International Science Council

A CONTEMPORARY PERSPECTIVE ON THE FREE AND RESPONSIBLE PRACTICE OF SCIENCE IN THE 21ST CENTURY

Discussion paper of the International Science Council's Committee for Freedom and Responsibility in Science

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IMAGE CREDITS:

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PREFACE

The International Science Council (ISC) works for the global scientific community: to advance science, to catalyse and share scientific expertise, to provide advice and influence on issues of concern to science and society, and to promote and safeguard free and responsible scientific inquiry. The ISC's commitment to science as a global public good is underpinned by its core Principle of Freedom and Responsibility in Science.

> **ISC Statute 7:** The free and responsible practice of science is fundamental to scientific advancement and human and environmental wellbeing. Such practice, in all its aspects, requires freedom of movement, association, expression and communication for scientists, as well as equitable access to data, information and other resources for research. It requires responsibility at all levels to carry out and communicate scientific work with integrity, respect, fairness, trustworthiness and transparency, recognizing its benefits and possible harms. In advocating the free and responsible practice of science, the Council promotes equitable opportunities for access to science and its benefits, and opposes discrimination based on such factors as ethnic origin, religion, citizenship, language, political or other opinion, sex, gender identity, sexual orientation, disability or age.

The contexts within which scientific research is undertaken and applied are changing rapidly, and these changes have prompted the ISC to re-examine the meaning of scientific freedom and responsibility in the 21st century. This Discussion Paper considers the new challenges that arise from the social and technological developments of the past two decades, as well as changes to the ways in which science is used and disseminated. It suggests several key freedoms and responsibilities that must be upheld for science to advance as a global public good. Finally, the paper offers guidance to readers in a range of settings on the actions needed to uphold these freedoms and responsibilities.

All stakeholders in global science systems are responsible for protecting scientific freedom, but each has their own role to play in this endeavour. Likewise, different stakeholders have different obligations to help ensure that the individual and collective responsibilities of scientific researchers are upheld.

Building upon the work of others, this paper describes these roles and obligations for:

- **Researchers** – when conducting research, collaborating and communicating.
- **Research organizations** – when managing and protecting scientific activities and researchers.
- **The private sector** – when engaging in basic and applied research.
- Governments – when developing governance standards and interfaces between science and policy.
- **International science organizations** – when fostering scientific collaboration, establishing principles for scientific inquiry, and advocating for the role of scientists in the global context.

The contribution of scientists to human and environmental wellbeing is maximized when they are free to meet their individual and collective responsibilities. The international scientific community, governments and the wider public must each develop a clear understanding of these freedoms and responsibilities, and of the strategies needed to achieve them. This Discussion Paper is a contribution to this aim, on which we hope others will draw.

1. INTRODUCTION

1.1 FREEDOM AND RESPONSIBILITY IN SCIENCE

The International Science Council (ISC) works for the global scientific community to advance science, to catalyse and share scientific expertise, to provide advice and influence on issues of concern to science and society, and to promote and safeguard the free and responsible practice of scientific inquiry. This activity supports the United Nations Universal Declaration of Human Rights,[1] which includes the right to share in scientific advancement and its benefits, whether as a scientist or a lay citizen. These rights recognize the value of science as an integral part of human culture, and the ISC's vision is of science as a global public good.[2]

The work of the ISC to advance this vision is underpinned by its core Principle of Freedom and Responsibility in Science.[3] This sets out the freedoms that scientists should enjoy, and the responsibilities they carry, as practising researchers.

It is legitimate to ask why scientists need particular freedoms, and why they have particular responsibilities in their scientific work. The reason lies in the unique capacity of science to drive intellectual and material change. This means that it should be enabled to maximize its potential for discovery and for beneficial application. Scientific discovery is favoured by settings where the freedom to explore, collaborate and communicate is upheld, and is not inhibited by undue political, legal or religious constraints. So scientists require these professional freedoms in addition to the universal human rights bestowed on all.

Scientific discovery is also maximized when researchers maintain the processes that characterize science as a valuable form of knowledge. This means that scientists have a responsibility to practise science in ways that meet globally recognized standards and so serve the global public good. In addition, the beneficial application of new scientific knowledge also depends on responsible scientists. New discoveries will be used by societies in accordance with their own values and power structures. This means that scientists have a responsibility to think about the uses to which their work might be put, and to advise stakeholders of the risks and benefits of these applications.

In emphasizing the interdependency of freedom and responsibility in science, this paper reflects an important shift in thinking between the 20th and 21st centuries. In the period after the Second World War, scientists and policy-makers thought of freedom (particularly autonomy in setting research agendas) and responsibility (specifically moral responsibility for the social impacts of scientific research) as being in direct conflict.[4] During the early 21st century, this perspective has shifted towards affirming a different understanding – that scientific freedom must come with social responsibility for scientists in all areas of research.[5]

1.2 WHY THIS PAPER NOW?

This paper is written from the position that scientific freedom and responsibility are historically specific concepts. While an understanding of these notions should be informed by the long history of scientific research, today's scientific freedoms and responsibilities are defined by the contemporary context in which scientists work. Similarly, the use of language and terminology in this paper is a reflection of modern society, which cannot foresee the ways in which the meanings of particular words and concepts may evolve. Explanations of some of the key terms used in this paper can be found in Chapter 8.

In the 21st century, new political tensions threaten scientific freedom, both on an individual level and for the wider scientific community, in addition to existing conflicts, forms of discrimination and other kinds of inequality. Advances in communications technology, and an increased focus on diversity and inclusion, help to expose and confront such threats, but numerous challenges continue to restrict scientific freedom around the world.

At the same time, the social and technological developments of recent decades continue to change the way science is practised around the world. Artificial intelligence, Big Data, the internet of things and social media all promise benefits to science, but these innovations are accompanied by new responsibilities for the dissemination and use of scientific and technical knowledge. These include individual responsibility and accountability when conducting and communicating research, as well as collective responsibility for research integrity and for maintaining public trust in science. In recent years, this trust has been compromised by individual cases of scientific misconduct in the form of fraud, plagiarism, fabrication and falsification, and by a lack of reproducibility throughout scientific research.

At the collective level, modern science systems also pose threats to freedom and responsibility in science. Such threats include inadequate recognition and reward systems; bureaucratic governance; problematic relations with the media; and tensions at the interface between public and private science. We must also recognize that research is undertaken in a range of settings in contemporary society: universities, government entities at central and local levels, independent research organizations, not-for-profit research organizations, the private sector, and through sole practice and volunteering. Each has its own obligations, revenue sources, operational environment, and contractual and employment arrangements. This diversity affects the freedoms that scientists are afforded, and the responsibilities that they need to fulfil when undertaking their research. A contemporary understanding of scientific freedom and responsibility requires sensitivity to these modern layers of differentiation and complexity, and a broad understanding of science as a collective institution with a range of practices and values.

These trends and challenges have prompted the authors of this paper to re-examine the meaning of scientific freedom and responsibility, and the role of bodies such as the ISC in upholding its basic tenets. Global emergencies such as climate change and the Covid-19 pandemic have demonstrated the key role that free and responsible science can play in protecting human and environmental wellbeing, as well as the dangers of failing to uphold these principles.

1.3 PROCESS

This paper was developed by an Expert Writing Group of scientists appointed by the ISC's Committee for Freedom and Responsibility in Science (CFRS), with oversight from the ISC's

Governing Board. The text was subjected to three phases of review followed by revision, involving CFRS, select members of the ISC Advisory Committees, and ISC Members.

1.4 OUTLINE

This paper begins with an overview of historical understandings of freedom and responsibility in scientific research. It then turns to consider new challenges to scientific freedom and responsibility arising from developments in the 21st century. Four principles to underpin contemporary scientific endeavour are introduced, revisiting the work of sociologist Robert K. Merton in the 1940s. Based on these principles, the paper suggests the key freedoms and responsibilities that should be upheld by scientists in order to advance the ISC's vision of science as a global public good. Finally, the paper offers guidance to readers on the actions needed to uphold and protect these freedoms and responsibilities.

2. A LEGACY OF SCIENTIFIC FREEDOM AND RESPONSIBILITY

People have thought about the questions addressed in this document for much of recorded history. In earlier centuries, a learned priestly class already had to balance intellectual freedoms with specific responsibilities (towards humans as well as gods); bureaucracies supported and limited the development of new knowledge (e.g. the Chinese scholar-officials or *shih*); and scientific academies could explore any subject on condition of leaving religion or politics aside. But as societies change, so too do perspectives on these issues. The concepts of freedom and responsibility in science therefore need to be revisited and reinforced periodically in line with the evolution of human society.

