Physics for a better world

The United Nations Sustainable Development Goals outline a roadmap towards a more equitable future for humanity. Along with other scientists, physicists have long made valuable contributions to this endeavour.

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The COVID-19 pandemic has become a feature of the daily news. Unfortunately, this is taking place against a backdrop of continuing deterioration of the public's trust in the evidence-based scientific process. This is another challenge that we must all face by engaging with the wider community (see trust-science.org) and by highlighting the key role science plays in bettering human welfare. Indeed, physics has long been instrumental in responding to critical societal challenges and improving the quality of life worldwide. As we move towards an international year devoted to basic sciences for sustainable development (see www.iybssd2022.org), we can celebrate by reflecting on some of these achievements.

For the purpose of discussion, it may help to roughly divide the members of our global communities — physicists and non-physicists alike — into those residing in a country characterized by the World Bank as having a high average income and those living in low- and middle-income countries (LMICs), historically referred to as developing countries. Of course, this cataloguing is much too coarse-grained to reflect socioeconomic realities, but there are advantages here to keeping it simple and binary.

At the outset, I would like to remark that there is a lot of fantastic work by dedicated and motivated physicists in many institutions around the world that comes under the deceptively simple description 'physics for development', which immediately begs the question: development of what?

But first, let us take a brief look at what many of our colleagues do, and what is better described by the permutation 'development for physics' or more precisely 'for physicists.' They often run or participate in programmes aimed at strengthening science in LMICs by supporting individuals who have an abundance of talent and aptitude but are held back by their poor working conditions. The goal is to reduce as much as possible the scientific isolation that impedes careers, and to encourage and facilitate effective collaborations. Educational outreach activities address a lack of resources at an earlier stage. They often use well-designed enquiry-based kits, for instance, those developed by professional societies, to help bright young students in LMICs express their scientific curiosity and keep them motivated for further studies (Fig. 1).

Fig. 1 | Undergraduates at Quaid-i-Azam University in Islamabad coming to grips with light. Credit: J. Niemela.

One institution dedicated to the development of physicists in a truly global sense is the Abdus Salam International Centre for Theoretical Physics, a United Nations Educational, Scientific and Cultural Organization (UNESCO) centre in Trieste. But there are, of course, many other institutions and programmes, both large and small, contributing to regional development, some of which were originally formed under the auspices of UNESCO, such as CERN and SESAME.

Let us now return to the question of what 'physics for development' is striving for. Applications for the benefit of society spring to mind. The current pace of technology development, derived downstream from fundamental breakthroughs in physics, seems ever more rapid. Combined with entrepreneurial innovation, it can help address — in sustainable and ethical ways — pressing societal challenges in all countries, such as access to clean water, affordable and clean energy, food security or health.

These efforts can be calibrated against the UN Agenda 2030 and its Sustainable Development Goals[1], which helps to answer the question posed above. Of course, basic or 'pure' physics has a position on the assembly line for building our technological base — including providing the context in which innovative applications can actually be conceived and implemented in the first place. However, it also has an intangible benefit in satisfying our natural and evolutionary instincts for exploration, discovery and understanding. Unfortunately, following the news may lead one to believe that our natural instincts are generally more in tune with ignorance and intolerance, two traits that have made conquering each other seem more of a priority for humanity than conquering the unknown.

Indeed, it was in response to the unimaginable devastation of the Second

World War that UNESCO was born. It is one of several UN agencies that have physical sciences in their mandates, including the Food and Agricultural Organization (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA), but perhaps the only one that naturally includes all of physics. Julian Huxley, UNESCO's first director-general, observed that it fosters and promotes "all aspects of education, science, and culture, in the widest sense of those words"[2]. Its constitution, penned by the American poet Archibald MacLeish, extraordinarily begins "That since wars begin in the minds of men, it is in the minds of men that the defences of peace must be constructed," supported in that task by the "unrestricted pursuit of objective truth, and in the free exchange of ideas and knowledge"[3].

Communication tools provided by the technologies that spring from basic research are essential to these ambitious goals. However, Huxley's brother, Aldous, pointed out the potential dangers to democracy through misinformation and propaganda. This was back in 1946, and he was mostly concerned about the influence of the radio[4]: "What Mark Antony could do to the mob assembled round Caesar's corpse, his modern counterpart can do to entire nations. Never have so many been so much at the mercy of so few." This problem still rings true today, changed only in details, and it runs counter to the principles of human dignity and mutual respect embedded into UNESCO's constitution. Even in this respect alone, it is unfortunate that the United States, a founding member of UNESCO, which gave Archibald MacLeish to the world, today remains outside the membership of that organization.

Since UNESCO was founded over 75 years ago, the world has become ever smaller and better connected. Sustainable development has been redefined in a holistic way within the UN Agenda 2030 and the importance of physics for development is clear. The motto for the IAEA, in fact, has changed from "atoms for peace" to "atoms for peace and development," emphasizing peaceful uses of nuclear technologies applied to the Sustainable Development Goals, including hunger (with the FAO), health and energy. Clean and sustainable energy has also benefitted from the continued development of the photovoltaic cell as well as progress in energy storage.

Energy consumption due to lighting has been radically reduced owing to the invention of the blue light-emitting diode (LED), for which the Nobel Prize was awarded in 2014 to Isamu Akasaki, Hiroshi Amano and Shuji Nakamura. For a community completely off the electricity grid, LEDs can help to end the use of unhealthy kerosene lamps, while not overtaxing portable power systems as the filament bulb did, enabling children and adults to safely read after dark. In high-income countries, where people unnaturally spend much of their time indoors, the same digital lighting can be tuned to help improve productivity and well-being by mimicking the diurnally varying spectrum of the Sun.

Tunable LED systems can address hunger by improving plant yield in indoor production sites, which are augmenting traditional farming to feed an ever-increasing population. Food production can also profit from remote-sensing and imaging of crops, and spectroscopic devices can be used to measure oxygen content in packaged food, indicating whether its shelf life has expired. Solar-powered desalination stations can help produce drinkable water in many parts of the world, and ultraviolet LEDs can help clean it.

We can also find physics in the healthcare applications that have recently preoccupied our minds. Anyone using the London underground lately will have noticed that ultraviolet radiation is being used to sterilize the escalator handrails. Photodynamic therapy, using lasers, is being employed in many regions of the world to treat certain types of cancer, and portable point-of care devices, lab-on-chip platforms and remote patient monitoring are helping to improve the health of many people in LMICs who are far away from hospitals.

And, of course, there are the optical fibres powering the Internet, increasing our connections globally in ways Julian Huxley perhaps could not have imagined.

What links all these examples together is the fact that physicists have either directly or indirectly contributed to the general welfare of humanity, helping to build stronger scientific ecosystems, driving the technological innovation needed to effectively address regional challenges. They have also brought to life major institutions that are international by design, and where important and inspirational discoveries in basic physics are being made today.

The 'S' very nearly didn't make it into UNESCO, but for the persuasive and heroic efforts of Joseph Needham, a British biochemist, who understood that the nationalities of scientists are irrelevant to their productive collaboration. He emphasized in 1943 that "science and technology are now playing, and will increasingly play, so predominant a part in all human civilization, that some means whereby science can effectually transcend national boundaries is urgently necessary"[5]. Physicists, acting as Needham would have predicted, have clearly shown by example the progress that can be made through peaceful and constructive international cooperation and shared experience. In Huxley's own words: "practical demonstration is the best form of education." ❐

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Competing interests

The author declares no competing interests.