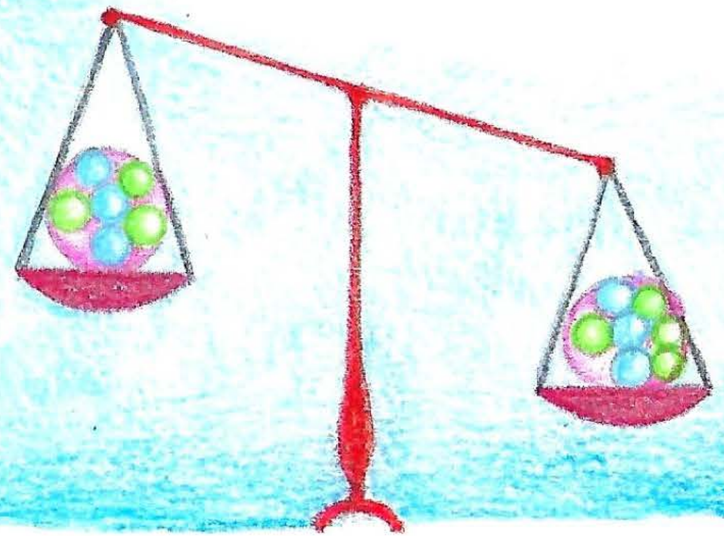
Who poisoned Family Mole?

A forensic story about isotopes



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Who poisoned Family Mole?

A forensic story about isotopes

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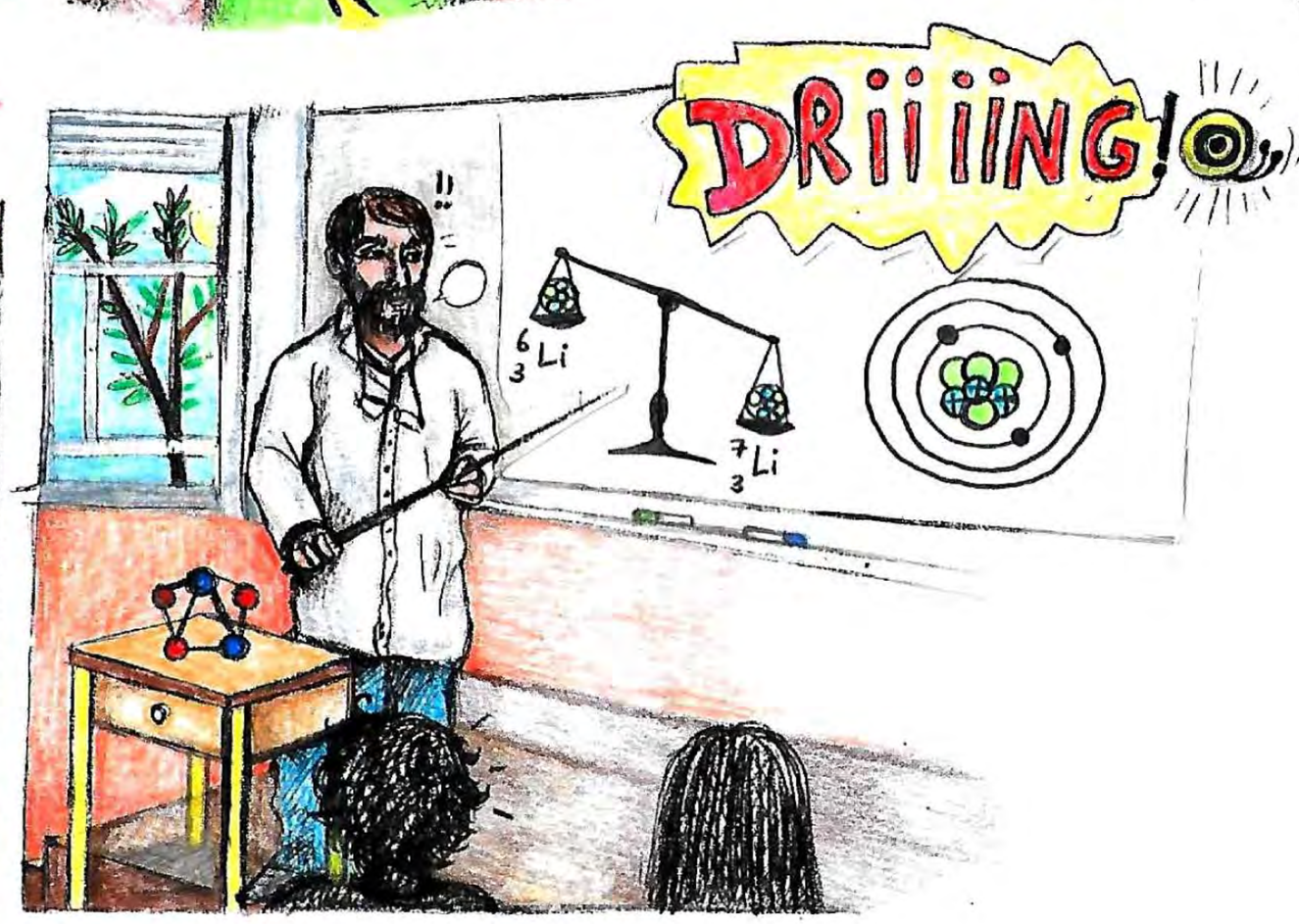
Our story begins in a chemistry classroom. Emma and Steven are learning about isotopes.

