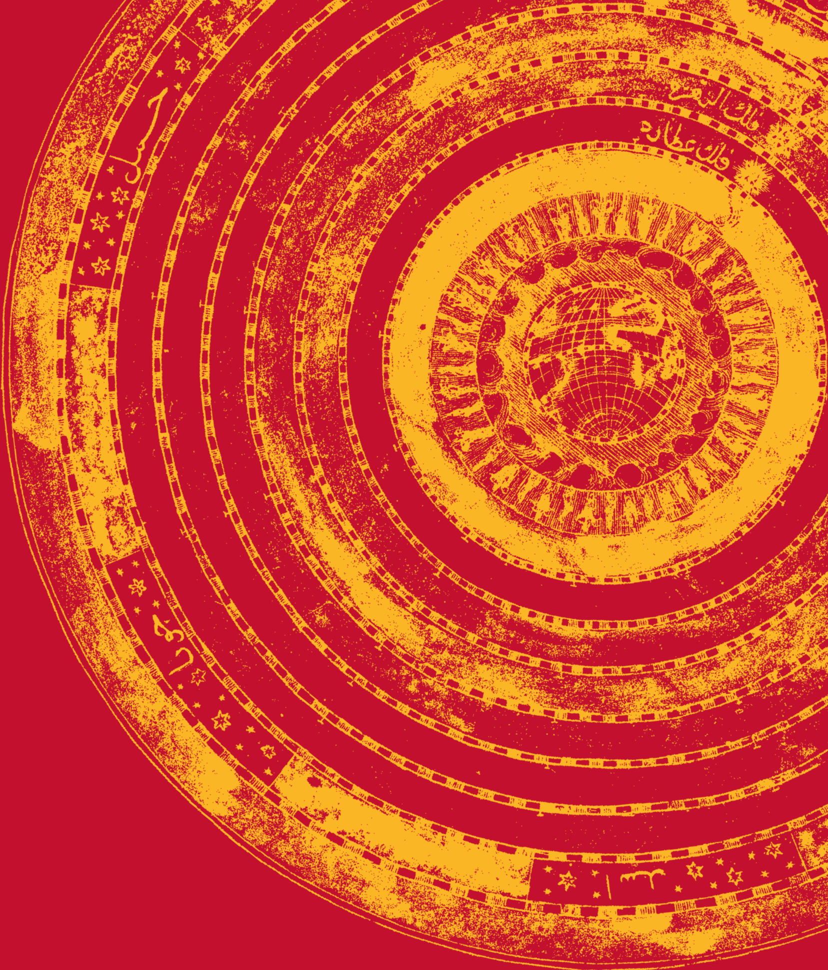

A new golden age?

The prospects for science and innovation in the Islamic world

June 2010

CELEBRATE
350 YEARS

THE ROYAL SOCIETY

Cover image: This image was taken from the book *Gihan numa* by Turkish geographer and historian Katib Tchelebi (1609–1657). It was drawn during the Ottoman era and printed in Constantinople ca. 1730. The image represents the regular circles of an armillary sphere, a model of the celestial sphere as envisioned by the Greek astronomer Ptolemy. The Earth is at the centre, followed by water, air, fire, the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the 'sphere of spheres' (sometimes called the ninth sphere). Courtesy of the Royal Society Library.

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A new golden age? The prospects for science and innovation in the Islamic world

A Royal Society briefing paper—June 2010

Contents

1 Introduction: a new golden age?

Few people are better qualified to assess the future of science in the Islamic world than Ekmeleddin Ihsanoglu. A chemist and historian of science by background, Professor Ihsanoglu was elected in 2005 as Secretary General of the Organisation of the Islamic Conference (OIC), the world's second-largest intergovernmental body after the United Nations.

In his spacious office on the top floor of the OIC's Jeddah headquarters, Professor Ihsanoglu's face lights up as he describes how he has prioritised science and innovation since taking up the reins of the OIC. As a historian, he devoted years of his life to studying the scholarship, learning and invention that flourished in parts of the Islamic world from the 8th to the 16th centuries. As a politician, he is acutely conscious of the challenges facing the Islamic world today, and the fact that many of the OIC's 57 member countries score well below international averages in education, science and research.

One of Professor Ihsanoglu's first acts as Secretary General was to oversee the adoption of 'Vision 1441', a 10-year blueprint for the contribution of science, technology and innovation to economic and social development across the OIC.[1] Vision 1441 says that by 2015, 30% of students in OIC countries between the ages of 18 and 24 should have the opportunity to go to university. It also suggests that OIC countries should spend 1.2% of their gross domestic product (GDP) on research and development (R&D).[2]

As Professor Ihsanoglu explains, 'We are now almost halfway through the 10-year programme of Vision 1441... and we should be able to take stock of our achievements and failures over these years. Are we today closer to reversing the malaise of insufficient human development, inadequate education systems and unfortunate dependence on borrowed technologies?'[3]

This paper tries to answer the question that Professor Ihsanoglu poses. The sections that follow summarise recent advances in science and innovation across the OIC member states, and review the barriers to further and faster progress. The paper also introduces a new initiative—*The Atlas of Islamic-World Science and Innovation*—which the Royal Society is coordinating with a range of international partners,[4] and which builds in a practical way on the themes discussed below.

1 '1441' is a reference to the Islamic calendar, which is equates to year 2020 in the Gregorian calendar.

2 Sawahel W (2005). *Islamic states urged to follow 10-year science plan*. Scidev.net. Available online at: http://www.scidev.net/en/news/islamic-states-urged-to-follow-10year-science-pla.html

3 Speech by H.E. Secretary-General of the OIC at the 27th meeting of COMSTECH Executive Committee, 23 February 2010. COMSTECH is the OIC's Standing Committee on Scientific and Technological Cooperation.

4 Project partners include the Royal Society, Organisation of the Islamic Conference, Qatar Foundation, Nature, British Council, Islamic Development Bank, SESRIC (Statistical, Economic & Social Research & Training Centre for Islamic Countries), ISESCO (The Islamic Educational, Scientific and Cultural Organisation), COMSTECH and the International Development Research Centre.

Defining our terms

Describing Islam-related terms in the English language is fraught with potential confusion. Is an 'Islamic country' one whose citizens are all observant believers in Islam? Is it a country which is governed according to the principles of Islam? Or is it a country with a predominantly Muslim population?

In addressing this topic—and for the purposes of *The Atlas of Islamic-World Science and Innovation* project—we have decided to use membership of the Organisation of Islamic Conference as a proxy for the Islamic world. Such a definition has limitations, by excluding non-OIC countries such as India and Russia despite their large Muslim populations.

The OIC represents a diverse set of countries. What connects Jordan to Nigeria, or Azerbaijan to Indonesia can be difficult to quantify. Yet unlike other faiths, some 57 countries across the Middle East, Africa and Asia self-identify as part of the Islamic-world, or 'Ummah', through their membership of the OIC, so this does succeed in providing some sort of workable framework for analysis.

In this paper, member states of the OIC will be described as exactly that (instead of using the phrase 'Muslim state', or 'Islamic country'). If the phrase 'Islamic world' is used, this will denote the OIC countries collectively. More details on the membership of the OIC is provided in Appendix 1.

