EINSTEIN FOUNDATION AWARD 2021

PROMOTING QUALITY IN RESEARCH

THE AWARD

Measuring short-term success is usually easy. Recognizing quality is somewhat harder, while predicting lasting significance is, in most cases, nigh on impossible. This goes for many situations both in the arts and the sciences. But what we seek is certainty, knowledge, and reliability in order to build on new findings and forge ahead. We need tools and methods that enable us to access and compare the vast amount of information that is quickly available around the world and to place it in its specific context and to classify it. The science and research community is attempting to accomplish this mission to help us navigate through a complex world.

This is an increasingly important and far-reaching goal. If researchers are to continue delivering reliable results and providing guidance to society, they need to work with robust, universally accepted methods. To ensure quality, we not only need to look at the science system and its methods, in other words the conditions defining how researchers work and how they design experiments, but also at the circumstances shaping their careers, at the digital infrastructures, and publication mechanisms, that is the rules underpinning academic competition. We need to take a clear-eyed look at all systems used to measure success in research and to decide on locations.

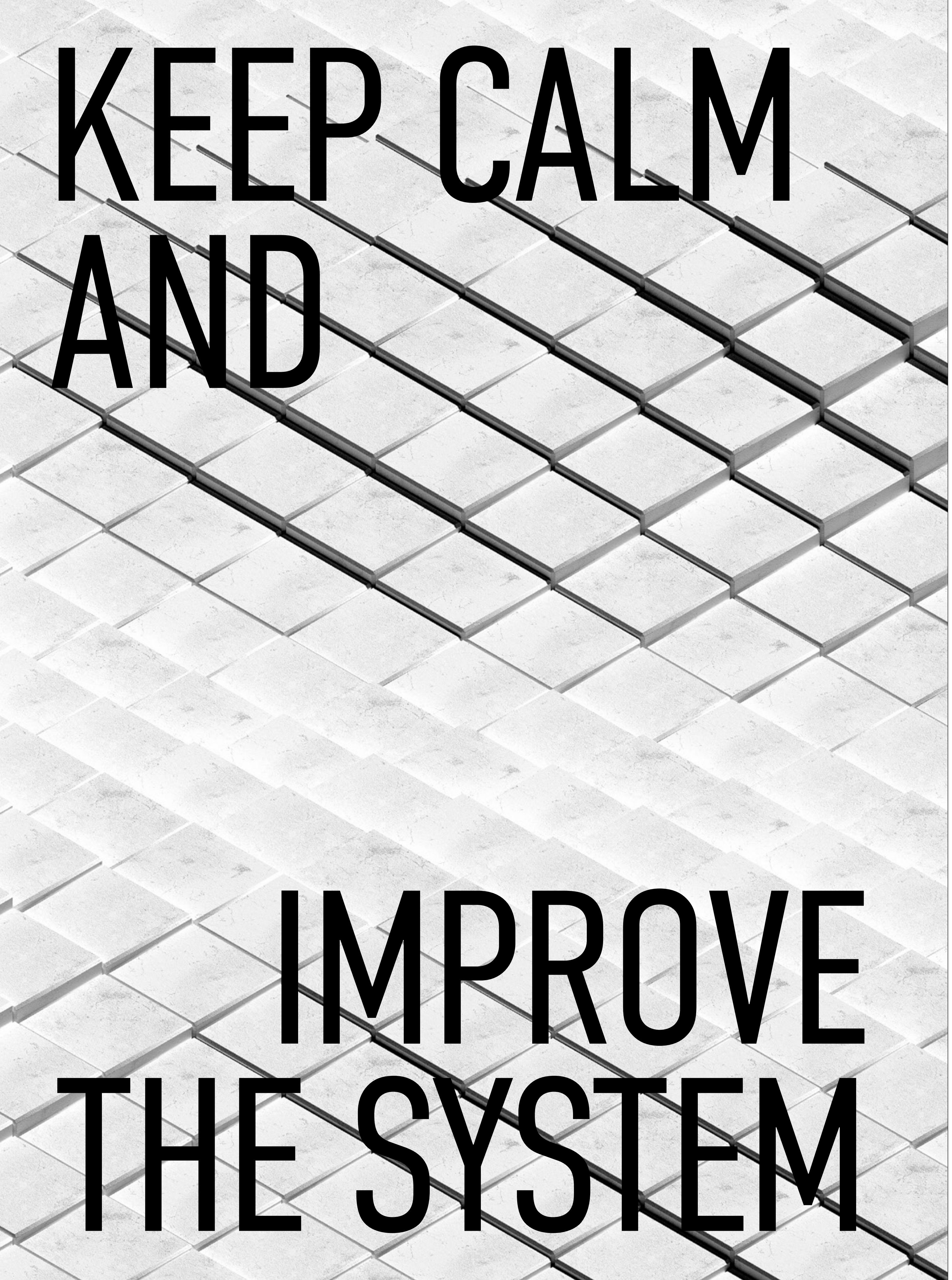
To create incentives for researchers around the world to take on these challenges, the Einstein Foundation Berlin joined forces with the Damp Foundation to launch the Einstein Foundation Award for Promoting Quality in Research. Thanks to the generous donation of €500,000 prize money annually over the period of ten years, the award will be presented regularly from now on.

In this booklet, we present the recipients of the inaugural award: Paul Ginsparg, honored in the Individual Award category (see p. 12), created arXiv.org, the first open access platform for academic preprints, which revolutionized the academic production of knowledge by making it much easier to share and discuss new findings and theories. The Center for Open Science, too, has been contributing to global research culture and has increased public trust in science. It provides researchers with the necessary tools and digital infrastructure to make open science the default. In recognition of their vital work, the Center for Open Science receives our Institutional Award (see p. 22). In today's academic culture, we need to promote and support especially those early career researchers who are alert to weak points and blind spots, who are keen and enthusiastic to take their subjects to a new level, and who are determined to make research conditions diverse, fair, and ethical. Four pioneering projects were shortlisted for our Early Career Award (see p. 28).

Since research quality is shaped by a multitude of factors, Ulrich Dirnagl, the head of our Award Office, provides us with a concise outline of the history of professionalization in the sciences—and of the problematic developments in quality assessment over the past few decades (see p. 16). Jury members Dieter Imboden and Dorothy Bishop give their views on this necessary debate and make recommendations on how to resolve current problems linked to high publication pressure and other systemic factors (see p. 4). Finally, Volker Stollorz of the Science Media Center Germany reminds us (see p. 26) that trust in science not only needs non-negotiable standards, but also relies on skeptical journalists as intermediaries.

WE HOPE THIS BOOKLET PROVIDES A HIGH-QUALITY READING EXPERIENCE!

MARTIN RENNERT
CHAIR, EINSTEIN FOUNDATION BERLIN



KEEP CALM AND IMPROVE THE SYSTEM

How can we create incentives that encourage scientists to use even more solid methods and reliable research? Dorothy Bishop and Dieter Imboden, jury members of the Einstein Foundation Award for Promoting Quality in Research, discuss time as a factor in research quality and ways to stay level-headed and ethical in a competitive system.

An interview with Dorothy Bishop (DB) and Dieter Imboden (DI) by Manuela Lenzen

The quality of science is currently an important issue. But has science ever been better than it is today?

DB Yes, I think it has. In the second half of the last century, maybe even in the first half, we had fewer people carrying out a more careful type of science.

DI I only partly agree. Yes, science has become a victim of its own success. There was a time when there was little money, few scientists, and to become a scientist was not really the best career choice. Then—especially in the second half of the twentieth century—science became a huge business; a mass movement. But even though research may have been more effective then, it is now much more influential and important. One hundred or even fifty years ago, it would not have been possible to develop a vaccine within just one year.

What made the quality of science, at least in some specialist fields, decline in particular?

DB To some extent, it is the incentive structure which has created a very competitive situation. Junior researchers are usually funded only for a short period and have to make their mark very quickly. They are often encouraged to cut corners because they do not have enough time for careful work. In addition, the publication system is really broken. It no longer plays a communicative role. Researchers do not publish because they have found something new and good; they publish for the sake of publishing—for their resumes. I hear young people in my discipline of psychology talking about publishing ten papers per year during their PhD studies. That is ridiculous—one per year might be realistic. And if you want to evaluate a scientist, you do not have the time to read what this scientist has written, so you have to rely on metrics such as the impact factor of the journal you publish in, which is not very useful.

DI It is the same with project proposals. There are too many of them, which are written too fast, and often the reviewers don't have the time to read and evaluate them properly. It is difficult to decelerate the system, but we should do it.

Professor Bishop, you mentioned that young researchers are forced to cut corners. What do you mean by that?

DB If you think back to the big discoveries, they were made by people working intensively for several years to solve a problem. Now you have to get results quickly: sometimes that means that you publish something before it is really certain that everything has been done right. Sometimes it also means that you make things look exciting when they are not particularly exciting. Or you use problematic methods to squeeze something out of your data. Or you just talk about the part that allows you to tell a good story and then you do not mention other things. Some people do not have the time to check if the cell lines they are working with are contaminated. Looking through the literature, I find a lot of papers I do not believe or that I think are overhyped.

DI I do not think the situation is this bad. The intensity and speed of progress in certain fields today is much higher than ever before. But if you look at the output in relation to money spent, we can now afford to have a system in which high-quality output is hidden among a huge amount of waste output. To use an expression from biology: the system became eutrophic—like a lake overfed with nutrients. In a eutrophic lake, the actual biomass in the water increases, but biological diversity diminishes, and water quality goes down.

Is there an awareness in science that things cannot go on like this? Or is this a minority viewpoint?

DB It is a minority viewpoint. Because those who have benefited from this system are those who tend to be in a position of power, and so they are not particularly keen to change it. But the younger generation really wants to change things.

