



Final Statement on Basic science for human development, peace, and planetary health

2022 Plenary Session



Abstract

The 2022 Plenary of the Pontifical Academy of Sciences explored and highlighted the driving forces and opportunities related not just to basic science per se, but to basic science for human development, peace and planetary health. The topic is also timely in view of the United Nations' "International Year of Basic Sciences for Sustainable Development".

There are certain key areas where basic science is going to improve human welfare directly, such as medicine, food systems, energy and more. Progress is also happening in interdisciplinary science building on strong basic science, such as: Mathematics and AI; Astronomy; Physics and Biophysics; Climate Science; Chemistry / Bio-Chemistry; Life Sciences and Medical Science.

The fact that important discoveries do not come about because of a goal, but because of curiosity and imagination as a result of wonder and admiration, raises philosophical, ethical, religious, and science policy questions. We thus noted the importance and benefits of long-term perspectives in science, and called for society – including faith-based communities – and policy to recognize and more strongly support basic sciences.

We emphasize that it is ever more important for science to have peace as a goal. As scientists, we must neither neglect the fundamental drivers of conflicts, nor ignore the role of science.

The Pontifical Academy of Sciences remains concerned about neglect or ignorance of science-informed rational arguments and science skepticism in parts of the general public and in conventional and social media.

The abovementioned powerful contributions of basic science and its related capacities need to be shared more equitably – especially by the rich nations – with low-income regions of the world.

1. First of all, let us clarify the concepts embedded in the Plenary theme “*Basic science for human development, peace, and planetary health*”:

- *Human development* is understood here as the process of enhancing people’s and communities’ freedoms, capabilities, and opportunities, improving their physical, mental, and social well-being, so to achieve their aspirations.
- *Peace* is, first and foremost, the absence of wars and violent conflicts, but there is more to it: it includes overcoming divisiveness, racism, nationalism, and growing inequalities often combined with crime, human trafficking, and marginalization. Promoting justice, cooperation and peace in the world requires a science that seeks the truth, considers potential misuses, and is free from ideologies.
- *Planetary health* means the health of human civilization and the state of the natural systems which sustain it, recognizing that all life, not just human life, depends on the state of the biosphere and geosphere and their interdependence. Examples of disequilibria are self-destructive lifestyles, pandemics, climate change, loss of biodiversity, devastation of ecosystems and of natural beauty.
- *Basic research* advances fundamental knowledge and is a source of new scientific ideas and ways of thinking. It is often curiosity-driven, truth-seeking and questioning of established theories.

At first glance, the three goals – human development, peace, and planetary health – and the values underpinning them, do not seem related to basic science, because that type of science is driven by epistemic interest rather than the need to solve practical problems. Yet, in the long term, basic sciences often become the foundation for applied science and technological innovations. Moreover, there are indications that the transformation of new basic knowledge to societal applications has been progressing more rapidly in recent years.

2. The 2022 Plenary of the Pontifical Academy of Sciences explored and highlighted the driving forces and opportunities related to *basic science for human development, peace and planetary health* by addressing the following questions: What are the new and emerging breakthroughs in the sciences? How did these science breakthroughs come about? How can these discoveries instruct new, better and more effective ways to reduce the threats and problems for people, peace, and planet? The first two questions address processes intrinsic to science. The third concerns the translation of knowledge, which is a major challenge that we must also engage in. Emphasis on basic sciences with a human and planetary health perspective is very much in line with the

Academy's Statute, "The aim of the Pontifical Academy of Sciences (PAS) is to promote the progress of the mathematical, physical and natural sciences and the study of epistemological problems related thereto", and the PAS "...promote(s) the progress of sciences and the solution of important scientific-technical problems, which are fundamental for the development of mankind".

3. **The theme of the 2022 PAS Plenary, "Basic science for human development, peace, and planetary health", is timely in view of the United Nations' "International Year of Basic Sciences for Sustainable Development"** that has just started on the basis of topics identified as priorities by UNESCO and the United Nations. The PAS is committed to continuing its close cooperation with the UN in fields of science and related policy consultations, as we have done in the recent past on climate, food, biodiversity, pandemic, universal health care, and other issues.

