Science and trust

Executive summary and recommendations

To reinforce trust in science, we recommend more comprehensive education about the scientific method; an improved dissemination of science to the public; communication modes that do not minimize doubts or exaggerate promises; a requirement for rigor and integrity from scientists; improvements in science assessment emphasizing quality and relevance; and better dialogue between scientists, social groups, and decision makers to inform choices about the major issues facing society.

The increasing pace of technological change, and the need for science and innovation contributions to solve local and global challenges requires societal trust in science. It is essential that we find ways to maintain and increase confidence in science. It is the responsibility of everyone, scientists, educators, the media and politicians to establish or maintain a relationship of informed trust between science and society.

Policy makers should encourage and scientists should commit to:

- Promote science education and an understanding of how research is conducted from elementary school onwards, to ensure that all students, both girls and boys, acquire a sufficient background to understand the world around them and the benefits of science.

- Cultivate dialogue, mutual trust and confidence between public, politicians and scientists to ensure that scientific input is considered in decision-making especially on topics of high scientific content.

- Ensure that the fundamental principles of ethics, integrity and responsibility are a major component of science education, to increase awareness of scientific responsibility and of the structures and policies that support it, including peer review and research ethics boards and transparency about potential conflicts of interest. Breaches of ethics and research integrity should be treated with full transparency and rigor to ensure that the misconduct of a few does not discredit the whole scientific endeavor.

- Ensure that the evaluation of science is based on criteria of quality, reproducibility, originality and relevance rather than on counts of publications, citations, or impact factors to avoid the race for publication that downgrades the value of scientific research and can lead to breaches in scientific integrity.

Introduction

The scientific method and scientific knowledge about humans, societies and the world around us has been one of the drivers of human life, and an undeniable source of progress for centuries. Scientific knowledge, with the growth of research and the technologies that accompany it, belongs to the

heritage of humanity, and has provided great benefits. However, in recent times there has been an apparent erosion in the level of public trust in science. As the global community faces increasing challenges, it is essential that we maintain a high level of confidence in science. Science has recently addressed major issues with broad implications for policies and economic interests, and the public and therefore politicians have not always made the choices based on scientific evidence.
Trust in science cannot be assumed. Thus, the scientific community, together with educators, journalists and politicians, must work together to strengthen and maintain an informed relationship of trust between science and society.

An in-depth understanding of the contribution of science to technical progress

Our era is exposed to a constant flow of scientific discoveries, inventions and innovations. Never before has the history of humanity witnessed such technological revolutions that affect all countries and sectors including communication, transport, the environment and health, the ability to read, understand and alter or edit genomes. Digital technologies and advances in machine learning are changing the science of data, while artificial intelligence is profoundly modifying everyday life. Science is addressing major global challenges including public health issues, dwindling natural resources, reduction in biodiversity and climate change. However, with scientific advances come new and unintended ethical questions. Understanding how technology works and the relationship of science to technology is becoming more difficult as the technology becomes more complex. While there is generally more reliance on technology, citizens may justifiably be taken aback by the accelerations of knowledge and its applications. It may be difficult for citizens to distinguish credible scientific information from unfounded claims, an urgent question because of the rapid dissemination enabled by digital technology with considerable expansion of fake news and pseudo science and their commercial or ideological exploitation. Although people frequently express doubts about scientific facts, they nevertheless often trust blindly in what they find from web searches because they are overconfident about technology, uncritical with respect to reliability of new sources and misled by the apparent validity of pseudo documents.

Building and maintaining a relationship of trust between science and society with respect and dialogue

