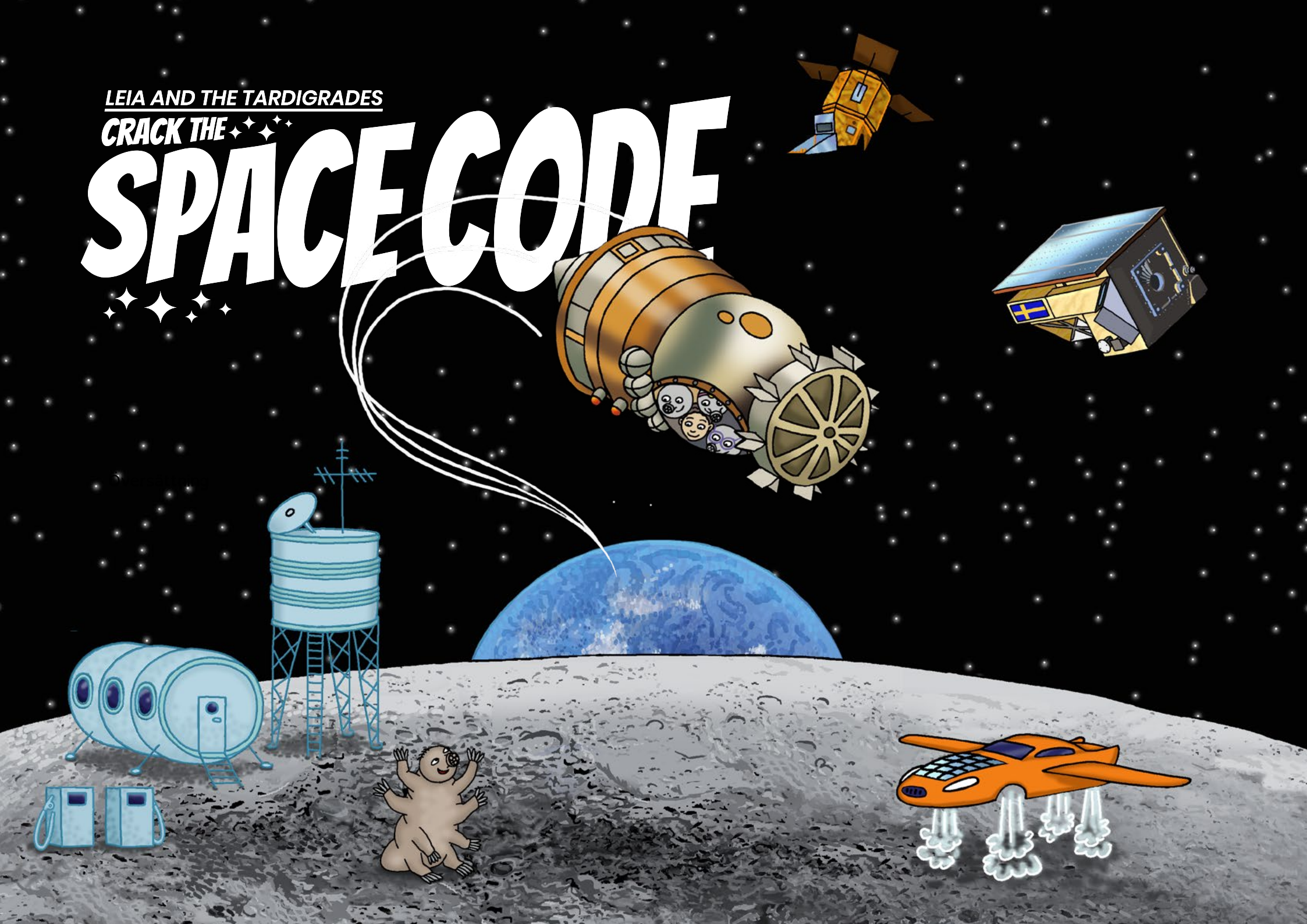

LEIA AND THE TARDIGRADES
CRACK THE
SPACE CODE

Hi!

Want to come with us?

We're going on a space adventure – and it's no ordinary adventure. We're going to Mars! We've been given a difficult mission. We have to build an environmentally friendly filling station on Mars.

Does that sound strange? Yes, it probably does – but you'll find out more soon.

You'll learn lots about space and satellites, planets and space junk, and you'll also use your math skills. You need to help us reach our goal, and we can't do that without doing some math and some programming. You're going to create your own computer game – isn't that cool?

Come on, let's get going!

Best wishes,

Leia and the tardigrades

Margaret Hamilton next to the handwritten code that ensured that humans reached the Moon.

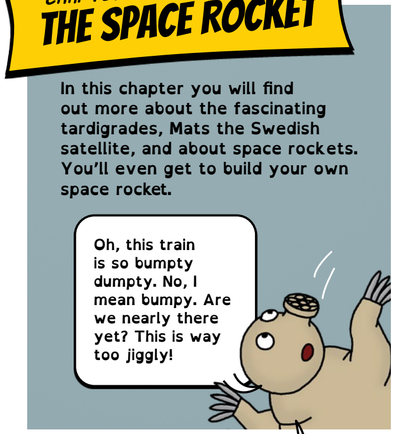
Photo: Draper Laboratory. Wikimedia Commons

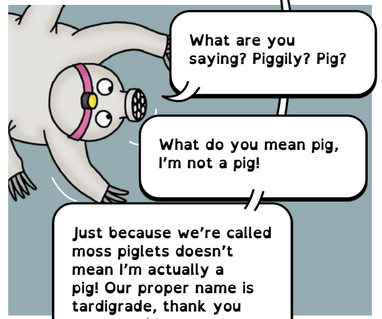
This is Margaret Hamilton. She is really interested in space, mathematics and programming. She has worked for the American space agency, NASA. When she worked there, she helped develop the code necessary for landing the first manned space rocket, Apollo 11, on the Moon in 1969. But there was almost a real catastrophe. Just as the astronauts were about to land on the Moon, the computer became overloaded. There was so much information that the computer did not know what to do. Margaret and her colleagues tried desperately to solve the problem, otherwise the entire mission would have to be aborted. At the last minute, they sent a small piece of code to the computer that meant it could remove all the unnecessary information and focus on its main task – landing the spaceship. Margaret and her colleagues were heroes. They saved the mission!

CHAPTER 1

THE SPACE ROCKET

In this chapter you will find out more about the fascinating tardigrades, Mats the Swedish satellite, and about space rockets. You'll even get to build your own space rocket.





The three tardigrades, Obi, Wan and Zen are on the train. Well, they are hiding on the train. After their last adventure out in the solar system, they went on holiday to the giant mosses on Elbrus. Elbrus is a really high mountain on the border between Europe and Asia. Now they're finally on their way home to their own moss on the island of Öland.

Because tardigrades are really small, a millimetre long at the most, there's no point in them buying train tickets. They can't even reach the counter to buy them! Now they are curled up by a window, watching the world go by, and all they want is to get home to their moss on Alvaret. There's no place like home! And, when they get home, they will see their friend Leia again. She and her dad live on Öland, and they're humans.

Leia met the tardigrades last year when she was on a school trip*. She'd fallen flat on her face on their moss, just as they were about to head out on an amazing adventure. Tardigrades are very inquisitive animals, and they had built a rocket so they could travel into the solar system. Leia had gone home to get changed and cleaned up, when she felt dizzy. It was as if her stomach was on a giant fairground ride, and suddenly she was as tiny as the tardigrades. As soon as she was used to being so small, she went with them on their adventure. They had an exciting time and really enjoyed themselves.

*Leia and the Tardigrades – a journey of discovery in space

The train slows down and comes to a halt at the platform.

SKREEEEEEE-EEEEEEE-ETCH

This train stops everywhere.

ZZZzz

Zzzzzz...says Obi, who's fallen asleep, just as a train going the opposite direction stops on the tracks beside them.

Look – isn't that a Swedish flag? Why? Where is that train going? Come on, we need to check this out!

This is more exciting than travelling home to our moss. We must solve the mystery of the Swedish flag.

That's not surprising. We're on the Trans-Siberian Railway.

Wan is small, no longer than 0.8 mm, but he's an engineering genius. He knows everything about railways, trains and Russia.

The Trans-Siberian Railway is the longest railway in the world. It goes all the way from the Russian capital city, Moscow, to Vladivostok and over 20,000 containers are transported on it every year...

It's very cold outside, the type of freezing cold that Russia has in the winter. It must be -40°C, but the tardigrades don't care. There aren't many more hardy animals than them, as they can be cooled to below -270°C and heated to more than +100°C. They withstand radiation and dehydration and can go into suspended animation for more than ten years, a little like hedgehogs, bears and frogs do in the winter.

Zen jumps up on the old railway wagon and helps Obi and Wan up. They are just in time, as the train has started moving again.

Goodbye train, goodbye Öland! I hope everything is great at home, as I'm almost happy-ish to be going on a new adventure.

