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IN KATOWICE

Problems with Water in Cities

Stop the Water!

Recovering Rainwater

In the Search for Chemical Water Contamination

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SCIENCE NEWS

Katarzyna Stołpiec

MORE ACCURATE
DIAGNOSIS OF COLORECTAL CANCER

Fluorescent dyes are chemicals used, among others, in medical diagnostics for imaging organs and cells. They can be successfully applied in order to assess the size of a tumor or to determine where it is located. This is particularly important with regard to treatment methods for surgical cancer. Most diagnostic and histopathological methods are based on the use of selective dyes. Due to contact with the human body, dyes used for such purposes should be non-toxic and photostable, which means that their properties must not change under the influence of light radiation. If they are intended for use in an environment with different conditions e.g. with regard to temperature or pH level, they should also be chemically neutral. New styrylquinoline derivatives developed by scientists from the University of Silesia have these properties. Favorable physico-chemical parameters of these compounds will make it possible to use them for imaging biological structures in the diagnosis of cancer, especially colorectal cancer. The solution has been protected by patent. The authors of the new application of para-iminyristrilequinoline derivatives are Assoc. Prof. Anna Mrozek-Wilczkiewicz, Dr. Katarzyna Malarz, Assoc. Prof. Robert Musioł, and Dr. Barbara Czaplińska.

A NEW QUALITY
OF DENTAL IMPLANT COATING

Scientists from the University of Silesia were approached by a manufacturer of dental implants, who asked them to develop special coatings. The aim was to make a new product more resistant to scratches during application. When an implant is screwed in, mechanical damage to its coating often occurs. As a result, up to 10% of the protective layer can be lost, which naturally has an impact on product quality and durability. The newly developed coating, which is produced at room temperature, adheres so strongly to the surface of the implant that it does not need to be additionally sintered at high temperatures, which could contribute to defects. Moreover, amorphous calcium phosphate has excellent tribological properties. In an artificial saliva environment, a lubricant is produced on the surface of the implant, thanks to which the coating is neither rubbed off nor destroyed. Additionally, it supports the regeneration of bone tissue. The coating can be used on two types of materials. The first one are nickel-titanium alloys with shape memory designed for short-term implants, such as implants for surgical correction of skull deformities in children. The second material are titanium alloys designed for long-term use, e.g. dental or spinal implants. The authors of the method for depositing bioactive calcium phosphate coating on the element made of nickel-titanium alloys are MSc Eng. Patrycja Osak, Assoc. Prof. Bożena Łosiewicz, Assoc. Prof. Tomasz Goryczka, MSc Dariusz Gierlotka, Dr. Julian Kubisztal, and Assoc. Prof. Danuta Stróż. The method for depositing bioactive calcium phosphate coating on a titanium element has been developed by Assoc. Prof. Bożena Łosiewicz, MSc Eng. Patrycja Osak, Dr. Grzegorz Dercz, MSc Dariusz Gierlotka, and Dr. Julian Kubisztal.

NEW LAYERS
FOR ELEMENTS MADE OF ALUMINUM AND ITS ALLOYS

Dr. Joanna Korzekwa and Assoc. Prof. Władysław Skoneczny have developed methods to produce composite layers and a double top layer on substrates made of aluminum or its alloys. Both inventions have been patented. Machine, vehicle, or equipment parts made of aluminum or its alloys cannot be used as sliding elements because of too low hardness and susceptibility to adhesive bonding with metals. Therefore, it is necessary to develop layers that will protect the parts designed in this way. Properly composed layers have self-lubricating properties, increase the hardness of aluminum components, and improve their anticorrosive properties and thermal conductivity. Thus modified materials could be successfully used as a structural element in systems with strong friction and wear of parts, such as slide bearings or guides. Researchers from the Faculty of Science and Technology at the University of Silesia have developed two new, relatively simple, and economically efficient methods to obtain materials based on aluminum, characterized primarily by high resistance to abrasive wear.

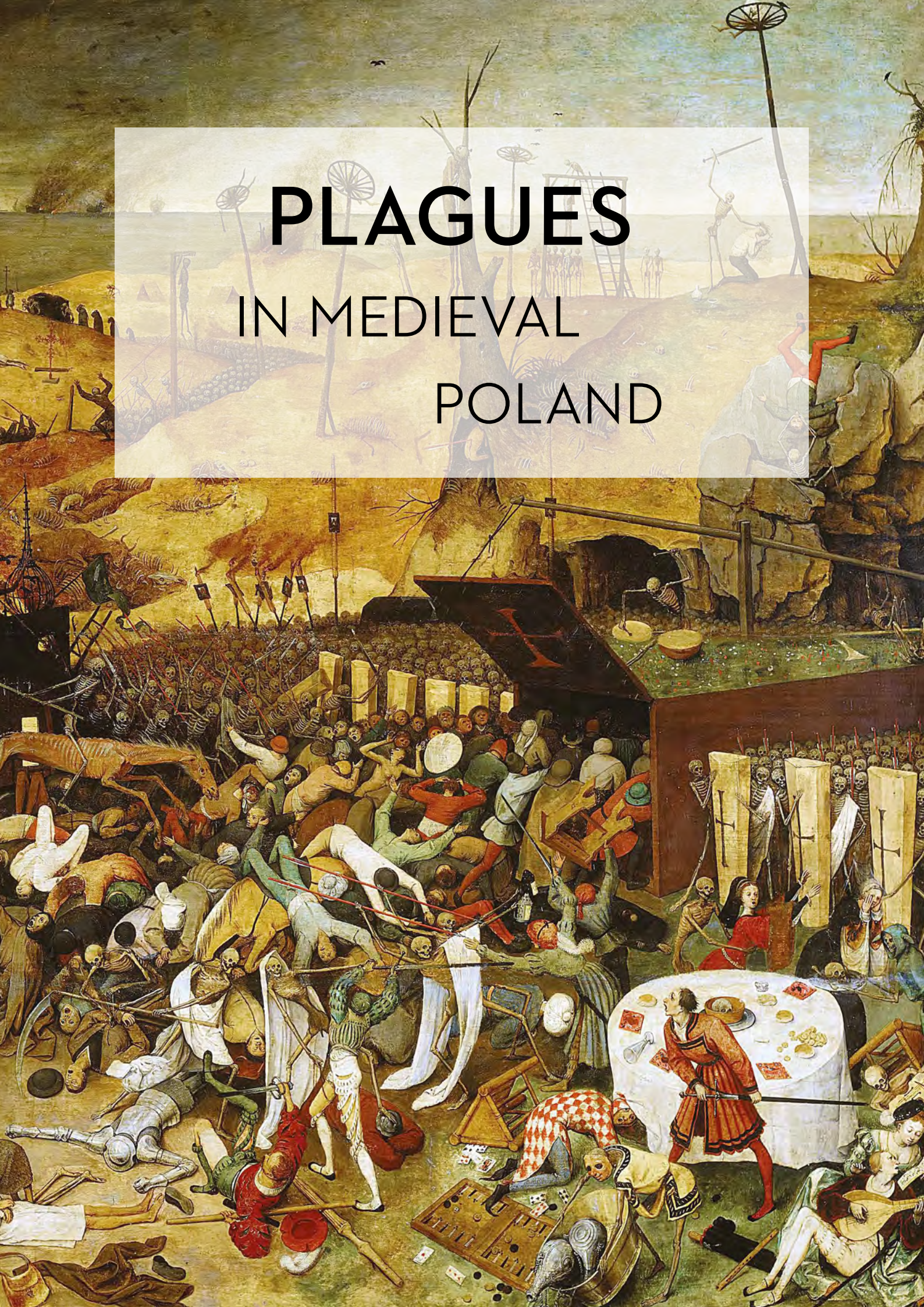
ESTABLISHMENT OF THE SPIN-LAB
MICROSCOPIC MATTER RESEARCH CENTER

In April 2020, scientists at the University of Silesia started to work on the creation of a Poland-wide unique competence center specializing in the field of microscopic soft matter research. The undertaking is a part of the project "Microscopic Matter Research Center (CMBM SPIN-Lab)," and its implementation allows for advanced scientific research, R&D, and training activities. The project involves the construction of a new facility on the premises of one of the campuses of the University of Silesia which will be equipped by several modern electron microscopes permitting to perform correlation studies of matter, including a cryogenic transmission microscope and scanning microscopes coupled with spectroscopic techniques, as well as confocal and atomic force microscopes. The establishment of the CMBM SPIN-Lab is intended to consolidate and to develop research conducted in the region on, among others, physico-chemical properties of modern materials and nanomaterials used in medicine, pharmacy, aviation, automotive, and many others.

THE T2K EXPERIMENT
IN *NATURE*

The April 2020 issue of the scientific journal Nature featured the publication of research results obtained by an international team of scientists in the Tokai-to-Kamioka neutrino experiment (T2K). This discovery is intended to help to understand, among other things, why there is much more matter than antimatter in the universe and why a difference between the laws of physics governing particles and antiparticles exists. Physicists from the research group of the Institute of Physics at the University of Silesia, headed by Professor Jan Kisiel, also take part in the T2K experiment. The participation of Polish scientific teams in the neutrino experiment, which featuresh a long T2K measurement base in Japan, began in 2006 with the involvement of researchers in building the close ND280 detector in the Japan Proton Accelerator Research Complex (J-PARC) located in Tokai on the Japanese east coast.

Triumph of Death (1562) by Pieter Bruegel the Elder, which reflects the shock and horror commonly caused in society by the black death / photo: public domain



PLAGUES
IN MEDIEVAL POLAND

We are living in a time when we are suddenly faced with challenges that plagued our ancestors. All over the world, we have well-equipped, modern medical laboratories, outstanding scientists; we are able to send humans into space, but in the face of invisible viruses or bacteria we are still helpless, similarly as the people in the Middle Ages.

Danse macabre **– Michael Wolgemut, drawing from 1493**

At the beginning, the black death should be mentioned. Lately, it has been frequently cited in the media and was allegedly epidemic in Poland in the 14th century. Some scientists, based on Jan Długosz's chronicle written over 100 years later (*Roczniki*, i.e. *The Chronicles of the Famous Polish Kingdom*, original Latin title: *Annales seu cronicae incliti Regni Poloniae*) believe that the black death reached the Polish borders at that time. However, research by Dr. Piotr Guzowski from the University of Bialystok should definitely put an end to these speculations. The chronicle of the undoubtedly outstanding Polish historian Jan Długosz was published much later than the sources on which the researcher from Białystok relied.

Most probably, the virulent strain of the bacteria *Yersinia pestis*, which caused the black death pandemic, came to Europe from the Caucasus on a ship carrying infected people, which reached Messina in 1347. A decade ago, DNA tests performed on skeletons from mass graves across Europe have unequivocally confirmed that the disease which caused the black death pandemic was the bubonic plague. These results have been published since 2010. The historian from Bialystok, together with a team of researchers, challenged the theory of the occurrence of the plague in the mid-14th century in our country. Their arguments are based, among others, on the very detailed accounts of the so-called *Świętopietrze*, i.e. the Pope's tax. This tax was paid per capita, so the great loss of population in those years should have been noted in the very meticulous accounts. No such evidence has been found. However, it is apparent in the registers of other countries. In other words, even if the black death, or the bubonic plague, reached the Polish borders of that time, it did not cause significant damage. Jan Dlugosz's message can be very simply explained in terms of "plagiarism" from the Western accounts concerning such events. This was not the first chronicler caught 'colorizing' history – especially with regards to events taking place before his birth.

