

ONCE UPON A TIME...

A SCIENTIFIC FAIRY TALE

- VOLUME I -



Once Upon a Time... a Scientific Fairy Tale

- volume I -

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“Sometimes reality is too complex.
Stories give it form.”

Jean Luc Godard

“People think that stories are shaped by people.
In fact, it’s the other way around!”

Terry Pratchett

“Education is the most powerful weapon
which you can use to change the world.”

Nelson Mandela

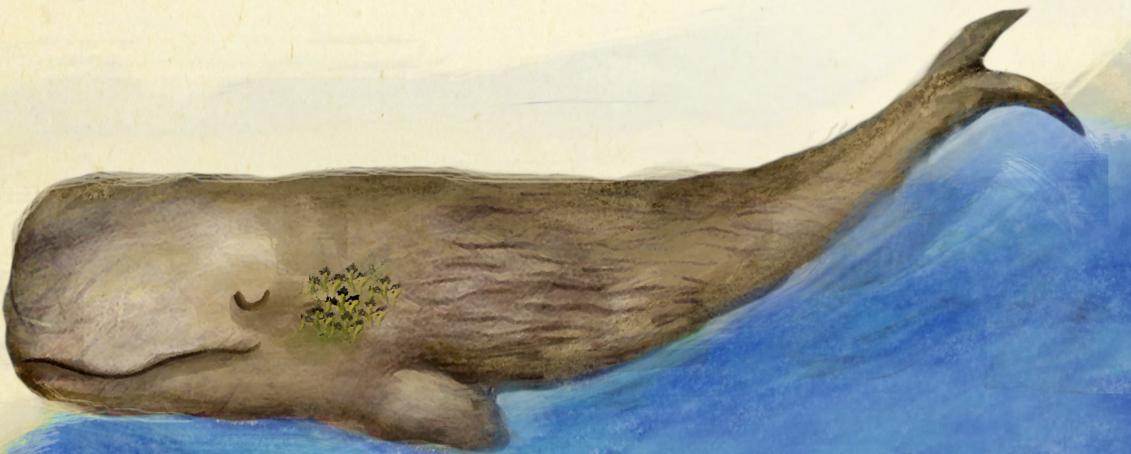


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Introduction

Once upon a time, a number of adventurous scientists moved out from the known terrain of scientific literature to explore the terrain of science related story writing and storytelling. They aimed to create short stories, which address the current threats our oceans undergo due to “human-made” climate change, contamination and exploitation.

The first part of the adventure is now completed. The imagination formed into words and several illustrators took a step further to transform words into images. We present before you these adventures and invite you to sail with us.

“Once Upon a Time... a Scientific Fairy Tale- Volume I”, is an anthology of nine stories, two poems and one sustainable lifestyle guide. This is the first result of a collaborative effort of 29 scientists (the “Once Upon a Time” Team, OUAT-team) and the professional support of several artists. The protagonist of the stories and poems are marine and terrestrial animals, grown-ups and youngsters, people like you and us.

As scientists, the OUAT-team members know first-hand facts of the ongoing atmospheric and ocean warming, of the snow and ice sheets diminishing in recent years... Such information of the current changes in climate is transmitted to the public through, for example, the reports of the “Intergovernmental Panel on Climate Change” (the IPCC). The reports that the IPCC publishes are based on the scientific knowledge developed by many scientists worldwide. The reports are open to the public and we invite you to visit <http://www.ipcc.ch>.

Nonetheless, we are also aware that the public is bombarded not only with information, but also with misinformation. Therefore, we decided to look for a way to further transmit scientific knowledge.

With our stories, the OUAT-Team aims to tell you about our oceans in an amusing and entertaining way. Adults and children can read the stories together, adults can tell the stories to children; children, adults, youngsters can tell the stories to each other... The images illustrate some highlights of the stories. Furthermore, wherever we felt additional information or scientific explanations were needed we have appended them at the end of the stories: in our “Would you like to know more?” sections. All in all, the stories aim to contribute to the understanding, protection, discovery and use of the oceans. We hope that you will learn about our oceans and share our call to raise the awareness about our environment, our home, our need to respect and take care of it.

This is an ongoing project., Please, feel free to contact us with suggestions for improvements and interactive extension of the existing concepts. The stories are first released in German, English and Spanish; more languages will follow: Italian, Korean, Chinese, Russian, Portuguese, Hebrew, Filipino...

For the time being, dear reader, come! Follow us through several adventures from the deep sea to the table of your house!

Hadar Elyashiv, Gema Martínez Méndez, Dharma Reyes-Macaya

OUAT-Coordination Team

Bremen, 31st of August 2017

Catalina is Inara

Vicente Durán-Toro

Illustrations Carolina Guarnizo Caro

And she was born in front of the Channel
And her grandfather called her Catalina
And Catalina opened her eyes for the first time-
Here, in our land
And Catalina saw the water, the seas and the ocean
And she saw that they were fierce and peaceful,
And Catalina heard the voice
And the voice took form and said:
'Your name will not be Catalina anymore-
Because the currents will call you Inara, Spirit of the Water.'
And Catalina was not Catalina anymore and she became Inara.



In eleven winters, Catalina fell in love with it,
In eleven winters Catalina grew up with it,
Effervescent white foam,
Offshore Lacao's coast
As a dark body of water -
The Chacao Channel boast.

The Chacao is being furious, the sailors are telling,
By massive high tides its waters were lifted
The Channel is being sad, women were whispering,
By gusts of 40 knots its waters were shifted.

No fury, no sadness
Catalina declared,
Of Chacao's madness
We should be aware.

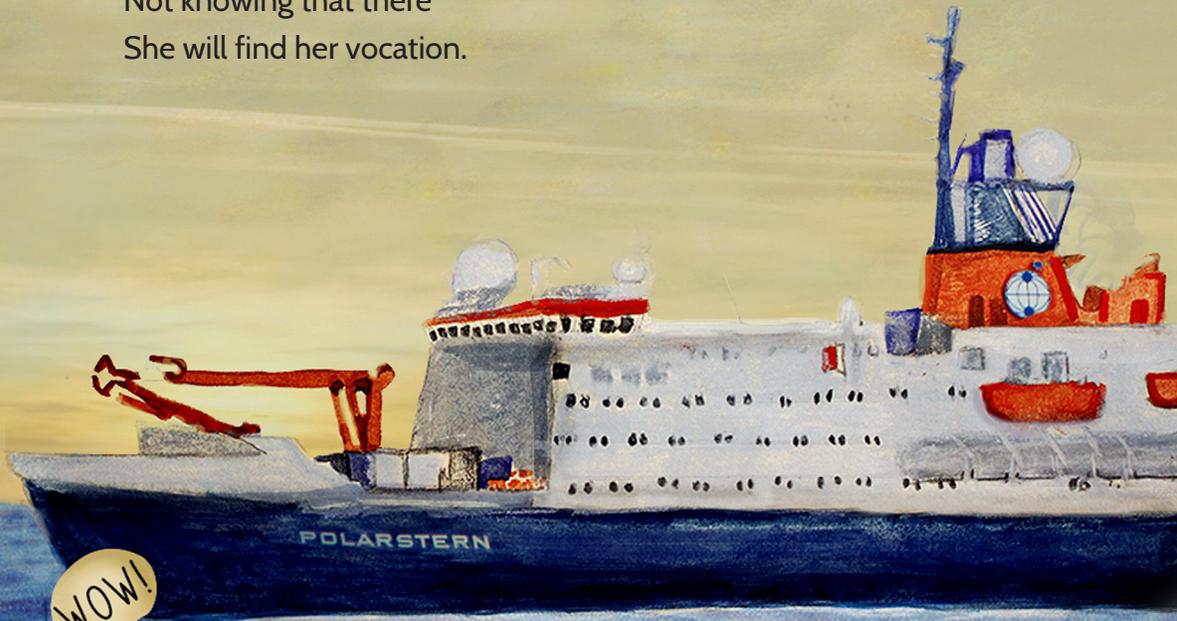
We live-
Cutting forests!
Clogging rivers!
Our lives are being consumed-
By the energies produced.



In the dawn of a clear day,
Catalina sailed away.
A quest for energy she begun,
To save the island and its people,
Before nothing could be done.

Dashing, in the prow of a ship, a name could be read,
The Polarstern Icebreaker was floating ahead.
To which adventure are we heading?
Catalina, for the first time, was dreading.

She took her chances,
She jumped on board,
Eluding despair
Feeling elation
Not knowing that there
She will find her vocation.



As a stowaway Catalina was taken
And for a couple of nights
In the dungeons forsaken
'A girl on my ship?'- the captain bawled
'For the labors of the sea, you are too small.'

Fearless, Catalina showed her teeth,
'Curses from heaven!' - she cried
'I might be young, I might be a girl
But my acts will define my soul as a pearl.'

'What bring you to our swirling waters?'- Catalina inquired
'What is your crusade?'
'What is this job, that if done by me,
Just cannot be made?'



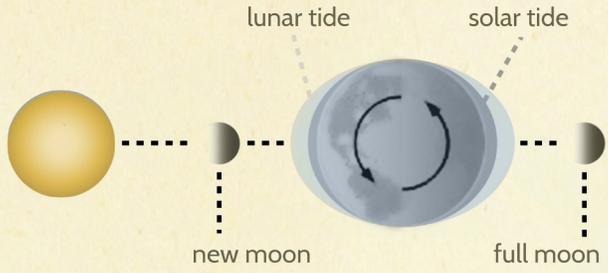
'We are oceanographers.' - The Captain replied
'We are studying the Chacao's remarkable tide,
Seeking for a renewable energy source,
Hidden in its great tidal force.'

'And if you find this submarine power?'- Catalina asked
'We install turbines that move with the flow of the tides.'
'Turbines at the bottom of the Channel?' Catalina replied
'To obtain tidal power that the ocean provides.'
'But what happens if the energy is over?' Catalina hesitated
Only then the Captain knew what the girl necessitated.

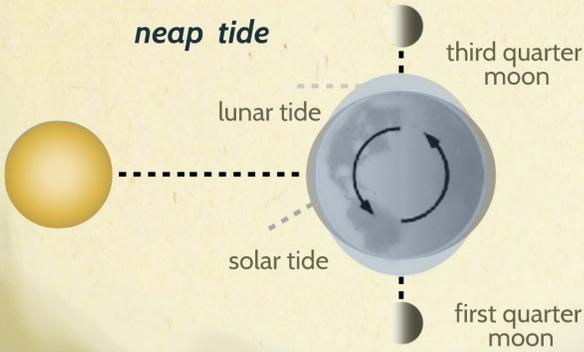
He smiled and explained
'The sun and the moon move our seas-
Using the gravity, perpetual gathering force
Creating tides, currents and waves.'

And Catalina saw the motion of the turbines
And how they spun following the currents
And how with every turn, new energy was formed
So Catalina studied her deepest love,
The Chacao Channel
And Catalina helped her town
And brought renewable energy
Because as long as above the Channel
The sun arises and the moon wanes
The Chacao will provide energy until the end.

spring tide



neap tide



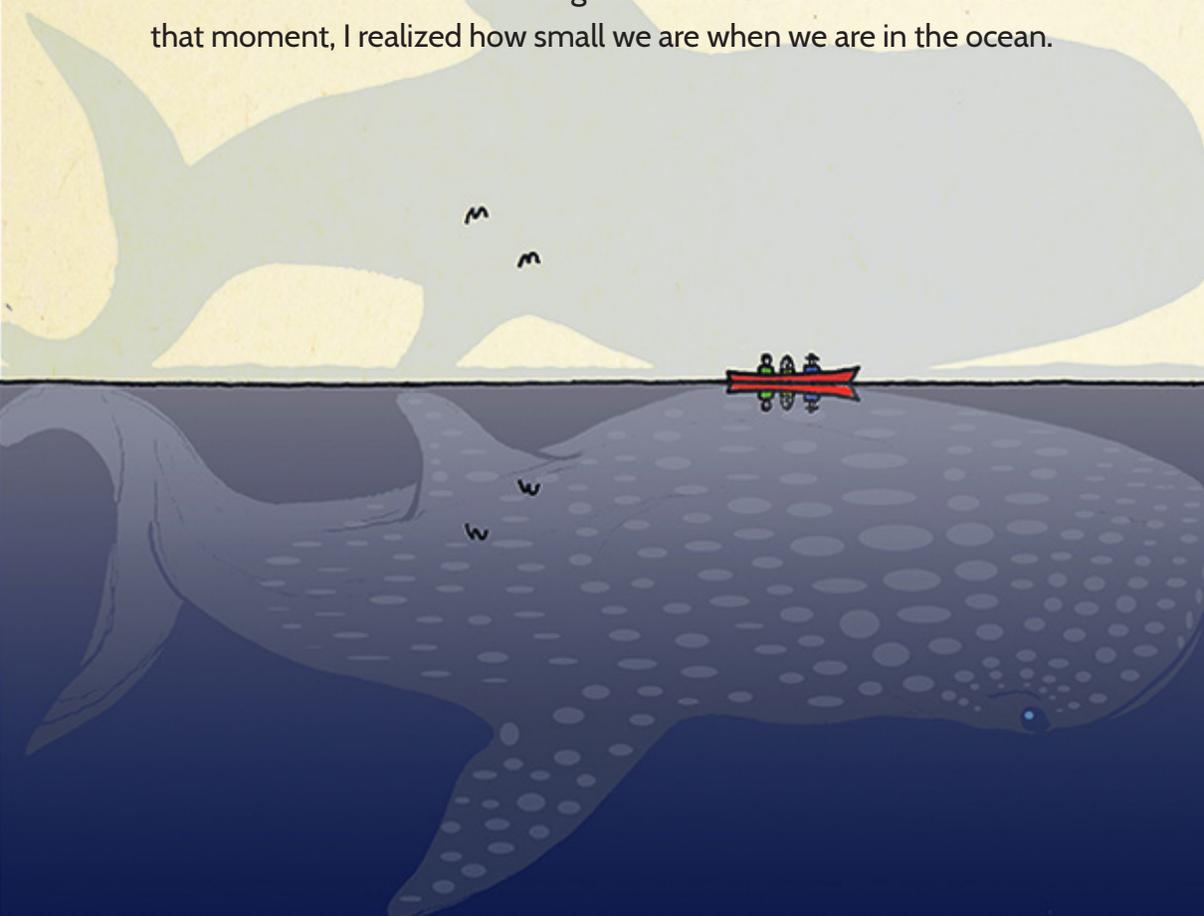
And Catalina crossed the oceans
Helping men and women of science
Studying the tides.
And Catalina contemplated the sea with new eyes
And the currents shone for her
And Catalina knew what will be of her.
And she screamed to the ocean in the middle of turbulent waves
'Oceanographer one day I will become!'
And the currents spoke:
'For a long time now your name has not been Catalina,
For a long time now you are Inara, Spirit of the Water.'
and Catalina remembered and she was not Catalina anymore
and Catalina was from now Inara, a student of oceanography.

Lucas, our common ancestor in the deep sea volcanoes

Pamela E. Rossel

Illustrations Bruce McCallum Reid

I still remember the day my interest in the ocean started. I was just a little girl when my grandfather, during a winter day, opened one of his old encyclopedias to entertain me. The first picture I saw was of a small boat with three people in the middle of the ocean, and below the boat there was a huge shadow. It was a whale shark! In that moment, I realized how small we are when we are in the ocean.





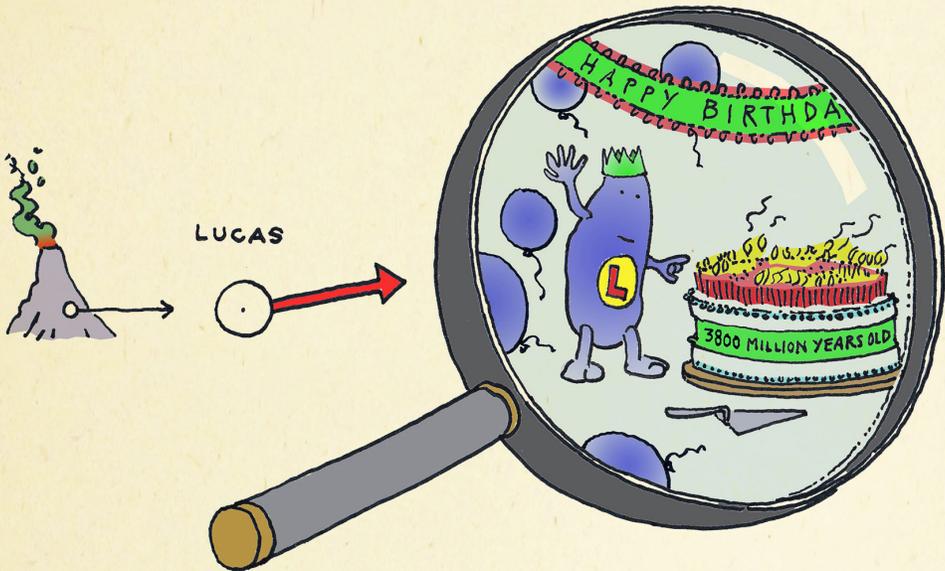
Now, 35 years later, here I am, in a submarine at 3500 meters below the ice of the Arctic Ocean, hunting for marine volcanoes (*hydrothermal systems*).

This is not so different from what my mother used to dream about what I would do as an adult. While I was growing inside her belly, she thought that by the time I would be a grown-up, I would have already been on another planet. And to tell you the truth, the landscape around these marine volcanoes appears to be from another planet. Can you imagine it? Big chimney-like structures releasing black smoke and hot fluids at high speed. When lava from these volcanoes is released, it is cooled down as soon as it gets in contact with seawater, forming pillows over the seafloor, creating unimaginable scenes. Whatever animal would dare to cross over these fumaroles would be cooked like in a pot. And yet, around these fumaroles, where the water is not so hot, there are diverse types of life. Huge areas are covered by molluscs, white shrimps wander like ghosts and dense groups of crabs with hairy legs (known as yeti crabs) walk over the fumaroles' walls. This diversity of forms give life to this landscape, that otherwise, looks inhospitable. Isn't that amazing? Do you want to explore these places with me? Then let me take you down into the deep, dark ocean.

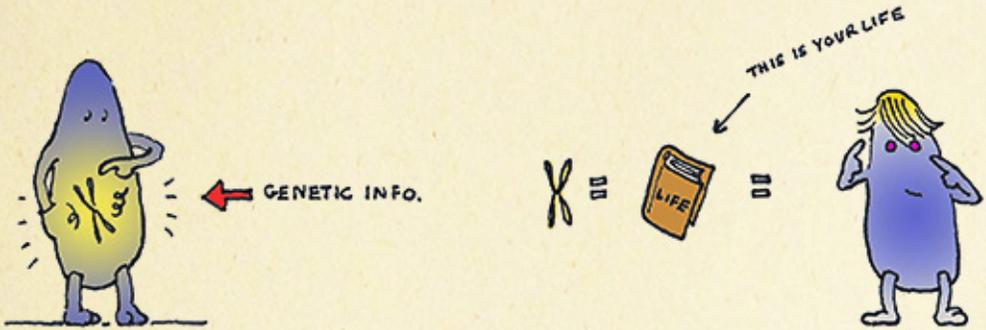


Among the organisms, which thrive in this extraordinary habitat, is a type of life invisible to our eyes. An unknown majority composed of tiny little living forms named *microorganisms* (e.g. bacteria). These microorganisms perform a wide variety of processes that, in some way, influence the climate of our planet. Yes, believe me, even though they are in the deep ocean, they can influence the climate up here, where humans live. For most microorganisms, in contrast to plants, the energy source is not the sunlight but rather the material that is dissolved in the water, some of which are gases that in high concentrations are even *toxic* for humans.

But maybe for you, the most interesting aspect is that *life on earth is believed to have started in such a place*. You know, the first step to create something living from something inert took place here. In this intermediate step, between something inert and something living, the ancestor of all living beings appeared. Our common relative with microorganisms, who we will call Lucas.

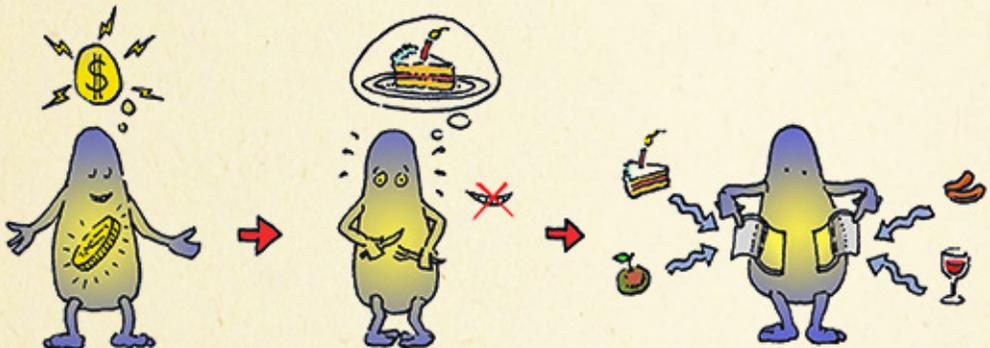


Lucas was born approximately 3800 million years ago (the Earth is around 4500 million years old) and he shares some common characteristics with us. Lucas has *genetic information*, a kind of written information inside every living being that, in our case, is inherited from our parents. For example, this genetic information determines the color of our eyes and hair, and small variations in it make each one of us unique.

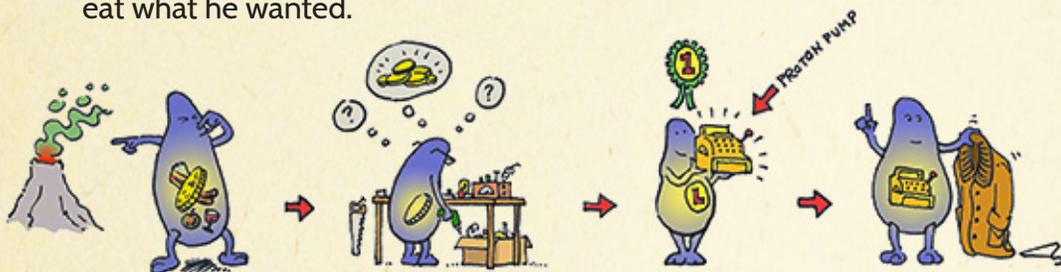


Moreover, Lucas is also able to use the same “fuel” that we use to obtain energy. It is kind of a coin that stores energy for us so that we are able to play and think every day and that can be regarded as precious as a gold coin. However, we get energy from the food we eat which allows us to grow, play and continue eating, whereas Lucas does not have a mouth. In that sense he is more like a microorganism.

