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The Right to Participate In and Enjoy the Benefits of Scientific Progress and its Applications: A Conceptual Map

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I. Introduction

The last generation experienced extraordinary progress in science and technology. Scientific and technological progress is now increasingly seen as essential in addressing the pressing global challenges we face as a human civilization. These advancements have led international organizations, scholars, and practitioners to pay increasing attention to the right to participate in and enjoy the benefits of scientific progress and its applications or, as it is often referred to, "the human right to science."[1]

Codified in Article 15(1)(b) ("Article 15") of the International Covenant on Economic, Social and Cultural Rights ("ICESCR"), the right to participate in and to enjoy the benefits of scientific progress and its applications (right to science) remains underdeveloped.[2] Its exact content is still somewhat undetermined, and the right is rarely invoked in debates of the governance of science. This is not surprising. Writing at the end of the 1990s, Janusz Symonides noted that cultural rights are "the least developed as far as their scope, legal content and enforceability are concerned."[3] These rights, he adds, "need further elucidation, classification and strengthening."[4] Following the growing interest in the right, the Committee on Economic, Social and Cultural Rights ("CESCR") adopted General Comment No. 25 on science and economic, social, and cultural rights in April 2020.[5] This instrument provides an opportunity to conceptualize the normative content of Article 15 as it articulates the various elements of the right, its limitations, and the obligations for State parties. It also looks at the relationship between Article 15 and other economic, social, and cultural rights, and international cooperation issues, expressly mentioned in Article 15(4), and national implementation.[6]

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1. Comm. on Econ., Soc., and Cultural Rts. (CESCR), *General Comment No. 25 (2020) on science and economic, social and cultural rights (article 15(1)(b), (2), (3) and (4) of the International Covenant on Economic, Social and Cultural Rights)*, UN Doc. E/C.12/GC/25, para. 1 (Apr. 30, 2020) [hereinafter General Comment No. 25].
2. *Id.* ("UNESCO, declarations made at international conferences and summits, the Special Rapporteur on cultural rights, and eminent scientific organizations and publications have upheld the 'human right to science', referring to all the rights, entitlements and obligations related to science.").
3. Janusz Symonides, *Cultural Rights: a Neglected Category of Human Rights*, 50 INT'L SOC. SCI. J. 559, 559 (1998) [hereinafter Symonides].
4. *Id.*
5. General Comment No. 25, supra note 1.
6. *Id.*

General Comment No. 25 gave impetus to the human right to science and serves as a call for conceptualizing the right to science further. The General Comment acknowledges that the right "contains both freedoms and entitlements" and identifies several of them [7] The next step towards a more complete conceptualization of the right to science is to map out the various freedoms and entitlements, organize them, and define their content. This article offers such conceptualization. With the goal of "elucidation, classification and strengthening," as called for by Janusz Symonides, this article proposes a more coherent account of the entitlements secured in Article 15 and a conceptual map to organize them as a cluster of rights.[8] When adequately parsed, the "right to science" contains three distinct but interrelated clusters of rights (first-level rights): rights to scientific progress; rights to participate in scientific progress; and rights to benefit from scientific progress. In turn, each of these first-level clusters of rights can be further disaggregated into discrete second-level rights.

The article follows this logic. First, it presents the assumptions and methods at the foundation of the analysis. It then turns to the various rights under the broad right to science umbrella, cluster by cluster. Finally, it concludes with a general reflection on the normative content of the right and directions for further conceptual work.

II. The Framework of the Analysis

A. Sources

The point of departure of the analysis is General Comment No. 25. General Comments are authoritative interpretations of human rights treaties made by the expert body entrusted with supervising their application.[9] As Nisuke Ando points out, general comments tend to have a "quasi-legislative character." "Since the quality of information contained in the reports is decisive to effective monitoring by the bodies," Ando notes, "the reports are indeed a vital instrument in the implementation of States Parties' legal obligations under the treaties."[10] Further, Ando adds, "they are not a mere reflection of the human rights situation of a State Party. Rather, they could and should reflect goals for the attainment of which the monitoring bodies wish the State Party to strive and serve as authoritative interpretation of the provisions of treaties."[11] This article identifies all the entitlements and freedoms acknowledged in General Comment No. 25, organize them coherently, and articulate their normative content more specifically than how the CESCR conveys them.

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7. *Id.* at para. 15.

8. Symonides, *supra* note 3.

9. *See generally,* Elena A. Baylis, *General Comment 24: Confronting the Problem of Reservations to Human Rights Treaties*, 17 BERKELEY J. INT'L L. 277, 284–85 (1999); Nisuke Ando, *General Comments/Recommendations*, *in* MAX PLANCK ENCYCL. PUB. INT'L L., https://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1730?prd=EPIL&fbclid=IwAR0dchip59rF3QWovmBvfyKXAWIGY92yKGTTuFyvN-i08g_3jTAbE-Dr8qc#(last updated Nov. 2008) [hereinafter Ando]; Eibe Riedel, *Committee on Economic, Social and Cultural Rights (CESCR)*, MAX PLANCK ENCYCL. PUB. INT'L L., https://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e765?prd=EPIL&fbclid=IwAR1vgA4tAYHnwKA2HErqhQJEdeYboUgRnJ5fqHFDJacuaz-wvO63zheSjJc (last updated Nov. 2010).

10. *Id.*

11. *Id.*

Further support comes from additional legal and non-legal sources. The first source is the text of Article 15, read in conjunction with Article 27 of the Universal Declaration of Human Rights ("UDHR").[12] According to the accepted practices of interpretation of international law as codified in the Vienna Convention on the Law of Treaties, Article 15 must "be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and the light of its object and purpose."[13] The reconstruction of the normative content of Article 15 is further enriched by state practice.[14] Yotova and Knoppers recently completed a thorough analysis of state practice concerning Article 15 as it emerges from the reports filed by State parties to the treaty monitoring body.[15] The authors concluded that State practice suggests that the right to science includes at least the following two rights: the right to access scientific knowledge and information and the right to benefit from scientific applications.[16]

The analysis is further supplemented by other authoritative legal sources, particularly reports of holders of special mandates of the Human Rights Council (rapporteurs and working groups) and various instruments adopted by the United Nations Educational, Scientific and

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12. Article 27.1 proclaims: "[e]veryone has the right freely to participate in the cultural life of the community, to enjoy the human right to science and to share in scientific advancement and its benefits." G.A. Res. 217(III)A, Universal Declaration of Human Rights ("UDHR") (Dec. 10, 1948). There is a historical account of the inclusion of the right to science in the UDHR. *See* Mikel Mancisidor, *The Human Right to Science as a Key Element for the Rapprochement of Cultures*, *in* PROMOTING PEACE, HUMAN RIGHTS AND DIALOGUE AMONG CIVILIZATION 297–314 (2020), https://www.upeace.org/files/Publications/Promoting%20peace%2C%20human%20rights%20and%20dialogue%20among%20civilizations.pdf; RICHARD PIERRE CLAUDE, SCIENCE IN THE SERVICE OF HUMAN RIGHTS 27–39 (2002) [hereinafter CLAUDE]; William A. Schabas, *Looking Back: How the Founders Considered Science and Progress in their Relation to Human Rights/Un Regard Rétrospectif: Comment les Fondateurs Envisageaient Science et Progrès Dans Leur Relation Aux Droits de l'Homme*, 2015 J. EUR. DROITS HOMME / EUR. J. HUM. RTS. 504 (2015).

13. Vienna Convention on the Law of Treaties, art. 31(1), May 23, 1969, U.N.T.S. 1155. Article 15 of the ICESCR reads:

> 1. The States Parties to the present Covenant recognize the right of everyone:
>
> (a) To take part in cultural life;
>
> (b) To enjoy the benefits of scientific progress and its applications;
>
> . . . . 2. The steps to be taken by the States Parties to the present Covenant to achieve the full realization of this right shall include those necessary for the conservation, the development and the diffusion of science and culture.
>
> 3. The States Parties to the present Covenant undertake to respect the freedom indispensable for scientific research and creative activity.
>
> 4. The States Parties to the present Covenant recognize the benefits to be derived from the encouragement and development of international contacts and co-operation in the scientific and cultural fields.

International Covenant on Economic, Social and Cultural Rights, art. 15, Dec. 16, 1966, U.N.T.S. 993 [hereinafter ICESCR].

14. According to the general rule of interpretation codified in Article 31(3)(b) of the Vienna Convention on the Law of Treaties, subsequent practice is a source of legal interpretation of the meaning of treaties: "There shall be taken into account, together with the context . . . any subsequent practice in the application of the treaty which establishes the agreement of the parties regarding its interpretation." *Id.* at art. 31(3)(b).

15. Rumiana Yotova & Bartha M. Knoppers, *The Right to Benefit from Science and Its Implications for Genomic Data Sharing*, 31 EUR. J. INT'L L. 665, 677–85 (2020) [hereinafter Yotova & Knoppers].

16. *Id.*

Cultural Organization ("UNESCO").[17] The most relevant example of the former is the 2012 report submitted by Farida Shaheed, the first UN Special Rapporteur in the field of cultural rights.[18] It discusses the normative content of Article 15.[19] Of particular interest is its discussion of the right to science as a "right to contribute to science" as knowledge producers and a right to "participate in science decisions" as citizens.[20] UNESCO has contributed to the development of the right to science with various legal instruments or recommendations.[21] Although not binding, they are valuable sources of interpretation of Article 15.[22] The most important is the revised version of its 1974 Recommendation on the Status of Scientific Researchers. Renamed Recommendation on Science and Scientific Researchers, this instrument sets forth principles and recommendations to guide States that integrate the duties they have under Article 15 of the ICESCR. It also establishes a monitoring mechanism for its implementation.[23] In 2009, UNESCO facilitated the adoption of the Venice Statement on the Right to Enjoy the Benefits of Scientific Progress and its Applications.[24] This widely read document has greatly influenced the debate on science and human rights.[25] Lastly, UNESCO has adopted an international standard-setting recommendation to foster open science.[26]

B. Interpretative Approach

So far, the article has identified the legal sources of interpretation. A few words are also needed to discuss how they are used. The premise is that an "evolutionary interpretation should play an important part in assessing the meaning of Article 15."[27] "Usually connected to human

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17. UNESCO (https://en.unesco.org/) is a specialized agency of the United Nations with the mission to promote world peace and security through international cooperation in education, the sciences, and culture.

18. Farida Shaheed, *Report of the Special Rapporteur in the Field of Cultural Rights: The Right to Enjoy the Benefits of Scientific Progress and its Applications (A/HRC/20/26)*, U. N. HUM. RTS. COUNCIL TWENT. SESSION (May 12, 2012) [hereinafter Shaheed]. The Report is a substantial step forward in sharpening the analysis of the normative content of and state obligations grounded in Article 15. *Id.* Most importantly, the Report argues that Article 15 guarantees both the right to contribute to science (as knowledge producers) and to enjoy opportunities to participate in decisions about science (as citizens). *Id.* Moreover, the Report articulates the State parties' obligations in terms of objectives. *Id.* These are accessible by all without discrimination, freedom of scientific research and opportunities for all to contribute to the scientific enterprise, individual and collective participation in decision-making, and an environment that enables knowledge production and exchange. *Id.*

19. *Id.*

20. *Id.*

21. *Id.*

22. *Id.* Typically considered "soft law," these instruments can be used in interpreting "hard law" to identify convergence and even consensus among sovereign nations on the international law issues addressed by an instrument. *See generally id.*

23. *Recommendation on Science and Scientific Researchers, Adopted by the General Conference at its 39th Session, UNESCO* (2017), https://unesdoc.unesco.org/ark:/48223/pf0000260889#page=116 (last visited Mar. 22, 2021) [hereinafter *Recommendation on Science and Scientific Researchers*].

24. Venice Statement on the Right to Enjoy the Benefit of Scientific Progress and its Applications, July 16–17, 2009, 5.

25. *Id.* It is important to note that the Statement conveyed the hope that the document would "give impetus to further elucidation and implementation of this right" and the need for the CESCR to adopt a general comment on the right. *Id.*

26. *UNESCO Recommendation on Open Science*, UNESCO (2021), https://unesdoc.unesco.org/ark:/48223/pf0000379949 (last visited Dec. 14, 2021) [hereinafter *UNESCO Recommendation on Open Science*].

