BE A MICROSCIENTIST!

WORKBOOK

River exploration and scientific research for microscientists

Produced with funding from the European Union. The opinions and statements expressed herein reflect the views of the author(s) and do not necessarily reflect the official position of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor the EACEA can be held responsible for them.

Funded by the European Union

BE A MICROSCIENTIST! WORKBOOK

Some of the river pollution is invisible to the naked eye. However, this does not mean that it does not have an impact on our lives . In order to learn about microplastics and spread plastic literacy, the Be a Microscientist initiative was launched. Our goal is to awaken curiosity in young people and increase their resilience to all kinds of pollution, especially the harmful effects of plastics.

Our workbook shows, through interactive tasks, simple tools and a playful way, how the integrity of our environment and our health are connected, how even the smallest things can have a huge impact on the ecosystem and on people who are an integral part of the living world. With the help of their sophisticated senses and some technical tools, children can discover the small wonders of nature, their own role and impact in it. They see the forms of pollution with their own eyes and develop solutions to the problem . The workbook is a complementary element of the Tiszta Tisza Textbook series. For background materials, additional exciting tasks and lesson plans, visit the website summarizing our educational materials:

www.tizstatisza.eu

Microplastic testing is being carried out using a digital microscope in the PET Kupa mobile lab. Photo: Anna Géczy

WELCOME ON DECK

FUTURE MICROSCIENTISTS!

I am Captain PlastiX, a pet pirate. My goal is to clean rivers and seas of plastic and to spread plastic literacy. Just as pirates set out to discover secret treasure with a map in their hands, scientific researchers also search for new knowledge in a similar way, purposefully. The real treasure of scientific discovery lies not only in observations and theories, but also in the results achieved based on your own thoughts and individual insights. You will find the “ map” that shows the way to knowledge through this workbook. To interpret the treasure map, you will need a code, which is nothing more than curiosity.

Every researcher is curious, and all research begins with questions.

In scientific research, as in treasure hunting, truly valuable discoveries are revealed only to those who search with open eyes and minds. To do this, you will need a special “ treasure chest”: this is nothing more than your mind, which you can constantly fill with new thoughts, experiences and feelings. Because the greatest treasure we can accumulate is knowledge itself.

So open your mind and embark on the adventure of exploration!

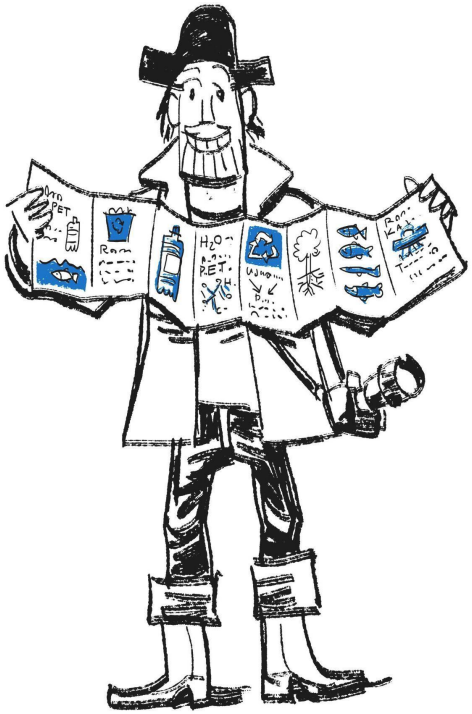
Each task begins with opening **a treasure chest** . See what you'll need to complete the task and set sail!

Before you start working, it is worth delving deeply into the topic.
The questions and the pirate note will help with this.

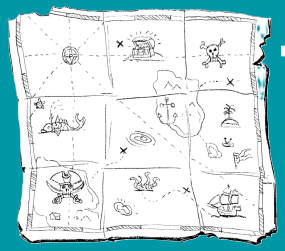
The navigator shows the steps and direction of the research.

You can collect the results and conclusions in the logbook.

TABLE OF CONTENTS



Time spent in nature recharges, calms and inspires. Cherry blossoms, floodplain forest in the background. Nagykörű, Hungary. Photo: Krisztina Pálvölgyi



TREASURE MAP

"Look deep into nature and you will understand everything better!"
Albert Einstein

The Treasure Chest hides information about what tools will be needed to complete the tasks.

Classroom and field assignments await you, distinguished by the following markings:

Classroom tasks

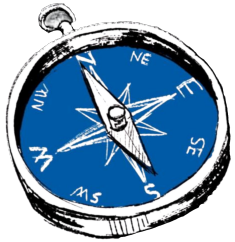
Outdoor tasks

Useful background information can be found in the pirate notes.

Microplastics identifier helps you navigate the world of tiny particles.

The difficulty of the task is indicated by black
oars indicate:
There are 3 levels of difficulty.

COMPASS



We are only a part of nature, not the whole of it!
This is the key phrase in recognizing that everything that exists in nature and What we do to nature is ultimately what we do to ourselves. We are in constant interaction with the air, the climate, the soil, the vegetation, the fauna, and the surface and underground waters.

Let's explore the connection with our environment through our senses!
What new things can we learn about nature this way? Let's observe how this connection affects our emotions.
Our senses are the primary sources of our knowledge of our environment and nature. They help us perceive sounds, colors, shapes, tastes, smells, as well as the temperature and surface of objects. In this way, our senses help us navigate the mysteries of the world, gather knowledge about the environment around us, and enrich our everyday experiences.
This observation through the senses can also be called **an empirical experiment in the language of science.**

The living and non-living world that makes up nature is not only closely connected, but also communicates with each other. For example, sounds are not only used by animals, so thunder warns of a storm, while the rumbling ground indicates an earthquake or a volcanic eruption. Our environment is woven with sounds, smells, colors and textures. Some are easy to notice, others hide behind the rest. But if we pay close attention, we too can perceive the many, many signals that swirl around us.

The river provides us with countless gifts.
However, we can only enjoy these in the long term if we pay attention to them and treat them responsibly. If we pollute rivers, we not only damage the river itself, but also endanger our own future. Irresponsible human activity limits the availability of the gifts that rivers provide, so it is our shared responsibility to preserve them.
In the second half of the 20th century, ecologists began to use scientific methods to investigate how nature what gifts it provides, what goods it provides for humans. These are collectively called **ecosystem services** , which include it includes both the living and non-living environment.

Overall, the concept of ecosystem services stems from the recognition that humans and nature form an inseparable whole, and that the survival of natural systems is crucial for human well-being.

Provisioning services : Rivers provide clean water for drinking, irrigation and food.
Regulating services: Rivers transport water across the landscape, connecting it to the great water cycle. They reduce global warming through their cooling effect.
Supporting services: Rivers provide habitat for a wide range of living things, such as fish, birds and plants. They also help transport nutrients to the soil.
Cultural services: Rivers are not only beautiful to look at, but they also inspire painters and poets, and provide places for hiking and relaxation. Just think of a quiet paddle!

Rivers do much more for us than we think. Whether you have a river near you or not, you still benefit from these gifts.

We can be grateful for every drop .

LET'S SEE WHAT KIND OF TASKS AWAIT YOU!

OBSERVATION

By focusing our attention, an unknown world can open up before us.

RESEARCH

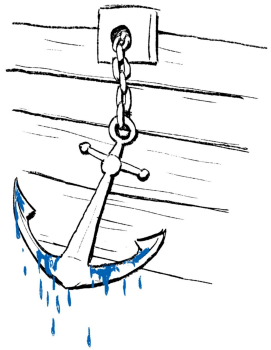
Deepening the understanding of the topic is facilitated by collecting information from as wide a range of sources as possible.

LABORATORY WORK

The classroom is transformed into a laboratory with the help of exciting laboratory equipment.

ANCHOR UP!

The main characteristic of nature is the cycle and the pursuit of balance.



Nature is an extremely complex system that operates through chemical, physical and biological processes. Nature includes living things (plants, animals, fungi, bacteria, etc.) and their non-living environment (e.g. mountains and valleys, rocks, soils and waters).
We call this complex system an ecosystem, which includes living and non-living environmental factors, as well as humans. Every single small component is important, as they affect each other, everything is connected to everything else.

The development of humanity is closely linked to the observation of nature. In ancient times, people determined the passage of time by following the movement of the stars, discovered the basics of agriculture by studying the behavior of plants and animals, and created the first tools by understanding the forces of nature. Recognition of the laws of nature led to scientific discoveries and technological innovations. Every great step of human civilization – navigation, flight, the discovery of energy sources – was born from the observation and imitation of nature.

Spending time in nature is extremely important for our mental health. It is here that we find peace, recharge, and harmony.

The puzzle lies in how we can make the invisible visible. That is, we try to make visible the invisible water, the feelings associated with water, and all the good that water provides us.
Photo: Balázs Pesti

OUR SENSES AS MAGNIFYING GLASSES

FIELD TASK

Questions:

- Which of our senses do we perceive what?
- Has it ever happened to you that one of you heard or saw something when the others hadn't seen or heard it yet?
- Can you name any animals that have a highly developed sense organ?
- Could it be that our senses, if we listen to them, magnify tiny signals from the surrounding nature?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ YOURSELVES AND YOUR PRESENCE
- ❑ YOUR ATTENTION, YOUR SENSES
- ❑ BLANKETS TO SIT ON
- ❑ LOGBOOK

OBSERVATION

The goal is to realize that nature is not a distant place that is difficult to reach. The school garden, an urban green space, is part of nature, but nature is also within us.

PIRATE'S NOTE

Most of our microscientists are young and healthy students, armed with excellent vision, smell, touch, and hearing.
In the first chapter, the senses are listed and what they are truly capable of is discovered.

Scientific methods are used for this. For example, in order to find out what the ear is capable of, you have to close your eyes.

What hidden abilities do our senses have, and what are their limitations?

It will be revealed in the next task!

NAVIGATOR

1. Choose an outdoor location. It's best to find a nearby waterfront that's quiet, away from the noise of the city and traffic. But the location could be a secluded corner of the schoolyard or a nearby park.

2. Discuss what you expect from the experiment! What will you feel through your skin? What will you hear? What will you smell? What will you see?

