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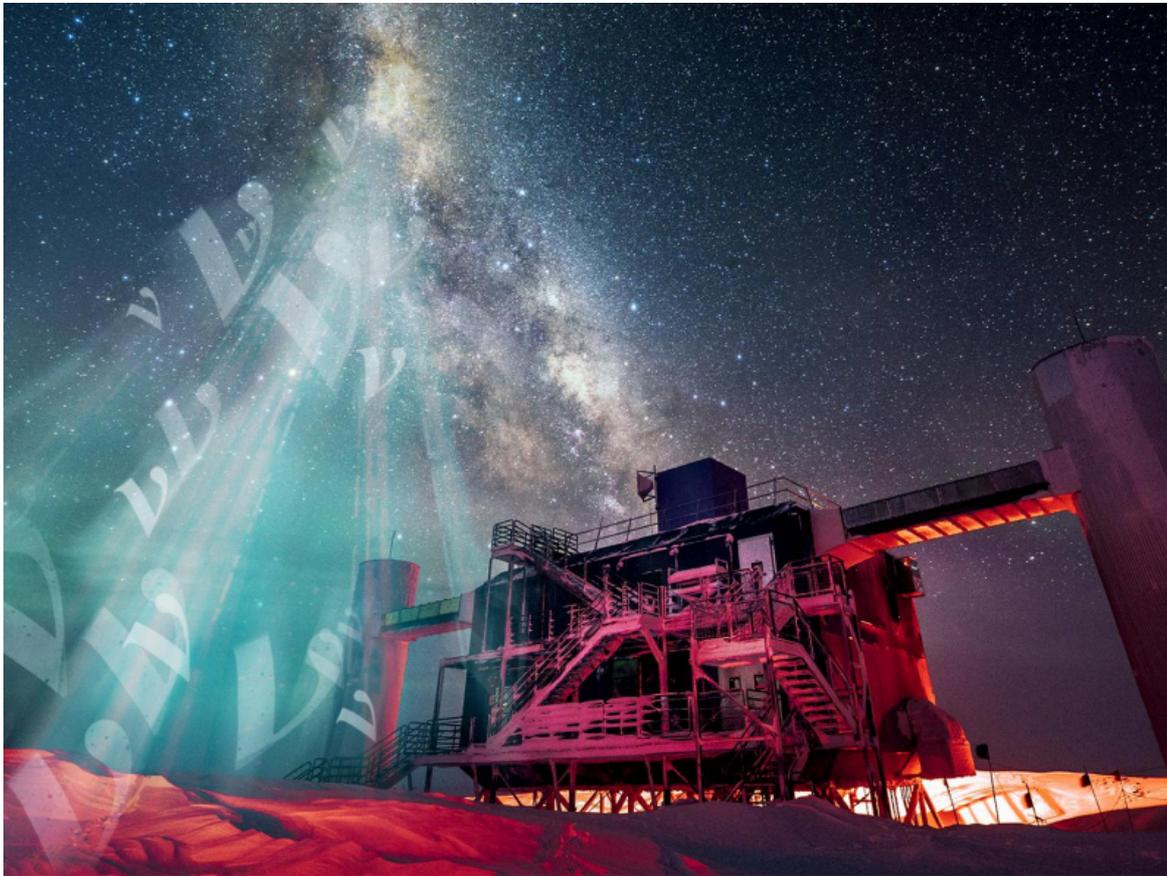
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Unraveling the Global Phenomenon of Mega-Science

A Journey Across the Century of Scientific Advancement

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In the midst of the COVID-19 pandemic, the world witnessed an extraordinary surge in scientific discovery, particularly focused on understanding the novel coronavirus and developing effective interventions. This rapid pace of research, which saw an exponential increase in the number of studies published on the virus within months, was not a stroke of luck, but rather the result of decades of investment in global scientific infrastructure. It required the collaborative efforts of thousands of scientists worldwide sharing their knowledge and engaging in the now-typical ways of mega-science. Previous mega-science projects, from the Manhattan Project to the Human Genome Project, were more locally-based and were conducted over many years, not months.

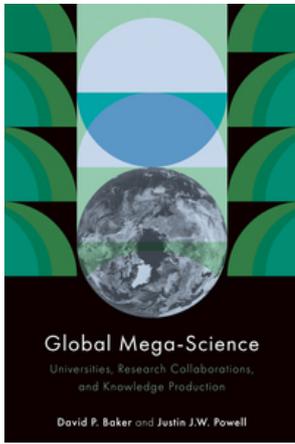
In 2020 alone, over three million articles were published in leading scientific journals, showcasing the extensive capacity for new discovery facilitated by highly-networked scientists across the globe. This phenomenon was not something foreseen by early skeptics, who predicted the stabilization of scientific progress—and growth to limits. Instead, it was and is propelled by a cultural transformation—the education revolution—creating an increasingly symbiotic relationship between higher education and science systems. This educational paradigm shift laid the groundwork for mega-science. Universities transformed from centers of learning to also becoming hubs of scientific inquiry. As ever more individuals pursued higher education (today, two-fifths of each cohort of youth worldwide participate in postsecondary education), universities evolved to prioritize research alongside teaching; they also attend to their third mission of helping to solve wicked problems of society and environment. This cultural process lies behind not only more people attending schooling for ever-longer phases of their lives than ever before but also, throughout the twentieth century and onwards, a steady inclusion of greater numbers of youth and young adults in universities and other postsecondary organizations across the world. In and of itself though, growing attendance alone could not have been the midwife to the mega-science we witness today. Also required was a concurrent influence of the culture of the education revolution on the very essence of what it means to be a university—and how this organizational form provides the crucial, well-resourced forum for the exchange of ideas and research for everyone devoted to scientific discovery.