Furthermore, it is believed that Lucas did not have a “skin” as resistant as ours, so certain elements that existed in these hydrothermal systems could penetrate his “skin”. Because of this, Lucas was able to take these indispensable elements to create his genetic information and “his first gold coin” that would allow him to eat so that he could obtain more energy.



Although, being very primitive, Lucas was an adventurer and finally he decided that it was time to move on. Lucas did not want to live near the deep sea black fumaroles anymore because it was dark and the gases started making him cough a lot. Lucas decided to explore other places. He worked very hard to build “**a machine that was able to produce his own gold coins**”, so that he would no longer have to depend on what would cross his “skin” from the hydrothermal system. Now, he would always have energy if he did not want to go to bed early. However, there was still a problem: Lucas was used to warm water and did not know what to expect from this new adventure of exploring the planet. Thus, he decided that before leaving the deep sea fumaroles, he needed a “skin” that would keep him warm and would only allow things from outside to cross through if he really needed them. In that way, he would only eat what he wanted.



These two new creations of Lucas (the machine to make gold coins and his awesomely resistant skin) would let him live in other environments without the need for hydrothermal activity. These vents gave him the initial energy but they had become only a memory because Lucas was now able to make his own energy like a complete living being. Thus, Lucas' inventions were the essential steps, which gave rise to all kinds of living forms outside of these habitats, including our life much later.

And now, approximately 3800 million years after Lucas' birth, here I am with other people, inside a submarine below the ice of the Arctic Ocean, engaged in this adventure to study the origins of Lucas and the other diverse living forms in these deep sea volcanoes. But who are we and why are we here? People call us marine scientists but the truth is that, like you, we are explorers, taking this journey out of curiosity. We are in pursuit of answers on how nature works, especially in the ocean.

But why do we care about *the ocean*? We care because it makes our planet a place we can live on. Thus, we invite you to pay attention to what we will tell you about the ocean, so you can learn to discover and protect it.



Would you like to know more?

Hydrothermal systems

Hydrothermal systems are formed due to volcanic activity associated with the movement of the tectonic plates. The movements of the tectonic plates give rise to the oceanic ridge (Mid-Ocean Ridge, the longest mountain range of the world). In this ridge, there are fissures through which lava is released forming a new seafloor and causing, over millions of years, the continents to move and to reorganize (e.g. currently the continents Africa and Europe are moving away from the American continent). In relation to the volcanic activity, there is a release of hydrothermal fluids which can reach temperatures of 400°C or more. The upper limit of temperature for life is 120°C and the average temperature for water depths deeper than 2000 meters is around 4°C.

Microorganisms

Hydrothermal systems are considered an oasis in the deep ocean because they support diverse lifestyles. Here life forms are especially adapted to high temperatures and conditions that, for other organisms, would be considered “toxic” (e.g. high concentrations of carbon dioxide, hydrogen sulfide, methane and heavy metals, as well as low pH). Among the life forms that exist here, there are bacteria and archaea, which are organisms that can be seen through a microscope and are thus called microorganisms. They are able to transform these “toxic” elements that are dissolved in water by a process known as chemosynthesis, into energy which they could use.

Life on earth is believed to have started in such a place

There is a theory that life on Earth started in the deep sea's hydrothermal vents. Life would have begun due to a series of complex chemical reactions that formed the first molecules with carbon, the building blocks for life in our planet. The environmental conditions in these systems (that produce a gradient between the seawater and the hydrothermal fluid) were not only the impulse for creating these first organic molecules but also the primitive cells or proto-cells like Lucas (whose real name in English is LUCA for Last Universal Common Ancestor).

Genetic information

Genetic information is inside of each cell, stored in the DNA (Deoxyribonucleic acid) or RNA (Ribonucleic acid), and controls the cell functioning. The DNA and RNA are formed by four different molecules that contain nitrogen (nitrogen bases) and that arrange themselves in sequences that constitute the genetic information. Despite of the high percentage of genetic information that is common in all humans (we are approximately 99.9% similar) and that we even share with other species of the animal kingdom (e.g. we have around 96% genetic similarity with a chimpanzee), there are small variations (one DNA sequence is never the same with another DNA sequence) that in combination with the environment to which we are exposed to (which causes natural selection of genes and also mutations) make us unique.

“Fuel”

ATP (Adenosine Triphosphate) is generated from the chemical transformations of the food inside the cells. This process is known as the metabolism and ATP is the main molecule involved in the transference of energy in the cell. Thus, it may be called our main “fuel”. Its responsibility is to support all cellular activities such as the movement of our muscles and our thinking.

“Skin”

The “skin” of Lucas was the cell membrane, which delimits the cell (to give mechanical support) and also controls the inward and outward movement of molecules such as oxygen, water, organic matter and ionic substances (that have an electric charge). It is believed that the first cell had a permeable membrane (substances pass through it freely), allowing it to obtain the energy from its surroundings. This initial energy was obtained from the difference between the seawater (rich in protons or positively charged particles) and the alkaline hydrothermal fluid (proton acceptor). This difference, or proton gradient, in the surrounding of this cell triggered the entrance of the protons allowing the formation of ATP.

“A machine that produces its own gold coins”

The initial cell became independent of the hydrothermal system once its cell membrane was able to actively pump protons (proton pump). This process promoted ATP production. Over time, this modification in the cell membrane induced the formation of a selective cell membrane.

The ocean

The ocean has a fundamental role in the habitability of our planet due to e.g. its ability to absorb and store carbon dioxide produced by human activities. If this carbon dioxide would have remained in the atmosphere, it would have affected the climate even more than it is doing at the moment, making it more hostile for us and other living beings.

The life cycle

Denise Müller-Dum

Illustrations Annette Leenheer

The temperature left no doubts: the sun was certainly shining. Single, yellow patches on the black water surface testified to its presence, too. But when Faizal looked around, everything was dark: it was hard to tell tree stems, ferns and leaves apart. The treetops, many meters above his head, formed a huge, dark green umbrella, which would only occasionally let a ray of sunshine pass through. Only the river, which laid itself out in front of him, offered Faizal some kind of orientation; at least it unmistakably determined the direction in which the boat was moving.

The stick that the driver used to move the boat ahead fell heavily onto the water's surface. The sound of splashing water and the boat's gurgling response formed a dull rhythm, to which birds and crickets improvised. Their singing faded as the wind turned, and Faizal could hear his own breath. He strained his eyes, trying hard to see, because he knew it could be anywhere without him noticing: the crocodile would remain completely still and indistinguishable from its surrounding, waiting until the boat came too close, and shocking the intruders with its sudden and vigorous movement. Faizal raised a hand to signal the driver to stop. The splashing and gurgling fell silent, and Faizal started to feel vulnerable. What lay in front of him was unknown, and he could not really see where the river would take

him because of all the ferns and grasses that covered its course. The way back was long. They had been out on the river since the early morning, and there was no place where they could have stopped to drink or to eat. The peat, the trees, the ferns and an old wooden boat, which was in need of considerable maintenance, suddenly seemed to him like props in the most threatening scene of a mystery movie. He imagined how a crocodile could have slid into the water behind them, shutting off their way back. He shuddered. But then the driver brought the stick back into the boat, wood knocked on wood, a match hissed, a cigarette rustled, and the driver's long exhalation reminded Faizal that at least one of them considered all this to be just unspectacular, everyday business.



Faizal, however, had never seen anything like this: the river water was as black as the tea that he had enjoyed that morning. Only when the sun touched the river surface, the water appeared somewhat yellow or reddish. Faizal took the glass beaker between his feet and made sure that the floating wood in front of him was not actually a crocodile. Then he held the beaker in the water and let it fill slowly. The boat driver observed what the scientist did and asked, 'What do you want with all of this?' - 'I want to find out how much carbon is contained in this water', said Faizal, knowing that the boat driver might not find this answer very helpful. He held the beaker against the light. The black water fascinated him. He closed the container and grabbed a rectangular device, which looked like a calculator and had several strings attached to it. He tossed them into the water and pressed a button on the device, causing the display to light up. Faizal searched his backpack for paper and a pen, while saying, 'Carbon is everywhere in this forest. In the trees, in the roots, in the soil. The plants take it in from the atmosphere... ' - He hesitated and corrected himself, '... from the air, pass it on to the soil when they die, and the soil releases it into the water.' The boat driver laughed. 'Of course that's how it works. You don't need all your funny devices to know that. It is completely logical: it's a life cycle.' He stretched his arms out into the air, seeming to pull something from above his head into the boat, and explained: 'Our souls come from the air, they go into our bodies, and when we die, a part of us becomes soil, and the soul goes back into the air. Does your carbon go back into the air, too?'

Faizal thought. He had never considered this idea. It had been so obvious to him that the carbon, of which so much was contained in the peat soil, would have to enter the river somehow. The water

flowed through the thick peat soils before entering the stream, taking up so much carbon from all the dead plant material. This was how he explained the water colour, too: it was just as black as the peat soil. But could there be a way that this carbon would be transferred back into the atmosphere? He shrugged.

Absently, he searched his notebook for a free page, then routinely looked at his watch and repeated the time to himself, before finding an empty page to write it down. He noted the numbers displayed on his measuring device, too, and pulled the strings back into the boat. 'Alright, let's turn around', he said to the driver, who nodded and attempted to turn the boat around. During the maneuver, the boat softly hit the bank, and Faizal reached out for the cold, wet soil. The peat was pitch-black. It stored carbon from the last millennia, had seen hundreds of inhabitants of the forest and had soaked up the monsoon rain many thousand times. Awestruck, Faizal looked at the brown crumbs in his hand, before rinsing them off in the river water, while the boat continued to move downstream.

The moist heat pressed down on Faizal. He felt strained and wiped the sweat off the sides of his nose. He felt the pressure in his head increase and took a few sips from his water bottle. His bottom hurt from sitting on the wooden bench all day, his knees felt stiff, because they had been in the same position since they had left the village. His arms felt weak and tired, and suddenly the only thing Faizal desired was to get back to the village as quickly as possible. He dreaded the coming hours. Reluctantly, he closed his eyes, trying to relax. Work was done, now all he had to do was wait until they got back.

He startled: had he fallen asleep? Sweat covered his eyelids and

burned as he rubbed his eyes. His neck was stiff; his left foot had fallen asleep. He would have loved to stretch his legs, but the size of the boat denied him this relief. Faizal thought about what the driver had said: does the carbon go back into the air? He knew that the forest and the peat soil release carbon into the atmosphere, that they breathed. But how about the carbon that he suspected to be in the river?

Faizal stayed in the village for two more nights before loading his jeep and travelling back to the city via two ferries. From there, he reached his domestic flight and, more quickly than he thought, he found himself sitting in a big armchair at an American coffee chain, checking his emails. As he drew patterns into his milk foam, his phone rang. 'Back to civilization?', asked his colleague, Jack, on the other end of the line. Faizal looked at his free hand, which was still a bit brown with a few cuts from the wooden boat. 'Yes, I am back', he answered. He gave Jack a short summary of his expedition, and Jack replied that he would be ready to take delivery of the samples.

Only many years later did Faizal return to the black water. His study in the jungle was received by his colleagues with high interest, and Faizal had always romanticized about the latent danger of crocodiles. He had made himself known as an expert in the fields related to chemistry, and going back to the jungle would not really have been necessary for his career. But there was still this question that he hadn't been able to answer, the question he couldn't let go: was carbon released back into the atmosphere from the water surface?

Faizal did not arrive alone: a colleague from the United States and one of his students had been excited to join him, and the American

brought a device that allowed for the measurement of the gas carbon dioxide, a prominent so-called greenhouse gas, which promotes global warming. The river had changed its appearance: the water colour was still that of black tea, and the different shades of green reminded Faizal of his previous visit. But many more bald spots had appeared in the treetops, letting the sun through. Large parts of the shore seemed somewhat naked, brittle tree stems with broken crowns told a story of clearing and fire. Ferns were much more present than the majestic trees. The roaring noise of the motor was the only sound one could hear, and Faizal was almost a bit disappointed by the lack of silence and the missing tension. They had had to rent a different boat. The former boat driver had stopped his business, and somebody else had been recommended to them.



The new driver was rather stoical, he stopped when asked, and when Faizal and his colleagues threw their sensors over board and collected their water samples, he absently stared into the forest, bored, and smoked his cigarette. He did not talk much, and responded to Faizal's appeals to stop or go with a polite nod.

Darkness settled over the houses, as they returned to the village. Curious faces met the scientists, as they came back on shore. Faizal was exhausted, but also felt exhilarated. It was true! The river did release carbon into the atmosphere! As simple and easy as the boat driver had predicted years ago. They had already noticed it at the very first stop during their sampling trip, and all other sampling points confirmed it: the greenhouse gas carbon dioxide escaped from the water surface into the atmosphere. What a breakthrough discovery! Other scientists had never considered it, even though it now seemed so obvious to Faizal. While he heaved boxes full of sample bottles and scientific equipment into the jeep, he imagined himself presenting his new insights at his institute and at conferences. So this was how it felt to write a small piece of the history of science. He smiled to himself with satisfaction.

After paying the boat driver and making sure that he hadn't forgotten anything on the boat, Faizal walked to the jeep's passenger seat and opened the door. But before he got in, he hesitated. He walked back to his silent companion and asked him where he would find the boat driver, with whom he had visited the river the first time. He got the directions and asked his colleagues to stop at the boat driver's house. He couldn't wait to share his discovery with the aging partner.

The boat driver lived in a neat wooden house. A woman opened the door. Faizal assumed that she was the boat driver's daughter. He explained how he knew her father and that he would like to share his new insights with him, in person. The woman nodded and smiled, but looked slightly confused. She stepped aside to let him in, saying 'He is not as fit as he used to be.' She pointed to her forehead and added, 'but his mind is still fresh, so go and talk to him.'

The boat driver was sitting on a couch, smiling knowingly as he saw Faizal enter the room. He had aged, and wrinkles covered his face, but his eyes shone whimsically, as they had back then. He asked Faizal to sit down next to him. After a day on a wooden boat, the saggy sofa was a treat. He put the pillow behind him in place and began to tell the boat driver about his experiences and his new discovery. 'I just couldn't let go of it', said Faizal. 'It is exactly the way you predicted: the carbon goes back into the air. It is released as a gas from the water's surface. Like a life cycle, indeed. I am so surprised, nobody had ever thought of that!' He observed the smile emerging on the boat driver's face. 'You would have made a great scientist', he said, trying to break through his reserve. But the boat driver shook his head. 'That wouldn't have been a job for me. I am just so surprised about how overly intellectual you scientists are sometimes, so much so that you fail to notice the obvious!' He patted Faizal on his back, in a friendly way, but also indicating it was perhaps time for his guest to leave. Faizal understood and got up. He held his hand out to the old man and said: 'It was really a pleasure to see you again. If I come back to the river, maybe I'll stop by again!' Silently, the boat driver shook Faizal's hand. His

response came when Faizal was already standing in the doorway: 'I don't think I'll see you again next time. You learned a lot about the life cycle – well, so did I. My soul came from the air, into my body many years ago, and it is ready to go back there.' He smiled and wiped the portentous statement away with a dismissive hand movement. 'All the best', he said to Faizal.

The Bremen Town Musicians set sail

Gema Martínez Méndez
Illustrations Peter Marten

In an unnamed and vaguely located place somewhere close to Bremen, four old old friends stared at a bundle of luggage. They were old, since the meandering path of life, which they all left behind, was long. They were old friends, since they had lived through many adventures together.

The four lived in harmony in a little house they had won a long time ago from some vile thieves, their more well-known *epic tale*.



The warmth of the home they created was the fair compensation for a long life of hard work. Sadly, they had experienced little recognition by those whom they had served.

The animals however, had a high degree of understanding for their old masters. The last years had been even colder with very hard climatic conditions. Much colder than the previous years. The crops had failed again and again. The masters could not afford to keep animals who were getting too old for the heavy and hard-going farm work. None of them knew about it but they were immersed in the final and very cold stages of the *Little Ice Age*, a cold period that lasted between the years 1275 and 1850.

'I cannot take it anymore,' Donkey cried, 'the last few summers have been short and rainy but this is by far the worst! We have not seen the sun for the whole season. Maybe we cannot even call this "a summer". Can you believe it, a year without a summer? I have been telling you that I am fed up with this cold, which gets into my bones. I have been seriously considering emigrating for a long time now. I do not want to wait any longer! 1816 is my last year here... I am leaving!'

Year after year he was having more difficulties to cope with the cold. Working in the field in winter, autumn, spring and even sometimes summer, had been hard in his younger days. As he aged, his weakening strength made his master question his usefulness. Finally, Donkey had to leave the farm to save his life. The idea of migrating again was not appealing for him, as the animals had enjoyed a peaceful life in their little house for such a loooooooooooooooooong time. But, it was becoming increasingly difficult to find food for

everyone and the animals were aware that they were undermining their environment by chopping firewood in order to keep warm.

‘You would not leave without us, would you?’ Dog whimpered. ‘Perhaps the cold will soon go away. My great-great-great-grandfather told my great-great-grandfather, my great-great-grandfather told my great-grandfather, my great-grandfather told my grandfather, my grandfather told my father and my father told me, how much he enjoyed the heat of the summer as a puppy and that there was only little snow in winter... Perhaps the warmth will come again soon... What a pity we do not know how the climate will develop in the next few years...’ he whimpered again. ‘It would be so convenient to have a few predictions to know what to expect and how to act.’

Rooster looked at him with an understanding. It would indeed be a great help to know what to expect. He was worried, he did not want his little family to break apart and with his battered plumage, he feared, he could not survive a long trip. He did not want to leave the vicinity of Bremen. He looked at Cat with concern, but he could not meet his gaze. This was lost in the remoteness of the white forest across the window.

“It is his defense mechanism,” thought Rooster, “he does not want us to see the sadness in his eyes. The only one here who does not have troubles with expressing his emotions is Dog. Poor darling, as he moans, he passes on his sorrow.”

He had seen that one coming as the patience of Donkey was running low, What a stubborn fellow Donkey was!

This evening was not extraordinary, as the animals have had this conversation for days, weeks and months after the failed summer. The climate plays a central role in every creature's life and if one is adapted to a lifestyle in accordance to certain climatic conditions it will be difficult to adapt to rapid changes. Especially, if you are not aware of them or if you do not know in which direction they will go and when these changes will take place.

Cat turned around, looked at each of them one by one and for the first time in many nights, he contributed to the discussion. Or rather than contributing, he finished it.

'Donkey, leaving now is crazy, you would freeze to death. In spring, we, ALL of us, ' he looked specifically at Rooster, 'will leave. We will go to the south, we will seek the sun. We are going to Mallorca!'

And so, with the new joy of knowing (or believing) themselves owners of their destiny again, our four friends enjoyed the remaining winter. They went out wrapped up in warm clothes to skate, engaged in countless snowball fights, read and told stories of fear and laughter. Mentally, they prepared for a much longer journey than the one, which brought them to their little house in the forest a long time ago.

In spring, the animals were ready, they were stocked up with food, the roads were cleared and the days grew longer. Cat wore his boots, which were a present from a good friend. He was the first to cross the threshold of their little house and all the other animals followed him. Cheerfully and enthusiastically, the group started their journey. Their first destination was the great harbour of Amsterdam where they would embark upon a ship heading to the Mediterranean.

The adventures they had in their way to Amsterdam are worth a separate narration. For the time being, we should be happy to know that they arrived safe and sound to the harbour. They jumped excited into the first ship they saw and set sail!

'Ah! The smell of the sea! The breeze in the face! What a delight! Adventure, guys! Mallorca awaits us!' They all cheered.

And the minutes, and the hours, and the days, and the weeks, and the first month, and the second month went by, and they continued sailing and sailing and sailing. And it was cold, and it was hot, and they sailed through troubled waters, and they saw whales, and they saw many kinds of seabirds, and it was cold again, and it was hot again...



One boring afternoon Donkey cautiously approached Cat.

'Soooo... Cat... I passed by the bridge a while ago and I saw the navigation charts on the table... and... I took one and a sextant..'

'Hmm, and?'

'Well... it is just that... well... maybe it is a guess, I cannot be sure, maybe I have the wrong interpretation of the sextant reading but according to this navigational chart, if it is a navigational chart, it is my humble opinion that..'

'What on earth are you trying to say Donkey? spit it out!' Cat snapped.

'Okay... but do not be angry... I believe that we are in the Pacific Ocean... and well, if you think of it... it makes sense because Mallorca is not that far from Bremen... we would have already arrived a long time ago... I think.'

'Oh no! You are right, we took the wrong ship! Well, never mind, we have had some bad luck again and we may not arrive at the planned destination. It does not matter, until now we have been doing well, we will find a solution.'

Dog jumped in excitement.

'In the Pacific Ocean? That is cool, dudes! That is even better than Mallorca, we can settle on a tropical island! We can live in a little hut by the ocean and watch the waves every morning when waking up! How cool is that!'

Rooster was not so excited, after all, he had never wanted to leave the surroundings of Bremen.

'I knew that leaving our little house was a bad idea. Now we are stuck on a ship, whose destination we do not know, in a huge ocean. How exactly are we going to find your tropical island paradise, Dog?'

'Well, with the navigation chart and the sextant...' said Donkey. 'I am sure we can find an island, according to the chart, there must be lots nearby. They call them atolls; they are like a ring of land with a lagoon inside. Let's take one of the safety boats and have a look ourselves.'

They looked at Cat with expectation. He nodded. The four friends left the ship on one of the safety boats, in search of tropical islands. The waves felt much stronger in the small boat, the group was filled with excitement, just like when they first set sail from Amsterdam.

Not long after they set off, however, the weather began to change. Sometimes in the tropical latitudes of the Pacific, an atmospheric anomaly meets the warm ocean waters and becomes a tropical storm, or even a hurricane. Little did they know but our four sailors were about to discover how this would feel...

