Thinking out loud: how science faces crises

Federico Fuchs Wightman, **Ezequiel Petrillo** and **Anabella Srebrow** (Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Fisiología, Biología Molecular y Celular, Buenos Aires, Argentina and CONICET-Universidad de Buenos Aires, Instituto de Fisiología, Biología Molecular y Neurociencias (IFIBYNE), Buenos Aires, Argentina)

At this point in time the coronavirus pandemic needs no introduction, as its deadly march has troubled the world and our lives beyond anything imaginable for the vast majority. The vaccination campaign now gives a glimpse of hope towards the end of the nightmare and a possible return to normality (whatever that might mean), with the risk of being too optimistic considering the emergence of new and even more contagious variants of this virus. Even if we reach the end, there will definitely be a lot to scrutinize and learn about the role science has taken during such a difficult and unprecedented experience.

To begin with, an extraordinary acceleration of the required times for biomedical research and biotechnological development has occurred. This is easy to realize if we compare the current pandemic with one of the few precedents that can be found[1]: Acquired Immune Deficiency Syndrome (AIDS) was first observed in 1981, followed by the isolation of its causative agent, the human immunodeficiency virus (HIV), in 1983 and the first blood test approved by the FDA in 1985[2,3]. This means that approximately 4 years were necessary just to identify and be able to diagnose what at that time was a new human disease. Two more years would be needed (1987) for the first treatment to emerge[2,3]. In a very different scenario, it took the scientific community less than a month to go from the first puzzling cases of pneumonia in Wuhan (China) during December 2019 to the isolation of the COVID-19-causing agent and the development of a diagnostic method[1]. Furthermore, as early as December 2020, the United Kingdom began with the vaccination process, soon to be followed by many other countries. It took science less than a year to go from the first reports on the clinical features of the new infection to the publication of phase III results of a vaccine[4,5].

Without any doubt, this high-speed research and development was possible due to the incommensurable body of scientific knowledge accumulated during the past decades, complemented by the quite widespread willingness of the scientific community to share preliminary results and experimental tools, the availability of well-established preprint servers, plus some particular features of this new virus (low mutation rate for an RNA virus, similarity with previous coronavirus infections) and the amount of attention and investment COVID-19-related research has received[6]. What comes across as relatively certain is that, at a technical level, science has outdone itself like never before (at least in this kind of situation and, of course, to the best of our knowledge). It seems that even the scientific community was astonished by its own capabilities, seeing how a variety of well-trained laboratories, including those previously dedicated to the so-called basic research, were able to shift gears and contribute enormously not only to the understanding of the disease at the molecular and physio-pathological level but also to the production of diagnostic kits, medical supplies and even personal protective equipment for the general public. Clearly, these are reasons enough to be proud of. This 'proudness' of the scientific community needs to be counterbalanced by modesty and self-criticism when thinking of the communication and dissemination levels, in terms of both skills and achievements, something that will be discussed later. However, despite all these scientific deeds, we consider that the technical capacities, expertise and knowledge of academic scientists could have been exploited even further and better. To illustrate this point, a good example would be the amount of idle capacity left aside despite the needs for massive testing. We dare to propose this reveals bureaucratic and organizational obstacles that would need to be revisited and if possible dismantled for future, although undesired, 'opportunities'.

The role of science during crises

Throughout history, critical times offer examples of extreme sacrifice from scientists. During World War II's 28-month-long siege of Leningrad (Saint Petersburg), several workers at the Leningrad seedbank transformed their workplace into a safehouse and bunker. They protected the seeds, fruits and other specimens from every threat that emerged, even their own hunger. Many of these workers starved to death while literally being surrounded by food. They were confident that their sacrifice for keeping those resources would allow many others to stay alive during the years to come. The scientist that started that germplasm collection, which reached about 250,000 specimens by the year 1940, was Nikolai Ivanovich Vavilov[7]. The work of Vavilov and the sacrifice of those workers that protected the seedbank paid off in following years. According to the writings of the Russian food historian Genady Golubev that came out in 1979, "four-fifths of all the Soviet Union's cultivated areas are sown with varieties derived from Vavilov's collection"[8]. Unquestionably, wars are quite different from pandemics, as they develop from human cruelty and barbarity, not as the unfortunate outbreak of a pathogen. Nevertheless, both can sometimes teach us similar lessons. Just like with the seedbank workers, healthcare professionals have been forced to face unimaginable sacrifice during the course of the pandemic[9] [10]. How science works towards easing that sacrifice, how it intervenes in the healthcare system and in decision-making, has been and will continue to be quite determinant in the near future.

