GREG TANANBAUM, CHELLE GENTEMANN, KAMRAN NAIM,
AND CHRISTOPHER STEVEN MARCUM

A Plan to Develop Open Science's Green Shoots into a Thriving Garden

Over the past several decades, the movement for open science, which promises a more inclusive, efficient, and trustworthy way of conducting and disseminating scientific research, has grown. Driven by the belief that openly sharing knowledge in all its forms—papers, data, software, methods, and more—can help address a raft of societal quandaries (including, though not limited to, systemic inequity and public mistrust in science), the adoption of open science principles has become increasingly mainstream. In the last five years, the White House Office of Science and Technology Policy; the governments of Ireland, Colombia, Spain, France, and the province of Quebec; higher education coalitions in the United States, Africa, South America, the United Kingdom, and Europe; professional societies and associations; and philanthropic funders have all taken steps toward strengthening policies for and reducing barriers to open science. Moreover, science and research ministers representing the member states of the Group of Seven and the Group of 20 have doubled down on their governments' commitments to invest in open, equitable, and secure strategies for research and development throughout the world.

As it's moved from an abstract set of principles about access to research and data into the realm of real-world activities, the open science movement has mirrored some of the characteristics of the open source movement: distributed, independent, with loosely coordinated actions happening in different places at different levels. Globally, many things are happening, often disconnected, but still interrelated: open science has sowed a constellation of thriving green shoots, not quite yet a garden, but all growing rapidly on arable soil.

It is now time to consider how much faster and farther the open science movement could go with more coordination. What efficiencies might be realized if disparate efforts could better harmonize across geographies, disciplines, and sectors? How would an intentional, systems-level approach to aligning incentives, infrastructure, training, and other key components of a rationally functioning research ecosystem advance the wider goals of the movement? Streamlining research processes, reducing duplication of efforts, and accelerating scientific discoveries could ensure that the fruits of open science processes and products are more accessible and equitably distributed.

In July 2023, NASA and the European Organization for Nuclear Research, known as CERN, jointly organized a week-long summit, "Accelerating the Adoption of Open Science," in an effort to push the movement forward. For three decades, NASA has worked on data sharing, team science, and public access to knowledge. In 2021, the agency launched Transform to Open Science (TOPS) to promote an inclusive culture of open science across Earth and space sciences by investing in training, infrastructure, and

advocacy. CERN has a similarly longstanding commitment to open science, supporting a range of initiatives that foster collaboration, improve the accessibility of research outputs, and promote reusability and reproducibility. Building on both this shared interest and the US federal government's designation of 2023 as the Year of Open Science (a project that NASA is leading together with other federal agencies), the two organizations brought together 100 representatives from more than two dozen countries, including policymakers and practitioners, to explore many facets of open science, including open source hardware, protection of sensitive data, the conferral of credit, and evaluation of contributer impact.

The event demonstrated the range of creative and clever ways in which organizations are advancing the cause of open science. The Chile-based Gathering for Open Science Hardware, for example, works to foster sustainable, ethical, and democratic collaboration within dozens of countries across the open science hardware community. The Colombian Science Ministry has embedded ancestral and traditional knowledge systems into its national open science policy. DiploCientifica centers equitable open science through a science diplomacy lens for Latin America and the Caribbean. And OSS4gEO, based in Europe, is actively building components of an open, sustainable, and interoperable geospatial data infrastructure. The diversity of these approaches speaks to the organic way the ideas of open science have propagated in different contexts. Despite their heterogeneity, participants generally share a set of values and common interests in building a more cohesive and equitable approach to open science. There is also broad agreement that the movement needs to prioritize the coordination of incentives, infrastructure, and training.

So, now what? Many a good intention stimulated over the course of a conference dissipates by the time suitcases are unpacked and airport gift shop souvenirs are dispensed. As summit participants, the four of us wanted to avoid squandering the opportunity. For open science to live up to its lofty aspirations, proponents should be deliberate in designing and executing the transition away from research and science policy siloes, data opacity, and publication paywalls. The movement will need to harness the collective wisdom of various communities, organizations, disciplines, career arcs, and perspectives to share lessons and promising ideas alike. And its proponents must embrace both public scrutiny and scientific rigor in assessing whether various efforts are having their intended effect.

