The First Mystery: The Big Bang

Our detective hunt begins 13.8 billion years ago! Back then, there was... nothing. No sun, no stars, no planets, no galaxies, no teachers, no homework, no elements, no matter, no clues. Then came the mind-blowing, monumental moment known as the Big Bang. This was when the universe was born, and it was the start of the incredible process that led to the elements being formed...

1. INFLATION AND COOLING
From nothing, THE UNIVERSE EXPANDED and cooled in the minutest fraction of a second.

2. THE FIRST PARTICLES
A millionth of a second later, PROTONS AND NEUTRONS STARTED TO FORM.

3. THE FIRST ELEMENTS
Within two minutes, the nuclei of THE FIRST ELEMENT, HYDROGEN, BEGAN TO FORM. A MINUTE LATER, THE NUCLEI OF HELIUM FOLLOWED. After this, it took about 380,000 years for things to cool down enough for these nuclei to form stable atoms.

4. THE FIRST STARS
Clouds of hydrogen and helium were flung out across the newly formed universe. About 200 MILLION YEARS LATER, THE FORCE OF GRAVITY BEGAN TO FORM THEM INTO THE FIRST STARS. And these stars hold your first clue to the secrets of the elements.

What existed before the Big Bang? No one knows. One theory says there was one infinitely hot, infinitely dense point known as a 'singularity'. Some also say there may be other universes!

How are elements formed in stars?

Elements are constantly being created in our universe. In the super-hot, super-dense centres of stars, the nuclei of hydrogen atoms are squeezed together. This nuclear reaction produces helium. It also creates visible light and other forms of radiation. That's what is happening in the centre of our sun.

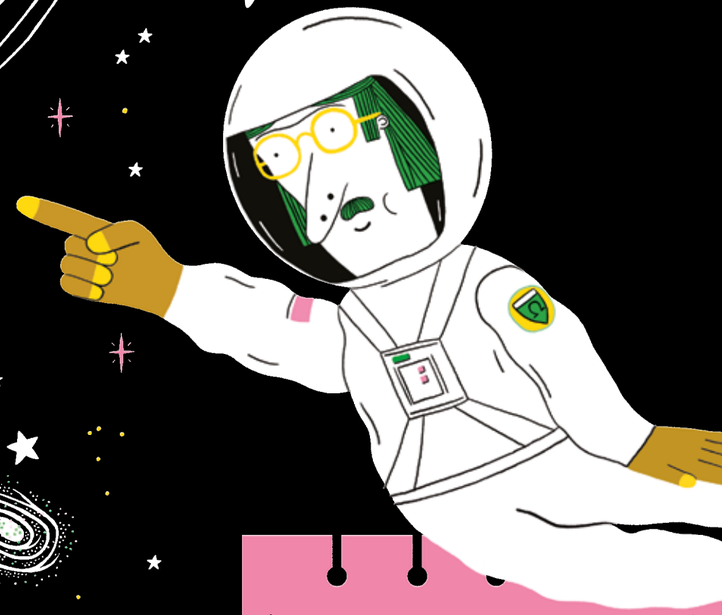
Larger stars

Larger stars continue fusing elements to produce heavier elements (with more protons), from oxygen all the way up to iron, before they also collapse and die. The reactions within them may also produce even heavier elements such as copper and zinc.

Massive stars

Really massive stars – many times bigger than our sun – eventually collapse, producing a mega-explosion called a supernova. This can produce extra-heavy elements such as gold and uranium, which are then flung far into space.

Evidence of the Big Bang can still be discovered almost 14 billion years later. The radiation it released is visible in space as background microwaves, and can be detected by special radio telescopes.



The case of the disappearing sun

Our sun is vital for life on Earth but is actually quite a small star. Eventually it will run out of the elements that fuel fusion and will get colder and collapse, shedding its outer layer of heavier elements into space. But don't panic – it won't happen for about 5 billion years.

The mystery of the cosmic rays

Three lighter elements – lithium, beryllium and boron – are thought to be made by 'cosmic rays' splitting heavier elements in space into simpler atoms. Cosmic rays are high-energy particles whose origins are a mystery. They pose a serious health risk to space travellers, but rarely reach Earth's surface thanks to its atmosphere and magnetic field.

Xe Marks the Spot: Periodic Table

Every detective should draw up a list of suspects. Element detectives have a list of 118 to choose from, already arranged in a special table according to their weight and properties. Chemists call this the 'Periodic Table'.

The idea for the table originally came from a brilliant Russian boffin called Dmitri Mendeleev. And it was such a good idea that Mendeleev was able to use his table to predict the existence of elements that hadn't yet been discovered! However, the information the table contains today is the result of hundreds of years of detective work by lots of clever chemists, many of whom you will meet in our amazing Atomic Comics scattered throughout the book!

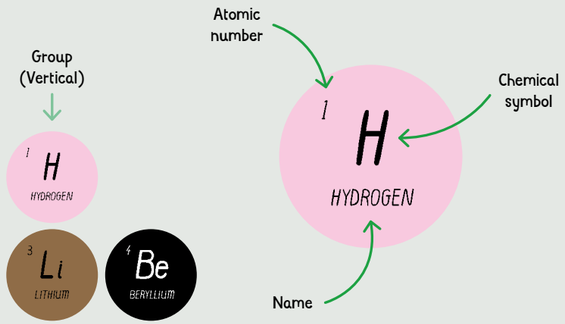
As you can see, the elements are arranged into rows and columns. The horizontal rows are known as 'periods', giving the Periodic Table its name. The vertical columns are called 'groups'. Today's Periodic Table includes the 118 elements known so far, from hydrogen to oganesson, but could still acquire new members.

Each element has a chemical symbol, like a code name, which is made up of one or more letters. So Xe is the symbol for xenon.

Know your suspects

Like a map, the Periodic Table is full of information. Each element has a number at the top, which increases by one as you travel along each row from left to right. This is the element's 'atomic number', and it tells you how many protons it has in its nucleus and is the key to an element's chemical identity. Hydrogen has one proton and therefore the atomic number 1. Helium has two protons and atomic number 2. As you travel along a row, the elements gain protons and become heavier. An electrically neutral atom has the same number of electrons as protons, so the table also reveals that a helium atom (atomic number 2) has two electrons orbiting its nucleus, and so on for all the other elements.

Also as in maps, elements in the table can be colour-coded to indicate they have similarities. Most of the 118 elements are metals (like iron, Fe) – a large category which is then divided into several smaller groups. Then there are 'non-metals', including the halogens and noble gases (like Xe, xenon). There are also some strange in-between elements called 'metalloids'. To make the table easier to show, two groups of metals called the lanthanides and actinides are usually placed in rows underneath the main table.



Many elements are named after famous people and places. Mendelevium (Md) is named after Dmitri Mendeleev.

KEY

Non-Metals

Noble gases | Halogens | Other non-metals

Metals

Metalloids | Alkali metals | Alkaline earth metals | Lanthanides | Actinides | Transition metals | Post-transition metals

Hydrogen

1 H

👁 Colourless, odourless gas
⚠ Highly flammable ☆ Invisibility

Hydrogen makes up almost three-quarters of the total mass of elements in the universe. If you could count all the different atoms in the universe, over 90% of them would be hydrogen atoms. You won't be able to spot them, because hydrogen is an invisible, odourless gas. But you can track them down in millions of different substances.

Hydrogen is a highly reactive element, which means it forms lots of compounds with other elements. These include natural substances such as fats, oils, sugars and starches, so you can have fun finding hydrogen by eating it in your food!

You will also find hydrogen atoms in yourself: they are in proteins and bodily fluids, and make up almost 10% of the weight of your body.

Key

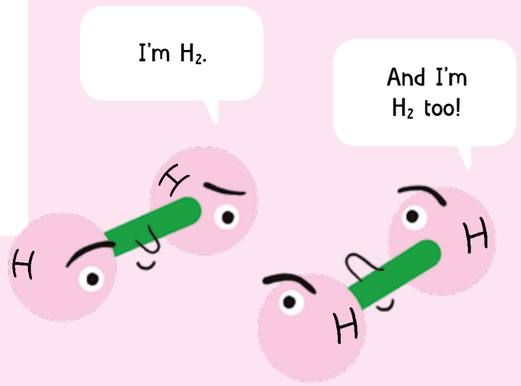
👁 Appearance
⚠ Element of danger
☆ Superpower
📍 Find it in:

The case of the underwater battery

You can use electricity to release the hydrogen atoms from water molecules. Chemists call this 'electrolysis'. Submerge a 9-volt battery upright in a glass of cold water. Small bubbles of hydrogen gas form at the negative terminal (marked '-') and rise to the surface. Ask an adult to hold a lit match to the bubbles, and they will ignite. Make sure to take the battery out and dry it off afterwards, or it will quickly go flat.

