The radical openness of science and innovation

Why uncertainty is inherent in the openness towards the future

Helga Nowotny

In summer 2015, Carlos Moedas—the new European Commissioner for Research, Science and Innovation—presented his vision for the future of science and innovation in Europe. In doing so, he identified three challenges facing EU member states in the years to come. First, he said that Europe is lagging behind in transferring the results of research into new products and services: too often, new technologies that are developed in Europe are commercialized elsewhere. Second, Europe needs to improve the quality of its research output: although the EU generates more scientific results and publications than any other region in the world, it does not capture a proportional share of high-impact or highly cited landmark publications. Third, he noted that Europe punches below its weight in international science and science diplomacy: Europe’s voice should be more actively raised in global debates. Recent discussions and moratoria about gain-of-function experiments in virology or about modifying the human germ line confirm the Commissioner’s point: they are mostly initiated and driven by US researchers, and the USA is still the most influential country in terms of international science policy debates.

In order to meet these challenges, Commissioner Moedas proposed three strategic priorities: “Open Innovation,” “Open Science” and “Openness to the World” [1]. Open Innovation consists of policy measures intended to speed up the commercialization of research by introducing novel funding sources and modes of investment. Open Science, the Commissioner believes, is the key to increasing excellence, which he hopes will spread from the European Research Council and the Marie Skłodowska Curie Actions programme to the rest of Horizon 2020. Concrete policy measures in this regard are a call for a European Science Cloud Project and support for open access publishing to make the results of research immediately available without any constraints. Finally, Openness to the World will comprise a wide spectrum of scientific and political initiatives intended to meet the major social, health and environmental problems faced by humankind.

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The Commissioner’s goals are laudable and timely. But many scientists fear that the focus on innovation and on rallying science to address global problems will come at the expense of basic, curiosity-driven research that does not directly target application. Moreover, some argue that while nurturing and increasing excellence in science is necessary, the vast majority of scientists and research institutions—who do not play in the global premier league, but who are nonetheless important to the scientific enterprise—will miss out. Taken together, Open Innovation, Open Science and Openness to the World are important goals. However, I would argue that science, especially basic science, is in itself more radically open towards the future when it is free to explore the vast domain of the yet unknown. Innovation is part of an ecosystem in which contingencies abound. Uncertainty is therefore inherent to openness towards a future which in itself remains uncertain.

Acknowledging openness in this triple mode certainly reflects the contemporary transformation of science and innovation and how both now function in a global context. Science and innovation are open enterprises and neither can be contained within disciplinary, institutional, national or regional boundaries. At the same time, more openness to the world also increases international competition. Both Europe and the USA have seen their overall share of global research activities, scientific publications and claims of discovery decrease. Not because they have become worse, but simply because other countries and regions have begun to catch up after investing massively into research. Likewise, innovation and commercialization has become a high political priority everywhere. But, like science, innovation does not respect national boundaries. The relationship between a country’s investment into research and the benefits it reaps in terms of innovative new products and services is far from simple and involves many actors, factors and conditions. The river of research, ideas and innovation does not know its source—or its destination—in this case, the origin of national investments into them.

The hunt for innovation and commercialization has led to a flurry of policy measures involving many stakeholders. Researchers are increasingly expected to show entrepreneurial
spirit and recognize the commercial potential of their work; universities are encouraged to protect and capitalize on their intellectual property; and students are being trained to fill the gap between discovery of new knowledge and its development in the context of application. Entrepreneurs have become a much sought-after resource in Europe; venture capital, which in Europe is currently far below the US level, should be raised to be on a par; and citizens should become more involved with research, development and innovation. Pressure is increasing on scientists and their institutions to shorten the length of time it takes to get ideas “to markets.” Openness implies to somehow accommodate all these stakeholders. It is also about creating and shaping markets, not only about regulating them [2].