Even if the famous black death did not cause any major perturbations in Poland, it does not mean that there was no miasma in the country. The walled up cities and lack of ventilation caused the spread of various diseases, most often cholera, which are virtually unknown today. What was the behavior of people during such epidemics? In 1425, a plague spread in Lesser Poland, but unfortunately, the chroniclers did not specify the name of the disease. King Władysław II Jagiełło and his wife Zofia Holszańska left for Lithuania, but soon the plague spread there as well. The royal couple and Grand Duke Vytautas the Great had to flee from castles and fortified settlements into the Lithuanian forests. It is interesting to mention that the little prince Wladyslaw was sent back to Chęciny (Świętokrzyskie Voivodeship) with his nanny, hoping that he would be safe in the castle located at great height.

In 1451 a great plague broke out in Mazovia and quickly spread to Greater Poland. Many villages and small towns died out at that time, and the plague raged from April to late autumn.

text: Assoc. Prof. Bożena Czwojdrak

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Hygienic problems, poor nutrition, the emergence of many dangerous diseases, including an increase of the incidence of infectious diseases have led to greater interest in the subject of death, its inevitability and equality in the face of death. As a consequence, motives such as danse macabre (dance of death) have developed. The picture Taniec śmierci (Dance of Death) shows a painting from the Bernardine Church in Cracow 17th century).

Around July, the situation in the town Sochaczew was so severe that 40 people were buried in one grave every day. In October, the Chapter meeting in Gniezno was canceled, since at that time it required personal participation. The plague did not spare Silesia and the Czech Republic either, although it treated Lesser Poland gently. Unfortunately, the terrified people from the infected areas – if they could afford it – fled to the lands around Cracow, where they brought the plague with them. The plague broke out with impetus in 1452 in Cracow and in the region of Wieluń. For this reason, truces were quickly made, since there was no possibility of continuing to fight. 1452 was a bad year in the Kingdom of Poland and Lithuania. The plague also spread to the Lithuanian towns and cities, and a chronicler noted that it was so strong that people were walking, eating, or drinking – and suddenly died. The disease persisted until the end of the year.

In 1464, the plague in Prussia made the ongoing peace talks with the Teutonic Order more difficult, and their participant, the chronicler Jan Długosz, had to flee together with his company. A very great plague broke out in the year when negotiations with the Order were finished, and a peace treaty was signed in Toruń – the whole Kingdom of Poland was affected by it. Probably it was cholera, as it is favored by humid air and warm winter. In some areas, this plague existed until 1468, and in Cracow courts were held outside the city, in the surrounding towns, where the situation was less dangerous. Polish King Kazimierz Jagiellończyk left Krakow and went to Lithuania, and his children were placed in the Tyniec monastery, which was isolated and situated on a hill.

In 1482, Poland was hit by another pandemic; a severe plague of *pestis furiosa* spread across the country and lasted over a year. It probably came from Hungary, and therefore the first provinces of southern Poland were affected. In Cracow about 40-50 people died every day, but in Krosno (southeastern Poland) there were 80 daily deaths. As a result, the town was quickly depopulated. An interesting fact is that in 1495 in Silesia a venereal plague was believed to be spreading because of the immoral behavior of the local population, but there is no confirmation for this from other sources.

The plague was often relieved by the harsh winter and the long frost that had been waited for, since a wet summer was conducive to the development of miasma.

Of course, these are not all the plagues that broke out in medieval Poland, but they affected the entire country and constituted a real problem.

Which methods were resorted to save oneself in these times? The most common one was to escape from the infected places – of course, if a person had the required financial means and opportunities. The people of the Middle Ages were convinced that the further away from the outbreak of the plague they went, the safer they would be. However, it was not taken into account that in this way the fleeing people themselves contributed to the spread of the disease. When news came that miasma was approaching, preventive measures were taken. The gates were tightly closed, no one was allowed into the cities, and the inhabitants were isolated from the outside world. However, if the plague made it into the town, the infected houses were subjected to strict isolation, and their inhabitants were forbidden to leave. Visits were also no longer allowed. Food was left on the threshold, and if someone had to leave the house for various reasons, they were forced to carry a white cane, which indicated an infected person. Houses affected by the plague were marked with white paint so that it was known which of them were to be avoided.

Public gatherings, visits at the inn, and the use of bathhouses were strictly forbidden. The councillors also tried to keep the city clean, since they ware aware that the plague often resulted from disregard for hygiene. Therefore, it was forbidden to pour urine into the street, drive out pigs, and the inhabitants were ordered to keep the streets and gutters clean. Clothing and belongings of people who died form the plague were burned.

In the chronicles or other documents the preparation of medicines or doctors' visits are rarely mentioned. These measures were rather for the most affluent – predominantly the rulers and members of the court. The rest had to follow the rules and count on their instincts, luck, and their body's immunity.

text: Tomasz Płosa

STUTTERING IS O.K.

According to estimates by the Stuttering Foundation, there are over 70 million stuttering people around the world (about 1% of the total population). In the United States alone, there are 3 million people with this fluency of speech impairment, including famous actors such as Samuel L. Jackson, Harvey Keitel, and Bruce Willis or the former NBA basketball player and current TV expert Shaquille O'Neal. Marylin Monroe and Elvis Presley stuttered as well. Living with stuttering was an experience shared by many famous figures functioning in the public space, but the case of the British Duke Albert, later King George VI, has probably become the best known to the general public.

His struggle with stuttering, which became the basis of the Oscar-winning film *The King's Speech*, is undoubtedly an uplifting story, but the everyday life of stuttering people is not easy, even if no one requires them to make public appearances as heads of state. We have no data on how many people stutter in Poland, but it is assumed that the situation in our country does not differ from the global average: about 5% of preschool children show symptoms of stuttering. In the majority of them, this impairment disappears before they start school. Chronic stuttering (i.e. stuttering that does not disappear spontaneously) affects about 1% of the population, i.e. school-age children, young people and adults.

Scientists from the University of Silesia, headed by Prof. Katarzyna Węsierska, are conducting pioneer research in the field of Speech Therapy for Individuals with Stuttering Disorders, referred to, mostly in Polish research, as Balbutologopedics, a sub-discipline of Speech Therapy. It deals with the diagnosis and therapy of speech fluency disorders, including, among others, stuttering and cluttering. Their research interests also include the influence of speech disorders on the quality of speech therapy, on the environment of stuttering people, and on the social perception of stuttering. With regard to the latter aspect, it is also very important to change social attitudes towards this phenomenon.

In the scientific community itself, there is no general consensus on the etiology of speech disorders, but currently the vast majority of researchers and speech therapists believe that stuttering is a result of complex interactions between many factors. It is perceived as a neurophysiological disorder with a strong genetic component.

– We still have a lot of work to do in the field of Speech Therapy for Individuals with Stuttering Disorders in Poland, especially in terms of changing social attitudes towards people affected by this problem, Prof. Katarzyna Węsierska admits. – But we are acting consistently, and I think we have made significant progress in this matter.

The need to disseminate knowledge about stuttering or cluttering has been confirmed by research carried out in recent years under the project IPATHA (The International Project of Attitudes Toward Human Attributes) among various social groups, including students, graduates of humanities and social studies, teachers, students, speech therapists, and people associated with religion (priests, clerics, and catechists). Although Poland does not differ significantly from the world average, it should be remembered that this average consists of very good indicators in Western European countries, Canada, or Australia and much less favorable ones, e.g. in African countries. The most adequate level of awareness is shown, not surprisingly, by students of speech therapy and teachers. It is worrying that in Poland we do not have too much confidence of specialists in speech fluency disorders, and knowledge about the etiology of the lack of fluency in speaking is still relatively poorly established.

The scientific activity of experts in Speech Therapy for Individuals with Stuttering Disorders from the University of Silesia is connected with working on changes in attitudes towards speech fluency disorders, manifested among others in the organization of workshops for stuttering children and their parents. For the time being, the InterACT project is in its pilot stage, the aim of which is to modify attitudes towards speech disorders in preschool children – the first results are more than promising. Another important initiative is the recent LogoLAB grant "Dialog without barriers." Its aim is to improve the quality of speech therapy with regard to chronic stuttering (in older children, adolescents, and adults), and it will include a website designed as a reliable source of knowledge about stuttering and a textbook for educating speech therapists in this field (eminent specialists from many countries participate in its development). The scientific results will be made available to all interested parties in an *open access* form.

Prof. Katarzyna Węsierska and her collaborators take part in international research, in cooperation with scientists from Czechia, Slovakia, Norway, Lebanon, and USA. Their aim is to create a set of good practices to support stuttering people, both children and adults, in communication, with the assumption that these guidelines should be useful for the general public. The results of these studies have already been partially described and published (for the time being in relation to adults), and thus it was possible to create a catalog of basic "hints" (cf. the adjacent infographics), available, for the time being, in eight language versions: English, Arabic, Czech, French, Polish, Dutch, Slovak, and Bemba, which is used in Zambia and in the Democratic Republic of Congo (a Russian version is being developed).

– We are aware that for some people these indications are quite obvious, and that there is nothing new or revealing about them. I agree, since these are the golden rules of good communication, and each of us wants to be listened to with attention, empathy, and without being judged. Nevertheless, we all know that it doesn't work that way on a daily basis, and people struggling with fluency of speech experience additional difficulties. They really need to be treated like any other person who maybe needs just a little more time and patience. That is why we have to work towards treating stuttering as an atypicality or difference and not a defect. In other words, we want to convince both fluent speakers and people with an impaired fluency of speech that stuttering is a phenomenon experienced by some of us, but it does not have to define them or exert a destructive influence on their quality of life, Katarzyna Węsierska explains.

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SUPPORT ABC

Show commitment
by trying to maintain natural eye contact!

Be patient,
and give me enough time to think and express myself!

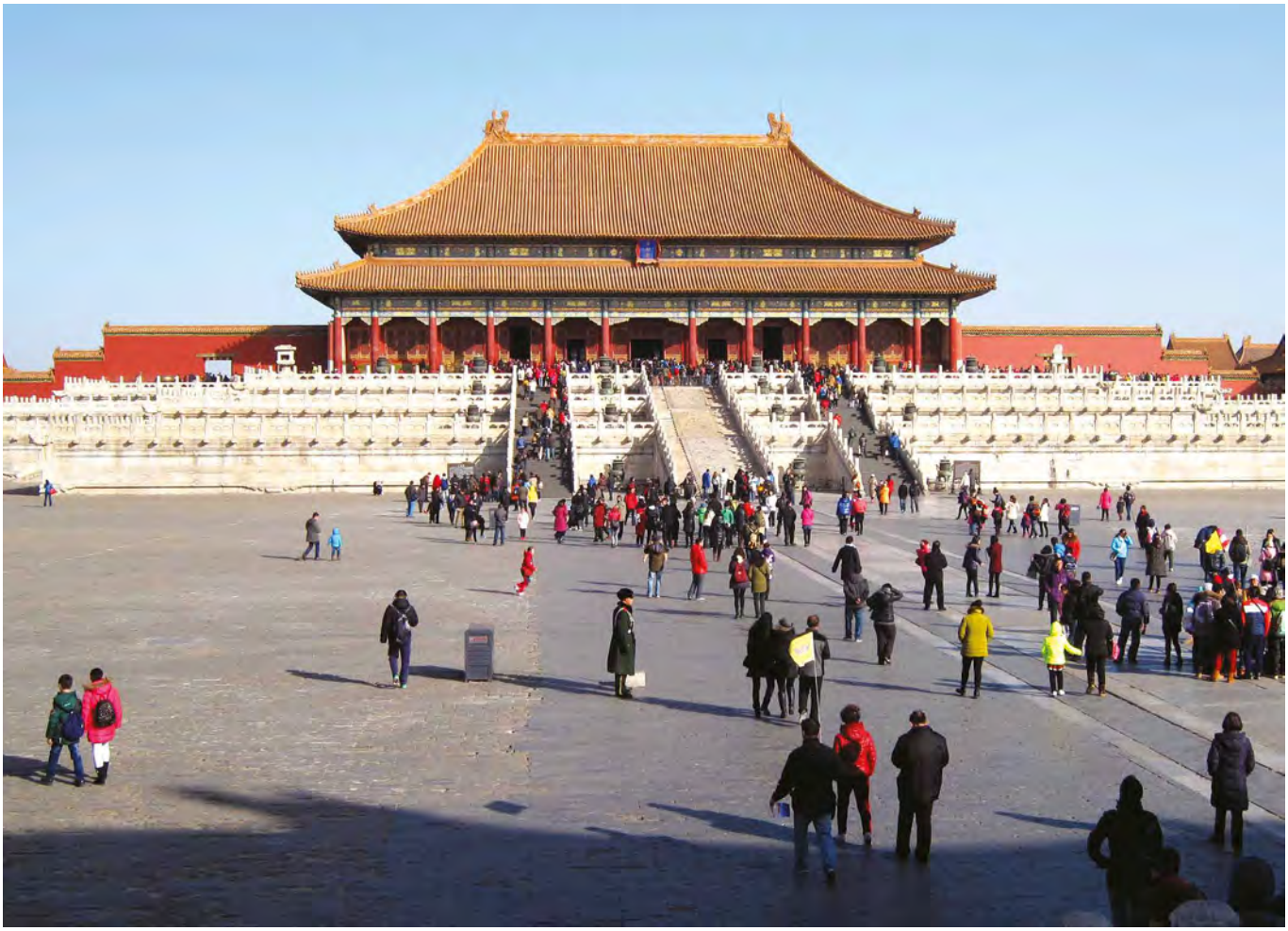
Your acceptance is important to me;
try not to judge, show empathy!

