SCIENCE FOR PEACE

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Abstract

We discuss the role of science in connecting people from around the world, using the example of two leading scientific organisations, CERN in Geneva, Switzerland, and SESAME in Allan, Jordan. We argue that knowledge, technology, training and education, collaboration across borders and open science are crucial for a sustainable future for humanity and for the planet and for addressing today's global challenges. Over the past decade, the Edoardo Amaldi Conferences organised by Accademia Nazionale dei Lincei and the National Academy of Sciences, have provided an international Forum for the scientific community to discuss nuclear disarmament and non-proliferation issues, see Refs. 1 and 2 for the latest Conference Proceedings, accessible as open-source publications.

Keywords

Science, Technology, Peace, Collaboration, Training

Introduction

We are very pleased to have the opportunity to write about Science for Peace, by presenting two brilliant examples of successful international collaboration: European Organization for Nuclear Research (CERN), the European laboratory for particle physics based in Geneva, Switzerland, and SESAME, the Synchrotron-Light for Experimental Science and Applications in the Middle East, based in Allan, Jordan.

Science can play a key role in connecting people in today's fractured world because it is universal and unifying. Science is universal because it is based on objective facts and not on opinions. The laws of nature are the same everywhere on Earth, at any time in history.

Science is unifying because the quest for knowledge and the passion for understanding how nature works are aspirations and values that are shared by all humanity. Scientific knowledge has no passport, gender, race or political party. The heroes of our physics students, Einstein, Dirac, Fermi, Yukawa, Bose, Feynman, Landau, Yang, just to mention a few names, come from all over the world and are part of the heritage of all cultures.

This common heritage allows scientists from India and Pakistan or the United States and Iran to work together in experiments at CERN. Likewise, scientists from Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine, Türkiye and other countries collaborate in experiments at the SESAME facility in Jordan.

Another important role of science is related to the fast-growing technology and innovation in today's society. While these developments have mostly positive consequences in terms of progress, they bring with them the risk of exacerbating inequalities, hence contributing to political and social unrest and widening the gap between high- and low-income countries, the rich and the poor, those who have access to education and those who do not. Thus, open science (open-source software, open hardware, publishing in open-access journals, open data) and scientific education accessible to all play a crucial role in reaching out to the less privileged sections of humanity, thus contributing to capacity building and to reducing cultural and social gaps. Niels Bohr, a key figure of last century's physics, was among the first scientists to realise that sharing scientific discoveries could be a key step against the dangerous arms race started after Hiroshima and Nagasaki.

Last but not least, it is important that scientists contribute to the debates on the big societal and planetary challenges (e.g. the UN Sustainable Development Goals) by bringing facts and scientific evidence to the table. They should advocate for scientific development as the foundation of progress against science-sceptical trends. They should make governments and society aware of the consequences of the possible misuse of scientific knowledge and technology and contribute to the development of adequate policies (e.g., on the ethical use of artificial intelligence, nonproliferation of weapons, etc.). And they should promote discussion at the global level and multilateral approaches.

Scientific academies, in particular, can play a leading role in this context by bringing scientists, governments and policy makers together. Their impact is more significant when they join forces. CERN, the largest particle physics laboratory in the world, is a brilliant example of what science can do for peace.

CERNS's Role in/for Diplomacy

CERN is an intergovernmental organisation based on a treaty between Member States. Its primary mission is research in high-energy particle physics. Particle physics studies the elementary constituents of matter and the laws of the universe at the most fundamental level. Over the decades, research at CERN has led to great discoveries, for example, the Higgs boson in 2012, and to the award of Nobel Prizes to CERN scientists. CERN is also a driver of innovation as, to accomplish its ambitious scientific goals, it needs to build complex instruments in the fields of particle accelerators, particle detectors and computing infrastructure, and to develop cutting-edge technologies in various domains, from superconducting magnets to cryogenics, vacuum, robotics, big data, artificial intelligence, etc. These technologies are transferred to society with no profit, for the benefit of everybody's lives.

The most famous example of CERN's spin-off is the World Wide Web, which was developed at CERN in 1989 by Tim Berners-Lee and collaborators to facilitate the exchange of information among the Laboratory's scientists and was released in 1993 royalty-free for anyone to use and improve. Other CERN technologies find today important applications in medical imaging, cancer treatment and environmental protection.

The training of tomorrow's scientists and the scientific education of the general public are also part of CERN's mission and are achieved through a large number of initiatives that target, for instance, high-school students and teachers. Last but not least, and most relevant to this discussion, CERN is a concrete example of peaceful collaboration across borders, with its community of 17500 people from all over the world (more than 110 nationalities are represented).

CERN was founded in 1954, in the aftermath of World War II, on the initiative of visionary politicians and scientists with the twofold goal of bringing back scientific excellence to Europe after the war, counteracting the brain drain and promoting peaceful collaboration among European countries through science. Hence, the concept of "Science for Peace" is enshrined in CERN's foundations. The CERN Convention, which was signed in 1953 by 12 European countries under the auspices of UNESCO, states that "The Organization shall provide for collaboration in nuclear research of a pure scientific and fundamental character ... The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available...". Thus, CERN's Convention promotes scientific developments for peaceful applications ("no concern with work for military requirements") and open

science ("the results of its experimental and theoretical work shall be published or otherwise made generally available"), two extremely modern concepts whose spirit was already captured by CERN's founders (Maiani et al., 2020; Cotta et al., 2023).

The Convention also supports collaboration across borders ("the organization and sponsoring of international cooperation") and training and education ("the dissemination of information and the provision of advanced training for research workers").

