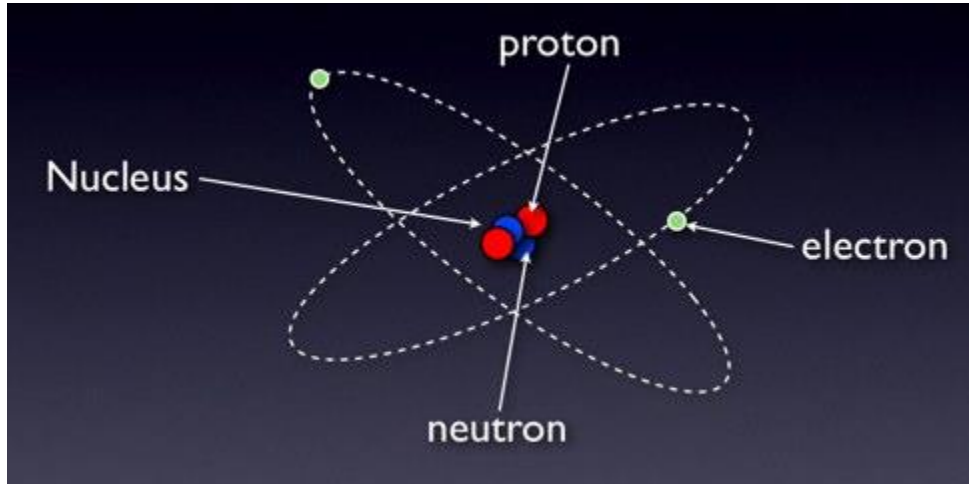


FROM WIRED MAGAZINE:

The screenshot shows a web browser window with the URL `wired.com/2009/09/the-development-of-the-atomic-model/`. The page features the Wired logo and navigation menus for categories like BACKCHANNEL, BUSINESS, CULTURE, GEAR, IDEAS, SCIENCE, and SECURITY. A secondary menu includes CORONAVIRUS, FAQs, BEST FACE MASKS, ESSENTIALS, HOW TO DISINFECT EVERYTHING, SYMPTOMS AND TESTING, and NEWS. A dark banner at the top of the article content reads "Travel to faster, trusted decisions in the cloud" and "JOIN THE VIRTUAL EVENT ON FEB. 11" with the SAS logo. Below the banner, the author's name "RHETT ALLAIN" and the date "09.04.2009 10:59 PM" are displayed. The main heading is "The development of the atomic model". The introductory text reads: "It is a story of how ideas changed about the nature of the atom. These are the notes (and diagrams) I use when I teach the atomic nature of matter to non-science majors. The best thing about this story is that it is a great example of science. Science (or scientists) build a model. If new evidence comes along, the model gets changed."

I LOVE THIS story. It is a story of how ideas changed about the nature of the atom. These are the notes (and diagrams) I use when I teach the atomic nature of matter to non-science majors. The best thing about this story is that it is a great example of science. Science (or scientists) build a model. If new evidence comes along, the model gets changed. There are several other websites that describe all of this stuff, I will list a couple at the end of this post.

Typical textbook model of an atom



Look in an intro, non-science majors textbook and you will probably see a picture like this of the atom. This model has some good ideas in it, but overall it has some problems. The key (and not incorrect points) of this model are:

- The atom is made of protons, neutrons and electrons
- Most of the space is taken up by the area where the electrons exist
- The protons and neutrons are in the core of the atom - called the nucleus.

Greek Model of the Atom

It always has to go back to the Greeks, doesn't it? Well, they did do a lot of stuff. I know they were really scientists but it is still a good place to start. Here is a picture of bust of Democritus.



