ISSN 1689-488X

PAUza Akademicka

Rok XI

Tygodnik Polskiej Akademii Umiejętności Nr 457 Kraków, 7 lutego 2019

pauza.krakow.pl pau.krakow.pl

Dzisiejszy numer jest inny niż zazwyczaj. Prezentujemy dwa teksty **Rolfa-Dietera Heuera**, profesora Uniwersytetu w Hamburgu, członka zagranicznego PAU, który w latach 2009–2015 był dyrektorem CERNu, największego laboratorium naukowego na świecie (członkiem CERNu jest również Polska). Pierwszy tekst jest streszczeniem wykładu, wygłoszonego 4 października 2018 podczas inauguracji roku akademickiego na AGH w Krakowie. Drugi opisuje krótko SESAME, niezwykłą organizację ośmiu krajów z Bliskiego Wschodu, która zbudowała w Jordanii nowoczesny synchrotron (akcelerator elektronów będący potężnym źródłem światła, umożliwiający badania w szerokim zakresie – od archeologii do biologii molekularnej). Dzięki temu udała się rzecz „niemożliwa": nawiązano bliską współpracę pomiędzy uczonymi z tego – pogrążonego od lat w konfliktach – regionu. Profesor Heuer jest przewodniczącym rady naukowej SESAME. (REDAKCJA)

Fot. Andrzej Kobos

# In praise of the virtuous circle

Science. It's all about discovery, innovation, publishing and sharing information within the scientific community, isn't it? But what is its role in society as a whole? The answer may seem obvious, but it's more subtle than you might think.

Science is all around us, underpinning just about every aspect of modern life, and its influence is becoming ever greater. We rely on science in our everyday lives, and we need science to overcome a range of challenges facing society today: challenges ranging from climate change to energy supply, and from antibiotic resistance to feeding a growing population.

Thanks to science, human health has been vastly improved for much of humanity, and thanks to science, each new generation enjoys a new range of creature comforts unimaginable to the one that came before. Many might be tempted to think that all this innovation comes from industrial applied R&D facilities, and they'd be largely correct, but the knowledge that innovation builds on comes from basic research. In this article, I will argue that once basic, curiosity-driven, research has sowed the initial seeds, innovation is a cycle, a virtuous circle that must remain unbroken if science, and society, are to thrive.

It's traditional to think of scientific innovation as a linear process. Basic research generates knowledge, thereby fostering educated minds. Some of these minds take that new knowledge and innovate, thereby changing society. Sometimes, that innovation is disruptive, transforming society in ways previously unthinkable. Michael Faraday's early experiments on electricity are a classic example: he was curious about a natural phenomenon, yet the knowledge he produced was soon applied to producing electric light. No amount of applied industrial R&D on candles could ever have done that. Equally significantly, however, it was not long before applications of electricity were also being applied to basic research, completing the virtuous circle.

It is investment in work such as Faraday's that has laid the basis for our society and our well-being today, and it is similar investment in science today that will pave the way to future well-being. But how should we organise science, and where should it be carried out? In today's challenging world, all regions need to step up support for research and innovation in order to ensure, in a global competitive environment, the sustainable development of science and technology necessary to ensure future prosperity. Institutions like the AGH University of Science and Technology are part of a global scientific infrastructure, and they are vital for our society.

Scientific research needs to be structured so that basic and applied research complement each other, such that it can be conducted on a scale appropriate to the questions being addressed, and such that nations can be proud of their national research output as well as their contributions to international research. Within such structures, there should be one prime criterion for supporting research: excellence.

Such structures already exist, and one that's very familiar to me is CERN, the European laboratory for particle physics of which I had the honour to be Director-General from 2009–2015. CERN is a unique international institute providing global research infrastructure that is vital for large scale projects. But CERN relies on strong na- ►

tional research programmes, and on strong research institutes like the AGH University of Science and Technology. When CERN experiments make major discoveries like the Higgs boson, it is thanks to the dedicated collaborative efforts of hundreds of institutes and thousands of individuals from all over the world working together. The existence of the CERN laboratory makes that collaboration possible, and gives a strong message to other areas of human endeavour: with mutual trust and sustained commitment, we can achieve great things together.

