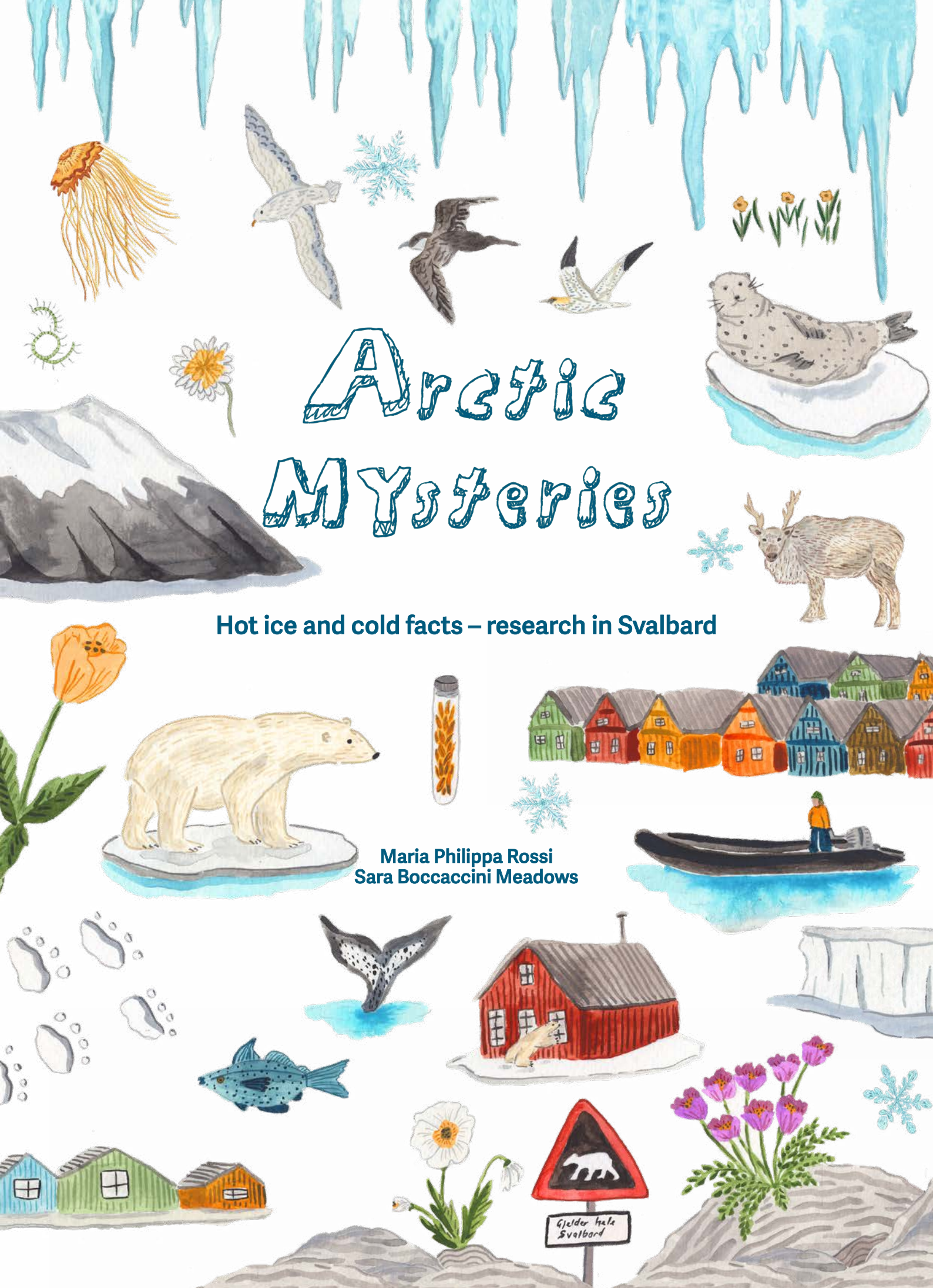
Arctic
Mysteries
Hot ice and cold facts – research in Svalbard
Maria Philippa Rossi
Sara Boccaccini Meadows
Gjelder hele
Svalbard

Svalbard

N
W
E
S

Polhavet

Nordaustlandet

Liefdefjorden

Spitsbergen

Blomstrandhalvøya

Ny-Ålesund

Skansbukta

Eskerdalen

Longyearbyen

Marmorbreen

Edgeøya

Rindersbukta

Hornsund

Hopen

Arctic Mysteries

Hot ice and cold facts – research in Svalbard

Maria Philippa Rossi
Sara Boccaccini Meadows

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Maria Philippa Rossi (born 1984) is a freelance journalist living in Longyearbyen in Svalbard. She writes about people, outdoor adventures and science, and sleeps best in a tent. Maria's previous work includes the book *Verdens fineste fjellturer (The World's Best Mountain Hikes)* (Fri Flyt, 2015). *Arctic Mysteries* is her first children's book.

Sara Boccaccini Meadows (born1986) is an artist, illustrator and print designer from England, but now she calls Brooklyn, New York her home. Through her art, she reminds us of the importance of protecting nature. Sara has written and illustrated several books for children and adults.

Contents

Welcome to Svalbard!

Let's go to Svalbard! Svalbard is a Norwegian archipelago – a group of islands – far out in the Arctic Ocean, just south of the North Pole. Svalbard is a special location for all kinds of research, and that is what this book is all about.

Doing research means investigating and discovering new things. I am not a scientist myself; I am a journalist. I also like to investigate and discover things, but I do so by interviewing people and asking questions.

The scientists I have spoken to while working on this book are all experts in different fields. Some know a great deal about polar bears or tiny crustaceans, while others are brilliant at Northern Lights or glaciers. These scientists will help me explain all the fascinating, strange and unknown things happening in the Arctic.

Living in Longyearbyen for many years has allowed me to see how the environment has changed around me. The glaciers nearest town have melted and shrunk. There is an unusually high number of storms every winter, and the weather is warmer all year round. With the higher ocean temperatures, I have been seeing less and less sea ice, followed by more and more new species of fish in the fjords.

In fact, Svalbard is one of the places on Earth where it is easiest to notice that something is happening to our environment.

We need knowledge to understand what is going on and to help us make smart decisions to protect our planet.

That is where the scientists come in! They are extremely good at searching for knowledge. They go out into the field and collect data. Then, they try to find answers about glaciers, about the flowers growing on the tundra, or about the gas seeping out of the ground. They are curious; they want to know more!

Have you ever heard that children are scientists by nature? I bet you are a curious person who asks a lot of questions! Like: What will happen then? Can you explain that again? What do you mean? Why is that?

These are excellent questions to ask when you are doing research.

Next time your mum or dad says you are asking too many questions, just tell them: 'This is for science!'

DENMARK

ICELAND

NETHERLANDS

RUSSIA

SWITZERLAND

AUSTRALIA

GERMANY

UKRAINE

CANADA

NORWAY

SYRIA

BRAZIL

FRANCE

SWEDEN

PHILIPPINES

CZECH REPUBLIC

The largest settlement in Svalbard is Longyearbyen. People from over 50 different countries live here. There are two Russian settlements in Svalbard, called Barentsburg and Pyramiden. In the settlements Ny-Ålesund and Hornsund, you will find research stations that run all year round.

THAILAND

JAPAN

INDIA

PRIDE

SLOVAKIA

SPAIN

ARGENTINA

PORTUGAL

ITALY

USA

And you do not have to wait until you are a grown-up to do research. You can start right away! Next time you see something strange or exciting out in nature, try asking questions like a scientist: Why is that happening? How can I find out more?

There are many 'TRY IT YOURSELF' experiments in this book. Maybe they will help you find out more? Think like a scientist and see what happens when you do them.

You will also learn about something called citizen science. Citizen science is practised by people who are not scientists. Nevertheless, they can still contribute to science by gathering information and making observations.

It is possible to do scientific research on almost anything: people, animals, plants and rocks. You can research history, the body or teddy bears. You can even do research on researchers! How cool is that?

Gabrielle Kleber
– Methane

Jon Aars
– Polar bears

Kristine Bakke Westergaard
– Non-native species

Cheshtaa Chitkara
– Phytoplankton

Heïdi Sevestre
– Glaciers

Alex Klein-Paste
– Snow and ice

Maria Jensen
– Coal

These scientists will join us across different chapters – keep on reading to find out where!

Geir Wing Gabrielsen
– Environmental toxins

Lauren Philippa Peach
– The ocean

Katie Herlingshaw
– Northern Lights

Hanne Hvidtfeldt Christiansen
– Permafrost

Robynne Nowicki
– Zooplankton

Hi – or "Hei" as we say in Svalbard. This is me, Maria. I am a journalist and have written this book.

Each chapter will introduce two slightly tricky words that you might not have heard before. They will be explained along the way.

So, are you ready to get started? Welcome to Svalbard!

Maria

The ocean and landmasses surrounding the North Pole are what we call The Arctic. It borders Norway, Finland, Alaska (a state of the USA), Canada, Greenland, Iceland and Russia.

The break-in

I felt a chill run down my spine as I read the message to my kids.

There are no thieves in Svalbard. At least, that is what I have been telling them.

'What happened?' they asked.

'I don't know, but I will go find out,' I said.

The burglar had broken one of the windows and climbed into the kitchen. There must have been a tremendous ruckus as the thief pulled out every drawer, stomped all over the cutlery and ate the whole jar of chocolate spread. Indeed, it was licked completely clean.

The cabin is not far from our home; I can actually see it from our living room window. Despite already living at the end of the world, many people in Longyearbyen love going to even more remote cabins in their spare time. We enjoy being as close to nature as possible up here.

It was people from the Governor's office, the island's police, who realised what had happened when they were out on their patrol ship. They were standing on the ship's bridge, looking towards the cabin with a thermal imaging camera.

Guess what they were looking at!

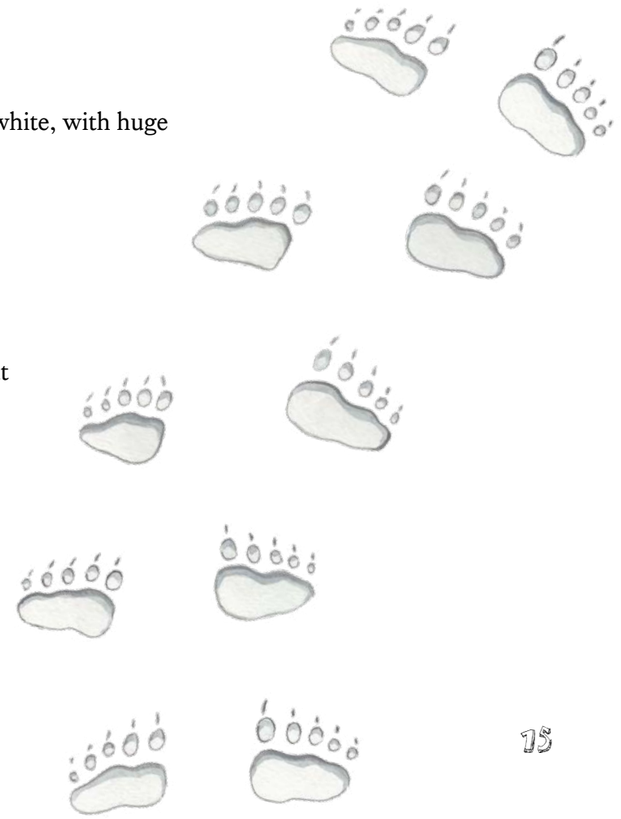
A huge, fuzzy creature lurking nearby! It was white, with huge paws and small ears.

So, it was not a burglar or a thief after all.

It was a polar bear!

I thought it was funny that the polar bear had enjoyed our Nugatti (the chocolate spread), but it was no fun having to clean up after it.

Now, every time I see a jar of Nugatti, I think about polar bears and wonder how they are doing.



It's dinnertime

'Look! A reindeer! Far up the mountainside!' I shout.

We are on a ship in Skansbukta – a pretty little bay with steep mountains on one side and a rocky beach on the other.

People are standing on the deck, looking up and pointing. We stare at a reindeer, which has climbed high up on the steep mountainside. It seems incredible that it does not fall.

A couple of years ago, a nature photographer spotted something truly remarkable here. Through his camera lens, he spotted a polar bear mum with her cub.

But that was not all.

The polar bear mum had locked her eyes on a reindeer. That one was not high on the mountainside, but was strolling casually along the beach. Mama Bear quickly decided they would have reindeer for dinner.

She crept closer. Held her breath. Waited.

Then she leapt forward, bounding towards her prey as fast as she could.

The reindeer did not stand a chance. Yum yum. Bon appétit.

Over short distances, polar bears can run as fast as 40 kilometres per hour. They can also swim at a speed of nearly 10 kilometres per hour.

HIGHER TEMPERATURES, LESS SEA ICE

The polar bear is a pretty cool animal. In just a few months, this big ball of fur eats nearly all the food it needs for the entire year.

Just imagine yourself munching piles of ice cream, sausages, pork chops, cheese, watermelon, pizza, chocolate cupcakes, waffles, bananas, burgers, doughnuts, popcorn, apple pie, fried eggs, tomato soup, pancakes, tacos and lasagna – ALL of that just during your summer holidays and then only eating a few dry biscuits for the rest of the year.

You have heard that our planet is getting warmer, right? The higher temperatures come with various consequences. In Oslo, Norway, people might go outside wearing a T-shirt in April. In Southern Europe, higher temperatures can cause extreme heat and heatwaves, which can be dangerous for both people and animals. In Svalbard, the ocean is getting warmer, and a warmer ocean means less sea ice.

Freshwater freezes at 0°C while saltwater freezes at -1.8°C. This means that seawater has to cool down to minus degrees Celsius before starting to freeze.

Sea ice functions like a dinner plate for polar bears. This is where seals live and have their pups. Seal is a polar bear's favourite food. Forget about the chocolate spread. As the ice melts, there are fewer places for polar bears to hunt for seals. They are forced to find prey ashore, and that is where they can stumble upon reindeer!

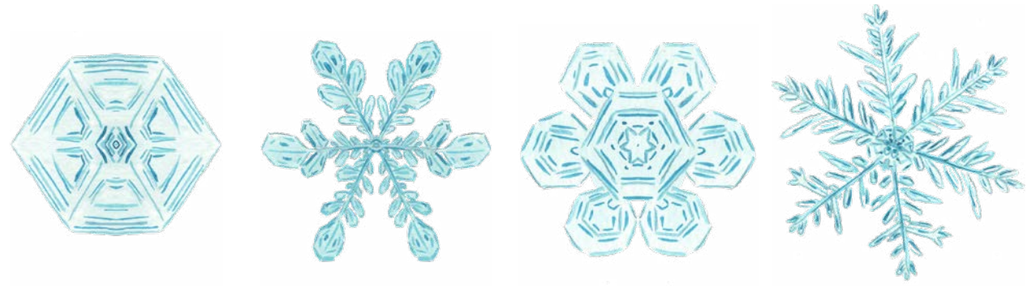
Despite there being less sea ice, polar bears are still thriving in Svalbard. Half of the archipelago is covered in ice and snow all year round. In Svalbard, the Norwegian Polar Institute studies polar bears.

One of the scientists who has studied polar bears the longest is Jon Aars. He says there are several reasons why it is more common to see polar bears eating reindeer these days.

Not only are polar bears spending more time on land, but there are also more reindeer than before. There is simply more food wandering around on the tundra.

In fact, some scientists think it would be good if polar bears learned to eat reindeer. The sea ice seal buffet is vanishing, so levelling up their reindeer-hunting skills would give them more to eat all year around.

Today, there are also more people visiting and living in Svalbard than ever before. In every crack and fjord, there is someone with a big camera who can take pictures and document what the polar bears do.



The Norwegian Polar Institute is eager to know more about the polar bears that hunt reindeer. They greatly appreciate people reporting their interesting sightings of polar bears. This is when it becomes important to think like a scientist and note down as many details as possible.

But remember: keep your distance from the King of the Arctic!