Two's company

Hydrogen atoms are the simplest of any element, with a single proton in the nucleus and a single orbiting electron. But when it's a gas, the atoms gang up in pairs to form hydrogen molecules (H_2) as these make them more stable.



FIND IT IN:

- ☐ YOU
- ☐ WATER
- ☐ EVERYTHING THAT CONTAINS WATER
- ☐ FOOD
- ☐ FARTS
- ☐ BATTERIES
- ☐ THE SUN

Follow the scent

Harmless bacteria in our intestines produce a mixture of gases that come out when we break wind (everybody does it!). This mixture includes some smelly gases, as well as nitrogen (the major component of air) and even a big hunk of hydrogen. This means some farts can literally be explosive!

Code name 'water former'

When hydrogen burns in air, water is produced. Early chemists spotted this, and hydrogen's name means 'water former' in Greek. Water is a compound with the formula H_2O, meaning that a water molecule has two atoms of hydrogen (H_2) for every single atom of oxygen (O). So, if you have a thirst to find the element in the room, you can gulp down billions of atoms in a single glass of water!

What a gas!

Scientists estimate that there are about one quinvigintillion atoms in the universe. That's a 1 followed by 78 zeros. Or if you prefer, one million million million million million million million million million million million atoms. Either way, it's a huge number, and nine in every ten are hydrogen atoms!

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Carbon

6 C

👁 Often dark, sometimes shiny
⚠ Possible planetary menace!
☆ Master of disguise

Carbon is common! It's the second most common element in the human body after oxygen. It's the fourth most common element by mass in the universe. It's the fifteenth most common element in the Earth's crust. And yet carbon is also super-special – it is essential to all known life.

Carbon atoms are very versatile in the bonds they can form with other elements. There are over 10 million carbon compounds, and the study of these is called organic chemistry. Carbon is found in every living thing – including us. It's also in the things we eat, drink, wear and use. Everything made of plastic contains carbon.

Carbon copy

To get on the trail of carbon, just look at the pages of this book and the ink printed on them: they both contain carbon.

It's a steel

Adding a small percentage of carbon to steel makes it stronger and harder. Carbon steel is used to build bridges, houses, washing machines and fridges. Adding even more carbon creates cast iron. This is a brittle but strong metal, and you can track it down in railings, manhole covers, pots and pans.

Master of disguise

Carbon is a master of disguise. It can arrange its atoms in different ways to produce different materials, known as allotropes, all of which are still 'pure' carbon. Some occur naturally, others are manmade. Allotropes of carbon include diamonds, coal, graphite, charcoal and graphene.

The case of the lemon fire extinguisher

Carbon dioxide is a compound of one atom of carbon (C) and two atoms of oxygen (O_2), with the code name CO_2. It is the gas that makes drinks fizzy and is also used in some fire extinguishers.

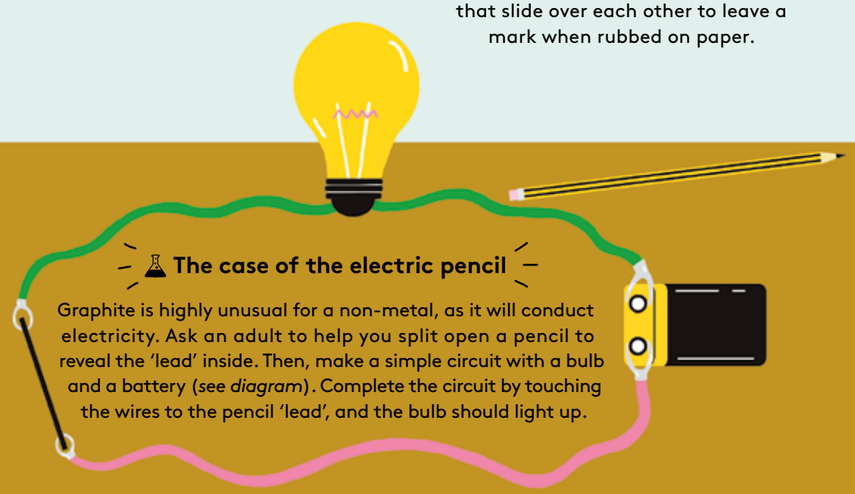
You can produce your own carbon dioxide by mixing some bicarbonate of soda or baking powder with lemon juice in a cup or glass. The chemical reaction gives off CO_2, which is heavier than air. If you very gently tilt the cup or glass over a lit candle, the flame should go out.

Global warming

Coal, the fossilised remains of plants that died over 250 million years ago in the Carboniferous Period, is full of carbon. Billions of tonnes of coal are mined every year and burned to generate electricity. This produces carbon dioxide, a 'greenhouse gas', which contributes to global warming. That's why we are trying to find cleaner forms of energy than carbon-rich fossil fuels such as coal, gas and oil.

2B or not 2B

Make a sketch of your suspect, and you will be sure to track down carbon: it is contained in the pencil you are using! The 'lead' in pencils is not actually made from the element lead, but rather from graphite, an allotrope of carbon. In graphite, carbon atoms are arranged in weakly bonded layers that slide over each other to leave a mark when rubbed on paper.



The case of the electric pencil

Graphite is highly unusual for a non-metal, as it will conduct electricity. Ask an adult to help you split open a pencil to reveal the 'lead' inside. Then, make a simple circuit with a bulb and a battery (*see diagram*). Complete the circuit by touching the wires to the pencil 'lead', and the bulb should light up.

FIND IT IN:

- [ ] YOU
- [ ] PETS
- [ ] FOOD
- [ ] TOAST
- [ ] SUGARY DRINKS
- [ ] PLANTS
- [ ] COAL
- [ ] CHARCOAL
- [ ] OIL
- [ ] PETROL
- [ ] CLOTHES
- [ ] PLASTICS
- [ ] RUBBER
- [ ] THIS BOOK
- [ ] PENCILS

ATOMIC COMICS 2

THE ALCHEMY DETECTIVES: THE CASE OF THE PHILOSOPHER'S STONE

Fluorine

9 F

👁 Pale-yellow gas
⚠ Extremely reactive ☆ Serious bite

Fluorine is rare, which may be a good thing given how fiercely reactive it is. It reacts with almost every element, even including some noble gases.

Fluorine reacts with water to form hydrofluoric acid, an acid so strong it can burn through glass. Many chemists who tried to isolate fluorine as an element suffered terrible accidents, losing eyes, limbs and their lives. They are known as the 'fluorine martyrs'.

FIND IT IN:

- ☐ FLUORIDE TOOTHPASTE
- ☐ TEA
- ☐ NON-STICK (TEFLON) SAUCEPANS
- ☐ BREATHABLE (GORE-TEX) WATERPROOFS

Smile please

Tooth enamel is the hardest substance in the body, but it still gets destroyed by the acids produced when the bacteria in our mouths break down sugars. That's why we need to brush twice a day. The fluorine atoms in fluoride toothpaste bond with our tooth enamel to make it even harder and more resistant to decay.

Neon

10 Ne

👁 Colourless, odourless, tasteless gas ⚠ None, it's inert
☆ Glows in the dark

Look at the Periodic Table, and you will find neon among the noble gases, which are all very unreactive. Its name means 'new', which neon was in 1898 when it was first discovered! It is so light that it can float up and escape from the Earth's atmosphere.

If you pass electricity through neon it produces an orangey-red glow. So if you track down an old advertising sign, it might contain neon. Painting the glass turns neon signs different colours.

FIND IT IN:

- ☐ AIR
- ☐ NEON SIGNS
- ☐ OLD CD PLAYERS

See the light

Helium-neon (He-Ne) lasers, which produce a red light, were fitted in early CD players. These have mostly been replaced by cheaper diode lasers, but your parents might still have one.