27. Yotova & Knoppers, *supra* note 15, at 674.

rights treaties,"[28] evolutionary interpretation captures the idea that obligations evolve over time and that legal and factual change must be accounted for in interpreting treaties.[29] To be able to use this approach, though, interpreters must find support in the treaty parties' intent.[30] According to Julian Arato, "[o]bligations can evolve, only if the parties intended that a particular term, or the treaty as a whole, have an evolutionary."[31] What was the intent of State parties when Article 15 was drafted and adopted? The record shows that, similar to other rights enshrined in the ICESCR, the drafters intended to leave Article 15 open for future development.[32] Article 15 was adopted with the understanding that its formulation captured the substance of the rights but that the precise meaning of the provision could not be defined once and for all at the time of the adoption of the Covenant because its concerned matters that were evolving.[33]

An evolutionary approach extends also to the factual underpinnings of Article 15. The concepts of "science," "scientific knowledge," "scientific progress," and "benefit" must be re-evaluated and re-interpreted as science evolves.[34] Think, for instance, at what "progress" and "benefit" meant in relation to human genetics in 1957, the year in which the ICESCR was adopted, and in 2020, the year in which Nobel Prize for Chemistry to Emmanuelle Charpentier and Jennifer A. Doudna for their discovery of CRISPR/Cas9 genetic scissors.[35] Back in 1957, Crick and Watson had just published their seminal paper suggesting that DNA had the structure of a double helix. [36] In announcing the 2020 Nobel Prize for Chemistry the Royal Swedish Academy of Sciences noted that the CRISPR/Cas9 genetic scissors are a tool that

> has contributed to many important discoveries in basic research, and plant researchers have been able to develop crops that withstand mould, pests and drought. In medicine, clinical trials of new cancer therapies are underway, and the dream of being able to cure inherited diseases is about to come true.

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28. Malgosia Fitzmaurice & Panos Merkouris, *Treaty Interpretation and Its Rules: Of Motion through Time, 'Time-Will', and 'Time-Bubbles*,' TREATIES IN MOTION: THE EVOLUTION OF TREATIES FROM FORMATION TO TERMINATION 121–81, 130 (2020) [hereinafter *Treaty Interpretation and its Rules*].

29. *See, e.g.*, Eirik Bjorge, *The Evolutionary Interpretation of Treaties*, Oxford Scholarship Online (2014), https://oxford.universitypressscholarship.com/10.1093/acprof:oso/9780198716143.001.0001/acprof-9780198716143; Julian Arato, *Subsequent Practice and Evolutive Interpretation: Techniques of Treaty Interpretation over Time and Their Diverse Consequences*, 9 L. PRAC. INT'L CT. TRIBUNALS 443–94 (2010) [hereinafter Arato]; *Treaty Interpretation and Its Rules*, *supra* note 28.

30. *Treaty Interpretation and Its Rules*, *supra* note 28, at 134 (noting that the parties' intent is the "cornerstone of evolutionary interpretation").

31. Arato, *supra* note 29, at 466.

32. *See* G.A. Rep. of the Third Comm., U.N. Doc. A/3764, para. 74 (Dec. 5, 1957). The report of the session at which the Covenant was adopted, in December 1957, includes the following paragraph: "It was generally agreed that article 16 dealt with important human rights and should be retained in substance although certain concepts or notions contained therein might be still in the process of evolution." *Id.*

33. *Id.*

34. HENRY H BAUER, SCIENCE IS NOT WHAT YOU THINK: HOW IT HAS CHANGED, WHY WE CAN'T TRUST IT, HOW IT CAN BE FIXED 17–24 (McFarland 2017).

35. Press Release, The Royal Swedish Academy of Sciences, The Noble Prize in Chemistry (Oct. 7, 2020), https://www.nobelprize.org/prizes/chemistry/2020/press-release.

36. James D Watson and Francis HC Crick, *Molecular Structure of Necleic Acids: A Structure for Deoxyribose Nucleic Acid*, 171 NATURE 737 (1953), https://www.nature.com/articles/171737a0.pdf.

> These genetic scissors have taken the life sciences into a new epoch and, in many ways, are bringing the greatest benefit to humankind.[37]

The ever-changing nature of science calls for definitions of scientific concepts that are coherent with evolving practices. Since the underpinnings of Article 15 are dynamic and its language purposely subject to evolutionary interpretation, the normative content of the article must be anchored to the contemporary understanding of its terms and underpinnings, with an eye to the future. "The key to understanding the right," Yotova and Knoppers write, "lies mainly in the present and future, not in the past."[38] This goal is accomplished by grounding this contemporary understanding on scholarship in the history, sociology, and philosophy of science.

C. Terminology

Although both the ICESCR and the UDHR mention science, neither define the term.[39] However, the 2017 UNESCO Recommendation on Science and Scientific Researchers and General Comment No. 25 do.[40] They define "science" as:

> [T]he enterprise whereby humankind, acting individually or in small or large groups, makes an organized attempt, by means of the objective study of observed phenomena and its validation through sharing of findings and data and through peer review, to discover and master the chain of causalities, relations or interactions; brings together in a coordinated form subsystems of knowledge by means of systematic reflection and conceptualization; and thereby furnishes itself with the opportunity of using, to its own advantage, understanding of the processes and phenomena occurring in nature and society.[41]

Further, "science" is defined as "a complex of knowledge, fact and hypothesis, in which the theoretical element is capable of being validated in the short or long term, and to that extent includes the sciences concerned with social facts and phenomena."[42] However, this definition is still not sufficient to clarify other key terms (*i.e.*, "progress," "knowledge," "best available evidence") at the core of the right to science and all rights that fall under its umbrella.[43] Hence, a more robust and coherent analysis of the normative content of the right to science must incorporate the definitions and norms emerging from scientific practices. To this end, the insights from the philosophy of science and science policy are particularly valuable in defining key con-

37. The Royal Swedish Academy of Sciences, *supra* note 35.

38. Yotova & Knoppers, *supra* note 15, at 668.

39. *See* G.A. Res. 217 (III) A, Universal Declaration of Human Rights ("UDHR") (Dec. 10, 1948); International Covenant on Economic, Social and Cultural Rights, art. 15, Dec. 16, 1966, U.N.T.S. 993.

40. *See generally, Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 1(a)(i).

41. *Id.*

42. *Id.* at para. 1(a)(ii).

43. *Id.*

cepts such as "scientific progress," "scientific evidence," and so forth. These insights contribute to identifying the "ordinary meaning" of the text of Article 15 and the entitlements and freedoms listed in General Comment No. 25.

Before moving forward, an additional aspect of the normative treatment of science in international law must be discussed. Science is recognized and protected as a cultural activity able to produce "benefits" for humanity.[44] The drafters' choice of the term "benefits" restricts the normative content of the right to science to beneficial, not harmful, activities. Non-beneficial scientific knowledge and applications are thus outside the scope of protection of Article 15. According to Claude's analysis of the drafting debates of the ICESCR, Article 15 codifies "a minimalist Hippocratic injunction," which binds the scientific enterprise to the principle; "first, do no harm."[45] Yotova and Knoppers further argue that the choice of the word "benefits" "could be interpreted as imposing a positive obligation on states to protect everyone from the negative effects of science and technology."[46] Taken as a whole, though, the architecture of human rights involves more than a requirement not to harm, to nonmaleficence as bioethicists label this principle; it requires science to be beneficial.[47] Support for a codification of the principle of beneficence in human rights law can be found in General Comment 25, stressing that science must "contribute to the well-being of persons and humankind," and that States should prioritize "the development of science in the service of peace and human rights over other uses."[48] An interpretation that limits the protection to beneficial scientific progress is also consistent with the broader framework outlined in the UN Charter, whose goal is to promote peace, development, higher standards of living, and universal respect for human rights and respecting human dignity,[49] and Article 1 of the UNESCO Constitution, which commits the organization to the goals of the UN Charter.[50]

Finally, a comment on the usage of the terms "right," "entitlement," and "freedom." General Comment No. 25 uses all three without specifying their meaning.[51] The lack of definition leads to some ambiguity because these terms are not used uniformly in legal scholarship. Building upon the premise made in the General Comment, that the "right" to science contains both "entitlements" and "freedoms," and with the understanding that the analysis concerns human rights, that is, a form of right, guaranteed in an international treaty and creating obligations for State parties, the terms are used as follows. In absence of a definition in the General Comment, the term "entitlement" is used throughout this article as the trigger of positive duties of States parties. A rightsholder who is "entitled" possesses the power to claim the fulfillment of this aspect of the right. In the terminology of political and legal philosophy entitlements overlap with positive freedoms. By contrast, "freedom" consists of the power to claim the respect and

44. *See generally id.*

45. CLAUDE, *supra* note 12, at 43.

46. Yotova & Knoppers, *supra* note 15, at 673 (citing in support General Comment No. 17 on Article 15(1)(c) of the ICESCR and the Economic and Social Council's Guidelines on Treaty-Specific Documents).

47. *See generally* General Comment No. 25, *supra* note 1, para. 6.

48. *Id.*

49. U.N. Charter art. 1, 55.

50. *See generally Recommendation on Science and Scientific Researchers*, *supra* note 23.

51. *See generally* General Comment No. 25, supra note 1.

protection of that aspect of the right. This is not to say that "freedom" is akin to the narrower concept of a "negative freedom" in political and legal philosophy. The dichotomy between positive and negative rights is not particularly useful in the context of human rights.[52] As Andreas Schmidt points out:

> Human rights practice now commonly replaces the negative/positive distinction with a threefold distinction. First, States ought themselves to respect human rights and not violate them. Second, States ought to protect rights against those that seek to violate human rights. Third, States and the international community need to develop the necessary infrastructure, monitoring and delivery systems to positively fulfill human rights.[53]

This article names the rights included in the right to science and specifies if the right is an entitlement or freedom with an understanding that claims and "positive" duties of governments correspond to both entitlements and freedoms.[54]

Finally, a brief comment on the scope of the analysis. The aim is to provide a robust and coherent mapping of the rights recognized in Article 15. This analysis does not exhaust the normative issues connected with the ICESCR provision. Thus, it does not directly address State parties' duties, limitations of freedom and entitlements, international cooperation, the relationship between the right to science and intellectual property rights, or the monitoring and justiciability of treaty obligations. With these assumptions and caveats in mind, we can now turn to mapping the bundle of rights that constitute the entitlements and freedoms secured in Article 15.

III. Mapping the Cluster of Rights Secured in Article 15(1)(b) of the ICESCR

A. The Right to Scientific Progress

The first cluster of rights are the rights to scientific progress. This cluster comprises two second-level rights: the right to scientific activities and the right to responsible science.

1. Right to Scientific Activities

The CESCR summarizes succinctly and brilliantly the essence of the right to scientific activities when it writes that States must ensure that "scientific progress happens."[55] The right to scientific activities contains both entitlements and freedoms. The public can claim entitle-

52. For a critique of the dichotomy between negative/positive rights, see HENRY SHUE, BASIC RIGHTS: SUBSISTENCE, AFFLUENCE, AND U.S. FOREIGN POLICY 21 (2d ed.1996); Ida Elisabeth Koch, *Dichotomies, Trichotomies or Waves of Duties?*, 5 HUM. RTS. L. REV. 81, 81 (2005).

53. Andreas Schmidt, *Is There a Human Right to Tobacco Control?*, HUM. RTS. TOBACCO CONTROL, 32 (2020), https://www.elgaronline.com/view/edcoll/9781788974813/9781788974813.00010.xml (last visited Mar. 31, 2021).

54. I will thus list claims that correspond to the entitlement or freedom without ambition of exhaustivity given the word limit of journal articles.

55. General Comment No. 25, *supra* note 1, para. 16.

ments. One entitlement is to freedoms by scientists or nonscientists who participate in citizen science projects. In this light, the public's entitlement to scientific progress joins with the freedom *of* scientists to be able to "do science." The convergence of the two rights — *to* science and *of* science — can be found unambiguously in the text of Article 15(3), which provides that State parties must "respect the freedom indispensable for scientific research."[56] The realization of the right to scientific activities can be broken down into three steps: respecting the scientific enterprise's autonomy; protecting its enterprise from undue external influences; and creating a supportive environment.

The first step consists of respecting the autonomy of the scientific enterprise. A free, independent, and well-supported scientific enterprise is needed for scientific progress to happen. Scientists' autonomy is the ability of scientists to self-govern in matters that only pertain to science. These matters include defining credentials for accessing the profession, scientific quality standards, and peer review norms.[57] Some deference to scientists and their ability to organize the scientific enterprise is essential for scientific progress to happen.[58] This deference is not absolute. Being that science is coproduced with society, nonscientific considerations, such as the social acceptability or desirability of certain research strands, must be considered. Yet, some degree of autonomy must be preserved for the scientific enterprise to function. Respecting the scientific enterprise entails securing the rights *of* science, particularly the various freedoms that must be respected for scientific progress to happen. General Comment No. 25 frames these guarantees as follows:

> [Scientists must be free to] set up autonomous research institutions and to define the aims and objectives of the research and the methods to be adopted . . . to freely and openly question the ethical value of certain projects and the right to withdraw from those projects if their conscience so dictates, . . . to cooperate with other researchers, both nationally and internationally . . . and to shar[e] scientific data and analysis with policymakers, and with the public wherever possible.[59]

Freedom of association, and in particular the freedom to "form and join professional associations as well as to collaborate with others in their own country and internationally [and the freedom of movement] including the freedom to leave and re-enter their own country," are critical to the scientific enterprise.[60] Of course, the freedom of scientific freedom is crucial to scientific progress. Because of its prominence, it is discussed here in some detail.