3. When you arrive at your chosen location, form a circle, standing at a comfortable distance from each other. If the weather permits, take off your shoes so you can feel the ground and grass under your feet (only do this if it doesn't cause discomfort). But if the ground is not cold, you can sit down. The main thing: feel comfortable!

4. Before you begin the task, close your eyes, take a deep breath, and exhale slowly. Imagine that all noise and rushing disappear. It's just you, the environment, and what you are about to discover. There is no rush, your attention is complete. The task leader will guide this attention, and you can linger for a while at each station.

5. Let's start with touch. We experience touch not only through our palms and fingers, but with our entire body. The caress of the wind, the warmth of the sun, the feeling of the ground beneath our feet all belong to this sensation. Notice where you experience sensation through touch! What feelings does this evoke in you?

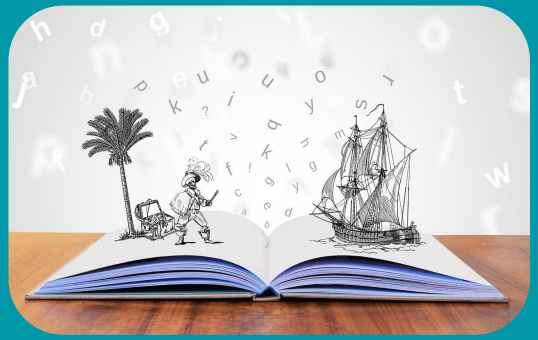
NAVIGATOR

6. Next, smell. Pay attention to your nose, the wind, and the air that carry the scents and odors. Follow the path of the air in your mind and discover how the air connects you to distant lands, to nature, and to each other. Breathe slowly, deeply, and observe this flow. Become aware that the fresh air flowing into your lungs contains oxygen, which reaches all your cells. Pay attention to the smells. With your eyes closed, imagine where they come from, what colors and shapes can be associated with them. The moisture, tiny water droplets in the air, are also found in your body. Just as they are in the clouds above you, and in the river and sea. Everyone has a drop of the ocean in them, even if they have never been to its shores. Water molecules connect people to the universe through the water cycle.

7. Let's move on to hearing, but let's stay with air. Air is responsible for transporting not only smells, but also sounds. Direct your attention to your ears and how you perceive sounds. Sound is a vibration, and we hear it not only with our ears, but also with our whole body. Notice the intensity with which the stimulus comes to you. Which sound came from the closest, and which one you feel is the furthest. Remain in complete silence for 1-2 minutes, and while doing so, count how many different sounds you hear! Which sounds come from human activity, and which ones from the natural environment?

8. The last sense we use is the eyes, or vision. Open your eyes carefully, covering them with warmed, rubbed palms (so that the sunlight doesn't blind you) and open them slowly. Look into each other's eyes, and then look around. Observe the landscape and area around you again, and find out what the sounds and smells you heard before belong to. What special colors or shapes do you see that you hadn't noticed before?

LOGBOOK



The more you do this experiment, the more things you will notice: it's as if nature is befriending you, starting to send you little signals, and slowly revealing its secrets to you.

Collect some of the feelings you experienced on the riverbank!

Write these on small pieces of paper and put them in a mason jar!

Place the gratitude jar in a visible place in the classroom. If anyone is feeling down and you want to remind them of the wonders that surround them, take out a note and talk about it. Just as every small particle in nature affects the whole, it is no different when it comes to people's mental state. The balance of a community is like a chain or a river itself: if someone is sad, it affects everyone, just as a river connects the source region, the settlements and the sea. But when you manage to cheer up your sad classmates, the feeling of joy has a positive effect on everyone's mood. Joy is not only a good feeling, but it is also important for our health!

THE SECRET LIFE OF RIVERS

CLASSROOM ASSIGNMENT

Questions:

- What do you think we owe to rivers?
- What processes are they involved in?
- How can humans connect with rivers?
- Are there any human activities that show our dependence on rivers?
- What can a river give us?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ NOTEBOOK
- ❑ GOOD OBSERVATION SKILLS
- ❑ INTERNET ACCESS FOR RESEARCH
- ❑ SCHOOL LIBRARY
- ❑ LOGBOOK

RESEARCH

A river monitoring mission and an adventure on the water.
Mapping ecosystem services.

PIRATE'S NOTE

After becoming familiar with the possibilities and limitations of their senses, microscientists expand their horizons! They realize that a river is not the same as the short stretch of river that they can see with the naked eye. A river is part of a much larger system that stretches from the clouds in the sky to the seas. But what does this mean specifically for a given school or settlement? Where does the water flowing between the two banks of the river come from and where does it go next? What does it provide for the plants, animals, and people living on its banks along its journey?

Examine the river through the ecosystem services you learned about in the Guide.

the **catering** services, you can follow the food chain from tiny river plankton to insects, birds, and mammals.

a cultural service, you can also start by considering how the sight of the river, its quiet gurgling, and the smell of the water's edge affect you. Write down these feelings!

In your research, also explore the poems, tales, paintings, or musical works that were inspired by the river!

It can be exciting to compare the Earth's ecosystem to the functioning of your own body. When studying **regulatory** services, look for similar connections! What happens in your body when you get sick, and what processes are triggered in nature when there is pollution? In both cases, the goal is to restore balance.
A similar “guardianship” to your immune system exists in nature. Predators help keep the population of their prey animals in check. For example, they can prevent herbivores or rodents from overgrazing the vegetation, so predators maintain the balance of the entire system. One such predator is the ladybug larvae, which hunt aphids, thus helping to protect the crop.

What is the situation with this balance in the rivers? Who is on guard duty in the seas? The water cycle is realized through supporting, or also called **sustaining,** services. Follow the path of water through states of matter and across continents. Travel in space and time with water.

NAVIGATOR

1. Form groups (max. 4 groups)! Each group should be given an ecosystem service with its corresponding examples.

2. Let's do some research! If you have the opportunity, use the internet to find out what you can find about the given service.

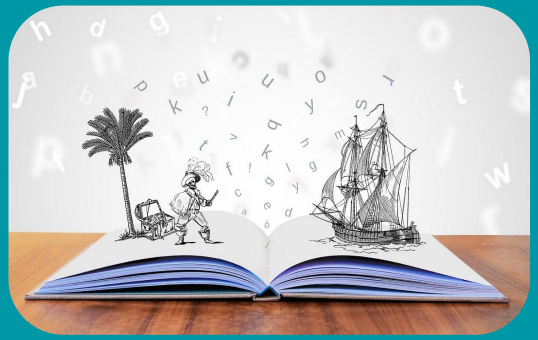
- Find an example of how a given service appears by following the path of a water molecule (from oceans to clouds to rivers).
- You can also use the school library if you don't have internet access.
- Discuss each person's thoughts and feelings on the topic.
- We need some movement! Bring the river into the room with a rain game! See how the petkalóz do it.

The author of The Little Prince, Antoine de Saint-Exupéry, wrote in his work “The Land of No Man”:

"Do you know what water is? Water is not just a chemical formula, it is life itself. You are responsible for what you save, what you share. Water not only quenches thirst, but also becomes the source of the soul."

The service-like, categorized approach may seem flawed after studying the gifts of rivers, as the same phenomenon can appear in multiple services.
The truth is that all natural values are closely intertwined, just as the natural system is a large interconnected system whose elements affect each other. It is not possible to interpret the functioning of the subsystems or the elements that make them up independently, just as it is not possible to classify any of them into just one service category.

LOGBOOK



Use the pirate community database!

the collected information to the website www.riversaver.eu and see the results of others.

Wherever we are in the world, the river connects us with invisible threads!

Have you ever heard of the seven generation principle?

This is an ancient Native American wisdom that states that every decision should be made with the impact not only on the present, but also on the lives of the next seven generations. Sustainable development is also formulated along similar principles and goals.

Share this wisdom with adults, and remind them that every decision they make affects your future.

From now on, before making any decision, think about its long-term effects!

EXPOSING POLLUTION

CLASSROOM ASSIGNMENT

Questions:

- What kind of river flows in your area? Where does it come from and where does it go?
- How does the river help our lives? How does society utilize its water?
- What natural and artificial substances can be found in river water?
- Do watercourses need protection?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ ATLAS, MAP
- ❑ INTERNET ACCESS
- ❑ LOGBOOK
- ❑ CREATIVE TOOLS FOR POSTERS
- ❑ (COLORED PENCILS, PAPER, GLUE, SCISSORS, ETC.)
- ❑ JAR

RESEARCH

Choose a river to explore! Find out every little detail about it, including what it has to offer you!

PIRATE'S NOTE

The natural environment includes living things, the atmosphere, the topography, the soils, the rocks, and the water system that connects them. The natural environment is crucial for humans, as it determines what kind of food we eat, what resources we have, and of course it also affects our health and well-being. The role of rivers, streams and lakes in the natural environment is outstanding, as they are present in our lives in many ways and help our well-being in countless ways. But in order for the opportunities provided by rivers to be sustainable in the long term, and for us to be able to enjoy the benefits provided by rivers and lakes for a long time, we must do the same: we must understand and protect our waters!

Let's follow the path of the river closest to us in our minds and on a map, and discover how we connect to it! Imagine the landscapes it runs through and how the people living there influence the life of the river, and how the river influences their lives!

After learning about the gifts of rivers, the Microscientists turn their attention to the "gifts" of humans. They raise awareness among themselves and each other of the many ways in which humans can influence the life of rivers.

The truth is revealed: pollution reaches rivers in hundreds of ways, many of which the living system can cope with, while others thoroughly test the living waters. In addition to the many visible sources of pollution, what invisible pollutants do we have to deal with that may even endanger our health?

In the 21st century, unfortunately, there is no child who has not seen a PET bottle floating on water. The bottle sends a clear warning to the world that the waters are being polluted. Many people think that the PET bottle is the real problem. But the Microscientists are not fooled by appearances, they know that the PET bottle is just the tip of the iceberg: they are aware that pollution does not only reach us in a form visible to the naked eye. They list the dangers that come in invisible forms, dealing with air pollution, dust and noise. They also dedicate time to stress and light pollution. Then they project this list onto the river. They realize that people often pollute the waters consciously, sometimes out of ignorance. Microplastics fit well into the list of these pollutants. The only way to stop it is to make ourselves aware of how it is created, how it migrates in nature, and what happens to it, how it affects the lives of others.

