CARBON COMICS 2

CENTER FOR APPLIED ISOTOPE STUDIES

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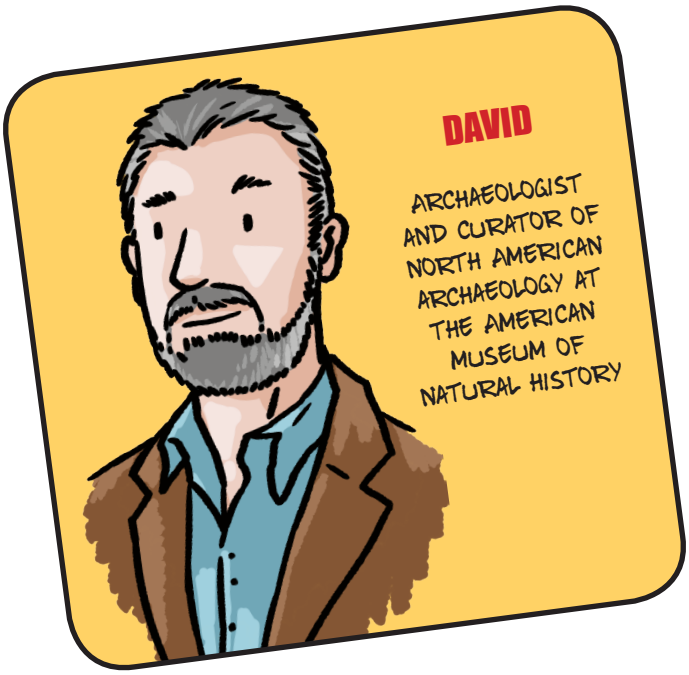
UNLOCKING the PAST!

THE SCIENCE OF ARCHAEOMETALLURGY

HOW THE TEAM AT CAIS KNOWS WHERE THIS MISSION BELL WAS MADE!

WELCOME TO THE CENTER FOR APPLIED ISOTOPE STUDIES (CAIS), AND THE AMAZING WORLD OF ARCHAEOMETALLURGY - WHERE GEOSCIENTISTS AND ARCHAEOLOGISTS USE SCIENCE TO UNLOCK THE PAST! WE'RE GOING TO BE SHOWING YOU HOW THE CHEMICALS INSIDE ANCIENT OBJECTS CAN TELL US WHERE AN OBJECT WAS MADE - EVEN SOMETHING THAT'S BEEN BURIED IN THE EARTH FOR HUNDREDS OF YEARS.

DOING THIS KIND OF SCIENCE TAKES A WHOLE TEAM OF PEOPLE. HERE ARE THE ARCHAEOLOGISTS AND SCIENTISTS AT CAIS WHO MAKE ARCHAEOMETALLURGY POSSIBLE. THEY'RE GOING TO TELL YOU WHAT ARCHAEOMETALLURGY IS USED FOR, HOW IT WORKS AND HOW THEY DO IT.



DAVID

ARCHAEOLOGIST AND CURATOR OF NORTH AMERICAN ARCHAEOLOGY AT THE AMERICAN MUSEUM OF NATURAL HISTORY

ANNA

ARCHAEOLOGIST AND LAB DIRECTOR AT THE AMERICAN MUSEUM OF NATURAL HISTORY

ALICE

SCIENTIST AT CAIS. SPECIALTY: MATERIALS ENGINEERING

DOUG

SCIENTIST AT CAIS. SPECIALTY: GEOSCIENCE


ANNA AND DAVE ARE EXCAVATING A SPANISH MISSION ON ST. CATHERINES ISLAND.
DAVE, I'M FINDING A LOT OF FRAGMENTS OF METAL IN THE TRENCHES WE'RE EXCAVATING.
IT'S BRONZE: THAT'S REALLY INTERESTING!
I THINK THEY'RE PIECES OF MISSION BELLS.
YES, I THINK YOU'RE RIGHT.
THE ARCHAEOLOGISTS ON ST. CATHERINES ARE LOOKING FOR EVIDENCE THAT HELPS US UNDERSTAND THE LIVES OF THE FIRST EUROPEAN SETTLERS IN THE NEW WORLD.
MISSION BELLS WERE USUALLY MADE BACK IN SPAIN OR MEXICO AND BROUGHT WITH MISSIONARIES WHEN THEY SETTLED THE NEW WORLD.
PERHAPS WHEN THE MISSION WAS DESTROYED, PEOPLE WANTED TO KEEP FRAGMENTS OF THE BELLS TO RECYCLE THEM INTO OTHER OBJECTS.
HMM. I WONDER WHERE THE BELLS WERE ACTUALLY MADE?

AT CAIS IN GEORGIA:

HI ANNA! YES, WE CAN DEFINITELY HELP YOU FIND AN ANSWER. YOU'VE SENT US SOME OF THE BELL FRAGMENTS SO WE CAN GET STARTED!

HMM. I CAN SEE UNDER THE MICROSCOPE THAT SOME OF THE METAL HAS NOT BEEN CAST VERY WELL.

CAN YOU SEE THOSE BUBBLES? THEY MEAN THE BRONZE USED TO MAKE THE BELL COOLED TOO QUICKLY IN THE MOLD.

HOW WERE THE MISSION BELLS MADE?