If we take the pulse of science today across the 57 countries of the OIC, R&D spend averages just 0.38% of GDP[5], compared with a global average of 1.7%.[6] There are 402 researchers per million people compared with a global average of 1,544.[7]

This is not simply a sign of relative poverty: oil-producing states such as Saudi Arabia and Kuwait have been, until recently, among the lowest investors in research. In 2005, 17 Arab-speaking countries together produced 13,444 scientific publications; fewer than the 15,455 achieved by Harvard University alone.[8] According to a 2009 UNESCO Report, OIC countries contribute just 4.18% of the total papers in world scientific publications.[9]

5 Butler D (2006). *Islam and Science: The data gap.* Nature **444**, pp 26–27.
6 UNESCO Statistics Division (2007). *Science Data and Statistics*. United Nations Educational, Scientific, and Cultural Organization Statistics Division: Paris, France. Available online at: http://stats.uis.unesco.org/ReportFolders/reportfolders.aspx.
7 OIC Outlook (2009). *Research and Scientific Development in OIC Countries*. The Statistical, Economic and Social Research and Training Centre for Islamic Countries: Ankara, Turkey.
8 Bin Mohd Nordin R (2007). *Global scenario of science, technology and innovation: perspective of OIC countries.* Presentation at International Symposium on Science, Technology and Innovation in the Islamic World, Kuala Lumpur, 9–11 August 2007.
9 Naim S & ur-Rahman A (2009). *UNESCO Occasional Paper no. 17. Mapping Scientific Research in Member States of the Organization of Islamic Conference (OIC)*. United Nations Educational, Scientific and Cultural Organization: Paris, France.

1.1 Big plans

This picture is now starting to change. Eye-catching developments in several countries suggest the potential for a wider renaissance in the science and innovation capabilities of the Islamic world. Understanding these changes and the opportunities for, and constraints to, further progress is an important task for the international scientific community. Just as China, India and Brazil emerged over the past 20 years as significant players in international research, so countries like Turkey, Iran, Qatar and Saudi Arabia are now investing at such a scale that their future contribution to global science deserves serious and sustained attention.

Perhaps more importantly, through the promotion of collaboration and exchange, science provides avenues for rebuilding trust and understanding between the Islamic world, Europe and the United States, after a period in which relations have sometimes been strained.

The ambitious plans in the OIC's Vision 1441 are complemented by other regional commitments. In 2007, countries within the African Union committed to spend 1% of GDP on research. That same year, the Arab League's 22 countries signed up to spend 2.5% within 10 years.[10]

The Association of South-East Asian Nations (ASEAN) has also developed a series of 'Science Action Plans' since 1978.[11] Yet, many are sceptical of such plans, with good reason. The African Union, for example, first made its 1% commitment in 1980. Thirty years later, barring South Africa, no African country is anywhere near this target.

Given limited resources and the complex realities of policy implementation at a national level, there is also little scope for monitoring and enforcing such commitments, however well-intentioned. There are also difficulties in gathering robust and comparable national data. And as always, statistics only tell part of the story. R&D investment and publication rates do not capture the array of 'hidden' and non-traditional forms of innovation that occur in OIC countries.[12] For example, the countries of South Asia have blazed a trail in social innovation. Bangladesh has pioneered the mainstreaming of micro-finance. Pakistan has used participatory mechanisms of development in making improvements to slum townships.

10 Sawahel W (2007). *Arab States Sign Ten Year Science Development Plan*. Scidev.net. Available online at: http://www.scidev.net/en/news/arab-states-sign-tenyear-science-development-plan.html

11 ASEAN Official Website (2009). *Overview of the ASEAN Ministerial Meeting on Science and Technology.* Association of Southeast Asian Nations: Jakarta, Indonesia.

12 NESTA (2006). *The Innovation Gap; The STEPS Centre (2010)—'innovation, sustainability, development: a new manifesto*, Sussex University: Sussex, UK.

2 Infrastructure and investment

With a theatrical flourish, Professor David Keyes points from his window at the spectacular jigsaw of buildings that have been constructed at Thuwal, on the shores of the Red Sea. 'Two years ago', he says, 'all of this was desert. Now it's one of the most exciting universities in the world.' He is talking about the King Abdullah University of Science and Technology (KAUST). Opened in September 2009, this flagship investment by the Saudi Arabian royal family is intended to usher in a fresh era of scientific discovery in the Middle East.

It is difficult not to feel inspired by an experiment on such a scale. With an endowment of around US$20 billion, KAUST is attracting faculty and postgraduate students from across the world. As a graduate-only institution, it aims to rival the California Institute of Technology for prestige within 20 years.[13] And ambition is not KAUST's only distinctive feature. In a country where women's rights are tightly restricted, the campus is uniquely co-educational, women are allowed to drive and many choose not to wear the veil. The university's founding principles include a commitment to 'nurture and protect freedom of research' and to 'provide researchers the freedom to be creative and experiment.'[14] It is the only Saudi university not to fall under the supervision of the Ministry of Higher Education; having been constructed by Saudi Aramco, the state oil company, it is overseen instead by the Ministry of Petroleum.

After a 25-year career in Ivy League US universities, David Keyes was poached from Columbia University to become KAUST's inaugural Dean of Mathematical and Computer Sciences and Engineering. He was partly attracted to KAUST by its infrastructure (it currently houses one of the top 10 super-computers in the world), but it was the opportunity to build something from scratch that ultimately drew him from New York to Saudi Arabia. 'KAUST is largely without precedent. It's not dominated by any one nationality, or any one research culture.'[15]

KAUST's buildings were put in place very quickly. Other aspects of the university are growing more incrementally. Halfway into its first year, it has 73 faculty and 360 postgraduates (of which just 15% are Saudi nationals). By 2020, the goal is to reach 250 faculty and 2,000 students. It has also been successful in establishing partnerships with leading international universities, including Cambridge, Oxford and Imperial College, and expects these links to yield many new projects over the next decade.

KAUST is one of 50 universities in Saudi Arabia, designed to serve a population of just over 26 million people. Under

13 Corbyn Z (2009). *Oasis in the desert*. Times Higher Education. Available online at: http://www.timeshighereducation.co.uk/story.asp?storycode=408895

14 Source: KAUST website. Available online at: http://www.kaust.edu.sa/about/about.html.

15 Royal Society interview with David Keyes, 2 May 2010.

construction at the moment is the world's biggest women-only university based in Riyadh, covering eight million square metres and expected to accommodate 40,000 students.[16] The impact of KAUST on other local universities is still unclear, but already there are pressures to offer better working conditions to women academics, in order to compete with the more liberal policies of KAUST.

Looking beyond investments such as KAUST, Saudi Arabia is now the world's fifth largest spender on education as a percentage of total government expenditure, dedicating 27.6% between 2000 and 2007.[17] Alongside its expansion of higher education, the Saudi government has also continued to build up the King Abdul Aziz City for Science and Technology in Riyadh. Founded in the 1970s, this acts as a national science agency and national laboratory and has over 2,500 staff.[18] A number of special economic zones are under construction across the kingdom, including a high-tech city that borders the KAUST campus. For all these reasons, international science policymakers are looking with increasing interest at Saudi Arabia. But for a country that is used to having 1.6 billion Muslims turn in its direction five times a day, such attention comes naturally.

16 Butt R (2008). *Saudis build world's biggest women-only university*. The Guardian. Available online at: http://www.guardian.co.uk/education/2008/nov/01/saudi-arabia-middle-east

17 UNESCO Institute for Statistics (2009c). *Data Centre Education Module*. United Nations Educational, Scientific, and Cultural Organization Statistics Division: Paris, France.

18 Source: King Abdulaziz City for Science and Technology website. Available online at: www.kacst.edu.sa.

2.1 Promise on the Peninsula

Neighbouring Qatar is far smaller in terms of geography and population, but shares Saudi Arabia's levels of ambition and investment. Led by the efforts of Her Highness Sheikha Mozah bint Nasser Al Missned, Qatar aims to spend 2.8% of its GDP on research by 2015—which equates to approximately US$1.5 billion. Since the mid-1990s, the Government has introduced a number of education reforms and invested around US$133 billion in infrastructure and projects designed to create a knowledge-based economy.[19]

The jewel in Qatar's scientific crown is Education City, a 2,500 acre campus on the edge of Doha, where seven top US universities have opened international campuses, including Carnegie Mellon, Weill Cornell and Texas A&M. Alongside these sits the Qatar Science and Technology Park, which was launched in early 2009, and now includes Shell, Rolls Royce and Cisco among its tenants. Just down the road, the US$8 billion Sidra Medical and Research Centre will open shortly, under the leadership of Professor David Kerr, an Oxford University oncologist, who moved to Doha in 2009.

