INSIGHT

A Common Passion

Prof. Przemysław Perlikowski, a mechanical engineer, and his wife **Asst. Prof. Renata Perlikowska**, who studies opioid peptides used in medicine, discuss the challenges of research work and life.

ACADEMIA: **Prof. Perlikowski, can you first please tell us about your work?**
PRZEMYSŁAW PERLIKOWSKI: I'm a mechanical engineer and my work deals with mechanical vibrations. In nature, everything vibrates, but I focus on the vibrations that the observer sees as oscillatory motion. For example, I'm interested in the force generated by an oscillating bell that is transmitted to the bell tower, not in the vibrations of the bell that create sound. The bell is a musical instrument and is designed to produce the best possible sound, so there is no need to interfere with its shape. By changing the construction of the bell mount, we can alter the magnitude of the forces transferred to the bell tower, or we can also modify the bell ringing patterns. For example, the classic suspension system we are familiar with in Poland, in which we have two impacts for one full bell oscillation, can be used to produce only one impact from one side, or to produce a so-called double kiss, i.e. two impacts, one after the other, on either side of the bell. The theoretical study of the design of bells and bell towers is very important for unique designs, since typical solutions do not need to be interfered with. However, when we are dealing with historic bells, they are usually old bells that have seen better times, so during renovation we need to design the mount of the bell in a way that doesn't weigh it down any more, and actually reduce the forces conveyed to it. Unique bells are also a challenge, such as bells weighing upwards of 20 tons. Designing a mount for them is a very difficult engineering and scientific task.

You have traveled to Singapore to work on a project. What did you do there, was it also related to vibration modeling?
P.P.: In Singapore my work involved mitigation of vibrations with tuned mass dampers. Using the Taipei 101 skyscraper in Taiwan as an example, one of the tallest in the world, imagine a large pendulum on its top, weighing 660 tons, which is used to absorb energy from the building. When the structure begins to vibrate, its energy is transferred to the pendulum, damping the building vibrations. Our team from the Łódź University of Technology has a patented device that ensures efficient energy transfer from vibrating structures. Bridges can benefit from this device, for example, as many contemporary bridges have a lightweight construction, making them susceptible to vibrations. So the whole system must be stable enough to ensure the vibrations do not exceed the dangerous limit. Our invention ensures that excess energy is transferred in time, which stabilizes the structure. We are currently working on a second, improved prototype, which we will try to commercialize.

There have been cases that ended in disaster...
P.P.: Yes, there are two well-known cases. One is the Tacoma Bridge disaster in the US in the 1940s, when strong winds caused a suspension bridge to vibrate so much that it was completely destroyed. The second one is the Millennium Bridge in London, although this was a different situation. As people walked, they swayed sideways, so the bridge began to synchronize with their movements, and as more people continued to cross it this way, the bridge began to have significant transverse vibrations.

Was it a design error?
P.P.: It was not the typical kind of resonance phenomenon that is observed in tall buildings or in classic bridge design, as it involved the synchronized movement of a large group of people. In the case of cars, this phenomenon does not occur because they move in a straightforward way. In addition, cars are massive and there are only a certain number of them on a bridge. There were, however, a lot of people on this bridge, and as human beings they adapted to what was happening around them, so as the bridge vibrated, they also began to gently sway, and each step added a bit more transversal force and increased the entire bridge vibration.

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Are there methods or devices that ensure the safety of large structures? Is it even possible for buildings or bridges not to vibrate?
P.P.: One of the simplest devices is a body with much smaller mass than the vibrating structure, attached to it by a spring. This is the simplest system of tuned mass damper. It allows energy to be absorbed from the main structure during its resonance, by transferring energy to the tuned mass damper. Another device used to dampen vibrations is a pendulum.

Prof. Przemysław Perlikowski (ME, PhD, DSc) works at the Faculty of Mechanical Engineering, Łódź University of Technology. His main research focus is on nonlinear dynamics. Together with colleagues, he has developed a hybrid bell model, innovative designs of dynamic vibration dampers, and described new phenomena in coupled oscillator networks. Since 2016, he has been a member of the Polish Young Academy and the PAS Committee on Mechanics.

