Integrated Science
Rutherford's Experiment, "Black Box" (adapted from Lab-aids #100 OB-Scertainer kit)

Science thinking involves observation, experimentation, gathering and analyzing data, and drawing conclusions. Often, this process includes examination of events in which the particles cannot be directly observed (cannot see, touch, taste, hear, or smell). Many things, such as atoms, the origins of the universe, energy and dinosaurs cannot be observed directly; therefore, indirect observation must be employed. For example, although an atom is too small to be seen, scientists have learned much about it's structure. These particles cannot be directly observed, but the properties associated with them are interpretations of indirect measurements and experiments with observable results.

Many of the explanations about the structure of the atom are too complex to discuss here. However, there was one important experiment performed by an English physicist in 1911 that gives us a clue to how scientists "looked" inside the atom. Ernest Rutherford designed an experiment as shown in the Figure 1. He decided to test a sample target by shooting it with atomic "bullets." The target was a piece of gold foil, the gun was a piece of radioactive radium, and the bullets were alpha particles from the radium.

He drilled a hole into the center of a block of lead and dropped a bit of radium inside. Lead is a shield against radiation, so no alpha particles came out except through the drilled hole. The hole was like the barrel of a rifle, and the atomic particles came out like bullets from a gun.

He aimed the atomic bullets toward a screen coated with a material that glowed when struck by radiation. In this way it was easy to see where the atomic bullets were hitting. Rutherford then placed the thin piece of gold foil between the barrel and the screen to see what might happen. To his surprise, the screen continued to glow as if the foil did not even exist. The atomic particles went right through the foil!

He observed the event for a long time. Then, he noticed that occasionally a tiny fleck of light appeared on the screen OUTSIDE the target area. Careful study showed that only 20 out of every 1 million bullets were deflected. Rutherford wondered why these particles were hitting other parts of the screen. He concluded that (1) since most bullets went right through the foil, the atoms of gold must consist mostly of space: (2) the bullets that did not go right through were bouncing off of something – he called that "something" a nucleus; and (3) since the nucleus was able to deflect the bullets, the nucleus must be very heavy compared to the rest of the atom. Rutherford was able to support this conclusion with his data.

To put the model of the atom into perspective; if the nucleus of an atom were 1 centimeter in diameter (in actuality, more than one millionth of a centimeter) the outer part of that atom would be 120 meters away, or farther than the length of a football field. In other words, only about one part in 50,000 parts of the atom is actually solid!

In order for Rutherford to arrive at his conclusions, he had to make several inferences. An inference is an explanation based on observation, prior knowledge and experience.

Discussion Questions

1. What was Rutherford's conclusion regarding the structure of the atom?
2. Can you identify at least 1 observation and 1 inference that Rutherford made leading to this conclusion?
3. Why do you think other scientists accepted Rutherford's model of the atom?

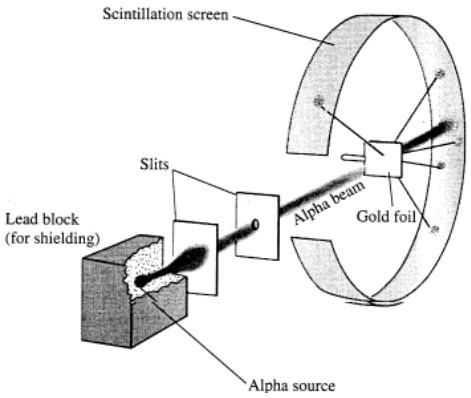

Figure 1: Rutherford's famous 'Gold Foil' experiment