DI Again, I am less pessimistic. I have many colleagues who share the view that we should change things. In the past twenty years, there have been many initiatives developed by individuals and organisations that lead in this direction. The Einstein Foundation Award is one striking example. So, there is hope. What worries me is that some of the best PhD students, often women, decided not to stay in research because they are not willing to compromise in order to be successful. When I have discussed this face to face with PhD students who have decided against a research career, I always felt that I was caught in a dilemma: Should I convince them to stay because they are excellent or should I admit that they actually have a point?

> “It is difficult to decelerate the system, but we should do it.”
>
> Dieter Imboden

DB Yes—those are the ones we should be keeping because they are conscientious and careful scientists; the ones that carefully assess the situation and say they cannot do the right kind of science in this environment. We need to work on structures that prevent these people from giving up and leaving.

> “We should remind ourselves that to say ‘I have changed my mind because I have new facts’ is a virtue.”
>
> Dorothy Bishop

It seems that during the pandemic many people wondered about the amount of discussion among experts. Did it damage the reputation of science that its progress could be followed in public or is this kind of transparency helpful?

DI As a scientist, I would say the system functioned quite well, with a few exceptions. But often the public had the expectation that science has to have an answer to every question and that scientists never change their minds. Maybe we did not explain how science functions well enough and that different views are common, especially in a new field. And that later on, knowledge becomes more and more consolidated. And maybe we have forgotten to point out that to say “I don’t know” or “I have changed my mind because I have new facts” is a virtue.

> “What has harmed science has been the tsunami of rubbish results that have been generated far too quickly and to some extent also fraudulently.”
>
> Dorothy Bishop

DB There is a saying that you should not wash your dirty linen in public, but I think if there are problems, we should talk about them. What has harmed science more has been the tsunami of rubbish results that have been generated far too quickly and to some extent also fraudulently by people trying to make money. People who are skeptical about science now have the means to promote their opinion very strongly. Even as a small minority, they can produce a lot of noise.

DI The largest issue perhaps is that the media always wants to balance opinions. You have to have someone from a different point of view, even if 99.9% of scientists agree on a certain point. The public is then left with the impression that there is a lot of fundamental disagreement, even though this is completely disproportionate. That has done a lot of damage.

Are certain disciplines affected more than others by the quality issue?

DB The hardest problems I am aware of exist in disciplines where you deal with probabilistic phenomena to explain complex findings. A lot of people are using complex statistical methods without any real understanding of what they are doing. In psychology, researchers were among the first to become aware of how bad the problem is. I think it is as least as bad in biomedical science. The only subfield that has done well is clinical trials. Here the problems were found quite early in the 1970s and methods were developed to deal with them. But if you look at preclinical studies, animal studies, biology, and ecology, the situation is still problematic, in my opinion, because it is not even broadly accepted that there is a problem. Issues around quality of research affect the humanities, too, but they are different in kind, and it is important to identify solutions that are relevant for each field.

DI In physics and chemistry, there are difficulties as well, but the self-correction system usually works more reliably and faster. For instance, when 35 years ago, scientists in Salt Lake City claimed to have found so-called cold fusion, but in reality, misinterpreted some of their experimental results, within no time at all many groups started to do the same kind of experiments. Cold fusion was off the table in less than two years. In some of the “softer” disciplines, like the social sciences, psychology, and others, it is not so easy because it can take a lot of time to do the experiments and to reproduce them.

What is the role of the funding agencies in improving the quality of science?

DB They are the ones who really want to solve the issue and are heading in this direction because they do not want to waste their money. They have started to develop new criteria. For instance, research must be more open so that people can look at the results and the methods. When I give talks about the need for more reproducibility in science to young researchers, many of them say they would love to work that way, but they fear that their career will suffer. I try to show that it is the other way round, that their work will be respected when it is reliable. There are more and more individuals and institutions who fiercely defend reliable research, and who in turn are looking to employ and support those who share their committed approach.

Is there a need for more meta research on science?

DI My impression is that meta science became too much of a philosophical task and did not do much to keep research clean. For me, the highest priority should be to keep the right people in research. The quality of research will stay high if we manage to attract and keep the right people in science.

DB I think we need more down-to-earth metascience, more documentation, and evaluation. Personally, I try to be a role model to show that yes, you can preregister your study to make sure its results are going to be published, regardless of the outcome. You can post your data openly; you can deposit your code so that others can have a look at it; you can actually work in this way. Of course, I do not have to worry about career suicide; I can just do it. But I see a lot of junior people becoming very enthusiastic about these ideas—they say it feels like doing real science. This way of working seems to be more satisfying for the researchers themselves, too.

> "When I give talks about the need for more reproducibility in science to young researchers, many of them say they would love to work that way, but they fear that their career will suffer. I try to show that it is the other way round."
>
> Dieter Imboden

As chair of the Advisory Board of the UK Reproducibility Network, you are engaged in a radical form of Open Science. Could you describe your perspective?

DB Open data is important. But even if you have the data, you cannot necessarily reconstruct the results. You need to have access to the script, the processing steps too—not only to get your own research clear but also for the next generation that wants to learn how to do good science. I like the idea of open protocols, even using videos, showing, for example, how exactly a researcher shakes their test tubes. Sometimes there are really minor differences in methods people use and the descriptions are often not detailed enough. The more we can make clear and transparent what we did and what we concluded, the better it is. Of course, when I make my data or my code available, others might find an error in them. But instead of being afraid, I should be happy that the error has been found; there are always errors and that is not a source of shame. And if someone finds new things in my data, I very much encourage that.

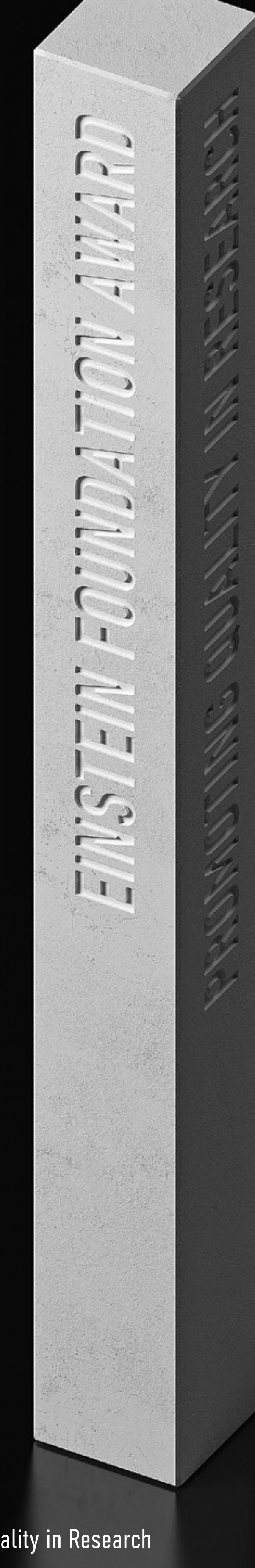
Will the Einstein Foundation Award help in the promotion of quality in research?

DB The Award is such a great thing because it sends out a big signal: Look, here is a funding institution with an international committee of experts and scientists demonstrating that what they really value is researchers who work in this particular way. By honoring those who are pushing for improvements in the nature of science itself, they are sending a signal to the scientific community across the whole world. I was astonished by the quality and quantity of the applications. It also helps us to build a community of people doing this sort of good science. And thanks to its international outreach, you get ideas from people working in different scientific contexts. I think the prize has a real potential to accelerate improvements worldwide.

DI It will definitively help and it is a fantastic chance for the Einstein Foundation and also for Berlin. Berlin is an important place for science, especially since all the universities are working together. And it fits really well: I think Albert Einstein is the perfect example of a scientist whose publication list isn't actually really long but undoubtedly outstanding. He always felt strongly about the responsibility of research. Einstein would probably be unhappy about certain developments in modern research, but he would certainly be happy to see that his name is being used for a prize that advocates a fundamental change in doing research and that is boosting its overall quality.■

DOROTHY BISHOP
is a Professor of Developmental Neuropsychology at the University of Oxford, and outgoing chair of the Advisory Board of the UK Reproducibility Network.

DIETER IMBODEN
is Professor emeritus of Environmental Physics at the Swiss Federal Institute of Technology (ETH Zurich).



THE TROPHY

The Einstein Foundation Award trophy is made of chalk. It was created by Axel Kufus, Professor of Design at the Institute for Product and Process Design at the Berlin University of the Arts. The trophy's concept is based on the idea of honoring a basic tool that has been used to bring knowledge into the world for as long as we can remember.

> "A scientist will never believe that the results of his efforts are definitive."[1]
>
> Albert Einstein, 1945

Chalk is a hybrid thing: solid and durable, soft and ephemeral. It brings thoughts, ideas, explanations and evidence to life—yet it can be easily erased to make room for something new. Writing or drawing with chalk gives you freedom to err, to add corrections, and reconsider your ideas.

Thus, chalk resembles quality: It symbolizes the importance of questioning something again and again if we want our knowledge of the world to grow. This masterpiece made of chalk invites the awardees of the Einstein Foundation Award for Promoting Quality in Research to share their next discoveries with the world.■

1 Extract of a letter to J. Lee, September 10th 1945; Einstein archive 57-601, German original: "Ein Wissenschaftler wird nie verstehen, warum er allein deshalb an etwas glauben sollte, weil es in einem bestimmten Buch steht. (...) Er wird niemals glauben, daß die Ergebnisse seiner eigenen Bemühungen endgültig sind." Found in: A. Calaprice: *Einstein sagt*, Munich (1997).