The boat began to rock more and more with each coming and going wave and the torrential rain was filling the boat fast. The friends had to hold onto anything they could, the banks, the length and each other, to prevent being thrown overboard. The howl of the wind made it almost impossible to communicate. Donkey, with his fur soaked and eyes watered from the wind, struggled to steer the small boat. Another large wave pounded the boat and the helm hit Donkey on the forehead. "Plommm!" A bump immediately emerged on his forehead. He lost his balance and Dog just managed to grasp him in time to prevent his friend falling overboard. However, rescue did

little good as a new pounding from the waves turned the boat upside down, throwing all into the furious waters. The animals struggled in the water. They felt themselves sinking, tasting and swallowing the salty water and fighting to stay afloat amongst the huge waves...

The four friends panicked. With the last breath in his lungs, Cat looked around and thought: "The deep ocean is like a starry night, dark and with points of light." (The bioluminescence of some tiny marine creatures). Cat's head was spinning and he could only repeat that thought to himself until he closed his eyes to the dark night. Rooster closed his eyes to the dark night. Dog closed his eyes to the dark night. Donkey brushed all of them with his tail with one last thought of sun and tropical beaches and closed his eyes to the dark night.



Would this be the wet end of the famous Bremen musicians? Would the history only know about their epic battle against the thieves?

Cat opened his eyes and stared at the stars of the sea. "Beautiful vision," he thought. "Shame because of all the moisture, I do not like to bathe. Hey! Wait, I am not in the water! Where am I? There is sand under my body! And real stars above my head! He looked around excitedly. Donkey, Rooster and Dog were lying a few meters away and he ran to awake them."

'Boys, wake up! We are alive, alive, aliiiiiveeeeeeeeeee!!!'

Soon the new day broke, after a storm comes a calm, the sun smiled at them from the blue sky and the tropical, white sands caressed their furs. They found the boat, the navigation chart and the sextant on the beach. They were thus able to deduce that they were in some atoll of Kiribati. They rather seemed to be on an isolated beach, there was no evidence of an inside lagoon and the beach proved to be shorter than expected once they had explored it.

'This is strange,' said Rooster, 'according to the navigation chart there are many atolls here, it says nothing of an arm of sand. Either, we are wrong or this island is not shown in the chart.'

They decided to get back to sea, according to the chart there were many atolls around, surely they would find one where to make a new home.

But that was not the case, they sailed and sailed and sailed and sailed, they only found small spits of sand which looked like submerged atolls.

'It is puzzling,' reiterated Rooster, 'it seems as if the ocean had swallowed all of these atolls off the chart. It seems as if the whole archipelago of Kiribati had disappeared...'

Finally, they decided to go ashore on an island that seemed to be a little bigger. There, they met a girl. She was very surprised about meeting the famous and ancient Bremen Town Musicians there, in the “middle of the Pacific Ocean”. Candela, that was her name, told them that yes, they had arrived to Kiribati, or what remained from *Kiribati*. From the old archipelago of atolls and one island, only that bit of Banaba (the island), remained above sea level. She told them that the majority of the population emigrated in the year 2050 because *the rise of sea level* was reducing the quality of life by affecting the crops through the salinization of groundwater and the loss of land. Besides, security during stormy periods was becoming a big issue. In the year 2080 the few remaining inhabitants abandoned the last atolls and Banaba. Candela decided to go back to the little piece of dry land that still peeked out of the sea as a tribute to her recently deceased grandfather who was one of the last to leave the island.

Besides, she was a professional diver and she was thinking about opening a new business taking travellers to dive into the submerged cities and explaining what had happened to the archipelago. She planned to open her business in the year 2118.

‘Year 2050, year 2080, 2118? How can that be?’ asked our little animals.

Since we all know that in stories sometimes inexplicable and wonderful things can occur... Something miraculous had occurred. In the night of the storm, our friends’ lives had not only been saved but they had also awakened 300 years later, in the year 2116.

Candela told them that things had changed extremely since 1816

and they had missed a lot of events because of their time travel. She explained them that humans had invented plenty of things, which made life much easier, and therefore the number of people on Earth increased enormously. But they did not pay attention to the environment. Better and stronger houses were built, with heating, with air conditioning and vehicles to travel faster and more comfortably by land, sea and air. Humans invented every kind of useful and useless objects for the house, better clothes, devices for computing, for listening to music, for taking images, for watching images, for communicating... Uff... So many things! For producing those objects, big industries were needed and during manufacturing many gases were emitted to the atmosphere thereby contaminating it. Aside from the atmosphere, also lands and waters were contaminated with waste from the industries and other rubbish. Mountains of rubbish became common features of landscapes in substitution of forests, many of which had been destroyed. Just in case the Musicians were not aware of it, she explained them as well, that forests are very important for generating oxygen and the contact with nature produces well-being. In a nutshell, humanity lived without taking any care of keeping what they had, ignoring the renovation time of resources and losing all notions about what means quality of life and what is disproportionate consumerism.

As a consequence of these actions, and others, a global warming started to take place. Many scientist and people, who were worried about the future of humankind and of Earth, spent many years warning about the risks at play. But people took too long to accept these facts and kept continuing with the same lifestyle. In this way, step by step, atmosphere temperatures rose and the waters of the

oceans warmed and increased in their volume. The melting water of the polar ice caps and of continental glaciers flowed into the ocean. Many lands flooded, for example the archipelago of Kiribati. Many people were living at the coasts and consequently many social problems were generated by the loss of coastal land.

Candela also told them about the agreement between the country of Kiribati and other countries to be welcomed as “climate emigrants”. With sadness, she explained them the telling of her grandfather about the final moment when he left the island. Everybody was leaving with tears in their eyes and helplessness in their hearts because of the feeble attempts to mitigate the effects of human-driven climate change. In the end, there were too few efforts that were made to change the prevailing way of living, which was abusive for the environment, despite so many warnings. She also spoke about the inertia of the system as many of the changes will continue to take effect for many, many more years.

The animals were impressed by her explanations... and amazed about all the funny devices Candela had with her. They would have never thought that humans would be able to make so many changes to a planet and be so blind about them. They remembered the cold that they had left behind, in time and space in the vicinity of Bremen. They also remembered their thoughts, back in the days of “if at least we knew what to expect, we could act accordingly.” What a foolishness to have ignored so many warnings about the effects of global warming! These thoughts plunged them into a meditative silence. Candela said goodbye and dived into the water. After a while, Dog finally broke the silence.

'Guys! If what Candela says is true, there are no more extremely cold summers, springs, autumns and winters in Bremen anymore! Let's go home! Perhaps the climate there is now similar to what my great-great-great-grandfather told my great-great-grandfather, my great-great-grandfather told my great-grandfather, my great-grandfather told my grandfather, my grandfather told my father and my father told me!'

'Cock-a-doodle-dooooooooooooo!!!' clucked Rooster. 'It is the best idea I have heard in months (or centuries). Cock-a-doodle-dooooooooooooo!!! We go home!'

Donkey joined the cheers with loud heehaws.

'Heeeeeehaw heeeehaaaaw heehaaaaw!!! Bremen, Bremen, Bremen!'

'Ooh well... Meow... I do not want to be a party pooper... But... If Candela is right, the navigation charts have changed and I do not know if we will be able to make such a long journey on our boat... especially now that we know that from here to Australia or Asia, there are many sunken islands under the sea...'

'Oh... What a disappointment... Hard cheese. It is true!' said Rooster.

'Donkey, why don't you teleport us like the unicorns do?' proposed Dog thrilled.

'Because I am a donkey and not a horny horse...' Donkey answered, somewhat irritated.

'It was only an idea...' replied Dog.

There were a few moments of silence. The initial enthusiasm and joy gave way to an uncomfortable stillness. Cat's head was spinning around

a thought. He pulled away for a moment and returned with an oar from the boat.

'Cat, why do you look at me like that? Sometimes you frighten me, get that feline look away from me!' said Donkey. 'Cat, what are you doing? Where are you going with the oar? Cat? Do not come any nearer! I do not like your look! Cat!'

"Plommmm!" Cat hit Donkey with all his strength on the forehead. Soon, the bump that Donkey had gotten on his head during the storm and which was almost cured began to grow and grow and grow... it almost seemed like a horn!

'Now Donkey! Think of Bremen with all your strength, think of the attic of our home. Boys, get closer; let's grasp his tail!'



And since we all know that in stories sometimes inexplicable and wonderful things can occur, a donkey with a bump on the forehead can have as many powers as a unicorn. This was exactly Cat's thinking that maybe that had happened during the storm and thus he tried to prove his theory. Dog's idea was not so wrong, after all. Thus, Donkey, Dog, Rooster and Cat opened their eyes in their small house close to Bremen. Luckily, in the attic... As the ground floor was flooded. Rooster soon put two and two together and understood why Cat had insisted on the attic.

'Ouch! The thing is, sea level has also risen here and we did not think about it before coming home... Bremen and most of its surroundings are, or were, only a little above sea level... And therefore, many places are now flooded. Once more, we have had some bad luck. Opps... and thinking about our trip, I wonder what Amsterdam and the Netherlands will look like now? Hmm... we are going to need some time to get up-to-date about all those events Candela told us about.'

Dog quickly intervened, before pessimism could enter the house.

'Every cloud has a silver lining. Before the storm, we were dreaming of our new floating home on a paradisiacal, pacific island and watching the waves each dawn. Now, we have some kind of marsh on our doorstep. Furthermore, we know what to do to keep it and enjoy maaaaaaaaaaaaany more years together: Do not abuse the environment and do not litter our own house!' he put his head outside the window. 'Hmmm... Enjoy the smell of the sea, Rooster!'

'HmMMMMM...' all took a deep breath and smiled.

Much remained to be done to refit their little house to the new conditions. Our friends got their paws to it with hard work and good humour. Now, they knew what to expect and how to act accordingly. What could go wrong?

And that's all folks, the end.



Would you like to know more?

Epic tale of “The Bremen Town Musicians”

The fairy tale “The Bremen Town Musicians” was collected and written by the Grimm Brothers and first published in 1819. The tale tells the story of a donkey, dog, cat and rooster who run away from their respective farms. Their owners had decided to sacrifice them since they had outlived their usefulness. The donkey first made his way to Bremen, where he planned to become a musician. Along the way he met and collected the other animals. However, they never made it into Bremen because when crossing through a forest, they found a house stocked with food, loot and thieves! They managed to scare away the thieves and stayed in the little house and lived happily ever after.

The Little Ice Age

The Little Ice Age corresponds to a cold period, which followed on from the warmer temperatures of the medieval era and mainly affected the Northern Hemisphere. It lasted from approximately 1275 to 1850 but there were fewer cold intervals intercalated. One of the main triggers of the cooling may be located in a series of volcanic eruptions in the tropics, occurring within only a few years of each other. In tropical areas, the ash released during a volcanic eruption can reach high layers of the atmosphere. This results in the blocking of some of the solar radiation reaching Earth. Furthermore, this was coeval with a period in which less energy was produced by the sun. This is called a period of low solar activity. Changes in ocean

circulation were also likely to play a role. This means, that the Earth became colder and remained colder. Towards the end of the Little Ice Age, volcanoes came again into play and the eruption of the Tambora volcano (on the island of Sumbawa, Indonesia) in the year 1815 led to even lower temperatures. The year 1816 is known as the “year without summer”. When the above-described environmental conditions changed, the Little Ice Age ended.

The adverse climate conditions resulted in a lot of social and political instability due to strong and long famines. In those years, many villages were buried under advancing alpine glaciers; in London, fairs were celebrated on the frozen River Thames... Several paintings from the time illustrate those situations. The genre of gothic literature developed a lot in those years drawing inspiration from the prevailing cold conditions, social instability and existential fears.

Additional reading:

<https://skepticalscience.com/coming-out-of-little-ice-age.htm>

Kiribati

The Republic of Kiribati (spoken “Kíribas”) is a country composed of 31 atolls and one emerged coralline island called Banaba. The population of Kiribati is estimated to be around 110,000 inhabitants (estimation from 2016). The capital is the atoll island Tarawa and holds nearly half of the population. The archipelago is located in the central-west zone of the Pacific Ocean and experiences, even today, the consequences of rising sea levels due to global warming. For example, the effects of erosion, high-risk situations during storms and the salinization of fresh water sources and agricultural land are noticeable. The government is currently undergoing

negotiations so that all inhabitants are to be welcomed by other countries and to be recognized as “climate emigrants”. They do not want to be received in a status of living from social help and with no perspective for a future with dignity. They are working with the aim of ensuring a future life for the population and the preservation of their cultural identity. Aside Kiribati, other islands and coastal zones are vulnerable to negative and rising sea levels continue to threaten island populations.

Sea level rise

The sea level rise associated to global warming is caused by several factors. The most obvious one is the melting of the polar ice caps and continental glaciers as the melted water eventually reaches the oceans. But this is not the only cause, aside the atmosphere, also the oceans are heating up. Warm water occupies a volume slightly higher than cold water. If the amount of hot water is very large (all oceans) changes become noticeable and leads to the flooding of coastal areas. It is also noteworthy that the warming of the oceans has consequences for many marine organisms and ecosystems.

Additional reading:

<https://realclimate.org/index.php/archives/2013/10/sea-level-in-the-5th-ipcc-report/>

Eddie Earth

Sabrina Hohmann

Illustrations Sabrina Hohmann

Once upon a time, there was a planet. His name was Eddie, Eddie Earth. He was a very proud planet, because he was the only one in his neighbourhood where living beings were at home.

Far or near, there was no other planet like him. You could say that Eddie was outstanding. Although Eddie had a lot of fun with his residents, it was not always easy for him. One day, there came a time when it was particularly difficult. It was a time when the humans who resided on Eddie were starting to build machines without thinking about what this might do to their planet.

They were driving around with cars that used fuel. They had TVs, computers and cell phones that all needed electric **energy**. In the factories, which made clothes, toys and much more, the machines also consumed a lot of energy. This energy was mainly produced by burning wood, petroleum, natural gas or coal. While burning these things, some gases were released into Eddie's air. Other gases that ended up in his air were released by the huge amount of **animals**, which the humans farmed for meat, milk and eggs. The most well-known of them was called **carbon dioxide - CO₂**. With this gas in the air, adding to some other gases, it started to get warmer on Eddie Earth.



Eddie had noticed already before that he always started to sweat when more of this CO₂ was in the air. He knew that because his climate - for example his temperature - had changed on him since his birth, long before humans existed. Repeatedly colder and warmer times alternated. This was normal. Nevertheless, when humans started burning wood, petroleum, natural gas and coal for their machines, it began to get warmer much faster than ever before!

Eddie was worried, because he had no idea what would happen if this went on. Some of his inhabitants had already begun to address him in order to find out what was going on. Many of them had problems living as before, as the environment around them began to change.

One of the earth dwellers, who then turned to Eddie with concern, was *Isa*. Isa was a small sea creature. She lived happily in cold seawater. She especially liked it when some ice floated on the surface of the sea. For her and her family, the ice was great. Particularly good was, that many other plants and animals did not like *sea ice*. Isa had therefore always enough space and food and never had to compete a lot with others. For that reason, most of her family members could be found in cold waters, only a few of them lived in warmer regions.

When Isa talked with our Eddie Earth, she was very excited. She told Eddie the story of her family. For some years now, there was less and less sea ice, as the seawater became warmer and warmer. Plants and animals, which had formerly lived in warmer regions, had now moved into their neighbourhood. Isa found it very exciting, but many members of her family were worse off, since they now had to compete for food and the warmth exhausted them. Many had

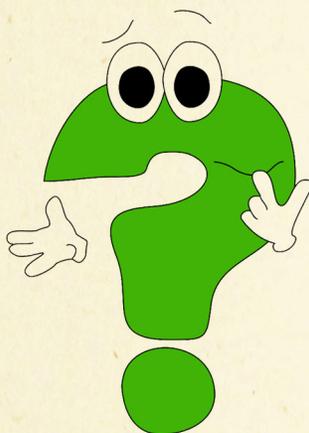
already moved further towards colder waters in the North Arctic, where there was still more sea ice.

Eddie understood Isa's worries well. For what could happen if there were no sea ice? What if all the ice were to melt? Then there might be no place for Isa and her family and friends on him!



Eddie knew it was important to make it clear to all humans that their help was needed in order to not heat him any further! He knew that not that much wood, no petroleum, no gas and no coal could be burnt any longer. And he also knew that there were already people who worked diligently to use sun, wind or wave power to get energy for their factories, cars, cell phones and televisions. Many of them were riding bicycles or the bus instead of driving a car or they were saving electricity at home or changing their diet by eating less animal products. The humans had begun to realize that their environment was changing and becoming warmer because of them. Therefore, our Eddie, Isa and all the other earth dwellers rested on the hope that the humans would be able to stop releasing these huge amounts of greenhouse gases into the air.

However, how will this little story about our proud planet Eddie Earth and our little Isa end? Can we write a happy ending in which all earthlings will live happily ever after? Unfortunately, ***we do not know yet*** the end. Only the decisions and actions of humans in the next years will decide which end we can write for this story and how warm it will become on our Eddie.



Would you like to know more?

Energy-Fossil fuels energy production

Petroleum, natural gas and coal were formed from the remains of dead plants and animals deeply buried beneath the Earth's surface and subjected to great pressure and heat over a long period. By using these so-called fossil fuels, we can generate enormous amounts of energy. However, the burning of fossil fuels and timber has not only triggered industrial development but became the largest source of carbon dioxide emissions.

Animal products

Animal farming is one of the biggest factors for global warming. Globally, it is responsible for about 14% to 18% of the greenhouse gas emissions. The livestock sector contributes to climate change through deforestation. This is caused by turning forests into grazing and arable land in order to grow crops and by breeding large amounts of ruminant animals like cattle. Cattle produce methane during the digestion process – a greenhouse gas 20 times more potent than CO₂. Eating vegetables causes much less greenhouse gas emissions. A portion of potatoes, for example produces approximately 3-5 times less greenhouse gases than an equivalent mass of poultry. It is more efficient to grow a crop and consume it than growing a crop, feeding it to an animal and then consuming the animal.

Sources:

World Resources Institute, UN Food and Agriculture Organization, Pitesky et al. 2009, Environmental Working Group 2011.

Carbon dioxide

Carbon dioxide (CO₂) in low concentrations is naturally present in the Earth's atmosphere. It derives from various sources like volcanic outgassing, respiration, fermentation processes, natural combustion of organic matter and its decomposition. CO₂ is a greenhouse gas, which means that it traps heat in the atmosphere. The Earth's surface is therefore the warmer the more of the gas is present. The burning of carbon dioxide emitting energy sources, like fossil fuels and timber increases temperatures on Earth. For more than 800,000 years during ice ages, CO₂ levels were around 180 parts per million (ppm). During warmer interglacial periods they hovered around 280 ppm. In 2013, the atmosphere's CO₂ levels surpassed 400 ppm!

Source: https://climate.nasa.gov/climate_resources/24/

Isa – a dinoflagellate

Dinoflagellates are microscopic unicellular organisms. They live in lakes, as well as the open oceans from the equator to polar seas, where they live in the upper meters of the water column. Some dinoflagellate species conduct photosynthesis; others feed on even smaller organisms, or do both. They play an important role for the ocean's primary production.

Isa belongs to a species (*Islandinium minutum*) that feeds on other organisms but she was also able to conduct photosynthesis. Her species lives in seas with temperate to polar waters. However, she feels most comfortable, and is therefore relatively abundant, in waters below 0°C in winter and in a sea that is covered by ice most time of the year. There, her species can feed on the photosynthetic organisms that also dwell in these ice-covered regions, without having to compete with other species.

For more information: de Vernal and Marret (2007) Organic-Walled Dinoflagellate Cysts: Tracers of Sea-Surface Conditions. In: Developments in Marine Geology Volume 1, Chapter 9; [https://doi.org/10.1016/S1572-5480\(07\)01014-7](https://doi.org/10.1016/S1572-5480(07)01014-7)

Sea-ice decline in the Arctic

The increasing amount of CO₂ and other greenhouse gases in the atmosphere traps the heat on our planet. Both air and water temperatures are increasing. Warmer waters in polar-regions result in a permanent melting of sea-ice. Sea-ice in the Arctic is declining fast. The ice reaches its minimum expanse in September. The sea-ice expanse in September is declining at a rate of over 13% per decade, relative to the 1981 to 2010 average. During the 1980s, the area of ice-covered oceans in the northern hemisphere fluctuated between 7 and 8 million square kilometres, which equals the size of Australia. During the previous ten years, it fluctuated around 5 million square kilometres, which is about the half size of Europe.

Source: <https://climate.nasa.gov/vital-signs/arctic-sea-ice/>

We do not know about the ending yet - Consequences

A change in ocean temperatures and sea-ice cover expansion and duration affects the distribution and the abundances of marine organisms. Changes within microorganism communities like Dinoflagellates might affect bio-productive patterns since they are primary producers. Primary producers are key players in the marine carbon cycle, which in turn controls the ocean's uptake of atmospheric CO₂. Even small changes within primary production patterns can have significant impacts on the concentration of carbon dioxide in the atmosphere. Scientists call this a feedback

mechanism: A change in primary productivity triggered by increased atmospheric CO₂-concentrations would cause changes in atmospheric CO₂-concentrations! Depending if the latter is further increasing carbon dioxide content or decreasing it, the mechanism is called a positive or a negative feedback. Unfortunately, scientists are not entirely sure yet, whether it is a positive or negative one. However, science is onto it!

For further information: <https://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-carbon-cycle>

Climate Ghostbusters

Christiane Schmidt

Illustrations Annette Leenheer

OUAT newspaper

20.07.2099

Science and Climate

200 people found dead after an encounter
with Climate Ghosts in New York

Yesterday, 200 inhabitants of Manhattan died in an attack by the Climate Ghosts. The information provided by the police revealed that the ghosts had stolen the "life energy" from the victims' wristbands. Subsequently, the people died on the spot since they had no energy left. At the scene of the crime, the police found a sticky liquid, which belonged to the ghosts and indicated that the ghosts killed the victims.