But what path does microplastic take in the world?

NAVIGATOR

1. Interview parents or local residents about the role the river plays in the life of the settlement. What do they know about its history and significance? Collect emotions related to the river. An emotion map can also help with this.

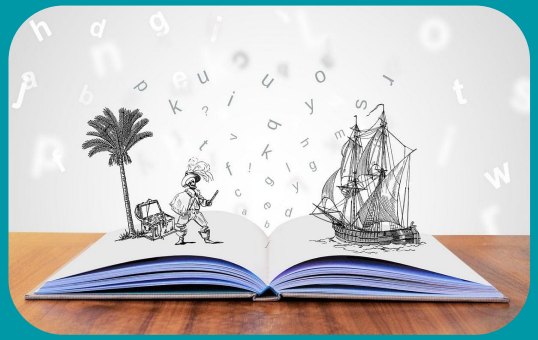
2. Use maps to determine the course of the river and make notes based on the following criteria, then create a table of the data you have collected. Each column of the table should contain the main sections of the river (e.g. upper, middle section). Each row should contain a characteristic feature of the river (e.g. tributaries, larger settlements, protected areas, and sources of pollution).

3. Use the internet or library books to search! Look for literary works (e.g. poems, fairy tales and short stories) and artistic works (e.g. paintings, music, sculpture) that can show what other people think about the river!

4. Create a drawing, poster or digital illustration that shows the natural values and threats of the river, the settlements along the river and the artistic inspirations.

5. Write a letter to the river, addressing it and expressing your thoughts on its protection!

LOGBOOK



Think about and discuss the following questions.

- What connection did you find between the state of the river and human activity?
- How could the pollution of the river be reduced?

-How do you imagine your future on the riverbank? How will it change in a few decades?

Share your thoughts with the pirate community!

Place the gratitude jar in a visible place in the classroom. If anyone is feeling down and you want to remind them of the wonders that surround them, take out a note and talk about it. Just as every small particle in nature affects the whole, it is no different when it comes to people's mental state. The balance of a community is like a chain or a river itself: if someone is sad, it affects everyone, just as a river connects the source region, the settlements and the sea. But when you manage to cheer up your sad classmates, the feeling of joy has a positive effect on everyone's mood. Joy is not only a good feeling, but it is also important for our health!

ANCHOR DOWN!

Tie up for a while so you can rest and load up the treasures in the central pirate warehouse.

At the port, you can upload the data collected in the logbook to the central microscience database. Let the information flow away on the back of the waves!

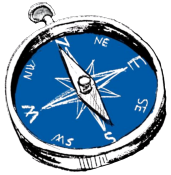
See what wind the other microscientists got in their sails and where they managed to navigate their ship on the sea of science.

Maybe joint missions, new discoveries, or even forging into a larger fleet await you!

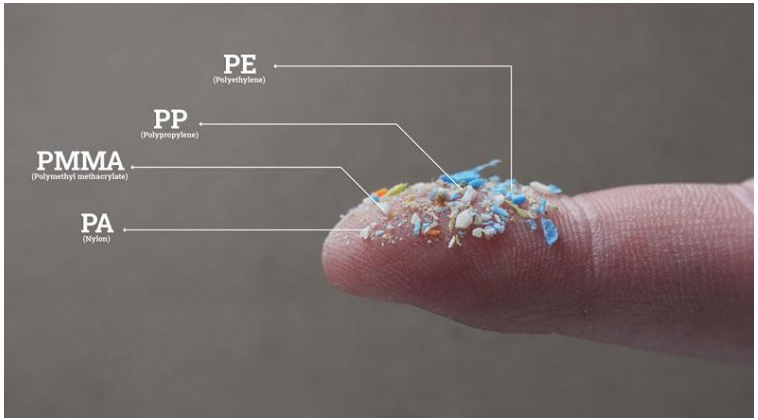
www.tizstatisza.eu

CLAUSE!

COMPASS



We invite you to do research.
Real detective work ensues, as researchers, like detectives, look for clues, observe, and draw conclusions.
We are looking for micro-traces that are barely noticeable or even invisible to the naked eye.



Just as there are many different types of plastic, microplastic pollution contains particles of different sizes and types.

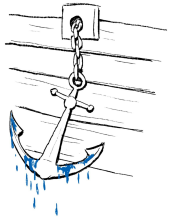
Pollution often reaches us in forms that are invisible to us - think of the soot particles in diesel smoke! But it is only invisible to our eyes: as soon as we increase the power of our eyes, for example with a magnifying glass or microscope, the invisible becomes visible. Microplastics are also hidden forms of pollution, trying in every possible way to hide from prying eyes. But that does not mean they do not exist!

The main tools of microscientists are: curiosity, technology, and preparedness. Microscientists work in teams, dividing tasks. They communicate and share their results with their community, not only within the walls of the school, but also outside it.

But what are we really looking for?
To understand the concept of microplastics, we first need to find the answer to what plastics are.
Let's start at the beginning and travel back in time.

natural resource that serves as the basis for plastic production has emerged as a result of millions of years of geological development on Earth . It is a decomposition product of once-living organisms, which migrated drop by drop into the reservoir layers from which it is extracted today. These reservoirs are called oil traps, and the resource is **petroleum** , also known as mineral oil.

RAISE ANCHOR!



LET'S GO BACK TO THE SEA OF KNOWLEDGE AND ADVENTURES!

After discovering the nature around them and discovering that plastics are also present on their own bodies, our microscientists are tracking down plastic particles found in our environment but not or barely visible to the naked eye.
The scientific research continues! But first, let's take a look at what exactly our microscientists are looking for!

Microplastics are particles smaller than 5 mm. Some of them are deliberately manufactured to this small size (e.g. for toothpastes, facial scrubs), which is why we call them primary microplastics. Most microplastics are secondary, i.e. they are created by the breakdown of larger plastics. For example, nylon bags fall into tiny shreds, and our clothes break down into tiny fibers.
Due to their very small size, microplastics easily enter the environment and can even "float" in the air.
Are they really everywhere? If you look around with the naked eye, do you see any signs of this?
In the following tasks, we invite you to participate in various classroom and outdoor experiments. The mission becomes a real scientific research when you record the data collected during your observations in a community scientific database. Here you can not only track your own results, but also learn about the discoveries of other microscientists.

If we group microplastics in the environment by their shape, it turns out that there are several types. And their shape can also indicate their origin. Microfibers come from synthetic clothes or drawstrings. Shreds and fragments come from discarded bags, PET bottles or other plastic objects. Spheres end up in wastewater from facial scrubs or toothpaste.

Unfortunately, even wastewater treatment plants cannot filter out all microplastics, so microplastics are also entering the river with the treated water. Today, we produce so much microplastics that they are found everywhere, in the water, the air, and the soil.

Plastics were originally made from by-products of the oil industry that the industry could no longer use, and thus became waste. These by-products were transformed into usable objects, thus giving rise to the plastics industry, whose first product was Bakelite in 1907. After Bakelite, many new types of plastics appeared, and plastics began to be used in more and more areas of life.

Their positive qualities are that they are light and easy to shape. Therefore, they were almost immediately used in the packaging industry, where they replaced glass, metal and wooden containers. The packaging industry still uses most plastics in the world today, but almost all of our everyday objects produced in recent decades contain plastics.

The problem stems from the fact that only a very small part of the plastics that are no longer used and have become waste, about a tenth, are recycled on Earth. The rest are landfilled or incinerated and - unfortunately in many cases - end up in nature. Plastics that end up in nature do not disappear for a long time, they usually break down and enter the water and air cycle. This endangers not only living beings, but also numerous environmental elements, such as the soil, rivers and seas, and through them the quality of our drinking water and food.

The environmental consequences are now well known: some animals mistakenly consume plastics that end up in nature as food, others get entangled in them, and still others incorporate the plastic waste into their nests. The effects on human health are still poorly understood, but it is probably not good for us either if we consume tiny micro- or nanoplastics with our food or tap water.

Vinyl records - They store audio recordings in an analog format and can be read by mechanical playback, with a needle.
Have you ever seen anything like this?

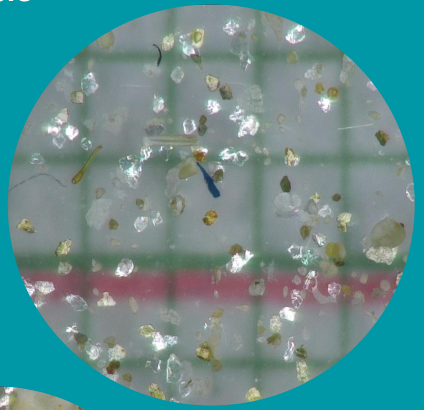
Plastics have become so popular that nearly 500 million tons of them are now produced worldwide every year.

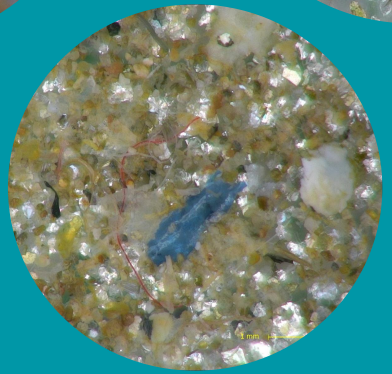
According to some research, it is now unavoidable, especially due to the popularity of plastic packaging, to consume plastic, even in small quantities. Every year, an amount roughly the size of a bank card enters our bodies in small and large pieces, randomly (e.g. from PET bottle pieces, clothes).

PET Kupa mobil lab in action
Photo: Anna Géczy

During sampling, we get to know the real excitement of research!

With the help of interesting lab equipment, the goal remains: to see the invisible





MICROPLASTICS IN THE SPOTLIGHT

CLASSROOM ASSIGNMENT

Questions:

- What are microplastics?

- Where have you met them?

- Do you think there are microplastics in our immediate environment (e.g. in the classroom, in our school bag or on our phone)?