In a country flush with gas revenues, with a population of just under one million people—of which only 300,000 are Qatari—the task of reorienting society towards education and scientific inquiry is substantial. To engage the wider Qatari public in this process, downtown Doha is dotted with brightly coloured billboards

19 Source: Qatar Foundation website. Available online at: http://www.qstp.org.qa/output/page559.asp.

urging people to 'Think', 'Create', 'Dream'. Whether this inspires young Qataris to pursue careers in research, at the expense of higher-paid jobs in finance, oil and gas or the military remains to be seen.

2.2 Crude investments

There is a common thread amongst the OIC's biggest investors in science and innovation: they are all amongst the world's biggest exporters of oil and gas. The economies of Saudi Arabia, Qatar and the UAE are heavily dependent on natural resources. There is, however, growing support among the leaders of these countries for reforms aimed at creating more diversified and competitive economies. This is accompanied by a recognition of the need to prepare for a post-oil world. Oil and gas are finite assets, and with the added pressures of climate change, resource-rich countries are keen to direct the windfalls generated in these boom times towards more restructuring of their economies, based on knowledge and research.

Across the UAE, there are different economic strategies being trialled. Dubai has opted for a financial services, property and tourism-led model (and has suffered in recent times as a result). Neighbouring Abu Dhabi is seeking to capitalise on its energy expertise to create a more renewable future. At the core of this strategy is the Masdar Initiative.

This is Abu Dhabi's attempt to create the world's first fully sustainable city and innovation hub. Due to open later this year, Masdar will eventually house 50,000 people and 1,500 businesses focused on renewable energy and sustainable technologies.[20] Abu Dhabi's leaders argue that such investments in sustainable technologies are critical if they are to maintain their status in the top echelons of the energy sector, while reducing their long-term dependency on hydrocarbons.

Masdar is attracting powerful partners. Companies like Credit Suisse and Siemens are backing the US$250 million Masdar Clean Tech Fund. Six leading research institutions, including Imperial College and Columbia University, are part of the Masdar Research Network. And GE, BP, Shell, Mitsubishi and Rolls Royce are among those who have joined as strategic partners.[21]

The project is not without its critics. OIC nations are latecomers to the table of environmental sustainability and have not previously invested heavily in renewable technologies. Indeed, several OIC countries have for decades worked to undermine international efforts to tackle climate change. Other less developed OIC countries remain concerned that efforts to address climate change might mean putting a brake on industrialisation.

Some argue that Masdar is greenwash: a token investment made by a government flush with cash as a concession to environmental pressures. Critics like to point out that Masdar's carbon-neutral targets only apply from the moment it

20 Source: Masdar City Overview. Available online at: http://www.masdar.ae/

21 England A (2007). *Abu Dhabi Eyes Renewable Energy Future.* The Financial Times. Available online at: http://www.masdarctf.com/pdf/FT_AbuDhabi.pdf

goes into full operation, and not during its energy-hungry construction phase. However, the fact remains that few countries have the capacity to invest so substantially in clean technologies. Masdar's targets are ambitious, but the entire world and not just the Gulf region will benefit if they are achieved.

2.3 Building with more than bricks

The bricks and mortar are arguably the simple part of any educational or scientific investment. Beyond architecturally stunning buildings, the success of initiatives such as KAUST, Masdar and Education City will rest on their capacity to develop a pool of high quality, locally trained graduates and faculty members. To achieve this, the Qatar Foundation has established explicit targets for the number of Qatari students that foreign campuses should aim to attract, and is encouraging each campus to develop outreach campaigns to local high schools. In 2007–2008, Education City's student population totalled 2,647, of which 50.8% were Qatari, still some way below the Foundation's 70–75% target.[22]

Alongside infrastructure, strategic and sustained investment in all levels of the education system is required. Primary and secondary schools must be equipped with quality staff who can inspire students to pursue further academic study. Graduates need a vibrant research and entrepreneurial community in which to pursue rewarding careers if they are not to be tempted overseas. It is too early to assess the extent to which such holistic approaches will accompany flagship initiatives like KAUST and Education City, but they will be fundamental to any long-term success.

2.4 Beyond the Gulf States

Outside of the oil-rich states, Turkey has been a quiet but steady achiever. Having made research a priority in the 1990s, the Turkish government increased its spending on R&D by 566% between 1995 and 2007, and now spends more than Denmark, Finland and Norway.[23] Over this period, the proportion of Turkey's GDP spent on R&D rose from 0.28% to 0.72%, and the number of researchers increased by 43%.[24] Four times as many papers were published in 2008 as in 1996, making Turkey the world's eighth 'most improved' country in terms of publication output in that period.[25]

After decades of neglect, Pakistan embarked on a steady drive to reform research and higher education from 2000 onwards. Under the leadership of Professor Atta-ur-Rahman FRS, the then Minister for Science, the research budget increased by 6,000% between 2001 and 2003, and the higher education budget increased by 2400% between 2004 and

22 Bains E (2009). *Doha's Experiment in Education*. MEED Insight. Available online at: http://www.meed.com/supplements/2009/qatar-education-city/dohas-experiment-in-education/3000792.article.

23 OECD (2009). *Main Science and Technology Indicators (MSTI): 2009 Edition.* Organisation for Economic Co-operation and Development: Paris, France.

24 *Ibid.*

25 Data provided by Elsevier.

2008. With over 50 new universities established between 2002–2008, the numbers of student enrolments tripled from 135,000 to 365,000.[26] Investments in digital libraries and journal access provided greater access to intellectual infrastructure. New initiatives were launched to increase the volume of research papers and PhDs, and to improve the international visibility of Pakistani research.

This concerted effort led the United Nations Commission on Science and Technology to applaud Pakistan as a 'best practice example for developing countries' aiming to establish an innovative, technology based economy.[27] In the past two years, with a different government in power and heightened security concerns, progress has slowed. Temporary sanctions imposed by the US have also caused frustrating delays in obtaining scientific supplies. It is hoped, however, that the momentum developed over the past decade will not be lost.

In December 2006, Egypt's President Mohammed Hosni Mubarak announced the start of a 'Decade of Science'. In addition to extra funding for scientific research, he authorised the creation of a Higher Council for Science and Technology, to be headed by the Prime Minister Ahmed Nazif with senior figures from industry, academia and the diaspora community. Egyptian-born Sir Magdi Yacoub FRS, a leading cardiothoracic surgeon from Imperial College, was appointed to this council, and says the group was given a blank sheet of paper on which to reinvigorate Egypt's research system. The new Library of Alexandria is one example of a world-class teaching and research institution that has developed independently of the university system—it reports directly to Egypt's Parliament.

In August 2009, Iran announced a 20-year 'comprehensive plan for science' focused on higher education and stronger links between industry and academia. The establishment of a US$2.5 million centre for nanotechnology research is one of the products of this plan. Other commitments include boosting R&D investment to 4% of GDP, and education to 7% of GDP by 2030.[28]

Among Africa's OIC states, Nigeria has been one of the most active. In 2006, it created a National Council for Research and Development, and invested US$5 billion in its Petroleum Technology Development Fund. This fund now awards scholarships, conducts training programmes for the petroleum sector and has supported the establishment of specific colleges and a national laboratory dedicated to petroleum-based studies.[29]

26 Ur-Rahman A (2010). *Innovation: the path to socio-economic development*. Paper presented at the World Islamic Economic Forum, Kuala Lumpur, May 2010.
27 Rode M (Former Chairman of UN Commission on Science, Technology and Development; 2008). Letter from Chairman/European Coordinator of ASEA-UNINET. October 2008. Available online at: http://dildilpakistan.wordpress.com/tag/dr-atta-ur-rehman/.
28 'Sawahel W. *Iran: 20-year plan for knowledge-based economy*. University World News. Available online at: http://www.universityworldnews.com/article.php?story=20090827175231370.
29 Source: Petroleum Technology Development Fund website. Available online at: http://www.ptdf.gov.ng/index.php?option=com_content&task=view&id=13&Itemid=29.

