Once upon a time... a scientific fairy tale

Volume II

Short stories about our planet and the world of research, written by scientists

'What place would you advise me to visit now?' he asked.
'The planet Earth,' replied the geographer.
'It has a good reputation.'

The Little Prince
Antoine de Saint-Exupéry

Several scientists will accompany you on the journey.

Once upon a time... a scientific fairy tale – Volume II –
OUAT team

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Once upon a time... a scientific fairy tale

– Volume II –

Once upon a time, there was a brave young girl

She shouted aloud for all to hear: 'We have to start treating the crisis like a crisis—and act even if we don't have all the solutions' and 'Listen to the scientists!' She went on strike from school, marched through the streets proclaiming her message and fearlessly faced and challenged world leaders. Her actions inspired children and adults all over the world to take to the streets, to social media and to their local communities to voice their own concerns regarding the climate crisis and the future of society on our planet.

These profound actions and the simple message of the young climate activist Greta Thunberg created a new viral platform, bringing people together to counteract the advancing global warming. Although major actions against human-made climate change, overexploitation of resources and pollution are still to be taken, and it will take a long time before their environmental benefits become visible, collective acts of public education and demonstrations about the climate crisis across the globe are a sign that the population is ready for them and willing to make them happen.

The 'Once Upon a Time' team was founded in 2016 by a group of scientists who want to be listened to. Scientists who want to transfer knowledge as entertainingly and comprehensibly as possible without compromising on accuracy or scientific precision. In 2017, we published a first volume with stories about the threats that the Earth is facing and the amazing secrets it holds for us. The current lust for knowledge and action in environmental matters now provides the perfect backdrop for the launch of our second volume packed full with new fun and factual tales.

Immerse yourself in these stories and scientific facts about our planet and its inhabitants and share them with others. Take a dive with Ollin and Phoenix to the bleaching coral reefs or dive much deeper to the deepest place in the ocean—the Mariana Trench—on a thrilling voyage. Read Earth's own telling of its history and let the beautiful scarlet birds of Brazil tell you about their unique home: the mangroves... These are just some of the intriguing tales waiting to be discovered within these pages.

As you learn more about our amazing planet and your role in everything, consider what actions you and your family can take to protect our planet—our home—and to ensure a good future for every living creature on it. You can find some of those actions in this volume and many more in volume I.

We hope you have a wonderful journey!

Hadar Elyashiv and *Gema Martínez Méndez*
on behalf of the whole team
Bremen, 11th February 2021

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My life, your life

Rodrigo da Costa Portilho Ramos and Sonja Böske da Costa
Illustrations: Yuly Lorena Allende

Allow me to introduce myself—I am the Earth, the beautiful blue planet on which you live.

Today, I am going to tell you a little bit about the story of my life, which will hopefully also help you to understand more about who you are and how the world around you developed. I will be talking about evolution and I will also explain how your life and mine are intertwined and why right now I need some help—YOUR help!

Let me start at the very beginning. They say that everything—including space and time—was created about 13.8 billion years ago during an event called the Big Bang. I wasn't there to witness it because I was born a long time after it happened. My story begins 4.6 billion years ago and it begins with loneliness.

In the beginning, I was very sad and lonely because I was all alone. I was extremely hot with lots of active volcanoes spewing lava and toxic gases into the air. No rainwater could reach my surface because everything evaporated before even touching me. There was no oxygen either. To make things worse, I was being bombarded by thousands of meteors coming from space every day. Life could not exist; I was a very hostile environment for anything living. Just imagine—for millions and millions of years I was all alone... with no humans or other animals, no plants...to keep me company.

It took about a billion years for me to cool down and become less hostile. When I did, rain was finally able to reach my surface and water started to accumulate in the first lakes, lagoons and oceans. Soon, life appeared in these new environments.

In the ocean, the first living organisms began to develop, the so-called microorganisms, which are really miniscule creatures comprising one cell. It is even possible that some of the new inhabitants originally arrived on the meteors that fell from space. I am actually not sure myself how it happened; I just know it was very important for me that it did happen!

At some point, small green algae began to grow in the ocean. These algae were able to produce and release oxygen into the water, and from there a lot of it escaped into the air. Over time, this oxygen accumulated and helped to form a new **atmosphere**, which was essential for the development of life outside the oceans. The presence of oxygen opened the door for the development of new life forms. It is what you use now to breathe and to live.

Almost 600 million years ago, the microorganisms evolved into larger and more complex organisms. Soon the oceans were filled with more complex life.

Oh, sorry—when I say 'soon', I am thinking in my timescale. You do remember that I am 4.6 billion years old, don't you? So, a few million years for me are 'soon'.

So—what did that evolution actually look like? Well, imagine colourful fish swimming between rocky shores, jellyfish dancing all around, sharks swimming through the waters...it was absolutely beautiful!

Being beautiful is one thing, but, as you know, cleanliness is also important for staying healthy, too. Thankfully, there are animals such as mussels and clams which filter the seawater and act as 'cleaning staff' for the ocean. I am grateful that they exist, too.

But after that, the whole thing really started. Over millions of years, I witnessed so many beautiful developments in, on and above me. I was blessed to witness fish crawling from the sea and turning into amphibians. Then I watched these pioneers produce their first hard-shelled eggs. They later developed into the first lizards and snakes. At some point, life even conquered the air around me. The first flight attempts were still a little sluggish, but soon there were a lot of flying animals. I was absolutely thrilled.

Around that time, I was especially excited for another reason: there were many animals and plants that actually look quite similar to how they do today, only much bigger. For example, there were huge dragonflies about as big as present-day hawks. When these dragonflies flew from swamp to swamp, they helped to spread plant seeds. This allowed the huge lycopods (club mosses), horsetails and ferns to spread faster. Dense evergreen forests formed, covering mountains and valleys. Such forests offered good shelter for amphibians, which could sometimes grow up to six metres long. My life was amazing!

In all honesty, I can say that I was (and I am sure you will agree, still am) very pretty, colourful and full of life. And I was happy. Finally, no more loneliness: animals, plants, fungi and other organisms living

together in complete harmony for the most part. I was very healthy. Even though I was sometimes a little bit out of balance, I always had enough time to get used to the new circumstances.

Another very exciting time for me occurred around 200 million years ago. At that time, the largest land animals of all time ruled the Earth: the dinosaurs.

They existed in all shapes and colours: some were gigantic and slow, others were small and agile. Some had long necks, others had very short arms. Some of them could fly, whilst others decided to go back into the water and reclaim the ocean. Overall, everything looked very promising for the dinosaurs. But then, something happened that nobody had expected...

Suddenly, BOOOM, a giant meteor hit me, coming from outer space.

Forests burned, black smoke filled the skies and blocked the sun's rays. **Acid rain** polluted the oceans and killed almost everything that was alive. It reminded me of the hostile early years of my existence. So, for me, it was (almost) back to loneliness and sadness. I had experienced **mass extinctions** before, but this time everything happened so fast. My climate and my environment changed so quickly that it seemed impossible that organisms would have any time to adjust to the new conditions. I genuinely thought that life was coming to an end...

Imagine how happy I then was when I discovered that there were still some forms of life! For example, I noticed many small mammals living in caves and tunnels underground! Some fish and cold-water corals that lived in the deep dark sea had also survived. Soon the world of plants also recovered completely. From these survivors, a whole variety of life forms developed and a new era began.
From your point of view, almost nothing has ever happened really 'fast' in my whole history, but I was very surprised to see very varied and diverse fauna and flora only a few million years after the mass extinction of the dinosaurs.

I saw horses galloping around the plains, giant sloths eating fruits from the big trees, mammoths and sabre-tooth tigers roaming the forests. I saw your ancestors making fire, working with stones, crafting new tools and inventing the wheel. It was amazing and I loved hosting so many amazing developments.

I have just told you how animals and plants have been developing and changing on me over millions and millions of years. New climate and environmental conditions allowed the development and adaptation of older life forms into new ones better accommodated to the prevailing conditions. This is what is called 'survival of the fittest' in one of the most accepted theories in science. It means that only those best adapted to the environment survive and have babies to ensure future generations. Species which do not adapt to new environments go extinct sooner or later. However, if a species succeeds in adapting step by step, new species with new traits can evolve. In most cases, however, these steps take millions or at least thousands of years.

As you can see, my story is one of change. Changing environmental conditions are therefore by no means something 'bad' per se. On the contrary: they made me who I am today. However, it is also not about how much our environment changes, but about how quickly everything happens. You really don't have to worry about me. I know that I will recover from any change, sooner or later. The question is whether this will happen with or without you humans.

So far, only a few species have been able to change the living conditions on me. One example of such a living being are the algae which first produced oxygen and thereby dramatically changed the environment. However, this change happened over millions of years. It was a very slow process. Nowadays, humans are the ones who influence my environment the most. Everything is changing so fast that my head is spinning!

Change has sped up a lot since the invention of the steam engine. Humans have been using their intelligence to create new machines which continuously improve the quality of their lives. Please, do not

get me wrong: innovations are great, and I am amazed at how the human brain has developed and how humankind has come up with all of those smart things. However, many of these inventions at this point use **fossil fuels**. When the fuel is burned in an engine, it produces CO_2 and other gases, which are released into the atmosphere. These gases are also often referred to as greenhouse gases because they function similarly to the walls of a greenhouse, letting the solar rays in but preventing heat from escaping (this way plants in a greenhouse grow even when it is too cold for them outside).

Put simply: this greenhouse effect is the reason why I am getting hotter. The atmosphere around me is changing and this is changing my climate very, very fast. Millions of years used to be fast for me. Imagine now how I feel with this happening over a few centuries or even decades! I am overwhelmed! I have never yet seen any species change the conditions on me so quickly in my whole life.

Because of you, humans, I am experiencing a new mass extinction. If you do not modify your behaviour very, very soon, I am really frightened about experiencing a very dramatic one.

I am merely a planet; I have seen many different life forms come and go. There were dinosaurs and now there are humans prevailing on me. Perhaps in the future, I will host other life forms. It is nature's way of evolving. I know, I should not care, but I really like you guys and I would be happy to host you humans much longer.

Dinosaurs did not have a choice, their death was caused by an external event, but YOU can change your fate. The beautiful thing is that:

EACH AND EVERY ONE OF YOU CAN CONTRIBUTE EVERY DAY AND MAKE A CHANGE!

Generally, make sure to use the resources on me, your planet Earth, with care. Act as sustainably as possible. There are so many ways to be more sustainable. Here are some ideas for what you can do:

- You could eat less meat, as mass animal production not only emits greenhouse gases but also uses a lot of water.

- Save water. Take a shower instead of a bath. When you turn on the tap, collect the cold water until the water flow turns warm and use it to water your plants. Do not leave the water running while you brush your teeth.

- Do not litter! When you go to the beach or walk in the street collect rubbish and put it into the bins provided. The environment will thank you—but be careful with sharp objects. Make sure not to hurt yourself and do not forget to wash your hands afterwards!

- Rethink the way you shop: reduce plastic waste by not buying wrapped products or using plastic bags. Reuse as much as you can and separate your rubbish to support recycling efforts! When you are about to buy something, think of the 5 Rs! Rethink (Refuse), Reduce, Reuse, Repurpose (Upcycle) and Recycle!

- You could grow your own vegetables in the garden: the more organic, more locally and seasonally grown, the better your vegetables are. Transporting food in container ships and trucks uses fossil fuels and emits CO_2. If you eat food from your garden (or the local region), you transport it to your kitchen table yourself (or from nearby) and Planet Earth loves that.

You may remember that I gave my story the title **'My life, your life'**,and I think now you understand why. My life and your life are very much interconnected. If I am feeling good, you also have a chance to feel good. If my current environment is destroyed, your life will change for the worse as well.

There are so many ways to make me—your planet Earth—a better place!

Thank you so much for contributing!!

What a wonderful world

I see trees of green
Red roses too
I see them bloom
For me and you
And I think to myself
What a wonderful world

I see skies of blue
And clouds of white
The bright blessed day
The dark sacred night
And I think to myself
What a wonderful world

The colours of the rainbow
So pretty in the sky
Are also on the faces
Of people going by
I see friends shaking hands
Saying, 'How do you do?'
They're really saying
'I love you'

I hear babies cry
I watch them grow
They'll learn much more
Than I'll never know
And I think to myself
What a wonderful world

Yes, I think to myself
What a wonderful world

Oh yeah

Lyrics: George Weiss / Robert Thiele

Would you like to know more?

An **atmosphere** is a layer of air formed by a mixture of gases that surrounds a planet and is maintained around it thanks to gravity. In the case of the Earth's atmosphere, today, it is composed predominantly of nitrogen (78 %), oxygen (21 %) and 1 % of other gases, such as argon, helium, neon and carbon dioxide (CO_2 accounts for 0.04 %). It protects the Earth from the dangerous ultraviolet rays that come from the sun. Most life has adapted to breathe oxygen; nitrogen is essential for building life components and carbon dioxide is required for photosynthesis.

Acid rain is rain with an unusually low pH level, meaning it contains acidic components such as sulphuric or nitric acids mostly generated by human pollution and/or volcanic eruptions. Imagine rain made of lemonade without water and sugar. It can have harmful effects on plants as well as on animals and some human health problems have been associated with acid rain, too. It can also cause paint to peel, steel structures such as bridges to corrode and stone buildings and statues to erode.

Mass extinction is the disappearance of a large number of species of animals, plants and other organisms within the same time frame. It can be caused by climatic and environmental changes and/or catastrophic events like the meteor impact, which was the case for the extinction of the dinosaurs around 65 million years ago.

Fossil fuels are mineral substances originating from the decomposition of organic matter under conditions of high pressure and temperature within the deep layers of the ground and/or the seabed. The process of the transformation of organic matter into fossil fuels can take millions of years, so they are considered non-renewable natural resources. They are burned in order to be used to generate energy, power engines and vehicles, generate electricity (in the case of thermoelectric power plants), etc. The burning of fossil fuels is the main cause of the growing concentration of greenhouse gases in our atmosphere. The most well-known fossil fuels are coal, natural gas and petroleum derivatives such as petrol and diesel.

The goat and the tree

Denise Müller-Dum
Illustrations: Yuly Lorena Allende

The little goat is up for a hike.
She packs a stick and the hat that she likes.
She walks up the mountain, enjoying the view,
until she feels like a break might be due.

A big, leafy tree provides her with shade.
The little goat thinks: 'Oh my! I can't wait
to take off my shoes and sit down for a while.'
She settles down onto the grass with a smile.

Leaning her back up against the tree,
she says, 'It's really nice for me
to have this comfy resting spot,
which I appreciate a lot.'

'You're welcome,' a gentle voice replies.
'You can talk?' says the goat in surprise.
'I can,' says the tree, 'did you not know that?'
The goat shakes her head and takes off her hat.

'We talk, we think, we feel just like you.
We make the whole planet liveable, too.
It's because of the oxygen that we trees provide,
that you animals can all breathe and survive.

'That's nice,' says the goat. 'Well, thank you for that.
And many thanks too for the shade and the chat!'
'You're welcome. And one more thing you should know:
trees also help keep CO_2 levels low!

I'm sure you've heard tell of CO_2,
a gas that they call carbon dioxide too.
Its amount in the atmosphere matters a lot,
as if there's too much, it can get very hot!

But trees do absorb it and store it within.
It helps us grow too, so it's truly win-win,'
the tree says with pride, but makes a sad face:
'There really is only one problem these days.

Humans are tearing down forests so fast,
I'm really not sure how much longer they'll last.
Dying trees release much CO_2,
but humans don't care; it is just what they do.'

'But if carbon dioxide makes our planet so hot,
humans should try to stop it, or not?'
The tree smiles, shrugs and starts to explain,
'Those humans love growth and wealth and gain.

They need the space for all of their crops
like palm oil and soy and corn and hops.
They need it to fatten up their stock
and then they kill it.' The goat looks shocked.

'To eat it,' continues the tree, 'that is true.'
'They love their meat. And lots of it, too!
Other plants are grown to make oil.
They're destroying the forests and draining the soil.

The forests are suffering,' the tree says saddened.
The goat responds, visibly maddened:
'Then humans should do something before it's too late.
That must not be our planet's fate!'

The two fall quiet, not quite sure what to say.
'I'd best head back, it's late in the day,'
says the goat. When suddenly on the trail they spot
a group of humans. Believe it or not.

Four hikers approach, and settle at last,
sitting down by the tree and the goat in the grass.
After listening to them as they chat for a bit,
the goat can hold back no more: 'That's it!

You guys make me mad. You're hanging around,
while everywhere forests are razed to the ground.
The planet is suffering because of your greed.
Our forests and nature are in dire need.'

The hikers are startled, quite taken aback.
A goat that can talk. Now who's heard of that?
But even greater so their surprise,
when the tree up above also speaks to the guys.

'You're mean,' says the tree, not really amused.
'You can talk too?' ask the bewildered accused.
In the meantime, the goat starts anew:
'That's enough! You're ruining our climate, too!'

'We know,' one hiker guiltily replies.
'We are really sorry! We apologise!
You're mostly right, but please be fair.
Not all humans are bad, some of them really care.

They recycle, they share, they travel by bike.
They purchase less stuff, don't just buy what they like.
They do not eat meat, or at least they eat less.
They're well aware of this ecological mess!'

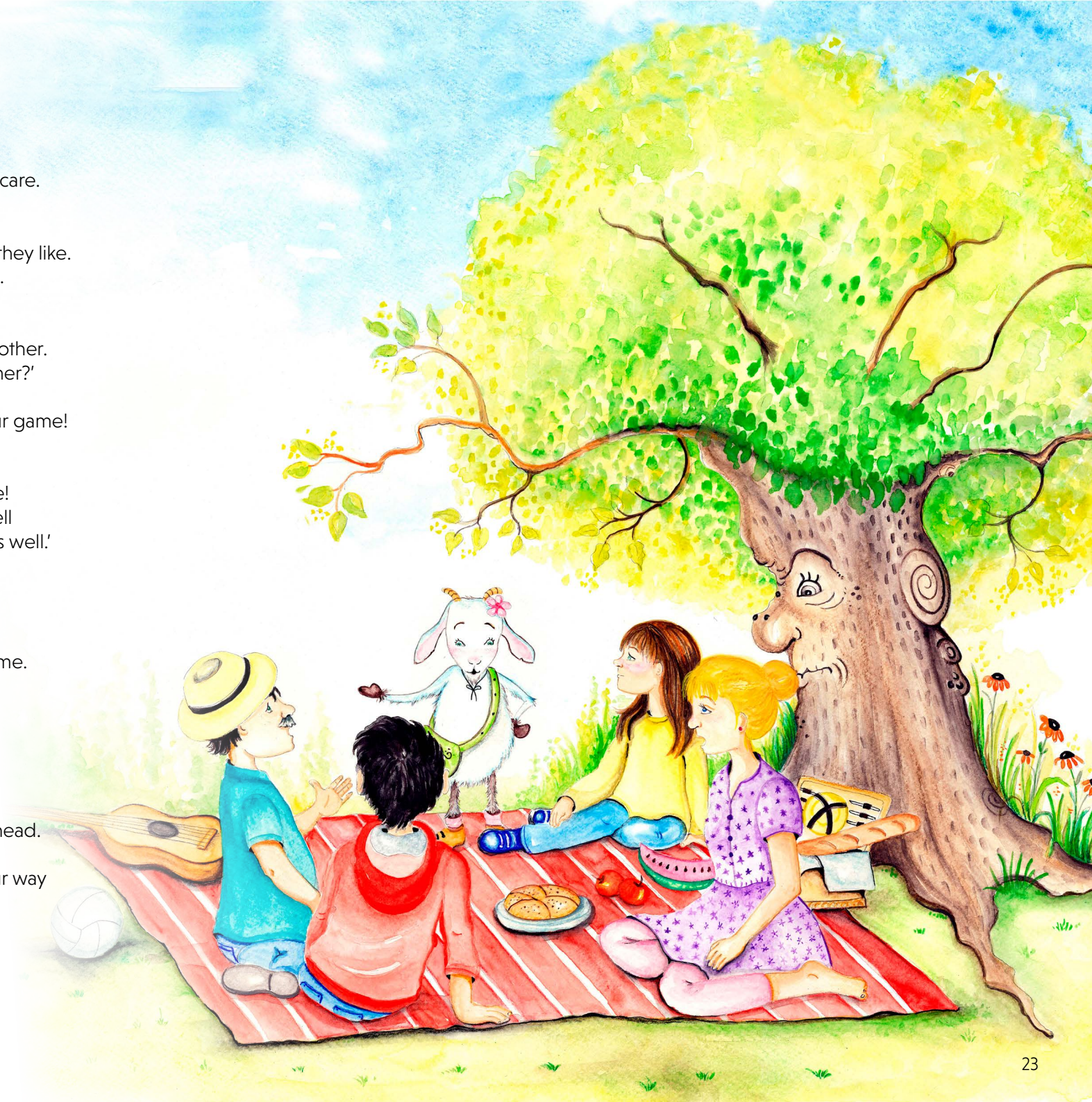
The goat and the tree stop and look at each other.
'And do you adhere to this agenda, my brother?'
The hikers shake their heads in shame.
The tree says, 'Then you'd better step up your game!

No one can save the planet alone;
but you have to get out of your comfort zone!
You clean up your own mess and then you tell
your friends and your neighbours to do so as well.'

The hikers nod. 'You're right, we should take
responsibility, because nature's at stake!'
Then they pack up and get ready to go,
they wave their goodbyes and set off for home.

After they're gone, the goat concludes,
'I guess it's up to them what they do.
I really hope that they will act wisely
and treat our planet and nature more nicely.'

The goat ties her shoes, puts her hat on her head.
'It was really nice here, I'm glad that we met.'
The tree nods and says, 'Now be safe on your way
and feel free to come visit again some day.



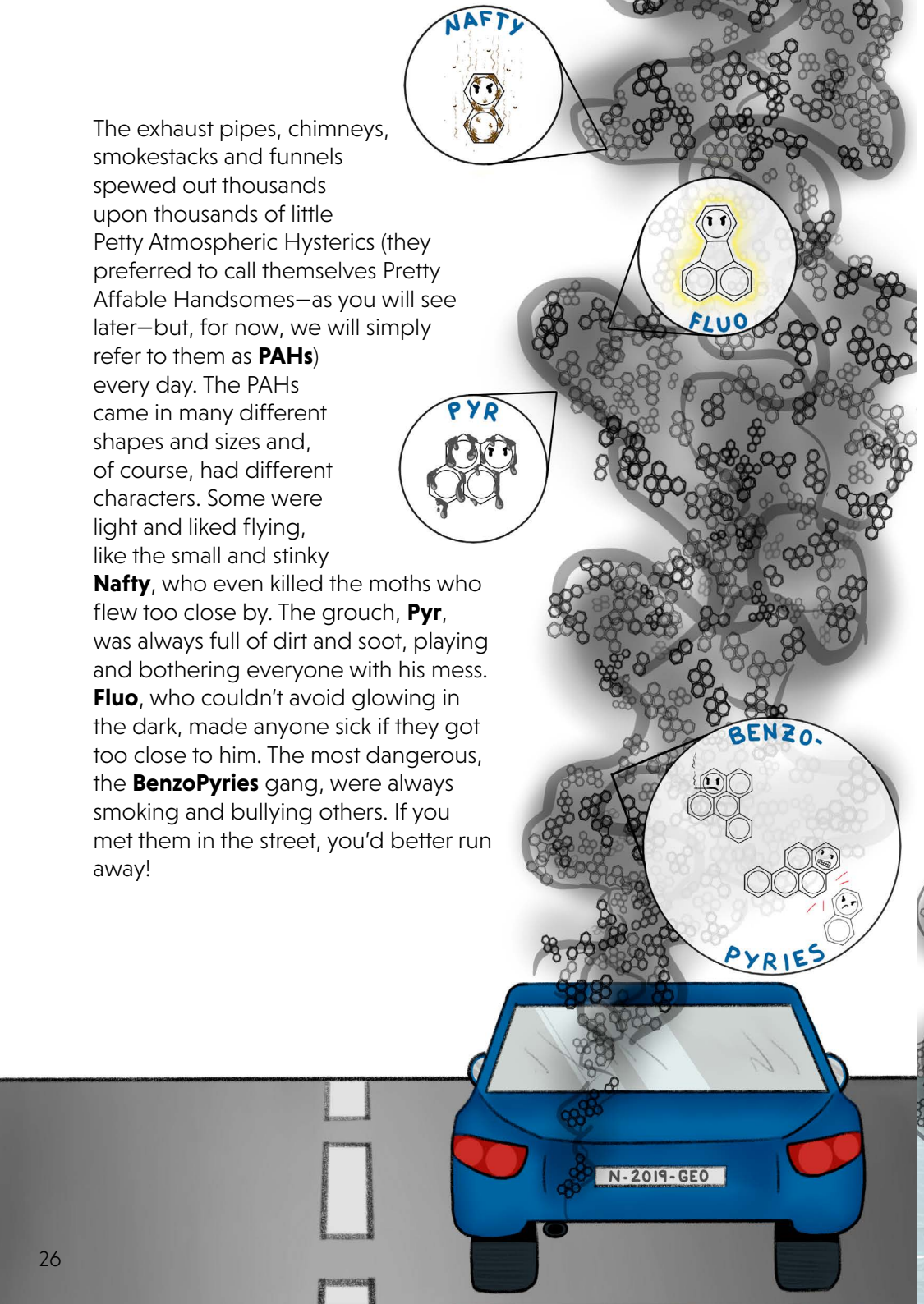
The lonely bacterium and her toxic friends

Belén González Gaya and Maria Vila Costa
Illustrations: Aida Zuriñe Campos Vivanco

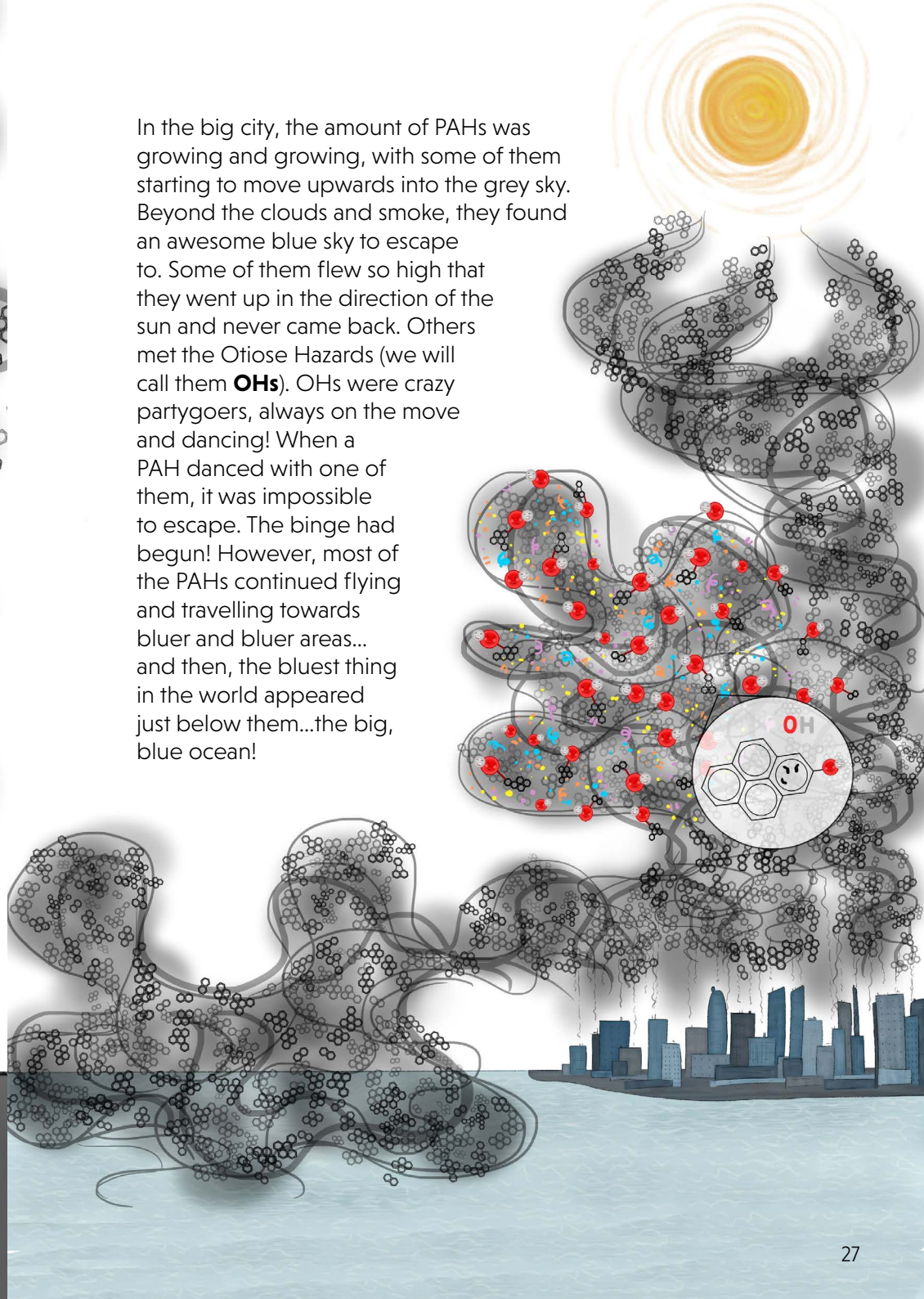
Sarah was a **bacterium** who lived on the surface of the open ocean, the part of the ocean furthest away from the coast. She often felt lonely because she was very shy, even when trying to talk to her friends. Her friends were outgoing, like ***Roseobacter***, who was so pink and glamorous, always surrounded by **algal cells**, and the glutton ***Alteromonas***, who could spend the whole day eating non-stop. Sarah preferred the quiet and peaceful life, looking up at the sun, drifting slowly here and there on the marine currents. Still, she missed someone she could share that peace and tranquillity with...

Far away on the land, in the big city, the way of life was faster and more stressful. People moved quickly from one place to another with shiny new cars, aeroplanes, boats and trains. Factories and industrial plants produced all kinds of things all day long, non-stop manufacturing to feed the rapid growth of the city and its people! In that city, all the houses had tall chimneys to keep the people warm and cosy, as the winters there were quite harsh.