In real life, he probably had color. Democritus is credited with coming up with the atom. The question was, what would happen if you keep taking something (like a tree) and breaking into smaller and smaller pieces? Would it always be a piece of a tree? Could you keep breaking it into smaller and smaller pieces? Democritus said that if you keep breaking it down, you would get to a size that could no longer be broken. This would be the indivisible piece. In Greek, atomos = indivisible. Thus, the atom. (I know there is more to the Greeks, but I need a place to start)

Dalton's Model



I am not going to go into the experimental evidence for Dalton's model of the atom, it's good stuff though. Let me just state what Dalton said:

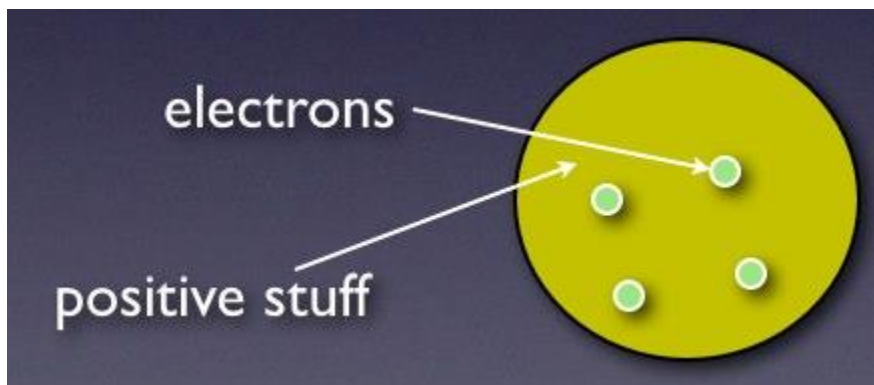
- Stuff can be broken into elements (the things listed on the periodic table).
- Elements are atoms with different masses.
- Compounds are a combinations of elements. You know, like water, salt or pizza.

Basically, Dalton just expanded on the Greek idea of the atom. An atom is a small things, and there are different masses with different properties.

J. Jonah Jameson Thomson - (AKA J.J.)



Thomson played with cathode rays. These are just beams of electrons (but cathode ray sounds cooler). By having the beam interact with electric and magnetic fields, Thomson was able to determine the mass to charge ratio for an electron. So, from that he knew that the electron came from the atom, it had a negative charge and a small mass. Here is the model that he proposed.