There are times to act and times to react

A necessary learning process ought to take place within the scientific community to overcome the still undergoing pandemic and to be better prepared for future crises. In the same way as installing airbags and fastening seat belts would not be feasible *during* a car accident, acting without extensive previous preparation during a pandemic has likely limited our variety of responses and their outcomes. As with the current COVID-19 pandemic, there may only be a few hints about the kind of problems we will face in the future. However, there are some general actions, common ideas, basic preparations that could be adopted to confront the next crisis in a better manner. Our proposal is based on these ideas, learning from the current experience to optimize the strengths and minimize the weaknesses of the scientific system to streamline responses when critical situations arise.

The articulation with the rest of the society

A key element to take into account is that science needs to be involved in the decision-making process. For that, it is unquestionable that a better interaction has to be developed and established with the decision makers, without which proper guidance based on scientific evidence is impossible. Concurrently, a better interaction with the general public should also be developed, since improving that would encourage compliance of the chosen measures. In brief, science needs to build a connection network with relevant social actors to be ready to explain and recommend decisions and to provide guidance. That articulation might not look as crucial during calm times but is extremely difficult to implement once a crisis has already started, as we are seeing today. By working together with politicians, health authorities, communicators and other social actors, scientists could become better integrated to the region's/country's response to whatever disrupting event might develop, diminishing the material and human costs produced by extra-logistics or bureaucracy.

Taking all of the above into account, we would like to scrutinize the role of science from two different angles. The first one, *technical*, includes providing concrete solutions that help ameliorate the consequences of the pandemic. The second one, *social*, includes providing non-scientists the tools to help them deal with an abrupt change in their context, both now and in the challenges that the future holds. It seems improbable that this last-mentioned aspect could be accomplished without deepening the articulation with other actors of the society and for this, it is essential to think not only about what to do during a pandemic but also what science needs to build up during 'normal times'. Let's start from the latter.

Concrete preparation for the pre- and post-crisis times (the easy-going days)

Developing communication skills, channels and networks: Modern society provides a plethora of possibilities for communication and dissemination, although unfortunately they seem to be poorly exploited or misused by the scientific community. We consider that training scientists in the art of communication could enhance understanding, reliability and recognition from general audience. In terms of reliability, it is not a good practice to 'oversell' scientific discoveries, particularly those dealing with human health and disease, as they generate high expectations that many times do not end up properly fulfilled. It is noteworthy that scientific findings do need certain level of comprehension of the underlying concepts for their proper dissemination. Therefore, without competing with or excluding specialized journalists, scientists could grow a more personal involvement by participating in discussion forums, as well as social, graphic and audio-visual media. To this end, workshops and courses could be designed and established to take place during undergraduate, masters and/or PhD studies.

Improving lab networking for sharing methodologies and know-how: Connecting labs more deeply can streamline decisions and optimize the use of resources. With properly established nodes led by institutions specialized in diagnosis and disease, non-biomedical research laboratories could be 'prepared' to jump in, allocating different kind of resources (human and equipment). Among the latter, there are a large number of professionals that despite not being dedicated to diagnosing on a daily basis can easily handle biochemical and molecular techniques as well as make available appropriate lab equipment during urgent times. If such networking would be organized during 'normal' times, it could help act faster in response to emerging diseases, by tracking infections, spreading, identifying underlying causes, developing methods for detection and so on.