Scientists assume that the increasing appearance of the Climate Ghosts is associated with the changing climate. Nancy Vaughan, one of the leading specialists on ghosts at the New York

University says: 'We are currently calculating with modern analysis tools how the ghosts can come to our dimension and survive here.' These ghosts were first described in the scientific literature as Climate Ghosts. Professor Tim Bronner, who works on the Climate Ghosts for more than 20 years at the New York University, says: 'The Climate Ghosts were observed for the first time in 2080 in New York. Their origin and their connection to human-made climate change are not entirely resolved. The team of scientists has preliminary evidence that the increasing activity of the ghosts may be associated with heavy rain and thunderstorms.'

The city of New York is suffering the effects of human-made **climate change**. Since the Industrial Revolution, at the beginning of the 19th century, the levels of **greenhouse gases** are increasing in the atmosphere. More often, now the city is suffering from strong weather events and heat waves. The streets and basements are flooded, and due to the heat people suffer from strokes. A team of scientists, led by Prof. Bronner, has been appointed by the government to develop a strategy how to deal best with the burning issue of Climate Ghosts.

Nancy dropped the newspaper on the table, as she finished reading the article published that morning. She was sitting in a busy coffee shop in Manhattan, the most vibrant part of New York. Unbelievable these Climate Ghosts, she thought, they are doing so much harm.



She twisted her brown ponytail as she was thinking and glancing out of the window at the many modern skyscrapers alongside small old houses. She muttered to herself: 'What can we do to stop the Climate Ghosts from stealing people's energy?'

As a physicist, Nancy studied the scientific basis of ghosts. She was a ghost specialist and tried to calculate how ghosts could come to our dimension in the first place. When her boss, Tim, came to her last week and asked her to join the appointed research team about the Climate Ghosts, she accepted. Sometimes she did not understand why she was putting herself through all this stress; her life as a scientist was very demanding. So, she decided to go to her favourite cafe, where they served the delicious "New York cheesecake", to relax and have time to think about this case.

She remembered that already as a child she was eager to

understand ghosts and paranormal activities. She never lost this childhood curiosity, and it led her to the job she held today. For the past years, she was thinking about possible solutions, but could not develop actual means to prevent the ghosts from entering the Earth dimension. She devoted most of her time to study whether the ongoing human-made **climate change**, had an influence on the sudden appearance of the Climate Ghosts. However, today with 200 people dead, the media has started to pick up the story, and now their research team had more pressure to come up with solutions.

Hence, she thought to invite her friends, Paul and Tracy for some coffee and cake with her and to talk about the recent events of this week. They always have brilliant ideas, and now, with the increasing public pressure, Nancy needed some mental support from her friends.

Paul was a tall and dark-haired engineer for renewable energies, and had an extensive knowledge about these new technologies. As a renewable energies engineer, he designed **wind farms** and **solar panels**. He liked his work, because it contributed to reduce the greenhouse gas emissions that by now, have been generated for centuries. As a hobby, Paul designed small toys for children and appliances for the household using solar cells.

Tracy was a marine scientist and **biotechnologist** at the University of New York. She studied the potential use of microscopic small **green algae**, of the specie *Chlorella vulgaris*, and its uses to generate **biofuel**. Such microalgae are common in lakes and in the ocean and are part of the base of the marine food chain-the **phytoplankton**

community. She cultured these algae in large outdoor tanks, where they received optimal conditions, such as light for *photosynthesis* and nutrients for their growth. Besides her scientific career, Tracy liked fashion, second hand fashion mostly, because it is good for the environment to reduce, reuse and recycle things. She liked to wear her “hippy” blond hair in curls, and retro clothes from the 20th century 70’s.

Tracy and Paul agreed with Nancy that a solution was needed quickly, in order to stop the Climate Ghosts from killing more people. Nancy told the others in detail about her latest project and - how together with her boss and colleagues, they had been asked by the government to study the Climate Ghosts. Last week a flying saucer was seen to land in Central Park in Manhattan. Using a flying saucer, the Climate Ghosts passed from their dimension to Manhattan at midnight. They stole the “life energy” from the wristband of 200 people and scared many more. As soon as they used up all the human life energy they had stolen, they vanished and were transported back to their own dimension individually.

Following the explanation Nancy asked: ‘Do either of you have any idea how to fight the Climate Ghosts? It would be helpful for people in New York to live without a continuous fear of a Climate Ghost attack.’ After some lively discussion about physics, engineering and climate science, the three came to the conclusion, that the best option is to capture the ghosts with catchers which remove the stolen life energy from the ghosts so that they immediately vanish. Paul said: ‘The question of the connection between Climate Ghosts and climate change is more complicated. More scientific research would indeed be useful, but at the moment we need a quick solution

to save people's lives!

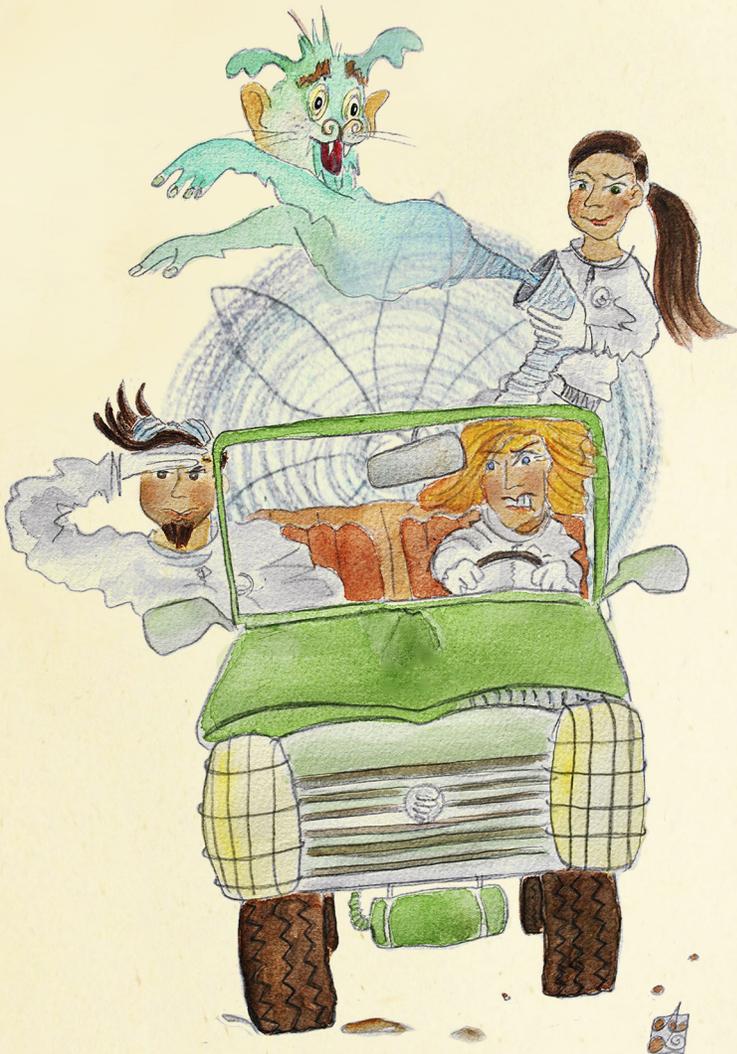
In the following weeks, the three designed a plan to fight the Climate Ghosts - The Climate Ghostbusters were born!



They bought a car, since before they had always travelled by public transportation or bicycle. With the help of Paul's engineering knowledge, they adapted the car to hunt Climate Ghosts. Paul calculated that a wind turbine engine will provide enough power to drive the vehicle as fast as the speed of the ghosts. No sooner said than done, the car was modified with the wind turbine engine and at the sides they built tanks which could be filled with biofuel. Tracy developed this backup energy reserve to power the car with ***algae fuel***. This would provide energy for moments when the wind strength were weak or the batteries powered by wind energy were empty, in case the hunt lasted longer than expected. Nancy, the expert on ghosts, developed special catchers to hunt and capture the Climate Ghosts. They look like large suction tubes with an ancient Native American dream catcher attached. The Natives were the inhabitants of the Americas before the Europeans arrived. They had been living on these lands for centuries and developed an object to catch bad dreams. This, inspired Nancy to generate her own bad-dream catcher to stop the Climate Ghosts.

After a few weeks of intensive work, The Climate Ghostbusters designed a detailed hunting plan for the next attempt of the Climate Ghosts to attack people. Nancy predicted that the ghosts would cross to the Earth's dimension in Central Park again, at midnight of the 24th of July. The three parked the climate ghost hunter vehicle and went to a restaurant close by to play cards, relax and eat a little until 11 p.m. They came back to the vehicle for some last preparations before the hunt will begin. Shortly before midnight, Paul saw one of the ghosts and immediately started the engine of the vehicle. The car came to life at once, so Tracy shouted to Paul: 'Go a little faster

Paul, we need all the speed we can get!' The wind turbine was doing the best job possible and their vehicle was approaching quickly to the first ghost. The ghost made a sudden turn and as it moved towards an area protected from the wind and the gap between the car and the ghost was growing bigger. The Climate Ghostbusters started the biofuel tank, speeded up but then a sudden jump of the vehicle knocked it off balance; it threatened to tip onto one side. They managed to stabilize it and caught up with the ghost.



The three friends smiled to each other and turned on the power of the climate ghost catchers. Now, the suction stopped the ghost from moving further away, still, it was not strong enough to suck it inside the catcher. Suddenly, the wind blew again, driving the wind turbine into action and the vehicle got the push it needed to bring them closer to the ghost. All three pressed their catchers together once more and the first ghost was trapped. Their plan succeeded! Full with adrenaline and enthusiasm they hunted ghosts through the whole night.

The day after the hunt, the rumour that some Climate Ghostbusters had caught the Climate Ghosts, spread throughout the city. It took only a few more hunts before they became famous. Life in New York once again was safe. Many newspaper agencies and TV channels asked for exclusive interviews. Unfortunately however, the strong weather events were still plaguing New York. The Climate Ghostbusters could save the people of New York from losing their life energy to the Climate Ghosts, but as long as the extreme weather events continued, nothing guaranteed that it would stop more appearances of the Climate Ghosts. The three friends stayed alert in case of Climate Ghosts appearance and at the same time, worked hard to help New York become more sustainable. Rather than relying on fossil fuels, they promoted the development of widespread wind farms, solar and algae energy to sustain the energy needs of New York. The realization of their vision was possible since more and more people became engaged; even the banks of New York started to invest in sustainable technologies. In 2100 and for many more years after that, life was once again safe in New York, all thanks to the Climate Ghostbusters!

Would you like to know more?

Climate change

In general, it refers to alterations in the mean state of climate conditions (e.g. temperature and precipitation) of a region, measured over a period of a decade or longer. Along the Earth's history, the climate has changed in different scales of time and space, due to internal natural processes or to changes in external forcing (e.g. modulation of solar cycles). According to the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) in 2013, the "Anthropogenic Climate Change" (or human-made climate change) is the current change in the climate, which cannot be explained by natural variability but is rather induced by human activities. Although the media commonly call the current climate change only climate change, it is necessary to refer to it as "Anthropogenic Climate Change". One of the effects of current climate change is the increase in temperature of the Earth's surface, commonly known as "global warming".

For more information, visit the webpage:

www.ipcc.ch/report/ar5.shtml

Greenhouse gases

Certain gases, which are present in the atmosphere, and have the ability to block the heat escaping from the Earth's surface. The primary Greenhouse gases are water vapor, carbon dioxide, methane, nitrous oxide and ozone. These gases, respond physically or chemically to changes in temperature. Without the gases layer

in the atmosphere, the average of temperature on Earth would be around 15°C below zero. In the past 200 years, one of the most abundant greenhouse gases, carbon dioxide (CO₂), has increased its concentration from 280 to 400 parts per million. The IPCC panel concluded that 95 percent of probability of this rise is explained by human influences and this is causing the global warming
For more information, visit the webpage: <https://climate.nasa.gov/>

Wind farms

Extended open areas in which wind turbines are dispersed to use wind currents to generate electricity, through the movement of an air turbine. This energy is then stored in generators and distributed. The wind turbines can be built either on land or offshore. The energy produced by the wind is mainly influenced by the wind's intermittent flow, it's unpredictability and change of flow direction. Therefore, it is necessary to store the energy in order to be able to supply it when there is no wind.

Solar panels

Devices composed of photovoltaic cells using solar energy as a source to provide electricity or heat. Its use has extended in the last decades, allowing to a limited extent to refrain from the use of fossil fuels. On a large scale, they can be used in solar farms or on a smaller scale, in houses to meet the energy demand of the domestic level. Recharging the batteries allows the storage of solar energy for a later use.

Renewable energies

A variety of energies produced from natural sources, that can be replenished on a human timescale. For example, the electricity produced from the motion of wind, rain, tides and waves, as well from the sunlight, geothermal heat and biomass decomposition and its burn. The disadvantage of such energies lays in the inability to be continuously produced, thus they require energy storage technologies for further use. The electricity produced from renewable energies is more environmentally friendly.

Fossil fuels

Derive from non-renewable energy resources that formed due to the burial of organic matter (dead plants and animals) under sediment layers millions of years ago. Over time, the buried organic matter was exposed to high pressure and heat conditions, which chemically changed it to these fossil energy sources. Coal, oil and natural gases are the main raw materials of fossil fuels. The use of fossil fuels is raising serious environmental concerns. The use (burn) of these fuels emits large amounts of carbon dioxide (and other gases) to the atmosphere, which is considered to be the major contributor to the current global warming.

For more information, visit the webpage:

<https://energy.gov/science-innovation/energy-sources/fossil>

Biotechnologist

Scientists who combine scientific knowledge developed by the physics, chemistry, biology and engineering sciences. Its main objective is to use living organisms or biological systems to produce new products or to develop processes for specific uses. It is extended

in fields such as medicine, agriculture, pharmaceutical industry or the environmental sciences.

Green algae

A diverse group of algae within the Kingdom Plantae. Today, about 7000 species of green algae grow in different habitats. The group generally has different types of pigments and shares some characteristics with terrestrial plants such as making sugars and other products.

Photosynthesis

A process performed by plants and other organisms as a chemical reaction that converts light energy to chemical energy. To perform photosynthesis, plants and algae require carbon dioxide, light and water as energy sources. As a byproduct of this reaction, oxygen is released to the environment, the atmosphere or water. This process is important since it leads to the primary production of organic matter.

Phytoplankton

A group which includes all photosynthetic organisms that are buoyant and float in the upper part of the water column, where sunlight penetrates with a certain intensity, in oceans, lakes and rivers. The group includes photosynthesizing microscopic algae and constitutes the base of many food chains in aquatic environments.

For more information visit the webpage:

<https://oceanservice.noaa.gov/facts/phyto.html>

Algae fuel

This is a source of energy generated from products derived from algae. The algae contain oils, which can be modified into different types of fuel through the change of the molecular structure. These Algae fuels (and other organic-derived fuels) are called biofuels and are usable for cars or airplanes. These fuels can be found as: biodiesel, bioethanol, biogas, biohydrogen and more. This type of resource is considered renewable; however, recent studies revealed that the massive production of algae produces a very potent greenhouse gas called nitrous oxide. Biofuels are considered an alternative option to fossil fuels; however, their use is not yet extended and their price is higher than the fossil fuel.

SWIM! It's trawling!!!

Haozhuang Wang

Illustrations Peter Marten

Once upon a time, there was a small reef city in the deep ocean. It was mainly built by **stony corals** called the *Madreporas* and the *Lophelias*. Due to some unknown reasons, most *Lophelias* moved away and most of the remaining citizens were *Madreporas*. The reef city they built was not only for themselves, but it was also home for many different deep sea animals. In and out of the city, grown-up belly sharks were swimming between the reef buildings while little sharks preyed on shrimps and other animals. Bony fish and some small worms also lived happily with the corals. The reef city was very busy and interesting: Crabs hid themselves within the shells of sea snails and in self-dug holes; rockfish shuttled in the reefs and played games; spider crabs and squat lobsters crawled on the coral skeletons and moved slowly as they hunted prey with their pliers, and small shrimps swam within the reefs in a lively fashion and played with small fish. Sometimes, these small creatures also met octopi, which disguised themselves within the coral colors, resting or waiting to trap their prey. At the bottom of the city, sponges lived on the coral skeletons, drilling through the reef foundation and thereby breaking them down.

Our *Madreporas* preferred to live in the cold deep-sea far beyond the sunshine, without the symbiotic algae that their tropical cousins

need to feed. But this did not mean that they were ugly. On the contrary, they were very beautiful creatures! They had pink cup-shaped-bodies, with a big mouth in the middle, rimmed with many tentacles. By waving these tentacles in the water, they preyed on small organic particles or animals to eat. Usually, their small larvae settled directly in the neighborhood nearby and built a new home among the existing buildings. In this way, the new Madreporas would spend their whole life in one place close to their relatives and the ancient houses made out of their ancestor's skeletons. But this did not mean they were oblivious about what was going on in the open ocean. They had many friends passing by, who carried news from places far away from the city.

One of these friends was a velvet belly lanternshark. No one knew his real name, and he did not want to talk about that subject. He was known in the reef city as Mr. Belly; not only because of his particularly big beautiful velvet belly but also because he had swam further from home than any other lanternshark. He had even visited the eastern part of the ocean, where nobody in the city had ever been before.

Once, when he was on one of his excursions to the eastern side of the ocean, he happened to confront a human's ship trawling. Although, he managed to escape eventually, he got badly injured and lost part of his dorsal fin. Fortunately, he succeeded to escape to the city and to meet the Madreporas. Since then, he spent most of his time with a very caring and generous Madreporas family, the Mandi family. For many weeks, the family gave him protection and took care of him. He told the family about his adventures abroad. Whenever corals listened to his adventure stories, their eyes glittered with admiration.

How desperately they wished to travel around and to see what the outside world was like!

Mandi was a *newly born larva* from the family that took care of Mr. Belly. He was born after Mr. Belly came to the city, and was growing up listening to all of Mr. Belly's stories. He wanted to follow Mr. Belly and it was his greatest wish to travel around the ocean with his friend! He often talked with his coral friends about the adventures he wished he would have one day. However, his friends were not so enthusiastic; they just wanted to settle down where they were born and live their lives peacefully, just as the rest of the corals did. Thus, Mandi stayed floating around the city, unable to decide where to build his skeleton, while more and more of his friends were starting to build their houses.

One day, after swimming around the city with the help of a current, finding once more nowhere fancy enough to settle, Mandi came home, spiritless.

He saw Mr. Belly, resting nearby.

'Hi, Mr. Belly, what's up? Is everything good? How are you recovering from the trawling injuries?' asked Mandi, concerned.

'Oh. Hi, Mandi. Nice to see you here. I'm very good. Can you see my scars? Sometimes they hurt, especially when cooler currents pass by. But I'm recovering well, getting better every day. The doctor told me that I would be able to swim again in about two weeks,' he pointed at his bandaged fins and belly, and continued, 'Thanks to your family's help in the past months, I recovered very quickly. But what about you? How was your trip? Why don't you just enjoy the freshness of the water here?'



'You will be swimming again in two weeks? That's GREAT! Finally, you can help me to travel far away, to the eastern side of the ocean!' yelled Mandy, his face beaming with joy, 'I was swimming around the city to find a more exciting spot to settle down. But I found nothing exciting... Again... Anyway, I've got nothing to do at the moment or at least nothing better than looking for the perfect place to build my home. Even if I do not feel like it, it is what corals are supposed to do..'

'My friend, your life now is really good. You must be aware that it's not safe to go outside. Look at your pretty city, it's such a GREAT place!!! It's soooo beautiful! We have plenty of food and good ambient conditions here. Well, maybe not as great as several other places where I have been to, but..!' Mr. Belly seemed to be lost in thoughts

for a moment but continued: 'And the water is still fresh sometimes, sometimes cold, just perfect for us. We also have an amazing landscape here. Everyone is so nice and beautiful. Everything here is just more than perfect! Above all, the most important thing is that we are SAFE here! It is far from the human's cities and humans still do not know about this place.'

'Mr. Belly, you have changed a lot. You are a very different from the shark you talked about when you were telling us about your adventures before the accident'. The disappointed Mandi realized his friend was not really eager to go on new adventures. He continued: 'Anyway, I still want to discover the big ocean and see the other corals around the world, or at least visit my cousins. Although, my family said there has been no contact with them for the last several hundred years'. While speaking about this, he was glowing with anticipation. 'During those times, the current around the city suddenly changed, and nobody knew what had happened. My ancestors' cousin Lophelia Luoqi could not adapt to the change here and drifted away with that current. It was since then that we could not travel far away, because the long distance trips with the current were not possible anymore. This lack of connection has lasted for the past hundreds of years. But we have a chance now, because I heard from the Coral-Research-Centre that there has been a re-enforcement in that current. Soon, we will be able to travel much further and faster than before!!! This will be so amazing! I'm going to...'

Suddenly the whole city seemed to be swaying, and the two friends felt dizzy. The feeling increased, and they turned around to see what had happened. From the other side of the city, a thick turbid cloud rose, and was approaching fast.

Mandi and Mr. Belly were shocked and froze on the spot. Quickly, Mr. Belly realized what was going on. 'Trawling' he murmured stiffly. Then he yelled 'It's TRAWLING!!! SWIM OUT OF HERE!!!' Everyone around them started eagerly to swim, however, it was too late... Most of the animals were swallowed by the fishing nets and large parts of the coral city were destroyed. Fear and panic gripped the city. Little corals, fish, crabs and that everyone that survived the trawling was now homeless.

Half an hour later, the survived citizens gathered on a high stand in front of the relics of the city. Everything was ruined by the trawling. The fish, crabs and lobsters started to talk about swimming away and leaving the waste land. The coral larvae were devastated as most of their family members, relatives and friends were taken away and killed by the nets.



'Our homes are destroyed...'

'Where can my children live in the future?' sobbed a coral polyp. The nearest coral hugged her tightly and sighed...

Finally, Mr. Belly broke the silence and started to explain 'Dear friends! What we have seen just now was human's deep-sea fish-trawling. The number of fish in the shallow sea has decreased drastically in recent years. So, humans are using now trawling to fish in the deep-sea. My injured dorsal fin is the result of an encounter with trawling before...' he continued, 'Now, they have found this place and will come back again in the near future. No one will be able to escape... It is not safe here anymore.'