Now they're travelling north again – fast. The train doesn't stop at a single station.

SWOOSCH

I wonder why they're in such a hurry?

They have crept into the wagon with the Swedish flag on it and it's dark, like being in a cave.

I can't see a thing. Wan, you're so clever, can't you find us some light?

Wan takes a big torch out of his backpack and turns it on.

Sure. Now let's see what we have here...

In the light of the torch, they see...

AHHHHH!!

IT'S A MONSTER, A GIGANTIC MONSTER! LOOK, WHAT A HUGE EYE!

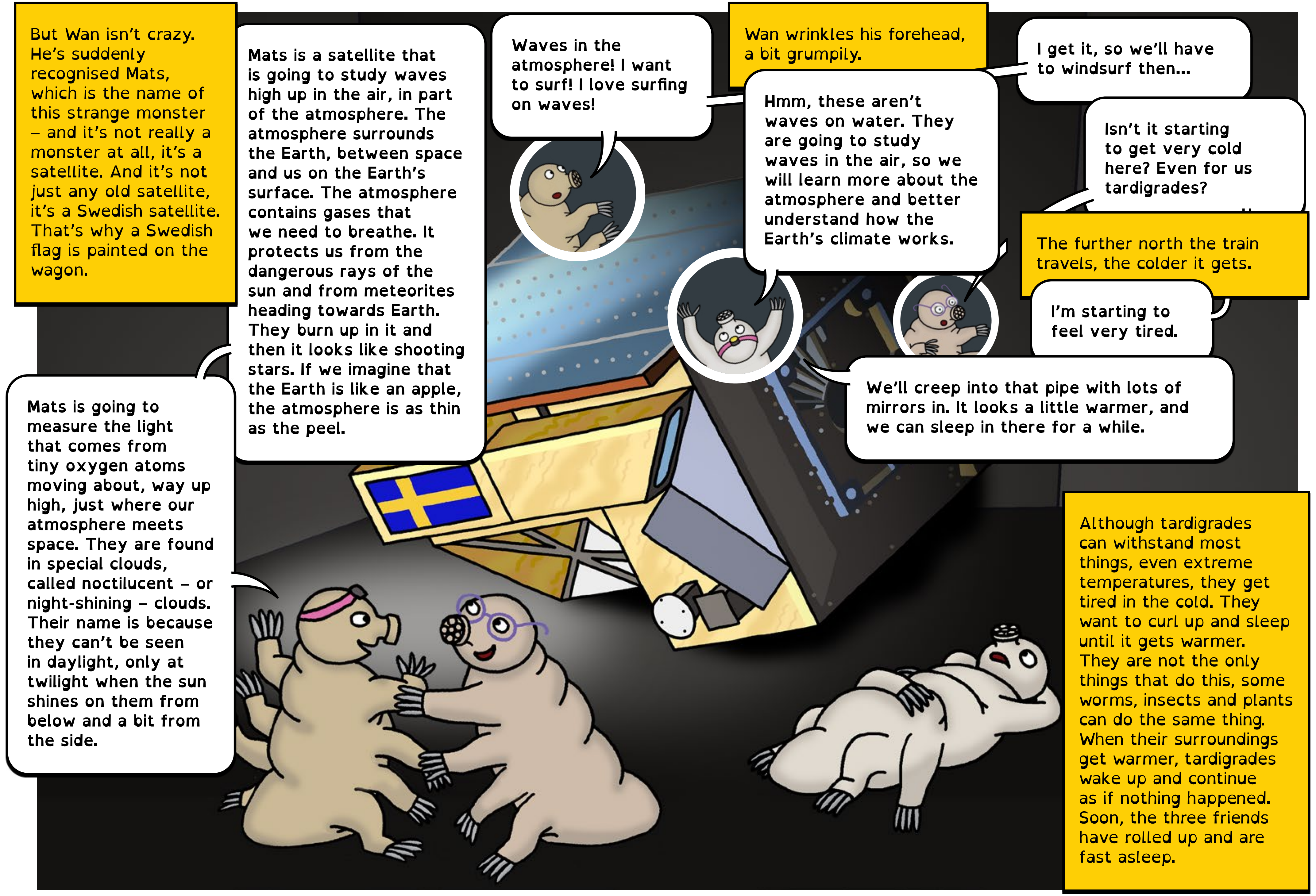
Both Wan and Zen jump with fright when they see what's in the wagon. It looks like a huge box with a giant eye is staring at them, and it has a tube that looks like it could shoot flames out of it at any moment.

What are we doing here? The only positive thing is that it seems to be asleep. We'll have to keep quiet.

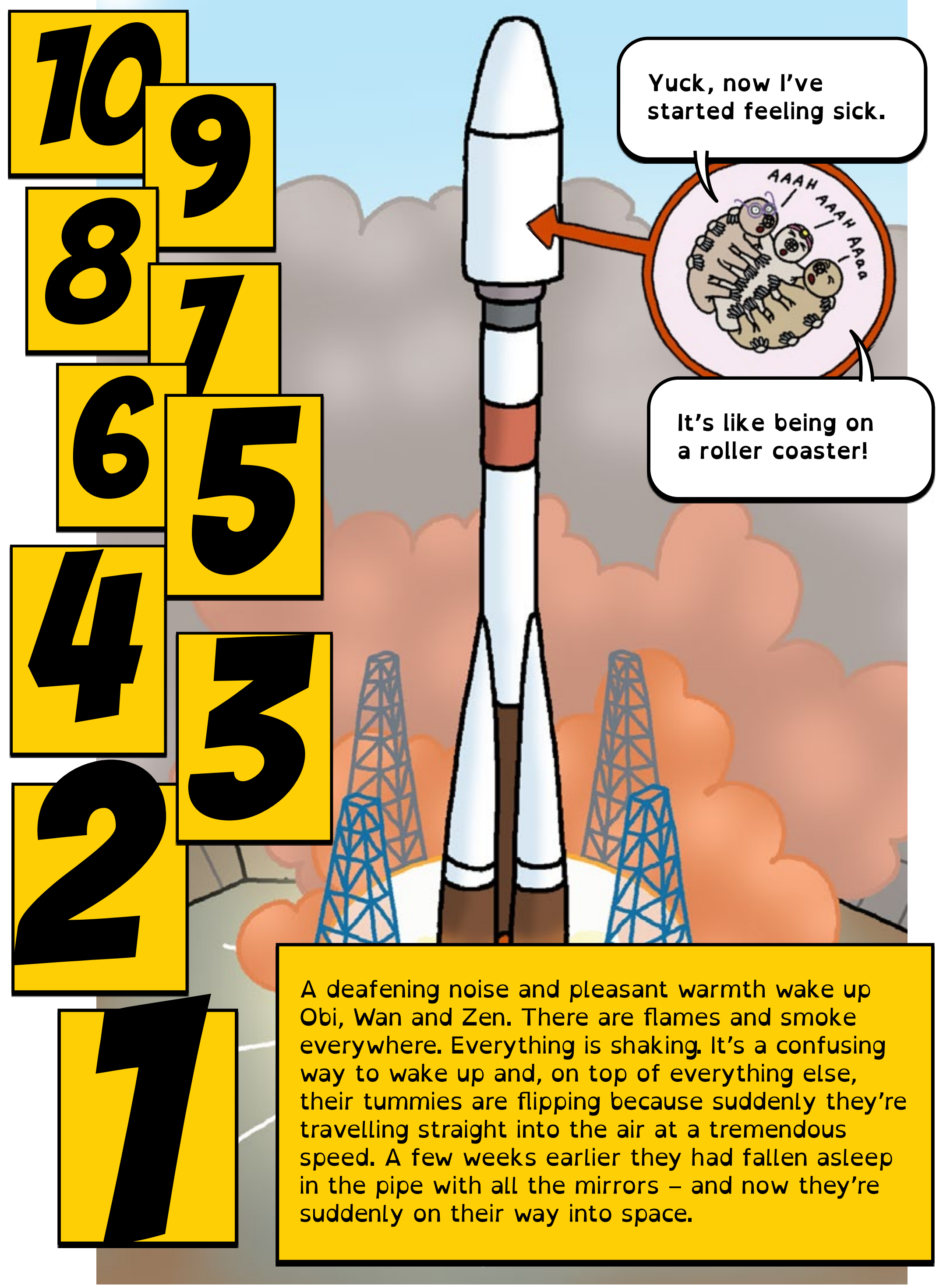
Once their eyes have adjusted to the light, Wan starts speaking through his laughter.

I know what it is. It's amazing, it's really truly fantastic!

The other two tardigrades just stare at him. They look as if they think he's crazy.