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56. It is important to note that, when scientists work in educational institutions (be they public or private), they also enjoy academic freedom, which is enshrined in Article 26 of the UDHR and Article 13 of the ICESCR. Furthermore, they enjoy the freedom of opinion and expression recognized in Article 19 of the International Covenant on Civil and Political rights (ICCPR).

57. Stephen M. Maurer, Self-Governance in Science: Community-Based Strategies for Managing Dangerous Knowledge (2017), *passim*.

58. *See* David B. Resnik, *Scientific Autonomy and Public Oversight*, 5 Phil. Sci. 220–38 (2008).

59. General Comment No. 25, *supra* note 1, para. 13.

60. Shaheed, *supra* note 18, para. 40 at 12.

The duty to respect scientific freedom is spelled out expressly in Article 15(3), requiring State parties to "respect the freedom indispensable for scientific research."[61] The centrality of scientific freedom is further recognized in the Preamble of the 2017 UNESCO Recommendation on Science and Scientific Researchers, which states that scientific freedom and academic freedom lie "at the very heart of the scientific process."[62] Consistent with UNESCO's definition of "science" as an "enterprise whereby humankind, act . . . individually or in small or large groups," scientific freedom is enjoyed as both an individual and a collective right.[63] A scientist is free to "attempt . . . to discover and master . . . process and phenomena occurring in nature and society,"[64] both as an individual and as a member of the scientific community.

Respect for scientific freedom entails first the respect of the freedom of scientific opinion. The 2020 Report to the UN General Assembly of the Special Rapporteur on Promoting and Protecting the Right to Freedom of Opinion and Expression explores the connection between freedom of opinion, academic freedom, and scientific freedom.[65] The then-rapporteur David Kaye defined "scientific opinion" and how it forms as follows:

> In an academic context, certain aspects of research and pedagogy are closer to opinion than expression. For instance, a scholar conducting research may collect data and carry out analytical work with respect to those data, evaluate the data and then articulate an interpretation (in the form of a paper) for distribution, sharing with colleagues and, ultimately, publication. That analytic work depends upon the right to seek and receive information as a component of expression, and that process must be protected, with its limitation subject to narrow restrictions. However, even before the stage of imparting information, the scholar's work product should be protected from interference as an opinion, subject to no restriction of any kind.[66]

In other words, scientific freedom entails the right to formulate hypotheses, design studies, and articulate theories, knowing that scientific opinions can never be subject to legal or political restrictions. It is important to note that the right to hold opinions enjoys absolute protection in international human rights law. The Human Rights Committee has unambiguously recognized that, along with opinions of political, historical, moral, and religious nature, scientific opinions are protected under Article 19(1) of the ICCPR and Article 19 of the UDHR.[67]

61. General Comment No. 25, *supra* note 1, para. 3.

62. *Recommendation on Science and Scientific Researchers*, *supra* note 23, Preamble at 117.

63. *Id.* at para I.1.(a)(i), at 118.

64. *Id.*

65. David Kaye (Special Rapporteur on the Promotion and Protection of the Right to Freedom of Opinion and Expression), *Promotion and Protection of the Right to Freedom of Opinion and Expression Note by the Secretary-General*, 2, U.N. Doc. A/75/261 (July 28, 2020) [hereinafter Kaye].

66. *Id.* at para. 16, at 8.

67. U.N. Hum. Rts. Comm., *General Comment No. 34*, 2, U.N. Doc. CCPR/C/GC/34 (Sept. 12, 2011).

Second, Article 15 protects "scientific expression." According to the Human Rights Committee, freedom of expression "includes the expression and receipt of communications of every form of idea and opinion capable of transmission to others."[68] By extension, freedom of scientific expression includes the communication of every form of scientific idea and opinion, particularly the results of research efforts, within the scientific community and to the public. General Comment No. 25 asserts that scientific freedom includes both the freedom of expression and the freedom to seek, receive and impart scientific information."[69] Farida Shaheed elaborated on the concept of scientific expression, noting that "scientific freedom encompasses the right to communicate research results to others freely, and to publish and publicize them without censorship and regardless of frontiers."[70] The UNESCO Recommendation on Science and Scientific Researchers identifies publication as a medium of expression and recommends Member States to:

> encourage and facilitate publication of the results obtained by scientific researchers, and extend this to the data, methods, software, that they used, with a view to assisting them to share scientific information, and to acquire the reputation that they merit, as well as with a view to promoting the sciences, education and culture generally.[71]

The publication of results of scientific research is thus protected as an exercise of scientific expression. The ability to publish in peer-reviewed papers and books is paramount to scientific freedom. Two considerations follow. First, the protection of freedom of expression is not absolute. Scientists' ability to publish their research can be limited, but only according to the narrow parameters set in Article 4 of the ICESCR.[72] As Kaye observed, limitations "should be drawn extremely carefully to avoid . . . interference."[73] Second, the publication process itself, including peer review, must be respected and protected.[74] Governments should not interfere in the process and prevent these parties from impeding the free exercise of scientific expression (the duty to protect is discussed later in this section).[75]

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68. *Id.* at para 11, at 3.

69. General Comment No. 25, *supra* note 1, para. 46.

70. Farida Shaheed, Keynote Speech at International Conference on the Human Right to Science: New Directions for Human Rights in Science (May 22, 2015).

71. *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 35 at 12.

72. General Comment No. 25, *supra* note 1, para. 21.

73. Kaye, *supra* note 65, at 8 n.25. According to the European Court of Human Rights, scientists in academia also enjoy the freedom to express their views and opinions freely "even if controversial or unpopular in the areas of their research, professional expertise, and competence." Erdogan v. Turkey, App. Nos. 346/04 and 39779/04, para. 40 (May 27, 2014), https://hudoc.echr.coe.int/app/conversion/pdf/?library=ECHR&id=002-9461&filename=002-9461.pdf&TID=thkbhnilzk.

74. General Comment No. 25, *supra* note 1, paras. 24, 42.

75. *See generally* Kaye, *supra* note 65, para. 11.

The second step is an entitlement to the protection of the scientific enterprise from third-party interference.[76] Protecting the scientific enterprise means, first, that science must be shielded "from undue influence on the independent judgment" of scientists.[77] The goal is to shield science from external influences that would corrupt or undermine the knowledge production process in the sciences. This entitlement translates to protecting the scientific enterprise from private interests' interference.[78] Second, scientific knowledge should be recognized for its uniqueness as a form of cultural knowledge, distinct from other types of knowledge. It should be appreciated for its ability to provide unique insights into social and natural processes and phenomena, and its claims should only be assessed based on scientific standards, not other value systems.[79] Thus, science must be distinguished from pseudoscience, science denial, and other anti-science perspectives,[80] which, General Comment No. 25 notes, "create ignorance and false expectations among the most vulnerable sectors of the population."[81] It is an entitlement to a clear demarcation between science, pseudoscience, and nonscientific cultural expressions.

The third step is an entitlement to an environment where the scientific enterprise can flourish. General Comment No. 25 points out that Article 15 contains State parties' commitment to undertake "*positive* steps for the advancement of science (development) and the protection and dissemination of scientific knowledge and its applications (conservation and diffusion)."[82] The right to scientific activities is realized if, among other things, the scientific enterprise is adequately funded, research infrastructures are built and maintained, and scientists are adequately trained.[83] To ensure that the right to scientific activities is fully realized, General Comment No. 25 requires states to "develop a national plan of action to promote scientific progress,"[84] which should include, among other things:

76. *See generally id.* These entitlements correspond to governments' duty to protect scientific progress and enable it, and the duty to respect scientific freedom. *Id.*

77. General Comment No. 25, *supra* note 1, para. 13.

78. *Id.* at para. 43. "In some cases, scientific research conducted or financed by private actors can create conflicts of interests, for instance, when business corporations support research related to the type of economic activities in which they are involved, as happened in the past with some tobacco companies. Mechanisms should be established for the disclosure of these actual or perceived conflicts of interest." *Id.* at para. 59.

79. Emily L. Howell et al., *Deference and Decision-Making in Science and Society: How Deference to Scientific Authority Goes Beyond Confidence in Science and Scientists to Become Authoritarianism*, 29 PUB. UNDERSTANDING OF SCI. 800–18 (2020).

80. *See* Sven Ove Hansson, *Defining Pseudoscience and Science*, PHIL. OF PSEUDOSCIENCE RECONSIDERING DEMARCATION PROBLEM 61–77 (2013); Martin Mahner, *Demarcating Science From Non-Science*, GEN. PHIL. OF SCI. 515–75 (2007) (Distinguishing between science and pseudoscience is the subject of a vast literature in the philosophy of science that goes under the name of "demarcation problem.").

81. General Comment No. 25, *supra* note 1, para. 44. Governments are mandated to "adopt mechanisms to protect people from the harmful consequences of false, misleading and pseudoscience-based practices, especially when other economic, social and cultural rights are at risk. *Id.* at para. 52.

82. *Id.* at para. 14 (emphasis added).

83. The duty to invest in infrastructure features in UNESCO's Draft Recommendation on Open Science. *See*, *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 6.

84. General Comment No. 25, *supra* note 1, para. 87.

> [M]easures to strengthen human and institutional scientific capacities in the State; adequate public funding, especially for research that is relevant to meet the needs of the population and for the promotion of access to scientific education, particularly for groups that traditionally face discrimination in this field; mechanisms to promote a culture of scientific inquiry, public trust and support for sciences in society, particularly through a vigorous and informed democratic debate on the production and use of scientific knowledge, and a dialogue between the scientific community and society.[85]

The Annex to the Recommendation on Science and Scientific Researchers includes additional entitlements.[86] These include "an enabling environment for science and research" and "a stimulating environment for a sound science system with adequate human and institutional capacities."[87] These can be achieved if States facilitate "satisfactory work conditions, moral support, and public recognition of the successful performance of scientific researchers."[88] Similarly, the Venice Statement highlights that State parties must "adopt a legal and policy framework and to establish institutions to promote the development and diffusion of science and technology in a manner consistent with fundamental human rights."[89]

To summarize, the right to scientific activities is an entitlement to an environment where the scientific enterprise flourishes, empowered with a sufficient degree of autonomy, recognized as distinctive, and protected from anti-scientific distortions and undue external influence.

2. Right to Responsible Science

The right to scientific progress contains another second-level right, the "right to responsible science."[90] Citizens are entitled not only to progress but to it happening responsibly. This is the entitlement to a responsible scientific enterprise. The language of "responsibility" is borrowed from the science policy's vocabulary, where it is used in a variety of meanings, ranging from ensuring scientific integrity to valuing research that serves societal goals.[91] Responsible science finds its equivalent place in the human rights vocabulary where science, like any other

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85. *Id.* at para. 87.

86. *Recommendation on Science and Scientific Researchers*, *supra* note 23, Annex, KEY AREAS RELATING TO THE DRAFT RECOMMENDATION ON SCIENCE AND SCIENTIFIC RESEARCHERS, #10 (indicating that this duty is expressed in paragraphs 5, 11, 14a, 17, 24a, 26, 37, 43, 44, 45, 46, 47 of the Recommendation).

87. *Id.*

88. *Id.*

89. Venice Statement on the Right to Enjoy the Benefit of Scientific Progress and its Applications, *supra* note 24, para 16(a).

90. General Comment No. 25, *supra* note 1, paras. 18, 43.

91. *See*, *e.g.,* NATIONAL ACADEMY OF SCIENCES, NATIONAL ACADEMY OF ENGINEERING & INSTITUTE OF MEDICINE, RESPONSIBLE SCIENCE: ENSURING THE INTEGRITY OF THE RESEARCH PROCESS: VOLUME I (1992), https://www.nap.edu/catalog/1864/responsible-science-ensuring-the-integrity-of-the-research-process-volume (last visited Dec 14, 2021).

right, is protected by serving peace, respecting human dignity and human rights, and contributing to human progress.[92] To this right corresponds the duty of scientists to act responsibly and of governments to create an environment conducive to responsible science.[93]

Acting responsibly is at the core of the very definition of what it means to be a scientist. According to the Recommendation on Science and Scientific Researchers, the "status" of "scientists" can be bestowed only on those who "perform research and development in science and technology . . . taking [into] due account . . . the responsibilities inherent in and the rights necessary to the performance of that work."[94] The standing of a scientist depends on the "level of appreciation both of the duties and responsibilities inherent in their function and of their competence in performing them."[95] The price to pay for the protection and autonomy given to the scientific enterprise is a duty to act responsibly. General Comment No. 25 and the Recommendation on Science and Scientific Researchers stress States' obligations in this regard.[96] They emphasize the external checks of science over scientists' responsibility.[97] This is unsurprising. After all, it is States that bear the duties corresponding to human rights. However, when scientists work for the government, in public universities or labs, and, arguably, when research is financed by public money, human rights might impose obligations directly on scientists.[98] When scientists have no connection with the government and thus are not directly bound by international law, a reasonable argument can be made that the scientific community's rules of conduct must incorporate human rights standards.[99] C.G. Weeramatry labeled this approach "regulation from within."[100]

The requirements for "acting responsibly" are three. First, scientists must respect the *integrity* of the scientific process. They must refrain from engaging in scientific fraud or scientific misconduct, disclose any conflict of interest that may unduly influence their activity, respect

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92. General Comment No. 25, *supra* note 1, para. 6 ("the development of science in the service of peace and human rights should be prioritized by States over other uses.").