In Asia, Malaysia is amongst the more sophisticated champions of science and technology, largely as a legacy of former Prime Minister Mahatir's 'Vision 2020'. Extensive investments in human capital and research are gradually starting to yield results. In 2004, the number of R&D personnel reached 31,000—an increase of 270% since 1998.[30] Patent applications have also grown, with Malaysia now producing the highest number of applications across the OIC.[31]

2.5 The innovation ecosystem

Investment in research in OIC countries is still heavily dominated by the public sector, with a small amount channelled through companies, NGOs and others. Examples of world-class basic or applied research remain thin on the ground. Moreover, where research is of a high quality, it is often directed towards local problems, which are unlikely to feature in the top international journals. One example can be found in Bangladesh, where researchers developed a new approach to remove arsenic from drinking water.[32] Whilst not written up in the scientific literature, such research can have very practical implications—in this case, by improving the quality of life in three municipalities of Bangladesh.

Developing countries have pressing needs in areas such as transport, urban planning, sanitation, biodiversity, micro-generation, primary healthcare and defence. It is in these areas where the research base is often strongest. If enough resources are available, investment in infrastructure can be relatively straightforward. However, the more complicated yet vital aspect of a knowledge-based economy is its people. It is to this that we now turn.

30 MOSTI (2006). *Malaysian Science and Technology Indicators 2006 Report*. Ministry of Science, Technology and Innovation: Putrajaya, Malaysia.

31 OIC Outlook (2010). *Research and Scientific Development in OIC Countries*. The Statistical, Economic and Social Research and Training Centre for Islamic Countries: Ankara, Turkey. Available online at: http://www.sesrtcic.org/files/article/394.pdf

32 Johnston R & Heijnen H (2001). *Safe water technology for arsenic removal.* Paper presented at the International Workshop on Technologies for Arsenic Removal from Drinking Water: Dhaka, Bangladesh.

3 People

Described by Newsweek as the 'icon of the tiny emirate's modernization efforts', Her Highness Sheikha Mozah is an impressive force for change in Qatar.[33] When she visited Lord Rees, President of the Royal Society, in April 2010, there were a number of items she wanted to raise. At the top of her agenda was how to engage young people in the excitement of science, both in Qatar and across the Islamic world. Building partnerships to assist in this task will be key, and the meeting concluded with the signing of an agreement between the Royal Society and the Qatar Foundation to promote scientific collaboration.

Inspirational figures such as Sheikha Mozah in Qatar and Princess Sumaya in Jordan are the driving forces behind scientific advances in their respective countries. The symbolism of these women in societies that are dominated by male clerics and political leaders should not be underestimated. Their voices are important for two reasons. First, they are powerful people in their own right, so what they say matters. Second, they are passionate about the need to invest in people, particularly young people, to build up a new generation of scientific and research leaders.

3.1 Young people and universities

The OIC countries have a predominantly young population. In the Arab region, some 60% of the population is under 25 years old, with a median age of 22 years compared with a global average of 28.4.[34] Pakistan's median age of 20.8 years is even younger.[35]

As a result, there are huge demands on higher education. Across the OIC, there are large university building and upgrade programmes taking place. Malaysia, Pakistan and the Gulf states have all more than doubled their number of universities in the past 10 years. The biggest expansion has been in Iran where there are now ten times as many young people in higher education as was the case in 1979. Less developed countries tell a different story: The Gambia built its first (and so far only) university in 1999, 30 years after independence.

In some countries, the expansion of private universities has occurred at such a pace that processes of accreditation and standardisation have struggled to keep up. In the 1990s, the Government of Malaysia supported the rapid growth of private universities, leading to the establishment of 27 institutions in a relatively short period.[36] Whilst important in addressing rising educational demands, these private universities stirred sector-wide concerns

33 Newsweek (2003). *Hillary Clinton, stand back*. Newsweek. Available online at: http://www.newsweek.com/id/60480.

34 CIA (2010). *The World Factbook*, Central Intelligence Agency: Virginia, USA.

35 *Ibid.*

36 The World Bank (2007). *Malaysia and the Knowledge Economy: Building a World-Class Higher Education System*. The World Bank: Washington DC, USA. Available online at: http://siteresources.worldbank.org/INTMALAYSIA/Resources/Malaysia-Knowledge-Economy2007.pdf

about the quality of courses on offer, and the reputational risk to Malaysia's education system more broadly.

Expansion is being helped by UK, US and Australian universities creating campuses abroad. This can be a win–win for both sides. The exporting university gains cash and kudos, while the recipient countries can expect to gain from higher standards. The expansion in university enrolment reduces brain drain, allows for more home-grown research, and opens up higher education to a bigger percentage of eligible young people—not just the elite or the middle classes.

As university numbers grow, so does the attention given to university league tables and rankings. So far, only three OIC-based universities have made it into the Shanghai Jiatong index of leading universities. None were ranked in the top 400 universities in the world, but King Saud University in Saudi Arabia, Istanbul University and the University of Tehran were ranked amongst the 500 best universities.[37] The OIC now plans to develop its own university ranking system for its member countries. However, to date, this initiative has been slow to develop, with some countries fearful that it may harm the reputation of institutions in their countries.

Beyond universities, young scientists themselves can play a pivotal role in promoting science and technology within their own countries and the broader OIC. In Pakistan, early-career scientists have recently launched a National Academy of Young Scientists to share research findings, and address concerns over brain drain and a lack of career opportunities.[38]

There is also a pressing need for more vocational training, apprenticeships and other initiatives to create highly skilled jobs. Such initiatives can help to combat chronic levels of youth unemployment. In 2005, Algeria had 46% youth unemployment, Jordan 37%, and Morocco 16%. The UAE was the region's best performer at 6.3%.[39] This problem is not unique to the Islamic world, but with over 700 million people below the age of 19, the scale of investment required is huge.[40]

A recent report, commissioned by the British Council, with surveys conducted by AC Nielsen, highlighted the frustrations of young people in Pakistan, a country where two-thirds of citizens are yet to

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37 Institute of Higher Education of Shanghai Jiao Tong University, China (2009). *Academic Ranking of World Universities (ARWU)*. Available online at: http://www.arwu.org/ARWU2009.jsp; The ARWU ranking does not classify universities above the top 100 individually, but by the next best 100 universities at a time (e.g. 101–200, 201–302, 303–401, 402–501).

38 Khan A (2010). *Pakistan's Young Scientists Recognized in New Academy*. Scidev.net. Available online at: http://www.scidev.net/en/news/pakistan-s-young-scientists-recognised-in-new-academy.html

39 Mohammed bin Rashid Al Maktoum Foundation (MBRF) and UNDP/RBAS (2009). *Arab Knowledge Report 2009. Towards Productive Intercommunication for Knowledge*. Mohammed bin Rashid Al Maktoum Foundation: Dubai, United Arab Emirates and United Nations Development Programme/ Regional Bureau for Arab States: New York, USA. Available online at: http://www.mbrfoundation.ae/English/Documents/AKR-2009-En/AKR-English.pdf

40 Ur-Rahman A (2010). *Innovation: the path to socio-economic development*. Paper presented at the World Islamic Economic Forum, Kuala Lumpur, May 2010.

reach their 13th birthday.[41] Only one-fifth of those interviewed had permanent jobs, whilst half believed that they did not have appropriate skills to enter the workforce. Even those with good qualifications struggled to find relevant employment. To avoid a socio-economic disaster, the authors calculated that the Pakistani economy would need to create 36 million jobs over the next decade, compared with the current rates of around one million jobs a year. Education will be critical, but measures to strengthen the labour market for the younger generation will also be fundamental to the future of Pakistan.

