Fantastic science and where to find it

Citation for the original published paper (version of record):
Mijakovic, I. (2021). Fantastic science and where to find it. Periodicum Biologorum, 123(1-2): 45-47.
http://dx.doi.org/10.18054/pb.v123i1-2.16473

PERIODICUM BIOLOGORUM
VOL. 123, No 1–2, 45–47, 2021
DOI: 10.18054/pb.v123i1-2.16473

UDC 57:61
CODEN PDBIAD
ISSN 0031-5362

Letter to the Editor

Fantastic science and where to find it

IVAN MIJAKOVIC[1,2,*]

[1] Division of Systems and Synthetic Biology, Department of Biology and Biological Engineering, Chalmers University of Technology, 412 96 Gothenburg, Sweden

[2] Novo Nordisk Foundation Center for Biosustainability, Technical University of Denmark, 2800 Lyngby, Denmark

Correspondence:
Ivan Mijaković
E-mail: ivan.mijakovic@chalmers.se

Gathering reproducible experimental results and using impartial analysis of these results to build hypotheses that explain natural phenomena – these are the immutable tenets of science. But that is just a very abstract view of science. Science is also a social activity, whose everyday practice is heavily influenced by societal trends that have been changing throughout history. With this view, we seek to explore what characterizes the way we do science in the 3rd millennium. Science, as one of the key contributing factors to the overall progress of human civilization, is often tracked by its landmark achievements and breakthroughs. Reasoning in those terms, the 20th century was truly a century of science. The humanity learned how to split the atom and harness nuclear energy. We understood the molecular basis of life (DNA/RNA/proteins) and mastered genetic engineering. Via progress of molecular science and medicine, many of the dangerous infectious and non-communicable diseases were eradicated or placed under control. Last but not least, in the 20th century we put a man on the Moon. By contrast, the humanity seems to be achieving fewer true scientific breakthroughs in the 21st century. Societal trends responsible for such developments are likely to be many and complex. While one may be tempted to relate this turn of the tide to the notion of circular history proposed by the Italian philosopher Gianbattista Vico in his book Prinzipi di Scienca Nuova (1), philosophical and historical aspects of science will not be discussed here. Another important aspect of science as a social activity, relating to plagiarism, fabrication of results, nepotism, intellectual inbreeding, sectarianism, and other common human transgressions will also not be discussed. Instead, we will focus on the ongoing changes in how science is performed, financed, published, and evaluated in the 21st century.

Many countries are witnessing a massive shift from fundamental and open-ended scientific research to applied and goal-oriented science. This follows a shift in government funding schemes, redirecting resources towards projects that are more likely to have an immediate impact on the society. Not all countries are following the exact same path, and notable exceptions to this trend exist. Some universities (e.g. in the USA) provide beginner principal investigators (PIs) with sizeable starting packages and no strings attached. This ensures that these young PIs can focus exclusively on building a strong research profile during several initial years of their careers, not having to apply for any grants to sustain their research groups. This typically leads to research on open-ended scientific questions, during that initial period. After that, young PIs are supposed to use their boosted CVs to enter the arena of competition for external grants with everyone else. In that arena, the possibility of focusing on open-ended scientific questions gradually decreases. In many other countries, young PIs enter that arena from day one.

Besides addressing the perceived societal needs, another criterion emerges as very important for funding science. Projects must be amenable to certain schemes of administration. A very popular format for administering and implementing scientific projects is the one where future scientific progress is described in "work packages", each lasting for a precise duration of time and leading to predefined "deliverables". In order to get government funding for research, in most cases the PIs are required to describe not only the exact timeline, duration and outcome of their future experiments, but also the future impact that their science will have on the society in quite some detail. Yet history teaches us that this sort of prediction is an impossible task, unless the future work is heavily derivative, and the outcomes are already known to a large extent. Is knowing the results of our future research before we even commence the investigation really a good guarantee of excellent science? Many governmental funding agencies seem to believe that this is the most effective way to invest the taxpayers' money. But some scientists would argue that this type of science is not worth doing at all.

Another societal context in which the contemporary science operates is a tremendous imbalance on the job market. The offer of trained scientists surpasses the demand in gargantuan proportions. Mass-production of PhD graduates is flooding the job market, leading to fierce competition. Across the board, universities are stimulating PIs to educate more experts with PhD degrees. This "stimulation" sometimes takes the form of shortening the PhD programs, reducing publication requirements and in general lowering the requirements for obtaining a PhD degree. Expectations of many of these newly trained scientists revolve around a career in academia. Yet the numbers do not add up – there are not nearly enough academic positions for all of them. By consequence, academic careers are becoming increasingly competitive, with a growing number of "dropouts" at all career stages from postdoctoral fellows to full professors. While most of these scientific "dropouts" end up having very successful careers in the private sector, it often happens that the private sector does not fully utilize their extensive set of research-related skills, leading to some personal disappointments. Contemporary scientists that manage to persist in academic careers undergo a constant Darwinian selection, which focuses their intellectual capacities mainly on the battle for survival: pushing out an increasing number of papers and grant applications, devising strategies for their research to attract more citations and demonstrate more societal impact. With researchers of all ages locked in this battle for survival, using most of their efforts on writing grant applications, one cannot help but wonder if this is the best way for the humanity to use the collective brain power of our scientists. Well, Darwinian selection seems to have worked very well in the evolution of life on Earth. So maybe it is also the best strategy for doing science. Still, as the human society matures, perhaps we do not have to educate 10 or 100 times more scientists than the society needs, and then let the natural selection pick the best. Perhaps just a solid education system with serious quality control before bestowing academic degrees could do the trick.

