Rebooting disruptive science: Exploring the challenges and potential solutions

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COMMENTARY

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Rebooting disruptive science: Exploring the challenges and potential solutions

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Abstract

There has been a decline in the number of disruptive scientific discoveries and breakthroughs. Here, reasons for the decline of disruptive science are explored including declining funding for basic research, increasing risk-aversion among scientists, pressure to publish quickly and increasing administrative workload. Solutions are proposed to reverse the trend and encourage disruptive research especially for young scientists.

KEYWORDS

basic research, disruptive science, funding, preclinical research

In recent decades, there has been a decline in disruptive scientific discoveries and breakthroughs.[1] Disruptive findings can fundamentally change existing scientific paradigms and are usually identified by the consolidation-disruption (CD) index, which measures the degree to which subsequent papers that cite the disruptive discovery do not reference the previous concepts. One of the most prominent examples for disruptive findings with a high CD index (+0.62) is the Nobel-prize winning paper by Watson & Crick describing the new DNA structure that debunked Pauling's previously existing model of the DNA structure. A Nobel-prize finding with a relatively low CD index (−0.55) is for example Baltimore's discovery that virus with RNA genomes can be inserted into host cells, which was built on prior knowledge regarding genetic information transmission between DNA and RNA.[1]

This decline has raised concern, as breakthrough discoveries have the potential to change our daily lives, or have the power to solve unmet medical needs for major diseases. Here, some possible challenges are discussed (Figure 1A–C).

One reason for the decline in disruptive science is that relative funding for basic research has been decreasing. For instance, the US federal government (a major funder of basic research) reduced the relative share of basic research funding from 58% to 42% in the last two decades while increasing the absolute and relative funding for applied research (composition federal funding in year 2000: basic research 58%, applied research 27%, other 15%; year 2017: basic research 42%, applied research: 35%, other: 23%).[2] Basic research is often the foundation for disruptive science, as it allows scientists to explore new ideas and make unexpected discoveries. On the contrary, research funding of applied science considerably increased favouring incremental innovation, a series of small improvements made to a previous finding. Funding incremental innovation is

