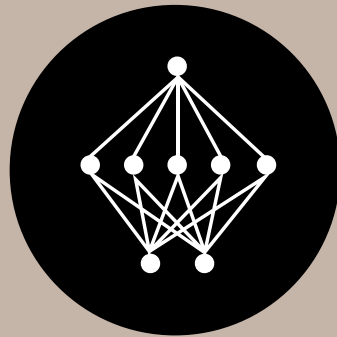
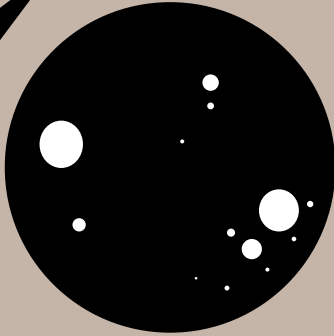


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**JAGIELLONIAN  
PROJECTOR**

**'21**





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**Kraków 2021**



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Dear Readers,

it is with great satisfaction that we present to you another issue of the Jagiellonian Projector, a popular science publication presenting selected research projects carried out at the Jagiellonian University.

The University always was and still is a place where researchers explore various fields of research, reflect on the world and make insightful observations. Its academic community constantly seeks answers to questions and solutions to challenges.

In order to let the Readers explore the mysterious world hidden behind the closed doors of laboratories, libraries and lecture halls, researchers of the oldest Polish higher education institution have presented here an overview of their selected study projects, showing that science, aside from carrying a huge weight of responsibility, can also have fun and engaging aspects.

In this book, experts from more than a dozen disciplines based in the University's faculties and other JU research units talk about what they study and why. The Projector is therefore a collection of science communication texts written by a diverse group of researchers.

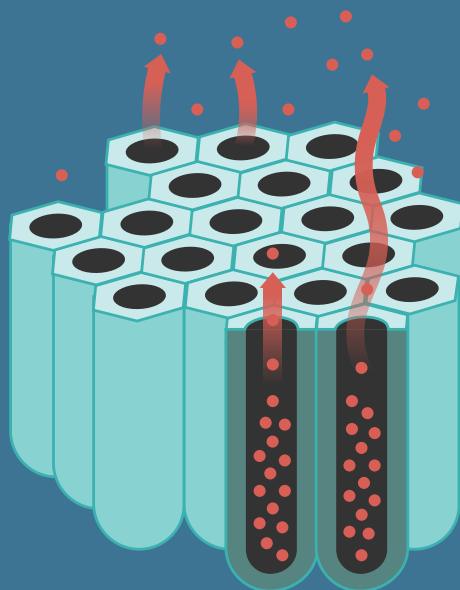
This issue of the Jagiellonian Projector features a series of original illustrations that accompany the articles, resulting in a cohesive publication that can be enjoyed on both textual and visual level. We hope that this form of science communication attracts Readers of all ages.

Promoting research accomplishments is a critically important and necessary endeavour. The Jagiellonian Projector is therefore a worthwhile part of the publishing market, offering a free dual-language science communication book that is available to everyone. And as emphasised by the Jagiellonian University's motto: 'Reason is more important than force', the world needs science in the service of humanity.

Prof. Piotr Kuśtrowski  
Vice-Rector for Research  
Jagiellonian University



**EXACT  
SCIENCES**



**TiO<sub>2</sub>  
NANOPORES  
/NANOTUBES  
SYSTEMS**

**UNIQUE APPLICATION  
FEATURES**



**ENERGY  
STORAGE**

**LITHIUM  
ION BATTERY**

**SUPERCAPACITORS**



**POWER C  
ONVERSION**

**WATER  
DECOMPOSITION**



**ENVIRONMENTAL**

**POLLUTANT  
DEGRADATION**



**SENSORS**



**BIOMEDICAL**

**DRUG  
CARRIERS**

**NANOSTRUCTURAL TiO<sub>2</sub> –  
FROM MEDICINE TO POWER INDUSTRY**

**The contemporary world with its fast technological progress poses a lot of serious challenges, the most important of which include the need for producing clean energy from renewable sources and the constant improvement of healthcare services. Titanium dioxide (TiO<sub>2</sub>) is a very promising material, which has been used both in the process of obtaining energy from sunlight and in the production of modern implants. Studies on the development of electrochemical methods to produce its nanostructural layers have been carried out for more than 10 years. What makes this unique material so versatile?**

In order to obtain nanostructural materials, titanium undergoes a relatively simple process of anodisation – a controlled electrolysis, resulting in the emergence of a thin layer of porous TiO<sub>2</sub> with a specific structure on the metal surface. What is crucial is the fact that one square centimetre of dioxide layer can contain as many as 10 billion parallel tubules, whose diameter varies from a dozen to several hundred nanometres (a nanometre is one billionth of a metre). The nanostructural TiO<sub>2</sub> is of special interest to researchers due to its unique features, which include very promising photocatalytic properties (enabling the occurrence or considerable acceleration of chemical reactions under the influence of light), high stability (resistance to chemical factors), and low toxicity.

The current research mainly concentrates on practical applications of this kind of materials, two of which are worthy of special attention: creating modern multifunctional implants and the possible production of hydrogen using solar energy.

### Durable implants

As life expectancy increases, older people remain active for a longer period of time. Besides its obvious advantages, this phenomenon also poses various challenges, including a growing number of injuries, especially those involving damage to the skeletal system. More complicated bone fractures often require inserting an implant, which should be as durable as possible. Unfortunately, the currently used materials can only last a little over a dozen years and often start to cause problems much earlier, usually due to a bacterial infection or poor fitting of the implant to the bone. Hence, scientists seek solutions that could prevent these situations from happening. One of them is to create an implant perfectly matched to a specific patient, with the help of 3D printing and imaging techniques. To achieve an even better personalisation of the implant, it is coated with a nanostructural layer of the oxide, whose special structure enables the introduction of antibacterial agents (like nanoparticles or antibiotics). Such multifunctional implants can revolutionise the modern medicine allowing patients who undergo implantation surgeries to stay fit and healthy much longer.

### Energy from hydrogen

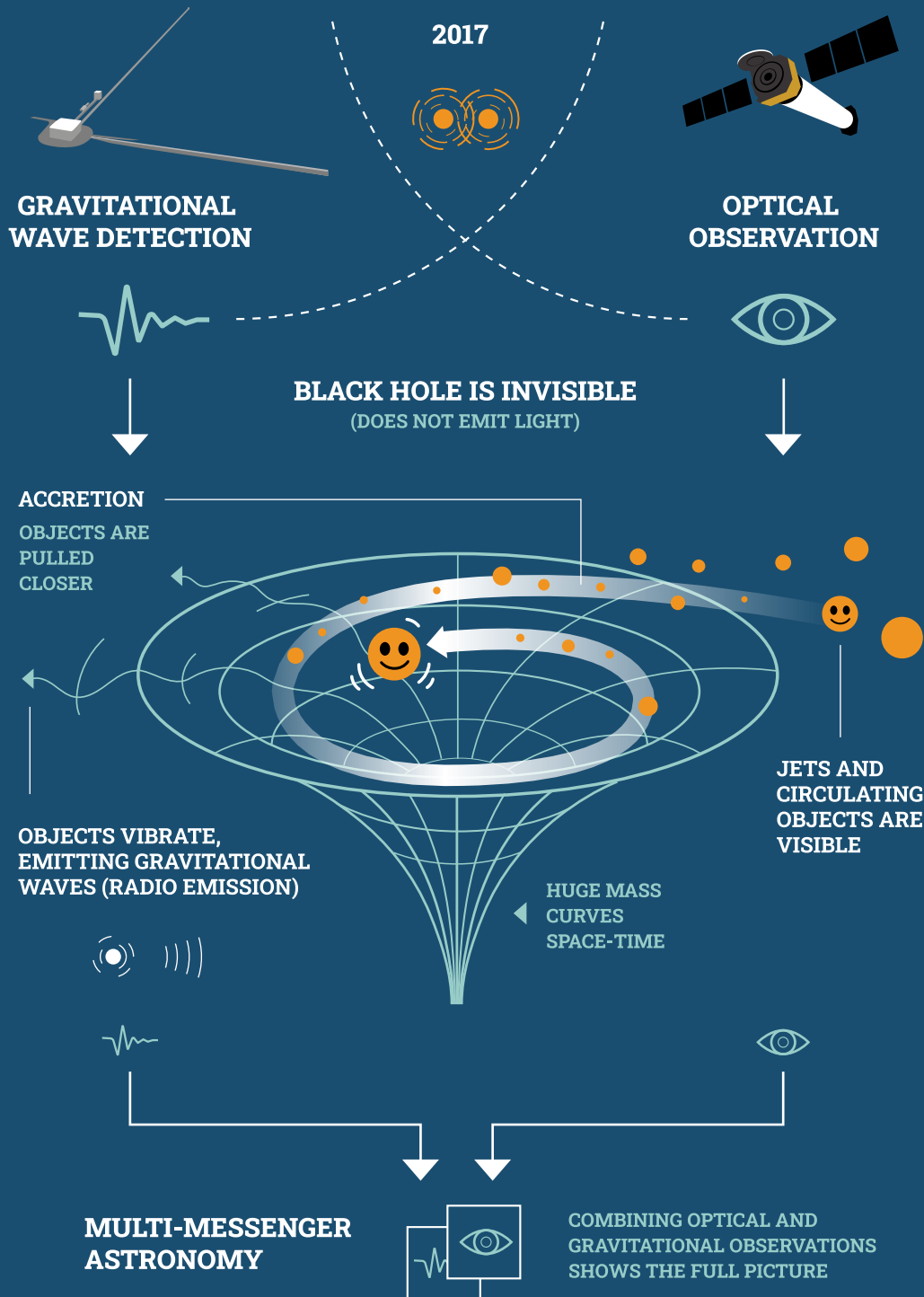
The current global energy crisis is related to the search for the so-called clean energy sources. One of the most promising possible solutions is to use gaseous hydrogen in order to store energy from renewable sources. Among all known fuels, this is the cleanest and environmentally least invasive energy carrier. Nanostructural layers of TiO<sub>2</sub> can also be successfully applied in devices for obtaining hydrogen from water, known as photoelectrochemical cells. They are built of a semiconductor material (such as TiO<sub>2</sub>) capable of absorbing light and a metallic electrode (e.g., a piece of platinum sheet). During the process of photoelectrolysis, water under the influence of sunlight is decomposed into gaseous hydrogen and oxygen. The resultant pure hydrogen, used as a fuel, is the best response to the challenges related to the global warming and energy crisis. The current research mainly focuses on the development of methods of creating and modifying the nanostructural layers of TiO<sub>2</sub> allowing the improvement of efficiency of photoelectrochemical cells, which would enable obtaining hydrogen from water using sunlight on a large scale.

The presented examples are only some of many possible applications of electrochemically produced nanostructural layers of TiO<sub>2</sub>, currently studied by the Electrochemistry Group at the Jagiellonian University. There is also ongoing research on using these materials as modern photoelectrochemical sensors – small and simple devices for fast and accurate measuring of concentration of various chemical compounds, e.g. glucose, as well as effective removal of pollutants from water under the influence of sunlight.

#### i

Dr Magdalena Jarosz, Dr Joanna Kapusta-Kołodziej, Dr Karolina Syrek, Prof. Grzegorz Sulka, Electrochemistry Group of the Jagiellonian University, [www.elektro.chemia.uj.edu.pl](http://www.elektro.chemia.uj.edu.pl)

The research is funded by the National Science Centre, Poland (projects No. UMO-2016/23/B/ST5/00790 and UMO-2017/25/B/ST8/01599).



## SEARCHING FOR BLACK HOLES



**In 2020, the Nobel Prize in Physics was awarded to Roger Penrose, Reinhard Genzel and Andrea Ghez – a cosmologist and two astronomers. What they have in common is the fact that all of them study mysterious objects called black holes. Incidentally, black holes are also one of the ‘favourite’ subjects of research at the Jagiellonian University Astronomical Observatory.**

When in 2017 the detectors LIGO and Virgo independently identified signals from long sought-after gravitational waves, NASA’s orbital telescope has almost immediately detected a bright gamma flash in the sky. Not long after, the flash was also registered in the visible light. These seemingly unrelated phenomena were later discovered to be a collision of two neutron stars. It is important to note that gravitational waves differ from ‘ordinary’ electromagnetic waves (like light) not only in their length. From the physical standpoint, they propagate in space-time in an entirely different way, which can be described by complex mathematical formulae. The discoveries of 2017 have caused the birth of a new branch of astronomy, multimessenger astronomy, combining the goals and methods of standard celestial observations with gravitational wave studies.

Although last year’s Nobel Prize is not directly related to gravitational waves, it honours research projects from different branches of astronomy, both theoretical and practical. Penrose received his half of the award for the entirety of his scientific contribution, including the proof that black holes are formed in accordance with Einstein’s general relativity theory. The other half was given to Genzel and Ghez for their years-long observations that resulted in proving the existence of a massive object in the centre of the Milky Way galaxy. In an area the size of the Solar System, there is an object with a mass equal to that of four million Suns! We now know that it can only be a black hole. Thanks to these two astronomers, black holes, which had previously been thought of as purely mathematical phenomena appearing in general relativity theory formulae, have gained the status of ‘real’ astrophysical objects. In these formulae, black holes appear as curved areas of space-time, from which nothing can escape due to their strong gravitational pull caused by high density of matter in a limited space. Such objects are not easy to observe, but their presence can be deduced in various ways; for instance, researchers can study their gravitational pull’s influence on the surrounding matter or investigate exotic phenomena related to pulling that matter by a supermassive black hole, resulting in jets and, in extreme cases, formation of giant radio galaxies, the largest individual objects in the Universe.

Every department at the Jagiellonian University Astronomical Observatory carries out some research projects more or less related to black holes. Solutions of Einstein’s equations are analysed at the Department of Relativistic Astrophysics and Cosmology along with other theoretical aspects. Black holes and their accretion mechanisms (i.e. the pulling of surrounding matter) are studied at the Department of High Energies Astrophysics. These objects are connected to the highest energies in space, including the formation of relativistic jets (supercharged particles travelling just below the speed of light), created by supermassive black holes residing in the centres of galaxies. Researchers also study the evolution of supermassive black holes and their accompanying active galaxies.

The latter of these subjects is also researched at two other Observatory units: the Department of Stellar and Extragalactic Astronomy and the Department of Radioastronomy and Space Physics. Galactic supermassive black holes are studied not only as individual phenomena, but also in their statistical aspects, as part of analyses of entire populations of active galaxies. These galaxies often contain a large black hole, which results in the formation of very large structures that shine bright in radio waves. They can be observed through radio telescopes, while the centre of an active galaxy can also be investigated by means of optical instruments as well as infrared, X-rays and gamma rays.

Blazars are a particular class of active galaxies. Their radiation is dominated by relativistically enhanced jet emission that can be observed on Earth at a low angle. In the case of blazar SBS B1646+499, studied jointly by researchers from three JU Astronomical Observatory departments, it turns out that the galaxy, and consequently, the black hole in its centre, went through at least two separate stages of activity, and the surrounding traces of strong radio emission are what remains of the first one.

The situation is similar with the famous blazar OJ 287. Recent observations of the predicted increase in luminosity of this distant galaxy have proven the hypothesis

which posited that its centre contains not one, but two supermassive black holes. Their results have prepared the ground for the planned imaging of the OJ 287 black holes by the EHT telescope; they also contribute to the international efforts in direct detection of gravitational waves emitted by such pairs of massive objects. New data has also confirmed the unique, theoretical property of black holes discovered by Stephen Hawking and his associates – the lack of ‘hair’, i.e. irregularities on their surface.

OJ 287 and other active galaxies have been monitored at the JU Astronomical Observatory for over a decade, with almost half of the Observatory’s staff and PhD students involved in black hole research. Yet again it becomes clear that the combined efforts and knowledge of scientists from different fields facilitates unravelling even the most mysterious natural phenomena.



Elżbieta Kuligowska, Jagiellonian University Astronomical Observatory

Grant No. NCN 2018/29/B/ST9/01793, research carried out at the Department of Stellar and Extragalactic Astronomy of the JU Astronomical Observatory



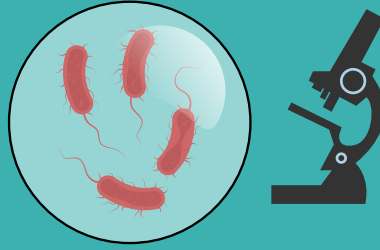
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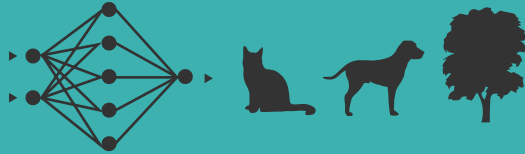
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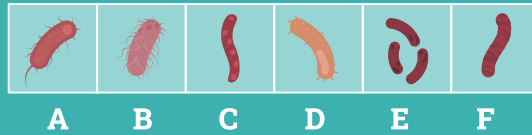
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## DATA ANALYSIS

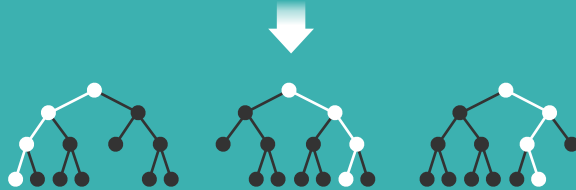
DEEP NEURAL NETWORK USING  
KNOWLEDGE TRANSFER METHOD



INITIAL RESULT



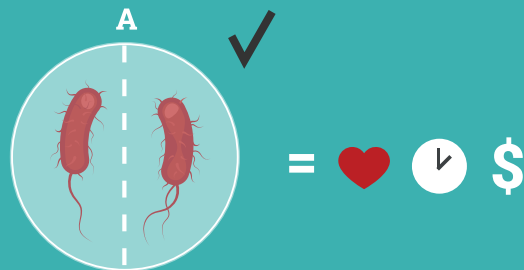
FURTHER MATCHING,  
CLASSIFICATION  
USING RANDOM  
FORESTS METHOD  
(MANY RANDOM  
TREES)



3

## OUTPUT DATA

RESULT MOST FREQUENTLY  
PROVIDED BY RANDOM TREES



# FACIAL COMPOSITE OF DEADLY PATHOGENS

**Will artificial intelligence soon revolutionise the methods used in microbiological diagnosis? Will using deep neural networks lead to faster identification of pathogens in patients and an earlier onset of effective treatment? A team of researchers from the JU MC Chair in Microbiology and the JU Institute of Computer Science and Computer Mathematics are seeking answers to these questions.**

In routine microbiological diagnostics, species identification procedure consists of multiple stages and can take several days, or even up to several weeks in the case of microbes grown on an artificial medium. Yet, the process can be significantly shortened thanks to a method based on a form of machine learning known as deep learning. In this case, species identification procedure based on the recognition of microscopic images from microorganism cultures can be completed in a dozen hours and, when based on direct clinical material, even in several minutes. This innovative approach not only significantly reduces the costs and the amount of work, but also, most importantly, considerably shortens the time of identification of microbes that cause life-threatening infections. This speeds up the diagnosis, and, consequently, makes it possible to quickly apply the right antimicrobial treatment leading to the patient's recovery.

Deep learning solves more and more complicated problems with a level of effectiveness similar to that of a human (for instance, in the case of photo classification or text translation). But to achieve that level, it needs hundreds of thousands of observations, which,

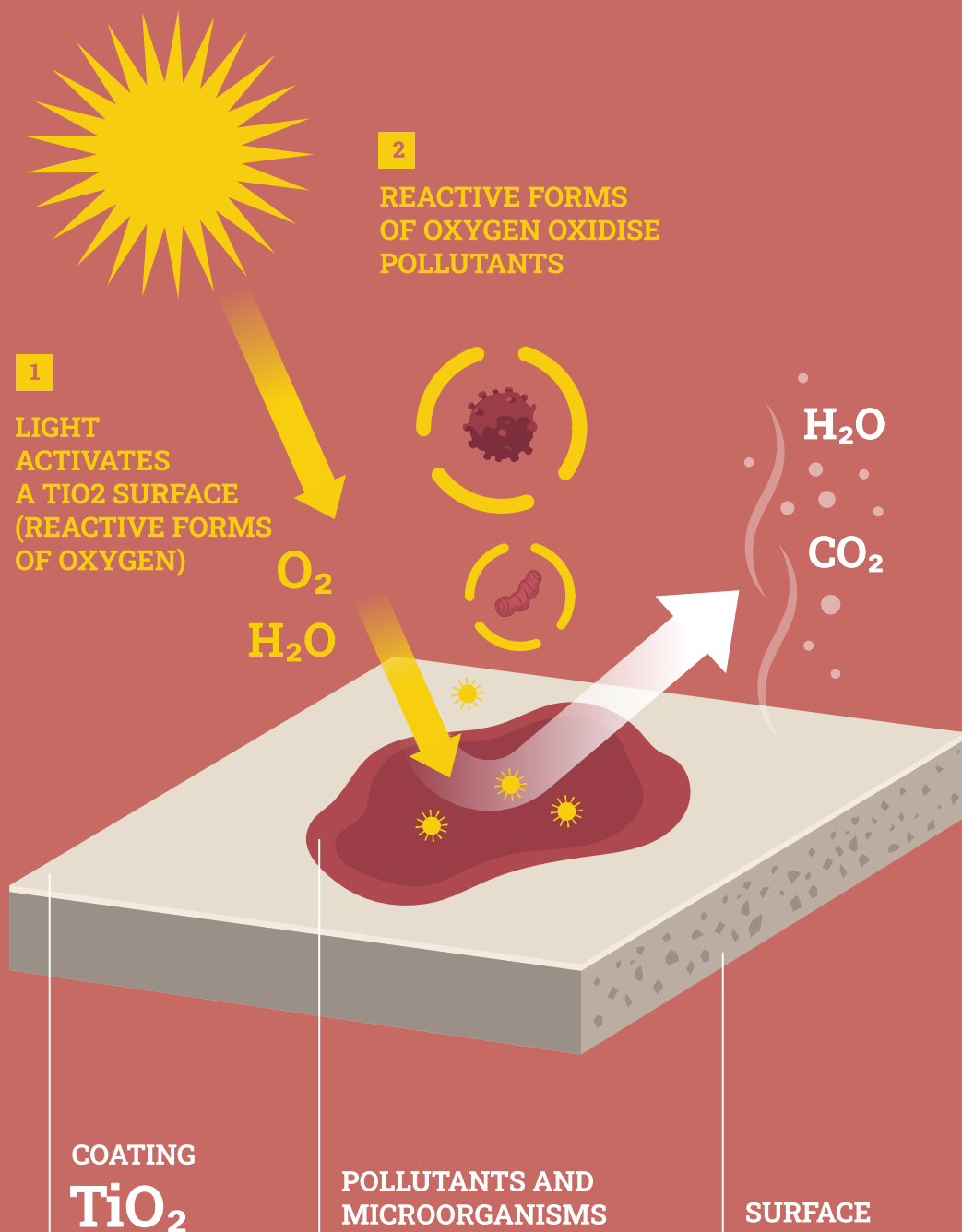
to a large extent, makes it impossible to use in medicine. To overcome this problem, the researchers applied the transfer learning method, which consists of using deep neural network trained on natural images (of dogs, cats, and trees) to obtain microscopic image representation. Then this representation was classified by means of the so-called random forests.

The research results, published in the PloS one journal, not only indicate the high effectiveness of the discussed methods, but also contain an in-depth analysis of the functioning of models with the use of explainable artificial intelligence methods, providing a detailed explanation of the features of images that are important for classification, which improves the confidence in the proposed solution. The current work of the team focuses on the classification of a number of pathogenic species of bacteria and yeast-like fungi in a mixture as well as the recognition of clones of the same species, which is especially crucial for analysing direct clinical material and conducting epidemiological investigations in order to identify the source of infection.

**i**

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**PHOTOCATALYSIS:  
CATALYSIS  
DRIVEN BY LIGHT**

**The material TiO<sub>2</sub> is known under several names: titanium dioxide, titanium white and E171. This inconspicuous and not-too-reactive white chemical compound serves a variety of purposes. Since it absorbs UV light, it is an ingredient of sunscreens that protects us from cancer. Due to a low reactivity and its optical properties it is used as a pigment and food additive; however, it has a hidden potential that only becomes visible after exposure to UV light. Under such circumstances, TiO<sub>2</sub> becomes a highly reactive oxidant and reductant at the same time, showing its 'aggressive' side, which is thoroughly studied by the Team of Photocatalysis from the JU Faculty of Chemistry.**

When activated by light, titanium dioxide can generate what is called 'reactive oxygen species': very reactive and highly oxidising molecules and ions that are formed as a result of photocatalytic reactions that happen on its surface. Reactive oxygen species have the ability to oxidise organic matter, i.e. typical pollutants found in air, water and on a variety of surfaces. What is more, this also affects microbiological pollution, meaning that photoactive TiO<sub>2</sub> has antibacterial, antiviral and antifungal properties. These very properties can be used to create self-cleaning and self-sterilising surfaces. In the current epidemiological situation, these advantages are exceptionally noteworthy.

The properties of TiO<sub>2</sub> are determined mostly by its structure and morphology. Fragmentation of materials in the nanometric scale not only facilitates the creation of durable coatings, but also increases photocatalytic activity. The Team of Photocatalysis has developed effective methods of applying thin, transparent layers of TiO<sub>2</sub> on various surfaces, such as polymers, glass or metals. To act as a photocatalyst, titanium dioxide needs to be activated by UV light, which limits the application of its pure form to surfaces exposed to direct sunlight or artificial UV light. That is why TiO<sub>2</sub> photosensitisation to visible light attracts attention of scientists worldwide. Researchers from the Team of Photocatalysis have developed several such methods, one of which was purchased for commercial use by the Polish company InPhoCat – Innovative Photocatalytic Solutions. Employing non-toxic, biologically neutral photosensitiser molecules allows for designing new photodisinfecting materials for various health care applications. Simple and cheap dye molecules may also work as activators of surfaces covered with titanium dioxide-based paint. Although these degrade over time, the surface can be easily regenerated by simply rinsing it with the solution of fresh photosensitizer.

The work of the Team of Photocatalysis is focused on studying photocatalytic processes, developing new materials based on TiO<sub>2</sub> and other wide bandgap semiconductors and searching for new photosensitisers. Such materials can be used in CO<sub>2</sub> reduction, which leads to the synthesis of valuable organic compounds, generation of hydrogen from water, organic synthesis, and the abovementioned degradation of organic and microbiological pollutants.

The research of Team of Photocatalysis has resulted in several patent applications, including the methods of production of active photocatalytic coatings, ways of activating these surfaces by the visible light, photoactive contact lens solutions and high-grade UV filters for sun-tan lotions and cosmetics. They have also implemented a photocatalytic system for removing undesirable odours from cooling devices.

**i**

Team of Photocatalysis (JU Faculty of Chemistry)

Prof. Wojciech Macyk, Dr Joanna Kunciewicz, Dr Przemysław Łabuz, Dr Marcin Kobielski, Dr Taymaz Tabari, Dr Mateusz Trochowski, Dr Kaja Spilarewicz-Stanek

PhD students: Paweł Mikrut, Agnieszka Jarosz-Duda, Paulina O'Callaghan, Kasidid Yaemsunthorn, Kamil Urbanek, Anna Jakimińska, Krystian Mróz

Students: Wiktoria Adamowicz, Magdalena Pilzak

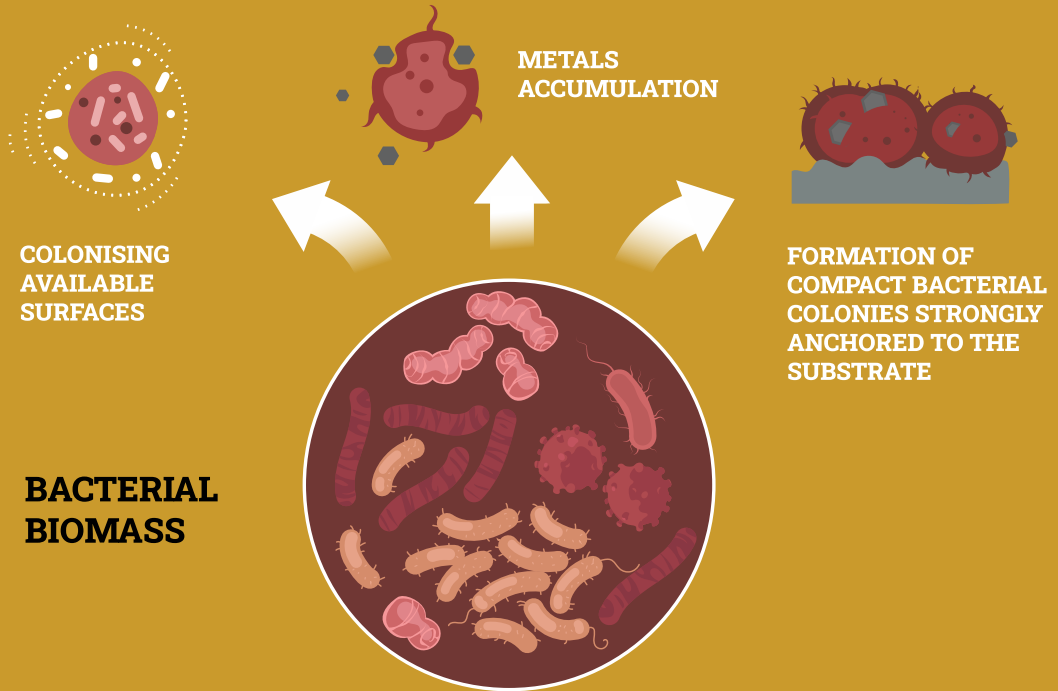
Collaboration at the Faculty of Chemistry: Prof. Grażyna Stochel, Prof. Zbigniew Sojka, Prof. Andrzej Kotarba, Prof. Lucjan Chmielarz

Projects:

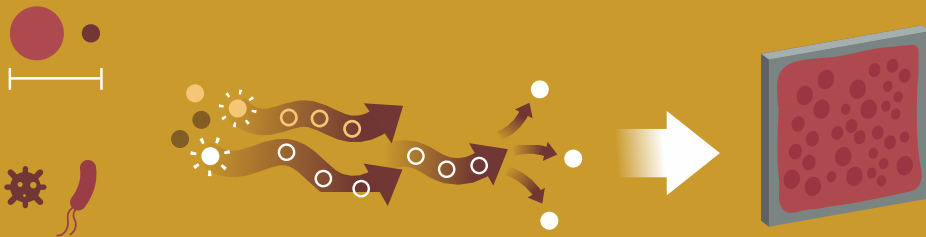
2x TEAM (Foundation for Polish Science), 2x OPUS (National Science Centre), SHENG (National Science Centre), Solar-Driven Chemistry (National Science Centre) 2x SONATA (National Science Centre), PRELUDIUM (National Science Centre)

For a complete list of projects and publications, please visit the website  
<http://fotokataliza.pl>

## USING THE PROPERTIES OF BACTERIA



**BACTERIA OF VARIOUS SIZES, MORPHOLOGY,  
AND SURFACE CHARGE ACT AS A BIO-CARRIER**



**OBTAINING MATERIALS WITH A HIGH DEGREE  
OF DISPERSION ON THE SURFACE, STABILISATION  
OF NANOPARTICLES, AND CONDUCTIVITY**

**THE LITTLE BUILDERS,  
OR HOW CHEMISTS  
COLLABORATE WITH BACTERIA**



**Although the microworld has always been the subject of human fascination, we were not aware of the existence of bacteria until the 17th century, while their pathogenic activity was evidenced two centuries later. Nowadays, we also know the brighter face of these microorganisms: beneficial strains of bacteria exist in yogurts, silages, and probiotics. Furthermore, we use bacteria to remove water and soil contamination as well as for the manufacturing of pure chemicals. Bacteria also come to the aid of researchers focused on the synthesis of new materials featuring various peculiar properties.**

Bacteria constitute a tremendously diverse kingdom of microorganisms with a number of interesting features, i.e. a specific structure, morphology, or electric charge accumulated on the outside of cell walls, which can be used in an ingenious way. The most interesting properties include the ability of bacteria to colonise the whole available surface (the so-called race for the surface), their capability to accumulate metals, and the formation of compact bacterial colonies strongly anchored to the substrate. These features inspired researchers to use bacteria in the synthesis of modern functional nanomaterials, such as structural catalysts and electrode materials.

The wide range of application possibilities of materials containing functional nanoparticles has contributed to the increase in their popularity. Nevertheless, the syntheses of such structures are multi-stage processes and generally require the use of harmful chemicals. Moreover, one of the most challenging issues in the synthesis of modern materials on a technical scale is the preparation of a homogeneous dispersion of the active

phase (i.e. the component that gives the material specific properties; commonly metal nanoparticles or respective oxides) over the entire volume of the porous support.

This issue was answered by the development of an innovative method of producing materials based on bacterial biomass. For this purpose, scientists utilised bacteria of various sizes, morphology, and surface charge, which act as a bio-carrier capable of efficient capture, transport, and controlled dispersion of metal nanoparticles and respective oxides onto the surfaces of various supports (e.g. porous carbon, alumina, or zirconia). Thanks to those little builders, chemists can synthesise new materials with a high degree of dispersion on the surface, stabilization of nanoparticles, and, in the case of electrode materials, the solids characterized by electric conductivity.

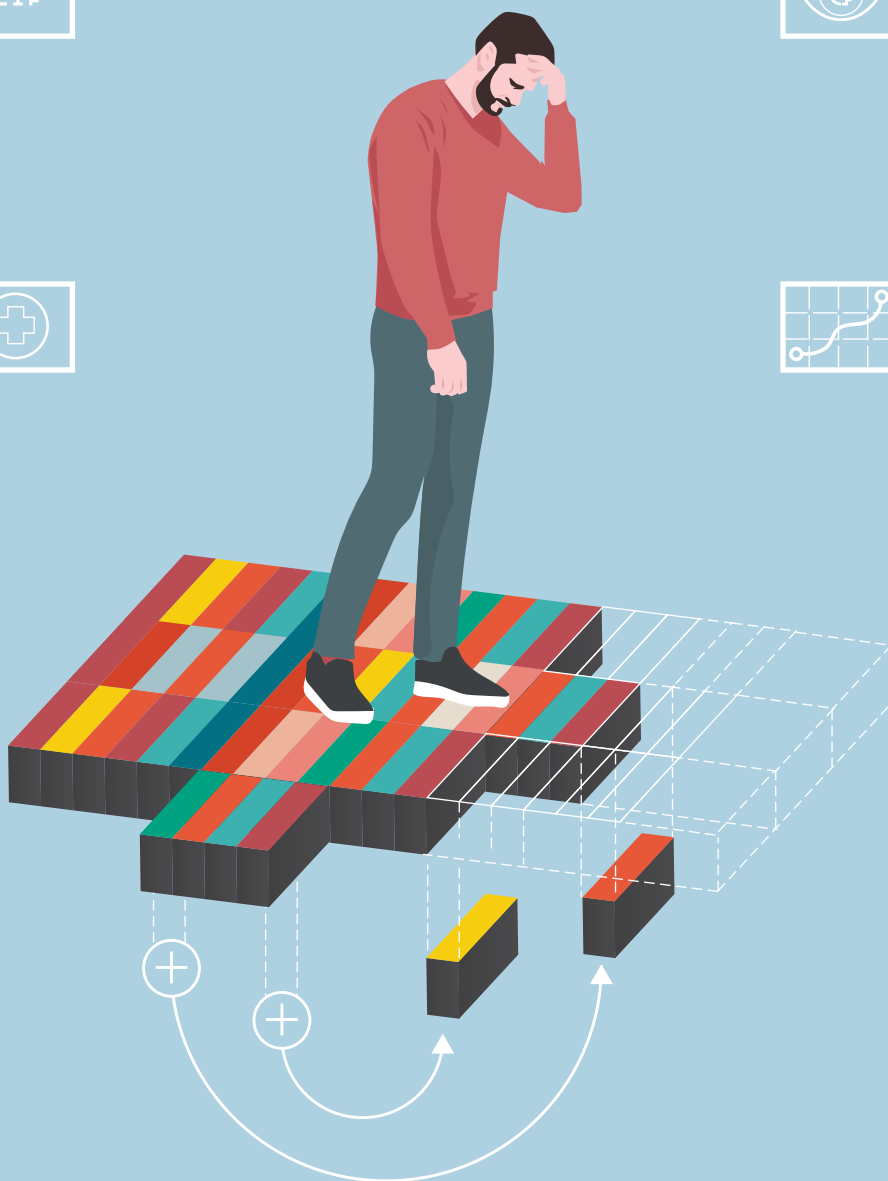
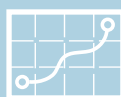
This line of research is developed by scientists from Materials and Surface Chemistry Group (JU Faculty of Chemistry) headed by prof. Andrzej Kotarba.

**i**

Dr Paula Janus  
JU Faculty of Chemistry  
JU Centre for Technology Transfer CITTRU



?



**APPROXIMATION  
AND INTERPOLATION  
IN EVERYDAY LIFE**

**Mathematicians specialising in the theory of approximation and interpolation are working on developing quick methods of providing information about complex objects by studying simpler elements. By investigating such elements present in the object's vicinity, one can glean some insight about the object itself. Sounds abstract? Maybe so, but approximation and interpolation help us in this way in our everyday life, and the explanation is quite simple.**

By studying the proverbial apple, one can deduce a lot about the tree it fell from: its species, size, age, the amount of sunlight and water it receives etc. There is another colloquial saying that refers to this exact issue: 'Show me your room and I will tell you who you are'.

The same principle is relevant in some branches of mathematics, particularly approximation. The properties of polynomials found in the vicinity of a function can let us deduce the properties of that function. Other complicated structures can also be investigated in a similar way. It is the process of approximation that allows us to do that.

Interpolation, meanwhile, lets us make estimations about collections of data through the use of functions. Interpolation can help us predict the outcome in cases where a full set of data is not yet available. Its importance is even more clearly visible during the pandemic, since we can use interpolation to estimate the number of COVID-19 cases in the coming days based on the numbers we have seen recently. The more information we collect, the more precise our estimates become.

Approximation and interpolation can also enable us to make estimates about complex data collections through the process of smoothing. In this way, we can recover missing data, recreate complex images, and enhance

their quality. Approximation is a powerful method used in image compression and data transmission (e.g. in spectroscopy), which means we encounter it every day when we use our smartphones and other electronic appliances.

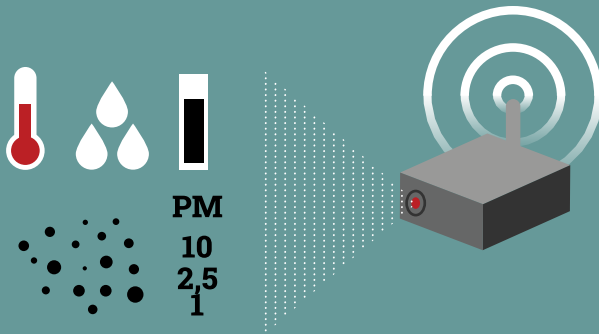
Approximation and interpolation can also be successfully used in medicine, for instance in magnetic particle imaging (MPI) in clinical medicine diagnostics. Thanks to them, it is possible to perform reconstruction procedures as well as make automatic comparisons of MPI images. This makes it easier for doctors to give diagnoses or allows them to see improvements in the patient's condition.

A seemingly small discovery in the area of approximation or interpolation may cause a significant leap in the development of technology. Computer programmes that solve differential equations provide estimated solutions based on approximation. To find out how far from the exact solution is the approximated one, we have to assess the approximation error (the smaller, the better). On the one hand, these are subtle mathematical issues, on the other – they are extremely important in the context of certain technologies. For instance, better approximation of constants in the case of Markov's-type inequality allows for the development of GPS technology, effectively providing us with a faster and more precise way of locating objects.

# i

Dr hab. Leokadia Białas-Cieź, Prof. UJ has received two National Science Centre grants: 2017/25/B/ST1/00906 *Konstruktywna aproksymacja na zbiorach algebraicznych* [Constructive approximation on algebraic sets] (carried out by Prof. Mirosław Baran, Dr Tomasz Beberok and Dr Agnieszka Kowalska) and 2019/35/O/ST1/02245 *Wybrane węzły interpolacji w aproksymacji wielomianowej* [Selected interpolation nodes in polynomial approximation] (carried out by Dimitri Jordan Kenne).

MEASUREMENT STATION

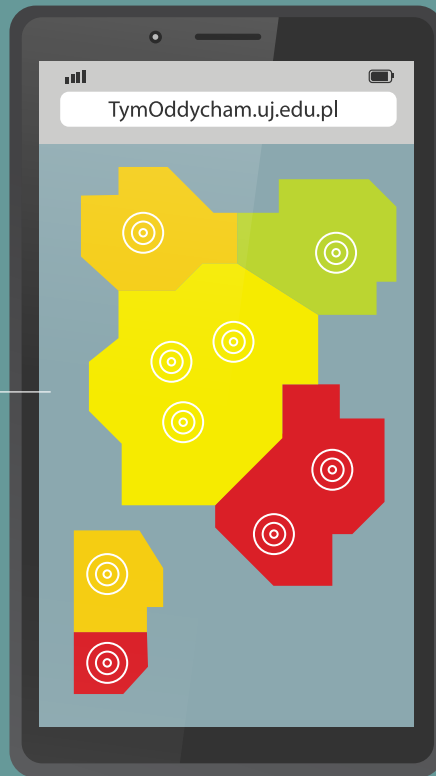


STATIONS NETWORK



MONITORING  
APP

AIR QUALITY  
MAPS



ANNUAL AIR  
QUALITY REPORTS



TO BREATHE  
GREEN

**The Marian Smoluchowski Institute of Physics of the Jagiellonian University has created a wireless network of stations to monitor air and atmospheric conditions, named Storm&Dust-Net, with the aim of improving the quality of air.**

In 2019, as many as forty thousand people in Poland died because of air pollution (according to the EEA report Air quality in Europe). Social awareness related to this challenge is growing. For several years, researchers from the Jagiellonian University have been trying to measure the amount of smog to which inhabitants of villages and small towns are exposed as well as gauge how the air quality changes with time.

