Creativity rush

Creativity in science seems to have evolved over the centuries from mainly a solitary effort to a more collaborative one.

One of the major characteristics of science is of course creativity and innovation. One can define creativity as a process leading to a disruptive new theory (like the Copernican model against the Ptolemaic one), a new material or device (such as plastic or the transistor). Figures like Galileo Galilei, Isaac Newton, Neils Bohr, Albert Einstein and many others that revolutionized their respective fields come to mind when thinking about creativity — great examples of what we usually define as a solitary genius. So many effects, techniques and fundamental constants used in physics, chemistry, biology, medicine and other fields are named after one individual. These ideas and inventions shaped science deeply and provided profound knowledge in several areas, eventually leading to societal transformation; for instance, Abraham Darby's idea of using carbon in order to melt iron was a crucial step towards the industrial revolution.

Although not directly linked to creativity, context is important: many of these instances occurred in periods where major questions were still unanswered, immediately before the occurrence of a major scientific revolution (for example, the transition from Newtonian mechanics to general relativity), according to physicist-turned-science philosopher Thomas Kuhn¹. These periods alternate with periods of 'normal science', where scientific frameworks are well established and can explain (with some incremental improvements) the issues under investigation. An accumulation of questions that can no longer be explained by the established theories will require a paradigm shift and will eventually instigate another major scientific revolution.

Additionally, these leaps in science, although unexpected, were very often pushed by a practical need: Planck formulated the founding hypothesis of quanta of light by trying to explain the spectrum of the light emitted by ovens in order to measure their temperature with a contactless technique; the foundation of quantum mechanics was born in the blast furnace. As such, it is possible to consider the creative process in science as a solitary one, even if it is often pushed by very practical needs and thus strongly influenced by the contingent issues of the surrounding environment.

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Inevitably, the vast amount of data and knowledge accumulated means that it is very hard for a single person to acquire the necessary information to cover in an exhaustive manner even an individual discipline. Individuals spend more time learning, which leaves less time in the lifecycle for innovation: the mean age at which great inventors and Nobel laureates made their major contributions has risen by six years over the twentieth century². Alternatively, they might compensate by focusing on a narrower expertise. The Renaissance man is a concept of the past.

This narrowing expertise can reduce individual capabilities, and push innovators to work in teams. Studies have indeed demonstrated the shift that occurred in the twentieth century from influential thinkers to iconic dyads (such as Microsoft's Bill Gates and Paul Allen) and later on to the emergence of large interdisciplinary teams³. Research, be it experimental or theoretical, has in fact become tremendously complex, which justifies bigger teams across different disciplines. Behind some of the most recent remarkable results such as the merger of the black holes, one can find teams made out of hundreds of individuals. Thus, it seems that, owing to the increasingly larger complexity and 'size' of the scientific discipline, the creative process is necessarily becoming a 'cohort mechanism': direct contact between people belonging to different domains can promote creative ideas. The funding agencies have certainly understood this

change of paradigm in the creative process in science and have structured their financial instruments accordingly. Most open calls for funding now require interdisciplinary teams of groups across countries, bringing together different expertise.

Going from the lone genius to collaborations across the globe, the scientific community does not cease to be part of something bigger, the human society as a whole. There has therefore been some discussion about including non-experts in the scientific process, as they can not only propose important problems to be solved but will also be the prospective users of any technology and innovation that might be derived. Researchers strongly interact and even depend on society on several aspects: from inspiration to addressing specific societal needs to improving daily life, from funding for their work to commercializing innovation. Pierluigi Barrotta, author of the book *Scientists, Democracy and Society*, firmly believes that a more active participation of non-experts in the scientific process is not only possible but also highly beneficial for all, despite the gap in expertise. In a Q&A he explains to us the role of science in (democratic) societies, and how its workings get affected by social and moral constraints, putting forth the idea that despite the antithesis between scientific rigour and moral values that characterize research and society respectively, they both share similar methods and a common goal: the truth.

We often focus on the financial and commercial impact of research for society, but we seem to forget that social and moral values are equally powerful in shaping not only its workings but also the facts it relies on. Creativity will always remain at the heart of science but it has also changed significantly as a process, having evolved from being mostly a solitary effort into a more complex process relying mainly on collaborative forces. □

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