Support me as a human being by showing kindness, a sense of humor, and friendliness!

Show peace of mind as much as you can,
behave naturally, be yourself, and concentrate on what I'm saying, not on how I'm saying it!

Be flexible about adjusting your behavior and try to respond to my needs!

CHINA – A GIANT WITH FEET OF TERRACOTTA?



Hall of Supreme Harmony in Beijing / photo: Tomasz Okraska

One of the most interesting differences in the perception of China by the Chinese themselves and by Westerners is related to language issues. The meaning of the terms 'Central State' or 'Middle Kingdom,' which are used at times with regard to this country, is largly not really clear to us. In China, however, the corresponding term *Zhōngguó* is one of the official names for their homeland. In the past centuries, it reflected the way of thinking in which the emperor sitting on a dragon's throne was not only the sovereign of China, but also – indirectly – the ruler of the entire world. According to their own world view, the Chinese had created the highest or even the only civilization, surrounded by a sea of barbarians, of whom those living in the neighborhood were the happiest, as the glow of Chinese culture flowed down on them.

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Famous terracotta army located in the tomb of the first Chinese Emperor Qin Shi / photo: public domain

Inhabitants of the 'Middle Kingdom' had some reasons for such a perspective, since it resulted from the multitude of inventions that had been developed earlier than on the Old Continent. Consequently, it was a huge shock for them that, due to the weakness of the empire, they were dominated by Europeans in the 19th century. Today, in turn, after a century of disgrace and humiliation, the madness of the Maoist era, and the subsequent reconstruction, China is once again a great power. The Chinese often do not perceive their homeland as a conventional nation state, but rather as a permanent natural phenomenon ("China has always existed at an impressive cultural level'), and therefore, they regard the current international situation not as a new phenomenon, but as a return to a natural state of affairs in which the 'Middle Kingdom' dominates over others.

In the 21st century, Chinese politicians felt so confident at the helm of their growing power that they broke with the previous low-profile foreign policy of Deng Xiaoping's 24-Character Strategy based on caution and self-restraint. The current leader, Xi Jinping, has already made it clear that China is a superpower, feels like a superpower, and will participate in world politics. At a time when the importance of the United States and the entire West is declining, the People's Republic of China presents itself as a potential new leader, or even a champion of globalization and free trade – in opposition to US President Donald Trump. The global expansion has been underlined by the launch of Xi's Crown Project, i.e. the Belt and Road Initiative, which is to further enlarge China's economic sphere of influence. The huge number of Chinese projects on all continents has made it clear to the West that Francis Fukuyama's predicted end of history, assuming the final global triumph of liberal democracy, is clearly outdated. The People's Republic of China has proposed a different model for drawing some (but not all) ideas from the West in the economic sphere while maintaining the primacy of the communist party over the state and society. The Beijing Consensus, which is to replace the Washington Consensus of the early 1990s, assumes that it is possible to transfer Chinese solutions to other countries, for example on the African continent. However, at present it is difficult to notice such a tendency, and it is worth mentioning that many Chinese researchers have doubts about copying their model, claiming that the Chinese people themselves are necessary for its proper functioning.

However, does the model even function properly in the PRC? It has a lot of internal problems: demographic imbalance, social stratification, ecological disaster, and growing internal debt are just a few of them. China's reputation as the world's factory is also slowly becoming obsolete – local workers want to earn more, and thus cheap production will no longer be possible. The irony is that Chinese companies are moving their own factories to Africa, where labor costs are lower, and at the same time they are not poisoning their own, but others countries' environments. Moreover, the great protests in Hong Kong in 2019 have showed that not everyone is equally happy to live in the PRC. The Beijing authorities are also aware of various challenges. Thus, for example, Xi Jinping once said that China may become a superpower as late as in 2049.

The COVID-19 pandemic may be very important for the present and future perception of China. The fact that it began in the PRC and has spread on such a scale is not only a matter of chance, but also shows a weakness of the Chinese system. The voice of Li Wenliang, the doctor who warned about the epidemic, was not heard. Instead, he was detained by the police, and the local authorities concealed the information with the help of Beijing. Information issued by the government was chaotic and focused rather on intra-state propaganda than on the effectiveness of the implemented measures. At the same time, the PRC tried to change its image from a culprit to a savior by means of supplying (partly non-commercially) protective equipment to other countries. Despite its quality problems, the action allowed China to present itself as a responsible world power with a policy of "generosity." It is noteworthy that many European countries are more eager to emphasize Chinese aid than EU aid, even though the latter has been more substantial. This shows the effectiveness of Chinese efforts in building soft power and shaping a positive image of the country over the past decades.

PROBLEMS WITH WATER IN CITIES

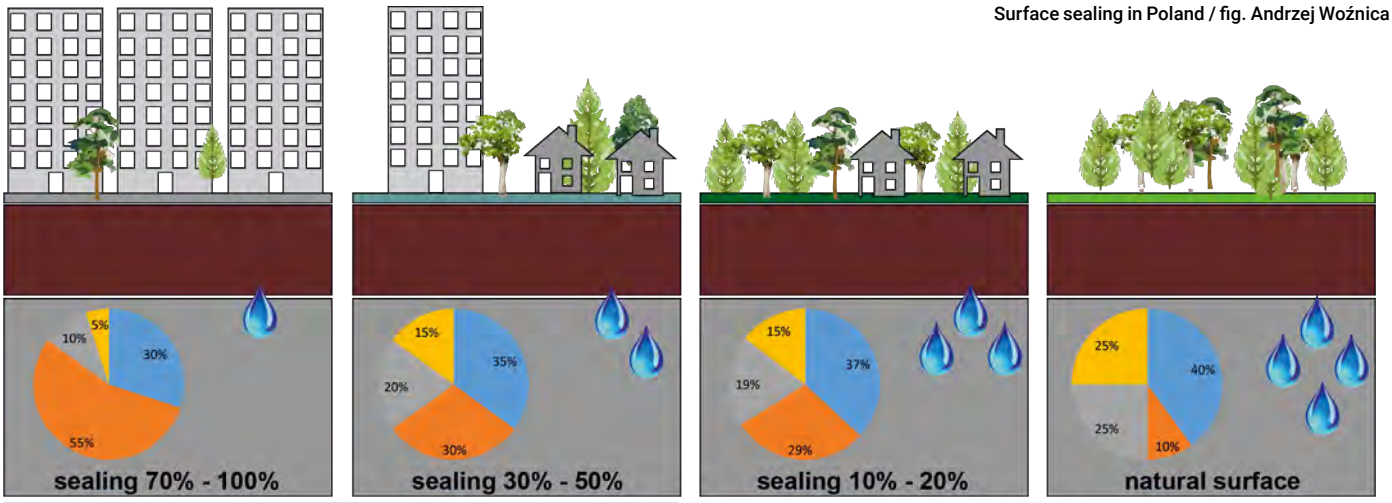
It takes only a few minutes of a sudden downpour to paralyze not only the traffic in the city, but also to flood houses, cellars, or public buildings. The cost of removing the losses is enormous. One of the tasks of the Silesian Water Centre, a unit at the University of Silesia, is to search for solutions of these problems and to indicate ways to mitigate and eliminate the effects of such phenomena.

Due to climate change, extreme weather phenomena are becoming increasingly common in various regions of the world. Not only farmers suffer from drought, which destroys crops, since excess water is a problem as well. This is particularly true in large cities and agglomerations.

Since the dawn of history, cities have been built near rivers and water bodies, but water was managed in a more sustainable way. Today's cities are characterized by a high density of buildings, roads, concrete squares, and car parks, i.e. a large part of impermeable surfaces and urban heat islands. At the same time, they feature a small proportion of green areas.

Particularly in the Silesian Voivodeship, many cities have a strong surface sealing, which poses a serious threat, since it becomes difficult for precipitation to infiltrate groundwater and, consequently, groundwater cannot rapidly flow into surface waters. For this reason, the risk of urban floods occurring during sudden and heavy rainfall increases. Other problems are posed by mining activities in Silesia which result in land subsidence, which affects the occurrence of local floods. Additional issues are poor water quality, concreted river beds, their reduced cross-sections, and lack of floodplains. Currently, these problems are becoming intertwined with the threats resulting from global warming. According to climate change scenarios, it should be assumed that we are threatened by alternating waves of heat, cold, drought, and intense rainfall and flooding.

The complex problems of climate change can be alleviated by introducing a so-called blue-green infrastructure. Its main aim is to protect and restore the urban environment in the context of ecosystem services, i.e. the numerous and different benefits people derive from the environment and properly functioning ecosystems. Such ecosystems include, for example, agro-ecosystems, forest ecosystems, meadow ecosystems, but water environments fulfill particularly important ecosystem functions. The city's water bodies are important because they provide services such as water filtration, nutrient circulation, carbon fixation, control of erosion, flood, and water resources. Moreover, they are habitats of protective importance. Thanks to these services, water bodies influence the environment, i.e. they improve water quality, regulate local temperature, prevent floods, and preserve habitats and species. As a result, society derives specific benefits from these services: it has access to clean drinking water and attractive places for recreation. Moreover, the effects of warming are reduced, and the costs of damage to property, e.g. as a result of flooding, can be avoided.



Surface sealing in Poland / fig. Andrzej Woźnica

Concrete riverbed of Rawa in Katowice / photo: Agnieszka Sikora

Around the world, attempts are made to mitigate the effects of heavy rainfall using appropriate urban and architectural solutions. Increasingly, cities are trying to deal with these problems by planting trees and shrubs, giving up mowing lawns, and establishing flower meadows or even gardens on roofs. The next step should be to collect rainwater from the roofs of houses, shopping malls, car parks, and roads. Assuming that during a single cloudburst about 100 mm of water falls, a total of over 20,000 m^3 of water will pour down on the sealed surface around the shopping mall Silesia City Center in Katowice. This amount fills a pond of 20,000 m^2 surface and 1 m in depth. The solution can be sustainable rainwater management. For instance, runoffs could be stopped at the place where the rainfall occurs and returned to the ecosystem by means of retention and subsequent infiltration to the ground. In order for this to happen, new methods must be introduced along with the application of traditional rainwater drainage systems, e.g. the so-called sustainable drainage, which consists in replacing impermeable surfaces with permeable or semi-permeable ones, which results in prolonging the outflow time and limits its size. Perforated paving slabs, gravel surfaces, or openwork concrete slabs with grass coverings can be used for this purpose. Thanks to the use of such materials, it will be possible to restore the natural circulation of water in urban spaces and at the same time to relieve storm drainage.