1. FIRST, THE SHAPE OF THE BELL IS MADE OUT OF WAX SURROUNDED BY A MOLD MADE OF CLAY.

2. RED-HOT LIQUID BRONZE IS POURED INTO THE SPACE BETWEEN THE TWO PARTS OF THE MOLD. THE WAX MELTS AND RUNS OUT.

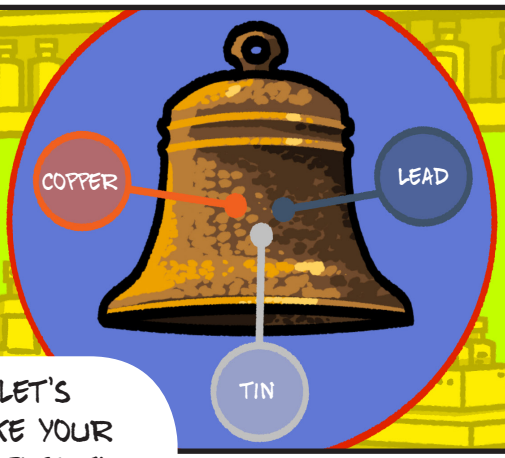
3. THE BRONZE GOES INTO THE SPACE LEFT BEHIND BY THE MELTED WAX, TAKING THE SAME SHAPE.

THE BUBBLES MEAN THE BELLS PROBABLY WEREN'T MADE IN SPAIN. SPANISH BELL-CASTERS WERE VERY GOOD AT MAKING BELLS, AND THEY WOULDN'T HAVE LET THE METAL COOL TOO QUICKLY.

CAN WE FIND OUT WHERE THE METAL CAME FROM? THAT MIGHT TELL US WHERE THE BELLS WERE MADE.

WELL, THE METAL CONTAINS COPPER, TIN AND LEAD... *

... SO, YES: I THINK THE LEAD ISOTOPES COULD TELL US.



LET'S TAKE YOUR SAMPLES TO DOUG.

* SCIENTISTS OFTEN USE THESE ABBREVIATIONS:
COPPER: CU TIN: SN LEAD: PB

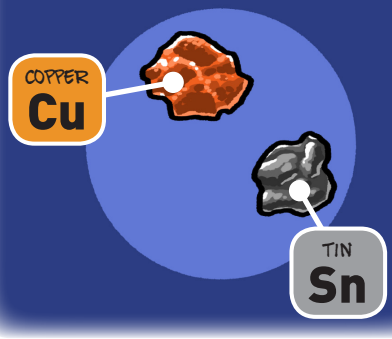
4 THE BRONZE COOLS AND GOES SOLID.

5 THE CLAY PARTS OF THE MOLD ARE TAKEN AWAY, AND WHAT IS LEFT IS THE BRONZE BELL.

6 FINALLY, THE BELL IS TRIMMED, POLISHED AND TUNED SO THAT IT MAKES THE CORRECT SOUND.

WHY IS THERE LEAD IN THE BRONZE BELLS?

BRONZE IS AN "ALLOY," WHICH MEANS IT IS A METAL MADE FROM TWO OTHER METALS.

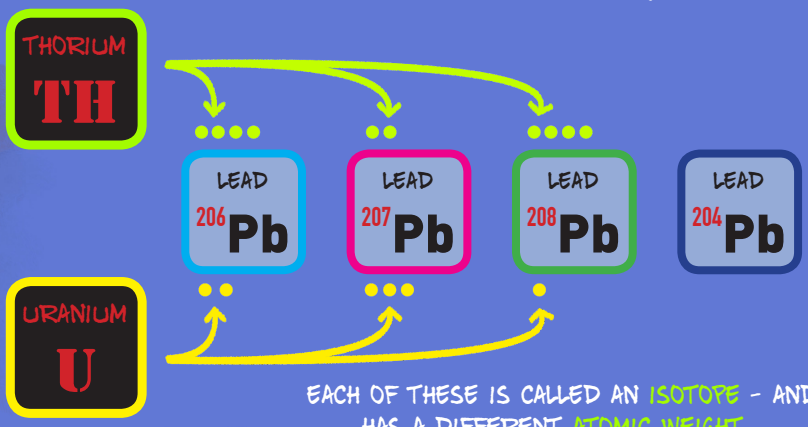


HOWEVER, BOTH COPPER AND TIN ARE VERY SOFT – SO BRONZE CAN OFTEN CRACK.

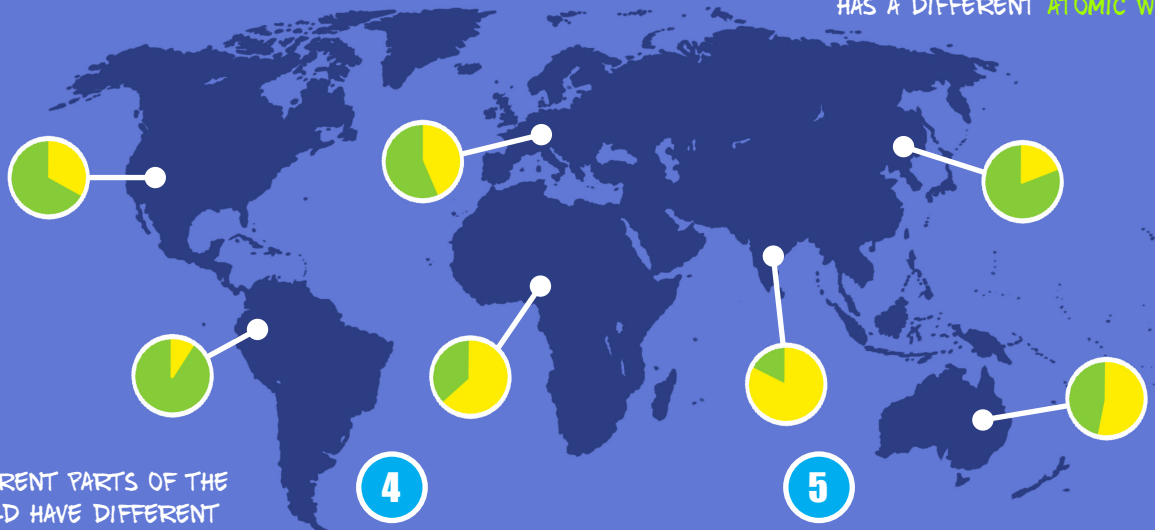
LEAD WAS ADDED TO THE BRONZE TO MAKE IT STRONGER. IT COOLS MORE SLOWLY THAN COPPER AND TIN.