But Wan isn't crazy. He's suddenly recognised Mats, which is the name of this strange monster – and it's not really a monster at all, it's a satellite. And it's not just any old satellite, it's a Swedish satellite. That's why a Swedish flag is painted on the wagon.
Mats is a satellite that is going to study waves high up in the air, in part of the atmosphere. The atmosphere surrounds the Earth, between space and us on the Earth's surface. The atmosphere contains gases that we need to breathe. It protects us from the dangerous rays of the sun and from meteorites heading towards Earth. They burn up in it and then it looks like shooting stars. If we imagine that the Earth is like an apple, the atmosphere is as thin as the peel.
Waves in the atmosphere! I want to surf! I love surfing on waves!
Wan wrinkles his forehead, a bit grumpily.
I get it, so we'll have to windsurf then...
Hmm, these aren't waves on water. They are going to study waves in the air, so we will learn more about the atmosphere and better understand how the Earth's climate works.
Isn't it starting to get very cold here? Even for us tardigrades?
The further north the train travels, the colder it gets.
I'm starting to feel very tired.
We'll creep into that pipe with lots of mirrors in. It looks a little warmer, and we can sleep in there for a while.
Mats is going to measure the light that comes from tiny oxygen atoms moving about, way up high, just where our atmosphere meets space. They are found in special clouds, called noctilucent – or night-shining – clouds. Their name is because they can't be seen in daylight, only at twilight when the sun shines on them from below and a bit from the side.
Although tardigrades can withstand most things, even extreme temperatures, they get tired in the cold. They want to curl up and sleep until it gets warmer. They are not the only things that do this, some worms, insects and plants can do the same thing. When their surroundings get warmer, tardigrades wake up and continue as if nothing happened. Soon, the three friends have rolled up and are fast asleep.



10
9
8
7
6
5
4
3
2
1
Yuck, now I've started feeling sick.
AAAH AAAH AAAH
It's like being on a roller coaster!
A deafening noise and pleasant warmth wake up Obi, Wan and Zen. There are flames and smoke everywhere. Everything is shaking. It's a confusing way to wake up and, on top of everything else, their tummies are flipping because suddenly they're travelling straight into the air at a tremendous speed. A few weeks earlier they had fallen asleep in the pipe with all the mirrors – and now they're suddenly on their way into space.

FACTS

Tardigrades

Tardigrades, which are also called water bears or moss piglets, are tiny animals that mostly live in water. They like mosses and lichens. Tardigrades can be found everywhere on Earth, from high mountain tops to deep oceans. They have eight legs with claws. Tardigrades are 0.05 to 1 millimetre long and can survive extreme temperatures, both cold and hot. During a space flight in 2008, Swedish and German researchers proved that tardigrades can survive extreme dehydration and radiation in space.

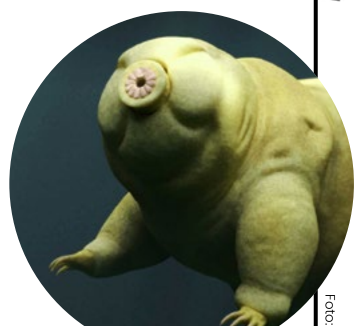


Foto: dottedhippo, iStockphoto

Space rocket

A space rocket can be used to send things into space, away from the Earth's atmosphere. To succeed with this, and to avoid falling to the ground, a rocket must have a velocity of at least 40,300 kilometres per hour. Compare this to a car, which can drive about 200 kilometres per hour. It gives you an idea of how fast a rocket has to travel.

A space rocket is big and very heavy. Most of this weight is fuel, which is necessary for the space rocket to be able to move so fast. The fuel is combusted, forming hot gases that jet out of the mouthpiece at the back of the rocket. A space rocket must withstand a lot, such as extreme heat and extreme cold.

Mats

Mats is a Swedish research satellite that investigates waves in the atmosphere. One way that Mats does this is by studying the differences in light in noctilucent clouds, using a telescope with three mirrors. Mats helps researchers create 3D images of the waves. These images will be used to make maps that show how waves move in the atmosphere. No one has done this before. It will help us understand more about climate change, among other things.

Mats is a microsatellite, which means it is a small satellite. Mats weighs just 50 kilos and looks a bit like a big cardboard box. It was built as a cooperation between several Swedish space companies and universities. You can read more about Mats on the Swedish National Space Agency's website.

MISSION 1

THE SPACE ROCKET

Before you can start your journey into space, you need to have a space rocket to travel in. On this mission, you will learn about space and then build a space rocket using paper and geometric shapes. Then you will program your very own space rocket and launch it into space.

As you can probably work out, a space rocket needs a nose, a body and fins. The rocket's nose is where all the astronauts sit. The body holds all the fuel and the fins are so that the rocket can be steered in the right direction. Your task is to create a space rocket so that your journey can get started.

1. What do you know about space?

1. What type of creatures are tardigrades?

2. What is the atmosphere and what is it made from?

3. Write down three facts about space rockets

2. Build your space rocket

Now you're going to build a space rocket using geometric shapes.

You can find the task here:
Matteboken.se/the-space-rocket

Something to think about

What would you explore if you had your own space rocket? Write about it and draw some pictures.

3. Code your space rocket

Now you're going to draw a space rocket using the Scratch programming tool and code it to launch into space.

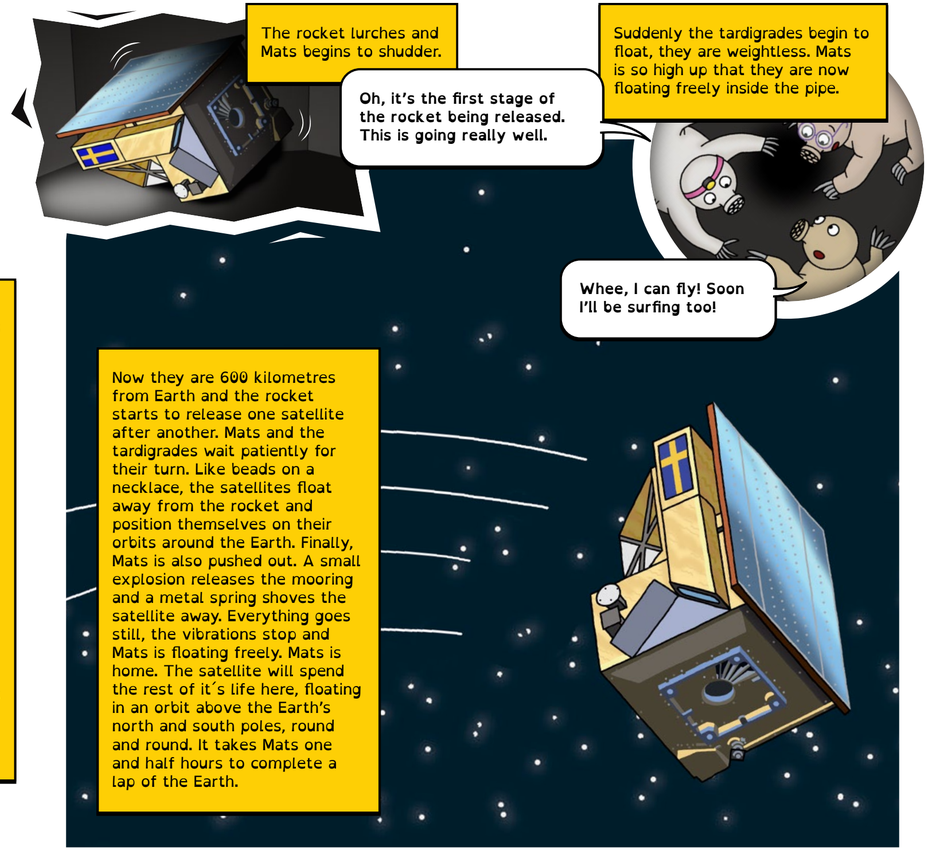
You can find the task here:
Kodboken.se/thespacerocket

CHAPTER 2

SPACE JUNK

In this chapter you will learn about space junk, what it is and why it is so important to keep track of it. You will also learn a little about satellites.

The following is what had happened. The train carrying Mats the satellite had finally arrived at Vostochny, a Russian spaceport, and Mats had been mounted in the nose of a rocket called Soyuz-2. The launch was actually for a big satellite, but the rocket also had room for several small satellites, so Mats could go along as well. Lots of technicians and engineers had inspected whether Mats was ready for launch. A satellite has to be able to deal with lots of poor conditions, cold and heat, vibrations, lurches and small explosions. Launching a satellite costs a lot of money and, once Mats is in space, it is impossible to fix it if it breaks. Everything must be checked again and again to make sure that Mats doesn't fall apart. This all happened while the tardigrades were sleeping peacefully.



This is not the first time that Sweden has launched its own satellite. This is the seventh research satellite we have launched. Mats is going to teach us more about the atmosphere and the climate.

Floating high above the Earth and looking down on everything may sound wonderful, but satellites in space are far from safe. Mats faces several threats. If the sun has an eruption, the high energy it emits could affect the satellite's electrical instruments. In the worst case, Mats might even stop working. Another problem is the huge temperature differences in space. The side of the satellite that faces the Sun can reach temperatures of +100°C, while the other side can get very cold, as cold as -50°C.