93. The duty of scientists may be enforceable in international law only when their actions amount to "state action" (*i.e.*, when employed or funded by governments and acting as a public authority). However, according to some scholars, international law creates duties also for private individuals, such as privately-funded scientists engaged in scientific activities. *See, e.g.*, DOUGLAS HODGSON, INDIVIDUAL DUTY WITHIN A HUMAN RIGHTS DISCOURSE (Routledge 2016); LAURA A. DICKINSON, THE STATE ACTION DOCTRINE IN INTERNATIONAL LAW, SPECIAL ISSUE HUMAN RIGHTS: NEW POSSIBILITIES/NEW PROBLEMS (Studies in Law, Politics, and Society, Vol. 56), 213–32 Austin Sarat ed., 2011), https://doi.org/10.1108/S1059-4337(2011)0000056009 (last visited Nov. 19, 2021).

94. *Recommendation on Science and Scientific Researchers*, *supra* note 23, Preamble.

95. *Id.* at para. 1(e).

96. *See generally Recommendation on Science and Scientific Researchers*, *supra* note 23; General Comment No. 25, *supra* note 1.

97. *See generally id.*

98. For an analysis of "state function" and human rights, *see, e.g.*, Stephanie Palmer, *Public functions and private services: A gap in human rights protection*, 6 INTERNATIONAL JOURNAL OF CONSTITUTIONAL LAW 585–604 (2008).

99. CLAUDE, *supra* note 12, at 70.

100. C. G. WEERAMANTRY, JUSTICE WITHOUT FRONTIERS: FURTHERING HUMAN RIGHTS 631 (1998).

authorship norms, and act with collegiality towards other scientists.[101] The Recommendation on Science and Scientific Researchers pinpoints scientific integrity in various paragraphs, particularly under the heading "Rights and Responsibilities in Research."[102] There, States are urged to "seek, in their treatment of and attitude towards scientific researchers, to express encouragement for [a] broad spirit of responsibility"[103] and "encourage conditions that can deliver high-quality science in a responsible manner."[104]

Second, scientists must respect and protect nonscientists who participate in the scientific process, either as research participants or merely as individuals or communities affected by scientific activities.[105] General Comment No. 25 touches upon this duty when it articulates governments' responsibility to ensure the "quality" of science, which "includes regulation and certification, as necessary, to ensure the responsible and ethical development and application of science."[106] States must thus protect "[p]eople from participating in research or tests that contravene the applicable ethical standards for responsible research and guaranteeing their free, prior and informed consent."[107] Additionally, national plans should include "measures to ensure ethics in science, such as the establishment or promotion of independent, multidisciplinary and pluralist ethics committees to assess the relevant ethical, legal, scientific and social issues related to research projects."[108] UNESCO also stresses the integral role that ethics of science, training in ethical issues, and "independent, multidisciplinary and pluralist ethics committees" play in ensuring that science is done responsibly.[109] Additionally, scientists must act responsibly when interacting with society. In these interactions, they must "minimize impacts on living subjects of research and the natural environment and should be aware of the need to manage resources efficiently and sustainably," disclose conflicts of interest, and "express themselves freely and openly on the ethical, human, scientific, social or ecological value of certain projects."[110]

Third, scientists must "do science" that is beneficial to individuals. Article 15 can be interpreted as codifying the principle of beneficence.[111] The public is thus entitled to beneficial science, progressing in a way that brings benefits to humanity. Beneficence includes

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101. The guidelines adopted by the US Office of Research Integrity define scientific misconduct as "one or more of three activities: fabrication of data, falsification of results, and plagiarism or the improper appropriation of other people's ideas or written work."

102. *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 15.

103. *Id.*

104. *Id.* at para. 16.

105. It is important to recall the overarching principle of non-discrimination in the enjoyment of scientific progress and its benefits, which is fundamental and applied to all human rights.

106. General Comment No. 25, *supra* note 1, para. 18.

107. *Id.* at para. 43. *See also*, G.A. Res. 2200A (XXI) International Covenant on Civil and Political Rights (Dec. 16, 1966) ("No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment. In particular, no one shall be subjected without his free consent to medical or scientific experimentation"); G.A. Res. 61/295, United Nations Declaration on the Rights of Indigenous Peoples (Sept. 13, 2007).

108. General Comment No. 25, *supra* note 1, para. 87.

109. *Recommendation on Science and Scientific Researchers*, *supra* note 23, paras. 5(d), 12, 14.

110. *Id.* at para. 16(a)(ii)–(vi).

111. *See* General Comment No. 25, *supra* note 1.

"peacebuilding, as well as the responsible and peaceful application of science and technology [and] addressing the root causes and impacts of conflict, and [] achieving sustainable development."[112] Science is beneficial when equitable, inclusive of all populations, particularly understudied and underserved populations,[113] and concerned with social progress, particularly by focusing on dismantling structural inequalities, including those plaguing the scientific enterprise.[114]

In sum, the right to scientific progress is a right to the development of science responsibly. A responsible science respects the norms of scientific integrity, protects the interests of all involved in or affected by the scientific process, and is oriented towards humanity's well-being, peacebuilding, and social progress.

B. The Right to Participate in Scientific Progress

The right to participate in scientific progress is the second first-level right. According to the CESCR, Article 15.1.b incorporates "a right to receive the benefits of the applications of scientific progress but also a right to participate in scientific progress."[115] The right to participate in scientific progress contains four second-level rights: the right to scientific literacy; the right to access the scientific professions; the right to contribute to scientific progress; and the right to participate in policy decisions relating to science.[116] The common denominator of these second-level rights is that they create the possibility for the public to engage with the scientific enterprise by becoming aware of what science is, joining the scientific profession as fully-fledged scientists or citizen-scientists, and participating in science policymaking. Individuals are no longer spectators or consumers of progress; they must be considered actors in scientific progress. Arguably, the drafters of the UDHR and the ICESCR contemplated the need to ensure the active participation of the public in scientific progress.[117] The CESCR finds support for that in the *travaux préparatoires* of the ICESCR,[118] the principles of participation and inclusiveness underlying the ICESCR, and the UDHR "which recognizes not only a right to benefit from the applications of science but also to participate in scientific advancement."[119] Active participation is also consistent with the inclusion of the right to science among cultural rights. As the Special Rapporteur on the Rights to Culture recognized, the right to participate falls in

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112. *Id.* at para. 5(e)–(f).

113. David H. Strauss, Sarah A. White & Barbara E. Bierer, *Justice, Diversity, and Research Ethics Review*, 371 SCI. 1209, 1209–11 (2021).

114. H. Holden Thorp, *Time to Look in the Mirror*, 368 SCI. 1161, 1161 (2020); Esther A. Odekunle, *Dismantling Systemic Racism in Science*, 369 SCI. 780, 780–81 (2020).

115. General Comment No. 25, *supra* note 1, para. 11.

116. *Id*. at paras 16–19, 24, 52, 54–55.

117. Sebastian Porsdam Mann, Helle Porsdam & Yvonne Donders, *"Sleeping Beauty": The Right to Science as a Global Ethical Discourse*, 42 HUM. RTS. Q. 332, 336 (2020).

118. *See generally* THE INTERNATIONAL COVENANT ON ECONOMIC, SOCIAL AND CULTURAL RIGHTS, TRAVAUX PRÉPARATOIRES 1948-1966 (Ben Saul ed., 1st ed. 2016).

119. General Comment No. 25, *supra* note 1, para. 10 ("The English version [of the UDHR] refers to the right to 'share' but the expressions 'participer', 'participar' or 'участвовать', appear respectively in the French, Spanish and Russian versions, which are also official texts of the [UDHR], and which refer to the right of all persons to participate in scientific advancement and in the benefits derived from it.").

the broader context of the "right to participate in cultural life," which lays the foundation for allowing "people to reconsider, create and contribute to cultural meanings and manifestations in a continuously developing manner."[120] The right to participate in scientific progress is closely connected to the other rights in the broader "right to science" cluster. Participation in science contributes to scientific progress and enhances the possibility to benefit from scientific progress by fostering trust in science and orienting scientific activities to directions that the public believes most beneficial.

1. Right to Scientific Literacy

The right to scientific literacy is an entitlement to attain a critical level of scientific literacy, which is essential to participate in and benefit from scientific progress. According to the Organisation for Economic Co-operation and Development ("OECD") Programme for International Student Assessment ("PISA"), "scientific literacy" is defined as:

> [A]n individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen.[121]

Education in science is the pathway to attain a critical level of scientific literacy that enables citizens to participate in scientific progress. Scientific literacy also produces the additional benefit of fostering citizen empowerment by forming critical and responsible participants in a democratic society.[122] This education must be of a particular type and quality. General Comment No. 25 refers to this entitlement where it specifies that scientific education must be of a certain "quality."[123] According to the document, it is a core obligation of State parties to:

> Ensure that people have access to the basic education and skills necessary for the comprehension and application of scientific knowledge and that scientific education in both public and private schools respect the best available scientific knowledge.[124]

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120. Shaheed, *supra* note 18, para. 18 (explaining that The Special Rapporteur 2012 cites her 2010 report to the Human Rights Council as an independent expert in the field of cultural rights).

121. OECD, *PISA 2009 Assessment Framework, Key Competencies in Reading, Mathematics and Science* 1, 14 (2009), https://www.oecd.org/pisa/pisaproducts/44455820.pdf (last visited Mar. 1, 2021).

122. General Comment No. 25, *supra* note 1, paras. 8, 10; Jessica M. Wyndham & Margaret Weigers Vitullo, *Define the Human Right to Science*, 362 SCI. 975, 975 (2018).

123. General Comment No. 25, *supra* note 1, para. 52.

124. *Id.*

Further, State parties must "carefully design and implement quality scientific education programmes in order to allow all persons equal opportunities to gain a basic level of understanding and knowledge of the science and training needed to pursue careers in science."[125] A reasonable reading for this standard in conjunction with the goals of Article 15 is that, at minimum, educational programs must ensure that students possess a degree of scientific literacy sufficient, to understand what science is and how individuals can participate in and benefit from scientific progress. PISA provides States with valuable indicators to identify benchmarks and measure their efforts to secure basic scientific literacy.[126]

In addition to an entitlement to formal education in their formative years, citizens are also entitled to lifelong learning opportunities in science, technology engineering, and math, which are collectively known as the STEM fields.[127] Throughout people's lives, both formal and informal learning opportunities foster the continuous development and improvement of the knowledge and skills needed for participating in scientific progress.[128] These opportunities are crucial, particularly for vulnerable groups and groups directly affected by scientific progress in novel ways. In fact, arguably, they can serve as the basis for understanding how scientific progress impacts them and allowing themselves to protect their interests. This goal can be accomplished by consuming educational materials, enrolling in adult classes, and attending science festivals.

In sum, citizens are entitled to attain a degree of scientific literacy that empowers and allows them to understand, appreciate, and participate in scientific progress and enjoy its applications and, more broadly, the life of a democratic society. This goal is accomplished by enjoying educational opportunities within the formal system of primary, secondary, and tertiary education, as well as outside the formal educational system.[129]

2. Right to Access the Scientific Professions

The right to participate in scientific progress encompasses the second-level right to access the scientific profession. Nonscientists are entitled to educational opportunities that enable them to become scientists.[130] It is an entitlement to educational pathways to careers in the STEM fields to attain the skills and credentials necessary to join the scientific enterprise as a

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125. *Id*. at para. 27.

126. *See Science Performance (PISA)*, OECD, https://data.oecd.org/pisa/science-performance-pisa.htm (last visited Dec. 7, 2020). PISA periodic testing program measures the academic performance of 15-year-old students. *Id.* Scientific literacy is one of the academic performances measured by the program. *Id.* The program measures students' use of scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues. *Id.*

127. General Comment No. 25, *supra* note 1, para. 27. For evidence supporting the argument that science centers contribute to fostering and maintaining a scientifically and technologically informed, engaged, and literate public, John H. Falk et al., *Correlating Science Center Use With Adult Science Literacy: An International, Cross-Institutional Study*, 100 SCIENCE EDUCATION 849–76 (2016).