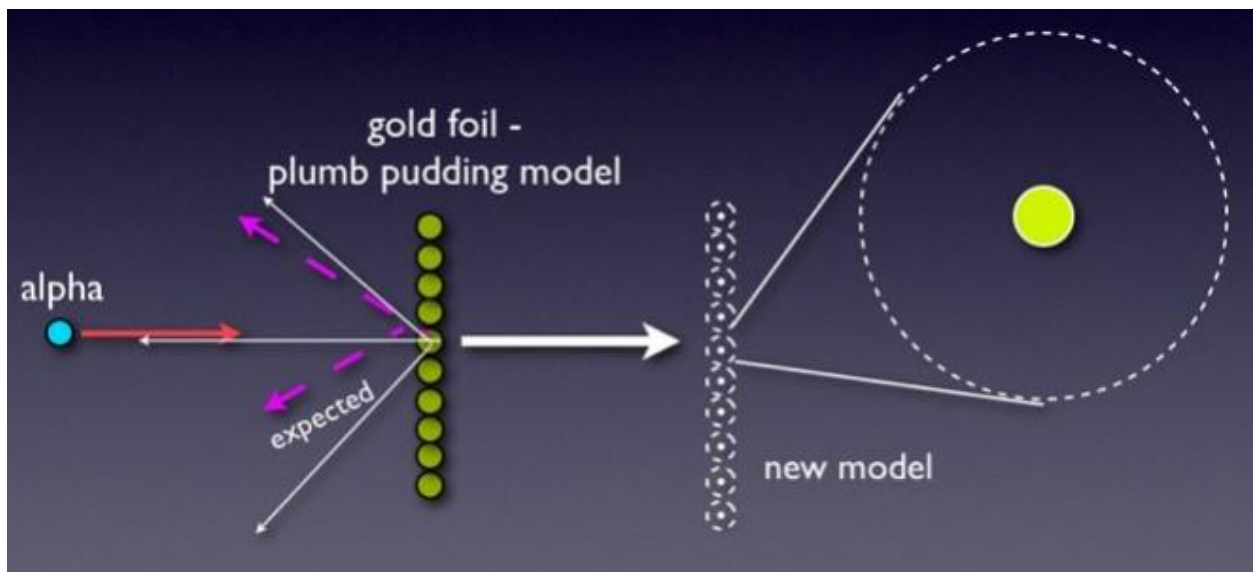


Thomson took the idea of the atom and tried to incorporate the evidence for the electron. In this model, the electrons are the small things and the rest of the stuff is some positive matter. This is commonly called the plum pudding model because the electrons are like things in positive pudding.

Rutherford Scattering



Ernest Rutherford said one day "hey, I think I will shoot some stuff at atoms." I am sure his wife said "oh, Ernie" (she probably called him Ernie) "if it makes you happy to play with your little physics stuff, go ahead. I know how much you like it." So he did. He shot some alpha particles (which are really just the nucleus of a helium atom) at some really thin gold foil. Here is a diagram of his experiment.



If you shoot these positive alpha particles at this positive pudding atom, they should mostly bounce off, right? Well, that is not what happened. Rutherford found that most of them went right through the foil. Some of them did bounce back. How could that be if the plumb pudding model was correct? Rutherford's experiment prompted a change in the atomic model. If the positive alpha particles mostly passed through the foil, but some bounced back. AND if they already knew that the electron was small and

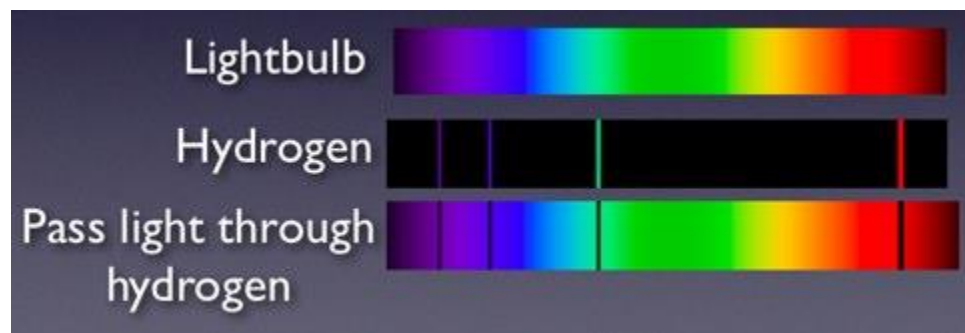
negative, then the atom must have a small positive nucleus with the electrons around them.

Bohr Model



The model proposed by Niels Bohr is the one that you will see in a lot of introductory science texts. There are a lot of good ideas in this model, but it is not the one that agrees with all of the current evidence. The model tries to make a connection between light and atoms.

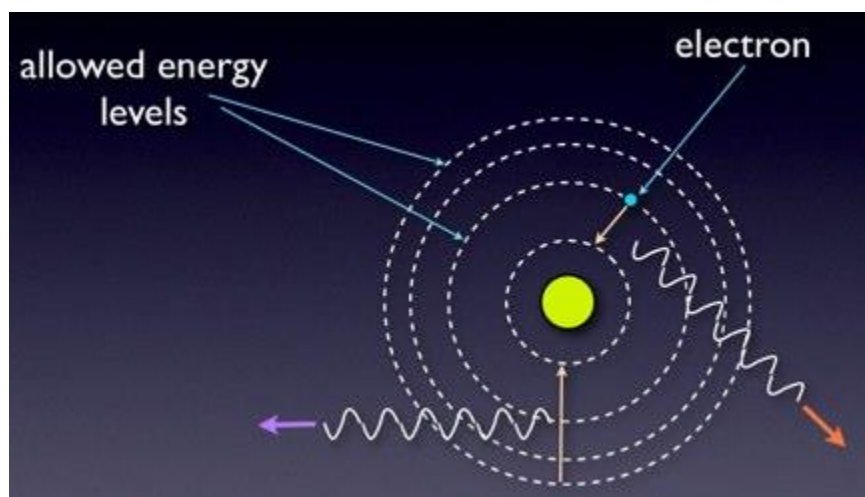
Suppose you take some light and you let different colors bend different amounts (think rainbow). This way, you could see what colors are present for different light sources. Here are three different light sources.