QUALITY NUMBERS

According to a 2020 survey, one in five early career researchers has already felt pressured by their supervisors to produce a certain number of publications. 43 percent of researchers said their working environment valued metrics more than actual research quality, while only 14 percent found metrics to have a positive impact on research culture.

1 in 5

70%

According to a 2016 survey by Nature, 70 percent of researchers had failed to replicate a colleague's research findings. In chemistry, this figure was 87, in biology 77, and in medicine 67 percent. Half of the respondents had failed to replicate their own experiment. 24 percent had published a successful replication, while only 13 percent had published a failed one.

85 percent of health research is wasted because of failure to publish completed research, lack of complete reporting, and lack of good and serious design.

85%

1 in 5 Wellcome Trust: What Researchers Think About the Culture They Work In (2020), https://wellcome.org/reports/what-researchers-think-about-research-culture;
70% M. Baker: 1,500 scientists lift the lid on reproducibility (2016), https://www.nature.com/articles/533452a; **85%** I. Chalmers, P. Glasziou: Is 85% of Health Research Really "Wasted"? (2016), https://blogs.bmj.com/bmj/2016/01/14/paul-glasziou-and-iain-chalmers-is-85-of-health-research-really-wasted

20%

In November 2020, 20 percent of German households stated in a survey that they trust science *completely*, 40 percent said they *tend to trust* it, whereas 30 percent were undecided. In April 2020, 36 percent had indicated that they *fully trust* science.

Publication pressure is enormous: In the natural sciences alone, the number of publications increased from 472,086 in 1990 to 2,166,236 in 2013. During this period, the so-called *publish or perish* principle led to an annual increase in publications of 6.6 percent.

2,166,236

153

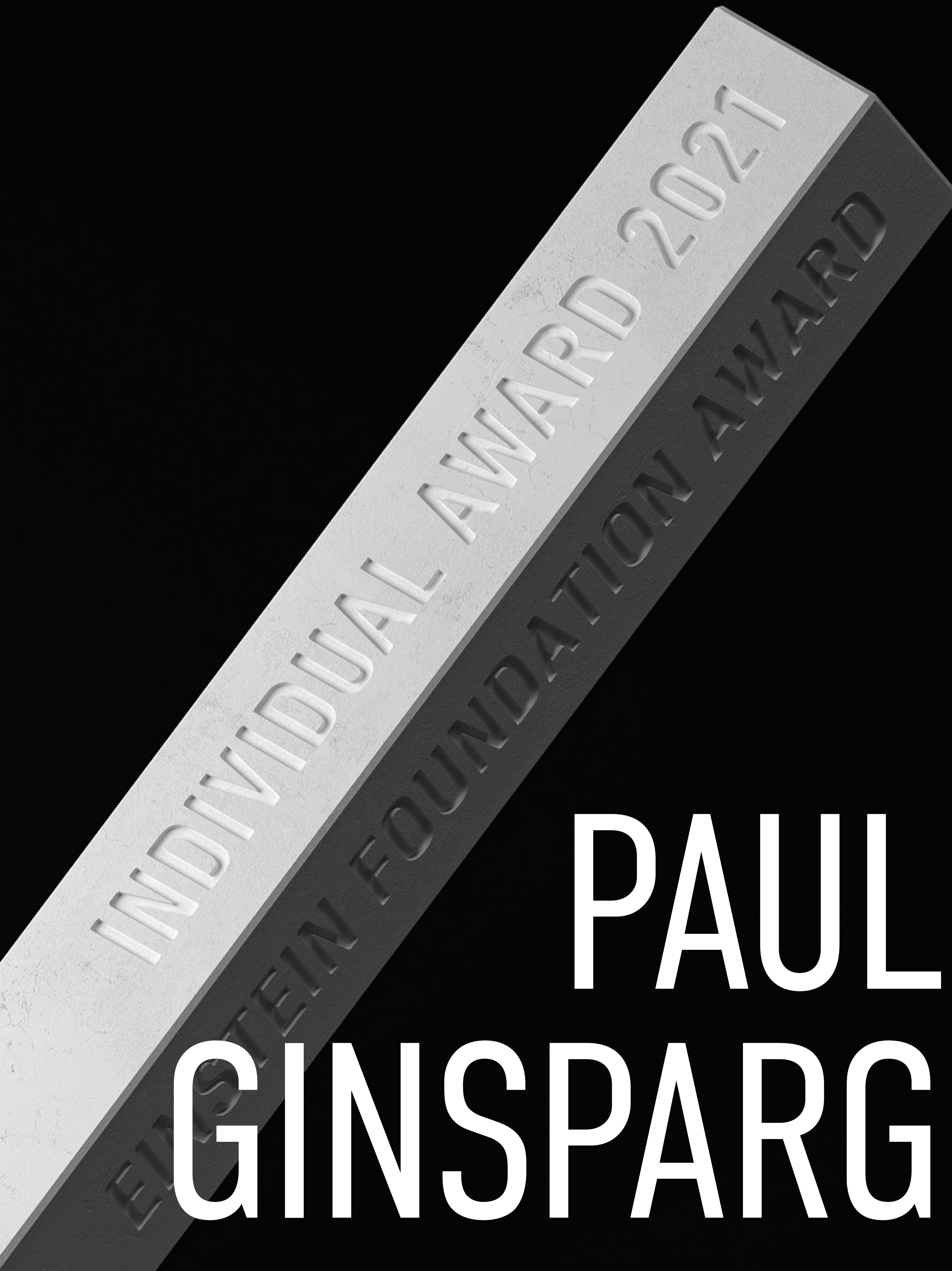
A study published in Scientific Advances in 2021 showed that non-replicable results are cited 153 times more often than replicable ones. Only 12 percent of citations of non-replicable findings, meanwhile, indicated a failed replication during the study period. Reproducibility (or replicability) refers to obtaining the same results by conducting an independent study whose procedures are as closely matched to the original experiment as possible.

Approximately USD 28 billion is spent each year on preclinical research that is not reproducible in the US alone. More than 50 percent of preclinical studies in the US are irreproducible, which results in delays and increases the cost of therapeutic drug development.

28,000,000,000

20% Wissenschaft im Dialog/Kantar: Wissenschaftsbarometer (2020), https://www.wissenschaft-im-dialog.de/fileadmin/user_upload/Projekte/Wissenschaftsbarometer/Bilder/Wissenschaftsbarometer_2020/20_Wiba_2020_Vertrauen.jpg; **2,166,236** I.A. Moosa, Publish or Perish: Perceived Benefits versus Unintended Consequences (2018), Cheltenham, UK/Northampton, USA, pp. 18-19;
153 M. Serra-Garcia, U. Gneezy: Nonreplicable Publications Are Cited More Than Replicable Ones (2021), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8139580/; **28,000,000,000** L.P. Freedman, I.M. Cockburn, T.S. Simcoe: The Economics of Reproducibility in Preclinical Research (2015), https://doi.org/10.1371/journal.pbio.1002165

Individual Award 2021



PAUL GINSPARG

Preprints have been shared in the physics community since the early 1950s but mostly among well established professors. Physicist Paul Ginsparg, who receives the Einstein Foundation's Individual Award, set out to democratize access to scientific results. Today, his preprint server arXiv has spread to many other fields—and made science progress more efficient and fairer.

By Andrew Curry

In August 1991, Paul Ginsparg was a mid-career physicist at Los Alamos National Laboratory in the U.S. He had a desktop computer of his own for the first time, but most of his colleagues still measured e-mail storage space in the hundreds of kilobytes, meaning they often had no room to store work-in-progress papers sent by colleagues.

Harnessing the fledgling internet—then still mostly the province of academics and computer experts—Ginsparg set up an e-mail server that stored articles remotely, allowing anyone with an e-mail account access to the latest research in high-energy physics before it was published in journals and available in university libraries. At the time, Ginsparg had no idea that his solution to the problem would one day change the face of science.

Now known as arXiv, Ginsparg's invention was the first preprint server. In the more than 30 years since it went online, arXiv has revolutionized the way research results are shared. Put simply, Ginsparg's key innovation was to make sharing early versions of research results possible online, something that may seem obvious today but was decidedly not in the late '80s and early '90s.

Iulia Georgescu, chief editor of Nature Reviews Physics, who nominated Ginsparg for the Einstein Foundation's award, calls arXiv the first digital platform for scholarly communication. "What Ginsparg did, changed the way we work," Georgescu says. "ArXiv is a tool for collaboration and communication, and that makes science better."

When he started thinking about creating a server to distribute early copies of unpublished articles, Ginsparg says, he was drawing on a much older tradition. By the late '50s, sharing preprints—experimental results or theoretical insights that had not yet been published in a peer-reviewed journal—was a common practice in the rarefied high-energy physics community. "Long before I was a grad student in the late '70s, there was already an organized preprint distribution system in high-energy physics," Ginsparg says. But the system was decidedly analog. More prominent professors got photocopies and passed them to friends and colleagues, whose grad students saw them first. Photocopies eventually went out in the mail, to be shipped across the country or across the Atlantic at surface-mail rates to save costs. "Every week," Ginsparg recalls, "libraries would put up the new collection of preprints and you would go and have a coffee and peruse preprint stacks." For Ginsparg, who worked at Harvard before heading to Los Alamos in 1991, the system worked fine. But for people at smaller institutions, waiting on a physical copy published in a scholarly journal might mean a delay of up to a year before the latest research made it to their libraries.

In the fast-moving field of high energy physics, where theories about how the world worked could be upended by the discovery of a new sub-atomic particle, the lag could be a career-killer. "When there were rumors of new experiments that showed a new particle had been discovered, you couldn't wait six months to a year to start thinking about new, amazing results," Ginsparg says now. "It was unfair: There were privileged people who had advance access to research information." It was also an inefficient way to move science forward. "It meant multiple people plugging away at the same problems, not realizing they may have already been solved," Ginsparg says.