...and someone is not very focused on the subject.

Now we look closer at elements and their isotopes...



I can't wait to go to the lake!

But I really wanted to know what isotopes can be used for.

Emma, please stop thinking about school now and let's go to our lake!

Later that day...

Yay, almost there!

It's strange... There used to be more life around...

OH MY GOSH!

Look at all the dead animals, Steven!

I see... birds, moles... This is horrible! What is going on here???

Oh no! Look over here!
There are two mole[1] pups...
They are barely breathing.

Quick, we should bring them to my aunt Claudia! She is a vet.

Aunt Claudia examines the moles and runs some tests. The moles were poisoned with phosphine.

Zinc phosphide used to be a common pesticide, and some may be polluting the area around the lake.

Unfortunately, she doesn't know the source of the pollutant...

A good friend of mine is an environmental scientist and works at the university.

His team can help us to find the source of pollution by looking at isotopes.

I will phone him.

Fantastic! Our teacher was just explaining about isotopes!

More homework... Well, at least it will do some good if we find the pollutant!

[1]A Mole can be an animal but is also a collective number, just like a dozen. A dozen is 12 things of something. A mole is 6.02×10^{23} things of something. Chemists use moles for counting tiny things like atoms, molecules.

The next day at the university, in the office of Professor Avogadro.

Hello, you must be Emma and Steven.

Claudia told me you need some help.

My name is Professor Avogadro[2].

Nice to meet you, Professor Avogadro! We heard that you could help us use isotopes to find the source of the pollution that contaminated our wonderful lake..

...and save many animal lives!

Ah yes, my team and I are currently studying the behaviour of metals within soils.

Your mystery is relevant to our research and is going to be very interesting for us too.

We use stable isotopes to find sources of environmental pollution. In this case, it is zinc probably from rat poison that contaminated your lake according to Claudia.

But first...
Have you already learned about isotopes?

?

Well...
maybe...

Yes, we DID!
Aren't isotopes forms of the same element just differing in the number of neutrons? So, they have different weights but their chemical properties are the same?

[2]Amedeo Avogrado was an Italian scientist. The Avogadro's number is named after him and is the number of particles, usually atoms or molecules, that are contained in the amount of substance given by one mole.

Emma is right. To simplify and explain Professor Avogadro compares isotopes to fruits from the same tree.

Imagine a tree with several fruits

Normally, the fruits are all growing together, tasting the same and having a very similar shape, but their masses differ, of course.

This is the same for isotopes. Same material but different masses – and in nature, the isotopes can move around at different speeds according to their masses.

Steven is getting more interested in science.