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When such a pendulum is mounted inside a building, then like a tuned mass damper it absorbs energy from the building, stabilizing it. Currently, very intensive research on this subject is underway and there are many advanced methods to mitigate mechanical vibrations.

We now know a bit more about what you do, but we are curious about your wife's work. We know you also conduct research together, despite the fact that you work in quite disjoint fields.

RENATA PERLIKOWSKA: I began working as a scientist in 2006 under Prof. Anna Janecka at the Department of Biomolecular Chemistry, Medical University of Łódź. My work involves studying the role of opioid peptides in the body and the various possibilities of their use for clinical treatment. In this area, I deal with the design and synthesis of new opioid peptide analogs, as well as study their biological properties. Until now, the goal of my work was to look for compounds that might replace morphine. Morphine is still the most effective remedy for acute pain, despite having many side effects it has yet to be replaced by safer means. In the first stage of my work, I focused on studying compounds that were linear derivatives of endogenous opioid peptides, known as endorphins. In September 2011, after a one-year break (for maternity leave), I continued my search for similar compounds with potential analgesic effects, but this time among cyclic compounds. After returning from my second maternity leave in 2018, I began research on the neuroprotective properties of opioid peptides.

What does this involve?

R.P.: Anything that prevents the loss of nerve cells is considered a neuroprotective mechanism, involving antioxidant or anti-inflammatory processes. The first thing we can do to protect our cells, not just nerves, is follow a proper diet and ensure the right balance between work, rest and exercise. Achieving homeostasis is important in order to prevent the continuous release or excess of the stress hormone, cortisol. This has become a trendy topic that is widely discussed in

the media. Many natural compounds have neuroprotective effects, such as polyphenols or their derivatives, as well as peptides acting through opioid receptors. This is why in the near future we will focus on the neuroprotective effects of naturally occurring peptides, isolated from spinach leaves. We will check whether these compounds will protect neurons from harmful factors, or reduce damage caused by cortisol, which is necessary for proper functioning, but in excess destroys cells.

Do you think that pain is a bit of a taboo subject in Poland? That some people feel that the compounds you are studying are dangerous, that it is best not to treat pain because it will stop on its own, or that pain is God's will?

R.P.: We always treat pain to minimize its effects, only it can be done in different ways, of course depending on the type of pain, its cause and location. The right treatment also includes manual therapy. I think that a pill, a band-aid or an injection is the last stage, because the pain should be eliminated at the earliest possible stage. In terms of research, many institutes are still searching for compounds with analgesic or anti-inflammatory effects, because in the future they could replace the ones that have side effects. We are trying to eliminate morphine and replace it with an equally effective but safe substance.

We mentioned earlier your project in Singapore – how did you end up working in such an exotic place?

P.P.: The Singapore project came quite unexpectedly. In 2013, we decided to travel abroad on another research internship. Earlier, we had both been taking longer or shorter internships. I had gone to Berlin, for example.

R.P.: It was the right time because our daughter was in kindergarten, so we wouldn't have to disrupt her life.

P.P.: And we found ourselves both applying for internships in scientifically interesting places. We wanted to go somewhere outside Europe and were particularly focused on the United States, Australia, Singapore and Hong Kong. My application, which I sent to Singapore, was accepted and this is how we ended up living in Asia for a year. The project took place at the National University of Singapore, which is one of the best universities in the world.

Are you still planning to work abroad? Is it absolutely necessary in this job, or can you stay in Poland? And do you want to?

P.P.: At the moment our older daughter is in school, which means we're not as mobile. We are open to traveling abroad, but we can't afford to be away from home for long periods of time. We can do shorter trips now to gain specific knowledge or skills.

R.P.: There is no need to leave for a long time anymore. I agree with my husband that short trips would suffice in order to work with other institutes, gain specific skills, or search for new opportunities.

Mobility is still considered important because it gives you the opportunity to work with different people, learn how they work in other countries. Is this important from the point of view of your work?

