Creating Science – Atoms.

What makes up stuff? Atoms. Who says so? Hmm…..

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Processing and analysing data and information Y5: Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS090)

Science as a human endeavour y7: Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE223)

Also;

Physical science y5: Light from a source forms shadows and can be absorbed, reflected and refracted

Chemical science y9: All matter is made of atoms which are composed of protons, neutrons and electrons

Warning

- This demonstration uses plasma. It is not a children's activity.

Preparation

- You'll need an air powered rocket or puff bottle.
- A piece of metal, a chair leg will do.
- You might need a picture of the periodic table of the elements.
- Some pictures of what atoms might look like – see appendix.
- Pictures of scientists – see appendix.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

It is wiser to abbreviate the history of the concept of the atom, cutting out all except Democritus, and point out that his idea after much testing is the one we still use today.

Focus on observation during the activities phase.

Middle:
As intended. You might be able to display a spectrum and point out the wavelengths of light. Giving a number to a colour opens up a whole new world of mathematics.

Teen:
You can elaborate on the concept of the history of the atom (see appendix) to illustrate how 1/ we use our imagination to understand what we cannot see and 2/ we use experiments to support all our theories.

Engage
- Perform a cognitive dissonance attention activity, such as the puff bottle. Have student's practice scientific thinking. Point out that :
    - 1/ We use our imagination to create ideas that explain things we cannot see.
    - 2/ We use experiments to test those ideas.

Explore
- Get out a piece of metal and explain:

History of atomic thought
Over 2000 years ago there was a certain question; what is everyone made out of? The original answer was something along the lines of; fire, water, air and earth. That was why rocks fall down, because they 'belong' on the earth and will 'jump' down to get there. And fire 'belongs' in the heavens, and that's why it tries to wriggle its way up there. When you take the fire out of wood, it leaves the earth and ash behind it. The hope was that if you could get just the right amount of fire, earth, air and water into lead, you could even turn it into gold!

The problem was… the underlying explanation (or "theory") was what we would consider nowadays to be WRONG. It does not explain or predict the arrangement or movement of things very well at all!

Nowadays we use a theory called "atomic theory". Have you ever heard about ATOMS? Well, who came up with that idea? And what does that idea mean?

Democritus
Take this piece of metal. If you break it in half, what are the two pieces made out of?

Still metal, right.

Well, if you keep on breaking a piece up, smaller and smaller, do you think we'll eventually come to a piece so small it cannot be broken, or will we always have smaller and smaller pieces of metal?

A philosopher (someone who 'loves wisdom') in ancient Greece, drawing on good ideas of his time, decided it was the former: there must exist *tiny* pieces of matter that cannot be broken down any more. He called the Atom, meaning, unbreakable. And he was Democritus (see appendix).

Well, it's not science if you don't test it, right?

So as time went on, people began to try and find out what the world was made of. One way to do this is by smashing things apart and seeing what comes out. Then they got really good at taking things apart – burning them, throwing acid on them.

After several hundred centuries, it began to look like there were about 80 raw materials that could not be broken down any more[1]. They called these atoms.

For instance, if you put lightning through water, do you know what you get? Hydrogen and Oxygen. And while you can make things out of hydrogen and oxygen, you can't break down the hydrogen or oxygen into anything else. And it turns out people are 90+% only 4 kinds of atoms, Carbon, Hydrogen, Nitrogen and Oxygen – the same ingredients as tree's! (simply arranged differently)

This would have to mean, however, that atoms are SMALL. In your body there are around 1,000 billion, billion of them! If atoms were the size of jellybeans, you'd be bigger than Australia!

(If time and interest permit, show a periodic table of the elements and discuss)

Explain

Explain: atoms are too small to see, but there are other ways we can appreciate them.

Hand out the rainbow glasses, and have students get used to them. Have them note the differences between natural sunlight and some artificial lights (particularly old fluorescent tubes).

- ⇨ Have students title a page "Atoms make rainbows" or similar (Older groups may prefer the equally accurate 'atomic spectrum') and try to accurately draw what they see.

NOTE: that each light has a different spectrum

NOTE: That some spectrum have missing colour: DRAW THE GAPS, THEY'RE NOT SOLID RAINBOWS.

NOTE: These rainbows aren't curves. Students will still try to draw them as curves.

DRAW WHAT YOU SEE, NOT WHAT YOU THINK YOU SEE.

This is a very important skill in science.