Maybe the light from the light bulb is what you would expect. These are the colors of the rainbow. However, suppose you took some hydrogen gas and excited it. There would only be certain colors (only certain wavelengths) of light produced. If you shine light through some hydrogen gas, there will be dark bands of light at those same colors.

So, Bohr said that these colors of light in the hydrogen gas correspond to different energy levels the electron in hydrogen can have. And this is the key to the Bohr model - electrons can ONLY be at certain energy levels in the atom. This is crazy (at least it was crazy for its time). Think about a planet orbiting the Sun. It can be at any energy level. In this case, there is a gravitational force attracting the planet which produces orbital motion. This will work anywhere in the solar system.

Early physicist thought of the electron in an atom a lot like a planet orbiting the Sun. The key difference is that the electron (in the Bohr model) orbits due to an electric interaction and not a gravitational interaction. Well, the other difference in the Bohr model is that the electron can not orbit (if it does orbit, which it doesn't) at any distance and any energy. Here is the essence of the Bohr model.



The Bohr model depends on a connection between the frequency of light and the energy of the level change. If light of a frequency corresponding to the energy change interacts with the atom, the electron can absorb the light and jump up a level. If an excited electron jumps down a level, it loses energy. The energy the electron loses becomes light with a frequency corresponding to the change in energy.

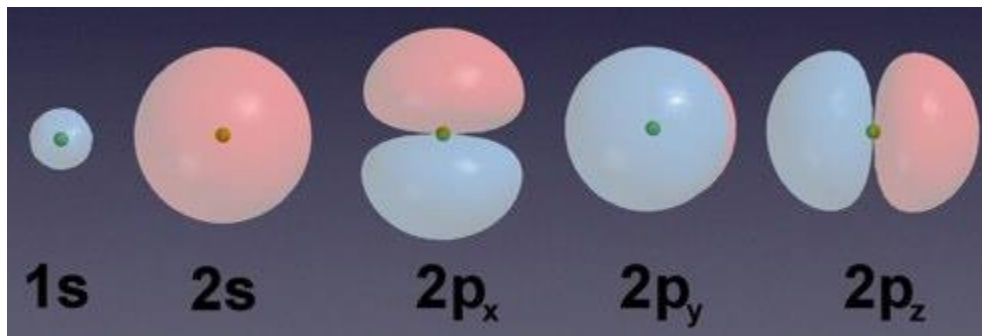
The Bohr model can be quite confusing to introductory students, but the important point is that this model agrees with the following evidence.

- Electrons are small and negatively charged
- Protons are in the nucleus which is small compared to the size of the atom
- For a particular element, only certain frequencies (colors) of light are absorbed or emitted.

Schrodinger and Heisenberg Model

There is a key point about the Bohr model that is no longer accepted in current models of the atom. In the Bohr model, the electrons are still thought to orbit the nucleus just like planets orbit the sun. Actually, this is something that we can not say is true. The problem with atoms and electrons is that we humans expect them to obey the same rules as things like baseballs and planets. Actually, the rules are the same, but baseballs and planets follow the rules of quantum mechanics without us humans even noticing.

It turns out that we can't really say anything about the trajectory or position of electrons in an atom. What we can say is all about probabilities. We can say what regions an electron is likely to be. Here is a diagram that might help. These are probability distributions for the different energy levels in an atom ([from wikipedia](#))



Summary

Scientists build models. When new evidence is collected, the models change.