P.P.: From my point of view working abroad was very important, considering that I was going to places where there were people specializing in other fields. At the Humboldt University in Berlin I worked at the Institute of Mathematics, while in Singapore I worked at the Department of Civil and Environmental Engineering. This gave me a much broader view of engineering and expanded my research. These days, however, my focus is more on development in Poland, on working with postdocs and doctors in our division.

Asst. Prof. Renata Perlikowska (PhD, DSc) is a lecturer and researcher at the Department of Biomolecular Chemistry, Medical University in Łódź. She studies the role of opioid peptides in the body and their various uses in treatment.

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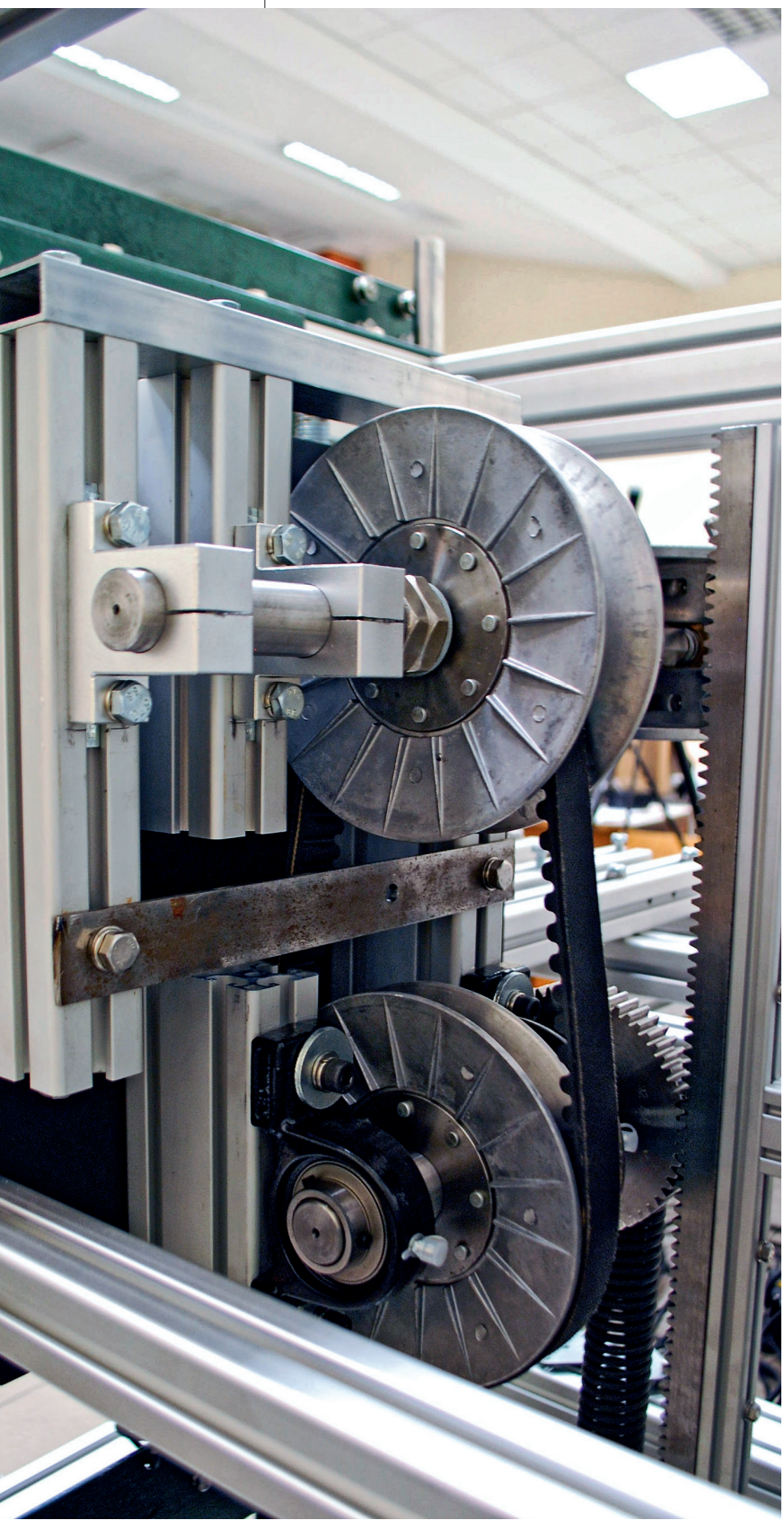