The exhaust pipes, chimneys, smokestacks and funnels spewed out thousands upon thousands of little Petty Atmospheric Hysterics (they preferred to call themselves Pretty Affable Handsomes—as you will see later—but, for now, we will simply refer to them as **PAHs**) every day. The PAHs came in many different shapes and sizes and, of course, had different characters. Some were light and liked flying, like the small and stinky **Nafty**, who even killed the moths who flew too close by. The grouch, **Pyr**, was always full of dirt and soot, playing and bothering everyone with his mess. **Fluo**, who couldn't avoid glowing in the dark, made anyone sick if they got too close to him. The most dangerous, the **BenzoPyries** gang, were always smoking and bullying others. If you met them in the street, you'd better run away!



In the big city, the amount of PAHs was growing and growing, with some of them starting to move upwards into the grey sky. Beyond the clouds and smoke, they found an awesome blue sky to escape to. Some of them flew so high that they went up in the direction of the sun and never came back. Others met the Otiose Hazards (we will call them **OHs**). OHs were crazy partygoers, always on the move and dancing! When a PAH danced with one of them, it was impossible to escape. The binge had begun! However, most of the PAHs continued flying and travelling towards bluer and bluer areas... and then, the bluest thing in the world appeared just below them...the big, blue ocean!



One day, when Sarah was looking up at the sky, she noticed something falling into the water. It was a little smaller than her and had a geometric shape almost like a diamond. It was the first time she had ever seen anything like it! What could it be? She decided to help it.

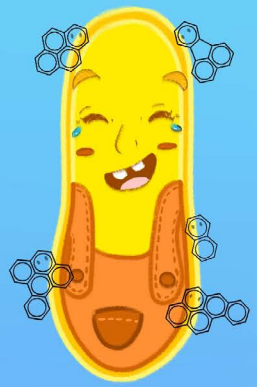
'Hi! I'm a bacterium and my name is Sarah. What's your name?'

'My name is Nafty, I belong to the Pretty Affable Handsome molecules. I've just arrived from the big city far away. I'm new to the ocean.'

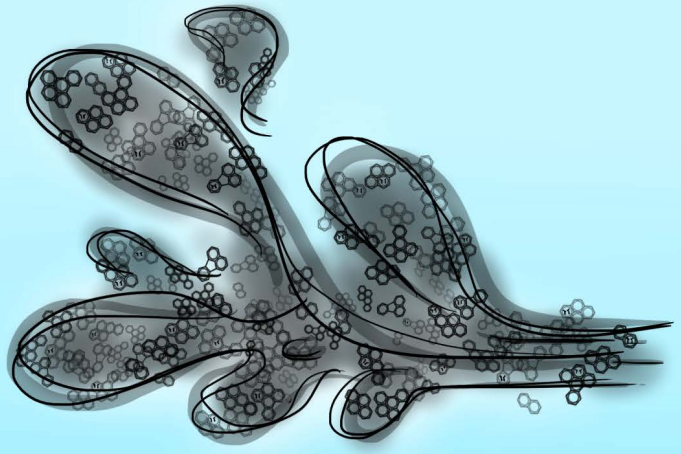
'How did you arrive here?' asked Sarah.

'Flying over the sky! What a cool trip; I had so much fun! I was blasted out of the exhaust pipe of a car and was flying for several days before I fell down here! I lost some of my friends on the way, but I'm sure they will arrive eventually,' answered Nafty, looking up to the sky.

Since Nafty didn't know how to swim, he clung on to Sarah's cell envelope and never left. Sarah couldn't have been happier! Finally, she had found somebody to play with all day long!

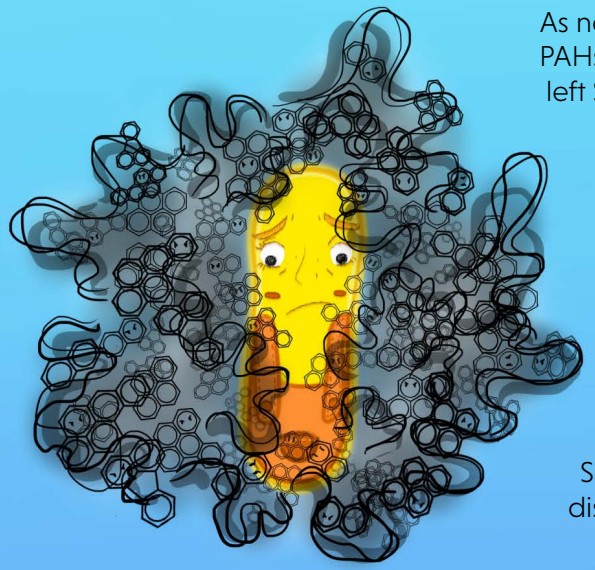


Nafty was right. After his arrival, more PAH molecules started landing on the surface of the ocean. All clung to Sarah and she couldn't have been more delighted. Sarah became so chatty, going here and there with her new friends. The PAHs drove her crazy tickling her all day!



After a week, Sarah began to need a little more personal space. These new friends never left her alone, always there, always tickling her! Rather than Pretty Affable Handsomes, they seemed like Petty Atmospheric Hysterics. At least they could leave her alone to sleep, right?

'Guys, you know, this is starting to be a toxic friendship,' she told them. 'You don't let me do anything alone! Could you please go away for a while? Please?!'

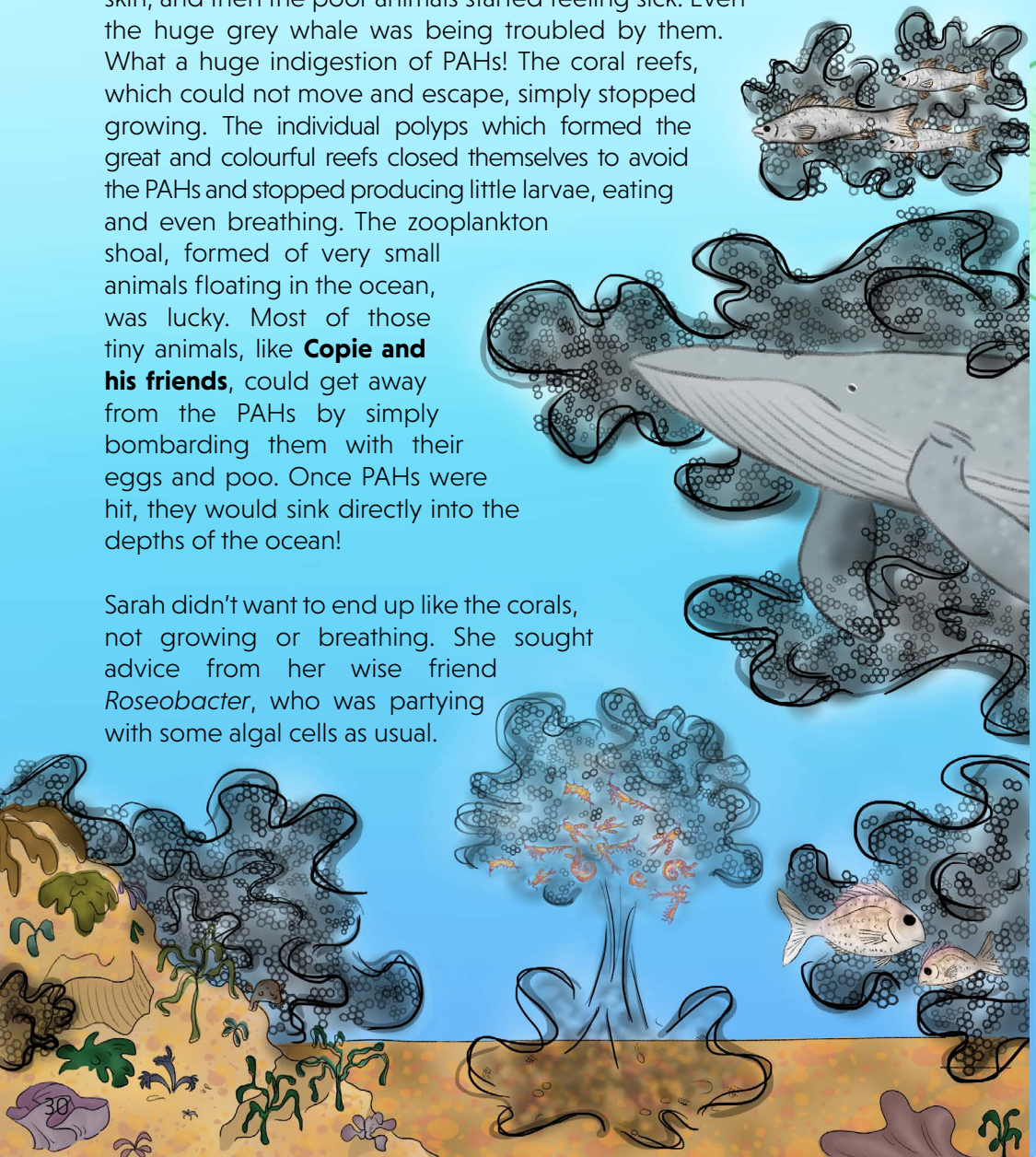


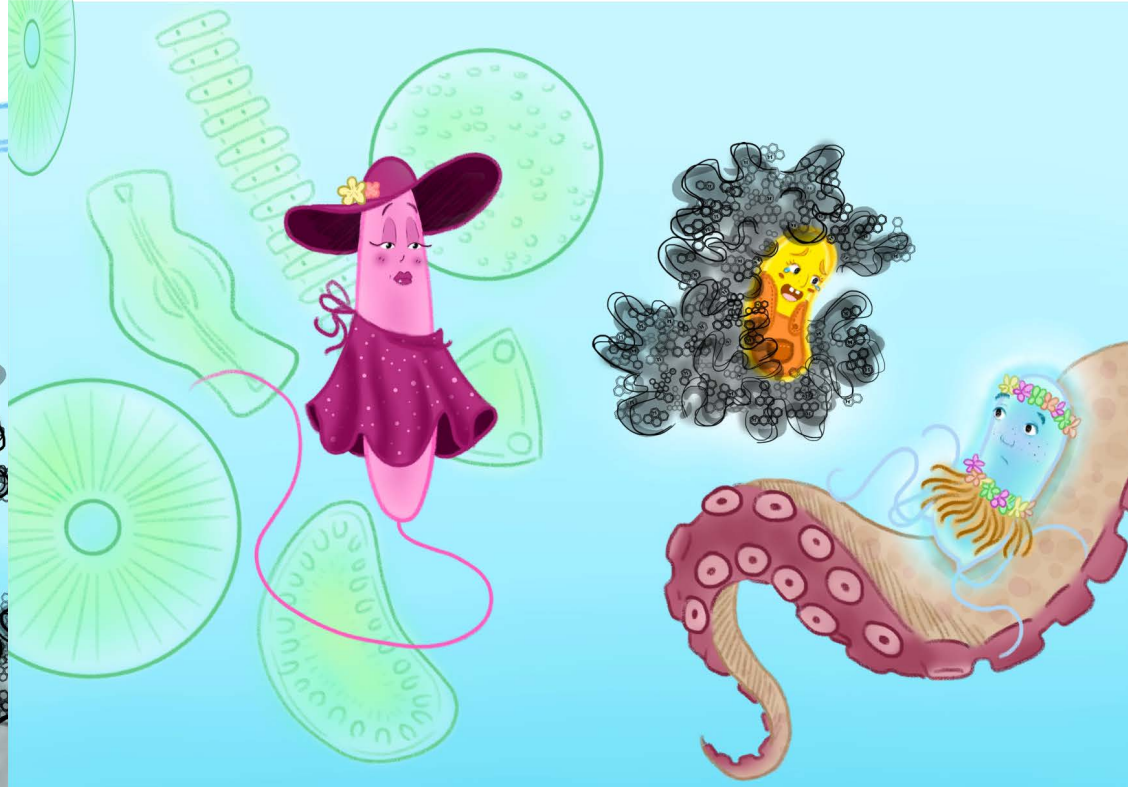
But there was nothing to be done. As neither Nafty nor any of the other PAHs knew how to swim, they never left Sarah's side. She was desperate. She tried swimming really fast, baking under the sun, looping the loop, sweating... anything to get rid of the PAHs, but all to no avail. The PAHs remained attached forever!

New PAHs didn't stop falling from the sky and, since Sarah was very small, they started disturbing other bigger animals in the blue ocean.

The PAHs were so numerous that they did not care if they were attached to a small bacterium or the largest coral reef; they just annoyed anyone who happened to be passing by or lived where they fell. Some fish, like the sea bass and the sea bream, were in trouble. The PAHs were entering through their gills and mouths, sticking to their scales and skin, and then the poor animals started feeling sick. Even the huge grey whale was being troubled by them. What a huge indigestion of PAHs! The coral reefs, which could not move and escape, simply stopped growing. The individual polyps which formed the great and colourful reefs closed themselves to avoid the PAHs and stopped producing little larvae, eating and even breathing. The zooplankton shoal, formed of very small animals floating in the ocean, was lucky. Most of those tiny animals, like **Copie and his friends**, could get away from the PAHs by simply bombarding them with their eggs and poo. Once PAHs were hit, they would sink directly into the depths of the ocean!

Sarah didn't want to end up like the corals, not growing or breathing. She sought advice from her wise friend *Roseobacter*, who was partying with some algal cells as usual.



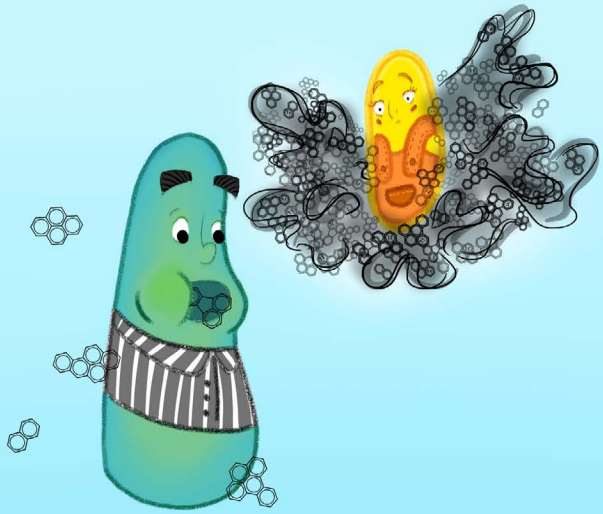


'Hey Roseo, I need your help. These PAHs won't leave me alone. How can I get rid of them?'

Roseo, a very snooty bacterium, told Sarah that she had no idea how to remove them and asked Sarah to go away since she was very smelly with all those PAHs on her body.

'Sarah, please, go away! Your smell is scaring my algal friends!'

Then, Sarah passed close by a squid, where she saw a ***Vibrio*** bacterium sitting comfortably on its tentacle. The *Vibrio* said that perhaps the PAHs would get scared and disappear if she could become bioluminescent like him, but, try as she might, Sarah couldn't produce any light. Sarah left in tears. Having close friends had been her dream, but now it was turning into a nightmare!



Alteromonas, the biggest glutton among the bacteria, found her looking very sad and exhausted after so much non-stop tickling.

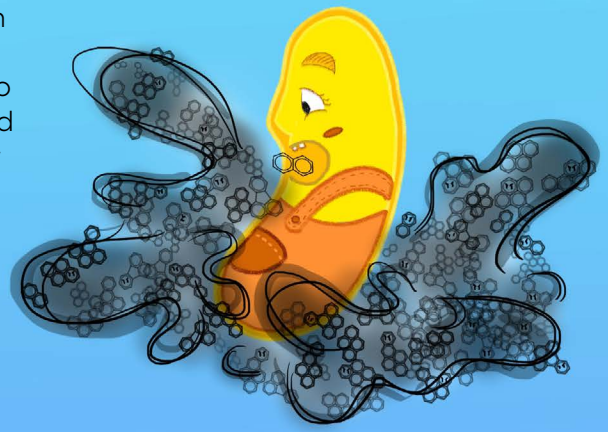
'Hey Sarah, what's up? I see you have new treats attached to your body! I love these shapes. May I try one please?'

Sarah had no time to answer before *Alteromonas* started devouring Nafty, then Fluo, then Pyr and even the fearsome BenzoPyries gang.

'Yum, yum! So delicious!'

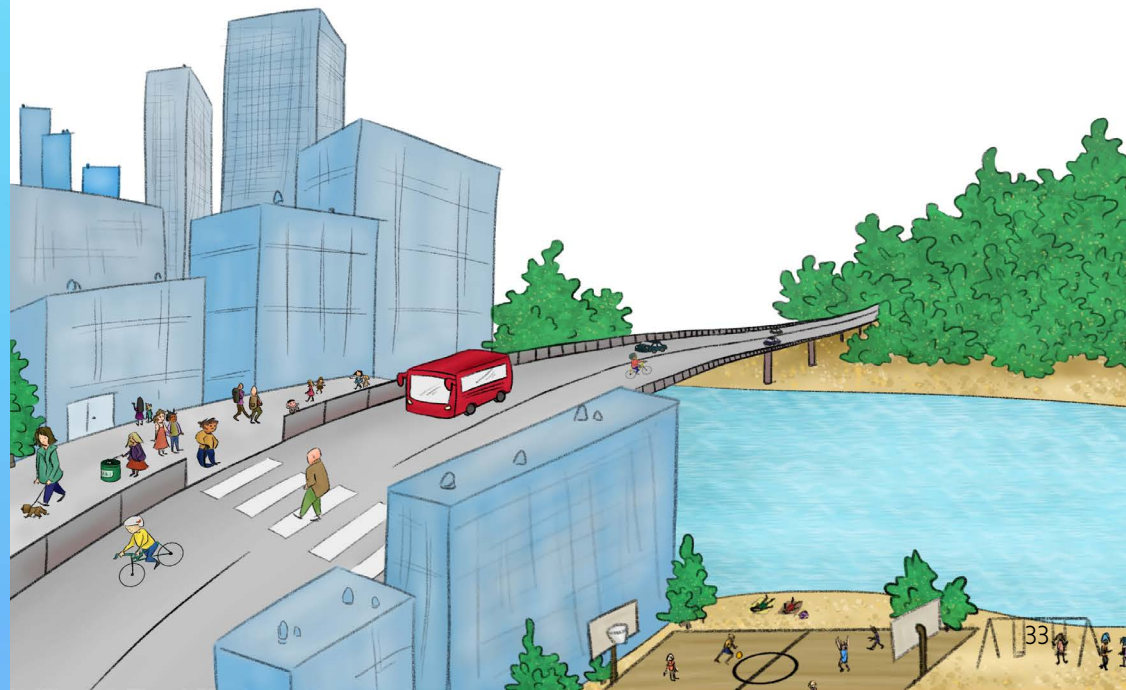
Alteromonas had just found the best solution for getting rid of the PAHs: eating them!

Sarah tried one, and although it was not her favourite taste by any means, she was able to finish it, and then another, and then another. And that is how Sarah and the other bacteria managed to get rid of some of the troublesome PAHs in the ocean!



Bacteria turned out to be the most efficient solution for the high abundance of toxic PAHs in the ocean. All the marine wildlife was so happy! However, in the city, production of PAHs did not cease...and bacteria cannot cope with all the new arrivals to the ocean.

So, why don't we, the people, start helping marine bacteria out and make a change? We would produce fewer PAHs if we rode our bicycles more, used public transport and drove electric cars. We should recycle and use recycled and environmentally friendly materials, buying as few industrial goods as possible! We can also plant trees, participate in beach-cleaning campaigns and collaborate with nature reserves, where wildlife lives in safe and unpolluted areas. We should bear in mind that bacteria will not be able to eat all the PAHs because there are simply too many of those Petty Atmospheric Hysterics. Let's help them! We can all do our bit to save the planet, our home!



Would you like to know more?

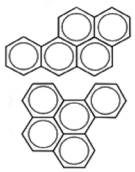
PAHs: The Petty Atmospheric Hysterics or Pretty Affable Handsomes are in fact polycyclic aromatic hydrocarbons, pollutants of general concern, harmful to ecosystems and humans.

Nafty: Naphthalene is a small and volatile PAH known for being rapidly transported in the atmosphere to distant ecosystems. It is the least harmful of the PAHs, although it can be toxic at high concentrations, as for instance in some pesticides (mothballs).

Pyr: Pyrene is a very stable PAH of medium size, produced in large amounts in combustion systems such as car engines. It was first identified in coal tar, which is why it is so dirty!

Fluo: Fluoranthene is a PAH that emits fluorescence under UV light (where it gets its name) and it is blamed for causing severe damaging effects (such as tumours) in living organisms.

BenzoPyries: The benzopyrenes are the most dangerous and carcinogenic pollutants among the PAHs. We have to be very careful about them, as they can be found in coal tar, tobacco smoke and chargrilled foods.



OH: The hydroxyl radical is not an Otiose Hazard, but rather a very active molecule which neutralises PAHs in the upper atmosphere.

Copie and his friends: Copepods are the most abundant invertebrates among the marine zooplankton (very small aquatic organisms which drift and swim in the ocean). They are found in every marine ecosystem.

Algal cell: Organism formed of only one cell which is able to photosynthesise.

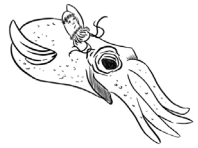
Bacterium: Organism formed of only one cell, smaller than the algal cells but very important in recycling organic matter. As a Latin loanword, the singular and plural forms bacterium and bacteria are used in formal writing.

Sarah: Sarah is in fact a SAR11 bacterium. SAR11 are the tiniest and most abundant marine bacteria and have a very frugal lifestyle.

***Roseobacter*:** Marine bacterium usually found associated with algal blooms. The first described members formed pink-pigmented colonies, which is where they got their name (roseo = pink in latin).

***Alteromonas*:** Marine bacterium which takes advantage of large doses of nutrients and organic matter to grow. Alteromonas are key agents in PAH biodegradation and bloom in crude oil-spill accidents. Good cleaners of PAHs in seawater!

***Vibrio*:** Some bacteria are bioluminescent (generate light). Luminous Vibrio species symbiose with marine invertebrates (such as squids). These use Vibrio light for certain nocturnal behaviours.



Many bacteria have the capacity to degrade PAHs, but the true extent of PAH biodegradation in the oceans remains unknown.

An oily birthday surprise

Nelson Bralade Selekere, Hadar Elyashiv, Gema Martínez Méndez, Dharma Reyes Macaya
Illustrations: Yuly Lorena Allende, Mariem Saavedra Pellitero and Heather Johnstone

Once upon a time, there was a little girl called Luna. She lived with her family in Bremen, a city in Northern Germany. Luna was fascinated with science and loved water sports as well. She spent every moment of her spare time in the water. She and her little brother Jeremy often visited the local swimming pool, and during the summer holidays she spent most of her time with her family and friends at the most popular spot for summer leisure in the city—The Big Lake. Her absolute dream was to go to the endless open sea.

Luna's 10th birthday was approaching and the family was making plans for how to celebrate the big day. This year, she was not going to have much of a birthday party. Instead, her parents gave her a small envelope several days in advance. When she opened it, Luna got so excited! Her mum and dad had prepared a surprise for her—a cruise to the North Sea! For days after she learned of her surprise, she would lie awake in bed for hours after bedtime, simply imagining what it would be like to be on a cruise ship where the endless sparkling ocean waters are. Waters that stretch far, far into the horizon, as far as the eye can see!

Her parents told her that she would be able to see many wonderful fish and different marine animals swimming in the ocean and flying above it. Luna imagined how she would be able to see mummy dolphins swimming along with their calves!

'Oh, this cruise is going to be so much fun!' thought Luna.
She was so happy; she just couldn't wait!

Her birthday finally arrived, and Luna was so excited that she was ready to go long before anybody else in the house was awake. When everyone else was ready, they went to the port in Hamburg, where the whole family boarded the cruise ship. Captain Fischer welcomed them aboard *The Sea Lion*. He showed them and the other guests around the ship and introduced the members of the crew. As they were about to set sail, the captain explained that the Port of Hamburg is actually located on a river, more than 100 kilometres inland! So, to reach the North Sea, the cruise had to start down the river Elbe.

When they finally reached the sea, a big 'WOW' escaped Luna's mouth. The ocean was so huge! Bigger than anything she had ever imagined! The ship's crew gave the passengers binoculars. Now Luna was able to look into the distance. She and her family were all standing at the bow, watching, trying to spot dolphins or other sea creatures. Captain Fischer provided explanations about the big offshore facilities at sea and different ships they could see in the distance.
At this point, Luna was focused solely on spotting dolphins or any kind of fish or sea bird...soon she became very disappointed that she had still not seen a single animal!

'Where are all the dolphins and other animals, Captain Fischer?' asked Luna. 'My parents promised I would see them, but I can't find any anywhere.'

Captain Fischer scratched his head. 'Well, Luna...there are usually dolphins and other animals around here at this time of the year. I have seen them plenty of times with my own eyes!'

'So why aren't they here today?' Luna asked in a sad voice. 'I was really looking forward to seeing them.'

While Luna and Captain Fischer were having their conversation, the people around them started pointing at the horizon. They also looked in the same direction with their binoculars. They could see that they were slowly getting closer to a ship far bigger than *The Sea Lion*.

'Which ship is this, Captain Fischer? Do you know who is on it?' asked Luna.

'Oh, that is the *Atlantica*. It belongs to the offshore oil production facilities nearby. I know a scientist who works over there, Dr Petra. She is a scientist specialised in cleaning polluted water and she has been working with the oil operator in a project to improve their cleaning procedures. Maybe she knows why you can't see the dolphins and other marine animals today,' said Captain Fischer. 'I have an idea,' he said suddenly. 'Would you like to talk to Dr Petra?'

'YES, PLEASE!' Luna exclaimed in excitement. I have a thousand and one questions to ask her.'

The captain went to the bridge to use the ship's radio. He contacted the *Atlantica* and spoke to Dr Petra. Over the radio, Dr Petra sounded very concerned and instructed them not to come any closer. She would come over in one of the small boats and explain the situation. Soon Luna and all the other passengers saw one of the *Atlantica's* lifeboats launched into the water with several people on board.
At the same time, Luna noticed some changes in the appearance of the water. Its colour was gradually changing from greenish blue to somewhat blackish, and this added to the thousands of questions in her mind.

'Captain Fischer, what's happening?' asked Luna. 'Is this water colour normal? Why is the water turning black?'

Captain Fischer frowned and, while looking through his own binoculars, said: 'Something has happened at the oil platform, that structure you see over there, Luna.'

Captain Fischer already had a suspicion of what might have happened, but he was hesitant to tell the little girl. 'I am not sure what it is, but I already see my friend Dr Petra over there and she may be able to tell us.'

The scientist boarded *The Sea Lion* and Captain Fischer introduced Dr Petra to Luna, her family and the other passengers on the ship.

'Dr Petra, could you please explain to my guests what you are doing?' asked Captain Fischer.

'What's happening? Is this normal?' Luna asked anxiously.

'Hello everyone,' started Dr Petra with a smile. 'Pleased to meet you all, as much as I would have preferred it to be under different circumstances.' She then took a deep breath and continued, 'Something unexpected has happened. My crew and I received an emergency call telling us of a failure on the oil-drilling rig. Due to the failure, a large amount of **oil** was spilled into the sea. We came as fast as we could to start the **clean-up operation** before the spill spreads any farther,' said Dr Petra.

Luna wondered 'Could this be the reason why the dolphins and other marine animals weren't out here today?'

The thousand and one questions started running through her head. She moved closer to Dr Petra and asked, 'Dr Petra, why is the water here black?'

'The water is not actually black; it is covered by a black liquid. This black liquid is called **petroleum** or simply oil,' answered Dr Petra. 'We all use petroleum,' she continued. 'For example, in our cars. Petroleum comes from two Latin words 'petra', which means rock, and ''oleum'', which means oil. As you can see from the water around us, it is an oily liquid which is black or dark brown in colour.'

'Wait, how are rocks getting into the story?' asked Luna, the minute Dr Petra stopped to take a breath.

'I was just about to get there,' laughed Dr Petra, continuing to explain, 'Petroleum is formed and found in places deep below the Earth's surface, so that is why petroleum simply means OIL (that comes from) ROCK.'

'That is interesting!' said Luna, who still wanted to know more and asked Dr Petra: 'How is it formed?'

'The oil is formed from the remains of marine plants and animals. After they die, these big and also very tiny marine organisms sink to the seafloor. If that happens in a place with little oxygen, they do not decompose quickly. As time passes, layers of sand and mud cover them, crushing the remains down into the seabed. When this process continues and as the depth below the seafloor increases, the **pressure and temperature** exerted on the remains also increase. Pressure and temperature can help to change the **chemical composition** of any material in or on the Earth.'

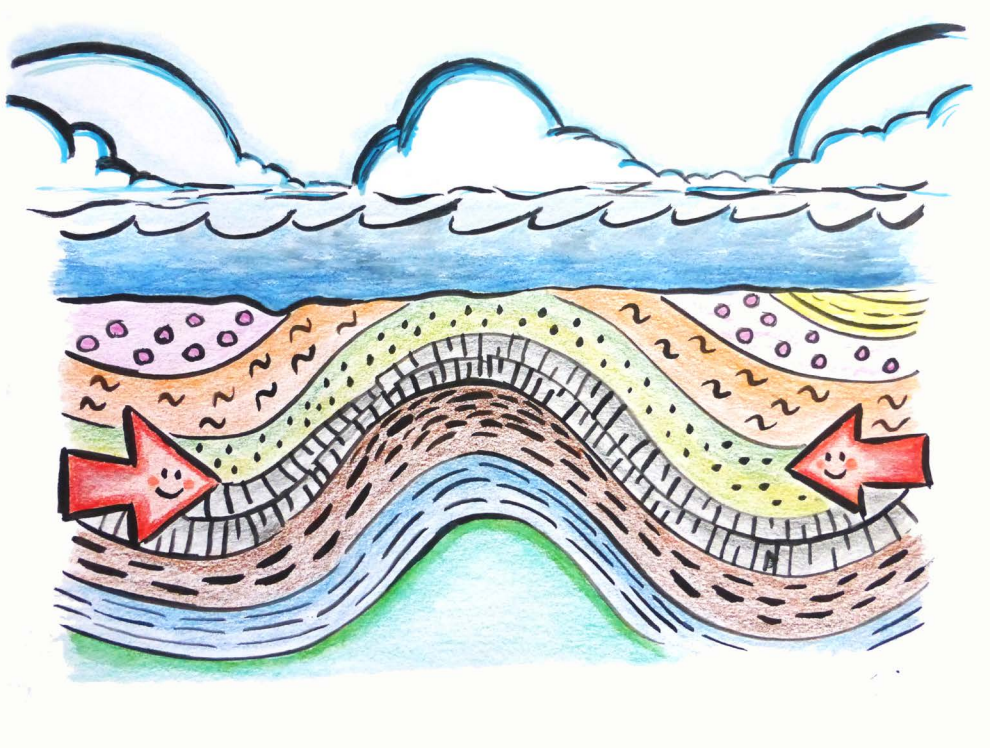
Luna was fascinated and asked, 'So I could make petroleum if I had a special machine?'