Aluminium

13 Al

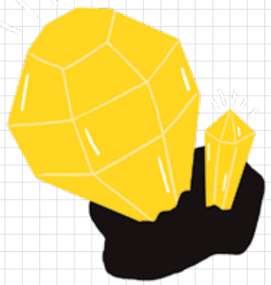
👁 Light, silvery-white metal
⚠ Mostly harmless ☆ Eternal recycler

Aluminium appears on Earth in the form of compounds in rocks, though the molten pure metal may exist inside some active volcanoes. It is incredibly versatile and can be found all around our homes. The recycling bin is a good place to start.

Aluminium is highly malleable, which means it can be pulled and squashed into different shapes, including a thin foil that is safe to wrap around food. As it keeps out light and air, aluminium foil is good for keeping chocolate fresh. But be careful not to leave foil on your food if you have metal fillings in your teeth: the foil and fillings can react with the spit in your mouth to produce a tiny electric shock!

Aluminium jewels

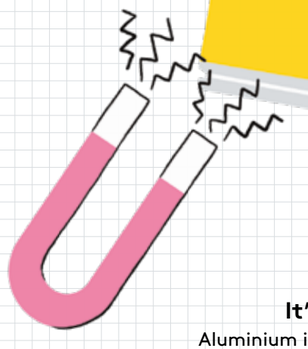
Large crystals of aluminium oxide (Al_2O_3) occur in nature, and traces of other elements turn these crystals beautiful colours including red (rubies), blue (sapphires), green and yellow.



The case of the failed magnet

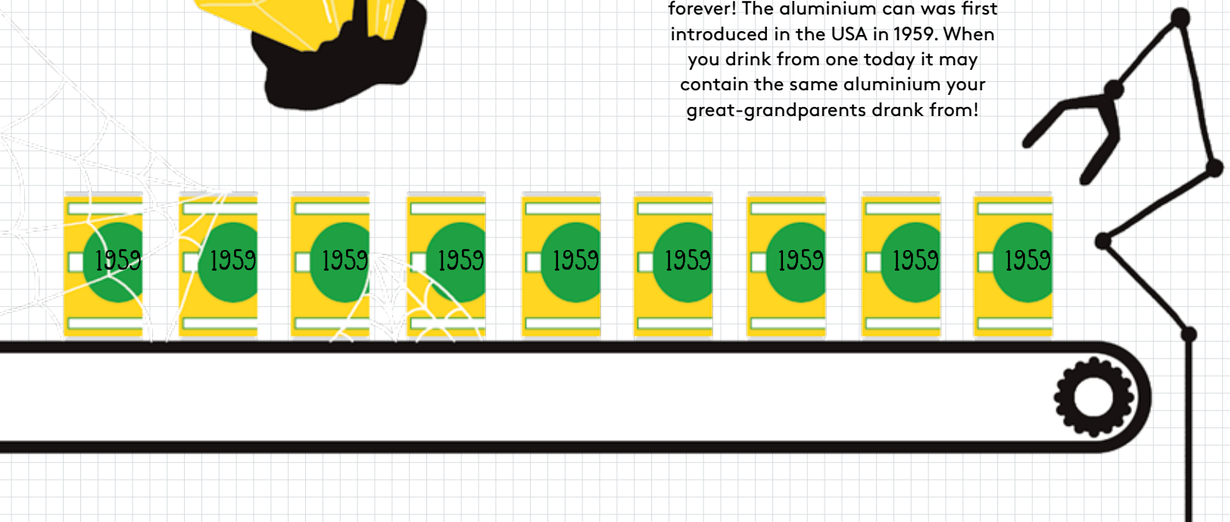
Food and drink cans are made either from steel (a form of iron) or aluminium. Both can be recycled and YOU can sort them the same way they do at the recycling centre. Take a fridge magnet and see if it sticks to the side of the can. Make two piles. Aluminium is non-magnetic, so only the steel cans will have been attracted to the magnet. Sorted!

Fe



It's etern-Al

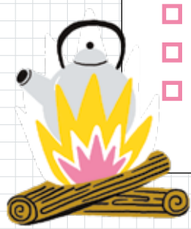
Aluminium is infinitely renewable. Anything made of aluminium can be melted down and made into new things without any loss of quality, forever! The aluminium can was first introduced in the USA in 1959. When you drink from one today it may contain the same aluminium your great-grandparents drank from!



The case of the boiled foil

Pure aluminium reacts with oxygen in the air to form a coating of aluminium oxide. This protects the rest of the metal from further chemical change.

You can make your own aluminium oxide by carefully boiling aluminium foil in water (ask an adult to help you). Boil a square until the foil darkens and turns black or brown. This coating is aluminium oxide. When everything has cooled, scrape it off carefully with scissors to show the bright metal beneath.



As good as gold

Aluminium was first isolated in tiny quantities in 1825. At the time, it was so rare and expensive that the French emperor Napoleon III ate off aluminium plates rather than gold ones. Just think of that next time you're sitting round the campfire boiling the aluminium camping kettle!

FIND IT IN:

- ☐ CDS
- ☐ DVDS
- ☐ BLU-RAYS
- ☐ COMPUTERS
- ☐ MOBILE PHONES
- ☐ WINDOW FRAMES
- ☐ KITCHEN FOIL
- ☐ FOOD AND DRINK CANS
- ☐ SAUCEPANS
- ☐ SILVER PAINT
- ☐ MIRRORS
- ☐ TOOTHPASTE
- ☐ SUNSCREEN
- ☐ BIKE FRAMES
- ☐ POWDER INSIDE AN ETCH A SKETCH

Hot properties

Aluminium powder mixed with several other chemicals burns at an incredibly high temperature. Known as thermite, it is used to weld railway tracks together. It can get as hot as 2,500°C – the same as some stars in outer space!

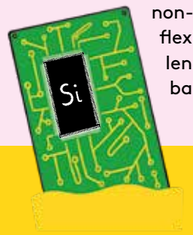
14 Si

Silicon

👁 Blue-grey crystalline non-metal
⚠ Safe in most forms ☆ Computer genius

Silicon makes our modern world possible! As a 'semiconductor' (meaning it can conduct electricity under certain circumstances), it is used in electronic equipment such as computers, mobile phones and tablets. Miniature circuits are printed on tiny pieces of silicon, creating processors known as microchips.

Silicon also forms soft, rubber-like substances called silicones. These are used to make non-scratch, non-stick cooking utensils, flexible baking moulds, soft contact lenses, charity wristbands and even babies' bottles and dummies.



Sand is the main material used in the production of glass, which can be made naturally when lightning strikes a beach and melts the sand!

The case of the sandy beach

Take a trip to the beach and you'll find silicon gets everywhere! That's because silicon combines with oxygen to form silicon dioxide (SiO_2), better known as sand. Sand is made of tiny grains of silicon-containing minerals, with quartz and feldspar the most common.

FIND IT IN:

- ☐ NETTLES
- ☐ CUCUMBERS
- ☐ SAND
- ☐ QUARTZ
- ☐ PRECIOUS STONES
- ☐ GLAZED POTTERY
- ☐ PLATES
- ☐ PORCELAIN
- ☐ MOBILE PHONES
- ☐ COMPUTERS
- ☐ TABLETS
- ☐ TVS
- ☐ CAT LITTER
- ☐ COOKWARE
- ☐ WRISTBANDS
- ☐ BABY EQUIPMENT

15 P

Phosphorus

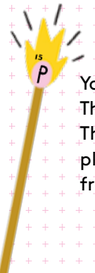
👁 Variously coloured non-metal
⚠ Poisonous ☆ Underwater fire

As it was the thirteenth element isolated by early chemists, superstitious people called it 'The Devil's Element'. As if to prove them right, it has two main allotropes – white and red – both highly toxic and so reactive that they burn in air, and even underwater!

Phosphorus is essential to all living things, as it's part of DNA and helps to release energy from cells. Despite this, animals – including humans – excrete almost all the phosphorus they consume each day!

Strike a light

You can track down phosphorus in a box of safety matches. The match head contains phosphorus sesquisulfide (P_4S_3). The striking surface on the box has more phosphorus, plus glue and tiny glass particles. These produce heat from friction when the match is struck, lighting the tip.

