Bottlenecks in Science

The logic of "bottlenecks"

People seeking to advance the scientific enterprise encounter many different types of challenges. Only some of these are *bottlenecks*. A bottleneck exists when there is an excess of resources available to solve a problem —time, money, talent—but the resources have not yet found their proper deployment. In manufacturing, one can see a bottleneck on the factory floor when boxes are piling up next to one conveyer belt. In science, there is excitement and energy to "fix science," but a lack of clarity about what the problem really is.

One way to address bottlenecks is with careful analysis. Problems in scientific fields can often be examined in terms of their *social*, *technical*, and *institutional* factors. While major bottlenecks likely involve all three components, one is often overriding and also the primary target for intervention. One can determine which factor type is the most important by looking at what is working well. Does a field have social support? Are breakthroughs being made? Are institutions functioning efficiently?

Identifying bottlenecks can be challenging. Promoters will seek to make their fields seem unpopular, even when they have broad social support. Entrepreneurs will tout recent advances, even when breakthroughs are small or inconsequential. Organizations will show a polished exterior, at least until there are major reorganizations or staff departures. With bottlenecks, seeing beyond the surface is essential: if the core problems were actually visible, the available resources might have been used to solve them already.

Bottlenecks at different levels

There are bottlenecks in many scientific fields. Consciousness studies, for instance, is bottlenecked on a technical framework or paradigm that is sufficiently concrete, plausible, and shareable to permit routine, legible exploration on the part of many scientists. The science of AI alignment, on the other hand, is bottlenecked on institutions: substantial progress, very plausibly, depends on independence from commercial funding and incentives that lead researchers to share progress despite entrenched philosophical differences.

Bottlenecks can change. In quantum biology, the field had a social bottleneck: disunified support, yielding a lack of fundraising power. That bottleneck was broken in 2024 after money was raised for a decentralized funding organization, the Quantum Biology DAO. In 2026, the new bottleneck is technical. Despite there being the will and resources to make progress, researchers are largely still exploring versions of an old biochemical hypothesis from 1978, the "radical pair mechanism," without having confirmed or disconfirmed it.

Bottlenecks occur at different levels. There can be bottlenecks within an organization, in an entire field, and even for the scientific enterprise itself. These bottlenecks are often related, but still can be analyzed separately and broken down into "technical," "social," and "institutional." Of course, not every field has a bottleneck. Some fields, like cognitive science, are currently well-resourced and making substantial progress. Others, like magnetobiology, are under-resourced on all three dimensions simultaneously.

Bottlenecks in science itself

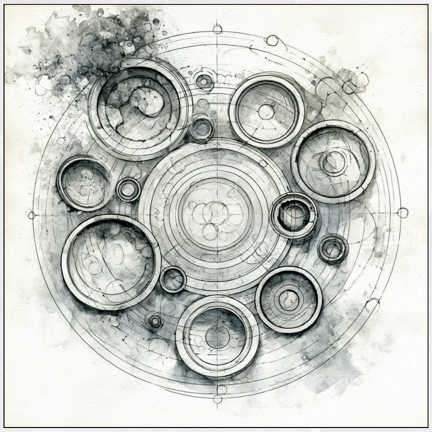
It has now, in 2026, become clear that science itself is stagnating. The sharpest indication of science's decline is the character of recent technological advances. Technology is not stagnant. Advances in electric batteries and geospatial mapping have made drones possible, changing the face of war. New algorithms and better chips led to generative AI, which is now transforming industries. Further advances are on the horizon, as better engineering brings down the cost of solar panels, and AI and geospatial mapping unlock self-driving cars.

Notably, however, the current batch of new technologies are based on old science. Lithium ion batteries are based on advances in chemistry from the 1970s. Solar panels are based on the photovoltaic effect, originally discovered in 1839. Generative AI itself runs on neural nets, which were invented in 1958, based on neuroscience from the late 1800s and computer science from the 1940-50s. Even prospective technologies, like nuclear fusion and quantum computing, are based on previous scientific paradigms, rather than new ones.

