Great Science Begins with Big Questions

The Nobel Prize captures the public imagination, but according to **Prof. Tomasz Dietl**, a theoretical physicist affiliated with the Institute of Physics of the Polish Academy of Sciences and formerly with the University of Warsaw, as well as a recipient of the Foundation for Polish Science Prize, it is a poor measure of the quality of a country's scientific system. Nobel Prizes are rare, unpredictable and heavily influenced by what he calls the "law of small numbers." A better measure, he argues, is whether a country consistently produces excellent research and wins competitive international grants.

Does the question "When will Poland win a Nobel Prize?" actually make sense?

TOMASZ DIETL: I think the Nobel Prize is what mathematicians would call a singular event. It happens very rarely. Some countries receive the prize every few years or every decade, but one has to remember that the law of small numbers applies here. It is an extremely noisy measure and one that is heavily influenced by chance. For that reason, I do not think the Nobel Prize is a particularly good way of assessing the quality of a scientific system.

A much better indicator is the number of European Research Council grants. The sample size is larger, which makes comparisons between countries and universities far more meaningful.

It is also worth remembering how Nobel Prizes are awarded. The final decision is made by a relatively small group of people at the Royal Swedish Academy of Sciences. Opinions are gathered, conferences are organised, candidates are invited and the broader scientific community is consulted. Even so, the final decision remains extraordinarily difficult.

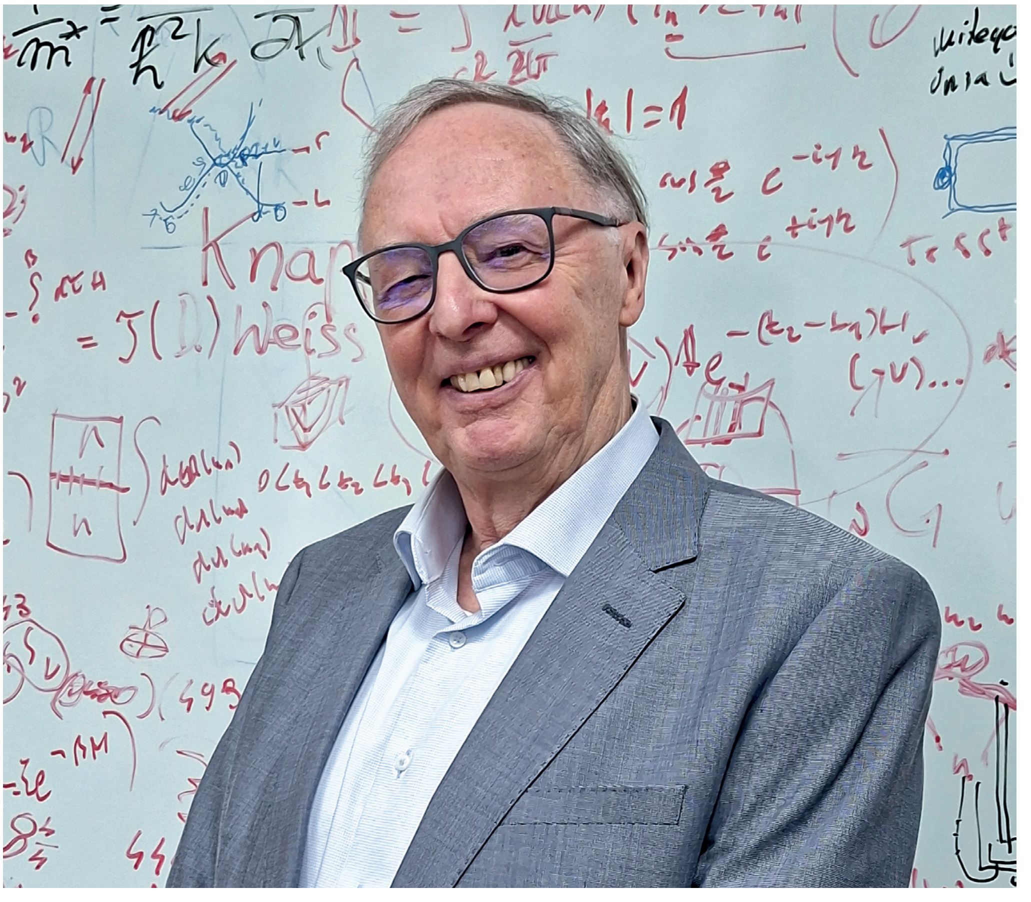
In physics alone, the shortlist of plausible candidates may include around three hundred people. Physics itself encompasses many different fields, and no member of the Academy can be equally familiar with all of them. That inevitably introduces an element of chance. ERC grants provide a more robust measure precisely because there are many more of them and statistical patterns become visible.

And what do those statistics tell us about Poland?

To be honest, they are not encouraging. More and more young Polish researchers are winning ERC grants, which is an excellent sign. But overall, Poland has received roughly fifty times less ERC funding than Germany. Germany's economy is obviously larger than Poland's, but not by a factor of fifty.