The project consists of four actions: measuring the concentration of particulate matter (PM) in the air; online visualisation of the results ([TymOddycham.uj.edu.pl](http://TymOddycham.uj.edu.pl)), educating the society on adverse health effects of high PM concentration, and raising social awareness of the fact that high PM concentration is a direct and measurable result of human activity. The project involves collaboration with two municipalities: of Kalwaria Zebrzydowska (12 spots) and Skawina (10 spots). The measurements are carried out in 22 places, most of which are situated at local schools.

The JU measurement stations are small devices (20x15x7 cm) fitted with several sensors measuring PM concentration (PM10, PM2.5, PM1) as well as atmospheric conditions (temperature, humidity, pressure). The

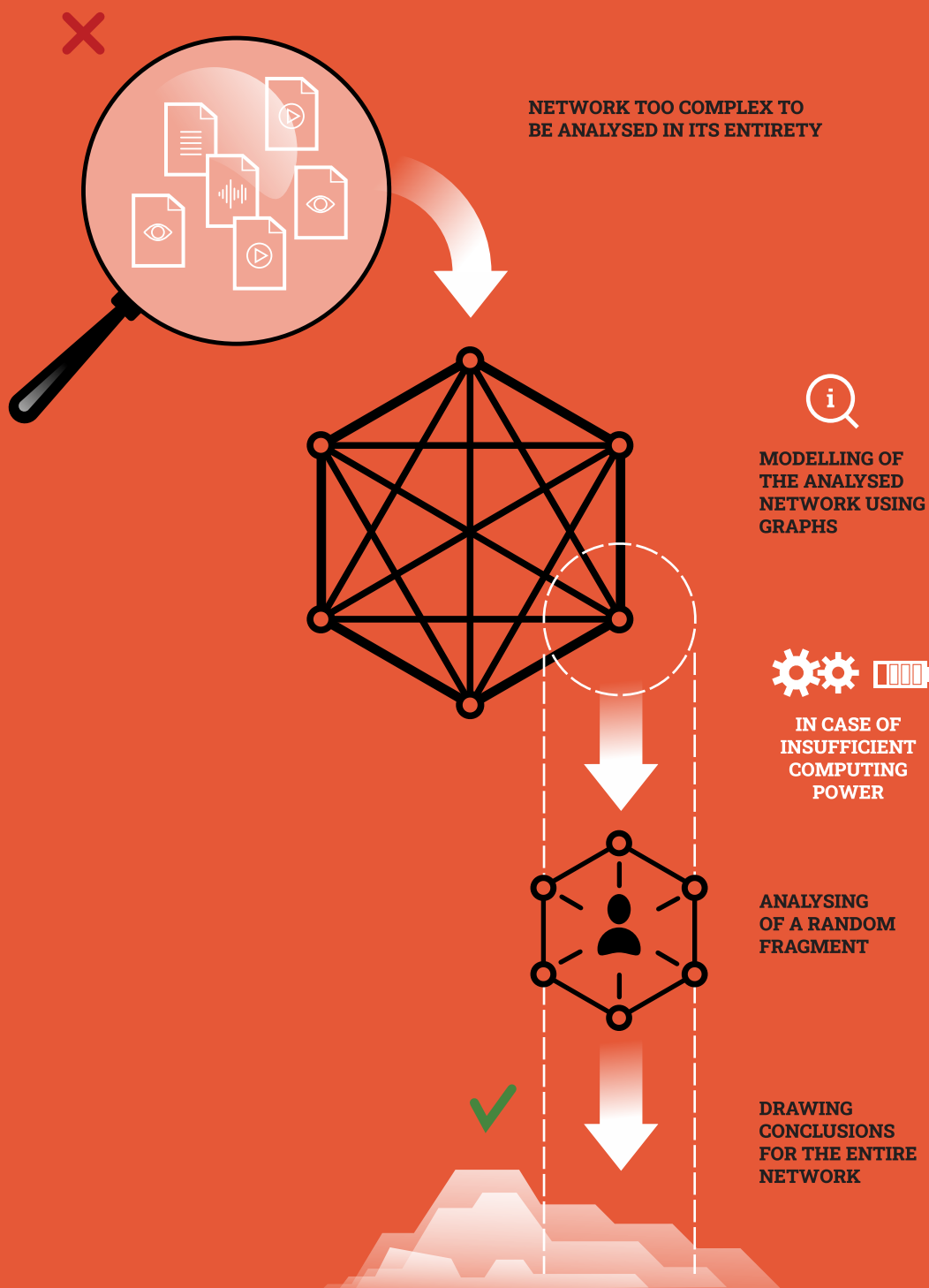
stations only need to be connected to a power source (power consumption: 5 W) and the measurement results are sent wirelessly to the data server via a GSM model. Hence, the stations can be installed almost anywhere.

The results of PM concentration measurements form a basis for a live air quality map available online to everybody ([TymOddycham.uj.edu.pl](http://TymOddycham.uj.edu.pl)). Besides, a general report on air quality in specific locations is created annually. This allows the assessment of long-term changes in air quality, with special focus on the results of locally implemented stove changeout and emission reduction programmes.

In the future, the stations used in the Storm&DustNet project will be equipped with additional environmental sensors allowing, for instance, the detection of odours and volatile organic compounds. This aspect of environmental monitoring is especially significant for communities living in the vicinity of economic activity zones. The measurement stations are also planned to be fitted with small lightning detectors making it possible to monitor local storm activity and assess the intensity of electrical phenomena in the atmosphere.



Dr hab. Zenon Niekarz, Prof. UJ  
Department of Experimental Computer Physics,  
Marian Smoluchowski Institute of Physics,  
JU Faculty of Physics, Astronomy and Applied Computer Science  
<http://tymoddycham.uj.edu.pl>



## BIG NETWORKS AND HOW TO ANALYSE THEM

**Imagine a network of connections between people on a social media platform such as Facebook or a collection of smartphones accessing the Internet. The size of such a network is so vast that it is impossible to view it in its entirety or make any calculations on it (for instance: how fast information is spread). How do we approach such massive structures? The answer lies in graph theory.**

Many objects and real-world phenomena can be modelled using a graph: a collection of points (called vertices), some of which are connected by an edge. For instance, one can use graphs to construct a model of road connections between cities or of a social media site like Facebook, where vertices are all users, while edges are connections between friends. This graph can then be used in mathematical calculations that enable easier analysis of the initial network's properties and more effective creation of algorithms. This, in turn, facilitates acquisition of information, such as the shortest route between cities or the speed at which information is spread between people.

### Big networks in pieces

Sometimes networks are too large to be analysed in their entirety, as in the aforementioned case of social media services or links between websites on the Internet. What do we do in a situation like that? Firstly, we can choose to investigate only a selected part of the graph (e.g. the connections between the friends of a single Facebook user). The idea of studying a random piece of a graph and extrapolating the data to make predictions about the entirety of the network was the main driving force behind the research conducted several years ago in Microsoft Research. Within the framework of that study, Borgs, Chayes, Lovász, Sós and Vesztegombi introduced the concept of graph limits. To keep it simple, they defined convergence of a sequence of increasingly large graphs to the limit and presented a limit object of such a sequence. Such a graph limit can be easily analysed using known mathematical tools, and many of its properties are closely approximating features of the big graphs.

### Extremal graph theory

It turns out that graph limits not only can be used for analysing big networks, but they are also a very effective tool in extremal graph theory, which is a branch of graph theory focused on finding the minimum and maximum values of graph parameters in networks with particular properties. For example, over 100 years ago mathematicians determined the number of edges in a graph on a fixed number of vertices which does not contain any triangles. Interestingly enough, a very similar problem – how many pentagons can be contained in a graph that does not contain any triangles – remained open for over a quarter of a century. This problem was solved relatively recently with the use of graph limits by Dr Andrzej Grzesik from the JU Faculty of Mathematics and Computer Science and, independently, by an international team of scientists (Hatami, Hladký, Král', Norine and Razborov). Applying graph limits have reduced this problem to one that can be easily solved with the use of a computer.

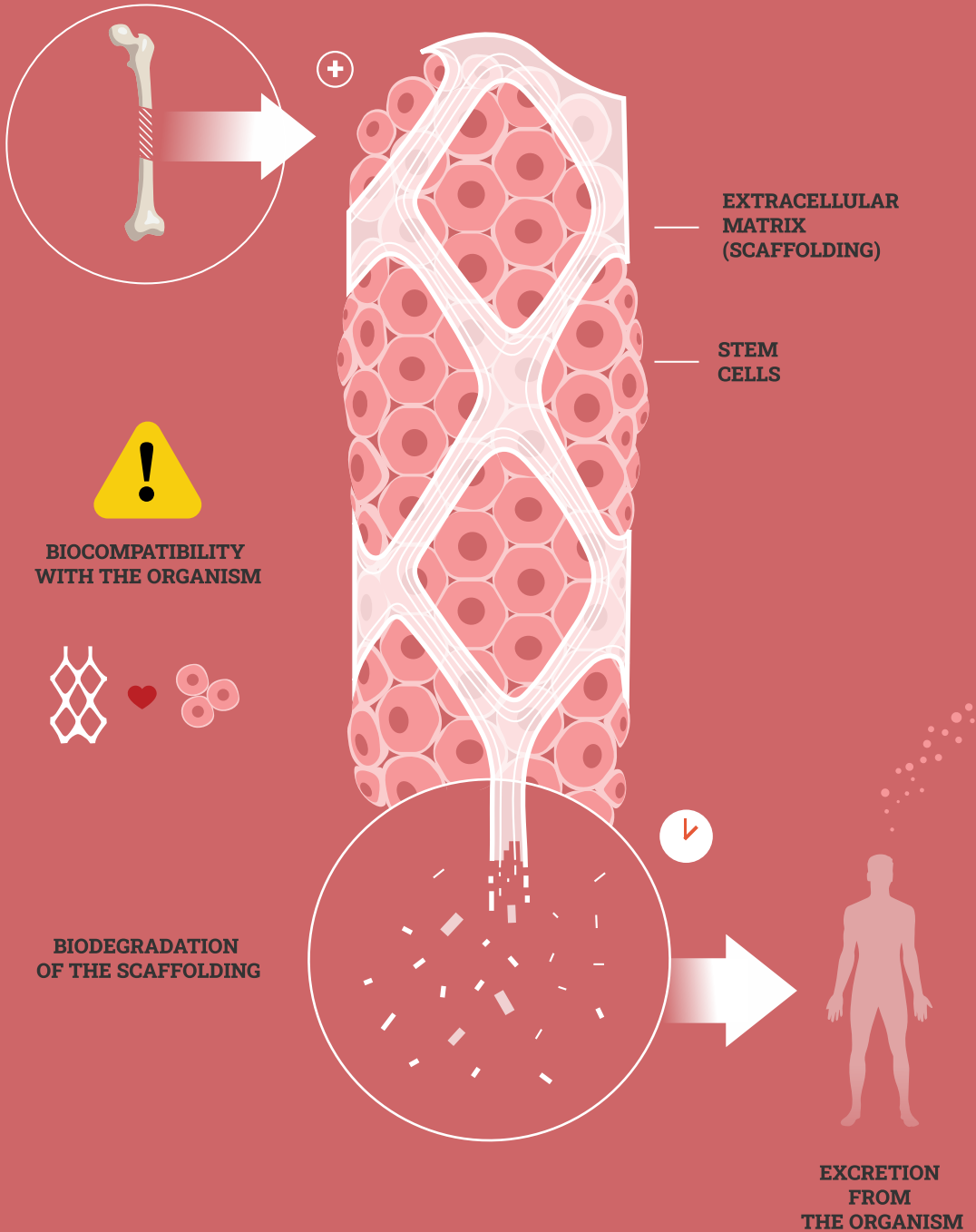
### Looking into the future

In recent years, mathematical proofs based on graph limits have been greatly developed and have contributed to advances not only in extremal graph theory and big network study, but also in statistical physics and data analysis. Therefore, it is necessary to further study and develop theory of graph limits and methods based on them. As is usually the case with new techniques, their limitations and possible wide usage are not yet known.

#### i

The European Research Council awarded Daniel Král' with a grant for his research on graph limits, which is realised at Masaryk University, University of Warwick and Jagiellonian University. Within the framework of that project, Andrzej Grzesik from the JU Faculty of Mathematics and Computer Studies along with a team of international collaborators develop the theory of graph limits, prove conjectures concerning extremal graph theory and design new algorithms for large networks. In particular, they settled a conjecture proposed by László Lovász, one of the founder of the theory and the recipient of this year's Abel Prize, the most prestigious award in mathematics.

**TISSUE  
REGENERATION**



**VANISHING IMPLANTS –  
STUDYING THE BIOCOMPATIBILITY  
OF BIOMATERIALS**



**Tissue engineering is a rapidly developing interdisciplinary branch of research that is chiefly focused on designing replacements for missing tissues. It has emerged as a response to a large number of constraints that limited the traditional transplantation procedures, for instance, low availability of organs and high risk of transplant rejection.**

Currently, one of the most important challenges in tissue engineering is designing a material that would serve as scaffolding that would support growth and differentiation of stem cells (in essence, it would remain inside the organism as a ‘native extracellular matrix’). This could allow the tissue to regenerate in the place where it is missing. One of the more important properties of such a material is the duration of its biodegradation: the scaffolding would encourage tissue regeneration up until the moment it becomes self-sustainable. After that, it would be expelled from the organism.

Therefore, a question arises: how close is tissue engineering to designing an ideal material? What are the biggest obstacles that prevent scientists from reaching their goal? It turns out that despite many years of research, we are still very far away from this method of treatment becoming a standard procedure. Contrary to what may seem, the biggest problem is not designing a biomaterial with a specific time of biodegradation and durability, but rather producing one that attains a certain level of biocompatibility while retaining other desirable properties related to mechanics, porosity and biodegradation. Therefore, it is crucial to assess the levels of biocompatibility of the proposed material as quickly as possible and modify its composition based on cellular response.

For many years, the Group of Oscillation Spectroscopy from the JU Faculty of Chemistry has been working on finding nanocomposite polymers that could be used in bone tissue engineering. The matrix of such composites are polymers, like polycaprolactone (PCL), which

are then modified to have a higher biocompatibility with special additions, such as nanotubes, carbon nanofibers, graphene derivatives, and magnetic nanoparticles. However, the design of the abovementioned materials is not the main goal of the Group. Indeed, the task they took on is inventing a method of testing the biocompatibility of those composites.

Some of the readers probably had the idea of seeding the surface of a material with model bone cells and observing their growth. This is partially right, because observation itself is not enough. JU researchers went a little further by studying the well-being of the cells on the surface of materials. In order to do that, they used the laser-based Raman microscope: the scientists focused the laser beam on samples and registered the diffused light in order to assess the response. The resulting spectroscopic image (i.e. the relationship of diffused photons and their energy) contained coded information about the interaction of atoms in the system. By comparing the spectroscopic images registered across the duration of the experiment using 2D Raman correlation analysis, researchers could study interactions on the molecular level. This allowed them to observe how a particular material interacts with cells in early stages of their development, most importantly – the impact of nanoadditives introduced to polymer matrix with respect to cellular response.

To sum up, Raman spectroscopy is an interesting and innovative method of quick assessment of biocompatibility in tissue engineering.

#### i

Anna Kołodziej<sup>1</sup>, Aleksandra Wesełucha-Birczyńska<sup>1</sup>, Małgorzata Świętek<sup>2</sup>, Łukasz Skalniak<sup>1</sup>, Marta Błażewicz<sup>3</sup>

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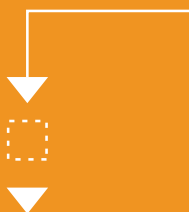
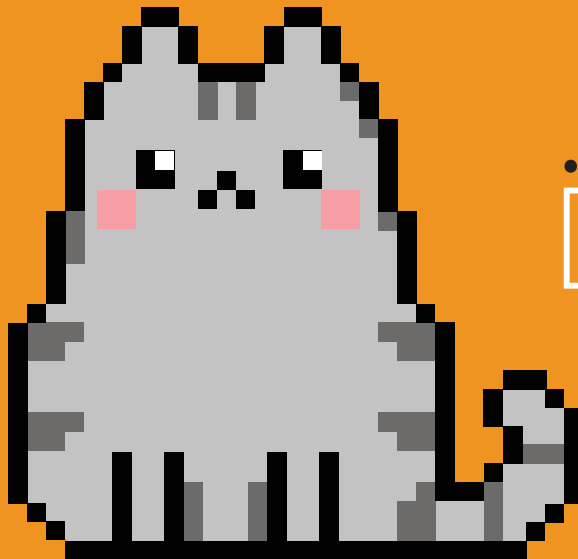


1 sec



2 mb

## DATA COMPRESSION



PROCESSING FILES INTO  
A SERIES OF SYMBOLS

THE MORE FREQUENTLY A SYMBOL  
APPEARS, THE LESS BITS IT CONTAINS

	→	A	→	10 KB	
	→	B	→	20 KB	
	→	C	→	0 KB	
	→	D	→	40 KB	
	→	E	→	30 KB	

## ANS CODING

3 TIMES SMALLER  
AND MORE EFFICIENT



JPG XL



30 TIMES FASTER

|| 'JU CODING':  
A DIGITAL REVOLUTION

**ANS coding has become one of the fundamental components of the digital world. The method was first proposed and developed by Dr Jarosław Duda from the JU Faculty of Mathematics and Computer Science. Thanks to this technique, the speed and effectiveness of data transfer has increased 30 times. Currently, ANS coding is used in a new image format, JPEG XL, which has brought about even more convenience.**

The amount of data produced worldwide is truly astounding. The digital world is composed of over 1,000,000,000,000,000,000,000,000,000 bytes, and statistically, each of us produces about 1.7 MB (more than a floppy disk) every second. In light of this, Bill Gates' alleged quote from 1981 – '640 KB is more memory than anyone will ever need' – can only be smirked upon. Naturally, to be able to process this ever-expanding amount of information, science has to find a way to streamline it. Enter data compression: a way to 'shrink' pieces of information so that they can more easily travel in cyberspace.

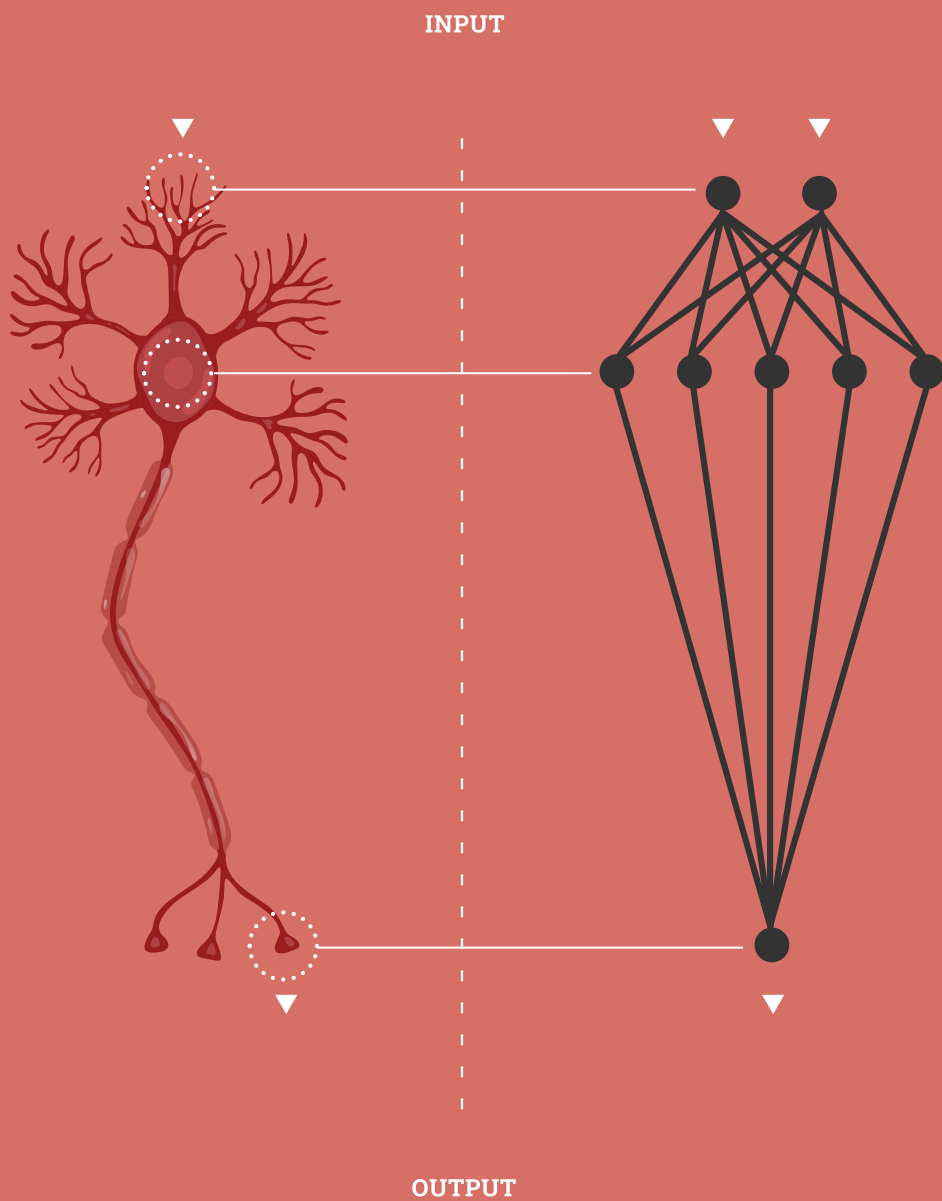
To put it simply, data compression is based on isolating a particular set of data from a file and then saving it in an optimal form. Its founding principle is that rare events carry more information than common ones. This can be illustrated by a simple example: if we took a specialist research paper and removed from it all commonly used words, the text would still be quite lengthy, but if we did the same with a newspaper article, there would be hardly anything left. Thus, processing a number of variable events (or, in the case of coding, symbols) into the shortest string of bytes possible is the essence of data compression.

As time passed and more data was being produced, methods of compression had to adapt and become more advanced. People started using optical fibres to send fractions of bits (arithmetic coding), which, though reducing the speed of data transfer, allowed for sending more of it at the same time. Unsurprisingly, a few years later this method has also become insufficient. The amount of transmitted data was growing exponentially, forcing programmes to find new solutions. Fortunately, the problem was resolved by ANS coding developed by Dr Jarosław Duda from the JU Faculty of Mathematics and Computer Studies. Both the speed and the levels of compression offered by this method are unprecedented, providing its users with a way to send data as much as 30 times faster than before. It is now employed by tech giants such as Facebook, Apple and Google.

The introduction of ANS coding also paved the way for a new image format – JPEG XL. It has already been implemented in the three most popular Internet browsers, shrinking the size of files by three times without any loss of quality, improving the processing of animations and allowing for progressive coding (one file for various resolutions). Therefore, the JU coding method became the driving force behind many aspects of our digital lives.

# i

Jarosław Duda – assistant professor at the Institute of Computer Science and Computer Mathematics, lecturer at the Jagiellonian University. He has developed a data compression method called asymmetric numeral systems (ANS), currently used in a wide variety of electronic devices. The method has changed data compression worldwide since its implementation in the new image file format JPEG XL (2020).



**TO BE LIKE THE BRAIN –  
AI ON THE PATH TO PERFECTION**

**How to overcome the limitations of artificial neural networks? Can the mechanisms observed in the human brain help in improving their performance? How to implement these mechanisms in programming languages? These and other questions are addressed by an interdisciplinary team comprising researchers from three JU faculties: of Mathematics and Computer Science, of Physics, Astronomy and Applied Computer Science, and of Management and Social Communication.**

The development of artificial neural networks, often referred to as the new industrial revolution, provided artificial intelligence with the ability to solve tasks based on image recognition better than humans. The creation of artificial neural networks was inspired by neural systems present in the brain or retina, which allow human beings to learn and develop new skills. As time progressed, the artificial networks were gradually moving away from their biological counterparts, becoming a purely mathematical model. On the one hand, the currently used networks can be taught quickly and effectively, on the other hand, they require provision of large amounts of data, have problems with learning to perform many tasks, and the results of their activity are very difficult to interpret. These problems do not affect the brain, which leads to the question: what kind of mechanisms help preventing these negative effects? The answer, impossible to find at the time of the emergence of artificial neural networks, now seems within arm's reach, thanks to a state-of-the-art medical technology allowing better insight into how the brain works, making it possible to understand the complicated mechanisms of the brain and apply this knowledge in the field of artificial neural networks with the goal of eliminating many of the current limitations, typical of classic machine learning.

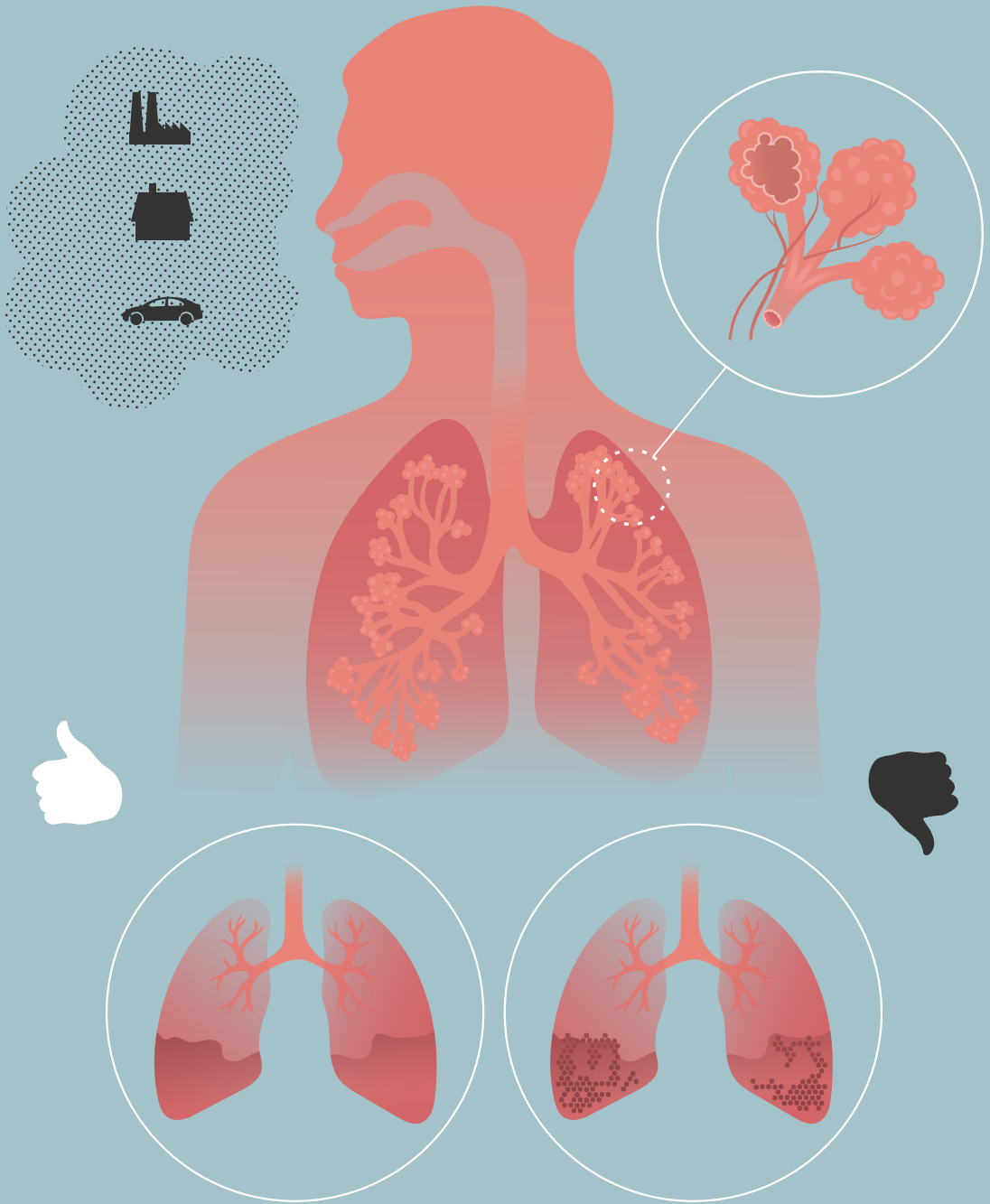
The project is primarily aimed to use natural biological mechanisms to create models capable of overcoming the

present weaknesses of artificial neural networks, such as catastrophic forgetting, that is, the tendency to suddenly and completely forget the previously learnt information after acquiring new knowledge. Another problem is the black box character of artificial neural networks, which means that even though they are able to produce better results than humans, the reasons behind the decisions they make remain unknown. This largely limits trust in the constructed model. This problem led to the creation of what is known as 'explainable artificial intelligence', which, in addition to providing a solution, should produce an answer comprehensible to humans. This is not the only problem that can be addressed based on the mechanisms observed in the brain. Catastrophic forgetting can be remedied by proper reactions to the reduced plasticity of neurons, which prevents effective learning of new information. In the case of interpretable AI, prototypes correlating with characteristic objects observed on images may be used (e.g. a red beak or white wings might be a prototype for the classification of birds).

The project carried out at the Faculty of Mathematics and Computer Science pertains to artificial intelligence, but clues how to solve the problems faced by the researchers are found in biological sciences. Imitating broadly understood nature can lead to a breakthrough in advanced technology.

#### i

The team running the project *Inspirowane biologicznie sieci neuronowe* [Biologically inspired neural networks] is led by Prof. Jacek Tabor and divided into six research groups. Other researchers involved in the project include Prof. Maciej Nowak from the JU Faculty of Physics, Astronomy and Applied Computer Science, and Prof. Tadeusz Marek from the JU Faculty of Management and Social Communication. The project has received funding within the framework of TEAM-NET competition run by the Foundation for Polish Science.



**POLYMER FILMS:  
A WAY TO FIGHT  
LUNG DISEASES**

**The ever growing level of air pollution caused by technological progress has caused many people to suffer from lung diseases. Since some of them are difficult to tell apart and, consequently, to treat properly, researchers from the JU Department of Molecular and Interfacial Biophysics (Faculty of Physics, Astronomy and Applied Computer Science) in collaboration with JU MC Clinic of Pulmonology have decided to develop solutions that would aid in diagnostics, reducing the cost and increasing the effectiveness of treatment.**

The fact that smog is a direct threat to our health is widely known. The problem is very real: even the smallest particles suspended in the air we breathe may find their way into the pulmonary alveoli of our lungs, causing a lot of damage.

The pathological changes in our lungs may be related to interstitial lung diseases (ILD), which cause disorders of ventilation of the pulmonary system and respiratory distress. One of the most common ILD is idiopathic pulmonary fibrosis (IPF); the word 'idiopathic' meaning that the condition was caused by an unknown factor. The cause of IPF is unknown, but certain environmental factors and exposures have been shown to increase the risk of developing this disease. The pathological changes in IPF are the result of an aberrant wound healing process with abnormal and excessive deposition of collagen (fibrosis) in the pulmonary interstitium. The interstitial space in the lungs becomes filled with cells called fibroblasts and myofibroblasts and the lungs are covered with scars. This leads to chronic respiratory distress, and may cause untimely death – the median life expectancy following diagnosis is about 3–5 years.

When it comes to ILD, there are no easy answers, since the most important issue is a correct diagnosis. Currently, these diseases are identified by a multidisciplinary team

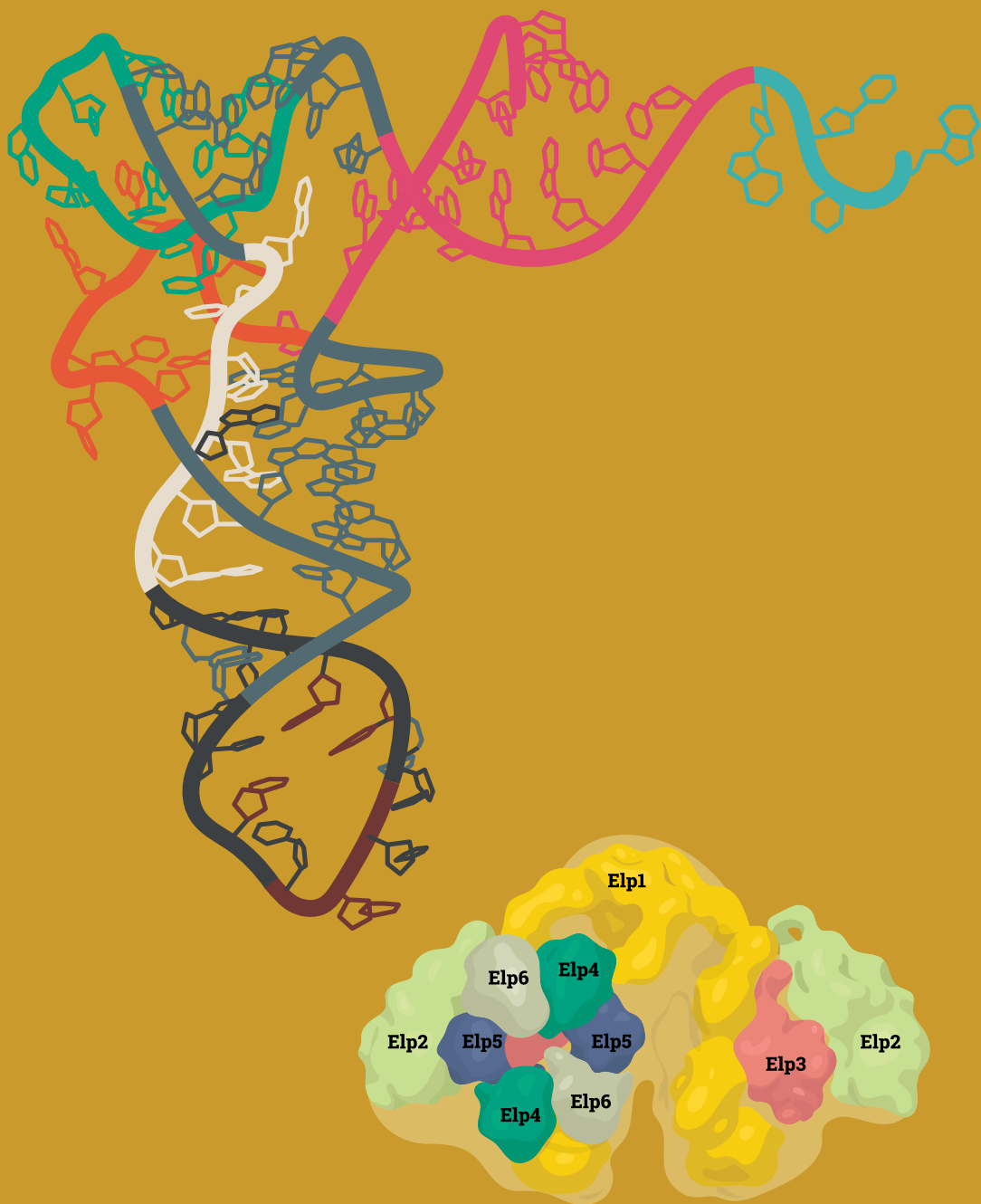
consisting of a pulmonologist, radiologist and pathologist (and frequently also clinical immunologist) on the basis of imaging and data gathered during the clinical interview. The problem, however, is that when it comes to most ILDs, these images may be very similar. Because of this, ILDs are often misdiagnosed, and the prescribed treatment is ineffective. For example, when it comes to radiological imaging, the previously mentioned IPF may mimic a different disease entity – e.g. nonspecific interstitial pneumonia (NSIP). Currently, one of the most crucial issues for specialists in this branch of medicine is developing comprehensive diagnostic techniques that could unambiguously identify specific diseases, which would allow patients to be treated much faster.

Researchers from the JU Department of Molecular and Interfacial Biophysics and the JU MC Clinic of Pulmonology are working to resolve this issue. They aim to create thin polymer films for growing fibroblasts with specific mechanical and chemical properties, designed in such a way that it would be possible to directly influence the processes of cell adhesion and proliferation. Discovering the sets of parameters that would allow for unambiguous differentiation between IPF and NSIP could become the basis for new diagnostic tools that would facilitate faster and cheaper therapy for people suffering from those diseases.

**i**

Joanna Raczowska, Kamil Awsiuk, Tomasz Stachura

Research funded by the National Science Centre within the framework of OPUS 13 project (UMO-0017/25/B/ST5/00575)



**STUDYING  
PROTEIN SYNTHESIS  
AND ITS IMPACT  
ON OUR HEALTH**



**Our cells produce new proteins every second of our lives, so it is no surprise that the process has always attracted a lot of attention from scientists. Thanks to researchers from the JU Małopolska Centre of Biotechnology, we have the opportunity to learn more about how this process can be modified to prevent many neurodegenerative diseases and cancer.**

The instruction manual on how to create every protein that makes up the human body is encoded in our genetic material in the form of a sequence of nucleotides – the building blocks of the DNA chain. However, before it can be used by the cells, it is processed by an auxiliary molecule called mRNA, in a similar way that we copy instructions for our favourite cooking recipe from a cookbook for easier access. The process of protein synthesis is known as translation. During that process, the cell decodes the sequence of amino acids of the currently created protein. This decoding is, in turn, possible thanks to ribosomes – complex molecular machines, millions of which can be found in every cell. They are responsible for providing the proper environment needed to create a chain of the correct sequence of amino acids that make up the protein. This is assisted by transfer RNA molecules (tRNA). As it turns out, they can be modified in a variety of ways in order to better perform their function.

tRNA modifications involve adding to it a set of specific chemical groups in specific places. On average, each molecule is modified as many as 11 times. These changes, though subtle, have a great impact on the stability, shape and proper functioning of tRNA and, consequently, the process of translation. They are also strictly evolutionarily conserved, as we can find them in all living organisms. They also affect the speed of the translation process, which means that proteins can come into being and fold in the proper way – not too quickly, but also not too slowly. The modifications are introduced by a large protein complex called the Elongator, which has been studied by JU scientists for several years.

To obtain images of the studied molecules, the researchers make use of cryo-electron microscopy, an innovative technique available to them thanks to two world-class microscopes – Cryo-EM Titan Krios and Glacios – operated at the JU National Synchrotron Radiation Centre SOLARIS. Cryo-electron microscopy allows the scientists to study the structure of biomolecules in 3D and with extremely high accuracy (up to a single atom). The 2017 Nobel Prize in Chemistry was awarded for developing the technique for this type of research and algorithms for data analysis. Cryo-electron microscopy is an advanced technology and therefore requires supervision of skilled professionals that monitor every stage of the analysis, from collecting samples to image processing, which provides the researchers with a large amount of data. The result of their work is the unique opportunity of looking into macromolecules and investigating their activity.

This research is not only scientifically, but also clinically important. It aims to explain the role of tRNA modification both in healthy cells and in diseases related to protein synthesis disorders. ‘We know that changes in these mechanisms play a key role in the development of cancer and neurodegenerative diseases. Our goal is to provide new diagnostic and therapeutic tools to fight conditions that are currently considered to be incurable’, says Dr Sebastian Glatt, the leader of the research team.

**i**

The research carried out by the scientists is funded by many grants from the National Science Centre, Foundation for Polish Science, Ministry of Education and Science, National Information Processing Institute, European Molecular Biology Organization, and European Research Council.

Structural Biology Core Facility website:  
<https://structuralbiology.pl/>  
 Max Planck Research Group website:  
<https://glatt-lab.pl/>



|| **DETECTING DNA DAMAGE**

**The genetic material contained in human cells is critical to their existence, functioning and development, which, in turn, is necessary for our organisms to work properly. The DNA found in human cells contains records of thousands of genes. In order for those cells to correctly play their roles in their respective tissues, those records need to not only be complete, but also passed on further, i.e. copied to daughter and reproductive cells without any errors.**

DNA has a number of extraordinary physical and chemical properties that allow it to act as a data carrier, but at the same time it is susceptible to many external factors, both physical and chemical. UV light, X rays and various chemical compounds present in the environment that can penetrate the cells may cause DNA damage. If that damage is not repaired, it can lead to the death of the cell or uncontrollable changes in its behaviour, including transformation into cancer.

JU researchers are conducting a study focused on the mechanisms of induction and repair of DNA. The aim of their project is to describe the composition and role of ‘DNA repair foci’ – small structures that emerge around breaks in DNA strands. They are made up of tightly packed protein particles that participate in the process of repairing such breaks. The scientists have reached a conclusion that the structures formed in the case of double-strand DNA breaks have a distinct internal architecture, and its composites are subject to dynamic exchange with a pool of unbound proteins in the cell’s nucleus.

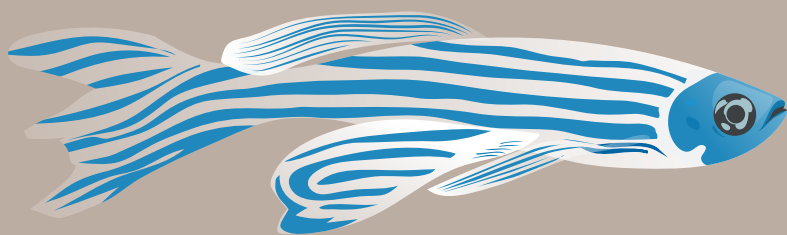
Pinpointing a break in a DNA strand in close proximity to the nucleus requires an extremely accurate and precise method of detection of the strand’s tips. Up until now, detection techniques known to science were inadequately sensitive, only allowing to detect hundreds of thousands of breaks in DNA strands, which rendered them ineffective for JU team’s research project. Therefore, a new and improved method needed to be developed, one that would allow researchers to detect even a single break. They have succeeded in their attempt, creating the innovative STRIDE microscopy technique, which shows DNA breaks on a microscopic image as dots in the cell’s nucleus.

The STRIDE technique is already used in basic research, but can be successfully employed in applied research as well. Some examples of its use include studying the effects of new drugs, causes of infertility, and the impact of ionising radiation on people that are excessively exposed to it (e.g. during high-altitude flights or space travel).