2.1 INSTITUTIONAL AND INTELLECTUAL AUTONOMY

The autonomy of the institution where research is conducted, most prominently the university, has been a cornerstone of scientific freedom. Originating in Asia and Northern Africa, the university developed as a legally autonomous corporation of scholars with the right to self-governance. They retained this institutional autonomy when they spread around the world, becoming the dominant institutions of higher education and knowledge production.[6]

In the early 19th century, a global reform of universities inspired by the ideas of Wilhelm von Humboldt integrated teaching with research and institutionalized 'academic freedom', ensuring permission to think, criticize and do research.[7] During most of the 20th century, tenure for university faculty was seen as an important guarantee of academic freedom. While tenure was stressed in the context of private universities, where it was feared that private interests would impose certain views on university staff, it also became a general tool to ward off funder, political and bureaucratic interference.[8]

Although the Humboldtian ideal continues to shape debates on academic freedom, the university itself has changed radically in the past few decades. Universities have been subject

to the massification of higher education, the expansion of university status to non-research institutions, a new managerial culture, decreasing government funding, the focus on innovation and on economically important activity, and demands for impact and accountability. These and other factors have eroded the institutional autonomy of universities since the 1970s and have led to a decline in the number of tenured positions. In combination with the rise of populism and related attacks on 'intellectuals', 'academics' or the 'elite', this decreasing institutional protection poses a serious threat to academic freedom in the 21st century.

2.2 FREEDOM OF THOUGHT AND EXPRESSION

In the face of totalitarian regimes, scientific freedom became an important topic of global discussion in the interwar years, and even more so during the Second World War.[9] Pseudo-scientific approaches supported the racial ideology that underpinned policies in Nazi Germany. Lysenkoism, a theory that rejected genetics and science-based agriculture and distorted established theories for political and ideological purposes, was dominant in the Soviet Union from 1935 to the mid-1960s. Thousands of scientists in the USSR were dismissed, imprisoned or executed at this time.[10]

Apartheid, the ideology of the white, minority-rule governments in South Africa from 1948 until the establishment of democracy in 1994, institutionalized racial segregation policies that had been in place during British colonial rule. The majority Black population had limited access to education and training, including tertiary education, at segregated facilities. Scientists who robustly and rigorously investigated and published on the negative impact of apartheid policies were often harassed, imprisoned or forced into exile. Within medical research, programmes that directly addressed the social determinants of health and development, such as discrimination and stigma, the subordination of women, poverty and inequality, violence, and traditional practices, were severely restricted.[11]

While scientific censorship is seldom so explicit and direct in contemporary society, the modern scientific community is subject to political pressure, concerns for national security and new ideological tensions in society. The social sciences and humanities are especially vulnerable to ideological attacks and political pushback, as they often study current societal issues and subjects of contemporary debate.[12] In other areas of science, industry interests have influenced scientific results by creating funding biases. The tobacco industry's historical obfuscation of facts about cancer and smoking is now well known, but money has also had more subtle distorting effects on medical, pharmaceutical, environmental and other research.[13, 14]

Within the scientific community, divergent understandings of academic freedom itself have sparked complex debates over the boundaries of academic expertise, science communication and free speech.[15] In the current climate of a renewed politicization of personal freedom, it is all the more important to define and defend the principles of scientific freedom and responsibility.

2.3 'INTERNAL' AND 'EXTERNAL' RESPONSIBILITIES FOR SCIENCE

In 1942, the sociologist Robert K. Merton recognized the need to defend science from rampant anti-intellectualism, from attacks on the integrity of scientists and from an assault on the autonomy of science.[16] He argued that a specific 'scientific ethos', which results in the generation of reliable knowledge, makes science special and separates it from other spheres

of social life. Merton distinguished four key values to guide this ethos: communism (later relabelled 'communalism', meaning that the findings of science are common property, and that scientific progress relies on open communication and sharing), universalism (meaning science is impersonal and objective, despite nationalist attempts at the appropriation of science), disinterestedness (meaning results are not influenced by interests external to science), and organized scepticism (meaning the freedom to criticize). From these values emerge a range of actions – or responsibilities – 'internal' to the scientific community, through which scientists could uphold the reliability and credibility of science.

The use of nuclear weapons at the end of the Second World War was a watershed moment for how scientists and the public thought about the 'external' responsibilities of scientists to society. Society as a whole became more aware of the destructive power of scientific and technological innovation, ranging from war technologies to pollution and climate change. This has led to continuing debates about the responsibility of scientists: for the potential use of scientific discoveries, for their unintended negative consequences, and for societal interpretations of scientific results.

In the 21st century, it will be important to strengthen the connection between internal responsibilities, external responsibilities and scientific freedom. In the 20th century, the freedom of science was typically referred to as a negative freedom from government interference. In the present century, it will be important to reframe scientific freedom as a positive freedom, including for example the freedom to communicate with the public. Some responsibilities of scientists can only be met if they are afforded appropriate freedoms, but, in turn, these freedoms generate further responsibilities. Conditions should be created for a positive and constructive research culture in which scientific freedoms are supported and promoted. Only in such a context can new responsibilities for scientists be seen not as restrictions but as enabling factors. This paper advances the notion that freedom and responsibility are two sides of the same coin.

2.4 'FREE' SCIENCE VERSUS 'PLANNED' SCIENCE

The Second World War challenged scientific freedom in many ways. Nazi Germany not only limited the freedom of scientists by imposing its ideology, but also started some of the first government-controlled 'big science' projects in biomedical, agricultural and defence research.[17] This development launched a new debate on scientific freedom in terms of curiosity-driven versus planned research. These approaches would characterize the dominant post-war and Cold War ideologies on science policy.

In 1945 Vannevar Bush, Director of the US Office of Scientific Research and Development, wrote in a report to the President:

> *We must remove the rigid controls which we have had to impose [during the war effort], and recover freedom of inquiry and that healthy competitive scientific spirit so necessary for expansion of the frontiers of scientific knowledge. Scientific progress, on a broad front, results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown.*[18]

This document provided the blueprint for the US National Science Foundation, which was founded in 1950 with unprecedented scientific autonomy and freedom of inquiry. It embodied

a vision in which scientific freedom was merged with a capitalist ideology of individualism, progress and competition. Such initiatives were meant to be a counterpoint to the state planning of science as in the Soviet five-year plans, or the Chinese 12-Year Science Plan.[19, 20]

Despite the rhetoric of freedom in science, which was based in the political ideology[21] of the time, free, curiosity-driven research declined in the second half of the 20th century. Universities became less dominant in the conduct of scientific research and were subject to neoliberal reform in many countries. There was a push towards project-funded and mission-oriented research aimed at addressing specific challenges. In many places, these changes have decreased the freedom of scientists to choose their topics, the timeline of their research, and how and where they communicate their results.

2.5 FROM FREEDOM OF MOVEMENT TO HUMAN RIGHTS

Various regimes of the 20th century targeted scientists, specifically or as part of a broader group of citizens. Diplomatic tensions, especially the Cold War, hampered their freedom of movement and scope to collaborate. These developments were part of the reason for founding the International Council for Science's (ICSU) Standing Committee on the Free Circulation of Scientists (SCFCS) in 1965.[22]

The concerns which led to the foundation of the SCFCS also served to highlight the overlap between scientific freedom and universal human rights. During the latter half of the 20th century, the scientific community rallied around wider problems of discrimination, harassment, persecution and inequality. The interconnected nature of scientific freedom and human rights was then emphasized in a range of treaties, declarations and legal instruments. For example, UNESCO's 1997 Recommendation concerning the Status of Higher Education Teaching Personnel considers that 'the right to education, teaching and research can only be fully enjoyed in an atmosphere of academic freedom and autonomy for institutions of higher education'.[23]

3. THE 21ST CENTURY: NEW CHALLENGES, NEW OPPORTUNITIES

The 21st century presents new threats and challenges for science, as well as many new opportunities to realize the vision of science as a global public good.