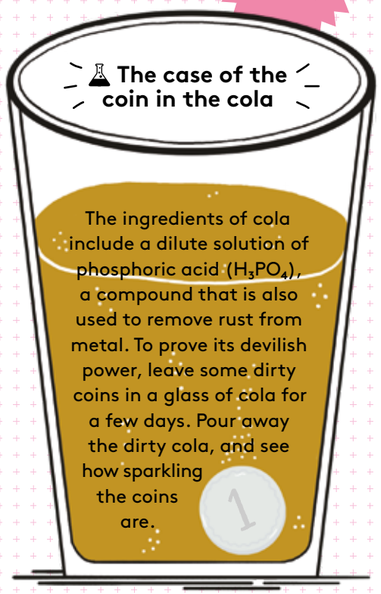


FIND IT IN:

- ☐ YOU
- ☐ BONE CHINA
- ☐ PLANT FOOD
- ☐ SAFETY MATCHES
- ☐ DOGS
- ☐ CATS
- ☐ POO
- ☐ WEE
- ☐ COLA

(WARNING! Do not drink it!)

The case of the coin in the cola



The ingredients of cola include a dilute solution of phosphoric acid (H_3PO_4), a compound that is also used to remove rust from metal. To prove its devilish power, leave some dirty coins in a glass of cola for a few days. Pour away the dirty cola, and see how sparkling the coins are.

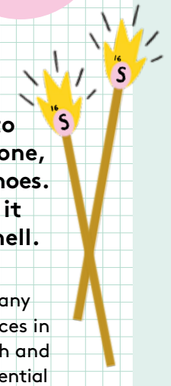
16 S

Sulfur

👁 Yellow crystalline non-metal
⚠ Essential for life ☆ Super smells

One of the ancient elements known to alchemists, who first called it brimstone, sulfur is found in hot springs and volcanoes. Because of this, people used to think it bubbled up from some underground hell.

The yellow element itself does not smell, but many of its compounds do – including stinky substances in rotten eggs, garlic, cooked cabbage, bad breath and farts. Despite this drawback, sulfur is part of essential substances such as many vitamins and proteins.



FIND IT IN:

- ☐ HAIR
- ☐ FUR
- ☐ FEATHERS
- ☐ BAD BREATH
- ☐ FARTS
- ☐ EGGS
- ☐ CABBAGE
- ☐ ASPARAGUS
- ☐ SAFETY MATCHES

Flash in the pan

Sulfur is mixed with charcoal and saltpetre to make the gunpowder that adds the fizz to fireworks. That's why the air smells strongly of sulfur dioxide after a firework display. Safety matches also contain sulfur and smell bad when you blow them out. For this reason, some people light a match so that the stinky SO_2 masks a bad toilet smell!

The case of the smelly feather

Many proteins in humans and animals are made from building bricks called 'amino acids', which contain sulfur. Hair, fur and feathers are all formed from proteins. With an adult present, hold the tip of a feather in a candle flame. As the sulfur compounds are released, you will smell the same horrible smell as when your hair gets too hot under a hairdryer.

17 Cl

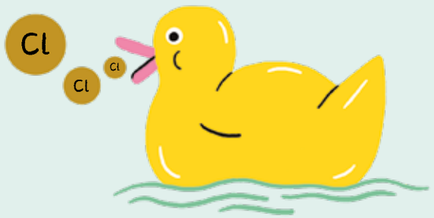
Chlorine

👁 Greeny-yellow gas
⚠ Toxic and choking
☆ Bacteria biffing

Chlorine comes under fluorine in the Periodic Table and is nearly as nasty. It is very reactive and mostly found in compounds, including table salt. Chlorine gets its name from the Greek for 'pale green', the colour of the elemental gas, which is highly dangerous if inhaled and was used as a weapon in World War I.

The chlorine found in bleach is effective at killing many micro-organisms, even when very diluted. That's why it is often added to swimming pools – the drawback being that the chlorine bonds with the proteins in your skin and hair to leave you smelling of the pool.

Because it is so brilliant at biffing bacteria, chlorine is used to make drinking water safe and can be found in household cleaning products.



Particularly Versatile Chlorine

PVC (polyvinyl chloride) is a polymer formed from chlorine, carbon and hydrogen atoms. The long chains of molecules produce a plastic with lots of applications, including drainpipes, flooring, furniture, and many toys. Most 'rubber' ducks are made from PVC!

FIND IT IN:

- ☐ TABLE SALT
- ☐ BLEACH
- ☐ CLEANING PRODUCTS
- ☐ TAP WATER
- ☐ DRAINPIPES
- ☐ VINYL FLOORING
- ☐ VINYL SOFAS
- ☐ PVC JACKETS
- ☐ RUBBER DUCKS

Zinc

👁 Soft bluish-grey metal
⚠ Essential ☆ Super protector

There are many zinc-containing minerals and mining them is an important and very old business. Ancient people alloyed zinc with copper to make brass, which we still use today.

Zinc assists in many important processes in cells. Plants grow poorly in soils without zinc. It assists us brain function and reproduction, and in making DNA, the blueprint for our bodies. Some people believe it also helps fight off colds.

FIND IT IN:

- ☐ MEAT
- ☐ FISH
- ☐ OYSTERS
- ☐ WHEAT
- ☐ SPINACH
- ☐ SUNFLOWER SEEDS
- ☐ PEANUTS
- ☐ PARMESAN CHEESE
- ☐ GALVANISED ITEMS
- ☐ ANYTHING BRASS
- ☐ SUNBLOCK
- ☐ NAPPY CREAMS
- ☐ ANTI-DANDRUFF SHAMPOOS

Zinc or skin

Zinc oxide (ZnO) is a common zinc compound that is very useful for our skin. It is used in sunscreens and sunblock, reflecting ultraviolet light and stopping skin from burning. It also soothes some of the most sensitive skin around babies' bums, as it is the main ingredient in creams for nappy rash.

Getting galvanised

Half the world's zinc is used to protect iron or steel from rusting by 'galvanising' – coating them in a thin layer of zinc. Zinc is more chemically reactive with water and air than iron, producing a compound that acts as a protective barrier against rain.

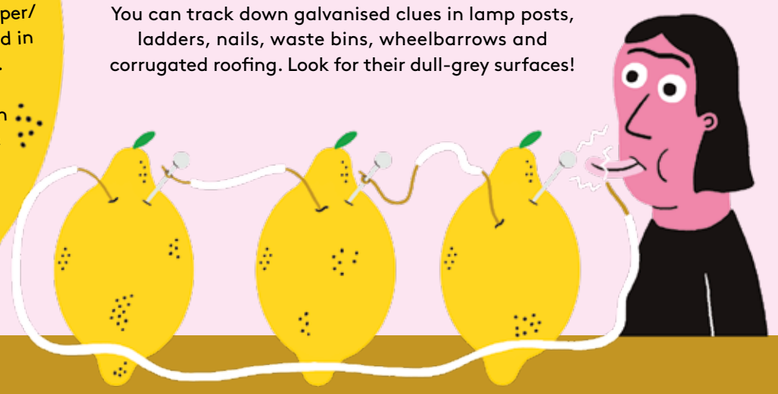
You can track down galvanised clues in lamp posts, ladders, nails, waste bins, wheelbarrows and corrugated roofing. Look for their dull-grey surfaces!

(WARNING! Never touch your tongue to any electrical terminals or other devices.)

The case of the electric lemon

Build your own battery using 3 galvanised (zinc-plated) nails, 3 lengths of copper wire and 3 lemons. Push a nail into each lemon, joining it to the next lemon with the copper wire. Push the free end of the wire into the lemon near to but not touching the nail. Each zinc/copper/lemon unit forms an electrical cell. Joined in a series like this, they form a battery.

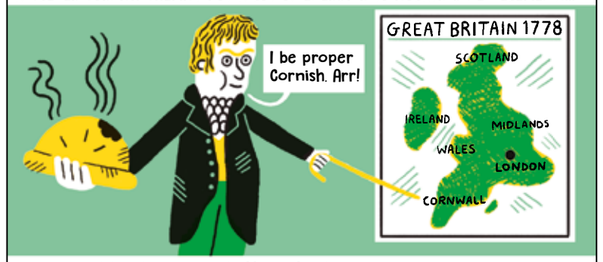
The zinc and iron react with the acids in the lemon to produce a small electric current that will flow if you touch your tongue across the zinc and copper end terminals. You should just feel a little tingle.



ATOMIC COMICS 5

DAVY THE DETECTIVE: THE CASE OF THE ELECTROLYSED ELEMENTS

A CLEVER CORNISH CHEMIST PUT A LOT OF ENERGY INTO ISOLATING NEW ELEMENTS...