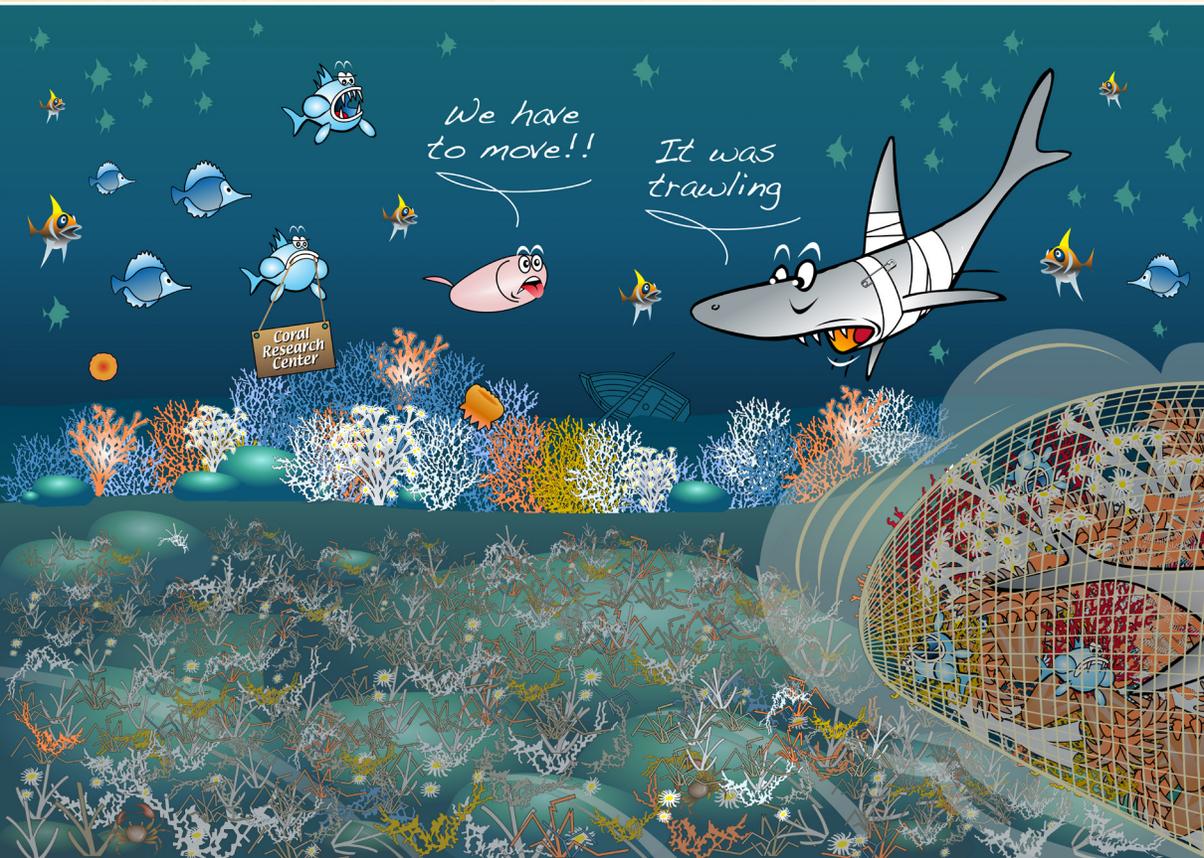
The whole city was silent. Mandi overcame his grief and moved closer to Mr. Belly.

'My friends and loved ones,' Mandi came forward and took over: 'I'm deeply saddened to see that our precious city has vanished. It is human trawling that caused us so much pain and destruction. However, we cannot do anything to prevent this from happening again. They found a tremendous amount of fish in our city with their high-tech machines and came to hunt us. And they will probably do it again. We cannot stay here and rebuild our city. But we are lucky that our Coral-Research-Centre is still standing and many instruments survived the catastrophe. Our scientists have found out that the current around our city has been strengthening in the past years. Let's go to new places with the current and build new homes there!' he paused to see that he had got everybody's attention and then continued, 'My dear friends, our coral adults cannot move anymore, they cannot come with us. The older survivors will have

to do their best to live here, even if the trawling ships may come back. For us, we will build a new city as beautiful as this one, with a big monument in the centre to honor all those who lost their lives today.'

Within two months, the current was already strong enough to carry the young citizens to further places. The larvae coral, some shrimps and some other citizens readied themselves for departure. Some fish decided to stay with the remaining adult corals after all. Mandi and his followers started traveling eastwards to find other corals in the sea and a new place to settle.

With an unknown journey lying ahead Mandi's adventures were only about to begin...



Would you like to know more?

Reef-forming scleractinian cold water corals (stony Corals)

Reef-forming scleractinian cold water corals can be found worldwide. *Lophelia pertusa* and *Madrepora oculata* are the two most prominent cold water corals species. These corals are different from the tropical corals. They do not live with symbiotic algae, while tropical corals live on the food provided by these algae. The different colors of this tropical corals can be traced back to these algae. They prey on their food by waving their tentacles. Also, within suitable environment (e.g. temperatures around 4°C to 15°C, salinity around 32 to 39, abundant food supply and highly hydrodynamic settings), they can also form reefs, providing habitats for various deep sea species and thus act as an oasis in the deep sea. Usually, new-born coral larvae will settle directly nearby, but sometimes they can also travel along far away with currents and settle down in new optimal environments and generate new reefs. The formation of a cold-water coral reef takes several thousands years, or even longer.

Newly born larva

When corals reproduce, they form small coral larvae. Species such as *Lophelia pertusa* and *Madrepora oculata* are no exception and spawn every year. Unlike the sessile mature parents, coral larvae are mobile. They can either settle within the same reef or they travel in the currents. When the larvae find the perfect conditions, they settle and attach themselves to a hard substrate (e.g. rocks, stones, dead corals, shells...) and begin to build a brand new reef.

These reproductive processes of the corals play a vital role in the survival of the species, as well as many other fauna that relies on the reefs. As the reefs continue to grow, the surrounding environment changes; this includes the current flow within the reefs. In a healthy reef, the corals expand outward towards the main current, which delivers food to the corals.

Here are some additional links where you can further explore:

Videos from MARUM about the cold-water corals and also trawling effect on deep sea coral reefs:

<https://www.youtube.com/watch?v=Fb1go4zcTUQ>

Deep sea trawling influence:

<http://www.lophelia.org/conservation/threats/deep-sea-trawling>

Cold water coral ecosystems:

<http://www.lophelia.org/latest/378-coral-worm>

Lophelina

Leonardo Tamborrino

Illustrations Annette Leenheer

Once upon a time, there was a wonderful city called Corallia. It was built by Corals, the cute and cheerful little polyps of the Underwater World.

Under the sea, there was no place so lively, so colourful and so beautiful as Corallia. The city was founded millions of years ago, thanks to the friendship between Corals and Algae. Corals needed more energy in order to build better homes and the Algae were able to collect the needed energy from the sunlight. In return, the Corals hosted and protected the Algae. To live with the Algae though, the Corals had to stay only in the tropical shallow water of the oceans since this was the only place where the sunlight penetrated deep enough into the Underwater World. And so the Algae lived happily with the Corals.

The king of Corallia was called **King Rubro**. He had decided that new, magnificent and beautiful palaces should be built out of the finest calcium carbonate. His wish was fulfilled by the coral-architects, the so-called **Scleractini**. The buildings were enriched by the many algae colours and became true works of art.

Wonderful palaces and tropical climate were not the only positive features of Corallia. Over time, other animals (fish, crustaceans,

sponges, sea stars, bryozoans...) began to visit or even live in Corallia and slowly the city became even more lively, vibrant and cheerful. It was filled with restaurants and clubs of all kinds, offering the best food and the most glamorous parties in the entire ocean.

Corallia soon became famous for its magnificent art, rich history and democratic meetings, where everyone was welcome. In terms of living quality, Corallia was certainly the most marvellous city in the Underwater World.



One of the most famous and beloved architects of Corallia was ***Pertusa Scleractini***. He was not originally from Corallia as he was born in the deep ocean. Since Pertusa was a child, he wanted to live in Corallia and he frequently argued with his grumpy sister ***Madrepora*** about this topic.

In Corallia, Pertusa found his happiness, having a lot of friends and creating his masterpiece: The Coral Mound. It was a perfect hill-shaped building, which provided the best access to sunlight and to the water currents rich with food.

One day, Pertusa became the father of a beautiful baby coral girl; he called her ***Lophelina***. Unfortunately, the little coral girl was born with the serious problem that no Algae wanted to attach themselves to her! And without Algae, she could not grow properly! Pertusa was very concerned about her health as she was very pale and small. He called the best doctor of Corallia, ***Dr. Di Plorio***, who had a very wise and funny coral brain. After visiting Lophelina, Dr. Di Plorio said bitterly, 'Dear Pertusa, unfortunately I cannot do anything for your Lophelina.'

Dad Pertusa asked, 'What do you mean you cannot do anything? Don't you see she is dying?'

The father was shocked to hear the terrible news about his daughter's health. After thinking for awhile, the doctor said, 'Maybe there is a solution, but it would not be an easy one for her... Nor for you...'

'Tell me doctor, I am willing to do anything for my baby girl!' the architect replied full of hope and new joy.



'Well, Lophelina cannot stay here in Corallia because of her condition. Without Algae, she could only get the extra energy she needs to grow from concentrated food currents... Like the ones you find in the deep underwater world..'

'Oh no! I know that place very well! The deep ocean is too cold and ugly and it's always *snowing!* There may not be many places where Lophelina can live and certainly, I do not want her to live in the deep ocean where many people live on "*chemicals*".'

'There is not only the *Lost City* and *Metania* in the deep ocean. There are also many corals living down there. You know that well. Thus, she would not be entirely alone down there... '

Pertusa interrupted the doctor, 'No, I know what you are thinking but I will not send my beloved Lophelina to my old harpy sister Madrepora.'

'My respected friend Pertusa, please think twice about your words. If Lophelina stays here, she will surely die! Our only hope of saving Lophelina is sending her to live with Madrepora. I know you do not like the idea because you have to give Lophelina away and you also have not resolved your difficulties with your sister yet. However, there is no alternative! I am sure Madrepora will be happy to take her in. Additionally, another architect down there would not be a bad idea!'

Dad Pertusa sighed, apparently that was the only way to save his child. Reluctantly, he sent Lophelina to live with his sister Madrepora.

Soon after arriving in the deep, Cold-Water World, Lophelina began to heal and grow and became a beautiful and a smart coral girl.

Aunt Madrepora loved her very much but she was very strict with Lophelina as well. She taught her in detail how to draw beautiful buildings in aragonite, an ideal calcium carbonate material in the cold deep-sea environment. Shortly after, Lophelina and Madrepora's palaces formed a small town, **Cold-Corallia**, which became a new meeting point in the cold, dark depths of the deep Underwater World.

Lophelina was beautiful, talented and intelligent but also somewhat rebellious. Aunt Madrepora became stricter with age and Lophelina, though she loved her aunt very much, could no longer stay with her. She yearned for the paternal love which she had missed her entire life. It was her greatest wish to meet her father, Dad Pertusa, and longed to see her hometown of Corallia.

One day Lophelina came home, sad, frustrated and full of rage. She went to talk to her aunt Madrepora, 'I want to go back to Corallia, I want to know my Dad and I do not want to stay here anymore. You have always said that Corallia is a wonderful place, full of life and colours. Here, it is always cold, always snowing and it is very different from up there. I want to leave!'

'Lophelina, calm down! These thoughts are not worthy of a respectable girl like you!' said Madrepora sharply.

Soon after, however, Madrepora became softer, 'I understand what you are saying but try to stay calm. Please, relax for a moment and sit down. I have feared the day when I would have to tell you what I am going to tell you now. This is very important and you have to pay very close attention. But now, I can no longer hide the truth from you. My dear girl, you cannot go back to Corallia... Because Corallia...

no longer exists!

'The city does not exist anymore?' Lophelina asked, 'What does it mean?'

Calmly, Aunt Madrepora began to explain, 'Since you came here to live with me, your father wrote many letters, asking me about you. He was very happy and satisfied with the way you were growing up. I told him that you were healthy and smart. You have always been his most beautiful creation, he often wrote. I had never believed that Pertusa could be that tender-hearted. Unfortunately, he also used to tell me about Corallia and what was happening to his beautiful city.'



Aunt Madrepora took a break, drinking a sip of coral-tea and continued the tale, 'In recent years, strange, negative and catastrophic events rained down on Corallia. It all began with the attacks against King Rubro. It was not known who, how, and why but someone from the Overwater World frequently attacked him. With each attack, he lost a piece of his palace. Although he was strong, at the end of these lengthy attacks he began to vanish. However, he was not the only one to suffer from such attacks. Unfortunately, also many fish and molluscs were taken by that new species living outside the ocean. Finally, a time came when King Rubro was about to die and all the Corals became afraid of their own future.

After the attacks, another strange event occurred. The waters of Corallia warmed up and became too hot for our Algae friends. They began to spend their time away from Corallia, sometimes returning after a few hours or days when the temperatures dropped, sometimes disappearing forever. Finally, the Corals themselves were feeling under so much stress and tension that they kicked out their own Algae friends. On those occasions, their mood was unbearable and they just wanted to be left alone. The loss of the Algae for longer periods is a very serious problem for the tropical Corals and they became ill. A new medical term was coined for that illness and the process became to be known as "**bleaching**". Many Corals, which were bleached for long periods, began to die without the energy provided by the Algae.'

Lophelina interrupted her aunt, 'Is that what happened to me when I was a baby?'

Madrepora replied, 'More or less, yes. You survived but you were

not able to live in Corallia. Since you are indeed a cold-water coral, you are rather special than sick and just a little bit different from the tropical corals. Dr. Di Plorio understood your nature and luckily this saved your life as baby and now as well, since you escaped the fate of the other inhabitants of Corallia.'

Madrepora returned to her tale, 'The situation in Corallia was becoming more and more serious. King Rubro, completely worn out, asked all the species of the Underwater World for help. He wanted to understand why his wonderful city was about to be destroyed and who was responsible for destroying Corallia. Scientists from around the Underwater World collaborated to find out what was happening. Corallia was the symbol of the beauty of the oceans and no one wanted its destruction.'

Aunt Madrepora took another break. She was overwhelmed by her feelings and she was not able to continue. She was thinking about the picture of Corallia, completely destroyed, pale and lifeless. Tears came to her eyes.

Lophelina started to cry too and desperately asked her aunt, 'Who can be so wicked as to destroy Corallia? Who is this monster? Why?'

Aunt Madrepora replied, 'My dear child, sometimes one does a lot of harm unintentionally.' She thought about her own disputes with her brother Pertusa back in the days, when both of them were young and impulsive. 'It is possible that whoever destroyed Corallia did not actually want to do it.'

Lophelina argued, 'Auntie, I do not understand. Someone did not want to destroy it, and yet, did it all the same? Who was it?'



Madrepora continued her story, 'As I was saying, all the scientists of the Underwater World worked together to understand what was happening. Everyone had realized that these strange negative phenomena were related to a new species that lived mainly in the Overwater World. They are called 'the Sebastians.' Lophelina asked surprised, 'The Sebastians? Who are they? What do they look like? Are they monsters? I have never seen them down here!'

Aunt Madrepora patiently answered, 'No, they are not monsters. Do not be afraid, it would be very rare that you see them down here,

although not impossible. However, they were often seen in Corallia.'

Lophelina replied, 'Wait Auntie! Have you really seen them in Corallia?'

Aunt Madrepora replied, 'Not me, I have always lived down here. They appeared recently and the Corals were curious about of this new species. Pertusa told me they have different colours and hairs but the Sebastians that commonly swam in Corallia had a second black, sometimes colourful skin and two cylinders full of air to breathe underwater, so that they could stay longer in Corallia.'

Lophelina asked, 'Stay longer in Corallia with cylinders full of air? What a futuristic monster! Aunt Madrepora, this is not funny, I don't believe you!'

Aunt Madrepora smiled, 'Oh Lophelina, you will never change! They are real and they have wonderful technologies which would allow them to even come here to Cold-Corallia.'

Lophelina proudly said, 'I am not scared of the Sebastians! If they come here, I will defeat them. I am a strong Coral! However, I am curious and I want to know more about them.'

Aunt Madrepora continued the description of the Sebastians: 'They are said to be very intelligent creatures but also very selfish ones. They do not seem to be evil and even those that were seen in Corallia were very relaxed and happy. Nevertheless, since the Sebastians appeared in both the Underwater and Overwater World, the existing natural balance began to change.'

'The entire world changed because of only one species?' asked Lophelina with incredulity.

'Apparently, yes.' answered Madrepora, 'The underwater scientist made many discoveries about the Sebastians and how they changed the world. Clam-chemists analysed compounds gathered by their filters, and noticed that the water was contaminated by the Sebastians' activities. Octopi started to correlate the chemical-physical data of ocean waters with air data collected by the Penguins. They discovered that the temperatures of air and seawater were rising. This was caused by the activities of the Sebastians which triggered a number of global processes, for example, warming both of the air and the ocean waters. With the rising ocean temperatures, the Algae left our tropical relatives or our relatives became depressed and expelled them, and... Corallia died, as I told you before. In addition, the Mussels from Coquina, the city on the border of the Underwater World, realized that it was becoming increasingly difficult to build with calcium carbonate. Their houses became unstable because of more **acidic water**. This also happened to the buildings of Corallia and likely contributed to the breakdown of the city. The Mussels found out that the Sebastians were also responsible for chemical changes in our oceans all around the planet.'

Lophelina asked, 'Have these Sebastians never noticed what they were doing? If they were so happy swimming in Corallia, didn't they realize that the bleaching, rising temperatures and the ocean acidification were destroying our city, a place they loved?'

Aunt Madrepora replied, 'From what we know, it appears that some Sebastians knew about all of this. They knew about the evils they were doing and they tried to let other Sebastians know. Many Sebastians began to protect Corallia but many more were convinced that their activities did no harm to either the Overwater

or Underwater World. Finally, the indecision among the Sebastians became fatal for Corallia. Time passed by, and although many Sebastians finally committed to do something, it was too late for Corallia. King Rubro died and after him all the corals died from bleaching.' For a few moments, Madrepora thought about her brother and this image shocked her mind. She sadly sighed 'Pertusa' and with a shaking voice continued: 'has not written to me for a long time. I am sorry, my dear, but... I am afraid that he might have passed away, too.' Aunt Madrepora wiped a tear from the corner of her eye and swallowed. She took a deep breath and continued, 'In his last letter, he told me that he was glad that at least you would be safe. He even thanked me for taking care of you and that our old disputes were finally over.'

This tremendously sad news made Lophelina cry. She had just learned that her loving father Pertusa and her hometown, no longer existed. She felt a deep sadness inside her and also much anger toward the Sebastians which were the cause of this catastrophe. Aunt Madrepora knew how Lophelina was feeling at that moment and she hugged her. She wiped away her tears and said, 'I know what you are feeling now. I know you are sad and angry, but don't worry. Chin up, Lophelina. Remember that you are a Coral, a cute and cheerful little polyp of the Underwater World and that is what your father wanted for you. About the Sebastians, I can tell you this: All scientists of the Underwater World agreed that if the Sebastians are the cause of our problem, they can also be the solution. They have realized that they cannot continue with their activities. If they continue with their current lifestyle, even the Sebastians will disappear.'

'In the future, things will change and then, my dear Lophelina, your children will go back to the tropical waters and rebuild Corallia. We will tell all newly born baby-polyps what happened in the past and how they can get the help of the Algae and all our friends of the Underwater World. We will even build a nicer Corallia. And who knows? Maybe even with the help of the Sebastians.'

Lophelina stopped crying and after some thought, she said, 'I am looking forward to a New Corallia. A world without Corallia does not make sense!'



Author's Note

'Lophelina' is full of references to the ocean related topics that scientist have to deal with every day. Besides, this tale reflects the story of many young researchers of the project 'Once upon a time' and beyond. For various reasons, they also moved from their 'Corallias' in order 'to grow' and develop their dreams.

Would you like to know more?

King Rubro-Red corals

King Rubro was named after the *Corallium rubrum*, a red coral species living in the water of the Mediterranean Sea and the Eastern Atlantic Ocean. The hard skeleton of red coral branches exhibits a range of warm reddish pink colours from pale pink to deep red; the word coral is also used to name such colours. Owing to its intense and permanent colouration and glossiness (after polishing), precious coral skeletons have been harvested since antiquity and used as gemstones. Coral jewellery and apotropaic amulets have been found in ancient Egyptian and prehistoric European burial sites. Modern societies continue to use corals for a variety of purposes. According to the legend first introduced by the Roman poet Ovid, the red coral was born from the blood of the gorgon Medusa in the moment when she was decapitated by Perseus. All gorgons had the ability to petrify living and inanimate beings and objects with their eyes. After her decapitation Medusa's blood came in contact with the foam created by sea waves, petrifying some seaweeds which turned red from her blood. And thus all corals belonging to the order of Alcyonacea, including the red coral, were formerly known as Gorgonians.

Scleractinians

Scleractinians, also called stony or hard corals, are polyp living on the seabed. They build themselves a hard skeleton. The original polyp settles on the seabed and starts to secrete calcium carbonate

(to lime, the same mineral precipitating in your sink) to protect its soft body.

Many scleractinians are also hermatypic corals, in other words, corals which build reefs by depositing hard calcareous material for their skeletons thereby forming the stony framework of the coral reef. Very well-known scleractinians are the brain corals, e.g. the genus *diploria*, after which Dr. Di Plorio was named.