The inequality of the situation gnawed at Ginsparg and many of his colleagues. "There was this feeling that if you do great work, you want to think you worked harder or were more inspired than your competition," Ginsparg says, "not that you succeeded because you had privileged access to information." But in the '70s and '80s, with e-mail still in its infancy and data at a costly premium, there weren't any obvious solutions. "We wouldn't have done it this way if we had the technology to disseminate it differently," Ginsparg says. "Given the technology of the time, there was no way of doing it that was intrinsically fair."

> "It meant multiple people plugging away at the same problems, not realizing they may have already been solved."
>
> Paul Ginsparg

Then technology began to change. By the '80s, most people in the physics community had access to e-mail, a near-instantaneous, near-free means of communicating. In the summer of 1991, Ginsparg spent a few hours talking with colleagues about a central server for physics preprints. Although a central server that could store papers until a researcher requested them had logistical advantages—many e-mail accounts at the

> "It was unfair: There were privileged people who had advance access to research information."
>
> Paul Ginsparg

time counted their storage capacity in kilobytes—Ginsparg also hoped to make the distribution of research results more democratic. "This fairness issue was paramount," he says.

It was the right idea at the right time: 1991, the first year of what eventually became the arXiv, coincided with the collapse of the Soviet Union, a difficult time for scientists in former Soviet republics whose universities lost access to expensive journals. "I received e-mails from people everywhere from former Soviet republics saying their libraries were no longer able to subscribe to journals and it didn't matter as long as they had a modem," Ginsparg says. "That was really gratifying." Georgescu, too, relied on the arXiv to access the latest results when she was an undergraduate student at the University of Bucharest in Romania. And when she began publishing preprints of her own, comments from other users helped her improve them. The preprint's ability to democratize access to scientific results—and science itself—only grew stronger over the decades that followed.

Ginsparg and Georgescu agree that the attitude towards preprints is closely tied to the culture of high-energy physics, where experiments in the '60s and '70s involved hundreds of co-authors and massive facilities. As a result, researchers—both experimentalists and the theoreticians who dominated arXiv's early submissions—tended to approach problems in a collaborative way.

Yet over the past decade, the preprint concept has spread from physics to conquer other fields in science as well. One major stumbling block was the way some researchers emphasized publication in a journal. In many fields, credit for discoveries goes to whoever publishes a final paper first. "To us in physics, this was nonsensical," Ginsparg says.

Slowly, however, researchers began to realize that time-stamped preprints were an alternate way of establishing that you arrived at a key insight or result first. "Things are really starting to change," Georgescu says. "Today, researchers from life and clinical sciences are more open to the idea of preprints because a large part of the community consists of younger scientists who grew up with the ideas of sharing and of having easy digital access to scholarly content." That, Georgescu says, helped the model spread to other fields of science. BioRxiv, a preprint server for biological sciences, was founded in 2013; medRxiv, focused on health sciences, followed in 2019. There is an AfricArxiv, a NutriXiv and a techRxiv, plus dozens more servers devoted to other scientific or geographic niches.

Slowly at first, and then like a tidal wave, the preprint server concept that Ginsparg pioneered has profoundly changed the way science is done. Thirty years later, arXiv handles 200,000 submissions each year, and automated algorithms written by Ginsparg or his collaborators step in hundreds of times a day to address issues with submissions or to weed out problematic papers.

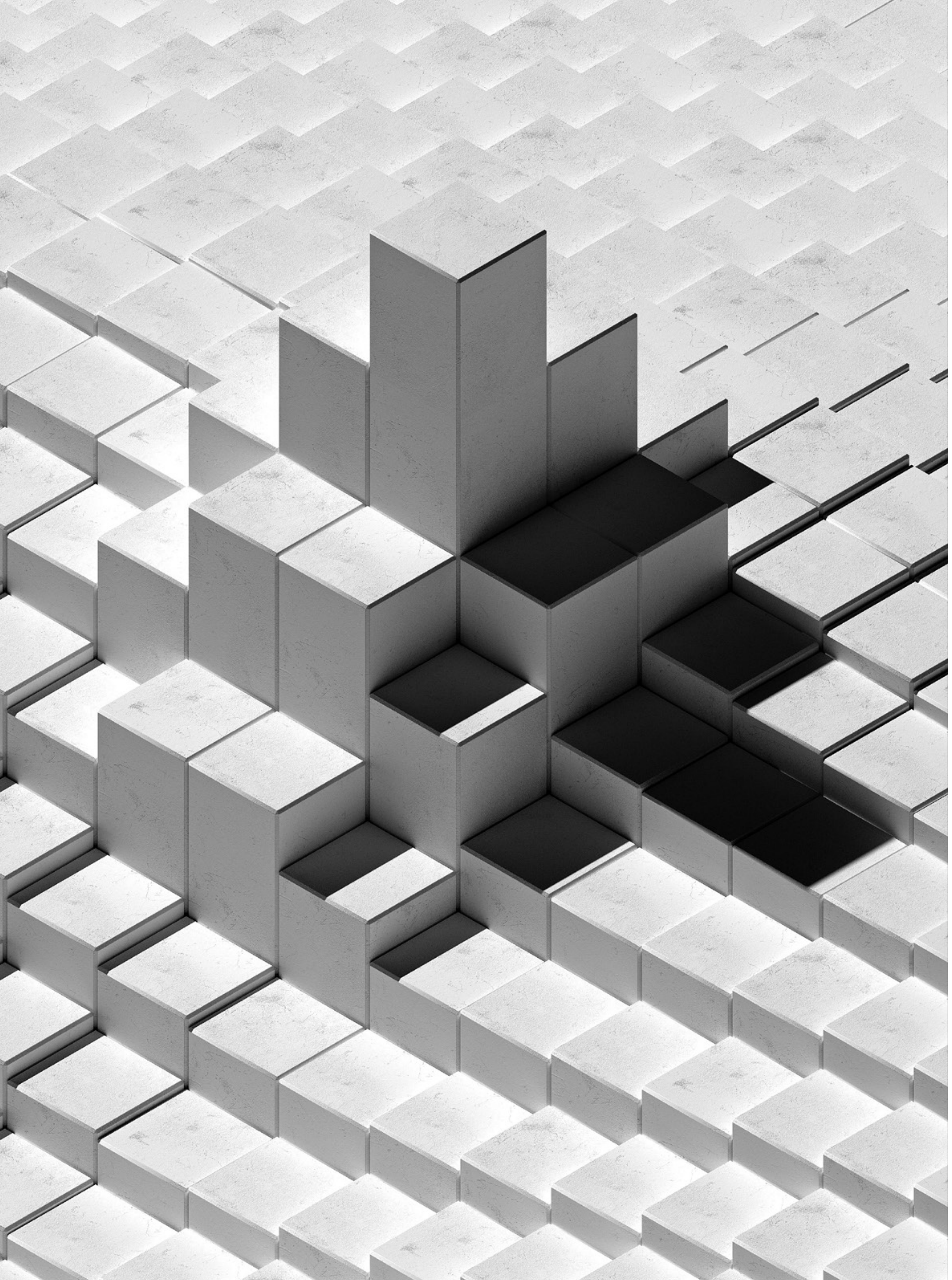
In its early years, arXiv was controversial—distributing preprints for free was seen as a threat to established journals, with their infrastructure, editors and anonymous peer reviewers. "Initially, I thought those two systems couldn't co-exist," Ginsparg says. But the journals didn't disappear: Journal publications continue to serve as the peer-reviewed "version of record" for science, and they remain important for early-career researchers, who at the same time have access to early results via arXiv and other preprint servers.

> "Today, researchers from life and clinical sciences are more open to the idea of preprints because they grew up with sharing and having easy digital access to scholarly content."
>
> Iulia Georgescu

Early concerns that preprints would disseminate erroneous results, or put bad science into the public sphere, have proven not just unfounded but incorrect. During the COVID-19 pandemic, peer-reviewed journals have published a string of papers that had to be retracted—"things that never should have made it through peer-review," Ginsparg says. Meanwhile, preprints put out in the early days of the pandemic were retracted or improved after feedback from colleagues. And others communicated new results about treatments to doctors at a time when waiting for peer-review could cost lives.

Preprints, it turns out, are the perfect way to put information in front of a wide audience of experts, who can weigh in early on any issues. And journalists are learning to report on preprints with appropriate qualifiers: Identifying information drawn from preprints as "not yet peer reviewed," for example.

The future of arXiv looks bright. Ginsparg continues to tinker, working to bring artificial intelligence tools to further streamline the preprint process. "I want the processes of navigation, information and discovery to be improved," Ginsparg says. "We want a system that keeps us informed. Ideally, it will have personalized highlighting of the latest results and breaking developments."■



CAN SCIENTIFIC QUALITY BE QUANTIFIED?

Why has evaluating quality in science changed from asking "What" to "How much"? How did measuring quality become a goal in itself in the scientific community? And when did all these problems begin? Ulrich Dirnagl, Einstein Foundation Award Secretary and Director of Experimental Neurology at Charité, provides a brief outline of the evolution of quality in science.

By Ulrich Dirnagl

Quality is a challenging notion. Everyone likes to champion, but it is notoriously difficult to define. The standards used to define quality are often disputed, whether in industry, the arts and culture, or the sciences, and they are continually changing. When we take a closer look at the origin of the word, it is easy to understand why it raises so many questions. It stems from the Latin interrogative pronoun *qualis* which asks for the character or nature of something to be defined.