EAT ALMOST ANYTHING

Polar bears are opportunistic. They look for opportunities and eat whatever food they come across, whether it is reindeer meat or eider duck eggs, or yeah, chocolate spread. Scientists have observed polar bears eating berries, seaweed and grass. They have been spotted climbing cliffs where birds are nesting. They can even eat walrus, and if a whale carcass should happen to wash ashore, there will be an all-day, all-night beach party. Jon says a large whale can feed several polar bears for over a year.

Since 1987, scientists in Svalbard have been collecting samples from polar bears. To get close enough, they shoot the polar bear with a tranquilizer dart. As the bear sleeps, the scientists collect their samples. Some of the bears are fitted with collars that hold GPS trackers, and a few of them even have small heart-rate monitors placed under their skin.

Scientists only put collars on female bears. Male bears have huge cone-shaped necks and heads, making it difficult for the collars to stay on.

GPS stands for Global Positioning System.

The GPS collars tell the scientists where the polar bears are, and the heart-rate monitors show what they are doing and how they are. Are they asleep? Tired? Have they just gone for a run? The scientists receive data on all of this.

Every year, 10–20 polar bears are fitted with GPS trackers and heart-rate monitors. This provides scientists with loads of important information about the lives of polar bears.

In the past, many trappers lived in Svalbard. They were hardy people who stayed in small cabins far from other people.

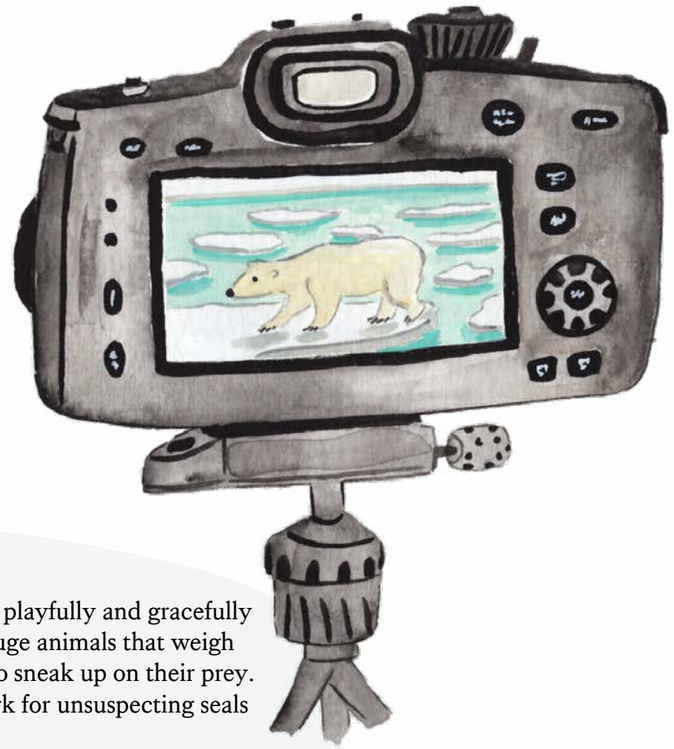
The trappers made a living from hunting polar bears, arctic foxes, ptarmigan and reindeer. In 1973, it was decided that killing polar bears was no longer okay, so the polar bear became a protected species.

As a consequence, it is illegal to hunt or kill them. You are also not allowed to taunt or mistreat them or try to lure them closer to you. So go fry your bacon somewhere else!

IN THEIR DENS

Polar bear cubs are born around New Year's Eve. At birth, a cub weighs just half a kilogram – the same weight as a small bottle of water. After a few months in the dark den with its mother, the cub crawls out through the snow, into daylight and spring. It weighs around 10 kilograms now. The cub stays with its mother for two and a half years. Then, it heads out into the world on its own.

Only animal babies are born in Svalbard. Longyearbyen only has a small hospital, so pregnant women who live in Svalbard have to travel to the Norwegian mainland at least three weeks before they are due to give birth.

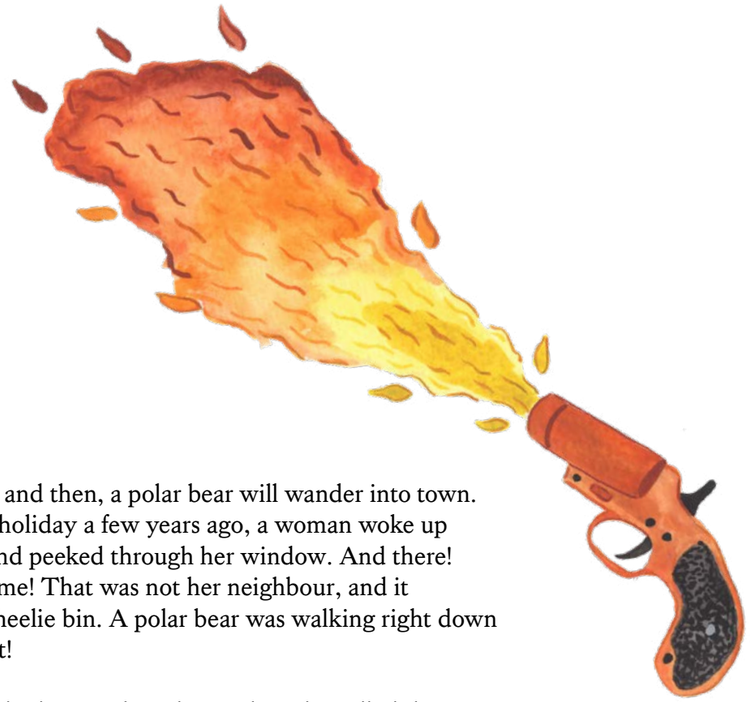


Polar bears are majestic, and they move playfully and gracefully through the landscape. Despite being huge animals that weigh up to 800 kilograms, they are still able to sneak up on their prey. Like giant, furry ballet dancers, they lurk for unsuspecting seals on the ice.

Although polar bears are found in numerous pictures from Svalbard, people living in Longyearbyen rarely see these large bears in their everyday lives. Polar bears live in solitude, except during the years the mothers spend with their cubs. They are the kings and queens of the Arctic, and dangerous predators. So, it is actually a good thing that they prefer to stay far away from people.

What's a polar bear's favourite part of a house?

THE SEALING



However... every now and then, a polar bear will wander into town. During the Christmas holiday a few years ago, a woman woke up early in the morning and peeked through her window. And there! You got to be kidding me! That was not her neighbour, and it definitely was not a wheelie bin. A polar bear was walking right down the middle of the street!

First, she filmed the polar bear on her phone, then she called the police. They soon arrived and scared the bear away. Afterwards, the police told the lady off for not calling the officials before filming the bear.

What should you do if you meet a polar bear? Make a ruckus! Most polar bears do not like loud sounds or noise.

What do you think is the noisiest thing in the world?

A flare gun is often used to scare away polar bears. It looks like a handgun but shoots fireworks instead of bullets. If you are in a cabin, you could also try banging two saucepan lids together – that makes a racket, too.

But it is always best when polar bears can live peacefully, far away from people.

Breath from the sea

In summer, pods of beluga whales sometimes swim all the way into the shallows of Adventfjorden. From my kitchen window, I can see their white backs dipping up and down through the water's surface. I once counted more than thirty of them!

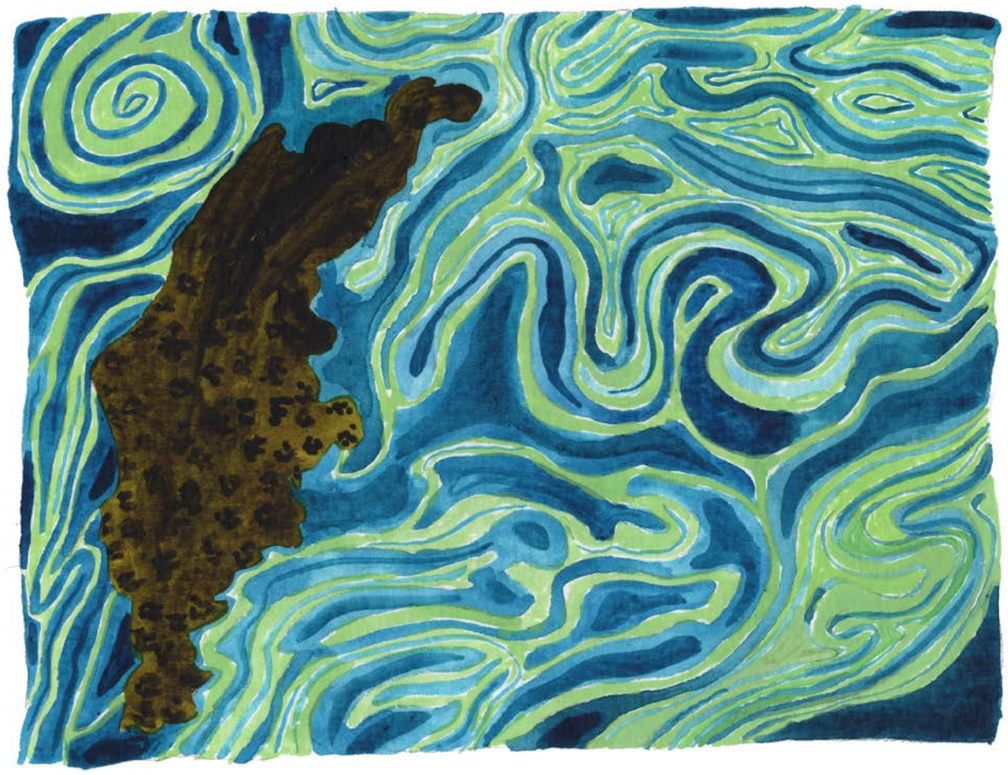
A small huddle of walruses often settles just outside the town. They lie there, farting and enjoying themselves under the midnight sun.

Midnight sun, what was that again? Because we are so far up north here, it stays light outside all day and all night from April to August. Even at midnight, the sun sits high in the sky in Svalbard. It simply refuses to go to bed! Falling asleep can be a bit difficult with the sun shining into your bedroom.

Read more about the opposite of the midnight sun in the Northern Lights chapter on page 50.

'Could you pass me my sunglasses? They're at the top of my rucksack,' says marine biologist Cheshtaa Chitkara.

Cheshtaa studies phytoplankton. She has just managed to start the engine, and the small rubber dinghy is puttering toward a GPS location in the fjord.



No buoy or flag is telling her where the right spot is. Only the GPS can confirm: ‘Yep, this is it.’

The fjord is completely still this afternoon, and the mountains are reflected in the glossy surface. There is hardly any snow anymore on their peaks.

BILLIONS AND TRILLIONS

It is not just above the surface that you can see the seasons changing. You will find clear evidence beneath, too, and that is what Cheshtaa is looking for.

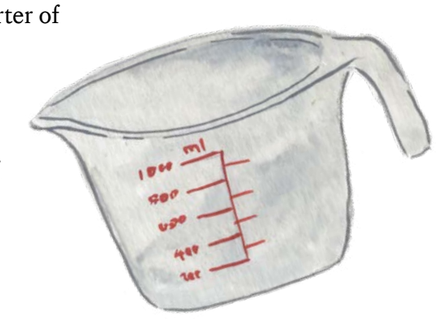
Phytoplankton are tiny microalgae that float freely through the water. Each phytoplankton is made up of a single cell. They rely on wind and ocean currents to carry them across great distances.

‘Here we are!’

Cheshtaa has reached the GPS location, and she lowers a bottle-like device into the sea. Its correct name is “Niskin bottle”. It was invented by the Norwegian polar explorer Fridtjof Nansen and was therefore first known as a Nansen bottle.

The Niskin bottle is a cylinder that is lowered into the sea. When Cheshtaa sees that it is deep enough, she triggers a spring mechanism that closes both ends. She pulls the bottle back up, excited to learn what is in the water sample.

She only needs a single drop, but since it is difficult to keep track of one teeny, tiny drop, she usually ends up with about a quarter of a litre.



In a sample like this, there can be several hundred million cells! Scientists count how many are present in just 0.01 millilitres of water, but they still find thousands of phytoplankton cells.

Wow, that is a lot!

You cannot see phytoplankton with the naked eye, but, amazingly, you can see them on satellite images from space. When billions of phytoplankton swarm together, it is called an algal bloom. This usually happens in spring. When there is such a crazy number of them, they can turn the sea brown, red or green.

Have you seen a fjord turn turquoise green during an algal bloom in spring?

SPLOTCHES AND BLOBS

Before Cheshtaa began studying phytoplankton, she imagined them looking like little, green blobs.

‘Imagine my surprise when I looked through the microscope for the first time!’

She waves her arms enthusiastically.

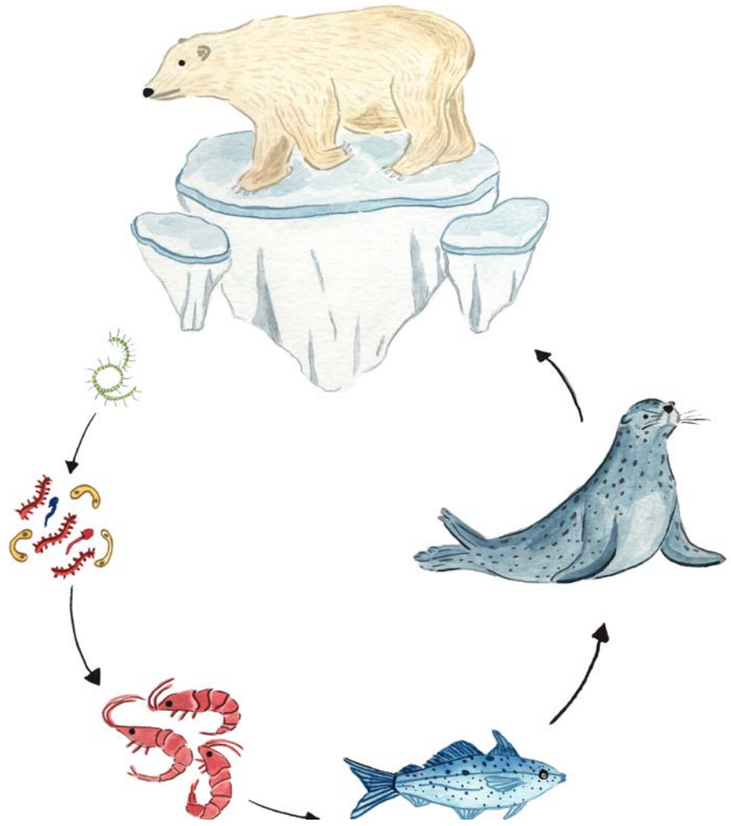
‘The phytoplankton was so beautiful! Some were shaped like long sticks, others like a row of pearls. Some were small, spiky circles, almost like shining stars.’

Some types of phytoplankton use their shape as protection from predators.

Copepods – which you will learn more about in a moment – love phytoplankton. Basically, phytoplankton are at the very bottom of the food chain.

A food chain shows us who eats what in nature.

Phytoplankton are eaten by copepods, which are a type of zooplankton. Copepods are eaten by small fish. Small fish are eaten by larger fish, and so on and so forth. That makes plankton the foundation for all other life in the sea.



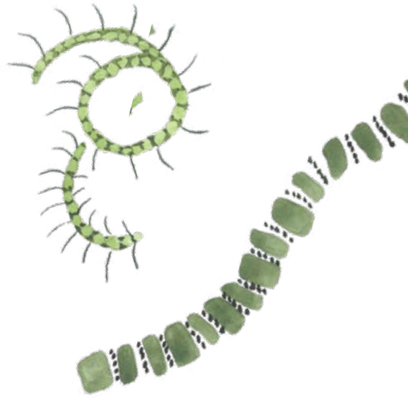
But we can thank phytoplankton for more than just being able to eat fish on Fridays. Phytoplankton are the trees of the sea. They produce about half of the oxygen in the Earth's atmosphere.

'They're small, but mighty!'

Cheshtaa laughs and explains that phytoplankton produce more oxygen than the whole Amazon rainforest.

'That's pretty wild!'