The simple explanation is that atoms will glow in a different colours depending on the kind of atom it is. While you can't see individual atoms, you can see the light they produce when you get billions of them glowing at once.

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[1] (Older groups = OK that last sentence isn't very accurate. We've since learned you CAN break atoms into other things, protons and electrons, for instance but the point is you cannot break atoms and they'll still be a smaller version of what they already were. They become something else. So you can smash a giant atom of uranium apart, but it's not uranium any more. So it IS accurate to say that you cannot CHEMICALLY break down atoms into anything smaller.)

This is called the science of *spectrometry*.

- ⇨ Perform the flame tests or the plasma chamber activity. Be sure to have a fire extinguishing equipment on hand.
- ⇨ Have students draw the spectrum or 'rainbows' that each colour creates.

Remember: We can use rainbows to see what atoms are around.

A lovely picture of what one student saw when she looked at the lights. Please note:

- Colour order in a spectrum
- Great use of gaps to illustrate missing colours.

Elaborate

There is plenty of opportunity for further research and study from the following:

- ⇨ Rainbows (spectrum) can tell us a LOT MORE about the universe than we sometimes realise.
    - We can know what atoms make up the sun by their colour
    - We can detect minute impurities in metals from the colour.
    - We can guess what atoms make up stars we might never visit from their colour.
    - We can tell the far away stars are moving further away, the faster and faster the further we look, by the red shift of their colour.
    - And much more!

Evaluate

Diagnostic:

Take time to focus on planned content material during the engage phase, for example, survey students regarding their understanding of the concept “atom”. Have them draw what they think they might look like, or have them draw their understanding of what metal looks like as you get smaller and smaller.

Formative:

Have student tell or retell parts of their story, and welcome them sharing their contributions. There are far more scientists than this brief retell shares, and contributions may be welcomed.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do. Perhaps they can:

- Design a time line on the *history of the theory of the atom*, highlighting the major experiments that changed our way of thinking, as well as the scientists and the countries they came from.

Creating science

Processing and analysing data and information Y5: Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships – especially with scientifically accurate rainbows with colours in order and appropriate gaps.

Science as a human endeavour y7: Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures, including ancient Greek, British, German and more!

Also;

Physical science y5: Light from a source can be refracted to create rainbows. These actually tell us a lot about what atoms we are dealing with.

Chemical science y9: All matter is made of atoms, which is a very old theory that has evolved and adapted through experiment and reason, as scientists have struggled over 2000 years to answer the question “what is stuff made from”?

Activity – capturing rainbows (or rather, measuring spectrum)

Draw some of the spectrum you see around. Make sure you note how they are made!!!

Spectrum made by:	Spectrum made by:
Spectrum made by:	Spectrum made by:

Appendix – famous scientists

Famous scientists in atomic theory – a VERY small list of contributors, can you find more? Particularly James Chadwick and John Dalton.

Democritus

Democritus, working with some good ideas around at that time, thought atoms might be different shapes, you know, sharp ones for spicy lemon, nice smooth ones for sugar. Is this what atoms look like? (show Democritus atoms)

Mendeleev

Scientists tried and tried to find a way to organise atoms, because they knew some where heavier than others, and they knew they had about 80 of them.

But it wasn't until a Russian scientist, using a principal he found in playing card games, was truly successful at it. He made up a table, and then LEFT GAPS for chemicals which hadn't been discovered yet.

Well, it's not science unless you can test it, and Mendeleev's table predicted we should find new chemicals, what they would be like, and how much they should weight, and guess what: we did!

We now use the periodic table, with over 118+ different atoms!

JJ Thompson

Jumping back to the past, however, atomic theory in the 18th century was proving its use.

A British scientist, JJ Thompson, came up with a clever addition to the theory.

He believed atoms were probably all little round balls, around the same size, that could stick to each other somehow. He wondered if electricity, teeny, tiny bits of electricity, could be that force that held atoms together.

Through his experiments, he found all atoms have electricity. It was as if, to him, atoms were little round balls with tiny bits of electricity on the outside that could be pulled away and used to make sparks, electricity, maybe even lightning (though probably not lightning).

Is THIS what atoms look like? (Show JJ Thompson atom)[2]

Rutherford

New Zealand born British scientist, Ernest Rutherford, came up with a clever experiment soon after.

For example, when you throw a ball at a wall, what do you think will happen? (it bounces back)

Well, if you throw an atom at something relatively thick, like gold foil, what do you think will happen (most students say it will bounce back).