Lophelia pertusa, Madrepora oculata and Cold-Coralia

Lophelia pertusa and *Madrepora oculata* are common species of stony cold-water corals that, contrary to the more popular warm-water corals, live in the tropics and in the deeper, darker parts of the oceans. In order to live in the deep ocean, cold-water corals must live without the support of the zooxanthellae (the Algae) which cannot live far away from the photic zone. Marine snow and food brought by strong deep currents compensate for the lack of algae. Like tropical coral reefs, cold-water corals are significant engineers of underwater ecosystems which can be found along continental shelves, slopes, canyons, and seamounts across the globe. Cold-water corals can be found all over the world from the Arctic to the Antarctic. The hard parts of the cold-water corals can accumulate to tens of meters above the sea floor. They create specific geological structures (often thousands of years old) known as coral mounds, which provide niches for a diverse species living on the seafloor of the deep ocean. In the Northeast Atlantic, around 1,800 species have been recorded to be associated with habitats created by the coral *lophelia pertusa*. Technological achievements, such as the development of deep-diving remotely operated vehicles (ROV), research submersibles, autonomous underwater vehicles (AUV),

landers and high-resolution acoustic mapping devices, have tremendously increased our knowledge of these formerly hidden marine ecosystems. Altogether, our knowledge of the deep and dark ocean has tremendously increased in the past 15 years. Although the awareness of cold-water corals is growing, even among the scientific community the interest for these creatures is remarkably low. In the public eye, these cold-water corals are virtually non-existent. The first studies revealed that cold-water corals are strongly sensitive to environmental conditions, which make them an important source of information about past global changes. For the same reason, “Cold-Corallia” is strongly threatened by the activities of “The Sebastians”.

Marine snow

The marine snow is the shower of organic and inorganic detritus (mostly dead or dying organisms like phytoplankton and protists but also faecal matter, sand or dust) falling from the upper portion of the water column to the seafloor. The mechanisms that allow to sink, this otherwise light detritus, is the aggregation of the colloidal matter derived from the different sources. When these aggregates reach the critical weight/size, they sink to the bottom of the ocean. The formation of marine snow is strongly influenced by the seasonal fluctuations of phytoplankton. Marine snow is an important food source for organisms living in the aphotic zone (the region of the ocean where the sunlight is too weak to allow photosynthesis). The snow is particularly important for organisms, which live deep in the water column, like the cold water corals, for example *Lophelina* and *Madrepora*.

Lost City, Metania and chemicals

In the deep ocean, where sunlight cannot penetrate, life as we commonly know it, is not possible and needs other strategies to develop. Thanks to chemosynthesis, microorganisms build up organic compounds retrieving energy from the geochemical elements released by hydrothermal vents (geological fractures where geothermally heated water is issued, often found near to volcanic complexes of the mid-ocean ridges or hot spots) and by hydrocarbon seeps (sites on the seafloor characterized by the leakage of hydrocarbon-rich fluids, known also as “cold seeps” because of the absence of heated fluids). Specific endemic macrofaunal organisms also live at hydrothermal vents and hydrocarbon seeps thanks to different biological interactions with the chemosynthetic microbial communities.

“Lost City” is a famous hydrothermal site in the Mid-Atlantic Ocean, while “Metania” is a name developed for this story based on the high amount of methane leaked from the cold seeps.

Coral Bleaching

The Algae, single-cell endosymbiositic zooxanthellae living within the coral tissues, are also responsible for the unique and beautiful colours of the tropical corals. Sometimes when corals become physically stressed, the polyps expel their algal cells and the colony takes on a stark white appearance. On other occasions, the algae experience stress and leave the polyp, to return sometimes after few hours but sometimes never. This is known as “coral bleaching”. The phenomena of bleaching has variable periods but since most of the coral’s energy is derived from the relationship with the

zooxanthellae, long periods of coral bleaching can result in the death of the polyps and in some unfortunate cases, the whole colony and/or reef. There are many causes for coral bleaching: Change in ocean temperatures (increased temperature by climate change is the leading cause of coral bleaching), runoff and pollution (especially for near-shore corals), overexposure to sunlight and extreme low tides.

Acidic water - ocean acidification

There is a natural interchange of CO₂ between the ocean and the atmosphere with more CO₂ entering than leaving the ocean. The oceans store a lot of CO₂. When atmospheric CO₂ enters the ocean, it undergoes some chemical reactions, which ultimately transform it into carbonate and bicarbonate ions and set free hydrogen ions to the water. The concentration of hydrogen ions in a liquid defines its pH value (more or less acidic or basic). The chemical reactions, in which CO₂ takes part when entering the ocean, are reversible, so that the pH value of the ocean stays within a rather narrow range (7.8 to 8.2). This is a so-called buffer system. However, when the atmospheric CO₂ concentrations increase very rapidly, as it occurs since the industrial revolution, the buffer system cannot cope with the high amount of entering CO₂. The reactions become unbalanced in a direction that produces more acidic water. Since the beginning of the industrial revolution, it is estimated that the ocean has become more acidic by 30%. This process is called "ocean acidification". Future predictions indicate that the oceans will continue to absorb CO₂ and become even more acidic.

In most of the oceans there used to be more than enough concentrations of the molecules needed to form calcium carbonate,

the building block for the skeletons and shells of many marine organisms. The “ocean acidification” is altering the availability of those building blocks and it is therefore feared that the capacity of some organisms to produce and maintain their shells will diminish. Aside from altering the ability for building shells and skeletons of some organisms, increasing acidity may have other potentially harmful consequences for the marine life, such as depressing metabolic rates and immune responses in some organisms, threatening food chains and causing coral bleaching.

While the ongoing “ocean acidification” is caused by human activities, there have been similar situations in Earth’s history. The most notable example occurred during the Paleocene-Eocene Thermal Maximum, around 56 million years ago. Due to not yet well-understood reasons, massive amounts of carbon entered the ocean and atmosphere and led to the dissolution of carbonate sediments in all of the ocean’s basins. Examples from the past tell us about the dangers associated with “ocean acidification”. Ocean acidification is also called “the evil twin of global warming” and “the other CO₂ problem”.

The Plastic Island

Ivan Hernández Almeida

Illustrations Carolina Guarnizo Caro

'Yuck!!! Dad! How is it possible!? There is a piece of plastic in my seafood. Did you drop it in while you were cooking? Yuck, there are so many!'

'Aurea, what are you talking about? That is impossible! I went to the fish market myself to buy fresh fish. And no, I did not drop any plastic while cooking.'



When her Dad looked at the dish, he was surprised to see many little pieces of plastic inside his daughter's seafood.

'Whoa! Aurea, I do not know what to say... This is unexpected! Anyway, it is not a big deal, just take them out and finish your food, please.'

'Sorry, Dad but I want to know how the plastic ended up inside my seafood!'

Finding a piece of plastic inside your seafood would be a funny anecdote to tell their friends for most people, but not for Aurea. She was nine years old and a very curious little girl. Her thirst for knowledge could be so extreme that it often annoyed adults. When something was stuck in her mind, she bombarded every adult with questions until she was satisfied or the adult had left the exhausted.

While struggling with the last pieces of her meal, Aurea looked through the window. A flock of seagulls were fighting over a piece of plastic lying on the beach. Aurea very much liked walking along the beach and she always enjoyed the view of the bay. She loved the sightseeing, the seaside smells, the bird's cawing and the feeling of wet sand under her feet. For her, best time of the year was fall. School had not yet started but together with the first showers of rain the tourists, which annually invaded her personal playground, had already disappeared. Although almost no one was at the beach, there was garbage here and there. While Aurea was gazing into the distance, she was trying to find an explanation for the pieces of plastic in her seafood.

'Ocean, fish, plastic... there must be a connection!'



Aurea mumbled, while finishing her food with a bit of disgust, trying to fit the pieces of the puzzle together. Not being able to find an explanation about things that intrigued her was like torture for the little girl. She started to plan the next steps of her investigation. If her Dad could not give her an answer, the next stop would be the harbor where the fish came from. She was confident that this would be the place to find answers. She finished her food and got ready to go out to the harbor.

At the same time in the afternoon, the fishing boats were returning from a full day of fishing along the coast. Her parents told her that many years ago the town was a prosperous fishing village. Nowadays, only a handful of fishing boats were still active and very often they came back

to the harbor with their fishing nets half-empty. Shallow-water fishing was declining due to the scarcity of fish living near the coast and the increasing popularity of fish farms. That day, there was only one boat in the harbor. Its nets were almost empty despite having spent the entire day at sea. While a few men were unloading the hold, a harsh-looking man was yelling at them from land. The sailors sped up their work, following the Captain's orders.

Nevertheless, Aurea was not easy to impress, in particular when she was trying to satisfy her curiosity. She thought that if that man was giving orders, it was because he was in charge. It was likely that he would be able to answer her questions.

'Excuse me, Sir. I found some pieces of plastic inside my seafood and I would like to ask what you know about a fish's diet. Do they eat plastic? Why do they eat plastic? Where does the plastic come from?'

The Captain did not react immediately. After a few seconds, he stopped giving orders and turned around to look in Aurea's eyes. His eyes were surrounded by wrinkles making him look old and tired. He fixed his eyes on Aurea.

'What are you saying little girl?! Can't you see we are busy? I am the Captain of this boat and I have no time for little brats like you. Get out of my way!'

If there was one thing that annoyed Aurea more than unsatisfactory answers, it was bad manners. When both things happened at the same time, Aurea would become even more stubborn.

'I have asked you something! And until you reply I am not going anywhere!'

The furious reply attracted the crew's attention. They stopped working and turned around towards the Captain and Aurea. It was very unusual that someone, either adult or child, would dare to speak to the Captain in that tone. One of the sailors, who lived near Aurea's house, recognized her.

'Boss, it will be much better if you give her some answers. She is a very stubborn and persistent girl!'

For a few seconds, the only sounds that could be heard were the splashing of the water and the cawing of the birds. The Captain was speechless, and tried to show some restraint.



'What are you all looking at?! Put the fishing nets away and go home!'

The Captain stood up pondering about the situation. The fact that someone addressed him in that manner was very unusual. He leaned forward to look into Aurea's eyes again.

'Well girl, do you have a name? What do you want to know?'

'My name is Aurea. I found pieces of plastic inside my seafood. My Dad does not know how they ended up there. Where does the plastic come from? If fish live in the ocean, why would they eat a piece of plastic? Where does the plastic come from? I need answers!'

After listening carefully to Aurea, the Captain replied:

'Well, I see. Do you want answers? I will give you answers. Your questions do not have an easy answer and I am not a very good speaker. I think, it would be better if I show you the answers. Come tomorrow at dawn and bring warm clothes. We will spend the day at sea.'

Aurea returned home somewhat disappointed because she did not get the answers she was looking for. However, she had some hope of getting them the next day. She was very excited about tomorrow's day trip! She explained to her parents what had happened today. They were not particularly surprised about the situation. They knew their daughter and her stubbornness well enough. Thus, it was easy to convince them to let her sail with the Captain, who was a well-known and respected person in the village. Aurea went to sleep, looking forward to set sail the next day and following-up her investigation.

When the sun was about to rise, Aurea woke up and got dressed

quickly. She headed to the harbor for her appointment. There, the Captain was waiting for her. Aurea said good morning, and the Captain nodded his head in agreement.

‘So, you want to find out about the source of those plastic pieces you found in your food?’

The Captain, with his rugged appearance, tanned by the years he had spent offshore, was an honest and comprehensive person but without much patience. Where others only saw a nine year old cheeky brat, as was most people’s first impression, he recognized Aurea’s insatiable curiosity and also realized that this little girl could help him with promoting his own message.

‘Well, I am going to tell you something you will find hard to believe. Many people think I am just an old fool, telling everyone crazy stories. Nothing could be further from the truth! People do not want to believe unless they see something with their own eyes.’

Aurea’s expectations grew and grew while the Captain was talking. She was totally focused on every word that came out of his mouth.

‘Far beyond the horizon, there is an island!’

‘Well, I am nine years old, but that is no news to me. There are thousands of islands in the ocean!’

‘Yes, that is true. However, this island doesn’t show up on any map because it is a floating island made out of plastic! Hundreds, thousands, millions of plastic pieces drifting through the ocean end up together thereby forming that huge island. If you were in the middle of it, you would only see plastic and more plastic everywhere

around you.'

Aurea looked at him with a furrowed brow. She was a very critical and smart girl for her age, always suspicious about whether people were telling her the truth or just trying to fool her.

'Well, where do these plastic pieces come from? How is it possible they accumulate on that island? Moreover, what is the connection to the plastic in my food? This explanation about a plastic island sounds a bit like a made-up story.'

'I see you do not believe me. Since a picture is worth a thousand words, we are going to set sail and you will see for yourself.'

Aurea got on the ship and took a seat on deck while the crew unmoored the ship. The temperature outside was nice, the sea breeze stirred up her hair and the air was rich with the smell of sea salt. Aurea went to the railing to observe the sea's surface. From time to time, a fish jumped out of the sea and the seagulls, that were flying overhead, tried to catch it. As they travelled further from the coast, seagulls and fish were fewer and less frequent. The sea was quite calm that day. Towards mid-day, Aurea started to spot plastic objects floating on the surface: A water bottle here, a plastic bag there...

'Puaaaaaaj, this is disgusting! Who has come here to dump this garbage?'

'Little girl, this is nothing compared to what is about to come... '

They kept moving in silence. Aurea became stiffer with every minute with her eyes focusing on the sea's surface. The floating garbage became more and more frequent. There were not only a

couple of bottles and plastic bags. Now, plastic garbage was literally surrounding the ship. Aurea was able to identify pieces of plastic bottles, food containers, a plastic glove, a flat plastic ball, plastic caps and dishes... She soon realized that no one had sailed until that point to discard all that garbage. It must come from the dry land. With a strong feeling of guilt, she questioned whether any of this floating plastic had been discarded by herself at some point.

The Captain stopped the boat. Aurea looked around and she was unable to see to the end of the plastic island. It looked like they had arrived to a plasticized beach. The floating garbage was rocked by the waves, hitting the boat. Both, Aurea and the Captain stood in silence, looking at the bleak landscape for a long time. Suddenly, Aurea was overwhelmed by a feeling of deep sorrow and she started to cry. The Captain, who rarely showed his feelings, felt very touched by the situation. He laid a hand on her shoulder, trying to comfort her.

'How is it possible, that all this plastic garbage ends up in here, so far from beaches and cities?'

'It is due to the marine currents. In the place where we are, two surface currents meet, slowing down the circulation and the plastics accumulate. And you know what? I read some time ago in a book that there are even bigger plastic islands in the middle of the oceans. They are found in some type of giant loops in the ocean. Plastic pieces are concentrated there and then seabirds and turtles and fish and even us end up having those plastic pieces in our food, as you have seen yourself. For a sea turtle, a floating plastic bag does not look very different than its main food source, the jellyfish. A giant whale, which filters tons and tons of seawater every day, is also at danger

swallowing many plastic pieces. What we can see on the surface is not the biggest problem but rather what we do not see. The plastic pieces are broken into much smaller pieces which are then dispersed throughout the ocean, ultimately reaching the bottom of the sea. Now you know the fate of the plastic pieces we use in our everyday life. Many of them are dumped into the sea and from there they can end up in your food... I am so sorry, Aurea. Many times, I have tried to warn people about what I have seen while at sea, but no one listens to me. I am fed up of spending the day at sea and coming back home with my fishing nets filled with plastic instead of fish.'



Despite her sorrow, Aurea understood what the Captain had told her. The Captain set the course back to the harbor. Aurea stayed on deck looking at the floating garbage. Her sorrow became rage. Although her initial curiosity had been satisfied, she soon realized the implications of her discovery. The ocean was being transformed into a huge rubbish dump! Aurea told herself that she could not let this happen. She had to find a solution! She had to do something to change the people's attitude and make them act.

After she arrived at home, Aurea told her parents everything she had seen. Although they could not come up with any solution or advice, this did not discourage her. A few days after, the terrible picture of an ocean covered in plastic was still very fresh in her mind. Everywhere she looked she saw something made out of plastic, imagining its path into the sea, polluting the water and harming the marine animals. The Captain sympathized with her cause. Despite having seen that terrible picture multiple times, the impact it had had on Aurea made him regain his own motivation to act. The two spent more time together, thinking about a possible solution. In the days they spent together, they visited the public library, reading about oceanography, ecology and recycling, trying to find inspiration and ideas of how to change the situation. Finally, one day when Aurea was walking around on the beach, she saw a group of fishermen putting the fishing nets together on the sand after a day of work, something she had seen many times. The men fixed the nets and removed the numerous pieces of plastic that they had accidentally fished out of the sea. While others only saw fishing nets, Aurea suddenly saw a solution. If fishing boats had stopped fishing fish, they could at least help to clean the plastic from the sea!

Aurea went running to find the Captain to tell him about her plan. After they discussed a few details, they met with the local fishermen to explain their idea. Surprisingly, a big crowd came to meet them. Not only the fishermen came but also friends and neighbors, mostly out of curiosity about what Aurea and the Captain had to tell them. The village was very small and rumors about their boat trip and the story of the plastic island had spread quickly.

Aurea was nervous. She had never imagined that her plan would generate such response. Everyone she knew was there. Her parents cheered her as she climbed up onto a chair to speak aloud in front of the audience. Aurea was getting nervous, yet knowing that her parents and the Captain were supporting her, calmed her down a bit. She took a deep breath, hoping she would be able to remember the entire speech she had in her mind. She started describing to everyone about what she had seen a few days ago. People were astonished. Despite their consciousness about the pollution caused by discarding plastics, nobody was aware of the real consequences of their actions. Aurea continued with her speech.

'The sea is our livelihood; it provides us with food and resources and it brings us business from visiting tourists. But not only that. The marine plankton produces a big portion of the oxygen we breathe. A portion of the pollution we generate is absorbed by the oceans. What we eat, what we breathe, almost everything starts and ends in the ocean. But we are using it as a trash bin! If we do not act soon, it will be too late.'



After a few more minutes of talking, Aurea finished her speech. She climbed down from the chair and together with the Captain, they dragged a fishing net full of plastics they had fished during a trip and put it in front of the audience. The guilt slowly overcame the people. Nobody wanted to look directly at the fishing net full of garbage. Some of the objects could be theirs. Facing the garbage also meant facing their own irresponsibility. Maybe the idea of cleaning up the ocean using fishing boats seemed a bit unrealistic at first but Aurea's and the Captain's optimism had rubbed off on people and before they knew it, they had the complete support of the whole community.

And this is how Aurea and the Captain started their battle against plastic pollution. Friends, family and neighbors radically changed their minds. People started to collect plastic on the streets and beaches. They reused it, started reducing the amount of plastic in

their everyday shopping and began to sort their garbage. Many of the ships, which had been inactive and moored for long time at the harbor, were again at sea under a new role: Fishing plastic! Plastic disposal started to return to the land from the sea and small piles were stocked up at the harbor. Their little revolution started to become viral and the media, scientists and local authorities became interested in it. They designed a strategy to extend the plan to other villages and funding the expenses of the fishermen and even started to recycle the recovered plastic. The PVC bottles and plastic bags were transformed into synthetic yarn which was then used to make clothes and shoes, sunglasses and toys. After many, many years and little by little, the plastic island had decreased and sea life flourished once again. The ships started to fill up their nets with fish again and many more years later, the plastic island disappeared completely. And never again did anyone find plastic in their food.



Would you like to know more?

Here are some links you can where you can further explore:

<http://news.grida.no/more-garbage-than-fish-the-worlds-largest-beach-clean-up>

<http://news.grida.no/plastic-can-end-up-on-your-dinner-plate>

http://www.huffingtonpost.com/entry/this-company-turns-used-plastic-bottles-from-shorelines-into-clothing_us_57d17909e4b06a74c9f301f3

<http://ocean.si.edu/ocean-news/upcycled-ocean-plastic>

Forams are fantastic! But what if they are made out of plastic?

Deborah Tangunan

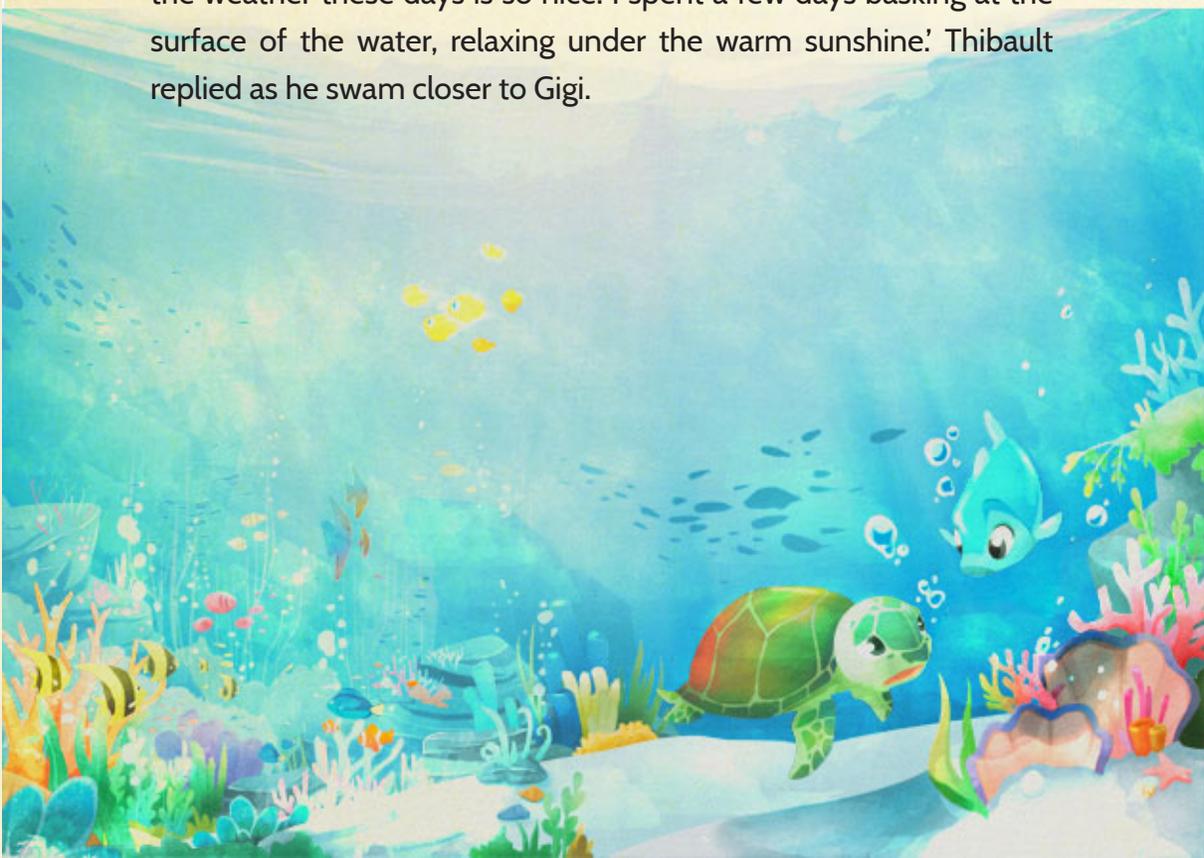
Illustrations Deborah Tangunan and Jay Nogot



Once upon a time, a curious young fish named Gigi lived with many other marine animals under the sea. Gigi had an equally inquisitive friend. His name was Thibault, a sea turtle. Together, they went on fun adventures, exploring each and every corner of the underwater world, going in and out of the coral tunnels, swimming from one reef to another. When the two friends were not at school, it was difficult to find them. They could be anywhere and everywhere, out on an adventure somewhere in the great wide sea.