…Different zinc isotopes move at different speeds?

Yes, indeed!
Let me explain this to you with the image of two hikers climbing a mountain.

One hiker has a light backpack, the other a heavy one.

At some point the hiker with the lighter backpack will climb faster.

As a result, the hiker with the heavy backpack falls behind and the two hikers will become separated.

For isotopes, this separation is called isotopic fractionation.

So, the amount of isotope fractionation depends on the relative speed at which different isotopes are moving?

Isotopes can also be fractionated by chemical reactions. This is because it is easier to break bonds between a light isotope and a material, than breaking bonds of heavier isotopes from the same material. The light isotope requires less energy.

Of course that is a lot of information for Emma and Steven.

Mainly, keep in mind that isotope fractionation means that every material and environment..

..such as rivers, lakes, soil, rock, plants, even animals, has different proportions of each isotope.

So, the isotopic composition is like a specific signature?

Yes, it is. Like your fingerprint. And this signature we can identify.

Can the isotopic composition of zinc change with time?

Good question Steven. In general, the proportion of zinc isotopes in a material remains unchanged over time. Therefore, they are called stable and do not see their numbers decline gradually with time.

Some isotopes are unstable and decay. These isotopes are called radioactive isotopes. They can be used to determine the age of samples.

As this doesn't happen for zinc, we can use it to find out where the pollution around the lake comes from.

O.K...
But how will we do this?

You compare the isotopic composition of the sample you are looking at with the isotopic compositions of potential pollutants and see if there is a match.

Compare?

1

?

We need first to do some research on the possible sources of zinc pollution close to the lake and its vicinity.

2

?

After that, we need samples to analyse in the laboratory - that means we have to go there and collect them.

Let's start then!

Claudia already told me that you are eager to solve this puzzle.
Unfortunately I have a lot to do and I need to leave to teach a class.

KNOCK KNOCK

Hello?

But, I have the perfect person to help! Please come in Maria.

Maria is a researcher in my group and she offered to do the research and the analysis with you.

Hello Emma and Steven, nice to meet you!

Hello! Nice to meet you as well.

Prof. Avogadro told me all about your discoveries. I started to work on that area a few weeks ago. If you want you can help me.

Yes, of course!

Alright then! I really need to go now.

Let me know if you need some help. Good luck guys!

See you later!

After a lot of research...

Ok we found three possible sources for the zinc pollution.

It could come from either a dumping area, a nearby garage - their waste often contains toxic substances or from the barn by the crop field.

You often find rats close to barns or sheds and people use rat poison to get rid of them.

We should take some samples from there now, right?

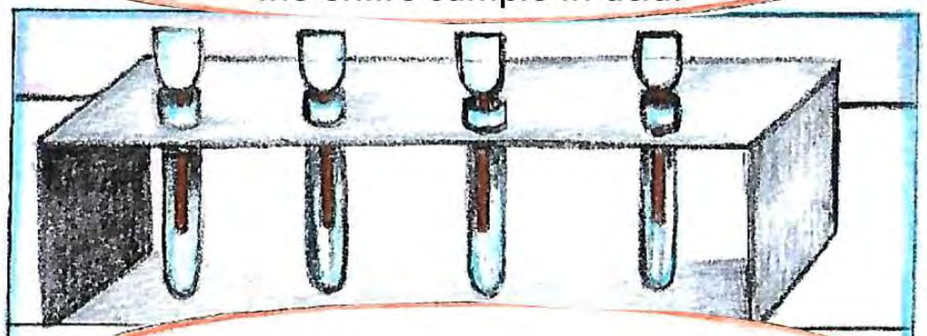
Yes, very good! Let's get the material.

They sample in the three areas. Despite all the efforts the mood is still high.

A couple of days later in the lab...