128. For a discussion of "informal STEM education," *see*, Sue Allen & Karen Peterman, *Evaluating Informal STEM Education: Issues and Challenges in Context*, 161 New Direction for Evaluation, Evaluation in Informal Science, Technology, Engineering, and Mathematics, Education 17–33 (A. Kannan & R.J. Shavelson 2019).

129. General Comment No. 25, *supra* note 1, para. 11.

130. *Id.* at para 42.

professional. This entitlement goes beyond the education attainment connected with the general scientific literacy discussed earlier; it is an entitlement to educational programs that enable those who complete them to join the scientific community.[131]

This right is also a right to *equal* access to the scientific professions. Educational programs must be set up "to allow all persons equal opportunities to gain a basic level of . . . training needed to pursue careers in science, and to ensure access without discrimination to available employment in scientific research fields."[132] General Comment No. 25 sheds light on the gender gap in scientific professions and the limited access for persons with disabilities[133] and persons living in poverty.[134] Data published by the UNESCO's Institute of Statistics show that only 30 percent of the world's researchers are women.[135] The same problem plagues access to the scientific progression of other minorities and members of vulnerable groups, particularly the disabled community and indigenous populations.[136] Regarding the gender gap, the instrument demands that governments "immediately eliminate barriers, which affect girls' and women's access to quality science education and careers."[137]

3. Right to Contribute to Scientific Research

The right to participate in scientific progress entitles the public to contribute to scientific research as nonscientists. The most significant method of participation is what is referred to as "citizen science" or "crowdsourcing science."[138] General Comment No. 25 refers to it as "ordinary people doing science."[139] Citizen science and crowdsourcing projects bring together scientists and nonscientists in doing science together. Nonscientists can play one of these three roles: contributors by collecting data; collaborators by contributing to data analysis, interpretation, or dissemination; or co-creators when they are involved in all stages of research, including research design.[140] Thus, the right to become a citizen-scientist is a freedom—the freedom to participate in scientific activities as a nonscientist.

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131. *Id.* (the obligation to respect includes "eliminating barriers to accessing quality science education and to the pursuit of scientific careers").

132. *Id.* at para. 27.

133. *Id.* at para. 34.

134. *Id.* at para. 38.

135. UNESCO Institute for Statistics, Women in Science (June 2019), https://en.unesco.org/news/just-30-world%E2%80%99s-researchers-are-women-whats-situation-your-country.

136. Colin A. Scholes, *Recognise and Represent: Getting Indigenous Kids into Science*, 86 AQ: AUSTRALIAN QUARTERLY 3–6 (2015); Julia P. Sarju, *Nothing About Us Without Us – Towards Genuine Inclusion of Disabled Scientists and Science Students Post Pandemic*, 27 CHEMISTRY – A EUROPEAN JOURNAL 10489–10494 (2021); Create Access To Tech Careers for the Indigenous Community, *The 360 Blog from Salesforce* (2021), https://www.salesforce.com/blog/tech-careers-indigenous-community/ (last visited Dec 14, 2021).

137. General Comment No. 25, *supra* note 1, para. 31 (emphasis added).

138. *Id.* at para. 10.

139. *Id.* (defining citizen science as "ordinary people doing science").

140. *See* Rick Bonney et al., *Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy*, 59 BIOSCIENCE 977, 979 (2009).

In addition to realizing the right to participate in scientific progress, citizen science is also a way to realize the right to scientific progress by contributing to scientific advancement and benefiting from science. The most common form of public involvement in producing science is in the form of data contribution. Many projects seek the help of nonscientists in gathering data in a variety of disciplines, from the sighting of wildlife to analyzing pictures of galaxies and newly discovered planets.[141] Furthermore, citizens have contributed to scientific progress by "[c]oming up with research ideas, assembling the research team, designing the study, collecting and analyzing the data, replicating the results, writing the article, obtaining reviewer feedback, and deciding next steps for the program of research."[142] Science crowdsourcing has allowed researchers to collect and analyze data on a much larger scale, faster and cheaply. After proper quality control, citizen-sourced data have led to dozens of publications contributing to scientific progress.[143]

Regarding the right to benefit from scientific progress, citizen science fosters trust in science and expands scientific literacy. Crowdsourcing leads to knowledge acquisition and dissemination among nonscientists who learn about science and the scientific method by engaging in research projects.[144] As a result, they are more likely to spread their interest in science in their communities. Citizen science promotes civic engagement by enabling citizens to guide research priorities towards questions relevant to their communities.[145] Finally, it is an opportunity to include people and groups whose voices are typically not represented or underrepresented in the scientific world.[146]

It is important to note that when nonscientists participate in citizen science projects, they temporarily join the scientific enterprise. When actively engaged in scientific projects, it is plausible that nonscientists enjoy the same rights (scientific freedom) and bear the same burdens (duty to act responsibly) of the scientific community's professional members.

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141. *See generally Projects*, EUROPEAN CITIZEN SCIENCE ASSOCIATION, https://ecsa.citizen-science.net/projects/; *Resources,* CITIZENSCIENCE, https://citizenscience.org; *Resources,* AUSTRALIAN CITIZEN SCIENCE ASSOCIATION, https://citizenscience.org.au/; *Catalog,* CITIZENSCIENCE, https://www.citizenscience.gov/.

142. Eric Luis Uhlmann et al., *Scientific Utopia III: Crowdsourcing Science*, 14 PERSP. ON PSYCHOL. SCI. 711, 720 (2019).

143. *See generally* Roman Lukyanenko, Jeffrey Parsons & Yolanda F. Wiersma, *Emerging Problems of Data Quality in Citizen Science,* 30 CONSERVATION BIOLOGY 447, 448 (2016) (finding that citizen science raised concerns over data quality). *See e.g.*, Margaret Kosmala et al., *Assessing Data Quality in Citizen Science*, 14 FRONT. ECOL. ENVIRON. 551, 558 (2016) (discussing methods to address concerns about citizen science). *See also* Michael F Goodchild & Linna Li, *Assuring the Quality of Volunteered Geographic Information*, 1 SPAT. STAT. 110, 111 (2012) (finding citizen science contributed to the scientific community).

144. Ria Follett & Vladimir Strezov, *An Analysis of Citizen Science Based Research: Usage and Publication Patterns*, 10 PLOS ONE e0143687 (2015).

145. Jylana L. Sheats et al., *FEAST: Empowering Community Residents to Use Technology to Assess and Advocate for Healthy Food Environments*, 94 J URBAN HEALTH 180–89 (2017); Abby C. King et al., *Maximizing the promise of citizen science to advance health and prevent disease*, 119 PREV. MED 44–47 (2019).

146. NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE, LEARNING THROUGH CITIZEN SCIENCE: ENHANCING OPPORTUNITIES BY DESIGN, 44–45 (Rajul Pandya et al. eds., 2018) (ebook).

Another effective method of participation in scientific progress is the ability to participate as research subjects. Citizens must be free to contribute to knowledge growth by volunteering in research. From their involvement in the studies, scientists can produce data and eventually scientific knowledge. Needless to say, research must be respectful of the right of study participants, carried out responsibly, and produce beneficial outcomes.[147]

In sum, the right to contribute to scientific research protects citizens' freedoms to participate in scientific progress as citizen-scientists or research subjects.

4. Right to Participate in Science Policy Decision-Making

The right to participate in scientific progress also includes the right to participate in science policy decision-making. According to General Comment No. 25, "the right of everyone to take part in cultural life includes the right of every person to take part in scientific progress and in decisions concerning its direction."[148] The General Comment elaborates further:

> Some decisions concerning the orientation of scientific research or the adoption of certain technical advancements, should be subjected to public scrutiny and citizen participation. As far as possible, scientific or technological policies should be established through participatory and transparent processes and should be implemented with accompanying transparency and accountability mechanisms.[149]

The participation of the public in policymaking is one aspect of public engagement. Public engagement methods may involve one-way communication (uni-directional methods) or two-way communication (bi-directional).[150] According to Tina Nabatchi1 and Lisa Blomgren Amsler:

> One-way communication is the unidirectional flow of information from a sender to a receiver. Typically, the direction is from the administrator to citizens (e.g., through websites, social media, pamphlets, and similar mechanisms), though sometimes it may be from a citizen to an administrator (e.g., through "customer" or "client" surveys). Two-way communication is the bidirectional flow of information among individuals who act as both senders and receivers. This communication mode is found in traditional public meetings, hearings, and focus groups, as well in most online activities.[151]

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147. *Recommendation on Science and Scientific Researchers*, *supra* note 23, § 85(9).

148. General Comment No. 25, *supra* note 1, para. 10.

149. *Id.* at para. 55.

150. Tina Nabatchi & Lisa Blomgren Amsler, *Direct Public Engagement in Local Government*, 44 THE AM. REVIEW OF PUB. ADMIN. 73S (2014).

151. *Id.*

Gene Rowe and Lynn J. Frewer have cataloged the "most formalized public participation methods" as follows; referenda, public hearings/inquiries, public opinion surveys, negotiated rulemaking, consensus conference, citizen jury/panel, citizen/public advisory committee, focus groups.[152] The "the right of every person to take part in scientific progress and in decisions concerning its direction"[153] clearly goes beyond uni-directional methods of engagement, such as fostering civic engagement in science policy and public outreach initiatives. These methods help the public benefit from science but not take part in it.[154] To "take part," the public must be consulted and heard and, in the best case, become a co-producer of science policy. The methods to ensure participation of the public in science policy are thus directional and purposeful. They include public consultation (*e.g.*, asking the public for input, feedback, or recommendations), public deliberation (*e.g.*, involving the public in a way that it can contribute to forming a shared understanding of the issues and meaningfully influence the outcome), and other forms of sustained involvement of the public in policymaking (*e.g.*, granting permanent or semi-permanent law representation on advisory committees).[155] The right to participate in science decision-making applies, among other things, to publicly funded research programs, initiatives that touch upon controversial issues or affect specific populations.[156]

It is important to note that public participation also serves another human rights goal: self-determination. Self-determination, which is codified in Article 1 of the ICESCR, is mentioned in General Comment No. 25 in the context of indigenous peoples' rights over traditional knowledge[157] and the right of "peasants" vis-à-vis the right to food.[158]

In sum, no matter what the chosen method is, Article 15 gives the public a right to a meaningful opportunity to provide input to develop policies and programs with real potential to help shape the decision or action.

C. The Right to Benefit from Scientific Progress

The third cluster of rights under the larger umbrella of the right to science is the right to benefit from scientific progress. This right can be conceptualized in four second-level rights: the right to access scientific knowledge; the right to access existing applications of scientific progress; the right to the development of new applications of scientific progress; and the right

152. Gene Rowe & Lynn J. Frewer, *Public Participation Methods: A Framework for Evaluation*, 25 SCI. TECHNOL. HUM. VALUES 3, 8–9 (2000).

153. General Comment No. 25, *supra* note 1, para. 10.

154. *See infra* Section III.C.

155. Gene Rowe & Lynn J. Frewer, *A Typology of Public of Engagement Mechanisms*, 30 SCI. TECHNOL. HUM. VALUES 251, 254 (2005).

156. Community advisory boards in the context of clinical trials are an example of a public participation mechanism. *See* L. E. Cox et al., *Community Advisory Boards: Their Role in AIDS Clinical Trials. Terry Beirn Community Programs for Clinical Research on AIDS*, 23 HEALTH SOC. WORK 290, 290–97 (1998); Godwin Pancras et al., *How do Community Advisory Boards Fulfil Their Ethical Role in HIV Clinical Trials? A Protocol for a Systematic Review of Qualitative Evidence*, 10 BMJ OPEN (2020), https://bmjopen.bmj.com/content/bmjopen/10/4/e035368.full.pdf; Andrea DeLuca et al., *The Evolving Role of Advocacy in Tuberculosis*, 2 LANCET RESPIRATORY MED. 258, 258–59 (2014) (providing an example of publically funded research regarding tuberculosis).

157. General Comment No. 25, *supra* note 1, para. 40.

158. *Id.* at para. 64.

to policies based on scientific evidence. These second-level rights are rather heterogeneous, creating entitlements that touch upon different aspects of how science benefits humankind. Nevertheless, the thread that links them together is the fact that these entitlements enable citizens, individually and collectively, to "consume" science in a way that benefits them directly or indirectly. These benefits are enjoyed when scientific progress and application are appreciated and accessed and when regulatory frameworks let scientific progress flourish.