'Hey, Thibault! How's it going? Where have you been?' shouted Gigi when she saw her best friend swimming towards her. 'I haven't seen you for quite a while!'

'Oh! I just came back from an excursion close to land. You know the weather these days is so nice. I spent a few days basking at the surface of the water, relaxing under the warm sunshine.' Thibault replied as he swam closer to Gigi.



'Another trip close to land? What did you see this time? Tell me, tell me!' Gigi was always eager to hear news from Thibault's adventures. Unfortunately, she could not go close to the shore. She also knew that Thibault could not stay with her underwater for long. He always needed to go up the surface to breathe. However, this small difficulty had not affected their close and loving friendship.

Thibault was usually enthusiastic to share his adventures, but that day it was different.

'It's a sad, sad day, my friend... A relative of mine choked on a piece of trash swimming in the water and died. She thought it was a jellyfish'. Oooh... I am sorry' said Gigi, immediately comforting Thibault.

'And what is even more depressing is that she was supposed to go to dry land to lay her eggs... I have also seen some of the trash that choked her but I was lucky. I did not try to eat it because I wasn't hungry at that time,' Thibault continued.

'We have to do something,' Gigi broke the silence.

'Oh! I thought of something!' Thibault immediately exclaimed before Gigi could even start thinking of what to do next. 'Are you in for a little adventure?'



'Of course!' Gigi replied. She knew that she didn't have to ask where they were going. The little fish knew her spontaneous friend. They were going somewhere; that was for certain!

'Let's get going then!' said Gigi and Thibault in concert.

And so the two friends began their journey. Maybe they will have another fun adventure together: exploring new corners of the underwater world, going in and out of the coral tunnels, swimming from one reef to another.



The journey led them to a part of the ocean they had not visited before. Along the way, they were astonished to see plenty of those things that Thibault called “**deadly jelly**”. The small, colorful pieces were everywhere, trapped on sea grasses, stuck on corals, draped on their branches, some floated along with water, and some just sat on the seafloor. They were green, yellow, red, pink, blue, orange and white, so many colors!

‘So many deadly jellies!’ Thibault said.

And just as they were about to leave, something in the sand caught Gigi’s eyes.

That was the first time that she saw such creatures. They were so tiny and appeared very peculiar in her eyes. They looked far more complex than other small creatures that she had seen and eaten before. Their shape and size was similar to those teeny tiny white shells that she sometimes ate by accident. But that was where the similarities ended. Those are probably foraminifera, she thought. Gigi clearly remembered her lessons with Professor Fina.

Gigi knew that there are **foraminifera** which have round, globular shells. Some of them have different number of rays, others are opaque, white or translucent or even have transparent shells. Others have elaborate shapes and some of them had milky white covers that made them look like popcorn! Some of them even attached little grains of sand to their tiny bodies to form a protective layer.

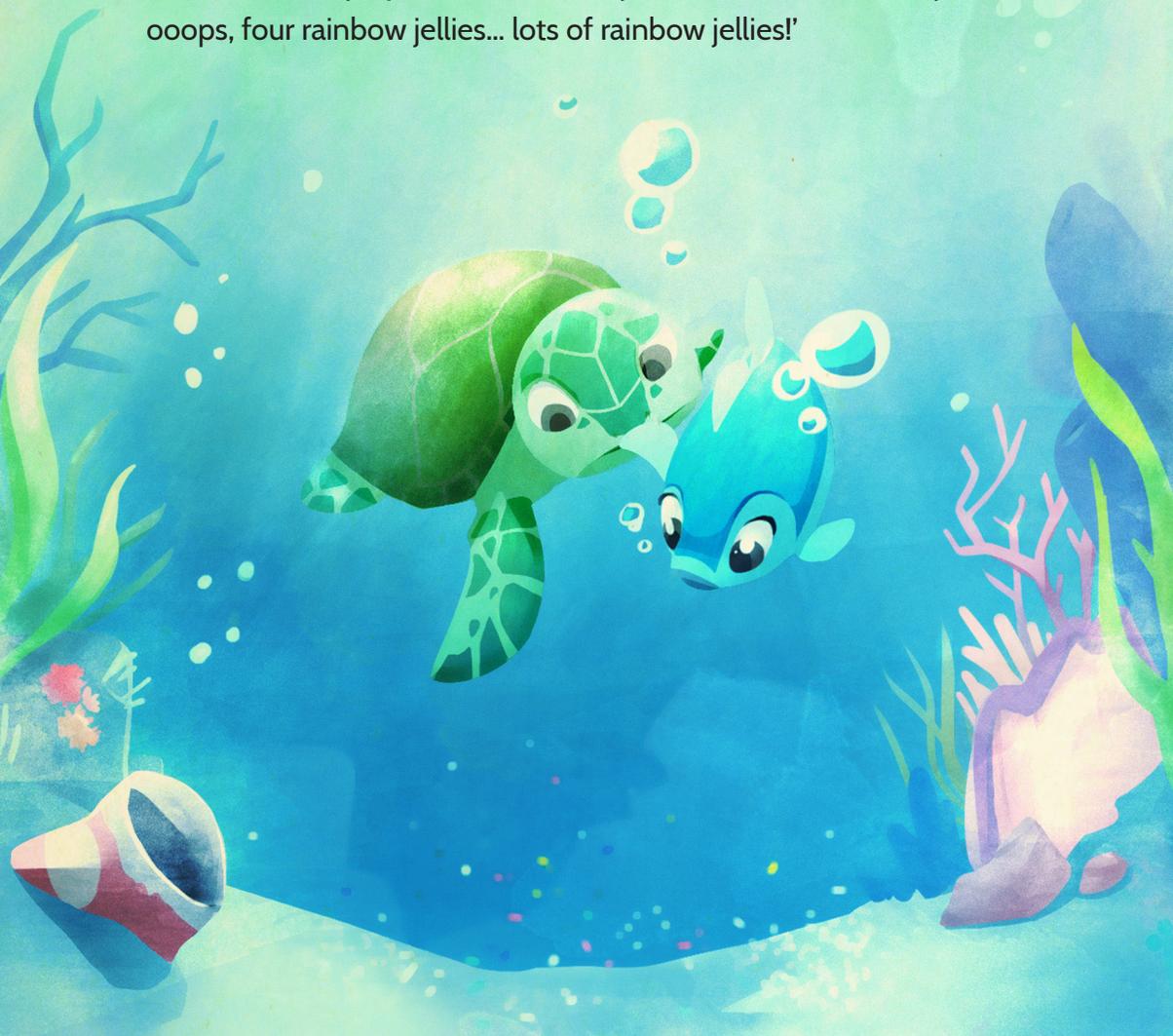
But these... these tiny, peculiar organisms that she was looking at were unlike all these other teeny tiny creatures that she knew. They were full of colors!

'What are these things?' shouted Thibault. 'They look like rainbow jelly to me!' Before Gigi could even say another word, Thibault already moved closer to take a look at them.

'Careful, Thibault! We don't know what those are!' yelled Gigi.

'Look! There are lots of them!' Thibault exclaimed. Thibault then took one of the deadly jellies hanging on a coral branch and filled it with some rainbow jellies.

'One rainbow jelly... two rainbow jellies... three rainbow jellies... ooops, four rainbow jellies... lots of rainbow jellies!'



'Let's bring them to Professor Fina. I know she has the answer to every question!' said Thibault as he was busy packing the rainbow jellies.

And so they continued swimming until they reached the Underwater School for Marine and Human Sciences. This was an institution where marine animals study all about their own and human ecosystems.

They immediately went inside Professor Fina's office. Professor Fina was sitting at her desk, preparing her lessons. She looked busy and didn't seem to notice them.

'Good day, Professor!' said Thibault.

'Oh! Good day to you too, Thibault... and Gigi!'



The Professor was already a bit old and she had been teaching for quite some time now. But she loved teaching, she loved the underwater world and she loved humans, too. That's why she continued to spread and share her knowledge about them.

'What brought you two here? Your class will be in two days from now, right?'

Thibault showed the deadly jelly filled with rainbow jellies to Professor Fina. The scientist was not surprised, since this was not the first time that she had seen plastic. But when she opened the plastic bag and saw what was inside, her forehead wrinkled.

'Follow me.' said Professor Fina to Gigi and Thibault. They went to an adjacent room, which served as a laboratory. Professor Fina placed the plastic bag on the table and took out a binocular microscope.

She transferred a few of the rainbow jellies to a dish, took a picking needle and brush and looked at the tiny, peculiar jellies under the microscope.

'Well, this is interesting! These are no doubt ***agglutinated foraminifera***. But these are not like those forams that I showed you in class. These are not made out of sand grains or broken shell fragments. Their shells are made up of plastic litter that was cemented together!' said Professor Fina.

She shook her head as she continued to explain. 'This and this are the same. These colorful pieces that you call rainbow jellies are what humans call plastic.' while pointing to the plastic bag and the rainbow jellies under the microscope.

‘So we should not eat those things, either?’ asked Gigi.

‘No! You see, if these small creatures are eaten by fish or by other creatures, they will choke you to death,’ warned Professor Fina.

‘Yeah! Like my relative!’ Thibault joined the conversation. ‘She choked on something like that, thinking that it was jellyfish and died,’ Thibault said pointing at the plastic bag.

‘Sure, they look appetizing!’ Professor Fina continued. ‘They are colorful and pretty! But let’s say, a small fish ate them, and that small fish got eaten by a larger fish, and then this larger fish was eaten by a fish larger than the larger fish. In the end, it would not only be harmful to every single one of them but also to the last one who will eat them all!’

‘Oh, I see! May I guess who that last one might be? Humans?’



'Well, well. That's right, Gigi. This plastic waste that humans recklessly throw into the water kills sea turtles, seals, sea lions, seabirds, fish, whales and even dolphins like me. Eventually, this waste will return to them,' said Professor Fina.

'Oh my Neptune!' Gigi exclaimed.

'Can I have a look at these agglutinated foraminifera under the microscope?'

'Go on, Gigi. And you can have a look at them, too, Thibault. I will get another microscope for you.'

The two spent some time looking at these new creatures under the microscope. Gigi and Thibault enjoyed looking at the teeny, tiny creatures from which they now knew they should not eat.

'Maybe I can be a *micropaleontolofish* one day.' Gigi thought.

The two friends realized how much time they had spent away from home. For Thibault, it was time to return to the surface and Gigi knew that her mother must already be getting worried. Thus, the two friends decided to swim back home.

'Bye, Professor Fina! See you in two days!' said Gigi and Thibault in concert.

'Bye, you two! Have a safe swim back!' shouted Professor Fina.

The next day, Gigi and Thibault went back to the place where they found the agglutinated forams with plastic shells.

But much to their surprise, they were gone! And so was all the plastic litter!

Professor Fina closed the book that she had just read to her class.

It was her storytelling class. She had written so many stories but her favorite characters were her students. She loved to read these stories to her class. Sometimes, she would also go out of the classroom and read her stories to other marine creatures whom she fondly called her fellow “seatizens”.

‘But... where did the rainbow jellies go? Somebody might have eaten them! Is the story finished, Professor Fina?’ said Thibault.

‘Well, well, that will be your homework for today,’ said Professor Fina.

‘I want all of you to think of your own ending to that story,’ continued Professor Fina.

‘Maybe they were gone because some marine creatures ate them as you said, Thibault. Or maybe they were not really there after all and Gigi or Thibault only had a bad dream. Or maybe all the marine animals have worked together, collected every single piece of that litter and put them all in one place. Or the ocean found its own way to protect itself by using its currents, so that the litter piled up in one area for humans to see and clean up. Or maybe the humans cleaned it up already...

You can think in so many other possible ways of how this story might end. Just as there are so many possible places where all of this plastic litter might go.’

‘Hmmm...’ The class responded with a nod. Probably, everyone in class already had ideas running through their heads.

‘Maybe in fifty or a hundred years, there will be less plastic litter in

the oceans than there is today. Or maybe there will be more. We do not know. Thibault might still be there to see that or maybe there will be no more “Thibaults” by that time.’

‘Only humans can know that. Funny how we all got along just fine before plastics were invented. Now it looks like humans can’t manage life without them. But I know they have realized they can’t go on using plastic like they did before. I also know that they are doing something about it now. I know that,’ Professor Fina continued.

‘Uhm... Professor Fina, how come you know so much about humans and what they do?’ asked Gigi politely.

‘I’ve already told you that story, didn’t I?’ asked Professor Fina.



'Well, well...' Professor Fina said.

'I've lived with humans for quite a while when I was young. Humans took care of me until I was ready to go back to the sea. You know humans have this giant ocean with walls... I've lived there.'

'But that story, my dear students, will be for our next class. It is your task to go home now and to write a *nice end for the plastic agglutinated foraminifera story.*'

Would you like to know more?

Sea Turtles are in danger!

Did you know that based on current data, 52% of the world's sea turtles have ingested plastic? Modeling results from risk analysis of these plastic wastes also suggest that the eastern Indian Ocean, Southeast Asia, and east coasts of USA, Australia and South Africa are the regions of highest risk to the global sea turtle population.

Source: Schuyler et al., 2015; *Global Change Biology*, 22(2), 567-576.

“Deadly jelly” - Plastic is not so fantastic!

Did you know that the current estimate of plastic debris floating in the ocean amounts to 5.25 trillion pieces? Out of this number, 269,000 tons float on the surface while about 4 billion microplastics per square kilometer litter the deep sea.

Source: <http://oceancrusaders.org/plastic-crusades/plastic-statistics/>

Foraminifera- the tiny giants of the great seas!

Did you know that there are around 4,000 living species of foraminifera (forams) in the world's oceans? Forty species float in water (planktic) while others live on sand, mud, rocks and plants at the bottom of the ocean (benthic). Forams are single-celled organisms with shells that are composed of chambers. The simplest forms are open tubes or hollow spheres. Their shells can be made of calcium carbonate, organic compounds, sand grains or other particles cemented together.

Source: www.ucmp.berkeley.edu/fosrec/Wetmore.html

Agglutinated foraminifera - Stick them all together!

Did you know that the oldest forams are 541 million years old? They are simple agglutinated tubes composed of organic test walls or shells. 'Agglutinated' refers to shells formed from foreign particles glued together with various cements. The living foram cell uses its pseudopods to take materials from its immediate surroundings and uses them to make its own shell.

Source: <http://www.ucl.ac.uk/GeolSci/micropal/foram.html>

"Micropaleontologist" - Through the lens!

A micropaleontologist is a scientist who studies microfossils. Fossils are remains of plants and animals that died and have been buried in the Earth for a very, very long time. They can be bones, teeth, horns, feathers, shells, seeds, pollens, footprints, burrows and any other things that were once part of an animal or plant. A micropaleontologist works with microfossils or tiny fossils that can only be seen with the aid of a microscope. Microfossils such as the shells of foraminifera are used to determine the age of rocks or sediments and in what kind of environment the organism lived. Analyzing microfossils enables scientists to tell the story of the Earth even up to millions of years ago.

A nice end for the plastic agglutinated foraminifera story?

Did you know that if we keep dumping our plastic litter in the ocean, there will be more plastic than fish in the ocean by 2050?

There have been no known occurrences of these agglutinated foraminifera with plastic tests yet. However, there will come a time when our oceans will contain too much plastic litter so that even the smallest of organisms will have to use these plastics as shells.

Tonight you will dream about the ocean

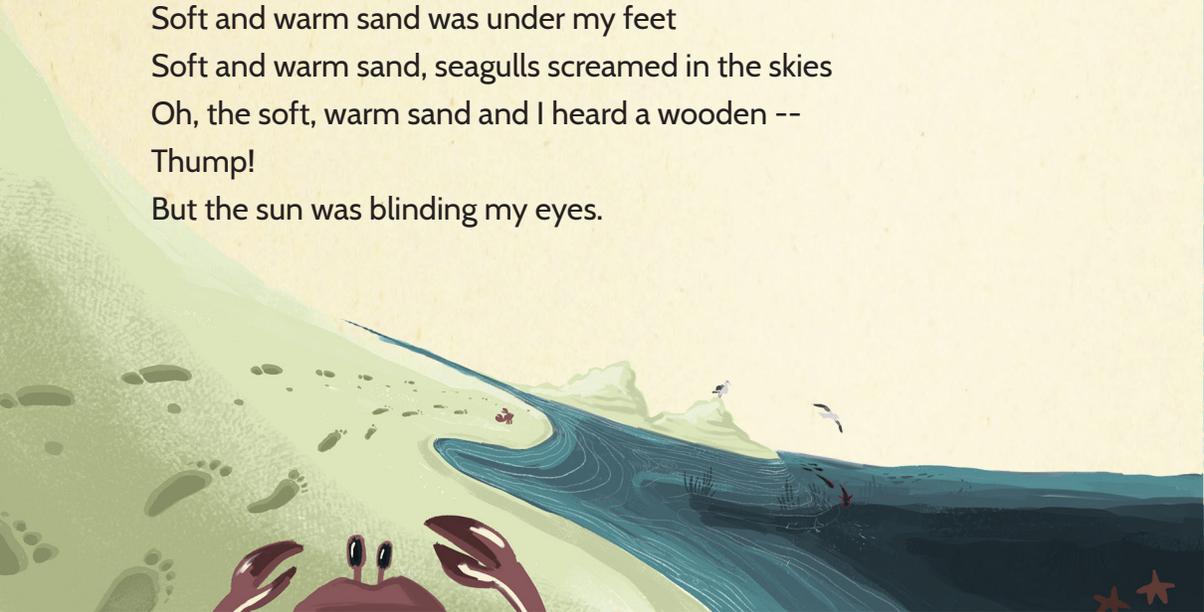
Hadar Elyashiv

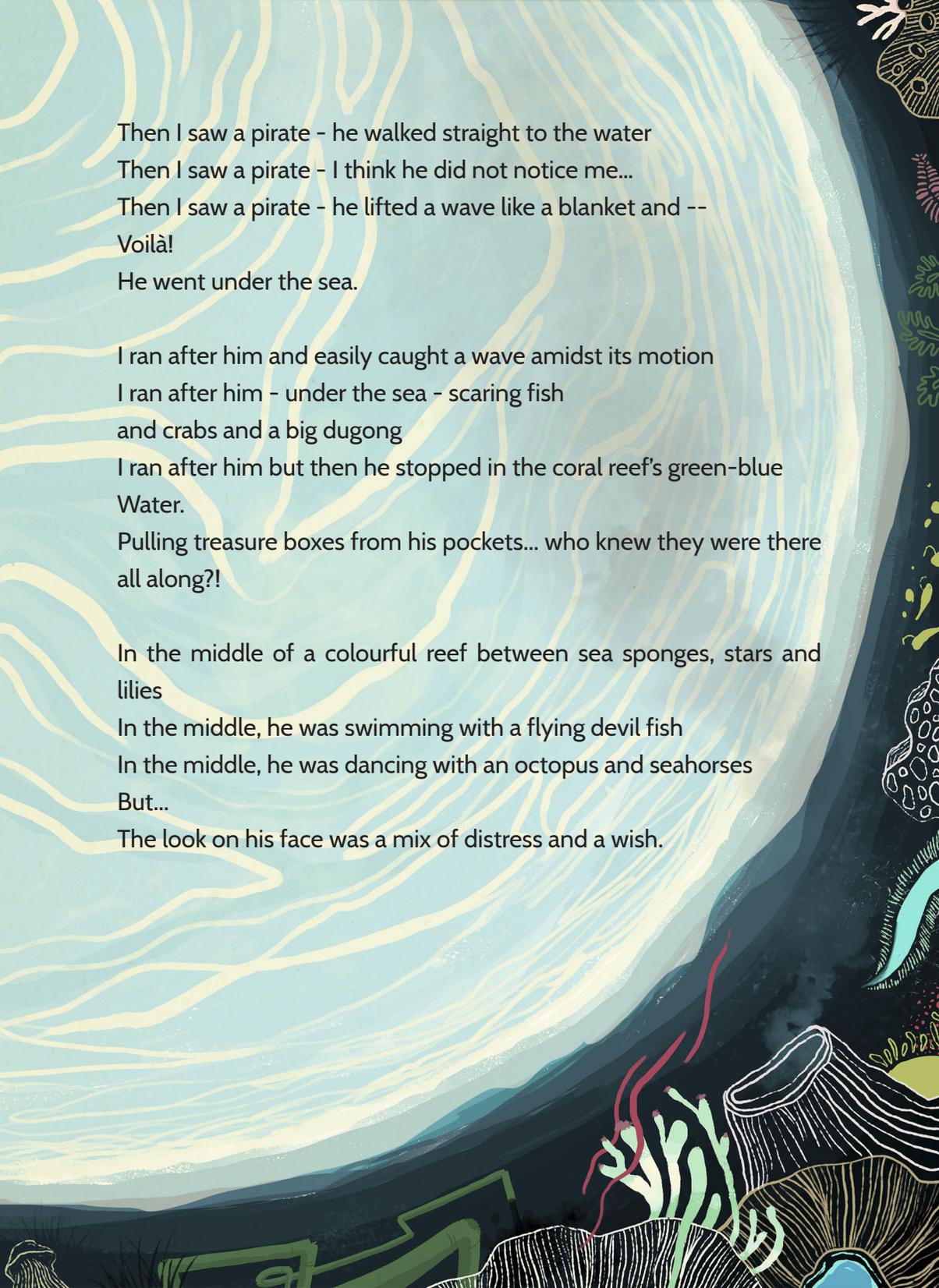
Illustrations Boaz Balachsan

And perhaps... these things have never happened
And perhaps... I never crossed through the deep sea
And perhaps those events were be only dreamt by --
Pirates,
Or... perhaps by me.