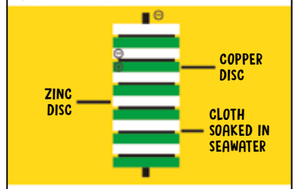


SIR HUMPHRY DAVY BORN CORNWALL, ENGLAND, 1778

DAVY USED ELECTRICAL ENERGY GENERATED BY THE NEW SCIENTIFIC TOOL, THE VOLTAIC PILE*...

*NAMED AFTER ITALIAN INVENTOR ALESSANDRO VOLTA, 1745–1827

THE PILE WAS A SIMPLE BATTERY MADE FROM ALTERNATE DISCS OF TWO METALS, ZINC AND COPPER, WITH WET FABRIC BETWEEN.

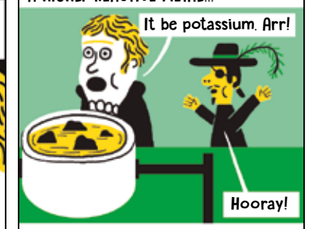


IT WORKED LIKE THE LEMON BATTERY (SEE PAGE 36).

IN 1807, DAVY USED POTS OF PILES TO PASS A STRONG CURRENT THROUGH SUPER-HOT MOLTEN CAUSTIC POTASH (SEE PAGE 29)... NO GOGGLES, NO SCREENS, NOTHING...

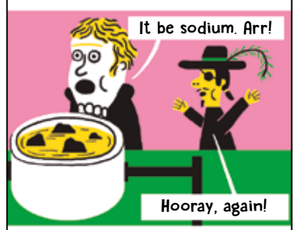
CHEMISTS CALL THIS PROCESS ~~CRAZY~~ 'ELECTROLYSIS'.

TINY GREY GLOBULES FORMED. DAVY HAD ISOLATED THE FIRST SAMPLES OF A HIGHLY REACTIVE METAL...



BUT COULD HE DO IT AGAIN?

DAYS LATER, DAVY ELECTROLYSED MOLTEN CAUSTIC SODA, AND THIS TIME...



MORE FOLLOWED...

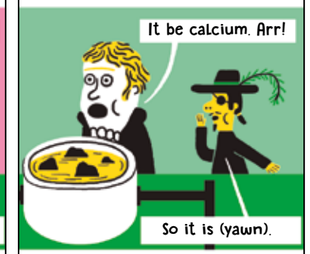
SOON AFTER...

AND ON HE WENT...

IN 1808...

THEN...

NEXT TIME...

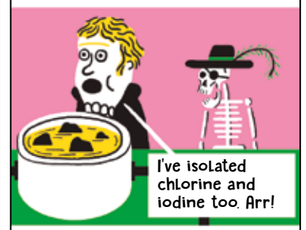


MORE?

YES! AGAIN IN 1808...

BUT THAT NOW WAS FINALLY IT...

ER, UNTIL A FEW YEARS LATER, WHEN...



DAVY WAS AN INCREDIBLE CHEMIST AND WAS KNIGHTED FOR HIS MANY DISCOVERIES.

BUT THERE WAS ONE ELEMENT HE DIDN'T DISCOVER, BUT MAYBE SHOULD HAVE....

*THE CHEMICAL SYMBOL FOR ARGON. DAVY DIED IN 1829. ARGON WAS DISCOVERED IN 1894.

(PS: IN REAL LIFE, DAVY MAY OR MAY NOT HAVE HAD A STRONG CORNISH ACCENT.)

31 Ga — Gallium

👁 Soft silvery-blue metal
⚠ Non-toxic ☆ Laser power

In 1871, Dmitri Mendeleev predicted the existence of both gallium and germanium before they had been discovered. French chemist Paul-Emile Lecoq de Boisbaudran isolated gallium four years later, naming it for France (aka Gaul).

FIND IT IN:

- ☐ SAFE THERMOMETERS
- ☐ MICROCHIPS
- ☐ BLU-RAY DISC PLAYERS

Gallium is a solid at room temperature, but only just: at 30°C it melts. The human body has a temperature of 37°C, so this is incredibly useful: gallium metal (which isn't poisonous) can be used to replace liquid mercury (which is) in thermometers.

Gallium gadgets

You can track down gallium nitride (GaN) in LED lights and lasers. The light it produces is violet rather than blue, but the gallium lasers used to read Blu-ray discs give them their name. The lasers read tiny holes on the surface of the discs.

32 Ge — Germanium

👁 Shiny silvery metalloid
⚠ Safe at low levels ☆ Superfast

Germanium and gallium have a lot in common. Both were predicted by Dmitri Mendeleev, and both were named after the country of the chemist who first isolated them. (German chemist Clemens Winkler discovered germanium in 1886.) Both elements are used in transistors and microchips – the first working transistor was made in 1947 with a crystal of germanium.

FIND IT IN:

- ☐ TRANSISTORS
- ☐ HIGH-TECH EQUIPMENT
- ☐ FIBRE-OPTIC CABLES

Watch it!

Germanium is a component in the fibre-optic cables used for the internet and on-demand TV. These have a central core containing silica, to which the compound germanium oxide is added. So if you have superfast broadband, you can detect germanium by watching TV!

35 Br — Bromine

👁 Smelly brown liquid
⚠ Toxic, burns ☆ Super smelly

Bromine is one of only two elements that are liquid at room temperature (25°C). It is found in seawater, though in smaller quantities than its related element chlorine. Bromine is sometimes added to the water in pools and hot-tubs to keep down the growth of nasty bacteria.

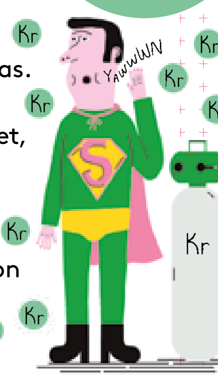
FIND IT IN:

- ☐ HOT-TUBS AND POOLS
- ☐ TVS
- ☐ COMPUTERS
- ☐ FLAME RETARDANTS

36 Kr — Krypton

👁 Colourless, odourless gas
⚠ Non-toxic ☆ Energy efficient

Is it a bird? Is it a plane? No, it's a noble gas. You might know Krypton as Superman's home planet, but unlike the fictional kryptonite – which sapped Superman's superpowers – real krypton isn't so alarming...



FIND IT IN:

- ☐ FLUORESCENT BULBS
- ☐ COMIC STRIPS

33 As — Arsenic

👁 Grey, yellow or black metalloid
⚠ Deadly ☆ Potent poison

Arsenic is an ancient element that has been poisoning people for thousands of years! Many of its compounds can be deadly, too. Some occur in the Earth's crust, and in some regions millions of people are affected by water contaminated by minerals containing arsenic. There is also arsenic in the sea and air, often due to smoke from volcanoes.

Deadly arsenic

Arsenic is just one of the many toxins in cigarette smoke, as tobacco plants take up arsenic from the soil. Arsenic compounds were once prescribed in medicines and used to kill everything from microbes to mice before they were largely banned worldwide. They were also a favourite poison in murder plots! You might track down the name on an old chemist's jar.

'It was used in rat poison too!'

FIND IT IN:

- ☐ SMOKE
- ☐ POISONS
- ☐ MICROCHIPS

34 Se — Selenium

👁 Silvery metalloid
⚠ Too much is toxic
☆ Completely nuts

Selenium is a rare element in the Earth's crust, almost as uncommon as gold. Too much can be toxic, but some scientists think we need traces to stay healthy. Foods high in selenium include tuna, sardines, eggs, spinach and Brazil nuts.

FIND IT IN:

- ☐ BRAZIL NUTS
- ☐ TUNA
- ☐ SARDINES
- ☐ SPINACH
- ☐ CHICKEN
- ☐ GRASS-FED BEEF
- ☐ EGGS
- ☐ ANTI-DANDRUFF SHAMPOOS (SOME CONTAIN SELENIUM DISULFIDE (SeS_2) WHICH KNOCKS OUT CERTAIN FUNGI)...

⚗ The case of the burning Brazil nut

Brazil nuts aren't just high in selenium but also in natural oils – so much so that they can be used as a torch. Lay one on a plate and hold a burning match to one end (ask an adult to help). The oil in the nut will catch fire and give a strong light. It will burn for a very long time, so make sure you blow it out afterwards and don't touch the hot nut.

37 Rb — Rubidium

👁 Silvery-white metal ⚠ Uncertain
☆ Super scientific

Rubidium is in the same gang as sodium and potassium, and is just as reactive. Rubidium compounds mostly turn up as impurities in other minerals, making them harder to extract. But there isn't that much call for rubidium anyway. Rubidium nitrate ($RbNO_3$) turns fireworks purple, but otherwise most uses are super-scientific ones.

