BBC Bitesize - Chemistry

Episode 2 – The history of the atom

SUNAYANA: I'm Dr Sunayana Bhargava, a scientist and poet.

TULELA: And I'm Tulela Pea, a science communicator and podcaster.

SUNAYANA: And this is Bitesize Chemistry. This is the second episode in an eight-part series on atomic structure and the periodic table. In this episode, we're going to look at the history of the atom and how that model has developed over the centuries.

TULELA: We'll look at how this led to our understanding that atoms are made up from protons, neutrons and electrons.

SUNAYANA: And we'll end with a quick summary of the main important facts for you to take away because life is just so darn busy these days.

TULELA: But also because that's why we're here after all - to help revise GCSE chemistry and combined science.

SUNAYANA: Our chat bot NNICK is with us again.

NNICK: Oh, I love Chemistry, I adore it, divine chemistry!

SUNAYANA: Before we unleash NNICK, what I like about the history of the structure of the atom is that it's a really good example of how science works. You come up with a new idea or hypothesis, devise an experiment to test the hypothesis and if the evidence backs up your predictions then it becomes a better theory. And our understanding is a little better than it was before. And this is exactly true with how the model of the atom has developed throughout history.

TULELA: Totally! So if we begin say only 200 years ago, back then what we thought an atom looked like was actually quite basic, tiny.

SUNAYANA: Very, very tiny.

TULELA: Very, very, tiny spheres that can't be divided. This idea was proposed by a scientist from Manchester called John Dalton in 1804.

SUNAYANA: Actually, it kinda goes all the way back to the ancient Greeks and the word atom comes from the Greek 'atomos' – which means uncuttable.

TULELA: Nice trivia, Sunayana! But since then, we now know that atoms are composed of electrons, protons and neutrons arranged in a particular way.

SUNAYANA: So how did we get from there to our understanding today? NNICK, can you give us a quick history of the structure of the atom?

NNICK: The history of ideas about atoms. The most sensible, mature and adult way to discuss the history of ideas about atoms is through the medium of song.

SONG
Mr John Dalton imagined that atoms
Were miniature spheres that you cannot divide
And then JJ Thomson, who probably liked snacking
Described them as a plum pudding with electrons inside

Rutherford, who was Ernest, suggested a nucleus
Which no one had ever considered before
And around that were shells filled with orbiting electrons
According to that fascinating fellow Niels Bohr

Experiments suggested the existence of protons
Which contribute to the nucleus in a positive way
Add to those the neutrons discovered by Chadwick
And that's the atomic model which we still use today, OK!

SUNAYANA: Thanks, NNICK! Lots to unpack there but sounds like there are some key moments in this history of the atom that we should explore a little. And each one has progressed our understanding. First up, JJ Thomson. From his experiments, he concluded that atoms weren't solid spheres and he proposed that they looked more like a plum pudding.

TULELA: Who even eats plum pudding these days?

SUNAYANA: Sounds like the kind of dessert they'd have had in 1904 when JJ Thomson came up with the idea. His plum pudding model could be thought of as a positively charged dough spread out evenly in which negatively charged electrons...

TULELA: ...the plums...

SUNAYANA: ...were embedded. Quite simple, but an advance from the solid spheres model.

TULELA: Anyway, JJ Thomson's plum pudding model of the atom didn't last very long because only about a decade later, along comes Ernest Rutherford who tested Thomson's theory and proved that the plum pudding was way past its sell-by date. And he did this by showing that the positive charge in the atom wasn't spread out evenly and was in fact concentrated in the centre – the nucleus – where most of the mass of the atom is. And his evidence came from firing positively charged alpha-particles at a very thin sheet of gold foil.

SUNAYANA: Which I shall now demonstrate in the Bitesize studio purely by the magic of sound effects! If Thomson's plum pudding model was correct then when I fire some alpha particles at the gold foil...

TULELA: Whoa! Careful with that sound effect, Sunayana!

SUNAYANA: Because the positive charges in the gold atoms were thought to be evenly spread out, all the alpha-particle bullets would simply pass straight through – or deflected just a tiny amount if they travelled close to an electron in the plum pudding.