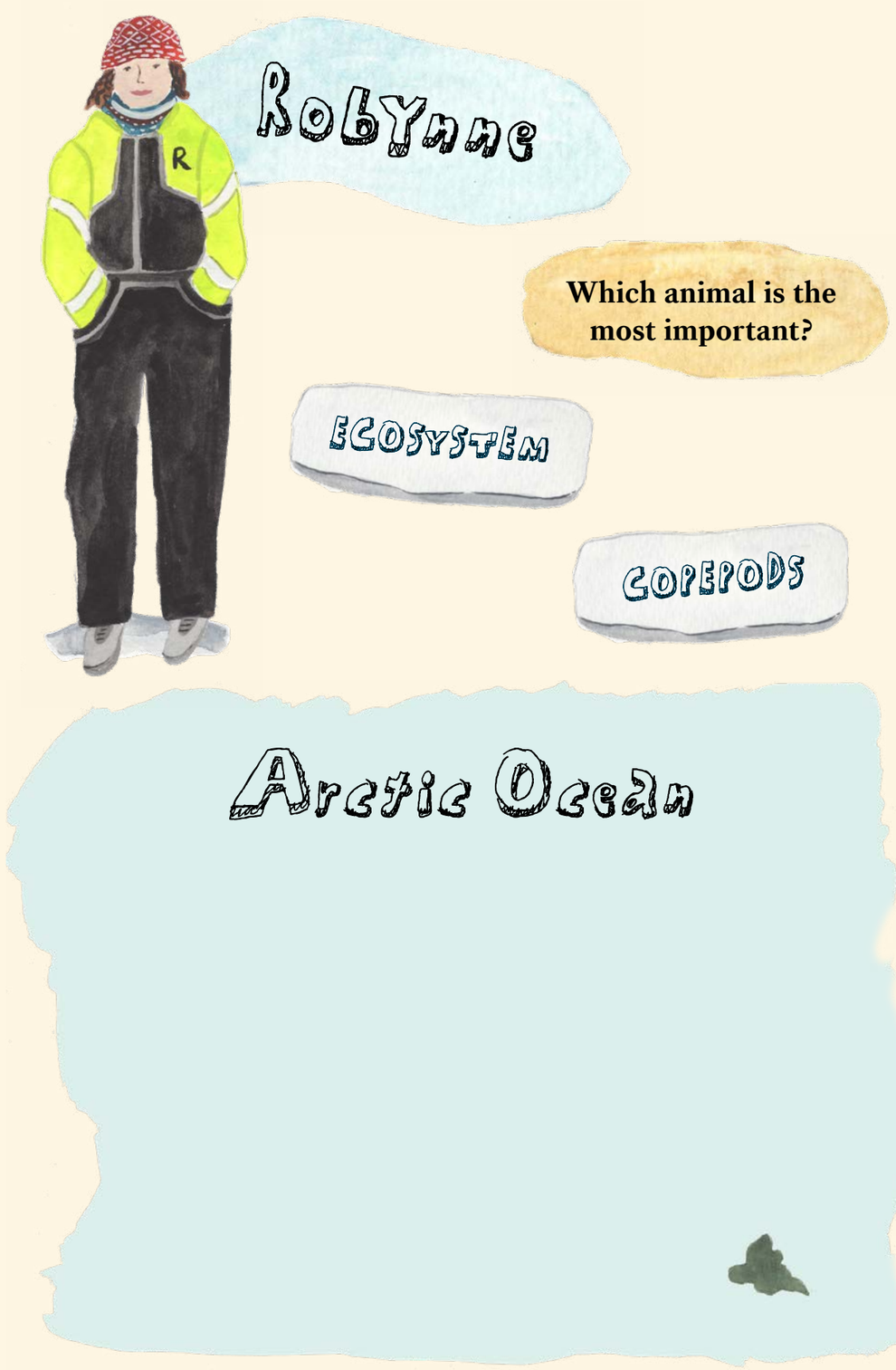
TIME SERIES
Once Cheshtaa has collected samples from the same location over a longer timeframe, she starts comparing the results. Can she notice any changes?



Change is exactly what Cheshtaa and other scientists are curious about. It allows them to ask more questions and continue their detective work. Is the number of phytoplankton increasing or decreasing? Is there more or less variety in different species?

Research projects often take many years to complete. Scientists can start reporting on whether or not there are changes once they have observed the same thing for twenty, thirty or forty years. This is called a time series. With a long time series, scientists are able to see connections to, and effects on, the rest of the food chain and predict what may happen in the future.

'Phytoplankton form the basis of the entire marine food web. Changes in the phytoplankton can change the entire ecosystem. That's why it's so important to study them,' Cheshtaa explains.



Small but mighty

Every summer, more than a million pairs of little auks nest in Svalbard. The little auk is a small bird weighing 200 grams – just about the same as a large chocolate bar.

If you get close to one of the hundreds of colonies on the archipelago, you might hear a sound like 'kreee-ack ack ack ack ack!' And when you do, you can be pretty sure that there are heaps of copepods nearby in the ocean, as that is what little auks like to eat.

Copepods are a major food source for numerous animals that live in the sea. Many species of fish, seabirds and even whales eat copepods. Copepods are small crustaceans, brimming with fat. Fat makes up more than half of their body.

There are 8,500 different species of copepod in the world. The three species that live in the Arctic are *Calanus finmarchicus, Calanus glacialis,* and *Calanus hyperboreus.*

Those are scientific names. Luckily, the scientific name for the little auk is nice and simple: *Alle alle*.

Scientists worry that as the ocean warms, other species of copepods will arrive from the south. These species are not as fatty as the ones that already live in the Arctic. If each tiny copepod contains less fat,

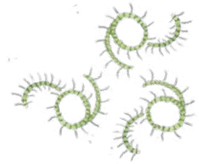
the predators that eat them put on less weight, too. This means the entire food chain of birds, seals and whales may become thinner. In the Arctic, being fat and well-fed is a means of survival.

Scientists are trying to understand how nature will cope when the climate changes. How much can the ecosystem withstand before it is in trouble? When we understand how much an ecosystem can handle, governments can protect the fragile environment by creating necessary laws.

An ecosystem consists of all the species that live in a particular environment and the environment itself. Some ecosystems are small, like a lake or a tundra. There are also large ecosystems, such as planet Earth, where all living organisms form a single, gigantic ecosystem.

Do you live far from Svalbard? If so, you may wonder if any of this affects you. Yes, it does! The whole world is connected like a gearbox. Changes in one place have consequences in another. Like when plastic is thrown into the sea right off the US coast and can get carried all the way to Svalbard by ocean currents.

Read more about plastic floating in the ocean on page 106.



And what happens in the Arctic does not stay in the Arctic, either.

WHAT DO YOU WANT TO BE?

Robynne Nowicki grew up on the Gulf Coast of Florida. The ocean was her next-door neighbour.

She had dreamed of working with the cool animals in the ocean ever since she was six years old. She was never in doubt – Robynne would grow up to become a marine biologist.

'Think about everything that lives in the sea! It's so close to us, yet so strange and mysterious. I'm still amazed by how little we know about our oceans. It's still as exciting as when I was a kid,' says Robynne.

She explains that most people think of *megafauna* when they think about life in the ocean – meaning large animals like dolphins, sea turtles and fish.

'Zooplankton are these amazing little aliens that often fly under the radar,' she says with a knowing grin.

'Aliens?' I look at her sceptically.

'Yes, aliens! Search for an image of *Themisto libellula* and tell me it doesn't look like an alien,' she laughs.

TRY IT YOURSELF

Search for an image of *Themisto libellula*.

‘These tiny creatures, ranging from a few micrometres to a few centimetres in length, are powerful engines in the ocean. I think it is incredible that something so small plays such an important role.’

THE STRONGEST OF ALL

‘Want to see?’

Robynne steps back, and I peer into the microscope.

Boing. Boing. BOING!

‘Wow!’

Despite being tiny, copepods possess tremendous muscle strength – the greatest ever measured in any animal, in comparison to their body size.

It jumps back and forth in the Petri dish. *Boing. Boing. BOING!*

Not only do copepods have incredible strength, but did you know they are also some of the most crucial animals in the Arctic? No, I am not kidding! Maybe you thought it would be one of those big, furry animals? No – these little creatures are among the most important.

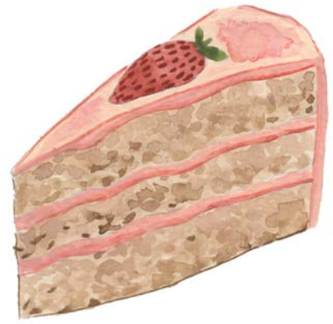
Without copepods, the entire Arctic ecosystem would collapse. Copepods are responsible for the well-being of fish, seals and polar bears. They are the link in the food chain between phytoplankton and the larger animals of the Arctic, and they form the foundation for an enormous variety of life – like fish, seabirds and whales.

Robynne says that the better we understand the lower levels of the food chain, the easier it gets to understand how the entire ecosystem is connected.

‘This is especially important in our rapidly changing oceans, where any change can send major ripple effects through the whole ecosystem.’

THINGS DO NOT ALWAYS GO TO PLAN

Much of Robynne’s work is fieldwork, and a considerable portion of this work requires her to be aboard research vessels. These expeditions take her far out into the Arctic Ocean, sometimes for several weeks at a time.



She was once tasked with catching amphipods – a type of zooplankton found beneath the ice. She thought it would be easy but one by one, their amphipod traps disappeared.

‘Some weren’t properly secured, and we accidentally cut the ropes of others when we were pulling them back up. However, nothing beats the time one of our traps caught a polar bear!’

Robynne had thought rotten fish would be the perfect bait to attract small amphipods. The problem was that a polar bear had found the smell exciting, too. It went straight to the traps, pulled one of them out of the water and began chewing away. Munching. Chomping.

‘No one said it would be easy doing research at the end of the world!’

Another time, Robynne had been sorting zooplankton for 18 hours straight. She was exhausted and went to get a few hours of sleep. When she woke up and looked in the mirror, she found copepods all over her curly hair!

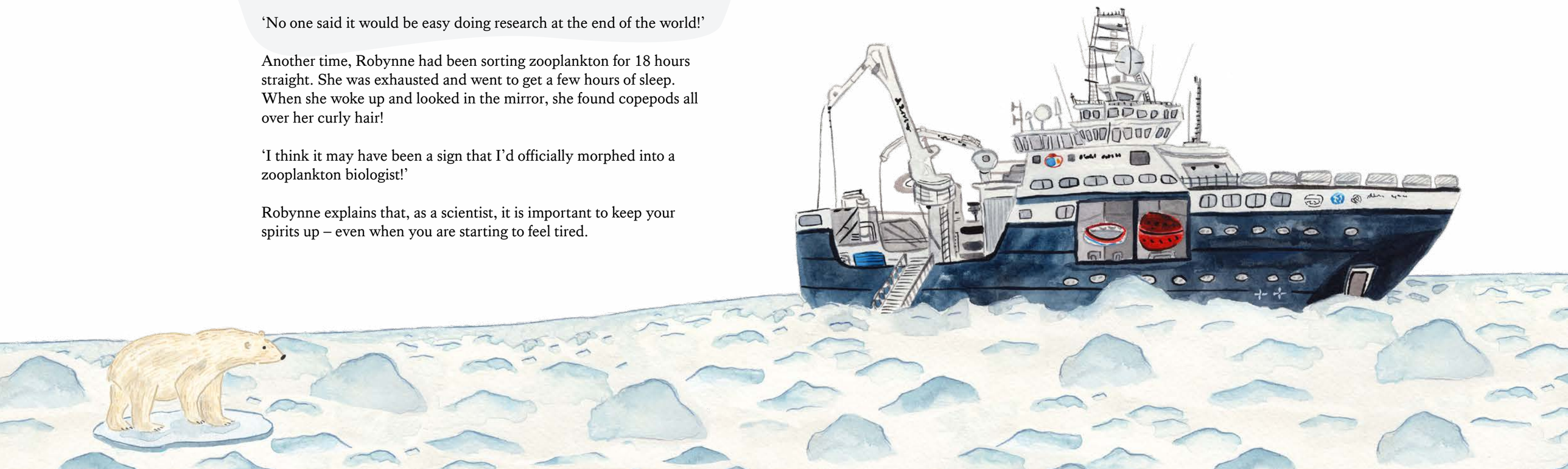
‘I think it may have been a sign that I’d officially morphed into a zooplankton biologist!’

Robynne explains that, as a scientist, it is important to keep your spirits up – even when you are starting to feel tired.

‘You have to appreciate the little things. Luckily, it’s fairly easy, as the Arctic is such a magical place. Often, a glimpse through the window is all it takes to fill me with an enormous sense of gratitude for being here. It makes me forget that I’ve hardly slept, or that I’ve copepods in my hair,’ she laughs.

Another thing that helps lift the mood on board is *cake o’clock*. Every day at three o’clock in the afternoon, cake is served!

‘Good food and good company are so important in the middle of the Arctic Ocean!’



Hanne

How do you build on ground that is always frozen?

PERMAFROST

ACTIVE LAYER

A tilting town

Physical geographer Hanne Hvidtfeldt Christiansen looks out over Longyearbyen. It is a cloudy day in June. The students she is showing around town are wearing warm jackets, gloves and hats.

The thermometer reads 3°C. That is what we call Arctic summer.

‘Studying something you can’t see is a bit odd,’ she says.

The purpose of this tour is to take a closer look at the houses, roads and buildings of Longyearbyen with respect to how a town must be built when the ground is permanently frozen.

We are here to see how what is below the ground – the permafrost – affects what is going on above.

‘Permafrost is almost like a little mystery. How do you even know it’s there?’ she asks.

THE GLUE IN THE GROUND

Permafrost is ground that is permanently frozen. For something to be classified as permafrost, the ground temperature must remain at or below zero degrees Celsius (°C) for at least two years in a row.

‘Can permafrost be made of anything? Like dirt, stone, sand, rock, organic matter or ice?’ I ask.

Organic matter refers to the remnants of things that were once alive, such as plants, animals and tiny organisms.

‘Yes!’ says Hanne enthusiastically. ‘Permafrost is a state of temperature, not a specific material – but it’s always below ground.’

In Norway, permafrost can be found in Svalbard, and in the highest mountain areas of mainland Norway and on the Finnmark plateau. In the rest of the world, permafrost exists in cold regions both to the north and to the south, as well as in alpine areas. Greenland, Siberia, Canada and Alaska all have plenty of permafrost.

Permafrost is found beneath roughly 20% of the world’s land area. If you imagine the world as a cake and cut it into five equal slices, one slice would have permafrost under its landmasses.

The layer of permafrost in Svalbard is several hundred metres thick in some places. But its temperature is typically only a few degrees below freezing. This makes permafrost vulnerable to a changing climate and rising temperatures.

Global warming means that large parts of the planet are getting warmer over time. This can lead to more extreme weather conditions and environmental changes. Humans are responsible for one of its causes: greenhouse gases emitted by cars, factories and airplanes. These gases form an invisible layer around the planet that traps heat inside. This is called the greenhouse effect.

Above the permafrost is an active layer. This is ground that thaws and freezes every year, as it warms up in summer and cools down in winter. Its thickness can vary from a few centimetres to several metres.

SVALBARD IS A LABORATORY

Hanne has been doing research in the Arctic for more than 20 years. She says that Svalbard is the perfect place to study permafrost.

‘I’ve worked a lot in Greenland, and I feel at home here in Longyearbyen. Living and doing research in the Arctic is fantastic as a permafrost researcher.’

Hanne works at the University Centre in Svalbard. Each semester, students come from all over the world to study Arctic conditions. Much of the teaching takes place outside, in nature. That is called fieldwork. Everything the students learn in the classroom, they get to experience right outside their door. This helps them practise thinking like scientists. Maybe that is going to be their job one day?

Just outside Hanne's office is a huge container that stores a permafrost drill rig. The drill rig is used to drill down many metres in the ground and extract samples from the permafrost. These samples are 5 centimetres in diameter and about 30 centimetres long, shaped like rolling pins or cylinders. They are called core samples.

Hanne examines the samples with her students. Core samples can tell us how old the permafrost is, what materials it is made of and how much ice it contains.