'Oh, no,' Dr Petra continued. 'It takes millions of years under those conditions. Think of it as a very, very slow cooking process, in which the Earth is the pot. The remains of these marine plants and animals are then slowly transformed into what we now know as oil. Sometimes the heat and pressure are so strong that it even becomes gas.'

'So, if it is so deep under the ground, how does it come up here and into the ocean?' Luna wanted to know.

'That is a very smart question! Today there are companies that drill oil wells through layers of sand, mud and rock to reach the sites deep under the Earth's surface that contain petroleum. The petroleum is pressurised and flows through the oil well upwards in the direction of the surface, where the pressure is lower, and then through a pipe connected to the production platforms (drilling rig or ship). At the connections or anywhere where the pipes are exposed, there is the risk that a problem like too much pressure will cause the pipes to burst and then the oil will leak into the surrounding land or water. Fortunately, that happens only occasionally. These events cause great disasters. Here there is a leak in a pipe junction; operations have been stopped so that it can be repaired and we are cleaning the oil spill at the same time.

'Wow,' said Luna, who was now getting more curious. 'But why go to all of this trouble just to get petroleum for cars?'



Dr Petra replied, 'Petroleum is a central part of our modern life and the world's main energy resource today. In fact, our world would almost come to a screeching halt without it. Most factories would stop running, as would cars, aeroplanes and even the ship you came on. Without oil, tractors on farms would stop working. If the heating system in your home uses oil or natural gas, without it your home would become very cold during the winter. Oil is also used to make many products such as plastic toys and cosmetics, clothing and many more. Everyday items we use like our mobile phones, computers and even nappies contain products originating from oil and its by-products.'

Luna was left perplexed. She never knew her phone and football all came from the by-products of oil. The same oil that was now polluting the water that she was looking at.

'So, Luna, now you know all about petroleum, how useful it is to us and how much harder our lives would be without it,' said Dr Petra. 'But here you are witnessing with your own eyes that **finding and getting petroleum**, if not handled properly, can harm the environment. Here, a mechanical failure—a leak in a pipe junction—caused an **oil spill**. If we do not take care of it immediately, it will result in the death of marine and coastal plants and animals.'

'Really? How is it killing them?' The black and oily waters did indeed seem very threatening.

'It simply blocks some animals' airways. Also, birds' feathers get stuck together by the sticky oil, so they are unable to stretch their wings and fly to find food. When animals live in the water, it can burn their skin and impede their ability to swim.'

'Oh, no!' cried Luna. 'What about the dolphins?'

'Unfortunately, all marine animals which are close to the oil spill will suffer the same fate; they may be harmed and might die.' Dr Petra realised that Luna was very close to tears, so she quickly added, 'Hey, don't worry, Luna. Look, that's why my crew and I are here: to clean up the spill.'

'Oh really?!' wondered Luna. Dr Petra's words were cheering her up. 'I really don't want any animals or plants to die. How are you going to clean? Will the dolphins come back when you finish the clean-up?' she asked.

Dr Petra smiled reassuringly at Luna. 'You see that we are not the only ship around here, together we will use booms.'

For a moment, everyone around Dr Petra was laughing.

'Yes, I know, it sounds funny, but what we call booms are actually long floating barriers that we use to minimise the spread of the oil spill. Once we get that under control, we will start vacuuming the surface water. I have developed a new vacuuming method myself. I have been working with the oil operator for some time now on that project and today we have the opportunity to test it for real. And yes, Luna, I'm sure that with time and as the marine currents mix the water, the dolphins will return. The fish and seabirds too.'

'Wow, scientists are doing such complex and interesting work,' she exclaimed. 'Mummy, Daddy, when I grow up, I want to become a scientist! And then I am going to find a way to generate energy without petroleum, without pollution or risk to the environment!'

Her parents smiled at her. 'That is a great idea, Luna...you can become a scientist when you grow up. You can be anything you want.'

Luna hugged them happily and they hugged her back.

Dr Petra smiled and said to Luna. 'I'm sure you will have a bright future. Now I have to get back to work and handle the situation!'

And so, with a big hug and lots of smiles, Luna and the people on the cruise ship said goodbye to Dr Petra and her clean-up crew. Luna was determined in her little heart to become a scientist when she grew up. Maybe she would find new ways to harvest energy or maybe she would help protect the environment and her beloved dolphins or perhaps find a way to stop oil spillage or... So many thoughts were spinning around in her head as they sailed home.

Would you like to know more?

Oil or petroleum

A liquid found in certain underground rocks. The extraction from the Earth is performed by specialised workers (geologists, geophysicists, technicians, engineers, drillers, etc.) to use it for fuel and other by-products. As Dr Petra explains in the story, almost every aspect of our modern lives involves a by-product of petroleum: petrol or diesel for cars, clothes, toys, umbrellas, fertilisers, soap, etc.

Pressure and temperature inside the Earth

The Earth's structure dictates a trend that as you go deeper—closer to the Earth's core—the temperature and pressure increase. The pressure rises with depth due to the load of rocks on top of the buried material. Temperature increases with depth, mostly due to the internal heat coming from the Earth's core and the remainder is due to different processes in the Earth's crust and mantle.

Chemical composition

Every material on Earth is composed of very small particles called atoms. Atoms which are bonded together are called molecules. Materials like oil are composed of thousands of molecules with different bonds. The molecules found in petroleum mainly consist of hydrogen and carbon atoms, thus we call them hydrocarbons.

Finding and getting petroleum (also called petroleum exploration)

There are many stages involved before a drilling rig will drill an oil well into the seabed and this new well is connected to a production platform on the surface. In an early stage, a company receives a licence to explore an area and collects all the available information about it. Then a seismic survey is conducted. The results of the survey are similar to an ultrasound performed by doctors when they examine a baby in a womb. Based on the seismic survey, scientists can recognise structures that may contain gas and oil. The next stage is drilling to places where oil operators expect there to be gas or oil. The company extracts a sample to evaluate the quality of the oil. The last stage is the exploitation, in which an oil platform is set in place connected to the different oil wellheads thanks to pipelines laid on the seafloor. From the moment of the first drill, there are many professional and environmental hazards and risks—one of them being an oil spill.

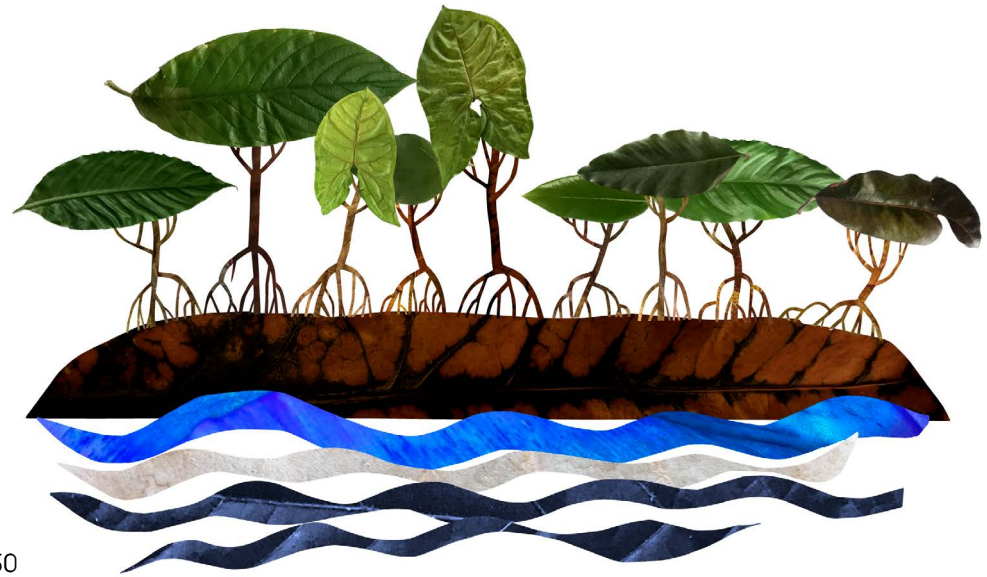
Oil spill

An oil spill at sea can happen either during oil production or during transportation by ships or pipelines. In both cases, the environmental damage is much larger than for an oil spill on land. When oil spills, it will spread across the sea surface with currents and winds. The weather, sea conditions and proximity to the shore will determine if the oil will be washed ashore. An oil spill poses an immediate risk to animals in the sea and in nearby shore habitats. For oil categorised as 'persistent' (e.g., crude oil), **it requires immediate treatment and response**. The response includes various offshore and onshore operations. Offshore operations are applied according to the damage and include containment and recovery, burning and application of chemical dispersants. Onshore treatment may include actions such as sand clean-up and the rescue and cleaning of affected animals. What cannot be cleaned will eventually—taking from weeks to hundreds of years depending on the kind of petroleum—be eliminated by biodegradation processes (bacteria, fungi and a few other organisms feed on the hydrocarbons and break down the bonds).

Scarlet and the mangroves

Rebecca Borges and Guilherme Abuchahla
Illustrations: Guilherme Abuchahla

Once upon a time, there was a sunny island called Guaraoca. The island was surrounded by a turquoise sea of warm water, which was home to dozens of fish, shrimp, turtles and dolphins. Fine golden sand beaches met the calm ocean, inviting visitors to sit down and relax. Guaraoca was covered with beautiful forests but they were quite different from other forests and gardens. Their trees had thin trunks and their roots arched and sprawled over the ground like gnarled fingers. Those trees were **mangroves**.



The mangroves thrived happily in mud. Mussels clung to their roots, which were submerged by the tide twice every day. Within the mangrove trees, long shipworms lived a quiet, peaceful life. Beneath the roots, fiddler crabs enjoyed scavenging for food whenever the tide was low and the mud was exposed. Flying over them all, high above the canopy, were beautiful birds of various shapes, colours and sizes. The red birds with long beaks, which they used to search for food in the mud were called ibises. **Scarlet** was a young, curious and particularly bright red ibis.

Scarlet used to love flying over the mangroves and seeing how other animals lived. She also enjoyed watching human fishers go about their daily chores. Her mum, **Potira**, was everyone's favourite among all of the birds on the island. All of the animals used to visit her for a chat and a smile.

One day, whilst flying over the far side of the island, Scarlet noticed a bare strip of mud—a large section of the mangroves was gone! Right next to it, she could see huge barges carrying the trunks away. Some humans were taking the mangrove trees somewhere else, leaving the animals homeless! She quickly flew back to her mother to tell her all about it.

'Mum! You won't believe what I've just seen. All of the mangrove trees on the far side of the island have been taken by humans. They're not the same fishers and villagers we see every day, who simply take a few mangroves every now and then though.'

Before Potira could say anything, the strong swamp ghost crab **Alcides** yelled up from the mud below:

'I've heard about that! My cousins from that area ran to our side of the island to dig a new burrow to live in. Humans have always visited our mangroves in search of food and wood, but they've never taken so much before! I don't know what's happened.'

'I don't know either, but we can ask around to try to understand why this is happening now,' said Potira, determinedly.

The sound of flapping wings approached the group. Potira looked up and couldn't believe her eyes. It was her beloved cousin **Cordelia**, who lived far, far away from the island. Although she was very happy to see her cousin, she couldn't help but notice that Cordelia looked tired. Worried, she asked:

'My dearest Cordelia, it's so good to see you here! But what has happened to you? You don't look very well.'

Scarlet only knew of her mother's cousin from stories. She knew Cordelia had a special way of saying things in a melodic fashion reminiscent of the famous **cordel literature** from her hometown.

'Auntie Cordelia, how nice to finally meet you!' said Scarlet, excitedly. 'My mum always speaks of you so fondly and has told me everything about your time together in your hometown, far from here. How is it there? How is your home? Why are you visiting us now so unexpectedly?'

Cordelia, with her unique form of speech and a soft, calm voice, answered:

'Allow me, dear, to tell you
Why I had to leave my home
I really didn't want to
But now I'm forced to roam

One day, some nasty people came
And took my trees away
Those people, they were not the same
I'd seen before that day

They came and stole our precious trees
Cut down the homes of birds and crabs
They're simply overcome with greed
And anything is up for grabs

Now you might think (though sadly wrong)
There are other trees along the coast,
The bird can fly, the bird is strong,
Another forest can be its host.

The problem is, it's not just that
The mangrove trees are so much more
A source of food, rich habitat
Not just free timber on the shore

Imagine, Scarlet, how life would be
With all the mangrove trees cut down
No place to roost, to live and feed
A beach devoid like a ghost town'

Listening to Cordelia's words, Scarlet remembered her life as a chick up in the nest in the mangrove tree. She could not see how life without mangrove trees could be possible. How could her friends, family and she survive if not in the mangrove forest? Puzzled, she asked:

'Your home is gone?! But how? Are all the mangroves on your island gone? Are humans doing this everywhere? That does not make any sense! I thought they needed mangrove forests too, not only the timber, but also for food and other useful products. Why would they do something that would cause themselves harm?'

Again, Cordelia wisely replied:

'Why? I can't explain, my dear
The humans' thoughts aren't always clear
Some people think only of their own gain
And don't consider others' pain

There are people from other places
Who live their lives at different paces
They don't respect nature or oceans
Nor do they consider others' emotions

Those people act without a care
Taking things that are not theirs
And, dear Scarlet, you know what's funny?
It's all just for the sake of money'

'That's absurd! What could we do to protect ourselves against this danger?'

Young Scarlet wanted to do something. She wanted to talk directly to the humans. She wanted to ask for help from the fishers who had lived alongside them in harmony for so long. When explaining her plans, Potira reminded her:

'My dear Scarlet, don't forget that humans don't understand us. They don't speak our language. We have to find another way to show them that cutting down too many mangrove trees is bad for them as well.'

'You're right!' agreed **Alcides**. 'But how can we do that?'

It was then that Scarlet had an excellent idea. They would assemble all their friends and all the other animals who lived in the mangroves.

'We will parade together through the mangroves in front of the fishers so that they see how many of us live here and depend on the mangroves to survive. Then they will have to realise, won't they?'

'Good idea!' said Potira. 'I'll fly over the entire island summoning all of our bird friends for a parade tomorrow morning.'

'Great!' said Alcides, in excitement. 'I'll wander the entire mangrove floor and talk to my tiny friends, the fiddler crabs. I'll call my swamp ghost crabs to leave their burrows. I'll climb the trees and ask the mangrove tree crabs to join us. Finally, I'll ask the mighty land crabs, who live in the driest areas of the mangroves, to show off their beautiful colours.'

Scarlet was responsible for talking to all of the bees, butterflies and spiders. Cordelia decided to talk to the raccoons and the sloths.

The next morning, all of the mangrove animals assembled in the mangroves near the village dock, where the fishers usually arrived with their catch of the day and all the villagers and children came to buy supplies for dinner. All of the men and women marvelled at the huge number and beauty of the animals. They had never seen them all together at once and wondered what had happened. A class from the local school was returning from a field trip near the harbour. The science teacher was also surprised but took the opportunity to explain to the students—and to everyone around who could hear—how important mangroves are to all animals, including humans. She also took the opportunity to warn how harmful the deforestation was that was happening on the far side of the island.

Listening to her words, the eldest of the fishers added:

'Without mangroves, the animals would have no place to live, to feed and to raise their young. There are also many fish and other sea creatures to be found there at high tide. Without mangroves, men and women could not rely on the shade of the trees, the protection of the roots against storms and so many other things the mangroves offer us. We have to do something to protect this beautiful forest!'

Several days later, some people from far-away towns arrived to cut down more mangrove trees and take them away. The villagers saw them and told them to go away; they would not allow those strangers to cut down more trees! The children left school with their teachers to join the elders in sending a very clear message to the strangers: 'These mangroves are not yours to take. Go back where you came from.' The animals from the mangrove also came to the dock and seemed to be observing the situation closely. Feeling uneasy, the strangers left.

Many weeks passed and life on the island returned to normal. The area where the trees had been cut down started to recover and was soon covered with little mangrove trees, thin and numerous in the glistening mud.

By watching that recovery day by day, the villagers decided to take action to avoid any other strangers from ever trying again to cut down Guaraoca's mangroves again. They decided to push for the declaration of the island as a **nature reserve**, although keeping their rights to use whatever the mangroves provide them with in a sustainable way. The government explained to them that they would need to collect a minimum of 10,000 signatures to get their petition considered. And so, the villagers joined forces with people from neighbouring towns, islands and even from the mainland. Scarlet, Portia and Alcides heard what they were planning and decided to do their bit.

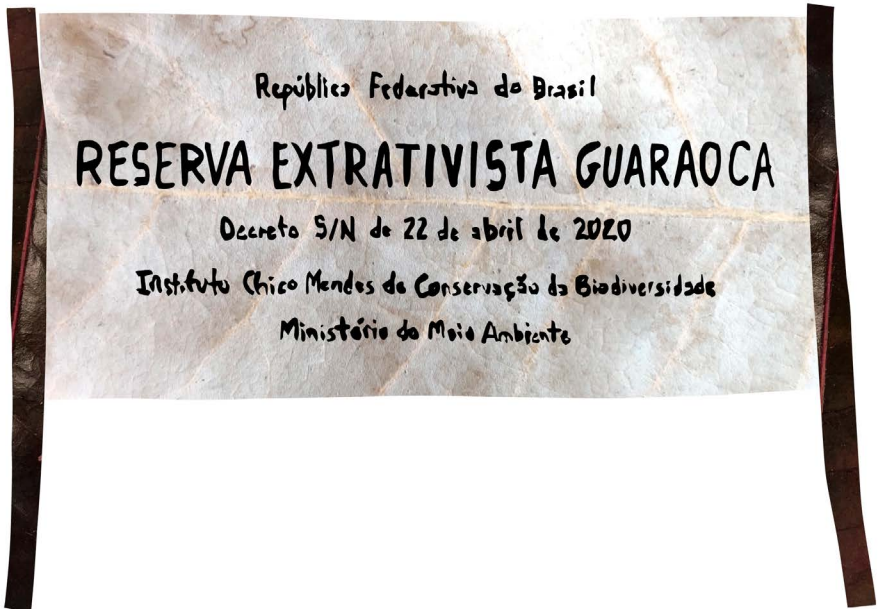
'The villagers have had a fantastic idea!' said Potira. 'Let's help them!'

'We can fly to the cities and take the flyers with information that they are distributing; it will be much quicker!' said Scarlet, with great excitement.

'And I will get all the crabs to bring the signed forms to the collecting boxes,' added Alcides.

The villagers were surprised once again by the behaviour of the animals. Strange things were going on with them lately. First the parade, then turning up at the dock and now the birds were taking their flyers to many places and the crabs were quickly taking the signed forms to boxes arranged on the streets, allowing them to focus on talking to as many people as possible and collecting many more signatures. It was almost as if all of the animals knew exactly what was going on.

One sunny day, about a year after their beautiful parade, Scarlet and the other mangrove residents woke up to a banging sound. They were afraid the strangers were back to cut down their mangrove trees. Scarlet and her mother Potira hurried to the source of the noise. Some humans were putting something in the ground—a kind of big plaque. They waited until the humans were done with their work to check what it was.



Unfortunately, the animals could not read the humans' signs. They waited for some humans to arrive and maybe give them a clue what the writing meant. The first to arrive were two children. Scarlet and her mother were very quiet, observing them from the canopy of a mangrove, when one of the children, a little girl with curly hair, said:

'My mum and dad are so happy that our island is now a nature reserve!' Her friend responded:

'Yes! My teacher told me that this nature reserve is a specific type of protected area and that we can keep on using the mangrove resources in a sustainable way. That means that we take only what is necessary for us to live and no more. In this way, the mangrove forest survives and all of the animals can continue living here in peace.'

Then he added:

'My mum told me that the leaders of our village showed the authorities how important the area was for the survival of all animals, including ourselves. The village representatives had to meet a lot of people and gather information to prove it. Then the authorities finally understood and decided they could protect the area in a way we could keep living here. And that's why we are having a big ceremony later and a big party tonight!'

'Oh, wow!' exclaimed the little girl. 'I was worried when those people were cutting the trees and the animals looked so sad, confused and annoyed at the same time. I'm glad we don't have to worry about that anymore. Look how happy those two birds right over there look!'

The children were smiling and looking at the two ibises. And the birds were smiling and looking back at them.

Scarlet and Potira told the news to the animals in the mangroves. Everyone was so happy! Cordelia recited one more cordel:

'Of all the places I have ever been
Both north and south of the equator
Such teamwork I have never seen
Between humankind and nature!
Working together, parading in droves
Pooling their efforts to save the mangroves

If our planet needs assistance
To save it from these strangers' hands
We must help and show resistance,
The only means to save our lands
We cannot let them raze our forests
Just to line their greedy pockets

We have to see the whole connection
Between the humans, animals and trees
With persistence, method and reflection
We can save our land and seas
Failure to act now and protect nature
Will surely result in regret later

Happy is he who understands
How much nature is truly worth
Long live the mangroves that grace our lands!
And, of course, long live the Earth!'

Would you like to know more?

This story is based on the fauna that inhabits mangrove forests in the north of Brazil.

Mangroves are tropical trees that grow in salty, coastal waters in the area left exposed during the ebb and covered during the flow of the tide: the so-called intertidal zone. Mangroves are found on the coasts of 118 tropical and subtropical countries. In total, they cover more than 137,000 square kilometres—an area roughly the size of Greece!
Mangrove forests have been used by local communities for a variety of purposes, for example as a supply of wood for cooking, heating and constructing houses as well as for flavouring agents, textiles, mats, paper, baskets and boats. Mangroves are home to bees that produce honey and wax; fish, shrimp and crabs live in the mangrove forests and are a primary food and subsistence source for the local populations.
Not only are mangroves important for the direct use of the resources they provide, mangrove forests are also vital to shoreline communities as a natural form of protection against storm surges and tsunamis. Storm surges are an increasing threat in a changing global climate with rising sea levels. Furthermore, in relation to the present human-made global warming, mangroves have the ability to store vast amounts of carbon and can thus act as a mitigation tool against climate change. However, mangroves are under threat worldwide, especially as their original locations are often cleared to build shrimp farms and tourist resorts. Once lost, mangroves can be difficult to replant. Taking care of the existing mangroves is very important for protecting the future of our planet, our home. The creation of reserves is a good option for protecting them.

Further information on mangroves can be found here:
https://www.conservation.org/stories/11-facts-you-need-to-know-about-mangroves

Nature reserves or **protected areas** are regions of land, coast or sea that are set aside for conserving nature, biodiversity and ecosystems such as mangroves. These areas serve a broad range of functions, for example for scientific research, the preservation of biodiversity and the protection of environmental services such as carbon sequestration, education, tourism and recreation.

For further information, please visit:
https://globalforestatlas.yale.edu/conservation/protected-areas

Who are the characters in our story?

Scarlet, Potira and **Cordelia** are birds of the *Eudocimus ruber* species, also known as the scarlet ibis. This species inhabits tropical South America and the islands of the Caribbean. Its remarkably brilliant scarlet colouration makes it unmistakable. The species has protected status around the world.

Alcides is a swamp ghost crab (*Ucides cordatus*). This species of crab is native to many coasts of the Western Atlantic Ocean from Florida to Uruguay. U. *cordatus* is especially noteworthy in Brazil as it plays an important role in the economy, primarily as a food source.

What is cordel literature?

Cordel literature is a genre of poetry typical of the north of Brazil. The poems are generally published in small booklets with a woodcut cover hanging from strings and relate stories of regional folklore or traditions in an informal and rhythmical way. Although printed, cordel literature retains a strong oral component.

Its origins go back to the medieval troubadours in Portugal in the 12th and 13th centuries, who sang poems, spreading stories to the mostly illiterate population. During the Renaissance, following the creation of the printing press, these poems were printed as booklets and sold in markets and at fairs hanging from strings, hence the name

'cordel literature' (in Portuguese, the word for 'string' is 'corda'). It arrived in Brazil with the Portuguese colonisers but it developed its own characteristics when Brazilian poets began including popular traditions and folklore. It is still displayed hanging from strings and so it has retained the name. Cordel literature became very popular in Brazil at the end of the 19th century, helping to create and maintain the popular and folkloric imagery in the Northern and North-eastern states. It is still very important for preserving regional customs and encouraging reading among the local population.

In this story, the Brazilian authors wished to pay a humble tribute to this genre of literature, illustrating the detrimental effect humans have on mangroves in a melodic way.

Ollin and Phoenix's adventures in the city of corals

Ameris Ixchel Contreras Silva
Illustrations: Yuly Lorena Allende

Allow me to tell you a story about Ollin, an adventurous loggerhead sea turtle with big sparkling eyes. Her life began under the white, warm and soft sand of a Caribbean beach, where her mother had laid her eggs. Beneath the sand, the eggs were kept warm and protected from predators—other animals that would like to eat them—until they hatched. Ollin was born with many, many siblings, but the path to the blue home awaiting her—the ocean—must be braved alone. The way was frightening and perilous; not all of her siblings would succeed. Having courageously arrived at the sea, Ollin grew to be a genuine marine adventurer. By the age of seven, she had already crossed seas and oceans all over the world following different ocean currents, the highways guiding her travels.

One day, she will return to the very same beach where she was born and will never forget. There she will lay her own eggs. But that day is still far off. Ollin is still a young loggerhead sea turtle and loves to dine on the best seagrass and jellyfish along the way. The most exciting part of Ollin's adventures is meeting other animals and making new friends. And this is where our story begins...

It was a bright morning. The sun was shining in the clear, blue sky and Ollin paused swimming to snack on a mouthful of delicious seagrass. Whilst eating, she saw a large, slightly chubby animal with a spoon-shaped tail. She realised that the poor thing was trembling with fear. Ollin decided to approach to check if the animal needed help.

'Hello, my name is Ollin and I am a sea turtle. Are you okay?' she asked.

Ollin realised that the poor creature was holding back tears as it shakily responded: 'I am afraid! I've lost my mummy!'

'Oh, no! What happened?' asked Ollin, trying to gain the other animal's trust.

'We were eating on the edge of the mangrove swamp...'

'Mangrove what?' Ollin interrupted.

'Don't you know the mangrove swamp? Can you see those trees over there with the massive roots?' the animal poked her head out of the water and signalled towards the beach. 'They look like fingers delving into the mud. That is the mangrove swamp. Along the edge, there is a lush, green field full of tasty food.'

Ollin also raised her head out of the water and gazed in the direction of the beach.

'Ah! Of course I know it. I just didn't know its name.'

'My mummy and I were grazing there when we heard the roar of a motorboat. She immediately told me to swim as fast as I could to the seagrass and to stay hidden there until she could come to get me. But, but... it has been a long time now, and she has not come back yet. I want my mummy! I'm so scared!'

The animal's eyes, red with tears, gazed up at their surroundings. Ollin, not having any experience with babies, tried to distract her from her sorrows.

'Hey, what is your name and what kind of animal are you with that unusual tail?' Ollin asked.

The animal trying to hide in the seagrass responded in a soft voice: 'My name is Phoenix and I am a manatee.'

'Nice to meet you, Phoenix! You know, I thought since you're all alone; maybe I can help you look for your mother in the mangrove swamp. What do you think?'

Phoenix jumped and happily exclaimed, 'Oh, that would be wonderful!' Phoenix approached Ollin and, after stroking her shell with her flippers, said, 'Thank you so much, Ollin.'

As they arrived in the lagoon area near the mangroves, both started swimming slowly and looking around. Everything seemed so quiet. Not so far away, they noticed a beautiful blue crab busy scuttling through the soft mud hunting for tiny snails.

Ollin approached carefully, trying not to interrupt his lunch, and asked: 'Excuse me, Mr Crab. My friend here is looking for her mother. They became separated when a roaring boat approached them whilst they were eating here around the mangroves. Have you seen her by any chance?'

The blue crab stopped his hunting. He looked up at Phoenix and Ollin, his large eyes on stalks waving. He adjusted the tiny lenses of his eyes to get a better look at them, 'Hmm... I saw an animal that looked like you a few minutes ago,' the crab replied, pointing to Phoenix. 'But it was older and bigger.' Without a care in the world, he turned around and continued his scavenging.

Clearing her throat, Phoenix quickly asked: 'Did you see which direction that animal went?'

The crab turned back again and said: 'Look, kid, I am not a police officer!' The crab seemed a bit annoyed. He adjusted his lenses again and pointed one of his pincers in the direction of the **coral reef.** Then he rolled his eyes and disappeared into the sand before either Ollin or Phoenix had a chance to ask another question.

For a few seconds, Phoenix was stunned. She looked around with her big, wide eyes and began to sob.

'Oh, no! How am I going to find my mummy in this huge ocean?'

Ollin saw Phoenix crying and quickly suggested: 'Phoenix, let's go together to the reef. There are a great many animals there and surely someone has seen her.'

'Hmm, my mummy told me about the reef... but she said it's dangerous because there are so many humans there. Some of them hunt us. They can also hurt us with the propellers of their boats because we live in shallow waters. We are mammals and we need to stay close to the surface to breathe air; we are not fish, you know.'

'I also need to go to the surface to breathe, but I am a reptile,' said Ollin, swimming up and down with excitement. 'And as far as the dangers in the reef are concerned, you don't need to worry. I'm a reef expert! I can warn you if I see something unsafe. Now, should we go to the reef and look for your mother there?'

For a moment, Phoenix's face turned very pensive, but then she looked at Ollin with a glint in her eyes.