I was sitting in my bed after two late night stories
I was sitting in my bed reading three poems more
I was sitting in my bed tonight to fall sound --
Asleep,
When all of a sudden, my feet touched a shore.

Soft and warm sand was under my feet
Soft and warm sand, seagulls screamed in the skies
Oh, the soft, warm sand and I heard a wooden --
Thump!
But the sun was blinding my eyes.



The background is a stylized illustration of an underwater scene. The upper portion is dominated by light blue and yellow wavy lines representing water currents. On the right side, there is a dark blue area representing a coral reef, with various colorful coral structures and sea sponges. At the bottom, a pirate ship is partially visible, with its hull and masts. The overall style is artistic and whimsical.

Then I saw a pirate - he walked straight to the water
Then I saw a pirate - I think he did not notice me...
Then I saw a pirate - he lifted a wave like a blanket and --
Voilà!
He went under the sea.

I ran after him and easily caught a wave amidst its motion
I ran after him - under the sea - scaring fish
and crabs and a big dugong
I ran after him but then he stopped in the coral reef's green-blue
Water.
Pulling treasure boxes from his pockets... who knew they were there
all along?!

In the middle of a colourful reef between sea sponges, stars and
lilies
In the middle, he was swimming with a flying devil fish
In the middle, he was dancing with an octopus and seahorses
But...
The look on his face was a mix of distress and a wish.

One side of the reef was sick... seaweeds were creeping
across its corals

At this side of the reef, slurry water were blocking the sun

At this side of the reef, oil spots and years of pollution were slowly --
Creeping.

Oh, now I saw the pirate trying slowly to undo
the years of damage done.

He unleashed surgeonfish from his treasure boxes - to graze the
weed

He unleashed nets and tires, hooks and plastic
between corals caught

He unleashed more and more magic tricks from his boxes and...

TRAPPP

Locked away all the dirt and filth from this spot.

Once this was done, he closed and packed his treasure boxes

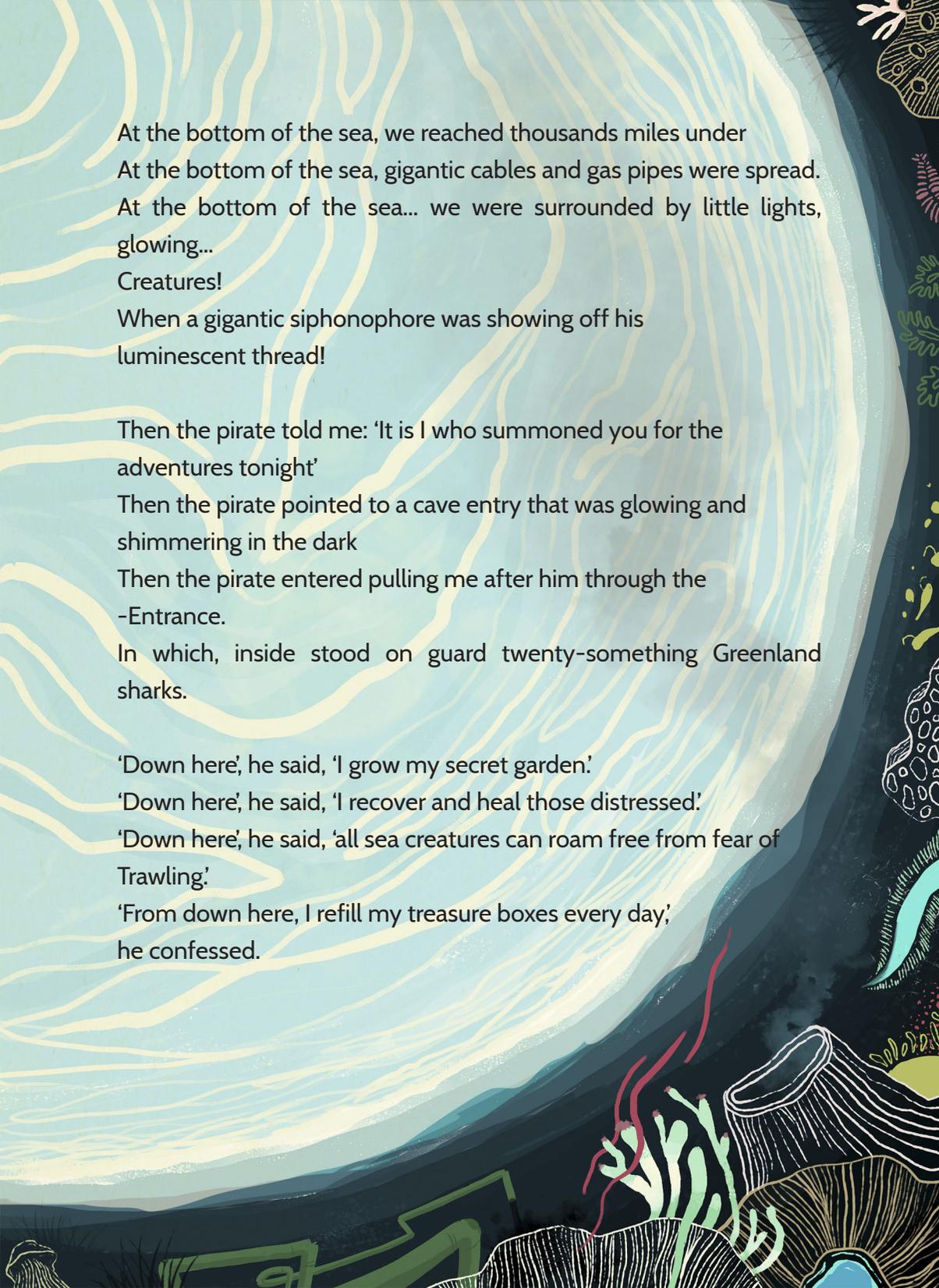
Once this was done, a pack of whales appeared out of the blue

Once this was done, he turned around and reached out to me

And said:

'Ride with us, down a big slope to the deep deep ocean and through!'





At the bottom of the sea, we reached thousands miles under
At the bottom of the sea, gigantic cables and gas pipes were spread.
At the bottom of the sea... we were surrounded by little lights,
glowing...
Creatures!
When a gigantic siphonophore was showing off his
luminescent thread!

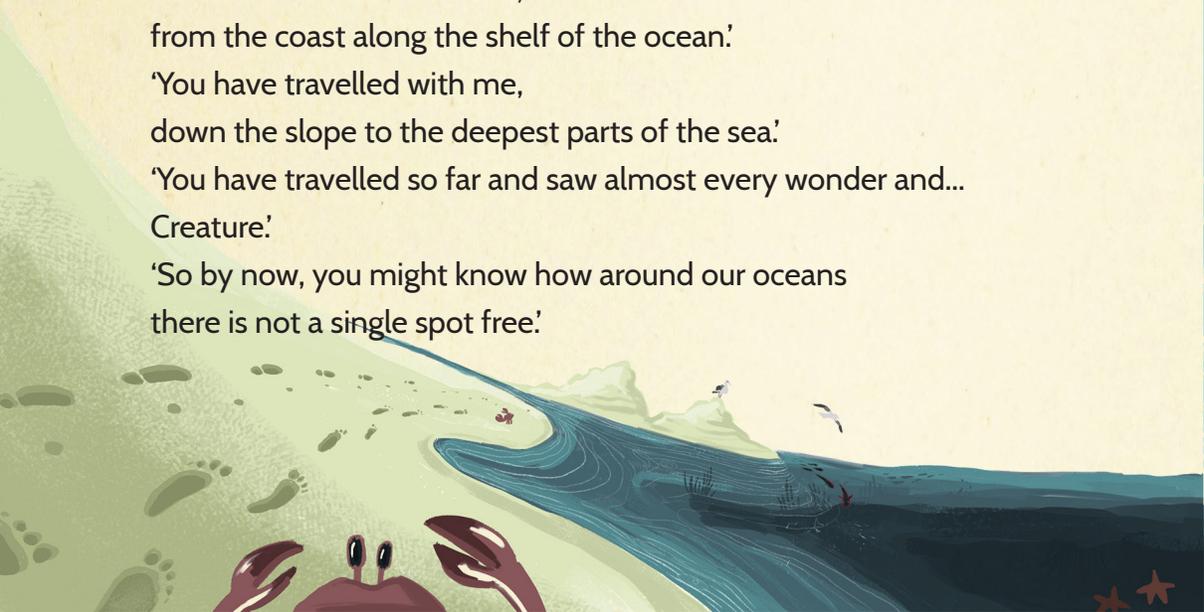
Then the pirate told me: 'It is I who summoned you for the
adventures tonight'
Then the pirate pointed to a cave entry that was glowing and
shimmering in the dark
Then the pirate entered pulling me after him through the
-Entrance.
In which, inside stood on guard twenty-something Greenland
sharks.

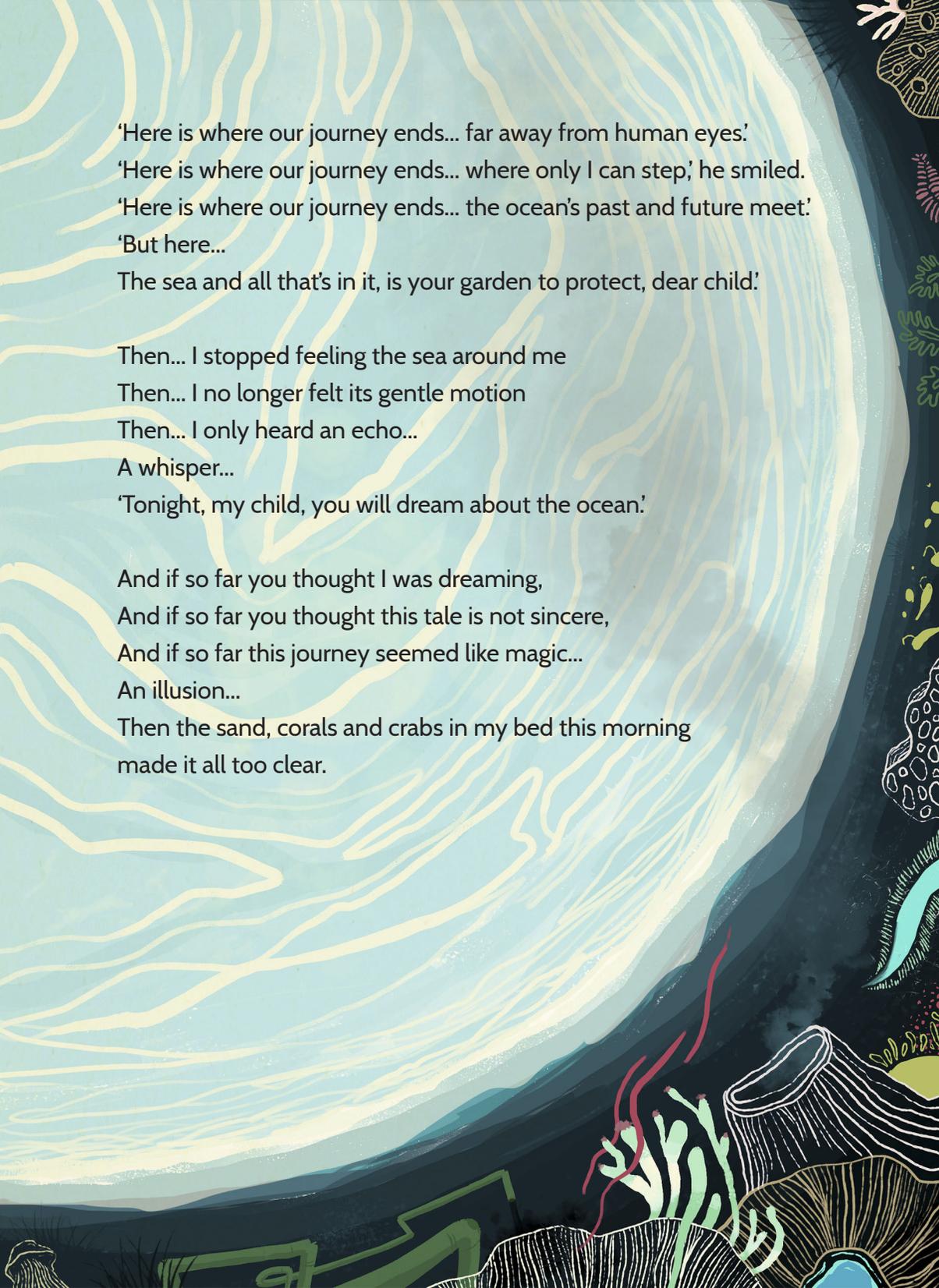
'Down here', he said, 'I grow my secret garden.'
'Down here', he said, 'I recover and heal those distressed.'
'Down here', he said, 'all sea creatures can roam free from fear of
Trawling.'
'From down here, I refill my treasure boxes every day,'
he confessed.

We continued travelling, passing sunken ships
with treasures spilling from their broken guts.
We continued travelling along molten sulphur
-pools where only flat fish can survive.
We continued climbing over fire spitting submarine -
Volcanoes.
When we reached to the mid-ocean ridge,
where huge worm tubes feast and thrive.

I could no longer hold the questions...
how's and why's flew out of my mouth.
I could no longer hold...
'Do you throw all the dirty treasure boxes outside?'
I could no longer hold...
'How do you manage to clean all the oceans?...
By yourself?'
And a thousand more questions filled my head when he replied:

'You have travelled with me,
from the coast along the shelf of the ocean.'
'You have travelled with me,
down the slope to the deepest parts of the sea.'
'You have travelled so far and saw almost every wonder and...
Creature.'
'So by now, you might know how around our oceans
there is not a single spot free.'





'Here is where our journey ends... far away from human eyes.'
'Here is where our journey ends... where only I can step,' he smiled.
'Here is where our journey ends... the ocean's past and future meet.'
'But here...
The sea and all that's in it, is your garden to protect, dear child.'

Then... I stopped feeling the sea around me
Then... I no longer felt its gentle motion
Then... I only heard an echo...
A whisper...
'Tonight, my child, you will dream about the ocean.'

And if so far you thought I was dreaming,
And if so far you thought this tale is not sincere,
And if so far this journey seemed like magic...
An illusion...
Then the sand, corals and crabs in my bed this morning
made it all too clear.

Actions towards a (more) sustainable lifestyle... or how to keep a friendship with planet Eddie Earth!

Célia Santos and Andrea Orfanoz-Cheuquelaf
Illustrations Carolina Guarnizo Caro

Our habits and daily choices have a huge impact on the environment we live in. We are part of this large ecosystem which we call Earth. Our actions are deeply interconnected with the other parts of this system: physical environment (air, water, soil, etc.), biology and ecology (living beings and their interactions) and culture (communities, societies, languages, politics, arts). The way we decide to live our lives has a direct effect on ourselves, on our local communities and, to a large extent, on the society and the planet.

In this e-book you have read interesting stories about the challenges that our oceans currently face: anthropogenic climate change and global warming (for example, the rise of the sea level and water temperature), habitat destruction, species extinction and pollution caused by (micro-)plastics in the sea. It is up to us to decide, if we want to be a part of the problem or if we rather want to be a part of the solution. Instead of being overwhelmed by a dark scenario, we prefer to organize ourselves and develop strategies that promote a change toward a more eco-friendly and a fair society.

There are a lot of small actions which can make a difference. Daily choices which contribute to a more responsible, ethical and

ecological way of living. Daily actions which make ourselves, our society and our planet happier!

Maybe some of these actions are already part of your daily life. Maybe there are others you already thought of while reading this e-book. Maybe you have other ideas you would like to share and discuss with your friends and family or even with us. And that is great! Educating ourselves and being open to participate actively in a discussion about protection and fair use of the environment, are necessary to make our society and our planet a better place to live (for us, our children and our grandchildren).

Here, we are suggesting a few ideas which you can use to become part of the solution and help to mitigate the human-made climate change. Together, we can raise awareness about our responsibilities towards our environment, our fellow humans and also about all the other living organisms - our neighbors who share planet Eddie Earth with us. Together we can protect our oceans!

Please, keep in mind that we don't expect you to see these suggestions as a strict set of rules. It is important that you try by yourself and find out what you feel comfortable with. Choose one idea which resonates with you the most, and develop your own strategy to put it in practice. Once you are comfortable with your new habits and routines, choose another suggestion and so on. Every little step counts!

Living a more sustainable life is a collaborative process. This way, we want to invite you to contribute with your own ideas and discuss them with your friends, family, teachers and with us. This is just a beginning: You have the main role in this story now! You can now take over the roles of Inara, Aurea and the Captain, Isa or the Pirate and take actions to contribute to a sustainable way of living. We are all in this together!



Suggestions for a sustainable lifestyle

- Whenever possible, avoid (taking) airplanes! Try to take the train, the bus or share a car. Choose the bicycle or other eco-friendly public transports for your daily commuting or short-distance travelling!
- Try to avoid that your food takes airplanes as well! Prefer local and seasonal products. Visit your local farmer's market!
- If you do not do it already, why not considering having a few meals a week without meat or fish? If you eat meat or fish, choose sustainable sources!





- Inform your family and friends to prefer and use – whenever possible – renewable energies.
- Avoid using disposable objects and/or packages made of plastic. Use your own cups, bottles or shopping bags which you can re-use. Avoid cosmetic and cleaning products which contain microbeads. Develop your action plan for a life without plastic!
- Use the things (clothes, toys, tools, etc.) which you already have, repair broken objects, swap the things which you do not use or need any more with your friends. In case you need to buy something, prefer second hand. Are you really sure nobody can use something anymore? Recycle it!
- Organize a discussion group with your friends where you can learn collaboratively, share ideas and promote more actions towards environmental protection.

If you need more information or wish to share your own ideas with us, we invite you to follow this link:

<https://www.marum.de/en/Discover/Once-upon-a-time/Stories.html>

Would you like to contact us and share your ideas with us?

You will find the Once Upon a Time project at Facebook (Once upon a Time a Scientific Fairytale – OUAT), Twitter (@OUAT_sci_story) or you can contact us via email (ouat.scientific.story@gmail.com).



Would you like to know more?

Airplane CO₂ emissions: Don't take the plane! Take the train!

According to the European Environment Agency (EEA), if you choose to use a train as a mean of transportation, with a capacity of 156 passengers, it emits 14 grams of Carbon Dioxide (CO₂) per kilometer. For a shared car of 4 passengers, it emits 42 grams per kilometer. A car with 2 passengers emits 158 grams of CO₂ per kilometer per person. The emission rate of an airplane with the capacity of 88 passengers is 285 grams of CO₂ per kilometer per person (EEA report TERM, 2014: <https://www.eea.europa.eu/media/infographics/co2-emissions-from-passenger-transport/view>). If you take an airplane from Bremen to Rome (1274 km) it emits 363 kilograms of CO₂, which is approximately the same emitted amount of CO₂ as if you burn 220 kilograms of wood (<http://www.paperonweb.com/A1110.htm>). Consider that CO₂ is 65% of the global greenhouse gas emissions (IPCC, 2013).

Less animal products

Please see page 65 to learn more about the environmental consequences of animal farming.

Renewable Energies

Please see page 81 to read more about renewable energies.

Plastics in the sea

Please see page 145 to learn more about the environmental consequences of the plastic marine litter.

You can find more information in the following online articles:

“More garbage than Fish” (in English)

<http://news.grida.no/more-garbage-than-fish-the-worlds-largest-beach-clean-up>

“Plastic can end up on your dinner plate” (in English):

<http://news.grida.no/plastic-can-end-up-on-your-dinner-plate>

“This company turns plastic bottle trash from the ocean into clothing (in English):

http://www.huffingtonpost.com/entry/this-company-turns-used-plastic-bottles-from-shorelines-into-clothing_us_57d17909e4b06a74c9f301f3

“Upcycled ocean plastic”:

<http://ocean.si.edu/ocean-news/upcycled-ocean-plastic>

“Pacific garbage screening will remove tons of plastic waste from the ocean” (in English):

<https://utopia.de/pacific-garbage-screening-plastic-60278/>

Microplastic pollution:

Plastic microbeads are used in some cosmetic (toothpaste, facial cleansers, scrubs, shampoos, sunscreens, etc.) and cleaning products as physical abrasives. The most common microbeads used in these cosmetics products are Polyethylene (PE), Polypropylene (PP), Polyethylene Terephthalate (PET), Polymethyl methacrylate (PMMA) and Nylon. However, there are more than 60 different

microplastics ingredients currently used in cosmetics, medical and cleaning products. Microbeads can be harmful for the marine life, since marine animals can mistake them for food. Additionally, plastic particles are not biodegradable, so once they enter into the marine environment, they cannot be removed or degraded naturally. This way, any product containing these ingredients should be avoided. You may find more information about microbeads in cosmetics, the scientific evidence about microplastic ingredients and how to identify the products which do not contain them at “Beat the Microbead” website (<http://www.beatthemicrobead.org/>).

Additionally, you may find more detailed information about microplastic pollution here:

Browne M.A. (2015) Sources and Pathways of Microplastics to Habitats. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, Cham (https://link.springer.com/chapter/10.1007/978-3-319-16510-3_9).

“How many planets Eddie Earth does it take to keep up your lifestyle?”

The amount of natural resources which can be regenerated by Eddie, the planet earth, are limited. It is important to be conscious that the continuous production of new goods and products implies the use of these natural resources and, in certain cases, the pollution of the environment. “Do I really need something new or can I be satisfied with what I have?” Or “Was this object produced being respectful with the workers which made it and the environment?” These are important questions to reflect upon sustainability. Take into consideration that recycling also implies resources, consumption (water, energy), therefore, re-using is more environmentally sustainable. “How many planets Eddie Earth does it take to keep up your lifestyle?” You may calculate your ecological footprint here: <http://www.footprintcalculator.org/#/>

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