CERN also serves to illustrate my key theses: that science and innovation form a virtuous circle, and that all innovation can be traced back to curiosity. Acceleration and detection of particles are the key techniques of CERN's research in particle physics. They are also techniques that have applications in many other fields, notably medical diagnosis and therapy, and this has yielded incalculable benefits to both medicine and basic research for decades. In 1929, physicist Paul Dirac derived an equation to describe the behaviour of particles such as electrons. It was an equation with two solutions – one for negatively charged particles, the other for positively charged particles. Electrons have negative charge, and on the basis of his equation, Dirac predicted the existence of a positively charged equivalent. In short, he predicted the existence of antimatter. Four years later, Dirac's positive electron – the positron – was discovered. A more esoteric piece of basic, curiosity driven research would be hard to imagine, and indeed there was a long wait before antimatter was put to practical use. The idea of using positron-electron annihilation as a means of seeing inside a patient's body originated in the medical community, but it was not long before scientists at CERN in the 1970s started working on the sensors that would be needed to detect the resulting photons emerging from the patient's body. They contributed to the construction of prototype positron emission tomography, PET, scanners in collaboration with Geneva's university hospital. Over the ensuing years, the circle has come full turn on more than one occasion, as enhanced detectors have resulted both for basic research and for medical imaging. In a recent development, devices developed for an experiment at the LHC have provided a route to combining PET and MRI imaging techniques in a single device, producing a yet more powerful imaging tool. In therapy, meanwhile, it is the accelerator physicists' expertise that is being deployed to develop facilities for proton and light-ion cancer treatment.

Up to this point, I have focused on the practical benefits that accrue to society through the virtuous circle of science and innovation, and through carefully structured research such as exemplified by CERN. But these are not the only reasons for supporting science, pure and applied, at all scales, and at both national and international levels. The global scientific endeavour is a blueprint for peaceful collaboration between nations. That was one of the driving forces behind the creation of CERN, the first ideas for which can be traced back to as early as 1946 when the guns that had ravaged Europe through two world wars had barely fallen silent. Using the neutral language of science as a catalyst for peaceful collaboration is also one of the motivating factors behind another laboratory that I know well. Since 2017, I have been President of the SESAME Council, following two illustrious predecessors who were also former Directors-General of CERN. SESAME is a light source laboratory conceived of first and foremost to provide a world-class research infrastructure for the Middle East and neighbouring regions. In order to do that, it was modelled on CERN. Like CERN, SESAME was nurtured into existence under the auspices of UNESCO, and like CERN it is an intergovernmental organisation. Located in Jordan, its members are Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine and Turkey. SESAME's experimental programme got underway in 2018 with experiments ranging from the investigation of heavy metal pollution in the Jordan river valley to studies of novel treatments for disease. I look forward to the day, not far from now, when we'll be celebrating important discoveries at SESAME that help build knowledge and change society through innovation.

To conclude, it's vital that the all regions step up their support for science and innovation, that funders whether private or public sector understand the nature of the virtuous circle, and that the scientific model of global progress through trust and collaboration be heeded by other areas of human endeavour. Without this, we will not overcome the challenges facing society today, and we will not pave the way to future peace and prosperity. In today's world, the role of a scientist goes beyond the laboratory bench. We are all ambassadors for the benefits of structured, sustained and peaceful collaboration.

ROLF-DIETER HEUER

# SESAME – a new source of light for the Middle East

On 19 July 2018, a team led by bioarcheologist Kirsi Lorentz of the Cyprus Institute became the first scientific users to carry out an experiment at SESAME, the Middle East's new regional light source facility located in the town of Allan in Jordan. They were studying ancient human remains from the region in a bid to understand the uptake of metals by humans at the dawn of metalworking.

SESAME, which stands for Synchrotron-light for Experimental Science and Applications in the Middle East, is an intergovernmental organisation established to provide a world-class research facility for the region, and to stimulate international collaboration in science. Established under the auspices of UNESCO, its members are currently Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine and Turkey. Dr Lorentz' experiment was one of over 50 received by SESAME following the laboratory's first call for proposals, 19 of which were accepted. A second call for proposals in autumn resulted in over a hundred proposals being received from across the SESAME region and further afield, a strong sign that SESAME is already establishing itself on the world stage.

Research at light sources covers domains ranging from healthcare to the environment, and from agriculture to cultural heritage. For the established scientists of the region, SESAME promises to be a boon, giving them a facility on their doorstep rather than having to travel to light sources outside the region, and for young aspiring scientists, it will be transformational.

ROLF-DIETER HEUER