1. Right to Access Scientific Knowledge and Outputs

The right to access scientific knowledge and outputs is a second-level right essential to the enjoyment of scientific progress.[159] Without access to scientific knowledge, the right to benefit from scientific progress cannot be fully realized. In her 2012 report, the Special Rapporteur on Cultural Rights acknowledged that this second-level right "is pivotal for the realization of the right to science."[160] It is embedded in the concept of "diffusion of science," codified in Article 15.[161] General Comment No. 25 discusses access to scientific knowledge in the context of "availability" and the positive obligation to "disseminate" science.[162] "Availability is linked to the obligation of States parties to take steps for the conservation, the development and the diffusion of science. Thus, availability means that [] scientific knowledge and its applications are protected and widely disseminated."[163]

Access to scientific knowledge is also essential to the "development" of science. Without the circulation of data and knowledge among scientists, science could not advance.[164] The 2017 UNESCO Recommendation further states that access to knowledge is "[a] social and ethical requirement for human development [and] essential for realizing the full potential of scientific communities worldwide."[165] However, this aspect of knowledge access is better safeguarded as a right to science secured by the first-level right to scientific progress.

The entitlement to access scientific knowledge and outputs is at the core of this right. The positive claims associated with this entitlement are framed in General Comment No. 25 as governmental duties.[166] According to the instruments, State parties must "eliminate laws, policies and practices that unjustifiably limit access by individuals or particular groups to facilities, services, goods and information related to science [and] scientific knowledge" is a core obligation for States.[167] Furthermore, "[s]tates must exert every effort to ensure equitable and open access

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159. Yotova & Knoppers, *supra* note 15, at 681 (finding that "defining the right to benefit from science as a right to access science" is a "detectable and growing trend").

160. Shaheed, *supra* note 18, para. 27.

161. General Comment No. 25, *supra* note 1, para. 3.

162. *Id.* at para. 15–16. The terms "disseminate" or "dissemination" appear 14 times in the document. *Id.*

163. *Id.* at para. 16.

164. *See* Yotova & Knoppers, *supra* note 15, at 685–90; Theresa L. Harris & Jessica M. Wyndham, *Data Rights and Responsibilities: A Human Rights Perspective on Data Sharing*, 10 J. EMPIRICAL. RES. HUM. RES. ETHICS 223, 334–37 (2015).

165. *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 18(b).

166. General Comment No. 25, *supra* note 1.

167. *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 52.

to scientific literature, data and content,"[168] particularly for "[r]esearch findings and research data funded by States . . . ."[169] State parties must also "eliminat[e] censorship or arbitrary limitations on access to the Internet, which undermines access to and dissemination of scientific knowledge . . . ."[170] Traditionally, the public has accessed scientific knowledge by visiting libraries, websites, and other knowledge commons that offer public access.[171] Notably, General Comment No. 25 requires states to "promote open science and open source publication of research" as a less traditional mechanism of access to scientific knowledge. Expanding open science is the subject of an initiative led by UNESCO. In November 2021, UNESCO adopted a recommendation on open science.[172] The draft recommendation defines "open science" as:

> [A]n umbrella concept that combines various movements and practices aiming to make scientific knowledge, methods, data and evidence available and accessible for everyone, increase scientific collaborations and sharing of information for the benefits of science and society, and open the process of scientific knowledge creation and circulation to societal actors beyond the institutionalized scientific community.[173]

As the definition suggests, open science is intended to benefit both the scientific enterprise and society. It is therefore relevant to all three first-level rights, namely the right to scientific progress, to participate in scientific progress, and to benefit from scientific progress. One of the pillars of open science is open access, which is defined as a user's ability "to gain full and immediate access to and unrestricted use of scientific outputs including scientific publications, data, software, source code and protocols, produced in all parts of the world, free of charge to the user and re-usable."[174] Open access facilitates access to scientific knowledge both by scientists and nonscientists, as highlighted by the recommendation's demand for "permanent and unrestricted access" by the public to open science infrastructures.[175] More generally, the public is considered an essential stakeholder of open science, and the recommendation calls for the open engagement of societal actors.[176]

Having discussed the normative content for the right to access scientific knowledge and outputs, the analysis now turns to the definition of "scientific knowledge and outputs." Scientific knowledge is not defined in either General Comment No. 25 or the UNESCO recommendations. So, what is scientific knowledge?[177] At a basic level, knowledge is a form of

168. *Id.* at para. 49.

169. *Id.* at para. 16.

170. *Id.* at para. 42.

171. *See* Charlotte Hess, *The Unfolding of the Knowledge Commons*, 8 ST ANTONYS INT. REV. 13–24 (2012); Katherine J. Strandburg et al., *The Knowledge Commons Framework*, GOV. MED. KNOWL. COMMONS 9–18 (2017).

172. UNESCO General Conference, 41st Sessions, Summary Debate of the Natural Sciences and Intergovernmental Oceanographic Commission, https://www.unesco.org/sites/default/files/medias/fichiers/2021/11/15Nov_2nd%20meeting_SC_SoD_En.pdf (last visited Nov. 19, 2021).

173. *UNESCO Recommendation on Open Science*, *supra* note 26, para. 8.

174. *Id.* at para. 9(i).

175. *Id.* at para. 9(iv).

176. *Id.* at para. 9(vii).

177. The definition of science adopted by international legal instruments is discussed at the outset of the article.

cognitive success. We "know" when we can make sense of information. Scientific knowledge concerns data and information generated within the sciences. Leaving aside the demarcation issues between science and other forms of knowing, what is important here is to stress that knowledge becomes "scientific" when published after peer-review.[178] The golden standard of the scientific community, peer review, is incorporated in UNESCO's definition of science—"validation through sharing of findings and data and peer review" is constitutive of science.[179] It is a gateway to scientific publications entering the scholarly record, therefore qualifying as "scientific knowledge."[180] Without validation, ensured by peer review, there is no scientific knowledge. However, an exclusive focus on peer-reviewed publications may be too narrow as we are dealing with access to knowledge by the public (access of scientists falls under the first-level right to scientific progress). While refereed publications—books, journals, conference proceedings, and others— are the primary vehicles of scientific knowledge circulation, the public can access scientific knowledge published in non-refereed publications, such as those summarizing or popularizing knowledge. While this is not scientific knowledge in a formal sense, from a substantive perspective, it is. Accessing a non-refereed but accurate and jargon-free account of science helps the public digest scientific knowledge and thus constitutes an opportunity to access scientific knowledge and outputs. Science outreach contributes to the realization of this right. Access to technical and non-technical knowledge is not mutually exclusive, and governments should strive to guarantee both.

In addition to knowledge, the public is entitled to access "scientific outputs," which UNESCO defines as "original scientific research results, raw data and metadata, software, including source code, source materials, digital representations of pictorial and graphical materials and scholarly multimedia material."[181] Even peer-review publications may not convey all information relevant to access the *full* knowledge behind a publication. For instance, journal articles are typically limited to a certain word count, even in a digital format. Further, they may not provide a full account of the methodology used to achieve those results, and raw data may not be available. While few nonscientists may fully appreciate how these "outputs" contribute to scientific progress, access to them is necessary for the public to enjoy the benefits of scientific progress. It is important to note that the entitlement to access scientific knowledge and outputs is closely related to and arguably dependent upon the entitlement to scientific literacy. The public must be equipped with the skills and knowledge necessary to make sense of scientific knowledge to enjoy access to them.

In sum, the right to access scientific knowledge and outputs entitles the public to retrieve published scientific studies, non-refereed publications that deliver quality scientific information to nonscientists, and additional data and information produced by scientists during their research.

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178. To be noted that scientific evidence in the legal field is not always peer reviewed as many law journals do not use peer review.

179. *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 1(a)(i).

180. This approach to constructing scientific evidence will come handy later in the article, where I discuss the use of the "best available scientific evidence" in decisionmaking and the role that non-peer-reviewed scientific outputs may play. *See infra* at III.C.4.

181. *UNESCO Recommendation on Open Science*, *supra* note 26, para. 9(i).

2. Right to Existing Applications of Scientific Progress

The right to benefit from scientific progress incorporates the second-level right to access its existing applications. General Comment No. 25 defines "applications" as "the particular implementation of science to the specific concerns and needs of the population."[182] Applications include "the technology deriving from scientific knowledge, such as the medical applications, the industrial or agricultural applications, or information and communications technology."[183] The concept of "benefits" also incorporates that notion of applications as it "refers first to the material results of the applications of scientific research, such as vaccinations, fertilizers, technological instruments and the like."[184]

An entitlement to access the existing applications of scientific progress is linked to the duty, listed in Article 15(2), to "take steps to achieve the full realization of the right to science including those necessary for the . . . diffusion . . . of science." General Comment No. 25 explains that this means that "States must take positive steps for [] the protection and dissemination of scientific knowledge and its applications (conservation and diffusion)."[185] Thus, diffusion includes an entitlement to access applications in existence, on the market or about to enter the market. This entitlement primarily triggers the duty to remove barriers that might prevent or hinder access. General Comment No. 25 mentions on several occasions the responsibility of governments to identify and remove such barriers:

> States parties should ensure that everyone has equal access to the applications of science, particularly when they are instrumental for the enjoyment of other economic, social and cultural rights.[186]
>
> The duty to eliminate discrimination is a cross-cutting obligation that States should take into account when fulfilling all other obligations. For instance, the duty of States to take steps for the development and the diffusion of science (art. 15 (2)).[187]
>
> The duty to combat discrimination on those grounds has implications for the design and implementation of all policies related to the right to participate in and to enjoy the benefits of scientific progress and its applications.[188]
>
> [A national] plan of action should include, inter alia: measures to facilitate access without discrimination to the applications of scientific progress, especially when these applications are needed for the enjoyment of economic, social and cultural rights.[189]

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182. General Comment No. 25, *supra* note 1.
183. *Id.* at para. 7.
184. *Id.* at para. 8.
185. *Id.* at para. 14.
186. *Id.* at para. 17.
187. *Id.* at para. 26.
188. General Comment No. 25, *supra* note 1, para. 27.
189. *Id.* at para. 87.

Non-discrimination is a general principle that applies to all rights recognized in the ICESCR,[190] and it applies to accessing existing applications.[191] It is worthwhile, though, to point out two aspects of discrimination particularly salient in connection with technology. First, applications may be developed in ways that are biased against certain groups or populations.[192] As a result, these applications may be less beneficial to these groups or populations than to the general population, non-beneficial, or even harmful. Think, for instance, about drugs that are developed mainly by testing a male population and, therefore, do not take sufficient account of side effects on female patients.[193] Second, unequal access may be rooted in economic conditions. Many technologies are accessible only to those who can pay, and not everyone can afford them. Governments can undoubtedly play a role in facilitating access to these technologies. Often the problem relates to the recognition of intellectual property rights that, while incentivizing innovation, may be an obstacle to its enjoyment. Balancing intellectual property rights with human rights is a thorny issue that exceeds the scope of this article.[194] Here, it suffices to say that the CESCR in General Comment 17 concluded that intellectual property rights are not human rights, and they can be distinguished from the human right to benefit from the "protection of the moral and material interests of the author" recognized in Article 15, paragraph 1(c) of the ICESCR.[195] Whereas human rights are "timeless expressions of fundamental entitlements of the human person," intellectual property rights "are generally of a temporary nature, and can be revoked, licensed or assigned to someone else."[196] After mentioning General Comment 17, General Comment No. 25 acknowledges that "intellectual property can negatively affect the advancement of science and access to its benefits"[197] and stresses that:

> States should make every effort . . . to guarantee the social dimensions of intellectual property, in accordance with the international human rights obligations they have undertaken. A balance must be reached between intel-

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190. ICESCR, art. 2(2) ("The States Parties to the present Covenant undertake to guarantee that the rights enunciated in the present Covenant will be exercised without discrimination of any kind as to race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status.").

191. Non-discrimination applies also to other rights discussed in this article that include access entitlements.

192. A growing body of scholarship addresses the issue of algorithmic bias. David Danks & Alex John London, *Algorithmic Bias in Autonomous Systems.*, 17 4691–4697 (2017); Shahriar Akter et al., *Algorithmic bias in data-driven innovation in the age of AI*, 60 INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT 102387 (2021); Megan Garcia, *Racist in the Machine: The Disturbing Implications of Algorithmic Bias*, 33 WORLD POLICY JOURNAL 111–17 (2016).

193. For evidence of gender bias in clinical trials, see, e.g., K. Ramasubbu, H. Gurm & D. Litaker, *Gender Bias in Clinical Trials: Do Double Standards Still Apply?*, HTTPS://HOME.LIEBERTPUB.COM/JWH (2004), https://www.liebertpub.com/doi/abs/10.1089/15246090152636514 (last visited Dec 16, 2021); María Santos-Casado & Adela García-Avello, *Systematic Review of Gender Bias in the Clinical Trials of New Long-Acting Antipsychotic Drugs*, 39 JOURNAL OF CLINICAL PSYCHOPHARMACOLOGY 264–72 (2019); M. Alonso-Moreno, M. Ladrón-Guevara & P. Ciudad-Gutiérrez, *Systematic review of gender bias in clinical trials of monoclonal antibodies for the treatment of multiple sclerosis*, NEUROLOGÍA (2021), https://www.sciencedirect.com/science/article/pii/S0213485321000086 (last visited Dec 16, 2021).