3.1 NEW MEDIA, NEW SCEPTICISM

New media have made science much more accessible to the general public. Access to information has been extended to a much larger share of the population through resources such as Wikipedia, online university lectures and direct access to scientific publications. However, access to these resources is hampered by poor internet connectivity in many parts of the world. Furthermore, growing tensions between national governments and online platforms risk damaging the accessibility of information in many countries.[24]

While those who have access to online resources experience many benefits, the internet has also facilitated the spread of disinformation, particularly among vulnerable communities. Science has always faced scepticism from some groups in society, but online platforms give this opposition unprecedented visibility. On the other hand, these platforms offer scientists new opportunities to engage directly with public concerns about research, and to combat misinformation with scientific evidence.

For journalism, the rise of social media has dramatically changed the ways in which information is gathered and reported. In some countries, the shift towards digital platforms and 24-hour news cycles offers scientists new opportunities to reach public audiences as demand for content increases. However, these trends also present new challenges for science communication. Journalists face increasing time and financial constraints which risk the accuracy, depth and breadth of science stories in the news.[25]

Meanwhile, social media have also altered communication within the scientific community. Scientists, too, write blogs addressing peer audiences,[26] or converse on social networks.[27] While this form of science communication can improve public opinion of scientists and scientific research, these practices also raise important questions about social responsibility. If scholarly debates unfold online, the opportunity to probe and question the work of fellow researchers in public challenges scientists to maintain professional standards of behaviour and to uphold public trust in the systems by which scientific knowledge is generated and peer reviewed.

3.2 OPEN SCIENCE

The International Science Council defines open science as:[28]

> *Science that is open to scrutiny and challenge, and to the knowledge needs and interests of wider publics. Open science makes the record of science, its evolving stock of knowledge, ideas and possibilities accessible and free to all, irrespective of geography, gender, ethnicity or financial circumstance. It makes the data and evidence of science accessible and re-usable by all, subject to constraints of safety, security and privacy. It is open to engagement with other societal actors in the common pursuit of new knowledge, and to support humanity in achieving sustainable and equitable life on planet Earth.*

The open science movement introduces new opportunities to advance science as a global public good. It facilitates interdisciplinary scientific collaboration; enables public engagement and understanding of science; helps to ensure the quality and integrity of scientific research; and increases the accessibility and utility of scientific evidence and advice in government policy-making.

However, this vision of science as an open enterprise depends, at both the individual and collective level, on the full range of scientific freedoms and responsibilities which the ISC seeks to uphold.[29] The open science movement also challenges scientific freedom and responsibility in new ways. Freely available research and data create new opportunities for abuse and misinterpretation, as well as complex security risks. While open access publishing has widened access to research results, author processing charges may raise new hurdles for the Global South, for those in underfunded research fields, or for independent researchers who wish to share their knowledge.[30] Digital technologies are central to the evolution of open science, but they also raise many concerns about privacy and data use, and point to the need

for greater accountability, intelligibility and accessibility. The UNESCO Recommendation on Open Science[31] highlights the roles that stakeholders in the global science system must play in responding to these challenges and opportunities.

3.3 THE GLOBALIZATION OF SCIENCE

The increasingly global nature of scientific enquiry has impacted the entire science system. Rapid change is occurring in what has thus far been a scientific narrative dominated by monolingual male voices, along with Western perspectives on learning, teaching, research, assessment, publication, funding and governance. There is an increasing recognition of the need for greater pluralism in thought and normative values, seen in the rise in transdisciplinary approaches and citizen science, and in changes to the way the quality and impact of research are evaluated. Innovative pathways in publishing have emerged, among them a substantial increase in open access journals. Meanwhile, more and more countries are investing in scientific knowledge. For example, massive investments in science and technology have contributed to economic growth in India and China.

While the globalization of science serves to widen the overall knowledge base and creates enormous potential for science as a global public good, it also creates tensions within the scientific community. New research communities bring their own epistemologies and institutions, their own concerns, and subtly different appreciations of scientific norms, most conspicuously with respect to individual authorship. Increasingly diverse research communities are raising new questions over shared understanding of what constitutes scientific knowledge, quality standards and research ethics. Efforts to decolonize the structures within which science takes place are a major priority in some parts of the world, where multiple approaches and epistemologies are enriching research as a whole.

Inequities still exist in the ability of individuals to access and interact with science. This in turn creates inequalities in scientific outcomes.[32] Scientists from low-income countries face the hurdles of limited research funding, inadequate research infrastructure, limited access to library and data resources, and prejudice from global research elites. Monolingualism continues to dominate scientific publication and scholarly exchange, creating global inequalities in freedom of communication and access to information. Given these limitations, emerging research communities may struggle with cultural and political tensions that are unfamiliar to scientists from countries with well-established structures and institutions. At particular risk are the scientific diasporas of refugee scientists, as well as those who have relocated for economic reasons.[33]

The increased internationalization of science has introduced new challenges that risk undermining scientific freedom and the safety of scientists.[34, 35] Collaboration between researchers in different nations may bump up against political tensions that can serve to curtail exchange and enquiry. Greater openness and transparency, as well as the shift towards online collaboration with the onset of the Covid-19 pandemic, have brought growing scrutiny and control of scientists' endeavours. For example, fears of economic espionage have led governments to adopt research policies that may damage the ability of scientists to obtain funding or to collaborate with peers in certain countries. Meanwhile, governments continue to restrict freedom of movement and association through targeted actions including the denial of entry and exit, as well as policy restrictions frustrating the flow of scientific ideas across borders.[36]

3.4 MANAGED SCIENCE: PUBLIC ACCOUNTABILITY AND OUTPUT MEASUREMENT

In the name of public accountability, science has become the object of new managerial regimes that demand demonstrable value for money and other inputs via research output measures. These measures (such as publications, citations and patents) are intended to achieve effective allocation of research resources and rewards for excellence. However, over-reliance on output metrics in the management of science has had significant implications for the free and responsible practice of scientific research.

Performing to the indicator rather than to the underlying, substantial value of good science may distort research agendas and skew opportunities between research fields. Scientists may feel pressured, or even permitted, to redirect research priorities for output purposes, or in the worst case, to compromise the ethical or scientific quality of their research to achieve higher output scores. The pressure to justify and bring in sufficient funding can increase the temptation to over-promise the impact of research projects, for example by extrapolating the results of animal research to human health outcomes. This pressure affects a range of stakeholders within an academic institution, including individual scientists, research managers and those involved in science communication and institutional public relations.

After a global wave of complaints from researchers across the scientific disciplines, it is increasingly evident that expanded output-indicator regimes are ineffective at demonstrating value for money, and detrimental to the value of science as a global public good. As a result, there are increasing calls for moderation and a return to more qualitative research assessment[37] in science systems around the world.

3.5 ILLIBERAL SCIENCE POLICIES AND THE CHALLENGE OF ANTI-INTELLECTUALISM

Maintaining the conditions for science as a collaborative, open enterprise is a fundamental responsibility for the leaders of today's scientific and academic institutions. The policy relationship between national governments, public-sector scientific organizations, universities and institutions is a critical one. Changes in the political arena can result in policies that threaten scientific freedom and undermine scientists' responsibilities. This situation presents a significant challenge to scientific governance.

In the third decade of the 21st century, a time when scientific research is of critical importance to human and environmental wellbeing, scientific freedom is under attack in many places. The most alarming threats, as noted by the Academic Freedom Index in 2020,[38] are: increased opportunities for the surveillance of research, teaching and discourse; increasing pressure for scientific enquiry and teaching to align with political agendas; sanctions, restrictions and online harassment.[39] Cases of political interference with academic leadership and with national scientific governance are growing in number. While they vary in nature between countries, they all involve pressures from interest groups and governments that can undermine the autonomy of scientific organizations to establish independent leadership, and significantly curtail the freedom of scientists to determine rigorous research agendas.

While trust in science remains high among the general population,[40] scientists continue to be confronted by critical, distrustful or sometimes openly hostile movements that question their methods, modes of reasoning and even integrity. Scientists who contribute to public debate are

at increased risk of ridicule, intimidation and violent threats, both from individuals and from organized groups.[41] This public backlash against scientific research and recommendations has influenced some policy-makers to reject responsible, rigorous scientific advice.

3.6 SOCIAL ENGAGEMENT AND RESPONSIBLE ADVOCACY

National and international efforts to address the challenges facing modern society and the planet often require scientists to take up visible public roles. Whether as spokespeople, panel members, report writers or advisers, many scientists now operate in a closer relation to the rest of society than in the past. This mode of operation redefines the societal position and expectations of researchers, including their engagement in responsible advocacy.