Some of the risks resulting from climate change, i.e. an increase in flood risk, reduction of water consumption, or an increased risk of extreme temperatures and fires can be avoided. Many of the solutions that can be used for this purpose are related to water management, such as the construction of retention tanks, small retention systems, systems that limit the rapid flow of water from impermeable surfaces, water tanks for fire protection or watering urban greenery.

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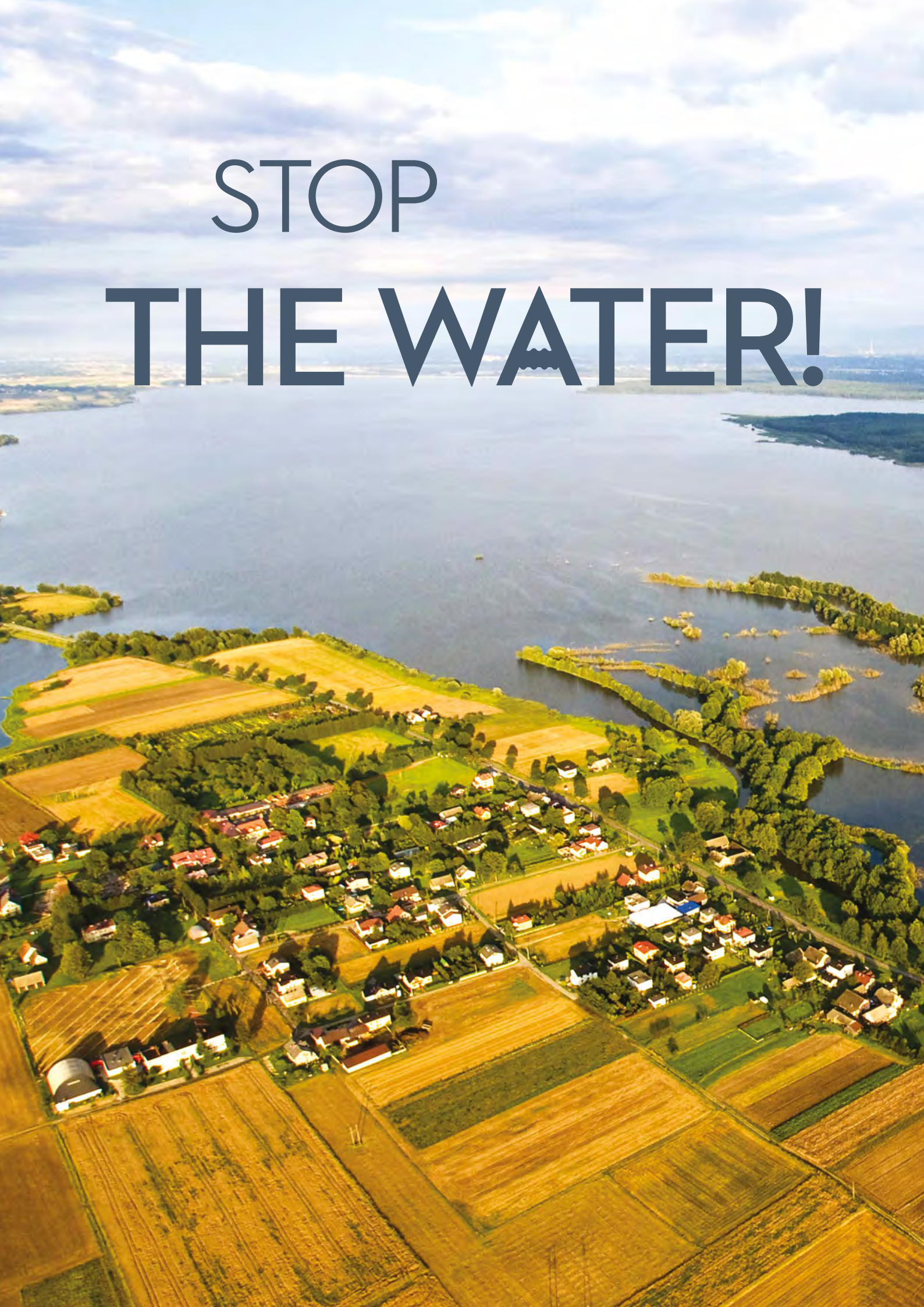
STOP
THE WATER!

There are about 1.3 billion km^3 of water on Earth. The waters of the oceans and seas account for 96.5% of the planet's total water resources, and the remaining saltwater makes up 0.9%. Freshwater accounts for only 2.5%. The Earth's total freshwater resources consist of glaciers and the planet’s ice cover – 68.7%, groundwater – 31.01%, surface water and other freshwater – 1.2%. Water is constantly moving in a closed circuit. It evaporates from the surface of seas, rivers, oceans, and land as well as a result of transpiration from green surfaces. Subsequently, in the form of precipitation, it falls to the ground, penetrates the surface, and supplies it with groundwater or flows down into lakes, seas, and oceans.

The Vistula River mouth at the Goczałkowicki Reservoir / photo: Andrzej Siudy

text: Dr. Agnieszka Sikora

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Fifty-kilogram silver carps caught in an overflow basin after the flood in 2010 / photo: Andrzej Siudy

Surface water is the water we should use. Groundwater as well as the waters of the glaciers and ice cap, in turn, should be an untouchable resource. Unfortunately, the ice sheet covering the Arctic and the Antarctic is currently undergoing severe degradation due to climate change. The melting of the glaciers causes the water from them enter the oceans, i.e. to become saline water. At the same time, fresh water resources are dramatically shrinking.

In Silesia there is a so-called anthropogenic lake region with numerous water reservoirs created as a result of human activity. These are mainly reservoirs with dams, cave-ins, and ponds. Currently, the number of reservoirs created as a result of ground subsidence due to mining activity is on the rise.

In this region there are approx. 15,900 water reservoirs occupying a total area of 194.7 km^2, which amounts to 2.64% of the total area of Silesia. This is a relatively large number, but once the so-called lake density was even greater – in the period from the 16th to 18th centuries it amounted to approx. 4.5%. In these times, water was intensively used in water mills. In the Duchy of Pszczyna alone, there were about 250 water wheels, which were used as propulsion for mill wheels, blowers, and hammers in forges and sawmills. The hydrotechnical solutions used at that time indicate other functions as well, such as flood control and drought prevention. Moreover, they can serve as a model for solutions in the construction or reconstruction of contemporary small retention systems. Since the invention of the steam engine, the role of reservoirs ceased to be important, and they have slowly disappeared.

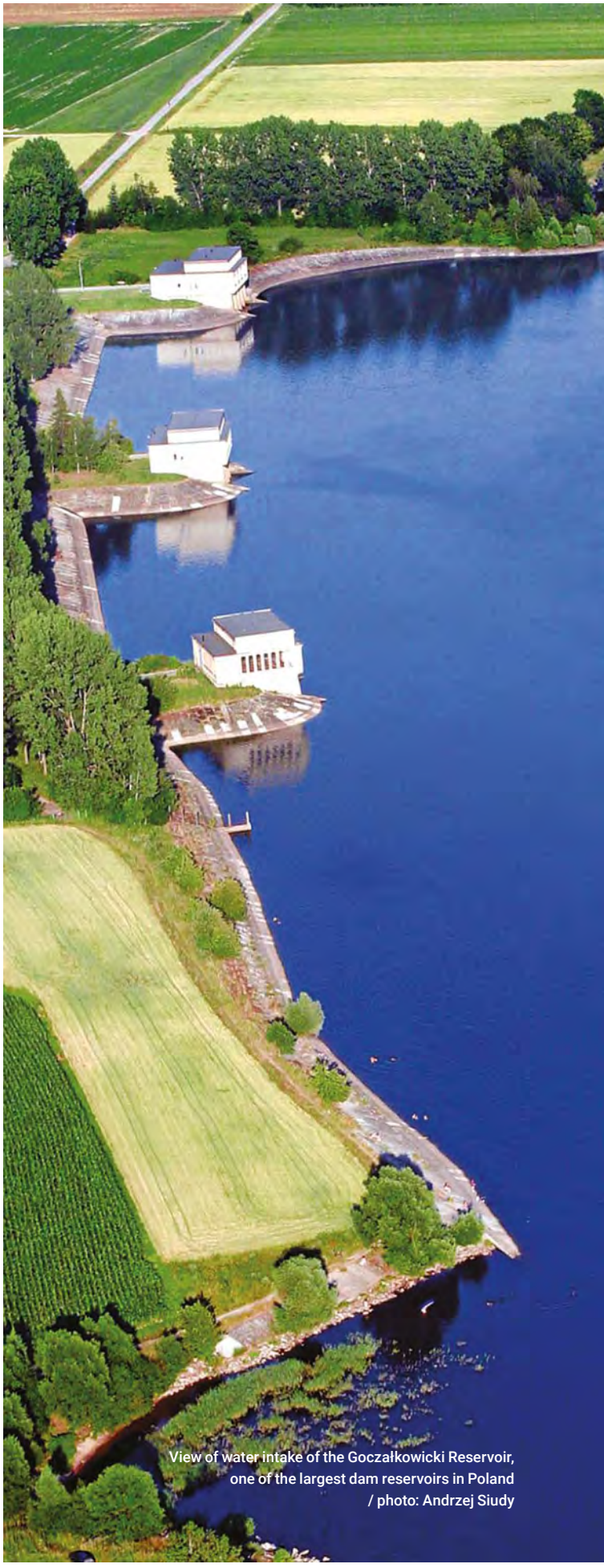
In Upper Silesia, sustainable water management was present since the Middle Ages – mainly on the land belonging to the Cistercians, the Piast dynasty of Cieszyn, and the noble families Thurzó, Promnice, Hochberg, and Donnersmarck. Almost every watercourse that functioned in Upper Silesia at that time in the form of cascade lakes, in which water was flowing from one to another. This shows that already in the Middle Ages people

were struggling with water shortages and saw the need to save this resource. Moreover, systems of connected cascade ponds offered protection against floods, as evidenced by the large proportion of dry reservoirs and dikes across the valleys of streams that slowed down the flow of water.

In addition to their functions of flood protection and water retention, these systems played an important role as reservoirs for animal and plant species, which is why the ponds were used for fish farming. The beginnings of pond management in Silesia go back to the 15th century, but the first breeding ponds were created earlier, probably due to the use of numerous old riverbeds of the Little Vistula, the Oder (Odra), and their river basins. The intensive development of settlements in Silesia and Lesser Poland gave the process of pond formation much more dynamics. The increasing number of inhabitants of the cities and towns caused an increase in the demand for fish, also due to compulsory fasting and the fact that dishes containing fish were considered meatless. At that time, several pond districts appeared in Upper Silesia, including those which supplied Cracow with fish. At the turn of the 15th and 16th centuries, Casimir II, Duke of Cieszyn, initiated the construction of ponds and the development of fishing in the Duchy of Pszczyna. In this region, water management was focused on fish production as early as in the 16th century. At the end of the 18th century, the area of the ponds in the Duchy of Pszczyna exceeded 48 km^2. Even at the beginning of the 19th century, almost every house had a pond, and fish was the basis of the diet of the region's inhabitants. Apart from its use in fish farming, water fulfilled two important functions in this region. It was a source of energy and, as evidenced by old maps, systems were created to keep large amounts of water in the environment.