- How can these particles get into nature, for example into rivers and lakes or into the soil?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ PLASTIC OBJECTS FROM OUR ENVIRONMENT (E.G., WORN SLIPPERS, LINT AT THE BOTTOM OF A BAG)
- ❑ RULER
- ❑ MAGNIFIERS, MICROSCOPE
- ❑ UV LAMP
- ❑ MICROPLASTIC DEFINITION
- ❑ LOGBOOK

Observation

After learning about the capabilities and limitations of their own senses, our microscientists will track down plastic particles in their environment!

PIRATE'S NOTE

Real scientific research begins, which is much like detective work, an investigation. Our microscientists, in the spirit of gradualism, first begin their work in their own living environment, in their school. The main question is, is there microplastic here, and if so, where did it come from? For their work, the young researchers use a tool that rarely makes mistakes: the UV lamp.

On stage, the actor usually plays under the light of strong lamps, so we can clearly see every movement of his face. Theater lamps give off light similar to the light of the Sun, which consists of many components. But there are also lamps that only give off one type of light, and they are often used for investigations.

Banks and money changers use UV lamps, which emit ultraviolet light, to detect counterfeit banknotes, for example. The microscientists first examine a few pieces of paper money. Once they have become familiar with the measuring device, the real investigation into microplastic particles can begin.

Using the scientific method, every possible source must be examined, which is why microscientists start with themselves.

They examine their own clothes and make a surprising discovery: Some of their T-shirts and hoodies glow strange colors under UV light.

Why?

It turns out from the first research!

Follow the navigator step by step!

NAVIGATOR

1. Examine each other's clothes, your own clothes (e.g. sweatshirt, jacket), shoes or plastic items (e.g. bag, pen holder, ruler) with a magnifying glass, microscope and UV light. What is the difference between looking at them with a magnifying glass and looking at them under UV light? What is the structure of your clothes or other items? Are there any signs that these items are slowly wearing out? Are the plastic parts chipping? Based on the marks, can pieces smaller than 5 mm come off?

2. Look around the classroom! Have you found any suspicious microplastic particles? Use a magnifying glass, a UV lamp and a microscope to observe the details! Suggestion: look at the bottom of your bags, the hidden corners of the room and shelves!

3. Where could the identified microplastic particles come from? Measure the size of a few pieces using a ruler and a microscope! (e.g. place the plastic particle on graph paper and look at it under the microscope)

4. Note-taking and documentation in the logbook:
   - Make notes and drawings of what you found!
   - What type and size of particles did you identify? Are these microplastics? How did you distinguish microplastics from other pollutants?
   - Where did you find them? Where could the microplastics in your environment come from?

5. Discussion:
   -How can microplastic particles get into our immediate environment?
   - How can these particles get into living waters?
   - What impact can they have on wildlife?
   - What is the connection between your daily habits and microplastic pollution?
   - Why is it important to examine microplastics?

LOGBOOK

What have you learned about microplastics and their effects?

If there were any interesting things that particularly touched you, make a note of them in the logbook.

Make a pledge on how to reduce plastic use!

Let's buy fewer new clothes or new school supplies, and try to take care of the ones we have so that they remain usable for as long as possible!

IMAGINARY REPORT WITH A MOP

CLASSROOM ASSIGNMENT

Questions:

- Do you know what microplastics are?
- Are there microplastics floating around in the air around us?
- Will we find a few particles of them on the floor?
- If so, how did it get there?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ MOP SET (BUCKET, MOP HANDLE WITH HEAD)
- ❑ TWEEZERS, SIEVE
- ❑ PETRI DISH
- ❑ MAGNIFIERS AND MICROSCOPES
- ❑ UV LAMP
- ❑ LOGBOOK

LABORATORY WORK

The main question: is there microplastic in the classroom? And if so, where does it come from? This interview with the mop reveals!

PIRATE'S NOTE

Just as scientists use questionnaires, so do investigators ask questions and take notes. The mop initially begs for answers from our microscientists, but then opens up and begins a long explanation. It explains that for thousands of years, all clothing has been made from natural materials - leather, linen, cotton, wool, silk. This has changed with the advent of plastics, and in the past few decades, more and more clothing has been made from artificial, synthetic materials. The mop knows that the composition of the dust picked up from the floor has changed, because clothes wear out, the fibers of the fabrics get holes and break.

The mop says that microplastics have appeared in the apartment, in the classroom, and are indeed on the floor. A good investigator doesn't believe everything at first sight.

You too, examine a worn sock or sweatshirt closely. If even that is not convincing enough evidence, then let the research begin and examine the mop water more closely, with scientific tools, using appropriate sampling methods and measuring instruments.

If you do your investigation well, you will find out whether the mop was telling the truth in his testimony.

Happy research, young scientists!

The school may be clean, but the water sure is mysterious!

NAVIGATOR

1. Mop the floor of the room (not when you are bringing in a lot of mud). Collect the sample!

- Make sure that the sample is not full of dirt (e.g. pick out large hairs or lumps of dirt with tweezers). - Carefully pour the mop water onto the sieve (the water may run into the sink).
-Transfer the sample from the sieve to a clean Petri dish using tweezers, or look at the sieve fabric itself.

2. Run your wet fingers along the windowsill and shelves. Wash the material from your hands (carefully, with a little water) into a petri dish, or if you use more water, wash your hands over the sieve and see what remains on the sieve cloth.

3. Observe the samples from the mop water and the windowsill with a magnifying glass!!
- What particles can you identify with the naked eye? Which ones come from where?
- Record what you find in the logbook! Draw something interesting if you see it.

4. UV lamp magic: will we see more things this way?!
- Turn off the lamp and shine a UV lamp on the samples.
- Many microplastics glow in UV light, so they are revealed! Note in the logbook if you see anything interesting.

5. Microscopic super discovery!
- Put the petri dish or the sieve under the microscope. What do you see?
- Look for tiny threads, pieces, or even shiny particles! These could be microplastics.
- Draw what you found in your logbook or make a short note of what you saw.

NAVIGATOR

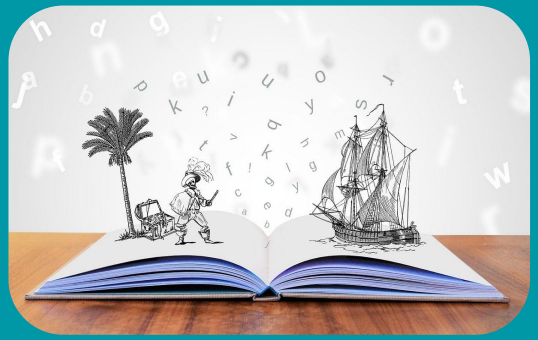
6. Find an explanation! Record your experiences in the logbook!
   - How could microplastics get into the water and onto the ledge or shelves?
   - Where could these particles come from? Could they come from the soles of shoes? Maybe from the school trash can or from plastic household items?
   - What plastic objects surround you? If you look at their surface (with the naked eye and under a microscope), do you see pieces breaking off?

7. Where do microplastics travel to?
   - Where do you usually pour the mop water at school? Where does the water used to wash the shelves and ledges go? Is there a sewer system?
   - If there is a sewer system, find out where the pipes transport the wastewater? Where is the nearest wastewater treatment plant and how does it work?
   - Where does the water purified by the wastewater treatment plant go?

8. Let's count!
   - How many classrooms are there in the school where microplastics, like yours, are released into the wastewater?
   - How many schools are there in the town where the same thing happens every day? Guess how much mop water goes into the sewer system and from there to the wastewater treatment plant in the town where you live.

This is a science mission, but don't forget: wash your hands afterwards and ask for adult help with the experiments!

LOGBOOK



Write a summary that presents the results of your investigation and provides ideas on how you could reduce the amount of microplastics in mop water and the environment.
If you have the solution, all you need is a little attention.

Also think about where else the particles flying in the air could end up? Could they also get into your body?

In addition to mop water, it is also worth paying attention to everyday waste production.

See how the river rescuers do it! Get ideas and inspiration from the River Rescue Handbook, Volume 3 , where you can also learn what the 9Rs are and how they help you achieve an environmentally conscious lifestyle.

ON MICROFIBERS TO THE SEA

CLASSROOM ASSIGNMENT

Questions:

- Which of you has gotten a new dress, shoes, or coat in the past few months? Was it really necessary because you outgrew the previous one, or did you get a new outfit because of fashion?

- Do you think that all the new clothes put a strain on the Earth? In what way?

- Have any of you ever sneezed when you took off your sweatshirt? What kind of micro-particle did your nose detect?

- We can see this piece during an experiment.

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ SIEVE
- ❑ WATER FROM A WASHING MACHINE COLLECTED IN A MASON JAR

  (OR MATERIAL STUCK IN THE DRYER FILTER)
- ❑ MAGNIFIERS, MICROSCOPE
- ❑ UV LAMP
- ❑ PETRI DISH
- ❑ LOGBOOK

LABORATORY WORK

Billions of microfibers leave households every day.
Let's track them down!

PIRATE'S NOTE

Now that it has been proven that microplastics are in the air and on the floor, the question arises: how do they get into the environment? Our microscientists are increasingly skilled in scientific research, which is why they are able to combine several methods. They follow the path of synthetic particles that make up clothes from the laundry basket to the washing machine, and from there - to the wastewater.
You might not have thought it, but the largest part of microplastic emissions into nature comes from our synthetic clothes. Our great-grandparents and their ancestors still used clothing made from natural materials, such as linen, hemp and wool. Although these were still expensive at the time, they wore the clothes made from them for a long time, so they rarely bought new clothes. In addition, washing by hand was very difficult, so they took better care of their clothes and washed them less often.

Synthetic fabrics became widespread when our grandparents were young, with the rise of the plastics industry. They were cheaper and more flexible, which encouraged people to buy more and more new clothes. Clothes slowly lost their value, which led to an increase in the amount of clothes produced and the amount of textile waste. In addition, with the spread of automatic washing machines, we wash clothes much more often than before. This means that the yarn from which the clothes are made slowly breaks down, and during washing we “produce” a large amount of broken plastic fibers.