That points to a problem with research quality. The same pattern appears in other indicators. If you look at the number of scientific publications, Poland ranks around twentieth in the world, which is fairly respectable and broadly consistent with the size of our economy. In terms of research spending, we rank somewhere around twenty-third or twenty-fourth.

However, when we look at citation rates, publications in Nature Index journals and other quality-related indicators, we fall to roughly twenty-fifth place. In other words, we perform below what one might expect given current levels of funding.



Prof. Tomasz Dietl

A physicist, researcher, and science communicator, he is a professor at the Institute of Physics of the Polish Academy of Sciences and a full member of PAS. His research focuses on solid-state physics, particularly semiconductors and spin-related phenomena. He is recognized as one of the pioneers of spintronics, and his work contributes to the development of new electronic technologies.

The same is true for patents. Depending on the methodology, Poland ranks around twenty-sixth or twenty-seventh globally. Again, that is weaker than one would expect based on our spending. By those measures, Polish science has a quality deficit.

Where does that gap come from?

Part of the explanation is historical. Under communism, Poland had nine times fewer researchers per capita than the Soviet Union. In a sense, Poland functioned as a scientific colony. That illustrates how weak our starting point was after 1989, both in terms of quality and sheer numbers.

Then there is emigration. Many of our best scientists left the country. Before that, we lost generations of talent in concentration camps, during the Warsaw Uprising and in Katyn. For decades, Poland experienced a form of negative selection. That remains one of the reasons for the situation we face today.

Funding is another issue, but it is connected to something deeper. In Poland, whether among the public, political elites or sometimes even scientists themselves, there is a striking lack of confidence that we are capable of producing truly exceptional achievements. There is too little determination and too little belief that we can compete with the best.

If you begin with the assumption that the world does not belong to you, you will never conquer it. Without ambition and the will to compete, there will be no major success.

You can see that confidence very clearly in countries such as the United States, Japan, China, Germany and the United Kingdom. It is somewhat weaker in France, but still present. In Poland, however, that confidence is largely absent.

Everyone talks about funding, and rightly so, because its impact is probably non-linear. When a system is forced to spread limited resources thinly, as is the case today, the consequences are serious. This year, for the first time in fifteen years, research funding in Poland has declined, despite the fact that it was never particularly high to begin with.

Funding had increased by roughly 80 per cent over recent years, but after reaching about 1.6 per cent of GDP it has fallen back to around 1.4 per cent. In absolute terms, spending has also decreased.

Chronic underfunding combined with a lack of confidence in our ability to achieve truly exceptional results creates a situation in which we produce good science, but only rarely outstanding science. You can see that in the small number of ERC grants and, indirectly, in the absence of a Nobel Prize.

Yet Poland does have research groups that are operating at the highest international level despite these constraints.

Absolutely. Some of the most important theoretical contributions underlying the Nobel Prize-winning work of Anton Zeilinger involved Marek Żukowski from the University of Gdańsk. The university hosts an exceptionally strong group in quantum information theory, including the famous Horodecki family.

A paper on quantum entanglement authored by Ryszard Horodecki and his three sons has received around ten thousand citations. This is an example of a research group outside Warsaw or Kraków that operates at the absolute forefront of global science. If this group were to receive a Nobel Prize, nobody would be particularly surprised.

Other figures associated with this area include Charles Bennett, Peter Shor and Artur Ekert, who was born in Wrocław and studied at the Jagiellonian University before becoming a British physicist. One should also mention Wojciech Zurek of Los Alamos, a graduate of AGH University, whose work helped explain how quantum systems begin to obey classical physics through interaction with their environment.

A similarly distinguished figure is Maciej Lewenstein, who originated from the Centre for Theoretical Physics of the Polish Academy of Sciences in Warsaw but has spent many years working in France, Germany and now Barcelona. He remains closely connected to Polish institutions and researchers in Warsaw, Kraków and Gdańsk.

Lewenstein developed the theoretical framework behind experiments conducted by Anne L'Huillier, who later received the Nobel Prize. She carried out her research in France and now works in Sweden, but the key theoretical foundations were developed by Lewenstein. Few people would be surprised if the Nobel Committee eventually concluded that his contribution was significant enough to deserve similar recognition.

A comparable case was Andrzej Trautman of the University of Warsaw, who passed away recently. In the 1960s, he and the British physicist Ivor Robinson found solutions to Einstein's equations that predicted gravitational waves. Nobody would have been shocked if he had shared a Nobel Prize with the scientists behind the LIGO detectors.

The Nobel Committee apparently concluded, perhaps correctly, that the decades-long effort of building instruments involving thousands of researchers carried greater weight than the theoretical breakthrough itself. Nevertheless, Trautman's group at the University of Warsaw represented, and continues to represent, world-class research in general relativity.

There is also the group around Prof. Andrzej Udalski at the Astronomical Observatory of the University of Warsaw. Using gravitational microlensing, they study planets and other astronomical objects. The method was originally developed by the late Prof. Bohdan Paczyński.