'Let's go and find my mummy,' Phoenix replied with courage and enthusiasm.

Together, they started paddling from the mangrove lagoon to the seagrass and the reef. On the way, Phoenix began getting more and more curious about their adventure and started asking a lot of questions. Ollin smiled; she liked seeing that Phoenix's curiosity was outgrowing her fear.

'Ollin, what exactly is a coral reef?'

'Here in tropical waters, reefs are like big colourful cities for many marine creatures. In the reef, you find algae, sponges, octopuses, starfish, seahorses, fish of various different colours and sizes, anemones, crustaceans like shrimps and crabs and also many visitors such as sharks, manta rays, other sea turtles like me...' Ollin paused to take a breath and continued: 'Reefs cover only tiny areas of the whole ocean. Despite that, I could never finish counting all the different creatures that thrive there. Many animals live their whole lives in reefs, whereas others come only to feed, to find a mate and start a family or to hide from predators. Of course, the most important animals in the reef are the **corals** themselves. Corals are tiny animals, which spend all their lives in a specific place and group together. They build a hard house around themselves. Those houses connect to many other houses, forming a big city, and that is what we call a coral reef. Corals come in many beautiful colours and shapes. A reef looks like a large, colourful, underwater garden. They are so pretty!'

Ollin stopped and popped her head out of the water to take another breath. She wanted to tell Phoenix so many things about the reefs that it left her short of air. At that moment, Phoenix started picturing a busy coral city with different colourful shapes and many kinds of animals. Questions kept coming to her.

'Ollin, why are reefs so colourful?' she asked.

'Ah! A fascinating question. Look, most of these colours come from very, very tiny algae, so small that they are called microalgae (the singular form is alga and the plural algae by the way). More specifically, the microalgae from the corals are called zooxanthellae. These zooxanthellae live in the tissues of the corals and give them beautiful, radiant colours. Corals and zooxanthellae work together as a team. The zooxanthellae make food using sunlight as a power source; this is called photosynthesis (phōs means 'light' in Ancient Greek and sunthesis means 'putting together': the ingredients for the recipe). They share the food with the corals and, in turn, the corals give the microalgae a safe and cosy place to live. In this way, they help each other out and live very happily together.'

Phoenix continued imagining a beautiful and colourful coral reef and carried on asking questions.

'So, the microalgae need sunlight to photosynthesise. Therefore, the water has to be clear?'

'Exactly. That is why the water of the reef must remain clean for the corals and microalgae to thrive!'

As they continued swimming, Phoenix saw an orange animal trying to escape from a big green net.

'Ollin, look! I think there is an animal trapped over there. Let's go and see if we can help him!'

Both animals swam fast in the direction of the animal. Ollin went closer and called out: 'Hey, do you need some help?'

The orange animal gazed at them and responded: 'Well, what do you think? Of course, I need help! I was trying to escape from a fishing boat when I got trapped in this heavy net.'

The animal was irritated, trying over and over to untangle his head and legs from the net.

'There's no need to be so rude. We only wanted to help,' said Ollin while trying to help the animal escape. However, she did not know where to begin. The net looked heavy and big and the animal was wrapping it all around himself. Minding her manners, Ollin asked: 'What is your name and what kind of animal are you?'

The animal nervously responded: 'I'm sorry for shouting, but I'm desperate and exhausted. I am a spiny lobster and my name is Spiky. Can you see these long antennae on my head? That's why we are called spiny. We use them to make noises and scare away our predators. Sadly, our greatest predator are humans; they love our meat, which is why they were trying to catch me. That is fine: other creatures in the ocean like to eat us as well and we are proud of being irresistible. You know? We are simply part of the food chain or, to be more precise, food web, as it is rather a network of many chains. The problem is that humans are taking way too many of us and not letting our offspring grow old enough to reproduce. They are **overfishing**—and not only lobsters, but also crabs and fish. We simply can't keep up and our group of friends and family is getting smaller and smaller.'

While saying this, Spiky stopped messing around with the net and Ollin and Phoenix were able to come up with a way out for him, like guiding him through a labyrinth. Finally, Spiky was free! Ollin and Phoenix looked at each other eyes with great satisfaction.

As he left, Spiky said gratefully: 'You two are amazing! You make a fantastic team. Keep working together! Thank you so much! Bye, bye!'

Ollin and Phoenix gave each other a high five and continued on their way to the reef, when suddenly Ollin saw a delicious jellyfish off in the distance.

'Phoenix,' said Ollin. 'Please wait for me here. I just saw a jellyfish over there. Those ones are deliciously irresistible!' Ollin darted towards the jellyfish and, just as she was about to devour it, she heard a gentle voice coming from the distance.

'Stop! Don't eat that; it's not a jellyfish!'

Ollin looked perplexed and tried to see who had spoken but was also really curious about the 'not jellyfish'. She examined it carefully and realised that it was indeed not a jellyfish; it was just a white, floaty thing without tentacles. Ollin turned around and saw an animal very similar to Phoenix but older and bigger.

'Thank you very much for the warning,' she said. 'Do you know what this thing that looks like a jellyfish is then?'

'It is a plastic bag. Nowadays, our ocean is full of this human rubbish. I know it well because I usually live on the coast and there we have much more. Anyway, I must hurry; I need to get to the reef as quickly as possible,' the animal explained and swam far away.

Ollin wanted to ask a question, but it stayed on the tip of her tongue. So, she simply swam back to Phoenix and they continued their journey to the reef, too. When they finally reached the reef, they saw how some of the reef inhabitants were nervously swimming around talking to each other. Ollin, who had been to many reefs, realised that the corals were looking pale and very sad. What is going on here? she wondered.

Phoenix looked all around with wide eyes: 'I think you were wrong in describing the coral reef. Where are the beautiful colours? This looks rather like a cemetery with all those white rocks.'

Ollin, confused, replied: 'I don't know what to say; this is not normal. I have never seen a reef like this before.'

In the distance, they saw a big cloud of colour swimming over the pale corals towards them. As it approached Ollin and Phoenix, it turned blue with yellow stripes that almost blinded them. As the cloud passed by, Ollin and Phoenix heard it mumbling:

'It's too hottttttt! It's too hottttttt!'

'We have to fleeeeeeeee! We have to fleeeeeeeee!'

'It's too hottttttt! It's too hottttttt!'

'We have to leaaaaaaaave! We have to leaaaaaaaave!'

'I know those animals,' Ollin said, 'They are yellowtail snappers. But that's weird; it looks as if they are abandoning the reef.'

'Ollin, let's ask them where they are going and maybe they have seen mummy and know what is happening here,' said Phoenix.

Phoenix and Ollin swam after the group and said, 'Hello, guys!'

The whole group turned around, blinding them again with sparkling blue bodies and yellow tails.

'HELLO! HELLO! HELLO!' the whole group said together.

'Have you maybe seen my mummy?' Phoenix asked with determination.

'No, I'm sorry, you are the first one of your kind I've ever seen in my life,' said one of the older snappers.

Ollin immediately asked: 'But where are you going? Do you know why the reef is looking so sad and colourless? And why are you saying 'It's too hot?'

The same old snapper replied: 'The **sea temperatures are changing**. The water keeps getting hotter every summer. When the sea temperature increases too much, we can't live here. It's suffocating and there is no more food.'

'It's too hottttttt! It's too hottttttt!'

'We have to fleeeeeeeee! We have to fleeeeeeeee!'

'We have to leaaaaaaaave! We have to leaaaaaaaave!'

'It's too hottttttt! It's too hottttttt!'

'There's no fooooood! There's no fooooood!'

An elegant barracuda swimming around, approached, slowly moving her tail, and spoke politely behind her fin as if it were a microphone.

'Excuse me for interrupting, but I overheard your conversation. Indeed, the water keeps getting hotter every year, but this summer has been extremely hot. This has stressed the corals and the zooxanthellae. Under stress, they do not know how to work as a team anymore. Some corals eject their zooxanthellae or the zooxanthellae abandon their corals. This is awful because the corals and the zooxanthellae need each other to survive. Without the colourful algae, the corals turn pale and look white or in other words: bleached.'

The older snapper stated: 'Indeed, this is **coral bleaching**.'

'Bleaching! Bleaching! Bleaching!' the whole group repeated after him.

Phoenix and Ollin witnessed for the very first time the so-called coral bleaching caused by the unusual increase of the sea surface temperatures. Ollin did not quite understand why this was happening, so she kept on asking:

'I don't understand! Are you saying that the corals and zooxanthellae are in danger? But if the corals are the building blocks of the reef, what will happen to all the reef creatures?'

The barracuda looked around at the corals and replied, 'I am afraid the corals are slowly dying. If the water cools down, maybe the zooxanthellae will return to their corals and the corals could then recover their health and colours. However, if the water stays so warm for much longer, I am afraid that the corals will die off and the animals living here will have to leave, too.'

'Exactly, we cannot live here anymore, so we have to go somewhere else,' confirmed the older fish from the schooling snappers.

'Somewhere else!' the school of snappers added in chorus. 'Somewhere else! Somewhere else!'

The cloud of snappers turned again in a shimmering sweep of yellow tails and swam away from the reef.

That is not good Ollin thought and immediately asked Mrs Barracuda, 'Do you know why the water keeps getting warmer, Mrs Barracuda?'

'No, but the trail of evidence leads back to the humans,' she responded and swam away.

Ollin and Phoenix wandered around for a while in the sad, bleached reef still looking for Phoenix's mother. They kept their eyes peeled and their ears wide open, also looking for other animals who could tell them more about what was happening.

A beautiful multicoloured parrotfish felt the need to talk and approached the two friends.

'You know, guys? We on the contrary, have plenty to eat. Much more than before. Many of the algae we, parrotfish, like to eat so much are spreading a lot and even overgrowing the corals.'

'I don't get it. I thought the algae and corals are good friends and live together. Is that not the case?' asked Ollin.

'Yes, the zooxanthellae and the corals are definitely the best housemates (when it is not too hot), but there are many more different types of algae of different colours and sizes in the reef. I, for example, like to eat big ones. By eating the algae, we help with the cleaning of the reef! But there are now way too many, meaning we cannot keep up the pace with our job. Don't get me wrong, the algae are also fine fellows of the reef (and tasty!), but they do not belong here in such large numbers!'

'But, Mr Parrotfish, why are there so many more algae?' Phoenix asked inquisitively.

'I'm not sure, but I overheard that humans are putting much more nutrients into the ocean, which is appetising food for the algae.'

Ollin and Phoenix were astonished listening to all the troubles in

the reef. Suddenly, a huge wavy movement caught Ollin's eye and she swam quickly in that direction pulling Phoenix with her. As they approached, they saw how several big octopuses were frenetically waving their tentacles, rummaging in the ground and searching for food.

'Hello, octopuses,' said Ollin as she approached them.

'Haaaa,' some octopuses groaned and did not even bother to look at them.

One of them, whilst rummaging in the ground, muttered: 'This is a mess. Our ocean is facing the consequences of human pollution. The equilibrium is broken. Our reef and millions of marine animals are dying and our ocean is crying. Sadly, humans do not seem to notice; they are changing the Earth for the worse. They are 'controlling' everything and it is a nightmare for us. Here, where I used to play, it now seems so filthy and decayed. Just look at all this rubbish!'

The octopus with his eight tentacles lifted some of the rubbish, coloured pieces of some unknown things. 'Plastic, plastic, plastic, all around! The worst part is that humans do not realise that without the reefs and us, they will also suffer. But there is nothing we can do. We are doomed. Where are we going to find a new home? We are all going to die!'

At that moment, the octopus became so restless and anxious that he moved away, releasing a thick cloud of black ink into the water. All the other octopuses did the same and disappeared in all directions, leaving a big black cloud ahead of the two friends. Ollin was speechless for a few moments.

'Oh, Phoenix, just imagine! What would happen to all the marine animals that depend on the reef if the corals are gone forever? The corals are the oldest and wisest creatures in the reef. They are the city builders, the most important inhabitants! It is the corals that make this paradise work properly.'

Phoenix moved closer to Ollin and whispered to her: 'Ollin, all I want is to find my mummy and see the reef as you described it to me. I want to admire its colours; I want to see all the animals living happily. The only thing I knew about the reefs before meeting you was that they are dangerous for us because of humans. Now I am learning that reefs are essential for many creatures in the ocean.'

Phoenix was worried about all the problems in the reef and of course thinking about her mother.

'My mummy says that humans are also part of this big house, that living beings interact with each other and also with our environment, she calls that an ecosystem. We manatees think that humans have forgotten that we are all part of a big, expansive ecosystem. We need each other, but humans think everything is just a matter of fun,' she complained.

Suddenly, from out of the black cloud that the octopuses had left in their wake, they heard a gentle voice calling to them: 'Phoenix! My baby! Where are you? If you are there, please answer me!'

Phoenix got excited and quickly answered, 'Mummy? I am here! I can't see you!'

Phoenix's mother appeared out of the black cloud swimming towards Phoenix also really enthusiastically. When they met, they gave each other a hug and danced together. Ollin was so pleased to see such a happy reunion.

'Mummy, I am so happy! How did you find me?'

'An octopus not far away told me a baby manatee is around the reef!'

'It's so nice to be with you again! But listen, mummy, we have a big problem here. Our ocean is polluted and getting hotter and hotter: that's why the corals are dying. All the animals in the reef are at risk! We need to do something; we cannot just wait here to die.'

Phoenix and her mother were rocking gracefully and gently in the water. In the meantime, the manatee listened to all the stories and adventures Phoenix and Ollin had experienced together. Then she said, 'It is true, our paradise is fragile; it is home to so many marine organisms. Humans also need healthy coral reefs, healthy mangroves and other coastal ecosystems. These ecosystems are a natural barrier that protects humans from the fury of the wind and storms along the coasts. Humans also need the resources from the sea; people rely on the oceans to survive. It is unbelievable that so many of them do not care or realise what is going on here. I hope that with time, maybe by themselves they will change how they act. Perhaps they will get a warning signal from us once they see that we disappear.'

Ollin and Phoenix did not like the idea of waiting to disappear so that humans could understand. They wanted to do something. A plan formed in Ollin's mind. During her travels, she had made friends with many animals. Her idea was to call on all of them to work together as one big team.

Ollin swam to the middle of the pale reef, attracting the surrounding animals' attention, and began to speak:

'Friends, I have a great idea! If all of us marine animals work together, we can send a clear and concise message to the humans to save the coral reefs and all the creatures that depend on them. The whales will create huge waves. Above us, the seabirds will fly in circles. Red crabs will carve the word 'HELP!' into the white sand. Hundreds of dolphins will jump together in front of the crowded beaches grabbing the humans' attention, whilst other dolphins still will whistle a message:

'Humans, please stop polluting the ocean and the atmosphere; this only leads to destruction. It is time to start saving energy and adopting sustainable ways of living. Do not forget to reduce, reuse and recycle! Moreover, messy tourists are no fun for us; we do not want you in the reef littering, trampling on corals and taking marine souvenirs.' Ollin paused and closed her eyes as she continued imagining.

At first, the people would not understand what was happening. However, the whole noisy spectacle from the sea would eventually help them to make a connection with the whistling message. Luckily, humankind, sometimes smart, sometimes blind, would realise what message the sea and all its inhabitants were trying to communicate. They would finally understand that the planet is suffering right in front of their eyes. And this is, of course, not good for any inhabitant of Earth, including themselves. As such, people would start to make radical changes to their way of living and, gradually, the delicate balance between humans and the environment would be restored.

The beautiful parade ended and a voice echoed in the distance:

'You know this is a dream, right?'

Suddenly, all the marine animals woke up from the beautiful dream and each of them parted company. However, the idea remained in their heads to spread the plan to all marine creatures on the way. Some day they will put the plan into action. In the meantime, Phoenix and her mother swam away back to their beloved mangrove swamp. Ollin felt very happy that the two manatees were together again. She was excited about her next journey across the ocean; she took the following current swimming like a great ballerina and slowly disappeared in the distance.

Snip, snap, snout, this is not a tale and it is not told out. Coral reefs around the world are suffering from bleaching, diseases and many more stresses that can lead to their disappearance. We need to become aware of the consequences of our way of living, to change our daily habits, to listen to, respect and take care of our environment. All inhabitants of Earth can live together in harmony, relishing the true beauty of blissful nature again. We should pay more attention to what happens every day on our beautiful, blue planet and live in harmony with everything around us.

We already know it, now we just have to do it!

Would you like to know more?

Coral reefs
What is a coral?
https://www.dkfindout.com/uk/animals-and-nature/jellyfish-corals-and-anemones/corals/

All about reefs:
https://kids.kiddle.co/Coral_reef

Threats for corals
Rising sea surface temperature
https://climatekids.nasa.gov/coral-bleaching/

Ocean acidification
https://climatekids.nasa.gov/acid-ocean/

Overfishing
https://kids.britannica.com/students/article/overfishing/631895

What can I do?
https://oceanservice.noaa.gov/facts/thingsyoucando.html

Plumi and the chocolate river

Camila Neder
Illustrations: Katja Bronner

Once upon a time, there was a **sea pen** by the name of *Malacobelemnon daytoni*. Her friends called her Plumi.

Have you ever heard of sea pens? They are marine colonial soft corals. WOAH! Slow down a bit! That was a little too fast! Sea pens are colonial corals: they are formed by many, many polyps that cannot live without each other. These polyps look like small versions of the anemones you may have seen on the rocks of some beaches. Sea pens live on the seabed of many marine environments, including the ice-cold waters of Antarctica! In contrast to their reef-forming relatives found in tropical oceans, which you may know from nature documentaries, they do not build a 'hard house' around themselves; their wormlike bodies are unprotected. That is why they are called soft corals. Speaking about soft—sea pens need soft ground in which to anchor their bodies, so that they can let them sway with the water. However, unlike plants, they do not have roots. And WATCH OUT: they are not plants; they are benthic animals! Benthic animals are creatures that live on the seabed (attached or mobile). Now you know the basics of sea pens, let's carry on with Plumi's story...

Her story began long before she reached the seabed where she settled to live. It started with a little egg drifting, suspended in the water close to the Antarctic Peninsula. One day, the egg split open, and Plumi was born as a tiny little larva. She grew bigger every day

and finally started searching for a suitable place to build a home. For this, she was looking for soft ground where she could bury her foot and anchor herself. She would not be able to bury her foot in a hard surface with her wormlike body. Can you imagine a soft earthworm burrowing into a rock?

There was Plumi, growing whilst suspended in the Antarctic Ocean, feeding on her egg and imitating the best rappers on Earth:

'Ground, ground, soft, soft ground, this is where I am going to land.

Ground, ground, where are you?

Please, come! I am looking for you.'

Finally, already a bit tired, she spotted a promising place on the seabed and decided to take a closer look. Eureka! It was soft and cosy, just as she had hoped! She had found the place where she would live for the rest of her life! It was a place called Potter Cove. She buried her foot firmly into the soft ground. Then she spread out her arms with her thousands of fingers, just like we stretch when we wake up, and said:

'Ah! This is the life!'

Well, they aren't actually real arms...or fingers for that matter. They are more like small branches with tentacles. The tentacles come from the small polyps that form the colony. When Plumi dances with the ocean currents and shakes her body and tentacles to the rhythm of the seabed, she catches food and absorbs oxygen from the water. That is how she eats and breathes. Down there on the seabed, many other filter animals that are attached to the ground like Plumi also breathe and eat from the water in similar ways.

She soon made friends with ascidians as well, of course, as with other sea pens all anchored on the sea floor around her. Sometimes they organised parties, where they danced and ate all together. She particularly liked dancing with an ascidian, Astrid, whose movements were very elegant. However, breathing and eating from the water can

sometimes cause problems at the bottom of the sea, as we will soon understand...

One sunny summer lunchtime, Plumi was very happy and comfortable at her place in the ice-free Potter Cove, when she suddenly saw a brownish wave heading towards her and her friends.

'MMM...it might be chocolate. Delicious!' she thought at first.

However, the power with which the brown wave was coming towards her frightened her at once. Soon, it became not that easy to breathe and she realised that it was probably not chocolate. Indeed, it was a huge amount of water with a great deal of mud and sand suspended in it. In a way, it was like breathing during a sandstorm for us. The brownish wave was turning darker and darker. It was coming directly towards her and all her friends! She could see how Astrid was getting

into serious problems trying to breath. Plumi started shouting for help in all the languages she knew. She was very scared about this unknown event.

'Help! ¡Socorro! Hilfe! Au secours! Someone, please help me! ¡Que alguien me ayude por favor! Bitte helft mir! Aidez-moi, s'il vous plaît!'

Dana, a scientist who was walking along the coast, suddenly heard something. She turned her head in the direction of the sound and saw something she had never seen before: brownish water, which looked like melted chocolate, was rushing into Potter Cove and partly sinking. After some time, it became less. Dana was astonished to have witnessed the event and immediately began thinking about all the poor creatures that lived on the sea-floor in the cove. 'They certainly won't like that,' she thought.

Dana had been studying the benthic community in Potter Cove for several months. As a marine ecology expert, she had dived there many times and knew how much life was down there. She was very excited about having discovered that a sea pen population had settled in an area previously covered by glacial ice and now open. It was something she had never seen before in other places in Antarctica! She was especially fond of a particular sea pen that she would visit on all of her dives. Can you guess which one it was? Our Plumi of course! Dana had found out that Plumi and the other sea pens absorb oxygen from the water in the same way that they eat—through their filtering system. So, breathing in that muddy water was surely no fun for them and probably not for many of the other benthic animals in the cove either. She turned her head once again. Now she could hear a voice.

'Is that someone calling for help?' she wondered. She couldn't tell where the noise was coming from. In this area of Antarctica where she and her colleagues were researching, there were not many people around. The cries seemed to be coming from the ocean. Was she imagining it all? Was there someone underwater crying for help? WAIT! How could that be possible?

'Who needs help? Stay calm! I will help you as soon as I find out what is going on here,' she shouted, begging that whoever it was who was in need of help could hear her.

Meanwhile, Plumi was trying to survive. She did not know if anyone had heard her. She continued doing her best by contracting her filtering apparatus so that less sediment would enter; it was exhausting, but she soon became adept at it and started to feel a bit better. Other

benthic animals did not seem to be faring as well though. Plumi was worried about Astrid.

After a few minutes of reflection, Dana, convinced of herself, committed to her scientific task:

'I have seen some weird things, but I am convinced of this one: someone was calling for help from underwater, and it might be related to the benthic animals. I will figure out what has happened and I will tell the benthic community about it!'

Luckily, Plumi and her friends were starting to feel much better. The scary river had passed, and with it the shock. Plumi was not afraid any more, but she realised that she and her benthic friends could have died! Oh my! She was shaken to her core at the very thought.

After a couple of months of intense research in her site office, Dana returned to the same area. She remembered all too well the cries that she had heard at the time when the chocolate river struck. Now, she knew why that had happened and wanted to tell Plumi and her friends about it.

She would have liked to dive, but she wouldn't have been able to speak and would definitely need the help of a colleague. The end of the summer was a bit of a difficult time, as it was also when their research term on site ended and there were not many scientists around any more. You never dive alone, especially in such a difficult environment as Antarctica. As such, she decided to take the message on her own by boat. She would send down the slate board she used to use on diving field trips with a message written on it.

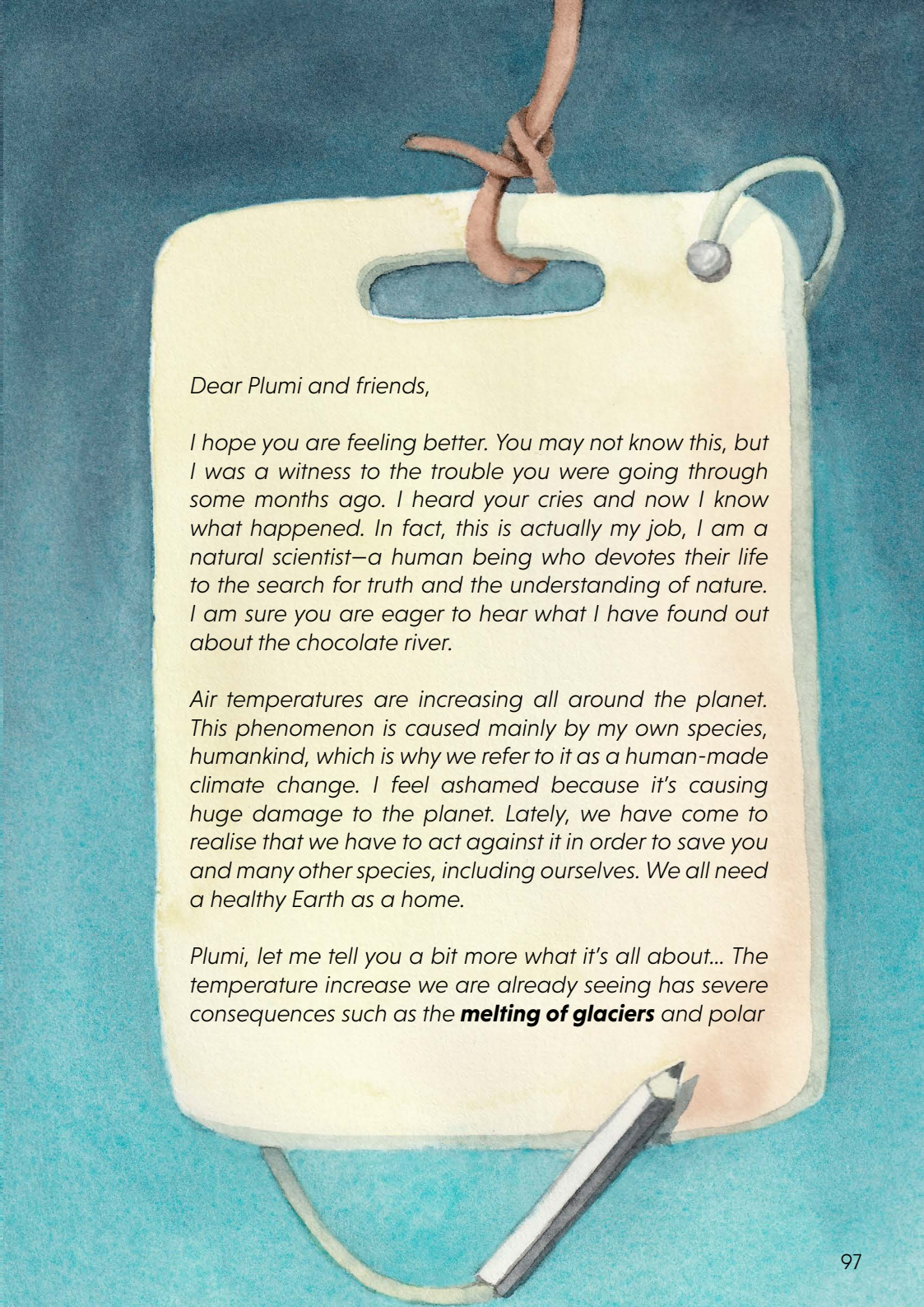
Do you know those whiteboards used in some schools? Ok, well, this one is quite similar, just a bit smaller and messages or notes are written with a simple pencil that works underwater and the writing is not washed away!

Dana took a pencil, wrote the letter to Plumi and her friends, grabbed a rope and tied some incredible marine knots to hold the slate board.

She got into a boat and sailed to the place where the sea pens lived. She cast the long rope out like a fishing line and when she felt the slate board touch the seabed, she sat in the boat and waited... and waited until Plumi could read the message.

Plumi heard something.

'Oh, no! Not again, please!' she thought for a moment, remembering the incident with the 'chocolate river'. She stayed still for a minute until she realised that it was an object coming down on a rope. She observed it carefully. It was a letter written on a slate board. She began to read.

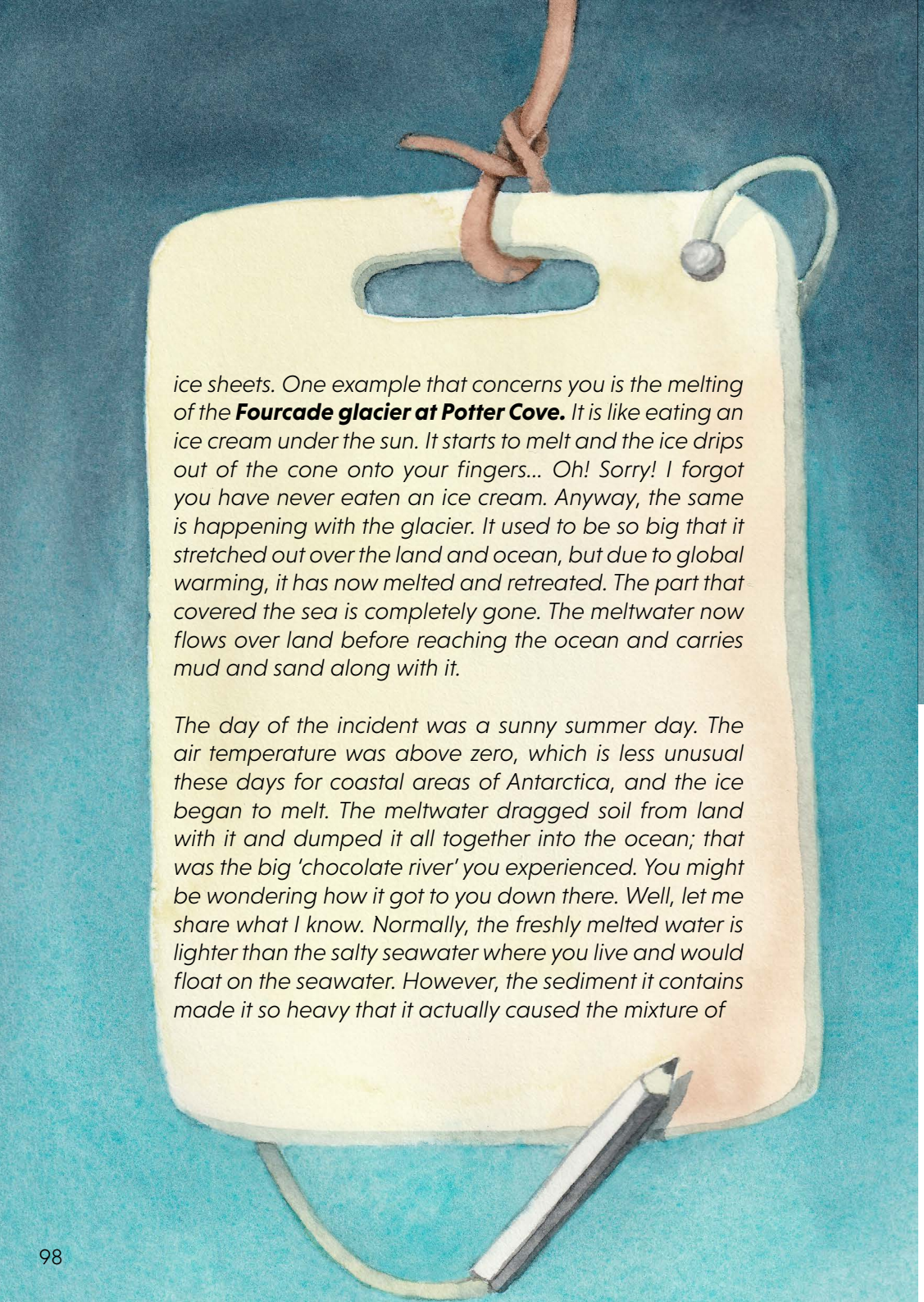


Dear Plumi and friends,

I hope you are feeling better. You may not know this, but I was a witness to the trouble you were going through some months ago. I heard your cries and now I know what happened. In fact, this is actually my job, I am a natural scientist—a human being who devotes their life to the search for truth and the understanding of nature. I am sure you are eager to hear what I have found out about the chocolate river.