# i

Research conducted at the Department of Cell Biophysics by a team led by Prof. Jerzy Dobrucki is funded by the National Science Centre within the framework of the international research project OPUS14 (2017/27/B/Nz3/01065) entitled *Globalna i lokalna reorganizacja chromatyny w odpowiedzi komórki na dwuniciowe pęknięcia DNA – badania metodami fluorescencyjnej mikroskopii wysokorozdzielczej (dSTORM/SMLM) oraz rezonansowego transferu energii fluorescencji (FLIM/FRET)* [Global and local reorganisation of chromatin in cell response to double-strand DNA breaks – research using high-resolution fluorescent microscopy (dSTORM/SMLM) and fluorescence resonance energy transfer (FLIM/FRET)]. The STRIDE method is protected by an international patent. Its inventors have established a spin-off company which provided university laboratories and pharmaceutical companies with various analyses that require proof of DNA damage (or lack thereof).





# **NATURAL SCIENCES**



**KILROY WAS HERE:  
MICROPLASTICS  
IN THE GEOLOGICAL PERSPECTIVE**

**Microplastics are all particles of plastics that are no larger than 5 millimetres in diameter. They can come from various sources: for instance, they are used in toothpaste and in peeling cosmetics, and can also form when clothes made from polyester fibres break down in the washing machine. Today we know that microplastics have become ubiquitous in the environment, and it is not without impact. As we are faced with an overwhelming problem of plastics contamination, should we be worried about those smallest of particles as well?**

When reaching the remotest of locations – the poles, the Himalayas, and even the Moon – man has always planted a flag as a symbol of perseverance and accomplishment. The flag would stay even if the explorer moved on, serving as both beacon and proof for others that would come later. However, we are now at a point in history in which the flag precedes the explorer. Our presence is felt deeper, higher and further than ever before, and more and more frequently it is not our intent. We reach new, undiscovered places only to find terrifying signs of our activity, even though we thought we have never been there before.

The depths of the ocean and snow-covered mountaintops are full of traces that even a regular person would immediately tie to a representative of *Homo sapiens* from the 20th century onwards. No other species and no natural phenomenon can create plastics, so their presence are as much of an evidence for human activity as fingerprints are in forensic science. Microplastics are particularly pervasive in the environment, as they are difficult to monitor due to the small size of the particles. For decades, it was easier to simply overlook the issue, but as a result, the problem has grown and is a lot harder to ignore. And it seems that we will never be able to get rid of it entirely.

Thanks to researchers from around the world, we have identified some of the ways in which microplastics ‘leaks’ into the environment. Based on previous observations, we have taken a number of steps in order to reduce pollution (reducing the amount of microplastics in beauty products, decreasing the number of garbage dumping grounds, and banning disposable straws and cutlery, just to name a few). Nevertheless, we are still far away from stopping the transmission of microplastics into the environment, and even further from being able to permanently remove it.

As of yet, not much is known about the impact of microplastics on human health, although the preliminary results of ongoing research projects are alarming to say the least. In December 2020, scientists have found microplastics in the placentas of unborn babies, which caused great concern. In light of this information, it seems all the more pressing to gather precise information on over 4,000 types of plastics that make their way into the environment.

Currently, we know the most (though still not much) about the transmission of microplastics through and in the aquatic environment. There is a number of interesting publications on how microplastics become part of the food chain and eventually end up on our plates. We know much less about microplastics found in the air and in soil. These two aspects are the main focus of the research project carried out at the JU Institute of Geological Sciences. Until now, the scientists have managed to gather some data on the microplastics particles found in the air in Kraków.

An interesting issue related to the presence of microplastics in the environment is the question whether we can use it as a marker for a proposed geological era – Anthropocene. The domination of mankind over the planet on such a large scale coincides with the invention of plastics, and their ubiquity and durability makes them good indicators in geological records. In essence, microplastics are akin to the flags we put in remote places to mark our presence.

Both of these aspects are researched at the JU Institute of Geological Sciences in collaboration with the JU Faculty of Chemistry, AGH UST Center of Energy and the Pedagogical University of Cracow Institute of Geography. The study is part of the Diamond Grant project *Mikroplastik we współczesnych osadach jako potencjalny wskaźnik antropocenu – analiza ilości-*

wa i jakościowa [Microplastics in modern sediments as a potential marker of Anthropocene – a quantitative and qualitative analysis]. Researchers at the JU Insti-

tute of Geological Sciences are also investigating other issues related to Anthropocene, such as air pollution analysis and chemical element recycling.



Diamond Grant: DI2017 021647.

Project supervision: Prof. Marek Michalik (JU Institute of Geological Sciences).

Project head: Kinga Jarosz.

Collaboration: Prof. Wanda Wilczyńska-Michalik (Pedagogical University of Cracow Institute of Geography, Dr Rafał Janus and Dr Mariusz Wądrzyk (AGH University of Science and Technology Center of Energy), Dr Piotr Natkański (JU Faculty of Chemistry).





**/cafenauka**

**[www.nauka.uj.edu.pl](http://www.nauka.uj.edu.pl)**



**NANOMACHINES  
INSPIRED BY NATURE  
BUT WITH THE ABILITIES BEYOND  
WHAT'S POSSIBLE IN NATURE**

**Biological nanomachines quite literally build the biological world molecule by molecule ('nano' simply means 'on the scale of nanometres', i.e.  $10^{-9}$  metres). Imagine if we could understand exactly the principles by which they work – we would be able to control natural nanomachines (particularly useful in combating diseases) and to build our own, capable of doing things not seen in nature (e.g. new enzymes, smart drugs, vaccines). We hope to achieve exactly that.**

### Natural Nanomachines

Bacterial resistance to antimicrobials threatens to undermine much of the progress in anti-infective medicine made in the last 70 years. Urgent action is needed to prevent a world without antibiotics becoming a gloomy reality and JU researchers are not standing idle. They are studying existing nanomachines, e.g. DNA topoisomerases (key DNA-binding enzymes in bacteria), with the goal of developing new antibacterial molecules. They are also studying how resistance proteins that interact with DNA gyrase help bacteria to counteract existing drugs and survive.

### DNA Nanomachines

Synthetic biology strives to build artificial cells in the image of the natural ones. Production of very simple protocells, with separate compartments for different reactions to take place within, would enable rapid progress both in drug development and biotechnology industry. This requires placing appropriate protein machinery with precise control of orientation to con-

trol traffic between the compartments. To do this the scientists are making nano-scale robots by folding DNA (so-called DNA Origami) and equipping them with tools required for handling and delivering their protein loads in a programmable fashion.

### Artificial Protein Nanostructures

Nano-size capsules are useful to deliver drug molecules to target cells in our bodies. JU researchers recently managed to construct a unique protein-based nanocapsule (a so-called protein cage, called 'TRAP-cage'). Uniquely, TRAP-cage is very stable (it does not fall apart even after hours in boiling water) but can be easily opened by some 'key' compounds that are abundant in cells. Potentially then, they can stably protect important therapeutic cargoes during delivery and only release it upon entering cells. This is ideal for many drugs: maximising medical potency while minimising unwanted side effects. The scientists are now further engineering this cage to give it further properties useful for medical use.

#### i

Jonathan Heddle, Bionanoscience and Biochemistry Laboratory (Heddle Lab), [heddlelab.org](http://heddlelab.org)  
 Malopolska Centre of Biotechnology, Jagiellonian University  
 Various grants realized in Heddle Lab include: NCN Symfonia, NCN Maestro, NCN Opus, FNP Team, EMBO



**BIOLOGICAL CLOCKS IN THE WILD:  
HOW ARTIFICIAL LIGHT AT NIGHT  
IMPACTS MIGRATORY BIRDS?**

**Biological rhythms regulate almost all aspects of life, including biochemistry, cell biology, physiology, and behaviour. These mechanisms can be very conspicuous in birds: it is not hard to notice that various bird species sing at different times of the day (for instance, skylarks at dawn, blackbirds and thrushes in the evening) or appear in certain seasons of the year (white storks are the harbingers of spring, whereas autumn starts soon after their departure). These observations inspired researchers, who soon discovered that this regularity of behaviour is controlled by internal biological clocks, synchronised with environmental cues, particularly light. Unfortunately, the rising human pressure, especially the light pollution, largely distorts these cues. It is surprising how little we know about the impact of these distortions on the functioning of internal time-keepers in free-living animals. So far, researchers have mostly focused on tracking the changes at the cellular level in clinical studies of humans or experimented on laboratory animals (often nocturnal), such as mice or rats, largely ignoring the fact that artificial lab environment is far from the conditions in which natural biological rhythms have evolved. Hence, there is a substantial gap in our knowledge about the natural circadian rhythms and the consequences of their disturbance on features important during the life cycle, e.g. crucial for the development or the immune response.**

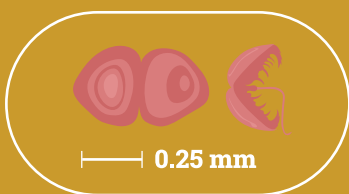
Researchers from the Jagiellonian University would like to investigate how the circadian clock is influenced by the disturbance of environmental cues (exposition to light). Studies will be conducted on collared flycatcher (*Ficedula albicollis*), a small migratory bird, because migratory birds can be both especially susceptible to disturbances of biological clock and exposed to artificial light during migrations. Hence, the scientists want to conduct an experiment introducing artificial light to nest boxes during the breeding season. The birds' circadian clock gene expression levels will be measured at different times of day and night. In other words, the researchers will check how the information present in these genes is decoded and translated into functional products, such as RNA or proteins. The scientists will also measure the levels of relevant hormones (melatonin – the hormone of sleep, ghrelin – the hormone of hunger and corticosterone – the hormone of stress) and study the impact of artificial light on the immune response by measuring immune gene expression levels. In order to check how the light changes the behaviour of birds, cameras will be installed inside the nest boxes. This will allow to establish whether the exposition to light can affect the hatching patterns and subsequent development of birds.

The results of this research can bring wide implications, because the magnitude of anthropogenic impacts on wildlife is unquestionable, yet we are still far from understanding its underlying mechanisms. Besides, as human beings, we are most interested in how the distortions of biological clocks impact our own lives. Conducting experiments on humans is very limited for ethical reasons, and only such studies can bring answers about the causes and consequences of certain phenomena (in contrast to observational research, including many clinical studies, which only indicate possible relations between those phenomena). The problem with the laboratory studies on animals conducted so far is that, although providing invaluable insights, they may have limited relevance as human clock analogy. On the other hand, wild birds, similarly to humans, lead diurnal lifestyle, have developed cognitive abilities, sociality and sensitivity to melatonin, and as such represent an excellent model for this purpose. The investigation of many interconnected mechanisms, such as the activity of the hormones of sleep and hunger, can help in understanding how light pollution or changes in circadian activities (e.g. working night shifts) relate to appetite disorders leading to obesity or malnutrition in humans.

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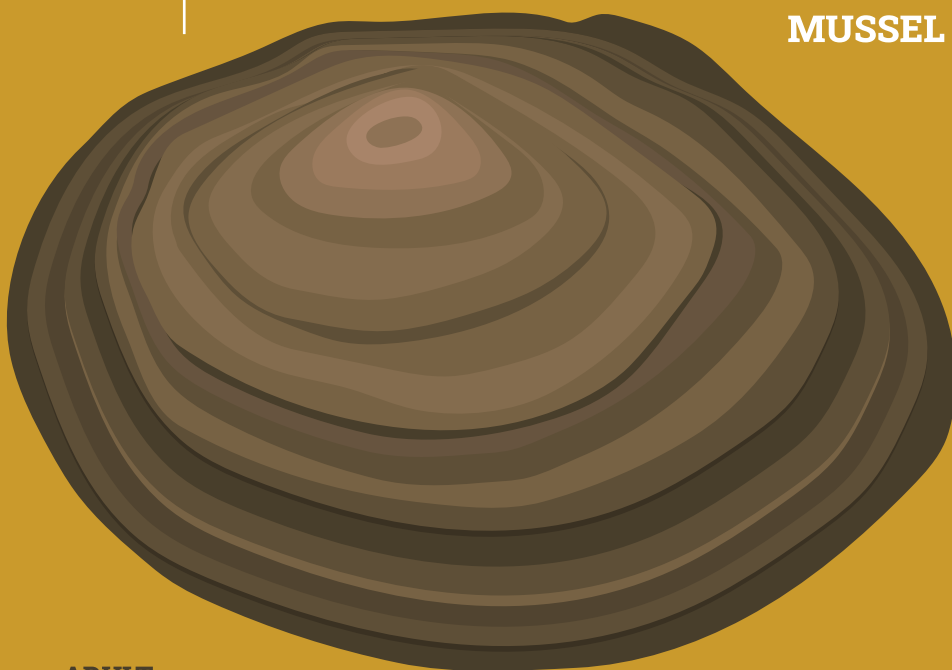
Joanna Sudyka - Assistant Professor at the Institute of Environmental Sciences of the JU Faculty of Biology

The research is funded by SONATA 15 grant of the National Science Centre and the fieldwork started in 2021.



LARVA  
(GLOCHIDIUM)

CHINESE  
POND  
MUSSEL



ADULT

26 cm

## THE SECRETS OF FRESHWATER MUSSELS

**The history of a person or an entire family can be reconstructed based on personal documents, diary entries, interviews, or medical records. And what about mussels? How is it possible to obtain such information about animals dwelling on the bottoms of lakes and rivers and living secretive lives?**

Mussels grow and reproduce throughout their lifespan. In less beneficial environmental conditions they significantly inhibit their growth. This mechanism is reflected in the formation of special rings on their shells, which, similarly to tree growth rings, allow researchers to reconstruct the history of their growth.

Increasing the size of the body can be beneficial to mussels as their larger females could produce more offspring, but rapid growth at the expense of faster reproduction or delaying maturation are risky 'decisions', which may reduce the lifetime reproductive success, as the genes must be passed on quickly enough. So when should they start to reproduce? What is the optimal pace of growth? How often should offspring be produced? What should be its optimal size and number to ensure its survival, especially in a newly colonised area?

JU scientist Dr Anna Maria Łabęcka is trying to answer these questions in her research on *Sinanodonta woodiana*, also known as the Chinese pond mussel. This species is not native to Europe; in Poland, it has first been observed in the 1980s. The Ministry of Environment has put it on the list of alien species which, if released to the environment, may endanger the local species or habitats. *Sinanodonta woodiana* forms female-biased populations and competes with local bivalve species for living space, food, and access to fish-hosts which the mussels' larvae parasitise right after their release from brood chambers. In Poland these mussels inhabit fish ponds, rivers and thermally polluted post-cooling water. Altogether, they have already been observed at more than 150 sites in our country.

In warm waters in the vicinity of power plants, the Chinese pond mussel becomes mature and ready for reproduction before reaching one year of age. Similarly to wide-hipped women, for whom it is easier to give birth to big children, large and convex-shelled female mussels are more effective at producing offspring. Investment in the enlargement of the body is also important because these mussels take special care of their progeny: the gills of females who become mothers are transformed into brood chambers,

in which larvae, called glochidia, develop. The greater size of shells provides the larvae with additional space for the brood chambers, where they can shelter and raise more offspring.

Gravid females of *Sinanodonta woodiana*, unlike other closely related species of mussels from the Unionidae family, can be found in freshwater bodies throughout the year. Dr Łabęcka studies their reproductive activity in laboratory conditions. Today, it is already known that these mussels breed every month, producing even several or several dozen times more larvae than native mussel species at one time. Their brood chambers are simultaneously inhabited by offspring of various ages, which is released to the environment time after time. This way of reproduction can pose a threat to seasonally breeding native mussels, such as the duck mussel, as well as the swan mussel and the depressed river mussel, which are rare and protected in Poland. The post-cooling waters have become a particularly good environment for Chinese pond mussel, as this is where they can breed and produce glochidia throughout the year, due to the increased temperatures. From there, the mussels can constantly migrate to natural freshwater habitats.

Research of the life history of these molluscs has shown that larger females reproduce more often. Their fertility increases along with the size of their bodies. It has been discovered that the number of offspring incubated in a single female can even reach one million. The largest larvae are born in winter, which may be caused by a longer incubation period during the colder season. By contrast, the larvae born in summer are the smallest, which probably helps them to survive the unfavourable temperature and oxygen conditions. Smaller mussels can have smaller cells, which allows them to conduct gas exchange at high temperatures, when the demand for oxygen is high. Large larvae, on the other hand, are more often produced by females who have stored supplies in their gonads.

Unionidae mussels are among the most endangered animals in the earth. We need to be aware that human

activity more and more often results in the introduction of alien species to new territories, where they can contribute to the extinction of rare native species. Will

we manage to change our behaviour to such an extent that the local fauna and flora are saved for future generations?

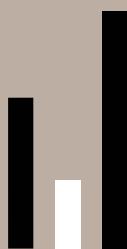
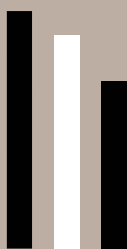
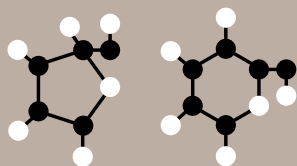
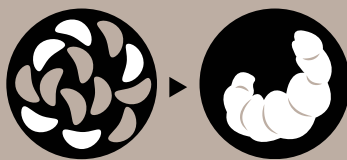
**i**

Dr Anna Maria Łabęcka  
[https://www.researchgate.net/profile/Anna\\_Labecka](https://www.researchgate.net/profile/Anna_Labecka)  
Institute of Environmental Sciences  
Faculty of Biology of the Jagiellonian University

The research was funded by grants from the Ministry of Education and Science NN303 068 32/2367 and the National Science Centre DEC-2017/01/X/NZ8/00946

Life cycle of *Sinanodonta woodiana*.





## RESEARCH INFOGRAPHICS

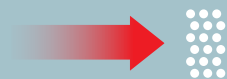
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**EVEN SPROUTING SEEDS DISTINGUISH LIGHT THANKS TO RECEPTORS**



**CRYPTOCHROMES  
PHOTOTROPINS**



**PHYTOCHROMES**

## **DE-ETIOLATION REPROGRAMMING**



**PHOTOSYNTHESIS BEGINS**



**PHOTOSYNTHETIC  
COMPLEXES EMERGE, FAST  
PRODUCTION OF CHLORO-  
PHYLL BEGINS**

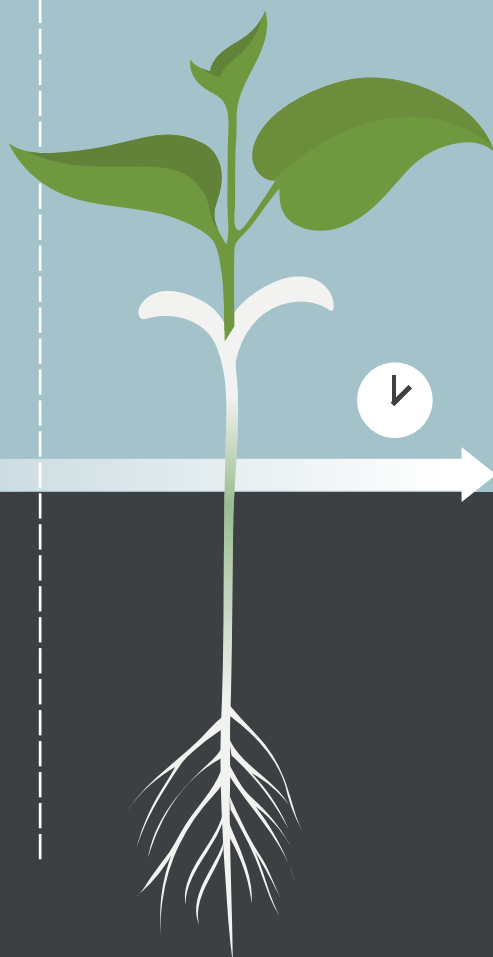


**EVERY THIRD GENE  
CHANGES ITS BEHAVIOUR**

## **PHOTOMORPHOGENESIS**



**11 MOLECULAR SWITCHES ACTIVATE  
TRANSCRIPTIONAL FACTORS, WHICH  
ACTIVATE GENES**



## **ETIOLATION**



**LACK OF LIGHT INITIATES  
ACCUMULATIONS OF  
HORMONES**



**SAVING OF RESOURCES  
NO CHLOROPHYLL PRODUC-  
TION  
SMALL AMOUNTS OF PRECUR-  
SORS ARE ACCUMULATED**

# **THE COLOURFUL LIFE AND DARK PROBLEMS OF PLANTS**

**Plants use resources sparingly. This also refers to the production of pigments. Researchers from the Jagiellonian University aim to understand the mechanisms regulating these processes.**

The life of plants can be as dynamic as the life of animals, but it is much more difficult to observe, as plants are rather secretive with their activity. Similarly to a laptop left on a table, they remain still and apparently passive, actually living a very rich virtual inner life.

Scientists and students conducting research at the Jagiellonian University Faculty of Biochemistry, Biophysics and Biotechnology as part of the team of Dr hab. Beata Myśliwa-Kurdziel, Prof. UJ are most interested in the beginnings of plant life, when young seedlings emerge from seeds buried in soil and, while in darkness, must force their way towards light. In angiosperms – fruit-producing plants, including grains, and other economically important crops – the absence of light triggers the process known as etiolation, during which the plant uses resources more economically and gets ready to start the process of photosynthesis as soon as it gets access to light.

What kind of substances do plants accumulate at early stages of their life and why do they do so? These

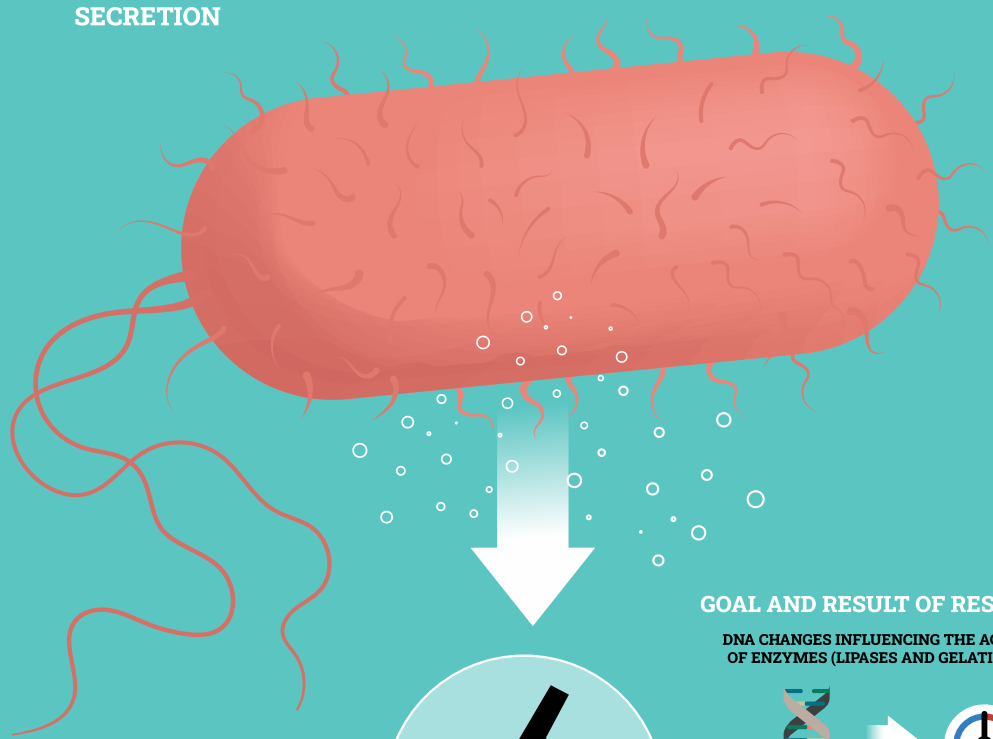
resources include basic building materials, proteins and lipids, but also pigments. The question is whether plants that are still in darkness already coordinate the production of different types of pigments needed for photosynthesis, such as greenish chlorophyll precursors and orange carotenoids. The scientists tried to answer these questions with the help of *Arabidopsis thaliana* (thale cress) – a widely used model plant, whose role can be compared to that of a lab rat. They triggered the etiolation process in the plant's seedlings by blocking their access to light. By comparing them to mutants which were deprived of almost half of carotenoids they checked how they managed to coordinate the production of chlorophyll precursors under the above mentioned conditions. Although chlorophyll precursors and carotenoids are produced as a result of two independent processes, it turned out that, in certain conditions, the amount of chlorophyll precursors was also reduced in mutants. This important discovery strongly proves the existence of mechanisms that strictly regulate the pace of production of both these pigments, in order to ensure their optimal proportion.

**i**

Dr hab. Beata Myśliwa-Kurdziel  
Dr Paweł Jedynak  
Faculty of Biochemistry, Biophysics and Biotechnology

Research funded from the National Science Centre grant UMO-2013/10/E/NZ3/00748.

ENZYMES  
SECRETION



IDENTIFICATION AND  
ISOLATION OF ENZYMES



GOAL AND RESULT OF RESEARCH

DNA CHANGES INFLUENCING THE ACTIVITY  
OF ENZYMES (LIPASES AND GELATINASES)



ISOLATING STRAINS OF BACTERIA , WHOSE  
ENZYMES BREAK DOWN ENZYMES AND FATS



BENEFITS - TAKING ADVANTAGE OF CHANGES IN ENZYME ACTIVITY

LIPASES



destroy fats

GELATINASES



destroy gelatine

PECTINASES



cut fruit pectins

CHITINASES



digest fungal cell walls

AMYLASES



digest starch

PROTEINASES



digest various proteins

|| MIRACLE IN A TEST TUBE

**The Jagiellonian University supports talented students with great ideas, as showcased by Szymon Kwaśnik's team, which received grant funding for their own research aimed at raising the efficiency of useful enzymes obtained from bacteria.**

Most people associate bacteria mainly with dangerous pathogens, whereas biotechnologists perceive them as... treasure chests, although the gems they contain are often quite bizarre. The initial phase of a unique research project run by a team of students led by Szymon Kwaśnik has just been completed at the JU Faculty of Biochemistry, Biophysics and Biotechnology.

The researchers aimed at identifying and improving the enzymes secreted by an unusual bacterium, named *Serratia marcescens*. Because of its blood-red colour it is suspected to be the culprit of many alleged miracles, but it also has another unusual property, which is of special interest to scientists – the ability to efficiently break down fats and proteins. They see it as a truly wonderful opportunity, as the enzymes can become handy biological tools that can be used to perform specific tasks.

Hence, the JU students grew the bacteria in laboratory and checked how efficiently their enzymes managed to break down proteins and fats. Having learnt about

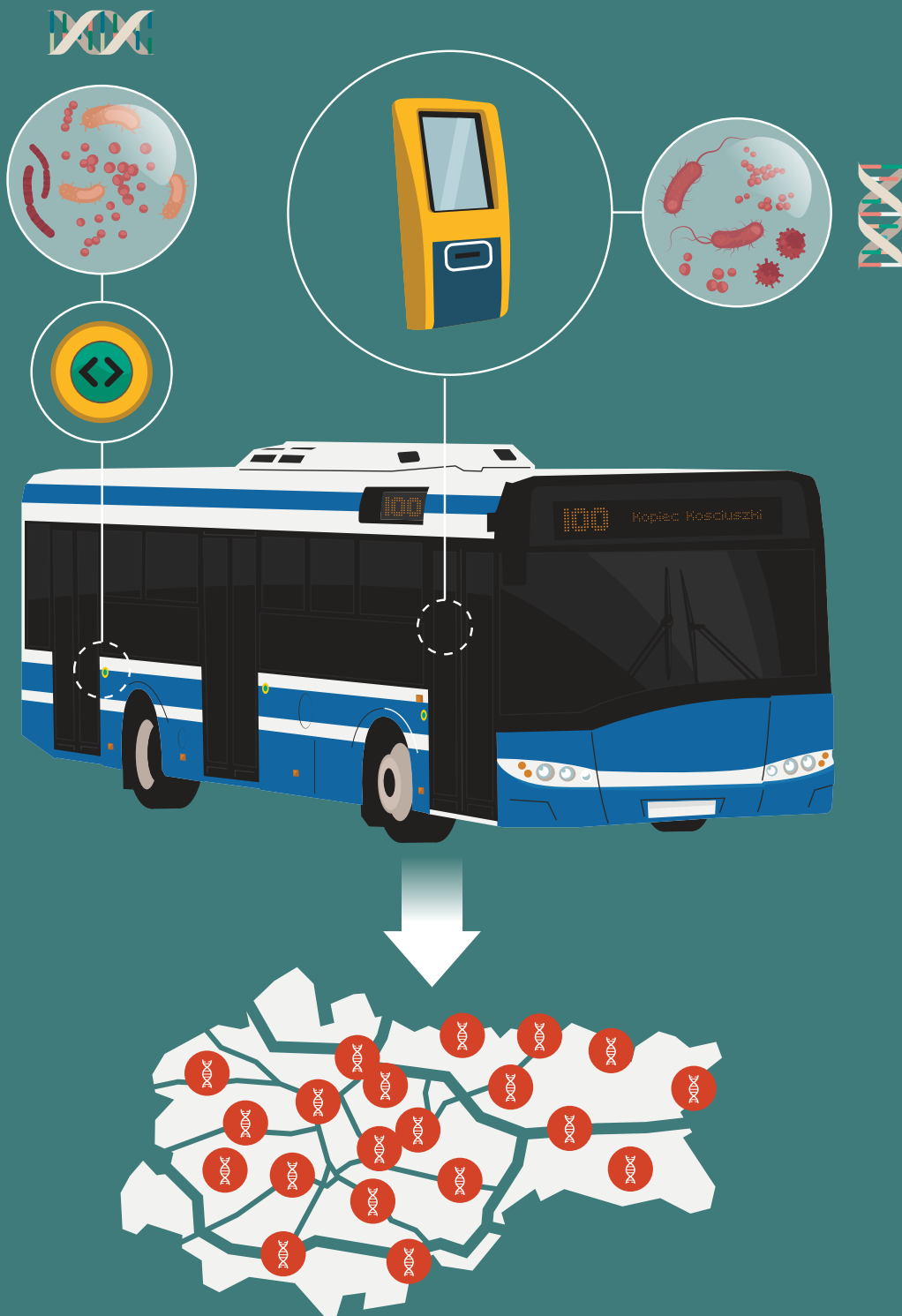
their activity, the researchers carried out over a dozen rounds of mutagenesis – a process aimed at generating mutations (slight changes) in the DNA, that is, a molecule that carries instructions on how to produce each enzyme of a given bacterium. These slight changes can have different results: the mutations may have no effect on the studied enzymes whatsoever, or they may cause their activity to either drop or rise. The latter effect was the ultimate goal of research conducted by the students.

Further efforts of the young biotechnologists focused on the selection of new varieties of the bacteria in order to single out those with an even greater activity of the relevant enzymes. The results seem very promising, so the students can now think about the possibility of using the bacteria in biological preparations production. Such enzymatic additions could have a wide variety of applications, from industrial and medical waste decomposition to scientific research, where they can be used as molecular tools, and even doing the laundry, as they can help to remove stubborn stains.

**i**

Szymon Kwaśnik  
Dr Paweł Jedynak  
JU Faculty of Biochemistry, Biophysics and Biotechnology

Research funded from 6/SPB/2018 grant.



**MICROBIOMES:  
FINGERPRINTS OF A CITY**

**Surfaces that can be found in the public space are covered by a diverse group of organisms we interact with every day. These include viruses, bacteria and fungi, which together form what we call 'microbiomes'. We do not know much about the dynamics of microbiomes on publicly accessible devices and facilities such as ticket machines, ATMs and grab handles, and yet interacting with the surface of those things can affect people's health and influence the overall condition of a city. To gain some insight into the microscopic world that surrounds us, JU researchers are carrying out a project that will help them develop genetic maps and learn the organisation of microbiological ecosystems of an urban environment.**

One of the aspects of the project is conducting an analysis of the genetic code of microbiomes (called 'metagenomes') of an urban environment. Data collected during a single metagenomics experiment is a functional conceptualisation of information gathered from thousands upon thousands of strings of letters that represent the genetic code. Such an amount of data is bound to take up a lot of storage space, sometimes as much as a few terabytes. Here, we enter the world of Big Data, machine learning and artificial intelligence. By using these tools, we can obtain what can be described as a 'fingerprint' of a place and learn more about the specifics of the microbiology of cities, countries or entire continents. Further analysis of this data could allow for the detection of previously undiscovered constituents of the animate world, observation of environmental incidents on a microbiological scale, and search for drug resistant pathogens. It may also be used in forensic science to find perpetrators of crimes.

In 2020, Kraków became part of the annual Global City Sampling Day. On this day, scientists from around the world gather biological samples from everyday use objects and places, such as ticket machines or bus stops. Data collected on that day will help create a 'fingerprint' of Kraków and allow the city to be identified solely by the microorganisms that inhabit it. In the face of COVID-19, researchers used their experience and expertise to join the effort of monitoring Kraków's level of SARS-CoV-2 infection. Starting in the second half of March 2020, they have monitored 20 public spaces in the city, chosen on the basis of an analysis of human migration. The virus was detected in many of those places; however, it seems that disinfection of public spaces carried out by Kraków public services coupled with social distancing and other measures helped reduce the transmission of the virus, since it was no longer present in the samples taken in late May and early June.

# i

The research project carried out by the Bioinformatics Research Group from the JU Małopolska Centre of Biotechnology led by Prof. Paweł Łabaj is part of the MetaCoV initiative, a global endeavour of investigating the SARS-CoV-2 virus in cities spearheaded by TheMetaSUB International Consortium. Additionally, the Group, together with ViroGenetics – BSL3 Laboratory of Virology and Human Genome Variation Research Group – both of which are also based at the Małopolska Centre of Biotechnology – have partnered up with the city of Kraków and other local institutions to monitor and combat the COVID-19 pandemic.



80%



200  
billion  
dollars



9.5%



DIET FACTORS  
IMPACTING  
THE HEALTH  
OF BEES



BALANCE



nectar



pollens



DIVERSITY AND PROPORTIONS

**BEES STUFFED  
WITH EMPTY CALORIES**

Institute of Environmental Sciences  
Faculty of Biology  
Jagiellonian University



**Earth is inhabited by about 20 thousand bee species, 500 of which live in Poland. The majority of them live a solitary life and do not produce honey. Very little is known about wild bees. For instance, we do not know what role different components of their diet play in the development, growth, health and condition of these insects.**

The work carried out by bees produces an annual income of nearly 200 billion dollars globally. It is estimated that this amounts to 9.5% of the world's entire agricultural revenue. Besides, it is also estimated that about 80% wild plant species and 75% of cultivated plant species require pollinators to produce seeds and fruit (besides the best known ones – bees and butterflies – pollinators include a large number of flies, beetles, and hemipterans, as well as some birds, bats, and other vertebrates.

Insect pollinators, including the several hundred species of wild bees living in Poland, subsist on a rich and varied diet, the staple of which are pollen and nectar supplied by trees, bushes and other flowering plants. Nectar gives the pollinators the energy to go about their day, while pollen is used as building blocks for the organisms of their offspring. Yet, high quality food is needed for a healthy bee to develop.

A mono diet – of low quality or rich in harmful substances – harms bees, which can lead to the extinction of entire populations of these insects. The mechanism is very similar to that of junk food in humans. Imagine a person who eats only doughnuts. Can he or she be healthy? Of course not, and the wrong diet, besides being damaging in itself, makes the body vulnerable to numerous harmful factors. It can be argued that eating only doughnuts is an extreme situation, which does not happen in real life. Yet, what about bees offered only “honey plants”, producing nectar which provides bees only with empty calories?

Diverse diet, on the other hand, ensures the right proportion of nutrients and mitigates the negative impact of harmful substances, such as pesticides. It is highly probable that the food produced by various plant species provides nutrients in various proportions, which are often far from optimal (like a human diet consisting solely of processed food, without fresh fruit or vegetables). This is why access to a wide spectrum of nutrients offered by varied plant species can be a key to ensuring that wild bee populations are large, healthy and diverse.

The decrease in plant diversity is considered one of the causes of the global decrease in the number and diversity of insect pollinators. The current efforts to counter this trend mainly focus on reducing the use of pesticides and improving the quality of food sources. Although the lack of well-balanced diet may be one of the direct reasons of the pollinators' extinction, there is little knowledge on how the situation can be improved.

Bees are known to be more healthy in environments with diverse flora, offering a wide variety of food. But the specific mechanism of this relationship remains unknown. Do particular bee species require specific proportions of nutrients in their diets? Does food from various plants provide them with different proportions of these ingredients? The answers to these and other questions will shed light on the observed relationship between plant diversity and the health and condition of various bee species.

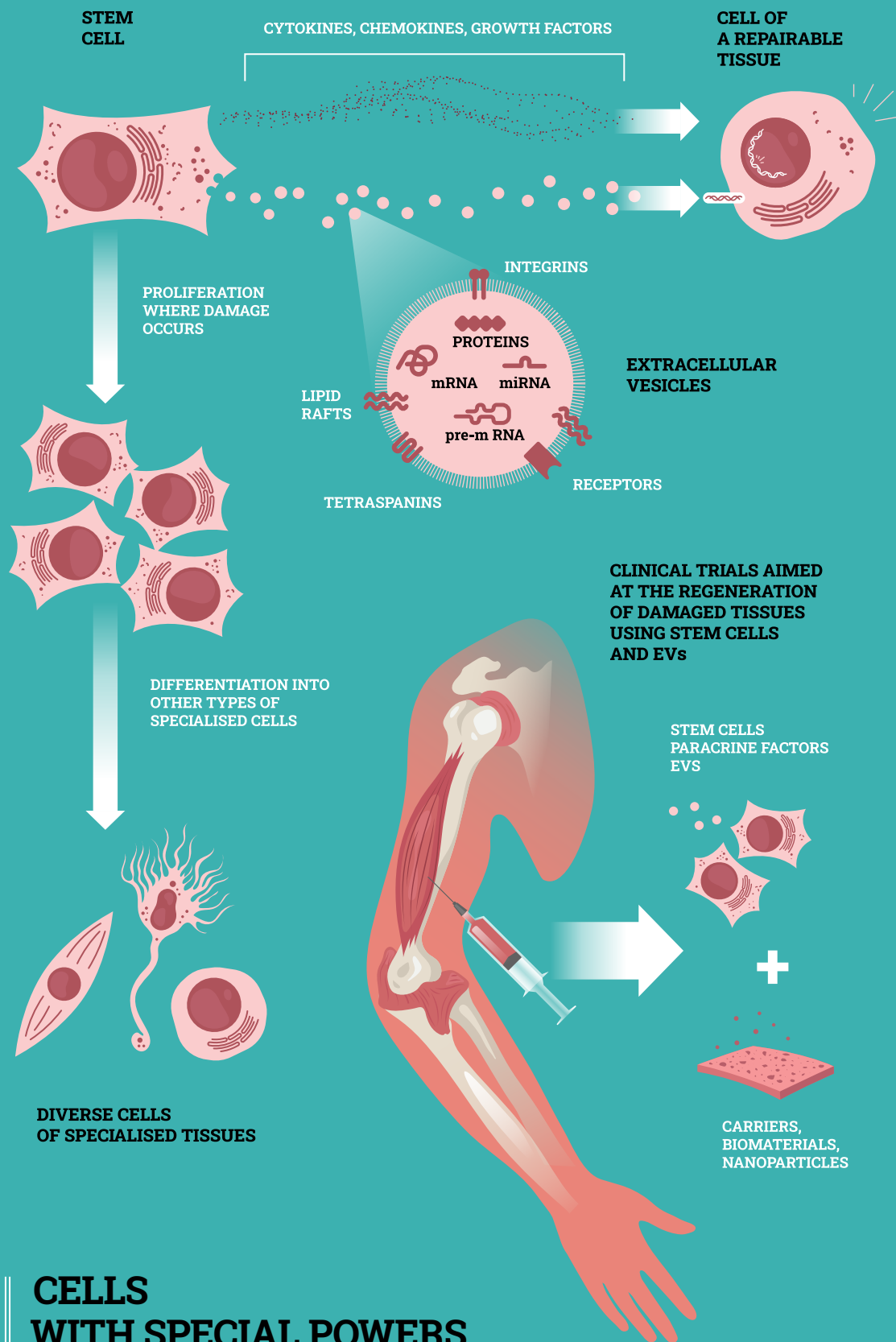
The research conducted at the JU is aimed at compiling the list of nutrients that play the vital role in balancing the wild bees' diet and determining the optimal proportions of these substances for various bee species. This important knowledge can be applied to improve the availability of bees' food sources, which will ensure that the pollinators have access to high quality food in urban areas or other environments lacking in nutrient-rich plants species. Hence, the scientists will create flower blends optimal for that purpose.

### i

Dr Michał Filipiak  
Institute of Environmental Sciences  
Faculty of Biology  
Jagiellonian University

In the next few years, the research will be published as part of two projects: 1. *Ekologia odżywiania pszczołowych: bilansowanie popytu i podaży materii do budowy ciała w kontekście różnorodności i składu gatunkowego flory* [Ecology of Apidae diet: balancing supply and demand of body building material in the context of flora diversity and species composition] – project funded by the National Science Centre within the framework of Opus17 competition (head: Michał Filipiak, start: 30 October 2020). 2. *NutriB<sup>2</sup>* <https://nutrib2.project.uj.edu.pl/start> – international project funded within the framework of biodivERsA network.

The researchers also participate in development of a new generation of complex tools for keeping honey bees and apiary management. The work is carried out as part of B-GOOD project, funded within the framework of Horizon 2020 programme: <https://b-good-project.eu/about>



## CELLS WITH SPECIAL POWERS

**What makes stem cells so special as compared to other types of cells in our body? Let us take a closer look at their potential and how it can be used in practice – from medicine to... the production of burgers.**

Most people have probably heard about stem cells, but, apart from scientists, only few of them know what they really are and where they are located. This is not magic or an invention of some crazy scientist; in fact, we all have stem cells in our bodies and would not be able to live without them. How is that possible? In order to understand stem cells better, let us take a closer look at the features which make this group of cells so special.

Our bodies contain many types of specialised cells that build various tissues and organs. But they are not immortal: some of them simply die after fulfilling their mission, while others perish as a result of pathological processes affecting our bodies, such as injuries or illnesses. At this point stem cells come to the rescue. Even though they are a very rare cell group, they are not only capable of constant self-renewal of their population, but also of transformation into other types of more mature cells, which then become part of our tissues, in the process known as differentiation. This allows a continual replacement of 'used' or damaged cells by new ones. This is perfectly exemplified by blood-forming stem cells, which can be found, for instance, in the bone marrow, where they comprise less than one percent of all cells. Nevertheless, they are able to continually produce cellular blood components at a pace of several hundred thousand per second.