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In a recent article, which is as thoughtful as it is critical, Claudio Sunkel questions some of the assumptions that the agenda of scientific research can be aligned with societal problems, concerns and preferences; that investment into science will reliably generate technical innovations; and that scientific expertise is increasingly needed for political decision-making. In particular, he takes issue with the expectation that science can and should generate innovation in the short-term. Moreover, he observes that excellent scientists are a small minority who are supported by a broad base of competent scientists. Sunkel warns that “excellence-focused” science policy may threaten the sustainability of the system, as it may erode the broad base of non-excellent scientists on which the top rests. Building up and maintaining a publicly funded infrastructure for research and innovation might easily be neglected if the focus is only on short-term results or excellence [3].

It might be understandable when politicians express impatience with the slow pace of “getting research ideas to market,” but what can realistically be done to speed up the process without pushing researchers to develop potential commercial uses for their discoveries, managing technology transfer or teaching students to become entrepreneurs? In a recent interview, Andre Geim, Nobel Laureate and “father of graphene,” acknowledged the vacuum between cutting edge basic research and commercialization by investors [4]. Yet, it is not necessarily the task of universities to close the gap. Academics do not know how to build up companies; their research mission is to produce new knowledge. It seems that the road that links science and innovation is still under construction: maybe Ph.D. students taking additional courses in business could build the bridge between research and business.

I would like to provide a more radical interpretation of the concept of Open Science and Open Innovation. At present, openness is seen as a means to eliminate barriers and forge new links between scientific disciplines, institutions, universities and industry, or between science and citizens. These are all important strategies to connect knowledge and know-how and to create new alliances between the public and private sector. Many of these developments are already taking place and have been enabled or are being intensified by digitalization and new means of communication. However, the radical openness I am speaking about is the openness of science and innovation towards the future. Short of a time machine, science is the most powerful tool that humanity has invented to bring the future into the present. By applying human curiosity, creativity and persistence, science explores the world, its transformations and its potential futures. Moreover, by better understanding these processes, science is able to extend the range of predictions. But the future remains as uncertain as it is radically open. Indeed, one of the greatest challenges ahead is to better understand the consequences of human actions on our planet, its biosphere and ourselves. The complexity we face emerges from the interactions between the parts of complex adaptive systems.

Radical openness towards the future also means that science explicitly acknowledges and embraces uncertainty; in fact, science thrives on the cup of uncertainty—the rare moments of intense creativity when completely new perspectives and visions open up and lead to new discoveries and insights [5]. It is the reason why research is inherently uncertain and why it cannot be foreseen what the outcome will be, nor when. Nobody could have predicted that Albert Einstein’s 1917 paper, *On the quantum theory of radiation*, would lead to the invention of the laser in 1960 and its numerous applications today. Similarly, nobody could have expected that the first discovery of clustered DNA sequence repeats in bacterial genomes in 1987 would eventually lead to the CRISPR/Cas technology to edit genomes in 2012.

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This long journey into the unknown is as exciting as it can be frustrating. François Jacob rendered a moving and inimitable homage by explaining the difference between what he calls “day science” and “night science.” Day science is the glorious moment, the successful end of the journey when the results of research are celebrated. Night science is littered with false starts and iterations, replete with tantalizing hints that fail to lead further and are filled with despair. Yet, day science and night science are the two sides of the same coin, linked by sheer perseverance and persistence [6]. Navigating uncertainty in the search for new knowledge is a tough challenge; the more so as the presumed certainty of knowledge remains provisional. It will be superseded by new observations, the discovery of new phenomena and by ever-new knowledge, expanding the range of what we know.

Innovation is a similarly arduous process and equally faced with uncertainties on the path to developing a new commercially viable product or process. It took Japanese researchers more than 20 years of painstaking work to develop the first bright blue LEDs (light-emitting diodes), which finally enabled white LEDs that are now replacing light bulbs and fluorescent lamps owing to their much higher energy efficiency. Moreover, as in science, the outcomes of innovation are difficult—or impossible—to predict [7]. The valley of death for innovators and entrepreneurs is a figurative but realistic description of the risks
of getting ideas to market; when financing suddenly drops off or when venture capital withdraws or banks are unwilling to extend a loan, the end of entrepreneurial dreams seems near. And yet, those who succeed against all odds remind us that innovation is a highly uncertain process that is driven not only by clever and determined individuals, but also by many interlinked processes, embedded in an ecosystem that thrives on many contingencies. This is one of the reasons why the literature on innovation replete with empirical case studies about successful and failed innovation, but still lacks a genuine theory of innovation [8].