3.2 Exceptional individuals

For many young people, the obstacles to a scientific career are significant. Lured by higher salaries elsewhere, frustrated by a lack of educational resources or infrastructure, uninspired by limited role models, other paths can seem far more attractive. The Pakistani physicist Perez Hoodbhoy claims that only the 'exceptional individual' is able to develop a mindset that is open to scientific inquiry within the current cultural constraints of the Islamic world. He describes 'a society in which absolute authority comes from above, questions are asked only with difficulty, the penalties for disbelief are severe, the intellect is denigrated and a certainty exists that all answers are already known and must only be discovered'.[42]

Looking back 800 years to the golden age of Islamic world science, there are a plethora of 'exceptional individuals' from whom to draw inspiration. Consider the work of mathematicians and scientists like Al-Khawarizmi who gave us the term 'zero' and wrote the first book on algebra; Ibn Sina whose textbook *Canon of Medicine* was a standard work in Europe's universities until the 1600s; or Ibn al-Haytham whose research into optics underpins the fundamental principles of cameras today.[43]

Today, inspiring figures are more difficult to find. To date, only two scientists from OIC states have won Nobel Prizes, the late Abdus Salam, a Pakistani (Physics 1979) and Ahmed Zewail, an Egyptian (Chemistry 1999). Both were awarded for work done outside of their home country, with Salam's Nobel Prize winning work conducted in the UK and Italy, and Zewail's in the US. Yet the achievements of these Nobel Laureates are a source of great pride in their countries of origin, with Zewail even enjoying popstar status. In 2009, he returned to his hometown of Alexandria to give a keynote lecture. Over 3000 fans turned up and security guards held back the hundreds of others who could not fit into the auditorium.

41 British Council.(2009). *Pakistan: The Next Generation. November 2009.* British Council: London, UK. Available online at: http://www.britishcouncil.pk/pakistan-Next-Generation-Report.pdf

42 Perez H (2007). *Science and the Islamic world—the quest for rapprochement*. Physics Today **60**, 8, pp 49–55. Available online at: http://scitation.aip.org/journals/doc/PHTOAD-ft/vol_60/iss_8/49_1.shtml?bypassSSO=1

43 Masood E (2009). *Science and Islam*, Icon Books: London, UK.

Across the modern Islamic world, role models play an important part in the quest for a knowledge-based future. In Turkey, no shop, restaurant or public venue is complete without a framed picture of General Kemal Ataturk, the father of modern Turkey, who was responsible for universal education and the development of the unifying Turkish language.

In Malaysia, former Prime Minister Tun Mahathir is still strongly associated with the nation's quest to become a knowledge economy by 2020. Since his retirement in 1998, some claim that Malaysia has lost the leadership required to fulfil its aspirations.

The search for role models is made harder by the significant impact of brain drain across the OIC. According to the Gulf Centre for Strategic Studies, Arab countries lose half of their newly qualified medical doctors, 23% of engineers and 15% of scientists each year, with most of these heading to the UK, US and Canada.[44] Young and ambitious, they are disenchanted by the lack of investment and career opportunities, or by political instability.

Europe is now home to around 20 million Muslims.[45] Many of these are from second or third generation migrant families, some have deeper European roots and others are more recent arrivals. To varying degrees, connections and goodwill towards their countries of origin run deep. While the focus of many efforts remains building the *stocks* of human capital within a country, research suggests that *flows* and *networks* of scientists, engineers and entrepreneurs have a greater impact on innovation systems in home and host countries.[46] Encouraging these talent flows, and building bridges to diaspora scientific communities is one way of strengthening national scientific efforts.

3.3 Women in science

Women account for 50.7% of the population of the OIC countries.[47] To European observers, the status of women in the Islamic world is often associated with clothing. Consider the banning of the niqab in France,[48] or Sudan's Lubna Husseini who attracted international coverage for her fight to wear trousers on a local university campus. To an outsider, the abaya[49] and niqab can symbolise the broader restrictions facing Islamic women. Yet the status of women across the Islamic world is more complex than these headlines portray.

44 Sawahel W (2004). *Brain drain threatens future of Arab science*. Scidev.net. Available online at: http://www.scidev.net/en/news/brain-drain-threatens-future-of-arab-science.html

45 Masood M (2008). *Our Shared Europe*. British Council: London, UK. Available online at: http://www.oursharedeurope.org.

46 Saxenian A (2006). *The new Argonaunts: regional advantage in a global economy.* Harvard University Press: Cambridge, USA.

47 SESRIC (2010). *Basic Social and Economic Indicators Database*. The Statistical, Economic and Social Research and Training Centre for Islamic Countries: Ankara, Turkey.

48 'Niqab' is a veil worn by some Muslim women which covers the face.

49 'Abaya' is a loose, usually black robe worn by Muslim women, especially in Arabic-speaking regions, covering the body from head to toe and often worn with a headscarf and veil.

According to a recent UNESCO Report, in 2007, 13 Islamic world countries produced a higher percentage of women science graduates than the United States.[50] Bahrain reached 73%, Algeria 71% and Palestine 49% compared with 41% in the US. In Saudi Arabia, women make up 58% of the student population (yet only 16% of the workforce).[51] And at Birzeit University in Palestine, in the 2009 academic intake, nearly 60% of the undergraduates and 55% of the graduate students were women.[52]

These are encouraging developments, but there are still many frustrations for women seeking to pursue a scientific career. In many countries, women are expected to marry and have children at a relatively early age—when they might just have completed their Masters or PhD-level training. This means that even if women are in a majority as students, few make it to the upper echelons of academia.

Motivations and perceptions of education also differ for many Islamic world women. The issue is less the number of women studying, and more the freedoms and choices they have afterwards. Some make good use of Islamic marriage contracts, which allow both parties to write bespoke clauses, by inserting clauses that guarantee their right to earn a living or undertake further study.

Statistics on the number of women in the scientific workforce are hard to obtain. The OIC's statistical body, SESRIC[53] finds that within the 24 OIC member countries with available data, only eight—including Azerbaijan, Kyrgyz Republic, Tunisia and Uganda—have a share of women in research above the world average.[54] Data for the remaining 33 member states are not available. The OIC commissioned a study in April 2008, which found that there were only 18 women among the top 380 OIC scientists.[55] In response, an Islamic Network of Women Scientists was established to help women share experiences and collaborate more effectively at a national level. More support is required if, as the 2005 Arab Human Development Report argues, the empowerment of women, in both intellectual and practical terms, is to become an 'essential axis of the Arab project for a human renaissance.'[56]

50 UNESCO (2009). *Global Education Digest 2009. Comparing Education Statistics Across the World*, United Nations Educational, Scientific and Cultural Organization Institute for Statistics: Montreal, Canada.

51 Butt R (2008). *Saudis build world's biggest women-only university*. The Guardian. Available online at: http://www.guardian.co.uk/education/2008/nov/01/saudi-arabia-middle-east

52 Source: Birzeit University (2010). *Facts and Figures*. Available online at: http://www.birzeit.edu/about_bzu/p/2630.

53 SESRIC is the Statistical, Economic & Social Research & Training Centre for Islamic Countries. See: http://www.sesrtcic.org

54 OIC Outlook (2009). *Research and Scientific Development in OIC Countries*. The Statistical, Economic and Social Research and Training Centre for Islamic Countries: Ankara, Turkey.