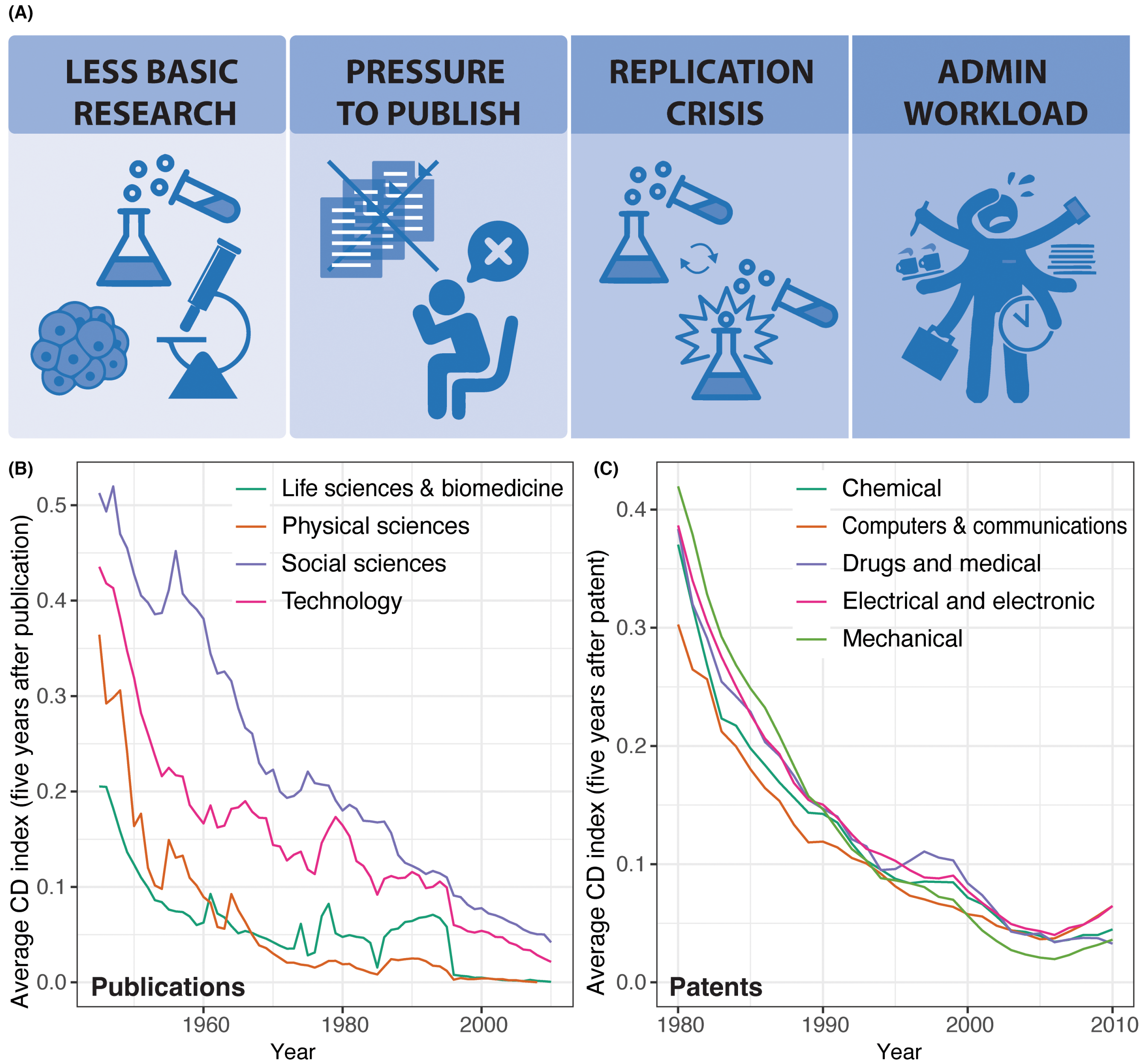

FIGURE 1 Current challenges for disruptive science. (A) Limitations of disruptive findings are less funding for basic research, pressure to publish, replication crisis and admin workload. (B, C) Decline in the consolidation-disruption (CD) index over time, separately for papers (A, $n=24{,}659{,}076$) and patents (B, $n=3{,}912{,}353$). Data from (B, C) have been generated from source data of Park et al., 2023, *Nature*.[1]

often favoured as it is more predictable, cheaper and has a shorter R&D cycle to reach a high-impact publication or a profitable product. However, it reduces the chances of unexpected discovered that can lead to disruptive science. To reverse this trend, governments, private foundations and industry may increase their investment in basic research to support innovative ideas and unexpected discoveries.

Furthermore, scientists are under increasing pressure to produce results and secure funding, which also favours incremental and descriptive rather than disruptive scientific discoveries. This means that scientists are more likely to work on projects with higher chances to succeed, rather than taking risks on bold and innovative ideas. Given that funding, especially for early-career scientists, is usually limited to few years and has a very limited scope, young researchers are under even more pressure to generate results in a short time and therefore are incentive to avoid risky projects. The increasing competition and pressure to publish papers quickly in prestigious journals leads to many descriptive studies using state-of-the-art technology. For instance, a screening study using novel single-cell technologies almost guaranteed a predictable outcome that can be published and utilized as a basis for a grant application in a relatively short period of time. Often these large-scale screens are not followed-up by tedious proof-of-concept in vivo studies to study individual pathways but rather followed-up by another screening study.[3]

The constant pressure to publish novel findings also exacerbates the replication crisis. Three out of four scientists have tried and failed to replicate another researcher's experiments.[4] While the lack of reproducibility affects incremental and innovative research equally, breakthrough research may require relying on several findings from multidisciplinary fields minimizing the success rate even further. In order to reverse the trend, there are measures that can be taken, which have already been partially implemented in recent years. For example, it is important to create an environment that fosters creativity and encourages risk-taking among scientists. This can be achieved by providing researchers with more autonomy and flexibility in their work, and by reducing the permanent pressure to produce results and secure short-term funding. Additionally, it is important to provide incentives for young scientists to take risks and pursue innovative and disruptive research. Transparency and reproducibility in scientific research can be improved by further promoting open science practices, such as open data and open access to publications, and by providing training and resources to help scientists improve the quality and robustness of their research.

Moreover, the administrative workload has become increasingly demanding for scientists. The administrative tasks such as paperwork, compliance, ethics and funding applications can take up a lot of time and energy, leaving less time for researchers to focus on their research. 95% of scientist reported to work more than 40 h per week and attributed only 30% of their working time on research. Administrative tasks were also considered as the most avoidable stressor for early-career researchers described as 'excessive and pointless'.[5] Especially for early-career scientists without the administrative resources of established researchers, the administrative workload takes a disproportionate share of the working time. In addition, unexpected preliminary findings often cannot be validated at all, since necessary animal licences or ethic approvals are usually pre-defined and may require up to a year to be approved in some countries. Reducing the administrative workload can be achieved by streamlining paperwork, compliance and funding applications, and by providing more support and resources to help especially early-career scientists to manage these tasks.

In conclusion, the decrease in groundbreaking scientific discoveries can be linked to several factors such as reduced funding for fundamental research, (early-career) scientists becoming more risk-averse, the urgency to publish in prestigious journals and increasing administrative workload. To counteract this trend, it is vital to allocate more resources to fundamental research and motivate scientists to take chances and pursue creative and innovative ideas.

AUTHOR CONTRIBUTION

R.R. wrote and revised the manuscript.

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CONFLICT OF INTEREST STATEMENT

The author declares that there are no competing interests.

CONSENT FOR PUBLICATION

The author consents to the publication of the manuscript.

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