Since its inception, CERN has played an important role in breaking political barriers, promoting in particular, collaboration between scientists from eastern and western countries during the period of the Cold War. The first scientific contacts between CERN and the Soviet Union were established in the early 1960s, and the first cooperation agreement between them was signed in 1967. According to this agreement, CERN would provide experimental equipment for a new accelerator being built at the Protvino laboratory in Serpukhov (near Moscow) and, in exchange, scientists from CERN Member States would participate in the scientific programme of the new accelerator. During the 1970s, several joint CERN-Soviet Union experiments were carried out at the Serpukhov facility and showed how scientific collaboration can surmount political obstacles even in a very tense international climate.

Today, CERN has 24 Member States and 10 Associate Member States (including Türkiye). Membership is not limited to European countries, Israel being one of the Member States. Big countries that are historical partners of CERN, namely the United States and Japan, are Observers to the CERN Council (the body that governs the Organisation). In addition, CERN has signed some 50 international cooperation agreements, most of them with low-income countries. For these countries, engagement with CERN is part of their efforts towards scientific and technological development and building a knowledge-based economy, as well as a channel to strengthen their relations with other countries. CERN's annual budget amounts to 1.2 billion Swiss francs, and the Member States contribute to it in proportion to their net national income. Non-Member States, such as the United States and Japan, contribute à la carte, i.e., through one-off contributions to specific projects. It should be emphasised that budget stability over the decades and international cooperation have allowed extremely ambitious projects to be realised that no single country could have afforded alone.

CERN currently operates the Large Hadron Collider (LHC), the most powerful accelerator ever built by humankind. It is housed in a 27-km ring, which lies 100 m underground, across the border between Switzerland and France. The LHC deploys the most advanced technologies in terms of e.g. superconducting magnets.

Operation started in 2010. Two beams of protons are accelerated in the two opposite directions of the ring up to the highest energies allowed by the technology and are brought into collision at four points of the ring, where four big experiments (ALICE, ATLAS, CMS and LHCb) have been installed in four huge underground caverns. The task

of the experiments is to detect and measure the product of the proton-proton collisions with high precision. The detectors are innovative instruments of spectacular size and complexity (ATLAS is about half the size of the Notre Dame Cathedral in Paris and CMS weighs twice as much as the Eiffel Tower).

Two years after start-up, on 4 July 2012, the ATLAS and CMS experiments reported the discovery of a new, very special particle, the Higgs boson. The Higgs boson is related to the mechanism that allowed the matter we are all made of to form in the early universe at the time of the Big Bang, some 13,8 billion years ago.

Over the past decades, experiments at the LHC and other CERN scientific facilities have contributed in a very important way to our understanding of the laws of nature at the most fundamental level. These and other great achievements would not have been possible without the contributions of scientists and engineers from all over the world. Today, some 17,500 people work at CERN. About 60% of them come from the Member States, some 2000 from the United State, and several hundred from Japan and China. Scientists and engineers from Türkiye, currently more than 180 people, have made very important contributions to CERN's scientific programme and technology developments over the decades. CERN also hosts scientists from low-income countries, and in this case, its mission is to build capacity and help these countries reduce the scientific and technological gap with other countries.

About 50% of the scientists working at CERN are younger than 40, and the CERN population is primarily composed of Ph.D. students and early-career scientists. At any given time, CERN is training 5500 young people, including physicists, engineers, IT professionals and technicians across a large spectrum of competences (superconducting materials, mechanical and electrical engineering, electronics, quantum technologies, etc.). Some 30% of these people remain in research in particle physics, whereas the others find jobs outside our fields: about 50% of them in industry and the others in academia and other public institutions. CERN thus provides society with a continuous stream of talents in science, technology, engineering and mathematics (STEM), trained in a leading scientific laboratory and a truly international environment.

CERN organises regular schools of particle physics, accelerators, instrumentation and computing. Since 2010, some of these schools have been held in Africa every second year (in South Africa, Ghana, Senegal, Rwanda and Namibia so far), and are jointly organised with research institutions across the world. Every year, the CERN Summer Student Programme trains some 300 undergraduate students from all over the world, including a significant number from low-income countries. The CERN-UNESCO schools on digital libraries are an example of the application of CERN's open science for education and training. These schools aim to provide African librarians with the skills they need to run digital library systems, thus improving African researchers' access to information and increasing the global visibility of African research. They have been held in Rwanda,

Morocco, Senegal, Ghana and Kenya so far and have been attended by 150 librarians from many African countries. The library system is based on INVENIO, an open-source digital platform developed at CERN.

Another brilliant example of science for peace is SESAME, the first facility for fundamental and applied research in the Middle East. It is based in Allan, Jordan. The founding countries are Bahrain, Cyprus, Egypt, Iran, Israel, Pakistan, the Palestinian Authority and Türkiye. Some of these countries would not sit around the same table for political discussions, yet at SESAME their scientists work together using the same research facilities. SESAME is an intergovernmental organisation based on the CERN model of governance and scientific cooperation. CERN has also provided some of the accelerator components. Operation started in 2017, and several scientific publications have been produced.

Places like CERN, SESAME and other international scientific organisations cannot directly solve geopolitical conflicts. However, they can break down barriers and help young generations to grow up in a respectful and tolerant environment where diversity, inclusiveness and collaboration are promoted as great values. They are shining examples of what humanity can achieve when we set aside our disputes and focus on the common good.

Conclusion

Science is the fuel of progress and growth. Without the innovative ideas and breakthroughs that emerge from scientific research, progress inevitably stagnates. Therefore, science is essential for ensuring a sustainable future for humanity and the planet. We cannot hope to address today's global challenges, from health to climate change and beyond , without science.

Moreover, because science has no passport, gender, ethnicity, or political affiliation, it can play a vital role in connecting people and fostering a shared future in today's fractured world. Research organisations like CERN and SESAME are outstanding examples of the values science upholds and the benefits it brings to humanity

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