Air temperatures are increasing all around the planet. This phenomenon is caused mainly by my own species, humankind, which is why we refer to it as a human-made climate change. I feel ashamed because it's causing huge damage to the planet. Lately, we have come to realise that we have to act against it in order to save you and many other species, including ourselves. We all need a healthy Earth as a home.

Plumi, let me tell you a bit more what it's all about... The temperature increase we are already seeing has severe consequences such as the ***melting of glaciers*** *and polar*



ice sheets. One example that concerns you is the melting of the ***Fourcade glacier at Potter Cove.*** *It is like eating an ice cream under the sun. It starts to melt and the ice drips out of the cone onto your fingers... Oh! Sorry! I forgot you have never eaten an ice cream. Anyway, the same is happening with the glacier. It used to be so big that it stretched out over the land and ocean, but due to global warming, it has now melted and retreated. The part that covered the sea is completely gone. The meltwater now flows over land before reaching the ocean and carries mud and sand along with it.*

The day of the incident was a sunny summer day. The air temperature was above zero, which is less unusual these days for coastal areas of Antarctica, and the ice began to melt. The meltwater dragged soil from land with it and dumped it all together into the ocean; that was the big 'chocolate river' you experienced. You might be wondering how it got to you down there. Well, let me share what I know. Normally, the freshly melted water is lighter than the salty seawater where you live and would float on the seawater. However, the sediment it contains made it so heavy that it actually caused the mixture of

water, mud and sand to sink right to the bottom of the ocean, where it reached you.

There, you experienced a strange situation: the amount of sediment this meltwater river transported might cause breathing problems and make you tired as it would take greater efforts to get more oxygen, but it could also bring more food, which wouldn't be all that bad, don't you agree? However, I am afraid that not all of you will be able to cope the same with that muddy water.

Plumi took a break from reading. She got caught up imagining what it would be like to eat an ice cream and see a glacier melting due to high temperatures. Meanwhile, many of her friends were speaking, gossiping and commenting that they had felt exactly the way the letter described when the incident with the chocolate river had happened.

'Acidians, fellows, please, keep calm! There is more news. I will keep on reading what the scientist says,' Plumi said and continued reading.

*In the meanwhile, I have used some scientific **models of species distribution**—simplified representations of nature to predict locations for a species to live—to find out where you and your friends could live with the present conditions in Antarctica. On the one hand, as the glacier retreats, new ice-free areas are opening up! There you will have a lot more space to colonise...new and empty places! The problem is: can you reach them? Potter Cove, the place where you live, is small and only about nine square kilometres. So, from your location, it will be only a few kilometres to colonise a new free spot. For you, Plumi, and the other sessile organisms—organisms attached to the ground—it is complicated since you have already settled, but maybe the eggs can make it the next time you reproduce! It is a complicated trip but promise me you will think about it!*

Another problem, and this is the critical one I saw in my models, is that in this new ice-free area, the 'chocolate rivers' will be more frequent. They will happen often in the summer and can come from three different places, dragging a lot of sediment with them into the fjord. Some calculations tell us that it will be between 23 and 39 tons of sediment every year! Do you know how much a ton is?

It is 1,000 kilograms. So, between 23 and 39 tons of sediment is the equivalent of between two and three fully loaded lorries. Can you imagine three lorries full of mud? Oh, well probably not. I forgot you have never seen a lorry! It is about as much as a humpback whale made of mud! That is a lot of mud!

Again, these meltwater rivers ('chocolate rivers') could indeed bring more food for you, but remember—if they become extreme, they might end up covering you with sediment and threatening your survival. So, you will need to be ready for that. Unfortunately, I am afraid that not all your friends will manage with so many chocolate rivers in the new ice-free area.

I do not really know what the best option is for you; the situation is very complicated. At least now you know the nature of the hazard experienced and that it will surely happen again.

Take care!

Best wishes, Dana

P.S. Plumi, give me a sign once you have finished reading this letter, so I can remove this piece of plastic from your pristine environment.

Plumi was stunned. She did not know what to say. Apparently, she had no choice but to tolerate the changing conditions. The scientist had given her some advice on where to send her offspring and said that they should be able to adjust better to the new conditions. She tugged on the rope and the slate board disappeared. She looked at her friends, who were also stunned after all they had heard.

Astrid was the first to speak: 'We, the ascidians, had a hard time with this single chocolate river. I do not think it is a good idea for us to send our babies to the new area, even if there will be more food there. But you should go on and discover a new place! Do not miss the chance to expand. We will be looking forward to hearing from you and we will think of another solution for ourselves.'

Plumi was glad to have Astrid as a friend. She nodded and looked at her sea pen friends. As the self-appointed leader, Plumi began to explain her plan.

'We will set up a guard to watch out for the chocolate river coming, and the sea pen in charge will give us a sign to contract our bodies and be prepared to face the sediment by breathing a bit less and not suffocating. Then, we will eat the food and send our offspring to the new area.'

With a synchronised tentacle movement, all was well understood.

'There we go,' the sea pens cheered up.

'Let's cope with the next chocolate rivers and let's wish our eggs a good journey into the new area and hope for favourable currents!' Plumi and her friends said as one.

And that is how everything was prepared for the next adventure: 'The establishment in the inner area of Potter Cove'.

Would you like to know more?

Sea pens and their life cycle

A sea pen like *Malacobelemnon daytoni* is a cylindrical, soft colony octocoral. They can reach, as far as scientists know, up to 14 centimetres in length and they are already mature at 1.5 centimetres. For comparison, other sea pens can reach a size of up to 2 metres!

They are a colony: one sea pen is composed of many polyps. These polyps look like smaller versions of the anemones visible on the rocks of some beaches at low tide. The mature sea pen develops from a main primary polyp called an oozooid and has a muscular peduncle, which is Plumi's 'foot' in the story. This single peduncle allows the sea pen to anchor itself in the ground, which should be a soft sediment like mud (clay and silt) but not too soft, which would render it unstable or result in weak anchoring. The main primary polyp further develops into an erect stalk (the rachis) from which other polyps responsible for feeding and reproduction develop. Those are part of the 'arms' and 'fingers' in the story. Each polyp has eight tentacles, which is why they are called octocorals.

Reproduction occurs externally. The reproductive cells (gametes) are released into the water, where the union of the gametes to produce a fertilised egg also takes place. The egg develops into a lecithotrophic larva. This strange word means that the larva feeds on the reserves in the egg until it settles. This larva cannot swim. Instead, it drifts along with the water currents. This is a limitation for the colonisation of new areas. Once established at a site, the sea pens remain mostly sessile, i.e., non-mobile, for the rest of their lives. Only occasionally, under some stress conditions, do sea pens detach from the seabed and move to a new spot in the same area.

Further scientific information regarding the species and its role in the ecosystem can be found at:

https://www.biologie-seite.de/Biologie/Seefedern (in German)

https://rdu.unc.edu.ar/handle/11086/11808 (in Spanish) or:

https://glacierhub.org/2017/09/07/future-yet-unwritten-antarctic-sea-pens-secrets-to-success/

If you are interested in other specimens in Plumi's taxonomic family, please visit this page: https://www.marlin.ac.uk/habitats/detail/1193

Climate change and glacier retreat with 'chocolate river' formation

Scientists from different disciplines are investigating climate change and its effects on the environment right across the entire Antarctic Peninsula. One of the main research focuses is glacial retreat.

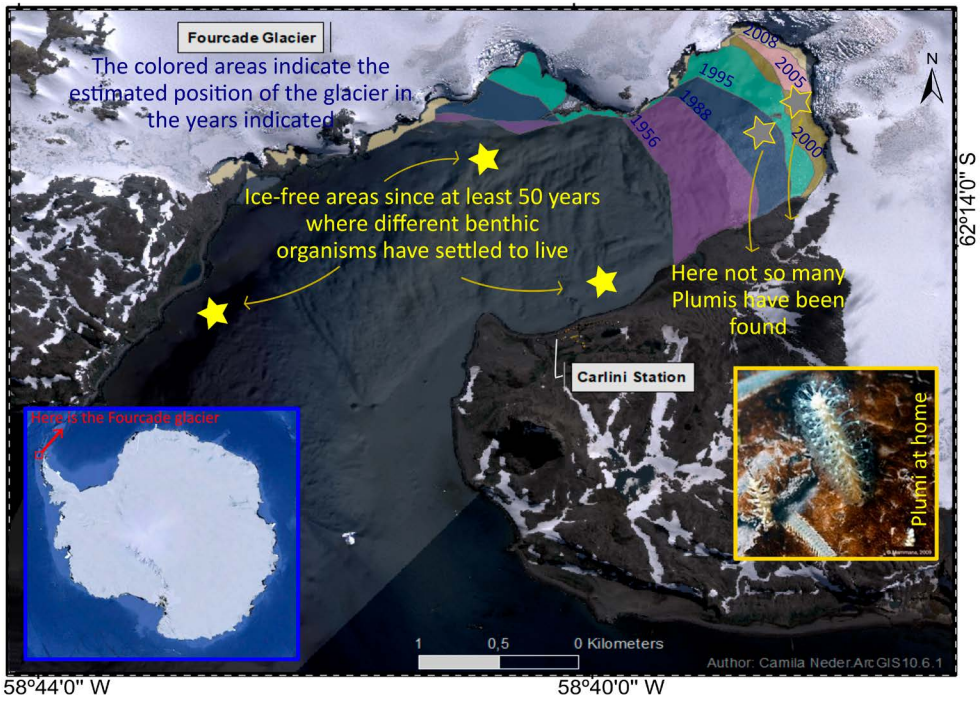
A glacier is an extended mass of ice formed from snow that has accumulated and compacted over the years. These ice streams move very slowly. Some glaciers reach the sea and extend beyond the shore, forming a block of ice called an ice shelf, which is no longer over land. In Antarctica, many glaciers extend over the continent and over the sea.

The increase in air temperature is affecting the whole planet. The air temperature on the Antarctic Peninsula has increased by about 3 °C since the late 19th century, leading the ice to melt faster.

When glaciers retreat, two main processes occur. On the one hand, new ice-free areas open up and can be colonised by various species. On the other hand, when the ice melts, the newly formed freshwater enters the marine system and modifies the environment due to it having different characteristics from the seawater. The freshwater contains up to one gram of salt per litre of water, whereas the seawater contains around 35 grams of salt per litre of water. Consequently, freshwater (meltwater), which is lighter, usually floats on the seawater. However, depending on the land characteristics where the glacier is based, the meltwater can also drag sediment into the marine system and become heavy enough to sink through the seawater. This modifies the marine environment even further through an increase in turbidity, decrease in salinity and effects in the chemistry of the marine system.

The Fourcade glacier in Potter Cove

In Potter Cove, the Fourcade glacier has been retreating from its known position since 1956. Today, the ice shelf has disappeared completely and the glacier is mainly over land. As it retreats, new ice-free areas are opened up for colonisation by benthic organisms. In the photograph below, the different colour bands show the positions that the glacier reached in different years.



Nevertheless, one problem as regards the colonisation of newly ice-free areas are what we call 'chocolate rivers' in our story. The meltwater

streams erode the ground and drag material (clay and silt) into the water, turning it brown. The different densities and colours of the waters—the freshwater, the seawater and the meltwater carrying sediment—make it possible to distinguish them by sight.

Can you identify them in this photograph?

There are now four main meltwater rivers in Potter Cove. Three of them are located in a newly sea ice-free area. This is the area where Dana suggests Plumi send her offspring in our story. Some estimations tell us that in the summer season one stream alone could discharge up to 18 grams of finely ground bedrock into the cove with each litre of water. Some temperature-based models estimate that some 23 to 39 tons of fine sediment could enter the cove every year.

In our story, we mentioned that it was not that easy for Plumi to breathe, but some of her benthic friends had serious problems breathing. Some research suggests that Plumi's species, *M. daytoni*, could tolerate exposure to up to 0.6 grams of sediment per litre of water. One possible explanation is its adaptation by contracting the filter apparatus, whereas some other benthic animals, like the ascidians—Astrid in our story—do not display this adaptive behaviour and, consequently, the sediment has a strong influence on them. Their metabolism is affected and they need to devote more energy to breathing.

If you would like to see a video showing a 'chocolate river' underwater affecting the filter-feeder benthic community, please visit:

https://twitter.com/NederCami/status/1287330633803616256

Where can Plumi live?

For a species to develop in a certain area, the environment must present some characteristics, which support its survival. The ecological niche of a species are the conditions required for said species to develop, considering not only the abiotic characteristics (non-living, such as available space, temperature, etc.) but also the biotic ones (other organisms around: for example, what is their prey or their predator, with which do they compete for a resource, etc.) and how the population responds to the existing resources.

Plumi's species has been found around Antarctica at depths of between 10 and 30 metres. It is particularly abundant at a depth of around 20 metres and displays a high tolerance to sedimentation. The inner area of Potter Cove offers the necessary conditions for M. daytoni and, even if the 'chocolate river' occurs more often, Plumi's tolerance to sediment and living depth will allow her and her friends to cope with the climate change perturbations such as ice impacts and meltwater streams resulting from glacier retreat. However, other species will not be able to adapt.

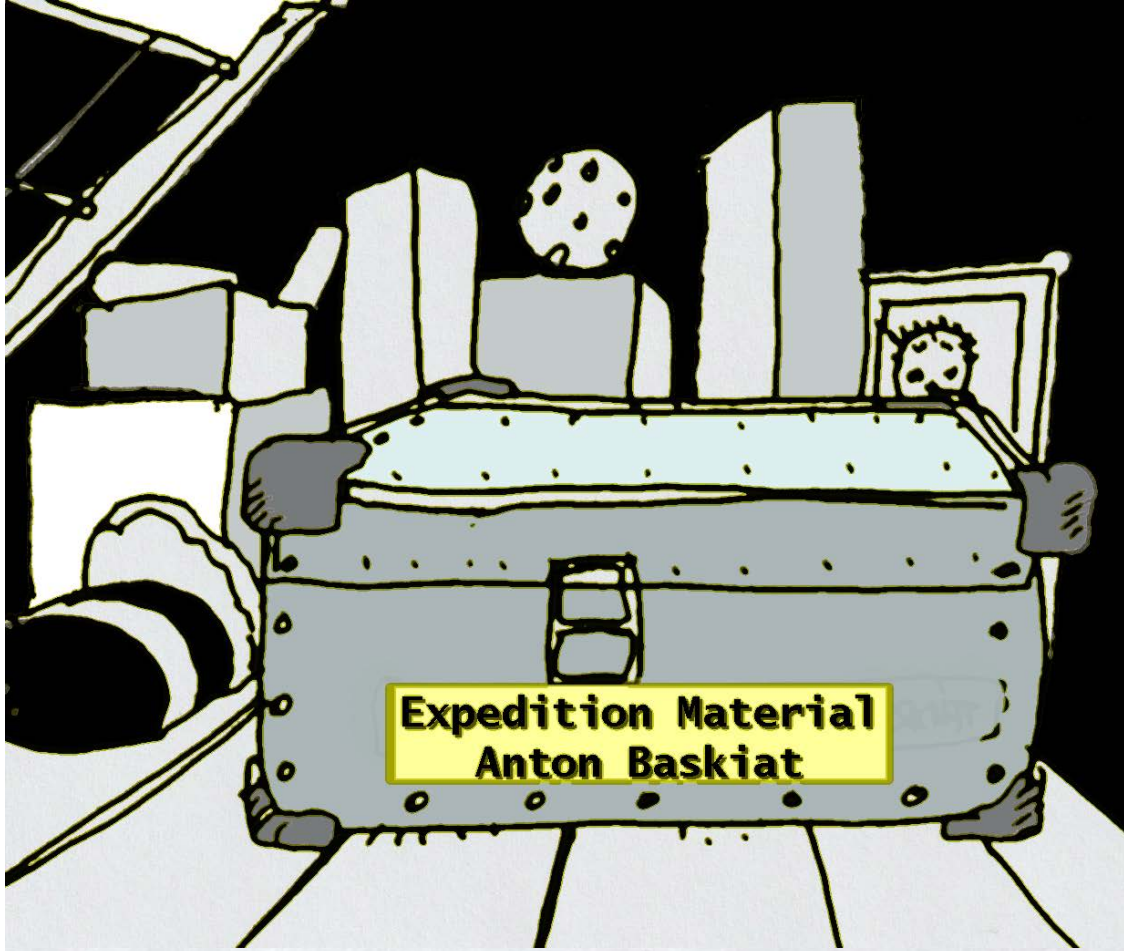
By compiling information on the habitat of a species, scientists can develop so-called species distribution models, with which they can predict where a species could live. This is how Dana, the scientist in our story, is able to suggest to Plumi where to send her offspring.

A deep-sea adventure in the Mariana Trench

Text and illustrations: Manfred Schloesser

Written down by Jan Baskiat

You can believe me when I say that I have thought long and hard about whether to go public with this story. You know, it all took place so long ago and sounds very strange, but I think the world has a right to know what really happened far off the coast of the Philippines in the Western Pacific back then. My grandfather told me this story twenty years ago, when I was twelve years old and at home in bed with the mumps. He explained exactly how he had been there as a young man more than 40 years earlier and how he had written everything down in his black diary precisely as it happened. Admittedly, the events were a bit strange. It was also strange that you could never have found out anything about the whole diving event from newspapers or the Internet. I remember like it was yesterday, how he mumbled something about some important people having confiscated everything and bullied all the witnesses to keep quiet. It seems that my grandfather's little diary is the only remaining evidence. I found this diary by chance last week, when I was looking for Christmas decorations and came across a box with 'Expedition Material Anton Baskiat' written on it in my parents' attic. In it, alongside the diary, was a teddy bear wearing orange overalls and a matching cap. My grandfather died ten years ago, so now it is up to me to bring the truth to light. The story unfolded exactly as he wrote it. Here is the complete, unabridged and unaltered report with his sketches from his diary.



Bremen, 22nd May 2026

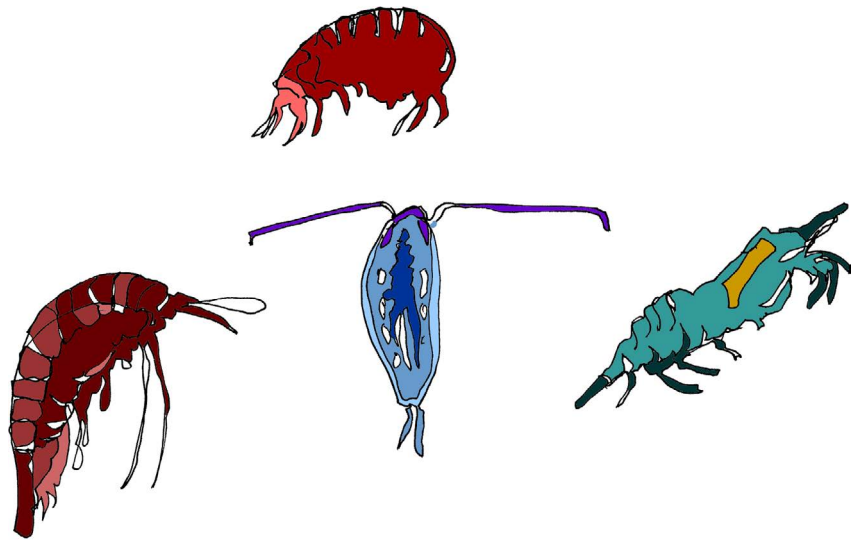
This diary recounts the events of 30th April 2026 on board the Shinkai 12000 **submersible**. I hereby confirm that everything happened as I describe it and it is the truth, the whole truth and nothing but the truth.

Anton Baskiat

Western Pacific, 8:00 am,
30th April 2026 11.3 °N, 142.2 °W

The blustery west wind has now calmed down, the sky is a bright blue and our dive boat is rocking a little roughly with the rise and fall of the waves. We can still hear the squawking of the seabirds as the hatch cover of the Shinkai 12000 closes with a dull thud. Yuri Ulyanov, our pilot, locks the bulkhead and holds up his thumb as a sign that everything is ready for immersion. In the cockpit, a sea of green indicator lights shine, reflected in the eyes and faces of our team. The boat jerks a little, then I watch the depth gauge as we descend into the blue void of the Mariana Trench—the deepest point in all of the world's oceans—at a speed of almost two metres per second. Dressed in our orange overalls with the blue embroidered inscription Shinkai 12000 on the breast and matching caps, I think we look like real marine explorers truly should. Yuri runs the fingers of his right hand through his black hair and looks at our scientific director, Sakura Sato, who has taken a seat between us. She beams at us: 'Guys, I'm so happy. It's finally starting!' Sakura is a professor at the Japanese Marine Research Institute and is responsible for the Shinkai 12000 submarine.

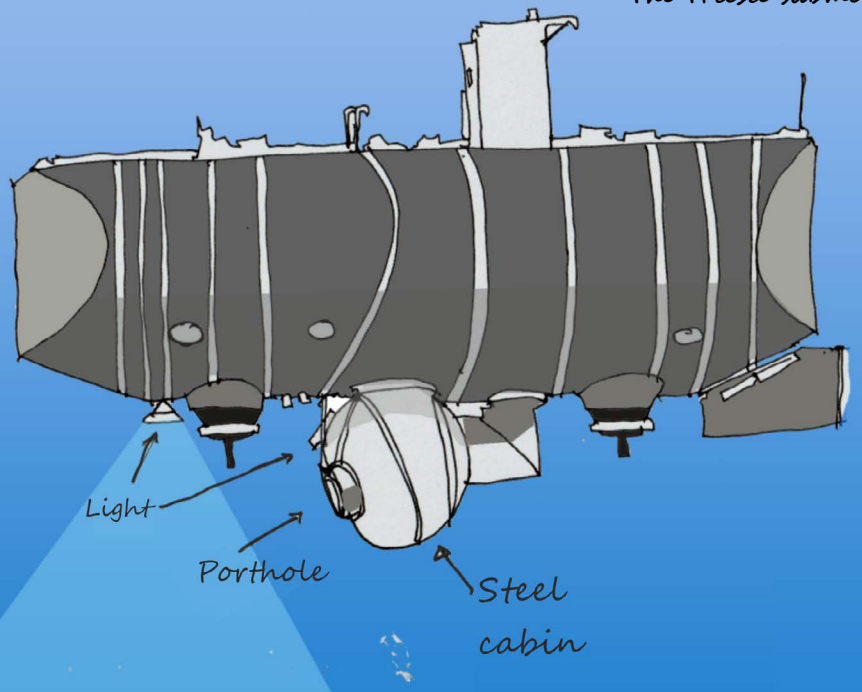
Our mission is to take samples from the deepest part of the ocean floor and study the creatures there. You might wonder why that is important. At the beginning of the 21st century, attentive oceanographers noticed that we know more about the surface of the Moon than about life under the sea. Water covers over 70 % of our planet, making it the largest habitat. That's when the great census of marine life began. Many countries took part in the project to create a large, publicly accessible database of all things and processes in the sea, because you can only protect what you know. After that, it went stroke for stroke. On average, three species were added every week, from all areas of life: from microscopic bacteria to algae and large animals. We wanted to know what lives where and how in the sea as well as how the **material cycles** in the sea make life on our planet worth living.

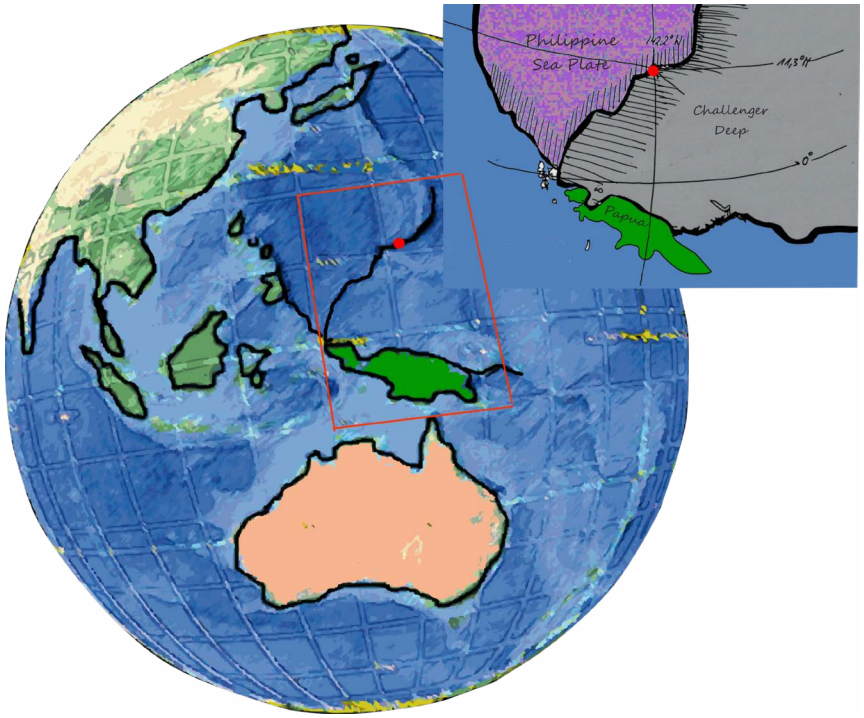


Copepods are only between 0.2 and two millimetres in size, but they are important food for larger creatures.

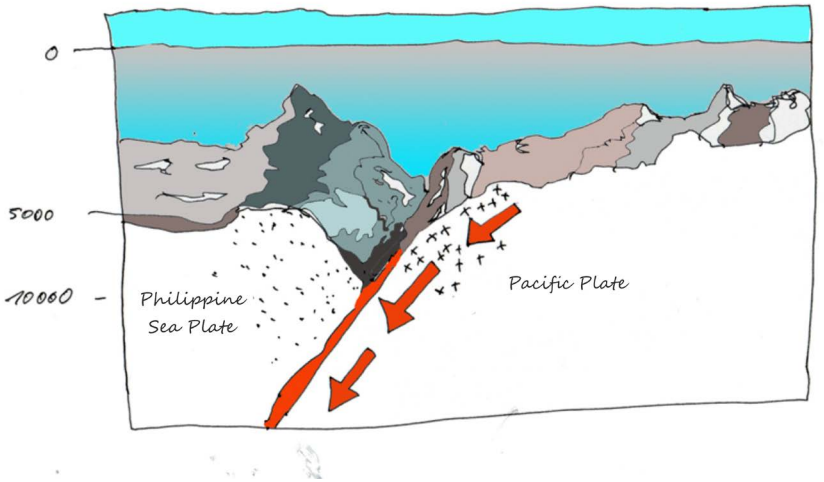
Back to me: I am responsible for the video and photo documentation. Our destination is a very special place in the Mariana Trench, the Challenger Deep—the deepest known point in the Earth's seabed at a depth of almost eleven kilometres. It is about 1,800 nautical miles east of the Philippines, where the Pacific Plate slides under the Philippine Sea Plate, and was discovered by chance in 1875 by the British research vessel HMS Challenger. The place was only given the name 'Challenger Deep' after the British research vessel HMS Challenger II determined the depth in 1951 with an echo sounder and taut wire. To date, it has only been visited by seven people. On 23rd January 1960, Jacques Piccard and US Navy Lieutenant Don Walsh were the first to descend and set the diving depth record of 10,912 metres of water depth with the Trieste's diving trip. However, deep-sea research is expensive and not without risk, so explorers' desire for ever better technology is understandable. Only 52 years later, in 2012, did James Cameron attempt a second dive with the Deepsea Challenger. Money does not seem to have been a problem for Victor Vescovo and his team, who made several dives in 2019 and sent four men to the deepest point on the planet. They also set a new absolute record of 11,928 metres of water depth.

The Trieste submersible.