No wonder the great potential of various types of stem cells is applied in modern medicine as a potential tool for regenerating damaged tissues and supporting the

body's natural repair processes. To achieve that goal, scientists isolate stem cells from various tissues, replicate them in laboratory conditions and then administer them to patients suffering from various diseases, in order to improve their health and quality of life. The researchers are also working to combine innovative solutions from the field of molecular biology and biomaterial engineering with the aim of increasing biological and regenerative potential of these cells.

What is more, contemporary medicine uses not only the stem cells' potential for proliferation and differentiation into other types of cells, but also their secretory activity, as it has been proven that they are capable of releasing biologically active factors from their surface. These factors include extracellular vesicles: membrane-coated nanostructures that can contain biological information in various forms, such as proteins and nucleic acids. What is especially important, is that these vesicles can transfer their content to other cells, thus influencing their functioning. Hence, they are viewed as potential therapeutics that can provide an interesting alternative to cell-based treatment.

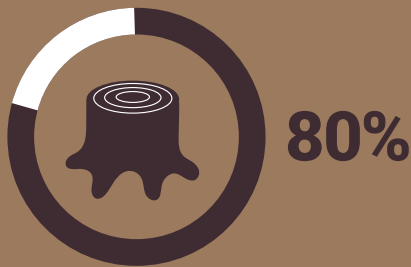
Stem cells have a wide-range of other possible applications. For instance, their potential for proliferation and differentiation can be utilised to produce laboratory-grown meat, which may then be processed into (reportedly quite tasty) burgers. Thus, only time will tell in what other ways we will be able to use the special powers of stem cells.



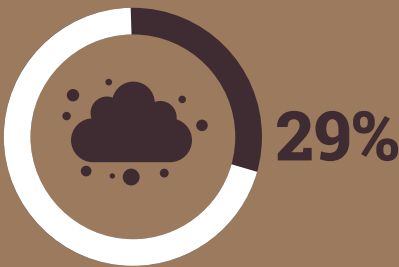
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The research is conducted by a team headed by Prof. Ewa-Zuba Surma in the Department of Cell Biology at the Faculty of Biochemistry, Biophysics and Biotechnology and the Małopolska Centre of Biotechnology of the Jagiellonian University, within the framework of the BioMiStem project funded by the National Centre for Research and Development (STRATEGMED3/303570/7/NCBR/2017).

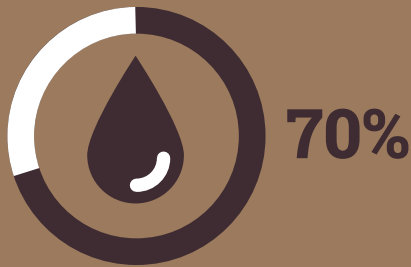
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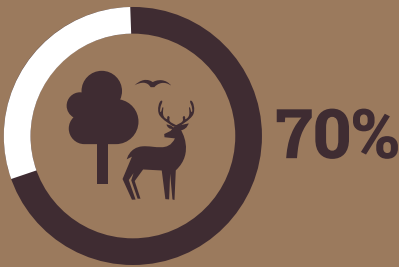
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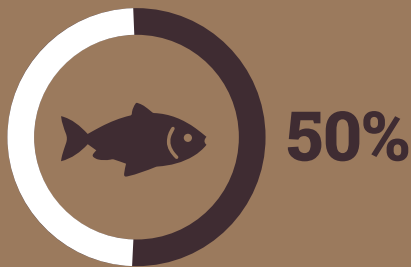
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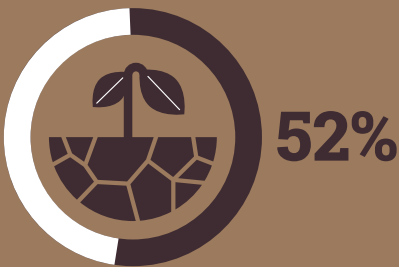
OF FRESHWATER  
CONSUMPTION



OF TERRESTRIAL  
BIODIVERSITY LOSS



OF FRESHWATER  
BIODIVERSITY LOSS



OF DEGRADATION  
OF AGRICULTURAL LANDS

**MORE HEAT,  
MORE EXTINCTION,  
MORE WASTED FOOD**

**We are experiencing a mass die-off of insects that are a key element of many ecosystems: they pollinate plants, serve as food for birds and other animals, and participate in the process of matter and energy cycle. One of the reasons of their extinction is industrial agriculture.**

The dominant form of farming, industrial agriculture, is based on large monocultures and intensive animal farming. This kind of activity leads to excessive emissions of greenhouse gases, deforestation and mass animal extinction. Moreover, the main aim of industrial agriculture is not providing food, but rather financial gain, which results in agricultural surplus in the richest countries. Industrial agriculture, despite owning 70% of world agricultural resources, provides with food only 30% of human population. The agriculture itself is responsible for troubling data: 70% drop in biodiversity of terrestrial ecosystems and 80% drop in forested areas. Along with fossil fuels, it is also a source of greenhouse gases, such as carbon dioxide, methane, and nitrogen oxide. These substances cause a rise in average temperatures on Earth, leading to global warming and increasingly frequent extreme weather conditions, like hurricanes, droughts and floods.

Agriculture is responsible for as much as 29% of greenhouse gases emission. In 1960, the concentration of carbon dioxide amounted to 310 parts per million (ppm), while contemporary measurements suggest it has risen by 34% to 416 ppm; if we count in other gases, the number rises even further to 500 ppm. At 550 ppm, the average global temperature will rise by 3°C, which coupled with continuing deforestation will prove disastrous to all living organisms, including humans. The number of floods and droughts will escalate, and more and more areas will become inhospitable to life.

Plummeting biodiversity and increasing deforestation are chiefly caused by the overproduction of meat and other animal-based foods, like milk and eggs. Farmlands comprise about half of all habitable land. As much

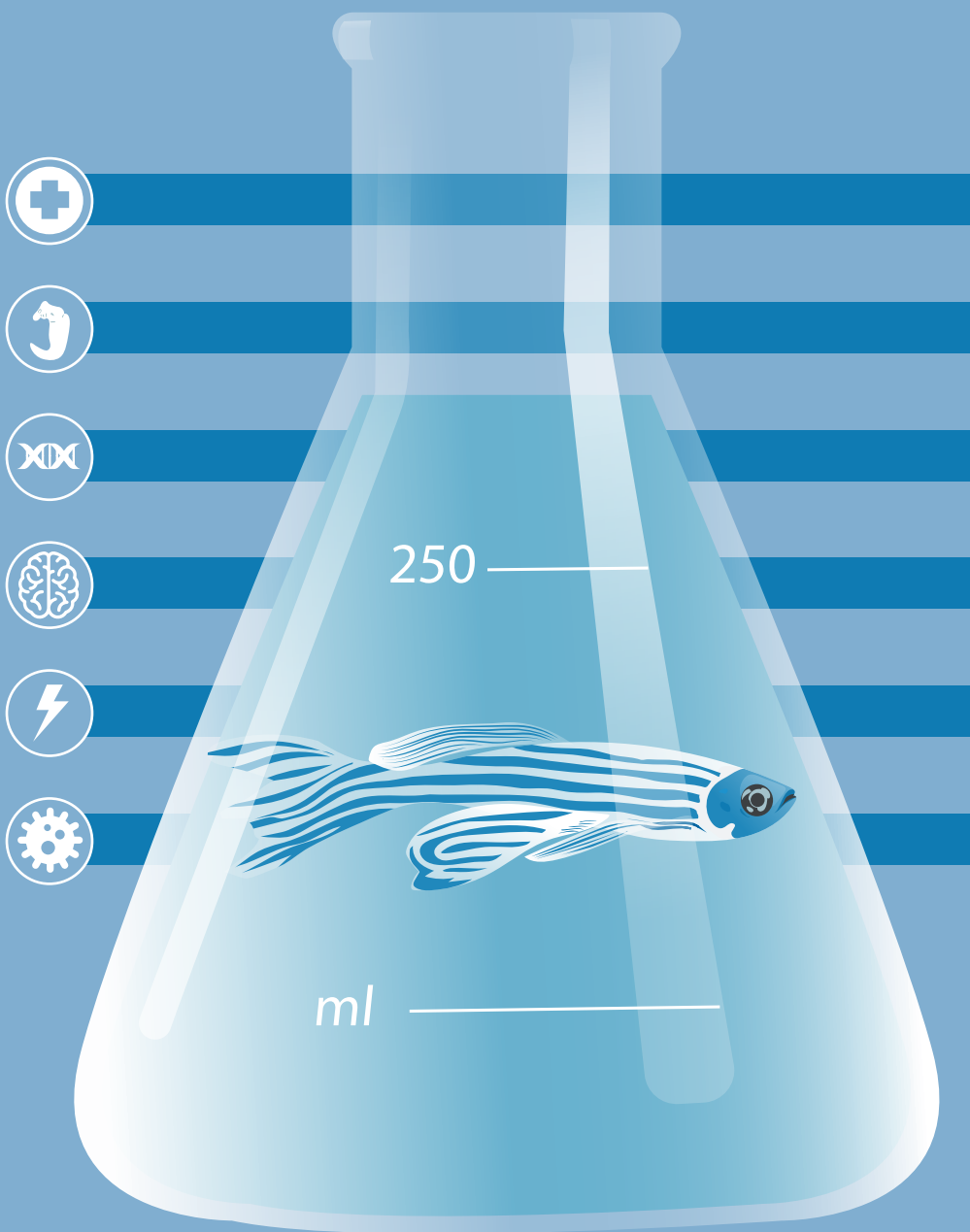
as 77% of that area is devoted to the production of meat, but meat and dairy products only provide 33% of protein requirement and 17% of energy requirement for the entire humanity. The rest is covered by plant-based foods, meaning they are much more efficient as a source of nourishment. 90% of animals are raised in industrial livestock production plants, which necessitates assigning large swathes of land to supply them with feed. This type of agriculture results in mass production of cheap meat and dairy products, consumed mostly in rich regions, like the United States, Europe, Oceania, and increasingly in China. This results in overconsumption of meat and dairy. According to dieticians, adults should eat a maximum of 0.5 kilograms of meat per week, while in Poland that number is three times higher. Cheapness and abundance of meat and dairy leads to them being wasted – for example, in Poland 47% of cold cut meats end up in garbage. At the same time, animal feed plants like soy are grown in poorer countries, often on deforested lands, such as the Amazon rainforest. This means that instead of producing food for their own needs, people in those countries export their produce to fuel excessive production of meat. This inequality in the global economic system serves only one goal – generating revenue for agricultural and biochemical corporations. The latter of those supply the former ones with pesticides and artificial fertilisers needed for large monocultures. That is why we need to change both the way we produce food and the way we distribute it.

**i**

Dr hab. Paulina Kramarz, Prof. UJ, Institute of Environmental Sciences  
naukadlaprzyrody.pl

For more information about global warming visit  
naukaoklimacie.pl

The data in the article was collected in 2015–2020.



**THE GREAT POTENTIAL  
OF A SMALL  
ZEBRAFISH**

**The zebrafish (*Danio rerio*) is a small exotic fish from the Cyprinidae family. It is bred by aquarists, at the same time making a big career in biomedical research. For about 40 years the zebrafish has been used as a model organism to study various biological processes, including those that take place in the human body. Its advantages include easy breeding and maintenance, transparency of larvae, fast development and sexual maturation as well as, most importantly, a fully sequenced genome and the availability of molecular techniques that allow the construction of various mutants and transgenic lines. All these features have made the zebrafish the second most popular model organism (after the mouse), used in embryological, genetic, neurobiological, pharmaceutical, toxicological, and immunological research, to name a few areas. For several years it has also been applied in the studies conducted at the Department of Evolutionary Immunology, Institute of Zoology and Biomedical Research of the Faculty of Biology at the Jagiellonian University.**

The JU biologists have been using zebrafish in a number of studies, including research on immune response to viral infections, some of which are caused by viruses that pose a serious threat to the global aquaculture (such as the tilapia lake virus). They are also using zebrafish to take a closer look at the interaction between immune cells and bacteria, including those which cause human diseases and are resistant to antibiotics, such as *Staphylococcus aureus* and *Porphyromonas gingivalis*, which causes periodontitis. In the latter case, the scientists aim to verify if these bacteria can get into blood and then into brain, causing inflammatory-based neurodegenerative processes, thus leading to the development of the Alzheimer's disease.

The zebrafish is also used to study the effects of hormones and neurotransmitters on immune system. The JU researchers are checking, among other issues, how

stress impacts the immunity of fish, including the activity of their white blood cells (leukocytes) protecting the body against infection. They are also investigating how the immunity of fish changes with the circadian cycle, and, consequently, how it depends on the light conditions in which fish are kept. In the future, these studies could enable the design of new strategies of fish farming, in which the reduction of stress and proper choice of the animals' living conditions allow the optimal functioning of their immune systems.

This small fish enables scientists to carry out research at molecular, cellular, and population level. This allows them to learn more about virulence factors – pathogens' molecules that are responsible for the development of disease, as well as mechanisms of immune response to various pathogens, which may lead to the development of new methods of treatment for infections.

**i**

Dr Krzysztof Rakus, Dr Tomasz Prajsnar, Dr Magdalena Widziołek,  
Prof. dr hab. Magdalena Chadzińska  
Department of Evolutionary, Institute of Zoology and Biomedical  
Research, Faculty of Biology, Jagiellonian University

The research is carried out in collaboration with the team of Professor Jan Potempa from the Department of Microbiology of the Faculty of Biochemistry, Biophysics and Biotechnology at the Jagiellonian University.



# VIRUSES WILL COMBAT DRUG-RESISTANT BACTERIA



**A research team led by Dr hab. Rafał Mostowy at the JU Małopolska Centre of Biotechnology uses bioinformatics to study bacterial viruses, also known as bacteriophages or simply phages. By reconstructing their evolution using computer models, we can understand how phages outsmart bacteria and efficiently kill them, while analysing millions of phage proteins can lead to finding innovative antibacterial drugs.**

Bacteria and their viruses, phages, have been locked in a constant evolutionary battle for nearly four million years. Bacteria change to be able to resist viruses, and viruses adapt to overcome these defences. As millions of years of evolution have given viruses a great deal of experience in finding ways to infect and kill bacteria, so too have bacteria become experts in fending off viral attacks.

There has recently been a lot of talk regarding this type of research, especially last year when the Nobel Prize in Medicine was awarded to the inventors of 'molecular scissors': the CRISPR-Cas method of genome modification. Some have called this technique the greatest and most controversial medical breakthrough in human history. However, this 'tool' is nothing more than a bacterial weapon against phages. Certain types of bacteria have short genetic sequences encoded in their genome that help them detect viruses. When a bacterium is attacked, it quickly uses these 'scissors' to precisely cut the virus up into pieces. In recent years, we have identified more than a dozen potentially interesting bacterial systems that microbes use to fight viruses. It may well be that CRISPR-Cas is just the tip of an iceberg when it comes to new methods of treatment.

Although most of our observations of bacteria fighting off phages come from the last two decades, humans have used phages to kill bacteria, with varying outcomes, for over 100 years. In the early 20th century, it was observed that the water collected from the environment from which bacteria were isolated has antibacterial properties. Phages were later revealed as the cause. These viruses quickly became a subject of research in phage therapy, a method of treating bacterial infections. Since this technique yielded mixed results, and penicillin was discovered soon after, it quickly faded from people's memories. Recently, however, researchers began to talk about phage therapy again, since bacteria are becoming more and more resistant to antibiotics and are more likely to cause untreatable infections. The grim vision of a world without effective antibiotics prompted scientists to return to researching phage therapy with re-

newed enthusiasm. But using phages to fight bacteria is much more complicated than we might think.

The one hundred years of experience in researching phage therapy, mostly in the countries belonging to the former Soviet bloc, including Poland, has shown that its effectiveness is difficult to predict. Thanks to the advances in biotechnology we have made since, we now know why: the interactions between bacteriophages and bacteria are incredibly complex. For a phage to kill a bacterium, it needs to attach itself to the exterior of its cell, often making its way through various molecules found in its surface, inject its genetic material inside, bypass the host's defences (such as CRISPR-Cas), and finally take control and turn the bacterium into a 'virus factory'. Every one of these operations is difficult and may end badly for the virus. This means that phages are highly specialised hunters and there are only a few viruses that can overpower a certain type of bacteria. What is more, both bacteria and viruses are very diverse genetically and evolve rapidly. Therefore, to become proficient in the use of phages to treat bacterial infections, we need to understand the mechanisms that govern them at the molecular level as well as their evolutionary potential and interaction ecology.

At the JU Małopolska Centre of Biotechnology, the research group led by dr hab. Rafał Mostowy studies one of the key stages of phage infection: the interactions between bacteriophage tail fibres and bacterial surface polysaccharides. A lot of bacteria that cause clinical infections are covered by thick polysaccharide layers called the bacterial capsules. The capsule protects the bacterium from our immune system and, in some circumstances, makes otherwise harmless bacteria attack a person's organism. For phages, the capsule is an impediment, so viruses have evolved proteins and enzymes that can break down the bacterial sugars. However, both bacteriophages and bacteria are very diverse, and we still know very little about their interactions. Describing and classifying them and understanding their evolutionary processes is extremely important if we want to learn how to use phages to treat infections.

Researchers working at the JU Małopolska Centre of Biotechnology use computers to investigate the interaction between bacteria and phages. They are particularly focused on a bacterium called *Klebsiella pneumoniae*, as some of its drug-resistant strains are starting to become a real threat in hospitals around the world. By analysing hundreds of thousands of bacterial and phage genomes, they can compare a vast number of certain proteins and predict which proteins and enzymes affect which bacteria and their sugars. The scientists are planning to collaborate with other research groups to test

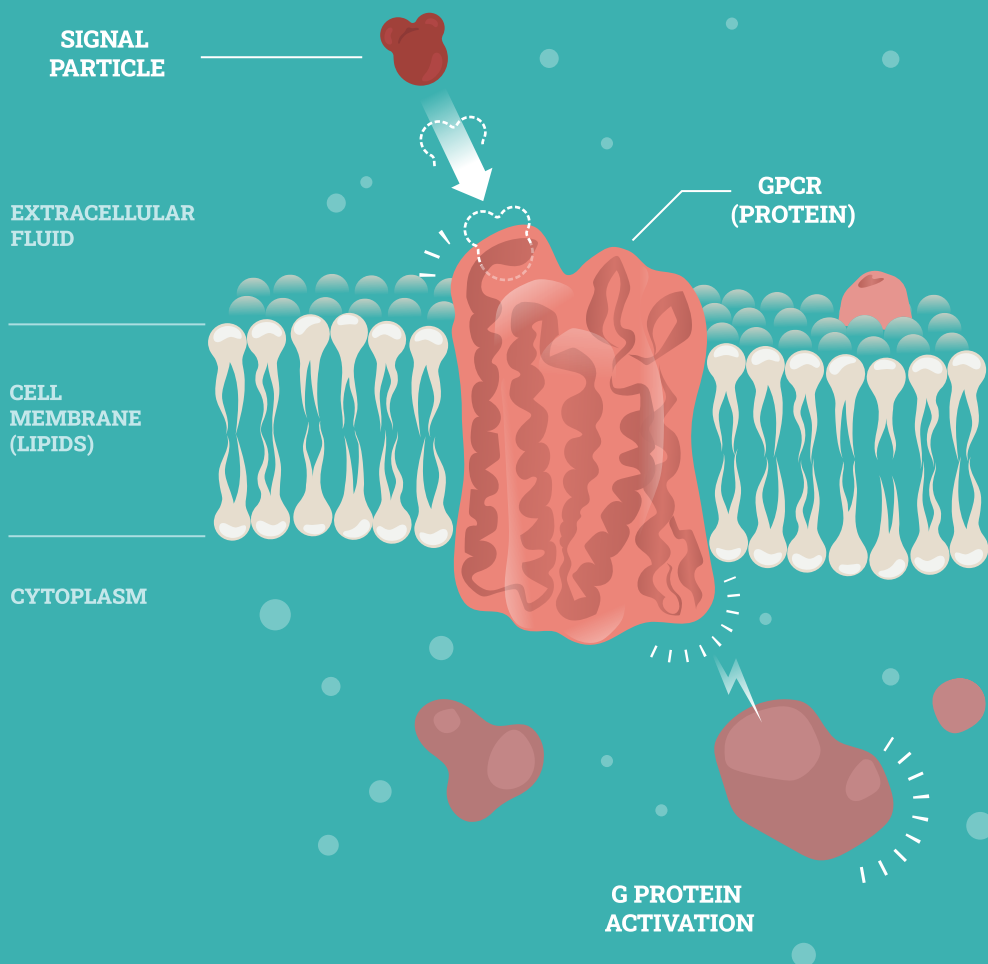
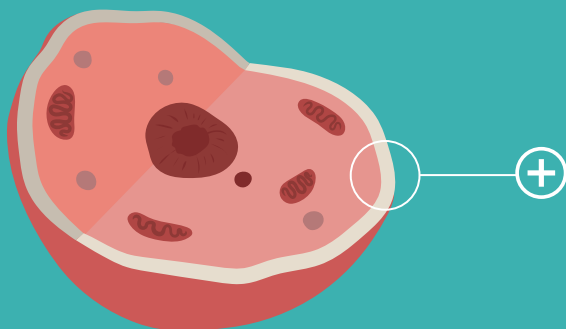
the hypotheses generated by the computers and isolate enzymes that break down particular sugars. On the one hand, this study will help to identify new ‘enzybiotics’: new types of virus-derived drugs that could be used against bacteria in the future. On the other, analysing the evolutionary processes behind viral proteins will allow researchers to understand how changes in sugars and proteins affect the phage’s chance of evolutionary success, and consequently, how to make better use of phages in fighting drug-resistant bacteria.

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The research project supervised by Dr hab. Rafał Mostowý is funded by the Polish National Agency for Academic Exchange, the Polish National Science Centre and the European Molecular Biology Organisation.



A series of posts (in Polish)  
devoted to the history of the Jagiellonian University,  
published every Friday morning  
on the JU Museum Facebook fan page



IT TAKES PROTEINS  
AND LIPIDS TO TANGO

**How is it possible that information about the surrounding environment travels to the inside of the cell in less than one second? How is it that, out of a vast number of chemical particles that surround them, cells are able to identify the relevant ones? These are just some of the questions posed by Dr Agnieszka Polit and her research team at the JU Faculty of Biochemistry, Biophysics and Biotechnology.**

Membrane receptors are key particles in the process of signal recognition and information transmission. The largest group amongst them are G protein-coupled receptors, also known as GPCRs. They are found not only in the nervous system, but also in almost every cell of our bodies, and more than half of them are potentially significant to the pharmaceutical industry. Human organisms contain dozens of types of GPCRs and several subtypes of G proteins.

GPCRs are large specialised proteins located in cell membranes. They are partly immersed in cytoplasm, while the rest 'sticks out' of the cell. Because of this, GPCRs serve as an excellent 'liaison' between the outside of the cell and the specialised biological machinery within it. When signal particles appear, which can take the form of chemical compounds (e.g. dopamine, serotonin, melatonin and neuropeptide Y) or physical phenomena (such as light), they immediately cause a cascade of events that allow the cell to adapt to new conditions, start producing required substances, and transmit information to adjacent cells and tissues. The first step of that cascade is the activation of a particular subtype of G protein by the stimulated receptor. The protein then interacts with other proteins, transmitting information to its intended targets.

In accordance with the fluid mosaic model proposed by S. Jonathan Singer and Garth Nicholson in 1972, cell membrane was depicted as a two-dimensional 'sea' of lipids (fats), in which proteins float around like regularly placed 'icebergs'. Currently, thanks to the development of various experimental techniques that allow us to gain better insight into the nanoscopic world of cells, we know that proteins are, in fact, not placed so regularly

and uniformly. However, the details on what exactly affects their placement and interactions, though important, are not yet fully understood.

The project carried out by the JU research team led by Dr Polit is focused on a thorough investigation of this intricate system, particularly the relationship between GPCRs, effector proteins (e.g. G proteins bound to the inner surface of the cell membrane), and certain lipids. The researchers have managed to prove that cell membranes feature specialised 'signalling platforms', which facilitate integration and interaction between particular receptors and G protein subtypes even before a signal particle is detected. This peculiar relationship between receptors and proteins causes signal particles to act selectively, not only in the case of receptor molecules, but also closely located effector proteins, which leads to activation of clearly defined signal paths. This explains why the response can happen almost immediately, and why the same signal can cause different cellular responses.

Additionally, JU researchers have identified factors responsible for directing individual effector proteins and GPCRs to certain areas in the cell membrane. These factors include certain amino acid sequences in receptor particles, types of lipids present in the cell membrane and lipid anchors, i.e. chemical compounds attached to G proteins.

Researching and understanding as basic a process as signal transmission on a molecular level, including the role of lipids in cell membrane, is important not only for basic research purposes, but also for health care, since in time it could allow for pharmacological treatment for GPCR-based diseases.

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Research on the relationship between GPCRs and lipids is conducted at the Department of Physical Biochemistry of the JU Faculty of Biochemistry, Biophysics and Biotechnology within the framework of the project *Wpływ domen błonowych na oddziaływanie białek G z lipidami* [The effect of membrane domains on the relations between G proteins and lipids] led by Dr Agnieszka Polit (OPUS 12, 2016/23B/NZ1/00530).





# **SOCIAL SCIENCES AND HUMANITIES**



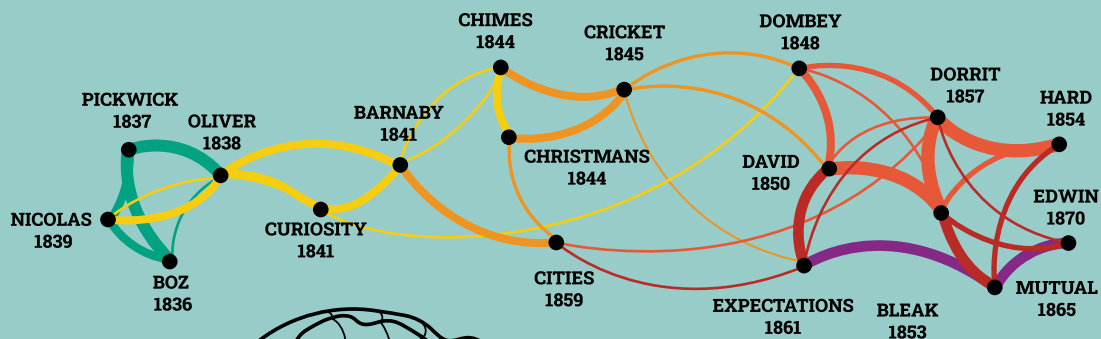
**PRUS**



**SIENKIEWICZ**



**ORZESZKOWA**



**CHARLES  
DICKENS**

**STYLOMETRIC RESEARCH –  
HOW TO CALCULATE  
THE AUTHORSHIP OF A TEXT?**



**For a few decades one has been able to see a growing significance of digital research in humanities, and a gradual dissolution of the old divisions into arts and sciences. Stylometry is part of this trend. It is a research method which allows one to determine similarities and differences between texts not through traditional 'human' reading, but through statistical analysis of linguistic features, such as sentence length or word frequency. And it is the frequency of words – the most common words, such as pronouns, prepositions or auxiliary verbs – that turns out to be most useful for authorship attribution, plagiarism detection or figuring out the chronology of texts.**

### Words Like Fingerprints

The idea to determine the author of a text based of most common word frequencies may seem counterintuitive. After all, we all appreciate our favourite authors' workshop not for the most frequent words, to which we rarely pay attention when reading a given text, but for how these authors construct plotlines, how they use irony, or how they employ ornamental metaphors. Yet, statistical studies demonstrate that it is indeed out of those simplest, most rudimentary words, and their frequencies that one can derive evidence on whether a given text was written by a particular author.

If we consider the fact that pronouns and linking words translate into an individual way of building sentences, or the perspective present in the text, the mechanisms behind stylometry become more understandable. For a number of readers recognising a given author's style is purely a matter of intuition – of 'impressions' that one reads particular texts written by different authors slightly differently. Stylometry introduces a sense of mathematical objectivism into these subjective impressions. However, nowadays in order to carry out advanced stylometric research one needs considerable computational power of hardware, and one needs to focus on those relationships between textual constituents that remain invisible and undetectable to the human eye. It is exactly because of that, the stylometric search for authorial signals in a text is oftentimes compared to the forensic search for fingerprints.

Visual representations of mathematical calculations are an indispensable element of stylometric research. Hundreds of strings with numerical frequencies need to be effectively interpreted. That is why, one "translates" numbers into images. Such visualizations of mathematical relations between texts allow one to study the investigated problems better, and provides an insight into the complex relationships between the whole groups of texts. What is called social network analysis

is among the most promising and comprehensive ways to illustrate the computational similarities and differences between texts – as demonstrated in the graph, in which texts by Orzeszkowa, Prus and Sienkiewicz form distinct authorial clusters. Of course, one is left to ponder on why Orzeszkowa's authorial signal is more distinct from the two male authors, than they are from each other...

There is more: similar analysis may well detect the evolution of a particular author's stylometric signal. Such development is visible below, in the graph of Charles Dickens's entire oeuvre. His texts align almost perfectly into a chronological order, moving from the earlier texts (left) to later texts (right).

### Literary Investigations

Since stylometry is so efficient in determining the authorship of a text, as well as its chronology, little wonder that it is often used in various 'literary investigations'. A good example may be here the case of Harper Lee, American writer born in 1926 in Alabama. Lee is known to Polish readers predominantly as the author of Pulitzer-winning *To Kill a Mockingbird*. The book is regarded as one of the evergreen classics of American literature.

In spite of the success of her debut novel, Lee never wrote another book. She also steered clear of public appearances. Thus, no wonder that when in 2015 the manuscript of her another book, *Go Set a Watchman* surfaced, the readers all over the world were electrified. In fact, *Go Set a Watchman* was written by young Lee as a submission to the J. B. Lippincott press which did not accept it, but which – with the help of an experienced editor Tay Hohoff – suggested extensive changes of the manuscript, such as changing the age of the protagonist, or placing the trial at the centre of the plot. Unsurprisingly, doubts regarding the authorship of two texts appeared promptly. Did Lee write the final

version of the novel, we all know as *To Kill a Mockingbird*, by herself? Should some of the credit for the authorship go to Tay Hohoff? Or maybe to Harper Lee's childhood friend, Truman Capote, who at times implied that he contributed to the final version of the book?

To put an end to these doubts, *The Wall Street Journal* asked the Kraków stylometrists to conduct a 'literary investigation'. The research carried out on two texts determined beyond doubt that Harper Lee is indeed the author of two novels. Yet there is more: further studies published in the journal *Mississippi Quarterly* indicate that in *To Kill a Mockingbird*, one can also detect a strong 'signal' of the editor. These results are interesting for historians of literature in so far, as they conclusively resolve some doubts, while, at the same time, they set new research goals, and inspire new questions. The literary investigation carries on.

Stylometrists from Kraków also contributed to another well-known episode regarding authorship attribution. In this case, the investigation concerned the true identity of an Italian writer known by the pen-name Elena Ferrante. The case drew considerable attention when Italian journalist Claudio Gatti controversially traced the royalties for Ferrante's books to Anita Raja, translator of German literature living in Rome. Kraków stylometrists and their colleagues from other countries gathered at a seminar hosted by the university of Padua in 2017, took on this case and with the help of far less invasive methods determined that Elena Ferrante is actually Domenico Starnone, Italian writer who is Anita Raja's husband. Anita Raja for years helped her husband in the editing of his books – what might explain the outcome of Gatti's financial investigation – or maybe Ferrante's novels are in fact authored by the couple together? Both of them deny having anything to do with these novels. And again: the literary investigation carries on.

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The Institute of English Studies at the Jagiellonian University is one of few academic centres in Poland where stylometric research is carried out, and where MA projects on stylometry are completed on regular basis (supervised by Prof. Jan Rybicki). In the recent years, the Polish National Science Centre financed two 'stylometric' research OPUS projects: *Film Genre and Audio-visual Translation Strategies. A Case Study: Historical Film* (principal investigator: Prof. Agata Hołobut, investigators: Prof. Jan Rybicki and Prof. Monika Woźniak (La Sapienza University, Rome)) in 2013, and *Language of eighteen-century American Colonial sermons. A rhetorical and stylometric analysis* (principal investigator: Prof. Jan Rybicki, investigator: Prof. Michał Choiński) in 2014. In the former project, stylometry was used to compare and contrast film dialogues; in the latter, it was employed to investigate authorship, chronology and language of colonial Puritan sermons. The Institute of English Studies is represented by Prof. Jan Rybicki in COST Action CA16204 project *Distant Reading for European Literary History*, financed by the EU. Prof. Michał Choiński represents the Institute of English Studies in an international project *Network Analysis and Spatial Stylometry in American Drama Studies* carried out in cooperation with the University of Potsdam and Staatsbibliothek in Göttingen. Stylometric research is also an important part of prelab Digital Humanities which is being formed at the Jagiellonian University as part of the Strategic Program Excellence Initiative: Digital World. The importance of the Kraków stylometric hub was confirmed by the Alliance of Digital Humanities Organizations (ADHO), which chose the Jagiellonian University as the host for its annual congress in 2016.



**Copernicus  
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of the Jagiellonian University



”

The beauty of research adventure lies in the fact  
that there will always be new questions to answer.

”

— Michał Heller

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BACKGROUND NOISE

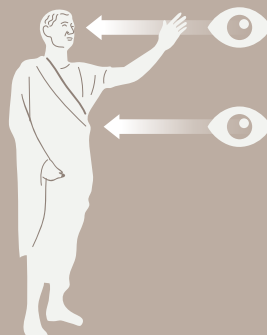


FORUM ROMANUM



max. 1,500

VISIBILITY OF  
FACIAL  
EXPRESSIONS  
AND GESTURES



**HOW MANY ROMANS  
COULD HEAR CICERO'S SPEECH?**

**Both ancient sources and modern history shows often share visions of inspirational speeches delivered to crowds of soldiers or ordinary people, such as the speech of Russell Crowe's general Maximus before the opening battle of *Gladiator* (2000). These speeches are so powerful that sometimes the viewer himself wants to help the protagonists achieve their goals. But if you look at them a little closer, you begin to wonder how many of the people in the crowd actually could hear what the speakers were talking about. Perhaps, in fact, such speeches were more like a parody of the Sermon on the Mount from *The Life of Brian* (1979), where people standing far from the speaker not only misheard and distorted the protagonist's words, but even silenced him.**

As political and military speeches played an important role in ancient Rome, an interdisciplinary team led by Dr Kamil Kopij from the JU Institute of Archaeology decided to study the abovementioned issue. But how to do it when ancient sources are usually silent about the number of listeners, at best indicating that the crowd was large or small? 'Nowadays, the size of the gathering is estimated by algorithms on the basis of, for example, images from a UAV', explains the project manager. 'Unfortunately, until we have a time machine at our disposal, this method is out of the question'. Until now, all estimates of the size of the gathered Roman crowd were based only on calculating the maximum capacity of the space in which the speech was delivered. However, this method does not work for large venues, such as the Roman Forum, which could hold 15,000–30,000 people, depending on the density of the crowd. Certainly not all of them could hear the speaker intelligibly, even more so because the larger the crowd, the louder they behaved, thus drowning out the speaker's voice.

'We decided to approach the problem differently, using acoustic simulations. In order to carry them out, we need 3D virtual reconstructions of the venues we are interested in which reproduce their appearance in antiquity', explains Dr Kopij. As part of the project, the team is reconstructing the Roman Forum in two different historical periods, as well as principia – the headquarters – of Roman camps in Novae in Bulgaria and Dajaniya in Jordan. 'Our preliminary results, which we still have to verify, show that a speech delivered at Forum Romanum could have been heard by several hundred people, about 1,500 at most, depending on the background noise, i.e. the noise generated by the crowd itself and the sounds of the city', Dr Kopij adds.

The acoustic simulations are run using specialised software applied to study today's concert halls or theatres. To make them as realistic as possible, in addition to the geometry of the space, it is necessary to take into ac-

count some other factors, such as the background noise. Thanks to these procedures, it is possible to determine the Speech Transmission Index for each place of the analysed space. This measure shows how well human speech is heard in a given place.

However, reading Roman rhetorical treatises (such as Cicero's *De Oratore* or Quintilian's *Institutio Oratoria*) indicates that in addition to words themselves, gesture was also extremely important to the art of speaking. Therefore, in addition to the acoustic simulations, the team will also carry out an analysis of the visibility of gestures. 'As it turned out that, apart from studies of the visibility of facial expressions, no research has so far been conducted into the maximum distance from which various hand gestures are visible, we were forced to conduct a series of our own experiments', says Dr Kopij. 'Although we based them on gestures taken from Roman treatises, the results will be universal and can be applied to any historical period', he added.

Based on acoustic simulations and visibility analyses, Dr Kopij's team will estimate the size of the crowd, taking into account contemporary knowledge of how people behave in similar situations. As a result, they will find out how many Romans could have heard the great speeches Cicero or Caesar made in front of the Roman people and soldiers.

### i

Project carried out as part of the National Science Centre programme SONATA 15, grant: *Raz, dwa, trzy! Czy wszyscy mnie słyszą? Czy wszyscy mnie widzą? – akustyka i proksemika rzymskich contiones* [Can everybody hear me? Can everybody see me? Acoustics and proxemics of Roman contiones] UMO-2019/35/D/HS3/00105.

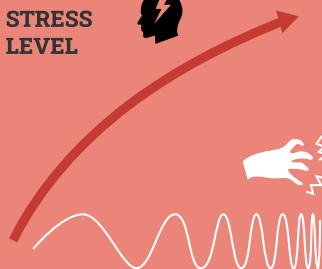
#### Team members:

Dr Kamil Kopij – JU Institute of Archaeology  
Dr Adam Pilch – AGH Laboratory of Technical Acoustics Science  
Kaja Głomb – JU Institute of Applied Psychology  
Monika Drab – PhD student at the Wrocław University of Science and Technology  
Szymon Popławski – PhD student at the Wrocław University of Science and Technology

WOUNDS,  
SCARS,  
INFECTION,  
STRESS

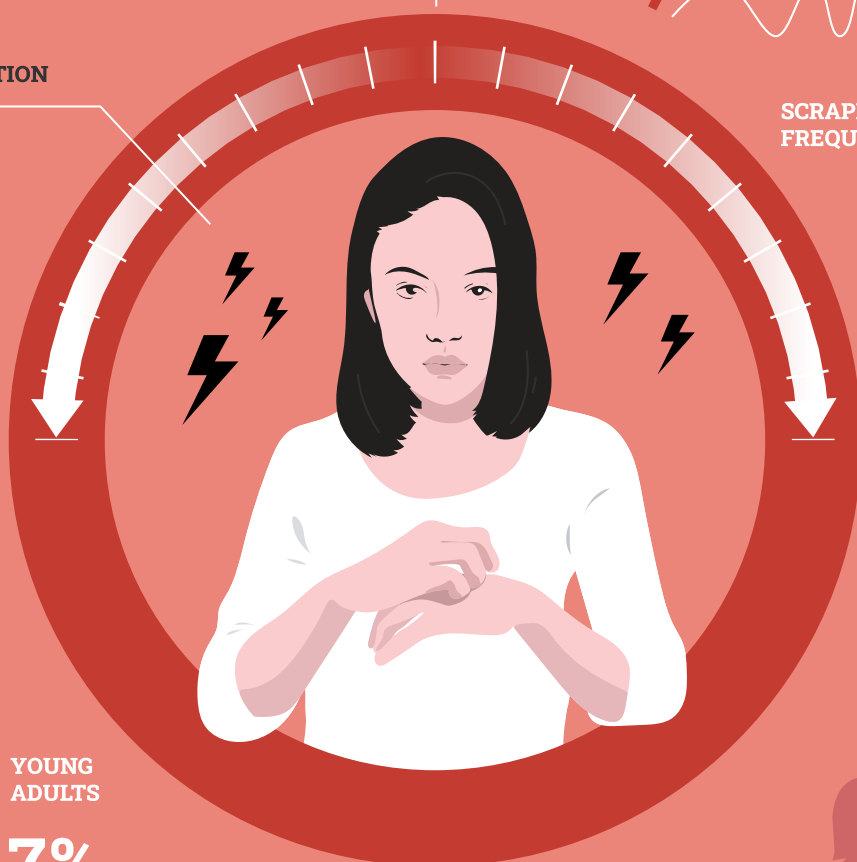


STRESS  
LEVEL



STRESS  
LEVEL  
REGULATION

SCRAPING  
FREQUENCY



YOUNG  
ADULTS

7%



47%

OF THE POPULATION  
EXHIBITS SUBCLINICAL  
VARIETIES



**DERMATILLOMANIA:  
WHEN STRESS GETS  
UNDER YOUR SKIN**

**Most of us know people who are prone to biting their fingernails or scratching their skin when they feel nervous. In most cases, this type of behaviour, though it may be viewed as unseemly, is not dangerous to the well-being of those people. However, it sometimes spirals out of control, reaching an intensity that bears the hallmarks of a mental disorder.**

In 2013, the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders published by the American Psychiatric Association introduced a new type of illness: excoriation disorder, also known as dermatillomania. People suffering from this condition are compelled to scratch their skin which they are usually powerless to curb or prevent. Scratching leads to wounds, scars and infections, causing stress and difficulties in everyday life. To properly diagnose dermatillomania, it is first necessary to exclude other causes (e.g. skin conditions).

During the last few years, the number of studies regarding this disorder has risen considerably, but its causes are still largely unknown. We also still do not know how to ameliorate the symptoms. Researchers are working on verifying the hypothesis that some people treat the behaviours associated with excoriation disorder as a strategy for regulating the level of arousal. In other words, the aim of these behaviours, sometimes engaged in consciously and sometimes not, may be to reduce tension or stimulate the organism and reduce boredom. This may be particularly visible in people who experience such state more often due to their temperament characteristics. In their projects, researchers take into account various categories of arousal: not only do they ask the

volunteers about their emotions, energy levels and mood, but also include more objective indicators of stress (e.g. the level of cortisol). Additionally, they check how the intensity of scratching changes in situations involving increased feelings of threat or stimulus deprivation (like during the pandemic lockdown).