In general, citizens trust science to solve the major problems of humanity, but their degree of trust varies considerably from country to country, depending on educational, social, economic, political, religious and historical factors, and on the area of science. Distrust in science may arise from a loss of confidence not so much in science itself but rather in the ability of scientists and experts to be forthright about sensitive societal or economic issues. Their conflicts of interest and integrity are questioned. In some cases, the perceived failure of the science community to address potential negative impacts of developments can be a source of mistrust. There are many other factors that may reduce trust in science: the lack of reproducibility of some published results, manipulation of science and information for ideological or commercial purposes, fraud, although rare and conflicts of interest; the tendency for risks that are generated by society itself to be more strongly questioned than natural risks; a growing level of distrust in many governmental institutions and agencies, fueled by the media and disseminated in a near viral manner on social networks; the production and spread of "fake news" feeding conspiracy theories that flourish on the internet and elsewhere. Moreover, distrust in science also often originates from ill-founded anxieties and insufficient training in science, numerical and abstract reasoning. Our societies may be tempted by a kind of skepticism, and cultural relativism that affects science and the voice of scientists. In the absence of critical thinking, doubt undermines societal confidence in science.
Science itself, however, includes a critical attitude that admits what we know at a given moment might be in itself refutable and revisable. Scientists are not always careful or successful in separating discussion of scientific understanding from personal political and social views.
Respect and dialogue between scientists and citizens are essential for building a relationship of trust. Opening up scientific data to public access may help, but this raises its own challenges, for example, for the established practices of scholarly publishing. Publications by non-profit organizations and

those in preprint servers should be considered as an alternative. Increased transparency can help to increase trust in science, together with the active participation of citizens in science development (see also the declaration on citizen science). Clearly, all of these aspects must be considered if we are to maintain and strengthen public trust in science and the scientific community.

Providing access to science for all through education

Young people must be made aware of scientific reasoning and rigour from a very early stage. A major effort should be made to teach the value of reasoning and rational thinking to schoolchildren, both girls and boys, starting at the elementary level. The practice of experimentation at a young age can be formative. Stimulating observation, methodically analyzing the results obtained and placing them in context are ways of developing a critical scientific mind. The rules of rigour and integrity must be reiterated throughout school and university education, and during researchers' careers.
Education must provide all young people with a foundation of scientific knowledge and convey the values of rigour and integrity that are inherent to science, so that they can distinguish between what emanates from opinions and beliefs (including from scientists) and what relies on scientific evidence and rigorous research. Of particular importance for a proper evaluation of scientific facts and technological risks are abstract and numerical reasoning skills in order to understand elusive concepts as probabilities, non-linear trends or unjustified generalizations. All educated citizens should be able to understand the principles of scientific reasoning and reject fake or distorted news conveyed by groups reflecting diverse interests and beliefs.

Promoting honest, ethical and responsible research

All new scientific contributions to knowledge, whether a discovery, insight, invention or innovation, require that the entirety of the evidence be reported truthfully. The public must be able to trust researchers and experts. Since funding, reputation and professional esteem are closely linked to the results of research, there may be undue pressure leading to poor quality or unethical science, with consequent implications for the reputation of the scientific community. A truncated, misdirected or falsified truth may have serious societal consequences and may cast lasting and unfounded suspicion on research and its goals. Scientists should be concerned by the ethical issues that shape their research questions and arise from their discoveries.
Citizens should be able to rely on the integrity and reliability of the scientific world and have access to rigorous and reliable information. The trust placed in scientific expertise depends on the quality of the experts, their objectivity and in appropriate management of conflicts of interest.

Increasing the quality of science dissemination

The entire knowledge-production chain is responsible for disseminating scientifically valid and high-quality information.
Researchers are responsible for making their research results accessible to an informed and specialized audience without overselling their results by minimizing doubts or exaggerating promises. Public authorities should support the creation of programs and events to ensure the high-quality dissemination of science.
Confidence in science is undermined by publications featuring limited or non-existent peer review. In recent years low-cost electronic journals offering rapid turnaround, with limited or non-existent peer review have enabled the publication of questionable research and downgraded the very notion of what constitutes an acceptable scientific publication. The open science approach recommends that evaluating scientists should be based upon a critical analysis of the content, originality and relevance of their work rather than parameters such as the number of papers published and the impact factor of the journals in which they appear. In brief, evaluation criteria should not rely exclusively on metrics but more on papers selected by the researchers themselves.
Trust in science will be augmented by improving the quality of publications and monitoring the reproducibility of the results and by ensuring that scientific publication is not compromised by commercial or ideological interests. The general public follows scientific news through different types

of media such as television broadcasts, the Internet and the press. It is essential to remind citizens that the timeline of science may be long, that scientific discoveries and progress are not always straightforward and cannot be produced on demand. Developing solutions to current problems does not follow a pre-determined schedule but often stems from research that breaks with so-called established ideas. The role of specialized journalists and the media in general is crucial and any initiative on their part to promote or improve the dissemination of scientifically valid knowledge should be supported. Moreover, methods to evaluate the credibility of informal information sources (e.g. web pages and blogs) should be developed and the accumulated credibility ratings of such sources should be documented and made public.