A prototype tuned mass damper, patented and built at the Division of Dynamics, Łódź University of Technology by Piotr Brzeski, Mateusz Lazarek, Tomasz Kapitaniak, and Przemysław Perlikowski.

What about in the fields of chemistry and medicine?

R.P.: In my case, working at other institutions gives me a chance to use better equipment and devices or acquire new skills. Exchanging experiences and knowledge is also an important aspect.

Can your fields be useful to each other?

R.P.: We have been thinking about a joint publication for years, but we haven't gotten around to it.

P.P.: There are some areas that overlap. I am not only an engineer, as I have also worked in the area of theoretical physics and modeling the activities of biological systems. I would like to create mathematical models of the phenomena occurring in my wife's experiments, but unfortunately we do not have time for this.

R.P.: Many biological phenomena can be described mathematically, allowing you to simulate a process or reaction without the need to carry them out. Based on the results obtained, the most interning cases can be selected and tested in a real experiment.

P.P.: The only thing we have managed to do was work together with my wife's associate, Asst. Prof. Katarzyna Gach-Janczak. We worked on the activity of astrocytes, i.e. glial cells of the nervous system. I wrote code that made it possible to read the activity of these cells from a film that was recorded during the experiment.

In any case, you work is very practical. You are working on things that can be used immediately. Do you have to fight to see your work put into practice?

P.P.: My background is in theory, on the cusp of mechanics and theoretical physics. Based on what I learned, a few years ago I transitioned from theoretical research to more applied research. However, when it comes to areas that are less often represented in the Polish industry, this is a very long and difficult path, but I think we are headed in this direction.

R.P.: In my case it is difficult because for a long time the pharmaceutical industry was not interested in peptides due to low synthesis productivity, the need for multi-stage purification and costs. This is changing, however, due to improved processes and new technologies, as short peptides are now being widely used in beauty products. The peptides that we intend to study for their neuroprotective properties have proven anti-aging effects.

You are active in science-related areas, on the PAS Committee on Mechanics and at the Polish Young Academy. What kind of satisfaction does it bring?

P.P.: This is a completely different type of work, because it offers a chance to leave the lab, step away from

the computer and look at science in a slightly different way. At the Polish Young Academy, we help young scientists, discuss laws and regulations, and take part in science fairs, showing the public what we do in a simple way. In other words, we must choose what is most interesting to the general public and present it in an appealing way. In our closed scientific community we use a completely different language, even jargon. As a member of the Polish Young Academy you have a chance to participate in the work of the PAS scientific committees. Working on the PAS Committee on Mechanics lets me learn more about the scientific environment and make contacts, which in the future may lead to joint projects.

We are seeing more and more women scientists. Are there more women attending technical universities nowadays?

R.P.: I graduated from the Faculty of Biotechnology and Food Sciences at the Łódź University of Technology. Later, because I was interested in the topic proposed by Professor Janecka, I transferred to the Medical University of Łódź, but I am constantly following what is happening at my faculty.

P.P.: A lot has changed since 1999 when I started university. At that time the Faculty of Mechanical Engineering at the Łódź University of Technology was mostly male. There are now many more women at technical universities and my faculty. The university takes part in the "Girls as Engineers" campaign, which does a great job to encourage women to work in technical fields, and I think it works.

Can you try to sum up, in one sentence, the benefits of being a scientist in Poland?

R.P.: Being a scientist is a challenge, but an appealing and motivational one.

P.P.: Being a scientist opens you up the world, to new people, allows you to make friendships and make your dreams come true.

Interview by **Anna Zawadzka** and **Katarzyna Czarnecka**
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