'This research helps us understand the potential effects of the permafrost getting warmer,' Hanne explains.

When dirt and gravel start thawing, they can create unstable layers in the ground. And if the permafrost contains a lot of ice and that ice starts melting, the water drains away. This will cause the ground to sink as the space of the frozen ice will disappear.

As permafrost samples are frozen, they need to be examined in a cold lab. It is freezing in there, so it is a good idea to wear a warm jacket and a hat! After the samples have been inspected, some are stored in a special freezer container. Others are fully used for measurements to determine the amount of ice in the permafrost.

PERMAFROST AND CLIMATE CHANGE

In some areas, the permafrost can contain much more methane than the amount that is already in the atmosphere. Scientists are doing research in various locations to figure out how much greenhouse gas could potentially be released from the ground.

When permafrost consists of rock, greenhouse gas emissions are low. However, in areas with a high concentration of organic matter, such as Siberia, thawing can release huge amounts of methane and carbon dioxide. That is why permafrost scientists are very interested in measuring the thickness of the active layer, to understand if the permafrost is thawing.

On page 62, read more about why we don't want more methane in the atmosphere.

A SINKING FEELING

Svalbard is the only place in Norway where an entire town is built on permafrost.

If you construct a house in Longyearbyen, the active layer and permafrost must be considered.

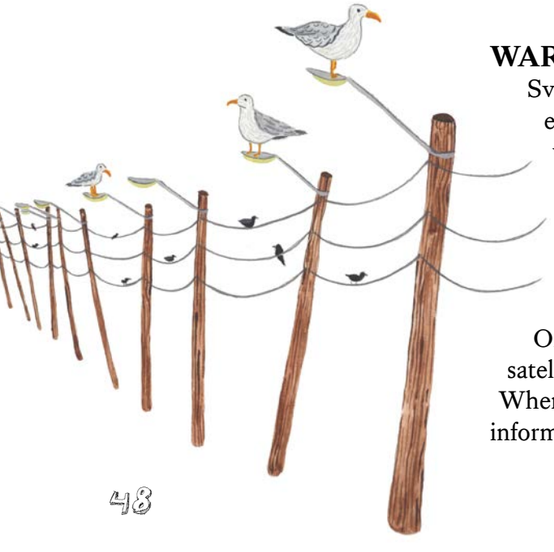
Placing something cold on top of something cold would not be a problem, but most people like to keep their houses warm. When houses are heated, some of the warmth can start to thaw the ground below, making their foundations unstable.

One solution to this problem is to build houses on piles – strong poles – that are frozen into the permafrost. That is why most houses in Svalbard are on stilts! The piles are driven so deep into the permafrost that it does not matter if the top few metres – the active layer – thaw in summer. The houses remain stable. If temperatures continue to rise for a longer time, however, the thickness of the active layer could increase beyond the length of the piles. Suddenly, the piles would be standing in soft ground, and the houses might start to tilt.

Some have started looking into a different solution. Instead of building houses on piles, they have built them on gigantic freezing mats. One of these buildings is Longyearbyen's Culture Centre, which houses the library.

No matter how warm and cosy it is inside, between the fantasy and non-fiction books, the freezing mat makes sure the heat from the building does not thaw the ground below.

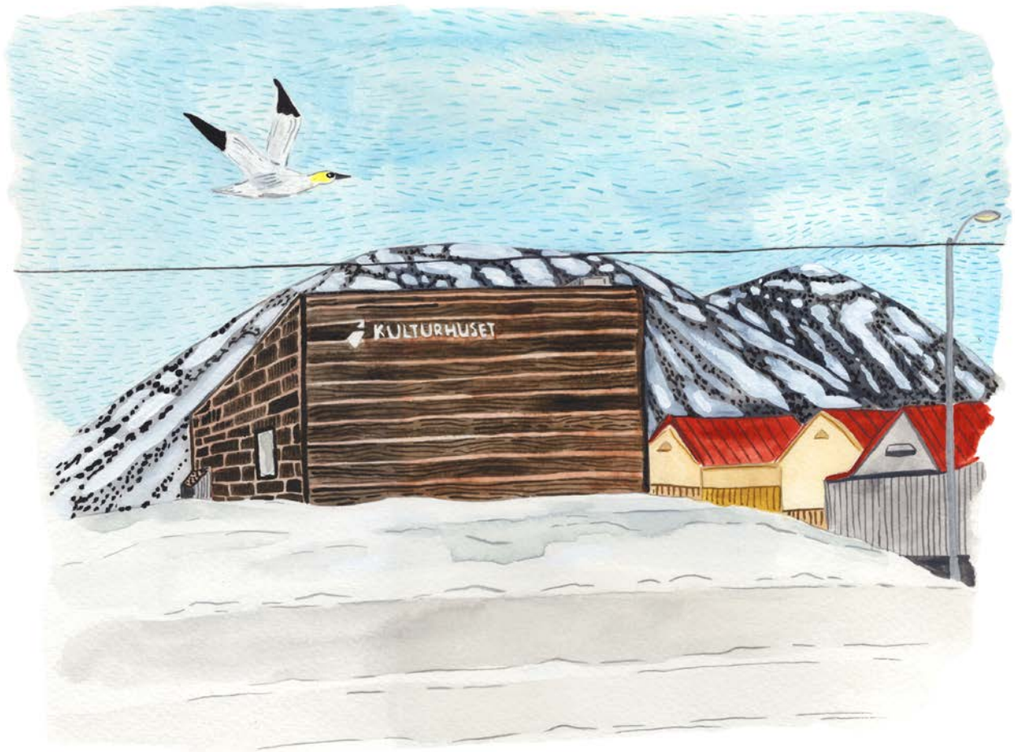
But, just in case, scientists have drilled a few holes under the building. In these holes, Hanne and her colleagues measure the temperature of the permafrost, making sure the ground stays frozen and the Culture Centre stays level.



WARNING SIGNS OF CLIMATE CHANGE

Svalbard and other permafrost regions in the Arctic are experiencing climate change faster than the rest of the world. What's happening in the Arctic now can tell us how climate change will affect other parts of the planet in the future. That is why it is important to monitor the permafrost and understand how it responds to higher temperatures.

One way that scientists observe the permafrost is by using satellites that can register changes in the ground surface. When they combine these observations with temperature information gathered from boreholes – such as the holes



underneath the library and other locations on the island – scientists get excellent data to analyse, and they can monitor larger areas and better understand what changes are going on.

Hanne has now given us a tour of most of Longyearbyen. We have looked at the large new buildings for student housing and the old *spisshus* – houses with distinctive steep, pointed roofs and cheerful colours. We have also visited the avalanche embankment to learn how the town is protected from natural hazards.

'The more we observe, the more we learn. The more we learn, the better we understand the consequences of the changes we observe.'

It is comforting to know that scientists are making sure it is safe to build houses and to live in this area.

But even so, when I get home, I have a good look under my house, to make sure the piles aren't leaning.

Solar winds and stardust

‘Turn off your head torch!’

Katie Herlingshaw is shivering. She is standing outside by the old Northern Lights observatory in the valley Adventdalen, just a few kilometres from Longyearbyen. She reminds the eager Northern Light photographers around her that artificial light is the Northern Lights’ worst enemy. One by one, we switch off our head torches, and soon, we are standing in complete darkness.

At first, all we can see is a haze in the sky. Actually, it looks like a cloud. Hang on! Is that a bit of green I see? Or is it purple? I am pretty sure I see purple! Now there is no doubt!

The Northern Lights twist and turn across the sky like a cinnamon roll.

If you are surrounded by streetlights or standing somewhere bright, it is almost impossible to see the Northern Lights. If, however, you walk into the wilderness or go on an adventure in a dark valley, you just might get lucky.

Isn’t it beautiful?

BEST TO TEACH THEM YOUNG

Katie is probably one of the people in Svalbard who is most interested in the Northern Lights. She grew up in a town in England. When she was little, she loved looking at the night sky. Sometimes, she woke her brother up in the middle of the night.

‘Let’s go outside,’ she said.

‘No,’ he grunted and shook his head.

‘Come on! Perhaps we’ll see a star explode!’

He looked up, then checked the time. It was two o’clock in the morning. It was pitch-black outside, and Katie wanted to go and look at stars and galaxies. He sat up in bed and put on some warmer clothes, still clutching his teddy bear.

‘If Mum tells us off tomorrow, it’s your fault!’

‘It will be fine,’ his big sister promised.

They went out into the garden. Katie brought a sleeping bag so they would not get too cold. The lights from town hung like glowing slime above the rooftops, but when they looked straight up, all they could see were stars.

It has been years since Katie sat in the garden with her brother, gazing at the stars, but she is still just as interested in what is going on above us.

EXPLAINING THE MAGIC

The Northern Lights have fascinated people for thousands of years. Even the Greek philosopher Aristotle knew about them. In the past, the Northern Lights were often veiled in mystery and superstition. Some people were frightened by them and thought they were signs of misfortune or war.

Luckily, we now know that is not true. The more recent curiosity about the Northern Lights has helped scientists understand more about the solar system and the universe. But we still know far from everything.

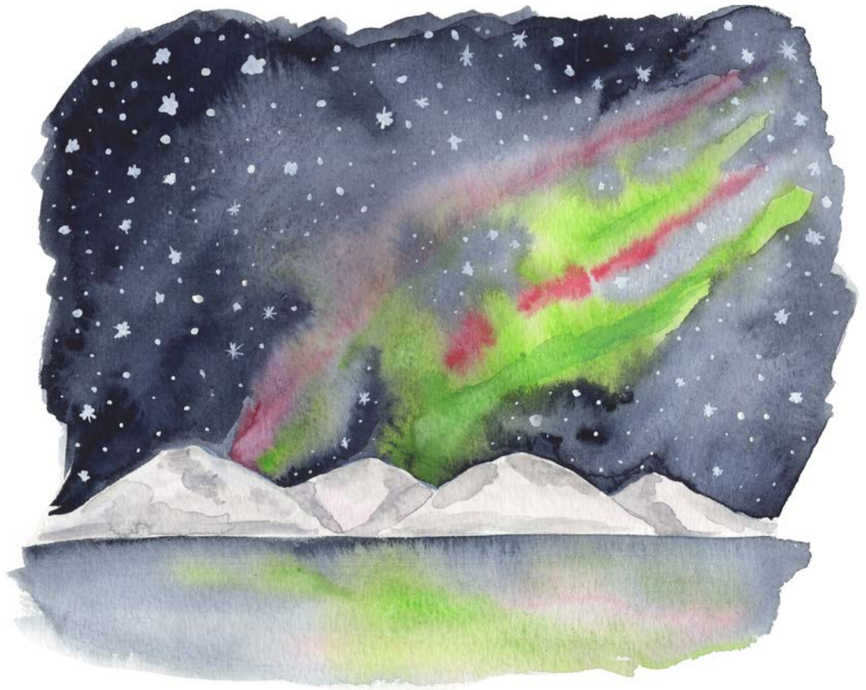
It would be easy to say the Northern Lights are magic. However, although people may have believed that in the past, we know better now. And we know one thing for sure: there are some crazy and difficult words used in Northern Lights research:

EL-EC-TRO-MAG-NE-TIC SPEC-TRUM. PHO-TON. NA-NO-ME-TRE. SUB-STORM.

In simpler terms, the Northern Lights – or *aurora borealis* – are particles from the sun that crash into the Earth's atmosphere, resulting in a light signal. Those of us with our feet firmly on the ground see this as the Northern Lights. Actually, you do not even need to be on the ground. If you are flying north during winter, you might see the Northern Lights from the plane. Remember to ask for a window seat!

TRY IT YOURSELF

There are lots of excellent Northern Lights apps. They will show you live images from Northern Lights observatories all over the world, and can notify you when there is high Northern Lights activity in your area.



CAN YOU HELP?

Katie is studying a new form of Northern Lights that was discovered over Svalbard in 2023. It looks like small fragments or specks and can be seen close to the regular aurora. Katie did not discover it herself, but she is one of the first scientists to work on learning more about it.

I have already told you that scientists are the ones who do scientific research, but occasionally, you and I can contribute too. This is called citizen science.

Today 14:15

Hi! I need your help. Do you have any pictures of the Northern Lights from 8th February 2019, 3rd January 2020, 1st December 2023 or 11th February 2024?

I might. Let me check my camera when I get home.

Katie and her colleagues had noticed a strange light on some wide-angle images and wanted to know more. Imagine how helpful it was to send a message to thousands of hobby photographers around the world and get access to many more pictures than they had taken themselves.

On one of the dates Katie asked for pictures from, there was a stunning pink aurora over Longyearbyen. I was actually on my way to pick up the kids from school, but if I hurried, I figured I would have time to take a couple of pictures first. I drove up to Nybyen, where the road ends, then walked past the sign that says: 'BEWARE OF POLAR BEARS – ALL ACROSS SVALBARD'. I got away from the streetlights and looked south towards the mountains.

It was -12°C and the wind was blowing at 12 metres per second. That made it feel like -24°C. That is cold! My fingers went numb as I set up the tripod. Then I mounted the camera, pressed the shutter button and waited. One Mississippi. Two Mississippi. Three Mississippi. Three seconds. The camera clicked and beeped, then shut itself off due to the cold. But when I got home, I saw that I had managed to capture the most beautiful pink sky and thousands of stars.

Today 20:30

I found a few pictures from one of the dates you requested. Sending them over now!

It felt great to send those photos to Katie and give the scientists one more piece of their giant jigsaw puzzle.

When the first ever Norwegian astronaut, Jannicke Mikkelsen, spent nearly four days in space in spring 2025, she was collaborating with Katie. Northern Lights photographers all around the world took pictures of the Northern Lights from below, while Jannicke took pictures from above. Having images taken at the same time from both Earth and space gives Katie a unique opportunity to learn more about the mysterious Northern Lights.

NO ON/OFF SWITCH

The Northern Lights appear in the sky randomly and are impossible for us humans to control. That makes them somewhat challenging to study, but a Norwegian scientist found a clever solution.

Terrella is Latin for 'little Earth', and it is a magnetic sphere used as a model of the Earth. It was invented by an Englishman in the 17th century, but it was the Norwegian physicist Kristian Birkeland who first used a terrella to create auroras.

Since then, other scientists have made different versions of the terrella. Creating auroras in a box looks amazing, but today, most experiments can be done through computer simulations.

The Northern Lights are connected to the sun. The sun follows an activity pattern known as the solar cycle, which lasts about 11 years. When sun activity is at its peak, as it was in 2024, the sun is sending more energy and particles into space than usual. Here on Earth, that means more frequent and more intense auroras.

The Northern Lights usually form as a belt, far north on the planet. Southern Lights exist too – *aurora australis* – and appear in the southern hemisphere, above Antarctica. But for now, we will stay in the north. Northern Norway, Finland, Iceland, Greenland, Canada, Alaska and northern Russia are usually among the best places to see the Northern Lights. But when there are major solar storms, you can see the Northern Lights as far south as Scotland, and sometimes even farther south in Europe.

While the Northern Lights look stunning, these solar storms can also affect satellite navigation systems, interfere with radio and TV signals and affect the power grid. The beautiful Northern Lights seem prone to mischief!

THE DARKEST NIGHT, IN THE MIDDLE OF THE DAY

Svalbard is actually a little too far north to see the most beautiful Northern Lights. But what makes Svalbard a good place for studying them is the polar night.

For three months of the year, it is dark enough to see the Northern Lights even in the middle of the day, because the sun stays below the horizon. These Northern Lights are called daytime auroras, and they are often slightly redder than the typical green ones.

TRY IT YOURSELF

Find Svalbard on the world map. Can you see how far north the archipelago is? Now, move your finger east or west. What do you find? No big cities, that is for sure!

It is possible to see daytime auroras in northern parts of Russia, Greenland and Canada, too. But the benefit of studying daytime auroras in Svalbard is that people live here all year round. In fact, Longyearbyen is the northernmost town in the world with a school, airport and nurseries. Scientists who are curious about the Northern Lights can enjoy a meal at a nice restaurant and sleep in a proper bed after being out in the cold all day. It is quite a contrast to being dropped off in the middle of the Canadian wilderness and just sitting there, all alone, staring at the sky.