One more aspect of water management should be mentioned at this point. The progressing development of industry and increasing urbanization caused a decline of water quality in Silesia. In 1867, in the meadows of the Gostynia river valley, a hydrobotanical cleaning plant was established. After being filtered through the ground and plant roots, the treated water flowed into the Paprocany reservoir, which is one of the oldest dammed reservoirs still existing in Poland (it is already visible on the maps of Christian Friedrich von Wrede from 1747–1753).

Nowadays, small water reservoirs or private ponds next to houses have disappeared and have been replaced by large dam reservoirs, e.g. in Goczałkowice. The reconstruction of cascade ponds may be a way to build small retention systems in Silesia. These reservoirs should be multi functional, and their functions should include: drought and flood prevention, fish farming, and leisure. Moreover, an emphasis should be but on values related to the landscape and nature, which will allow to increase the biodiversity of these areas. Moreover, a system of ponds built on single stream may significantly affect not only the amount of water in the environment, but also its quality, which will increase the amount of good quality water resources in the region. Due to the large dispersion of reservoirs in Silesia, the scope of their influence (retention, flood control activities, ecosystem services, counteracting the effects of climate change) will be significantly larger.



View of water intake of the Goczałkowicki Reservoir, one of the largest dam reservoirs in Poland / photo: Andrzej Siudy

Geophysical research in the pilot area – water intake Świerczków in Tarnów / photo: Sławomir Sitek

RECOVERING RAINWATER

The newest data provided by NASA satellites, which measure water beneath the Earth's surface by making use of the force of gravity, provide information about the rapid decline of groundwater resources. It could seem that the results of measurements of resources, which are invisible to the naked eye, are of interest only to specialists. However, in such a country as Poland, for example, about 75% of tap water comes from groundwater resources.

Additional groundwater supply from the Dunajec River through a infiltration trench in Tarnów / photo: Grzegorz Wojtal

Climate change is exacerbating the water deficit, and the Earth is threatened by drought, so hydrogeologists on all continents concentrate their research on the improvement of methods for providing additional groundwater supply. A real solution is the accumulation of excess surface water, i.e. using heavy rainfall, which can be stored in aquifers and resorted to when drought comes. Additional controlled groundwater supplies are possible thanks to Managed Aquifer Recharge (MAR) systems.

No continent is safe. Europe struggles with water shortages, too. An international team including scientists from the University of Silesia is preparing to develop solutions for additional artificial groundwater supplies in Central European countries by using rainwater. Partners from five countries – Poland, Hungary, Slovakia, Croatia, and Germany – also participate in the DEEPWATER-CE project. The team of hydrogeologists from the Institute of Earth Sciences at the Faculty of Natural Sciences of the University of Silesia is headed by Dr. Sławomir Sitek. The project began in May 2019 and is to end in April 2022.

The ongoing climate changes in Central Europe have had a considerable and negative impact on the level of groundwater resources. The region has to face rising average air temperatures and an increasing number of extreme weather events such as droughts, heat waves, floods, and violent thunderstorms. The quantity and distribution of precipitation varies over time, which leads to extreme fluctuations in river flows and limits access to water resources in industry and agriculture, but also for private consumers.

At the beginning of July 2019, the Polish Institute of Meteorology and Water Management issued a heat warning for the Silesian Voivodeship due to a threat of water shortage. At the end of the same month, record rainfall was recorded in Katowice, the capital of this region. Within an hour, a total of 74 liters of water per 1 m^2 fell, which was over 10% of the annual rainfall.

– If such an amount of water is not utilized even in a small percentage, we will lose it, since the surface run-off will direct it to the river, and subsequently it will flow into the Baltic Sea. The main issue, therefore, is to store excess water after heavy rainfall or snow and to use it in times of drought, explains Dr. Sławomir Sitek.

The most frequently used solution are intakes with filtering i.e. the construction of underground water intakes along river banks. Water drawn from such intakes is used, among others, by the inhabitants of Bielsko-Biała and Cieszyn in the Silesian Voivodeship. Rainfall water can also be directed by means of geological boreholes and pumps, with the help of filter ponds. This option is much cheaper than the construction of huge retention reservoirs. Countries which have been struggling with water shortages for many years have implemented such solutions. Spain and Australia are pioneers with regard to the application of methods for additional groundwater supply, however, the implementation of these technologies in Central Europe requires an adaptation of this method to geological and hydrological conditions. The DEEPWATER-CE project has been drawn up in order to review and identify the most effective options to be used in Central Europe, taking into account the area's exposure to climate change according to climate model projections. An analysis of climate scenarios for the Central European region will identify areas that could particularly benefit from additional groundwater recharge due to an increased risk of water shortage and drought.

The research area of the pilot project by the Polish scientific team is a groundwater intake in Tarnów, Lesser Poland, which supplies about 100,000 inhabitants with drinking water. As the scientists explains, the choice of this location was not accidental. Tarnów is a model example because it has some of the largest nitrogen plants in Europe, which may pose a potential threat to the groundwater intakes located there. For this reason, the hydrogeologists from the University of Silesia intend not only to adapt an appropriate method of increasing groundwater resources, but also aim to develop an early warning monitoring system that will ensure safety and good quality water for the city's inhabitants. Using the intake in Tarnów as an example, the scientists want to prove that additional water supplies can also be used in areas threatened by deterioration of groundwater quality due to neighboring industrial plants.

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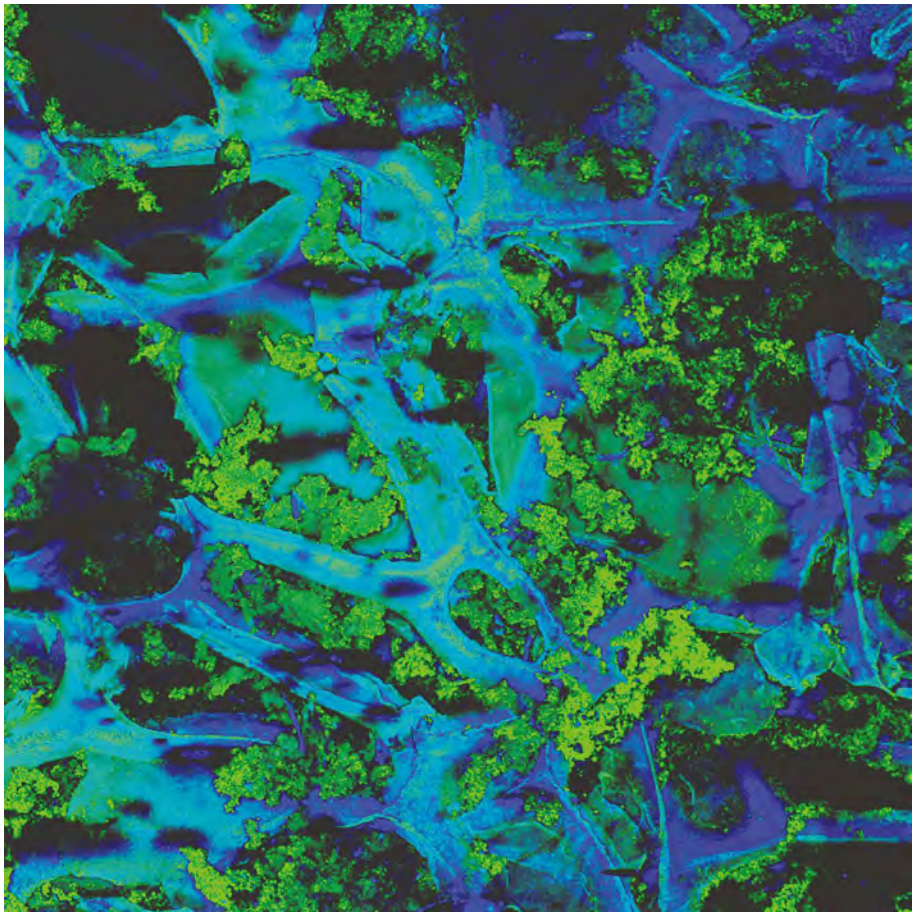
IN THE SEARCH FOR CHEMICAL WATER CONTAMINATION



Biological element ABTOW visualized by confocal scanning laser microscope (CLSM). Microorganisms are marked green and the polyurethane sponge blue / photo: Tytus Bernaś, Andrzej Woźnica

Humans have a huge influence on the quality of water in the environment; by introducing various chemicals into it as well as by interfering with its natural circulation. The sources of contamination are not only urbanization, mining, excessive and sometimes inappropriate use of various chemicals, mainly in agriculture, but – above all – industry.

Population growth in an area results in increased use of personal protective equipment (PPE) and pharmaceuticals, and the transport sector is a source of heavy metals and petroleum hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs). Important so-called point sources of pollution are landfills from which a variety of chemicals and even radioactive substances are released into groundwater. As a result of agricultural activities, many biocidal penetrate the environment. They often contain significant amounts of heavy metals, especially cadmium, zinc, copper as well as veterinary drugs. Chemicals used in industry are an entirely separate issue.

Pharmaceuticals are becoming an important problem, and they enter the water in three ways: through municipal sewage, sewage from production plants as well as from livestock breeding centers. Excreted antibiotics unfortunately still contain the active substance.

– Xenobiotic compounds, i.e. foreign compounds with a chemical structure not found in nature, which include the vast majority of pharmaceuticals, often do not undergo full microbiological decomposition but only partial transformation, i.e. biotransformation. Such a situation is observed in sewage treatment plants where microorganisms in the form of activated sludge do not have the enzymatic 'equipment' able to fully mineralize such substances, explains Dr. Agnieszka Nowak from the Institute of Biology, Biotechnology, and Environmental Protection at the University of Silesia.

Such a wide variety of substances that could pose a threat to the functioning of ecosystems required the introduction of legal regulations to control the concentrations of compounds that have been classified as toxic, dangerous, or potentially harmful. In 2001, in a decision of the European Parliament and the Council, a list of 33 priority substances and 8 other pollutants was established. The introduction of these compounds into the environment should be gradually reduced and, in the case of priority hazardous substances, completely banned. The first list of priority substances included hydrocarbons from insecticides and herbicides, other aliphatic and aromatic hydrocarbons, heavy metals and their compounds (mainly cadmium, nickel, lead, and mercury), and organometallic compounds. The 2013 Directive of the European Parliament and of the Council has paved the way for the establishment and continuous updating of a watch list whuch is the first to include pharmaceutical substances such as 17 α-ethinyl estradiol (EE2), 17 β-estradiol (E2), macrolide antibiotics (erythromycin, clarithromycin, azithromycin) and diclofenac. It is important to emphasize that the medical value of these substances has not been questioned, but it has been demonstrated that the presence of these compounds in the aquatic environment can have harmful effects on the health of fish, limit their reproduction, and pose a threat to other organisms.

– Already in the 1950s, research on aquatic ecosystems allowed to observe processes which result in an increase in the concentration of toxic substances in organisms occupying a higher trophic level, i.e. the so-called biomagnification. Fish species such as tuna and salmon are mentioned as particularly vulnerable, followed by birds eating fish, marine mammals (seals and dolphins), and humans. Hormonal, reproductive, endocrine, and steroidogenic disturbances are described as one of the most dangerous consequences of this phenomenon. Research in many European countries has also shown many disturbances in the functioning and reproduction of freshwater fish, adds Dr. Agnieszka Nowak.

Throughout the European Union, analgesics, antimicrobial drugs, antidepressants, contraceptives, and antiparasitics are found in surface waters.