Suddenly, Mats starts moving. It turns a bit to the right, a bit to the left, a bit backwards.

Mats needs to make its mind up soon.

They are trying to get Mats pointing in the right direction. This is actually done from Earth, from Kista, outside Stockholm.

BZZZZZT

ESRANGE

KISTA

There are technicians and researchers in Kista, sending signals to Mats so that the satellite is in the correct orbit around Earth. The solar panels must be turned towards the Sun so the satellite has power for its instruments and can begin taking measurements. They send the signals from Kista up to a big antenna at the Esrange space centre, which is close to Kiruna (a city in the north of Sweden).

Wan mumbles happily.

When Mats passes above the antenna, it gets messages about what to do and sends back messages with all the information it has collected. They are really clever, those engineers.

FACTS

Weightlessness

Weightlessness occurs when something is in freefall, such as when we jump into the air and can't feel any ground beneath our feet. If you go on the AtmosFear ride, at Liseberg amusement park in Gothenburg, you are dropped from a height of 146 metres and experience three seconds of weightlessness. If you want to be weightless even longer, you can orbit around the Earth. Some good locations for doing experiments in weightlessness – zero gravity – are on satellites that travel around the Earth or on manned space stations.

Telescopes

A telescope is a device that allows us to look at very small, dim objects in space that are difficult to see with just our eyes. You could say that a telescope is an improved version of binoculars. The first simple telescope was built by Hans Lippershey in the Netherlands in 1608. Galileo Galilei improved on this invention and is the first person known to have used a telescope for astronomy. We can use telescopes on Earth, but we can also send them into space so they are not disturbed by the Earth's atmosphere. The Hubble space telescope was launched in 1990 and orbits the Earth above the atmosphere, so it can take sharper pictures than are possible using a telescope on Earth.

HELP!

WHAT'S THAT? THERE'S ANOTHER ONE! DUCK!

Nuts and bolts, rockets and dead satellites! Oh no, it's space junk. Now we'll have to make sure that we and Mats don't get hit.

You'll have to read about it here, I don't have time to tell you.

He throws the computer at Obi, who reads aloud.

What – junk in space? What's that?

SPACE JUNK

Space junk – or space debris – is made up of the objects that people have sent into space, but which are no longer used. It can be broken old satellites or parts of space rockets. Space junk travels around the Earth at several kilometres per second and can collide with important satellites or space rockets carrying people at any time.

I really want to add tardigrades to this bit. Because I can't see a single person anywhere.

Shhhh, I want to keep reading.

Using telescopes and other instruments, we can keep track of how space junk moves around the Earth. It is possible to see and track items as small as five centimetres across. We believe that there are about 170 million pieces of space junk that we don't know about. These are often smaller than five centimetres.

I am getting really worried. What happens if one of those millions and billions of bits of debris hits us?

Zen crouches down as if he is going to be hit at any second. And that's a good thing, because suddenly a small piece of metal comes swishing past. Zen quickly pulls his head back and hides in the pipe.

In a firm voice, Wan says,

We have to deal with this. We must save Mats, right now!

MISSION 2

SPACE JUNK

Can you save Mats the satellite from the space junk? On this mission, you program a space game where the tardigrades collect space junk and protect Mats the Swedish satellite. You get a point for each ton of junk the tardigrades collect, but first you have to learn a little more about space junk.

1. What do you know about space junk and Mats the satellite?

1. What is space junk?

2. How can we keep track of space junk from down here on Earth?

3. What could happen to Mats the satellite when in space?

2. How heavy are the pieces of space junk?

We are now going to find out how much the pieces of space junk weigh. But there's a catch – you don't have any scales with you in space, so you can't weigh the objects until you are back on Earth. Luckily, the tardigrades have received a message to their computer that says how much all the space junk weighs. The message is a little tricky, and gives the answer in the form of mathematical challenges. Your task is to solve these challenges!

First you need to calculate what the pieces of space junk weigh.

You can find the task here: Matteboken.se/space-scrap

Something to think about

Foto: Lars-Erik Gothlund

The space rocket carried Mats the satellite 600 kilometres up. Can you describe how high 600 kilometres is using other words? For example, how many people have to stand on each other's shoulders to get that high, or how many Eclipses are needed. Eclipse is one of the world's highest star flyers. It is 121 metres tall and is at Gröna Lund amusement park, Stockholm.

3. Program a game about space junk

Now you're going to create a space game where the tardigrades will protect Mats the satellite from space junk. You convert the weight of the junk, which you calculated in the math task, into points.

You can find the task here: Kodboken.se/spacejunk

CHAPTER 3

JOURNEY TO THE MOON

In this chapter you will learn lots about satellites and how they can help us on Earth. You will also plan and make a journey to the Earth's own satellite, the Moon.

* Call from the Moon. Calling Obi, Wan and Zen. I repeat, calling Obi, Wan and Zen *

says a voice from Zen's back pocket.

Hurry up and answer! I need to talk to you now!

That sounded just like my cousin, Elin Mask. But what's she doing here? Where is she?

Zen turns around and looks even more confused.

What about answering your phone? I've fixed it so you get the important calls but don't need to press any buttons. Just say "answer" to take the call

Hmm, you do so many strange things.

Zen takes the mobile out of his back pocket and says "Answer".

Hi there cousin. How are things in the countryside? I mean up on your filling station on the Moon. Important things... help... now...

Zen mumbles and mmms in the phone and then hangs up.

We have to get to the Moon, pronto, because big things are happening!

We can't, Mats doesn't have an engine!

The tardigrades are stuck on Mats for now. They travel lap after lap around the Earth and can't get of.

57, 58, 59, 60... I'm counting satellites, they're everywhere. I wonder what they're doing up here?

We need our space rocket. It's on Earth, on Öland to be precise. We need Leia to help us, but where is she? Obi, can you stop sitting there counting? Come and help us work out how to find Leia instead!

Ahhh, you're world's best. I mean space's best! We're looking for Sentinels, of course!

Sentimental satellites? I don't think satellites have emotions. Wan, if anyone knows that, you should.

No, not sentimental – Sentinels. They're also called Copernicus satellites. Their job is to take pictures of Earth to discover fires, oil leaks from ships, air pollution, deforestation and lots of other things.

We'll simply have to use a rope to get to the first Copernicus satellite on its way past Mats. There's no time to lose.

Hold each other's hands. I have to aim right with the lasso so we can get across.

I can see one over there. Get ready. Grab your luggage.

And so the three tardigrades hold on tight to each other and their bags and head out into the unknown. A second later, they land on a speeding Copernicus satellite. It is busy taking picture of Earth and has no idea that it is now carrying three of the bravest tardigrades in the universe.

When they've caught their breath, and Wan has linked to the Copernicus satellite's computer, they can see the strangest images of Earth.

The satellite is moving amazingly quickly and spinning lap after lap around the globe.

I'm getting dizzy. I can't look at the screen!

Now they are above land and the image on the screen is getting increasingly red.

Yuck, it looks so dirty. It's getting redder and redder. What's happening?

I think we are above an area that has been polluted. This is where some of the things we often buy are made. Your jumper Obi, your four pairs of shoes Zen, and my backpack, they are all made here. There are lots of factories down there, and they emit a gas into the air. It's called nitrogen dioxide and is an air pollutant. There are similar areas in other places on Earth too.

No, we won't find Leia here, we'll have to keep looking. Look, here's another Copernicus satellite.

You're right! We're lucky, it's coming right when we need it. Get ready, it's time to throw the lasso again.

The tardigrades are now used to changing satellites. They quickly gather their belongings, grab hold of each other and use the rope to get to the next satellite. This time the satellite that gets to carry the tardigrades is heading straight across Öland.

Look over there. Is that a storm? What do you think?

Wan smiles a clever smile and points at a blue-green swirl in the sea off Gotland.

That's not a storm. You're trying to trick us aren't you? It's something that can be almost as bad as a storm, especially if you're a little animal...

It's an algal bloom! They're scary, as they can give you an upset stomach.

You're right, well done! Algal blooms can occur naturally, but can also result from human emissions of various substances, when it is called eutrophication.

Now the satellite is on its way across Öland.

Home again! Now we just have to find Leia. And how are we going to find her, she could be anywhere? At school, with her friends, at the shop...

If we know where she usually is, we'll find her. What does Leia love to do?

Watch YouTube. She loves watching films on YouTube.

Come on, you have to be serious Obi. Think about where she usually is instead.