55 Sawahel W (2008). *New Network to Raise Profile of Muslim Women Scientists*. Scidev.net. Available online at: www.scidev.net/en/news/new-netwrok-to-raise-profile-of-muslim-women-scientists.

56 UNDP/RBAS (2005). *Arab Human Development Report 2005. Towards the Rise of Women in the Arab World*. United Nations Development Programme Regional Bureau for Arab States: New York, USA. Available online at: http://www.arab-hdr.org/publications/other/ahdr/ahdr2005e.pdf

4 Culture

Religion is an important feature of life in the OIC states. Populations are devout. Atheism or agnosticism is difficult to admit to in public. Even in relatively multicultural societies, scientific meetings start and end with prayers. All of this has implications for how research is carried out.

Religion need not act as a brake on innovation. As the golden era of Islamic science shows, it can also act as a spur to creativity. And some interesting innovations are taking place within religion itself, or at the boundaries between religion and science. For example, Malaysians proudly point to the new international airport in Kuala Lumpur as leading the world in halal logistics. There is also a cornucopia of electronic gadgetry designed to assist the devout, such as digital prayer compasses, digital Qur'ans and GPS systems to guide the faithful to sacred sites. In the interest of sustainable water resource management, Islamic scholars are now debating the need to adjust religious guidelines on the status of water as a free good.[57] And in outer space, Malaysian researchers are grappling with how to pray five times a day, when astronauts might see 15 or more sunrises and sunsets in less than 24 hours.[58]

57 Faruqui N, Biswas A & Bino M (2001). *Water Management in Islam*. United Nations University/ International Development Research Centre Press: Tokyo, Japan. Available online at: http://www.idrc.ca/openebooks/924-0/

58 NASA (2002). *Mission Highlights—NASA STS 111 International Space Station*. Available online at: http://www.nasa.gov/missions/highlights/webcasts/shuttle/sts111/iss-qa.html

At a political level, parties sympathetic to religion are gaining support across the majority of OIC member states. Religious parties hold power in Malaysia, Turkey, Pakistan, Iran and Saudi Arabia, and are the main opposition in Egypt, Kuwait and Morocco.

Some might expect this to act as an impediment to growth in research. Across the OIC, disciplines such as politics, social science and economics tend to be weak. But attitudes towards science, development and religion are often more complex.

Islam struggles with issues raised by advances in science, just as every religion does. Areas of disagreement amongst Islamic theologians include evolution and bioethics. In a few areas, Islam has facilitated scientific leadership. Definitional differences over the stage at which an embryo becomes 'human' have enabled considerable freedom at centres such as the Royan Institute in Tehran, which conducts research using human embryonic stem cells.[59]

In 2009, when the Scientific and Technological Research Council of Turkey cancelled the publication of a journal celebrating the 200th anniversary of Charles Darwin's birth and his work on evolution, the international scientific community protested loudly. So did many

59 Al-Khalil J (2008). *While our scientists struggle with ethics, the Islamic world forges ahead.* The Guardian. Available online at: http://www.guardian.co.uk/commentisfree/2008/jul/31/genetics.ethicsofscience

scientists within the Islamic world. The Turkish Academy of Science denounced the Council's decision, declaring that evolution was a scientific fact and any 'falsification, evasion, obstruction of communication in any way of this fact was unacceptable.'[60]

Scholars such as Salman Hameed argue that a more serious debate about the compatibility of evolution and Islamic theology will soon be required across the Islamic world, because of rising education levels, access to the internet and greater exposure to these debates elsewhere.[61] In handling this issue, Islamic world scientists are likely to have an emotive battle on their hands.

4.1 Governance and policy

At least half of the 57 OIC countries do not have representative government, but rely on single party systems, royal families or military rule. What are the implications of this for research, knowledge and innovation?

Things are changing, albeit slowly. Indonesia, the nation with the largest number of Muslims, has a 10-year-old democracy. Nigeria and Pakistan also recently returned to a form of representative rule after lengthy periods in which the army was in charge. Saudi Arabia recently held local elections—though only men were allowed to vote. In Turkey, where democratic roots are stronger, the military is slowly learning to take a back step. But the situation is quite different in countries like the United Arab Emirates and Qatar. Here, royal families remain in charge and whilst they are often very generous to their citizens, there are complex loyalties at play, which can at times limit the prospects for social and economic reform.

There is a paradox here: those countries with the strongest R&D sectors are those that can also be more authoritarian. They include Turkey, Iran, the Gulf States, and Malaysia. In Pakistan, over recent decades, periods of military rule have tended to be more supportive of science than periods when civilian administrations have been in power.

Some commentators have suggested that there is something in contemporary Islam that is inimical to innovation.[62] To what extent can societies where open debate is not always encouraged become centres of creativity and invention? As Ismail Serageldin, Director of the Alexandria Library argues, science requires freedom, as much as it requires investment and infrastructure.[63]

60 Letter to Royal Society President Lord Rees of Ludlow from the President of the Turkey Academy of Sciences, Professor Dr Yucel Kanpolat, March 2009

61 Hameed S (2010). *Equating evolution with atheism will turn Muslims against science*. The Guardian. Available online at: http://www.guardian.co.uk/science/blog/2008/dec/12/islamic-creationism-evolution-muslim

62 Nature (2006). *Ambition and neglect: Science in the Muslim World* (Editorial). Nature **444**, 19. Available online at: http://www.nature.com/nature/journal/v444/n7115/full/444019a.html

63 Serageldin I (2008). *Science in Muslim countries.* Science **321**, 5890, p745. Available online at: http://www.sciencemag.org/cgi/content/summary/321/5890/745

Scientists need the freedom to enquire, to challenge and to envision the unimagined. In education systems where rote learning is still the main method of teaching, the development of these critical skills can be stifled. In societies where authority is unquestioned and sometimes feared, researchers have limited capacity to question and challenge the status quo. Despite the fundamental importance of science and technology policy to a country's development, relations between the academic community and government are often weak.

The controversial Egyptian religious leader, Yusuf Al-Qaradawi, argues that if there is to be a second golden age of Islamic thought and scholarship, Islamic governments need to encourage self-criticism and protect academic freedom. He criticises an Islamic movement that opposes free thinking because 'capable minds that can renew and innovate will escape from our ranks, leaving behind those conservatives who can only imitate and who reject change.'[64]

4.2 Infrastructure of a different kind

Merit-based structures that foster academic freedom and promote independent scholarship need to be embedded in research systems across the OIC. Countries such as Qatar argue that they have imported and applied rigorous peer review mechanisms within their research programmes. All of their branch-campuses have academic freedom ingrained in their tenancy agreements.

Yet there are also examples of scientific misconduct and failures of peer review. Iran's research credibility has been shaken by repeated incidents of senior government scientists, including the Minister for Science, being accused of plagiarism.[65] Concerns about promotions based on personal connections rather than merit in some OIC universities also raise concerns. And educational techniques based on rote-learning leave some sceptical as to whether genuine skills of inquiry, creativity and innovation can be fostered.

4.3 The role of the media

The media has an important role in promoting and defending science and rational inquiry in OIC societies. Yet the quality of scientific journalism and reporting varies dramatically across the Islamic world, and open dialogue between scientists, the media and the wider public is often non-existent.