Questions surrounding quality are particularly complex in science, which claims to uphold the highest standards in this regard. This means "quality" generally continues to be an implicit and multi-dimensional construct. It is not static and is judged under different criteria and standards in the natural sciences, the humanities, and the social sciences. These criteria and standards can also vary to a certain degree among the individual fields of research within the same scientific domain. In science, it can take on the form of methodological rigor, or expertise and quality within planning, implementation, and analysis; it is also evaluated in terms of reliability and reproducibility of results, plausibility, originality, and novelty. For many researchers, it also encompasses values such as respect, fairness, integrity, and ethical behavior. In order to judge quality according to all these factors, science must be transparent and lay all its cards on the table. This is why transparency is one of the many universal elements used to measure the quality of research. A further dimension to consider is the fact that quality in science is not only defined and monitored internally, namely within specialist communities, but is also influenced by external stakeholders such as institutions, funding bodies, members of the political arena, the general public and, of course, scientific publications. These influences have radically altered the global research culture in recent decades—and not necessarily for the better.

And so, in many quarters today quality is measured and evaluated in terms of numbers. There has been a shift from "What?" to "How much?", from substance to scoring credit points. It is understandable that there is a tendency to measure scientific quality against specific numbers. Using numbers simplifies broader issues, making it easier to gain a clearer overview; they are transparent, quantitative, simple, and workable. After all, measurements are an integral part of most scientists' daily work.

Given the massive output of research articles published by a myriad of scientists, it seems to be impossible not to rely on numbers that highlight the significance of the journal in which a piece of research has been published, or how often a researcher has been cited. It is therefore hardly surprising that this system of figures and metrics for measuring scientific quality has gained worldwide acceptance. At least one generation of scientists and scientific administrators has already incorporated it into its logic and in many cases could not imagine any other type of mechanism. They have become completely accustomed to evaluating the originality and quality of science and its originators based on citation metrics, the reputation of scientific journals, and levels of external funding.

However, the "metrification" of the concept of quality ultimately leads us down a blind alley. In fact, it is repeatedly threatening our high scientific standards. A brief foray into history tells us that various systems have been used and developed to evaluate science, and that some have helped, and some have hindered the production of knowledge. So, how did we come to mostly rely on metrics which are used to judge quality today and which are unfortunately often detrimental to the quality of scientific evidence?

The fundamental types of impure science—still practiced today—were outlined as early as 1830 by the inventor of the mechanical calculating machine, Charles Babbage.

Galileo Galilei, Robert Hooke, Robert Boyle, and Isaac Newton—all men due to the norms of the time—were able to pursue their scientific goals in the 17th and at the beginning of the 18th century because they were either born into rich families or could rely on the patronage of wealthy donors. Their efforts to reveal how the world works were devoted to pursuing the higher purpose of deciphering the divinely authored Book of Nature and thus, the order of things in the world. Scientific research was dedicated to a deeper faith and sought to promote piety in society; science was seen as a way to serve God. At that time, princes and kings tended to lend their patronage to inventors and engineers rather than scientists because only the former promised to help them subordinate the world through conquest and war. There was very little in the way of collaboration in the sciences during this period. Newton and his peers primarily regarded each other as competitors as they strove to achieve fame and recognition. Their motivation was to be the first to make a discovery and to be remembered in the history books for their noble findings.

In many quarters today quality is measured and evaluated in terms of numbers. There has been a shift from 'What?' to 'How much?', from substance to scoring credit points.

The handful of polymaths that existed at that time were fortunate to be able to record their studies and research on a virtually blank slate. The starting point for their ideas and hypotheses was what science historian Lorraine Daston calls "ground zero empiricism": Collective knowledge was limited and the amount of facts known in the scientific community were relatively straightforward. What is more, the scientific community itself was still a small village, consisting perhaps of a few hundred—or a few thousand at most—like-minded people around the world, who were loosely organized into academies where they presented and critiqued each other's theories and experiments. Scientific work was primarily published in monographs, or in journals produced by national scientific academies.

Around the turn of the 19th century, England's Royal Society was the most prolific and influential national scientific academy in the world. Its journal was printed twice a year, with eight hundred copies being sent out to its scientific counterparts and selected scholars in 1829. Studies were often published six months after they were presented or submitted, a short time span compared with today's peer review process. Back then, scientists did not compete for academic positions or research funding but for recognition and access to the major academies and their international networks.

As scientists began to gain a greater understanding of what binds the world together at its essence, people also began to take a greater interest in how scientific findings can benefit society, in other words, what we today call social impact or public health. Science's relevance for society as a whole rose up the agenda during this period, as rapid industrialization and the massive influx of people from rural areas to towns and cities caused severe health and social crises, unsanitary conditions, and epidemics. As middle-class societies emerged and mass production proliferated during the 18th and 19th centuries in the wake of rationalization and the exploitation of the working classes, governments began to organize science more systematically, most notably by establishing universities as research institutions. The physicist and discoverer of electromagnetic radiation James Clerc Maxwell, the founder of modern microbiology Louis Pasteur, the physician and pathologist Rudolf Virchow and many of their peers became the first salaried scientists in the northern industrialized nations to conduct state-sponsored research at universities.

Meanwhile, the sciences became increasingly specialized. Specialist journals emerged and became the most important medium of scientific discourse alongside lectures.

All scientists at this time knew all their peers in the particular discipline they were working in. Scientific debates—whether carried out via the written or spoken word—were not fought anonymously but face to face. The growing competition for academic tenure as an assistant or professor marked a completely new development at this time, however. Upholding your reputation among peers, academic hierarchies, and affiliations to scientific schools were considered key factors. Quantitative bibliometric indicators or third-party funding did not play a role at all because they simply did not exist back then. Scientists did not generally adhere to good scientific practice if it only served to further their academic careers. The fundamental types of impure science—still practiced today—were outlined as early as 1830 by the inventor of the mechanical calculating machine, Charles Babbage. In his *Reflections on the Decline of Science in England, and on Some of Its Causes*, he distinguished between hoaxing (fabricating), forging (falsifying), trimming (being selective when analyzing data), and cooking (creating flawed statistics).

In the early 20th century, third-party funding was added to the mix. Immediately after the First World War, German universities, academies and the Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaften, which later became the Max Planck Society, came up with a way to improve their precarious financial circumstances resulting from the war and the ensuing economic crisis. They founded the Notgemeinschaft der deutschen Wissenschaft—later to become the Deutsche Forschungsgemeinschaft (DFG)—which enabled them to raise money to fund individual research fellowships. A few years later, as national socialist ideology gave rise to a Deutsche Physik (literally German Physics), it was a scientist's beliefs and party affiliation that were critical when it came to receiving employment or tenure at a university.

It was not until into the Second World War that this system underwent fundamental change, both in Germany and internationally. During the war, research was industrialized on an unprecedented scale, most notably in the United States. Research programs that underpinned the development of long-range missiles, RADAR, the atomic bomb, computers and the like received enormous amounts of funding and were managed with military precision. In fact, by the end of the Second World War, most work in the (natural) sciences carried out in universities was in the service of the military. It was now a top priority to apply research findings to achieve military superiority. So much so, there was serious concern about the future of basic research because it did not promise to deliver immediate benefits. These developments prompted

We need to identify and reject systematic negative developments that nourish the illusion that quality can be objectively measured.

a sharp rise in research output, first, due to continuing specialization within the various disciplines and, second, because of increased government spending on academic research. Nevertheless, it remained easy for researchers to keep track of new developments, not only within their respective specialist fields but across other disciplines too. Editors decided which of the manuscripts that landed on their desks would be published or not. The concept of the peer review had not yet been conceived. Only a few journals existed for each subject and were produced in the language of the country of publication. Scientists still primarily shared knowledge and ideas within their own countries, which is also where it was decided who was "excellent" and who was not.

In the 1980s, the diversification of scientific disciplines, the number of researchers, and their output reached a tipping point. It became increasingly difficult to judge quality and originality based on the content of the research, which also made reaching decisions about funding and careers problematical. This was compounded in the late 1960s when many people started to rebel against outdated hierarchies.

The desire to objectively assess and quantify performance in research was born. Meanwhile, a hierarchy of journals had also been established, which became quantifiable in 1955 through Eugene Garfield's ingenious creation, the Journal Impact Factor (JIF)—an idea that he and the publishers commercialized on a massive scale. The impact factor has become the most frequently used metrics of scientific quality in many disciplines worldwide. According to UNESCO, there are now more than 400,000 full-time scientists in Germany alone and many millions more worldwide. These hordes of scientists now publish millions of articles every year. Within a century, the mean number of authors of an article has increased from one to six. But in those one hundred years, scientific productivity—defined as the ratio of the output of knowledge in relation to its input into science—has declined sharply. We have accumulated a considerable amount of knowledge about the world, and so original ideas have become rare. The low-hanging fruit have been picked, and both content and methods are becoming increasingly complex. Progress is continuing nevertheless because the number of scientists and thus their input into science has increased in parallel by roughly the same factor. It now takes ever higher numbers of scientists, as well as increasingly complex and expensive tools, to continue to reveal nature's secrets.

The swell in the academic ranks over recent decades has provided excellent conditions to establish a new understanding of quality. Simple, transparent, fair, and seemingly reliable criteria for evaluating researchers and research have emerged: the already mentionned JIF, the h-index, which indicates a researcher's citation record, and the number of externally funded projects.

The JIF, which is extremely popular in many areas of science, is a striking example of how assessing research quality has transitioned radically away from a focus on content to embrace a surrogate metric: If you publish in a journal with a high JIF rating, your work is associated with high quality. A high rating is rewarded with research funding and tenured positions. In other words, it makes it easier to climb the echelons of the academic system, but it ignores the fact that the JIF only really rates the popularity of a particular journal and subject. In addition, 80 percent of the citations in *Nature* and similar publications come from only 20 percent of the articles (including reviews).