1 LEAD IS DUG OUT OF THE GROUND IN LEAD MINES. THERE ARE OTHER ELEMENTS IN THE ROCKS AND SOIL SURROUNDING THE LEAD

2 TWO OF THESE ELEMENTS – THORIUM AND URANIUM – ARE RADIOACTIVE. AS THEY DECAY, NEUTRONS AND PROTONS LEAVE THE NUCLEUS OF THE ELEMENTS, CHANGING THEM TO LEAD. THIS CREATES LEAD ATOMS WITH DIFFERENT NUMBERS OF PROTONS AND NEUTRONS.



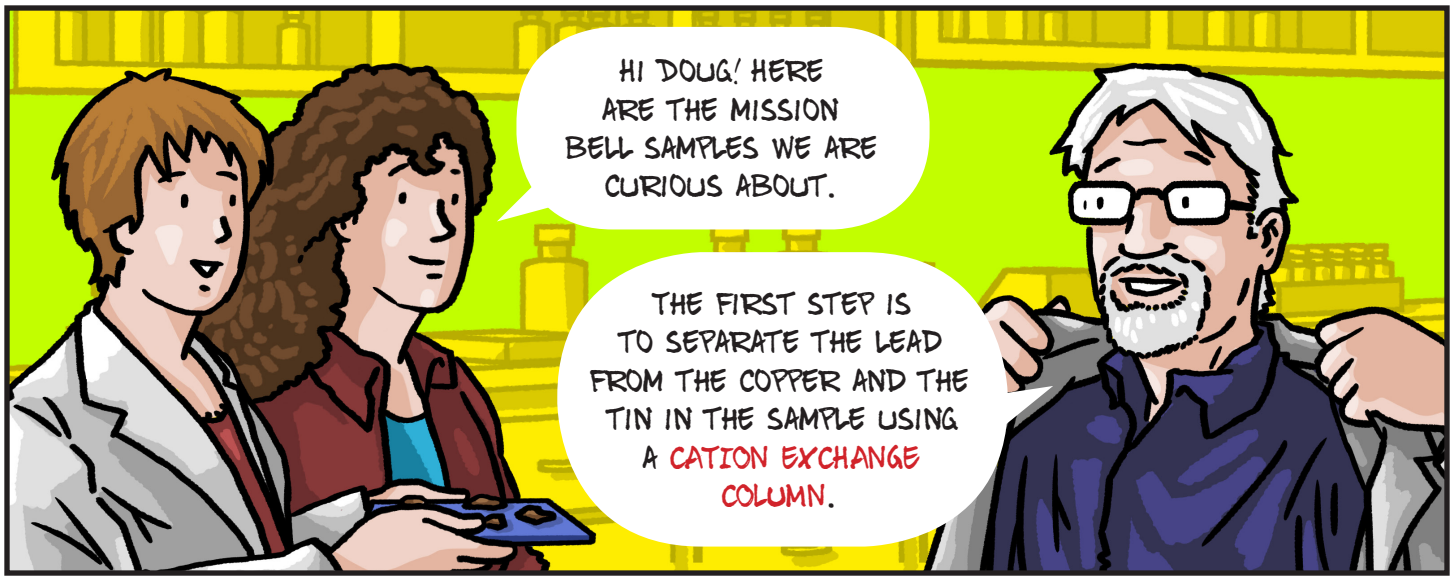
EACH OF THESE IS CALLED AN ISOTOPE – AND HAS A DIFFERENT ATOMIC WEIGHT.

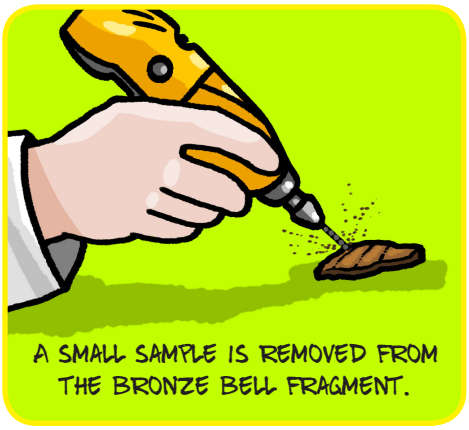


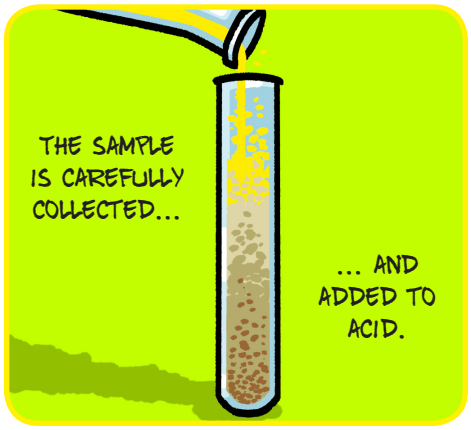
3 DIFFERENT PARTS OF THE WORLD HAVE DIFFERENT AMOUNTS OF NATURALLY-OCCURRING THORIUM AND URANIUM IN THE SOIL AND ROCKS...