Generally, the quality of scientific coverage across the Islamic world is substandard. Journalists are often under-qualified to translate complex scientific findings, interpret statistics or relate scientific developments to their broader policy

64 Masood E (2006). *An Islamist revolution.* Nature **444**, pp 22–25. Available online at: http://www.nature.com/nature/journal/v444/n7115/full/444022a.html

65 Butler D (2009). *Plagiarism scandal grows in Iran*. Nature **462**, pp 704–705. Available online at: http://www.nature.com/news/2009/091209/full/462704a.html

context.[66] News agencies are often government-owned, and coverage of government announcements can lack critical credibility. The recent protests by more than 300 reporters for the influential website *Islam Online*, based in Cairo, are a reminder of the threat of conservative editorial control encroaching on journalistic integrity.

Scientists are often overwhelmed by their own research priorities, so that their responsibilities to explain and promote broader public engagement in science are overlooked. Few scientific institutions in OIC countries have public relations officers equipped to deal with the media. For journalists, the issues are compounded by a lack of English-language skills, limited scientific sources in the native language, and few networks from which to seek advice.

But things are slowly changing. In 2006, the Arab Science Journalists Association was created. Today it has almost 180 members. *Al-Ahram*, Egypt's daily newspaper, now employs 20 full-time science journalists, more than many newspapers in the US or Europe.[67] In 2011, Cairo will host the World Conference of Science Journalists, and there are plans to delegate a significant part of the conference to agenda items specific to the Islamic world.

The quality of public scientific discourse will also be improved as more sources of information become available and accessible. *National Geographic*, *Scientific American* and other international journals are already available in Arabic.[68] In March this year, *Nature* Middle East was launched to support emerging science in the region. Saudi Arabia recently struck a deal with Google to increase the level of Arabic content available through its search engine. Strengthening relations between the research community, the media and the public must become an integral strand of any national strategy for scientific development.

66 El-Feki S (2008). *Strong medicine*. Arab Media and Society **5**, Spring 2008.

67 El-Awady N (2009). *Science journalism: The Arab boom*. Nature **459**, p 1057. Available online at: http://www.nature.com/nature/journal/v459/n7250/full/4591057a.html

68 Masood E (2002). *National Geographic: the world in Arabic*. OpenDemocracy: London, UK. Available online at: http://www.opendemocracy.net/globalization/national_geographic_4374.jsp

5 Prospects

The coastal resort city of Langkawi in northern Malaysia is not an obvious location for conversations about the future of science in the Islamic world. Yet, surrounded by palm trees, jet skis and honeymooning couples, representatives of the Royal Society recently talked science with Professor Zakri Abdul Hamid, the then Director of the Centre for Global Sustainability Studies at Malaysia's top university. At the time, he denied rumours that he was soon to become the country's Chief Scientific Adviser—a role he was appointed to a few weeks later.

People like Professor Zakri give hope for the future. Forward thinking, globally minded, he talks passionately about the critical role of science, technology and innovation in addressing today's grand challenges. OIC countries like Malaysia, he says, should be asking themselves: 'what can *we* contribute to tomorrow's world—to issues of global warming and climate change? We are all global citizens. We all need to worry.'

5.1 Environmental imperatives

Professor Zakri makes an important point. Given the potential of environmental degradation and climate change to exacerbate poverty and retard economic progress, these issues warrant greater attention across the OIC Member States.

Between 2004 and 2007, the OIC countries suffered 32 floods; 11 flash floods; 6 typhoons; 4 droughts; 3 tornadoes; and 3 snow avalanches.[69] Fatal earthquakes and tsunamis have hampered development in countries like Indonesia and Pakistan, exposing weaknesses in infrastructure, expertise and the capacity to contain the spread of preventable diseases.

In 2004, desert locust attacks on food crops threatened food security in 24 countries in the Middle East and North Africa.[70] Even the availability of bread, the staple of Arab cuisine, has been affected by up to 200% rises in grain prices since 2001.[71] In countries where large public demonstrations are rare, surging prices led Egyptians, Moroccans and Mauritanians to the street in protest during 2008.

Issues of water security are also pertinent in the Middle East, and are the cause of much geopolitical tension. While representing 5% of the total world population, the Middle East and North Africa (MENA) region contains only 0.9% of global water resources and has low levels of renewable water resources.[72] Per capita

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69 Jamil S (2007). *Climate Change and the Muslim World*. S. Rajaratnam School of International Studies, Nanyang Technological University: Singapore, Singapore.

70 *Ibid.*

71 United Nations Development Programme RBAS (2009). *Arab Human Development Report 2009. Challenges to Human Security in the Arab Countries*. United Nations Development Programme Regional Bureau for Arab States: New York, USA. Available online at: http://www.arab-hdr.org/publications/other/ahdr/ahdr2009e.pdf

72 Berman I and Wihbey P (1999). *The New Water Politics of the Middle East*. Strategic Review: USA. Available online at: http://www.israeleconomy.org/strategic/water.htm.

availability of water is the lowest in the world, rates of withdrawal are amongst the highest, yet millions rely on access to water as part of the path out of poverty.[73]

Competing water demands are exacerbated by high population growth rates and rapid urbanization, and a general decrease in water availability across the Middle East is a consistent projection across various climate models.[74,75] The UN Food and Agricultural Organisation warns of an increased risk of conflict over scarce resources in the Middle East, and predicts that as many as 600 million people could experience additional water stress if temperatures increase by just two or three degrees.[76]

When we consider the prospects for science and innovation in the Islamic world, these environmental threats must be at the forefront. What will it take for the Islamic world to place greater focus on issues of climate change? Where might countries be able to benefit from economies of scale by working together on regional sustainability issues?

73 SIWI (2009). *Water Resources in the Middle East: Background Report to Seminar on Water and Energy Linkages in the Middle East*. Stockholm International Water Institute: Stockholm, Sweden. Available online at: http://www.worldwaterweek.org/documents/WWW_PDF/Resources/2009_18tue/Backg_report_Energy_ME_Water_n_Energy_Seminar.pdf

74 *Ibid.*

75 UNESCO (2009). *Climate Changes, Water Security and Possible Remedies for the Middle East*, *The United Nations World Water Assessment Programme Scientific Paper*. United Nations Educational, Scientific and Cultural Organization: Paris, France. Available online at: http://unesdoc.unesco.org/images/0018/001818/181886e.pdf

76 UN (2008). *UN Warns of Climate Change Effects on Water Shortages*. United Nations: New York, USA.

5.2 Collaboration is key

The stakes are high. The numbers are alarming. Whilst action has been underwhelming, there are positive signs emerging across the environmental sustainability agenda—with collaboration and exchange at the core.

Issues of water management as well as technological imperatives have proven good stimuli for cooperation and diplomacy across the Middle East region. Key institutions, such as the Arab League, the Gulf Cooperation Council and the Arab Water Council are engaging with the issues but more regional interventions and collaborations are needed, for example, for improving desalination techniques.

The fifth World Islamic Economic Forum, held in Jakarta in early 2009, tackled the complexities of food security and called for greater public–private sector collaboration to increase agricultural productivity. This builds on the US$1.5 billion Jeddah Food Initiative of the Islamic Development Bank, announced a year earlier, aimed at assisting less developed OIC countries to increase agricultural production.[77]

Egypt recently held the first ever pan-Arab biodiversity conference, recognizing that biodiversity is something to conserve. And in July 2009, some 200 Muslim scholars gathered in Istanbul and formulated the first ever Muslim Climate Change Action Plan. The plan proposed the development of major cities in the Islamic world as

77 OIC General Secretariat (2009). *Report on food security of the OIC member states*. Twenty-fifth session of COMCEC, held in Istanbul, Turkey. Organisation of the Islamic Conference: Jeddah, Saudi Arabia.