In the 21st century, scientists have increased access to both public audiences and government policy-makers, increasing their opportunities to advocate on issues of concern. These include climate change, equitable vaccine distribution and even scientific freedom itself. This development raises important questions for the responsible practice of advocacy by scientists.

Scientists become advocates when they move beyond reporting, clarifying, interpreting and explaining scientific research to advising and recommending actions to a particular audience.[42] When communicating scientific research, scientists have a responsibility to provide balanced, understandable information, pointing out possible weaknesses and limitations in the evidence, to enable others to make informed decisions. When advocating for a particular outcome, scientists become 'partisans' and are no longer neutral conveyors of scientific information. This new perspective may pose a dilemma to the responsible scientist.

Scientists who seek to contribute their expertise as science communicators as opposed to advocates also face challenges, especially those caused by the link between scientific knowledge and contemporary socio-political movements. Conspiracy theories, vaccine mandates and climate change are all fields in which scientific information can have a polarizing effect when placed in the public domain. Scientists may experience tension between their responsibility to contribute to public debate and their duty to acknowledge the boundaries of their expertise. This is particularly relevant for large and multifaceted societal challenges, such as climate change and the Covid-19 pandemic.

Ideological tensions in contemporary society may also pose challenges to free and responsible social engagement, as seen in debates surrounding 'cancel culture' in universities. Researchers in various fields, particularly the social sciences, are experiencing increased scrutiny by employers, societal actors and politicians, typically with the aim of limiting controversy, defending ideologies or asserting political agendas.[43, 44] Researchers in many countries are increasingly engaging in academic self-censorship in response to the perceived risks of undertaking certain lines of scientific enquiry or of publicly communicating their research.[45] These trends raise difficult questions about the boundaries of scientific freedom and freedom of expression. But they also provide valuable opportunities to bring the concepts of freedom and responsibility in science to the fore in public and political debate.

3.7 NEW TECHNOLOGICAL POTENTIAL

The sciences have contributed enormously to humanity's ability to understand the world and to change it. But increased abilities to create and destroy raise difficult questions about scientific responsibility, for individual scientists and for scientific institutions and organizations.

These questions are now more important than ever. New technologies generate unprecedented capabilities that affect human life, including climate engineering, artificial intelligence, Big Data, robotics, genome editing and predictive medicine.

Much scientific knowledge has dual-use potential, posing risks as well as benefits.[46] A key problem is that classifying knowledge in particular fields as having dual-use potential (especially in areas such as engineering, computer science or information technology) can effectively stifle scientific freedoms, including communication and collaboration. Instead, a careful and nuanced approach is required to protect the freedom and uphold the responsibilities of researchers working in these areas. It must be based on international disciplinary standards, and on effective science diplomacy in instances where national security is implicated.

3.8 SCIENCE AND INDUSTRY

Basic and applied research have been critical components of industrial development since the 18th century. During the 20th century, collaboration between scientists working in the private sector, academia and government increased significantly and, by the 1980s, was being deliberately engineered by government ministries overseeing funding for research and innovation.

This development has posed challenges for scientists working in both industry and universities. There are no widely accepted guidelines for how their research relationships should be conducted.[47] There can be significant differences between what scientific freedom means in these different contexts, especially the freedom to disseminate the results of research.

Understandably, private sector funding for research is driven in large measure by company interests, not by the altruistic goal of contributing to knowledge for the wider public good. For scientists based in universities, and who are increasingly dependent on funding from industry for their research, this raises potential conflicts between private interests and incentives on the one hand, and public concerns and funding on the other. For example, the publication of research findings in media accessible to the wider public can be significantly delayed, or banned altogether, in the interest of protecting intellectual property resulting from industry funding.

From the late 20th century onwards, there has been a shift in emphasis from investigator-initiated, curiosity-driven, discipline-based research towards mission-led, problem-focused, interdisciplinary projects with specified time horizons for funding. This shift coincides with the growth of co-funding for research by key stakeholders in the private, government and university sectors.

The increasing frequency of public–private scientific partnerships inevitably poses questions about what shared responsibilities and norms of behaviour should be expected of scientists employed in industry or by government agencies, universities and other non-government organizations. The incentives and codes of practice that generate trust in public science are not necessarily present in other arenas, especially the private sector.[48] However, there are some scientific responsibilities, such as for public safety, that should be fundamental parts of scientific practice wherever it is carried out.

4. BASIC PRINCIPLES

As noted in the introduction to this paper, science has certain freedoms and responsibilities for a specific reason: the cultivation of these freedoms and responsibilities contributes to higher ends. The previous chapters outlined how developments in the 21st century pose key challenges to the definition and practice of scientific freedom and responsibility. In this chapter, four key principles are proposed to inform responses to these challenges, building upon the framework of Robert K. Merton's values for the 20th century.

4.1 SCIENCE FOR THE COMMON GOOD

The 20th century value of disinterestedness states that the findings of science are not subject to specific interests, instead being generated from a common perspective. The ISC's vision of science as a global public good takes this value into the 21st century. In practice, the ISC seeks to advance the production of science, its control, acquisition, validation and use, as a collective social endeavour that is common to all people.

The significant value of science for the common good is recognized by UNESCO as a foundation for the protection of scientific freedom.[49] The 2020 Bonn Declaration[50] asserts that, 'freedom of scientific research is a necessary condition for researchers to produce, share and transfer knowledge as a public good for the well-being of society'. Private rewards, fame and economic incentives may encourage discovery and innovation, but ultimately it is the common good (which includes veracity) that is the guiding value of the scientific endeavour.

Science contributes to the common good by preserving, transmitting and renewing knowledge, technologies and skills that help societies to: understand and solve problems; increase welfare and wellbeing; and reflect on and interpret existential questions; but also assist with the identification of new problems and threats.[51, 52] Scientific freedom is required precisely to allow science to make these contributions.

However, the contributions that scientists and scientific organizations may make to public and private deliberation are restricted by professional standards, determined mainly by expert communities. It is often legal to perform experiments that are in fact unethical; where there is uncertainty, scientists have a responsibility to look to community and professional standards for guidance. While the freedom to criticize and question such standards is vital to prevent stifling orthodoxies,[53] there are general values, inspired by Merton, that should guide these scholarly debates. They include honesty, fairness, objectivity, reliability, scepticism, accountability and openness.[54]

4.2 SCIENCE SHARED

Ultimately, science belongs to everybody;[55] the scientific knowledge and skills acquired through the ages are the collective heritage of all humanity. An important goal of scientific institutions is not only to discover and interrogate new knowledge, but also to share and explain what is known for the benefit of all.

Research and scholarly enquiry thrive when shared. In articulating the need for communalism within science, Merton emphasized the importance of collective discussion and analysis of scientific research. The principle of sharing science in the 21st century extends beyond addressing other scientists. It now includes the responsibility to engage with different audiences, including policy-makers and the wider public.[56]

The opening of access to science will help to reshape the relationship between science and society. The international scientific community, represented by the membership of the ISC, has recognized the urgent need for reform of the current system of scientific publishing, and has endorsed a series of principles that should underlie the future operation of scientific and scholarly publishing.[57]

Modern media have dramatically increased the range and diversity of platforms through which scientists can share and debate research findings. Meanwhile, nations around the world have sought to build or bolster their science advisory mechanisms to improve communication between scientists and policy-makers, and boost the role of science in government decision-making.[58]

The increasing visibility of scientific research in public and political domains means that scientists are also called on to defend or debate the management of scientific research. This may involve public justification of how research standards are set and maintained; accounting for and debating research priorities; and explaining ethical and legal restrictions on research.[59] Sharing science in the 21st century is a matter of collective deliberation, listening to stakeholders' concerns, and responsibly representing the scientific community, through transparency, integrity and clarity.

4.3 SCIENCE IS UNIVERSAL AND DIVERSE

The concept of universalism[60] suggests that scientific claims must be held to objective and 'preestablished impersonal criteria'. Over the past half century, the sciences have come to appreciate that universality does not imply homogeneity or stale uniformity. Science is diverse, with a wide range of methods, concepts, traditions, problems and fields of application. A range of disciplines, research communities and schools of thought is vital to the pluralism of the sciences. Debate between them offers a rich palette of perspectives and approaches. The ethnic, linguistic, cultural and gender diversity of research communities is not only a matter of social justice. Scientists with specific backgrounds or experiences may have understanding that is vital to the development of scientific knowledge. Perspectives shaped through gender, ethnicity or culture may enrich insights and inform the consequences and assumptions of research.