An interesting part of the dermatillomania research is the investigation of how employing some strategies of emotional management affects the frequency of compulsive skin scratching. Can we control this behaviour by using any particular method of stress management? Would it be possible to ease the symptoms of excoriation disorder if we 'blow off some steam' through physical activity? Research shows that people who try to look for positive aspects in a situation (i.e. deal with negative emotions through what is known as cognitive reappraisal) are less heavily affected by compulsive skin scratching. This seems to be particularly important in the design of therapeutic intervention programmes that can ameliorate the symptoms of dermatillomania. A study carried out in Poland in 2016 suggests that excoriation disorder might affect as much as 7% of adults, while its mild, subclinical varieties can be found in 47% of the population.

#### i

The project "Body-Focused Repetitive Behaviours (BFRBs). Risk Factors, Prevention, Treatment" is carried out by Dr hab. Katarzyna Prochwicz, Prof. UJ and Dr Joanna Kłosowska at the Department of Clinical Psychology of the Institute of Psychology at the JU Faculty of Philosophy

**Bruno  
Latour**

**Tomasz  
Zan**

**Izys  
Polska**

**Dziady  
part III**

**Electric fluid**  
Józef Osiński

**Collège de France**

**BETWEEN SCIENCE  
AND LITERATURE:  
HOW ELECTRICITY INFLUENCED  
POLISH ROMANTICISM**



**Studying the history of science can enhance the knowledge of culture. This is also the case with the Romantic era. Research into electricity can yield new information about social actors and figures of imagination which paved the way towards new sensibility in literature and philosophy.**

Let us imagine that before the outbreak of November Uprising (armed Polish rebellion against the Russian rule in 1830–1831) Adam Mickiewicz (the poet considered one of the ‘national bards’ of the Polish Romanticism) publishes an epic poem *Frankenstein*, telling a story of the ‘modern Prometheus’ – a young scientist using electricity to realise his ‘alchemical’ dream of creating a new human. This seems rather impossible: after all, Mickiewicz was mainly concerned with the concept of Polish martyrdom, and Romanticism was a movement ideologically opposed to the scientific vision of the world, preferring myths about return to nature.

Light, power, attraction (and repulsion), spark and wind – according to Józef Osiński’s writings from 1777, these were the signs of an electric fluid – a newly discovered substance, which was invisible and ‘spilled’ all over the natural world. These features were identified by scientists during experimental research conducted at universities in Kraków, Warsaw and Vilnius. They also studied a number of related issues, such as electrical conductivity and reflected on controversies linked to generating electric power by the human body (‘animal electricity’).

In 1826, an author of an article published in the popular periodical *Izys Polska* argued that mankind would soon witness the intensification of ‘electro-galvanic relations’ between bodies, which was reflected in cases of people burning alive as a result of spontaneous combustions. Unsurprisingly, features of electricity derived from science were used to describe some crucial social phenomena.

So far, literary historians found little interest in the micro-histories featuring electricity. Electricity was a social actor, in the sense of the term adopted by science and technology studies scholars, like Bruno Latour, as it was part of Romantic culture, considered a real being (according to some approaches the electric current was understood as a chemical element). As such, it was a subject of experiments, topic of discussions, a category of imagination and a language metaphor. All these aspects were intertwined and even played a role in the formation of certain social movements, like the Vilnius-based Radiant Association (*Związek Promienistych*), led by Tomasz Zan, with Adam Mickiewicz among its members.

Although Mickiewicz did not author *Frankenstein*, the third part of his poetic drama *Dziady*, includes the motif of the creation of a new man using figures derived from the electricity-related discourse. His new Prometheus burns with an internal fire, which at the end of the drama transforms into a thunder striking a traitor. Electricity as a metaphor for spirit was also referred to by Mickiewicz during his Slavonic Literature course in Collège de France. Other Polish Messianists, such as Juliusz Słowacki, August Cieszkowski, or Bronisław Trentowski, elevated the science of electricity to the rank of revelation heralding the coming of the Kingdom of God on Earth. Hence, studying various aspects of the relationship of Romantic literature and Messianist philosophy with electricity can provide new insights into the origins of these thought currents, which were crucial for the history of Polish culture.

# i

Piotr Urbanowicz conducts research in the Chair in Performance Studies at the JU Faculty of Polish Studies. He attempts to show that Polish Romantics and Messianist philosophers of the first half of the 19th century were considerably influenced by the science of electricity. Based on physics and chemistry textbooks, press articles and key works of Romanticism and Messianism, he analyses metaphors of electricity, their origins, semantic range, and functions.



|| ART IN A BOX  
OF CHOCOLATES

**Polish art in the 18th century includes pieces that can be seen as achievements on the European level. Lvivian rococo sculptures are a unique trend in modern sculpting; however, due to the outbreak of the Second World War and the following period of Communist rule in both Poland and Ukraine, any research on it was stopped. Thankfully, political transformations in both countries have made it possible again. Currently, the third generation of art historians investigate this aspect of our cultural heritage at the Jagiellonian University.**

### Genius expression

Lvivian rococo sculptures are unique in Europe thanks to masterful execution coupled with exquisite artistic values. Sculptures that are part of church decorations in the area of the former Ruthenian Voivodeship are the examples of the most expressive and dynamic style in the early modern European art. One of the trademarks of the Lvivian rococo sculpture are sharply, dynamically and almost ‘metallically’ shaped robe folds of the sculpted characters – indeed, they can be compared to ‘the bodywork of a crashed car’. The faces of the characters show strong emotions, and their gestures are forceful and energetic.

### Facing history

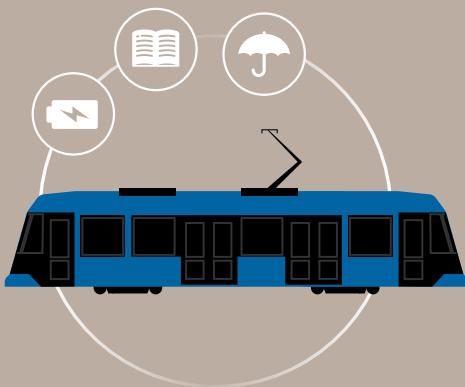
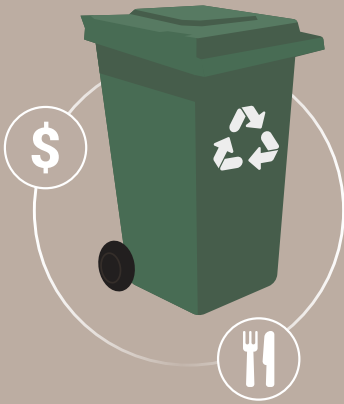
A large part of our cultural heritage was irretrievably lost during World War II. Therefore, it is all the more important to study the pieces that remain in order to help understand our art and history. To solve this ‘artistic-his-

torical puzzle’, it is necessary to gather as much information as possible. For a historian, sculptures may provide that information; however, they are often hidden in attics, locked away in museum storage, or fixed in place in their original location, which sometimes makes them hard to access. Nevertheless, once that happens, it is still essential to follow up the field research by studying written sources that can help understand the context behind a specific artwork. This involves days of investigative work on manuscripts, books, church inventories and ledgers – each of those is like a box of chocolates that may contain unexpected ‘delicacies’. Throughout the course of their investigation, historians gather a plethora of little facts that enrich the story of an artistic piece. It could be said that by studying our cultural heritage, we are faced with history itself in the form of written documents and works of art, taking a closer look at the building blocks of our cultural identity.

### i

Dr Agata Dworzak

Assistant professor at the Department of Early Modern Art History of the JU Institute of Art History. Her interests include early modern art, especially Lviv-based art in the 18th century, sculpture and architecture on former Polish territories, early modern artist families as well as ornamental graphics, ornament theory and design.



**CITY EXPERIENCED  
IN A HOMELESS SITUATION**

**It is estimated that there are over 1,000 homeless people in Kraków. How does the city look like from their perspective? The issue is investigated by Natalia Martini from the JU Institute of Sociology within the framework of a research project carried out with the participation of homeless Cracovians.**

The area surrounding the AGH University of Science and Technology student dormitories, where scrap can be collected in the evening to be carried several kilometres and sold at a junkyard which opens at dawn. A bench in Jordan Park, where you can sleep during the day after a busy night. The space around street performers at the Main Square, where you can take a breath from everyday worries. Galeria Krakowska shopping mall, where you can find shelter from heat in the summer and cold in the winter. And connecting all of those: a tram, where you can charge up your phone or read before you sleep. Between these places, there are also many invisible barriers and obstacles that need to be negotiated simply to be accepted in the public space and use it according to one's needs and capabilities. These few sentences sum up the image of Kraków as seen by its homeless inhabitants.

The research project conducted by JU sociologists shows that the city as a living space is not a uniform environment. The same elements of the urban fabric can be perceived differently based on diverse habitation practices. However, only some of those practices

become part of the normative order that determines the 'proper' meaning of urban settings, where one is expected to perform certain actions (e.g. shop for groceries) or play a specific role (e.g. be a consumer). As a result, the right to use those spaces is reserved solely for people in a specific social role. The presence of anyone who is either unwilling or unable to fill that role is seen as out of place.

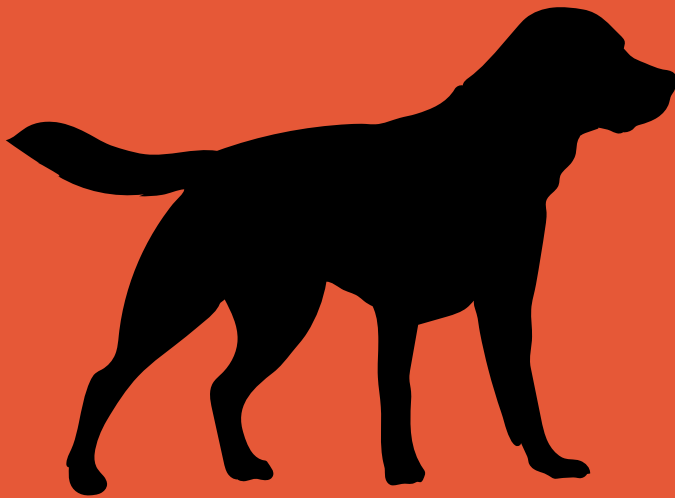
The way homeless people use public spaces and facilities such as shopping malls, libraries or buses often lies beyond what is considered a norm in these places. The everyday experience of the homeless inhabitants of Kraków points towards a correlation between transgressing the normative order in public spaces and restrictions placed upon their rights to use those public spaces and, consequently, to live in a city the way they want and need. In this context, it is worthwhile to mention that every normative order is based on an informal, conventional social contract. And every convention can be changed, in this case, with the aim of making the cities inclusive to everyone, not only to the privileged inhabitants.

# i

The project *Miasto doświadczane w sytuacji bezdomności. Studium społeczno-przestrzenne* [City as experienced in a homeless situation. A social-spatial study] is funded by the National Science Centre (2016/23/N/HS6/00810).

More information can be found at this website: <https://homeless-city.project.uj.edu.pl/>

**pies**



**dog**

**MOST OF US  
ARE BILINGUAL**

**Today bilingualism is almost as common as having a driving licence. What's interesting, is that it significantly impacts our behaviour, communication, and even health. The LangUsta Lab at the JU Institute of Psychology conducts research into how bilingualism, both acquired from birth and at later age, influences the functioning of our brains.**

Everybody who, either by choice or by necessity, has used a foreign language for a longer period of time has probably experienced a strange feeling when they switched back to their mother tongue. It suddenly turned out that it is very difficult to articulate their thoughts in their mother tongue without making mistakes. For some reason, the sentences tended to have a strange, foreign structure, which made them very hard to finish.

The problem of sudden difficulties in using mother tongue is quite common among people staying abroad. Research has shown that even a short conversation in a foreign language triggers considerable changes in the brain. All available evidence suggests that during such a chat access to the mother tongue becomes reduced. The question arises: is this state temporary or permanent? Fortunately, there is no reason to worry. Freedom in communicating in a mother tongue will come back with time. Yet, it will happen only when the brain readjusts to this language again. For a cognitive psychologist, this temporary difficulty in communication leads to a number of interesting research questions: Which parts of a language do we forget first? What can facilitate this process? Do all people forget language equally fast? Or does this happen faster in some of them? Does this temporary reduction in language skills have some impact on the work of brain in general? Is it possible

to retain native language skills until late old age without everyday contact with this language?

Even a short-term contact with a foreign language modifies our cognitive functioning. Command of a foreign language is not just another skill to list on a CV. The changes it causes on a neuronal, behavioural and social level have been indicated by numerous studies and can be observed even after a short period of learning. Researchers are working to better understand the functioning of a bilingual mind, and especially the experience of an intense contact with another language. The process of losing proficiency in a native language after emigration (known as language attrition) reveals the mechanisms of human mind. Hence, the problems of people who had to take a longer break in using their mother tongue are of special interest to researchers.

The processes of immersion in a foreign language are simulated in Kraków laboratory, which allows researchers to precisely track the dynamics of changes in brain activity. To achieve this goal, they are using not only behavioural methods, but, with the help of magnetic resonance imaging (fMRI) and electroencephalography, they are also able to observe even the most subtle changes occurring in the brain of a person who changes the 'linguistic environment'.

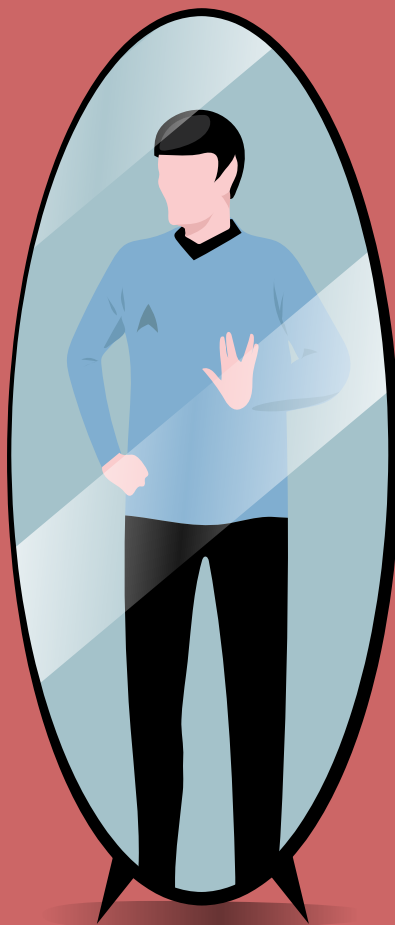
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The Psychology of Language and Bilingualism Lab in Kraków is run by 15 researchers, 6 of whom are from outside Poland. The team is also engaged in very active international collaboration, including participation in two large consortium projects, such as 'The Multilingual Mind' Innovative Training Networks – an interdisciplinary polycentric doctoral school in bilingualism funded from Horizon 2020 programme, and an initiative funded by the National Science Foundation (US) within the framework of the Partnership for Research and Innovations project run by the Pennsylvania State University and University of California, Irvine. The Lab also runs projects funded by the National Science Centre (Poland) in collaboration with other institutions, such as the University of Edinburgh, with which it studies the changes in Polish language among Polish emigrants living abroad. In 2018 a branch of the Bilingualism Matters centre was created based on the Lab's research. The centre aims to promote scholarly knowledge on multilingualism and improve the well-being of people using more than one language on everyday basis. Currently, the Bilingualism Matters network brings together almost 30 institutions from various countries.

NOW



FUTURE



**POLITICS IN SCIENCE FICTION:  
WHAT THE 'FUTURE'  
CAN TELL US ABOUT THE PRESENT**



**Imagine a future society. Will money still be used? What will the governmental system be like? Will nation states still exist? Will they have their own territories? What would a war without a territory look like?**

Science fiction does not answer these questions, but instead, it reflects how people at a certain point in history, living under certain social and political circumstances, imagine the future and new kinds of worlds. Leading science fiction scholars point out that the genre has a very long tradition, as it stems from utopia. Literary utopias have never aimed to describe a beautiful fictional world, but indicated what needs to be changed in our own world in order to make it better. Conversely, dystopias or anti-utopias, very roughly speaking, serve as warnings against what might happen if the current trends continue or if some ideas are implemented by force. Adopting this perspective, many science fiction scholars consider it to be a fundamentally political genre. Science fiction allows us to change our perspective and turn our attention to what we fail to notice in everyday life, e.g. inequality, violence, or exclusion. These problems can only be addressed when they are acknowledged.

Yet, does the very fact that some cultural texts include political metaphors, mean that they influence their recipients? Do all of them actually notice the presence of politics in the text?

The research carried out at the JU Faculty of Polish Studies concentrates on science fiction fans, a group of most committed audience members who analyse texts in detail and whose commitment to these texts becomes part of their own identity. Etymologically, the word 'fan' can be traced back to 'fanatic'. Studies on this group (fan studies) contradict stereotypes of passive and thoughtless pop-culture consumers. Instead, the fans are often praised as model recipients and... citizens. They form their own social and even economic structures. What is more, they have more and more influence on creators and their pressure can result in producing another season of a TV series or bringing their favourite character back to life.

The Star Trek fan community constitutes a basic point of reference for fan studies as a key example of left-wing potential of fandom, a minority-friendly space, and an illustration of how the marginalised can become emancipated. When approaching Star Trek from

the perspective of science fiction studies, as a complex left-wing metaphor, it should be remembered that metaphors by definition require interpretations, and there can be a lot of them. Thus the fan reception of Star Trek and its political message is an area of research aimed to explain how it is possible that a lot of dedicated fans of the socialist utopia are in fact very conservative. It turned out that a series about the world where borders and nation states have been abolished could be used by its fans, for instance, to promote the presidency of Donald Trump, who promised to build a wall along the US-Mexico border.

When studying this issue, it is important to bear in mind that different recipients can respond differently to the same text. It is possible to identify various types of fans' approaches to the object of their fascination. Some of them might understand the text in an opposite way to what has been intended by the authors. Others, which is very common, may not look for any hidden meanings and even refuse to notice them, as politics would spoil the fun of an escapist fantasy. This means ignoring or rejecting metaphors hidden in a given narration and limiting oneself to the most direct meaning, which actually attracts most fans to the text. Regardless of political views, people rarely become fans of a given text because of the message conveyed through metaphors. A fan is first of all a fan of the 'building blocks' of which the metaphor is composed: fictional objects, places, characters, spaceships, alien planets and races inhabiting them, etc. After all, this is what attracts most people to the fictional universe.

Another interesting issue is the impact of fan reception and the resultant expectations about what fans are fascinated with. Fans are the most attractive target audience for large media corporations, as they buy lots of merchandise, which brings more profit than movies or TV series. While a spaceship or insignia of a fictional organisation can easily be converted into a neat gadget, the same cannot be said about a metaphor. Hence, the most beneficial strategy is drawing the viewers' attention to the literal content and producing new parts of movies, TV series or video games with a maximum amount of content that could later be sold in the form of gadgets.

Finally, and perhaps most importantly, if metaphors related to the sources of evil and injustice in the real world are gone from the text, the fictional reality starts to increasingly resemble the real world. What will happen if science fiction becomes limited to imaginary worlds with more advanced technology, but without any considerable changes in the social sphere? What if we lose the ability to imagine a different future and

the envisioned change becomes limited to faster cars and faster computers? Will we only shrug our shoulders and decide that the existing injustices cannot be remedied and it is time to get used to them? The research aims not only to describe the former visions of the future and how they have been perceived, but also to ask questions on whether there are any prospects at all for a new radically different future for our society.

**i**

Agnieszka Urbańczyk, Faculty of Polish Studies at the Jagiellonian University. The project *Polityczność science fiction w recepcji fanowskiej* [The Politics of the Science Fiction Genre in Fan Reception] is carried out within the framework of Diamentowy Grant (Diamond Grant) programme.



**nauka  
w pigułce**

**Nauka w pigułce ("science pill") is a cycle of debates devoted to psychoactive agents, featuring pharmacologists, cultural studies scholars, and psychologists (website in Polish).**

**[lux.psychologia.uj.edu.pl](http://lux.psychologia.uj.edu.pl)**

**The project is run by the JU Institute of Psychology**

## MEMORY

AUTOBIOGRAPHICAL

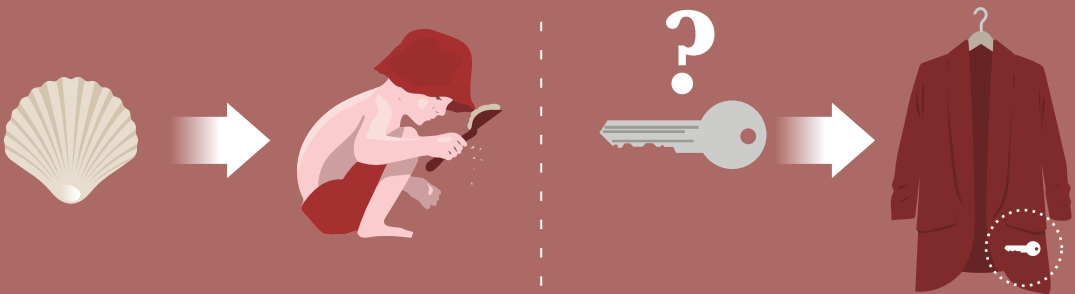
EPISODIC



## REMEMBERING

VOLUNTARY

INVOLUNTARY



**MEMORIES  
WON'T REMEMBER THEMSELVES**

**Phenomena related to recalling events from both individual and collective memory have been a subject of psychological studies for many years. On the one hand, our memories may relate to things that happened to us in the past, on the other – many events are also a part of collective, societal memory that shapes cultures, traditions and identities. These two issues intertwine with and supplement each other, allowing us to remember the past.**

Every day, we recall a lot of useful information. We remember where we put the keys to our apartment and when we are going to have an appointment at work. More broadly, we remember about the COVID-19 pandemic and the restrictions enforced to combat it. We are not always consciously aware of it – most of such processes usually ‘run in the background’. Our everyday life consists mostly of storing various information and recalling them when they are useful. Paradoxically, we become aware of that fact when we cannot remember something, e.g. if we have already paid our monthly bills or where exactly we have parked our car. It is in these situations that we realise how important our memory is and how much we rely on it. It is also important for another reason: it has a huge impact on our behaviour.

Our memory can be classified into various categories based on the kind of information we try to remember. In their study, JU researchers are focused mostly on two of them. The first one, episodic memory, is related to general information about events that occurred in specific times and places. This allows us to stay updated about what happens in the world and in our environment, even if we have not personally experienced the given event. In the context of the COVID-19 pandemic, researchers are investigating which issues will dominate our memories, how it may affect our perception of the past and if we are going to divide our memories into those that happened before and after the epidemiological crisis.

In a more general context, researchers are also looking at how we remember our historical past and its important events, such as the Second World War. Can there even be a consensus about such an event in the collective memories of states that participated in the war (like Germany, Russia, Japan, Italy, Great Britain, the United States, France, or Poland), or does every country have its own narrative, which is to a certain degree incompatible with others? Historians usually agree that the history of every country can be somewhat objectively described by pointing to events that happened in its past. However, it turns out that such objectivity is not often reflected by societies and the individuals that form them. Therefore, studying the way in which people remember historical events can contribute to a greater understanding of current political

situation and its development as well as societal attitude towards various issues in a particular historical context.

The second type of memory, called autobiographical memory, allows us to remember events from our personal past. This type of memory is key for building our own identity: who we know we are and what/who we feel we are. It is important both for our relations with other people and with society at large. As part of their studies of autobiographical memory, researchers are focused on two main processes of remembering: voluntary and involuntary. The first one happens when, for instance, we try to recall the holiday we went on a few years ago. The second one occurs when we are not actively trying to remember something, therefore they are often accompanied by a feeling of surprise. Involuntary memories are caused by a number of cues related to our past, which we can randomly encounter. These can be images, words or objects. On the basis of their experiments, researchers posit that involuntary memories are more often related to positive experiences. In their projects, they are trying to explain how such involuntary memories are formed, why they are mostly tied to positive feelings and what mechanisms could make them undesirable in our everyday lives.

In their studies, JU researchers are employing a series of experimental methods that will help us understand how we are remembering personal and general events, and what we are able to successfully recall. Memory and the ability to remember seem to be extremely important for our daily lives.

### i

Research in episodic and autobiographical memory is led and coordinated by Dr Krystian Brzykowski at the JU Faculty of Philosophy/Institute of Psychology. They are realised within the framework of the Applied Memory Research Laboratory ([www.memorylab.phils.uj.edu.pl](http://www.memorylab.phils.uj.edu.pl)) led by Prof. Dr hab. Agnieszka Niedźwieńska. They receive their funding from the National Science Centre, Poland (e.g., 2019/35/B/HS6/00528, 2015/19/D/HS6/00641, 2011/01/N/HS6/02370), the Polish National Agency for Academic Exchange (e.g. PPN/BEK/2019/1/00092/U/00001) and the JU Faculty of Philosophy (e.g. K/DSC/003323, K/DSC/004091, K/DSC/004788, K/DSC/005597). The research projects are carried out in collaboration with researchers from Denmark, France, Greece, Germany, the USA, New Zealand, Turkey, Great Britain and Italy).



**ROBOTS AND CRIMES –  
HOW TO ORGANISE  
HUMAN-ROBOT INTERACTIONS?**

## How to organize everyday life next to robots? Mutual interactions between humans and robots raise a number of important legal and ethical questions.

Robots are increasingly becoming part of our everyday lives. The most striking examples include the granting of Saudi citizenship to a humanoid robot named Sophia, robot dogs from Boston Dynamics used to enforce social distancing during pandemic in Singapore, and autonomous cars that are being tested in more and more countries.

We create robots mainly to make our lives easier and safer. They usually take over laborious and unrewarding tasks or provide entertainment. Generally, most of our interactions with them can be considered positive. Yet, sometimes they may go wrong. Similarly to crime, which exists on the margins of society, pathological situations can also occur on the fringes of our interactions with robots. 'Crimes' committed by robots are no longer a pure abstraction, as showcased, for instance, by accidents caused by autonomous cars. Robots can also become crime 'victims', as it has been indicated that people feel empathy towards them when they see them 'suffer'.

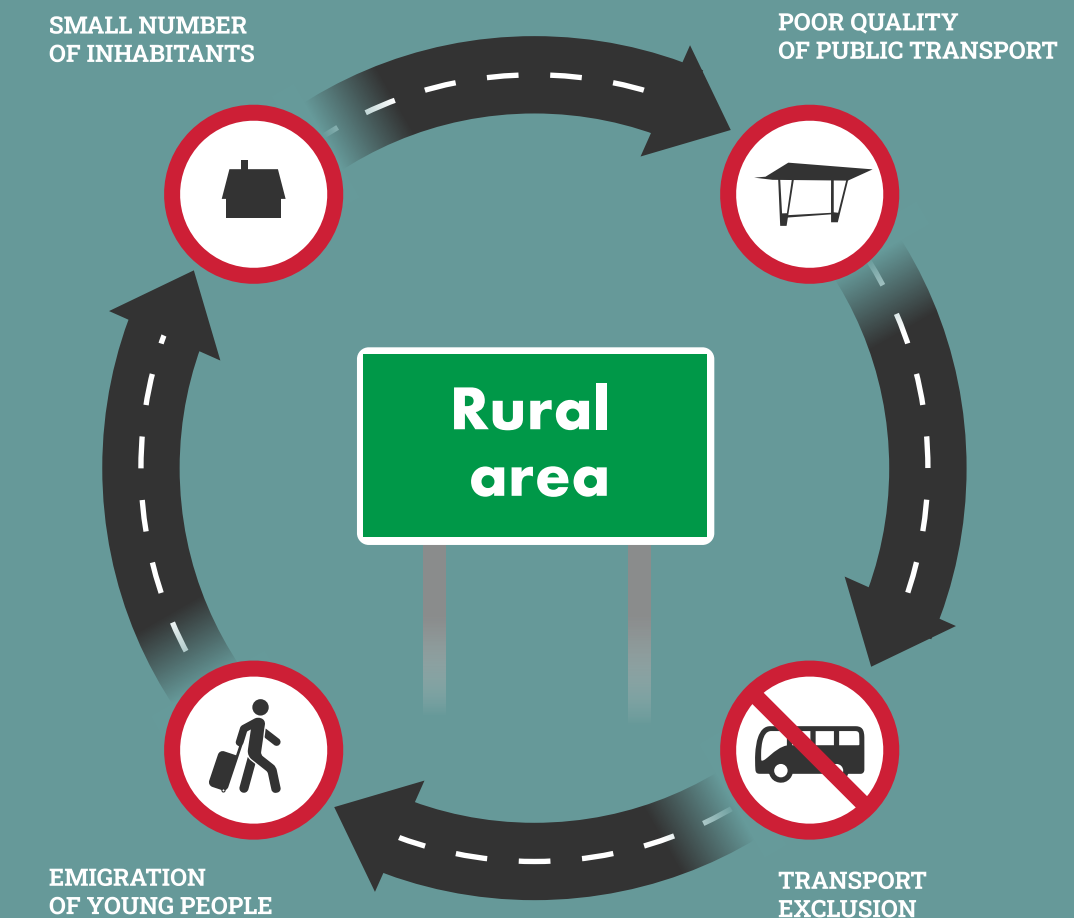
What does it mean for criminal law? Are robots something extraordinary from the legal point of view? It might be argued that nothing should change and robots are just objects that can be used as tools to commit crimes or become the subject of crime themselves. Yet, there is something specific in robots that makes the public perceive them differently to other objects. Some people think that this is enough to treat them differently. Maybe they should even be granted rights? The case of robots becomes even more complicated if we assume that in the future they may acquire their own inner life. This could lead to a number of dilemmas. For instance, who should be responsible for the robots' behaviour? Maybe the robots themselves? If so, how should they be punished? Our interactions with them may lead to a number of ethical and legal questions which will have to be answered sooner or later

### i

Dr Kamil Mamak, JU Chair in Criminal Law

Mini-grant competition POB FutureSoc – Future Law Lab (FLL)  
*'Prawo wobec wyzwań współczesności, nowoczesności i przyszłości' Roboty i przestępstwa. Aspekty etyczne i prawne* [Law faced with contemporary, modern, and future challenges' Robots and crimes. Ethical and legal aspects]

website: [criminalfuture.com](http://criminalfuture.com)



**ON THE PERIPHERY:  
THE PROBLEM  
OF TRANSPORT EXCLUSION**



**Travelling to certain places can pose a serious challenge to many people, especially those living far away from large cities. In such areas car is not just a convenience, but a necessity enabling people to satisfy their basic needs.**

We all have to travel in order to meet our various needs. To do this, we use different means of transport. In large cities people often travel to various centres – not only the very centre of the city, but also to shopping centres, commercial centres or administrative centres. The situation is different in rural, non-metropolitan areas (distant from large cities), as their inhabitants find it most important to be able to travel to a city (internal travel is less important because most key places are located close by). But how to get there?

Finding the answer is not always simple, as it turns out that as many as three out of four people living in non-metropolitan rural areas of Poland mainly travel by car, mostly as drivers. Only one out of ten uses means of public transport, such as buses or trains. About 5% travel by bicycle and 4% – on foot. This would suggest that car is the best means of transport in the countryside. Yet, this is far from true, as a significant part of the rural population is unable to use cars. These people are vulnerable to transport exclusion.

These problems could be remedied by an effective public transport system. Unfortunately, this is not the case in Poland, especially in the rural areas distant from urban centres. Currently, this kind of transport is regulated by the free market: an entrepreneur who decides to provide such services aims to minimise costs and maximise profits. In the aforementioned areas, the costs are high due to relatively large distances, and the profits are

low as there are relatively few passengers. Hence, few companies offer public transport services there.

This phenomenon is part of the so-called public transport vicious circle (fig. 1). Low quality of mass transit contributes to transport exclusion of certain parts of society. This leads to an increased migration to areas with better transport options, mostly by young people, which, in turn, results in the depopulation of non-metropolitan areas. As those who leave are mainly young people, likely to have children in the near future, there will be even fewer people living in these areas in the years to come, which will mean lower income for transport providers, even fewer trains or buses and further decline in the quality of public transport.

Difficulties in getting to cities largely stem from public transport solutions adopted in Poland, which do not work well in non-metropolitan rural areas. Many villages are not served by buses or trains, and even if they are, it is often necessary to walk several kilometres to reach the bus stop. This means that, for instance, in order to arrive at work or school before 8 o'clock one needs to take a 7 a.m. bus, which requires leaving home at about 6 a.m. Returning home is only possible by one or two buses, which often leave long after work or classes have finished. Thus, the only solution for many of the inhabitants would be to use their own cars, which is not always possible due to the lack of sufficient skills, driving rights or financial resources.

#### i

Lukasz Fiedeń  
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The research is funded by the Foundation for Polish Science within the framework of PRELUDIUM 15 competition (no. 2018/29/N/HS4/02742).



**A LEADER  
OF OUR DREAMS**

## Who should lead us? What are the differences between various types of leadership? What are we ready to accept and what only tempts us with illusions of effectiveness?

Leadership studies have a long history. The nature of 'good governance' was already reflected upon in ancient times, but empirical research into leadership traits started as late as the first decades of the 20th century, along with the reflections on the level of collaborators' involvement depending on situation.

The survey studies carried out for five years have indicated that both individuals and societies still perceive a leader as an 'alpha' male or female (irrespective of gender) – a charismatic individual, with a strong personality, capable of overcoming resistance, even with the use of coercion or violence. The list of 'top 10' leaders based on the surveys includes mainly historical figures who acted during wartime. They were highly effective, and often succeeded against the odds, even if their victories were short-lived. Most of them were authoritarian or totalitarian rulers, rather than democratic ones.

The situation only changes when the subjects are asked how people would like to be ruled. Then they start to point to completely different leaders than before, and the percentage of people willing to participate in the process governance rises significantly. For many years, there has been talk about the crisis of democracy or the crisis of leadership. Maybe the problem lies in the difference between the perception of leadership model and the model of governance we ourselves would like

to be subjected to? On the one hand, we would like a leader to be strong, decisive, well-oriented in the situation and achieving fast and brilliant victories (similarly to how some people believe in quick profit from pyramid schemes). Yet, on everyday basis, we cannot accept that someone could totally disregard the will of the people, e.g. do something without any public consultation or against the public.

Democracy, with its media-driven hunger for sensation and exaggeration of one-time events for commercial reasons, creates the sense of constant tension, which pushes the public towards strong leaders. On the other hand, participatory democracy, expecting our participation in governance and expecting us to have an opinion on all subjects, creates citizens who are unlikely to submit to this kind of leadership. Maybe this is the very reason for the crisis of democracy?

Maybe democracy needs different types of leaders? Competent managers, capable of inspiring others and cooperating with them? Persons eager to admit to their mistakes and to draw conclusions from them? Maybe this would also require a society willing to cooperate and solve problems by means of compromise? A society which understands that everybody makes mistakes and takes that into account? It will take some time before the full research results are known.





**YOGA: 'EXERCISING THE POWER  
OF SPIRIT OVER BODY'  
FOR THE GOOD OF THE NATION**

**In today's Poland, yoga is a widely practiced everyday activity. Almost all its practitioners perceive it as a way to relax, a remedy against stress, and a possible cure for back pain or stiff joints. However, only few people know that in the time when yoga first came to Poland – at the turn of the 19th and 20th centuries – it was supposed to play an entirely different role, as a strategy of national revival leading to the regaining of Polish independence and – in the long term – the betterment of the whole humankind.**

Research has shown that in Poland yoga was initially perceived as an exotic, if not weird, foreign practice undertaken by hermit 'fakirs', commonly referred to as 'penitents'. The image of yoga and its practitioners formed in that period copied the Western colonial, largely negative perspective of not only yoga and yogis, but also Indian ascetics and ascetism in general. This was par excellence an image of a stranger, who, for unknown reasons, tortures his body and, 'driven into frenzy', pierces his flesh with nails, burns himself, pours boiling oil on his wounds, hangs himself upside down, unnaturally twists his arms and legs, sits on a bed of nails or buries himself alive. At the same time, he was often considered a charlatan taking advantage of human naivety, or a parasite, useless 'like a roadside tree stump'.

Yet, as time progressed, the image of yoga in Poland started to change, influenced by new ideas that had emerged in Western esoteric, and, especially, Theosophical circles. It lost the stigma of foreignness and became 'domesticated'. Polish esotericists and some other non-mainstream thinkers interpreted yoga in the national, patriotic and messianic context. Yoga also became Christianised, or at least presented as a tradition parallel to Christianity. Hence, the idea started to be discussed using a new language. Its key aspects and concepts were redefined and adapted to Polish historical and cultural context. For instance, physical exercises (asanas) that were considered strange were presented as a spiritual practice, substituted with elements of gymnastics, or even given up altogether. Jesus Christ was put in place of a spiritual master (guru) and repeating mantras was replaced by prayers. Liberation (samadhi) lost its importance. Instead, yoga was viewed as a path to spiritual and moral perfection enabling full realisation of human potential, whereas yogic discipline was treated as a strategy of 'exercising the power of spirit over body' and a way to 'achieve knowledge, freedom and perfection by one's own power', a 'certain esoteric exercise, method of developing one's character, emotions, and thoughts – intellect, intuition, and will'. However, individual perfection was

not considered a goal in itself, but a means of achieving national revival (that is, regaining Polish independence and building a strong state), which would herald a new era in the history of mankind. In these visions, the reborn Poland was entrusted with a special mission from Providence: 'to create a living example of a reborn, highly spiritual human being, so that we truly become a Nation – a God's servant, Champions of the Cause, and Builders of God's Kingdom on Earth', as claimed by Józef Chobot (1875-1942) one of prominent Polish esotericists, who propagated yogic practice among his followers. There were also efforts to present yoga as an actually native tradition, seeing it as part of the 'ancient Aryan wisdom of our ancestors'. Due to these changes, yoga could be considered (and indeed was considered) possible to adopt and introduce to everyday life in Poland without giving up Polish national identity, or even changing it in any way. There were also voices claiming that the 'Polish yoga', distinct from its Indian counterpart, can only be practiced in Poland, since Poles are predisposed to do this by their race, language and the suffering of previous generations.

The first decades of the 20th century brought about practical implantation of these visions. Their creators, such as the philosopher and social activist Wincenty Lutosławski (1863–1954) and the photographer and parapsychologist Józef Świtkowski (1876–1942) turned to esoteric (Theosophical and anthroposophical) interpretations of yoga and used them as the basis for a consistent theory and method of the practice, which, in their opinion, addressed the specific conditions and needs of the Polish people (Lutosławski) and the modern Western man (Świtkowski). Both thinkers published their interpretations in the form of handbooks, containing descriptions of specific exercises, which together constituted the complete programme of the practice, along with numerous hints and pieces of advice, which could be considered a recipe against everyday problems. The readers treated both these books in this very way and many of them adopted yoga as their style and way of living.

The visions of the ‘Polish yoga’, as referred to by Lutosławski, were extremely diverse, and so were the effects attributed to this practice. Some perceived it as a method of personal refinement, a way towards perfection of emotions, thoughts, and will, which was to raise human consciousness to the sphere of pure spirit. For others, yoga was the ability to read the eternal laws of nature, accept them as the foundation for their own worldview, and behave accordingly, which would ensure achieving harmony on both personal and social level. Yet another group believed that yoga would allow the creation of a new human being, ‘renewed, reborn and spiritual’, who would create a brand new nation and a new better world. The practice of yoga also enabled transformation of specific social groups, which was of special interest to Lutosławski. By practicing yoga according to his guidelines, young people were supposed to learn discipline, so that they could serve the nation in the future, whereas workers were to discover a higher, spiritual dimension of their work. Using the recommended yogic

exercises was believed to make a woman the guardian of the hearth and above all, an ‘accumulator of prana, transmitting power to her husband, siblings, and parents’. It would also enable artists to overcome their fickle nature and fully develop their talents. Lutosławski even believed that the practice of yoga helped in the ‘difficult work of transforming the human being into a superior species’, not only in terms of moral and spiritual qualities, but also in a physical sense – yoga was to provide an opportunity to gradually improve subsequent generations of Poles and, finally, the whole mankind.

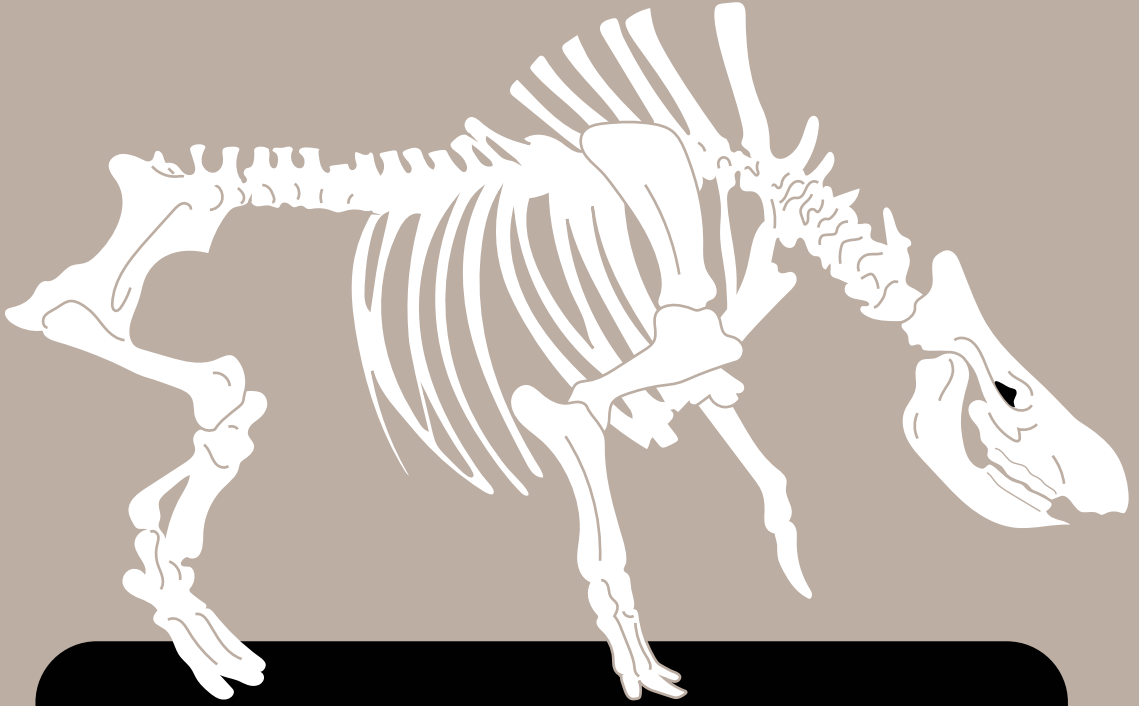
These visions were not purely theoretical ideas, as attempts were made to implement them to everyday practice. Besides textbooks, which provided step-by-step guidelines for individual practitioners, there emerged organisations bringing together such people, at least some of whom noticed positive results of their yoga practice. Yet, they did not manage to create a new human being...