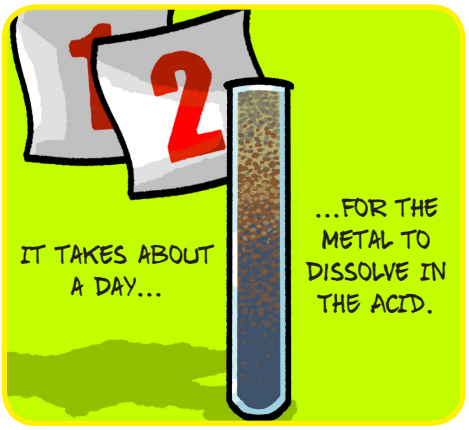
4 ... AND THEY CREATE DIFFERENT AMOUNTS OF EACH KIND OF LEAD ISOTOPE.

5 SO HOW MUCH OF EACH ISOTOPE YOU HAVE IN A SAMPLE OF LEAD CAN TELL YOU WERE THAT LEAD CAME FROM.







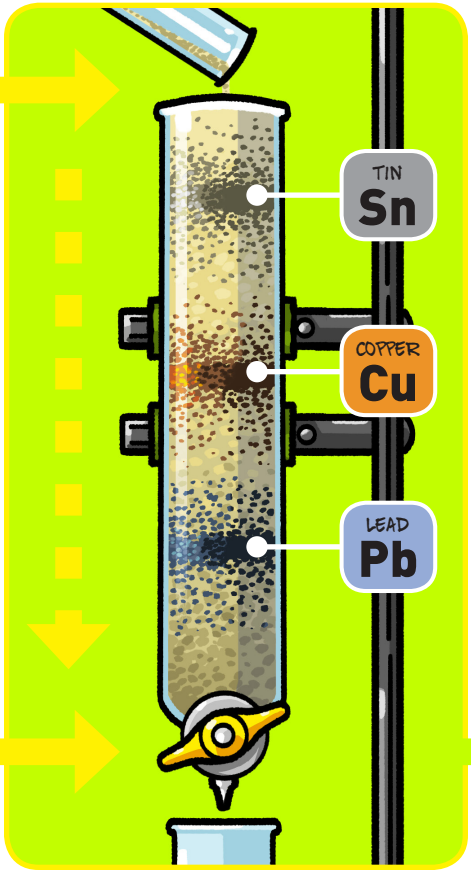


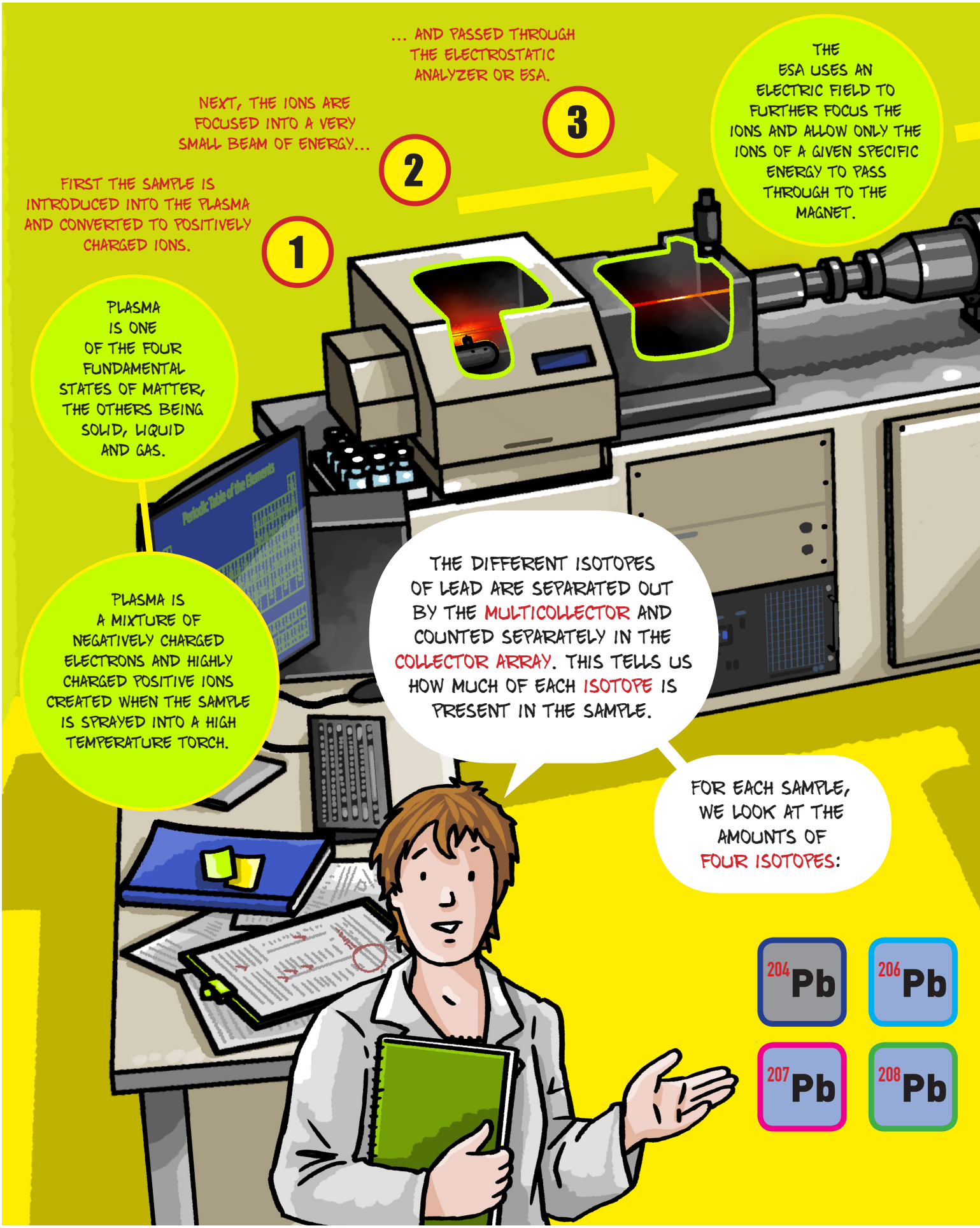
THE SAMPLE IS POURED INTO A COLUMN TO TRAP THE LEAD...