Broad-based, engaged, interdisciplinary and transdisciplinary science is imperative for a scientific response to the complex problems facing our societies. Its creation involves drawing on the wisdom of those formally trained as researchers, but also others whose knowledge comes from non-scientific work or personal experience; indigenous epistemologies; and methodical observation by citizen scientists.

4.4 THE PLURALITY AND AUTONOMY OF SCIENTIFIC INSTITUTIONS

The 20th-century value of organized scepticism argued that science should limit the influence

of bias as much as possible and should be done for the sake of advancing scientific knowledge, rather than self-interest or power.

The specific cultures and institutions of science are vital to its operation. Among these are professional organizations such as scientific societies, training programmes, peer review institutions, specialist communications channels, and reward and certification systems. In such institutions, knowledge is assessed, codes and norms of research practice are set, scholarly debate is nurtured and regulated, and new generations of scientists are trained. These institutions have evolved throughout the history of science, often in the best interests of the scientific community. However, concern about bias and conflicts of interest within science remain in the 21st century. They undermine the notion of scientific responsibility and pose significant threats to scientific freedom. The safeguarding of institutional autonomy, a key value of modern higher education, can mitigate the influence of political agendas and financial interests on scientific research.

In reflecting the diverse nature of modern science, pluralism of organizational forms and research funding streams is crucial for the flourishing of scientific research. However, such pluralism must not compromise the universal protection of scientific freedoms and responsibilities, but should instead enable the localization of these global principles.

5. DEFINING THE FREEDOMS AND RESPONSIBILITIES OF SCIENCE IN THE 21ST CENTURY

The developments outlined in Chapters 3 and 4 are the context for science in the modern era. In this chapter, the authors identify key freedoms and responsibilities that are required for the global scientific community to meet today's challenges and opportunities.

5.1 FREEDOMS AND RESPONSIBILITIES OF SCIENTIFIC INVESTIGATION

5.1.1 Research integrity

The vision of science as a global public good relies on public trust in scientists and their findings. To secure this trust, scientists must behave with integrity. Scientific institutions and national governments must protect this trust by enforcing processes that ensure the responsible conduct of science. Scientific fraud by individuals, and failures in research integrity due to defective systems and structures, damage public support for science and thus infringe on the human right to enjoy the benefits of scientific progress.

Among the key responsibilities of scientists is to meet the established standards of their specific discipline in the conduct of scientific research. To advance science as a global public good, scientists must do 'good' science. Integrity also implies that scientists uphold the basic tenets of a scientific ethic: they should expose their evidence for the truth claims that they make and disseminate their work in the public domain.[61] This responsibility is captured in the 2017 UNESCO Recommendation on Science and Scientific Researchers,[62] which states that scientists have a right and responsibility to 'pursue, expound and defend the scientific truth as they see it'

and to 'promote access to research results and engage in the sharing of scientific data between researchers, and to policy-makers, and to the public wherever possible'.

2017 UNESCO Recommendation on Science and Scientific Researchers

The Recommendation outlines several additional responsibilities that scientists must meet in the pursuit of integrity. These include: minimizing the impacts on living subjects of research and on the natural environment; managing resources efficiently and sustainably; disclosing conflicts of interest; consulting with communities whose members may be affected by the performance of research; and ensuring that knowledge derived from traditional, indigenous, local and other knowledge sources is appropriately credited, acknowledged and compensated, as well as ensuring that the resulting knowledge is transferred back to those sources. Furthermore, the Recommendation argues that scientists have a right to 'express themselves freely and openly on the ethical, human, scientific, social or ecological value of certain projects', and have both the right and the responsibility to express concerns where research projects undermine human welfare, dignity and human rights, or are 'dual use'.

The maintenance of research integrity is a responsibility for research organizations as well as for individual scientists. They should encourage a culture of research integrity through information, dialogue and transparency, incentive management, and procedures to deal with misconduct. This responsibility also extends to professional associations, the publishing sector,[63, 64] and funders and governments, as well as civil society and journalists.[65] Institutional measures should respect scientific freedom and diversity, facilitating responsible behaviour rather than stifling vibrant scientific culture.

5.1.2 Science ethics

Science is a never-ending quest for knowledge. But alongside producing new discoveries, scientists must reflect on the impact of their activities. According to François Rabelais,[66] a physician of the early 16th century: 'Science without conscience is but the ruin of the soul.'

Science ethics is the manifestation of this conscience. In the present context, three levels can be distinguished. These levels relate to direct consequences of scientific activity, possible damage caused by the application of science, and warnings about possible hazards.

The first level concerns the ethics of scientific experiments and data gathering, such as for clinical trials in medicine. These must respect human values, rules for animal experimentation and concern for the environment.

At the second level, things become more complex. Studies of innovation show how difficult it is to anticipate the dangers of applying scientific knowledge. It can be hard to explain the advantages of science-based innovation even to other scientists. Nevertheless, scientists must reflect on possible harm, misuse or accidents, and warn the public about uncertainties and

potential harm. Science-based innovations which pose obvious questions of public interest include genetic manipulation using CRISPR-Cas9 techniques, artificial intelligence, high-energy physics, machine learning and Big Data technologies.

To fulfil their responsibilities at the third level, scientists must communicate the uncertainties and long-term effects of new science and technology for humans and the planet, most notably as they relate to climate change. They must signal the risks, explain them and propose solutions, helping society to sift through the available information and make scientifically informed decisions.

5.1.3 New technologies

Emerging technologies often involve the complex interaction of several disciplines, such as engineering and mathematics with biology, or robotics and artificial intelligence with the life sciences. According to Hans Lenk,[67] 'As technology gets more complex, the problem of responsibility gets more complicated.'

New technologies raise a number of questions for scientific freedom and responsibility, from the ethical use of gene technology to the security of open access data. The aim should be to avoid the Collingridge dilemma,[68] whereby new hazards arising from technology cannot be predicted, and older ones cannot be removed. The case study below explores these issues with the example of CRISPR technology.

Case study A: Heritable human genome editing

CRISPR (clustered regularly interspaced short palindromic repeat) is a technique that allows genomes to be edited more simply, more cheaply and more accurately than before.[69] It can be used on somatic cells to yield changes that are not inherited by offspring, or on the genome to generate changes that may be passed on to future generations.

For example, in May 2020, CRISPR was used on somatic material in an attempt to restore some vision to volunteer patients. This type of use is more widely accepted than genomic applications, which modify early embryos, eggs, sperm or precursor cells that can be used to establish a pregnancy. Heritable human genome editing (HHGE) is particularly controversial, because human reproduction touches on a range of societal and personal values.

The first question that arises about HHGE is whether it is safe. Most inherited traits are polygenetic, the result of hundreds of genes acting in concert, together with many environmental factors. Altering genes is risky and uncertain. So, attention has focused on so-called 'single-gene' diseases such as cystic fibrosis and sickle cell anaemia, those caused by a relatively small number of genes. However, even the genetic interactions underlying these conditions are not fully understood.

The first human beings known to have been genetically edited are twin girls who were born in China in 2018 after being edited in a lab run by He Jiankui. There is now consensus that this experiment should not have been performed. The trait which it was designed to add, HIV resistance, is polygenic; the gene which was altered, CCR5, is not well-understood; and there are established alternatives such as sperm-washing.

Yet developing even this much consensus has been hard work. A series of commissions and reports now offer a pathway to tackle the complexities of HHGE governance. The most influential are the 2017 Human Genome Editing consensus report by the US National Academies of Sciences, Engineering, and Medicine,[70] the 2020 International Commission on the Clinical Use of Human Germline Genome Editing,[71] and the 2020 World Health Organization (WHO) Draft Framework for Governance on Human Genome Editing.[72] As the WHO Draft Framework points out, the ethical and societal questions raised make governance challenging. Different societies will have different answers to some of these questions.

These reports recommend that even when it is deemed 'safe', HHGE should be used primarily to prevent 'serious disease' when no 'reasonable alternative' exists. But even this formula is controversial. The severity of a disease is often contested, and the definition of 'reasonable alternatives' may depend on the parents' desire for genetically related offspring. Like any technology, CRISPR also raises questions about societal impacts and justice. Genetic engineering companies are large and well-resourced commercial organizations. Will HHGE exacerbate existing inequities in healthcare?