But how do microplastics from our clothes end up in the environment? And can they make it to the sea?
Currently, wastewater treatment plants can only filter out 80-90% of microplastics, meaning every 5th or 10th particle ends up in rivers. Because they are plastic, they break down very slowly. The problem is that tiny river organisms mistake the thread-like pieces for food (plankton) and feed on them, which makes them sick.

Natural materials also wear out, their surfaces start to crumble, and they can also release microscopic particles into the environment. The key difference, however, is that these materials act as part of the natural cycle and decompose, meaning they become part of nature again. Wearing clothes made from natural materials is not only good for the ecosystem, but also for your skin and health, as your body is also part of nature, that is, the ecosystem.

The water that drains from a washing machine or the filter of a dryer can be a veritable treasure trove for a microscientist: it is full of tiny pieces of plastic that are barely visible to the naked eye.

Your mission is to find them and find out where they are headed. At the end of the experiment, we will also look for answers to what can be done to reduce pollution.

NAVIGATOR

1. Collect the sample!
   - Collect the water that runs out of the washing machine in a glass container (e.g. a mason jar)! This will be the sample we will work with. Ask your parents for help with the sample collection!
   - Make sure that the sample is not full of dirt (e.g. large hairs or pieces of tissue paper).

2. Place the sieve so that the water flowing out of it does not cause any problems (hold it over a bucket or sink). Strain the sample, the size of a mason jar, through the sieve! It is also worth rinsing it with a little tap water to wash away dirt and detergent. We will continue working with the parts that get stuck on the sieve, which should be placed in a Petri dish (but you can also leave it on the sieve and look for microplastics there).

3. Observe the pattern first with a magnifying glass!
   - What do you see with the magnifying glass? Write down what you find in your logbook! What color are the pieces? What shape are they? Are there any shiny pieces of clothing? Draw them if you discover anything interesting!

4. UV lamp magic!
   - Turn off the laboratory lights and shine a UV lamp on the sample.
   - Many microplastics glow under UV light, revealing themselves! Note down in your notebook if you see anything interesting! (Caution! Not all plastic fibers glow brightly!)

5. Microscopic super-check!
   - Put the sample under the microscope!
   - Look for tiny threads, pieces, or even shiny particles! These could be microplastics.
   - Draw what you found in the treasure chest or make a short note of what you saw.

NAVIGATOR

6. Now look at the structure of your sweatshirt or jacket under a microscope or magnifying glass! Could the particles extracted from the wash water have come from clothes?

7. Come up with an explanation! Record your experiences in the logbook.

-Why can there be microplastics in water?

-What material are our clothes made of? (check the little note on the inside of your sweatshirts or jackets to see what material they are made of!)

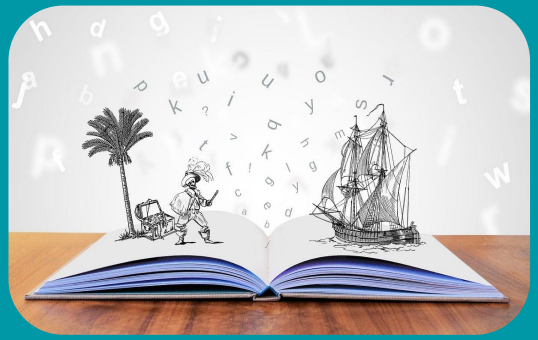
8. Where does microplastic travel with the water from the washing machine?
- Where does the water from the washing machine go? Do you have a sewer system?
- If you have a sewer system, find out where the pipes that carry the wastewater twist and turn? Where is the nearest wastewater treatment plant and how does it work? What happens in water treatment plants?
- What river does the water purified by the wastewater treatment plant flow into?

9. Let's count further (using the logbook)!

--How often do you wash clothes at home? Calculate how much water you use in a week and a year!
-How many households in your town do the same thing every day, from which microplastics, like yours, end up in the wastewater?

-Guess how much washing machine water goes into the sewer system each week and from there to the wastewater treatment plant in the town where you live.
-Assuming that there are 500 microplastic particles in one liter of wastewater, how much microplastic gets into the water treatment plant? If 90% of this is filtered out, how many particles are in the remaining 10%, i.e. how much ends up in nature?

LOGBOOK



Gather ideas and suggestions to mitigate the problem.

You can use the internet or check the pet pirate database.

Washing clothes less or more consciously produces fewer microplastics. https://holyduck.hu/2019/08/03/mikromuanyag-ellen-tippek-mosashoz/

During a single wash, up to 700,000 microfibers can break off from clothes (depending on the type of clothing, its age, the length of the wash, and the temperature).

Discuss what you will do differently from now on based on your proposed solutions and ideas.

Share your suggestions at home! Talk to your parents about laundry habits and the importance of environmental protection. Remember: the future is in your hands too!

THE TELLTALE SALT

FIELD TASK

Questions:

In the water, plastics either float like jellyfish or drift on the surface of the water like driftwood.

- Have you ever seen floating or floating plastics like this in a nearby river?

- Have you seen plastic floating in the oceans on TV or the internet? Where does most of it accumulate? Why do you think it doesn't sink to the bottom of the ocean easily?

- Do you think small ones swim in a similar way?

Let's take advantage of the buoyancy of plastics in water and lure them out of the sediment using a salt solution similar to seawater.

THE TELLTALE SALT

FIELD TASK

Questions:

In the water, plastics either float like jellyfish or drift on the surface of the water like driftwood.

- Have you ever seen floating or floating plastics like this in a nearby river?

- Have you seen plastic floating in the oceans on TV or the internet? Where does most of it accumulate? Why do you think it doesn't sink to the bottom of the ocean easily?

- Do you think small ones swim in a similar way?

Let's take advantage of the buoyancy of plastics in water and lure them out of the sediment using a salt solution similar to seawater.

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ FUNNEL
- ❑ PET BOTTLE (FOUND ON THE RIVERBANK IS BEST)
- ❑ PUTTY
- ❑ 1 KG OF TABLE SALT
- ❑ MAGNIFYING GLASS, MICROSCOPES
- ❑ SIEVE
- ❑ 1.5 METER PLASTIC PIPE
- ❑ UV LAMP
- ❑ LOGBOOK
- ❑ MICROPLASTICS DEFINITION

LABORATORY WORK

The river sediment holds many exciting secrets: the history of microparticles arriving from distant lands, and the imprint of the past.
Salt can help reveal secrets.

PIRATE'S NOTE

After successfully detecting microplastics leaving the washing machine and entering the water, the question arises: what will happen to this pollution in nature?
Our microscientists already know that wastewater treatment plants can handle most microplastic particles, but some still end up in rivers. So they follow the pollution's path into nature, but they certainly lose track of it when it reaches the big river.
The main question - where does the microplastic end up in the river? It's revealed thanks to the telltale salt!

When there is a lot of rainfall in riverside areas, the rain can wash away soil and dirt from the slopes of hilly and mountainous areas. In this case, garbage thrown along the riverbank is also carried by the water flow and transported downstream. The same happens with microplastic particles that enter the river with sewage.

Our microscientists suspect that as the river begins to recede, some of the sediment and pollutants (e.g. microplastics) will settle along the banks and on the bottom.
We know from chemistry that water found in nature is always a solution, the properties of which are determined by various physical, chemical and biological processes taking place in the water. River water can also be considered a dilute salt solution, since salts dissolved from groundwater and surrounding areas are also washed into the water.

After some thought, our microscientists think of changing the salt content of the river water a little to reveal hidden pollution. The more they increase the salt content, the more dense the water becomes. Therefore, lower-density materials, such as small plastic particles, float to the top of the water, making them easy to snag! If you do your research well, you will find out whether the telltale salt was telling the whole truth.

NAVIGATOR

Before we get started, it's important to clarify a few safety rules!
Safety is the primary consideration in all field work!

The physical safety of yourself and your companions is the most important thing when performing the task!

Please note the following:

- Always work as a team! Look out for each other so that no one gets into a dangerous situation.
- Approach the shore under adult supervision!
- Do not draw water from deep water.
- Use protective gloves when collecting waste.
- If you find something dangerous (e.g. broken glass, chemicals, dead animals), call for adult help.
- The quantity and quality of dissolved substances in the river are extremely important for the life of the river. Sodium chloride, i.e. common table salt, which we use in the experiment does not seem to be a dangerous substance, but its increased concentration causes problems for the life of the water. Therefore, do not pour the test substance, i.e. the salt solution, back into the river!!! The life of the river may be harmed by the changed conditions. It is best to pour it into the toilet and leave the solution to the sewage treatment plant!

NAVIGATOR

1. Waste collection:
   - If possible, use a bottle found on the riverbank for the experiment so that you don't produce extra waste during the experiment. Choose a 1.5 liter PET bottle (you can also find one in your bag if there wasn't one among the beach litter). Make sure that the bottle is not punctured or dirty, and has a cap.
2. Filling a bottle from the river:
   - First, put sediment into the PET bottle using a funnel: fill the bottom of the bottle with about 8-10 cm of sediment. Try to collect freshly deposited sediment (preferably sandy), as it was deposited by the last flood. This means that you should only collect the top few millimeters of sand using the spatula.
3. Making saline solution:

   - Add about 30 dkg of table salt to the bottle using the funnel (1 liter of water requires 30 dkg of salt, if the bottle is larger, you will need more salt)

   - Fill the bottle completely with running water (using the funnel and another bottle).
   - Close the bottle and shake vigorously until the salt is completely dissolved (this takes about 10-15 minutes).

4. Observation:
   - Let the bottle sit for at least an hour. Observe what happens: the heavier sediment sinks to the bottom, while the lighter materials, such as organic debris and plastics, float to the surface.
5. Testing with UV light:
   - After letting it stand for a sufficient amount of time, carefully pick up the bottle (do not shake it)!

   - Illuminate the material on the surface of the solution with a UV lamp! What do you see?

6. Magnifying glass examination:
   - Use a magnifying glass to take a closer look at the collected material. Did you find any microplastics in it?