In the 1980s, the diversification of disciplines, the number of researchers, and their output reached a tipping point. It became increasingly difficult to judge quality based on the content of the research.

Consequently, the vast majority of articles in these journals, often referred to as "glam" journals, do not attract more citations than those merely published in journals that have been at best rated as good or have no rating at all. Use of the JIF today brings to mind a rule formulated by British economist Charles Goodhart: "When a measure becomes a target it ceases to be a good measure."

We cannot turn back the hands of time; the expansion of science and indeed its industrialization have moved us a long way forward in our quest to understand what binds the world together at its essence. Nonetheless, it is important that we identify and reject systematic negative developments that affect our understanding of quality and nourish the illusion that it can be objectively measured. Conversely, we must support and reward those who develop and test strategies that once again focus on substantive "qualities" such as methodological expertise, reproducibility, originality, integrity, and transparency, rather than merely limiting ourselves to a few abstract numbers for the sake of convenience.■

CENTER FOR OPEN SCIENCE

Open research is on the rise, but a lot of research information still remains behind closed doors. The Center for Open Science, recipient of the Institutional Award, advocates for more transparency and open access, training scientists, publishers and funders, providing technology and policy recommendations. With this multi pronged approach, it has helped create an open science community which is becoming ever more self-sustaining.

By Helen Albert

In 2011, a group of scientists from the German pharmaceutical company Bayer tried to reproduce published data for 67 scientific studies in cancer biology, women's health and cardiovascular disease—around 64 percent of the results were unrepeatable. A year later, Amgen, an American pharmaceutical company tried a similar project to reproduce cancer studies and could only successfully do so for 11 percent. This problem was very much on cancer biologist Tim Errington's mind in 2013 when he applied for a job at a newly founded organization, the Center for Open Science (COS) in Charlottesville, Virginia. Increasingly aware of the reproducibility issues in science both from his own work and studies such as those completed by Bayer and Amgen, Errington was excited by the opportunity to help solve the problem. His enthusiasm and experience paid off and he was offered a job the Center the next day.

The open science movement has developed significantly since the early 2000s, calling for increased transparency and improvements in access to scientific data. It also calls for more studies without notable findings to be published, as leaving these studies unpublished further undermines scientific credibility and makes replicating results even more challenging. "There's the understanding that research is open, but it doesn't actually occur that way, or at least not as well as it should," says Errington, who is now Director of Research at the Center. "Study data, the protocols, and the experiments that people tried that didn't work: all that information doesn't really make its way out of the lab."

> "There's the understanding that research is open, but it doesn't actually occur that way, or at least not as well as it should."
>
> Tim Errington

The COS was co-founded in 2013 by Brian Nosek, now Executive Director, and Jeff Spies, who was previously Chief Technology Officer, to try and tackle this problem. Nosek, a Professor of Psychology at the University of Virginia, persuaded a group of colleagues to reproduce the findings of 100 psychological studies. This first reproducibility project really got the Center off the ground when it attracted a seed grant of $5.25 million from what was then the Laura and John Arnold Foundation, now Arnold Ventures. Notably, the results of this study supported previous claims and showed less than half of the original findings could be repeated. Just before Errington joined, another project to replicate the findings of 50 landmark cancer biology studies was funded, the full results of which will be available later this year. There is also an ongoing replication project in social sciences that has support from the US Government.

The Center's mission is split into five areas which include: training scientists, publishers and funders; helping to incentivize people working in these areas to adopt changes; building an open science community and building technology such as the Open Science Framework to help achieve this goal. While many people and organizations are involved in the open science movement, the Center's unique multiple pathway approach to this issue makes it stand out, according to David Mellor, current Director of Policy at the Center. "We're tackling a complex, system-wide process in a holistic, comprehensive way. We don't sugar coat the extent of the problems", he says. "But we also don't shrug our shoulders at it, we provide very concrete policy recommendations to universities, to publishers, and to funders." One such recommendation are the Transparency and Openness Promotion (TOP) Guidelines. Aimed at journals publishing research that has gone through review by other scientists, the TOP Guidelines include eight transparency standards. These deal with different parts of article publication such as registering studies before publication and making data analysis methods open for readers to review. Each of these standards is split into three levels, with level one showing moderate and level three excellent compliance with the transparency standards.

"The status quo for the vast majority of scientific journals is for articles to say, 'you can call us up and ask for the data and we'd be happy to provide it'. It almost never happens, and even when it does happen, underlying evidence is almost never actually provided," says Mellor. "Our recommendations are that there should be a specific disclosure, whether or not data are available. That's what we call the level one approach. A better approach is that it just needs to be made available in a public repository. Our level three approach is based on not only making the data available but also on ensuring a third party checks your answers."

The guidelines have been a success and the number of publications signed up to use them has risen from less than 600 in 2015 to over 5,000 in 2020. "I think it's a positive way to showcase those journals that are taking great steps," adds Mellor. Another positive development for the Center is the increasing use of the Open Science Framework (OSF), its online web platform built and maintained using open-source code. Cumulative user figures have jumped from less than 400 in its first year to almost 400,000 eight years on. The OSF is free for individual researchers to use and is designed to help them to carry out different open science actions such as data sharing, study preregistration, collaboration between researchers and a preprint publication server, a way of quickly publishing research before it undergoes any form of external peer review.

> "We don't shrug our shoulders at the problem, we provide very concrete policy recommendations to universities, publishers and funders."
>
> David Mellor

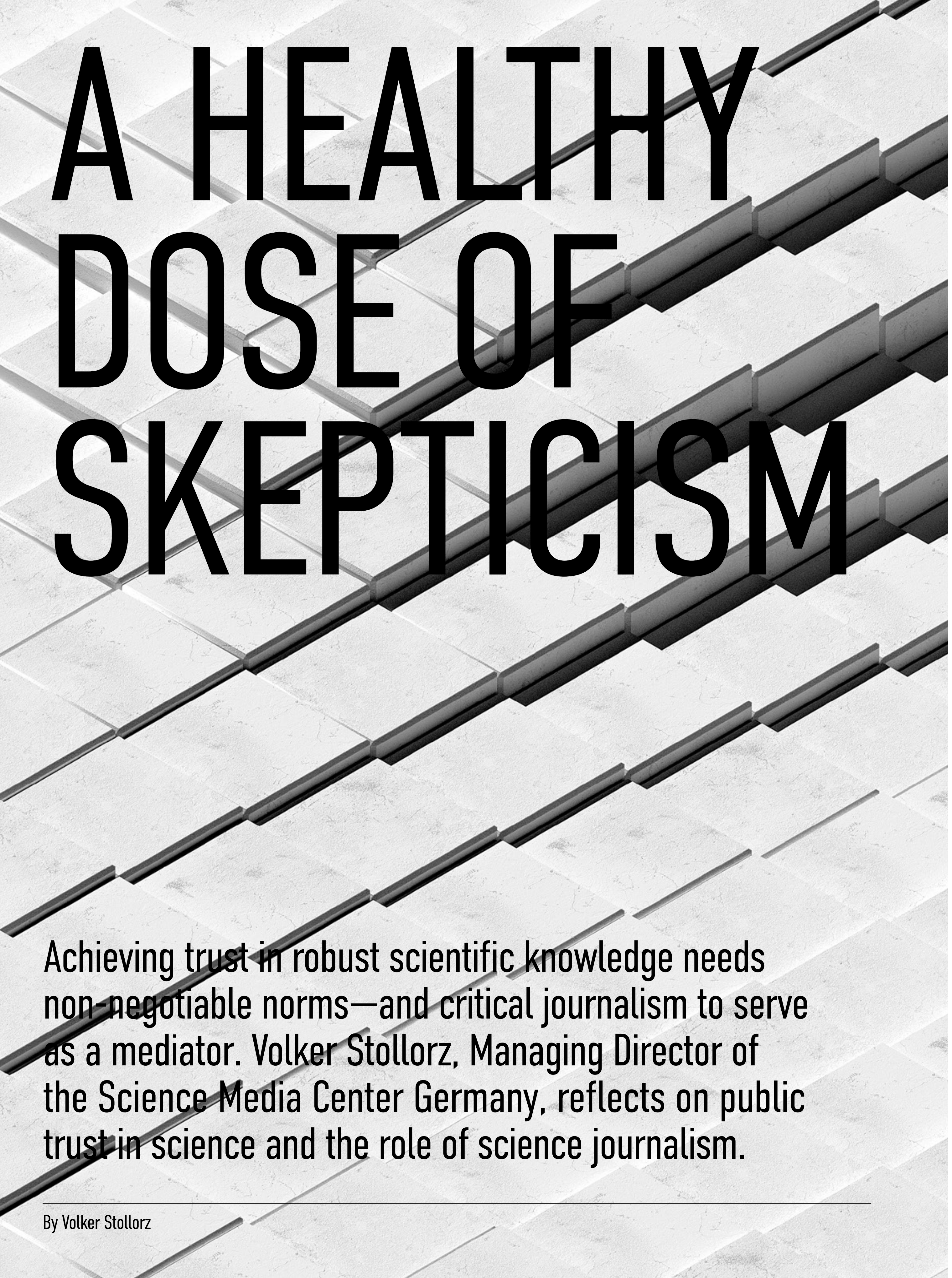
Lisa Cuevas Shaw recently joined the Center as Managing Director and Chief Operating Officer after a long career in scientific publishing. She explains that the purpose of the organization is not to police scientific research, but more to offer everyone involved a useful tool to enable more transparent practices. She adds that blaming researchers for not following open science principles during their research is rarely effective. "We really want to avoid that. It's understandable why things aren't enacted, due to either resourcing, lack of awareness, lack of any norms or understanding of what it could look like, lots of different things. And then again, the reward system is still what it is, which is publish a lot, publish your novel findings, not null results … it's a vicious cycle that researchers are a part of." Errington says he has really noticed an improvement in knowledge about open science principles in the academic community over the last seven years. "It shows that we can have an impact. If you keep doing this and working with communities. The adoption occurs in front of our eyes, once they get convinced, they're kind of excited. And then they come back to you."

