly open space. Atoms were not a pudding filled with a positively charged material.
- Rutherford concluded that an atom had a small, dense, positively charged center that repelled his positively charged “bullets.”
- He called the center of the atom the “nucleus”
- The nucleus is tiny compared to the atom as a whole.

Rutherford

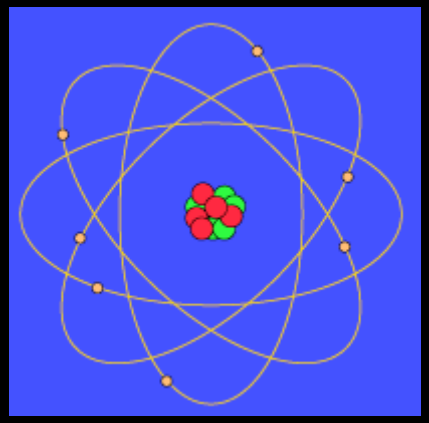


- Rutherford reasoned that all of an atom's positively charged particles were <u>contained</u> in the nucleus. The negatively charged particles were <u>scattered</u> outside the nucleus around the atom's <u>edge</u>.

Bohr Model

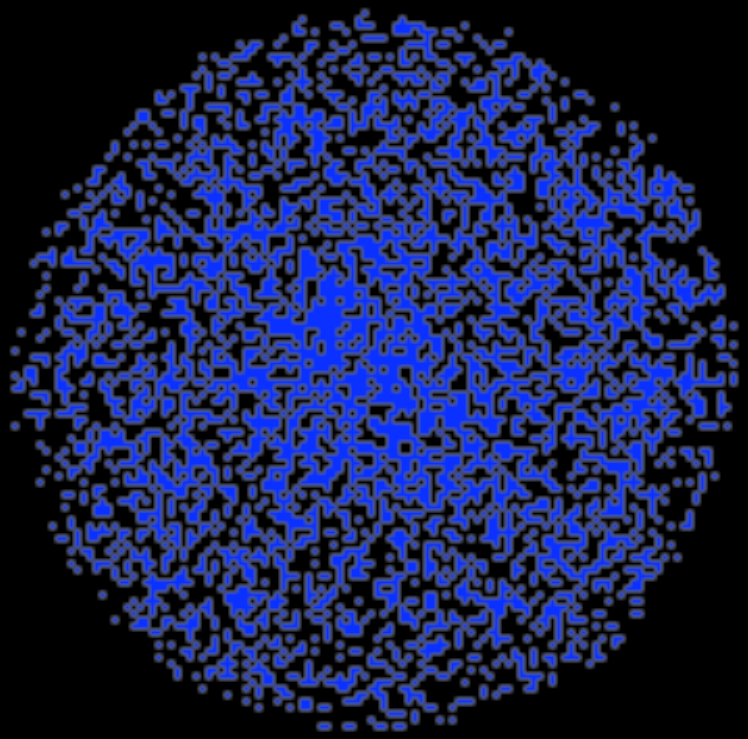
- In 1913, the Danish scientist Niels Bohr proposed an improvement. In his model, he placed each electron in a <u>specific</u> energy level.

Bohr Model

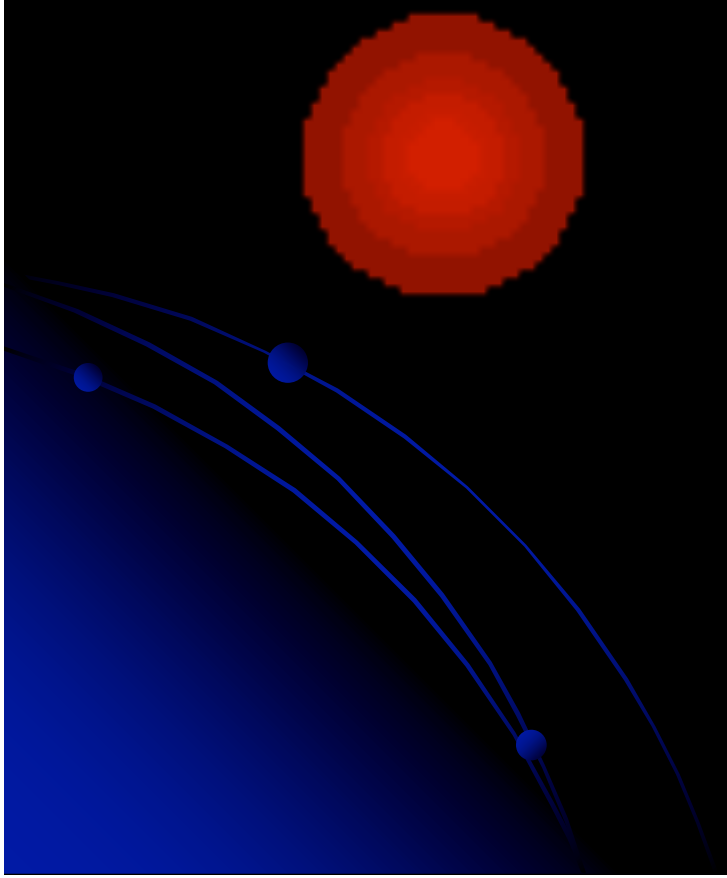


- According to Bohr's atomic model, electrons move in definite orbits around the nucleus, much like planets circle the sun. These orbits, or energy levels, are located at certain distances from the nucleus.

Wave Model



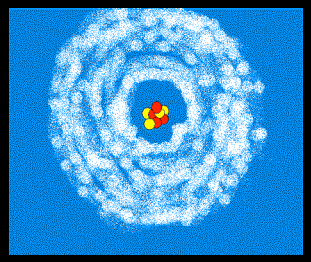
The Wave Model



- Today's atomic model is based on the principles of wave mechanics.
- According to the theory of wave mechanics, electrons do not move about an atom in a definite path, like the planets around the sun.

The Wave Model

- In fact, it is impossible to determine the exact location of an electron. The probable location of an electron is based on how much energy the electron has.
- According to the modern atomic model, at atom has a small positively charged nucleus surrounded by a large region in which there are enough electrons to make an atom neutral.



Electron Cloud:

- A space in which electrons are likely to be found.
- Electrons whirl about the nucleus billions of times in one second
- They are not moving around in random patterns.
- Location of electrons depends upon how much energy the electron has.

Electron Cloud:

- Depending on their energy they are locked into a certain area in the cloud.
- **Electrons with the <u>lowest</u> energy are found in the energy level <u>closest</u> to the nucleus**
- **Electrons with the <u>highest</u> energy are found in the <u>outermost</u> energy levels, farther from the nucleus.**

	Indivisible	Electron	Nucleus	Orbit	Electron Cloud
Greek	X				
Dalton	X				
Thomson		X			
Rutherford		X	X		
Bohr		X	X	X	
Wave		X	X		X

Play the Atom Song MP4

Assignment :

Read pgs 18 - 25

Research : Dalton, Bohr, Rutherford or Thomson.

Find two interesting anecdotes. (A story about them.)