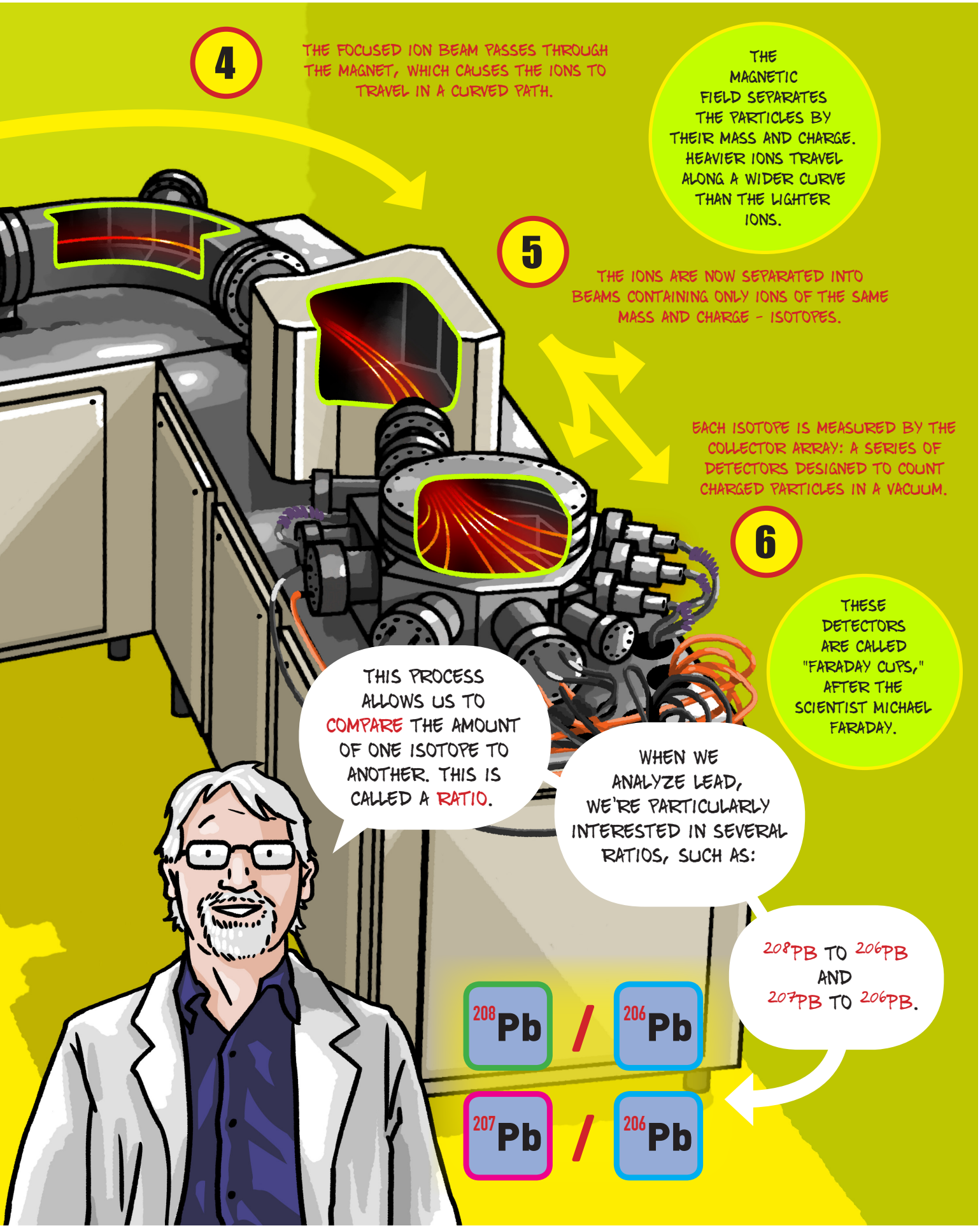
EVERYTHING ELSE - IE: THE CU AND SN - FLOWS THROUGH THE COLUMN AND DRIPS OUT THE BOTTOM.