Having the atoms bounce back is exactly what Count Rutherford expected too. But in fact – MOST OF THE ATOMS WENT RIGHT ON THROUH!

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[2] It also meant that atoms could be broken up – or at least, the outer bits can be chipped off.

How would you explain this?

That maybe there's holes in the wall we can't see?

That's what the good Count did. He decided atoms weren't think, like plum pudding. They were mostly empty space. He thought the electrons might spin around the atoms like planets around their sun – and in-between both there's mostly nothing but empty space. Is THIS what atoms look like (show Rutherford atom)

His theory worked, and still works, so we use it. But this would mean atoms are mostly empty space. It means that if you squashed your atoms together (similar to inside a black hole) so that the hard inner atomic nucleuses were stuck next to each other, there is actually less than a teaspoon of what makes up YOU.

Sure, that teaspoon still weighs as much as you do, 30-40 kilograms. But it's still only a teaspoon.

Heisenberg.

But the science doesn't stop there. Only a few years later Werner Heisenberg, from Germany, figured out using maths that the electrons are actually in several different places at the same time, depending on how you look at them. They form a fuzzy sort of statistical cloud where they *might* be.

So is this what atoms look like? (Show Heisenberg atom)

The future

So do you think there is ANOTHER, even more accurate description of what atoms should look like?

Do you think we should have a 5th model here?

Well, trouble is, we don't have one. Maybe we are standing in the room today with the next great atomic scientist who will give us an even MORE accurate way of imagining what atoms should look like? Maybe that person is YOU?!

Democritus

(painting by Hendrik ter Brugghen – Democritus)

Democritus (Greek: Δημόκριτος, *Dēmokritos*, "chosen of the people") (ca. 460 BC – ca. 370 BC) was an Ancient Greek philosopher born in Abdera, Thrace, Greece. He was an influential pre-Socratic philosopher and pupil of Leucippus, who formulated an atomic theory for the cosmos. He is shown near a globe for he loved to travel, and laughing because he could often see the ironic side of life. Taken 23 June 2011 from http://en.wikipedia.org/wiki/Democritus)

J J Thompson

Sir **Joseph John "J. J." Thomson**, OM, FRS (18 December 1856 – 30 August 1940) was a British physicist and Nobel laureate. He is credited for the discovery of the electron and of isotopes, and the invention of the mass spectrometer. Thomson was awarded the 1906 Nobel Prize in Physics for the discovery of the electron and for his work on the conduction of electricity in gases. He proposed the 'plum pudding' model of the atom in 1904.(taken 23 June 2011 from http://en.wikipedia.org/wiki/JJ_Thompson)

Ernest Rutherford

Ernest Rutherford, 1st Baron Rutherford of Nelson OM, FRS (30 August 1871 – 19 October 1937) was a New Zealand-born British chemist and physicist who became known as the father of nuclear physics. In 1911, he postulated that atoms have their positive charge concentrated in a very small nucleus, and thereby pioneered the Rutherford model, or planetary, model of the atom, through his discovery and interpretation of Rutherford scattering in his gold foil experiment. (taken 23rd of June, 2011, from http://en.wikipedia.org/wiki/Ernest_Rutherford)

Werner Heisenberg

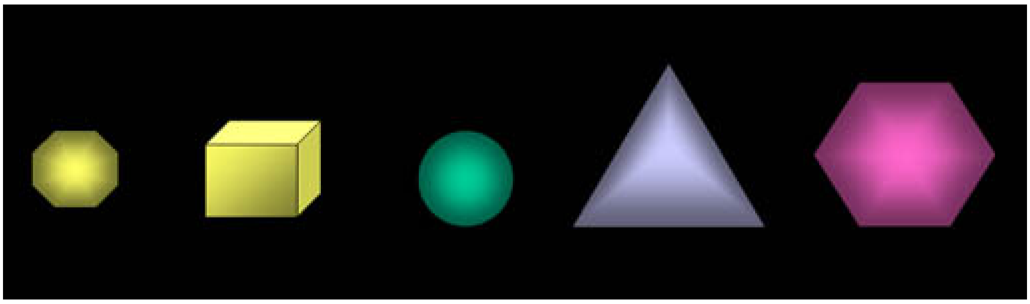
Werner Heisenberg (5 December 1901 – 1 February 1976) was a German theoretical physicist who made foundational contributions to quantum mechanics and is best known for asserting the uncertainty principle of quantum theory. Heisenberg was awarded the 1932 Nobel Prize in Physics for the creation of quantum mechanics. (Taken 23rd of June, 2011 http://en.wikipedia.org/wiki/Heisenberg) his work, along with other scientists such as Bohr and Schrödinger, led to the modern atomic orbital model.