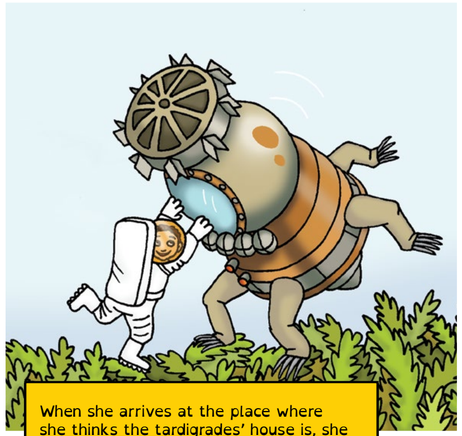
Wan has been quiet for a long time, but now he stands up and says

Obi, you're absolutely right. Leia loves YouTube and she watches it at home. We're going to move to that satellite. It's a communications satellite. We can send Leia a message from it. It'll be here in five seconds if I've calculated correctly. We can use it to link to Leia's computer, ask her to get the space rocket and travel up to us.

And that was that! The tardigrades throw their lasso one last time and have soon moved across to a new satellite. They are lucky they have Wan with them, because after a few minutes he connects to the satellite's computer and starts a video call. As usual, Leia has come home from school, had a snack and sat down for a while in front of the computer. She's going to watch her favourite youtubers. She has no idea that in just a few minutes she'll be going on a new adventure with the tardigrades. She's just started the first film when the tardigrades appear on her screen.

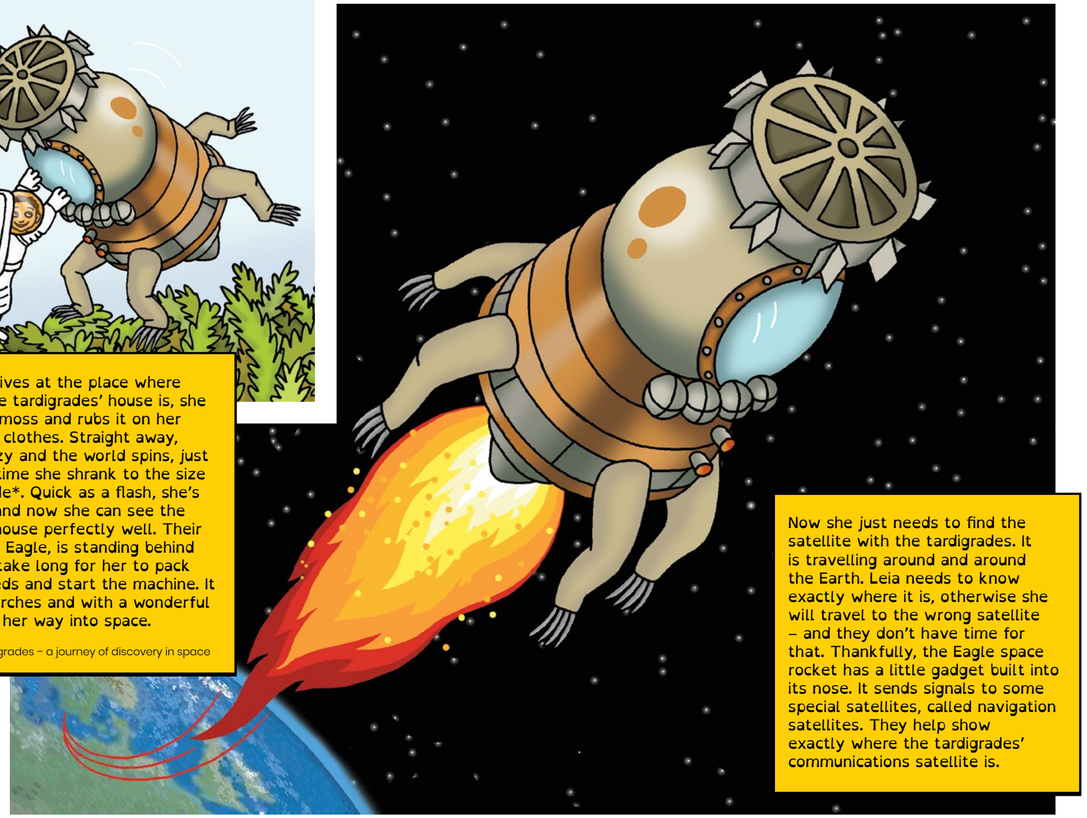
Leia, don't be scared. It's us, the tardigrades, and we need your help!

Leia jumps in surprise, what's going on? After they have explained that a new space adventure is underway, she doesn't hesitate. She packs her laptop and some bits and pieces. She writes a note to her dad saying that she'll be home for dinner, and goes out to Alvaret, where the tardigrades live.



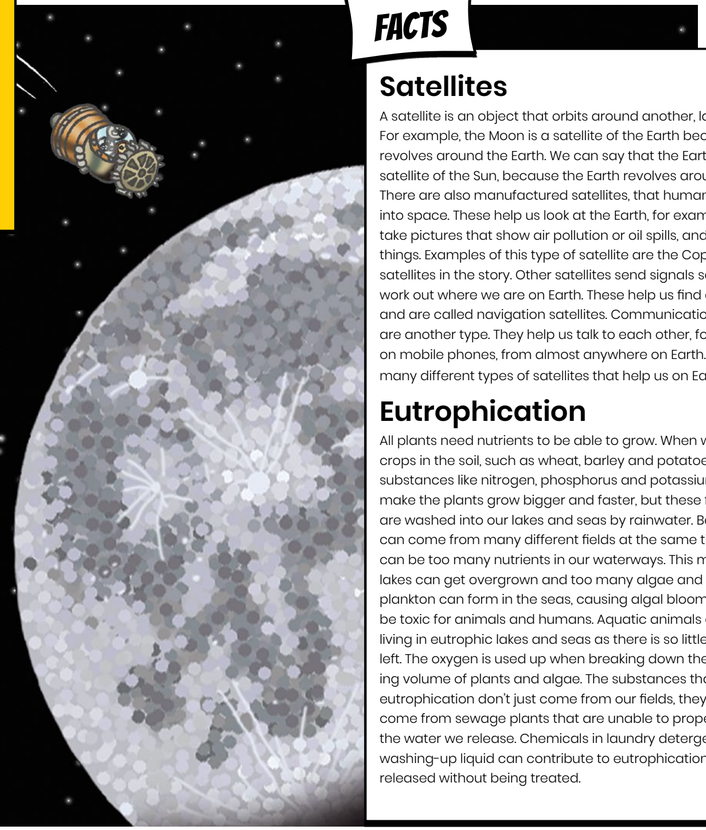
When she arrives at the place where she thinks the tardigrades' house is, she picks a little moss and rubs it on her nose and her clothes. Straight away, she feels dizzy and the world spins, just like the last time she shrank to the size of a tardigrade*. Quick as a flash, she's tiny again – and now she can see the tardigrades' house perfectly well. Their space rocket, Eagle, is standing behind it. It doesn't take long for her to pack what she needs and start the machine. It rattles and lurches and with a wonderful roar she's on her way into space.

*Leia and the Tardigrades – a journey of discovery in space



Now she just needs to find the satellite with the tardigrades. It is travelling around and around the Earth. Leia needs to know exactly where it is, otherwise she will travel to the wrong satellite – and they don't have time for that. Thankfully, the Eagle space rocket has a little gadget built into its nose. It sends signals to some special satellites, called navigation satellites. They help show exactly where the tardigrades' communications satellite is.

To say it's a happy reunion is an understatement. The tardigrades are happy to leave the satellite and Leia is happy to meet the tardigrades again. Now it's finally time to set a course for the Moon. The tardigrades are a little tired of satellites, and don't really think about how they are actually heading for the Earth's only natural satellite, the Moon. The question now is how quickly they can get there. Around fifty years ago, when the Apollo 11 space rocket travelled from the Earth to the Moon, it took 51 hours and 49 minutes.



FACTS

The Moon

The Moon is a natural satellite to Earth. It formed around 4.5 billion years ago. The surface of the Moon has about the same area as Africa. Its surface is rock and sand. There are two main types of landscape on the Moon, dark ones that are called seas and lighter ones that are called highlands. The seas on the Moon do not contain water. Instead, they are fields of lava that were formed when magma flowed out from inside the Moon several billion years ago.

FACTS

Satellites

A satellite is an object that orbits around another, larger object. For example, the Moon is a satellite of the Earth because it revolves around the Earth. We can say that the Earth is a satellite of the Sun, because the Earth revolves around the Sun. There are also manufactured satellites, that humans have sent into space. These help us look at the Earth, for example. They take pictures that show air pollution or oil spills, and lots more things. Examples of this type of satellite are the Copernicus satellites in the story. Other satellites send signals so we can work out where we are on Earth. These help us find our way and are called navigation satellites. Communications satellites are another type. They help us talk to each other, for example on mobile phones, from almost anywhere on Earth. There are many different types of satellites that help us on Earth.

