One problem at a time

Building research capacities in developing countries is necessary for economic success in the long term. But the numerous problems in doing so have to be solved for each country individually

Earlier this year, the Secretary-General of the United Nations, Kofi Annan, issued a new challenge to the world's scientists. It was not to find a source of cheap, unlimited and environmentally friendly energy, to develop cures for diseases that still haunt the developing world, or to improve worldwide food supply, but to make science a basis for economic growth and improved well-being for the developing world and its citizens. "Science has contributed immensely to human progress and to the development of modern society," he wrote in an editorial in *Science* (Annan, 2003). But "the way in which scientific endeavours are pursued around the world is marked by clear inequalities. … Ninety-five percent of the new science in the world is created in countries comprising only one-fifth of the world's population. And much of that science—in the realm of health, for example—neglects the problems that afflict most of the world's people."

Indeed, science and technology were the driving forces that led the developed world to make the first step from agriculture to industrial production as their economic basis, and have led to enormous progress in both economic development and the improvement of living conditions. Similarly, as Annan pointed out in his editorial, science will be the driving force for developing countries in which scientific capacity is still lacking or non-existent, to help them improve the living conditions for their people and, in the long term, catch up with the developed world. The question then—and the challenge put to scientists—is how to create and maintain a research base in developing countries to achieve this goal. Buying or importing knowledge and technology from developed countries is only a short-term solution. First, because it does not create a sound research base and second, because it still requires trained personnel to use and apply this knowledge. It follows that, in the long term, creating and nurturing home-grown research is the best strategy for developing countries to further economic growth and to improve living conditions. To discuss how this could be achieved in the life sciences, more than 40 scientists and science administrators from funding agencies and developing countries met in November 2003 in Trieste, Italy, at the "Promoting Life Sciences in Developing Countries" meeting, organized by the Human Frontier Science Program, the Third World Academy of Sciences (TWAS), The Wellcome Trust and the European Molecular Biology Organization.

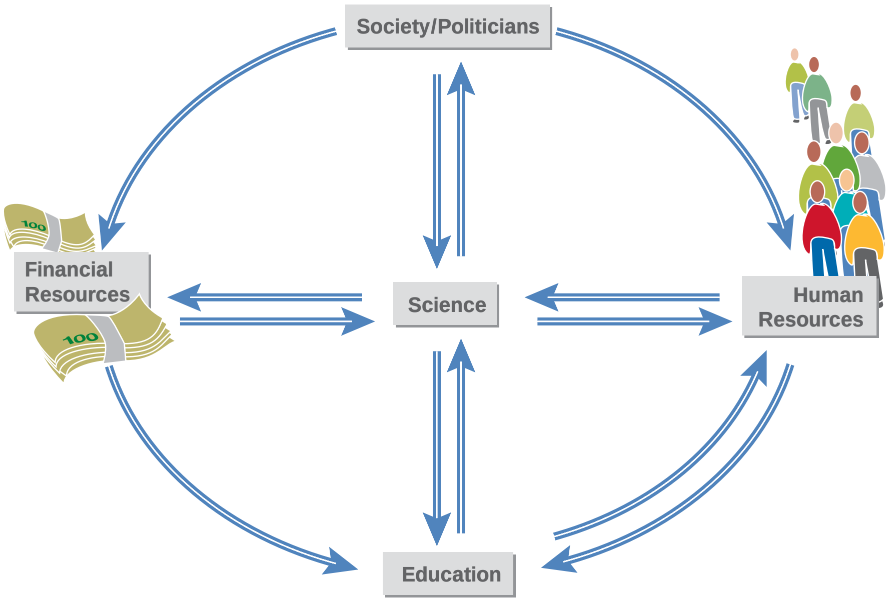

Fig 1 | Factors influencing and benefiting from scientific research.

Certainly, one major factor for successful research is financial resources (Fig 1). But most scientists in impoverished countries struggle with limited budgets that often do not allow for the purchase of expendable items or basic laboratory equipment, let alone pay their salaries. Clearly, many countries are not in a position where they can afford to spend a lot of money on research, simply because they need to address more pressing problems, such as obtaining supplies of potable water, food or basic health care. In addition, increasing the share devoted to research would help relatively little, given the impoverishment of many of these countries. If Uganda, for instance, increased its investments into scientific research to 2.5% of its Gross National Product (GNP), this would amount to a mere US$150 million, still considerably less than the investments made by countries with larger GNPs (Table 1).