But what they found is that although, yes, most of the alpha particle bullets did indeed pass straight through the foil undeflected, that a few alpha particles were deflected by extreme angles or even reflected backwards as if ricocheting from something.

TULELA: Whoa! Be careful!

SUNAYANA: And this could not have happened with the Thomson plum pudding model.

TULELA: Nice shooting, Sunayana. So, from this experiment, the new model of the atom was now one of mostly empty space where a positively charged mass or nucleus is concentrated at the centre and around this are the electrons. End of story?

SUNAYANA: Not quite yet! Because Rutherford's model only answered some questions but not all. It didn't tell us anything more about the electrons. To resolve those questions, we had to wait until Niels Bohr. We had to wait 'til he proposed a new development of the previous model of the atom. In this, the electrons orbit in particular shells – or energy levels to give them their correct name – which are precisely fixed distance from the nucleus. Again, his experimental observations agreed with his theorical calculations, updating the science and our ideas.

TULELA: So what does that mean, orbiting electrons in shells of a precise distance?

SUNAYANA: I like to think of them as if I were a gymnast twirling a baton over my head and I could choose a different length baton. The electrons are in the ends of the baton spinning around as I dance. They can't get any closer or further unless I change the baton size – which is like being in a different shell.

TULELA: Baton twirling and alpha particle sharp-shooter – you'd be so talented.

SUNAYANA: Thanks! But we're not finished yet – because even Niels Bohr's model needed refining and later experiments from Rutherford again led to the idea that the positively charged nucleus in the atom could be subdivided into a whole number of smaller particles called protons, with each proton having the same amount of positive charge.

TULELA: The end?

SUNAYANA: Not quite – because finally about 20 years after Rutherford's nuclear model, in 1932 James Chadwick put the final (for the moment) missing pieces into our model of the atom when he proved the existence of neutrons – chargeless particles, also within the atom's nucleus.

TULELA: And that is the model we use to visualise the atom today. A nucleus of protons and neutrons, with orbiting electrons at specific distances from the nucleus.

SUNAYANA: And if you decide to study chemistry or physics at a higher level, you'll see how even that model becomes more exciting and extraordinary.

TULELA: And an exciting and extraordinary career in science awaits everyone – every nationality, every gender, every background.

SUNAYANA: I couldn't agree more.

SUNAYANA: Time for a quick interactive quiz. Three questions, 5 seconds each – here goes…

TULELA: Question 1. Who came up with the plum pudding model of the atom?

SUNAYANA: Answer - JJ Thomson.

TULELA: Question 2. Who showed that this plum pudding wasn't correct and what was the experiment that proved this?

SUNAYANA: It was Ernest Rutherford who fired alpha particles at gold foil and updated the atom with his nuclear model.

TULELA: And Question 3. How did Niels Bohr's model update the nuclear model further?

SUNAYANA: He brought in the idea of electrons orbiting the nucleus in energy shells.

TULELA: OK, Sunayana, quick summary?

SUNAYANA: Sure thing.

TULELA: Let's go. From the ancient Greeks until about 200 years ago, the atom was thought of as tiny solid spheres.

SUNAYANA: Then JJ Thomson comes up with his plum pudding model.

TULELA: Rutherford fires alpha particles at gold foil and shows JJ Thomson was wrong. His nuclear model is one with a positive nucleus.

SUNAYANA: Bohr's orbiting electron shells helps modify Rutherford's model.

TULELA: Protons are discovered by Rutherford. Neutrons are discovered by Chadwick and the current model of the atom is in place.

SUNAYANA: And all these developments are a really good example of how science progresses though theory, experiment and evidence.

TULELA: And now I'm hungry. Plum pudding, anyone?

SUNAYANA: In episode three of this series, we'll be looking at the structure of the atom in more detail its size – its parts, charge and its mass.

I'm Dr Sunayana Bhargava.

TULELA: And I'm Tulela Pea.

SUNAYANA: To hear more, search 'Bitesize chemistry' on BBC Sounds.

TULELA: Say bye, Sunayana.

SUNAYANA: Bye Sunayana.

TULELA: Thanks for listening.