While beginning to decline, it is clear that there are still resources available to advance science. Science and scientists, despite a dip in popularity following the pandemic, broadly retain the public's faith and trust. Science funding, even while under attack by the Trump administration, remains at an all-time high, at least measured in nominal terms. There are also an army of trained scientists, many of whom are eager to do real science, not merely publish papers or seek professional rewards. There is, therefore, a bottleneck.

The bottleneck in science is institutional

What is the main bottleneck in science? Examining the enterprise in terms of social, institutional, and technical factors, the clear answer is: the bottleneck is *institutional*. There is, as noted, vast popular support for science. The bottleneck is, therefore, not social. Scientists are also making breakthroughs and discoveries, including deep, foundational advances that will resonate for years to come. One striking example is Stephen Wolfram, who published discoveries pertaining to complexity in discrete systems in 2002.



Scientists and non-scientists alike have critiqued scientific institutions. Scientific papers are paywalled. Peer review is broken. Scientists spend much of their time competing for grants rather than doing science. When theythey do science, scientists often cut corners, as part of a longstanding system of "publish or perish." Reforms are proposed, like paying scientists to engage in peer review or requiring preregistration for studies to ensure scientists don't tweak the experiments after the fact, but have largely not been implemented.

Bottlenecks are, however, typically comprised of problems people have *not* identified, rather than problems they have. The reason is simple: if there are resources available and people identify the bottleneck, the bottleneck soon gets broken. The bottleneck in science, therefore, is both institutional and something that has largely gone unnoticed. Solving the problem will likely involve fixing peer review, opening up journals, changing the granting system, and so forth, but those are consequences of the solution, rather than the core.

The problem in science

The central problem in science is the lack of communication between science funders. There are, of course, reasons funders do not speak with one another: funders have different priorities, different domains of science function differently, government agencies have divisions of turf, and so on. However, the overall effect of funders not communicating is that the entire system of funding does not learn from successes and failures. For something as difficult as science, funders need to learn from each other's mistakes, not merely their own.

The primary reason funders do not communicate with one about their successes and failures is that some of the failures are extraordinarily embarrassing. Funders will publicly trumpet a line of research, only to discover later than they've been duped. Funders allocate large sums of money, then find the money gone with not even a paper to show for it. Admitting mistakes is difficult, especially when there are careers and reputations on the line. This is especially true when funders are, for the most part, used to announcing success after success.

The key missing fact, necessary for funders to absorb, is that scientists have, for many years, been working hard to capture their funding sources. Two notable means are the increase in specialization and technical jargon, especially from the 1980s onward. While some attribute this to the accelerating pace of scientific breakthroughs, there is now ample evidence that the pace of advance has been exaggerated. A different explanation is that jargon and specialization make science harder to assess and funders easier to capture.

Viewed with the concept of "funder capture" in mind, many of the other dysfunctionalities of the scientific system are easily explained. Paywalled papers make science harder to access and, hence, hard to assess. Broken peer review increases the difficulty, both by being unreliable and it being known to be unreliable. Indeed, from the perspective of scientists who have captured their funders, science being broken isn't a bug, it's a feature—since the less assessable science is, the more their positions, as incumbents, are secure.

An experiment: decentralized funding

The problem of funder communication, in the context of funder capture, is unlikely to be addressed within the existing system of science. Funders, who have the ability to change it, have chosen to not do so, and the scientists who have captured their funders don't want them to. That said, the problem need not be terminal. It might be solved by independent action on the part of funders or by new systems and structures that incentivize the relevant sort of communication.

By way of concrete experiment, a single funder could allocate enough money to fund five distinct but overlapping scientific projects. Continued funding can be made conditional on honest reporting of problems, and gaming the system can be reduced by having people from each team embedded in each other's projects. Projects can be selected to be in adjacent and complementary fields and have ambitious, legible scientific goals. Incorporating teams with different scientific backgrounds and cultures, with demanding but realistic open science requirements can prevent early collusion as they projects get started.

Of course, there is an cheaper experiment that can be run in advance, which is to convene science funders to begin conversations about how their funded science is actually going. In these days of constrained time and attention, however, the cheaper experiment may be difficult to run without also running the more expensive one. Money, skillfully deployed, can grab people's attention. Whether these experiments are successful or not, the information generated will help to break the bottleneck in science that has existed for far too long.