Failure to clear these hurdles will almost certainly lead to one of two suboptimal outcomes. The first is reverting to a closed science system that erects barriers for students, practitioners, policymakers, industry, the general public, and—increasingly—researchers outside of the best-resourced institutions. The second is a sort of "Tower of Babel" scenario in which some materials are free to read, adhere to FAIR principles (i.e., findable, accessible, interoperable, and reusable), have well-curated metadata, and provide clear licensing terms—and many materials do not. This will generate confusion, inequity, and irreproducibility at a time when the world needs as many bright minds as possible engaged in existential challenges such as climate change, pandemic preparedness, and poverty alleviation. To avoid either of these negative outcomes, we propose a three-pronged approach to coordinating activities globally and across disciplines that mirrors three of open science's core tenets: intentionality, collaboration, and accountability.

First, participants at the 2023 summit committed in the closing statement to accelerating the transition to a more open, participatory, equitable, robust, and sustainable research ecosystem by articulating action plans—that is, practical ways participants and their communities can collaborate to advance specific open science considerations such as infrastructure, training, funding, and recognition schemes. These efforts will leverage a number of initiatives that are already off the ground: projects like the Coalition for Advancing Research Assessment and the Higher Education Leadership Initiative for Open Scholarship have begun to engage in the meticulous work of building coalitions to change research assessment policies and incentive structures. The community-developed TOPS Open Science 101 curriculum can equip researchers with the skills to prepare their research outputs in ways that are truly findable, reusable, and interoperable. Collaborative efforts such as OpenAIRE are demonstrating how to seamlessly integrate open science activities into existing workflows that researchers are already familiar with. Individually, the action plans generated by summit participants are designed

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to catalyze open science engagement within specific communities. Collectively, they will demonstrate the depth of interest in transitioning to an open-by-design approach to science.

Coordinating efforts across like-minded organizations is another way to magnify impact. At the summit's conclusion, participants identified areas in which they would benefit from ongoing peer support, as well as where they could provide support and expertise to others. These areas were as diverse as sustainable and interoperable open infrastructure, incentives, equitable open science, and evidence-based policy development. By organizing standing working groups that draw from a range of sectors on these topics, the community can identify areas in which collective action and collaboration are possible. For example, the evidence-based policy working group will be developing a framework for collecting and interpreting data measuring the impact of open science policy interventions, while the infrastructure groups will identify interoperability pathways across projects and domains.

Strategic coordination will have direct, real-world ramifications for researchers because it cuts down on the cacophony of signals they receive from their funders, governments, disciplines, and institutions. Coordination also reduces the possibility of uneven or even contradictory reporting requirements. And it sends a clear signal that critical actors are aligning across sectors to make open science both more common and easier to adopt. This community-centered model has shown promise in advancing shared open science interests such as research output tracking and reproducibility.

Finally, participants will develop transparent methods for reporting on progress, both as individual organizations and across the cohort of summit participants. This includes sharing evidence and outcomes (the good, the bad, and the unexpected) on the impact of open science interventions. Taken together, these commitments are critical to injecting a sense of public responsibility to the movement, and to ensuring that this work is consistent with the underlying values of open science.

Open science has continued to gain traction for reasons that are both aspirational—building public confidence in science, adding more diverse voices to the research conversation—and practical, such as increasing the pace of discovery, enabling verification, and leveraging emerging technologies such as machine learning. Given global technical and policy developments, the movement is rapidly approaching a moment of truth. This timely coordination of open science approaches across communities and domains will both accelerate the transition and increase the likelihood that these fast-sprouting green shoots grow into a lush and verdant communal garden: well-tended, sustainable, and accessible to all.

Greg Tananbaum *is the former director of the Open Funders Research Group.* ***Chelle Gentemann*** *is the Open Science Program Scientist at NASA on an Intergovernmental Personnel Act assignment from the International Computer Science Institute.* ***Kamran Naim*** *is the head of open science at CERN.* ***Christopher Steven Marcum*** *is senior statistician and senior science policy analyst in the Office of the Chief Statistician of the United States.*