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However, it is not only the total amount of money that counts, but also how it is spent. This is where many developing

Table 1 | Gross domestic expenditure on research and development (GERD) in US$ million and as a percentage of the country's Gross National Product (GNP)

Country	Year	GERD (10^6 US$)	GERD (% of GNP)
South Africa	2000[1]	753	0.64
Uganda	1999	45	0.75
Egypt	2000	170	0.19
China	2000	10,820	1.02
India	1998	3,036	0.81
Chile	2000	377	0.54
Mexico	1999	2,089	0.43
Peru	1999	42	0.08
Hungary	2000	374	0.82
Germany	2000	46,938	2.48
Japan	1999	146,303	2.94
USA	2000	264,622	2.69

Source: UNESCO Institute of Statistics, www.uis.unesco.org
[1]Estimate by the South African government.

countries could clearly do better. Joe Harford, Director of the Office for International Affairs at the National Cancer Institute (Bethesda, MD, USA), put this into straightforward language in Trieste: "[It] needs to be considered … whether or not we are not being overly diplomatic when we discuss countries of limited resources by not also referring to them as countries of limited resolve. I think that countries can find funds to do more science and technology research than they are finding. If armies can be built and nuclear weapons can be constructed, none of which is a cheap date, then I think that the resolve to do more research in science and technology is something that needs to be discussed." Indeed, countries such as North Korea or Pakistan obviously prefer to use their limited funds to develop nuclear weapons, which leaves little to none for addressing more basic and urgent problems in health care and nutrition, let alone fund research (Charles, 2003).

Corruption is another major factor that impedes the proper allocation of money—in 1998, about 5,000 scientists in India complained about embezzlement, favouritism and scientific misconduct at the CSIR (Council of Scientific & Industrial Research of India) (ScienceScope, 1998). The annual ranking of 133 countries from Transparency International, the world's leading non-governmental organization devoted to fighting corruption, shows that corruption is rampant and pervasive in many countries that are also known for their limited scientific capacities (Transparency International, 2003). Corrupt governing or national science bodies are not the only serious handicaps in building scientific capacity: the lack of independent peer-review systems to evaluate the quality of project proposals is also a problem. Grant applications are not solely awarded according to quality standards; personal connections to decision-makers often have an important role as well. As Mohamed H. A. Hassan, Executive Director of TWAS, pointed out at the Trieste meeting, "If we look at the situation in Africa we find a very disturbing picture. Africa has got 53 countries but they only have eight merit-based academies, academies where members are elected on the basis of merit. These are—if I may just recall them—Nigeria, Senegal, Kenya, Uganda, Madagascar, South Africa, Ghana and Cameroon." As a result of corruption and flawed peer-reviewing, the scarce funding available is squandered on projects that do little to improve scientific quality, let alone solve pressing problems.

In such a resource-limited environment, qualified scientists therefore often decide to leave the country for greener pastures, which further drains the already limited human resources in developing countries. Less-developed countries account for 79% of the world's population, but they represent only 27% of the total number of researchers in the world, according to the UNESCO Institute of Statistics. Germany's scientific workforce, for example, has 130 times more researchers per million inhabitants than Uganda (Table 2). And a glance at the gross enrolment ratios in tertiary education (Fig 2) shows that the availability of human resources in Africa is unlikely to improve in the near future. Countries with enrolment ratios less than 5% have not yet laid the groundwork for developing a strong scientific workforce. Another major and more basic factor is the literacy rate: in Ethiopia only 39% of people aged 15 years and above are able to read and write short simple statements on their everyday life (Fig 3), so the question is where high numbers of qualified scientists should come from. Jill Conley, Director of the International Program of the Howard Hughes Medical Institute (Chevy Chase, MD, USA) said, "If we have said that there are not enough scientists that are available to fund, maybe we should look earlier in the pipeline. Maybe if we looked at the level of high school students and developed more interests there then eventually we would get more scientists." Furthermore, the limited quality of university education offered in many developing countries drives the highly skilled to look for training opportunities abroad, further aggravating the availability of human resources in the developing world—a vicious circle.

Table 2 | Researchers per million inhabitants

Country	Year	Researchers per million inhabitants
South Africa	1993	1,031
Uganda	2000	24
China	2000	422
India	1996	157
Chile	2000	370
Peru	1997	229
Hungary	2000	1,445
Germany	2000	3,161
Spain	2000	1,921

Source: UNESCO Institute of Statistics, www.uis.unesco.org

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Another factor affecting the science and technology situation is public opinion and politicians' attitudes towards scientific research. Societies in developing countries are often not aware—because of a lack of education and political interest—of the potential of scientific research. "I think that most of our countries could do a lot more for their own scientific development than they are doing," Jorge E. Allende, Professor of Biochemistry at the University of Chile in Santiago, said. "What we really have to do is to convince our societies first and then our governments that science is important, and in that the scientific organizations and governments from outside can help but they

