

After World War I, many of the great minds of the early twentieth century returned from military endeavours to scientific research. One such scientist, Ernest Rutherford, returned from helping the English track down German U-Boats to carry out one of the most important experiments in chemistry. Rutherford's Gold Foil Experiment proved the existence of a small massive center to atoms, which would later be known as the nucleus of an atom.

Ernest Rutherford, Hans Geiger and Ernest Marsden carried out their Gold Foil Experiment to observe the effect of alpha particles on matter. Rutherford devised a way to record the location of the alpha particles by surrounding the bombarded object with a sheet coated in ZnS, which would emit a flash of light when hit with an alpha particle. Through previous experiments of shooting alpha particles, Rutherford knew they had considerable mass and speed. He then hypothesized that these particles would penetrate a thin metal foil, although they may scatter slightly because of the charge in the metal atom's subatomic particles. After shooting alpha particles through the thin sheet of gold, Geiger, Marsden and Rutherford discovered that a small proportion of the molecules were scattered at larger than  $90^\circ$  angles. This caused them to conclude that there was a small fraction of the total volume of the atom that held most of the mass of the atom.

## History

Explore the discoverer's biography, including general facts about his life and anecdotes regarding how he made this particular discovery. Also see other significant scientific discoveries built largely on this concept and other real-world applications in history that may not still be relevant.

### Discoverer/Developer

Ernest Rutherford was born in 1871 in Brightwater, New Zealand. After graduating from the University of New Zealand, Rutherford researched at both Canterbury University and McGill University, which are located in the United Kingdom and Canada respectively. At both universities he studied radioactivity and radiation. He eventually was offered the Langworthy Professor of Physics position at the University of Manchester. At the University of Manchester, Rutherford aided Professor Hans Geiger in creating the Geiger Counter. This device detects alpha particles. Geiger and Rutherford had previously revealed in 1908 that the alpha particles were helium ions, as both had the same atomic light spectrum (emission spectrum). With tensions high in Europe on the verge of WWI, and many German scientists working on x-ray and radiation research, pressure was put on English scientists to match these with new discoveries. After determining the identity of the alpha particles, Rutherford, Geiger, and Geiger's graduate student Ernest Marsden decided to test how alpha particles interacted with other elements. They tested this by shooting alpha particles at a thin gold foil.

### Use/Application through History

With the discovery of a small massive center to the atom, the idea of neutral particles, neutrons, was hypothesized. After Rutherford's famous experiment, and with Rutherford's aid, James Chadwick was able to isolate and prove the existence of neutrons.

The idea that the nucleus of an atom is made up of smaller particles also led to the first splitting of an atom. Ernest Cockcroft and J.D. Walton successfully split a lithium ion.

Niels Bohr created his model of the atom, with a positive center and electrons orbiting it, a model which is widely used today, from Rutherford's model.

The concept of nuclear fission, which is the addition of two nuclei, was also soon developed. This process is used by the sun to create solar energy as well as in a hydrogen bomb.

## Concept Definition

Study the primary definition of this concept, broken into general, basic, and advanced English definitions. Also see the mathematical definition and any requisite background information, such as conditions or previous definitions.

### Basic

The Rutherford Gold Foil experiment shot minute particles at a thin sheet of gold. It was found that a small percentage of the particles were deflected, while a majority passed through the sheet. This caused Rutherford to conclude that the mass of an atom was concentrated at its center.

### Advanced

Ernest Rutherford hypothesized that an atom's mass was uniformly spread out in its shape. In the Gold Foil Experiment he shot alpha particles at a thin sheet of gold; he thought the particles would travel right through the sheet, rather like a bullet traveling through a sand bag. However, he found that a minute percentage of alpha particles ricocheted backwards. This led him to conclude that most of the mass of an atom was centered in the positive nucleus, while only a small amount of mass surrounded this positive ball.

### Vocabulary

Learn important vocabulary for this concept, including words that might appear in assessments (tests, quizzes, homework, etc.) that indicate the use of this concept.

Important Vocabulary	Term	Context
	Alpha Particle	<ul style="list-style-type: none"><li>- Not every helium nucleus is considered an alpha particle.</li></ul>

	Emission Spectrum	<ul style="list-style-type: none"><li>- Every element creates its own unique emission spectrum.</li></ul>
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	Nucleus	<ul style="list-style-type: none"><li>- Rutherford correctly theorized that there was a dense center to every atom, the nucleus.</li></ul>
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	Radioactivity	<ul style="list-style-type: none"><li>- Lead is often used as protection against radioactivity because it is so dense.</li></ul>
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### Videos

Browse relevant videos from the Journal of Chemical Education's (JCE) Chemistry Comes Alive! library and other video sources.

#### Rutherford's Experiment

A basic description of what occurred during the gold foil experiment.

### Computer Animations

Experience computer simulators or animations that illustrate the concept discussed here. Many simulators or animations come with worksheets for use in class.

<http://www.teacherlink.org/mysteryshapes>

<http://www.micro.magnet.fsu.edu/electromag/java/rutherford/index.html>

<http://www.wwnorton.com/college/chemistry/gilbert2/contents/ch02/chemtours....>

### Summary

Read a summary of the concept, indicating the enduring understanding students should retain after class.

#### Summary

Ernest Rutherford's experiment of shooting alpha particles through a thin sheet of gold, and discovering that some were deflected, proved that an atom is actually a small dense nucleus surrounded by orbiting electrons.

### Works Cited

Review the works cited to write the researched parts of this page, such as the discoverer's biographical information and other areas.

#### Works Cited

[LINK URL: <http://micro.magnet.fsu.edu/electromag/java/rutherford/>]

[LINK URL: [http://www-outreach.phy.cam.ac.uk/camphy/physicists/rutherford\\_prelim.htm](http://www-outreach.phy.cam.ac.uk/camphy/physicists/rutherford_prelim.htm)]