Green auroras usually occur between 90 and 180 kilometres above the Earth's surface. You must go even higher to find the red auroras. They are formed by glowing oxygen atoms more than 150 kilometres above the ground.

In other words, although it may sometimes feel like you could, you cannot just reach out your hand and touch the Northern Lights.

Many aurora photos appear intensely green, pink or purple, but when you look up at the sky, the Northern Lights do not look quite the same. That is because a camera lens is much more sensitive than the human eye, and can capture more light.

But still, my advice is to simply enjoy the moment! Ask the adults to put their phones away and lie down next to you on a mat. Look up at the gigantic night sky. Try to see what shapes the Northern Lights are making. Do they form arches, spirals or crowns in the sky? Let your eyes adjust to the dark and enjoy the green waves dancing across the sky.

Be present in nature.

Bubbles in the ice

At the foot of the glacier Marmorbreen, about 60 kilometres from Longyearbyen, Gabrielle Kleber is jumping up and down to stay warm, wearing big snowmobile boots.

‘Ooohh! Did you see that? Did you see it?!’

A bright yellow flame flickers in the hole for a few seconds before it goes out.

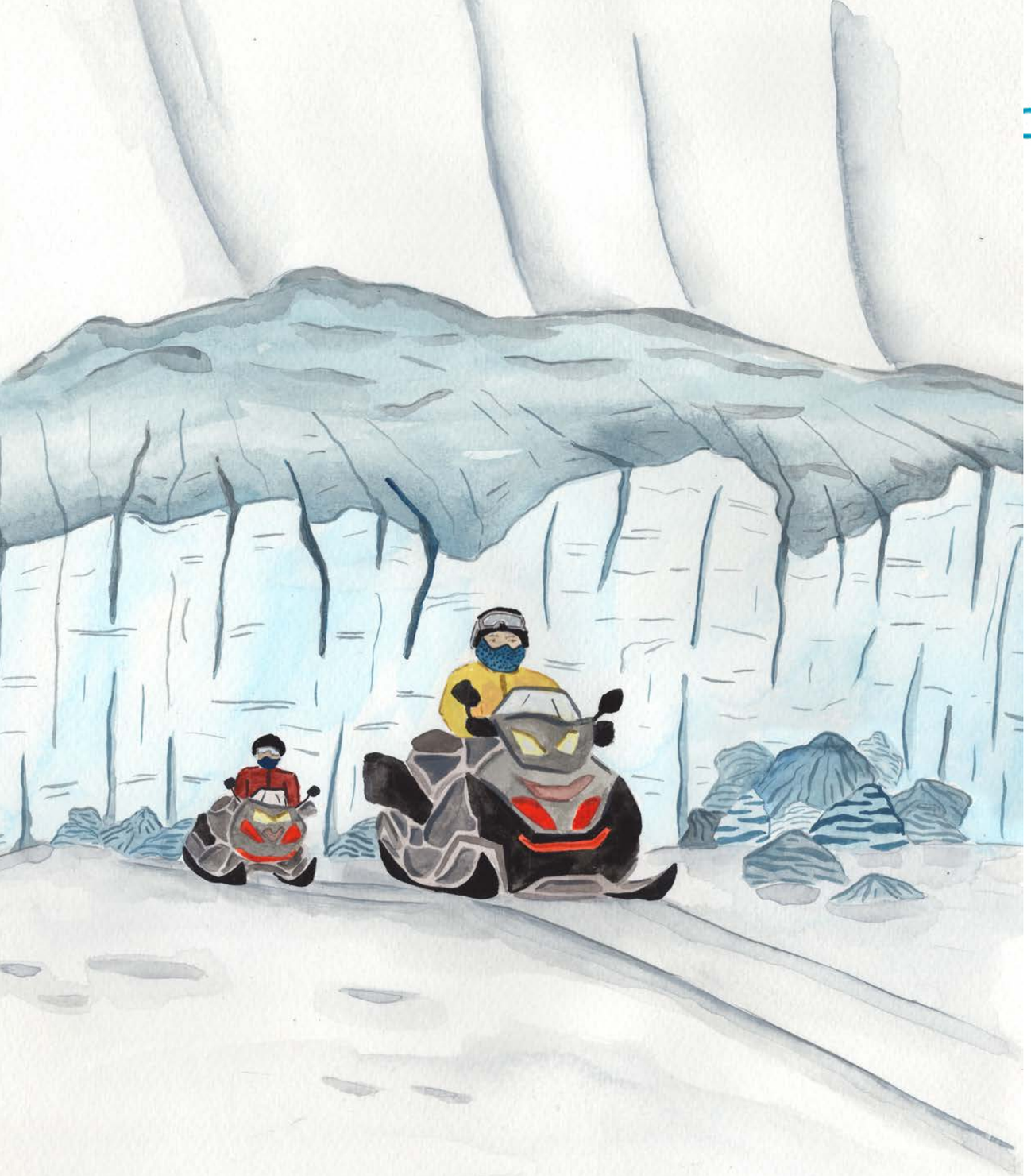
‘There is methane here.’

The small flame was far from strong enough to warm Gabrielle back up, as it was -26˚C, but finding what she was looking for made her feel warm inside.

GLACIERS IN SVALBARD

We will get back to Gabrielle and her research in a moment, but let us start by taking a closer look at glaciers. What are they?

Glaciers are formed from years’ worth of snow that has not melted during summer. The snow is slowly compacted until it forms a thick layer of ice. Glaciers are beautiful, majestic, dramatic and powerful. They can also be a bit dangerous if they feature big crevasses.



More than half of Svalbard is covered in glaciers. We often think of glaciers as things you find in polar regions, but they can be found all over the world – even in Africa. There is a glacier on top of Mount Kilimanjaro.

The world's glaciers contain most of the freshwater on the planet. That is why we are worried about the planet heating up. If all that water trapped in glaciers were to melt, the sea level would rise several metres. That would be a huge problem for everyone who lives near the sea – and that is quite a large number of people!

If just the glaciers in Svalbard were to melt, the sea level would only rise a few centimetres. If all the ice in Greenland melted, it would be a serious problem. And if Antarctica's ice cap melted, it would be a disaster.

COW FARTS AND FROZEN GROUND

Gabrielle is researching methane gas, which belongs to a category of gases we call greenhouse gases.

Greenhouse gases in the atmosphere are like clothes wrapped around the planet, keeping it warm. We need these gases. Without greenhouse gases – the 'clothes' – the average temperature on Earth would be -18˚C, and it would not be a particularly pleasant place to live.

But over the past 100 years, the amount of greenhouse gases, especially carbon dioxide (CO_2), has increased. The planet has been putting on more and more clothes and it has been getting warmer and warmer.

Many of these greenhouse gases are emissions caused by humans. The production of oil and gas causes emissions. Cows farting and burping causes emissions. But some of the emissions come from natural sources that we cannot control.

Gabrielle is trying to understand the role Svalbard plays in methane emissions. Does the bedrock beneath glaciers hold a lot of methane gas? Are the potential emissions higher than we thought they could be?

WHERE DOES METHANE COME FROM?

It is important to find out *if* there is methane under the glaciers, but it may be just as important to find out *where* the methane is coming from.

Gabrielle explains that some of the methane stems from the bedrock. The gas has been trapped in ancient geological formations for millions of years. When the glaciers retreat and meltwater washes down through cracks in the stone, the gases are pushed up and out.

Geologists call this process fracturing, or more commonly fracking. Fracking is also a method used in oil production; it is a controversial method as it can pollute soil and groundwater. Natural fracking, however, is something we cannot do much about, except try to understand it better.

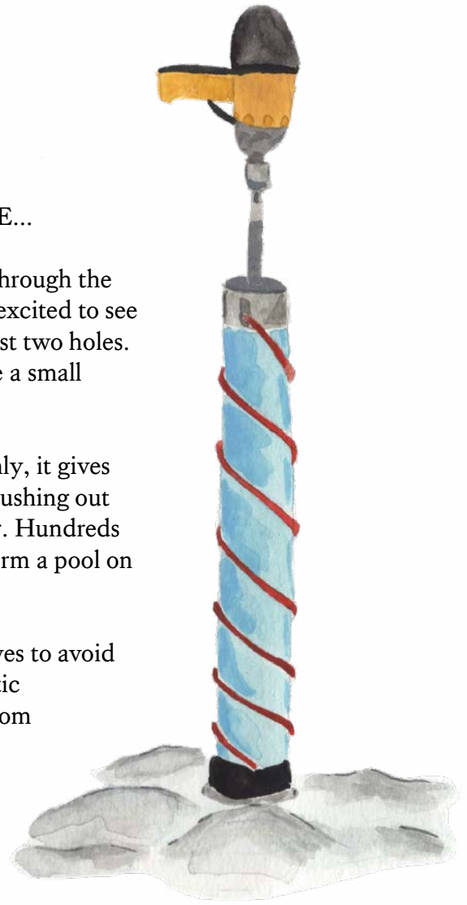
FACT CHECKING

WROOMMMM. FRRRRR... SHHHUUUEEEEEE...

The grey-and-red ice drill is working its way down through the ice in front of the glacier Marmorbreen. Gabrielle is excited to see what she will find. She discovered methane in the first two holes. Not a lot, but enough for her to light a match and see a small flame burn for a few seconds.

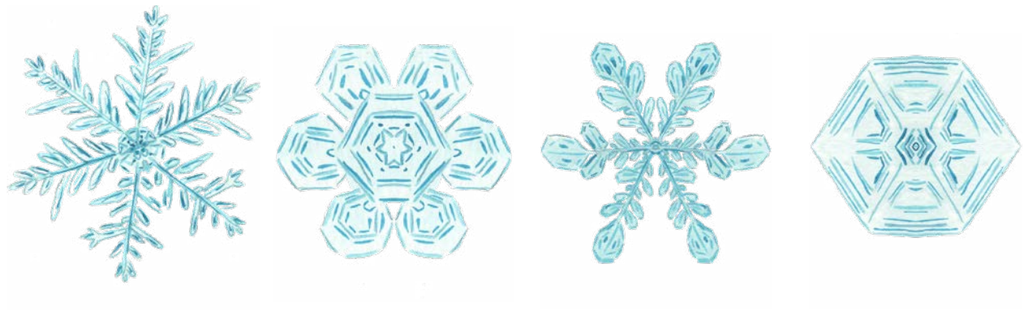
Gabrielle controls the drill, pressing it down. Suddenly, it gives way beneath her, and she pulls it back up. Water is gushing out of the hole! She has hit a spring in front of the glacier. Hundreds of litres spew up from the deep in just seconds and form a pool on the ice where we are standing.

Gabrielle crouches down and puts on disposable gloves to avoid contaminating the sample. She takes out a large plastic syringe. Once she has filled the syringe with water from the spring, she puts it in a bag and seals it.



Scientists are very thorough. Before they say or write anything, they check their findings again and again. And again. And again, and again. And again.

So, when Gabrielle says the glaciers in Svalbard emit methane gas, she has not just studied what is going on at Marmorbreen. She has studied 124 different glaciers!



Gabrielle has spent several winters driving snowmobiles thousands of kilometres back and forth across the island. Only after carefully checking all these glaciers, taking samples and analysing them in laboratories could she say with certainty that there is plenty of methane beneath the glaciers in Svalbard.

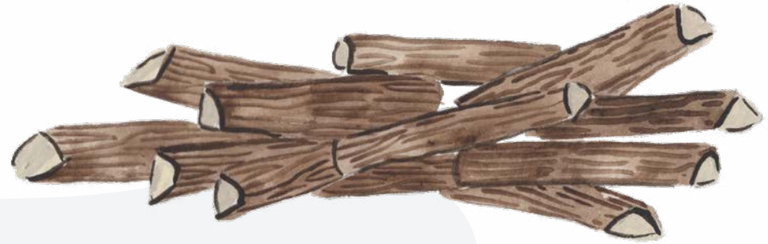
Scientists are just as determined as mums who say, 'You've had enough screen time!'

Some of the samples had 600,000 times more methane than is normally found in water.

A DIFFERENT KIND OF SUMMER JOB

Gabrielle is out in the field for fieldwork year-round. She has spent several summers in a small cabin in Rindersbukta, a bay south of Longyearbyen. It is easy to get to the cabin in winter – you just drive your snowmobile over the mountain – but in summer, getting there requires a long boat trip from town.

Gabrielle and her partner stayed at the cabin so they could take regular samples of meltwater from a glacier called Vallåkrabreen. Every other day, they walked 4.5 kilometres to the glacier, spent the entire day conducting their research, then walked the 4.5 kilometres back to the cabin.



'There was midnight sun, so we didn't have to worry about the time. Once, we worked through the night and didn't get back to the cabin until seven o'clock in the morning.'

Gabrielle says she quickly got used to simple cabin life.

'It was challenging, but not at all complicated. We spent our time doing fieldwork, collecting water and fuel for the fire, and observing nature around us.'

One day, as they were on their way to the glacier from the cabin, they realised the glacier on the other side of the fjord had changed dramatically. It was practically rushing towards them!

Could that really be possible? Can something as steady as a glacier really move?

You will find out more in the next chapter.

Heïdi

How do glaciers move?

SURGING GLACIERS

CALVING

Guardian of the ice

THUNK.

I flinch when my head hits the ice above me. It did not hurt, it just startled me.

‘It’s a good thing you’re wearing a helmet.’

Heïdi Sevestre is standing a few metres farther ahead, closely examining a large icicle.

We are deep inside a glacier called Longyearbreen. We came here on snowmobiles. Once we had parked, we had to search around in the darkness for a bit, until we found a few snow poles marked with reflective stickers. They were impossible to spot until our head torches shone on them.

Next to the snow poles, there was a hole in the glacier. The strong wind howled and pulled at our clothes. We strapped crampons to our snowmobile boots and made our way down into the deep. We had torches fastened to our helmets, because ice caves are pitch black. Darker than the darkest night.

To get to the ice cave, we needed to climb down steep ladders, holding onto ropes until we reached the glacier floor. We made it down safely, and ended up in a long, narrow corridor. The walls on either side were nothing but clear ice. I wondered if I would see a mammoth frozen inside the ice.

Heïdi had heard that there was a huge chamber in this cave, and that is what we were looking for when I hit my head.

CHANNELS AND CATHEDRALS

'I think we've found it!'

Heïdi's voice is full of excitement. I look around but do not see anything.

'We have to go through here,' she laughs. She lies down and wriggles through a narrow passage in the ice.

The room we enter is magical. The cave opens into an ice chamber. It is like a cathedral made entirely of ice. Large snow crystals hang from the ceiling like chandeliers, and tiny snowflakes drift down to us. The floor and walls are entirely smooth, except for the occasional band of gravel and rock that has been moved around by the ice for thousands of years.

These ice caves are formed by meltwater. Every summer, as the weather gets warmer, some of the snow and ice on the surface of the glacier melts. The water runs like streams and rivers through canyons cutting into the glacier.

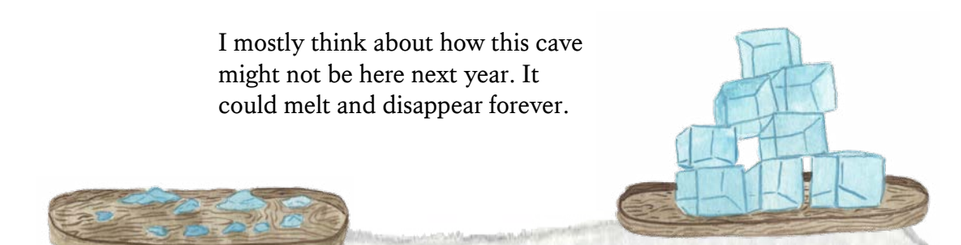
Throughout the summer months, water carves its way deeper into the thickness of the glacier, creating magical passageways and tunnels. When autumn comes and the weather gets colder, everything freezes, like something out of a fairy tale. These meltwater channels become amazing ice caves.

The cave is incredibly beautiful. Heïdi walks around the space, gently placing her hand against the wall.