4. **There are certain key areas where basic science is going to improve human welfare directly, such as medicine, food systems, energy and more.** Many of the main disciplines of science are involved in those areas. The progress and prospects of basic science related to those areas are crucial and clearly timely. Moreover, basic science is of intrinsic value. Its insights lead to deeper understanding, knowledge and possibly wisdom. Science's search for the truth remains fundamentally important. The PAS has held conferences and published science-informed statements urging to address issues such as the massive health problems caused by the pandemic and by inadequate health systems, the large-scale destruction of nature and the loss of biodiversity, the climate crisis, the opportunities and risks of artificial intelligence, rising inequalities, hunger and poverty, and increasing local and global conflicts. We were able to identify specific science opportunities to address these problem areas, emphasizing the opportunities of advancing the sciences in each of these fields, as well as the need to expand interdisciplinary research.

5. **We explored patterns in the progress of basic science insights in different disciplines and interdisciplinary linkages.** The conference discourse included voices of scientists on the challenges they faced in order to understand the very basic aspects of a given problem. Examples came from cutting-edge science like genetic modification (CRISPR-cas), quantum and laser physics, atmospheric science, mathematics (new algorithms) and astrophysics. The PAS Plenary 2022 addressed topics at the forefront of science in key areas that change world views and have the *potential to improve human development, peace, and planetary health*. The following are some of these highlights that should not be seen in isolation, but as a growing opportunity for cooperation among disciplines:

- **Mathematics and AI** addresses intrinsic insights from mathematics as well as the opportunities for new applications, e.g. mathematics of AI, and using AI to accelerate scientific discovery. DeepMind's AlphaFold algorithm has already had a disruptive effect on disciplines that are dependent on protein structure and it will likely have similar transformational effects in diverse fields including weather and climate forecasting, but also on behavioral science. If used

responsibly, AI has the potential to help with all of the aims of this Plenary Session – human development, peace, and planetary health. Teaching of mathematics and basic sciences in education systems needs to be intensified to tap these opportunities.

- **Astronomy** seeks to provide insights into the origin and evolution of stars, planets, galaxies (e.g. via galaxy archeology) and even the Universe itself. As Immanuel Kant wrote: “Two things fill the mind with ever new and increasing admiration and awe, the more often and longer the reflection occupies itself with it: the starry sky above me, and the moral law within me”. Where do we come from? Are we alone? What is the future of our Sun and its solar system, and of the Milky Way, the galaxy of which we are part, which we now know has a supermassive black hole at its center? Do the known laws of physics hold under extreme conditions? These are some of the biggest questions that humankind can ask, appealing to deep cultural and philosophical yearnings. Society has advanced through the development of new technologies driven in part by astronomy. Because of its broad appeal, astronomy is a gateway science that nurtures inquisitiveness and curiosity in children and students of all ages. The collective body of data sets, often openly accessible to the entire world for study purposes, trains scientists in the use of innovative big data and AI techniques that have their applications elsewhere in society. Astronomers also raise awareness and take actions to protect the dark and quiet skies, important for human culture, heritage and health, which are currently being threatened by urban artificial light pollution and swarms of satellites in space. Being able to view the pristine spectacle of the starry night sky is of fundamental value for every human being. We need technological developments that can serve both night light and satellite services on the one hand, and provide access to the view of the night sky on the other.
- The **Physics and Biophysics** science on the agenda considered both the large and the small. We saw how large-scale phenomena such as solar activity and its impact on earth need attention in areas such as climate, human health and infrastructure (e.g. electricity grid). As for the small, we examined how microscopy at molecular-scale resolution in fluorescence provides insights into molecules in living cells, offering new ways of disease detection; and we reviewed new pathways from protein folding to understanding viruses such as Covid-19 and designing new types of vaccines. Physics and biophysics have much to add to the understanding of biology and medicine through tools to observe and mechanically perturb molecular systems and, secondly, by developing new theoretical models and simulations for a more quantitative and predictive understanding of these processes.
- **Climate Science** critically relies on atmospheric, planetary, and ecological sciences. We also highlight the growing need to address adaptation and resilience to climate change in conjunction with mitigation, and with integral attention to loss of biodiversity and growing inequalities that make ever larger shares of the population vulnerable to climate stress and related health and food crises. Two of the solutions that came up were nature-based and climate-sensitive: for example, the building sector should adopt nature-positive materials as part of a circular bioeconomy approach; and urban designers should plan for climate change and pay close attention to transforming slum areas.