FIND IT IN:

- ☐ PURPLE FIREWORKS

38 Sr — Strontium

👁 Soft silvery-yellow metal
⚠ Radioactive ☆ Tooth repairer

Strontium is in the same group as calcium, and humans can store it in their bones in the same way. Because the body replaces calcium with strontium, strontium compounds are found in toothpastes for people with sensitive teeth, repairing them where enamel has worn away. Strontium compounds also give deep-red colours to fireworks.

FIND IT IN:

- ☐ SENSITIVE TOOTHPASTES
- ☐ RED FIREWORKS

39 Y — Yttrium

👁 Soft silvery metal
⚠ Can be toxic ☆ Picture painter

Yttrium is loved by Scrabble players! It takes its name from Ytterby, a village in Sweden where ores containing seven undiscovered elements were found. You might detect yttrium in an old-fashioned 'cathode ray' TV, where it was part of the red phosphors that dotted the screen.

FIND IT IN:

- ☐ OLD TVS

40 Zr — Zirconium

👁 Hard silvery-grey metal
⚠ Radioactive isotopes ☆ Sweat fighter

Zirconium and some of its compounds are used in the linings of nuclear reactors. At home, you can find zirconium compounds in deodorants and antiperspirants, while zirconium dioxide (ZrO_2) is a beautiful colourless crystal that can be cut to look like a diamond.

FIND IT IN:

- ☐ DEODORANT
- ☐ 'CUBIC ZIRCONIA' JEWELLERY

Platinum

78 Pt

👁 Soft grey-white metal
⚠ Non-toxic ☆ Super converter

The name for platinum comes from a Spanish word meaning 'little silver'. In the Earth's crust it is almost as rare as gold, and the metals are often found together. They are both very expensive. Platinum is highly ductile and is often used for fine jewellery, special collectible coins and even ceremonial crowns.

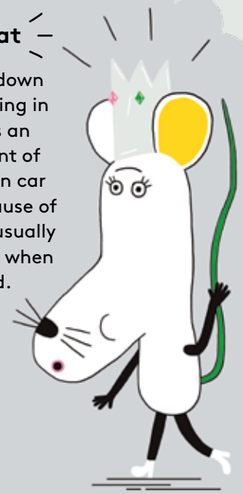
FIND IT IN:

- ☐ JEWELLERY
- ☐ SPECIAL COINS AND MEDALLIONS
- ☐ CROWNS
- ☐ CATAYLTIC CONVERTERS...

Britain's Crown Jewels include one crown made entirely from platinum (Pt) and 2,800 diamonds (C).

🔍 Check the cat

If you want to track down this element, try looking in the car. Platinum is an important component of catalytic converters in car exhaust systems. Because of its value, platinum is usually removed and recycled when cars are scrapped.



Gold

79 Au

👁 Soft shiny yellow metal
⚠ Non-toxic
☆ Shape changer

Gold is the noblest of the noble metals, being very unreactive and occurring naturally as grains, veins and nuggets all over the world. But it is very rare, and its scarcity along with its beauty create its high value.

Because it doesn't corrode in water or react with air like other metals it stays shiny forever – just think of all the gleaming treasures of ancient Egypt.

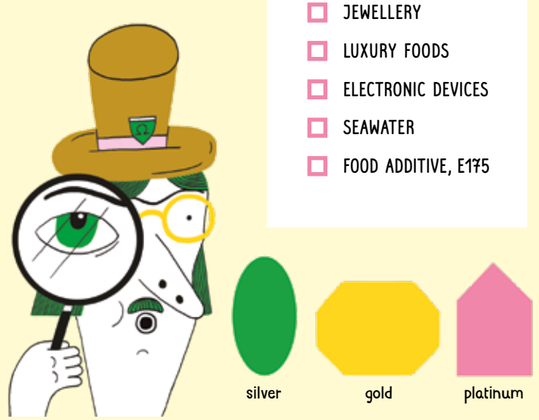
The gold in the Earth's crust is thought to have been brought here by asteroids that crashed onto the planet some 4 billion years ago, close to the time when life first arose. Gold can be found in veins associated with quartz and other minerals as well as in a mixture with silver known as electrum. Sometimes very lucky people just come across nuggets. So keep your eyes peeled!

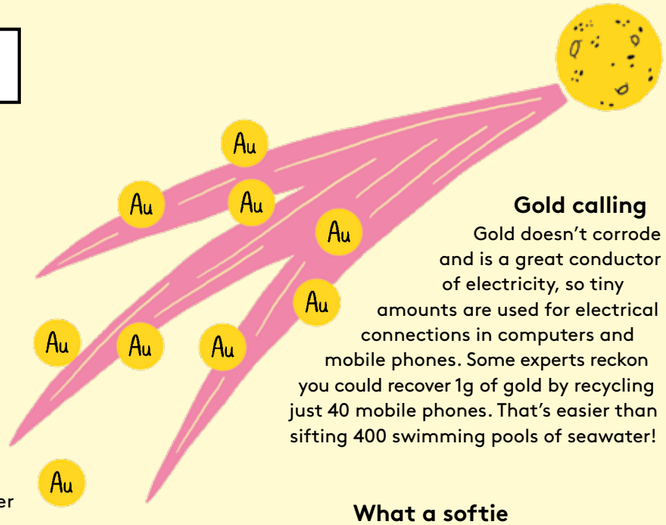
All at sea

Seawater contains gold, but you will have trouble detecting it. To recover just one gram of gold, you would need the equivalent of 400 Olympic swimming pools of seawater.

FIND IT IN:

- ☐ JEWELLERY
- ☐ LUXURY FOODS
- ☐ ELECTRONIC DEVICES
- ☐ SEAWATER
- ☐ FOOD ADDITIVE, E175





Gold calling

Gold doesn't corrode and is a great conductor of electricity, so tiny amounts are used for electrical connections in computers and mobile phones. Some experts reckon you could recover 1g of gold by recycling just 40 mobile phones. That's easier than sifting 400 swimming pools of seawater!

What a softie

Gold is a very soft metal. It is highly 'ductile' and can be pulled into a wire just one atom thick! It is also the most malleable metal, meaning it is easily reshaped. A single gram of gold can be beaten into an incredibly thin sheet that is an amazing 1 metre square. Thin sheets called 'gold leaf' are used to decorate books, furniture and ornaments. The leaf can be made so thin that it is no more than 400 to 500 atoms thick. Because gold is non-toxic, gold leaf is safe to eat, so you might find it decorating luxury chocolates.

🔍 The case of the gold stamp

Pure gold is known as 24-karat (24K). This is very soft, so gold is often alloyed with metals such as copper or silver to make jewellery. These alloys are given lower karat ratings (22K, 18K, 9K...). They are harder but contain less gold.

Gold items often carry a stamp known as a hallmark, which indicates the quality of the gold used and where the item was made. To track down some precious metal elements, grab a magnifying glass and examine some jewellery. Different precious metals have different marks, so check them against the secret codes below...

Mercury

80 Hg

👁 Silvery-white liquid
⚠ Toxic ☆ Superfast

Mercury is one of two elements in the Periodic Table that are liquid at room temperature. Spill the liquid metal and it forms shiny little balls that roll so rapidly that mercury is sometimes called 'quicksilver'. It was known to the ancient Romans as 'hydrargyrum', meaning 'water-silver', giving us its code name Hg.

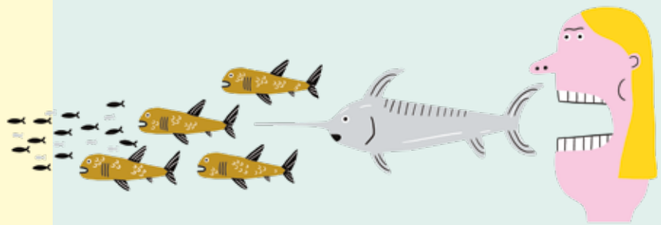
Mercury is extracted by roasting a red mineral called cinnabar. Prehistoric people used powdered cinnabar to make cave paintings, without realising how toxic mercury compounds can be. Renaissance painters also used it in the pigment vermilion, so many old masterpieces are potentially poisonous!