'Are you afraid of the dark?' she asks.

I shake my head in the glow of the head torch. She asks me to switch mine off and be very, very quiet. It is so dark that I cannot see anything at all, not even my own hand – even when I hold it up, right in front of my face. We stand there in absolute silence, taking the time to reflect on our place in the universe.

I mostly think about how this cave might not be here next year. It could melt and disappear forever.

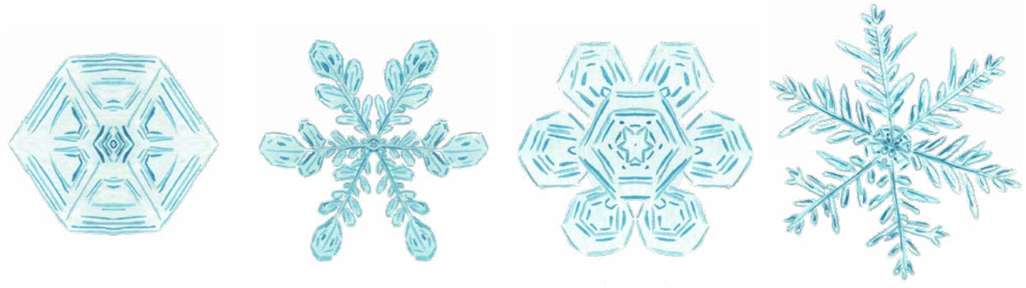


TRY IT YOURSELF

Make a tray of ice cubes and divide them into two equal piles. Give the cubes in one of the piles a few whacks with a rolling pin to make them smaller. If you want to be extra precise, like a scientist would be, you can weigh each pile and make sure they weigh exactly the same.

Spread the pile of crushed ice on a plate. On a separate plate, place the uncrushed ice cubes as close together as possible, and stack them two or three cubes high, if possible.

Note the time, then wait for 30 minutes. Whether you continue to read this book, bake some cupcakes or do your homework is up to you. What happens when you return after 30 minutes? You will probably find that the crushed ice has melted more than the uncrushed ice cubes. The same thing happens to glaciers in Svalbard when temperatures are above freezing. Glaciers with lots of crevasses are exposed to more warm air. They melt faster and from more sides than solid glaciers with fewer crevasses.



SURGING GLACIERS

Heïdi grew up in the French Alps and often went on hikes when she was younger. There are many glaciers in the Alps, and they are affected by the warmer climate, too. Heïdi loved walking across the glaciers and rarely wanted to go home for dinner. One day, when Heïdi was out with a guide, he told her it was possible to work with glaciers. Heïdi immediately decided to become a glaciologist – someone who knows a lot about glaciers.

Even though Heïdi is a master at giving ice cave tours, her real field of expertise is surging glaciers. A surging glacier is what Gabrielle saw on the other side of Rindersbukta.

Surging glaciers get their name from what they do: they suddenly move forward; they surge.

When a glacier surges, it starts moving much faster than normal – as much as 30–40 metres per day.

The greatest glacier surge observed in Svalbard was between 1935 and 1936, when Bråsvellbreen surged a full 20 kilometres.

Imagine you are walking at a normal pace, then suddenly start to run. That is kind of what it is like when a glacier surges. If the glacier reaches the sea, the surging ice will fall into the water and melt, making it lose a substantial amount of its mass.

When large lumps of ice break off a glacier and fall into the sea, it is called calving. This can be quite a sight to behold. Sometimes, just a few smaller lumps break off the glacier, causing nothing but tiny splashes. But other times, the lumps can be the size of a big truck. Those calvings can create great waves – big enough to capsize boats! That is why you should always keep your distance if you are lucky enough to be near a glacier front.

Surging glaciers only appear in a few places in the world, and it was because of them that Heïdi moved to Longyearbyen. Svalbard is one of the places with the most surging glaciers on Earth. She wanted to study them up close.

Scientists are a bit like detectives, trying to figure out what is going on in nature. They would like to understand why some glaciers suddenly start moving quickly while others do not. By studying surging glaciers, scientists can understand more about how glaciers react to changes in temperature, and how this might affect sea levels.

Surging glaciers are great examples of why scientists need patience. Nobody can predict which glacier will surge. The surge can go on for up to ten years, and then the glacier has a rest. It can rest for 30 to 500 years – and only the glacier itself knows how long it wants to rest for. It does not exactly make it easy to plan your workday!

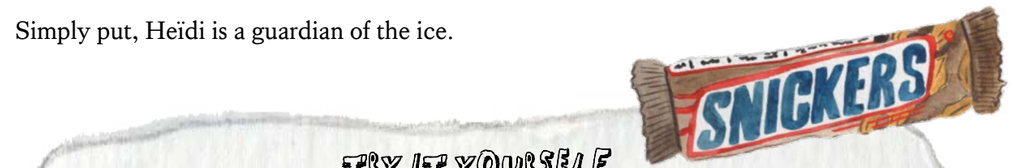
DREAM JOB

One of Heïdi's favourite things about her job is that she can spend a great part of her time teaching people about glaciers. She believes it is important that more people are aware of what is happening.

Heïdi has spoken to royals and politicians, schoolchildren and actors about what is going on with glaciers. She believes that knowledge can help us do something about climate change, and that it is our responsibility to protect nature.

'We all have the ability to make a difference,' she says.

Simply put, Heïdi is a guardian of the ice.



TRY IT YOURSELF

Have you seen a Snickers bar? Yes, the chocolate bar. If you want to understand what happens when glaciers move, find a Snickers bar. Try gently bending it. Do you see any cracks forming on top? Big and small cracks will spread down into the caramel. That is what happens to glaciers when they suddenly move over small elevations in the landscape. The Snickers can bend a little from side to side, too, just like glaciers that creep through the landscape over hundreds – or thousands – of years. If you put a Snickers in the freezer before you try to bend it, however, it will simply snap apart. This is what happens in Antarctica – the region surrounding the South Pole. It is horrendously cold there, and when deep-frozen Antarctic glaciers move, they can develop incredibly deep crevasses. Most of the glaciers in Svalbard are not that cold! They are still below freezing, of course, otherwise they would just be water. But slightly warmer ice is softer, a bit like a room-temperature Snickers bar.

Alex

Are all snowflakes the same?

SNOW CRYSTAL

WATER MOLECULES

Hot ice

brrrrrRRRRRR. nnnnEEEERRRRRR. rrrrrrRRRRR.

The sound of the snowmobile cuts through the Arctic silence. Morning light is just beginning to spread around us. There are beautiful silhouettes in the landscape. The mountains are covered in white and stand in stark contrast to the bright blue, starry sky.

Alex Klein-Paste pulls his thin hat over his ears, then puts on his snowmobile helmet. He checks that the equipment is securely fastened to the sledge.

‘Are you ready?’

Thumbs up. Everything is ready. He presses the throttle and speeds off into the wilderness.

A FROZEN WORLD

Most people living in northern Europe and America are familiar with snow and ice. But there are eight billion people on this planet. Many of them have never experienced freezing temperatures.

Can you imagine the excitement of waking up to a snow-covered playground for the first time? Or a dog discovering the joy of snowballs? Or a toddler, who was a baby just last year, but can now enjoy the soft snow?

All this white stuff – whether it is snow or ice – is made up of the same building blocks: water molecules.

‘Snow and ice are both solid forms of water, but they have completely different properties,’ Alex explains.

Ice forms when water freezes into a solid lump. Snow, on the other hand, forms when molecules of water vapour in the clouds freeze and clump together, one by one, into a growing snow crystal. Snow is much airier than ice, and that affects its strength and behaviour. Even though they are both made of water, being hit in the head with a lump of ice is much more dangerous than getting a snowball down your neck. Although that can be quite unpleasant, too.

IS EACH SNOWFLAKE UNIQUE?

You have probably heard that no two snowflakes are the same.

When I ask Alex about this, he smiles. As a scientist, he does not like confirming something if he is not one hundred percent sure it is true. To be certain that absolutely all snowflakes are different, he would have to compare every snowflake in the world. That is not possible!

But Alex says it is very unlikely that any two snowflakes are exactly the same. Each single water molecule can form four bonds in six different arrangements. That makes the number of possible shapes enormous.

Even though snow crystals might look the same as they fall from the sky, you can see that they are different if you compare them through a magnifying glass.

TRY IT YOURSELF

Dig a snow profile: find a slope and cut a straight wall with a shovel. Can you see different layers in the snow? Feel the snow with your hand and fingers. Are some layers harder or softer than others? Scrape out some snow crystals from the different layers. What do you see? Do the crystals from the separate layers look different? You might be able to tell with the naked eye, but it is even better if you can look through a magnifying glass!

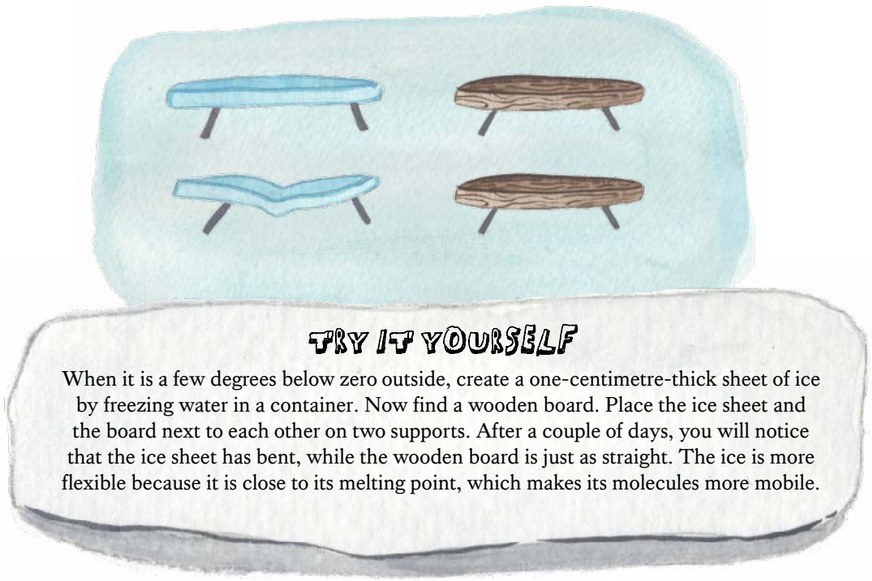
Sometimes, snow passes through a warmer layer of air on its way to the ground and starts to partially melt. This sticky snow has a thin film of liquid around its snow crystals, which acts like glue. When you ball up snow like this, it immediately turns into a snowball.

WARM ICE

Alex says that ice is considered a hot material. But that sounds crazy, right?! I certainly get cold fingers when I am holding an icicle.

He explains that it is because of the materials ice is made from. Ice and snow behave like many materials we usually think of as hot. In terms of temperature, ice is very close to its melting point.

‘Ice can slowly change shape over time, just like metal can when it is near its melting point. A glacier may look like a massive, immovable block, but it can move several metres in a single day,’ says Alex.



TRY IT YOURSELF

When it is a few degrees below zero outside, create a one-centimetre-thick sheet of ice by freezing water in a container. Now find a wooden board. Place the ice sheet and the board next to each other on two supports. After a couple of days, you will notice that the ice sheet has bent, while the wooden board is just as straight. The ice is more flexible because it is close to its melting point, which makes its molecules more mobile.

GROW, LITTLE SNOW CRYSTAL, GROW!

Alex has done research and taught in Svalbard, but he usually works at the Norwegian University of Science and Technology in Trondheim, Norway.

NTNU is an abbreviation for the Norwegian University of Science and Technology.

At NTNU, Alex has a snow laboratory where he grows snow. Inside a special freezer, snow crystals form. He studies them through a microscope and tries to understand how the ice and snow crystals are affected by changes in temperature or humidity.

According to Alex, there is still a lot we do not understand about snow and ice, even though plenty of research has been done on them already.

‘We know that snow and ice are slippery. We have tumbled on ice or gone skiing. However, we don’t fully understand where the friction actually comes from. The ice keeps secrets we still haven’t uncovered!’

Friction is resistance, and it is all around you. Sit on the floor and ask a friend to push you forward. Is it easy or hard? There is friction between your trousers and the floor. You can test this using different types of trousers, like leggings or waterproofs. Do different trousers make it easier or harder?

There are two types of friction: static friction and kinetic friction, also known as sliding friction. Static friction is, for example, when your toboggan stays absolutely still on top of a hill. As soon as you gain speed, the friction turns into sliding friction. The less friction you have, the faster you slide down the hill.

ENJOY THE SNOW!

As the climate warms, some areas will see less snow, while others may experience significantly more snowfall over a short period of time. This can cause problems when you are going to school or your after-school activities. Roofs can get overloaded, while antennas and power lines can be weighed down more than they can handle. Heavy snowfall can shut down airports and delay trains, too.

Even though snow can cause trouble, Alex is determined to enjoy it.

‘Snow and ice are so beautiful, clean and simple – and yet, they’re incredibly complex!’

Alex has stopped his snowmobile. We have arrived at Eskerdalen. The river here forms a frozen waterfall every winter. You can actually slip behind the ice and stand close to the frozen wall. I reach out to touch the ice. Yep, it is definitely cold.

Alex is looking at the ground. He is noticing the beautiful patterns the wind has created in the snow in front of the snowmobiles. With the next gust of wind or snowfall, these patterns will be erased and new ones will form.

‘The best thing about being a scientist is being able to ask new questions all the time,’ he says.

Every day, Alex can be curious and explore the snow.

‘I can ask questions and try to find answers that I’m not even sure exist. How will the glaciers move in the next ten years? How can we better predict the friction of snow?’

Questions like these drive research forward and prove that we still have much to learn about nature’s building blocks.

TRY IT YOURSELF

Place two ice cubes on the kitchen counter for a few minutes. When they start to melt, press them firmly together. Despite the room being warm, they freeze together! Ice can only melt on its surface. The water molecules inside the ice cubes are still frozen. When one wet ice surface is pressed against another wet ice surface, the surfaces disappear. When that happens, the thin layer of water between the two ice cubes freezes again.

The voice of Arctic plants

‘It’s illegal to pick the flowers!’

I yell as loudly as I can at a group of tourists. One of them had knelt down and reached out to pick a little souvenir. Now he stands up and brings out his camera instead. *Snap. Snap.*

We are on Blomstrandhalvøya, not far from the research town Ny-Ålesund. It is a small island in the middle of Kongsfjorden. There are enormous glaciers everywhere you look! In the far distance, we can make out three nunataks – mountaintops poking up through the ice. These mountaintops are called Svea, Nora and Dana, but are often just referred to as Tre Kroner – three crowns.

More than a hundred years ago, botanist Hanna Resvoll-Holmsen spent a lot of her time in this area. She was trying to find out what kinds of plants and flowers grew in Svalbard. Hanna was Norway’s first female polar scientist.

The word *halvøya* in the name Blomstrandhalvøya literally translates to ‘half island’ – the Norwegian term for peninsula. Until the 1990s, Blomstrandhalvøya was connected to the rest of Spitsbergen by the glacier Blomstrandbreen. When the glacier retreated, it turned out the peninsula was actually an island!

In 1907 and 1908, Hanna was dropped off at various places on the west coast of Spitsbergen with food and supplies. Once she got there, she had to fend for herself until she was picked up again several weeks later.

When Norwegian newspapers wrote about her work, they were more interested in how she wore skirts and slept in tents than in her research. But Hanna was the first person to start cataloguing the plants of Svalbard. That should have been their headlines!

In 1927, Hanna Resvoll-Holmsen published the first flora of Svalbard.

Svalbard consists largely of rock and gravel, but when Hanna looked at the grey landscape up close, she found many different flowers and plants to study.

Hanna loved nature and wanted to protect it. She noticed how centuries of uncontrolled hunting in Svalbard had come close to wiping out several species of animals, including the Svalbard reindeer. Hanna took part in conservation efforts and became one of our first Arctic conservationists.

In 1925, legislation was put in place to protect animals and plants in Svalbard and Bear Island. The Norwegian government used Hanna's research as a basis for the new law and picking flowers in Svalbard became illegal.