7. Further microscopic examination of samples:
   - Take the bottle with you to the classroom. Shake it vigorously and then let it stand for at least an hour, but if it stands for a day (or more), that is even better! This gives the microplastics more time to float to the surface of the solution.
   - Use a plastic tube to suck the salt solution out of the bottle (not from the bottom, but always with the end of the tube just under the water), or very carefully pour off the water! Do not stir up the sediment, as we will not need it anymore!

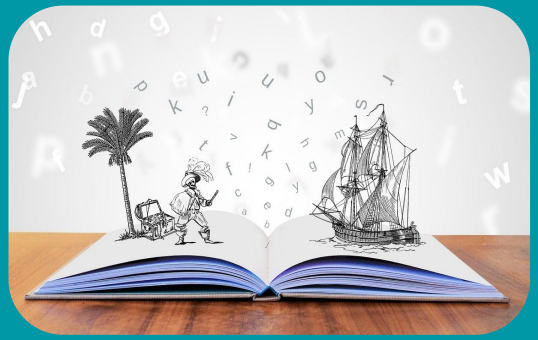
   - Pour the drained or sucked water onto the sieve. This will cause the suspended substances in the brine to settle on the sieve and become trapped.

   - Examine the material collected at the bottom of the sieve under a microscope and UV light.

   - What materials do you see? Is there plant residue in it? Is there plastic fiber or shreds in it?

8. Recording the results in the logbook:
   - Take photos and drawings of the microplastics you find and describe their characteristics.
   - Record the types of microplastics you find and try to determine how they may have entered the environment.
9. We evaluate the results:
   - Why were microplastics successfully extracted from the sediment? How did the salt help separate the sediment and the plastic? (Explanation of the dissolution process.) Why did they float to the surface of the water? (Discussion of specific gravity and density.) Are all plastics light or are there plastics that sink to the bottom of the water? If a mussel settles on a floating piece of plastic, how do you think the plastic's ability to float or float changes? When can plastics settle to the bottom of a riverbed?
   - Is there water on Earth saltier than rivers? Where in the seas does a lot of plastic accumulate: near the surface or down deep? How do you think the presence of microplastics affects river life? How can we reduce plastic pollution? Where can plastic pollution from the river you are studying end up? Which sea is the final recipient?

LOGBOOK



In freshwater, the concentrated salt solution we used is toxic to living things. If you are curious about who we are protecting by properly handling the test material, then take an adventure with Álmos Becz into the world of aquatic micro-organisms .

This experiment not only helps to recognize microplastics, but also highlights the importance of environmental protection and sustainable thinking.

The seas are much saltier than rivers or lakes. Therefore, larger and smaller pieces of plastic quickly accumulate on the surface of the seas. These can now drift for huge distances on the back of ocean currents and form islands where they accumulate. It is worth looking at pictures of marine pollution to imagine that microplastics also float in river water in a similar way, floating close to the surface. So the pollution that you see on the river now or that is floating invisibly in the water will sooner or later reach the seas. But if we have collected some plastic waste on the shore, then we have already reduced the amount of floating waste over a very long distance.

Pledge that you will not throw away any trash, and if you see it thrown away, you will take it to the nearest trash can.

IN THE FOOTSTEPS OF GOLD DIGGERS

FIELD TASK

Questions:

- What do you think if we started sifting the sand on the beach right now, what would we find?
- Have you ever seen an example of something being thrown or lost on the beach? What happens to the lost object?
- If the object is thrown into the water in the upper reaches of the river, what might happen to it before it reaches us or the sea?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ PUTTY
- ❑ MASON JAR
- ❑ MORTAR (OR SOMETHING TO CRUSH THE SAMPLE IN)
- ❑ SIEVE (FINE MESH, WITH 0.5-1 MM HOLES)
- ❑ UV LAMP, MAGNIFYING GLASS, MICROSCOPE
- ❑ PETRI DISH
- ❑ PLASTIC ADVERB
- ❑ LOGBOOK

LABORATORY WORK

We continue to examine the river sediment using the ancient method of gold diggers. What will we find? Treasures or pollution?

TREASURE CHEST

TOOLS AND SUPPLIES

ADDITIONAL TOOLS FOR ADVANCED USERS

- ❑ ALCOHOL FELT
- ❑ GPS APPLICATION ON MOBILE PHONE
- ❑ WATER SPRAYER (YOU CAN ALSO USE A SIMPLE WINDOW WASHER FLUID BOTTLE)
- ❑ GRAM-ACCURATE SCALE
- ❑ GRAPH PAPER (THE SAME SIZE AS THE PETRI DISH)
  DRAW 1 CM VERTICAL LINES ON IT: ONE LINE IN RED AND THE NEXT ONE IN BLUE. THIS WILL HELP WITH THE MICROSCOPIC WORK.

PIRATE'S NOTE

Gold diggers and panners were adventurers or craftsmen who searched for gold in the sediments of rivers in the hope of getting rich. In rain and wind, cold and heat, hungry and thirsty, they sifted and washed the gravel and sand of the rivers, hoping that a few grains of gold would get stuck on their sieves.

There is hardly any gold in river sediments anymore, as it settles in mountain reservoirs. At the same time, a new material, microplastics, has appeared in the deposited sediment: the river washed it from distant areas, deposited it somewhere, and then picked it up during the next flood wave and brought it to the sampling site. But the next flood wave carries the sediment and the pollutants it contains further from there.
Does the sand of the river (or lake) contain microplastics? Where does it come from? How did the microplastics end up in the river sand? What impact might it have on wildlife?

Follow them! Follow in the footsteps of modern-day gold diggers, i.e. researchers!

Even novice microscientists can do most of the work, identifying microplastics. But if you are an experienced and skilled microscientist, you can contribute a little more work to have your results included in a scientific study.

Safety rules:

Be careful when sampling! The river can suddenly become deep, do not fall in! Always have an adult helper with you.

To avoid contaminating the sample, try to wear clothes made of natural materials during the experiment (e.g. a linen lab coat) and minimize air movement in the room so that microplastics do not fly from your clothes and hair into the sample.

When using the UV lamp, avoid letting the light shine directly into your eyes.

When you are not working with the sample, cover it (with the top of the Petri dish or the sieve with aluminum foil)!

This task helps you gain insight into the basics of a scientific measurement. With some practice, sampling, wet sieving, and identification can be sped up, but it still takes several hours.

NAVIGATOR

For BEGINNER microscientists

1. Sampling

- Plan where you will collect the sample! It is worth collecting a fine-sandy sample close to the water level. If you don't have one, a clay sample is also good (but harder to work with!).
- Use the spatula to take a sample from the top (1-2 mm) layer of sediment. This way you are sure to sample the sediment from the last flood wave. Collect material from several points and mix it together!
- Place the sample in a glass jar and seal it.

2. Laboratory sample preparation

- Cleaning the sample: The collected sample contains various particles that you need to examine carefully. Remove larger pieces (e.g. roots, leaves, other organic matter) from the sand, this will not be necessary.
- Cleaning the sieve: Rinse the sieve thoroughly in tap water before testing.
- Place a coffee cup-sized amount (approx. 5-10 dkg) of the sample on the sieve.
- Hold the sample under the tap and run water through the sieve, moving the sieve in small circular motions. This will wash out the clay and silt particles. You should wash the sample until the water running out is crystal clear!
- You can also examine the sample through the sieve, or you can carefully wash it into a Petri dish. In this case, cover the top at an angle and place it on a heating element (or in the oven) or in the sun to let the water evaporate!

NAVIGATOR

3. Searching for microplastics with a UV lamp, magnifying glass and microscope

- We will continue to examine the material on the sieve or in the Petri dish!
- A UV lamp can help you identify microplastics, as some plastics fluoresce when exposed to ultraviolet light. Darken your lab and shine a light on the sample. If you see fluorescent light, it is likely microplastic.
- Use a magnifying glass or microscope to examine the sample in more detail. Look for small particles that resemble plastic (e.g. colored or transparent fibers, shreds). Use the microplastic identifier to identify the types present in the sediment.

4. Recording results in the logbook:

- Record the type of microplastics you identified, their color, and which one you found the most of.
- Take photos or drawings of the microplastics you find and describe their characteristics.
- Record the types of microplastics you find and try to determine how they may have entered the environment.

NAVIGATOR

For ADVANCED microscientists

1. Sampling

- Plan which section of the river and exactly where you will take samples!
- When you arrive at the sampling location, use a mobile phone application to determine the GPS coordinates of the sampling location. (This way, the data can be entered into the database and can be an important element of an international research project). Give the sampling location a name (e.g. Szolnok-1, so your sample number will be Sz-1). Record it in the logbook!
- If you see plastic waste around the sampling site, note it in your logbook! (The more waste in the environment, the more likely we are to find microplastics in the sediment).
- Also write down whether you collected the sample at low tide or high tide, and whether the river is ebbing or flowing.
- Use the spatula to take a sample from the top (1-2 mm) layer of sediment. This way you are sure to sample the sediment from the last flood wave. Collect material from several points!
- Place the sample in a glass jar and seal it. Write the number of the mina on the jar with an alcohol marker (e.g. SZ-1). This allows you to collect samples from multiple locations and prevent them from getting mixed up.

2. Laboratory sample preparation:

- Sample cleaning: The sample obtained in this way contains various particles that you need to examine carefully. Remove larger pieces (e.g. roots, leaves, other organic matter) from the sand, this will not be necessary.
- Cleaning the sieve: Rinse the sieve thoroughly in tap water before testing.
- Place 5 dkg of the (preferably) dry sample on the sieve (record the exact weight in the report).
- Hold it under the tap and run water through the sieve, moving the sieve in small circular motions. This will wash out the clay and silt particles. You should wash the sample until the water running out of the sieve is crystal clear!
- Wash the sample carefully (with a little water) into a Petri dish (use a water sprayer). First, write the sample number on the side of the Petri dish with an alcohol-based marker! Then, in both cases, cover the sample (e.g. with aluminum foil or the top of the Petri dish) and place it on a radiator or in the sun (in the oven) to let the water evaporate! Be careful! Plastics melt above 65 degrees C.
- ROOM MISCELLANEOUS (MSC): The air around us can also be full of microplastic fibers. These get into the sample from our clothes during sample preparation and increase the amount of microplastics there. If we include this in our results, we get a much higher level of contamination than the real value! Therefore, you need to go through the same steps with an empty sieve, for the same length as with the sample. Write the MSC on the side of the Petri dish, then wash in the apparent “nothing” from the sieve. Then the “room miscellaneous” result must be subtracted from the sample result. (But more on that later!)