Eutrophication

All plants need nutrients to be able to grow. When we grow crops in the soil, such as wheat, barley and potatoes, we use substances like nitrogen, phosphorus and potassium. They make the plants grow bigger and faster, but these fertilisers are washed into our lakes and seas by rainwater. Because they can come from many different fields at the same time, there can be too many nutrients in our waterways. This means that lakes can get overgrown and too many algae and phyto-plankton can form in the seas, causing algal blooms that can be toxic for animals and humans. Aquatic animals do not like living in eutrophic lakes and seas as there is so little oxygen left. The oxygen is used up when breaking down the increas-ing volume of plants and algae. The substances that cause eutrophication don't just come from our fields, they can also come from sewage plants that are unable to properly clean the water we release. Chemicals in laundry detergent and washing-up liquid can contribute to eutrophication if they are released without being treated.

MISSION 3

JOURNEY TO THE MOON

The first time that people travelled to the Moon was 1969. That journey was planned thoroughly and carefully, because space travel is not risk-free. Now, your task is to plan your journey from Earth to the Moon. On this mission, you will code a space game where your space rocket will travel between the Earth and the Moon. Before you start to code, you need to create a game board for your journey. Time for you to solve this challenge! When you plan a journey into space, you need to know lots about what is out there in space. You are going to begin by answering a few questions.

1. What do you know about satellites and the Moon?

1. What is a satellite?

2. The Moon is a natural satellite of the Earth. There are other satellites too, ones that people have sent into space. How can satellites be useful?

3. Air pollution can be seen from some satellites. What is it?

2. Plan and create your own game board for your journey to the Moon

You need to plan and create a game board with coordinates for your journey between the Earth and the Moon.

You can find the task here:
Matteboken.se/the-moon-journey

3. Code your journey to the Moon

Using the game board you created in the math task, you are going to program a space game where you use the coordinates to send the space rocket from Earth to the Moon.

You can find the task here:
Kodboken.se//journeytomoon

Something to think about

What can we do to reduce eutrophication and algal blooms, but still grow wheat, barley and potatoes?

CHAPTER 4

LANDING ON MARS

In this chapter, you will learn more about the Moon and Mars. You will get to know the eight planets in our solar system. Traveling to Mars isn't easy, so you will also learn about how to avoid collisions with asteroids.

Leia stands at the space rocket's viewing window and looks at the Moon.

I'd quite like to go swimming!

It looks like there are lots of lakes there. Look at all the dark patches. Here, on the map of the Moon, it says that this one is called the Sea of Tranquillity.

Once upon a time they were seas. Seas of lava that flowed from the inside of the Moon – not great for swimming in.

Zen slows the rocket down as they approach the Moon. Now they are going to travel round to the back of the Moon, where Elin Mask, Zen's cousin, has her filling station. But Zen is a little unsure about finding the way, because he hasn't been able to prepare properly. We can't see the back of the Moon from the Earth, we see the same side all the time. This is because the Moon rotates at the same speed as it rotates around the Earth. They need a steady hand if they are going to land safely. It's not entirely easy, because even though the Moon is small compared to the Earth, its craters are deep and have high edges. The tallest mountain on Earth, Mount Everest, would barely reach over the edge of several of these craters.

Finally, Eagle lands on the Moon and Zen breathes a sigh of relief.

Leia is the only one who needs to wear a spacesuit. The tardigrades can cope with almost anything, so nearly +100°C in the middle of the day is not a problem for them. Leia, on the other hand, complains about being hot and how awkward the spacesuit is. Not only that, but she needs to pee – and you don't want to have to do that when you've finally got into your spacesuit and onto the surface of the Moon.

You'll have to pee in the suit, like astronauts do.

Zen looks at Leia and grins.

No, Zen, that's disgusting! I'm not going to do what real astronauts do. Hold on.

Yippee, I'm floating! I'm light as a feather.

Obi feels light because the gravity of the Moon is just one-sixth of the Earth's. This means that you feel six times lighter on the Moon. Leia, who weighs 40 kilos on Earth, would feel as if she weighed just 6.7 kilos on the Moon – but now she's as tiny as a tardigrade and bounces around as easily as Obi. They skip around for a long time, before discovering that Zen's cousin has come to meet them.

I forgot to do something, I just have to say, "That's one small step for man, one giant leap for mankind".

Leia takes her first proper steps on the Moon.

I should be in the history books too now. No human has walked on the back of the moon before.

Zen's cousin has a nice little filling station. It has a shop with delicious things like sweets, ice cream, fruit, pizza and hot dogs, and you can fill up your space rocket with green fuel. The fuel isn't actually green, but it is environmentally friendly, so it's called green. Elin is a bit of an inventor too. She has developed a vehicle that runs on solar power. It's like a little hovercraft and Elin uses it to race against herself in the craters on the back of the Moon.

There's a bit of a rush, you see. I want to build an environmentally friendly filling station on Mars, but whoever gets there first gets the best place. I can't go myself, I have to run this filling station. A customer could arrive any day now, and I have a really important race tomorrow. I need your help. You have to go to Mars and build my filling station.

FACTS

The Sea of Tranquillity – landing on the Moon

The first humans landed on the Moon in 1969. It took several days for the Apollo 11 space rocket to travel there from Earth. While astronaut Michael Collins steered the rocket around the Moon, two other American astronauts, Buzz Aldrin and Neil Armstrong, landed the Eagle lunar lander in the Sea of Tranquillity. People used to believe that the dark spots on the Moon were seas, but they are actually lava that has cooled and turned to rock. They collected over 21 kilos of Moon rocks over two and a half hours and positioned instruments that would stay there after they left, and took lots of photographs. Neil Armstrong was the first person to walk on the Moon, and said the famous words, "That's one small step for man, one giant leap for mankind".

Leia and the tardigrades don't need to think about it for long. They're already having a space adventure and can definitely continue to the planet Mars. Soon they're back in the tardigrades' spaceship, Eagle, and on course for Mars. They have actually been to Mars once before, even if it was a quick visit. That time their mission was to mend a space robot, Curiosity.*

*Leia and the Tardigrades – a journey of discovery in space

The journey takes six months, so they need to take a lot of food and water. The tardigrades are tired of travelling and decide to sleep the whole way. They curl up and doze off. Leia, on the other hand, has decided catch up on all the YouTube films she's missed. She's sure she'll have plenty to do until they reach Mars.

The space rocket suddenly starts lurching and jumping. It lurches so hard that the tardigrades wake up and Leia falls off her chair. The space rocket has narrowly avoided colliding with Mars' two small moons, Phobos and Deimos.

These two moons aren't very appealing, so their names suit them perfectly. Phobos and Deimos is Greek and means fear and dread.

Zen's mum is from Greece and he's really good at Greek, which is very useful when travelling in space, as surprisingly many space objects have Greek names.

Zen unfolds the map of Mars. There's a map thanks to all the space probes that have been launched over the years, to look for Martians and other strange things. Unfortunately, researchers never found any Martians, but they did get great pictures of the planet. These were so good that a map of Mars could be made. This is very helpful right now, because they are looking for a quiet and flat place to land.

They were told to look for Elysium Planitia, but that's easier said than done. There are no signs and no one to ask. All they can see is red dust, stretching out for kilometres. Everything is red, red, red and even more red. There is a huge mountain on the horizon.

Dear friends, let us admire this gigantic mountain in silence.

They fall quiet, and Wan starts talking.

This is the highest mountain in the solar system, Olympus Mons. It is over three times as tall as Mount Everest, almost 30 kilometres straight up into the sky. Just imagine!

The others agree that it is a fantastic mountain, but think it's time to stop admiring the view and to get back to more practical issues, such as landing the space rocket.

FACTS

The solar system

Our solar system has eight planets, all orbiting our big, hot Sun. There are also several dwarf planets, and moons that orbit around the various planets.

Venus

Venus is easy to see from Earth because it is so bright. It is sometimes called the evening star or morning star. It is the hottest planet in the solar system, despite not being closest to the Sun. It is even possible to melt lead on its surface, as it can get as hot as +470°C there. This is because Venus' atmosphere is thick with carbon dioxide. It wraps around the planet like a lid and means that Venus is like a gigantic greenhouse. Venus is not only hot at the surface, but also has crushing atmospheric pressure: 92 times what we have on Earth. This pressure would feel as if you were diving 1000 metres deep in the ocean. The rain on Venus is sulphuric acid.

Mercury

This is the solar system's smallest planet and is closest to the Sun. One year on Mercury is 88 days, compared to 365 days on Earth. Its surface is quite like the Moon's and has many craters. The planet has no atmosphere and can be both icy cold, -173°C, and burning hot, up to +427°C.

Earth

Our own blue planet is named Tellus or Terra, but we call it Earth. Earth is the third planet from the Sun and, as far as we know, is the only planet with life. Out of all the planets in the solar system, only Earth has oceans. Around 70 per cent of its surface is covered by saltwater oceans, and the rest is continents and islands.