That law still applies today!

WHERE DO YOU BELONG?

Let's fast-forward to the present day. The environmental laws Hanna helped introduce in the 1920s saved the reindeer in Svalbard. Today, there are more than 20,000 Svalbard reindeer!

This means hunters can now fill their freezers with meat every autumn, and polar bears occasionally have a delicious feast.

Even though large areas of Svalbard are still untouched nature and wilderness, more people visit now than they did in the past. More people means higher chances of foreign (or what scientists call non-native species) arriving.

When non-native species compete with native species for resources like food or habitat, or when they pose a danger to the environment in some other way, they are called invasive species.

A seed can easily get stuck under your shoe on the mainland and hitch a ride up north. All of a sudden, raspberry bushes are growing on the side of the road in Longyearbyen.

This actually happens!

Botanist Kristine Bakke Westergaard studies non-native species in Svalbard. She explains that non-native species are species that have been introduced to a new environment by humans – sometimes by accident, sometimes on purpose.

Kristine works with the Norwegian Polar Institute and the Governor of Svalbard to monitor the spread of non-native species in Svalbard. She has done plenty of fieldwork in and around Ny-Ålesund, where Hanna Resvoll-Holmsen once studied flowers and plants.

Every five years, they publish a report of their findings. This is not quite often enough, according to Kristine. She has been to Svalbard every year for a while now and finds new non-native species every time.

TRY IT YOURSELF

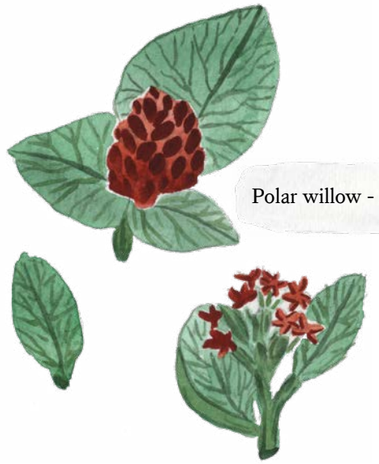
Seeds can get stuck under the soles of your shoes or to the velcro on your jacket. Have a look under your shoes! What do you see? Seeds, grass, dirt or stones?

Non-native species can disrupt the balance between organisms that have coexisted for a long time. Sometimes, invasive species can take over completely from the species that already live there.

Boat tours around Svalbard are very popular. Biologists have studied the most popular places for tourists to go ashore, and luckily, they have not found any non-native species there – yet!

Moss campion - *Silene acaulis*

Polar willow - *Salix polaris*



Svalbard poppy - *Papaver dahlianum*

Sulphur-coloured buttercup - *Ranunculus sulphureus*

Creeping sandwort - *Arenaria humifusa*

Arctic bell-heather - *Cassiope tetragona*

Purple mountain saxifrage - *Saxifraga oppositifolia*

Northern Jacob's-ladder - *Polemonium boreale*

Scheuchzer's Arctic Cotton-grass - *Eriophorum scheuchzeri* ssp. *arcticum*

Arctic dandelion - *Taraxacum arcticum*

Greenland scurvygrass - *Cochlearia groenlandica*

Polar bluebell - *Campanula rotundifolia* ssp. *gieseckeana*

TREASURE HUNT

'I'm a green biologist,' says Kristine.

She says that biologists usually fall into two groups: 'green' and 'white-coated'. White-coated biologists prefer to work in labs and peer through their microscopes, while green biologists prefer fieldwork in nature.

Kristine definitely prefers fieldwork. Out in the wild, she can observe where the plants grow, what they need and how they develop. If you want to be a biologist, it is good to have a keen eye for detail. You have to enjoy searching without knowing what you are looking for. It is like a mystery, or a treasure hunt!

Research and fieldwork can be surprisingly expensive, especially in Svalbard, where many research sites are pretty remote. It can be hard to get funding when you do not even know what you expect to find.

This kind of research is fuelled by wonder and curiosity, and it is incredibly important. This is how scientists keep discovering new things.

Kristine's favourite flower is the creeping sandwort. It is a lovely little plant with pink stamens. Can you find it in the overview on page 92?

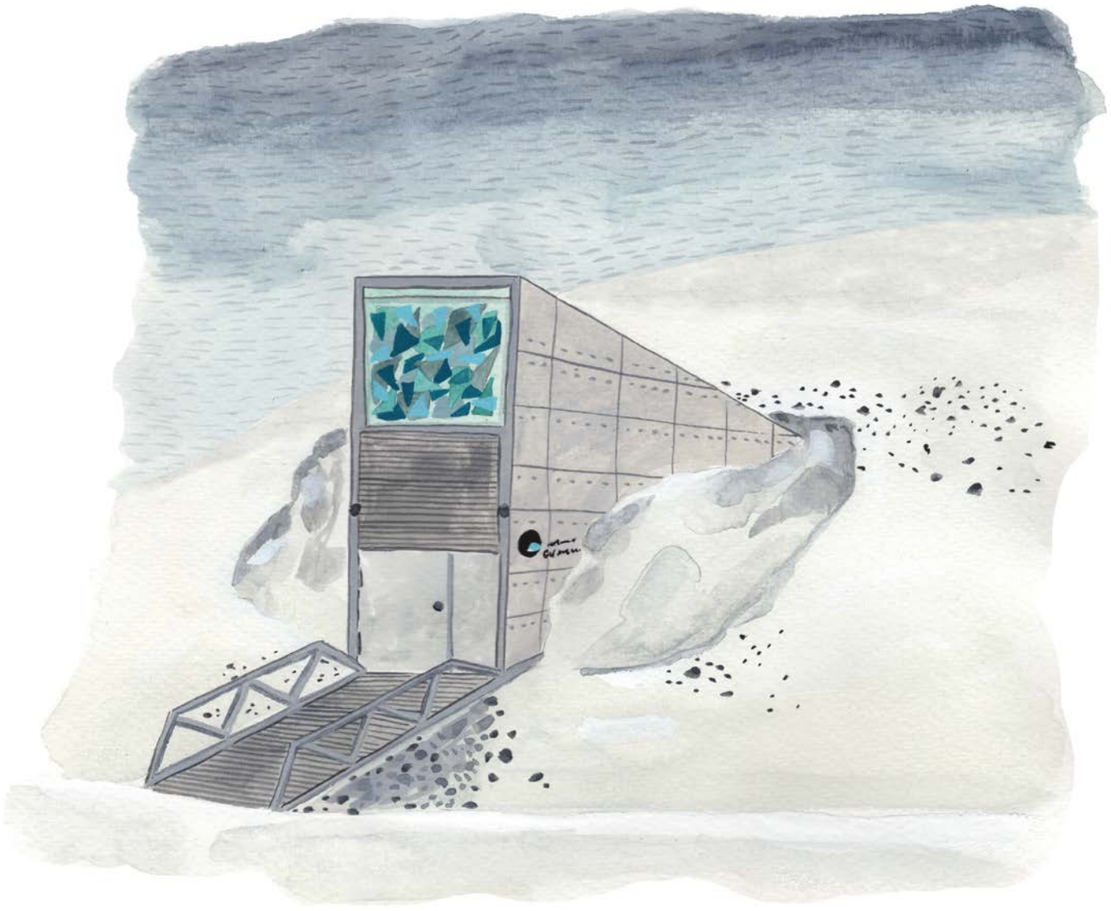
DO TREES GROW IN SVALBARD?

This is a trick question!

As I am sure you have realised by now, Svalbard is mostly wilderness, made up of glaciers, mountains and tundra. Trees – the way you would expect trees to look – do not grow in Svalbard. The closest thing to a tree is the dwarf birch – a tiny shrub in the birch family. It rarely grows taller than one metre.

Biologists can get into heated debates over where to draw the line between a shrub and a tree. Kristine says the dwarf birch is clearly in the shrub category.

More than a third of Svalbard's native plants are red-listed species, which means they are at risk. Most of the threatened species are High Arctic specialists. They need cold summers, and some depend on having a snow cover well into spring. As spring gets warmer and snow melts earlier due to climate change, these plants dry out.



During the last Ice Age, more than 10,000 years ago, Svalbard was almost completely covered in ice. Since then, many species have managed to arrive here on their own, but many were introduced by humans.

The moss campion grows in small, cushion-like clumps.
It blooms in the south first and then in the north.
Maybe people used them for navigation in the past?

ONE MILLION NON-NATIVE SEEDS

Just outside Longyearbyen, in the mountainside above the airport, lies the Svalbard Global Seed Vault. It holds more than 1.3 million seed samples from 85 countries. The seed vault was created to ensure that food crops do not go extinct due to wars or disasters.

The vault is built inside a mountain and is designed to withstand major earthquakes. It has been built into the permafrost, so the seeds will stay frozen even if there is a power cut.

The first withdrawal from the vault was made in 2015. During the Syrian civil war, the heritage seed collection of the ICARDA research centre was destroyed. Luckily, backup copies of their collection had been sent to Svalbard, and these could be retrieved.

Two years later, Syria sent seeds back to Svalbard, so the Syrian seeds are once again secure for the future.

It is funny to think how Svalbard is a place where we do not want non-native species to grow, and yet we keep seeds from all over the world here.

The fine machine

‘Here, here, here – and there! It is everywhere!’

We are on the second floor of the University Centre in Svalbard, and geologist Maria Jensen is pointing around her office.

Geologists study what our planet is made of, how mountains and rocks were formed, and why we have volcanoes and earthquakes.

No matter where you are, you can spot geological material. The tiles in your kitchen, your tablet, and your mobile phone charger all have one thing in common: they contain materials that were once in the ground.

Geology involves studying minerals and fossils, but also studying how continents move. And we cannot forget about space. There is geology in space, too! Scientists are very eager to learn more about what the moon and Mars are made of.

THE COAL TOWN

You may remember from the previous chapter that there are no large trees in Svalbard. There is no dense pine forest, or any tall birch trees with long roots. There is just a lot of exposed rock and bare ground.

The abundance of exposed rock makes Svalbard a very exciting place for geologists. Their fieldwork starts right on their doorsteps!

Svalbard was discovered by the Dutch explorer Willem Barentsz in 1596. For many years, people hunted whales, and later they started hunting polar bears, before coal mining began at the very end of the 1800s.

Coal is formed over millions of years, when plant matter, mostly from trees, is compressed under pressure. Hey, wait a minute! This does not make any sense! There are no trees in Svalbard, so how can the coal be mostly from trees?

60 million years ago, the climate in Svalbard was completely different. Summer temperatures were much higher than they are today, and winter temperatures rarely dropped below freezing. The conditions were closer to the climates of northern Germany or Denmark today. The whole archipelago was covered in forests. Several times, I have found beautiful leaf fossils in the moraine in front of Longyearbreen.

An American named John Munro Longyear opened the first commercial coal mine in Svalbard in 1906. It was just across the fjord from what is now Longyearbyen.

Longyearbyen is named after the American who founded the town.

Ten years later, in 1916, Norway purchased the mining company and established a coal company called Store Norske Spitsbergen Kulkompani. Norwegian coal mining in Svalbard lasted for more than a century, until 2025. For a long time, the coal was used to heat the town and shipped to metal factories in Europe.

Much of Svalbard's coal was of very high quality, but coal still causes a lot of pollution. Many countries are trying to reduce greenhouse gas emissions, partially by switching to more electric power.

This green transition depends on a variety of minerals. Where can they be found? The same place we found the coal: underground!

SIZE 46 SHOES

Just before Christmas in 2006, two miners were at work in Mine 7. They noticed something strange on the ceiling. Footprints! Very, very old footprints.

Those footprints had been left behind by one of the first mammals to evolve after the dinosaurs went extinct: a pantodont. 60 million years ago, pantodonts roamed the marsh and swamp areas in Svalbard. Their footprints filled with sand that eventually turned into sandstone, while the swamp turned into coal.

In the past, cable cars were used to transport coal from the mines to the harbour. The cable car towers are still visible in and around Longyearbyen, and they look especially beautiful at sunset.

Scientists are not entirely sure, but they believe pantodonts were the size of cows and looked a little like long-legged hippos.

What scientists *are* certain of is that pantodonts lived in North America, too. The footprints found in Svalbard confirm that there was once a land bridge between North America, Greenland and Svalbard.

READING THE PAST IN COAL

The different layers of coal can tell us about climate changes. By studying old coal layers, scientists can learn more about how the planet has heated up and cooled down throughout history.

This is what Maria finds so exciting about being a geologist. She can extract loads of information from the coal using special instruments.

When you look at a rock, you might just see a grey surface. A geologist, however, can see a whole world. Likewise, coal from Svalbard may just look like a black lump, but inside is layer upon layer of information.

In a chunk of coal, scientists can find traces from ancient swamps, or dust particles that reveal what the weather used to be like.

To understand global warming and climate change, it is important to know how conditions may have been in the past. This kind of information is stored in coal, helping to paint a picture of how things used to be.

Carbon dioxide levels in the atmosphere are measured in parts per million, or ppm for short. We know that CO_2 levels have varied throughout history. 61 million years ago, CO_2 levels were 1,000 ppm. Back then, the planet would not have been particularly inhabitable for us humans.

For most of the last 10,000 years, CO_2 levels stayed at a comfortable 280 ppm. Then came the Industrial Revolution, and people started using coal, oil and gas. Since then, over the past 200 years, levels have risen dramatically.

TRY IT YOURSELF

In July 2025, CO_2 levels were 427 ppm. Search the internet to find out what the ppm levels are today.

Geology is about reading the planet's history in stones. Stones can tell us a great deal about how the world has evolved over millions of years.

This can help us predict what might happen in the future.

A MATTER OF TIME

When we talk about geology, the timespans become mind-boggling. We are not talking about hundreds or thousands of years – but millions!

A geologist might find it funny if you say it is a long time until Christmas. Even if you read this on Christmas Day, those 364 days until next Christmas are just the blink of an eye in the history of rocks.

To a geologist, even 5,000 years is a short period of time. When Maria can take a sample from a lump of coal and uncover what happened over the course of 5,000 years, she gets *really* excited.

'It is very precise,' she says.

If you forget your packed lunch in your backpack, there is a big difference between leaving it for five days and leaving it for 5,000 years.

In geology, five days and 5,000 years are practically the same thing.

DO YOU KNOW HOW TO COLLABORATE?

Geology is a crucial part of o our modern, day-to-day lives. Geologists are not just scientists who study rocks – they help plan cities, tunnels and roads, too.

Maria explains that geology is such a broad field that many geologists work across disciplines.

They may work with experts on plants, ocean currents or chemistry, just to name a few. Collaborating can make it easier to find answers to difficult questions.

Many experiments do not produce any results, but Maria says they still provide valuable lessons.

Trying and failing often leads scientists to develop new techniques. And next time – or maybe after the next *ten* times – they just might find the answer!

The plastic plague

1, 2, 3, 4, 5, 6, 7... 14... 17... 67... 103... 173... 178... 199... 203... 209... 244... 298... 320... 367, 368, 369... 399, 400, 401, 402, 403, 404, 405.

Oh, no. Poor, sweet, lovely fulmar. This was not supposed to happen to you.

The northern fulmar is quite a stocky bird. It can grow to about half a metre long, and it can weigh almost a kilogram. It has a short, wide neck, and a strong head. It has a tube-like nostril on top of its beak. When the northern fulmar flies, it glides right above the ocean surface with stiff, straight wings. If it needs to speed up, it makes a few rapid flaps with its wings, then carries on gliding through the air.

Some may think the northern fulmar looks like a seagull, but the fulmar might find that insulting.

Fulmars are more closely related to albatrosses and storm petrels. They belong to the order of seabirds called *procellariiformes*, and they spend most of their lives at sea.

I think fulmars are incredibly beautiful. When I am out on a boat, I love to stand and watch one glide along the railing. I lean over and lock eyes with it until it suddenly veers to the side, flaps its wings to pick up speed, and slips back into position.

These birds are excellent flyers and use very little energy to move forwards. That is why they are so good at flying across great distances.