- **Chemistry / Bio-Chemistry** for human development, peace, and planetary health highlight innovation by evolution, bringing new chemistry to life, such as in food systems; brain organoids, that are stem-cell derived 3D cell culture models for human brain development, offer treatment of neurological disorders. The case of Uruguay exemplifies how science can and did make a huge difference during the pandemic by adopting science-informed approaches and cooperative engagement by health policy. Horizontal gene transfer in the context of a rich biodiversity as part of evolution was explained, in particular in relation to bacteria modification enzymes.
- **Life Sciences and Medical Science** are showcasing new opportunities for regenerating and rejuvenating aged tissues. Organ transplantation remains crucial for many diseases and is enhanced by scientific advances in immunology, organ repair before transplantation, and the emerging use of modified pig organs. Of similar importance are new insights into the causes of dementia from prion strains.

6. **The fact that important discoveries do not come about because of a goal, but because of curiosity and imagination as a result of wonder and admiration, raises philosophical, ethical, religious, and science policy questions.** Emphasizing these perspectives, this PAS Plenary Session featured a session in honor of H.E. Msgr. Marcelo Sánchez Sorondo, our esteemed former Chancellor, on the occasion of his shift to Emeritus, under the theme of science from a philosophical and religious perspective. We can relate to Aristotle, who said “It is through wonder that men now begin and originally began to philosophize; wondering in the first place at obvious perplexities, and then by gradual progression raising questions about the greater matters too, e.g. about the changes of the Moon and of the Sun, about the stars and about the origin of the universe”. “... therefore, if it was to escape ignorance that men studied philosophy, it is obvious that they pursued science for the sake of knowledge, and not for any practical utility” (Aristot. Met. 1.982 b 11-20). Aristotle pointed out another essential attribute of disinterested knowledge which is freedom: “Clearly then it is for no extrinsic advantage that we seek this knowledge; for just as we call a man free who exists for himself and not for another, so we call this the only free science, since it alone exists for itself” (Aristot. Met. 1.982b 28-30). The deliberations emphasized the key concepts of hope and the responsibility of the scientist. For sciences to flourish, scientists must enjoy scientific freedom: freedom of association, movement, and expression. This freedom is accompanied by responsibilities: to act with integrity; to uphold the values of science; to combat threats to science and scientific freedom; and to use scientific knowledge to benefit society. This is where ethical consultations between science and faith can be particularly valuable.

7. **We recognize the importance and benefits of long-term perspectives in science, and call for society, including faith-based communities, and policy to recognize and more strongly support basic sciences.** When emphasizing the importance of basic science, we are aware that there are also reasons to criticize the results of curiosity-driven investigations. And science must be transparent to the public at large: for example, it must be explained how it contributes to problem solving. Basic sciences are always at risk of being marginalized when crises, wars, and growing

insecurity occupy people's minds and divert resources to the mitigation of day-to-day problems, as is currently the case. However, science operates on long time scales and requires continuity. Certain issues such as climate, biodiversity, genetics, medicine, astrophysics and the analysis of intelligent systems, both natural and artificial, can only be pursued on time scales of decades, if not centuries. Still, science-informed actions on some of these challenges need to be taken now. We realize that the search for solutions to these existential societal challenges can come from advances in science. Therefore, paradoxically, curiosity-driven basic science needs to develop a stronger sense of urgency: we need more opportunity for inquisitiveness in the younger generation, fostered by vibrant educational systems that stimulate imagination. We note that strong support for curiosity-driven science has huge payoffs that often come about in unpredictable ways, mostly in the long term, but increasingly even in the short term. A fine example of what basic science can achieve is the rapid development of the COVID vaccine thanks to developments in the decade-long studies of messenger RNA, which were planned for completely different purposes.