Involve scientists more in engaging with the public and decision-makers

Scientists, at all stages in their career, should be provided with guidance and lessons-learned from the many extensive efforts to engage and build relationships of trust, and encouraged to work interactively with citizens, journalists, and decision-makers. Young scientists can be an engine of reform and improvement. Trust is earned by sustained engagement, including learning about the concerns and priorities of the public and getting involved in the public debate, discussing, clarifying scientific arguments and providing information for decision making.

The participation of scientists in the dissemination of knowledge and the popularization of science is essential and requires specific training and encouragement to devote part of their time to public engagement and to disseminating knowledge. Such public engagement should be rewarded in evaluation and promotion processes. Progress needs to be made in the organization of debates on sensitive subjects that touch on science to ensure that the presence of scientists to listen and understand the concerns of citizens, and to counter unfounded arguments, beliefs, and false controversies. The dissemination of deliberately false news requires increased research on ways to combat their appearance and propagation.

Scientists and politicians are working on different time scales but it is important that both work closely together for the good of all society in the development of science-based policies. At all levels, from local to international, scientists should not just be positioned as expert consultants but should be actively engaged in the planning and decision-making processes. They can provide an irreplaceable long-term vision on subjects that politics and policy-making often only consider in the short term.

Conveying the message that science has a crucial role for tackling critical challenges facing humanity

The challenges facing humanity today are daunting. The world is increasingly dependent on science and its applications in everyday life as well as in its long-term perspectives. The absence of a demographic transition in many countries and the resulting increase in global population raise problems of energy supply, water availability, threats to marine ecosystems and coasts, accelerated extinction of species affecting the planet's biodiversity, global warming, land degradation and its impact on food security which have been precisely described by scientists. They warn us that urgent actions are needed to reduce anticipated risks. Addressing these major challenges will only be possible through a systematic understanding of options and consequences, further scientific advances, accelerated technological progress, innovation and the existence of a political will to implement them. This is of particular importance because humans now face a profoundly different situation than generations ago. In earlier times, the risks and advantages of technological developments were immediately apparent to individuals. Nowadays, many developments have remote consequences and delayed risks can only be comprehended by abstract reasoning and an analysis of anticipated trends based on scientific models.
The issues addressed here are even more relevant and challenging for developing countries that may not have the capacity to generate and apply scientifically validated information and deploy appropriate technology and engineering know-how. These countries have significant scientific potential and natural resources but lack the means to develop them. The roots of trust and mistrust

have a historical dimension, which makes the building of local capacity of critical importance. More generally, augmenting impact of science impact and building trust will only happen through scientific education and the development of technical skills that the stakeholders should be able to define, implement and make their own.

Conclusion

The world is increasingly dependent on science and its applications in everyday life as well as in its long-term perspectives. Although confidence in science remains high, there are serious and rapidly changing challenges. In particular, policy makers and scientists must contend with misinformation that is now easily spread on the Internet. Decision-makers and scientists should establish more regular and effective contact with each other to provide the needed expertise in analyzing and finding solutions to major current and future challenges. Scientists should give a high priority to establishing a genuine dialogue with their fellow citizens, sharing scientific advances with them, understanding public concerns and priorities, and discussing potential negative impacts of science and technology. In general, an educational and engagement effort should be made at all levels to achieve rationality, rigor and critical thinking, understanding of urgently needed benefits and any relevant risks inherent in science, to foster an informed relationship of trust in science.

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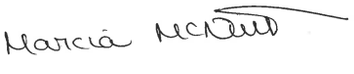

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