FIND IT IN:

- ☐ TINNED FISH
- ☐ OLD THERMOMETERS AND BAROMETERS
- ☐ MERCURY VAPOUR STREET LIGHTS

Something fishy

Mercury was used in thermometers until people realised the danger of sucking a breakable glass tube containing a toxic element. Dental fillings also contained mercury, but these are being replaced by safer resins. Today, mercury is almost absent from our homes, but you might track it down in tinned fish. Shark, swordfish, marlin and tuna accumulate mercury by eating smaller fish which have been feeding on smaller organisms containing the element. Stay safe by not eating the riskiest fish too often.



Thallium

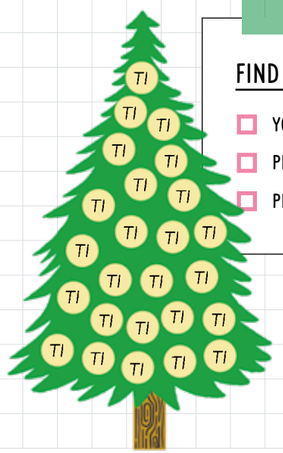
81 Tl

👁 Soft silvery metal
⚠ Highly toxic ☆ Secret poisoner

Thallium is very easily absorbed by plants and animals, and we probably all contain tiny traces of it (but not enough to harm us). You can track it down in pine trees, which seem particularly good at accumulating it – with up to 100 parts per million.

Where there's a will...

Thallium and its salts are all highly poisonous, and thallium sulfate (Tl_2SO_4) was once a popular rat poison. As it is tasteless and odourless, it was popular with murderers for killing rich relatives – earning it the nickname 'inheritance powder'.



FIND IT IN:

- ☐ YOU
- ☐ PLANTS
- ☐ PINE TREES

Lead

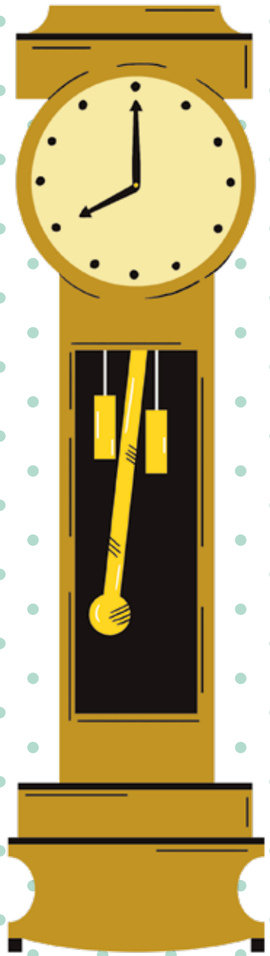
82 Pb

👁 Soft, dense, grey metal
⚠ Toxic ☆ Waterproof

The ancient Romans made lead into pipes to carry water in cities across their empire. The Latin word for lead, 'plumbum', gives us its code name Pb, and our modern word 'plumbing'. Copper and plastic have replaced it today, as lead is now known to be toxic, but you may still track it down in the plumbing of old houses. Lead sheeting is also used on roofs to keep the rain out.

FIND IT IN:

- ☐ OLD GRANDFATHER CLOCKS
- ☐ OLD PLUMBING PIPES
- ☐ LEAD FLASHING ON ROOFS
- ☐ CAR BATTERIES
- ☐ CAR WHEEL BALANCE WEIGHTS
- ☐ SOLDER IN ELECTRICAL COMPONENTS



Heavy metal

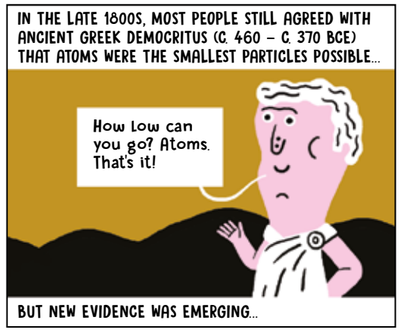
Lead is one of the densest stable elements, so you might find it in the weights of an old grandfather clock. It can be easily melted and moulded, so anglers once used small lead weights to sink their lines – but these were banned as swans mistook them for food and were poisoned. In the past, a lead additive called tetraethyl lead was added to petrol to help engines run smoothly. This was emitted in poisonous exhaust fumes, which is why we now use *un*leaded petrol.

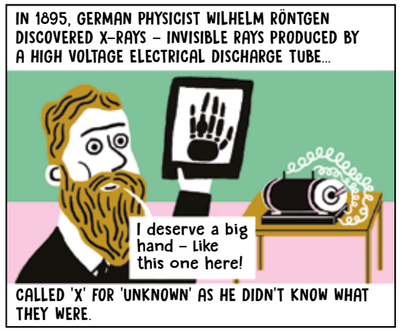
Take the lead

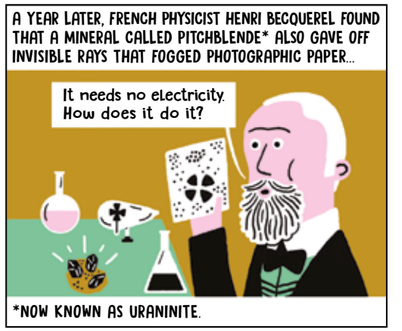
While lead is no longer added to fuel, most cars still rely on it to run. Most of the world's supply goes into making lead-acid batteries for cars, and lead weights are attached to car wheels to make them turn evenly. Some lead is added to glass to make expensive lead-crystal tableware. It can also be a component in pewter crockery and the solder used for electrical connections. However, because lead is so toxic, people will keep working on ways to replace it.

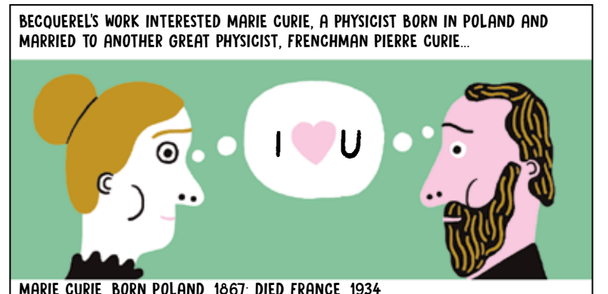
ATOMIC COMICS 8

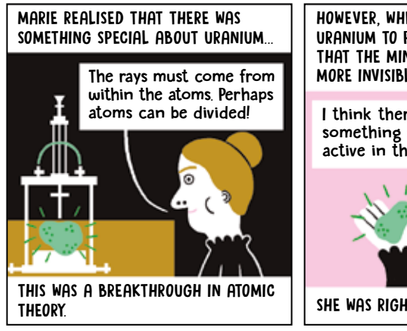
THE RADIOACTIVE DETECTIVES: THE CASE OF THE POISONOUS PARTICLES

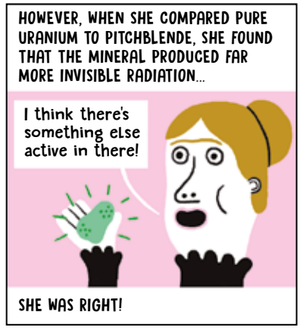


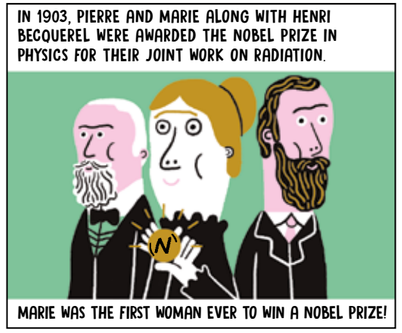


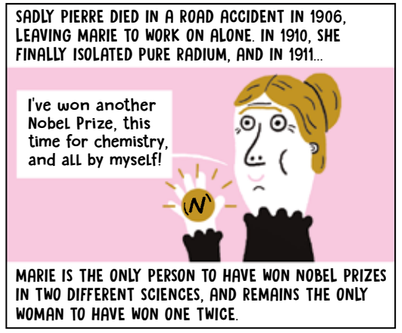


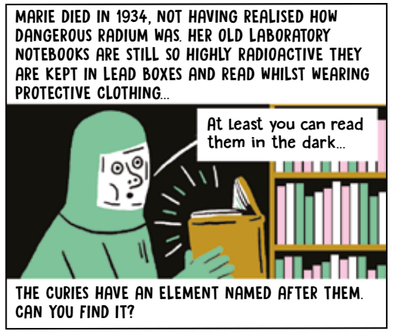












ATOMIC COMICS

THE MANHATTAN PROJECT DETECTIVES: THE CASE OF THE ATOMIC BOMB

10

AS YOU KNOW, IN THE PAST MANY NATURALLY OCCURRING ELEMENTS WERE DISCOVERED ACCIDENTALLY BY THE ANCIENTS...