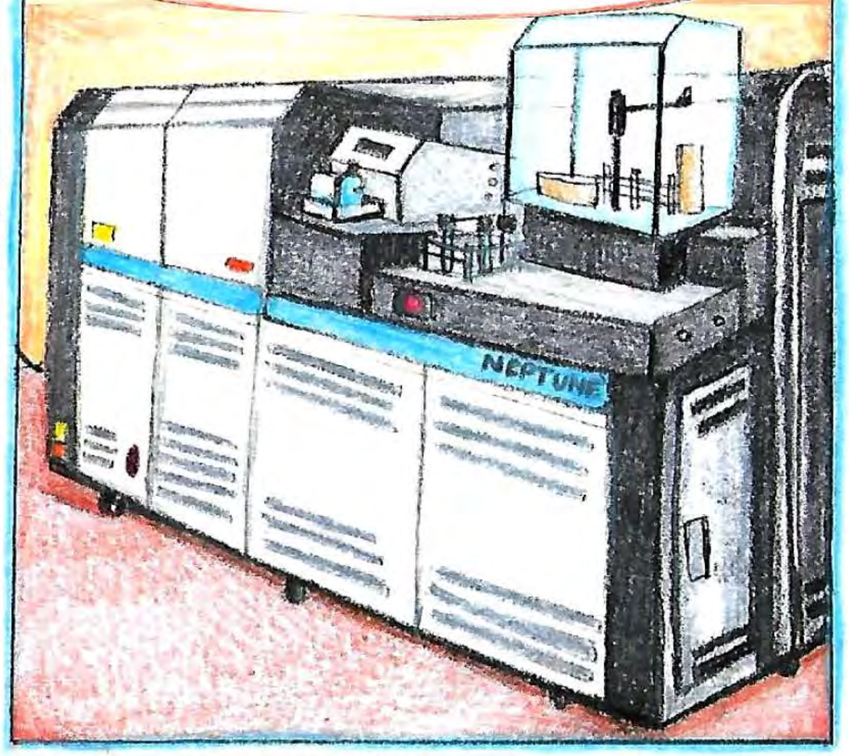
OK, we have all the samples we need. Let's go back and prepare them for analysis.

To analyse the zinc we need to isolate it from all the other elements in our samples. First, we dissolve the entire sample in acid.



Then, we purify it - we remove all the other elements except for zinc.

Only then we can finally measure the zinc isotopes in our samples!



Two weeks later... After analysis and data treatment.

So, what exactly do these numbers mean? Are these the isotopic signatures of our samples?

Yes,exactly!

And the Greek letter delta is its symbol.

Hello, hello. How is everything going?

Hi professor! We are about to find the source of the pollution.

Excellent news!

So, who is the culprit?

Well, looking at the isotopic composition of the samples we took from the lake, the barn, the garage and the dumping site, we have just one possible match!

It is the barn!

Let's hurry! We need to stop any further pollution now!

Well done team. I will call the farmer. There is a good chance that he has no idea of what is happening around his barn.

So, wait...I see that the isotope values of the soil sample we took from the lake and those of soil next to the barn are the same, and therefore the barn is the contaminating source?

Exactly!

A couple of days later...

The farmer found some old rotten barrels of pesticide with zinc phosphide in the back of its barn.

He was very shocked by that, but he remembered that his father used to put it down to get rid of rats when he was a child.

The farmer will take care of the barrels and clean the surrounding contaminated area.

Fortunately, we have these stable isotope methods, which help us to find such forgotten barrels contaminating a whole area.

You are right!

Claudia

Hello?

Hey Claudia!

The young moles are fully recovered? That's wonderful. Thank you so much!

The moles are fine! Let's go and see them!