# **i**

Agata Świerżowska is a religious studies scholar, historian of ideas, Associate Professor in Cultural and Religious Studies, academic staff member of the Centre for Comparative Studies of Civilizations of the Jagiellonian University. The results of her research into the earliest stages of yoga reception in Poland are presented in the monograph *Joga w Polsce od końca XIX wieku do 1939 roku: konteksty ezoteryczne i interpretacje* [Yoga in Poland from the late 19th century to 1939. Esoteric contexts and interpretations], Jagiellonian University Press, Kraków 2019.



Nature  
Education  
Centre

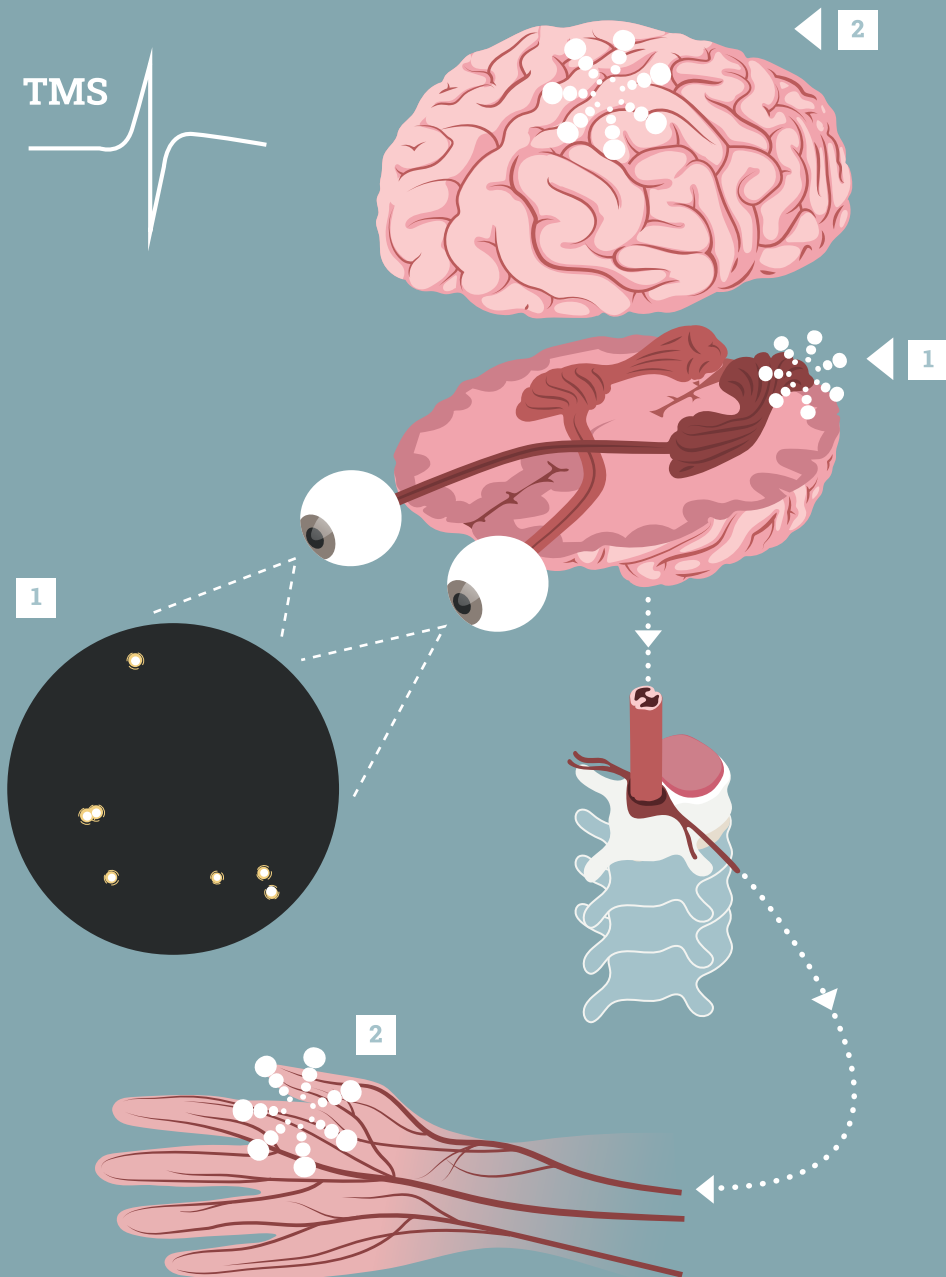


The JU Nature Education Centre is an extrafaculty unit which houses natural history collections previously kept in the Institute of Zoology and Biomedical Research, the Institute of Geological Sciences, and the Institute of Botany of the Jagiellonian University.



**/Centrum-Edukacji-Przyrodniczej-UJ**





**BRAIN STIMULATION  
CHANGES OUR AWARENESS**



**Explaining the mechanisms and neuronal basis of human consciousness is one of the greatest challenges in modern science. Attempting to understand our capacity to become aware of and analyse stimuli perceived by our senses is the main interest of consciousness researchers.**

How is it that when we see a round object, we are able to discern that it is a ball? Or that when we hear the sound of rolling, we can realise that it was made by that ball? The images created in our brain when we perceive things are the content of what we call 'visual awareness'. Because of it, we are able to point at the ball or catch it before we are even aware that it is coming our way. However, some stimuli are too fleeting or too weak to become fully and consciously registered, such as when the ball is one of multiple objects or it rolls too quietly. This is why researchers use subjective scales that allow the participants of their studies to subjectively assess the clarity with which they perceive certain stimuli.

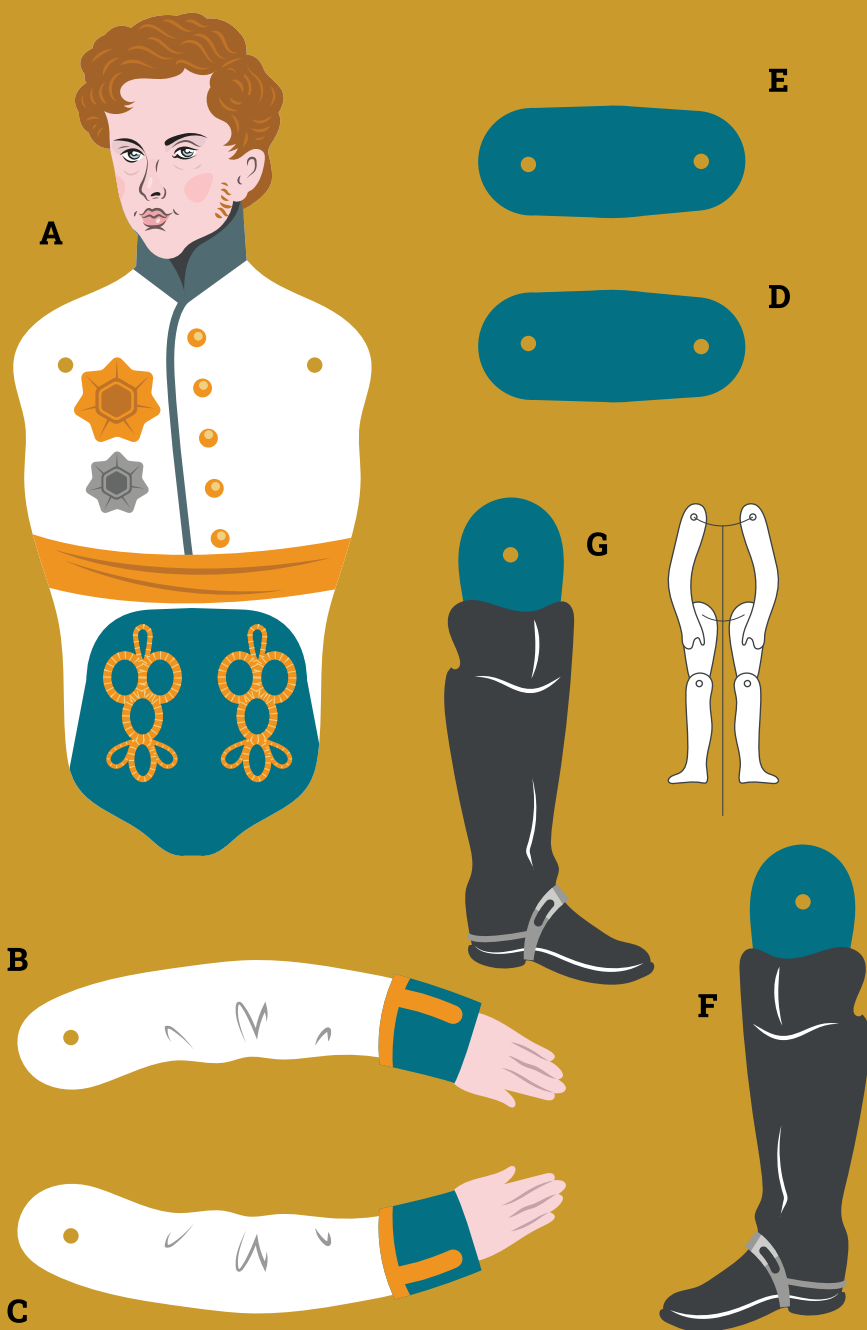
The brain is an organ that creates an image of the world for us. Nevertheless, the environment is first perceived by the retinas of our eyes. The information quickly reaches various parts of the brain, where neurons communicate with one another. Which parts of the brain are necessary and sufficient for visual awareness to arise? Researchers are still trying to answer that question. To that end, they measure the activity of particular areas of the brain using specialised techniques (like EEG and fMRI) in order to see how it changes based on how well we hear or see something.

There are methods that are used to externally influence brain activity. One of them is transcranial magnetic

stimulation (TMS). By way of electromagnetic induction, TMS can cause temporary changes in neuron activity in the desired part of the brain such as the occipital lobe or motor cortex, thereby affecting the processes that happen in those areas, effectively improving or impairing perception or memory.

Three studies carried out by the JU Institute of Psychology Consciousness Lab investigated how TMS-induced changes in different parts of the brain influence human visual consciousness. Their results suggest that the ability to perceive visual stimuli is largely affected by the brain's occipital region. It was chiefly its activity that allowed the study participants to indicate the direction in which stripes were slanted towards in an experiment. Conversely, the frontal parts of the brain affect our subjective experience – in this case, a change in brain activity affected how well the participants could see the stripes. However, we need to remember that our assessment of clarity with which we see an object is influenced by more than purely visual factors. For example, stimulation of the motor cortex caused the participants to report higher clarity of stripes. This kind of research helps us understand more about how our brains work and how awareness is formed.





**THE EAGLET:  
AN EMPEROR THAT NEVER WAS.  
WHO WAS NAPOLEON II?**

**The history of the Eaglet is a tale of a little prince who never achieved anything because he was not allowed to, and yet, or maybe because of that, became a celebrity. How is it that a young man who summed up his own life in the brief words 'I was born and I died – that is my story' became one of the most famous people in Europe?**

The answer to this question is seemingly simple: he was the son of the most influential man of his time, Napoleon Bonaparte, the emperor of the French. The son, a fruit of the Napoleon's marriage with an Austrian archduchess, was to be France's next ruler, but it turned out that it was not his fate. After his father's defeat in 1815, he found himself at the court of his grandfather, pushed ever deeper into oblivion and isolation. He died of tuberculosis at the age of only 21, as the Duke of Reichstadt.

However, he was not forgotten. As a romantic and enigmatic figure, an unhappy prince living in a gilded cage, with no hope of achieving his rightful political status, Napoleon II ruled the minds of the 19th century society. Newspapers published articles on his alleged escape from Vienna, political ambitions, romantic relationships and, eventually, his poisoning at the instigation of the chancellor Metternich. Revolutions that swept across Europe around 1830 took into account his presence as a political actor, although it was obvious that the Austrian ruling elite would never allow him to sit upon any throne.

During the period of Bourbon Restoration in France, he was the inspiration and central figure of many seditious images, pamphlets and literary works; actually, even invoking his name was severely punished by the royal government. After the July Revolution, when the Napoleonic legend was no longer repressed, the prince appeared in countless novels, poems and theatrical pieces.

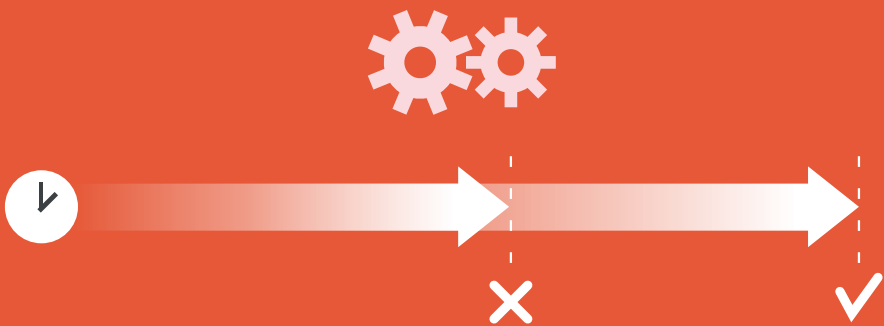
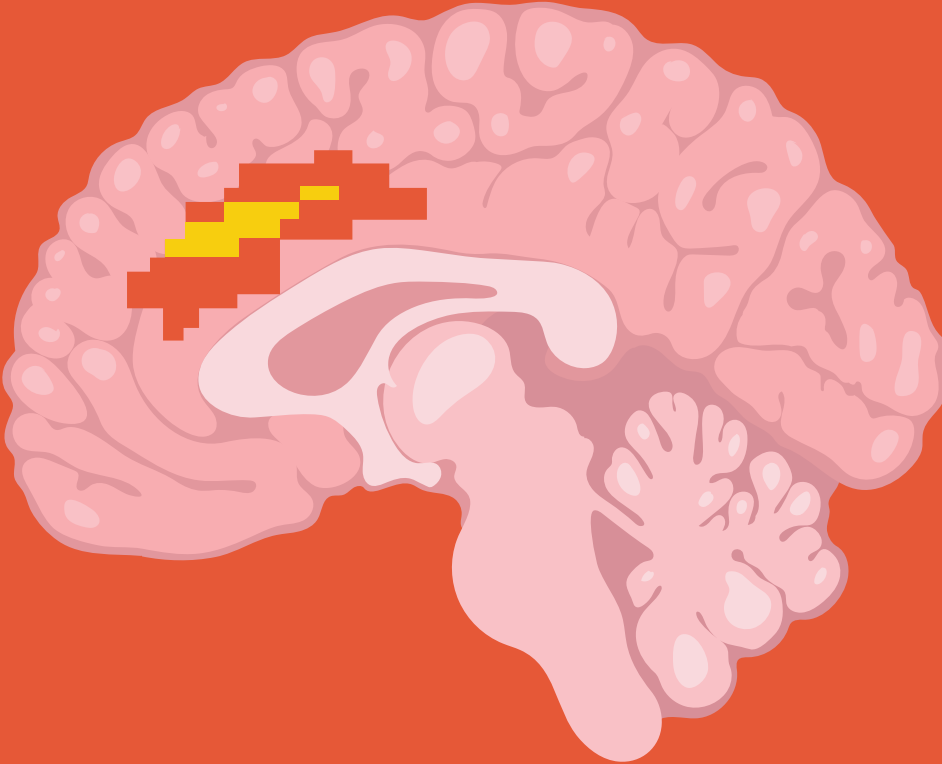
He was a 19th century icon, the Marilyn Monroe and Freddie Mercury of his time, known even on isolated islands of the Pacific Ocean. His popularity reached its peak in 1900 with the premiere of the drama *L'Aiglon* ('The Eaglet') by Edmond Rostand, written for the famous Parisian diva Sara Bernhardt. The play became an instant hit, and was played in the theatres around the world in the first half of the 20th century, with the Duke portrayed by most famous actresses (rarely actors). In the 1937 operatic version by Arthur Honegger and Jacques Ibert, the lead part was written for the soprano. Whence this feminisation of the figure? This is one of the many questions relevant for the research.

The legend of the Eaglet, very popular until World War II, is now a subject of research. Of particular interest are the changes in the way the prince was depicted, as well as their genesis and contexts: from an heir to the throne, through a recluse devoid of political influence, to a romantic hero of a legend in which the exile of both him and his father reached messianic proportions, and the Eaglet, of whom we know very little, was believed to support revolutionary and progressive ideas. A lack of well-documented biography proved to be a fertile soil for fables and speculations, as people filled in the blanks with their own dreams, nostalgia and hopes. This embellished history and imagined figure of the Duke will be the subject of the book entitled *Phantom Presence* by Dr Agnieszka Fulińska from the JU Institute of History.

# i

Dr Agnieszka Fulińska  
JU Institute of History

Project No. 2018/29/B/HS3/01913



|| HOW DOES OUR BRAIN  
SOLVE CONFLICTS?

**Cognitive neuroscience is a branch of science dedicated to studying the cognitive processes that happen in the brain. One of those processes is the ability to detect and resolve conflicts. But what exactly is conflict? This issue is being investigated by Dr Ewa Beldzik from the JU Department of Neurocognitive Studies and Neuroergonomics.**

Conflict is a situation which entails contradictory actions, assumptions or ideas. Cognitive neuroscience is interested chiefly in reactions which occur when there is a competition between two mutually exclusive outcomes. The most popular experimental task involving conflict is the Stroop test. In the most basic version of the test, the subjects are asked to identify the colour of a series of written words, with some of them matching or mismatched (e.g. 'red' printed in red vs. 'red' printed in blue). No matter how focused a person is on successfully completing the task, conflicting stimuli increase reaction time and cause more mistakes – it can therefore be inferred that they induce conflict.

Research projects carried out with the use of functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) have shown that conflict is detected and resolved in the prefrontal cortex. But there are many questions which are still left unanswered. Does the prefrontal cortex 'resolve' conflicts even when the stimuli are matching, but the reaction time is lengthened for

some other reason? Can conflict resolution be separated from reaction time effects? The results of fMRI and EEG scans are not clear on that issue.

These issues are being studied by Dr Ewa Beldzik and her team within the framework of the project *The thin line between conflict and time on task. Exploring the nature of the medial frontal cortex activity – a simultaneous EEG-fMRI study*. The aim of the project is to stimulate all markers of conflict processing and analyse whether they are susceptible to time reaction effect. Simultaneous registration of EEG and fMRI images will allow for an in-depth look at cognitive processes on the basis of electrical and physiological characteristics of the brain. Additionally, in this particular project, it is vital that the EEG and fMRI measurements refer to the same behavioural measurements so that responses can be classified as fast or slow for all brain markers. Such a comprehensive approach will allow the scientists to check if the prefrontal cortex resolves conflicts or just aids in the processing of stimuli.

# i

Dr Ewa Beldzik is an assistant professor at the Institute of Applied Psychology of the JU Faculty of Management and Social Communication. She has years of experience in neuroimaging and electrophysiological research of the human brain. Currently, she is the head of a project focused on the role of the medial frontal lobe in the process of resolving the conflict of reactions.



## RESEARCHING CHILDREN'S LITERATURE: LITTLE READERS, BIG ISSUES

**Almost everyone remembers their favourite childhood book (such as *Alice in Wonderland*, *The Secret Garden*, *The Little Prince*, just to name a few); some of us also discover new books when we are reading them to our own children. However, not everyone knows that studying children's literature is an important branch of literary studies, and books for children and young adults make a large portion of the publishing industry worldwide.**

Modern studies of children's literature are developing quite rapidly both in Poland and around the world. The Children's and Youth Literature Research Centre at the JU Faculty of Polish Studies was established at the Jagiellonian University Faculty of Polish Studies in 2013, so we can imagine it as an eight-year old that is interested independent reading.

Promoting knowledge of children's literature is important, as having accurate information on this subject is relevant to parents and grandparents, teachers and librarians, booksellers, publishers and arts and cultural workers. A person who studies children's literature can and should be an expert, advisor and reviewer, but more importantly, a guide that helps interpret both past and present cultures. What we choose to read to our children provides a great insight into our civilisation. Modern adaptations of the story of the Little Red Riding Hood are no longer similar to the versions written by Charles Perrault or the Brothers Grimm. Many contemporary Polish books feature new and surprising re-narrations of classic fairy tales.

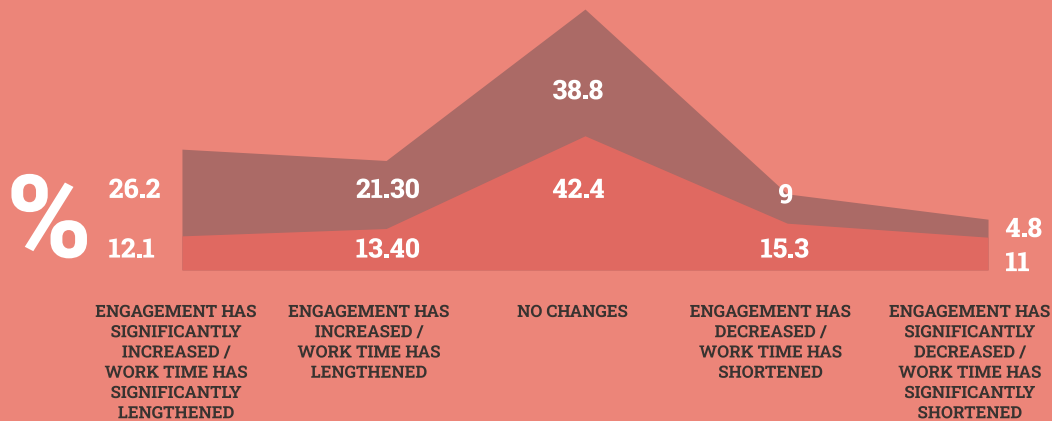
There are as many ways of interpreting children's literature as there are methodologies in the modern humanities, and the subject matter itself is very varied. The last two decades have seen a rise in interest in eco-

gy-themed books, not only encouraging children to learn more about animals and plants, but also to take care of the environment.

Another highly popular genre are biographical books for children (which is a reflection of the increased interest in biographies in adult readers); there is a wide selection of books for all age groups that discuss the lives of famous scientists, artists and composers from Poland and abroad. Local and regional subjects are also on the rise, with a clearly visible turn toward tradition and folklore (as exemplified by illustrations reworking elements of folk art).

The best books for children and youths in the 21st century help develop imagination, foster a culture of tolerance and appreciation for the many cultures of the world, and offer assistance in understanding oneself: some of those books provide tools for understanding feelings and emotions to very young children, others – to young adults. Modern children's books are rarely dedicated solely to children – writers frequently intend to make them interesting for adult readers. Some examples of such works include *The Lost Soul* by Olga Tokarczuk and Joanna Concejo, published in 2017 and awarded during the Bologna Children's Book Fair and translated into English by Antonia Lloyd-Jones in early 2021.

**COMPARISON OF WORKING PARENTS' ASSESSMENT OF ENGAGEMENT IN WORK WITH  
THE TIME DEVOTED TO WORK DURING THE PANDEMIC**



**WORK-LIFE BALANCE  
DURING THE PANDEMIC –  
WORKING PARENTS IN POLAND**



**Researchers from the JU Institute of Public Affairs have studied the everyday situation of parents who had to make almost overnight changes in their routines due to the outbreak of the COVID-19 pandemic. The coronavirus threat forced society to introduce numerous restrictions and sanitary regulations, leading to a revolution in remote work and education.**

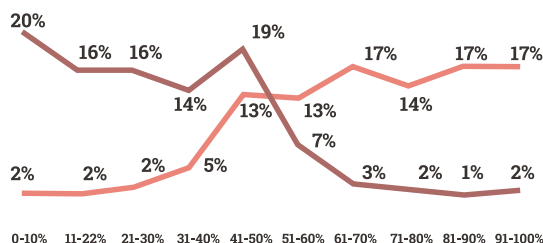
The new conditions proved to be particularly difficult for parents who, due to changes in the organisation of education, were forced to divide their time between their work responsibilities and child-rearing. In response to noticeable changes caused by the pandemic, researchers decided to carry out a nationwide study in the form of a questionnaire survey and analyse the situation of working parents and particularly how they combine work with childcare.

The study was conducted with the participation of 10,331 respondents, including 7,800 parents that are both working and caring for their children. It was carried out between 16 March and 2 April via the LIBRUS

education platform using Computer Assisted Web Interviewing. The study was designed to diagnose the everyday situation of parents in three aspects, i.e. professional responsibilities, parenting and house chores, and providing optimal setting for remote education.

The results of the study show that although most of the parents adapted to remote work and education during the pandemic, they experienced numerous professional and private issues. They also pointed to a series of solutions that would make it easier for them to achieve work-life balance and expressed their hope that their suggestions would be taken into account by both employers and policymakers.

### TIME DEVOTED TO CHILDREN BY MOTHERS AND FATHERS \*



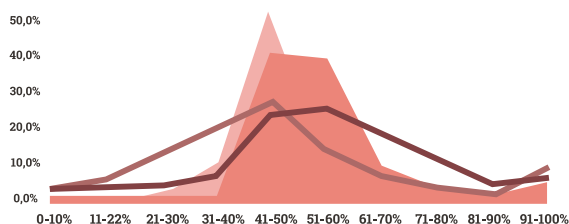
— Mother / Wife / Partner

— Father / Husband / Partner

\* Question: By your own estimates, how much time do you devote to childcare in comparison to other people raising your child, assuming that the total amount of time is equal to 100%?

Source: own analysis based on research

### REAL AND OPTIMAL CONTRIBUTION TO THE FAMILY BUDGET DURING THE PANDEMIC ACCORDING TO WORKING PARENTS



— Mother / Wife / Partner - Optimal

— Father / Husband / Partner - Optimal

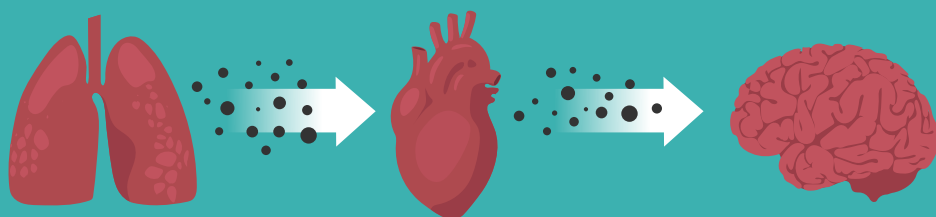
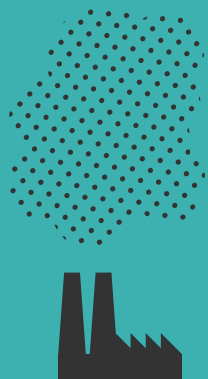
— Mother / Wife / Partner - Real

— Father / Husband / Partner - Real

Source: own analysis based on research

i

Research team:  
Dr Małgorzata Marzec  
Dr Agnieszka Szczudlińska-Kanoś  
Institute of Public Affairs  
JU Faculty of Management and Social Communication



**NEUROSMOG:  
DOES SMOG NEGATIVELY AFFECT  
CHILDREN'S BRAINS?**

**How does smog affect children's brains? Can toxic particles be responsible for neurodevelopmental disorders in kids? These issues are addressed by researchers who are part of the NeuroSmog consortium.**

Polish statistics regarding smog are alarming. As many as seven out of ten most polluted European towns and cities are located in Poland. Hardly anyone questions the threat which smog poses to our health. It is estimated that this factor is responsible for as many as forty thousand premature deaths in Poland. Scientists have long been studying how exactly inhaling heavily polluted air harms our bodies. The NeuroSmog researchers aim to investigate the impact of smog on the brains of children growing up in polluted environment.

### **A thorough investigation**

Epidemiologists have already discovered circumstantial evidence suggesting that pregnant women who breathe polluted air are at a greater risk of miscarriage and low birth weight. Besides, their children may have reduced IQ and/or be affected with the attention-deficit hyperactivity disorder (ADHD). The question remains whether smog is the main culprit. To check this, the researchers need to test several hundred children aged from 10 to 13.

Besides brain imaging, all the participants will undergo detailed psychological tests.

### **Special operations unit**

So far, no research into that problem has been carried out on a comparable scale. Lots of money has been spent on the project, which will involve the use of advanced pollution modelling methods as well as magnetic resonance imaging (MRI) scanning and complex psychological diagnoses, with the aim of finding out what specific disorders are caused by specific types and concentrations of smog. Bearing in mind that air in the Małopolska region is very highly polluted, the gathered data needs to be compared with the results from less polluted regions.

### **A problem of our times**

If the hypotheses are proven, scientists will be in possession of hard evidence against smog, indicating that it poses threat to the development of the youngest children.

### **i**

The NeuroSmog consortium consists of four research teams led by Prof. Marcin Szwed from the JU Institute of Psychology. Prof. Szwed's team comprises researchers from Poland and abroad, including the distinguished epidemiologist Dr Iana Markevych, who came to the Jagiellonian University from the Helmholtz Centre in Munich. The studies are carried out in collaboration with the JU Institute of Environmental Protection and the JU Institute of Applied Psychology. The project is funded from the EU funds obtained from the Foundation for Polish Science.

**ERISTIC**

**EUTORIC**



**EUTORIC: HOW TO FOSTER  
INTERPERSONAL UNDERSTANDING**

From time immemorial, people have fought one another, be it physically or verbally. Almost everyone dreams of 'winning' a debate, 'defeating' their opponent, 'rolling out' their arguments and 'defending' against opposing points of view. Since our childhood, we are immersed in this kind of confrontational language, and yet as participants and witnesses of various disputes we are often tired of futile conversations, arguing in bad faith and impolite remarks designed to upset others. We dislike people who try to dominate the conversation or denigrate people in our company and resort to manipulation instead of presenting honest arguments. In the media, we can frequently observe situations in which public figures refuse to play fair in debates: oftentimes, they come prepared, having attended special courses where they have learned about eristic – a practice of disputation that focuses on winning arguments at all costs. This branch of rhetoric, originating from Ancient Greece, was revitalised in the 19th century by Arthur Schopenhauer, who assembled a collection of 38 tricks of varying loyalty toward the interlocutor. Since that time, this list has been expanded and commented upon.

Eristic	Eutoric
Etymology: (Greek) Eris = discord, strife, conflict	Etymology: (Greek) eu- = good + rhetor (public speaker)
Aim: defeating the opponent, winning the argument regardless of who is right, dominating the opposition	Aim: understanding the interlocutor, establishing a relationship, creating an 'in-between'
Means: eristic techniques (tricks)	Means: eutoric devices
Example: ad hominem (to the man) – an argument designed to attack the character of others	Example: pro personae bono (for the good of man) – providing verbal support for others

For many people, it is clear that social life cannot involve constant conflict, and communication should not be based on trickery, dishonesty and domination, because it ceases to be communication at all (communicare is a Latin word for 'make common', 'share'). We need to be able to listen to one another, talk and seek understanding in order to maintain inner and social balance. We expect our loved ones, friends, acquaintances and colleagues to communicate with us in a special way – with mutual care, support and benefit. The question is: how do we achieve the goal of 'good communication'? How do we talk about things that are important to us while showing others that we are concerned for their well-being?

Eutoric provides the answers to these questions. It is a branch of rhetoric proposed by Dr hab. Dorota Korwin-Piotrowska, Prof. UJ from the Chair in Computational Linguistics as the opposite of eristic. It references many papers in the area of linguistics, psychology and sociology of communication. It is described in the book *Eutoryka. Rzecz o dobrej (roz)mowie* [Eutoric. On good conversation/speech]. It features a lengthy practical part with a list of 41 eutoric techniques that improve the mood and quality of the conversation. Below is a short list of the most important factors that help achieve that goal.

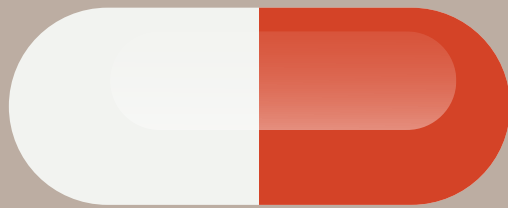
### The basics of eutoric

1. Eutoric attitude: seeking agreement, building relationships, creating an 'in-between'
2. Active listening: 'dialogic listening'
3. Correct assessment of issues and employing knowledge of constructive discussions and good practices
4. Empathy for interlocutors
5. Careful choice of words, establishing common meanings and use of eutoric devices.

### i

Dr hab. Dorota Korwin-Piotrowska, Prof. UJ  
Chair in Computational Linguistics  
JU Faculty of Management and Social Communication

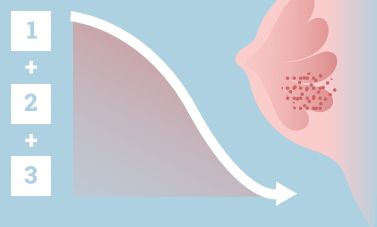




# **MEDICAL SCIENCES**



**PHYSICAL ACTIVITY  
AND BREAST CANCER:  
WHAT IS THE CONNECTION?**





**It has been known for some time that physical activity is one of the most successful ways of combating breast cancer. In the 1980s, scientists carried out a research project that compared the health of 5,000 American women, half of which have been physically active during their time in college. These women were less likely to get breast cancer than their less fit friends and colleagues. The role of physical activity as a factor in decreasing the risk of breast cancer is supported by many later studies. As it turns out, both sports and physical labour have positive effects on health.**

How does physical activity protect women from breast cancer? The most probable explanation is that there are several interconnected mechanisms at work here. Physical activity affects the concentration of sex hormones in the body, boosts the immune system and contributes to the lowering of body weight. Each of these effects has been proven to reduce the risk of breast cancer.

### **Task one: lowering the concentration of sex hormones**

Progesterone and especially oestrogen, produced chiefly during the menstrual cycle, stimulate cell division. The more cell division, the more chance of errors, i.e. mutations. Therefore, a high concentration of hormones can be the cause of more mutations. Unfortunately, hormones cannot differentiate between healthy and unhealthy cells, and by stimulating cell division in aberrant cells may lead to cancer. Sex hormones affect all cells that feature progesterone and oestrogen receptors, and that includes the cells found in breasts.

### **Task two: boosting the immune system**

The ability to fight cancer is an important trait of our organisms. The immune system recognises pathologies and helps to get rid of cancerous cells that act in a detrimental way. Since we know that physical activity is very good for the immune system, it also decreases the risk of cancer.

### **Task three: reducing body weight**

After menopause, ovaries stop producing sex hormones, but they are still present in the organism – for instance, they can be found in fat tissue. This is why post-menopausal women who have an excess of fat tissue may also have an increased concentration of sex hormones, which are the main cause of breast cancer in overweight and obese women. This is another way in which physical activity decreases the risk of breast cancer, as it helps women to stay fit.

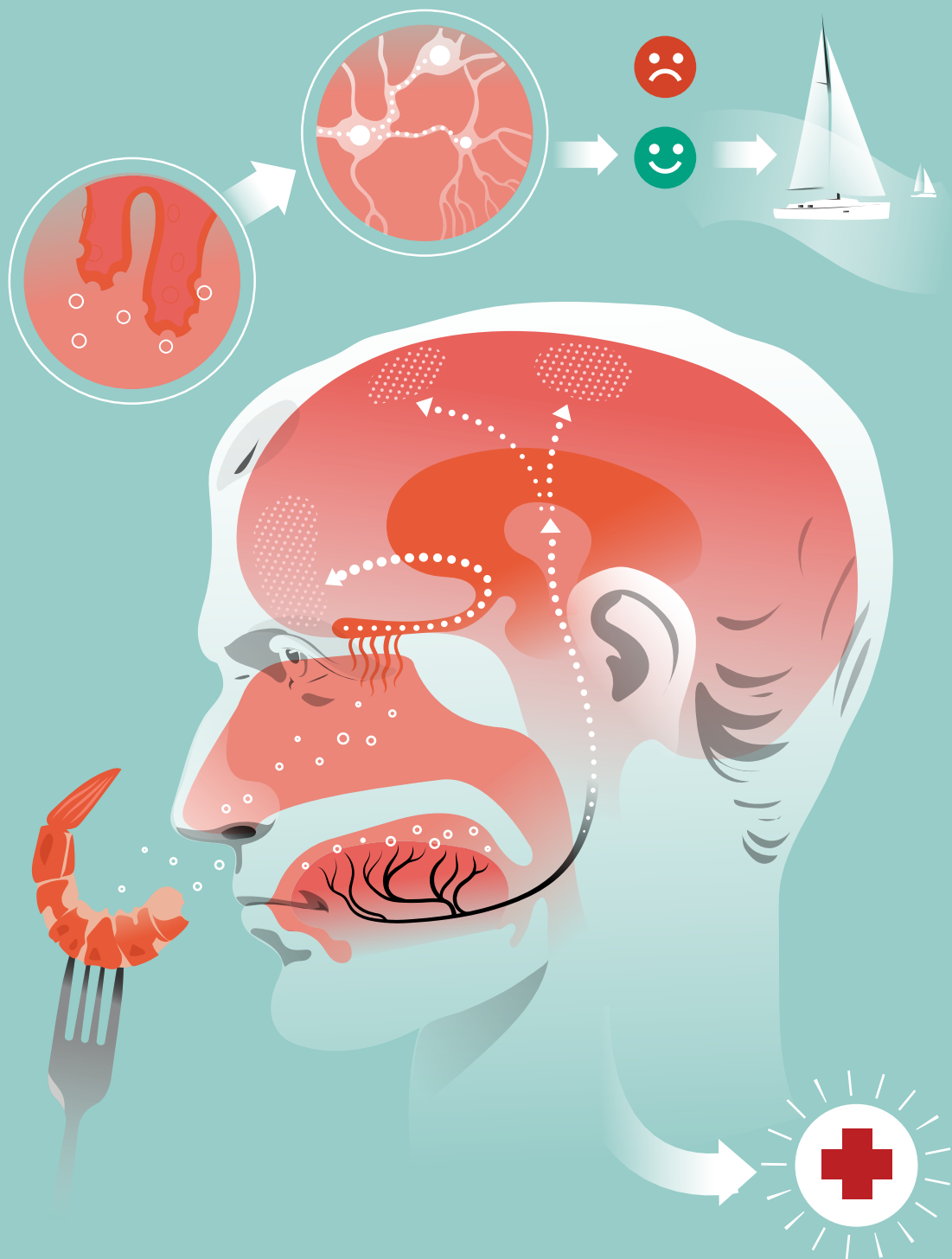
### **How much is enough?**

The researchers at the JU Department of Environmental Health are currently in the process of estimating how much exercise young and healthy women need in order to reduce the level of their sex hormones and improve the efficiency of their immune system. For the purpose of their study, they assume that the organism of every woman will have a different response. Preliminary research suggests that the decrease in the levels of sex hormones may depend of the quality developmental conditions of each woman in the early stages of life. It is speculated that women who were larger as newborns will require more exercise than smaller newborns in order to successfully lower their hormone level. Early childhood development may also have a similar impact.

Why is it important? If it is really true that every woman requires a different approach to physical activity, then physicians cannot recommend the same amount of exercise to everyone. For some women, the currently recommended workout regimens may prove inadequate.