All these questions are intensified when one considers modifications intended for human enhancement, as opposed to remedies for disease. This complex subject calls for responsible deliberation and action by scientists and scientific organizations and shows the importance of effective engagement with policy-makers and civil society.

5.1.4 Responsible research management

Research management involves private and public funders, universities, research institutions, the private sector, scientific societies, academies and publishers. Though each group has its role, they share responsibility for implementing clear, well-crafted rules that protect scientific freedom and promote responsible conduct.

During the 21st century, research has increasingly been managed and evaluated through the use of output indicators and other kinds of quantitative evaluation. In its most extreme form, the inappropriate use of quantitative research performance metrics contributes to academic labour insecurity and disturbs quality assurance and disinterested assessment. At their worst, these metrics can encourage fraud, plagiarism, falsification and fabrication. The managers of global science systems must attend to calls to re-evaluate these systems and to mitigate the risk they pose to the free and responsible conduct of science.

The increasingly interdisciplinary and globalized nature of scientific research calls for those involved in research management to consider new management systems which harness the benefits of these trends while combating the challenges they pose to scientific freedom and responsibility. For example, publication in diverse languages and different forms of science communication should be valued and rewarded in the scientific assessment system. The freedom of scientists to comment responsibly on the institution in which they conduct their research must be protected by all management systems, in accordance with globally recognized definitions of academic freedom.[73]

5.1.5 Science in the private sector

The private sector is a key component of the research ecosystem and contributes the largest share of most national research budgets. Moreover, the share of the private sector in research expenditure is increasing. This is true even for basic research and in frontier fields.

There are at least two contexts within which science is conducted in the private sector. The most significant is research undertaken by scientists employed by firms as part of their regular business operations. The freedoms and responsibilities of scientists working in such firms are heavily influenced by their employment contracts and by any employer guidelines relating to professional standards and ethics. It is unlikely that many scientists working in private sector firms are connected to institutions or organizations that have direct links with the ISC.

But there are ways in which scientists working in the tertiary sector, the private sector and the public sector may interact with one another and the ISC. One is in the international scientific unions and national academies that are ISC member bodies. Agreement to abide by certain codes of conduct can be a condition of membership of these unions and academies. At present, these institutions are heavily dominated by scientists based in tertiary institutions, and representation from scientists employed in the private sector and in government agencies tends to be low. Going forward, it would be valuable to have much wider participation of private sector and government agency scientists in the ISC's scientific unions and national academies.

A second and increasingly important context for research funded by the private sector is through collaboration with scientists in universities. In many countries, universities and university-based researchers are growing ever more dependent on private funding.[74] This means that for some scientists based in universities, private concerns and incentives outstrip public funding and public priorities.

A number of critical questions arise from the private sector's engagement with scientists in universities. How is the relationship between private funding and otherwise publicly funded universities and scientists regulated? What are the rules of engagement? What are the ethics that underpin these rules of engagement? What are the freedoms and responsibilities that attach to these arrangements? Are there some aspects of scientific good practice (as suggested above in section 3.8) that apply in all types of scientific organization? The answer appears to be that, currently, there are no widely accepted rules governing this type of engagement.

Achieving consensus on national standards for sound research practice, including the freedoms and responsibilities of scientists engaged in research, is not straightforward. New Zealand's national academy, the Royal Society Te Apārangi, experienced this in 2018 when it led an initiative to establish a Research Charter for Aotearoa New Zealand.[75] The consultations involved universities, Crown research organizations, independent research entities, the government ministry responsible for allocating public funding for research, and the government's chief science adviser forum. Conspicuous by its absence from the consultations was research funded by industry, except that share contracted out to universities and other research organizations. There is no umbrella organization that represents private sector research. This makes it difficult to consult over agreed national standards relating to research, including the freedoms and responsibilities of scientists engaged in research.

5.2 FREEDOMS AND RESPONSIBILITIES IN SCIENTIFIC COLLABORATION

5.2.1 Globalization of science

Science is increasingly characterized by interdisciplinary and international synergies.[76] This international collaboration is intended to generate global public good, while minimizing harm to those involved in the research or affected by it. Such international scientific collaboration can result in unprecedented innovation and in benefits to global sustainable development. The collaborations undertaken to develop vaccines for SARS-CoV-2 are a prime example.

This collaboration has been driven by the growth of digital technology, and is seen in an extreme form in the massive, pandemic-driven movement to online teaching and research collaboration. With these trends, the onus has fallen on academic institutions, governments and research commissioning parties to create the conditions for free and responsible scientific exchange, teaching and collaboration, enabling the respectful expression and exploration of diverse approaches in the digital realm.

The increased involvement of citizens, the private sector and civil society in scientific research, and the trend for co-financed and contract-funded, mission-oriented research, requires scientific freedom and independence to be balanced with social responsibility. In their role as researchers, scientists should take reasonable account of the interests of those involved in their research, and of possible impacts on the environment. Commissioning parties have a responsibility to respect scientific freedom, institutional autonomy, the health and safety of scientists, and local and global responsibilities to society.[77] National governments have the additional responsibility of maintaining unfettered research and education to a sufficient degree. In the absence of a supportive environment, academic institutions and other research organizations will be unable to deliver the competitive advantage and global recognition sought from them.[78]

5.2.2 Open science: sharing with care

Sharing scientific knowledge openly is a principle that should guide the scientific publication system, access to scientific data and public engagement in science.[79] But it is important to design these systems to ensure that both data and scientific results derived from them are reliable. Researchers in low-income countries, or ill-financed research fields, should not be disadvantaged by publication charges or the need to pay for data access. Governments and research organizations need to take action if open access is abused, such as in predatory publishing[80] or in the uncredited appropriation of research.

Sharing science openly involves consideration for the different values of different scientific disciplines, and for the values of different audiences. Scientists should assist access to their research by providing documentation that supports its interpretation, verification and reuse. This includes the clarification of uncertainty where it exists. Shared knowledge should explain which quality assurance procedures it has passed, by documenting peer review and the research standards involved. Scientists should explain the limitations of findings that are shared quickly but without verification, such as pre-prints or early releases to the press or social media.

In addition to the responsibilities it bestows on individual researchers, open science calls on scientists and governments to work together to protect national and economic security. A range of 21st century geopolitical pressures pose challenges to the sharing of scientific information. In light of these, policy-makers should engage the scientific community when establishing guidance and regulations for international collaboration.

5.3 Freedoms and responsibilities for scientific critique

There are times when scientists must challenge each other to uphold their individual and collective responsibilities. In peer review, chosen individuals are made responsible for assessing the methodology, data and truth claims presented in scientific and other types of publication. A key tenet of this process is that both the authors and the reviewers of publications should be protected from undue influence on their independent judgement. Here, all scientists have a responsibility to disclose perceived and actual conflicts of interest and to conduct the assessment objectively and with integrity.

Where there is evidence of professional misconduct, the wider scientific community has a collective responsibility to protect public trust in research, by supporting responsibly critical scientists. In order to meet this responsibility, individual scientists must have the necessary scientific freedoms. This includes access to data and freedom to speak out in their area of expertise without fear of repercussions.

5.4 Freedoms and responsibilities for science communication

As discussed in sections 3.2 and 4.2, science communication takes various forms with various audiences: communication within the scientific community, both formally and informally; communication between scientists and policy-makers through scientific advisory mechanisms; and communication between scientists and the public, as individuals or en masse.

In accordance with the UN Universal Declaration of Human Rights and the International Covenant on Economic, Social and Cultural Rights, researchers are duty-bound to make scientific knowledge accessible to public audiences with differing levels of science literacy.[81] In the 21st century, meeting this responsibility can involve collaboration with a range of other actors in various settings, including press offices, publishers, museums and festivals, social media, and traditional media outlets. Developments in contemporary society raise new personal and collective responsibilities for scientists when engaging in science communication through the media. These include, inter alia, consideration for the needs of diverse audiences; awareness of misinformation, disinformation and conspiracy theories relating to science issues; appreciation of the pressures facing modern media organizations; and an acknowledgement of the impact of personal social media use on public perceptions of scientists. In all forms of science communication, scientists are personally responsible for communicating scientific work with integrity, respect, fairness, trustworthiness and transparency, recognizing its benefits and possible harms.[82]

In order to meet these responsibilities, scientists must be afforded specific freedoms. While all people are entitled to the human right of freedom of expression, scientists should also enjoy the right to protection for academic expression when sharing knowledge within their scientific expertise outside the lab or classroom (also called extramural expression[83]). According to UN recommendations, and in line with the contemporary view of higher education,[84] the sharing of scientific expertise through mainstream or social media should be understood as an exercise of academic freedom. When scientists engage in expression outside their academic topic, whether outside their substantive area or methodologically, they retain the right to freedom of expression guaranteed by human rights law, even if that engagement is not considered a part of their academic freedom.[85]

Crucially, scientists should not be punished by their institutions or governments, or by private actors, for exercising their rights to academic freedom or to freedom of expression when participating in science communication activities.