The red dot indicates the location of the Challenger Deep



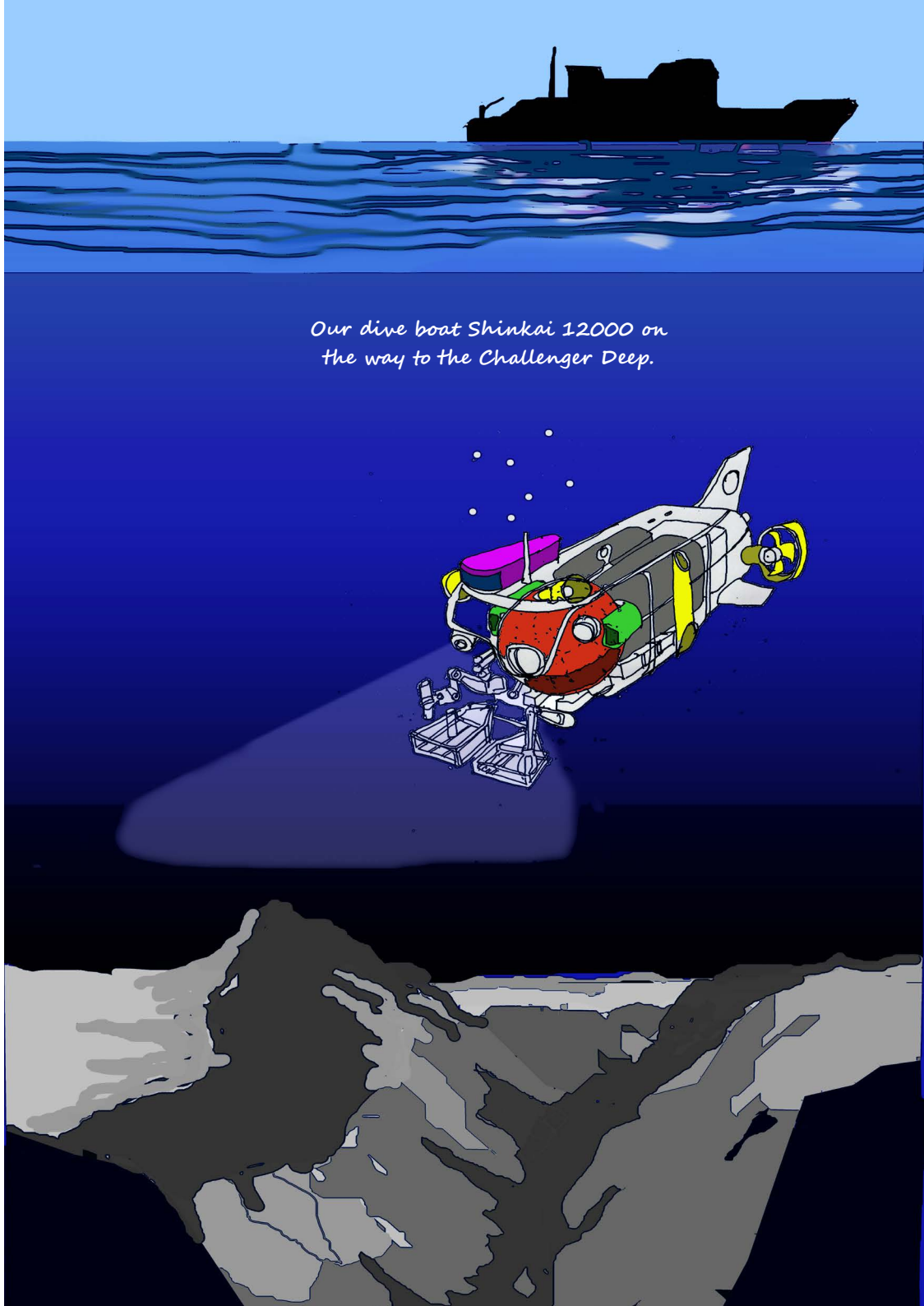
At the Mariana Trench, the Pacific Plate slides under the Philippine Sea Plate

Vescovo's team succeeded in collecting several samples and taking high resolution photographs and videos which prove that there are life forms down there that have never been seen before. Yes, although hard to believe, even **plastic waste** has made it to the deepest point on Earth. In 1960, Walsh and Piccard could only observe, photograph and film through a small porthole, as the circular windows in vessels are known. By 2012, Cameron was already much better off than the two pioneers; not only was he able to observe, photograph and film through a larger porthole, but he could also take **seabed samples** with a manipulator arm. Unfortunately, he was only able to take a single sediment sample during his dive.

But now, in 2026, it is our turn! Sakura proudly announces: 'Ha! Our dive boat Shinkai 12000 can do much more than the other dive boats. It is a further development of the Shinkai 6500 and a masterpiece of Japanese engineering. We have the best video cameras, searchlights and manipulator arms. With our state-of-the-art sampling techniques and sample containers, we will bring some of these creatures to the surface alive. We'll also have enough energy and breathable air for thirty hours of deep-sea adventure.'

We want to know how living beings adapt to the immense pressure and cold temperatures, almost near the freezing point of water, which prevail at the bottom of the Challenger Deep. All the cavities in their bodies must be filled with liquid, as cavities filled with air, such as the lungs in humans, would be crushed immediately.

I am roused from my thoughts as a loud buzz comes over the loudspeaker. The audio channel to the mother ship Yokosuka is very bad and I don't understand the distorted babble of voices, the rasping and crackling. Yuri Ulyanov, our pilot, understands everything though, nods, answers our colleagues way up in our mother ship and quickly mumbles some technical data to himself. Everything is going as planned: the electric motors are humming, outside a swarm of sardines are performing their pirouettes and whale songs and the chattering and shrieking of porpoises penetrate our steel housing via the outside microphones. The depth gauge shows 210 metres. We leave the light-flooded zone and plunge into the darkness of the greatest abyss on Earth. I am not afraid. We are all a little excited, even Yuri, who used to be a space engineer and circumnavigated the Earth on board the Russian space station Mir. When the research funds for his position dried up in the late 1990s, he switched to marine research.



Our dive boat Shinkai 12000 on the way to the Challenger Deep.

He leans forward and reaches under his control panel, digs into his leather bag and takes out a thermos and a small teddy bear, which he places in front of one of the portholes. 'Have some tea, tovarish. It will help you to calm down.'

I have to grin; this happens often to Yuri. When he's a bit excited, Russian words like tovarish (comrade) escape his lips. And his teddy bear is always with him for good luck, he tells us. Even on the space station, the teddy had to look at the Earth from above for hundreds of days.

Soon the depth gauge shows a depth of 6,000 metres. The steel of our submarine groans, but I know that this pressure is no problem for the Shinkai 12000. It sinks deeper and deeper, deeper and deeper. Piccard and Walsh were not this comfortable, I think to myself. Surrounded by a 60-centimetre-thick steel wall, we are sitting in our cabin, a hollow steel sphere, and can watch the action outside through four portholes.

Sperm whales can grow up to twenty metres long and dive up to three thousand metres deep. They sleep upright and only between 18:00 h and midnight.

'That was quick! We've reached 10,000 metres,' Sakura rejoices and turns on the big on-board lights. After three hours of diving, the grey sea floor comes into view. Sakura gives Yuri some coordinates and we head for the first measuring station. Now it is getting exciting and you can feel the tension in the team. However, it seems to be rather quiet out there. I think there is nothing to see but turn on the video cameras. Or is there something? A shoal of unknown fish darts past us and we follow them curiously as they disappear again into the darkness. Sakura points to the spotlight in the other direction. 'Look there! That looks quite interesting. See those strange footprints?' Yuri moves the joystick forward and carefully manoeuvres us closer to the seabed. I take a few pictures. Sakura activates the manipulator arms to take the first sediment sample. She routinely moves the arm and pulls one of the one-metre-long plastic pipes out of its holder, then sinks it about 80 centimetres deep into the surprisingly soft seabed. Sakura starts the oxygen sensors. 'So, the first quick measurement is done. Oxygen is important for life on the seabed too,' she explains.

The oxygen readings look good and we want to go to the second station. There, too, she carefully pulls the tube out of the seabed and stows it with the sample in one of the holders. We will measure the exact oxygen profile later in the laboratory on board. I follow what happens on the video monitor.

Sakura writes the number of the samples and comments in her black notebook, but then she raises her eyes and points excitedly through the porthole. 'There, look there, something is moving. It looks like a **Japanese spider crab**: the largest crab still in existence. Its ten long legs support a body measuring nearly half a metre in diameter. The largest leg-to-leg span ever measured was almost four metres,' Sakura exclaims enthusiastically. 'I know them from the Japanese coast, where they live at sea depths of between 300 and 400 metres at temperatures of around 14 °C. Strange, the specimens at this depth must belong to a different species,' she ponders.

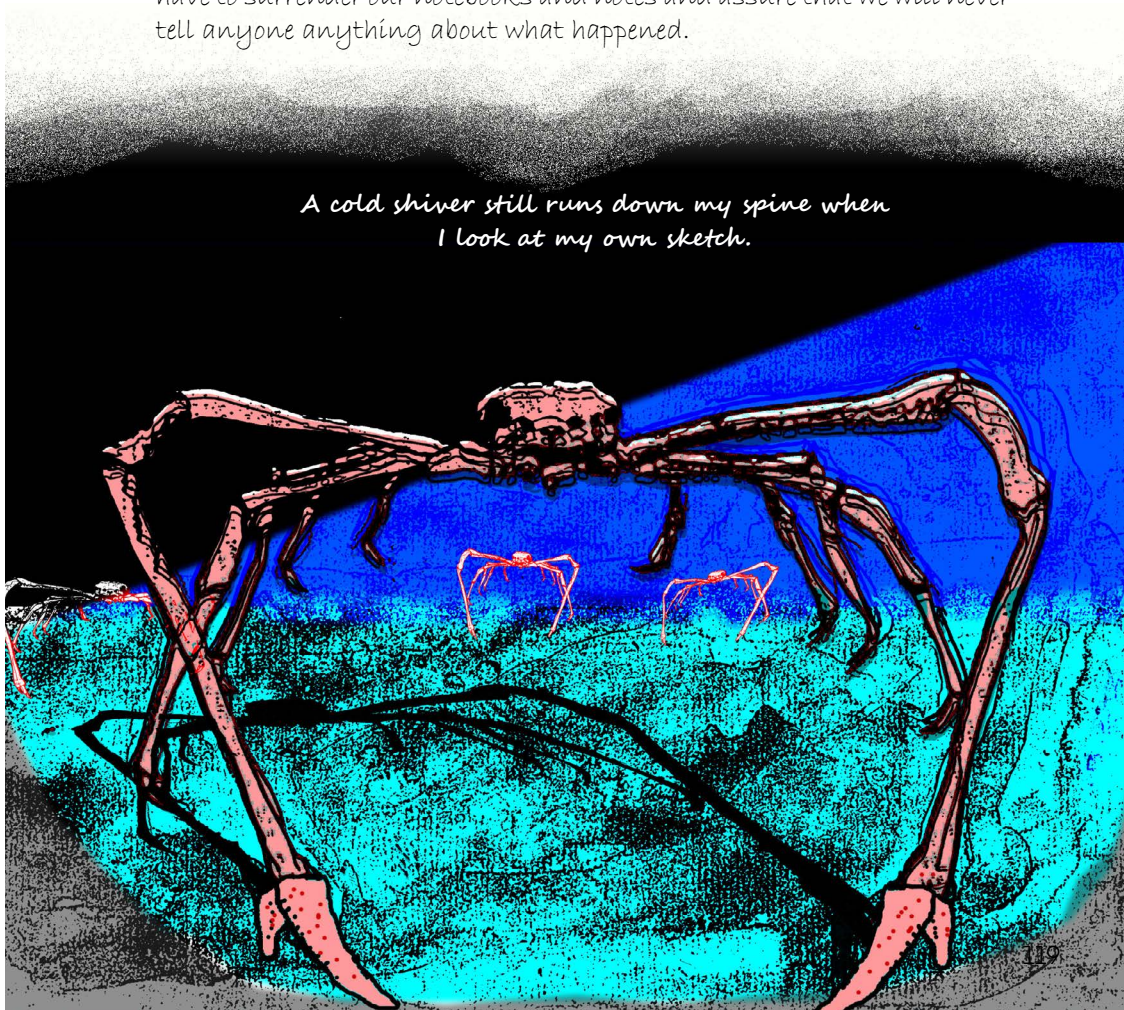
As the animal moves into the spotlight, we all hold our breath: this fellow is at least seven metres tall—and he has huge claws! The monster comes closer and closer. He seems to be interested in the manipulators of our dive boat. He opens his claws, then we hear a grating sound and our manipulator arm is just scrap metal. I switch on all the exterior lights and check if the video cameras are recording this incredible event.

'It's crazy! We'll be famous with these pictures,' I yell. In my imagination, I can see us giving interviews to all the TV stations in the world. Then, my heart almost stops: more of these huge creatures are approaching us from all sides. At least ten of them surround us.

Now panic overcomes me. The giant crabs close a tight circle around us. My heart is racing. We'll never get out of here goes through my head. However, Yuri calmly flicks a number of small switches on his control panel, ignoring the sound of the alarm siren. Almost all the lights in the cockpit are now red. It's high time to leave. Sakuro yells, 'All engines to full capacity!' Nothing happens, only a slight jolt goes through the dive boat. We're stuck. A smell of burnt electrics stings my nose and it seems like flames are emerging from the instrument panel. Outside it is a nightmare; the crabs keep moving towards us.

Yuri remains cool, calm and collected. He presses a blue button and the fire is extinguished. 'It was nothing'. Then he pushes a bright red metal cover aside and turns a gear lever to the left. This is the emergency release for our rescue system. With a jerk, our steel capsule separates from the rest of the submarine. Driven by the strong propellers and the buoyancy, we shoot up towards the sea surface like a rocket. The rest of our Shinkai 12000 submersible with all our evidence, our videos, our samples and our dreams remains on the ocean floor. We are safe, but no one will believe what just happened. Or will they?

Back on board the Yokosuka, we are questioned and interrogated one by one for hours. Not a word to the public, they say. Intimidated, we all have to surrender our notebooks and notes and assure that we will never tell anyone anything about what happened.



This is where my grandfather's diary entry ended. Nobody ever heard of the giant crabs. Even the remains of Shinkai 12000 seem to have disappeared. Or at least during my search in the archives I could not find any reports concerning the dive or the dive team. The only thing that remained is this diary with the drawings that my grandfather somehow managed to sneak out. And this teddy bear. When I took a closer look at it, I saw the words Shinkai 12000 embroidered in small blue letters on its overall. In the end, whether the giant crabs really existed will probably remain a secret. Or perhaps my grandfather just made up an adventure story for a twelve-year-old boy who was sick in bed?

Jan Baskiat

Curious? Would you like to know more?

The story about Anton Baskiat and his diving trip to the Marina Trench is fictitious. But, of course, you already knew that. Not everything is made up though.

The **Japanese spider crabs** (*Macrocheira kaempferi*) really exist and they can live for up to 100 years! With a body diameter of around 40 centimetres, they are the largest living crabs. The largest span ever measured from leg to leg was 3.7 metres and they can weigh up to 19 kilograms. The giant crabs live off the coast of Japan and in some other places in the Pacific at water depths of between 300 and 750 metres and temperatures of between 11 °C and 14 °C.

Giant crabs have not yet been spotted in the Challenger Deep. We still know very little about the life forms in this enormous depth of water and about the sea in general. I already hinted in the story about why marine research is important, but you can find out more here.

The life cycles

Up to one billion microorganisms can live in one litre of seawater, but they are so small that they cannot be seen with the naked eye. Some of these microorganisms are algae that live in the top light-flooded layers of the sea. Like plants on land, they perform photosynthesis with sunlight and carbon dioxide and generate oxygen. It is estimated that half of all the oxygen in our atmosphere comes from the sea. Other microorganisms in the seawater are specialised in processing the remains of dead organisms. They make sure that dead fish, squid, crabs and any other sea creatures decompose. Further microorganisms are waiting on the seabed to break down the remains that make it to the bottom. This invisible 'clean-up squad' ensures that the global cycles of the elements are preserved. Without it, life on Earth would come to a standstill. The natural cycles depend on everything that dies decomposing and the returned components being used for new life.

Furthermore, did you know that more than three billion people cover a fifth of their protein requirements from the sea at present? They do so by eating fish, crustaceans, mussels… and also algae. In addition to overfishing, marine life is threatened by the estimated more than **150 million tons of plastic in the sea**. And nine million tons are added every year. What is the problem? Carbon is a fundamental building block of life on Earth, but even if plastic largely consists of carbon compounds, microorganisms cannot break them down—or, if they can, then only very, very, very slowly. Why is that so? Over the course of millions of years, nature has produced mining specialists for everything imaginable, but plastics have only been around for a few decades. Even though researchers have recently discovered some plastic-eating microbes, the plastic problem is far from being solved. It simply takes too long: more than 500 years for one PET bottle. As a result, the pieces of plastic in the oceans become smaller and smaller due to abrasion. They then find their way into food chains as microplastics and ultimately end up on our plates. Bon appétit!

The oceans also store the greenhouse gas carbon dioxide, also the anthropogenic carbon dioxide (anthropogenic = man-made. The word comes from the Greek ánthrōpos = man and genḗs = offspring). A lot of this greenhouse gas generated by our modern way of life ends up in the ocean. Unfortunately, this leads to gradual acidification of the ocean, which affects marine life with calcium carbonate skeletons. Check it out: put a clam shell or a piece of eggshell or a raw egg in a glass of cola, a glass of vinegar or a glass with citric acid overnight and see what happens by the morning.

The current state of research in 2020 is that we know more about the Moon than about the sea. So far, twelve people have been to the Moon, whilst only seven have reached the bottom of the Mariana Trench. In 1960, Jacques Piccard and Don Walsh were the first with the Trieste, James Cameron followed in 2012 with the Deepsea Challenger and, in 2019, Victor Vescovo's team dived with the Limiting Factor. Each of the research **submersibles** used has space for the crew in an air-filled steel or titanium ball that can withstand the high pressures—more than 1,000 bar—of the Mariana Trench. That is a thousand times the atmospheric pressure of the lower atmosphere.

Research with submersibles is not without risk. There are usually several independent safety devices and the submersible is carefully balanced with buoyancy bodies and weights. In an extreme emergency—such as a total power failure—a mechanism ensures that the weights fall off the submersible and the resulting buoyancy makes it rise to the surface.

Alternatives to the manned submersibles

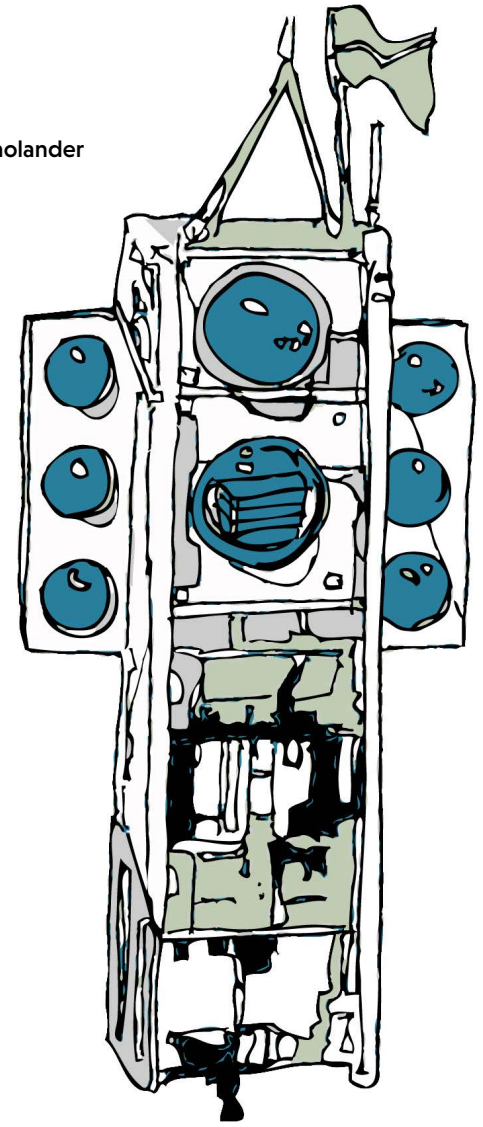
In addition to diving boats, **unmanned, remote-controlled vehicles** have been used for a long time. The **ROVs** (remotely operated vehicles) are connected to the mother ship via a communication cable and can dive up to 7,000 metres. Specially trained pilots control the manipulator arms, sensors and video cameras on board. Another type of vehicle is the **AUV**: autonomous underwater vehicle. It looks like a torpedo and its job is to take very accurate maps of the ocean floor. When travelling just above the bottom, it emits sound waves that are reflected by the sea floor and recorded as an echo in the AUV. Just as bats can use ultrasonic calls to map their surroundings, the AUV data give the researchers a fairly accurate picture of the ocean floor.

What is in and on the ocean floor?

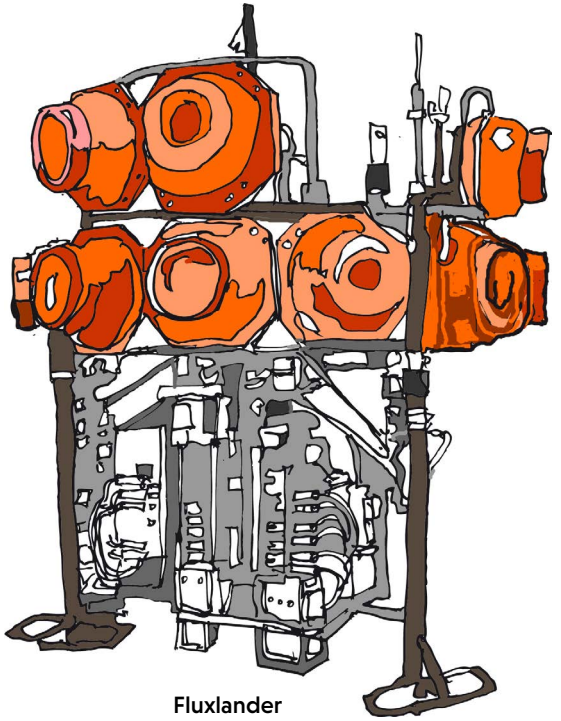
Landers

Landers slowly sink to the bottom of the sea in free fall without a direct cable connection to the ship thanks to the negative buoyancy given by iron weights. Once at the bottom, they start their measuring programs and can collect water samples. Control of the landers and their programs is not easy because radio waves and GPS (geographically positioning system) do not work under water. Sound waves move almost five times faster under water than in the air. Researchers take advantage of this and send their control commands to the lander as a special sequence of sound waves, which almost sound like the chatter of dolphins. For example, one command orders the iron weights to be dropped and the lander returns to the surface. The iron weights rust quickly on the seabed. The iron oxide produced is found almost everywhere in nature.

Nanolander

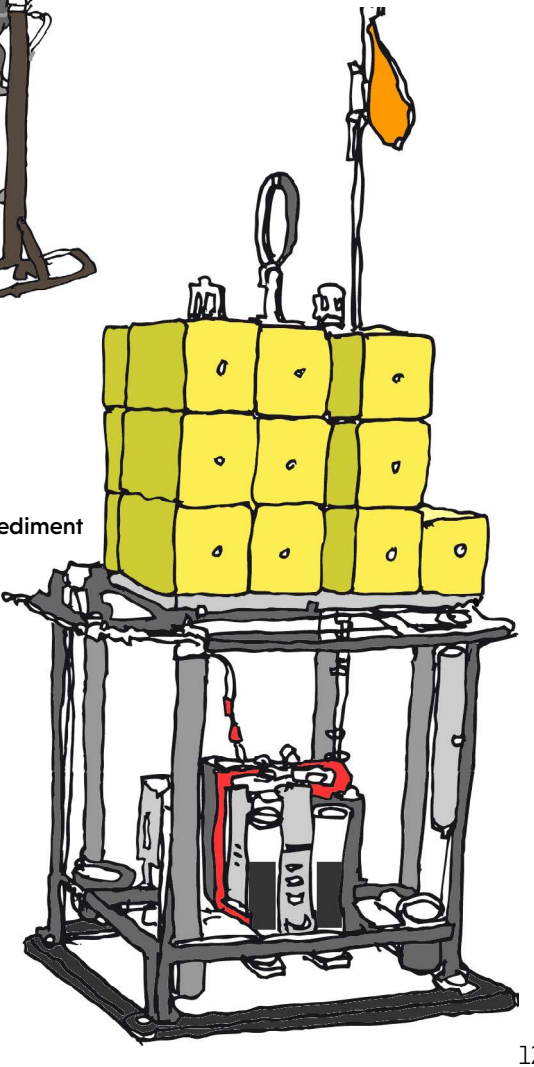


There is a special lander for every type of application. Most devices can stay under water for several days.



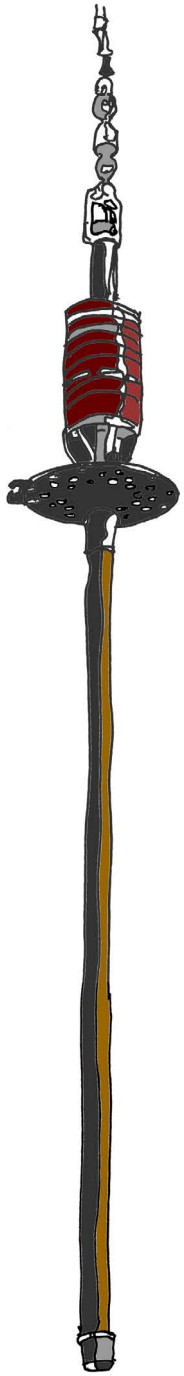
Fluxlander

Lander sediment



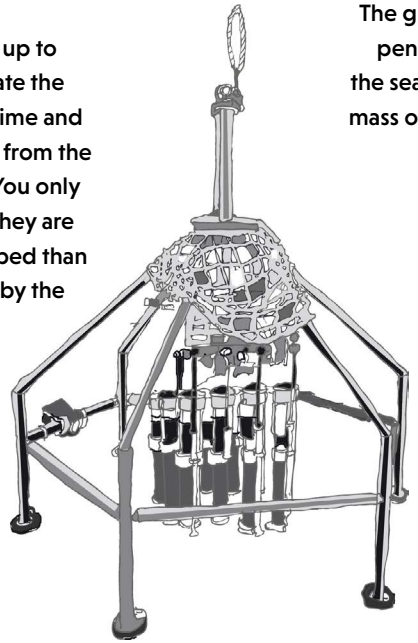
What is deep in the ocean floor?

Researchers use special grippers or long pipes to take samples of the sea floor. The top layers of the sea floor are the youngest; the deeper layers are the oldest ones. You will already be familiar with this: if you don't clean everything regularly at home, layer after layer of dust will gradually build up. Depending on how fast these layers of sediment accumulate over the centuries, you can trace the history of the Earth over millions of years. For example, evidence of the meteorite that struck the Earth 65 million years ago has been found in the waters off the Yucatán Peninsula. A lot of dust was thrown up into the atmosphere by the impact. It darkened the sky for years and prevented plants from growing. The consequences of the impact are ultimately believed to have brought about the disappearance of the dinosaurs. Traces of the impact can be found in many places on Earth as a layer of rock with a significantly high proportion of the element iridium.



The gravity corer penetrates into the seabed with a mass of one and a half tons.

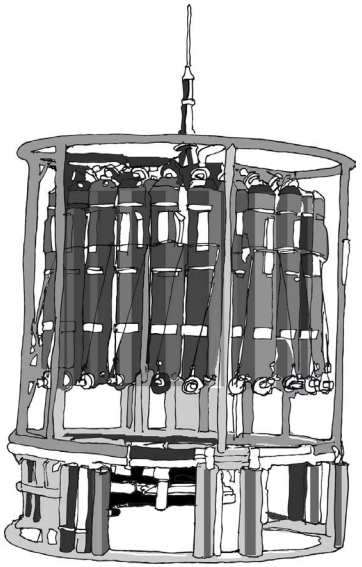
With the Multicorer, up to twelve pipes penetrate the ground at the same time and take sample material from the top 60 centimetres. You only get short cores, but they are much more undisturbed than the long cores taken by the gravity corers.



Marine research is not just about what happens on the ocean floor. What about the water?

Water samples are collected with a device called a rosette, which is a commonly used device in marine research. The rosette is lowered from the ship with a steel cable and usually holds twelve open plastic tubes in a circular array on a steel frame. Each tube has a seal at the top and at the bottom. If you want to take a water sample at a certain water depth, you can electronically close both ends of a certain pipe remotely from the ship, leaving the water at that depth trapped in the pipe. At the same time, a probe continuously records the values for conductivity, temperature and pressure and can thus instantaneously track the salinity (through the conductivity) and the water depth (through the pressure). Perhaps you have heard the term CTD? It stands for conductivity, temperature and depth. Additional sensors also allow measurement of the oxygen concentration, water turbidity and chlorophyll concentration. The water samples can be analysed to obtain important information such as the content of certain 'ingredients', which can be used, for example, to differentiate between different water bodies. Knowing which microorganisms live at certain depths is also important for understanding how the oceans work. Plus, of course, a variety of different nets are also used for marine research: from very fine-meshed nets for the floating plankton particles to larger nets for fish.

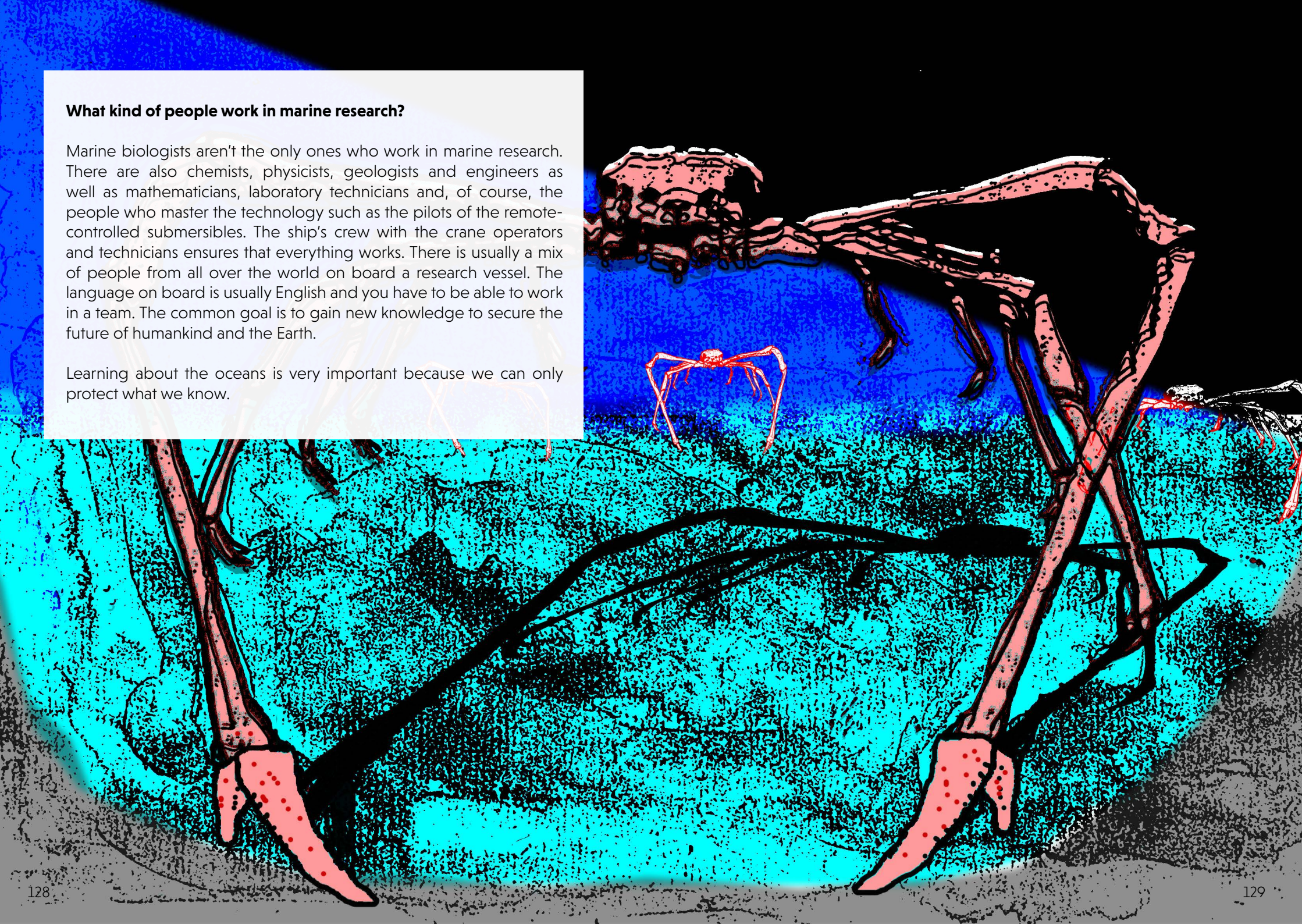
Rosette with CTD



What kind of people work in marine research?