NAVIGATOR

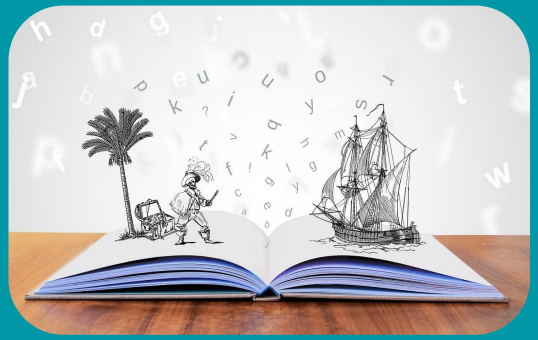
3. Searching for microplastics with a UV lamp and microscope:

- Using a microscope, systematically go over the area of the Petri dish! It helps to place the dish on the graph paper, on which there are red and blue lines to help you progress. Move the sample in a meandering manner (up and down) under the microscope, from one edge of the dish to the other. Be careful! Don't miss a single grain! This takes practice, you don't always succeed the first time!
- Record each microplastic: what type it is (e.g. colored or colorless thread, shred, sphere) and exactly how many there are. Use the microplastic descriptor to determine what shape types occur in the sediment.
- Record the type, color, and number of microplastics identified in the report.
- A UV light can help you identify microplastics, as some plastics fluoresce when exposed to ultraviolet light. Darken your lab and shine a light on the sample! If you see fluorescent light, it's probably microplastics. (But there are many more types of microplastics!)
- Do the same with the SzH pattern!
- Calculate the microplastic content of 1 kg (=100 dkg) of sediment: First, subtract the plastic content of the Room Error from the microplastic content of the sample! This is the corrected value. Microplastic content = (100* corrected value)/weight of measured material

4. Recording results in the logbook:

- Take photos and drawings of the microplastics you find and describe their characteristics. Expand the definition of microplastics.
- Record the types of microplastics you find and try to determine how they got into the environment.
- Upload the minutes to the online section! www.tisztatisza.eu

LOGBOOK



What should you and your family do to mitigate the problem?

For example, our pledge is to wash our clothes less often, so fewer fibers end up in the sewage treatment plant and then in the river.

What other solutions and ideas do you have? What will you do differently from now on to reduce the problem?

The research helps us understand how much microplastic is in our environment, and by comparing it with other people's data, we can determine how polluted your sampling point is.

Let's compare the data we collect with existing scientific **RESEARCH.**

Did the sample we tested contain more or less microplastics than previous values? What could be the reason for this? Where could the plastic pieces found come from? What living organisms might they have a harmful effect on? What could be done to prevent these microplastic pieces from entering living waters?

Don't forget: by recording your data, you can contribute to scientific research on the spread of microplastics, which will help you learn about this bad guy hiding invisibly in the sand!

THE MAN IN THE STREET AND MICROPLASTICS

FIELD TASK

Questions:

- Why do we chew gum? How long do we usually chew it?

- What can chewing gum be made of?

- What happens to chewing gum after we no longer need it?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ INTERNET ACCESS
- ❑ USED CHEWING GUM, OR CLEAN PIECES FOR MODELING
- ❑ A BOWL OR MASON JAR FILLED WITH WATER
- ❑ SAND OR EARTH
- ❑ PLANT LEAVES, SMALL PEBBLES
- ❑ PUTTY
- ❑ CHALK AND 1 PIECE OF 1 METER CORD
- ❑ LOGBOOK

RESEARCH

Microscientists use every method they've learned and every tool they've used to uncover what's lying on the sidewalk.

PIRATE'S NOTE

Having reached the end of the journey of microplastics from households, our microscientists are looking for new sources of pollution. They ask the man on the street, or rather the street, where other pieces of plastic come from? It soon turns out that many microplastic particles come from car tires, but there is also a completely unexpected, special source. To find it, the microscientists just have to follow the people on the street who have menthol breath.

Everyone contributes to microplastic pollution by walking on the street, yet few people think about what they can do about it. Microscientists examine car tires and the soles of their own shoes with magnifying glasses, finding that certain surfaces are constantly worn down during transportation, contributing to microplastic particles. But the sources of pollution don't end there!

Microscientists examine the asphalt of the street with a magnifying glass and determine that in many city districts the number of chewed chewing gums per square meter exceeds 10! But what happens to these single-use plastics out there, under the open sky?

If you do your research well, you will find out whether chewing gum also contributes to plastic pollution in rivers.

Chewing gum (or similar chewable material) has been used by humans for thousands of years to freshen their breath and relieve stress. The ancient Greeks chewed pine resin, while the Aztecs chewed chicle, a substance extracted from the sap of the sapota tree. Chicle became the raw material for modern chewing gum, which began to be produced in the United States in the late 1800s.

The worldwide spread and popularization of chewing gum was initiated by American soldiers serving in World War II, for whom chewing gum was part of their basic equipment.

Nowadays, the raw material of chewing gum is manufactured synthetically, i.e. made from polymers of oil industry (petrochemical) origin. The problem is that chewing gum made from artificial materials does not biodegrade, unlike the natural raw material derived from sap of the sapota tree. Chewing gum made from natural materials also degrades very slowly, since they also contain artificial materials for durability, for example to resist moisture and acids, since they come into contact with the acidic-moist medium of our saliva when someone starts chewing them. Once we get tired of chewing, we spit them out. This is where the fate of chewing gum starts to get exciting.

PIRATE'S NOTE

Chewing gum decomposes slowly, so it pollutes the environment in the long term. A sidewalk full of spit-out gum is not pretty, and its removal is very difficult. Chewing gum that has not yet stuck to it can be eaten by animals, which can cause digestive problems. If it gets into the sewer system, it reaches living waters, where it can damage the ecosystem.

Discover how chewing gum behaves under different environmental conditions! See what sticks to the surface of the spitted gum! Can this semi-synthetic material get into living waters (e.g. rivers, streams, lakes)?

Where does the chewing gum that has already been spit out go? What are the environmental impacts of chewing gum that has not been spit out?
Examine it based on the following criteria!

- Where have you encountered used chewing gum, where does it cause damage (e.g. on sidewalks, benches, in nature, around animals)? Where do people spit out the most chewing gum?

- What's on the surface of discarded chewing gum? - Look at the surface of a piece of chewing gum that has been stuck to the bench or the ground for a while with a microscope or magnifying glass!

Can you find any part of the chewing gum's surface that indicates that smaller microplastics have broken off?

- What are the environmental impacts of chewing gum? Why is it a problem if chewing gum is not thrown in the trash?

- Is it possible that chewing gum poses a danger to animals or the environment?

- How can chewing gum get into living water?

- What harm can chewing gum cause if it is eaten by animals or mixed with other contaminants?

THE JOURNEY OF MICROPARTICLES TO THE RIVER

CLASSROOM ASSIGNMENT

Questions:

- Have you ever seen (on TV, on the internet) a river that was polluted? What showed the pollution? How did the pollution get there?
- Have you ever seen plastic waste floating in a river? How did it get there?
- Are there only large pieces of plastic on the surface of the water?
- Besides plastic, what other pollution affects rivers?
- How can pollution be stopped?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ PAINT POWDER (E.G. GROUND FROM WATERCOLOR BUTTONS/FOOD COLORING) - THIS MODELS CHEMICAL CONTAMINANTS
- ❑ FLOUR - THIS MODELS MICROPLASTICS
- ❑ CONFETTI, OR SHREDDED PAPER - THIS REPRESENTS MACROPLASTICS
- ❑ CARDBOARD (THE LESS IT SOAKS, THE BETTER)
- ❑ DRAWING BOARD (UNDER THE CARDBOARD SO IT CAN BE MOVED)
- ❑ DRAWING TOOLS, SCISSORS, GLUE, INSULATING TAPE
- ❑ LOGBOOK
- ❑ PET BOTTLE CUT IN HALF
- ❑ SPRAY BOTTLE (E.G. WINDOW CLEANING SOLUTION BOTTLE) WITH WATER (THIS SIMULATES RAIN)
- ❑ COTTON WOOL/MOSS/SMALL STRIP OF MOSQUITO NET/CURTAIN MATERIAL - TO MODEL THE DENSE, BUSHY AREA

OBSERVATION

How do topography, the natural, and the built environment affect the spread of pollution?
Let's model it!

PIRATE'S NOTE

Rivers, streams or lakes that run through settlements make cities and villages special. Clean water, rich wildlife and good air provide us with excellent opportunities for recreation. At the same time, we must appreciate this natural resource: we must strive to preserve it in good condition or to improve its current state. One of the biggest threats to rivers is plastic pollution. We use more and more plastic devices, which end up in the environment due to improper waste management.

These macro- and microplastics and the compounds derived from them can enter watercourses during heavy rains or on very windy days, from where they are very difficult to collect, as the water carries them to distant areas. The more rain falls and the steeper the slopes, the easier it is for the materials to wash away from the houses and road surfaces of the settlement. However, by building appropriate barriers (e.g. tree rows, dense bush areas, flood protection dams), the materials can be prevented from entering the river, and even most of the pollution could be collected here.

Is there a stream or lake in your town where you usually walk? What do you think is the condition of this water and its surroundings?

How do macro- and microplastics, as well as chemical compounds, move from the settlement towards the river?

How can a river or lake in your community be protected from pollution? What can you and your wider community do to preserve water and its environment?

Let's model how plastic pollution of different sizes can get into a river flowing through a settlement!

In the second step of the research, we model how pollutants of different sizes could be stopped before they reach the river, thus saving the river from pollution.

The result can help us use and protect our environment more wisely and help us make more informed decisions in the field of environmental protection.