– It is worrying that drugs such as oestrogen, diclofenac, or naproxene have also been detected in drinking water. In Poland, pharmaceuticals have also been found in surface and drinking water, e.g. naproxene and nonafibrate in the river Warta or diclofenac in the river Oder (Odra). The concentrations of these pharmaceuticals were at levels of several hundred nanograms. The presence of non-steroidal anti-inflammatory drugs in concentrations of several nanograms has been detected in drinking water, explains the researcher from the University of Silesia.

One of the solutions to the problem, i.e. the appearance of xenobiotic substances in water, is to increase the efficiency and the level of their biological decomposition in sewage treatment plants. This can be achieved by introducing selected strains of microorganisms capable of the biodegradation of specific pollutants. Unfortunately, for the time being, these studies are mainly conducted on a laboratory scale.

There are many ways to detect contaminants in water. The researchers from the University of Silesia have also decided to contribute to the fight against water pollution. The Automatic General Water Toxicity Biodetector (ABTOW) is an automated system that combines the properties of selected microorganisms – nitrifying bacteria and electrochemical sensors. It was created thanks to the work of the interdisciplinary research team of the University of Silesia headed by Assoc. Prof. Andrzej Woźnica. Research on the Automatic General Water Toxicity Biodetector has been conducted for over a decade. The device allows for quick detection of contaminants that may be present in the water. It can be installed at a raw water intake or in a process line responsible for water treatment. It reacts to the presence of heavy metals, priority substances, and phenols, which are commonly used in industry.

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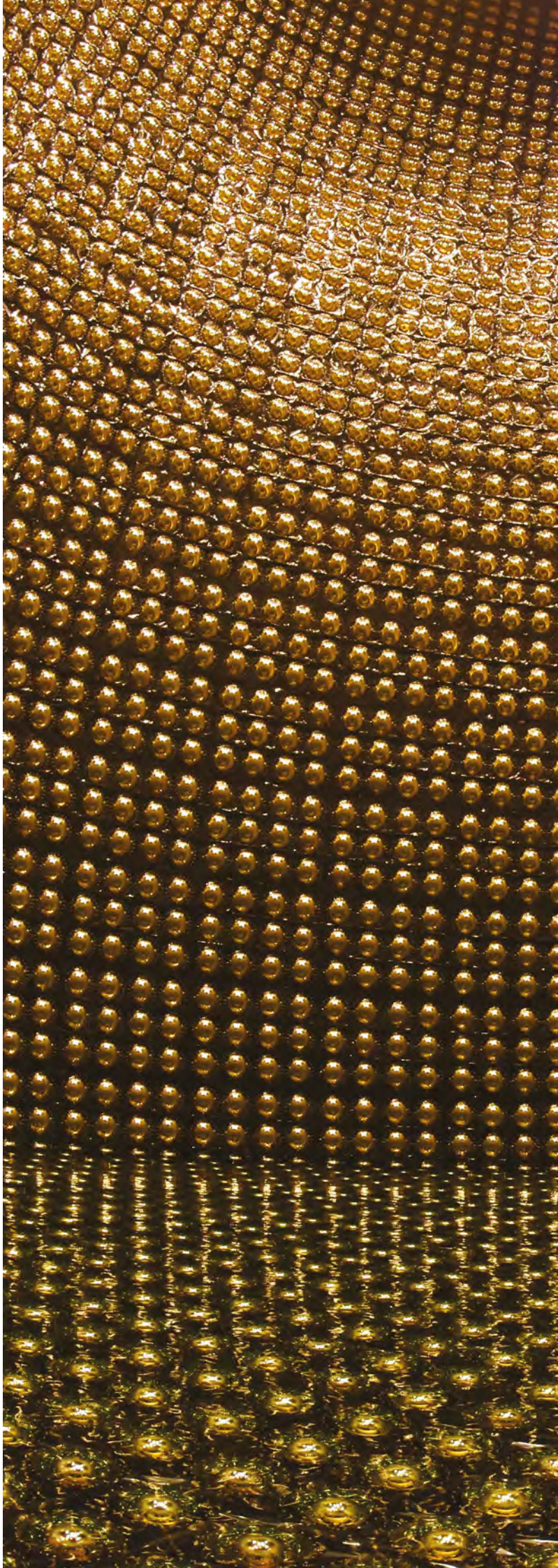
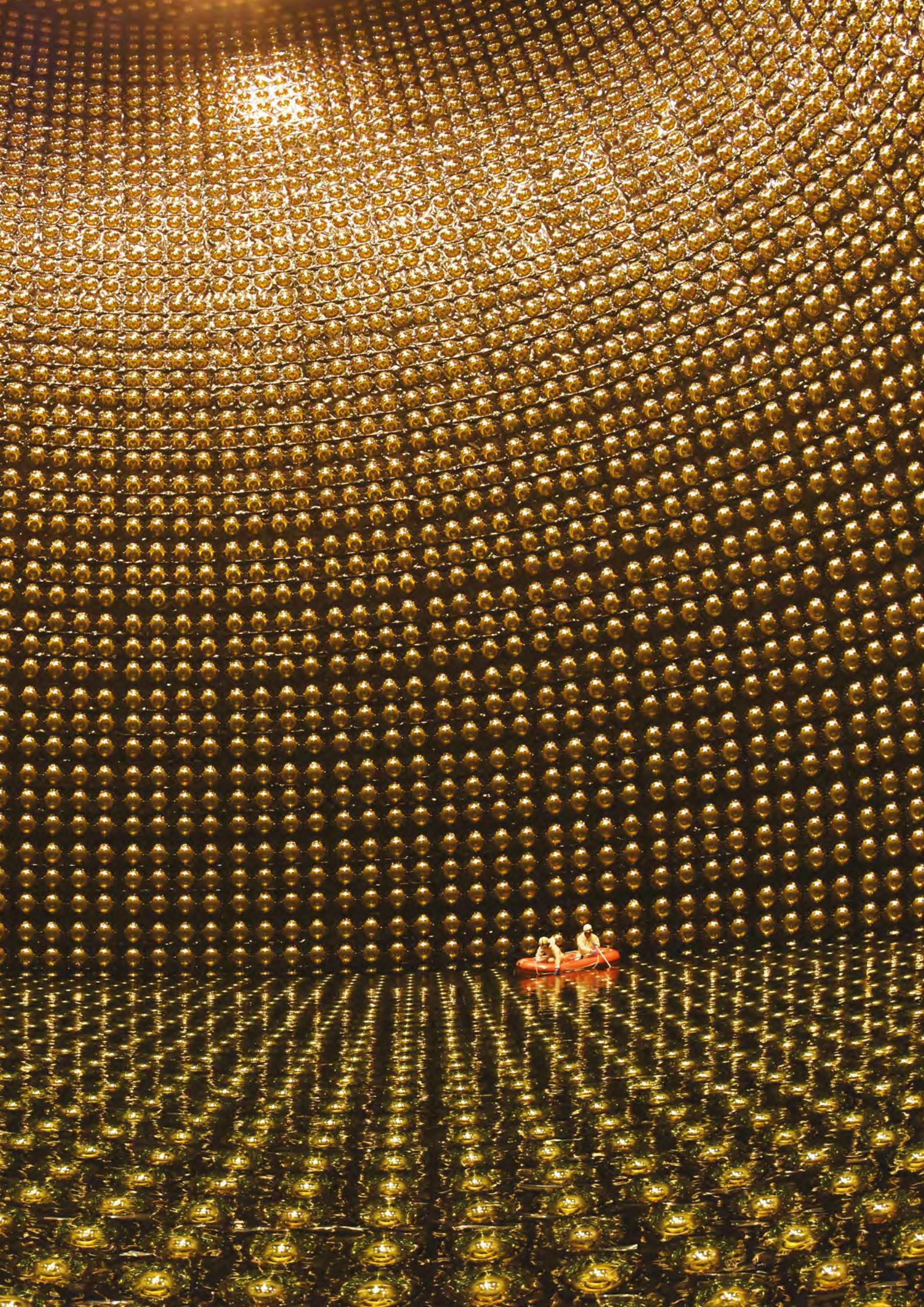
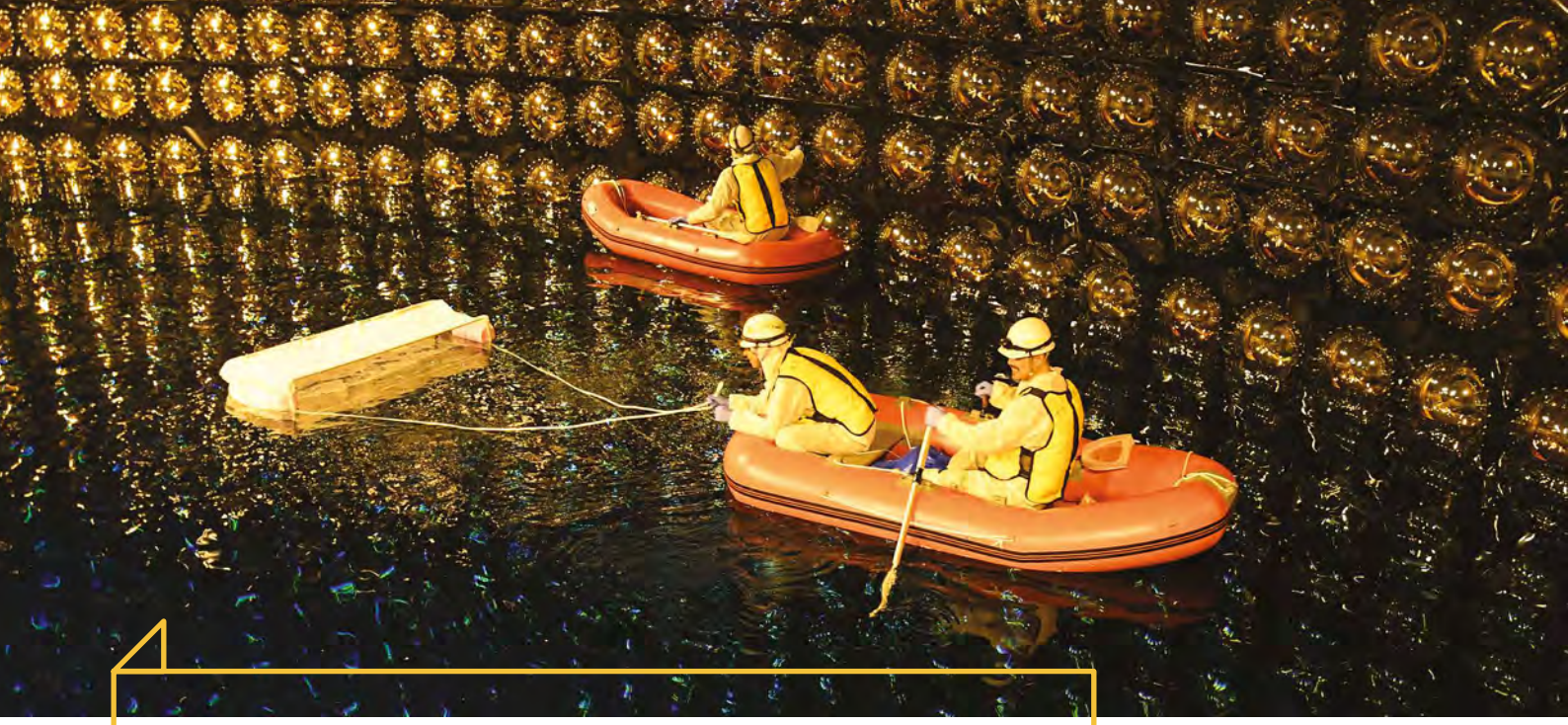
WHY

DOES THE UNIVERSE CONSIST PRIMARILY OF MATTER?