Marie Curie

Marie Skłodowska Curie (7 November 1867 – 4 July 1934) was a Polish–French physicist/chemist famous for her pioneering research on radioactivity. She was the first person honored with two Nobel Prizes—in physics and chemistry. She was the first female professor at the University of Paris. She was the first woman to be entombed on her own merits (in 1995) in the Paris Panthéon. (taken 23rd of June, 2011, from http://en.wikipedia.org/wiki/Madam_Curie) She sadly died from radiation poisoning form her own experiments, creating knowledge which has saved millions.

Appendix – model atom pictures

Democritus atoms- many different sizes and shapes



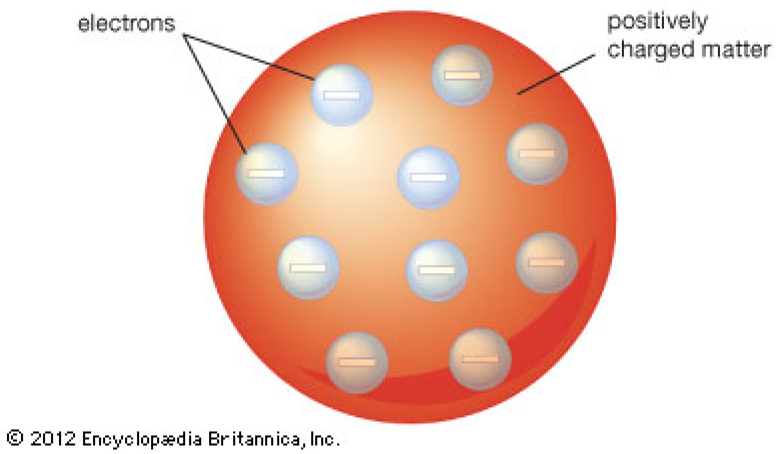
Atoms differ in size, shape, mass, position, and arrangement.

->Solids are made of small, pointy atoms.

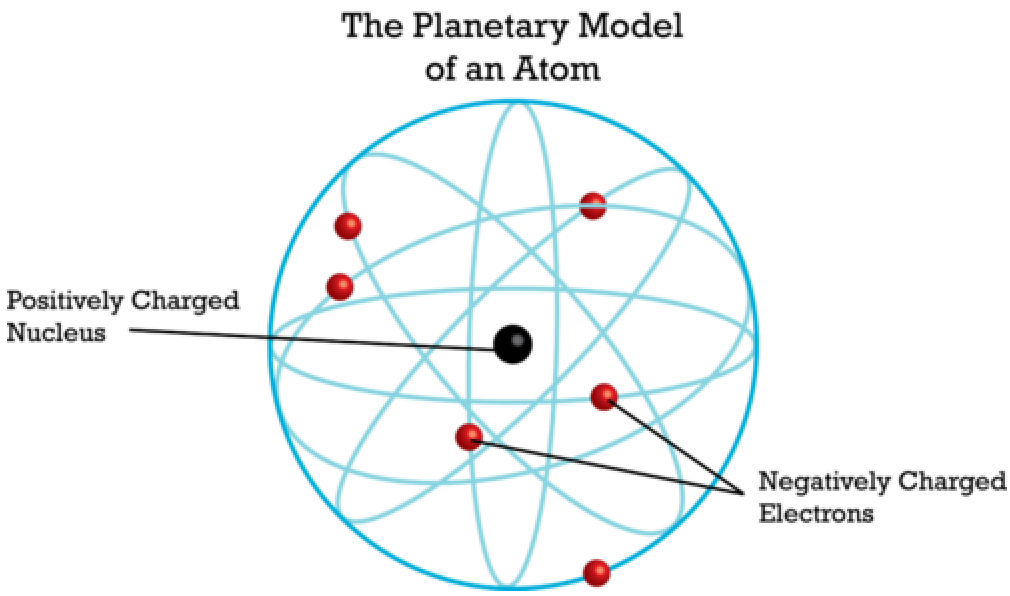
->Liquids are made of large, round atoms.

->Oils are made of very fine, small atoms that can easily slip past each other.

Plum pudding model of JJ thompson



Rutherford planetary model



Heisenburg's uncertainty model: note overlapping orbital shells where electrons *might* be found.