Mars

The red planet, Mars, is easy to see from the Earth with the naked eye. There are iron oxides in its atmosphere and on the ground, which give Mars its red colour. Mars is the closest planet to the Earth, and is like it in many ways. Mars has a summer and winter, there is ice and remnants of water and a very thin atmosphere, but the likenesses stop there. Its average temperature is -63°C. It is windy, dusty and dry. Mars has two small moons, Phobos and Deimos. The highest known mountain in the solar system, Olympus Mons, is about 25,000 metres tall and is on Mars.

Saturn

Saturn is the second-biggest planet in our solar system and could hold about 750 Earths inside it. This planet is most famous for its rings. They are really wide, as much as 272,692 kilometres, which is as far as seven laps of Earth. They can be 100 metres thick, which is as long as a football pitch. Each ring contains millions of different pieces, icy rocks and dust, everything from small grains of dust to pieces as big as a house. The temperature on Saturn is about -180°C. The planet has 31 known moons, and the biggest of them is called Titan.

Neptune

Neptune's name comes from the sea god, Neptune, because of its beautiful blue colour. Despite its name, the colour does not come from any seas, but from methane gas in Neptune's atmosphere. Uranus and Neptune are very similar. They have almost the same structure and size, and their magnetic fields are similar. However, Neptune has the solar system's most powerful winds. When the Voyager 2 space probe visited the planet, it measured winds of up to 2,415 kilometres per hour. Compare that to a hurricane on Earth, which has wind speeds of about 220 kilometres per hour. Neptune is the furthermost big planet in our solar system.

Jupiter

Jupiter is the biggest planet in the solar system, so big that more than 1000 Earths would fit inside it. It can be seen without using a telescope or other instruments. Jupiter is a dangerous place. It is surrounded by a powerful belt of radiation that would immediately kill a visiting astronaut. The radiation is so strong that it is even difficult for space rockets to survive when they orbit Jupiter. They also risk colliding with one of Jupiter's 60 or so moons.

Uranus

Uranus is so far away that it would take 3,000 years to drive there from Earth. With a rocket that travels at 11 kilometres per second, it takes 7–8 years. Uranus is a gas planet and is covered by clouds. Its green-blue colour is because there is a substance called methane in its atmosphere. There is a lot of ice inside the planet. Uranus also has rings, just like Saturn. The rings have been photographed by a space probe called Voyager 2. The space probe's visit also provided information about the planet's moons and Uranus' magnetic field and temperature. Voyager 2 is the only space rocket to have investigated the planet so far.

MISSION 4

THE MARS LANDING

Travelling to Mars is neither simple nor entirely safe. You must prepare carefully if you are to succeed. You're on your way from the Moon to Mars and have just found out that the time of day you choose to try to land on Mars can be very important. There are large asteroid belts moving around out there in space, depending on the time of day you choose to travel. Luckily, the tardigrades have created a program that simulates (tests something using a computer program) the chance of colliding with asteroids at three different times. Your task is to find out what time you have the biggest chance of successfully landing on Mars without colliding with an asteroid! Before this, you need to learn a little more about Mars.

1. What do you know about the Moon and Mars?

1. Describe what happened when people landed on the Moon in 1969.
2. Mars has two moons. What are they called?
3. Why are there such good maps of Mars?

2. Program a simulator for your landing on Mars

To work out which time is best for landing on Mars, you need to program a simulator that tests when there is the smallest risk of colliding with asteroids.

You can find the task here: Kodboken.se/landingonmars

3. Analyse the simulation and decide which time to land on Mars.

Using your simulation, you are now going to analyse the results and answer the question:

What time should I land on Mars to have the best chance of succeeding?

You can find the task here: Matteboken.se/landing-on-mars

Something to think about

Which of the planets in the solar system would you most like to live on? You cannot choose Earth. Explain why you chose that planet. Explain what is good and what is bad about the planet you have chosen.

CHAPTER 5

LIFE ON MARS

Finally, Eagle lands safely on the red dust. The dust is so red because it contains iron oxide. The friends peek out at the planet from Eagle's viewing window.

I miss my green moss, I really do. Isn't there any water here?

Obi looks questioningly at Zen.

Yes, there is actually. They have found ice at the poles in the winter – and look at these tracks in the sand. They look like riverbeds and lakes, don't they? There was once lots of water on Mars and there may be water below the surface, even if we can't see it.

It's so empty. I wonder if we're alone here? Nope, we're not, look over there!

Hi Curiosity! Nice to see you again, it's great you're still working.

FACTS

Research on Mars: Curiosity and Insight

There are several space robots on Mars. One of them is called Curiosity and has the task of investigating the planet's surface. One of Curiosity's major discoveries is that there is more water on Mars than previously thought. The robotic lander Insight landed on Mars on 26 November 2018. Insight studies what is far below the surface of Mars. Researchers hope that this way they will find out about the processes that shaped Mars and the other rocky planets in our solar system. Many people believe that Mars will be the planet that people travel to in the near future.

When Leia and the tardigrades made their first trip in the Eagle space rocket, they visited Mars on their journey through the solar system. They made a quick stop on Mars because Wan had been asked to mend the Curiosity, which investigates the planet's surface. It has an advanced laboratory where it analyses rocks and Martian soil and then sends the information back to Earth.

Look, Curiosity has a friend!

Another robot is standing and working next to Curiosity.

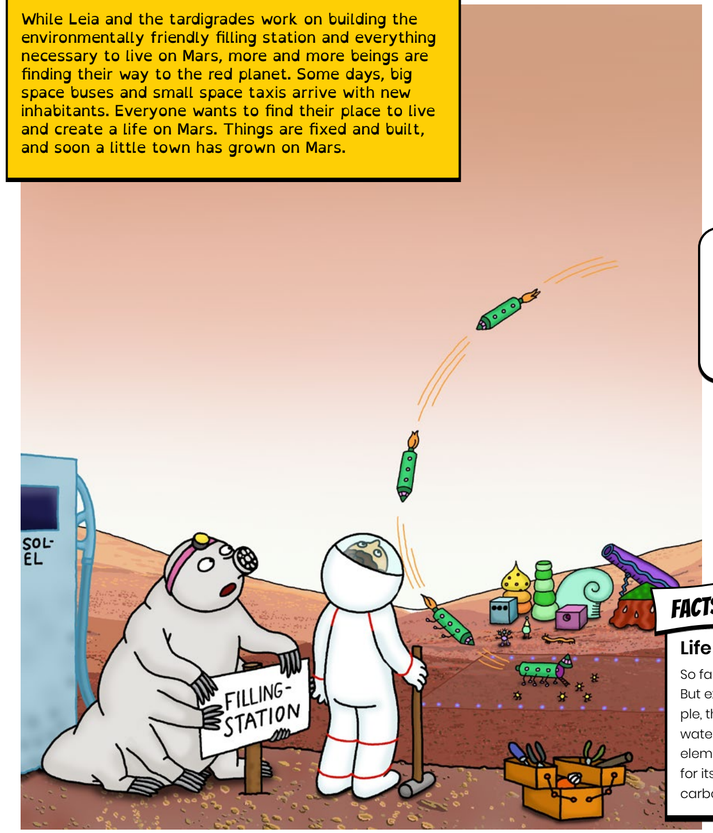
It is Insight. It's quite new on Mars, like us. It is measuring the inside of the planet. It has three instruments. One measures movements and vibrations in the ground. Another instrument measures how much Mars' north pole moves, and the third instrument is a thermometer that measures the temperature five metres below the surface. This is why Insight has its own drill.

Leia looks at the robots, with a smile.

Those space robots are really working hard. We have to work hard as well, because we have to organise everything we need and everything we want on our own. There aren't exactly any shops here. Obi, what do we need?

I want vegetables. I really want carrots and broccoli. And sweets, crisps and a fizzy drink! Hmm, I'd like oxygen to breathe and water to drink and some warmth.

While Leia and the tardigrades work on building the environmentally friendly filling station and everything necessary to live on Mars, more and more beings are finding their way to the red planet. Some days, big space buses and small space taxis arrive with new inhabitants. Everyone wants to find their place to live and create a life on Mars. Things are fixed and built, and soon a little town has grown on Mars.



No, I can't cope with this anymore!

Obi looks unhappy. He's once again come home from the shop and discovered that his box of eggs is full of golf balls.

And yesterday it was a raisin packet that was full of almonds. I'm really allergic to almonds! We need organising. You can't just do what you want!

You're right. But who should make sure that Mars gets organised? Who should decide?

This is a good question, because the beings come from all sorts of places in the solar system and are used to different rules and ways of organising things. Even the ones from Earth have different ways of solving issues and opinions about who has the right to decide.

FACTS

Life in space

So far, we humans have only found life in one place in space, and that's on Earth. But exploration continues. We are looking for planets that are like Earth. For example, they should have the same distance to their star as we do to the Sun. Flowing water on a planet increases the chances of there being life there. We also look for elements like carbon, hydrogen and nitrogen, substances that life on Earth requires for its development. On Mars, there are traces of organic substances that contain carbon. Perhaps there was once life on Mars.