### **i**

The research project is funded by the National Science Centre grant UMO-2017-25/B/NZ7/01509



**THE WAY TO HEALTH  
IS THROUGH STOMACH...  
AND BRAIN**

**Neurogastronomy is a young field of research (the first paper in this area was published in 2006) which uses knowledge from various disciplines concerning eating and nutrition, such as anthropology, neurology, biochemistry, bromatology, and molecular biology of taste and smell receptors.**

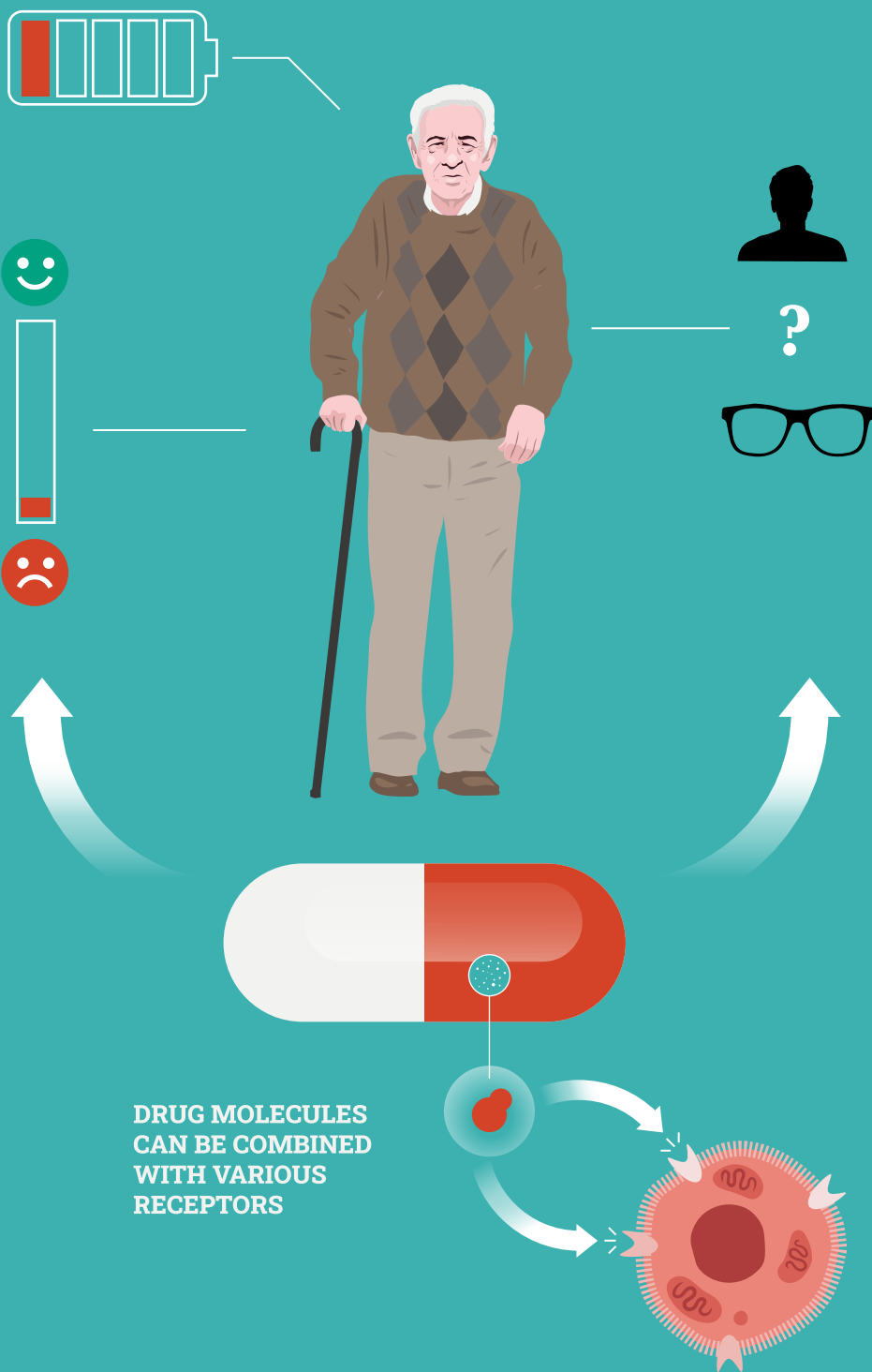
Neurogastronomy studies the ways in which different substances present in food influence our brains and how it is related to emotions, memories, eating preferences and cultural factors. It also investigates complex brain processes that have an impact on the reception of the taste, smell or flavour of consumed products. Experts in this field aim to assess whether and how it is possible to help people who lost their taste and smell as well as determine how to more effectively influence the dietary choices of persons suffering from diabetes, obesity, arterial hypertension and other diet-related diseases.

The clinical application of this research area also includes gaining better understanding of the patient's diet-related behavioural patterns that may contribute

to obesity and eating disorders. Besides, neurogastronomy studies how different diseases (Alzheimer's disease, Parkinson's disease, epilepsy, stroke, head injuries) as well as ingested medications change taste sensations.

Learning about the impact of various factors on the perception of flavour of different types of food can significantly contribute to improving the effectiveness of diets and nutritional support in treatment for various diseases. This new research area should prove useful in improving not only the patients' eating pleasure, but also their general quality of life.





DISCOVERING  
NEW MEDICATIONS

**Can treatment results be improved while reducing the number of pills ingested by patients? What are multifunctional compounds? Answers to these questions may be found in laboratories of the Chair in Pharmaceutical Chemistry of the JU Medical College.**

Since the second half of the 20th century, there has been a considerable growth in life expectancy. Unfortunately, it does not always go hand in hand with the increase in the quality and comfort of life. A popular Polish saying jokingly naming old age the Creator's failure illustrates this very well. Diseases linked to old age are often accompanied by anxiety or depression. On the other hand, most people consider forgetting to be one of the most typical symptoms of getting old. Problems with memory (e.g. forgetting names or planned tasks) and orientation ("Where are my glasses?") as well as a lack of judgement in everyday situations result from mild cognitive disorders. Modern medicine can alleviate these symptoms with drugs, which means that the older the patient, the more pills he or she has to take. This kind of treatment, known as polypharmacy, is based on the model 'one drug against one illness'. But can the treatment results be improved while reducing the number of ingested pills at the same time?

The activity of a drug usually results from the connection of its molecule with the relevant place in the body, such as a receptor or an enzyme. This mechanism is often compared to that of a traditional lock and key. The lock, i.e., a receptor or an enzyme, can be opened with the matching key, i.e., a specific chemical compound produced by our body or a medication. During an illness, the complicated network of interactions between various receptors, enzymes and compounds produced

by our bodies becomes distorted. Combined with a receptor or an enzyme, drugs either stimulate or hinder information transfer in cells, consequently repairing the body. In recent years, a novel strategy to develop new drugs has been adopted. It consists in the design of multifunctional compounds, which means that the structure of the new pharmaceutical is supposed to act through several selected receptors or enzymes at the same time, thus breaking free from the limiting pattern of 'one drug against one illness'.

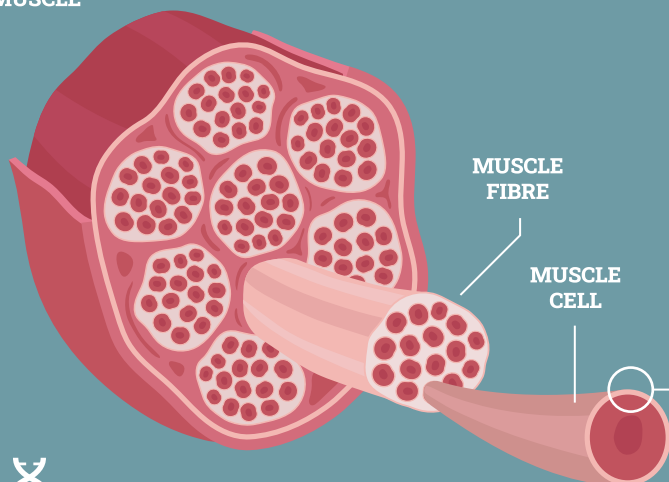
The project run at the JU MC Chair in Pharmaceutical Chemistry is aimed at obtaining multifunctional compounds that would improve the disrupted cognitive functioning in depression, anxiety or schizophrenia. The compounds were designed so as to combine the elements of the 'receptor key' and 'enzymatic key'. The researchers selected those receptors through which drugs for depression, anxiety or schizophrenia work (5HT1A and 5-HT7 receptors) and the enzyme causing the breakdown of compounds responsible for information transfer inside cells (phosphodiesterase 10a). The designed multifunctional compounds combine with serotonin receptors and hinder the work of phosphodiesterase 10a. They improve cognitive functioning and have a similar effect to pharmaceuticals used to treat depression, anxiety and schizophrenia. The project has resulted in a patent filing pertaining to the compounds that can be further studied to develop prospective medications.

**i**

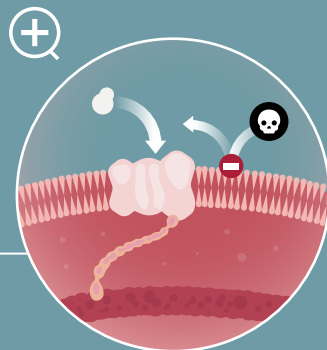
Dr hab. Agnieszka Zagórska, JU MC Chair in Pharmaceutical Chemistry

Project funded within the framework of Sonata NCN programme *Synteza i właściwości farmakologiczne zróżnicowanych strukturalnie analogów PQ-10 jako wielofunkcyjnych ligandów o możliwości poprawy funkcji poznawczych w zwierzęcych modelach depresji, lęku i schizofrenii* [Synthesis and pharmaceutical properties of pharmacologically diverse analogues of PQ-10 as multifunctional ligands capable of improving cognitive functions in animal models of depression, anxiety, and schizophrenia] UMO-2016/21/D/NZ7/01573. Patent filing no. P.434002 [WIPO ST 10/C PL434002]

MUSCLE



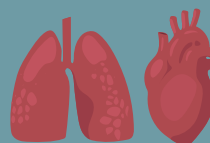
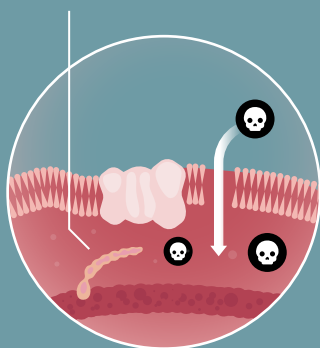
DYSTROPHIN  
REGULATES THE  
ACTIVITY OF  
MUSCLE CELLS



MUTATED  
DYSTROPHIN

LEADS TO DAMAGE  
OF MUSCLE FIBRES

RESULTING IN CIRCULATORY  
AND RESPIRATORY FAILURE



DISEASE PROGRESS

AGE

0



15



30



1/5000



WHAT INFLUENCES  
THE DEVELOPMENT OF DUCHENNE  
MUSCULAR DYSTROPHY?

## How the protein responsible for bruises and a volcanic gas can affect muscle function

For muscles to work properly, they need a protein called dystrophin, which is responsible for protecting them from mechanical damage when they contract. It guarantees accurate communication between muscle cells and their environment and secures the cell membrane, which ensures that only desirable particles can enter the cell, while at the same time keeping the ones that are needed inside. However, sometimes, due to a certain genetic defect, the organism is unable to produce functional dystrophin and muscles are not able to function as they should. A cell which is not adequately protected can easily be harmed by substances that should not get inside, like calcium ions. This causes an excessive growth of fibrocartilage at the expense of muscle. As time passes, muscle fibres become more and more damaged until they are replaced by other tissue, a process that is accompanied by intense inflammation. The disease responsible for these outcomes is called Duchenne muscular dystrophy (DMD).

The disease is incurable and hereditary, presenting almost exclusively in boys who inherit the harmful genes from their mothers. DMD is not a rare disease: it is found in one in every 5,000 boys and is the most common type of muscular dystrophy. Symptoms can manifest in the first months or years of life in the form of visible movement disorders: trouble with standing up, walking, running and using the stairs. These symptoms increase in intensity as time progresses, making teenagers with DMD unable to move unassisted and forcing them to use wheelchairs. Around the age of 20 to 30 years, everything becomes even more complicated. Due to the deterioration of pulmonary muscles, breathing also becomes difficult, resulting in circulatory and respiratory failure. In fact, cardiovascular disorders are the main cause of death in DMD patients.

We know the role of the mutated dystrophin in the development of DMD. Nevertheless, it is still an incurable disease. Currently, the main form of therapy is based on steroids, which combat the inflammation, but do not fight its root cause, instead causing a number of side effects. That's why laboratories around the world are searching for a way to delay the symptoms of DMD.

A while ago, researchers from the Department of Medical Biotechnology of the JU Faculty of Biochemistry,

Biophysics and Biotechnology have discovered new mechanisms of DMD disorders, pointing to promising prospective therapy. It is related to heme oxygenase-1 (HO-1), an enzyme which we all know from our everyday life, since it protects our bodies from negative effects of injuries by forming bruises. HO-1 plays an important role in the body – it inhibits the inflammatory response and protects cells from inflammation. In some sense, it can be compared to a firefighter who appears quickly to stop the spread of fire and neutralise the threat. Researchers have shown that HO-1 is an important factor in the development of DMD, and its deficiency exacerbates the inflammation and weakens muscles.

Researchers have also proven that DMD is affected by disorders related to the formation of new blood vessels which provide oxygen and metabolites to muscle cells. Interestingly, investigations into the causes of DMD before the discovery of dystrophin pointed to irregularities in vascular function, which in turn were believed to explain muscular dystrophy through lack of oxygen and nutrients. Although the 'vascular theory' was disproven by the discovery of dystrophin, many studies emphasise that defects in the cardiovascular system could impact the development of DMD, suggesting that methods of treatment that improve the functioning of blood vessels could help with DMD. This approach is the subject of the latest analyses made by JU researchers, who are attempting to use hydrogen sulphide (H<sub>2</sub>S) as an alleviating factor in DMD. The foul-smelling gas exhibits many beneficial properties – it prevents inflammation, oxygenation and fibrosis, while at the same time stimulating the development of blood vessels and protecting the heart, so it can be helpful in treating DMD.

To confirm that hypothesis, the researchers plan to carry out studies on two technologically advanced model systems: those of humans and mice. The experiment will feature a genetically modified strain of mice that do not produce dystrophin and induced pluripotent stem cells (iPSC), the latter of which can transform into specialised cells like musculoskeletal cells, endothelium cells and cardiovascular cells, making them a perfect tool for studying the mechanisms of DMD; even more so because the biological material for research

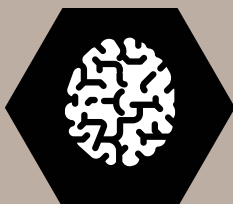
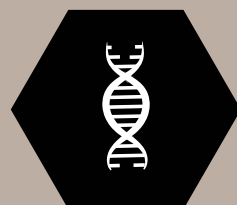
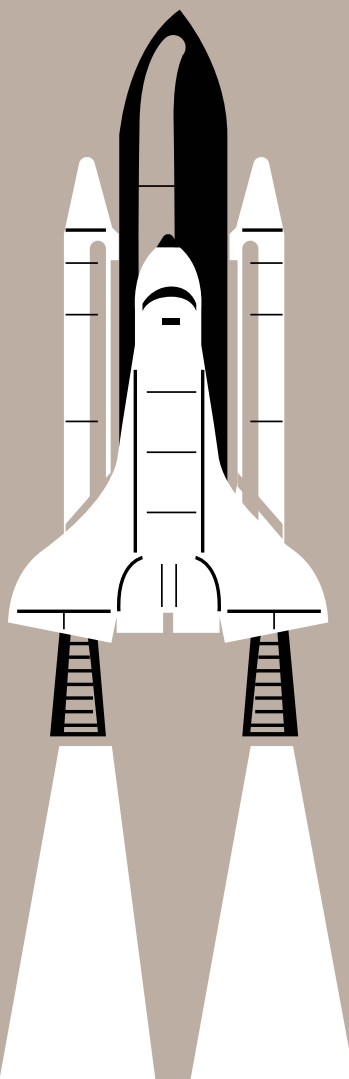
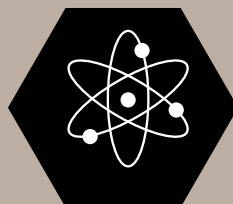
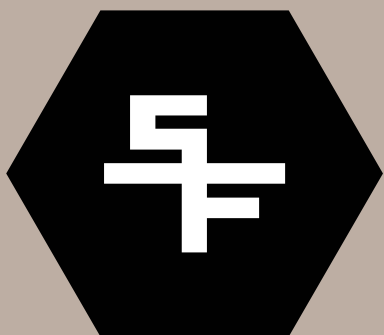
cannot be collected directly from DMD patients. What is more, thanks to the Nobel Prize-winning technology of ‘molecular scissors’, healthy iPSC cells can be turned into defective ones and vice versa. This is a unique research model in the investigation of DMD.

Researchers hope that these analyses will help them to better understand the molecular mechanisms in patients suffering from muscular dystrophy, resulting in new ways of treating DMD.

**i**

The research project conducted at the JU Department of Medical Biotechnology is realised within the framework of National Science Centre grants supervised by Prof. Józef Dulak (MAESTRO 3, #2012/06/A/NZ1/00004 and MAESTRO 10, #2018/30/A/NZ3/00412) and Dr hab. Agnieszka Łoboda (OPUS 11, #2016/21/B/NZ1/00293 and OPUS 18, #2019/35/B/NZ3/02817).



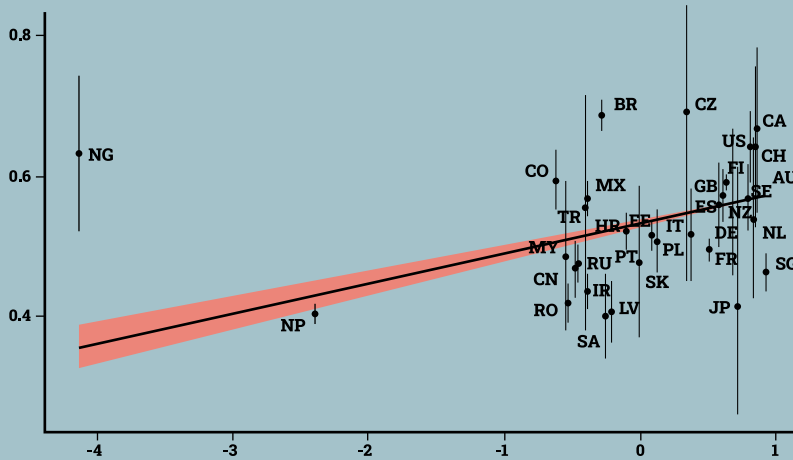


**/PraktycznyWymiarNauki**

**Science First** is a cycle of science communication meetings organised by the **All in UJ Association** and the **JU Institute of Psychology**.

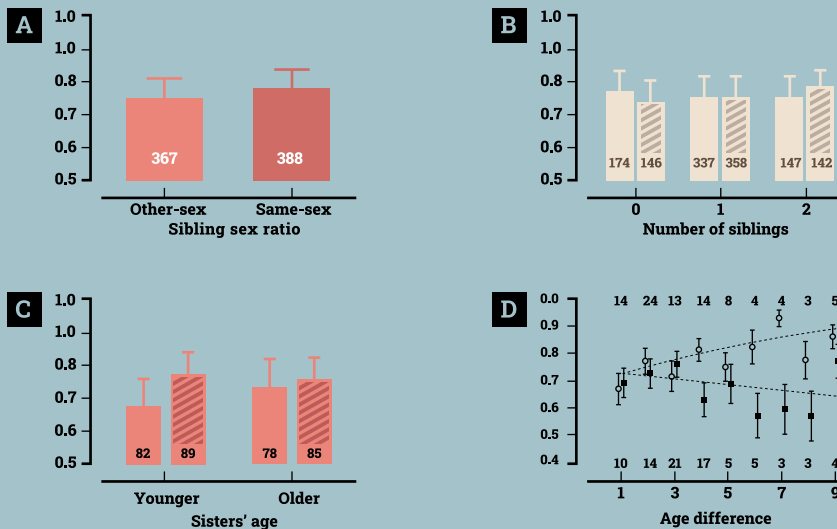
1

VARIANCE OF SEXUAL PREFERENCES OF MEN CONCERNING THE FEMININITY OF WOMEN'S FACES (Y AXIS) IN RELATION TO THEIR COUNTRY OF ORIGIN AND SOCIAL DEVELOPMENT MARKERS (X AXIS).



2

RELATION BETWEEN THE PREFERENCE FOR FEMININITY IN MEN AND THE NUMBER AND SEX OF THEIR SIBLINGS (STRIPED BARS SHOW THE PREFERENCES OF FATHERS, Y AXIS SHOWS THE STRENGTH OF PREFERENCE FOR FEMININITY). PREFERENCE FOR FEMININITY IN MEN WITH MALE SIBLINGS IS HIGHER THAN IN MEN WITH FEMALE SIBLINGS (A). FATHERHOOD INFLUENCES THE PREFERENCE FOR FEMININITY IN VARYING DEGREES BASED ON THE NUMBER (B) AND AGE (C AND D) OF SIBLINGS.



ŹRÓDŁO: [HTTPS://WWW.NATURE.COM/ARTICLES/SREP33545](https://www.nature.com/articles/SREP33545)

## THE ROLE OF FACE PERCEPTION IN SEXUAL PREFERENCES IN DIFFERENT CULTURES

**Sexual preferences are an important factor affecting our everyday lives and a number of decisions we make: our choice of partners, the first impression we get about a newly met person, and, according to some studies, our political views. But why is there such a diversity of preferences among humans?**

Sexual preferences are a fascinating yet difficult subject to study, particularly because they are so vastly diverse. We know they are impacted by culture, family, the levels of sexual hormones and sexual openness. What is more, we know that various social groups differ in their sexual preferences: men differ from women, straight people differ from gay people, and young people differ from old people.

A while ago, researchers from the Jagiellonian University Medical College Institute of Public Health decided to investigate what affects the choices and sexual preferences of people around the world. To make it possible, they first needed to collect data from a sizeable number of people of varying ages, cultures and socioeconomic backgrounds.

Participants of the study, both men and women, were asked to choose which faces they considered to be the most attractive and answer a series of questions related to their demographic information and sexual openness. The faces the volunteers were shown exhibited a varying degrees of sexual dimorphism, i.e. different levels of masculinity and femininity. Femininity is related to larger eyes, fuller lips and narrower chin. Conversely, masculinity is tied to, among others, more prominent brow and square jaw. The aim of the study was to show whether men's and women's preferences regarding sexual dimorphism differ based on their own characteristics (e.g. age, number of siblings, number of children) and life situation (e.g. average lifespan in a particular country, infant mortality rate, non-infectious diseases

etc.). In other words, the research project was designed to answer a series of questions such as: Are more feminine women more desirable in countries with shorter average lifespans? Do women in countries with higher infant mortality rate prefer more masculine men? Do older men prefer typically feminine faces?

The most important discovery in this large-scale project was that in the countries where people live the longest, are in good health and do not suffer as much from social inequality, the general preference leans towards more masculine men and more feminine women.

The second most important discovery was that younger men have a much more pronounced preference towards femininity than older men. It may be that as they age, men start to pay more attention to characteristics other than femininity, or that they are reluctant to compete for the most feminine partners with younger rivals.

It also became apparent that sexual preferences are fluid and change throughout life depending on each person's life situation. For instance, they are affected by factors such as the number of siblings or children. Men that had sisters, especially younger ones, were not as much into femininity as those who had brothers.

The data collected in this international project provided the basis for multiple papers. It can easily be said that they shed new light on the issue of human sexual preferences and point to various, sometimes counterintuitive, sources of their diversity.

# i

The project was realised within the framework of PhD studies at the University of Turku Faculty of Sciences in Finland. Some of the papers based on the project were used as part of the PhD thesis defended in 2014. The University of Turku presented the author with the award for the best thesis in the academic year 2013/2014.

Urszula Marcinkowska, [urszula.marcinkowska@uj.edu.pl](mailto:urszula.marcinkowska@uj.edu.pl), @urszulamarcin1  
Department of Health and Environment, Institute of Public Health,  
Faculty of Health Sciences, Jagiellonian University Medical College  
<https://evoecogroup.wordpress.com/urszula-marcinkowska/>

Low  
photostability

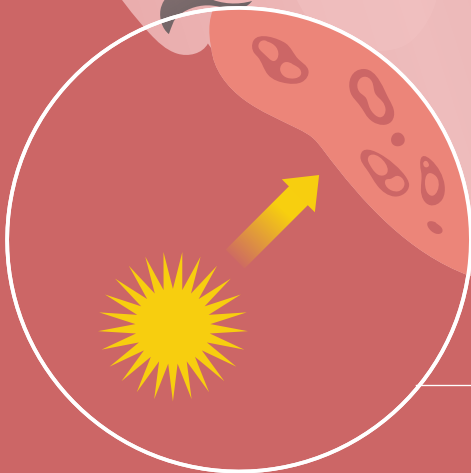


Toxicity



Disadvantages  
of UV filters

UV



Skin discolouration

80%



**MODERN COSMETOLOGY –  
INNOVATIVE SUBSTANCES AND  
ADVANCED RESEARCH METHODS**

**Nurturing and beautifying the body has been one of humanity's interests since the dawn of time. In the past, people most often used readily available natural resources; now, they study this issue through the lens of a specialised branch of science – cosmetology. In order to develop new products and treatments, cosmetology uses techniques developed in chemistry, biology, pharmacy, medicine and biotechnology, making modern cosmetics high quality products containing well researched active and supplementary ingredients.**

Currently, one of the most important cosmetics are the products that contain active UV filters. UV filter particles absorb or diffuse radiation, protecting the organism from its harmful effects, including sunburns, cancers and premature skin aging. However, UV filters that are now used also have a number of drawbacks. Some of them are toxic to our cells, others negatively impact the secretion of hormones, cause allergies, or have a very low photostability. It is therefore necessary to search for more effective and safe UV filters. Research projects in this area are carried out with the use of modern equipment, including a device for precise measurement of UV filter parameters in cosmetic formulations and a sunlight simulator.

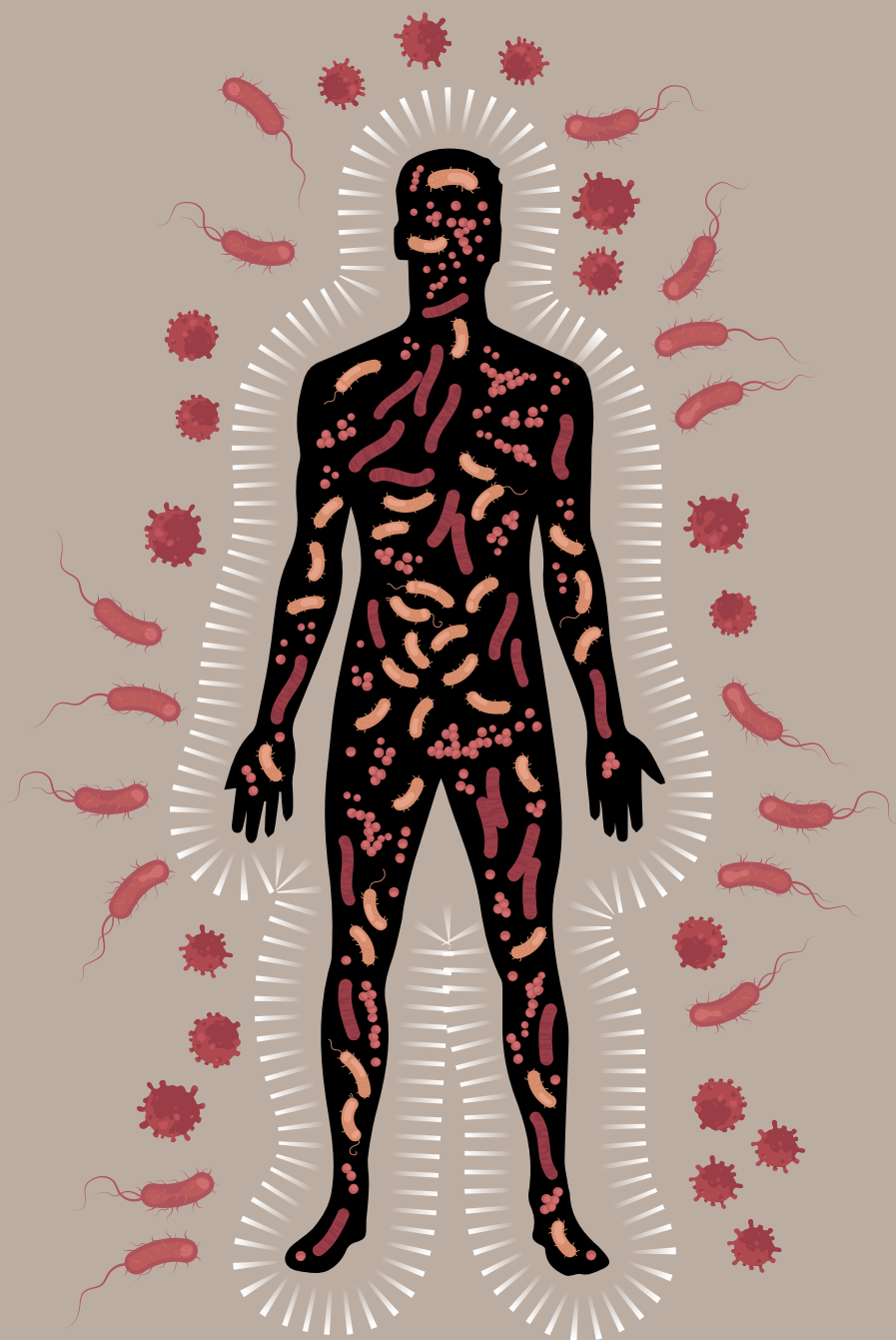
Another challenge faced by modern cosmetics is skin discolouration. These disorders are caused by incorrect synthesis or deposition of melanin, the natural skin pigment. For some regions, they may affect as much as 80% of the population. Some of the currently known substances

may have a whitening effect and smooth out complexion, but their effectiveness is unsatisfactory. Moreover, some of them have exhibited toxicity to cells in in vitro studies. This is why we need to develop new substances to aid in skin discolouration treatments. Previous research has allowed scientists to select chemical compounds that have been proven to effectively inhibit melanin synthesis. The proof was gained during experiments which involved the use of tyrosinase, immortalised cell lines and a model of reconstructed human epidermis fragment containing pigmentation cells.

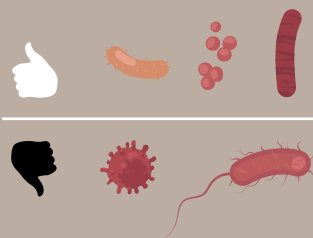
Safety of beauty products is just as important as their effectiveness, therefore the assessment of any potential side effects of both new ingredients and cosmetics is a top priority. From the very beginning of any research project, in vitro tests are conducted to exclude the possibility of potentially harmful substances reaching its later stages. To that end, scientists use immortalised cell lines and reconstructed human epidermis.

**i**

The research project is carried out at the Department of Pharmaceutical Biochemistry and the Department of Bioorganic Chemistry at the Chair in Organic Chemistry of the JU MC Faculty of Pharmacy. The project is funded by grants received from the National Science Centre (Opus No. 2016/21/B/NZ7/01756 and Miniatura No. 2017/01/X/NZ7/00410 calls) as well as the National Centre for Research and Development (LIDER XI No. LIDER/26/0094/L-11/19/NCBR/2020).



**MICROBIOTA:  
THE INNER LIFE  
OF HUMANS**



**In recent years, a mysterious word “microbiota” has often appeared in news stories as well as advertisements of food products or cosmetics. Generally speaking, microbiota is a community of billions of cells of bacteria, fungi, viruses, and protozoa inhabiting the human body.**

How is it possible? Since our childhood, we have been told that bacteria and viruses are the culprits behinds all infectious diseases and we should avoid them to protect ourselves from this danger. We have learnt about horrible epidemics decimating mankind. So why should we now think that this enormous community of microorganisms could help us instead of harming us?

Recent years have brought about a breakthrough in microbiological research. It has turned out that our bodies teem with microorganisms, which seem to be especially attracted to our digestive system, where they appear in greatest numbers, with almost as many inhabiting the reproductive tract and skin. They are also present in blood and the respiratory tract. Some of these microbes can indeed be dangerous, but a vast majority of them are harmless and can even be useful. This can

be compared to a trip to a forest, where it is possible to encounter some dangerous predators, but a vast majority of animals and plants do not pose any threat and can even serve as sources of food or medicine.

Our relationship with microbiota might be compared to our relationship with nature in general. If we treat them well, they can bring us numerous benefits, like protection against harmful pathogens. By contrast, disturbing the equilibrium can lead to various illnesses, including diabetes, depression, and obesity, to mention just a few.

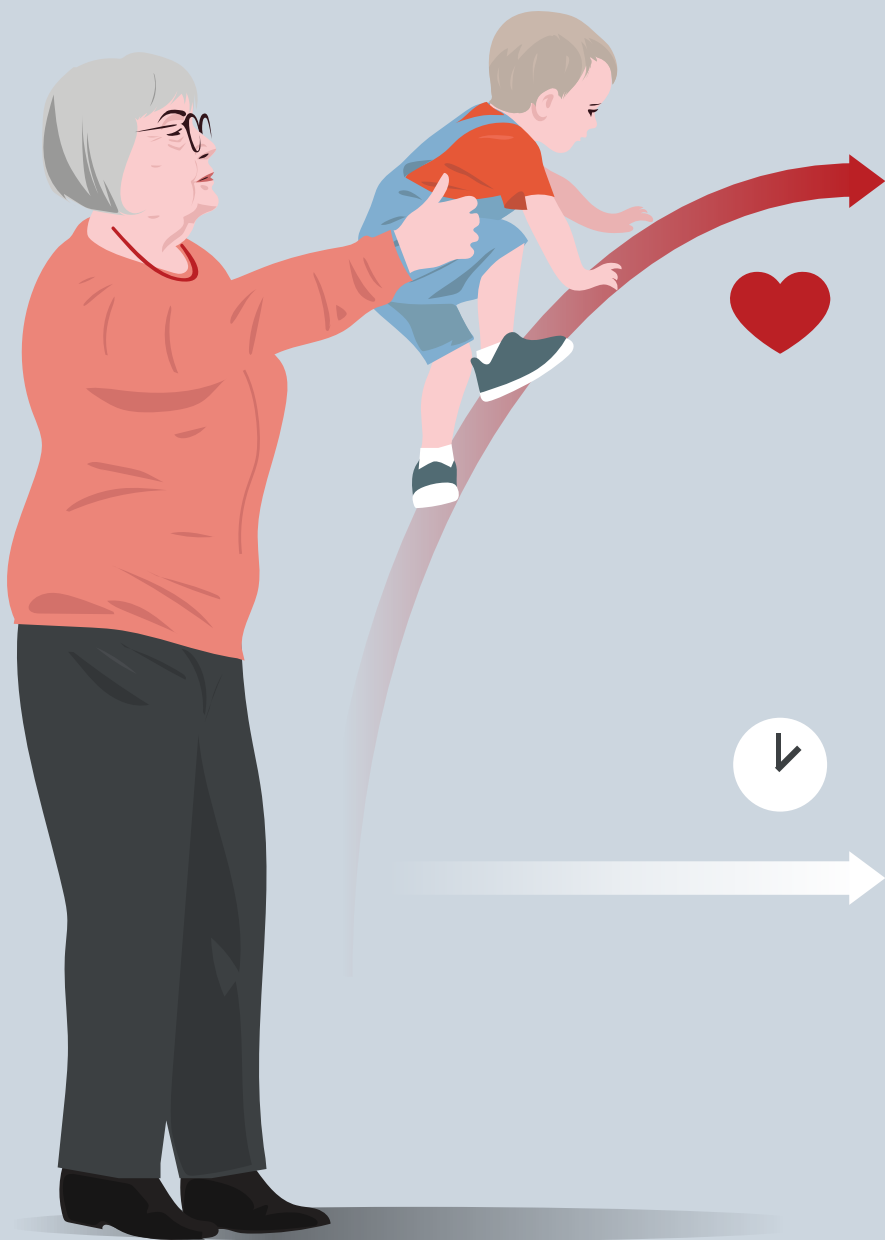
Scientists have only begun to explore the specific role microbiota play in our body and the consequences of upsetting their balance. However, one thing is clear: microbiota are an integral part of us, like our body organs, and disturbing them leads to illness.

**i**

A team of researchers from the Department of Molecular Medical Microbiology at the JU MC Chair in Microbiology, consisting of Dr hab. Tomasz Gosiewski, Prof. UJ, Dr Dominika Salamon, Dr Agnieszka Sroka-Oleksiak, Agnieszka Krawczyk, Dr hab. Monika Brzychczy-Włoch, Prof. UJ, conducts pioneering research on microbiota of digestive tract, blood, paranasal sinuses and reproductive tract.

The project is mainly funded by the National Science Centre: 2017/26/E/NZ5/00266; 2019/33/N/NZ5/00698; 2019/03/X/NZ5/00953

Dr hab. Tomasz Gosiewski, PhD, Prof. UJ  
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**GRANDMA  
KNOWS BEST**



**How does the presence of paternal and maternal grandmothers affect the well-being of children? Is there any difference in this respect between firstborns, twins, siblings born within a short interval and those born out of wedlock? It turns out that there is! Read on to find out which children need their grandmothers the most!**

What would life be without grandma, with all her experience, knowledge and her helping hand? Each of us learns very quickly that a grandmother is an invaluable person in our lives. But is every grandma equally important? Study shows that it is not the case. We have many reasons to think that maternal grandmothers are particularly important in the lives of their grandchildren. Looking at the matter at hand from another perspective: are all grandchildren similar? That is also not true, as they differ from one another not only in character, but also in their birth status: whether they are firstborns, twins, siblings born within short intervals or even those from outside of a marriage. These differences, however, tend to obscure the fact that those children also have a lot in common: higher risks of low birth weight, higher risk of getting lower Apgar scores and premature birth; consequently, they have a lower chance of survival.

Scientists decided to check whether the presence of a grandmother increases the chance of survival of children with a difficult start in life. To do this, they used Finnish genealogical data from 1730–1895, as during that time, both contraception and comprehensive health care were virtually unavailable for most people. Finland is an exceptional country for doing this kind of study, since Lutheran priests have kept extensive records of the population. The researchers analysed the information and assessed the likelihood of reaching the age of five in (1) children with both grandmothers, (2) children with only maternal grandmothers, (3) children with only paternal grandmothers and (4) children with no grandmother.

It turned out that firstborns, twins, children born up to two years after their siblings and children born out of wedlock did not gain any advantage from the presence of any grandmother: their likelihood of reaching the age of five did not change in any meaningful way. However, grandmas were extremely important to children who welcomed a younger sibling before their second birthday. Interestingly enough, the children with maternal grandmothers were 41% more likely to reach the age of five when compared to the children with no grandmother.

JU researchers have scientifically proven, for the first time in the world, that grandmothers are important for children whose mother has given birth to their younger siblings in a short time span. In such cases, mother had to focus most of her attention on the younger child, while the older benefitted from the care of other adults in the family, like grandmothers. So we know that the presence of a grandmother is advantageous to the children, but do grandmas get something in return? Indeed, they do. Evolutionarily speaking, not only does she increase the reproductive success of her daughter by ensuring she is, for instance, able to bear more children. In the case of maternal grandmothers, she can be sure that she helps to pass along her own genes. In other words, by taking care of their daughters, they are also taking care of themselves.

### i

Dr Ilona Nenko  
Department of Health and Environment  
JU MC Institute of Public Health

The research project was carried out by Ilona Nenko from the Department of Health and Environment of the JU MC Faculty of Health Sciences Institute of Public Health in collaboration with the University of Turku. It was funded by the Ministry of Science and Higher Education (K/ZDS/006115), National Science Centre (2016/21/D/NZ8/01306), Academy of Finland and Kone Foundation.

Original paper:

Nenko I, Chapman SN, Pettay JE, Lahdenperä M, Lummaa V. *Will granny save me? Birth status, survival, and the role of grandmothers in historical Finland, Evolution and Human Behavior* <https://doi.org/10.1016/j.evolhumbehav.2020.11.002>

**ANTIBACTERIAL PEPTIDES**

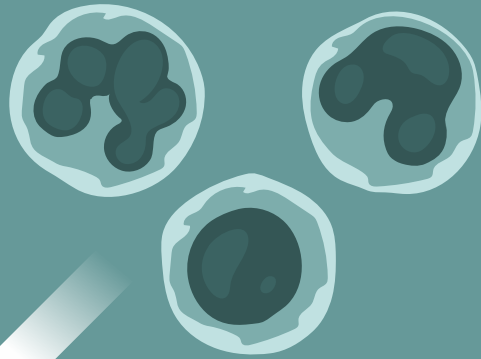


**DIRECT ELIMINATION**

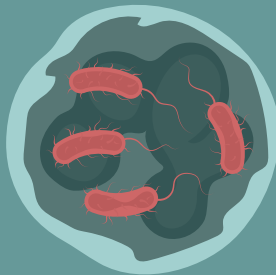


**IMMUNOMODULATION**

**RECRUITMENT AND ACTIVATION  
OF IMMUNE SYSTEM CELLS**



**MORE  
EFFECTIVE  
ELIMINATION**



**CONTROL OF  
SYSTEMIC  
INFLAMMATORY  
RESPONSE**

**IF NOT ANTIBIOTICS,  
THEN WHAT?**

**The goal of the research carried out by a team of mycologists from the Department of Pharmaceutical Botany of the Jagiellonian University Medical College is to learn about the dietary, prophylactic and therapeutic properties of edible mushrooms. Bearing in mind their beneficial health effects, especially against the so-called diseases of affluence, it is recommended to include them in one's daily diet.**

Mushrooms have been used for thousands of years as a dietary component and as a protective agent against various medical conditions. They are probably the oldest of the documented natural medicinal raw materials. About three thousand species are considered as edible, and one hundred are grown commercially, but only a few on an industrial scale. The aim of the research conducted by a team of mycologists from the Department of Pharmaceutical Botany of the Jagiellonian University Medical College is to learn about the dietary, prophylactic and therapeutic properties of fungi, useful in the prevention of the diseases of affluence. Mushrooms are a nutritious food product containing all the basic ingredients that are essential for the growth and development of the human body and supporting its life processes. They contain sugars, fats, vitamins A, B, C, D, E as well as elements such as zinc, magnesium, selenium, iron, copper, and calcium. The folk term that mushrooms are the 'meat of the forest' is not unfounded, because due to the content of highly nutritional protein,

they can be a dietary alternative to meat. In recent years, we have been observing dynamic progress in research on this natural food resource with remarkable therapeutic potential, which is still underappreciated in Europe. Due to the presence of medicinal compounds in mushrooms, they are used in the treatment of serious conditions, such as cardiovascular diseases, diabetes, and atherosclerosis. It is worth emphasising that mushrooms have the ability to strengthen the immune system, which is used in the prevention and treatment of cancer, and have anti-inflammatory, anti-aging and nerve-regenerating properties. Mushrooms also present strong antibacterial and antiviral properties. The fruiting bodies of edible mushrooms are a valuable source of dietary fibre, which stimulates the development of organisms that occur naturally in the intestines and detoxifies the human body from toxins and heavy metals. Bearing in mind the beneficial health effects of edible mushrooms, it is recommended to include them in one's daily diet.