NAVIGATOR

1. Drawing a part of the settlement and the river bank on the cardboard (you can make several drawings, and then we use separate drawings for each step):

- Cut a 3-4 cm strip from the cardboard. Fold in the bottom 1 cm edge. This will be the “flood barrier” or “embankment” that we will glue to the map in one of the steps of the experiment.
- Draw a top view of the natural strip along the river and some of the houses in the settlement on the cardboard.
- Attach the cardboard to a drawing board!
- Cut a PET bottle in half and attach it to one side of the drawing board (you can also tape it there)! This will collect the water that splashes onto the cardboard, representing the river.

2. Pollution washed into the river:

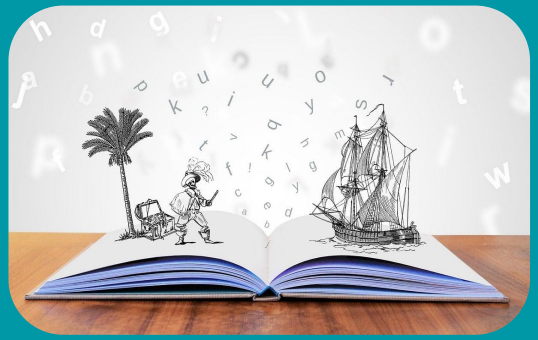
- Sprinkle different pollutants over the area of the settlement! The paint represents the smallest nanoplastics and chemicals, such as spilled oil, chemicals, the flour represents small pollutants, such as microplastics, while the confetti represents large discarded garbage (macroplastics).
- Tilt the cardboard towards the river (PET bottle). First tilt it slightly, then more (as if the village were in a valley between mountains).
- Spray water on it as if it were raining. The rain will reach the surface, but the water will start flowing towards the river (=PET bottle).
- Observe how the materials wash into the river! Which one washes in the easiest?
- If you have made several drawings, you can test how the materials released by the rain move when the area is flat (the drawing board is horizontal), when it slopes slightly, i.e. we are in a hilly area, or when the drawing board slopes sharply, like the slopes in the mountains.
- Adventurous microscientists can even make real streets (e.g. houses from medicine boxes), and then it turns out that water and pollution move differently on the street! Try to improve your models! (Take photos!)

NAVIGATOR

3. Maintaining the good condition of the river by preventing the ingress of pollution:

- Glue the dam (cardboard tape) and the cotton wool representing dense vegetation (moss or mosquito net) to the area between the river (PET bottle) and the settlement.
- Sprinkle the paint, flour and confetti over the town again. Let it rain!! Notice how the materials now wash into the river? Which one washes in the easiest?
- What stops pollution better, a dam or vegetation?
- In reality, what could be done to prevent pollution from entering the river?

LOGBOOK



Note down the steps of the experiment, draw each model step.

Make a poster about model building and the steps of the experiment!

Note when and which material found its way into the river most easily!

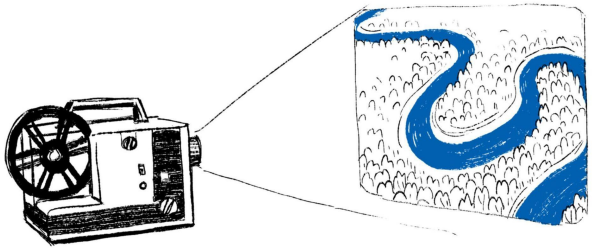
They could participate in garbage collection campaigns to reduce the amount of plastic that reaches the river.

Forest strips or thickets along the river are useful areas, as they prevent trash from entering the river while also providing habitat for many animal and plant species.

LET'S SHARE OUR KNOWLEDGE!

You've filled your logbook with exciting notes, experiences, and nuggets of knowledge. Aren't you eager to share them with others? Knowledge is the kind of treasure that, when shared with others, doesn't diminish, but multiplies.
Sharing scientific discoveries and results is science communication, and its wide range of tools offers countless solutions. The knowledge you have acquired can be conveyed in an exciting, attention-grabbing or playful way. Find a way to convey your results and bring the problem you have researched to an understandable level.
Include suggested solutions, but leave the audience open to thinking about what they can do to mitigate the problem.
In the long run, it is more effective to focus on the "why," which can trigger an intrinsic motivation toward the "how." For example, saying "don't throw away glass waste" is less effective communication than showing how glass shards hurt pets' feet.

Share your own resolutions and show how you managed to keep them.



SCIENCE IS FOR EVERYONE

INDOOR TASK

Questions:

- How do you come across a scientific discovery or result?
- Why is it important for others to be able to learn about the results of a research?
- How would you share your experiences as a microscientist with others (peers, family, strangers)?

TREASURE CHEST

TOOLS AND SUPPLIES

- ❑ LOGBOOK
- ❑ YOUR MEMORIES
- ❑ INTERNET, SMARTPHONE
- ❑ COMPUTER

KNOWLEDGE SHARING

The essence of scientific work is to continuously incorporate new perspectives, to learn from each other, and to enrich the knowledge of humanity.

PIRATE'S NOTE

Sharing scientific discoveries and results is **scientific communication** , which can help others understand and find exciting the problems and solutions discovered by researchers. You have also picked up many crumbs of knowledge, while becoming a true micro-scientist. Our goal is not only to tell what you found, but also to show why it is important for the community. With the knowledge you have gained, you will look at the natural environment differently, because you understand it better. Plus, you can help keep rivers and the environment in good condition for the future!

Open your logbook, where you have collected the most valuable treasure, knowledge, while completing tasks. This is the kind of treasure that does not run out when shared – on the contrary, it multiplies!

Win over as many people as possible to the cause of rivers!

Think about what interests different people and how you can engage them. Maybe a funny video will grab their attention, or a fascinating fact or drawing about the topic.

Remember: leading by example is always the most effective way to motivate action!

See how the young Petkalós perform this task? Petkány and Captain Szakállás introduce it.

NAVIGATOR

In the next task, form groups and choose from the different science communication methods, then present the completed materials and discuss which target groups might be interested in which. Possibilities: newspaper article, news report, social media post, short video, short lecture.

1. **Choose a science communication tool!**
   Form groups and decide in what form you would like to share your knowledge. You can choose from the following options:
   - **Newspaper article** : Imagine writing an article for a magazine or online portal.
   - **News reporting** : Compose a short report of a news program.
   - **Social Media Post** : Writing an Instagram, TikTok, or Facebook post that is engaging and easy to share.
   - **Mini-video** : A short, 1-2 minute video that conveys a message in a playful or visual way.
   - **Pitch** : A 3-5 minute presentation that you deliver live or online.

2. **Prepare your materials!**
   - Think about how you can explain the topic in an exciting and understandable way.
   - Go over the proposed solutions, but let the audience think for themselves: what could they do to solve the problem?
   - Emphasize the "why"! For example, don't just say "don't litter", but show how littering affects nature or living things, and give a good example!

NAVIGATOR

3. **Personal example**
   Share your own resolutions regarding the issue. What are you doing yourself and how do you manage to keep your own promises?

4. **Show us your work!**
   - Each group should present their completed material to the class or audience.
   - Discuss together:
     - Who were your materials intended for?
     - What methods did you use to capture the attention of the target group?
     - What worked best and why?

LAND ON THE HORIZON!

As long as we keep knowledge and understanding to ourselves, we cannot effectively help each other or the environment! If we work and think together in a research group, much more and more interesting results can be achieved, since everyone sees the same problem from a slightly different perspective.

If you have managed to complete several experiments, you may have noticed that the tasks are similar to each other. In general, the methods of scientific research and the steps of analysis are similar. The uniqueness of the research is given by the scientific question asked and the task to be solved. Just as you, microscientists, used similar methods, but sought answers to different questions and problems.

The point is to see the connections and think critically. The basis of critical thinking is to collect information from as many sources as possible and, if possible, to gain your own experience on a given topic. The methods you have just mastered for scientific data collection do not require special or difficult-to-obtain tools, but they provide an excellent opportunity to gain experience.
You can use them at any time if you want to investigate further beyond the tasks we recommend. In fact! If you have a good research plan, we would like you to share it with us. The essence of scientific work is to constantly add new aspects, to learn from each other, and to enrich the knowledge of humanity.
Research builds on human curiosity and thirst for knowledge, and gives us the joy of discovery, while using the results to make the Earth a better place.

Remember: a microscientist - like any other scientist - can research and disseminate his knowledge much more effectively in a research group than alone!

CLAUSE AND AFTERWORD

Don't worry, the world is still a wonderful place!

Did you know that microplastics are almost everywhere around us? It's true, but don't despair! Discovering them is already a huge step towards the solution. The world is full of beauty and opportunity, and many smart people are working to make our environment cleaner. You are already a part of it, because knowledge and mindfulness are the first step! Nature is incredibly adaptable and strong – just like us. Just do what you can: reduce waste, reuse what you can, and never forget that every little action counts. Together we will protect our planet, and in the process, we will have lots of fun adventures!

We leave you with the message that scientific discovery does not end here!
Your curiosity, questions, and experimentation will move you forward – and the world.
Always walk the world with open eyes and heart, dare to ask questions, and don't be afraid to try new things!

Be a Microscientist Workbook. E-book, first digital edition.
Published in As part of the Tiszta Tisza Textbook Series , in Hungarian, English, Romanian and Bulgarian, within the framework of the Be a microscientist! Erasmus+ program.

Authors: Dr. Attila Dávid Molnár, Dr. István Szabó, Katalin Vészity, Dr. Tímea Kiss
Illustrated by: Áron Gauder
Design, icons: Emese Silimon
Photos: Krisztina Pálvölgyi, Enikő Kubinyi, Vanda Molnár, Tamás Varga, Anna Géczy, Gergely Hankó and the PET Cup volunteers

Be a Microscientist! was created within the framework of the Erasmus+ project with the ID number 2023-2-HU01-KA210-SCH-000185151, with the support of the European Union.

Be a Microscientist Workbook - Tiszta Tisza Textbook Series
published by the PET Cup Association
5000 Szolnok, Gutenberg Square 2. V/3.

szemleletformalas@petkupa.hu

Funded by the European Union

Funded by the European Union. The opinions and statements expressed herein reflect the views of the author(s) and do not necessarily reflect the official position of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor the EACEA can be held responsible for them.