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Viewpoint

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Science in the Age of Digital Networking

Today, the world is moving fast, but we do not know exactly where this leads yet. As the economy of knowledge inevitably extends its tentacles on the realm of science, what are we—scientists—going to do? So far, an increasingly large number of critical voices are pointing out vast transformations that are occurring in the way that science, and scientists, perform their activity and especially how such activity is disseminated and valued. These changes are very likely associated with the sheer size of a global science system, and to the growing connectivity of scientists, that corresponds to very fast mutations operated in society by the omnipresence of the Internet and of portable computer devices. Indeed, many aspects of life like book reading, traveling, and social dating have been transformed beyond recognition in the last ten years. Now, a few companies such as Amazon and Facebook can manage in an instant the information and opinion of millions of people that in turn influences the way each person's decisions are made. Correspondingly, the complex processes of scientific peer review and publishing of scientific papers are reduced to a matter of weeks. Dissemination takes an instant. Is speed the main criterion for the evolution of knowledge?

Science is in a way a big "industry" today, and simple and swift methods to attribute value to scientific activity have been adopted that are now widely spread. The value of scientific work is becoming increasingly associated with the face value of the journal in which it is published, so that the final objective of doing science in these days is to get as many papers in such journals (put here, Science and Nature or the large-impact-factor journals of your field), rather than to solve scientific problems or challenges that the researcher deems important, original, and innovative. Scientific competition and scientific races have been always part of scientific production and probably represent a part of the thrill of scientific publication. "Publish or perish" is a very old master rule, but the publishing process was slow. One scientist could invest time, in the scale of years, to solve a particular problem at his/her own initiative, without penalization. Now, the digital interconnection and the speed of communication puts everyone under intense continuous scrutiny on a day-to-day basis.

The elementary reason for the impact factor metrics was to value top-quality scientific work in an easy and convenient way. This metric has become very popular among scientists and even more among managers, who value most of all things that can be easily accounted. In principle, a panel of unbiased experts could value high quality work of its own based on certain qualities of the results—say, the originality, the effect it has on the scientific activity of others, the previous production of the main author, the technical perfection, and a multiple facets of dimensions that make a particular scientist very good or outstanding.

But according to the perception of many scientists and scientific managers, today such evaluation can be done instantly by looking at the number and impact factor of publications or to bibliometric indexes such as the h-index. The consequence is that the focus of scientific work, which used to be to making high quality work in order to perform an admirable trajectory, is now centered instead in making a good bunch of high impact factor publications, ensuring a large dissemination of related work that warrants higher citations. There is a clear inversion of value.

This change of value has a far-reaching influence on scientific activity, as it favors the activity toward papers that will be welcome in high impact factor journals, in opposition to other types of activities. Because the scientific journal is no longer just a medium for dissemination but also attaches value to a paper, there is a strong competition to publish in the highest ranked journals. There are tactics that one can learn and try: aiming for world record properties (sometimes at a cost of reproducibility and sometimes without essential experimental descriptions), using certain types of graphs and pictures, or a certain standard narrative and title. Above all, the final goal is that they must be "liked" (cited by many). It seems sometimes that a goal of high impact journals is to quickly market their published scientific results, but remember that there is a difference between a high impact factor publication and high impact, as stated by one Editor in Chief from ACS. According to a recent analysis, "researchers should not overvalue or fetishize scholarly metrics. They are, at best, imperfect tools to measure the achievements of individual researchers, articles, and journals. The true measure of success is the carrying out of innovative and original research that is successfully shared with fellow researchers and adds to human knowledge."[1]

But there is not only competition among scientists. There is also a very tough competition within the publishers in order to get the "best" papers, those that will be appealing to as many authors as possible. Some editorial managers perform very well at this, and they adapt the characteristics of peer review and diffusion, and the design of new journals under their brand, to the perceived desires and trends of a swiftly moving market. So, the valuing of science by the score of publications changes both the scientific activity and the reporting system in a circle that pushed at its limits may not be virtuous.

It is interesting to observe the moment of emergence of a new fashion, one that will produce tons of papers; you can put your choice: carbon nanotubes, graphene, perovskite solar cells, and so forth. It is an opportunity to get papers in better journals than one can normally reach. It will attract an extraordinary number of people to this topic, as editors will want such papers because they are very likely going to attract a higher than normal number of citations. In principle, the creation of a strong community around an important topic is a natural and welcome fact, as the amount of creativity and mutual criticism will improve the exploitation of this finding. However, a vast set of global resources will be invested in one single thing. It looks that such trend will kill diversity and fundamental and critical science.

We also note that the social dimension of science, the shaping of communities, may be transformed. Is a fierce competition the only dimension needed? In the setting of a

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New Big Thing, it can happen that people become suspicious of cooperation. Even in one laboratory! There is so much rush, it is felt that you have a single shot to do such central paper that will improve your career forever, so why should you give up some of your chances? Your neighbor and colleagues become competitors that may take away the piece of gold that you deserve. You have to concentrate on politics a lot.

Nowadays, bibliometric success is perceived as the dominant objective to pursue a scientific career. Indeed, in some types of fund-giving panels or hiring commissions, it is possible that fast evaluation may be needed and impact factors, h-index, and so on are a convenient way to rank the projects and candidates and pick some winners. However, this is fortunately far from being the general case. In many hiring systems, expert opinion is demanded. Experts are persons that may have a global view of the field. Such evaluators may be able to judge the results of our scientific trajectory. They may actually penalize you if you have been adopting the dominant trend at every moment, as then you will be judged poorly as an independent thinker. As stated by Dick Zare,[2] with regards to researchers' assessment at Stanford: "We do not look into how much funding the candidate has brought to the university in the form of grants. We do not count the number of published papers; we also do not rank publications according to authorship order. We do not use some elaborate algorithm that weighs publications in journals according to the impact factor of the journal. We seldom discuss h index metrics, which aim to measure the impact of a researcher's publications. We simply ask outside experts, as well as our tenured faculty members, whether a candidate has significantly changed how we understand chemistry."

The world is changing very fast; it is a moment to construct how the future will deal when science is empowered with communication tools and social habits that did not exist before. These tools will significantly enhance the global productive capacity and create a dramatic acceleration in the pace of change. Science is a cooperative effort that lies in communities of experts. In one sense, scientific excellence arises from competition (*agon*), it is a contest in which best reason and good experimental proof makes some scientists prevail and others lose for the final benefit of all in establishing the right pathway, which is not easy. But we cannot lose the deep pleasure of learning, interacting, testing ideas, understanding, and seeing deeply. We cannot leave out of the game those that have patience to accurately check the results, those that work slowly to follow a particular problem that is not the central fashion of the moment, or that may even be disturbing for the mainstream research topic, those that may want to unite different ideas to establish a broader picture. Let us not forget the intuitive judgment of quality.

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Notes

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