> "We want to get stronger at how we can best maximize and leverage relationships in this system."
>
> Lisa Cueva Shaw

The COS is now looking to the future. Nici Pfeiffer, Chief Product Officer at the Center, says that a future goal in her area is to help funders see if their open science policies have been complied with. "If we're saying we really want open data, then how are we making sure that that is happening with studies they funded? We're supporting that by adding some new features and workflows in our platform." The management team at the Center has recently completed a plan for the next three years and identified some new areas it wants to focus on, according to Shaw. "We want to get stronger at how we can best maximize and leverage relationships in this system. And then the other area that we're really focused on is how do we design things so that they're self-sustaining by the communities themselves? That's a big emphasis for us," she added.

> "It shows that we can have an impact. The adoption occurs in front of our eyes, once researchers get convinced, they're kind of excited. And then they come back to you."
>
> Tim Errington

Bringing in more funding to expand their mission and increase visibility is also important. This September, the Center received $18 million in funding from Flu Lab, a private organization funding research projects and organizations targeting influenza. Following the upcoming publication of their cancer biology project, they plan to start work in this area. ■



A HEALTHY DOSE OF SKEPTICISM

Achieving trust in robust scientific knowledge needs non-negotiable norms—and critical journalism to serve as a mediator. Volker Stollorz, Managing Director of the Science Media Center Germany, reflects on public trust in science and the role of science journalism.

By Volker Stollorz

Research is a process that constantly places new pieces on the chessboard of the social world while simultaneously changing its rules. The swift development of COVID-19 vaccinations and the realization that only coordinated collective behavior can protect those who cannot protect themselves are recent examples that testify to this fact.

The pandemic as a global event also teaches us that the socialization of science is occurring in tandem with the scientification of society. This means that the importance that has been attached to scientific expertise through the ages is now becoming increasingly relevant in driving action in many areas of life. The production of knowledge is facing growing pressure to legitimize itself in the public and political domains.

Bertolt Brecht warned against the politicization of science by rulers who embraced the development of nuclear weapons. In the third version of his famous drama *Life of Galileo* published in 1955, Brecht has the character Galileo ponder the value of academic freedom. If research does not take a Hippocratic oath, that is, if it does not defend ethical norms, it could be “crippled” by those in power: “Given time, you may well discover everything there is to discover, but your progress will be a progression away from humanity.”

At a time when everyone seems to fancy themselves a virologist or epidemiologist, confidently voicing their doubts about the natural origin of SARS-CoV-2 or the reliability of new mRNA vaccines, the democratic dilemma confronting modern research is becoming progressively apparent. Because of its ever-increasing complexity, which sometimes even overwhelms the experts, it remains a specialist craft that cannot be practiced by armchair scientists. Laypeople are left to trust in processes and institutions that they do not fully understand—in other words, they are required to put their trust in the expertise of those who devote huge chunks of their lives to answering tricky questions.

But how is trust in robust scientific knowledge achieved? Researchers need to make sure they think independently and carry out their work meticulously to ensure they fulfill society’s expectations when it comes to scientific integrity. Laypeople are more likely to trust researchers if they are competent, behave with integrity, and always have the public good in mind. But even then, some people still have their doubts.

This is where good science journalism comes into play as an important mediator of trust. If science journalists want to promote or at least preserve the reputation of solid science, they need to show a degree of healthy skepticism towards research results and repeatedly remind researchers of society’s expectations. Good journalists are, at their core, activists of reality. One of their tasks is to critique the current scientific community and the logic that underpins the profession and evaluation methodologies. Above all, however, they have a duty to expose impure science and to avoid providing a forum for distorted niche opinions or false representations of facts.

Journalists need to be up to date with the latest research to be able to tackle misinformation, which is sometimes spread virally—even under the guise of science—in order to prevent or delay reasonable collective decisions. Tobacco companies and climate change deniers and their “Merchants of Doubt”, as American historian of science Naomi Oreskes calls them, are two notable examples. The latter are researchers who ally themselves with private companies and politicians driven by self-interest in order to purposefully spread misinformation—with commercial or populist interests in mind.

Journalists need to be up to date with the latest research to be able to tackle misinformation, which is sometimes spread virally.

As early as World War Two with its powerful propaganda campaigns, American sociologist Robert K. Merton attempted in his famous book *The Normative Structure of Science* to establish a scientific ethos and rules of conduct in the midst of moral collapse to bolster good science.

Much of what Merton called for science to do back then should also be the maxim of science communicators today: Constructive doubt, according to Merton, is the core of scientificity; new knowledge must be reviewed and critiqued impartially. Merton believed it is necessary to refrain from giving final judgments until “the facts are at hand”. In addition, the facts should be examined on the basis of empirical and logical criteria, and beliefs and convictions should be unbiased.

The time for reactivating evidence and integrity, and focusing squarely on the truth, is long overdue. These elements should be seen as non-negotiable norms in the process of research and learning—and they should apply to communicating about research and learning too. All our efforts should be directed towards achieving the best for the common good. We need to look for the most effective way to enable science to progress in a way that benefits humanity in the Brechtian sense—and never wavers from this goal. ■

Early Career Researcher Award 2021

THE NOMINEES

Is the choice of test groups representative? Are the data sets and protocols diverse enough? Four pioneering research projects pushing for more inclusive and replicable study designs were shortlisted in the Early Career category. The final awardee will be announced on November 24, 2021.

Nominee portraits by Nora Lessing

YURI PAVLOV

#EEGManyLabs: Making Cognitive Neuroscience More Reliable

→ www.eegmanylabs.org

To record electrical brain activity, or EEG, neuroscientists have been placing electrodes on the human scalp for almost 100 years. The catch: Each EEG experiment generates millions of data points and each researcher has their own way of dealing with these large and multidimensional datasets. "The consequence is that this calls into question the quality, reliability, and value of EEG research as it is currently done," says Yuri Pavlov. To remedy this situation, the postdoctoral researcher at the University of Tuebingen, Germany, and Ural Federal University, Russia, came up with the idea of *#EEGManyLabs*—a collaborative international effort to undertake the world's largest EEG replication project. "Using multiple laboratories around the world and working with at least 5,000 test subjects, we will replicate 20 of the most influential EEG studies," the psychologist explains. Subsequently, Yuri Pavlov and his colleagues will make all of their research data openly available to the community. Their goal is to generate a canonical set of reliable and trustworthy EEG data through large-scale multi-lab working practices. In this way, they hope to set the benchmark for cognitive neuroscientists for the next 100 years.■

DANIELLE PEERS, LINDSAY EALES, KRISTIN SNODDON & KATIE AUBRECHT

Reimagining Disability Research Ethics

About 15 percent of the world's population live with a disability and are therefore typically excluded from scientific research. "Research ethics protocols were put in about 50 years ago to protect disabled communities, and for good reason," comments Danielle Peers from the University of Alberta, Canada. "In recent decades, however, disability rights have emerged and disabled folks have become researchers and community leaders. Now those protections are serving to stop the kind of work that would be meaningful to these communities." With their project *Reimagining Disability Research Ethics*, Danielle Peers and her team set out to change just that: They are working to co-create studies with disabled communities and challenge existing policies to be more disability-inclusive and disability-affirming. Their vision: "Ideally, the scientific community in the future would more fully reflect to the community in general, and the kinds of methods, protocols, and worldviews we use in science would represent the range and diversity of humanity."■

