A Salute to Dr Ernest Rutherford

http://news.bbc.co.uk/1/hi/sci/tech/6914175.stm

No-one ever expected the atom to be as bizarre as it turned out to be. Since 1905 when a young Albert Einstein demonstrated for the first time that atoms must exist, they have consistently flummoxed scientists by their weird, almost contradictory behaviour.

And the story gets really strange. An atom isn't just tiny, it's over 99.9% empty space. All the weight of an atom is concentrated in a mind-numbingly tiny object at its centre. It's a trillionth of a centimetre across and is called the nucleus.

The rest of the atom is entirely empty apart from a few ghostly objects called electrons that skim about at a great distance from the nucleus.

If you removed all the empty space from the atoms that make up all the humans on the planet, then you could fit all 6 billion of us inside a single apple.

This astonishing discovery that atoms are mainly empty was made in 1909 at Manchester University by the indefatigable Ernest Rutherford. Rutherford had great courage as a scientist and was prepared to fly in the face of convention.

So when he announced that the atom was mainly empty, he did so knowing his claim flatly contradicted the then known laws of physics. These demanded that all atoms collapse instantly. It was a seismic moment in the history of science.

Forced to explain the atom's mysterious emptiness, scientists had to jettison everything they had believed to be true for the previous two centuries. Their response was to invent an entirely new science, which we now call quantum mechanics.

Exploring the atom has tested humanity's imagination and intellect more than any other scientific endeavour. Even now, as we peer deeper and deeper into the atom, it throws back as many questions at us as answers.

http://atomic-molecular-optical-physics.suite101.com/article.cfm/rutherford_and_the_atomic_nucleus

New Zealander Ernest Rutherford made waves in the scientific community in the first couple decades of the twentieth century with his work on the atomic structure.

After the discovery in 1897 of the electron by J.J. Thompson, the idea that there might be some internal structure to atoms (which were previously thought to be truly fundamental and indivisible particles) began to gain steam. The first such model, credited to Thompson himself, was the so-called "plum pudding" model, which paints an amusing mental picture of an atom as a mass of positive matter, with little "plums" of negative electrons scattered throughout.

Rutherford, Geiger, Marsden, and the Atomic Nucleus

In 1909, New Zealand physicist Ernest Rutherford, along with Hans Geiger and Ernest Marsden at the University of Manchester, performed a famous experiment in order to put the plum pudding model of the atom to the test.

In this experiment, alpha particles (a type of naturally-occurring radiation consisting of positively charged helium atoms) were fired at a high velocity into a very thin sheet of gold foil. The trajectories of these particles after passing through the foil were then detected. If the plum pudding model of the atom was correct, then it was assumed that many of the particles passing through would have had their courses slightly altered by the charge within the atoms, though in no dramatic fashion.

The end result of the experiment differed remarkably from expectation. Where most of the alpha particles passed right through the gold atoms as if they weren't even there, a small fraction of them got diverted at very dramatic angles. Some of the particles even bounced directly back in the opposite direction!

After analyzing the data, Rutherford realized that the plum pudding model could not account for this discrepancy, and in 1911 proposed a new and improved atomic model – called, appropriately, the *Rutherford Model*. In this model, the negative electrons orbited around a tiny, centralized, positively charged and incredibly dense central "nucleus." This was the first of what can be referred to as "solar system" models, where the electrons orbit the nucleus like the planets orbit the sun. While it is known today that there are certainly limitations to how well this model genuinely reflects what is really happening within an atom, it has proved tremendously useful in explaining certain very fundamental features of the atomic structure, specifically the behaviors of electrons, spectroscopic analysis, and the formation of atomic bonds.

The Constitution of the Atomic Nucleus

Now that Rutherford had made some progress in determining the shape of individual atoms, it remained to be seen exactly what this "nucleus" was made of. It was known that whatever it was had to be positively charged, and very dense, but apart from that, the nucleus was the next great frontier in atomic theory.

In 1918, while Rutherford was performing his various experiments in the field of radioactivity, bombarding nitrogen gas with *alpha* particles (alpha particles are a type of radiation), he noticed that one of the experimental results was a surge of hydrogen. He correctly deduced that the hydrogen atoms must have come from *within* the nitrogen atoms themselves, which would mean that there was something within all of these atoms which was divisible, the amount of which would determine what element the atom represented.

The particle Rutherford isolated was the proton, which by itself constitutes the nucleus of a single hydrogen atom, though in this case it was "ionized" (missing its electron, thereby giving it a net positive charge), which Rutherford determined by exposing the resulting hydrogen to magnetic fields, as had Thompson before him in order to determine the charge of electrons.

The proton was recognized to be the positive antithesis to the electron, thus creating a neutral atom. This meant that at this point, the atom could very well have been seen as complete. After the discovery of the electron, the proton was practically inevitable, as something had to be discovered that would have a positive charge in order to neutralize the negative charge of the electron. It was not immediately clear that any other atomic constituents would be ultimately necessary in order to complete the atom.
Of course in hindsight it is clear that this was wrong. After all, what of the neutron?

The fact was simply that this third atomic constituent, with its neutral charged, could not be discovered, as had the electron and proton, by magnetic means. It would take another 12 years and some rather ingenious means before it would finally be discovered.

But even with only the electron and the proton, physicists had already gained a decent, working model of the atom within the first two decades of the twentieth century.