Exploiting data science to predict future outbreaks: Computational power and artificial intelligence have achieved tremendous advances lately. Just recently, we have heard and read that machine learning could even predict protein 3D structure out of an amino acid sequence[11]. On the other hand, variables like population growth and reduction of natural environments suggest that issues such as pollution, drought, climate change, crop-yield loss and emergence of new pathogens are likely to worsen. Altogether these make it extremely important for data scientists to be integrated in the previously described network, in order to facilitate surveillance, identifying upcoming crises and predicting new threats.

What can science do during a crisis?

Science's duty. As scientists we are privileged, we deal with first-hand information (that most of the time we are able to understand) and carry technical knowledge and resources that can be helpful in these critical circumstances. These technical knowledge and skills could be used (in some cases) to detect pathogens, diagnose diseases and develop treatments. In such cases, we have a moral obligation to provide our intellectual resources and skills to society. By engaging in these tasks, we can help increase diagnostic capabilities in our region/country, while diminishing the burden on health personnel that normally runs these assays. Since early diagnosis could reduce the spread of the infection, by engaging we could also help reduce the number of cases and fatalities, lessening the damage (at different levels) and gaining time until a treatment is found or a vaccine is developed. To diagnose a disease, an illness, might require more than the knowledge to perform a molecular assay, that is why being part of a network that connects research labs with health institutions is crucial. As we expressed before, developing such a network during 'normal times' is of paramount relevance as this could ease the work during a pandemic.

Scientists with strong background, knowledge and experience of relevance for the causal agent of the pandemic (or the particular crisis whatsoever) must work to find treatments, to develop diagnostic tools and to generate ways to prevent or circumvent infections. Depending on the particular pathogen or event underlying the given crisis, this work may be carried out by a few groups working on related issues, with a bigger bunch of laboratories and scientists collaborating with these groups and also engaging in all the other activities previously described. We firmly believe that science has excelled in this matter and continues to do so during the current pandemic, probably reaching its peak once extensive vaccination throughout the world is accomplished.

Nevertheless, the weight that scientists have on the decision-making regarding the use and commercialization of the fruits of their research has a lot of room for improvement. We believe that a deeper influence on managerial choices could prevent the misuse/unfair usage of research, like the one exhibited by the uneven vaccine rollout. We understand the importance of companies recovering their investments and having reasonable margins of profit, but it needs to be contextualized within a pandemic where products can change the destiny of the global population, thus needing to be equally, globally and fairly accessed. Patents, copyrights and intellectual property ought to be considered in context.

Increasing the level of collaboration between different disciplines and between different countries as well as the speed of the publication process and equal access to the findings. This basically means to expand the borders for scientific collaboration and, even more than that, to eliminate these frontiers. Interestingly, this is also something that science has been able to achieve to a certain extent during the current pandemic. Scientific reports related to COVID-19 are involving interdisciplinary work, novel collaborative efforts among groups from different parts of the world and changes in the topics of study of a large number of labs. Scientists that were previously working in aspects related to the molecular and cellular biology of yeasts or plants are now working together with virologists to develop diagnostic tools and/or treatments. This way of 'producing' science, of generating knowledge, is far more convenient than a model based on competition between groups and hiding/keeping results to be able to generate more publications from an individual perspective. This is also true for the way scientific discoveries reach the worldwide audience. Preprint servers such as bioRxiv and medRxiv are now the first choice for scientists around the globe to rapidly publish and share their results. It is worth mentioning that manuscripts uploaded at those servers are lacking peer review; however, they rapidly gain high visibility and hundreds/thousands of scientists check, comment and discuss these findings in an almost immediate fashion. In this sense, findings reported as preprints are scrutinized by far more peers than those published in well-established journals that are only viewed by two or three reviewers. It is worth noting that along this pandemic year, several journals have made an effort to revise and adjust their publication policies in order to facilitate science dissemination and progress even during difficult times for experimental work. Nevertheless, paywalls, extremely long revision times and high publication costs are some of the features of a publication system that, in current times, is more a burden to the scientific community than a way to share our work and reach a wider audience. If we are a bit lucky (and also work for that to happen) we may conquer a better and more efficient way to do and share science thanks to this pandemic.