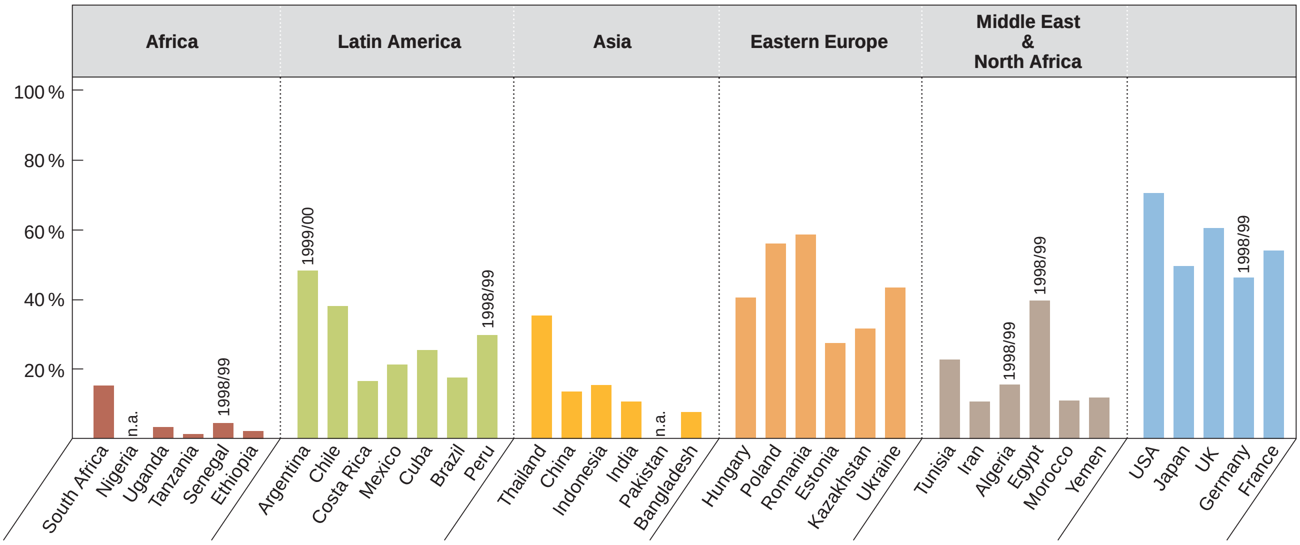

Fig 2 | Gross enrolment ratio in tertiary education: total enrolment ratio in tertiary education (university) regardless of age, expressed as a percentage of the population of the 5-year age group following on from the secondary-school leaving age. If not otherwise specified, data refer to the year 2000/01. Source: UNESCO Institute of Statistics, www.uis.unesco.org.

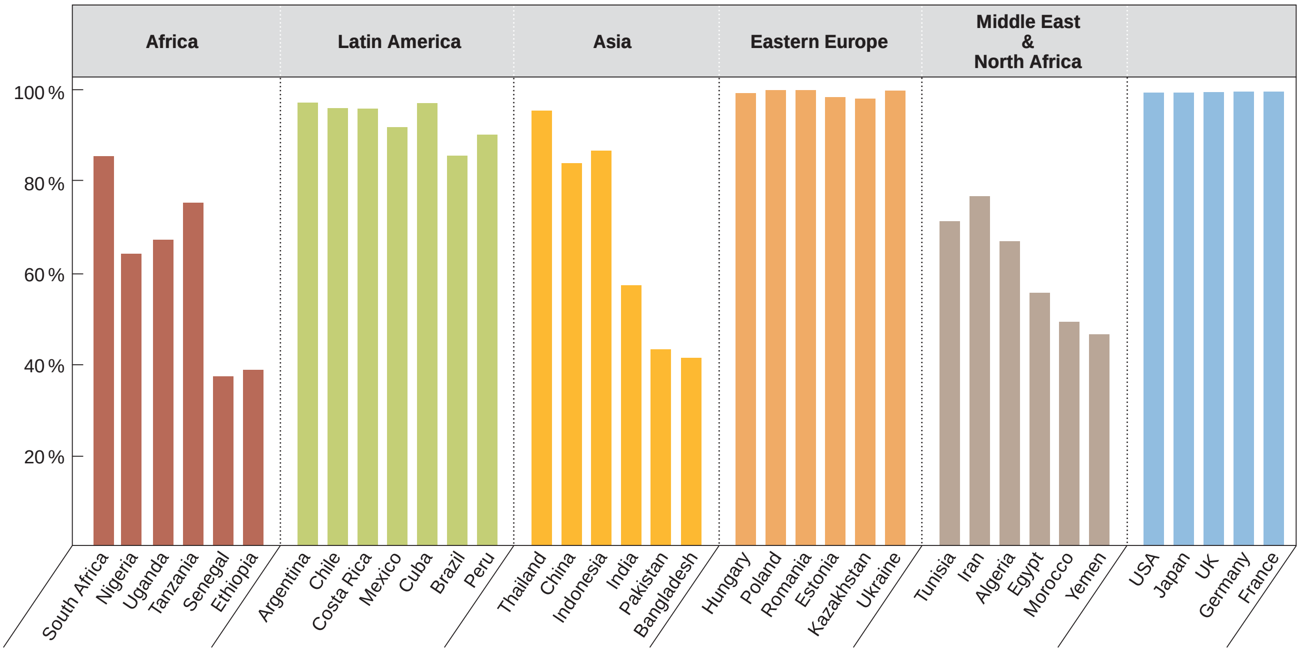

Fig 3 | Adult literacy rate: the percentage of people aged 15 and above who can, with understanding, both read and write a short, simple statement on their everyday life. Data refer to the year 2000. Source: Human Development Report 2002.