194. *See* AURORA PLOMER, PATENTS, HUMAN RIGHTS AND ACCESS TO SCIENCE (2015).

195. Comm. on Econ., Soc. and Cultural Rts., Gen. Comment No. 17: The Right of Everyone to Benefit from the Protection of the Moral and Material Interests Resulting from any Scientific, Literary or Artistic Production of Which He or She is the Author, 35th Sess., para. 3, U.N. Doc. E/C.12/GC/17 (Jan. 12, 2006).

196. *Id.* at para. 2.

197. General Comment No. 25, *supra* note 1, para. 60.

> lectual property and the open access and sharing of scientific [] applications, especially those linked to the realization of other economic, social and cultural rights, such as the rights to health, education and food . . . [I]ntellectual property is a social product and has a social function and consequently, States parties have a duty to prevent unreasonably high costs for access to essential medicines, plant seeds or other means of food production, or for schoolbooks and learning materials, from undermining the rights of large segments of the population to health, food and education.[198]

These statements support the conclusion that whenever intellectual property rights are a barrier to the enjoyment of the benefits of scientific progress, they must be not granted or able to be limited, or even revoked, to ensure everyone's access to the applications.

3. Right to the Development of New Applications of Scientific Progress

The public is also entitled to the development of new technologies. The right to new applications of scientific progress amounts to an entitlement to have scientific knowledge translated in applications whenever these applications are beneficial. That the applications be "beneficial" is a multifaceted requirement. At minimum, applications must contribute to scientific progress goals protected in international law (well-being, peacebuilding, social progress) without being harmful; that is, they should not violate human dignity and other human rights.[199] This aspect calls into play risk assessment; the beneficial nature of a technology must be assessed and supported by data. In drug development, evidence of both efficacy and safety is needed before a drug can be marketed.[200] More generally, General Comment No. 25 indicates that the precautionary principle is an acceptable method to conduct this assessment.[201] Finally, what is "beneficial" must also be the result of a political judgment. General Comment No. 25 indicates that governments must prioritize the development and diffusion of applications instrumental to enjoying other rights recognized in the ICESCR.[202] This interpretation is consistent with the broader international legal framework linking science and its protection to human progress.[203]

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198. *Id*. at para. 62.

199. U.N. Charter art. 1, 55; General Comment No. 25, *supra* note 1, para. 6.

200. Mwango Kashoki et al., *A Comparison of EMA and FDA Decisions for New Drug Marketing Applications 2014–2016: Concordance, Discordance, and Why*, 107 CLINICAL PHARMACOLOGY THERAPEUTICS 195, 198–99 (2020) ("We observed remarkable similarity in the basic scientific and data interpretation issues raised by the FDA and the EMA during reviews of the same applications.)".

201. General Comment No. 25, supra note 1, paras. 56–57. The precautionary principle is the subject of an extensive literature in science policy and the philosophy of science. A common critique is that, while conceptually adequate, the application of the principle to policy has resulted in an overly cautious approach with zero-risk tolerance. On the precautionary principle, alternative approaches include the principle of responsible innovation, permissionless innovation, and the innovation principle. *See* Thomas A. Hemphill, *The innovation governance dilemma: Alternatives to the precautionary principle*, 63 TECHNOL. SOC'Y 101381 (2020); Christian Munthe, *Precautionary Principle*, INTERNATIONAL ENCYCLOPEDIA OF ETHICS 1–10 (2020), https://onlinelibrary.wiley.com/doi/abs/10.1002/9781444367072.wbiee550.pub2 (last visited Apr. 5, 2021); Andrew Stirling, *Risk, precaution and science: towards a more constructive policy debate. Talking point on the precautionary principle*, 8 EMBO REPS. 309 (2007).

202. General Comment No. 25, *supra* note 1, para. 52.

203. CLAUDE, *supra* note 12, at 43.

If scientific progress can be translated into beneficial applications, then these applications must be developed, and governments owe a positive duty to ensure that it happens. General Comment No. 25 refers to this entitlement in the context of "availability" and the fulfillment of that obligation:

> Availability is linked to the obligation of State parties to take steps for the conservation, the development and the diffusion of science . . . State parties should direct their own resources and coordinate actions of others to ensure that scientific progress happens and that its applications and benefits are distributed and are available, especially to vulnerable and marginalized groups.[204]
>
> The obligation to fulfill is particularly important in creating and guaranteeing access to the benefits of the applications of scientific progress. States should use the maximum of their available resources to overcome hurdles that any person may face to benefit from new technologies or other forms of applications of scientific advancements. This is particularly relevant for disadvantaged and marginalized groups. Scientific progress and its applications should be, as far as possible, accessible and affordable to persons in need of specific goods or services. Knowledge about scientific progress and its applications should be made broadly available and accessible to the general public . . . .[205]

General Comment No. 25 also identifies as a core obligation the duty to "ensure access to those applications of scientific progress that are critical to the enjoyment of the right to health and other economic, social and cultural rights."[206] More broadly, this entitlement is linked to Article 15(2), as it is the right to access existing applications. "Diffusion" means that "[s]tates must take positive steps for . . . the dissemination of scientific knowledge and its applications."[207]

The right to the development of new applications is also intertwined with the duty to respect scientific freedom. In this case, it is the freedom to do applied science, translating foundational knowledge into applications.[208] The public is also entitled to have barriers to translating basic science into applications removed so that applications can become available to the public. A deficient legal framework or unwarranted recognition of intellectual property rights for foundational technologies may be an example of one of these barriers.[209] Finally, governments must protect from external threats those engaged in applied research and the marketing

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204. *Id.* at para. 16.

205. *Id.* at para. 47.

206. *Id.* at para. 52.

207. *Id.* at para. 14.

208. This is an area of clear overlap between this right to science and the rights of science and between the right benefit from and the right to scientific progress.

209. Andrea Boggio & Calvin W. L. Ho, *The Human Right to Science and Foundational Technologies*, 18 AM. J. BIOETHICS. 69 (2018); Andrea Boggio et al., *The Human Right to Science and the Regulation of Human Germline Engineering*, 2 CRISPR J. 134 (2019).

of applications. Some of these threats may be cultural or psychological, such as the misinformation caused by pseudoscience or science denial.[210] Vaccine hesitancy is a clear example of how misinformation may lead to segments of the public failing to access safe and beneficial applications of scientific progress.[211]

To summarize, the right to benefit from scientific progress includes the right to the development of new applications, that is, to technologies developed by applying scientific knowledge provided they are proven to be beneficial to the public.

4. Right to Policies Based on Scientific Evidence

The cluster of the "right to benefit from scientific progress" includes a third second-level right: the right to policies that reflect the "best available, generally accepted scientific evidence."[212] The public is entitled to policies and programs based on science, and governments must ensure that policies and programs are aligned with the best available generally accepted scientific evidence. General Comment No. 25 mentions this positive obligation on several occasions,[213] most notably as the common core obligation to "[a]dopt mechanisms aimed at aligning government policies and programs to the best available, generally accepted scientific evidence."[214] The principle of "scientific knowledge and integrity in decision-making" is also affirmed in the UNESCO Declaration of Ethical Principles in Relation to Climate Change, where it mandates that decisions "be based on, and guided by, the best available knowledge from the natural and social sciences" and "us[ing] the best available scientific knowledge and evidence in decision-making that relates to climate change issues."[215]

This right is more easily understood if the terms "best," "available," "generally accepted," and "aligned" are defined. General Comment No. 25 does not provide definitions. "Scientific knowledge" was defined earlier in this article as knowledge based on data and information generated within the sciences and published after peer review.[216] In this context, General Comment No. 25 aptly uses the term "evidence" rather than "knowledge." This choice can be understood as indicating that the scientific knowledge to be used in policymaking must be empirical, that is, factual or based on data. As we know from the discussion on scientific knowledge, evidence is "scientific" when validated by peer review, that it is published and formally

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210. General Comment No. 25, *supra* note 1, paras. 24, 42, and 52.

211. See, *e.g.*, Katherine Kricorian, Rachel Civen & Ozlem Equils, *COVID-19 vaccine hesitancy: misinformation and perceptions of vaccine safety*, 0 HUMAN VACCINES & IMMUNOTHERAPEUTICS 1–8 (2021); George Lăzăroiu, Ramona Mihăilă & Ludmila Braniște, *The Language of COVID-19 Vaccine Hesitancy and Public Health Misinformation: Distrust, Unwillingness, and Uncertainty*, 20 REVIEW OF CONTEMPORARY PHILOSOPHY 117–27 (2021); Virginia Morgan, Anna Auskova & Katarina Janoskova, *Pervasive Misinformation, COVID-19 Vaccine Hesitancy, and Lack of Trust in Science*, 20 REVIEW OF CONTEMPORARY PHILOSOPHY 128–38 (2021).

212. General Comment No. 25, *supra* note 1, paras. 52, 54, 65. One implied assumption is that the use of scientific evidence in policymaking is required only when policymaking involves facts scientifically studied. In these instances, governments must ensure alignment. In other cases, it is not a human rights requirement. *Id.*

213. *Id*. at paras. 52, 54, 82.

214. *Id.* at para. 52.

215. UNESCO, Declaration of Ethical Principles in Relation to Climate Change (2017).

216. To be noted that scientific evidence in the legal field is not always peer reviewed as many law journals do not use peer review.

entered in the scholarly record.[217] However, in a less technical sense, scientific evidence may become "available" even before peer review, as demonstrated by the success of preprint platforms, such as arXiv, bioRxiv, medRxiv, or SSRN, which have rapidly become a mainstream medium to circulate research output.[218] Should evidence published on these online platforms be considered "available" for the purposes of Article 15? Should policies and programs be aligned only with peer-reviewed evidence? A reasonable approach advocated in this article is that *ordinarily* pre-peer-review scientific outputs are not "available scientific evidence" because they lack the validation that only peer review guarantees, which, according to UNESCO, is constitutive science knowledge.[219] However, under *exceptional* circumstances, pre-peer review scientific outputs should be used to inform policy and provide robust policy learning mechanisms to adjust policies as evidence becomes "available" after peer-review.[220] This approach fits when no other evidence is available and, if preprints are ignored, policies could be otherwise based on no evidence. Policies adopted during the COVID-19 pandemic are an excellent example of the use of pre-peer review scientific outputs in policy and their superseding outputs once peer-reviewed evidence becomes available.[221]

Moving to the adjective "best," the term is a mark of a quality judgment. According to the norms of science, "best" evidence results from reproducible experiments. As Karl Popper noted, "non-reproducible single occurrences are of no significance to science."[222] An experiment is reproducible if a researcher different from the one that carried out the experiment to be reproduced can run the same experiment and reach the same conclusions.[223] The purpose is to test the internal validity (will a different researcher using the same methods achieve the same conclusions or modifying one controlling factor reach a different conclusion?) or external validity of the results (are the findings the same if the methods are used to study another population or environment?).[224] Ideally, policies are based on evidence from studies in which both internal and external validity have been verified. However, nowadays, reproducibility is often more an

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217. Jonathan P. Tennant et al., *A multi-disciplinary perspective on emergent and future innovations in peer review*, 6 F1000RES 1151 (2017) ("Traditionally, the function of peer review has been as a vetting procedure or gatekeeper to assist the distribution of limited resources.").

218. Simon J. Porter & Daniel W. Hook, *How COVID-19 is Changing Research Culture*, DIGIT. SCI., 1, 5 (2020).

219. *Recommendation on Science and Scientific Researchers*, *supra* note 23, para. 1(a)(i).

220. Claire A. Dunlop & Claudio M. Radaelli, *The lessons of policy learning: Types, triggers, hindrances and pathologies*, A MOD. GUIDE TO PUB. POL'Y (2020); Claire A. Dunlop, Edoardo Ongaro & Keith Baker, *Researching COVID-19: A Research Agenda for Public Policy and Administration Scholars*, 35 PUB. POL'Y ADMIN. 365, 371 (2020).

221. Yian Yin et al., *Coevolution of Policy and Science During the Pandemic*, 371 SCI. 128, 129 (2021) (showing that "policy documents in the COVID-19 pandemic substantially access recent, peer-reviewed, and high-impact science" and that "despite the volume of preprints, their impact in policy is rather limited because these preprint servers show consistently fewer policy citations than average").

222. KARL POPPER, THE LOGIC OF SCIENTIFIC DISCOVERY 66 (2005) http://strangebeautiful.com/other-texts/popper-logic-scientific-discovery.pdf.

223. KENNETH BOLLEN ET AL., *Social, behavioral, and economic sciences perspectives on robust and reliable science*, REPORT OF THE SUBCOMMITTEE ON REPLICABILITY IN SCIENCE ADVISORY COMMITTEE TO THE NATIONAL SCIENCE FOUNDATION DIRECTORATE FOR SOCIAL, BEHAVIOR, AND ECONOMIC SCIENCES 3–4 (2015).