Marine biologists aren't the only ones who work in marine research. There are also chemists, physicists, geologists and engineers as well as mathematicians, laboratory technicians and, of course, the people who master the technology such as the pilots of the remote-controlled submersibles. The ship's crew with the crane operators and technicians ensures that everything works. There is usually a mix of people from all over the world on board a research vessel. The language on board is usually English and you have to be able to work in a team. The common goal is to gain new knowledge to secure the future of humankind and the Earth.

Learning about the oceans is very important because we can only protect what we know.



The name's *Procavia, Procavia capensis*, but call me Ratiphant

Text and illustrations: Gema Martínez Méndez

Hello, my **scientific name** is *Procavia capensis*, and I am one of the five extant species of the order Hyracoidea. More colloquially they call me the rock hyrax ('oh yeah!'), but, as a friend, you can call me Ratiphant.

I live in a number of places in the Middle East (I am even mentioned in the Bible!) and across most of sub-Saharan Africa. Almost everyone who sees me for the first time thinks that I am some kind of marmot or guinea pig, but actually, I have little to do with any of them. Certainly, as far as my size (I measure between 30 and 70 centimetres and weigh from 2 to 5 kilograms) and shape are concerned, I am closer to them than to my true relatives, but I am not a rodent.

Believe it or not, I am the closest living relative of elephants and I am also related to manatees! Well, there is a bit of controversy about that, but saying it makes me feel important. Besides, I can tell you several of the characteristics that I share with elephants: similar shape of some bones, I have fingernails (similar to yours and not much like the claws of other mammals), small fangs that originated from the incisors and not the canines, I have excellent hearing, I am very intelligent, I have an amazing memory and...well, right now I don't remember any more.

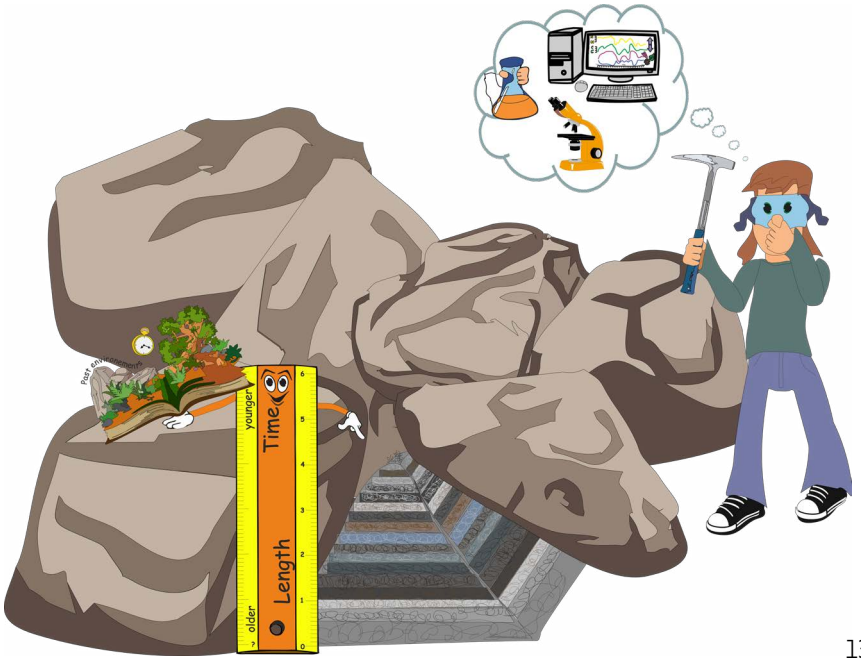
We ratiphants live in groups of up to 80 individuals in rocky areas and cliffs, where we can hide in the nooks and crannies. Sunbathing and warming my belly on hot rocks are some of my favourite activities; I love spending hours and hours sprawled out on the rocks: heat from below, heat from above, wonderful! The truth is that I am not very good at what they call thermoregulation —the control of body temperature— so if it is cold or rainy, I prefer to stay at home.

I am a herbivore and, although I do not ruminate like cows do, my stomach is divided into three chambers. There, friendly bacteria help me to digest the plants I eat. I was not born with the bacteria, to get them, when I was a pup, I had to...oh...I don't really like telling people this...I had to eat some of my parents' poo. There, it's done, I said it out loud. It is not like it's that bad; human pups seem to put just about anything in their mouths...

And, whilst we're on the subject, I'm going to let you in on a little secret: I really prefer to poo and wee in the very same place every time—just like many humans prefer their own toilet at home (although we don't flush). This is also the place where my parents go, my grandparents and great-grandparents went before them and so on and so forth, generation after generation. Whilst you might scrunch up your face at this, some scientists rub their hands together in delight!

When our 'toilets' are protected from the rain, the poo and wee can dry and be preserved for thousands of years! These piles of old droppings make excellent **'palaeoenvironmental archives'**: material that allows scientists to reconstruct what the environment of the past looked like (palaeo comes from Ancient Greek and means 'old'). To understand how, you can think of the universal principle: 'You are what you eat' (and excrete!). We eat plants, so our body waste is a reflection of the flora growing around our homes.

Depending on the environmental conditions (hotter vs colder, wetter vs drier, etc.), there are different kinds of plants growing where we live. We ingest the pollen of these plants as we snack away on the plants' leaves and bark and it is contained in our poo. Pollen is also brought in on our fur or by the wind, and it sticks to our wee as it dries. By examining samples from our toilets under a microscope, scientists can identify the pollen and tell which plants were growing in the area! In addition, the chemical elements that make up the plants' tissues can also tell scientists what the climate was like. Plants are also 'what they eat'. For example, they 'eat' a lot of nitrogen (from the ground) and carbon from the air (as CO_2).



The proportion of **light or heavy nitrogen** and carbon (yes, there is a light and a heavy version of those two, as there is of many other chemical elements) in the plants' tissues varies depending on how wet or dry it is. These changes show up in our waste and allow scientists to tell what the vegetation and climate were like!

Best of all, remember that my family has been using the same toilet for a very, very long time. When we go, fresh poo and wee are deposited on top of older waste and it all piles up over generations. When scientists cut open our toilets—which they call 'middens'—they can see the ancient excrement as a stack of thin layers, like the pages of a book. Each little layer is a visit to the toilet—or, if we want to sound more scientific a 'defecation event'—and since it all dries into something as solid as a rock, scientists can be sure that old and fresh poo are not mixed together (they say the stratigraphy is very well preserved, which I personally take as a compliment). The layers end up being so thin that it is not possible to study each visit to the toilet individually; scientists cannot say what we had for breakfast or dinner, today or yesterday, but it is possible to analyse samples thinner than one millimetre, which usually represent between 5 and 50 years of waste. By collecting hundreds of these thin samples all the way to the bottom of the midden, they can compile environmental records with a resolution of a few years or even seasons going back thousands of years! This is extremely useful for understanding how and why climates and environments have changed in the past! And just remember: **The past is the key to the future!**

So, my friend, as you see, generation after generation, we ratiphants have eaten, processed and expelled the plants around us, immortalising the environmental signal for science in our toilets! No need to thank us!

Oops, what with all this toilet talk, I need to...well, you know 'go and make my evening contribution to science', bye bye!

Would you like to know more?

Scientific name

The same animals, plants, fungi and other living beings are known by different names in different countries or even regions. Our Ratiphant is called the rock hyrax in English, damán de El Cabo or damán roquero in Spanish, Klippschliefer, Wüstenschliefer or Klippdachs in German, Dassie in Afrikaans... Scientists agreed long ago about giving every species a unique scientific name (mostly derived from Latin) that will be used in every country and 'forever'. In the 19th century, nomenclature codes were created to name species and classify them; these codes are periodically revised and updated by consensus.

The scientific nomenclature of species was created by Carl Linnaeus in the 1700s following the steps set out by the brothers Gaspard and Jean Bauhin and is called 'binomial nomenclature'. This name refers to the fact that it uses two designations: genus and specific epithet as the species name. The genus name is always capitalised and written first (*Procavia*); the specific epithet follows the genus name and is not capitalised (*capensis*). There are no exceptions to this rule. In addition, the scientific names of species are italicised or underlined. The full name can only be capitalised if it is part of a title or written in non-italics if it appears within a header in italics.

The genus or species name is abbreviated only when the name has already been used, and it is clear what the letters stand for. The last word in a species name is never abbreviated. For example, if we would have used in the story the scientific name of for the ratiphants again in the story, we could have written P. capensis but never Procavia c. or P.c. Furthermore, a genus name can stand alone when we speak about the genus, for example 'rock hyraxes belong to the genus Procavia', but the specific epithet can never stand alone; we cannot write 'rock hyraxes belong to the species capensis'.

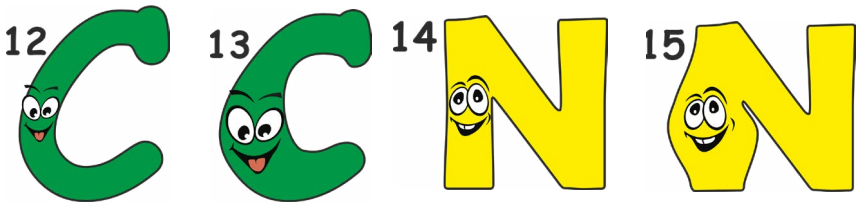
Light and heavy nitrogen and carbon
A little bit of chemistry: isotopes and stable isotopes

Most chemical elements on Earth are found in light and heavy versions. These are called isotopes.

Chemical elements are positioned in the periodic table according to their atomic number (number of protons in the nucleus), electronic configuration and chemical properties. The isotopes of an element differ in the number of neutrons in the nucleus but have the same number of protons. Thus, they occupy the 'same' (iso from Ancient Greek) 'place' (topos from Ancient Greek) in the periodic table: they are the same element. The sum of neutrons and protons of an atom gives an element its 'weight' (mass), which is called its atomic mass. As such, a different number of neutrons in the nuclei results in versions of the same element with different 'weights'.

Stable isotopes are isotopes that, unlike radioactive isotopes, do not spontaneously decay. However, their different atomic masses make them behave differently and these differences are used to understand what past climates and environments looked like.

In our story about the ratiphants, we referred to heavy and light nitrogen and carbon: their stable isotopes. Nitrogen presents two stable isotopes: ^{14}N and ^{15}N. ^{15}N has one more neutron than ^{14}N, both have 7 protons. Carbon also presents two stable isotopes: ^{13}C with 6 protons and 7 neutrons and ^{12}C with 6 protons and 6 neutrons. The proportion of one isotope over the other—the isotopic composition of a sample—is measured with respect to a standard and expressed in per mil (because the values are very small).



All living things incorporate isotopes from their environment into their bodies as they eat, drink and breathe. Through a range of rather complex processes, the amount of ^{15}N and ^{13}C in soils and plants change as climates change and, often under drier conditions, plants tend to accumulate more ^{15}N and ^{13}C in their tissues. In turn, when the ratiphants eat these plants, the amount of ^{15}N and ^{13}C in their bodies (and body waste) changes as well! Thus, by measuring the amount of ^{15}N and ^{13}C found in ratiphant excrement, it is possible for scientists to identify periods of wetter and drier conditions and therefore to reconstruct changes in past climates.

Paleoenvironmental archives

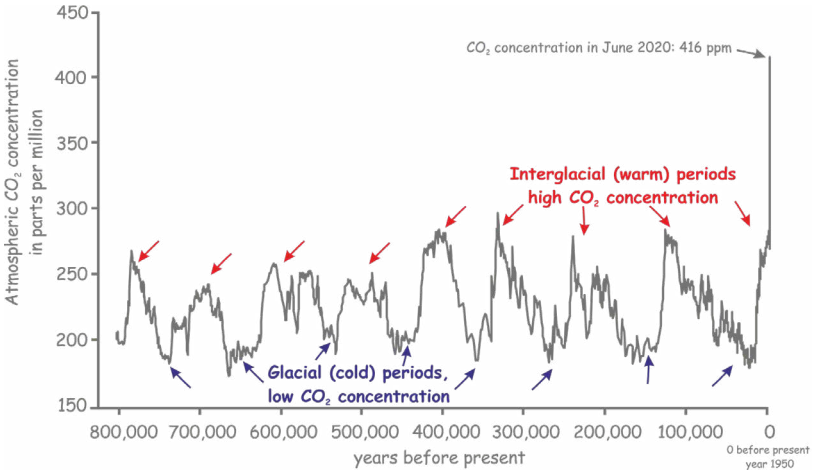
The environmental conditions, how hot/cold, dry/wet, how much CO_2 was in the air, how many nutrients in the water, which plants or animals were around... are recorded in different ways. This is very important because it allows scientists to figure out how the conditions on Earth were in the past. The past is the key to the future; better understanding how the Earth system worked in the past will help predict changes in the future.

In the context of today's 'human-made climate change', the study of past climates has been crucial in demonstrating that our actions—burning fossil fuels, etc.—are severely altering the atmosphere, which is leading to global warming.

Some of the most useful paleoenvironmental archives are:

Ice sheets: Gigantic masses of ice (larger than 50,000 km^2) have accumulated at the North and South Pole over thousands of years. This ice spreads out from so-called accumulation zones and forms domes. Scientists can drill and extract ice 'columns' (cores) in the centre of the domes and perform chemical analyses of water melted from different depths of the ice core or of gas trapped in tiny bubbles within the ice. For example, Dr Dieter Lüthi and colleagues measured the amount of CO_2 in bubbles from an ice core from Antarctica and published in 2008 a chronicle of changes in atmospheric CO_2 concentration from 600 to 800,000 years before present (present is set at 1950 in this

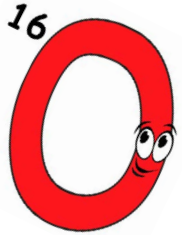
scientific context). The record shows that the concentration of CO_2 has fluctuated cyclically between 180 and 300 parts per million (ppm, one molecule of CO_2 per every million molecules of dried air) in parallel with alternating glacial (cold periods, big ice sheets on the poles) and interglacial (warm periods, small ice sheets on the poles) periods. This record has made it possible to put the rising CO_2 concentrations in the atmosphere since humans started burning fossil fuels on a large scale in the 19th century within a very long temporal context. I am sure you will immediately notice 'the human CO_2 spike' in the image below. The image represents the changes in atmospheric CO_2 concentration (y-axis) versus time (x-axis). The plot combines pre-modern data (a compilation of data from several ice cores by Bazin and colleagues in 2013) and modern data (values measured directly from the air—also referred to as instrumental data—at the NOAA's Mauna Loa Observatory in Hawaii (National Oceanic and Atmospheric Administration, Global Monitoring Laboratory, Earth System Research Laboratories, USA). These data can be freely downloaded from the Pangaea and NOAA data repositories.

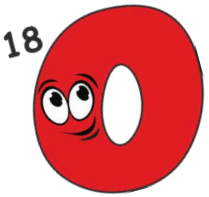


Marine and lake sediments: Mud, sand, dead organisms and other leftovers sink to the bottom of oceans or lakes, where they pile up: newer on top of older. Scientists take cores of this material deposited on the bottom (sediment) of the ocean or lakes and extract information from the sediment about the environmental conditions at the time the deposition happened. We do so, for example, by looking for pollen, for microfossils, analysing the chemistry of microfossils or organic remains, looking at the minerals in the sediment...

How far back in time and how precisely we can reconstruct the past environments depends on the so-called 'sedimentation rate'—how much material falls per unit of time—and on the length of the sediment cores recovered. In the open ocean, only between 1 and 2 centimetres of sediment normally accumulate every 1,000 years. In contrast, 10 metres of sediment can accumulate every 1,000 years in some coastal areas.

Tropical corals: Corals are marine invertebrates which live in colonies of many, many tiny individual polyps. The polyps build calcium carbonate 'houses' for themselves with a 'roof window' where their little tentacles reach through, move in the water and catch food. The union of many of these houses over thousands of years forms coral reefs. The thickness of the house walls (the calcium carbonate density) changes with the seasons, thinner in summer, thicker in winter. As the corals grow older, layers of calcium carbonate (the house walls) accumulate. Furthermore, the chemical composition of the walls changes with the regional environmental conditions. For example, when the waters are colder, there will be more 'heavy bricks' ('bricks' with heavy oxygen isotope: ^{18}O) than 'light bricks' ('bricks' with light oxygen isotope: ^{16}O) in the walls. Scientists take samples from coral reefs, both modern and ancient (for example, reefs that are not underwater anymore), analyse them and learn about the water characteristics at the time the corals lived. It is even possible to distinguish the characteristics of past seasons.





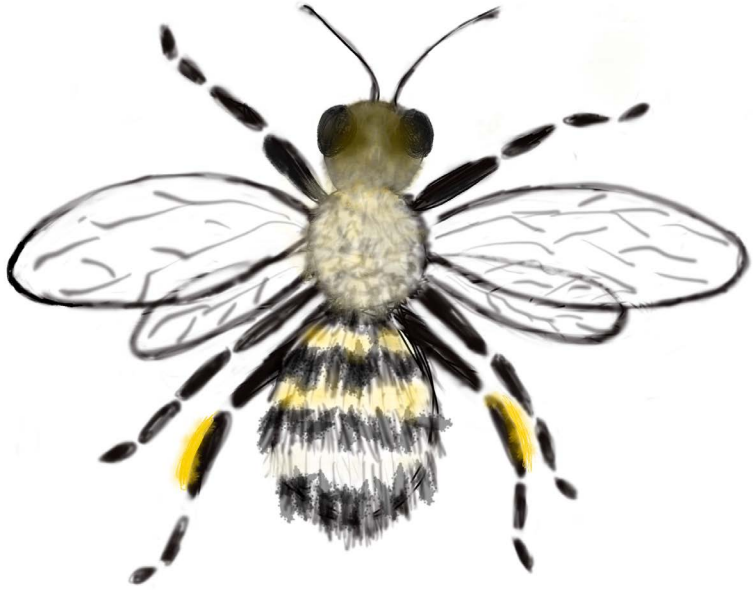
Speleothems (cave formations) and *tree rings* follow a similar principle when used as paleoenvironmental archives.

We explained hyrax middens in the story. Other middens, for example from ancient human settlements, can also provide valuable environmental information.

The honey hunter, the bird and the bees

Dorothea Brückner
Illustrations: Heather Johnstone

When I travelled to Cameroon two years ago to study African honeybees, an old man named Sardi from the Gbaya tribe told me a fantastic story. Sardi explained how he would go hunting for wild honey and a bird would show him the way to where the bees had a nest. He told me that this had been a tradition for a long time. He said that there was an old legend in his tribe of three hungry boys who were shown the way to a wild bee nest by the bird for the first time. *That must be a fairy tale*, I thought, but I was wrong.



I had to take two aeroplanes for the long journey from Bremen to Cameroon: one from Germany to France and then a second one for a night flight to Cameroon. The second plane did not land in Yaoundé, the capital of Cameroon, until the following morning. From there, I took an exhausting 12-hour trip by train to the city of Ngaoundéré in the central plains of Cameroon.

At every train station along the way, there were people trying to sell bottles of honey through the windows of the train to the passengers inside. I bought a plastic bottle with dark, almost black honey, which tasted very different from the honeys back in Germany. It had a far more intensive and aromatic flavour.

At the main station in Ngaoundéré, I could already see my friends from quite a way down the tracks. They had come to collect me. I was very happy to arrive at the final destination of my journey at last. It had been very hot in the train and I was sweating in the station even though it was only February, the month in which the first snowdrops and crocuses begin to bloom in Germany. Here, the earth was scorched and red with the sun beating down from the sky like on a very hot summer day at home in Bremen.

My friends gave me a ride to the hotel in their car and, while driving, told me about their experiences with African honeybees. They told me how bees are kept in Cameroon and how the honey is harvested: the beekeepers weave long baskets as beehives. Each woven hive has a round lid for the open end; in this lid is a finger-sized hole, through which the bees fly in and out once the colony has moved into the hive.

To protect the hives from the very hot sun and heavy rainfall in the region, the beekeepers wrap large leaves and dry grass around them. The hives are then hung high up in trees attached to large, long branches.

It does not take long for a swarm of bees to find and colonise a new hive. The bees immediately start to build round combs in the basket and the queen bee begins to lay her eggs. After just a few weeks, the colony fills up the long basket with the brood nest and the honeycombs. The beekeeper can then harvest the first honey. He climbs the tree, opens the lid with a knife and reaches into the basket with his arm to break off the combs within.

He carries the honeycomb back to his village in a basket and enjoys the sweet harvest together with his family. Then he expresses the combs with his hands and sieves the sticky mass into bottles, which he will later sell at the market. It was precisely this dark, aromatic honey that I had bought at the train station.

The next day, my friends went with me to a small village in the vicinity of Ngaoundéré, which is situated in the savannah of central Cameroon. There we met Sardi, the old man from the Gbaya tribe, who told us the story of his honey hunting.

A long time ago, before the time of woven baskets, the men of the Gbaya tribe led their cows and goats into the savannah to let their herds graze there. When they got hungry, they would search for bee nests to get some sweet honey. After a long search, they would sometimes be lucky enough to find a nest of bees in the ground or in a tree.

But one day, Sardi told us, *a little bird came to them and perched in a nearby tree just as the men were about to start hunting for wild honeybee nests. It flapped its wings and whistled a short tune. It appeared to be trying to attract the herders' attention. The bird then flew a short distance to settle in another nearby tree. The men became curious and followed the bird. It continued to fly ahead a little, settle in a tree and flap its wings. The herders continued to follow the bird in this way until they had covered a large distance. Then the bird landed in a bush and began hopping from branch to branch.*

It was clear that the bird wanted to show the men something. When they looked around the bush, they found a hole in the ground from which bees were emerging. The bird had led them to a wild bee nest that they would never have found by chance because it was so well hidden.

Then, one of the honey hunters began to open the hard ground around the entrance hole with his machete to reach the bee nest. When he could see the first comb, he reached in for all of the honeycombs buried underground. The men ate some of the honeycombs immediately because they were so hungry. They put the remaining combs into a bag to carry them back to their fellow herders, with whom they wanted to share their bounty.

However, they also left some for the bird, which began to feed on the wax immediately. Thanks to the bird's small size, only around that of a blackbird, it now had a large supply of food for the following days. The bird would return to this site many days to feed.

The bees, in contrast, had to look for a new nest site in the ground, as the honey hunters had damaged their old nest so badly that the next rain would flush out the hole and endanger the bees. They flew away to search for a new nest site in the savannah.

On my long trip back to Germany, I thought a lot about the little bird with its weak bill who got the honey hunters to help him get his food and how the people had let the bird help them find the wild bee nest. Birds and honey hunters cooperate in the savannah in Cameroon to obtain food, each of them their specific type. The bird eats the wax and the bee larvae; the people eat the honeycomb. Such a successful cooperation between animals and humans is rather rare in nature. Sardi had told us a wonderful story that sounded like a fairy tale but is in fact a true story.

Would you like to know more?

The central highlands of Cameroon are home to a tribe called the Gbaya, who go honey hunting with the honeyguide (*Indicator indicator*). This bird species is a type of cuckoo, which is a brood parasite of several insectivorous bird species in the region. It is a unique trait in birds that the honeyguide can feed on honeybee wax. In biological experiments, it proved possible to keep the bird in a cage with wax and water as the only supply of food for three months. However, the birds are not restricted to wax to survive; they also like to feed on bee larvae and other insects.

As the bird is a cuckoo, the honey-guiding behaviour must be innate behaviour. The individual never meets its parents and the host parents do not display this specific behaviour.

The bird's behaviour is reinforced by the positive reaction of the honey hunters to its hints and the reward with wax combs at the end of the joint search. If humans do not react to the bird's guidance behaviour, it loses its interest in humans.

Although the honeyguide is widespread across sub-Saharan Africa, even down to South Africa, and is used by other tribes in various African countries, the number of herders and honey hunters is shrinking in places like Cameroon and it is feared that this unusual cooperation between humans and animals will disappear in the future.

The African honeybee in Cameroon belongs to the subspecies *Apis mellifera adansonii*. This subspecies lives in great numbers in Central Cameroon and is used for beekeeping with traditional as well as modern techniques. The species disperses very quickly by producing many reproductive swarms every year.

Aside from traditional beekeeping with woven baskets, there is also a modern beekeeping approach using a type of hive developed in Kenya, the Kenyan top bar. As Cameroonian beekeepers use a somewhat smaller top bar hive, it is sometimes called the Cameroonian top bar hive.

Sardi, our contact from the Gbaya tribe keeps bees in around 100 traditional hives hanging in trees. In parallel, he also practises honey hunting.

The bee research in the Biology department at the University of Ngaoundéré was established together with Drs Tchuenguem and Mazi Sanda by Dr Dorothea Brückner from the Bee Research Unit at the University of Bremen in the framework of a DAAD (German Academic Exchange Service) partnership programme with the University of Ngaoundéré.

Endangered.
But still there is hope

Stephan Juricke
Illustrations: Thomas Rackow

It is a Monday morning in the Year 4 classroom of Bright Skies Primary School. Mr Goodheart is standing at the front of his class. He is an exceptional teacher you will not find anywhere else. Like most teachers, he cares deeply about his students and enjoys teaching. What makes him so special, however, is his approach to teaching and how he connects with his pupils. Every other week he organises a small day trip or an excursion to a museum or nature reserve. He prepares in-class experiments and he encourages his pupils to come up with and perform their own experiments. He is really good at explaining all the different subjects to his class, although he does not stick strictly to any lesson plan. Mr Goodheart wants the pupils to understand the connection between what he is teaching and why it matters to the life of every child in the class. Above all, he wants his pupils to grow into kind-hearted, curious and caring adults.

One of the things the children are most impressed by and look forward to most is when Mr Goodheart invites some of his friends: some very special people he has met in his life; special people from all around the world. So, every other week, some very interesting guests come to the class and talk about their own life experiences and what they do. They have had doctors, police officers and builders visit their class. However, aside from people with various jobs and fascinating life stories, Mr Goodheart also invites some very, very special guests every now and then: guests you wouldn't normally meet. Not well-known celebrities, but really, really special guests. Guests you wouldn't even think existed.

Today is one of those days, as Mr Goodheart announces: 'Someone very special is going to talk to you today.' He looks around the class with a big smile on his face. 'She is not on her own but has brought some of her friends with her. I am very happy that they agreed to come to the class. What they want to tell you is incredibly important, although some of it is actually quite sad.' The children in the class cannot wait to meet the special guest. Who will it be this time? And what friends will she bring with her? They all look expectantly at the door as the doorknob turns and it opens.

A very tall woman with skin the colour of earth and grey-green hair enters the room. It is impossible for the pupils to tell how old she is.

She looks quite young and most definitely not like a grandma, but her dark blue eyes have a look to them that make her appear very, very wise. She looks much wiser than any of the adults the children have met so far, wiser even than their own parents or Mr Goodheart.

She is wearing a long, dark-green dress but no shoes. A small girl, seemingly a year or so younger than the children in the class, walks by her side. She looks shy and a little scared and walks very close to the tall lady. It almost looks as if she is trying to hide behind the lady's dress. The girl's long hair has many colours and it is hard to tell which ones they actually are. Her eyes are big and round and sometimes look green, sometimes blue, sometimes even brown or orange. She is wearing a colourful dress and is walking barefoot as well. Her skin tone is lighter than the tall lady's and has a tinge of red to it.

'Say hello to Mona and her youngest daughter, Fauna,' says Mr Goodheart, introducing the two visitors, and the class responds with a loud and warm welcome. Mr Goodheart gestures to Mona to come to the front of the class and then steps back to lean against the back wall. The tall lady and her daughter move to the teacher's desk.

'Good morning, children,' says Mona with a lovely, musical voice and friendly smile. 'I'm very happy to be here today. But, actually, it's my daughter Fauna who wanted to speak to you. So, I shall let her explain why we are here.'

She looks down at her daughter and gives her a reassuring nod. The little girl looks a bit hesitant but steps forward after taking a long, slow breath. She faces the class, while her mother walks over to Mr Goodheart.

'My name is Fauna and I'm here to talk to you because I know you will listen,' Fauna addresses the class. There is sadness in her soft voice. 'I am responsible for many creatures who cannot make themselves heard. In their name, I have tried to talk to adults, but only a few will listen and especially those with the power to help them don't seem interested in doing so. So, that is why I'm here to talk to you children. Because children see the world in a different light from most adults. Children can still appreciate the beauty of nature.'