PATRICK FORSCHER

Leveraging Big Team Science to Expand Research in Africa

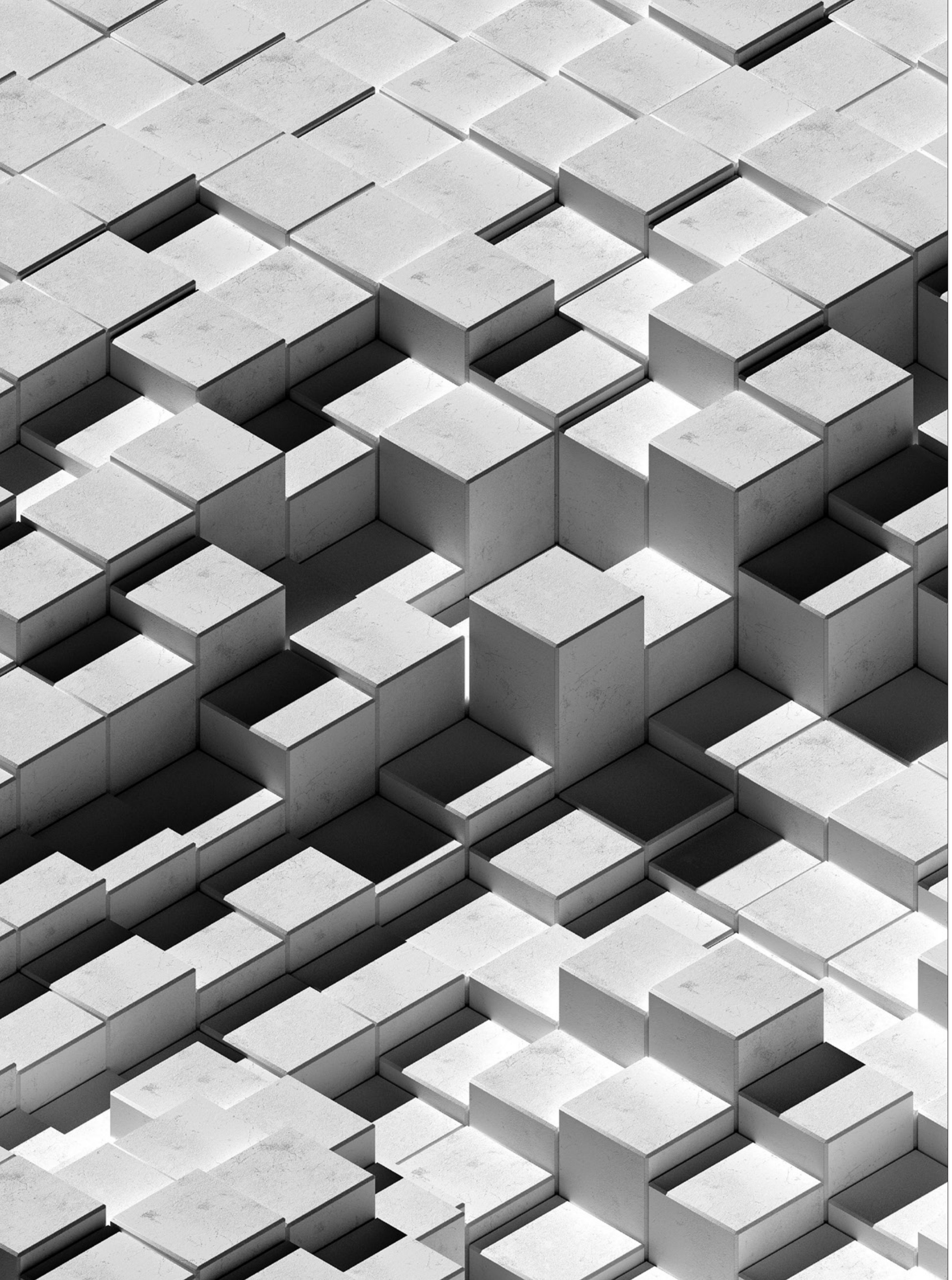
White, male, healthy, and from Europe or the United States: In terms of test subject diversity, studies in psychology tend to notoriously underperform. As results are supposed to apply around the world and culture is known to deeply impact psychological makeup, this is a pressing concern. "The problem is particularly dire in Africa, which has 17 percent of the world's population but, according to one study, provides less than 1 percent of research samples," says Patrick Forscher from the Busara Center for Behavioral Economics in Kenya. "The cost of this bias is hard to foresee. In any case, it's not reasonable to presume that results from Europe and the United States can be generalized." Patrick Forscher's project *Leveraging Big Team Science to Expand Research in Africa* addresses just this problem: It will make available resources and research training across Africa, provide a database in several African languages, and establish 20 new research labs throughout the African continent. "It's our goal to have African researchers fully participate in the academic commons. In this way, we hope to do our part to establish psychology as a field that is more robust, useful, and fair."■

MARTIN ZETTERSTEN & JESSICA KOSIE

ManyBabies5: Teaming up for Developmental Science

→ manybabies.github.io/MB5

Unlike adult subjects, babies cannot tell you what they are thinking. Therefore, researchers studying infant development use looking patterns to understand how babies think and feel about the world. "An overwhelming majority of studies use looking time to make inferences about infant cognition," comments Martin Zettersten from Princeton University in the United States. But what exactly is it that drives babies to pay attention to different things? To come up with a statistically sound answer to this question, he and his colleague Jessica Kosie initiated *ManyBabies5*, a large international consortium of infant researchers. "We aim to increase diversity amongst researchers and test subjects alike and collaboratively want to come up with the best test possible on how different factors matter in infant looking time," Jessica Kosie explains. To that end, the ManyBabies team will put together a diverse and sizeable sample of infants around the world. "To me, team science is a useful tool for producing high quality, robust science," says Martin Zettersten. "Embracing this approach as a field as many groups are doing right now—that feels revolutionary to me."■



ABOUT

OBJECTIVE AND FUNDER

The Einstein Foundation Award for Promoting Quality in Research aims to provide recognition and publicity for outstanding efforts that enhance the rigor, reliability, robustness, and transparency of research in the natural sciences, the social sciences, and the humanities, and stimulate awareness and activities fostering research quality among scientists, institutions, funders, and politicians. The award was launched in 2020 by the Einstein Foundation Berlin. It is supported by the State of Berlin and generously funded by the Damp Foundation for a period of ten years. The Damp Foundation was established by Dr. Walter Wübben, the former majority owner of the Klinikgruppe Damp, to fund medical research and teaching as well as social projects.

AWARD CATEGORIES

The €500,000 award is presented annually in three categories: individual researchers, institutions, and early career researchers. In the Individual Award category, researchers or small teams of collaborating researchers can be nominated. The laureate is awarded €200,000. The same sum is awarded to the recipient(s) of the Institutional Award, for which governmental and non-governmental organizations, institutions, or other entities can apply or be nominated. In case governmental organizations or institutions are the recipients in this category, they will not receive any funds in addition to the award itself. In the third category, Early Career Researchers are invited to submit a project proposal for an award of €100,000.

THE EINSTEIN FOUNDATION

The Einstein Foundation Berlin is an independent, notforprofit, science-led funding organization established as a foundation under civil law in 2009. Since then, its task has been to promote international cutting-edge science and research across disciplines and institutions in and for Berlin. To date, it has funded approximately 200 researchers, including three Nobel laureates, over 70 projects, and seven Einstein Centers.

THE JURY

The Einstein Foundation Council has convened an outstanding group of scholars representing the natural sciences, the humanities, and the social sciences. The international jury is presided over by Dieter Imboden and both defines the objectives of the award and selects the awardees. The following jury members have been appointed for the first three-year term:

DIETER IMBODEN (President), PhD, Theoretical Physics; Professor Emeritus of Environmental Physics, ETH Zürich; **DOROTHY BISHOP**, PhD, Neuropsychology; Professor of Developmental Neuropsychology, Oxford University; **ALASTAIR BUCHAN**, MD, PhD, Medicine; Professor of Stroke Medicine, Oxford University; **MICHEL COSNARD**, PhD, Computer Science; Professor Emeritus of Informatics, Université de Côte d'Azur; **LORRAINE DASTON**, PhD, History of Science; Director Emerita of the Max Planck Institute for the History of Science Berlin; **MOSHE HALBERTAL**, PhD, Philosophy; Professor of Jewish Thought and Philosophy, Hebrew University; **LENA LAVINAS**, PhD, Economics; Professor of Welfare Economics, Universidade Federal do Rio de Janeiro; **JULIE MAXTON**, PhD, Law; Executive Director of the Royal Society, London; **MARCIA MCNUTT**, PhD, Geophysics; President of the National Academy of Sciences of the United States; **EDWARD MIGUEL**, PhD, Economics; Professor of Environmental and Resource Economics, University of California, Berkeley; **ALVIN ROTH**, PhD, Economics; Professor of Economics, Stanford University; **SOAZIC ELISE WANG SONNE**, Economist, World Bank Group; PhD Fellow, United Nations University; **SUZY STYLES**, PhD., Psychology; Professor of Psycholinguistics, Nanyang Technological University; **E. JÜRGEN ZÖLLNER**, Dr. Dr. h.c. mult., Medicine; Chairman of the Board of Trustees of the Stiftung Charité, Senator (ret.), Berlin

PUBLISHER DETAILS

Booklet accompanying the Einstein Foundation Award
for Promoting Quality in Research 2021

PUBLISHER
Einstein Foundation Berlin
Jägerstr. 22/23
10117 Berlin
einsteinfoundation.de

EDITORS
Mirco Lomoth, Christian Martin, Eva Murasov (responsible)

CONTACT
Prof. Dr. Ulrich Dirnagl
Secretary Einstein Foundation Award
award@einsteinfoundation.de

Dr. Ulrike Pannasch
Coordinator Einstein Foundation Award
up@einsteinfoundation.de

**3D CONCEPT & ARTWORK,
GRAPHIC DESIGN & ART DIRECTION**
Fons Hickmann M23 GmbH
Prof. Fons Hickmann, Raúl Kokott,
Paul Theisen & Alessia Meyer

COPY EDITING & TRANSLATIONS
Lyam Bittar, Sarah Hudson, Ros Mendy

AUTHORS
Helen Albert, Andrew Curry, Ulrich Dirnagl,
Manuela Lenzen, Nora Lessing, Volker Stollorz;
data research and compilation: Sheena Fee Bartscherer,
Julia Heuritsch, Michael Meier

PRINT
Buch- und Offsetdruckerei
H. HEENEMANN GmbH & Co. KG
This booklet is printed on carbon-neutral, recycled paper,
certified by the Blauer Engel label.

STAY IN TOUCH

UPCOMING INFORMATION
Please find upcoming information and future calls
for the Einstein Foundation Award for Promoting Quality
in Research at einsteinfoundation.de/award

FOLLOW US
Twitter @Einstein_Berlin
Instagram @einsteinfoundationberlin
LinkedIn Einstein Foundation Berlin

FURTHER INFORMATION
For further information about the Einstein Foundation Berlin,
its funding programmes, fellows, and projects, please
visit einsteinfoundation.de and subscribe to our newsletter.

EINSTEIN Foundation.de

FUNDED BY

Damp Stiftung
Der Regierende Bürgermeister von Berlin Senatskanzlei – Wissenschaft und Forschung BERLIN

PARTNER

nature portfolio
BIH QUEST Center for Responsible Research
MAX PLANCK Förderstiftung

EINSTEIN
FOUNDATION
AWARD

EINSTEINFOUNDATION.DE/AWARD