Arguably, the reliance on governance by numbers has led to more focus and greater efficiency. Yet, while there are areas where this works well, there is a risk that indicators take on their own dynamics and may even run counter the objectives for which they originally were set up. They may turn out to be too inflexible if the objectives need to be adjusted. As always, it is important to know which kind of policies work best for which objectives.

The other trend is about openness, inclusion, participation and collaboration. Movements such as citizen science that invite lay persons to become part of research exemplify this trend. Partly, this means including and acknowledging the work of amateurs, which has a long history in fields such as astronomy or botany. The environmental sciences have championed the active participation of citizens with much success. But there are new research fields, especially in the life sciences, where the inclusion of citizens is rapidly becoming indispensable. They are the ones whose data—in the form of tissues, health records or whole genomes—are the main focus of research. Although many sensitive issues remain to be solved, from questions who owns what and who can give away what under which conditions to the technicalities of data disclosure, new forms of sharing are rapidly becoming part of the public commons. Eventually, a new culture of sharing, involving citizens as well as researchers, will need to emerge in the life sciences. It will transform authorship and forms of collaboration, the wide-spread sharing of data prior to publication and access to research infrastructures. The boundaries between public and private will be further eroded and questions of ownership will have to be renegotiated.

It is therefore crucial to distinguish when and where science needs space and time to engage with uncertainty. Conditions must be created to enable and encourage serendipitous discovery. When and where do we accept that it is not possible to state in advance what research will find or which applications will ultimately emerge from seemingly useless knowledge? This requires institutions and their leaders to exercise their judgment and to set up space and grant time to welcome uncertainty.

The same holds true for innovation. There are no simple straight trajectories that lead from research to promising ideas to commercial products. There are innovative clusters and their multidimensional interconnections. There are innovative sectors and innovative regions that are known to have a high density of networks that link people, companies, ideas, products and institutions. They are highly sensitive and adaptable to a changing environment. In the ongoing debate between those who argue that we have entered a phase of secular stagnation—meaning that there are not sufficient and rational breakthrough ideas in the scientific pipeline—and those who claim that we are on the verge of being overwhelmed by the next big wave of technological innovation, it is wise not to be swept away too quickly by either side [10].

Uncertainty is deeply inscribed into human existence. The only certainty in life is death, but it is uncertain when. The more we know about the world and ourselves, and the more we achieve, the more we discover what we do not know and cannot yet accomplish. It is this cunning of uncertainty that pushes us further into the unknown. Science has a powerful ally in serendipity. Innovation has a similar ally in the unpredictable interconnections, which make up networks between people, information, finance and advice. In his book, Why Information Grows, César Hidalgo shows how information grows as we develop new products, which are themselves packets of information. To develop new products, however, we need to accumulate knowledge and know-how within networks of individuals. Ultimately, these networks must be supported by cultural and institutional factors, which explains why some countries are better at making information grow than others [9].

Currently, we can observe two opposing trends in science and innovation policies. One is to tighten management for the sake of greater efficiency. Research councils and other funding agencies feel under pressure from governments and finance ministers to mandate prior assessments of societal impact. The use of performance indicators and various metrics has gained wide acceptance in the allocation of R&D funding. The radical openness of science and innovation towards the future is the fundament for the endeavour that brings the future into
the present. Embracing the uncertainty that comes with it presents many challenges to researchers as well as to entrepreneurs, to policymakers at national and global levels and to leaders of academic institutions. Not least, it is about timing—if not now, then when?

References