8. It is ever more important for science to have peace as a goal. The PAS had already actively engaged in support of this goal at critical junctures in the past, such as addressing threats of nuclear war and, more recently, risks of artificial intelligence and robotics in warfare. The many ongoing armed conflicts, such as the Russian attack on Ukraine, wars in Tigray/Ethiopia and in Yemen and Syria, as well as many other armed conflicts inside and between countries, are of grave concern to us because they cause great suffering for civilian populations, particularly for women and children. We condemn all atrocities against civilians, war crimes and crimes against humanity, and we call for accountability and independent investigations into these crimes. We also call for unfettered humanitarian aid, access to basic services to civilians and lifting of sieges. As scientists, we must not neglect the fundamental drivers of conflicts, and not ignore the role of science in the arms race. We thus take this opportunity to re-emphasize our recent statement on "Preventing Nuclear War and War Against Civilian Populations: Also a Task for the Sciences".[1] The accelerated – and even global – risks that emerge from threats or actual attacks by powerful countries on their neighbors are putting political order and human civilization at risk. At a time when science is so dominant in culture, all scientific disciplines should consider their potential contributions to peace. Peace is a precondition for human development. Divisiveness, for instance related to ethnicity and race – not just absence of war – undermines both peace and planetary health. This is part of the rationale of our theme "Basic science for human development, peace, and planetary health".

9. The Pontifical Academy of Sciences remains concerned about neglect of science-informed rational arguments and science skepticism in parts of the general public, and in conventional and social media.[2] These issues have escalated in recent years. During the Plenary 2022 it became necessary to re-examine the determinants of these tendencies, and the role that religion may play in both adherence to science skepticism and openness to science. The Academy would like to emphasize the importance of science education in the pursuit of truth and in better understanding

societal developments. We note, however, that there is also well-informed, important skepticism about sometimes overlooked disconnections between science, technology, and their real-world impact, such as rebound effects of innovations and externalities. These require more attention in the research process. The PAS adheres to transparent science discourse open to the general public, and follows established science ethics. Indeed, PAS Academicians and their narratives on basic sciences can appeal to a broad audience, to show how science is done and what can come out of it, without neglecting risks of misuse. PAS Academicians are encouraged to do more in sharing their diverse narratives on what brought them to a certain invention, what their discovery means, and how curiosity, imagination, and efforts drove their work, including how they connect to the broad issues mentioned above, i.e. human development, peace, and planetary health. Science skepticism can also be channeled into productive discourse by engagement of science with ethicists over the introduction of new technologies. In that context and in general, scientists must work hard on a language that is understood and identified by most of the population to communicate the goods that science delivers.

10. The abovementioned powerful contributions of basic science and its related capacities need to be shared more equitably – especially by the rich nations – with low-income regions of the world. Otherwise, the benefits for human development, peace, and planetary health will not come about. Scientific institutions, including Academies of Sciences, need to further strengthen their mechanisms of sharing and engaging with political and societal actors worldwide.[3] Transcending countries, cooperation in science is not only important to facilitate large-scale science programs, but also in terms of inclusiveness: it allows us to understand and welcome cultural differences that are important for peace. Two-way consultations with society are beneficial, for instance between science and faith-based organizations, embracing value and moral issues, as we practice in the PAS.[4]

[1] 8 April 2022 https://www.pas.va/en/events/2022/preventing_nuclear_war.html

[2] <https://www.pas.va/en/publications/acta/acta25pas.html>

[3] See events and conferences at <https://www.pas.va/en/events/plenary-session.html> and <https://www.pas.va/en/events/workshop.html>

[4] See addresses by the Popes from Pope Benedict XV to Pope Francis 1914 – 2022 at <https://www.pas.va/en/magisterium/francis/2020-7-october.html>. And cf. *Papal Addresses to the Pontifical Academy of Sciences 1917-2000 and the Pontifical Academy of Social Sciences 1994-2000*, ed. Marcelo Sánchez Sorondo, PAS, Vatican City 2003; <https://www.pas.va/en/publications/scripta-varia/sv100pas.html>