Case study B: Scientific freedom and responsibility in times of emergency

Scientists have a range of vital roles to play during emergencies, and for which they require scientific freedom. These roles include conducting primary research, peer reviewing new findings, establishing scientific consensus and communicating evidence to key stakeholders. Each of these roles carries its own responsibilities, which must be navigated carefully in the context of considerable pressure.[86]

When undertaking research during an emergency, scientists must take an ethical and responsible approach that is respectful of the affected communities[87] and the environment. When assessing the research of others, scientists are responsible for identifying signs of malpractice, as well as errors made unintentionally.[88]

Knowledge emerges rapidly in the context of emergencies, and it is critically important that scientists convey the associated uncertainties in ways that the public and policy-makers can understand and act upon. This is necessary to protect trust in science and to promote effective decision-making.[89] In all these roles, scientists must be responsible advocates for the scientific process, supporting the use of the best available evidence and ensuring balanced communication with society.

The Covid-19 pandemic illustrates what can be effective, and what can go wrong, when scientists respond to a global crisis. The sharing of data and knowledge between research teams, institutions and countries has been laudable. The number of research groups that pivoted their attention to the virus is unprecedented. Beyond their primary research, experts have engaged in clear, consistent and creative modes of communication which have served to boost public trust in scientific research and to promote adherence to public health guidelines.[90]

But the pandemic has been accompanied by the appearance of an enormous amount of non-peer reviewed research, as well as a significant number of retracted publications. These underscore the need for better curation of the literature.[91] Those who have tried to call out shortcomings in emerging research have been subjected to harassment and intimidation from their peers.[92] In some countries, scientific debate has clouded decision-making by key policy-makers, while in others, governments have denied researchers their scientific freedoms[93] and have failed to utilize scientific evidence in their pandemic response.[94]

Emergencies such as the pandemic pose unique and far-reaching challenges to the free and responsible practice of science. These include time pressures, funding shortages, infrastructure barriers, public confusion and political hostility. At the same time, it is clear that the principles of freedom and responsibility are key to the effective use of science in combating emergencies. Scientists must be protected and supported with the freedom needed to pursue effective research and communication, while being held accountable for the responsibilities they hold in these endeavours.

6. CONCLUSION

This Discussion Paper concludes on an optimistic note. Science is a unique human activity that, over time, has given us deep knowledge of ourselves and our place in the universe. The sciences, broadly defined, including technology, the social sciences and humanities, have played a vital role in human history and will be even more important in the 21st century.

Researchers are key members of contemporary society. Their contribution to human wellbeing and to planetary health is maximized when they are free to meet their individual and collective responsibilities. The international scientific community, governments, businesses, private research institutions, the public and other actors should all be aware of the freedoms and responsibilities of scientists. Those with influence over how science is performed should develop strategies that will help to achieve the free and responsible practice of scientific research, in the pursuit of a more sustainable world.

7. RECOMMENDATIONS

The ISC is committed to a vision of science as a global public good. This is a vision with profound implications for the ways in which science is prioritized, how it is conducted, how it is used, and the roles it plays in society. The authors hope that this Discussion Paper will help all stakeholders in the global science community to appreciate the need for free and responsible science, and to pioneer new ways to promote this endeavour at a vital point in human history. To that end, the following recommendations summarize the key messages of this paper for these stakeholders, and highlight tools which can help uphold scientific freedom and responsibility in the 21st century.

As well as applying to the scientific community, broadly defined, many of these comments are relevant to science publishers and to the media, whose responsibilities are not explicitly discussed in this paper. The ISC has a dedicated project which explores the role of publishing in the scientific enterprise and asks how the scholarly publishing system can advance science as a global public good. The responsibilities of science journalists and other actors in the media are covered by their professional codes, governing bodies and organizations.

7.1 RESEARCHERS

Scientists require both individual and collective freedoms in order to pursue high-value research. At the same time, each researcher has individual and collective responsibilities, which vary according to their scientific discipline and professional role.

In response to the challenges and opportunities of the 21st century, the ISC seeks to uphold four fundamental freedoms for scientific researchers:

- Freedom of movement;

- Freedom of association;
- Freedom of expression and communication; and
- Freedom of access to data and information.

These freedoms are grounded in internationally recognized human rights statements, treaties and instruments, including the United Nations Universal Declaration of Human Rights,[95] the International Covenant on Civil and Political Rights[96], the International Covenant on Economic, Social and Cultural Rights[97], and the UNESCO Recommendation on Science and Scientific Researchers.[98] These instruments are valuable tools with which researchers should defend their scientific freedoms.

While scientific freedom should be enjoyed consistently throughout a scientific career, the specific responsibilities of individual researchers evolve with time and experience. Furthermore, and as discussed in Chapter 2, the range of freedoms and responsibilities that should be upheld by and for the scientific community shifts as society evolves. This paper makes the following high-level recommendations for responsible research in the 21st century:

When conducting research, scientists must:

- Act with integrity;
- Expose the evidence for the knowledge claims that they make, and make that evidence available to be tested through the scrutiny of peers;
- Meet the international standards of ethical practice within their discipline;
- Consider the dual-use potential of their findings; and
- Act to mitigate their hazardous use.

When collaborating in research, scientists must:

- Uphold the rights and interests of those involved in collaborative research, including research participants and the environment in which research is undertaken;
- Assist equitable access to research; and
- Promote and embrace diversity in the scientific community.

When communicating research, scientists must:

- Consider the needs of diverse audiences;
- Explain uncertainties in scientific evidence;
- Signal the risks of emerging technologies;
- Challenge misinformation; and
- Advocate for equitable access to research outcomes while contributing to infrastructure that facilitates sharing.

7.2 RESEARCH ORGANIZATIONS

Institutions which fund or perform scientific research face a range of pressures in the 21st century. They include financial constraints, the complexities of transnational collaboration, political interference and, in some instances, the impact of armed conflict or humanitarian disasters. This paper proposes two main opportunities which may allow these organizations to promote the free and responsible practice of science in the face of these challenges.

In managing science, research organizations must:

- Uphold rigorous standards of research integrity;
- Deal with scientific misconduct fairly and consistently;
- Adopt appropriate performance evaluations for research and researchers; and
- Promote the communication of scientific evidence, including to the public and policy-makers.

In protecting researchers, research organizations must:

- Promote scientific freedom and the responsible practice of science through legislation and culture;
- Support efforts made by scientists to address structural and systemic challenges to scientific freedom, and to advance responsible research within their institution;
- Support the professional development of researchers;
- Defend institutional autonomy from external influence; and
- Protect staff from coercion, threats and pressures, including from political, religious and commercial interests.

The 2020 Magna Charta Universitatum[99] is a valuable tool for universities in considering these issues. It contains principles of academic freedom and institutional autonomy as a guideline for good governance. Similarly, the UNESCO Recommendation on Science and Scientific Researchers[100] provides a comprehensive list of rights and responsibilities of research institutions.

7.3 THE PRIVATE SECTOR

As discussed in Section 5.1.5, increasing private investment in scientific research offers new opportunities to researchers around the world. However, a major challenge when conducting research within the private sector, or with private funding, is the lack of national governance and internationally agreed standards in this domain.

A key recommendation emerging from this paper is for the development of frameworks and infrastructure through which such governance and standards can be secured, with an emphasis on protecting scientific freedom while upholding responsibilities at all levels. To aid this process, scientists working in or with the private sector, as well as those working in government agencies, should seek closer involvement in the unions and academies comprising the ISC's membership.

7.4 GOVERNMENTS AND ELECTED OFFICIALS

The State at all levels has a critical role to play in creating an enabling environment for the free and responsible practice of science. Governments can also threaten scientific freedom and responsibility. Governments at all levels can pose a significant threat to scientific freedom and responsibility. Governments must observe the existing declarations, instruments and treaties that list their responsibilities for safeguarding science and scientists. In addition, this paper proposes that governments must:

- Adopt and enforce standards for ethical practice in scientific research;
- Adopt legal frameworks which respect the autonomy of research institutes;
- Ensure scientific freedom, while protecting national security and individual privacy;
- Nurture diversity, equity and inclusion in science, through agenda-setting and funding strategies;
- Encourage science communication and engagement with diverse communities;
- Foster interfaces for the use of scientific advice in policy-making; and
- Monitor the state of science and scientific researchers according to international standards.