**i**

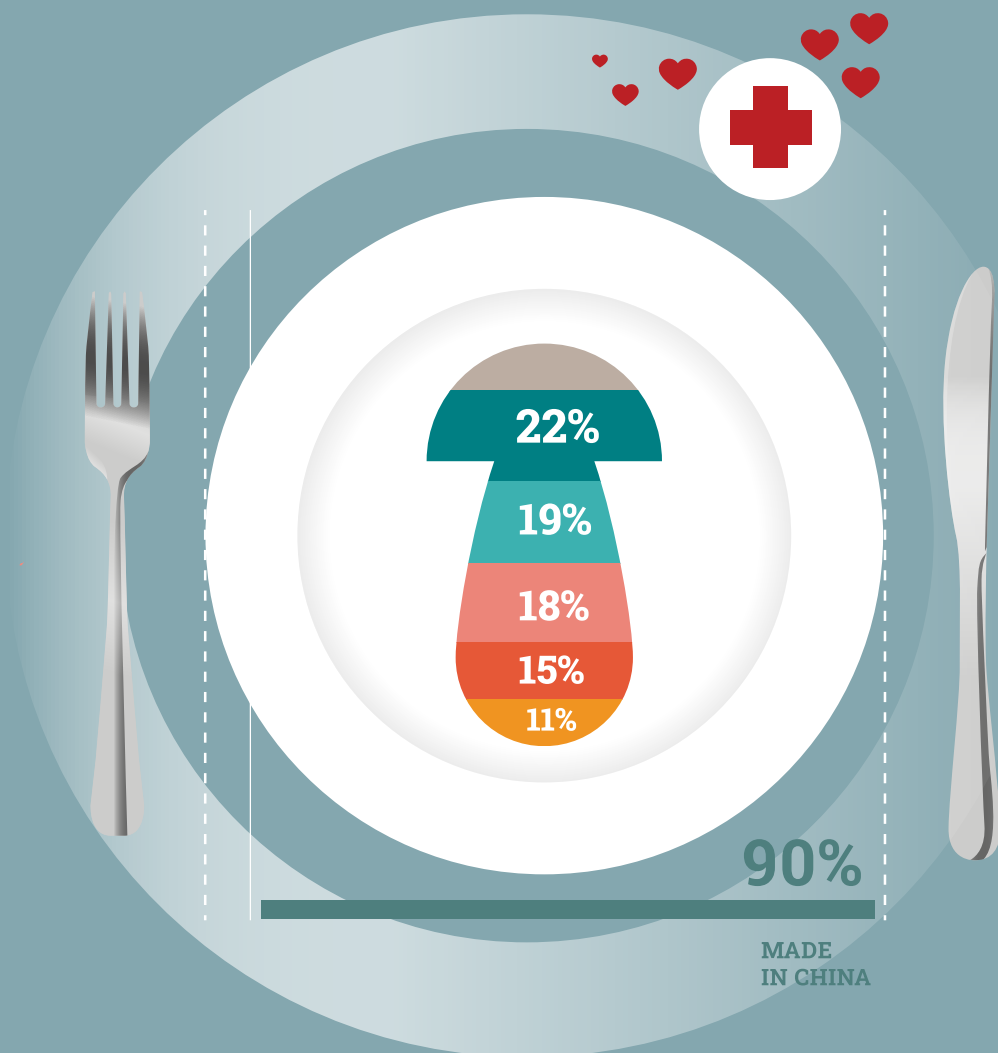
Prof. Bożena Muszyńska  
Dr hab. Katarzyna Sułkowska-Ziaja  
Jagiellonian University Medical College, Faculty of Pharmacy,  
Department of Pharmaceutical Botany, ul. Medyczna 9, 30-688  
Kraków

3000 🍴

\$ 100

Most cultivated species

● Shiitake ● Oyster ● Black wood ear ● Button ● Velvet shank



EDIBLE MUSHROOMS:  
A SUPERFOOD  
WITH OUTSTANDING  
HEALTH PROPERTIES

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▶ 250 

**BURNOUT IN NURSES.  
HOW DO WE TAKE CARE  
OF OUR CARERS?**

**It is supposedly rude to ask women about their age. However, when discussing the problems plaguing nurses in Poland, it is an issue that cannot be overlooked. A nurse in Poland is typically a woman over fifty, exhausted and working two jobs. Providing services in several places is not only financially motivated, but also a consequence of mass staff shortages in Polish health care centres. Since in Poland, statistically speaking, there are just five nurses for every thousand patients and the majority of them are middle-aged women, there is a worrying possibility that their number will decrease even further. In other parts of Europe, the number of nurses is double of that in Poland, which makes it easier for them to organise their work and ensure the safety of patients. It is difficult to imagine what would happen if Polish nurses suddenly decided to work only one job. Their absence would be immediately and painfully apparent in every clinic and hospital.**

### **What is burnout?**

According to most definitions, burnout is the state of physical and mental exhaustion caused by overworking and long-term stress. Being a nurse is a very demanding job, as they need to play many roles: professional carers, friends, therapists, logisticians, managers, secretaries and archivists. They have to provide help wherever they are needed. Often forced to choose between two or more people that require assistance, they may feel guilty or unfairly judged by patients and their families. Everyday life of nurses is filled with emotional tension, physical and mental strain, and taxing workplace responsibilities.

Burnout is a cyclical process, requiring decisive actions in order to prevent oneself from its consequences. In extreme cases, the condition can lead to drug and alcohol abuse, aggressive behaviour towards patients and even suicide.

People suffering from burnout try to combat it in various ways – most often they improve their qualifications and seek a new job, take a long break or change their working environment.

### **How to diagnose burnout?**

There are several tools that can be used to determine whether a nurse is suffering from burnout. For the purpose of their research, JU scientists asked a series of questions that helped them ascertain if a nurse is affected by burnout. By measuring the levels of emotional exhaustion, depersonalisation and sense of accomplishment, they were able to assess the severity of burnout using the Maslach Burnout Inventory – Human Services Survey (MBI – HSS), perform a preliminary diagnosis and suggest treatment that would improve their situation.

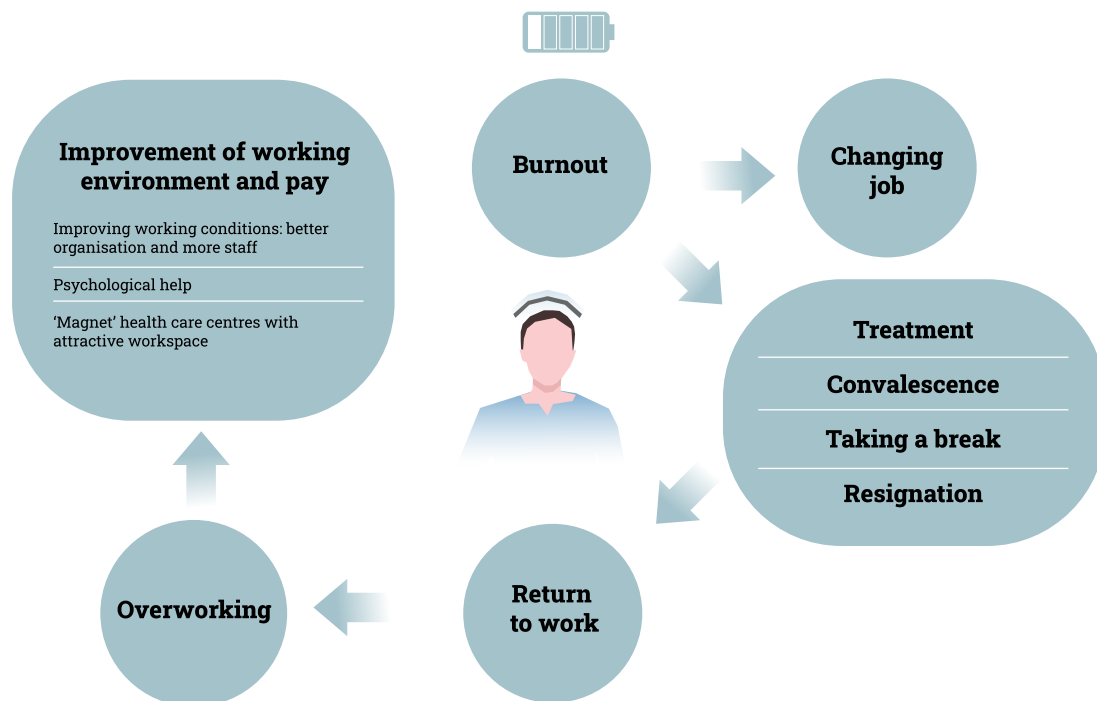
### **How to prevent burnout?**

In their study, JU researchers focused on interpersonal and organisational factors that lead to burnout, since they are the leading causes of the issue. Even if an individual nurse takes some steps to combat the negative impact of stress, without the support of their employer and favourable workplace conditions their efforts will be largely wasted. Proper organisation coupled with transparent and respectful communication play a key role in this situation.

One of the things we may do to prevent burnout is helping to build a friendly working environment – health care centres that are ‘magnets’ for staff, where the rate of burnout is much lower, leading to less staff shortages and satisfactory long-term employment. Some possible solutions include lowering the number of patients for every nurse, shorter hours with sufficient breaks, temporary changes in responsibilities and opportunities to relax. However, we need to bear in mind that respect and support of superiors and co-workers are also important, and that can be improved by organising training in communication and soft skills.

### **What can we expect from the research?**

The cross-sectional study conducted by the Department of Nursing Management and Epidemiologic Nursing and the Department of Internal Medicine and Environmental Nursing in collaboration with the Małopolska Regional Chamber of Nurses and Midwives will allow us to estimate the number of nurses suffering from burnout and describe the leading causes of the problem in their workspaces. The JU researchers would like to contribute to more effective detection and prevention of burnout in health care staff.



Dr Anna Nowacka *Wypalenie zawodowe, przewlekłe zmęczenie, bezsenność, psychospołeczne warunki pracy wśród pielęgniarek i położnych zatrudnionych w szpitalach w Małopolsce* [Burnout, chronic fatigue, insomnia and psychosocial working conditions amongst nurses and obstetricians employed in Małopolska hospitals]

Project financed by Faculty funds: N43/DBS/000147.



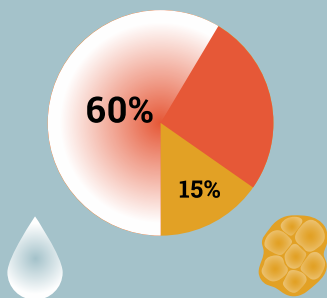


# Science in JU Medical College



[/poprostunauka](#)

## WATER AND FAT IN THE HUMAN ORGANISM



## WATER REQUIREMENT

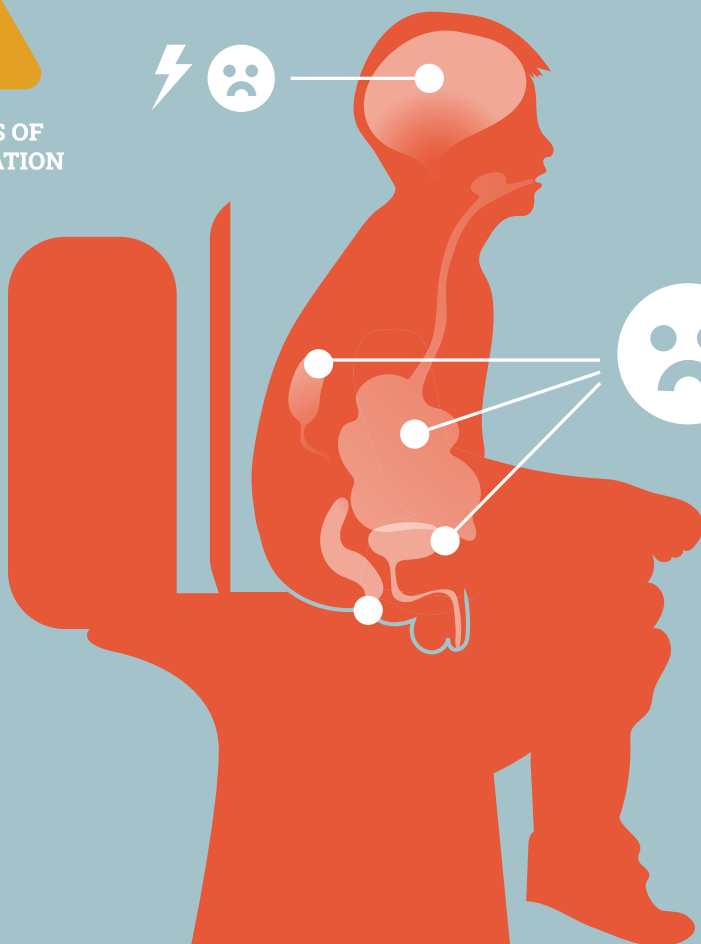
2-4%



10-15%



## EFFECTS OF DEHYDRATION



**A SIP OF WATER.  
ARE CHILDREN STAYING  
HYDRATED AT SCHOOL?**

**Proper hydration has a colossal impact on the development and cognitive function of school-children. As we know, children are liable to choose unhealthy, artificially sweetened drinks, but the more pressing issue is: do children at school even drink the amount of liquids necessary to stay hydrated? And what about overweight children, who need more water? Researchers from the Jagiellonian University Medical College found the answers to these questions and more.**

The body of every human, particularly a child, cannot function properly without water. Every day, we need to drink an amount of liquids sufficient to replenish the water we expel as waste, through skin and while breathing. Compared to adults, children need much more water in relation to their body mass: 10–15% of their body weight versus 2–4%. This is due to differences in body composition: water makes up about 60% of an adult's body, while fat accounts for about 15% (not considering any differences between the sexes). The younger a child is, the more water its organism contains. Additionally, during rest in an optimal temperature, children expel more water through their skin than adults, as their ratio of body weight to body surface is twice as high.

When there is too little water in the body, it becomes dehydrated. Liquids can also become part of transcellular fluid in case of burns or swelling. This is why it is extremely important to quickly and correctly assess the level of hydration of the ill. There are several methods of doing that, with some of them relying on analysing urine to determine its colour, specific weight and osmolality. The latter is the number of osmolites, i.e. particles that have a great impact on the properties of fluids, per one kilogram of the fluid. It reflects the concentration of such substances as sodium, potassium, chlorides, glucose and urea. Under normal circumstances, the two most important osmolites are sodium and glucose.

With the help of the Board of Education, researchers were able to convince parents and their children to take part in a study which involved the pupils giving urine samples during school hours. But why are researchers interested in the levels of hydration of healthy children? According to some recent studies, children at schools may be dehydrated despite eating breakfast, which in turn may result in lower cognitive abilities (memory, concentration, attention, reaction time etc.) and decreased performance in class. Water deficiency may also

impact a child's psychological condition, causing bad mood, gastric problems and constipation. When neglected for long periods of time, dehydration may lead to urinary tract infections and kidney stones and, ultimately, chronic kidney disease, an insidious illness that is slow to show any symptoms. This is why performing regular urine tests is important in the prevention of urinary tract and kidney diseases.

The study conducted by JU researchers is one of the first in Poland to include urine osmolality in the test results of healthy children from local schools. Scientists also took into consideration the relation between hydration and the amount of fat tissue in their organisms. Unfortunately, the results of their research are worrying. More than half of the children (53%) were dehydrated, while one in six (16.3%) showed signs of serious deficiency of fluids. Moreover, almost 17% displayed an excess of fat tissue (9.5% were overweight, 7.2% – obese). The symptoms of dehydration were the most visible in this group of children. Additionally, dehydration was also more frequent in younger children.

Since dehydration may be the cause of trouble with learning, it is vitally important that we strive for providing free access to high quality water in educational institutions. Combined with educating children on the importance of water conservation and the role of water in the human body, it could be beneficial in promoting healthy lifestyle choices and reducing obesity in school-children.

#### i

Dr Beata Piórecka, MD, Department of Nutrition and Drug Research, Institute of Public Health, JU MC Faculty of Health Sciences  
Dr Agnieszka Kozioł-Kozakowska, Centre for Paediatric Dietetics, Clinic of Paediatrics, Gastroenterology and Nutrition, Institute of Paediatrics, JU MC Faculty of Medicine

The research project was funded by the Jagiellonian University Medical College own funds, grant no. K/ZDS/006175. Full paper: <https://www.mdpi.com/1660-4601/17/19/7181>



## || VIRUSES VERSUS BACTERIA

**The discovery of the first antibiotic – penicillin – was expected to mark the beginning of the end of bacterial infections. Nothing could be further from the truth. The development of antibiotic resistance of bacteria opened another chapter of the battle between science and nature. Fortunately, the humankind found a new ally – viruses known as bacteriophages, which are natural enemies of bacteria.**

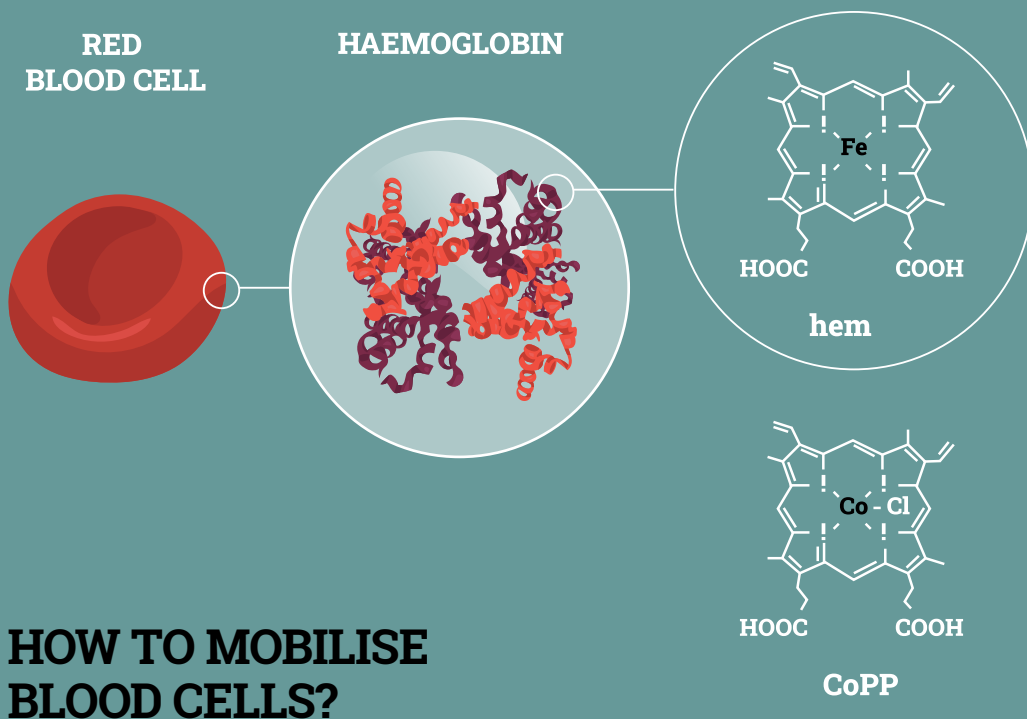
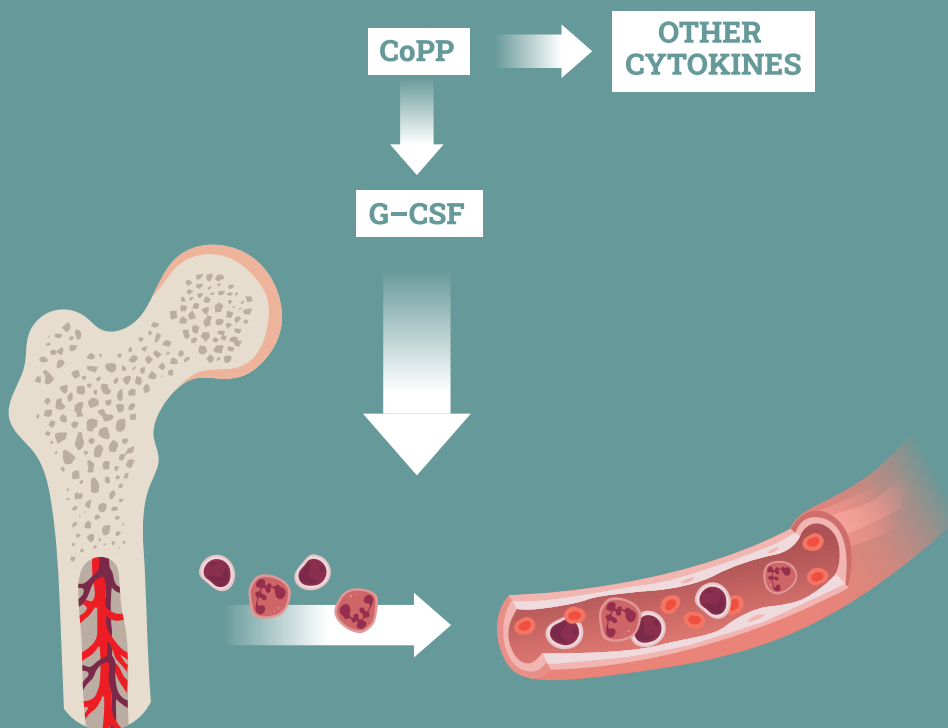
Unlike antibiotics, which usually kill both pathogenic and beneficial bacteria, bacteriophages are very picky and their particular types attack only specific bacteria strains. The first attempts to use them in infection treatment were made as early as one hundred years ago, but the situation later changed due to the discovery of antibiotics. Currently, there is a growing interest in bacteriophages, not only due to the alarming rise in bacteria's resistance to antibiotics, but also because the role of microbes in the development of diseases is now much better understood. It used to be thought that illness is simply the result of a bacterial invasion on the body, so in order to recover, it is necessary to get rid of all the bacteria. Today, it is known that the situation tends to be much more complicated, like, for instance, in the case of chronic sinusitis.

'Paranasal sinuses of every human being are inhabited by a variety of bacteria. They are necessary to maintain health, but in order to do so they must remain in an equilibrium with our body and among themselves. Any treatment for chronic sinusitis should consist of eliminating only those bacteria that disturb the balance, instead of getting rid of all microorganisms living in sinuses. Bacteriophages are perfectly suited for this task', explains Dr Joanna Szaleniec, who together with her team studies the possibilities of applying bacteriophages to treat sinusitis patients. The researchers have discovered that the majority of bacteria found in paranasal sinuses (including those resistant to antibiotics) are vulnerable to known bacteriophages. It seems that thanks to these viruses we once again have a chance to gain an upper hand in the unending battle against harmful bacteria.

**i**

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Chair and Clinic of Otorhinolaryngology  
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Dr hab. Tomasz Gosiewski  
Chair in Microbiology  
JU MC Faculty of Medicine



**In every second of our life, our body produces about a million new blood cells. They originate from hematopoietic stem cells (HSCs) in bone marrow and are gradually released to peripheral blood. However, in case of a serious infection or loss of blood, the production of blood cells has to be rapidly increased, and they have to be quickly transferred to the circulation. Yet, this is not as simple as it seems – the egress of cells from the bone marrow is a dynamic process and involves several different proteins, such as G-CSF, which precisely regulates the mobilisation. G-CSF is also responsible for the proper maturation of white blood cells, which then combat the invading pathogens. So, when the situation becomes really serious, the concentration of G-CSF protein in blood quickly increases. This gives the cells the signal that it's time to prepare for action.**

Thanks to advances in medicine and molecular biology, researchers developed drugs that can trigger the mobilisation. These medications are especially useful in two situations. Firstly, when HSCs need to be transplanted. There was a time when the only available source was a donor's bone marrow, most often harvested from pelvis. This procedure is usually performed under general anaesthesia. Today, this method is mainly used to collect HSCs for transplantation for children, whereas in most other cases, HSCs are isolated from the blood of a donor, who is treated for several days with mobilising agent. The second use of mobilisation is to prevent infection in patients who have undergone chemotherapy, which kills not only cancer cells, but also other dividing cells, such as blood cells. This is why chemotherapy patients have compromised immunity and are more vulnerable to life-threatening infections. Providing them with a mobilising factor results in faster production of white blood cells in their bone marrow, which are then rapidly released into blood and make their immune system better prepared for fighting the bacteria.

The standard medication used to trigger the mobilisation is the recombinant G-CSF protein. To obtain this protein, the human gene encoding G-CSF is introduced to bacteria. The gene serves as a manual or a recipe that allows bacteria to produce the desired protein. While this technology allows the production of proteins, such as insulin or coagulation factors, essential for treatment of several diseases, the recombinant proteins produced in bacteria tend to differ from those produced by the human body.

Unfortunately, in some patients the recombinant G-CSF turns out to be ineffective – the numbers of white blood cells and HSCs in their blood do not increase sufficiently. Therefore, researchers try to devel-

op a new strategy for cell mobilisation that could both help chemotherapy patients and facilitate obtaining HSCs from donors.

Research at the JU Department of Medical Biotechnology involves studies that use porphyrins, especially cobalt protoporphyrin IX. Porphyrins are an interesting group of chemical compounds, indispensable for the life of bacteria, plants and animals. They have a complicated structure, which determines their diverse colours. For these reasons, they are referred to as the 'colours of life'. Porphyrins include chlorophyll, the pigment responsible for green colour of plants, as well as some of the pigments determining the colour of birds' plumage. The abovementioned cobalt protoporphyrin IX (CoPP) is very similar to haem – a protein found in haemoglobin, responsible for binding oxygen in red blood cells. If the iron atom present in haem molecule is substituted by a cobalt atom, the resultant molecule would be CoPP.

During one of their experiments on laboratory mice, which had been administered CoPP, the scientists made an interesting observation: it turned out that administration of CoPP results in the increase of endogenous G-CSF protein level in their blood, which, in turn, leads to the mobilisation of HSCs and granulocytes from bone marrow.

Intrigued by this discovery, the researchers decided to take a closer look at how CoPP works. It turned out that increasing the production of G-CSF with CoPP can mobilise cells from bone marrow to blood more effectively than administering the recombined G-CSF to mice.

The aim of the ongoing research funded by grants from the DKMS Foundation, the National Science

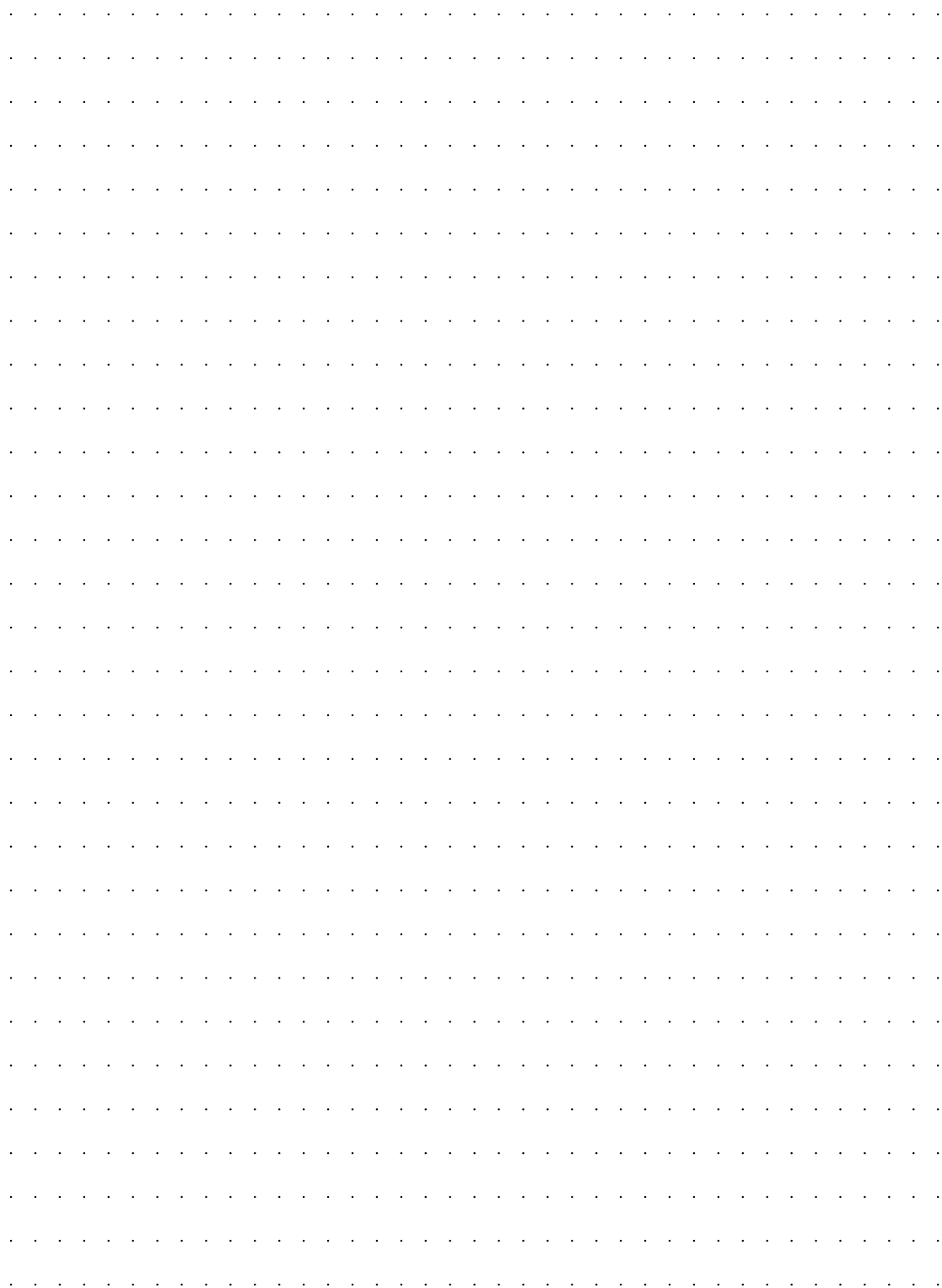
Centre, and the National Research and Development Centre, is to check whether CoPP can mobilise human cells as effectively as mouse cells and to understand the mechanism responsible for the increase

of endogenous G-CSF level in blood. The scientists hope that their studies will contribute to the development of new forms of treatment, which will help many patients.

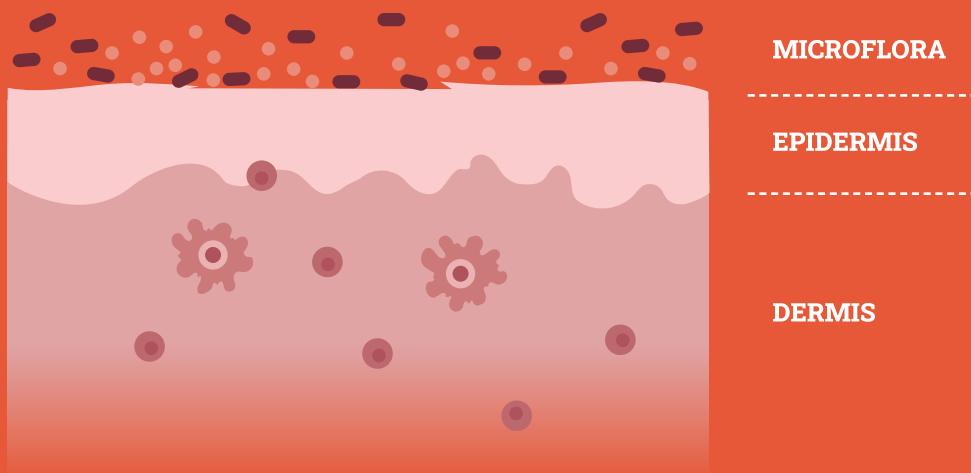


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<https://www.nicheworks.eu/hscs-and-their-niche>

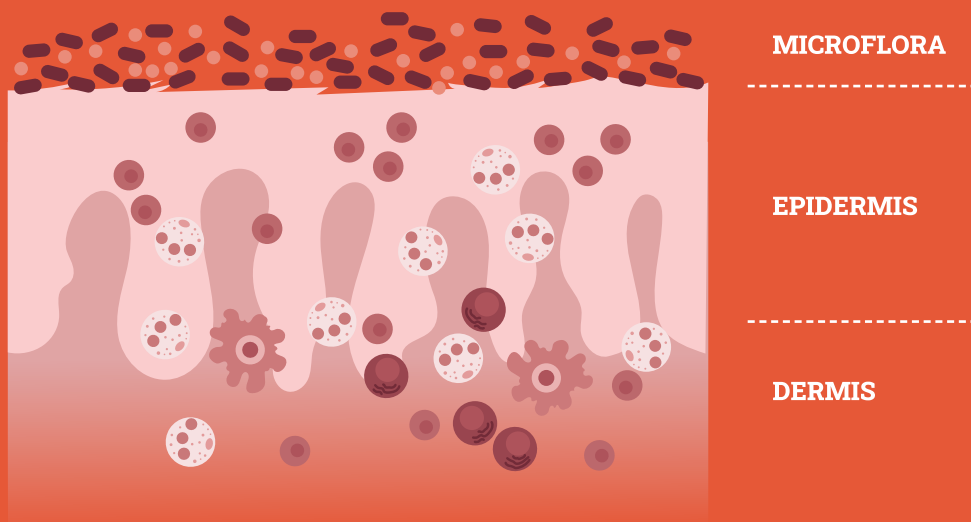




**A** HEALTHY SKIN



**B** PSORIATIC SKIN



● BACTERIA

● IMMUNE SYSTEM CELLS

**CHEMERIN –  
A UNIVERSAL REMEDY?**

**Natural antibiotics – that is, antibacterial molecules produced by the human body, are the key part of the barrier against the invasion of microbes into the body in such places as skin. Scientists from the Jagiellonian University are working to understand the mechanisms of production and activity of these natural antibiotics in order to apply this knowledge to gain better control over skin-dwelling microorganisms, which can cause numerous infectious diseases.**

The skin surface area of an average adult, including cavities, such as hair follicles, amounts to about 25 square metres, which makes skin one of the largest human organs, and one of the most exposed to external factors. This 'barrier organ' consists of several layers, the most external of which is the epidermis, with the dermis underneath (fig. 1).

Because of its strategic location, epidermis is characterised by very well developed mechanisms of protection against microbes, which include the constant production of bacteria-killing molecules, known as antimicrobial peptides, that is, compounds functionally similar to antibiotics. Their effect is often amplified by microorganisms living on skin surface, since they can induce synthesis of these molecules. Moreover, immune system is an integral part of the skin. This structurally and functionally interdependent defensive system plays a key role in maintaining the proper physiology of skin, and its malfunctions are behind the majority of chronic inflammatory skin diseases, including psoriasis.

Researchers from the Department of Immunology of the JU Faculty of Biophysics, Biochemistry and Bio-

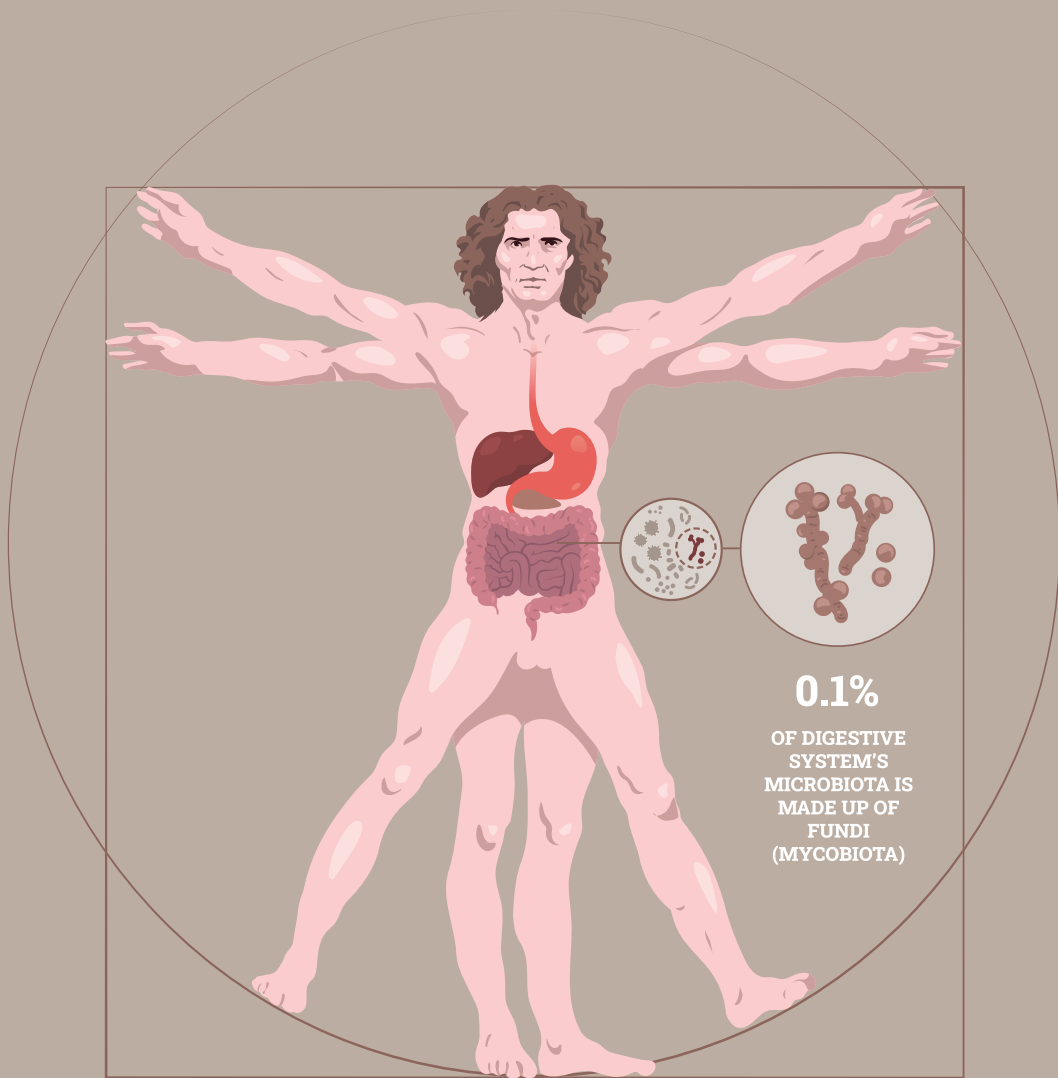
technology have conducted research into the previously unknown functions of some proteins present in epidermis, such as chemerin, SLPI, or Regnase 1. For instance, they have shown that chemerin, thanks to its newly discovered antibacterial properties, can directly hinder the growth of skin-dwelling bacteria (known as skin microbiota), reducing the numbers of the bacteria and shaping the composition of their population (fig. 1). In healthy people, this antibacterial function of chemerin results in maintaining the equilibrium between skin and the world of bacteria.

Describing these previously unknown properties of chemerin and finding the area in which antibacterial properties are located in the spatial structure of this protein have led the JU researchers to create an artificial antibacterial fragment of chemerin. Imitating nature – basing their project on the amino-acid sequence of chemerin (the arrangement of building blocks of this protein) – they synthesised its antibacterial part and showed that it can have therapeutic properties: an ability to limit the development of bacterial skin pathogens, such as methicillin-resistant *Staphylococcus aureus*.

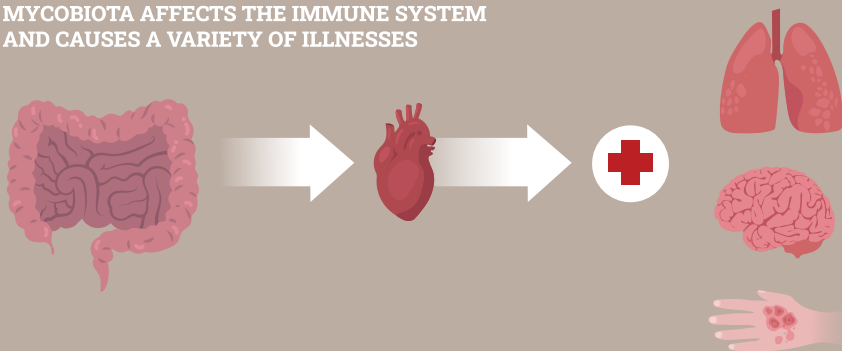
**i**

Prof. dr hab. Joanna Cichy  
Department of Immunology  
JU Faculty of Biochemistry, Biophysics and Biotechnology

The research on chemerin is conducted in the Department of Immunology of the JU Faculty of Biochemistry, Biophysics and Biotechnology, within the framework of the project funded by the National Science Centre and led by Prof. dr hab. Joanna Cichy (SYMFOPIA UMO-2014/12/W/NZ6/00454).



MYCOBIOTA AFFECTS THE IMMUNE SYSTEM  
AND CAUSES A VARIETY OF ILLNESSES



**HUMAN MYCOBIOTA:  
MOLECULAR MUSHROOM PICKING**

**Fungi evoke a wide range of connotations. On the one hand, we may think of an early morning trip to a forest to find mushrooms to serve as a homemade meal or of yeast that will be used to bake tasty bread. On the other, there are also far less pleasant associations, such as amanita poisoning, athlete's foot and mouldy patches on wet walls. These are but a few examples of the immense diversity of organisms that many people think of as plants, but which in reality belong to a separate biological kingdom.**

Aside from 'classic' fungi that possess a stem and a cap, there is a vast number of microscopic species, which nonetheless can have a profound effect on our lives. This effect is not limited to fungal infections, which can be serious diseases that require specialist treatment, but also involves everyday functioning of our organisms. It turns out that fungi work in concert with a plethora of bacteria in every person's body, including very complex systems inside the gastrointestinal tract called the microbiota. They seem to play a key role in the human immune system, and the presence or excess of some types of fungi may affect the development of diseases that are not normally related to fungi. Scientists speculate that these might include atopic dermatitis, irritable bowel syndrome or even Alzheimer's disease. In response to so many suspicions of fungi's 'undercover' actions, researchers have begun to study this group of organisms more closely, calling it 'mycobiota'.

Studies concerning the intestinal mycobiota bring more and more interesting information. They seem to be producing substances related to inflammation that travel through blood to the nervous system. The question that

follows naturally is: are fungi found in human gastrointestinal tract in some way responsible for neurological and psychological conditions? Do they work alone or together with other microorganisms? What makes them decide to attack the brain?

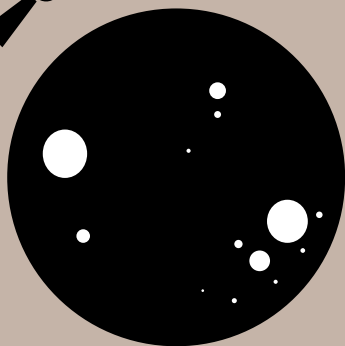
To answer these questions, one has to not only carefully select a group of patients for a study, but also use special tools to identify and count relevant fungal microorganisms. One of the projects conducted at the Department of Medical Molecular Microbiology of the JU MC Chair in Microbiology is devoted entirely to the relationship between bacteria and fungi of the large intestine and the progress of schizophrenia. To exclude any external factors that could prevent the researchers from getting accurate results, the experiment is carried out using animal models, and microbiota, including mycobiota, are identified using innovative molecular methods. Next-generation sequencing (NGS) analyses DNA of bacteria and fungi so thoroughly that it is impossible for any microorganism to hide from it. Time will tell if the microbes are willing to share their secrets.

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