Many people believe that if Paczyński had received a Nobel Prize, perhaps alongside Udalski or Aleksander Wolszczan, nobody would have found it surprising. The Nobel Committee ultimately chose two scientists from Geneva who discovered planets around Sun-like stars using a different technique.

Another important figure is the chemist Krzysztof Matyjaszewski. He has spent many years abroad, but his scientific roots are in the Centre of Molecular and Macromolecular Studies of the Polish Academy of Sciences in Łódź, and he remains closely connected to Poland. His work on polymers is cited extensively around the world. Although most of it was conducted abroad, its origins lie in Polish science.

A newer star is Bartosz Grzybowski, who has also spent much of his career outside Poland while maintaining close ties with the Institute of Organic Chemistry of the Polish Academy of Sciences. He developed computational methods for predicting chemical reactions and used them to plan and execute highly complex chemical syntheses. He now leads a major research group in South Korea. In my view, this is Nobel-level science.

One could name many more examples. I do not feel qualified to assess every discipline, but I assume there are researchers of comparable stature in other fields as well.

That is quite a long list. How do we convince young Polish scientists that they really can compete with the best in the world?

At least in physics, I do not see a lack of interest. At the University of Warsaw, there are around three applicants for every available place in physics. Young people have not turned away from science. I would say that the level of physics and astronomy at the University of Warsaw is now genuinely international.

There was a period when winners of national physics competitions preferred to study economics or business. That period is over. Students interested in science understand that they can pursue important and exciting work in Poland.

Some still leave the country, of course, but it is no longer true that Poland is seen as a scientific desert.

The quality of laboratory infrastructure has improved enormously. The achievements of Andrzej Udalski's group provide a good example. Their telescope in Chile was largely funded by the Foundation for Polish Science. They used CCD technology, now familiar to anyone with a smartphone camera, in an exceptionally creative way for astronomical observations. That demonstrates what is possible when you combine good ideas, the right tools and persistence.

In physics, many of the facilities we now have in Poland, both for producing advanced materials and for conducting measurements, are genuinely world-class. Young researchers also increasingly understand that science is international. They can work in laboratories across Europe and beyond. CERN is the best-known example, but it is far from the only one.

One such facility is Solaris in Kraków. Researchers come there from Austria, France and Germany. No country needs to possess every piece of infrastructure itself. Scientists can make use of shared facilities across Europe and around the world.

If Poland were to take one step that could genuinely improve its chances of producing world-class research, where should it begin?

Two competing approaches are usually proposed. If one accepts, and this is certainly debatable, that winning a Nobel Prize is a worthwhile objective, then one could consider creating an institution similar to the Weizmann Institute in Israel or the Institute of Science and Technology Austria near Vienna.

Anton Zeilinger was actually one of the active supporters of the Austrian project. The idea is to create a place that offers exceptional conditions to outstanding researchers from both the home country and abroad. Young scientists who win ERC grants would be encouraged to establish their groups there.

The logic is simple: excellence attracts excellence. When you bring together a critical mass of outstanding people, Nobel-level discoveries become likely.

Of course, there are legitimate questions about whether this is the best model. Austria is much smaller than Poland, yet it still maintains strong universities in Innsbruck, Linz and Vienna. Is it really desirable for the most talented researchers to concentrate in a single institution near Vienna? That is a genuine dilemma.

The second point is more straightforward. Without strong support for fundamental research, nothing truly significant will happen. Too often, science in Poland means distributing scarcity rather than building success. That has to change.

There is also a responsibility that falls on scientists themselves. We need to cultivate the belief that we are capable of achieving great things while understanding that success requires extraordinary persistence.

I often encourage younger colleagues to spend time abroad so they can see how leading laboratories operate. Computers do not write papers by themselves, and they certainly do not submit them to prestigious journals. Success requires very hard work.

When you look at the most important scientific breakthroughs of recent years, not just Nobel-winning ones, what drives them?

The answer probably varies from case to case. What is certain is that breakthroughs do not happen by chance.

A measure of luck is always helpful, but luck tends to favour people who are prepared to recognise and exploit unexpected opportunities. Persistence and a long-term perspective are crucial.

Scientists also need to understand that the goal of research is to solve important problems. The objective should not be to produce one paper per year for evaluation exercises or institutional metrics. It should be to take on an ambitious scientific challenge and pursue it for ten years if necessary.

That, perhaps, is what distinguishes great scientists from merely competent ones. Great scientists choose difficult and important problems even when they know that solving them may take a decade or more.

Looking at contemporary science, awarding a single Nobel Prize in physics across fields ranging from quantum mechanics and materials science to astrophysics and, recently, artificial intelligence sometimes seems a little like asking the entire film industry to gather once a year and hand out a single Oscar.

That is an excellent comparison. One has to remember both the law of small numbers and the limited ability of any committee to evaluate every branch of modern science equally well. Deciding who is "better" and who is "worse" is extraordinarily difficult. In many cases, there is no clear or objective answer. For that reason, there will always be an element of chance in the Nobel Prize. ■