Respect for the freedoms of scientists and for the autonomy of scientific institutions in determining funding allocations is a shared responsibility of multiple stakeholders, including governments, research organizations and the private sector.[101] The actions listed above are a necessary part of the responsible allocation of research funds, particularly those pertaining to ethical standards, evaluating merit, and promoting equity and diversity in the research community.

7.5 INTERNATIONAL SCIENCE ORGANIZATIONS

Science organizations that span national and regional borders have a unique role in promoting science as a global public good. This paper highlights the various responsibilities of such organizations in addressing the challenges of the 21st century, and in capitalizing on the opportunities this period brings. Five key recommendations emerge from these responsibilities:

- To foster international scientific collaboration, for example by advocating for funding and tools for transnational collaboration between nations in diverse cultural, scientific and legal environments;
- To promote diversity, equity and inclusion in the global science community;
- To protect the principle and practice of open science;
- To provide platforms for science communication and engagement with multiple stakeholders; and
- To advocate for the role of scientists in national and international policy-making.

8. KEY TERMS

Science

The ISC has a broad understanding of the sciences in all their diversity. It covers science as a collective institution with a broad range of practices and values, and also scientists as a community.

> *The word science is used to refer to the systematic organization of knowledge that can be rationally explained and reliably applied. It is inclusive of the natural (including physical, mathematical and life) science and social (including behavioural and economic) science domains, which represent the ISC's primary focus, as well as the humanities, medical, health, computer and engineering sciences.*[102]

The term 'scientists' includes people who are professionally engaged in and responsible for research and development. It is inclusive of social scientists, although some may not identify with the term, preferring 'researchers' or 'scholars'.

Human rights

The term 'human rights' refers to a set of legal claims to protection and benefits that are anchored in internationally recognized human rights statements, treaties and instruments. These include the United Nations Universal Declaration of Human Rights (1948) and two subsequent treaties, the International Covenant on Civil and Political Rights (1966) and the International Covenant on Economic, Social and Cultural Rights (1966). This understanding of 'human rights' includes legal obligations on States and their agents to respect human rights, to promote human rights and to protect people in their territories against human rights violations.

According to Article 27 of the Universal Declaration of Human Rights:

> *Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits.*

This is further ratified in Article 15 of the International Covenant on Economic, Social and Cultural Rights, whereby State Parties must protect the right to:

> *(a) Take part in cultural life;*
>
> *(b) Enjoy the benefits of scientific progress and its applications; and*
>
> *(c) Benefit from the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he [sic] is the author.*

The universal right to access and share scientific information is included under Article 19 of the International Covenant on Civil and Political Rights, which states that:

> *Everyone shall have the right to freedom of expression; this right shall include freedom to seek, receive and impart information and ideas of all kinds.*

Scientific freedom

The notion of scientific freedom is referred to explicitly in the 1966 International Covenant on Economic, Social and Cultural Rights. According to Article 15 (3) of this Covenant, States must undertake to respect the 'freedom indispensable for scientific research'.

The General Comment on Article 15, published by the UNESCO Committee for Economic, Social and Cultural Rights in 2020[103], elaborates on this freedom, in accordance with the 2017 UNESCO Recommendation on Science and Scientific Researchers.[104] According to these documents, scientific freedom includes, at a minimum:

- The freedom of researchers to pursue, expound and defend the scientific truth as they see it, with protection from undue influence on their independent judgment;
- The possibility for researchers to set up autonomous research institutions and to define the aims and objectives of the research and the methods to be adopted;
- The freedom of researchers to freely and openly question the ethical value of certain projects and the right to withdraw from those projects if their conscience so dictates;
- The freedom of researchers to cooperate with other researchers, both nationally and internationally; and
- The sharing of scientific data and analysis with policymakers, and with the public wherever possible.

The 2017 Recommendation also calls for freedom of movement for researchers, and places on Member States the responsibility to ensure that all scientists enjoy equal access to science and scientific freedoms without discrimination of any kind.

These rights and responsibilities underlie the ISC's Principle of Freedom and Responsibility in Science.

Academic freedom

The 1997 UNESCO Recommendation concerning the Status of Higher Education Teaching Personnel[105] defines academic freedom as:

> *The right, without prescription by prescribed doctrine, to freedom of teaching and discussions, freedom in carrying out research, and disseminating and publishing the results thereof, freedom to express freely their opinion of the institution in which they work, freedom from institutional censorship, and freedom to participate in professional or representative academic bodies.*

This was the first major attempt at defining and consolidating academic freedom principles at the international level. It is rooted in international law, including the Universal Declaration of Human Rights, the International Covenant on Economic, Social and Cultural Rights, and the International Covenant on Civil and Political Rights. Unlike scientific freedom, academic freedom is not explicitly referred to in these instruments, but much of its meaning is covered by protections relating to freedom of opinion and the right to education. Academic freedom can be considered as a particular, enhanced form of freedom of science, applicable to scientists in higher education institutions only.

Institutional autonomy

Institutional autonomy is a key component of academic freedom. Academic institutions should have the freedom to manage their core activities of research and teaching without fear of political or religious interference. According to the 1997 UNESCO Recommendation, Member States and higher education institutions should ensure a 'proper balance between the level of autonomy enjoyed by higher education institutions and their systems of accountability'[106].

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10. APPENDIX: PAPER PRODUCTION AND REVIEW

This Discussion Paper has drawn on a framing document drafted by Daya Reddy, ISC President and CFRS Chair from 2019 to 2021. The Framing Document responded to deliberations within the ISC and CFRS on the need for a re-examination of the meaning of scientific freedom and responsibility in the 21st century.

10.1 WRITING GROUP MEMBERS

The Paper was developed by an Expert Writing Group of scientists appointed by CFRS, with oversight from the ISC's Governing Board.

The Expert Writing Group members are:

Richard Bedford, CFRS member; Emeritus Professor at the University of Waikato and at the Auckland University of Technology, New Zealand; former President of New Zealand's national academy, the Royal Society Te Apārangi.

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10.2 INTERNATIONAL SCIENCE COUNCIL STAFF

ISC Secretariat: Vivi Stavrou (CFRS Executive Secretary and Senior Science Officer), Lizzie Sayer (Senior Communications Officer) and Mathieu Denis (ISC Science Director)

Royal Society Te Apārangi: Frances Vaughan (CFRS Special Advisor)

10.3 REVIEWERS

The text was subjected to three phases of review followed by revision, involving members of the ISC's Committee for Freedom and Responsibility in Science, select members of ISC Advisory Committees, and a global consultation with ISC Members. Members were invited to read and review a draft version of the paper, which was presented and discussed at the ISC 2nd General Assembly in October 2021. Feedback was gathered via a short online survey, and through direct communication with ISC staff. All feedback received from ISC Members was considered by the Expert Writing Group, and the final paper incorporates all changes agreed by the Writing Group, with editorial oversight from CFRS and ISC staff.

List of ISC reviewers

Geoffrey Boulton, Member of the International Science Council Governing Board; Regius Professor of Geology Emeritus, University of Edinburgh.

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Saths Cooper, Member of the International Science Council Governing Board and CFRS Vice-Chair, 2018–202; past President of the International Union of Psychological Science (IUPsyS); founding President of the Pan-African Psychology Union.

Enrique Forero, CFRS Member; Professor of Botany, Emeritus Scientist, President of the Colombian Academy of Exact, Physical and Natural Sciences (2013–2016, 2016–2019, 2019–2022) and of the Council of Colombian Academies (2015–2017).

Daya Reddy, Inaugural President of the International Science Council Governing Board and CFRS Chair, 2018–2021.

Sawako Shirahase, CFRS Member; ISC Vice-President for Finance (2022–2024); Senior Vice-Rector of the United Nations University; Professor of Sociology at the Graduate School of Humanities and Sociology, the University of Tokyo.

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Martin Visbeck, Member of the International Science Council Governing Board; Head of the Physical Oceanography research unit at GEOMAR Helmholtz Centre for Ocean Research, Kiel; professor at Kiel University, Germany.

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