The universe we know consists mainly of matter. All objects around us are made up of particles. Therefore, matter can be reached with our hands. What is more, it is the building block of these hands. It turns out that there are also traces of antimatter in the same universe. It is the rarest and thus the most expensive substance in the world. Why is the Universe much, much more material than "antimaterial?" The results of research on the nature of neutrinos and antineutrinos in the T2K experiment bring us closer to solving this puzzle | Photo: Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), The University of Tokyo





Cleaning the surface of water. The water level is about 31 meters / photo: Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), The University of Tokyo

Their nature is still being discovered. Observations from recent years suggest that the analysis of these particles may bring us closer to understanding why the universe is primarily composed of matter. The inconspicuous neutrinos discussed in this article have already paved the way to several Nobel Prizes. Will history repeat itself?

In December 1930, Austrian physicist Wolfgang Pauli proposed an ingenious solution to all the problems related to beta decay by adding a missing element to the model. It suggested the existence of a neutral particle of negligible mass, moving at a speed below the speed of light. The hypothesis of the existence of an electron-neutrino was confirmed only in 1956 in an experiment by Clyde Cowan and Frederick Reines. In the 1960s the existence of the muon neutrino was experimentally confirmed, and in 2000 the third and last type was discovered – the tau neutrino.

What do we know about these elementary particles? Assoc. Prof. Arkadiusz Bubak, from the Institute of Physics at the University of Silesia answers this question without hesitating.

– Five light years of concrete – a wall would have to be of this thickness to stop all the solar neutrinos (the stream on Earth: $10^{11}/cm^2/s$). These are unusual particles that have very little interaction with matter. To understand this, it is enough to imagine that billions of them pass each centimeter of our body every second. Has anyone of us felt how easily they constantly penetrate matter? – asks the scientist, who together with Prof. Jan Kisiel participates in the Tokai-to-Kamioka neutrino experiment (T2K).

In order to capture their presence and investigate the properties of neutrinos, it was necessary to design powerful detectors mounted in places which will be reached by a small amount of cosmic radiation. Only under such conditions it is possible to observe neutrino effects.

A huge technological challenge was met by the designers of two powerful detectors built for the T2K experiment. The near ND280 detector is located in Tokai, Japan. The Japan Proton Accelerator Research Complex (J-PARC) facility, which manufactures a proton beam directed towards a specially designed graphite shield, is also based there. As a result of the interaction between protons and the shield, other particles are produced, including pions, which decay and produce neutrinos. The newly created neutrinos can be registered by detectors e.g. by the already mentioned ND280 (located 280 m from the target) and by the far detector Super-Kamiokande, located 295 km from the J-PARC center, in a mine inside a mountain in Kamioka, Japan.

– Hence the name of the T2K experiment – Tokai-to-Kamioka, explains Prof. Jan Kisiel, who heads a group of scientists from the Institute of Physics at the University of Silesia in Katowice participating in the experiment.

– We look at the nature of neutrinos, we want to know them better. Physicists refer to the three discovered types of these elementary particle as flavors. These particles have an interesting "skill" and can change their flavor during weak interactions. In practice, this means that, for example, muon neutrinos "traveling" from the accelerator in Tokai to the detector in Kamioka, become... electron neutrinos. The process of flavor change is called oscillation, adds the scientist from the University of Silesia. It is worth mentioning that the two physicists who had discovered the phenomenon of neutrino oscillations, Takaaki Kajita and Arthur McDonald, were awarded the Nobel Prize in 2015.

Why is neutrino oscillation so important? To answer this question, we need to introduce one more protagonist, the antineutrino, the trace of antimatter in the universe.

As Professor Jan Kisiel explains, when we talk about matter and antimatter, we use the concepts of *particles* and *antiparticles*. Particles and antiparticles have identical properties, for example the same mass or spin, but they differ with regard to quantum numbers, such as electric charge or the so-called lepton number. Physicists know many such pairs. They include electrons and positrons, protons and antiprotons, or neutrons and antineutrons. The latter are electrically inert particles that differ from the quarks or antiquarks which form them.

– We treat antimatter as something unusual. However, antiparticles are found e.g. in our organisms. The human body consists mainly of matter. It is formed by such elements as oxygen, carbon, hydrogen, nitrogen, calcium, or phosphorus but also – in much smaller quantities – potassium, sodium, sulfur, magnesium, or chlorine. What is important is that some of them are unstable (radioactive) and undergo radioactive decay. This group includes a radioactive isotope of potassium ^{40}K, which as a result of β+ decay emits positrons, i.e. positive electrons which are... antiparticles, says Prof. Arkadiusz Bubak.

When a particle meets an antiparticle on its path, both are immediately annihilated and turn into pure energy. This is what happens in our body and in the universe, although we do not feel any effects of the processes that are permanently taking place. The same was probably the case shortly after the Big Bang when the universe was created.

– If the annihilation of all particles and antiparticles had taken place at that point, only pure energy would have been created. But this did not happen. Of course, the vast majority of matter and antimatter turned into quanta of gamma electromagnetic radiation, but there is a certain residue left, which is everything we know today and all that surrounds us. It has also formed us. It is estimated that 1 in 1 billion particles survived. This delicate difference was enough to create a whole universe, says Prof. Arkadiusz Bubak.

Scientists have long suspected that immediately after the Big Bang there might have been some differences in the way matter and antimatter interacted. Therefore, they started to look for traces of the source of this asymmetry in the universe. One of the theories assumes that just after the Big Bang there was a process called baryogenesis. At that time, particles such as protons and neutrons, the main components of matter, could have been formed. Soviet nuclear physicist Andrei Sakharov formulated three conditions which must be met in order to explain such a great quantitative excess of matter.

– One of the conditions is the violation of the charge conjugation parity symmetry. We already mentioned the fact that matter and antimatter have the same properties. We had also assumed that they interact in the same way. But it turns out that this might not be the case. There are some indications pointing to small differences in the interactions of particles and antiparticles, more specifically neutrinos and antineutrinos. Therefore, the key question is what these differences are and whether they were enough to cause the universe as we know it to come into existence, says Prof. Bubak.

So the right question is the following: Why is the oscillation of neutrinos and antineutrinos so important? Neutrinos and antineutrinos, like all particles and antiparticles, have the same properties and are able to oscillate, i.e. to change their flavor. So far, the results of the T2K experiment suggest that the process of oscillation itself may be slightly different for neutrinos and antineutrinos.

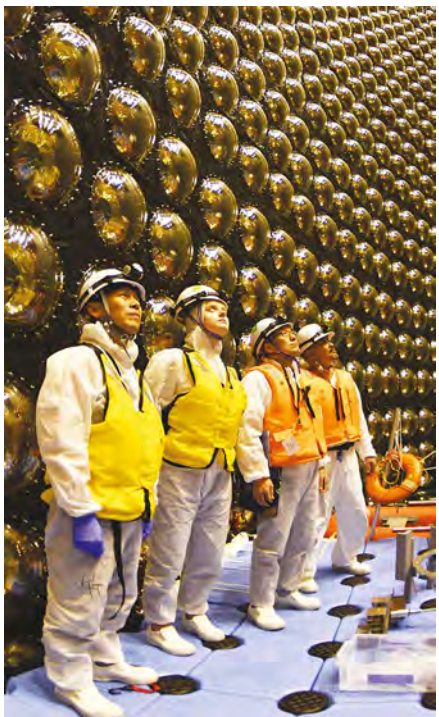


photo: Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), The University of Tokyo

– A beam of muon neutrinos is released from the J-PARC Center, and their oscillation into electron neutrinos is observed. Subsequently, a beam of muon antineutrinos appears, and we observe the process of their oscillation into electron antineutrinos. If the process was symmetrical, we would not notice any differences, explains Prof. Jan Kisiel. – However, it turns out that, with a certain degree of probability, we can assume that this symmetry becomes broken. This seems to be the missing element which may bring us closer to explaining the difference between the observed amounts of matter and antimatter in the universe.

However, this is still an indication, not a discovery. Therefore, physicists will continue to study the phenomenon of neutrino and antineutrino oscillations. In order to enable them to obtain even more accurate results, the infrastructure of the T2K experiment is being extended. Prototypes of two parts of the near detector are being prepared. Several segments will be modernized, which requires significant financial support and time. At the same time, work is underway to increase the intensity of the neutrino and antineutrino beams at the J-PARC Accelerator Center in Tokai. This will positvely affect the accuracy of the measurements and, ultimately, enable us to finally determine whether the assumptions of a group of several hundred physicists from around the world are correct.

The results of the research to date have been published in the article "Constraint on the matter–antimatter symmetry-violating phase in neutrino oscillations" written by scientists cooperating in the T2K experiment. The material was published in the April issue of the journal *Nature*.

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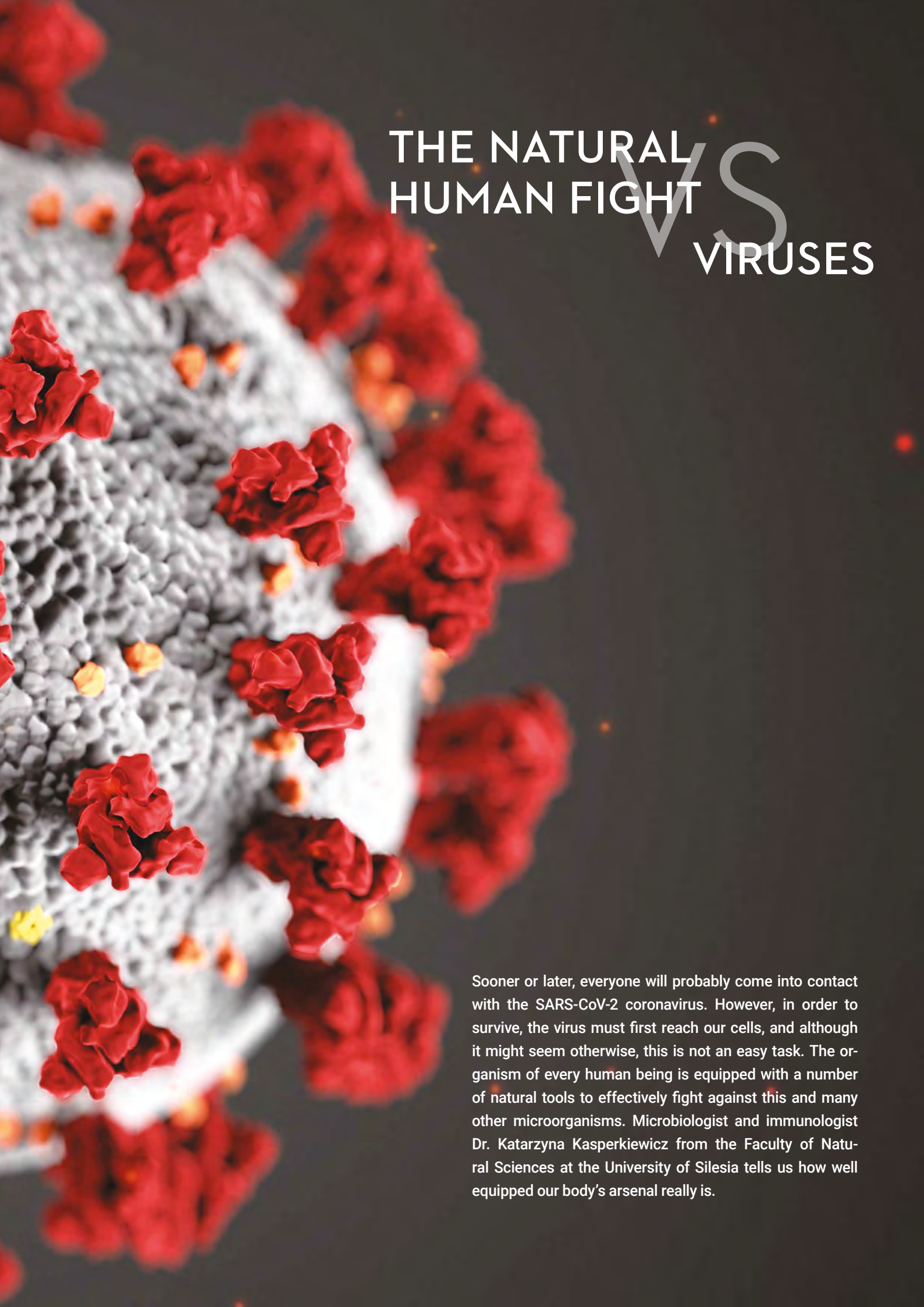

THE NATURAL HUMAN FIGHT VS VIRUSES

Sooner or later, everyone will probably come into contact with the SARS-CoV-2 coronavirus. However, in order to survive, the virus must first reach our cells, and although it might seem otherwise, this is not an easy task. The organism of every human being is equipped with a number of natural tools to effectively fight against this and many other microorganisms. Microbiologist and immunologist Dr. Katarzyna Kasperkiewicz from the Faculty of Natural Sciences at the University of Silesia tells us how well equipped our body's arsenal really is.