Ooh!

SOME WERE DISCOVERED ACCIDENTALLY BY ALCHEMISTS...

Ooh!

AND LOTS WERE DISCOVERED ON PURPOSE BY SIR HUMPHRY DAVY...

I found seven. Arr!

PLUS OTHER GREAT CHEMISTS TOO, OF COURSE...

SINCE THE BIRTH OF NUCLEAR PHYSICS*, MANY MANMADE ELEMENTS HAVE BEEN SYNTHESISED BY COMBINING PARTICLES AS WELL AS PULLING THEM APART...

Smashing atoms?

Yes, they are rather lovely.

*SEE ATOMIC COMIC #9.

AUSTRIAN–SWEDISH PHYSICIST LISE MEITNER AND GERMAN CHEMIST OTTO HAHN WERE THE FIRST TO SPLIT AN ATOM.

We split it...

Together!

LISE MEITNER, 1878–1968: OTTO HAHN, 1879–1968

IN 1938, WITH THE SUPPORT OF MEITNER, HAHN FIRED NEUTRONS AT URANIUM ATOMS. A URANIUM NUCLEUS ABSORBED A NEUTRON TO SPLIT INTO TWO SMALLER ATOMS...

235 U

92 Kr

Ba 141

Let's split!

A PROCESS WE NOW CALL NUCLEAR FISSION.

THIS RELEASED AN ENORMOUS AMOUNT OF ENERGY, CALCULATED ACCORDING TO THE MOST FAMOUS EQUATION IN SCIENCE, $E = MC^2$ (SQUARED).

Formulated by me, the great genius* Albert Einstein!

BORN GERMANY, 1879: DIED USA, 1955
*MAD HAIR, THOUGH.

OTTO HAHN WAS GIVEN THE 1944 NOBEL PRIZE FOR CHEMISTRY FOR THEIR WORK – BUT NOT LISE MEITNER! TO MANY THIS SEEMED VERY UNFAIR.

Otto was a great chemist, but he doesn't have an element named after him. I do!

CAN YOU FIND IT?

SCIENTISTS REALISED NUCLEAR FISSION COULD BE USED TO BUILD AN ATOMIC BOMB. AS WORLD WAR 2 RAGED, THE ALLIES* RUSHED TO SUCCEED BEFORE ADOLF HITLER'S NAZI GERMANY. THEIR TOP SECRET MISSION WAS CALLED...

The Manhattan Project, Shh!

*USA, UK, AND CANADA.

THE PROJECT ATTRACTED SOME OF THE GREATEST NUCLEAR SCIENTISTS OF THE DAY. THESE INCLUDED EDWIN MCMILLAN...

In 1940, I made the first ever transuranic element – 'element 93' – now known as neptunium*.

BORN USA, 1907: DIED USA 1991
*AFTER THE PLANET NEPTUNE.
SEE PAGE 58.

...AND DR GLENN T. SEABORG.

'Seaborg', not 'cyborg'!

BORN USA, 1912: DIED USA, 1999

IN 1940, ALONG WITH MCMILLAN AND OTHERS, SEABORG SUCCESSFULLY BOMBARDED URANIUM WITH HIGH-SPEED HYDROGEN NUCLEI TO CREATE NEW ELEMENT 94...

We call it 'plutonium' after Pluto.

Woof!*

*NOT THE DOG, THE PLANET!

PRODUCING PLUTONIUM WAS A MAJOR PART OF THE MANHATTAN PROJECT. IT FUELLED THE BOMB DROPPED ON THE JAPANESE CITY OF NAGASAKI ON AUGUST 9TH, 1945.

IT ENDED THE WAR WITH JAPAN, BUT KILLED OVER 70,000 PEOPLE – MOST OF THEM CIVILIANS.

IT REMAINS THE LAST TIME A NUCLEAR WEAPON WAS USED IN A CONFLICT...SO FAR.

ANOTHER TOP PHYSICIST ON THE TEAM WAS ALBERT GHIORSO...

You can call me Al.

BORN USA, 1915: DIED USA, 2010

ALONG WITH SEABORG, THE PAIR CREATED TWO MORE NEW ELEMENTS*, BUT HAD TO KEEP THEM SECRET BECAUSE OF THE WAR.

*AMERICIUM (95) AND CURIUM (96). (SEE PAGES 58–59.)

BUT AFTER IT ENDED THERE WAS NO STOPPING THEM...

I co-discovered 10 new elements!

And I co-discovered a dozen!

FIND THEM ALL ON PAGES 58 TO 60!

TO DATE, ALBERT GHIORSO HOLDS THE RECORD FOR HAVING DISCOVERED THE GREATEST NUMBER OF ELEMENTS.

I admit defeat. Arr!

DAVY 7
GHIORSO 12

SIX OF GHIORSO'S ELEMENTS ARE NAMED AFTER OTHER GREAT SCIENTISTS:

It's me again!

(ERNEST RUTHERFORD, GLENN SEABORG, DMITRI MENDELEEV, ENRICO FERMI, ALBERT EINSTEIN, ERNEST LAWRENCE)

NEW ELEMENTS ARE STILL BEING CREATED AROUND THE WORLD. SOMETIMES ONLY A FEW ATOMS EXIST AND LAST FOR LESS THAN A SECOND...

Where's it gone?

LIVERMORIUM (116) HAS A HALF-LIFE OF JUST 60 MILLISECONDS!

NEW DISCOVERIES HAVE TO BE CONFIRMED BY THE INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY BASED IN ZURICH AND CHICAGO...

I U P A C

LUCKILY KNOWN AS IUPAC, FOR SHORT.

THEY ALSO DECIDE WHAT NAME A NEW ELEMENT WILL HAVE...

Can I call it Fred? Eric? Agatha? Bimbleshanks?

Non.

TODAY, THE GREATEST LIVING ELEMENT MAKER IS YURI OGANESSIAN OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH IN DUBNA, RUSSIA.

So far I have co-discovered five!

Ha! Beat you! Arr!

YURI IS THE ONLY PERSON ALIVE WITH AN ELEMENT NAMED AFTER THEM. CAN YOU FIND IT?

NO DOUBT YET MORE ELEMENTS WILL CONTINUE TO BE CREATED. MAYBE ONE DAY, YOU MIGHT DISCOVER ONE! BUT WHAT WOULD YOU CALL IT?

118 Og GANESSON

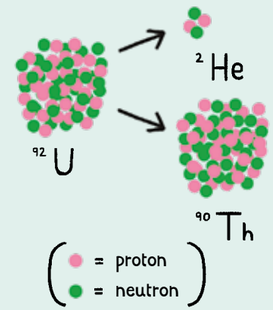
– YOUR-NAME-HERE-IUM

GOOD LUCK!

Splitting the atom

Elements not found in nature but made artificially in laboratories are called 'synthetic'. They include americium and all those beyond it in the table. They are all unstable: their nuclei change ('decay'), producing potentially harmful radioactivity which can be detected with special equipment such as a Geiger counter.

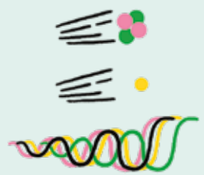
Intriguing isotopes



Atoms with the same number of protons but different numbers of neutrons are called isotopes. Uranium has several isotopes all with 92 protons but with between 140 and 146 neutrons in their nuclei. Uranium-235 has 143 neutrons, but its unstable nuclei decay by emitting radioactive alpha particles consisting of two protons and two neutrons. By losing two protons, uranium (92) becomes thorium (90) – a dangerous change of identity!

The three suspects

There are three types of radiation produced by the nuclei of radioactive elements. All can cause harm by damaging the cells and processes of living things through the creation of ions (see page 9). All three are best avoided!



α
β
γ

Get an adult to show you inside a smoke detector. The part containing americium will have a nuclear hazard symbol!

The case of the alarming alpha particles

All homes should have smoke detectors to warn us if a fire has started. They contain a tiny amount of radioactive americium (see page 58). Americium atoms constantly decay to emit alpha particles that cross a small gap inside the alarm and maintain an electrical circuit. Smoke entering the detector interferes with the alpha particles, breaking the circuit and triggering the alarm.