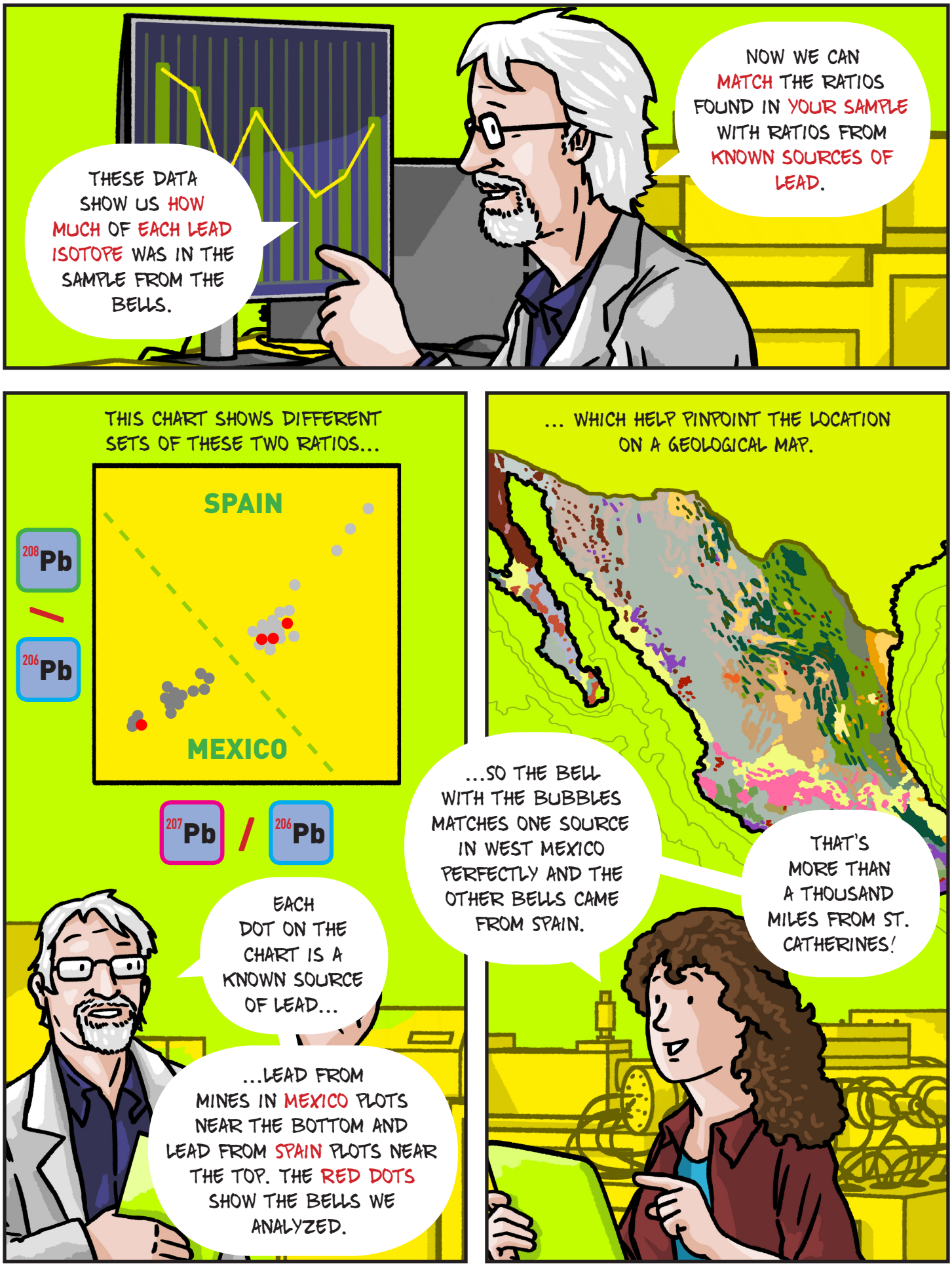
BECAUSE EACH ELEMENT BEHAVES DIFFERENTLY, THEY MOVE THROUGH THE COLUMN AT DIFFERENT SPEEDS.