Microorganisms can penetrate our body mainly through the conjunctiva, oral mucosa, and the upper part of the digestive tract. Fortunately, tears and saliva contain a highly bactericidal enzyme called lysozyme. Whatever comes into contact with our eyeball or with the inside of our mouth is immediately disinfected. Unfortunately, lysozyme does not work so effectively against viruses, and this is why we are often reminded about the necessity of frequently washing our hands and about the need to unlearn the habit of unwittingly touching our face with hands, especially the area of our nose, mouth, and eyes.

Our skin also contains a number of protective barriers. A prerequisite for the penetration of our cells by bacteria or viruses, is an adhesion between the surface layers of two objects, in this case the human skin and the microorganism. This is effectively prevented by the process of exfoliation of the epidermis and by the presence of natural fatty acids in our skin which are responsible for a properly functioning antimicrobial barrier. Therefore, we should not merely wash or disinfect our hands frequently, but also remember to properly moisturize the skin, since this makes the process of adhesion difficult.

Another natural barrier for microorganisms, including viruses, is... breathing. The upper airways are covered with cilia. The entering and leaving of air causes the movement of cilia, which automatically makes it harder for microorganisms to "stick" to our body cells. Continuous air movement certainly does not encourage an invasion of pathogens. In the bronchi and lungs, there are cells which produce mucus. When we have a cold, these cells become very active, and the mucous membrane swells. Precisely this is the body's defensive reaction. Mucus produced in excess glues the microorganisms together to prevent contact with the cell, and they are expelled as soon as possible while sneezing or coughing. When mucus accumulates in the lungs and bronchi, anaerobic conditions are created there, and this makes it for some microorganisms difficult to function.

Further defensive reactions include vomiting and diarrhea. Our body, by expelling rapidly a large amount of content, gets rid of the substances that have harmed it.

Another defense shield is the change of pH level in our digestive tract, from a very acidic environment in the stomach, through slightly alkaline in the duodenum, to acidic pH of the urinary system. In the stomach, only the *Helicobacter pylori* can exist. All microorganisms that cannot tolerate such a low pH will not survive.

Many microorganisms will die or will not multiply if merely the body temperature rises. We are usually overzealous and want to lower it as soon as possible. However, doctors indicate that only a fever of about 39°C or more can become dangerous, although of course there are sporadic cases where temperature of 38°C can cause harmful seizures in patients. Therefore, lowering body temperature blocks one of the more effective defense mechanisms in the fight against microorganisms.

If, despite our efforts, microorganisms come into contact with our cells, we still have a very well equipped system for special tasks, i.e. the immune system. In our body, two types of immunity – innate and acquired immunity – work together and complement each other. The most important innate immunity cells are macrophages. Among other things, they emit interferons, which are also effective against viruses. Microorganisms, i.e. foreign bodies, attract the attention of macrophages, which, using the process of phagocytosis, simply "swallow" the enemy and digest it. This is a very quick and effective response, and it remains unchanged throughout our lives.

The acquired immune system works a little differently. If, for example, a coronavirus attaches to a cell, it is 'noticed' and recognized as a foreign object. In a way, the 'patrolling function' is performed by certain types of T lymphocytes, which pass on the 'enemy' to B lymphocytes. They, in turn, are responsible for producing the appropriate antibodies to fight the microorganisms. Under these conditions, the so-called immune memory also has a chance to appear. This means that if we come across such a pathogen again in the future, our immune system will react faster.

However, this process requires much time and energy. When our body fights against bacterial, fungal, or viral infections, it consumes huge amounts of energy. When we are sick, we do not want to eat, we have no energy to exercise, and need more sleep. This is normal. The cells of the immune system belong to the group of cells with the highest metabolic activity. They must act quickly and effectively. They live shortly, multiply quickly, and work heavily.

We also have a subpopulation of T lymphocytes in the body. They are called *Natural Killer T-cells*, and for a good reason, since they look little like grenades and act accordingly. Once they are attached to the enemy, they just tear it apart. They become immediately activated, live shortly, and are very effective. The are launched mainly to fight cancer cells and viruses.

The ongoing search for an effective coronavirus vaccine is also worth mentioning. On the one hand, scientists are working on a solution that will contain a coronavirus antigen. When it is given to patients, their immune system will be able to produce suitable antibodies to fight the pathogen. In such a case there would be a chance for creating immune memory. On the other hand, patients can be given antibodies from plasma of recovered persons. This is an example of so-called passive immunization. These antibodies, however, do not destroy the coronavirus. They only make it unable to adhere to the host's eukaryotic cell, so that it cannot multiply.

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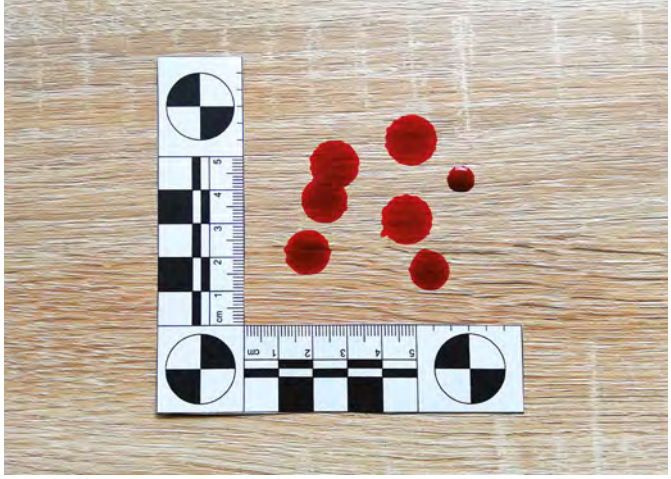
LETTING THE TRACES SPEAK

The conviction that the traces revealed during the examination of a suspect or the site of the incident carry a huge information load, a testimony of the committed deeds, is one of the pillars of modern forensic science. Traces speak, do not succumb to emotion and prejudice, and the only factor that can diminish their value are difficulties related to the investigation and interpretation of the evidence.

A batch of evidence that has gained prominence in courtrooms are blood prints, often the main driving force behind the investigation process. Thanks to Karl Landsteiner's discovery made the early twentieth century, which paved the way for dividing blood into groups on the basis of the antigens it contains, researchers were able to identify possible sources of preserved traces and thus to narrow down the group of suspects. However, the real serological revolution did not take place until a few decades later, when the technology perfected by the British geneticist Sir Alec Jeffreys was transferred to the forensics. With the birth of the DNA profiling technique, the repertoire of forensic research methods used in criminal proceedings was enriched by another valuable tool to identify individuals, i.e. a possible blood source.

The implementation of genetic identification tests into judicial practice was undoubtedly a milestone in the development of forensic science. However, it did not exhaust the in-



formation potential of blood – the dimension, shape, size, and distribution of traces revealed on clothing or the at site of the event, which often form a story, are also important. The interpretation of bloodstains based on their physical description, known as bloodstain pattern analysis (BPA), very often helps law enforcement officials to reconstruct an event, since it provides important information on the circumstances how the trace was created.

However, modern forensic knowledge, which allows for such a comprehensive use of bloodstain patterns, does not make full use of the information "recorded" in them. Forensic specialists are well aware of the urgent need to develop a technique able to estimate the age of a bloody trace. Among them there are researchers from the University of Silesia working in the Forensic Chemistry Department at the Institute of Chemistry: Dr. Eng. Agnieszka Martyna, MSc Alicja Menżyk, and Prof. Grzegorz Zadora, who, in cooperation with Italian scientists Prof. Gianmario Martra from the University of Turin and the team of Prof. Paolo Oliveri from the University of Genoa, explore the problem of blood dating, using the methods of instrumental analysis – mainly spectroscopic methods such as Raman or infrared spectroscopy. The choice of these analytical has not been accidental. The key factor is their non-invasive nature, which is very desirable in forensic research, and, most importantly, the richness of the information obtained. Spectroscopic techniques allow to explore the chemical information "recorded" in the examined material, since the way radiation interacts with the analyzed trace depends, among others, on its qualitative and quantitative composition, which changes during the progressive degradation of blood, thus laying the foundations for the methodology of dating traces.

The attempt to answer the question about the time of blood trace formation is possible due to aging processes, which lead to changes in physico-chemical properties of the tested material. In the case of bloody traces, the cascade of physico-chemical processes responsible for their degradation starts immediately after the blood leaves the body. At first, these processes include the coagulation and evaporation of the aqueous component of plasma, which causes a significant increase in blood viscosity. Thus, the resulting blood stain is formed mainly by morphotic elements, the dominant part of which are erythrocytes, filled almost to the brim with hemoglobin. The hemoglobin molecule consists of four sub-units, each of which is a protein structure wrapped quite tightly around an iron ion, and it is the iron center of the macromolecule that determines its entire structure. The iron ion, depending on the stage of degradation process, is combined with opposed groups called ligands, such as a molecule of oxygen or water, and creates complex connections, which are characterized by different spatial arrangement. This structural diversity, in turn, determines the physico-chemical characteristics of the protein, so that at least several forms of hemoglobin can be distinguished in the degrading blood traces, characterized by different ways of interaction with electromagnetic radiation and, consequently, with different spectral properties.

Therefore, the vast majority of the proposed methods of dating blood traces boils down to defining a certain measurable parameter reflecting the degree of hemoglobin degradation and then linking its changes with the time passed. The role of such an aging marker may be played by entire instrumental signals recorded by spectroscopic techniques. And it is from these spectroscopic "signatures," which are a combination of signals of all blood components actively interacting with electromagnetic radiation, that the members of the Forensic Chemistry Team successfully read out the time-dependent information, and additionally make use of statistical methods. It is also worth remembering that the vast majority of developed techniques model relationships observed during the degradation of samples stored in strictly controlled conditions. The aging process, however, is not only a matter of time. Evidence may degrade at different rates depending on many external factors, mainly environmental conditions at the site of the accident. Therefore, it is difficult to point towards a universal dating method. The solution proposed by the Polish-Italian team may be to treat the issue of blood dating as a comparative problem. The basis of this methodology is to assess the similarity between the degree of degradation of the evidence and the decomposition of comparative materials obtained during controlled blood aging, which would, as precisely as possible, recreate the degradation of the evidence on site. Thus, every dating procedure would be each time adapted to the protected traces.

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Humans have a huge influence on the quality of water in the environment; by introducing various chemicals into it as well as by interfering with its natural circulation.

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