Scientific "survival" described above depends to a large extent on meeting the expectations of editors - leading to publications in high impact journals. Meeting these expectations has in fact become one of the major driving forces behind modern science. PIs must increasingly consider the opinions of journal editors when they design their future research and choose which scientific questions to tackle. Many top scientific journals openly communicate that they are not concerned only by the scientific quality of the papers they publish, but also by the impact the papers are likely to have on the readership, measured by citations. In other words, they pick manuscripts that they estimate are likely to contribute to the high impact factor of their journals. Somewhat paradoxically, scientists support the current publication model financially (paying for publication fees from research grants, often taxpayers' money) and by contributing free labor at the same time. Most scientific journals charge the authors a processing and open access fee to the tune of >2000 euros per published paper. These same authors are also expected to provide peer review and editorial work to the journals free of charge, thus directly supporting the business model which converts their money (grants) and free labor (editorial and peer review work) into corporate profit. This business model is very successful, because the end users (scientists who pay the processing and open access fees) contribute their free labor to generate in great part the service that is being sold to them. This creates a virtual *perpetuum mobile* of corporate profits, which to a large extent incentivizes the current boom of predatory journals.

In some countries, state-funded agencies that finance research keep a relatively open mind as to the topics that the scientists are allowed to investigate. Countries like e.g. France and Germany have large national institutes (CRNS, Max Planck, respectively) dedicated to basic science. But increasingly often, state-funded agencies attach strings of "applicability" or "societal impact" to their funding calls: science must be performed within a specific narrowly defined area, with a concrete promise of future benefits to the society. In Europe in particular, state and EU funding agencies are channeling an increasing fraction of their resources to such calls, as exemplified by the popular document on Mission-Oriented Research & Innovation in the European Union (2). On the face of it, this seems like a very good thing: all our scientists working only on the issues that matter today. The only problem is, who and when will address the issues that will matter tomorrow? In recent past, open-ended scientific research defined our tomorrow. But the humanity can arguably find better ways to define its future development.

While the state governments seem to slowly converge on a consensus view as to how science should be funded and conducted in the 21st century, other sources of funding for science sometimes express different views. In 2018, among the 100 largest economies on our planet, only 29 were states, and the rest (71) were private corporations (3). Some private corporations have economies that are so large that they spend more resources on supporting scientific research than most state governments. Many private corporations are taking the societal responsibilities that go with such enormous power quite seriously. Private foundations are being set up to invest corporate profits in science, and they are funding research projects that are not directly linked to the primary activity of the funding companies. In some instances, their investment strategy is exactly the same as that of the government agencies: invest in research of established PIs with a strong publication and citation record, as long as they promise to perform goal-oriented science that can be neatly packed in "work-packages" and followed administratively along a well-defined Gantt-chart. However, some private foundations are choosing to head down a path less travelled. For example, the Knut and Alice Wallenberg foundation in Sweden has funding schemes that require PIs to do very little "promising" of future outcomes. Funding schemes such as e.g. Wallenberg Scholars (4) rather chose to support excellent scientist with long-term strategic funding with almost no strings attached. Other private foundations specifically support open-ended and curiosity driven science, with all the associated risks. For example, the Velux and Lundbeck Foundations in Denmark have recently come up with a grant scheme called the "Experiment" (5,6). Scientists at all career stages are eligible to apply with ideas for an ambitious experiment that will try to answer one meaningful scientific question and push the frontiers of science, even if the promise of societal impact is not immediately clear. In fact, these funding agencies go so far as to require the applicants to explain why their idea is not fundable by "traditional" funding sources. Evaluation is CV-blind, it is just the idea that is judged by expert reviewers. So, the applicant success rate is basically equal for junior postdocs and established professors. Could this trend be a turning point in how science is funded? It is still early days and the success of such funding schemes will require more scrutiny. But the "Experiment" grants certainly hold a promise of exploring curiosity driven scientific ideas that would otherwise never see the light of day.

In conclusion, the common view on what constitutes fantastic science has probably not changed much in the 21st century. Most people would still be likely to agree that unravelling the secrets of the atom, flying a rocket to the Moon or discovering penicillin have been fantastic achievements. On the other hand, the views may have changed when it comes to how do we ensure getting similar scientific breakthroughs in the future. Accountability seems to be one of the fashions of the day, and it can certainly go hand-in-hand with creativity. But accountability projected into the future, "guesstimating" future impact of science probably does not mix with creativity equally well. The author would humbly argue that one of the tenets of science, in addition to gathering of reproducible experimental outcomes and using impartial analysis of results, is intellectual freedom. Freedom is a word that is not very much used today, perhaps because we tend to take it for granted in some parts of the world. A certain disregard for freedom is very understandable on a planet with ever increasing population density, which naturally engenders over-regulation of all aspects of the society. Trading off on individual freedoms is a *conditio sine qua non* of ensuring that increasingly dense society functions. The burning question then becomes: is significant scientific progress possible in an over-regulated society, and if yes, how to best nurture it.

Acknowledgments: *The author wishes to thank Dr. Kirsten Leistner and Prof. Dina Petranovic for critical reading of the manuscript. In preparation of this manuscript IM was supported by funding from the Novo Nordisk foundation (grant NNF10CC1016517).*

REFERENCES

1. VICO G 1725 Principi di una scienza nuova intorno alla natura delle nazioni per la quale si ritruovano i principi di altro sistema del diritto naturale delle genti. Felice Mosca, Naples
2. https://ec.europa.eu/info/sites/info/files/mazzucato_report_2018.pdf
3. https://oxfamapps.org/fp2p/of-the-worlds-top-100-economic-entities-29-are-states-71-are-corporates/
4. https://kaw.wallenberg.org/en/calls/wallenberg-scholars
5. https://veluxfoundations.dk/en/technical-and-scientific-research/villum-experiment
6. https://lundbeckfonden.com/emne/lf-experiment