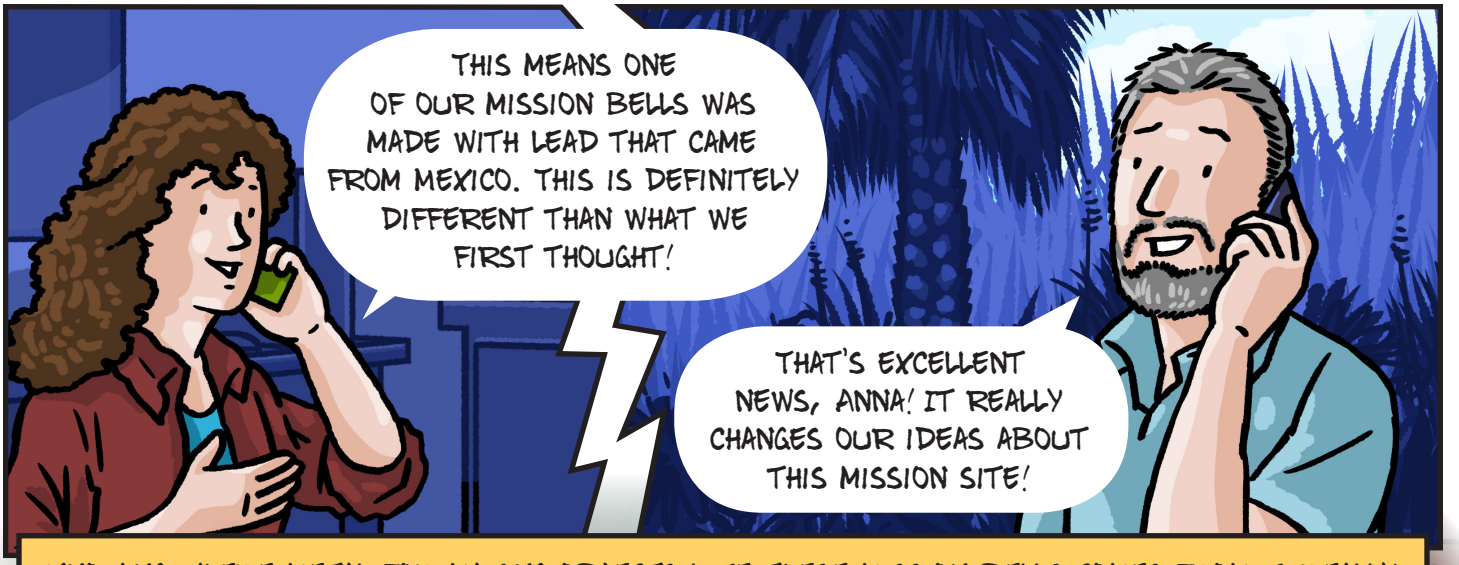
IT TAKES A WHILE FOR THE SAMPLE TO PASS THROUGH THE COLUMN, AND WE WAIT UNTIL THE TIME IS RIGHT TO EXTRACT JUST THE LEAD FROM THE SAMPLE.