Fauna pauses and looks around. She looks at every boy and girl in the class, one after the other. Her eyes are filled with sadness, but there is also something else. There is a spark of hope as she watches the children paying close attention to her words.

'I have brought some friends with me today who need to talk to you. All of them are in a very difficult situation and they need help—and they are not the only ones. They used to be able to take care of themselves, but things have changed. Things have changed because of humans. Humans have settled all around our planet and there are so many of them. They have brought destruction to the realms of nature, cut down entire forests and polluted the environment. They have changed the world we all live in. For many of my friends, the world has changed for the worse.'

As if on cue, the sound of footsteps comes from the corridor and, a moment later, an orangutan swings into the room supported by his long arms. He is a big ape covered in red hair, with a wide face and thoughtful eyes. The children are fascinated but also a little scared. His long arms look very strong. With a swift motion, he pulls himself up onto the desk and sits down to the right of Fauna.

'This is Marv, an orangutan from Borneo, a large island on the Equator south of the Asian continent,' says Fauna, placing a hand on Marv's arm. 'Not many of his kind are left. His species, like gorillas and chimpanzees, belongs to the great apes, the closest relatives to humans on Earth. They are very smart, but they are what we call **endangered**. Orangutans are likely to become extinct in the near future. Very soon, there might not be any orangutans left on the planet. There are many reasons for this. Marv will tell you the main ones.'

'Hello, everyone,' says Marv, addressing the class in a calm voice. None of the children is surprised to hear the orangutan speak. Stranger things than talking animals have visited Mr Goodheart's class. The children look at Marv in fascination and some even wave to him in greeting. 'What Fauna says is true. We are indeed very few now. Orangutans like me live in the rainforest, where we climb big trees and live off the fruits we find in the treetops. But the rainforest is disappearing.

Humans are cutting it down for precious woods and to clear space to grow other plants. What they harvest from these plants they then ship all around the world. Did you know that some of the things you eat or use at home come from our rainforest on the other side of the planet?' A few children shake their heads. Most of the children, however, just listen intently and watch the large, red-haired ape gesturing with his long arms while he speaks. 'Quite a few humans are trying to help us and prevent the destruction of our homes, but there are just not enough of them. The forest was big once. It still is. But it is shrinking every day. Not too far into the future from now we won't have a place to live.'

Marv lets his gaze wander over the faces of the children. Then he gives them a sad nod and hops off the table. The children don't say a word. They just stare at the big ape and wonder how they can help him. He lives on the other side of the world and they are still children. But, surely, Marv wouldn't tell them his story and Mr Goodheart wouldn't have invited him if the children really couldn't do anything to help the large orangutan.

There are many thoughts running through the children's heads —too many to count— and most of them are questions. But there is no time now. Splashing noises resound from the corridor. The children turn their attention back to the door. Through the open doorway comes a sea lion the length of a small car. It is moving a bit clumsily on its large, broad flippers and is covered in glistening brown fur, as if it has just surfaced from the ocean.

'This is Lyra, a sea lion,' says Fauna and strokes the large animal's smooth head. 'She comes from the Galapagos Islands in the Pacific, a beautiful island chain with animals and plants you can't find anywhere else on Earth. Lyra is here to talk on behalf of many other animals that spend all or most of their life in the oceans, such as whales, dolphins, sea turtles and all the different kinds of fish. She will tell you some of the reasons why they are threatened by humans, who—as you all know—actually live on land and not in the oceans.'

Lyra moves a bit further to the front of the class and claps her long foreflippers together. Her large and shiny dark eyes make her look as if she is both happy and sad at the same time. 'Hello everyone,' she greets the class. The children reply with a 'hello' in turn. 'Sea lions like me are made for the sea. We look a bit awkward walking on land, but in the water we are free. We dance and look more graceful than you could ever imagine.' Lyra closes her eyes and sways back and forth, trying to imitate the grace she is talking about. Some of the children can't help themselves and laugh. She really doesn't look very graceful right now. 'But the seas have changed,' continues Lyra, opening her eyes. The children fall silent. 'Humans are catching so many fish that there are not a lot left for us. Quite often, marine animals like us get caught up in the nets and die, even though we are not what the fishers are actually trying to catch. Some nets are just left behind and keep drifting through the oceans. There is also other plastic waste in the oceans that can become a dangerous trap. It entangles our bodies and some animals eat it by mistake. It then prevents them from eating anything else because their tummies are full of plastic and there is no room left for actual food. The oceans are not a rubbish tip. They are such beautiful places full of life. They deserve to stay that way.'

With those last words, Lyra waddles over to Marv. The orangutan gives her a big hug with his long arms. The two of them are now taking up most of the space in the front left corner of the room. It is an unusual sight to see an orangutan and a sea lion in a classroom full of children.

However, Lyra is not the last one to speak to the class. Next through the door comes a huge polar bear with bright white fur. Its big and massive body, giant claws and impressive jaws have the children shrinking back in awe. They know they are safe because they are in Mr Goodheart's class. Nothing bad can happen to them in Mr Goodheart's class. Nevertheless, it is difficult not to be awestruck when you are facing a fearsome hunter like a polar bear.

'Don't worry,' says Fauna. 'Hector is here as a friend today. If you were to meet him in his habitat in the Arctic, far in the cold North of the Earth, then you should indeed be frightened. Although their cubs look like cute teddy bears, they grow to become dangerous predators. But Hector is not here to frighten you. Quite the opposite.'

'I am Hector,' the bear says and sits down in front of the class. The front row of children actually have to move their desks back a bit to make room for the giant white animal. 'I come from the High North. I hunt in the cold, wandering the sea ice and swimming in the freezing waters. My fur is the colour of snow and I can withstand extremely cold temperatures. But my home is changing.' Hector rubs his large paws together and looks down. The children already know what will come next. They can see the grief in Hector's dark eyes. He might be fearsome, but the children feel sorry for him even before he has told them his full story.

'You humans need a lot of energy to run your cars, heat your homes and use all your electrical devices. To do so, you burn oil and coal and gas. This burning releases a gas called carbon dioxide. It is in the air all around you. Plants need it to grow. It also acts like a blanket for the planet. When you wrap yourself in a blanket at night to keep warm, the blanket prevents your body heat from leaving you too quickly. Carbon dioxide does the same for the planet: it makes the world warm enough, so that you can live on it. But there is now more and more of it in the air. The blanket is becoming thicker and thicker. That means it is getting warmer and warmer. Especially in the High North, the climate is changing rapidly.' Hector takes a deep breath and lets out a low growl. 'And while there is still plenty of sea ice in winter, more and more of it is melting in summer. The sea ice is our hunting ground. We need it. But it is melting away under our feet because there are so many humans needing so much energy. Without the sea ice, we have to swim long distances to hunt in summer. For some of us, the distances are simply too long. That changes everything. It changes our entire world.'

Hector ends his speech with another deep growl that sends a shiver down the spines of all the children in Mr Goodheart's class. The children feel sorry for the polar bears in the North, but they also don't want to think about coming face to face with one in the cold ice desert of the Arctic. Fauna takes one of Hector's large paws in her hands and the two look at each other in silence for a while. The children sit there and watch. They have so many questions in their heads, but they know that now is not the time to ask them. There will be time later. Now is the time to listen. After a few moments of silence, Fauna returns her attention to the class, while Hector moves to her side and sits down behind her.

'After all these large creatures from far away, please, say hello now to some much smaller and more fragile friends of mine,' Fauna continues. 'They actually don't live far from here.'

The flutter of a hundred wings sounds from the corridor as a swarm of butterflies glides into the room. The children have never seen such a beautiful spectacle. Even the children who are usually afraid of crawling creatures with fluttery wings are awestruck by the multicoloured cloud.

A very beautiful butterfly with beige-yellow wings decorated with black and blue lines flies to the front of the swarm and speaks with a clear and surprisingly loud voice.

'I'm Dalia, a yellow swallowtail, and I speak for all the insects and small creatures around the world,' she says and lands on the outstretched finger of a girl in the front row. 'You might think there are plenty of insects all around, because we are so small and you see us every day.

But if you think about it, there are so many different species out there, thousands and thousands of us, how can you know how many of each species still exist?' Dalia takes off from the girl's finger and flies around the room. Every now and then, she stops in front of a child. Sometimes she rests on the tip of a child's nose, sometimes on their schoolbooks or on the tops of their heads. Many children in the class have never seen a butterfly like her. They have seen butterflies, many different kinds, but not one like this. They start wondering how many different kinds of butterflies exist that they don't even know about.

'The truth is, there are fewer and fewer of us,' Dalia continues. 'Not just of us butterflies, but of most insects. Humans don't seem to worry about it. We are only little creatures. How could we matter? Most of the humans don't even recognise that there are many different species of us. They think we are all just the same buzzing, annoying bugs.' Dalia's voice is getting louder and louder as she gets more agitated. The children are captivated by both the butterfly's fragile beauty and the power of her voice. 'But we do some of the most important jobs around. We are responsible for the pollination of plants. Without us many fruits wouldn't grow. We are at the base

of the food web. Many plants wouldn't be able to reproduce without our help and then there wouldn't be enough food for all the plant-eating animals. But pesticides and pollution are doing us great harm.' The swarm of butterflies rustles its wings like a small thundercloud. Dalia continues: 'There are fewer and fewer flowering meadows around and our woodland homes are being destroyed. Grounds are being cemented or turned over, so that we have no places to hide in winter and no food to eat in summer. Imagine a summer without butterflies, a summer without bees or dragonflies.'

Dalia takes a final tour of the class and then returns to the swarm of butterflies. The little creatures start to calm down again. Together they glide over to Mona and settle in a rush of wings on her dress. She is covered from her shoulders to her ankles in a coat of multicoloured wings. The children would never have thought that butterflies could get so upset.

Fauna walks up to the front of the class again. She seems shaken by the words of her friends. The children feel the same way. Even though they hardly know Mona, Fauna and their animal friends, they already feel the need to help them.

'My friends here are just a few of those who are in trouble,' Fauna says and slowly shakes her head. 'To talk to all of them would take weeks and months. Just from the few friends who came along with me, you can see that the situation is not good for many, many animals out there. There are just so many of them endangered, and I am only responsible for all the animals. My sisters, who are responsible for everything else alive on Earth, would be able to tell you that it isn't any better for many living organisms. As I said, there are those humans who take action and try to help. But they are just not enough. I know that you care. I can see it in your eyes. But sometimes, when people get older, they forget to care, although they shouldn't, and that is incredibly sad.'

Right then, a fuzzy looking little creature with bright red fur, a dark chest and white markings on its little face comes running through the door and climbs onto Fauna's shoulder. He looks like a mix between a fox and a small bear, with a very long, bushy tail and a small face with a pointed snout and button eyes. He is so cuddly that he almost looks too cute to be real. Some of the kids clap their hands in excitement and forget the sorrow that has spread around the room for a moment.

'This is my good friend, Terry the red panda,' Fauna says, looking at him with a smile. 'He lives in Asia, somewhere east of the mountain range of the Himalayas. His kind is also endangered because their habitat has been destroyed. But the same as all the other living creatures, he has a right to live on Earth with us.'

Terry turns to the children with his furry little face. 'Sometimes humans ask what we animals provide to the world,' says Terry and rubs his nose with a little paw. He sneezes. The children are almost forgetting his question as they watch him, when he suddenly looks up at them with a very serious look in his button eyes. 'But why should we have to justify our existence and humans not? Why should we have to tell you, why we should be respected and protected?' Terry's fur bristles. His anger is in stark contrast to his soft and cuddly appearance. 'Just remember: it is always easier to destroy something than to create or protect it. Once something is gone, you cannot bring it back. So please, help us! You would already be helping us if you stopped threatening and hunting us. If you stopped destroying and poisoning our homes. That is not a lot to ask for, really.'

Terry's anger leaves him as he looks pleadingly around the room. Every child's heart melts under the gaze of his tear-dimmed eyes.

'Terry and all his friends here need your help,' continues Fauna. She strokes Terry's bright red fur soothingly with her hand, trying to calm him down. 'The good thing is that the world can be changed and be made a better place for both humans and all other creatures. All of you can help. That's why I'm here. That's why we are here. To tell you about the things that go wrong, but also to tell you that there is hope and that we can make the world a better place for all of us.'

With this, Fauna, with Terry on her shoulder, walks over to her mother. Mona gives her a kiss on the forehead and a warm smile. The eyes of all the animals as well as Mona's and Fauna's are now on the class.

The children don't know what to say. There are many questions and emotions going through their heads and hearts, from anger about what has been done to their new friends to helplessness and sorrow to hope and a thirst for action. They know they want to help.

'Thank you very much, Fauna, and all of you as well,' says Mr Goodheart and walks to the front of the class, exchanging glances with each of the friendly animals. 'There are certainly a lot of things going wrong.

But this is what we are here for, right?' Mr Goodheart claps his hands and the sorrow leaves the room. Everyone in the class can feel the wave of enthusiasm emanating from their teacher. 'We want to learn about those things that aren't going well and then we want to discuss everything and decide **how we can improve the situation**. Fauna and Mona will be staying with us for the rest of this week, as will most of their friends here. You will have the chance to talk to them and we will try to find ways to help them or to get others to help them. It is a big challenge, but as is the case with all big challenges: before you can solve them, you need to find out how and where to start. We will take it step by step. So, everyone, stand up and have a chat with our guests. Talk to them and learn from them. They have much to tell you. There is much to discuss and even more to do. Let's get started.'

The moment Mr Goodheart finishes talking, all of the children get up from their seats as if they were one person and run to the front excitedly. They are not afraid or shy to talk to their guests and, within minutes, the classroom is full of chatter and laughter, and even a little tear here or there.

Mr Goodheart walks over to Mona and they exchange a smile. They watch Fauna for a moment, deep in conversation with five children and Terry on her shoulder.

'Thank you for coming, Mother Nature,' Mr Goodheart finally says.

'Oh, there is no need to thank me,' replies Mona and the butterflies on her dress flap their wings in agreement. 'We've been quiet for far too long. It was high time to get involved.'

'So, will others be joining you in your efforts? Your other daughters? The great Caeli?' Mr Goodheart asks.

'We'll see. I'll try to convince them. Perhaps, with the help of these children, I can shake them from their dreaming. It's time to wake up and face the challenges. We all have to play our part. But these children most of all. It's their future after all. They should make sure that it will be the future they want.'

Mr Goodheart watches his class. Terry the red panda is jumping from the head of a laughing boy onto a girl's shoulder. Another boy and girl are sitting in the lap of Hector the polar bear, inspecting his huge teeth with deep respect. In one corner of the room, Marv the orangutan is telling several children a story, gesturing widely with his long arms.

'Well, seeing them like this gives me hope,' says Mr Goodheart and smiles.

Mother Nature nods. 'Yes, yes it does.'

Would you like to know more?

Endangered species

How does the classification of endangered species work?

https://www.nationalgeographic.org/encyclopedia/endangered-species/

The Red List of endangered species

Which organisms are endangered?

https://www.iucnredlist.org/

Conservation efforts

What can we do?

https://nationalzoo.si.edu/conservation

https://www.worldwildlife.org/species/directory?direction=desc&sort=extinction_status

About the Once upon a time (OUAT) team

The main authors of the stories and some of the illustrators are scientists from a variety of countries who are either working now or have worked at institutions in Bremen and Bremerhaven in Germany as well as further afield (Spain, Argentina, etc.) over the course of the project.

Rodrigo da Costa Portilho Ramos is a palaeoceanographer (an oceanographer of the past oceans) and an expert in planktic foraminifera and geochemistry. He is currently working at the MARUM - Center for Marine Environmental Sciences, University of Bremen, Germany, where his research is devoted to better understanding the cold-water coral ecosystems in the Atlantic Ocean and the Mediterranean Sea with regard to past climate changes. Rodrigo holds a bachelor's degree in biology/life sciences from UNIRIO, Brazil, and a master's and PhD in geosciences from UFF, Brazil. He wrote the story 'My life, your life' for this book with the support and contribution of his non-academic sparring partner **Sonja Böske da Costa**. Sonja has a degree in communication management and is a certified translator (German-English). She has been working as a scientific and legal translator as a side job for several years now.

Denise Müller-Dum is a professional science communicator and writer. She obtained her PhD in geosciences from the University of Bremen, Germany, in 2015 and worked as a postdoctoral researcher at the Institute of Environmental Physics, University of Bremen, before recently transitioning into science communication. She is a mother of two and the author of several children's books on environmental issues. www.muellerdum.net, Instagram/Twitter: @dmuellerdum

Nelson Bralade Selekere earned his master's degree in marine geosciences at the University of Bremen, Germany, and completed a two-month internship with the OUAT team in 2018. He wrote the story about Luna as part of his geoscientific project focusing on science and communication. Dharma Reyes Macaya guided him through the initial steps of writing and Hadar Elyasiv and Gema Martínez Méndez moulded the story into its final form.

Hadar Elyashiv is a marine geoscientist currently working on her PhD at the MARUM - Center for Marine Environmental Sciences, University of Bremen, Germany, and the Dr. Moses Strauss Department of Marine Geosciences at the University of Haifa, Israel. Her research is devoted to better understanding the distribution of mud and sand in the oceans through catastrophic events such as submarine landslides. She loves the discovery part of science and even more the sparkle in children's and adults' eyes once they understand the complexity and connectivity of natural processes. She gets involved in science communication as much as she can.

Dharma Reyes Macaya holds a degree in biology and a master's in oceanography from the University of Concepción, Chile. She is now completing a PhD in palaeoceanography at the MARUM - Center for Marine Environmental Sciences, University of Bremen, Germany, with frequent short stays at the Lyell Centre, Heriot Watt University, United Kingdom. She is currently researching changes in ocean circulation and oxygenation of the coastal region of South America. She is extremely enthusiastic about science communication and about connecting her research with the local communities. She is one of the founders of the 'Once upon a time' project and an active member of the NGO Conciencia Sur.

Mariem Saavedra Pellitero is a micropalaeontologist currently working at the University of Birmingham, United Kingdom, but previously affiliated with the University of Bremen, Germany (2011-2019). She joined the multidisciplinary 'Once Upon a Time' team in the hope of passing on her love and passion for 'science' in a creative and visual way. She illustrated part of Nelson's story and the main cover of this volume. Twitter: @MariemSaavedra

Belén Gonzalez Gaya and **Maria Vila Costa**, researchers in environmental chemistry and environmental genomics, met at the Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Spain, where they developed the scientific work now transformed into this children's tale. Belén is currently working at the Marine Station of Plentzia of the University of the Basque Country (EHU/UPV), Spain, where **Aida Zuriñe Campos Vivanco** illustrated the tale as her final assignment for the Master of Scientific Illustration (EHU/UPV). Twitter: @BGonzalezGaya (Belén), Instagram: @vivoenpangea (Aida)

Rebecca Borges is a marine ecologist passionate about nature conservation, cartography and good conversation. This brought her to science communication through maps and stories. Rebecca holds a bachelor's degree in biology from the Federal University of Ceará, Brazil, a master's degree in applied ecology and conservation from the University of East Anglia, United Kingdom, and a PhD in mangrove spatial planning and small-scale fisheries from the Leibniz Centre for Tropical Marine Research (ZMT), University of Bremen, Germany, in collaboration with the Federal University of Pará, Brazil. Rebecca is also enthusiastically learning about ecosocialism and Marxist ecology and, inspired by indigenous knowledge and resistance, she is trying to help in the search for, in the words of A. Krenak, 'ideas to postpone the end of the world'. Fairy tales are definitely one of those ideas.

Guilherme Abuchahla is a doctoral candidate at the Leibniz Centre for Tropical Marine Research (ZMT), University of Bremen, Germany. He holds a master's degree in environmental management from the Institute for Ecosystem Research at the Christian-Albrecht University of Kiel and a bachelor's degree in biology from Mackenzie Presbyterian University, Brazil. Drawing offers him a way of relaxing and a new dimension to communicate his science.

Ameris Ixchel Contreras Silva is a PhD researcher at the Leibniz Centre for Tropical Marine Research (ZMT), University of Bremen, Germany. Her research interests encompass coral reef ecology, spatial ecology and interactions as well as socioecological interactions. She is interested in determining how human impact affects or alters coral reef communities. She is currently investigating how local stressors (pollution, coastal development and mangrove deforestation) affect coral reefs in the Mexican Caribbean Sea. She earned a bachelor's degree in hydrobiology at the Metropolitan Autonomous University (UAM), Mexico. Subsequently, she completed a master's in geomatics at the Centre for Research in Geography and Geomatics (CentroGeo), Mexico. She then became passionate about mapping the space and time of natural ecosystems via remote sensing. Ameris enjoys communicating science through stories, theatre, music and maps.

Camila Neder is a biologist with a degree from the National University of Córdoba, Argentina. In her PhD research at the Institute of Diversity and Animal Ecology, National Scientific and Technical Research Council (IDEA-CONICET), Argentina, and the Alfred Wegener Institute for Polar and Marine Research (AWI), Germany, she focuses on the distribution of Antarctic benthic animals and how they are facing climate change with good chances of habitat extension, but also extinction (small wording difference, but huge ecosystem divergence). As air temperatures increased and glaciers retreated, sediment input into the coastal areas became more important. This combined with her interest in science communication brought her to write Plumi's story. Camila loves dark chocolate.

Manfred Schlösser has a PhD in chemistry and was a postdoc at the University of Pennsylvania, USA. Back in Germany, he worked in human genetics at the University of Göttingen. After almost 10 years there, he secured a permanent position at the Max Planck Institute for Marine Microbiology, Bremen, as a scientific coordinator. The translation of scientific topics into something understandable for the general public was his major task for more than 20 years in Bremen as a press officer. He is glad to have participated in several scientific expeditions in the Pacific, South Atlantic and the North Sea. Now he is enjoying his retirement and happy to participate in this project. He has been a sketcher and kept recording everyday situations in his sketchbooks all his life. You can take a look here: https://www.flickr.com/photos/manfredschloesser

Gema Martínez Méndez earned a bachelor's in marine sciences at the University of Vigo, Spain, a master's degree in coastal geosciences and engineering at the Christian-Albrecht University of Kiel, Germany, and her PhD in palaeoceanography at the Autonomous University of Barcelona, Spain. She returned to Germany in 2010 and worked at the MARUM - Center for Marine Environmental Sciences (2010-2017), and at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven (AWI) (2018-2019). She has researched about the past ocean circulation and climates for more than 15 years mainly focusing in areas of the Southern Hemisphere, including South Africa, whilst using marine sediment cores and not ratiphant middens. Nevertheless, she found it amusing that this rodent-like animal is actually genetically closer to elephants than rats and that their excrements are so helpful for climate research! www.martinez-mendez.com

Dorothea Brückner is a senior researcher at the Bee Research Unit at the University of Bremen, Germany. She was the supervisor of Drs Tchuenguem and Mazi Sanda during their PhDs. Later they established a collaboration between the University of Bremen and the University of Ngaoundéré, Cameroon, in the framework of a German Academic Exchange Service (DAAD) partnership programme.

Heather Johnstone works at the MARUM - Center for Marine Environmental Sciences, University of Bremen, Germany, and earned a doctorate in palaeoceanography from the University of Bremen. She conducts chemical analysis of foraminifera shells in order to reconstruct ocean conditions of the past. Heather is interested in science communication and teaching as well as how best to convey complicated topics like global chemical cycles. She also likes drawing... and bees.

Stephan Juricke is a climate scientist at Jacobs University in Bremen and the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. His research focus is on climate modelling: the simulation of weather and climate on supercomputers to help us better understand and predict future changes in the climate system. One of his reasons for becoming a scientist was the hope that he could help better understand and consequently protect nature and the biodiversity on the planet. Stephan has always been passionate about writing and telling stories as well as about science communication.

Thomas Rackow is a postdoctoral researcher and climate modeller at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. He works on mechanisms of climate variability and systematic errors in climate models. His scientific goal is to add previously missing features and processes (for example: mesoscale ocean eddies, leads in sea ice or the drift of icebergs) to current climate and weather simulations. These additions will improve the predictions made by the models. He is very interested in art and science communication and always looking for new creative ways to visualise climate change and its impacts for the public. Instagram: @polarthomas

Yuly Lorena Allende and **Katja Brommer** are illustrators who fell in love with the project when they learned about it and jumped at the chance to help us with the illustrations for this second volume. Please feel free to contact them if you are interested in their work:

Yuly: y_lorena_arias@hotmail.com, Facebook, Instagram @yulys_arte

Katja: info@kromafila.de, www.kromafila.de

The OUAT team also includes many more scientists in addition to the authors and illustrators listed above. They have also been key to the development of this volume and the project by providing input and feedback on the stories, translating them into several languages before sending the text for professional proofreading, writing proposals for funding and making sure we stayed visible on social media and at reading events.

Translation teams (from English)
German: Eva Alexandra Bischof, Sandy Boehnert, Sonja Böske da Costa, Friederike Grimmer, Stephan Juricke, Franziska Tell, Lina Madaj, Neele Meyer, Denise Müller-Dum, Manfred Schlösser
Spanish: Belén Gonzalez Gaya, Camila Neder, Gema Martínez Méndez, Lucía Rivero Cuesta, Mariem Saavedra Pellitero, Aida Zuriñe Campos Vivanco
French: Pierre-Olivier Couette, Sarah Coffinet, Yann Marcon, Julie Meiland, Alice Lefebvre
Chinese: Ting-Wei Wu, Ting-Yu Hsu, Nai-Hui Liao, Yancen Liu, Cenling Ma, Yao Xie

Funding team
Dharma Reyes Macaya, Ameris Ixchel Contreras Silva,
Natalie Höppner, Rebecca Borges,
Gema Martínez Méndez (CERFA funding)

Media, communication and marketing
Sandy Boehnert, Lina Madaj, Neele Meyer, Valeriia Kirillova, Franziska Tell

A second volume of stories was not the only objective of the 'Once Upon a Time' project in its second phase. We also hosted reading events of stories from volume I to disseminate their content followed by discussions with the public. In addition, members of the team sought help to translate the first volume into even more languages. You can find their names and their helpers (in italics) below:

Filipino: Deborah Tangunan, *Richard Jason Antonio, Jamila Abuda, Drew Carrillo, Pam de la Cruz, Karla Marlyn Escobar, Geleen Rica Javellana, Marietta de Leon, Marian Veronica Perote, Ma. Hilda Tarroc Ventura, Emmanuelle Villaflor, Timothy James Dimacali, Rogene Gonzales.*

Chinese: Haozhuang Wang, Yangyang Liu, *Cenling Ma, Yancen Liu, Yuqing Liu, Ziliang Qiao, Yu Wang, Huidi Xiong, Yu Zhu.*

Portuguese: Rebecca Borges, Catarina Cavaleiro, Rodrigo da Costa Portilho Ramos, Andreia Rebotim, Célia Santos, Marina Costa Rillo. *Proofreading on a collaboration basis by Profs. Gerson Roberto Neumann, Guilhermina Jorge, Angela M.T. Zucchi and the students Cátia Gomes, Cláudia Fernanda Pavan, Daniela Coelho, Frederico Figueira, Luana Aleixo Nobre, Marianna Ilgenfritz Daudt, Tânia Santos and Renato Pivato Rodrigues from the post-graduate programme in Translation Studies and Translation Laboratory of the University of São Paulo, Brazil, the Institute of Humanities at the Federal University of Rio Grande do Sul, Brazil, and Faculty of Humanities at the University of Lisbon, Portugal.*

French: Pierre-Olivier Couette, *Sarah Coffinet, Yann Marcon, Marine le Minor*.r

Hebrew: Hadar Elyashiv.

Russian: Valeriia Kirillova.

Italian: Leonardo Tamborrino, Mattia Greco, *Alessandra Assioli, Federica Capparelli.*

With regard to the books in new languages, a big thank you also goes to Melanie Wichlein, who helped us to create the new books in InDesign.

Where do we conduct our research?

Life in academia is often accompanied by a lot of moving around the world. Below is a list of our affiliations (current or previous) during the period of development of the book (2018-2020).

Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Bremerhaven, Germany

Centro de Ciências do Mar, lisboa, Portugal

Instituto de Diversidad y Ecología Animal (IDEA-CONICET), National University of Córdoba (UNC), Argentina

Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain

Institute of Environmental Physics (IUP), Bremen, Germany

Jacobs University, Bremen, Germany

Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany

Marine Station Plentzia, University of the Basque Country (EHU/UPV), Plentzia, Spain

MARUM - Center for Marine Environmental Sciences, Bremen, Germany

Senckenberg am Meer, Wilhelmshaven, Germany

The portuguese Institute for Sea and Atmosphere I.P. (IPMA, I.P.), Lisboa, Portugal.

University of Birmingham, United Kingdom

University of Bremen, Germany

University of Haifa, Israel

The closing words of this second volume are devoted to say: 'Thank you very much!' to...

... science writer Jaaspret Singh, who has been a very enthusiastic fan of the project. He held a seminar for us on writing stories and supported the writing process of volume II. Science writer Padma Venkatraman also shared her expertise in writing stories with us. Both seminars were organised in collaboration with the Hanse-Wissenschaftskolleg in Delmenhorst, Germany, and we warmly thank this institution for its support.

... many friends and colleagues who helped us complete this second phase of the 'Once Upon a Time... a Scientific Fairy Tale' project in various ways (reading stories, checking the scientific background, etc.): Brian Chase, Sophie Chattington, Aurelié Cou, Stefan Christ, Iván Hernández Almeida, Diederik Liebrand, Carolina Matula, Peter McInerney, Lottie Miller, Andrea Orfanoz Cheuquelaf, Montserrat Origel, Lisset Salinas Pinacho, Natalia Servetto, Matthias M. Schneider, Rosa Ivette Tapia Silva, Ulrike Prange and Henry Wu.

... Rita Kellner-Stoll and Reiner Stoll from the KELLNER & STOLL-STIFTUNG FÜR KLIMA UND UMWELT Foundation together with publisher Horst Temmen (www.edition-temmen.de) for making it possible to get volumens I and II broadly published in the web as eBooks and as print-on-demand.

KELLNER & STOLL STIFTUNG
FÜR KLIMA UND UMWELT
TREUHANDSTIFTUNG DER STIFTUNG DER UNIVERSITÄT BREMEN

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