V
E
T

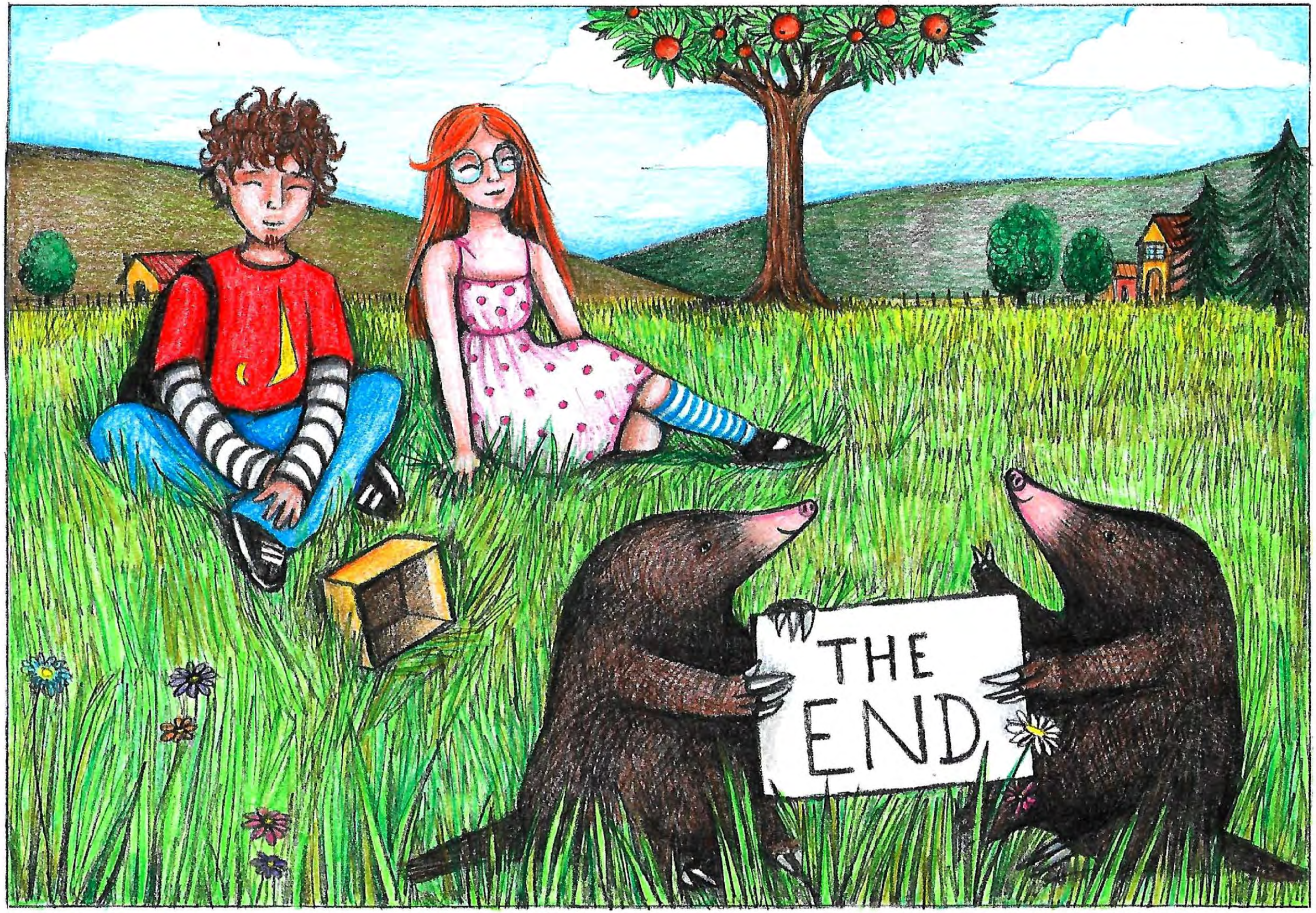
I think the two moles are ready to be released. But please don't bring them back to the lake.

Unfortunately, their environment will need a little while to recover.

Of course, we will find a new place for them to live.

Who knew that isotopes can be so useful?

You see, almost everything can be defined with them!


THE
END

ISONOSE

On a beautiful summer day Emma and Steven want to have fun at their favourite lake. However, a mysterious situation thwarts their plans. This leads the two friends on an unexpected quest...
Join Emma and Steven as they explore the vast, intriguing and efficient world of stable isotopes: What are isotopes? How do isotopes work? And last but not least, how can isotopes help Emma and Steven to finally answer the question: Who poisoned Family Mole?