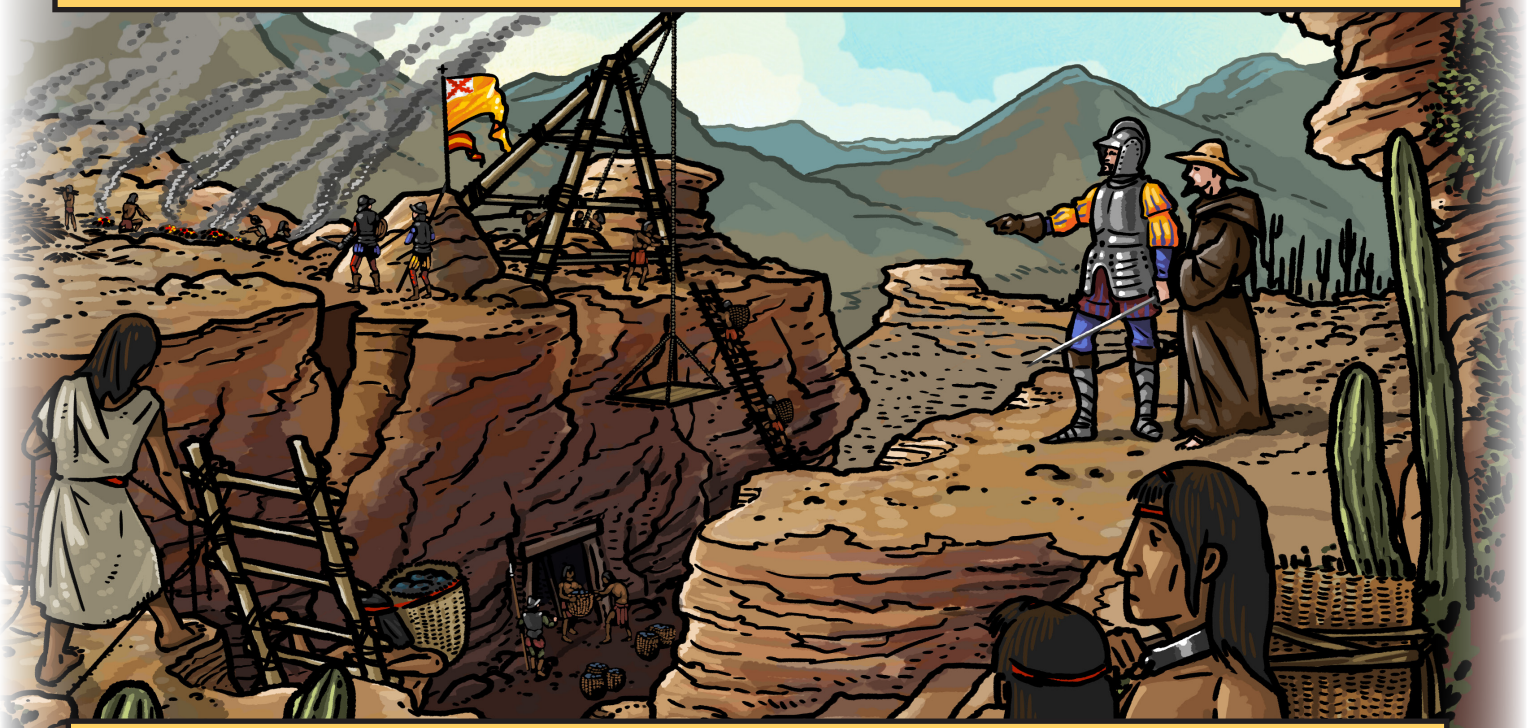

FIRST THE SAMPLE IS INTRODUCED INTO THE PLASMA AND CONVERTED TO POSITIVELY CHARGED IONS.
1
NEXT, THE IONS ARE FOCUSED INTO A VERY SMALL BEAM OF ENERGY...
2
... AND PASSED THROUGH THE ELECTROSTATIC ANALYZER OR ESA.
3
THE ESA USES AN ELECTRIC FIELD TO FURTHER FOCUS THE IONS AND ALLOW ONLY THE IONS OF A GIVEN SPECIFIC ENERGY TO PASS THROUGH TO THE MAGNET.
PLASMA IS ONE OF THE FOUR FUNDAMENTAL STATES OF MATTER, THE OTHERS BEING SOLID, LIQUID AND GAS.
PLASMA IS A MIXTURE OF NEGATIVELY CHARGED ELECTRONS AND HIGHLY CHARGED POSITIVE IONS CREATED WHEN THE SAMPLE IS SPRAYED INTO A HIGH TEMPERATURE TORCH.
THE DIFFERENT ISOTOPES OF LEAD ARE SEPARATED OUT BY THE MULTICOLLECTOR AND COUNTED SEPARATELY IN THE COLLECTOR ARRAY. THIS TELLS US HOW MUCH OF EACH ISOTOPE IS PRESENT IN THE SAMPLE.
FOR EACH SAMPLE, WE LOOK AT THE AMOUNTS OF FOUR ISOTOPES:
204Pb
206Pb
207Pb
208Pb


4
THE FOCUSED ION BEAM PASSES THROUGH THE MAGNET, WHICH CAUSES THE IONS TO TRAVEL IN A CURVED PATH.
THE MAGNETIC FIELD SEPARATES THE PARTICLES BY THEIR MASS AND CHARGE. HEAVIER IONS TRAVEL ALONG A WIDER CURVE THAN THE LIGHTER IONS.
5
THE IONS ARE NOW SEPARATED INTO BEAMS CONTAINING ONLY IONS OF THE SAME MASS AND CHARGE - ISOTOPES.
EACH ISOTOPE IS MEASURED BY THE COLLECTOR ARRAY: A SERIES OF DETECTORS DESIGNED TO COUNT CHARGED PARTICLES IN A VACUUM.
6
THESE DETECTORS ARE CALLED "FARADAY CUPS," AFTER THE SCIENTIST MICHAEL FARADAY.
THIS PROCESS ALLOWS US TO COMPARE THE AMOUNT OF ONE ISOTOPE TO ANOTHER. THIS IS CALLED A RATIO.
WHEN WE ANALYZE LEAD, WE'RE PARTICULARLY INTERESTED IN SEVERAL RATIOS, SUCH AS:
208PB TO 206PB AND 207PB TO 206PB.
208Pb / 206Pb
207Pb / 206Pb


THESE DATA SHOW US HOW MUCH OF EACH LEAD ISOTOPE WAS IN THE SAMPLE FROM THE BELLS.
NOW WE CAN MATCH THE RATIOS FOUND IN YOUR SAMPLE WITH RATIOS FROM KNOWN SOURCES OF LEAD.
THIS CHART SHOWS DIFFERENT SETS OF THESE TWO RATIOS...
SPAIN
MEXICO
208Pb / 206Pb
207Pb / 206Pb
EACH DOT ON THE CHART IS A KNOWN SOURCE OF LEAD...
...LEAD FROM MINES IN MEXICO PLOTS NEAR THE BOTTOM AND LEAD FROM SPAIN PLOTS NEAR THE TOP. THE RED DOTS SHOW THE BELLS WE ANALYZED.
... WHICH HELP PINPOINT THE LOCATION ON A GEOLOGICAL MAP.
...SO THE BELL WITH THE BUBBLES MATCHES ONE SOURCE IN WEST MEXICO PERFECTLY AND THE OTHER BELLS CAME FROM SPAIN.
THAT'S MORE THAN A THOUSAND MILES FROM ST. CATHERINES!



KNOWING WHERE METAL FOR MAKING OBJECTS LIKE THESE MISSION BELLS COMES FROM IS REALLY IMPORTANT. IT TELLS US HOW DISTANT HISTORICAL PLACES IN NORTH AMERICA ARE RELATED.



WORK DONE AT THE CENTER FOR APPLIED ISOTOPE STUDIES IS HELPING US CONNECT SITES LIKE ST. CATHERINES TO SITES IN OTHER PLACES AND OTHER COUNTRIES. THE SCIENCE AT CAIS HELPS US UNDERSTAND HOW THE FIRST EUROPEAN SETTLERS LIVED IN THE NEW WORLD.

Center for Applied Isotope Studies
UNIVERSITY OF GEORGIA

Carbon Comics No. 2 - *Unlocking The Past: Archaeometallurgy*

Written by Alice M. W. Hunt, John G. Swogger and Jeff Speakman
Illustrated by John G. Swogger
Translated by Kathy Loftis and Edgar Alarcón Tinajero

SEPARATE THE ISOTOPES!

GAME FOR TWO PLAYERS: TAKE TURNS DRAWING STRAIGHT LINES FROM ONE + TO ANOTHER, TRY AND MAKE A BOX AROUND A GROUP OF LEAD ISOTOPE ATOMS OF THE SAME COLOUR. WHOEVER SEPARATES OUT THE MOST ATOMS, WINS! ONE PLAYER CHALLENGE: DRAW A SINGLE, CONTINUOUS LINE FROM ONE + TO ANOTHER, WITHOUT CROSSING OVER YOUR LINE, AND SEE HOW MANY ISOTOPE ATOMS YOU CAN SEPARATE BY COLOUR!