cannot replace the effort [from] within." Indeed, politicians in many developing countries do not see immediate benefits in supporting basic research but are more interested in fast economic growth. For developing countries the easiest way to achieve this is through the export of natural resources and/or manufactured products instead of investing in research capacity, which shows effects only after a decade or more. Politicians who want to be re-elected therefore prefer to import technologies to improve production rather than developing them on their own. Furthermore—and this is true not only of the developing world but also of the developed world—there is a narrow definition of what scientific success means, usually measured in terms of publications and patents. However, the number of students trained in a developing country to become qualified scientists is also a measure of scientific activities, albeit one that is more difficult to monitor.

It is not easy to find solutions that apply to the great variety of problems haunting the developing world. It would surely be fruitless to try to establish research capacity in the Congo, Afghanistan or other countries that are shaken by war or civil unrest. Some of the least-developed nations, such as Ethiopia or Bangladesh, have much more urgent priorities and are often not even able to guarantee basic education for their population. More advanced countries, such as India, Romania or Bulgaria, already have a solid scientific workforce but not enough funds to employ all of them. Nevertheless, there are efforts underway to build scientific capacities in the developing world, and some of the measures implemented might serve as examples for other countries.

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The New Partnership for Africa's Development (NEPAD), representing 16 countries, has set itself the goal of eradicating poverty in Africa and supporting sustainable development. NEPAD has identified science and technology as being indispensable to this process (Scott, 2003) and at a Ministerial Conference on Science and Technology recently addressed the problem of obtaining financial resources. NEPAD member nations have agreed to devote 1% of their GDP to scientific research within the next 5 years. Nevertheless, there are serious doubts whether all nations will be able to reach this target. NEPAD and the Canadian International Development Agency are also backing a US$21 million project to improve Africa's bioscience research facilities. One outcome will be the establishment of a new facility for East and Central Africa at the International Livestock Research Institute in Nairobi, Kenya, to address some of Africa's biggest problems in health and agriculture (Chege & Mboyah, 2003). This highlights another aspect in building research capacities in the developing world: simply replicating foreign technology or research programmes from the developed world is not a good strategy; instead, efforts need to focus on and tackle local problems first to build a solid research base (Harris, 2004). One example of the building of such capacities through focusing on regional problems is the establishment of the National Virology Laboratory in Nicaragua, which has become a centre of excellence for dengue research in Central America.

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Chile is already further advanced in capacity building and is now addressing the problem of proper allocation of funds and quality of research. The country's Millennium Science Initiative, supported by a World Bank loan of US$5 million, relies on a Programme Committee consisting of eight highly qualified international scientists from different research fields and different countries to provide scientific guidance. They nominate and supervise panels of independent experts to evaluate Chile's participating institutions every 3 years. Similarly, one of China's main policies in reforming their research system was the introduction of peer-review schemes by national and international experts.

Such policy measures and the resolve of governments are crucial in building capacities, as the example of Iran illustrates. The country has experienced a tremendous increase in the number of publications registered by the Science Citation Index (SCI), with an average annual growth rate of 23.4% from 1992 to 2001 (Moreno-Borchart, 2003), compared with the global average annual growth rate during that period of 2.1%. The reasons for this marked increase in Iranian scientific productivity are mainly changes in research policies. The Science, Research and Technology Ministry in Iran awards prizes to scientists who publish in international journals indexed by the SCI. Governmental fellowships are offered to lure back students who have been trained abroad, and scientists gain increased access to international databases and electronic communication with international collaborators (Osareh & Wilson, 2002).

However, a perennial issue that must be addressed in order to build a sustainable capacity in developing countries is a change of mentality in society and among decision-makers. No capacity-building initiative will succeed if governments and the public are not determined to change the situation. Long-term commitment from governing bodies is needed to start to fill the human resources pool by raising a scientific workforce starting at the primary school level. Nobel laureate and TWAS Fellow Ahmed H. Zewail, in a keynote address at the TWAS 8th General Conference in New Delhi, India, in October 2002, commented, "It is not just a question of money. It's also a question of nurturing a scientific culture that encourages researchers to seek new knowledge and, in the process, challenges them to reach their full potential" (Zewail, 2002).

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