Mass education and scientific advancement have become intertwined—and truly global phenomena, with most countries investing in national research universities and contributing to global science via publication of cutting-edge research in an expanding list of specialized leading journals. These some 10,000 journals in the STEM fields and health alone, increasingly provided open access to anyone interested, vet and monitor quality and ensure the continuous worldwide dissemination of up-to-date knowledge.

Contrary to predictions, the university remained at the forefront of scientific research, even as other organizations entered the arena. Over 90% of the millions of new scientific publications each year are authored primarily by university-based scientists and their students globally. Collaboration between universities and with other organizational forms, from research institutes to firms, has become the norm, most spectacularly in places like Silicon Valley. This further amplifies the speed and the impact of scientific discovery. The rise of the internet itself, initially conceived in universities, has facilitated the transformation of international research collaboration among scientists, transcending geographical boundaries.

Critics often dismiss the surge in scientific publications as mere hyperinflation. Yet the exponential growth in research output reflects a corresponding increase in research capacity. Not only the existence of 40,000 postsecondary organizations but also hundreds of thousands of active scientists, each with a particular profile, work together in teams small and large. Advances in technology, coupled with this expanding pool of scientists, have energized this pure exponential growth, leading to breakthroughs across diverse fields. While often portrayed in hyperbolic media accounts of fraud and falsehoods, the quality of scientific research hasn't been compromised, despite this surge in quantity. Replication and synthesis of the huge volume of papers are perhaps more important challenges to address, even as contemporary artificial intelligence transforms how we access vast quantities of existing knowledge, with dramatic technological and ethical implications. Across the sciences, emerging subfields and transdisciplinary approaches have paved the way for novel discoveries with significant societal implications. Moreover, the increasingly diverse applications of scientific knowledge have revolutionized various science-based industries, from telecommunications to healthcare.

As we show in our book *Global Mega-Science: Universities, Research Collaborations, and Knowledge Production*, tracking the evolution of mega-science requires the fuller understanding of the cultural underpinnings of the education revolution. As with any robust institution within a specific cultural period, global mega-science becomes an intensified version of itself, an institution differentiated from the “inside out,” or what can be referred to as the scientization of science. This term reflects



Never has the world been as rich in scientific knowledge as it is today. But what are its main sources? In accessible and engaging fashion, [Global Mega-Science »](#) examines the origins of this unprecedented growth of knowledge production over the past hundred and twenty years.

the greater institutionalization of a broadening scope of scientific inquiry through expanding domains and a deepening of the scientific activity within existing disciplines.

From the first academies and salons of Europe to ancient universities now in existence for centuries, the university-science model became the blueprint for scientific progress. Our journey across the long “century of science” starts in the German-speaking region, moving west to the U.S. and then back again towards Europe and on to Asia, especially China, Japan, Korea and Taiwan, and, ultimately, worldwide. We track a university-science model developed to such a degree over the twentieth century that most research-oriented universities are similarly organized—everywhere from Berlin and Berkeley to Buenos Aires and Beijing. Adopting some parts of the model at different points in time with specificities of national history and culture, many thousands of universities and, recently, other postsecondary institutions have joined the research game. Universities in countries that produced little to any globally accessible science before the 1980s, including those in Brazil, Egypt, Iran, and Turkey, with their contrasting political systems and religious beliefs, now regularly contribute an appreciable flow of papers to the world’s major science journals, usually in English. Even smaller countries, from Sweden and Switzerland (the most productive per capita worldwide) to Luxembourg and Qatar (with their newer research universities), participate actively in global mega-science. This widespread orientation towards producing research not only underpins the training of scientists and the intergenerational transfer of knowledge but also makes universities the main place where research occurs. Today, universities serve as epicenters of research, transcending national boundaries to foster global collaboration.

Analyzing the global flow of scientific papers provides insights into the journey of mega-science over the past century. The exponential growth in publication volume reflects the expansion of scientific knowledge and collaboration on an unprecedented scale. Mega-science is not just a buzzword; it’s a tangible reality shaping the potentials of scientific inquiry. Testament to human ingenuity and continuous collaboration in service of universal truth-seeking, mega-science highlights the transformative power of education and the enduring relevance of universities in driving scientific progress. As we navigate the challenges and complexities of our contemporary world, understanding the foundations of mega-science is crucial for ensuring its sustainability into the future.

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