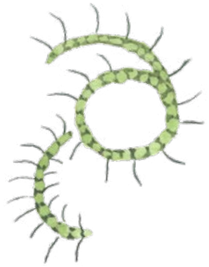
PLASTIC IS NOT FANTASTIC

Geir Wing Gabrielsen is an expert on Svalbard's birds. Geir has been studying seabirds and environmental toxins in Svalbard for more than 40 years. He has even written several children's books on the topic. Over decades, he has been keeping a close eye on how the birds' lives are changing.

'Unfortunately, it's not looking too good. I have observed the changes and been an eyewitness to what is happening in the Arctic,' he says.

Those numbers at the start of the chapter? Those are individual bits of plastic. In 2023, Geir and his colleagues examined the stomach contents of fulmar chicks and found scary amounts of plastic.

One tiny chick had 405 pieces of plastic in its stomach. Never have so many bits of plastic been found in the stomach of one bird. In a similar study from 2012, adult northern fulmars had an average of 15 pieces of plastic in their stomachs.



Geir explains that fulmars find their food on the ocean's surface.

'These pieces of plastic smell and taste a bit like plankton, which is a fulmar's favourite food. The birds mistake the plastic for plankton,' he says sadly.

When Mummy and Daddy fulmar return and regurgitate food for their children, the chicks' stomachs fill up with plastic.

A fulmar's stomach is not that big – it is just about the same size as a bottle cap. If you cram 405 small bits of plastic into a space no bigger than a bottle cap, there is not much room left for actual food. Instead of containing nutrients, plastics contain toxins that can spread to the rest of the bird's body.

ENVIRONMENTAL TOXINS

Scientists have been studying environmental toxins in fulmars for more than 30 years. In the early 2000s, the levels of toxins were going down. This was thanks to many countries banning several harmful substances like PCB, DDT and chlorine compounds. As lower levels of toxins were released in nature, fewer of them made their way into seabirds.

Unfortunately, humans have been using more plastic since the 1970s. Tremendously much more plastic. There are plastics in our homes, schools, clothes, toys and sports equipment. Plastic is derived from oil, and many toxic chemicals are added in the process of making it. Plastic is also quite durable and does not decompose in nature. It just breaks down into smaller pieces, until it eventually turns into microplastics and nanoplastics.

A great deal of the plastic that ends up in Svalbard comes from fishing boats – fishing nets, buoys, oil cans, bottles and storage crates. Plastic moves with ocean currents and can travel huge distances.

During a storm in the Pacific Ocean in 1992, a container carrying nearly 30,000 rubber ducks on a ship fell overboard. These plastic toys rode the currents for years. Occasionally, they still wash up on beaches, thousands of kilometres away from where they went into the sea. In 1997, a cargo ship travelling to New York was hit by a big wave. One of the containers that fell overboard contained 5 million Lego bricks. The bricks still wash up along the English coastline now, three decades later.

You can help! Never, ever, ever throw plastic into nature! Tell off any adults you see throwing plastic into nature! If you are out for a walk, bring any rubbish and plastic you find back home with you, so it does not end up in the stomach of a baby bird.

TRY IT YOURSELF

Create a litter-free zone! It is, of course, not your responsibility to keep your neighbourhood free from rubbish, but choose a stretch of road on your way to school or somewhere you walk often. Make it your mission to keep it rubbish-free.

PROFESSOR PLASTIC

Geir works for the Norwegian Polar Institute. The Polar Institute gives advice to the people who make laws in Norway. When politicians make new laws to better protect nature and the environment, they use the information given to them by Geir and his colleagues.

Geir says his life as a scientist has been exciting, but that his field of work has taken a turn for the disastrous.

Luckily, there are things we can do to change that.

‘We have to stop producing plastics that cannot be recycled,’ Geir says sternly.

He lists several things that we wrap in plastic for no good reason. Like when oranges and bananas are peeled and sold in plastic tubs. He encourages all of us to be more critical about when we use plastic.

‘We wrap an insane number of things in plastic. We need to be more conscious and make sure plastic does not end up in the sea. It can so easily make its way into the stomach of a tiny fulmar chick.’

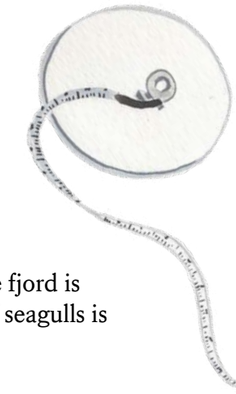
Lauren

How can you help scientists?

CITIZEN SCIENCE

SECCHI DISK

Me, a future scientist?



We are perching on the edge of a small rubber dinghy. The fjord is calm. There is barely a ripple on the surface, and a flock of seagulls is circling overhead.

'Do you know what this is?'

Marine biologist Lauren Peach holds up a round, white disk and looks at us expectantly. The disk itself does not weigh much, but a heavy lead weight is attached to one side.

Everyone in the boat shakes their heads. None of us have seen anything like it before.

'This is a Secchi disk,' Lauren continues.

A Secchi disk is used to measure visibility in water. Visibility can give us information about how much phytoplankton there is, and whether the water is high or low in nutrients.

The Secchi disk is named after Pietro Angelo Secchi, an Italian astronomer from the 19th century. He knew a lot about solar phenomena, stellar spectroscopy and spectral classification. Wow – that is a whole bunch of difficult words! To keep it short – this dude was very, very clever.

'How does it work?' I ask.

Lauren says it is easy. The Secchi disk, with its lead weight, is attached to a measuring rope. She tells me to lower the disk into the sea, and to stop the moment I cannot see it anymore.

Then, I start slowly pulling it back out, and as soon as I spot something white in the water, I have to shout: 'I see it!'

Lauren asks me to read the number on the tape measure, right at the water's surface.

'72 centimetres,' I say.

'Well, that's not great visibility,' she says.

But she tells us her earlier group had even worse visibility – just 68 centimetres.

CITIZEN SCIENCE

Lauren works for HX Expeditions. Every year, she sails around Svalbard, Greenland and Antarctica with tourists. Tourists are eager to visit these beautiful places, but to Lauren, it is important to teach them something about the fragile environment at the same time.

The measurements Lauren and the tourists take are sent to a global database. Scientists can use this data to track changes over time.

Do you remember Cheshtaa, who keeps returning to the same spot in the fjord outside Longyearbyen? And Kristine, who monitors the spread of non-native species? And Geir, who has been studying birds for more than 40 years? They are all making time series – tracking changes over time.

Scientists cannot be everywhere at once, and research is often very expensive. That is why scientists often appreciate help from people like you and me, even though we are not scientists ourselves. We can help gather information for them to use in their work. Citizen science is proper teamwork.

It is citizen science when Katie receives photos of the Northern Lights from photographers all over the world, and it is citizen science when people report their sightings of polar bears hunting reindeer to Jon. Scientists use observations like these to gain more knowledge and better understand the environment around us.

Every little piece of information helps us understand how the world is changing.

When scientists see that we are losing visibility in the water, that glaciers are melting faster, or that new flowers are blooming on the tundra, they see clues about what the future might look like. The more we understand about what might happen, the better we can figure out how to protect nature.

SCIENCE IS ABOUT CURIOSITY

You have now had glimpses into the lives of twelve scientists working in Svalbard. But in total, more than 6,000 scientists from around the world are involved in Arctic research projects.

It is amazing that this many people, from different nations, are working on finding solutions to the challenges the world is facing. That is cause for real hope.

Science is not just about big issues like climate change and sea ice. It is also about being curious in our day-to-day lives. Have you ever wondered why some stones on the beach are smooth, while others are jagged? Or why some birds fly south in winter, while others just stick around? Questions like these can be the starting point for exciting research projects!

If you want to learn more about any of the topics from this book, you will find a list of sources on page 122. That is a great place to start.

All the scientists you have met in this book loved asking questions as children. Some dreamed of studying glaciers, while others were fascinated by the night sky and the Northern Lights. Some were particularly fond of animals, while others had a passion for plants. But they have all got one thing in common: they are incredibly curious.

The world is changing, the climate is changing, and new questions keep coming up. Scientific mysteries can be huge or tiny, but I will tell you one thing for sure: they are all waiting to be solved!

Some of what you have read might have made you feel sad. If so, talk to an adult. Keep learning. Let yourself be inspired by the scientists working to figure out what is going on and how we can build a great future – without harming nature along the way.

Maybe you will be the one to solve some of these problems?

Thank You

Many people supported me in working on this book, and I owe you all a great thanks. An encouraging text message, words of inspiration, curious questions from the target audience, tips for great sources, and feedback on the book – I've appreciated all of it throughout the process.

The Norwegian version of this book would never have come into being without the support of NFFO – the Norwegian Non-Fiction Writers and Translators Association. Securing a spot at the 2023/2024 Writers' School gave me the motivation and encouragement to develop a draft idea into a finished manuscript. A huge thanks to Kristine Isaksen, Bjørn Arild Ersland and Hilde Hagerup for the opportunity, and to my fellow classmates for their support.

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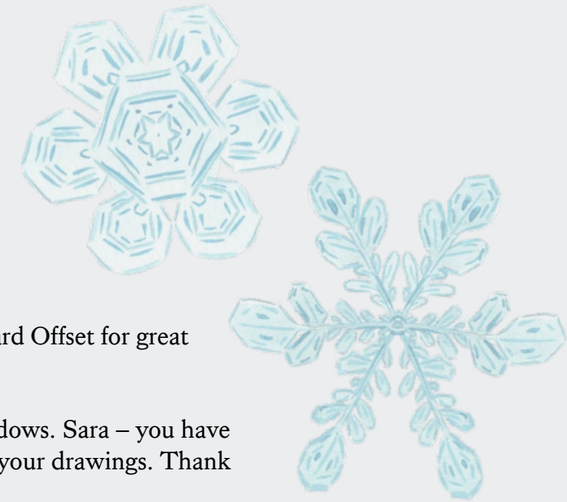

Thank you to designer Emilia Haugland and Ålgård Offset for great collaboration.

A huge thanks to illustrator Sara Boccaccini Meadows. Sara – you have perfectly captured the atmosphere of Svalbard in your drawings. Thank you so much for a wonderful collaboration!

This book would not have been possible without the unique science community in Longyearbyen. Huge thanks to everyone who let me interview them. In addition to the scientists featured in each chapter, I've had fantastic help from my former colleagues at the University Centre in Svalbard. Thanks to Ruben and Pernille Eidesen for letting me use your cabin. Special thanks to Ane Hammervoll Bjørsvik for encouraging me throughout the process. Thank you to Frank Nilsen for all your support and for being the scientific consultant for the book.

Frank has also had a polar bear break-in at his cabin. There it ate all the chocolate-covered marshmallows and pistachios.

A big thanks to Ingrid Ballari Nilssen at UNIS and Trine Lise Sviggum Helgerud at the Norwegian Polar Institute. You are both doing a brilliant job of communicating Arctic science.

Any errors or inaccuracies in the book are entirely my own and exist despite all the great help I have had.

Thanks to NFFO and Svalbard Environmental Protection Fund for their support in developing the Norwegian manuscript, and to Ragnhild for taking care of the accounting so that I can focus on writing. Thanks to my mum and dad, who have always encouraged my curiosity and given me wise answers to all my questions.

Thank you to Øyvind, Peter and Fredrik. Without your support, there would be no book.

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TopoSvalbard is the Norwegian Polar Institute's fantastic map service. It provides detailed and precise map data of Svalbard – perfect for those who dream of experiencing the beautiful landscape

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Svalbard

N
W
E
S

Polhavet

Nordaustlandet

Liefdefjorden

Spitsbergen

Blomstrandhalvøya

Ny-Ålesund

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Eskerdalen

Longyearbyen

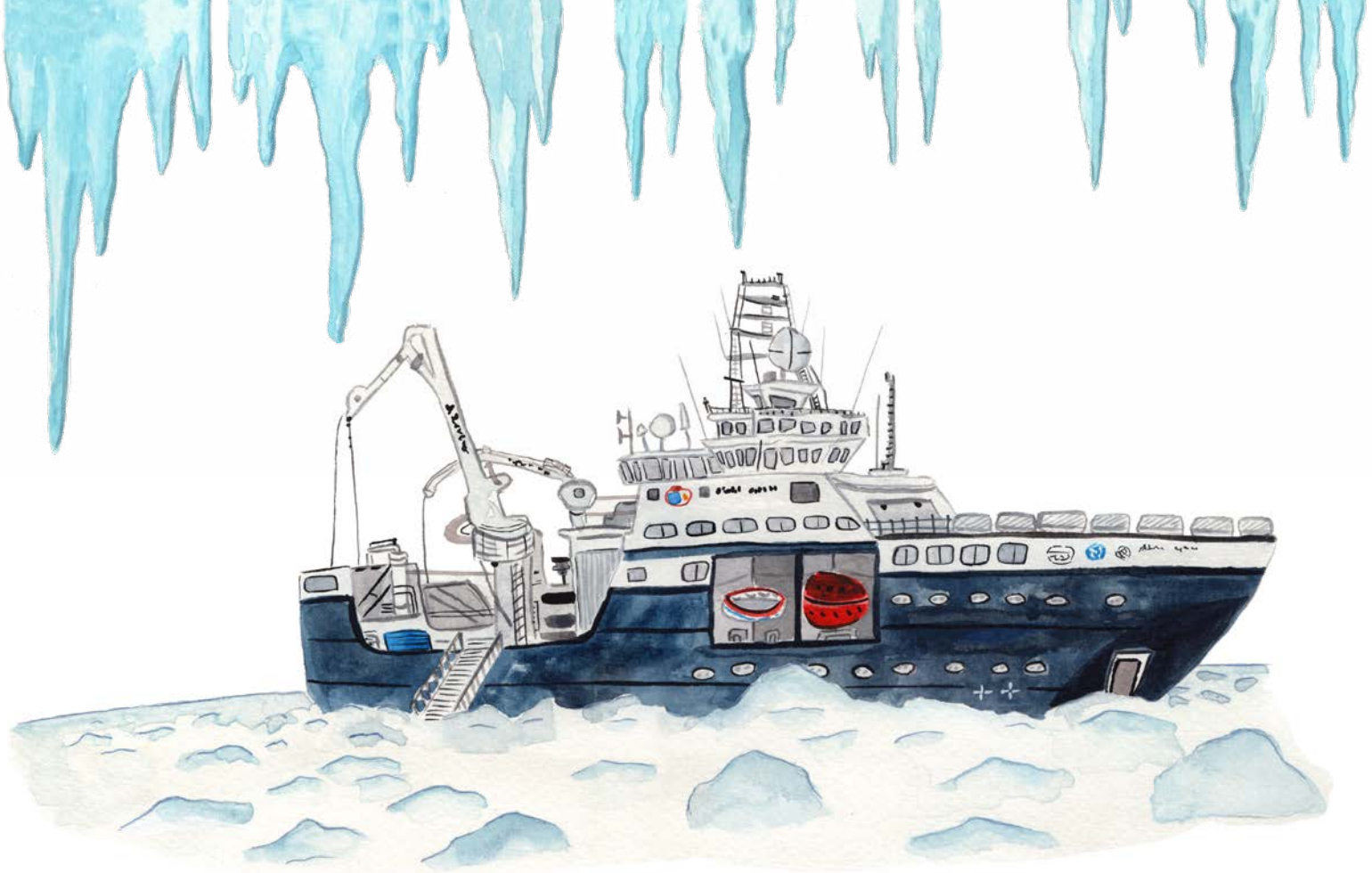
Marmorbreen

Edgeøya

Rindersbukta

Hornsund

Hopen



Ever wondered what polar bears eat for dinner? Or why marine biologists need to know how to count to a billion? Want to know why the Northern Lights are redder during the day than at night? Yes, there are Northern Lights in the daytime! But what even are Northern Lights?

In the Arctic, scientists study fascinating, fun and highly unusual things. And this 'climate change' thing adults keep talking about? In the Arctic, you can see and experience the changes.

This book will introduce you to some of the scientists working in Svalbard. They will tell you about their lives in the Arctic, and what they find beneath glaciers, out on the tundra and under microscopes in the lab.

Plus, you'll never eat a Snickers bar again without thinking of glaciers!

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