MISSION 5

LIFE ON MARS

Leia and the tardigrades were the first beings to arrive on Mars. No one had settled there before. Later, beings arrived from all over the solar system, with different experiences and ideas about how they want to live. The more beings arrive, the greater the need for law and order, schools, healthcare and other necessary things for life to function. The inhabitants of Mars need to cooperate if they are to build a good society. This is not always easy, because everyone has different opinions about what a good society is.

Your task is to think about how you would build a safe, good society on Mars. First, you need to answer a few questions.

1. What do you know about life in space and research on Mars?

1. Is there life in space?
2. Space robots were the first to land on the surface of Mars. What are the Curiosity and Insight doing on Mars?
3. Why was Obi so grumpy after he went shopping?

Something to think about

If you had travelled with Leia and the tardigrades and had the task of settling on Mars, what would you need to live on the planet? Write a list of the five most important things you think you need. Draw and describe.

2. Building a society where we thrive

Your task is to think about what you think a good society should be like. Do this task in groups, so you can help each other and discuss what is necessary to build a society. Use the following questions to help you:

1. How can the tardigrades, Leia and all the beings on Mars agree on how things should be run on the planet?
2. What rules are needed for them to be happy?
3. How are the people who decide appointed?

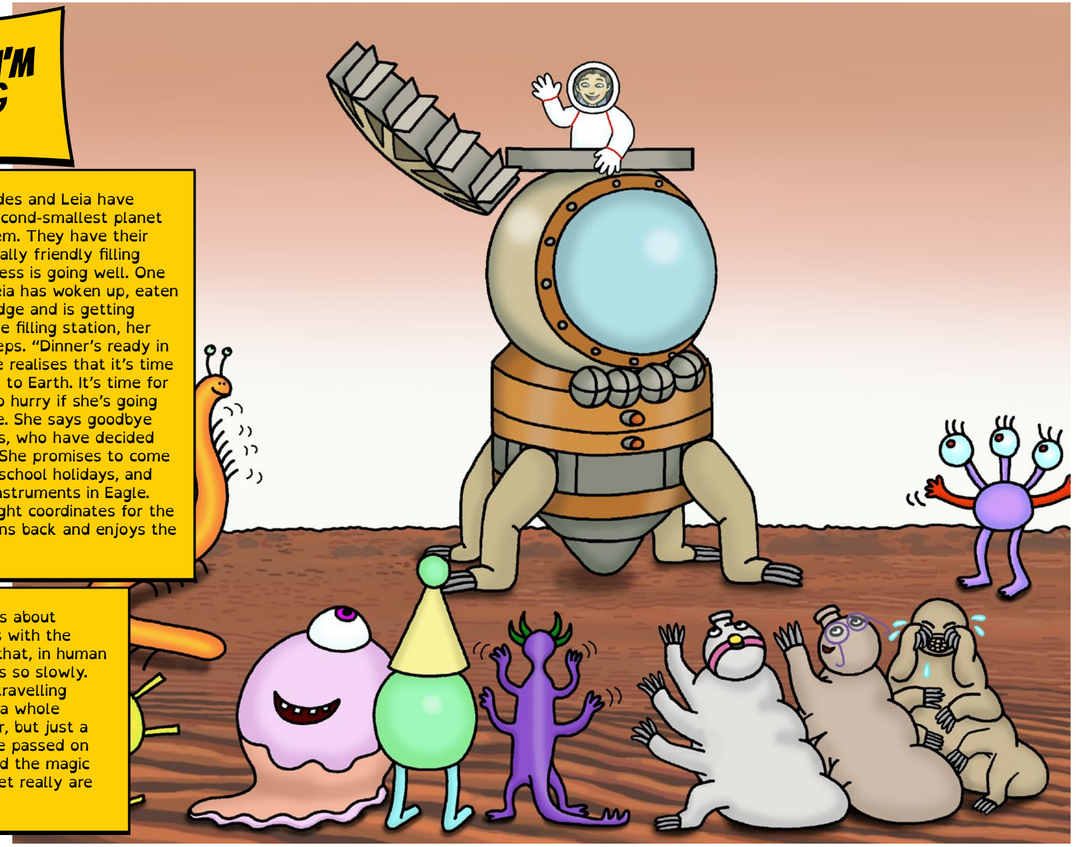
Take a big piece of paper. Draw and write what you would do to build a society on Mars, with rules and agreements. For example, would you allow human rights to apply to all beings? If so, explain which of them and what this means. When you have finished, put your paper up in the classroom and tell your classmates how you reasoned.

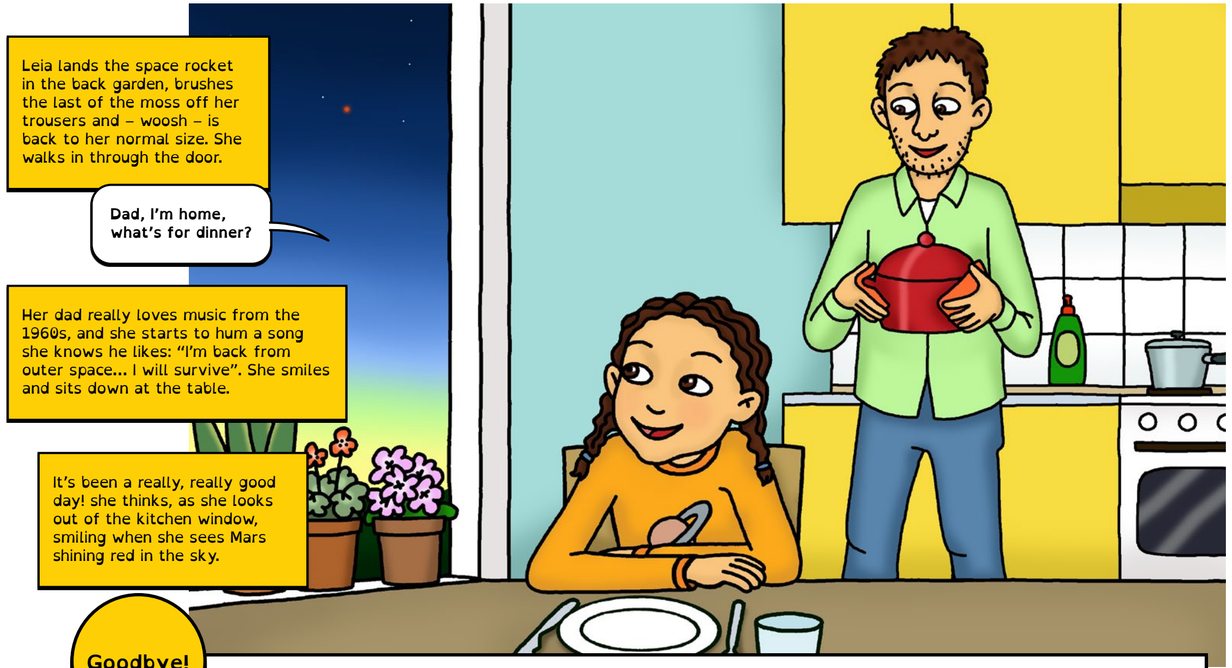
EPILOGUE

EARTH, I'M COMING HOME!

Now the tardigrades and Leia have settled on the second-smallest planet in the solar system. They have their own environmentally friendly filling station and business is going well. One morning, when Leia has woken up, eaten her Martian porridge and is getting ready to go to the filling station, her mobile phone beeps. "Dinner's ready in ten minutes!" She realises that it's time to go home, back to Earth. It's time for dinner. She has to hurry if she's going to make it in time. She says goodbye to the tardigrades, who have decided to stay on Mars. She promises to come back in the next school holidays, and then starts the instruments in Eagle. She enters the right coordinates for the space rocket, leans back and enjoys the journey home.

The best things about her adventures with the tardigrades is that, in human time, time goes so slowly. She has been travelling for more than a whole tardigrade year, but just a few hours have passed on Earth. Time and the magic moss on Alvaret really are mysterious.





Leia and the tardigrades' journey has finished, for now. Leia is back on Earth and the tardigrades have settled on Mars. We hope that their journey has made you want to find out more about space, that you have seen how useful counting is and that you have solved some difficult tasks by programming exciting games. In your work you have benefitted from combining different subjects and solved many tricky challenges. Good work!

There are more enjoyable maths exercises here: matteboken.se

Exciting programming tasks can be found here: kodboken.se

You can find out more about space here: rymdstyrelsen.se

We hope you've enjoyed it!

LEIA AND THE TARDIGRADES

CRACK THE SPACE CODE

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LEIA AND THE TARDIGRADES

CRACK THE SPACE CODE

Teaching material for Primary school Years 4-6, on space, mathematics and programming.

The material is produced by Kodcentrum, Mattecentrum and the Swedish National Space Agency and builds upon current Swedish space research.

Visit our websites Kodcentrum.se, Mattecentrum.se and Rymdstyrelsen.se for more material and inspiration about math, programming and space.