Communicating through the available channels. We have just mentioned the importance of developing communication strategies during quiet times, although that does not mean that there is nothing to be done currently, it is just being harder. In a world with a growing expression of anti-science movements like flat-earthers and anti-vaxxers, the effort towards bringing evidence-based facts to the general public needs to be maximized. As R. Dawkins would say: we need to convince the general audience that science works.

Conclusions

The scientific community ought to recognize itself with the privilege of knowledge, which in turn should motivate a commitment towards society. When disarticulated from the latter, the scientific community becomes an isolated elite. Then, our abilities to handle techniques, technologies and concepts that help evaluate, diagnose, treat and analyse situations become squandered. Cruel proof of this is how, after the fastest development of a vaccine ever recorded, there seems to be a growing disbelief and reticence from the public to use it.

The reason for such a counter-intuitive behavior, in our opinion, lies in the nature of the intricate relationship between the scientific community and lay audiences. Science is not a closed package consisting only of technical knowledge: it influences the decision-making of both politicians and everyone else, it affects the economy in innumerable ways and, most importantly, it shapes the paradigm of knowledge of a given era. The surge of anti-vaxxers, conspiracy theory advocates and other anti-science movements is not new but gained influence during the pandemic, exposing our incapacity or our failure to reach a large proportion of the population. Those groups also reveal that generating a deeper articulation among the academy and governments, media and the public is something quite difficult to achieve overnight, rendering it urgent to extreme the efforts on doing so, during this pandemic and also when it would be over. Only then will the science's resources be made the most of, specially facing future world-wide challenges that will likely arise.

The rise in distrust exhibits that there is a lot of room for improvement regarding the scientific communication and its interaction with the population. Through special attention in transparency, tone and patience, we believe it possible to achieve not only technical excellence but also higher and better appreciation and understanding from the public. These are key elements to build trust in order to apply massive treatments or vaccination protocols.

These seem a lot to achieve but there would be no harm in trying. We face a great opportunity to improve science as we know it, towards one that is deeply connected with society while also more collaborative, less inspired in impact factors and elitism, more empathic and motivated to solve problems.

The privilege of knowledge can be a great power; hence, it comes with great responsibility. There is definitely room for growth: taking part in the decision-making process by connecting with politicians, health authorities and other social actors; engaging in science communication; priming a publication system based on sharing findings and accelerating research and development. From our point of view, the best thing science can achieve during pandemics and also before/after them is embarking deliberately in a path of improving itself having in sight its integration with the rest of the society. ■

Acknowledgements

We thank all the people with whom we were able to interact and collaborate along different COVID-related projects for helpful and inspiring discussions.

References

1 MIT Department of Biology. COVID-19, SARS-CoV-2 and the pandemic.
2 Greene WC. A history of AIDS: looking back to see ahead. Eur J Immunol 2007;37 Suppl 1:S94–102.
3 Barré-Sinoussi F, Ross AL, Delfraissy J-F. Past, present and future: 30 years of HIV research. Nat Rev Microbiol 2013;11:877–83.
4 Huang C. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020.
5 Voysey M, Clemens SAC, Madhi SA, et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet 2021;397:99-111.
6 Else H. How a torrent of COVID science changed research publishing — in seven charts.
7 Crow JF. N. I. Vavilov, martyr to genetic truth. Genetics 1993;134:1–4.
8 Fry C. *Seeds: a natural history*. The University of Chicago Press.
9 Kambhampati AK, O'Halloran AC, Whitaker M, et al. COVID-19-associated hospitalizations among health care personnel - COVID-NET, 13 States, March 1-May 31, 2020. MMWR Morb Mortal Wkly Rep 2020;69:1576–83.
10 Shah ASV, Wood R, Gribben C, et al. Risk of hospital admission with coronavirus disease 2019 in healthcare workers and their households: nationwide linkage cohort study. BMJ 2020;371:m3582.
11 Jumper J, Evans R, Pritzel A. High accuracy protein structure prediction using deep learning.