224. Internal validity ensures that experimental results are a proper test of the hypothesis; external validity determines if the results are generalizable to different populations. For a thorough analysis of the variety of types and purposes of reproducibility, *see* Fiona Fidler & John Wilcox, *Reproducibility of Scientific Results*, THE STAN. ENCYCLOPEDIA OF PHIL. (Edward N. Zalta ed., Winter 2018 ed. 2018), https://plato.stanford.edu/archives/win2018/entries/scientific-reproducibility/ (last visited July 9, 2020).

aspiration than reality, with a significant number of studies not undergoing the test of reproducibility.[225] Even if reproducibility is reframed not as reproduced (the study underwent reproducibility tests) but reproducible (the authors have made available all tools necessary to reproduce their study), much "scientific evidence" in circulation would still be excluded from the reality of policymaking.[226] The movement towards open science, and greater data sharing, will reduce the problem over time, but we are years away from that moment.[227] Also, reproducibility is context-dependent, meaning that replication is neither necessary nor sufficient for establishing the validity of all research claims,[228] and it is not a well-established norm in various scientific disciplines.[229] An alternative account of "best" may be needed to supplement the standard for using scientific evidence in policymaking. "Best" could be construed in relative terms, that is, relative to the available evidence. When evidence from reproduced studies is not available, decisions should be aligned to the best evidence relative to the available evidence on a particular issue. Judgments of quality of evidence can be based on evaluating the methodology used to generate the evidence, its novelty (new evidence on understudied or new issues), and other considerations.

Finally, the evidence must be "generally accepted."[230] This expression may be interpreted as scientific consensus, which is present when the overwhelming majority of scientists agree that a hypothesis, group of hypotheses or a theory is true, that it is a "scientific fact." Consensus implies general agreement rather than unanimity.[231] Some level of contestation in scientific lit-

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225. This problem plagues the sciences: the lack of incentives to engage in the reproduction of studies, and the push to do new studies, results in very few studies being tested through reproduction. The literature on the so-called replication crisis or reproducibility crisis is vast, going back to a 2015 paper reviewing 100 studies in the field of psychology and finding that "[a] large portion of replications produced weaker evidence for the original findings." *See* Open Science Collaboration, *Estimating the reproducibility of psychological science*, 349 SCI. (2015), https://science.sciencemag.org/content/349/6251/aac4716 (last visited Mar. 5, 2021).

226. These comprise raw data and a set of instructions is provided explaining all steps used in the processing and analyzing the data.

227. Tsuyoshi Miyakawa, *No raw data, no science: another possible source of the reproducibility crisis*, 13 MOLECULAR BRAIN (2020).

228. Friedrich Steinle, *Stability and Replication of Experimental Results: A Historical Perspective*, REPRODUCIBILITY 39, 60 (2016), https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118865064.ch3.

229. Jeremy Freese & David Peterson, *Replication in Social Science*, 43 ANNU. REV. SOCIO. 147, 148 (2017); Jason Chin & Kathryn Zeiler, *Replicability in Empirical Legal Research*, 17 ANNU. REV. OF L. AND SOC. SCI. (forthcoming Oct. 2021) (Certain qualitative studies in the social sciences cannot be reproduced in a proper sense.).

230. This terminology is not foreign to the international law discourse. A "general practice accepted as law" under ICJ Statute, Art. 38.1.b is considered evidence of the existence of a norm of international customary law, one of the main sources of international legal obligations. However, the various ways in which a norm becomes generally accepted, is not relevant to interpret "generally accepted" in the context of scientific evidence. For the different ways in which international law construed "generally accepted." *See* Louis B. Sohn, *Generally Accepted International Rules*, 61 WASH. L. REV. 1073, 1073–74 (1986).

231. For instance, a review of studies on the scientific consensus around the hypothesis of anthropogenic climate change shows that 97 percent of climate scientists agree with the science that climate change is happening and that humans are contributing to it. *See* John Cook et al., *Consensus on consensus: a synthesis of consensus estimates on human-caused global warming*, 11 ENV'T RSCH. LETTERS (2016).

erature is expected and probably inevitable, but it is low whenever scientific consensus is reached. The residual level of contestation amounts only to "benign contestation."[232] There is no consensus if the contestation is a disagreement on core issues.[233]

A problem with interpreting "generally accepted" is that scientific consensus may not be formalized in consensus statements or consensus studies.[234] In such cases, a consensus might have to be reconstructed and become visible only after it has been painstakingly traced by analyzing scientific literature or surveying scientists. The textbook example is the scientific consensus that anthropogenic emissions are causing climate change.[235] Nevertheless, this is infrequent. In other cases, policymakers have commissioned consensus studies or relied on the recommendations of science advisory boards tasked with identifying areas of consensus among scientists.[236] However, this is not feasible in all situations.[237] Therefore, the meaning of "generally accepted" must be adapted to this reality and construed more broadly not to sacrifice the opportunity to align policies to valuable scientific evidence and frustrate everyone's right to benefit from scientific progress. An alternative approach that does not exclude the previous is to select evidence by assessing the process that has led to producing that evidence. Under this "methods-approach," scientific evidence is "generally accepted" when there is no disagreement among scientists that the assumptions, methods, and conclusions drawn from the evidence are correct. The emphasis is not on *what* is produced but *how* it is produced. Rather than focusing on the substance of scientific claims, a methods approach assesses the process followed by scien-

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232. According to Shwed and Bearman, this form of contestation results from everyday scrutinizing of generally accepted knowledge. *See* Uri Shwed & Peter S. Bearman, *The Temporal Structure of Scientific Consensus Formation*, 75 AM. SOCIO. REV. 817, 818 (2010). It is the expression of a fact "organized skepticism"—a core norm of science. *Id.* The distinction between "benign contestation" and "epistemic rivalries" is used by Shwed and Bearman to discuss scientific consensus. *Id.* They borrow the distinction from Kuhn's discussion of "normal science" and "revolutionary science" in *The Structure of Scientific Revolutions*. *Id.*

233. According to Merton, organized skepticism involves a "methodological and institutional mandate" in which scholars in a discipline collectively engage in the "detached scrutiny of beliefs in terms of empirical and logical criteria." *See* ROBERT KING MERTON, THE SOCIOLOGY OF SCIENCE: THEORETICAL AND EMPIRICAL INVESTIGATIONS 277 (Norman W. Storer ed.) (1973).

234. For a critical assessment of the use of consensus statements in policymaking, *see*, Camille La Brooy, Bridget Pratt & Margaret Kelaher, *What is the role of consensus statements in a risk society?*, 23 JOURNAL OF RISK RESEARCH 664–77 (2020); Liang Yao et al., *Discordant and inappropriate discordant recommendations in consensus and evidence based guidelines: empirical analysis*, 375 BMJ e066045 (2021).

235. Naomi Oreskes, *The Scientific Consensus on Climate Change*, 306 SCI. 1686 (2004) (analyzing 928 abstracts of peer-review publications on the topic and concluding that 75% of the abstracts accepted, either explicitly or implicitly, the consensus view, that 25% took no position on current anthropogenic climate change, and that no paper disagreed with the consensus position). Evidence of consensus has emerged from various approaches that include analyzing peer-reviewed climate papers, surveying members of the relevant scientific community, compiling public statements by scientists, and mathematical analyses of citation patterns. Cook et al., *Consensus on consensus: a synthesis of consensus estimates on human-caused global warming* (discussing the different approaches).

236. OECD, *Scientific Advice for Policy Making, The Role and Responsibility of Expert Bodies and Individual Scientists,* 21 OECD SCI., TECH. AND INDUSTRY POL'Y PAPERS 13–16, 20 (Apr. 20, 2015), https://www.oecd-ilibrary.org/content/paper/5js33l1jcpwb-en.

237. Consensus conferences are frequent within the scientific community to identify areas of consensus. They are much less frequent in connection of policymaking. For recent reflections on consensus conferences. *See* R. Norman Harden, Gary M. Reisfield & Rollin M. Gallagher, *Publishing Consensus Conference Proceedings: Can We Avoid Missed Opportunities While Effectively Managing Bias?*, 21 PAIN MED. 658 (2020); Asheley R. Landrum & Matthew H. Slater, *Open Questions in Scientific Consensus Messaging Research*, 14 ENV'T COMMC'N 1033 (2020).

tists to generate evidence and grounds policies on evidence that meets this standard.[238] Policymakers would still work with evidence not subject to epistemic contestation, which is ultimately the desirable outcome. This approach is functional when the scientific consensus is premature (*e.g.*, because the issue at stake has not been studied for enough years to generate the amount of evidence needed for scientists to agree on specific scientific "facts") or the issues are novel, unique to a small subset of a population, a small territory, or understudied.[239]

The last term to be interpreted is "alignment." According to the Oxford and the Cambridge dictionaries, to align means to "change something slightly so that it is in the correct relationship to something else"[240] or as "arrangement in a straight line."[241] According to these definitions, alignment means that two or more things are positioned in a straight line or parallel to each other, not crossing each other, not perpendicular, not pointing to opposite directions. Thus, a policy is "aligned with science" when two requirements are met: first, the policy and scientific evidence are in a relationship; second, the relationship is where policy and science converge on the same trajectory or parallel trajectories. To meet these policy requirements, policymakers must set up mechanisms to incorporate science in decision-making. Arrangements include scientific advisory councils, scientific advisory committees, interactions with national academies, learned societies and scientific networks, and chief scientific advisors.[242] Second, governments must ensure the policies and programs do not diverge from scientific evidence, that is, they do not ignore and contradict or scientific evidence. This is not to say that policies must reflect scientific evidence. Additional considerations, which may be ethical, economic, or political, may favor adopting policies that distance themselves from the scientific evidence. At any rate, the policy outcome can be considered to fully guarantee the public's enjoyment of scientific progress only if deliberations incorporate and adequately weigh the best available scientific evidence.[243]

In conclusion, the public is entitled to policies that align with the best available, generally accepted scientific evidence. Typically, evidence that qualifies underwent peer-review, meets specific scientific quality standards, and is not subject to epistemic contestation. Policymakers must ensure that such evidence is incorporated in developing policies and its outcomes align with such evidence.

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238. For a discussion of the relationship between methodology and evaluation of public policies, *see*, RAY PAWSON, THE SCIENCE OF EVALUATION: A REALIST MANIFESTO (2013), http://methods.sagepub.com/book/the-science-of-evaluation (last visited Dec 17, 2021).

239. Consensus materializes when the findings of a robust long wave of data production are not the subject of epistemic contestation, that is, there is no disagreement on core issues.

240. Cambridge Advanced Learner's Dictionary & Thesaurus, *alignment*, https://dictionary.cambridge.org/dictionary/english/alignment (last visited Dec 20, 2021).

241. Oxford Advanced Learner's Dictionary, *alignment*, https://www.oxfordlearnersdictionaries.com/definition/english/alignment?q=alignment (last visited Dec 20, 2021).

242. OECD, *supra* note 236, at 21. See also, J. Wilsdon, K. Allen & K. Paulavets, *Science Advice to Governments: diverse systems, common challenge* (*ICSU/Office of the Prime Minister's Chief Science Advisor, Auckland, N.Z.*, Working Paper 2014)*;* Jessica M. Wyndham et al., *The Right to Science*, *in* THE RIGHT TO SCIENCE: THEN AND NOW 211–30 (Helle Porsdam & Sebastian Porsdam Mann eds., 2021).

243. This is delicate and controversial. An in-depth analysis, which would certainly require discussing the general limitations to economic, social and cultural right codified in Article 4 of the ICESCR, exceeds the scope of this article.

IV. Conclusions

The right to participate in and to enjoy the benefits of scientific progress and its applications is a complex right that is better conceptualized as the sum of three clusters of rights (first-level rights), each containing several rights in turn (second-level rights). The three first-level clusters of rights are the right to scientific progress, the right to participate in scientific progress, and the right to benefit from scientific progress. This article offers a conceptual map to order the multiplicity of rights, entitlements, and freedoms involved (and some of the corresponding duties) that exist under the general umbrella of the "right to science." This conceptual work expands the current understanding of Article 15 and is helpful not only to clarify its normative content but also to build the foundations of the other elements of the right, particularly state duties, monitoring, and accountability for violations.

The various rights under the umbrella of the right to science, while conceptually distinct, are intertwined. There can be no participation in or benefit from scientific progress if the right to scientific progress is not realized. Meaningful public participation is intended to shape both the scientific enterprise and scientific progress and the resulting benefits of scientific progress. The right to benefit from scientific progress, while conceptually last, is the driving force behind Article 15. Science must not stay within the scientific enterprise's confines; it must be shared with the public to advance everyone's peace and well-being. Now that the right to science has been awakened and further developed by the international bodies, the challenge is to ensure that it is realized, that is, that scientific progress happens, and that its benefits are shared globally.