'green' role models and a best practice environmental guide for Islamic businesses.[78]

At a country level, there are some outstanding examples of national leadership with regard to sustainable technologies. The UAE's Masdar initiative has already been mentioned. Egypt is taking a lead in developing wind energy, aiming to meet 20% (7,200 MW) of its electricity needs from renewable sources by 2020. Kuraymat, just outside Cairo, boasts the country's first solar thermal power plant, contributing 140 MW to renewable energy.[79]

These are all positive signs but there is a long way to go. People like Professor Zakri argue that for science to flourish, OIC countries need to become more international in their outlook—benchmarking against global standards, promoting collaboration as a top priority. To do this, policy makers, academics and scientists need to create strategies for tapping into global networks of knowledge and ideas. National structures will always be important in promoting and regulating scientific activity, but encouraging Islamic world scientists to leverage the self-organising networks of global science and knowledge is increasingly critical. According to US science policy analyst Caroline Wagner, these networks are 'remapping science across the globe, and changing the rules by which it is conducted', and there is much to be gained from participating in this global shift.[80]

5.3 Science diplomacy

H.G. Wells once warned that 'Human history becomes more and more a race between education and catastrophe'.[81] Faced with mistrust and suspicion between the governments and peoples of many OIC countries and countries in the West, collaboration and exchange could not be more important.

Across the OIC, there is particular mistrust of the governments of Britain and the US—exacerbated by visa restrictions as well as foreign policy in Afghanistan and Iraq. Likewise, following the terrorist attacks of 9/11, 7/7 in London and 15/11 in Spain, there is now a significant section of the European and American public that mistrusts Muslim communities.

Science can be a bridge to communities where political ties are weaker. Through science diplomacy, cooperation can be an important tool through which to improve international relations, rebuild trust and promote mutual understanding.[82] Partnerships, therefore, between individuals and institutions from the

78 EMDC (2009). *Istanbul Declaration of the 7 Year Muslim Climate Change Action Plan 2010–2017*. Earth Mates Dialogue Centre: London, UK. Available online at: http://www.arcworld.org/downloads/m7yap%20dec%20july%2009.pdf.
79 Can't Drink Oil (2009). *Country Profiles*. IndyACT: Beirut, Lebanon. Available online at: http://www.cantdrinkoil.org.
80 Wagner C (2008). *The New Invisible College*, Brookings Institution Press. Washington D.C, USA.
81 Wells HG (1920). *The Outline of History*. Native American Books Distributor: USA.
82 Royal Society (2010). *New Frontiers in Science Diplomacy. Navigating the changing balance of power.* Royal Society: London, UK.

participating countries with the Islamic world and the rest of the world are critical.

President Obama's speech at Cairo's Al-Azhar University in June 2009 highlighted science as a key tool with which to help rebuild relations with the Islamic-world at a time when this is urgently needed.[83] Now, 12 months on, some express disappointment at the lack of resources and limited outcomes achieved since this much heralded speech. Three science envoys—Bruce Alberts ForMemRS, Ahmed Zewail and Elias Zerhouni have been appointed, but the scale of the task is clearly beyond the capacity of three individuals, despite their immense intelligence and goodwill.

Across the OIC there is an entire generation of scientists who were schooled in Western nations through scholarships from the British Council and the Ford and Rockefeller Foundations. They have fond memories of their host countries but are now mostly retired or close to retirement. Such scholarships no longer exist on the same scale, which means that an entire generation of scientists is growing up with little or no contact with Western nations.

Unless something is done there is a risk that each side will sink into isolation. Iran and Pakistan, if frozen out, will continue to develop with little outside contact. Likewise, developed countries will miss out on talent if they restrict scientists from Arabic-speaking countries and only further fuel mistrust.

Initiatives such as KAUST, Education City and Masdar that are wooing leading international universities and research partnership create a timely opportunity for Europe and the US. They enable countries to reach out to Islamic countries, using the soft power of science to facilitate cooperation, particularly around common interests such as low carbon innovation. The hope is that research communities in Europe, the US and Islamic countries could help to repair fractious relationships, and inspire a next generation of leaders in research, government, academia and industry.

One promising initiative of regional collaboration is the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), which is under construction in Jordan. Modelled on CERN in Europe, SESAME is a partnership between Bahrain, Cyprus, Egypt, Israel, Iran, Jordan, Pakistan, the Palestinian Authority and Turkey. Iraq is also considering joining. Synchrotrons are large and expensive facilities and are usually only found in wealthy countries. The synchrotrons built in Taiwan (National Synchrotron Radiation Research Centre (NSRRC) in 1993) and Brazil (Brazilian Synchrotron Light Laboratory (LNLS) 1997) have demonstrated the advantages for research in basic and applied sciences and for national technological development. By pooling regional resources, SESAME has the potential to build scientific capacity within the region.

83 Obama B (2009). *Remarks by the President on a New Beginning*. Speech by US President Barack Obama in Cairo on 4 June 2009. Available online at: www.whitehouse.gov/the_press_office/Remarks-by-the-President-at-Cairo-University-6-04-09.

Although it will not be fully operational until 2012, SESAME is already bringing together scientists from its partner countries for training and discussion meetings. It is hoped that SESAME will create research career opportunities that limit brain drain from the region, and serve as a model for other areas of scientific collaboration.

Projects and initiatives that aim to provide a platform for ongoing dialogue and collaboration are vital, especially at moments of tension. For example, after Iran's elections in June 2009, Iranian scientists called on the international research community to 'do everything possible to promote continued contacts with colleagues in Iran, if only to promote détente between Iran and the West when relations are bellicose'.[84] Scientists, both within and outside Iran, have a part to play in promoting a society that is more open to rational, critical thinking.

It would be naïve, however, to exaggerate the contribution that science can play in overcoming the deep and long-term foreign policy challenges in this region. In isolation, there is little that science diplomacy can do to build peace and stability in the Middle East. But as one small piece in the jigsaw of geopolitical relations, science can make a significant contribution.[85]

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84 Nature (2009). *We are all Iranians* (editorial). Nature **460**, pp 11–12. Available online at: http://www.nature.com/nature/journal/v460/n7251/full/460011a.html

85 Royal Society (2010). *New Frontiers in Science Diplomacy. Navigating the changing balance of power.* Royal Society: London, UK.

6 The Atlas of Islamic-World Science and Innovation

This paper has only scratched the surface of what is happening in science and innovation around the Islamic world. How far and fast any of these countries move up the science and innovation league tables remains to be seen. But just as small nations such as Finland and Singapore have proved some of the surprising success stories of global innovation in the past 20 years, individual countries within the Islamic world have the potential to make breakthroughs.

More robust analysis of the potential opportunities and challenges facing science across the Islamic world is needed. This is where *The Atlas of Islamic-World Science and Innovation* can play a critical role. Inspired by signs of renewed ambition and investment in education, science and innovation, this three-year project aims to explore the changing landscape of science and innovation across a diverse selection of countries with large Muslim populations in the Middle East, Africa and Asia. Looking in detail at 15 economically and geographically diverse countries, including Egypt, Iran, Jordan, Qatar, Pakistan, Malaysia, Nigeria, Senegal and Azerbaijan, the project will chart the delicate interplay between science, innovation, culture and politics. It will explore new opportunities for partnership and exchange with the wider world.

It is a project of many partners—from across the Islamic world, Europe and North America, including the British Council, the International Development Research Centre of Canada, the Qatar Foundation, *Nature*, the Royal Society and the five family institutions of the OIC. Jointly managed by the Royal Society and the OIC, this project is overseen by a Joint Management Team made up of all partners and chaired by Professor Ihsanoglu. In March 2007, the project was endorsed by all the Kings and Heads of State of the OIC in Dakar, Senegal, reflecting the importance of the project to senior figures across the Islamic world.[86]

Detailed country studies, to be released over the next two years, will provide an insightful overview of science and innovation in 15 countries. This will include an independent and authoritative assessment of how capabilities are changing, and analysis of the opportunities and barriers to further progress. It does not aspire to be a comprehensive analysis of every sector, but will map key trends and consider the role of international best practices at the country level.

Another important feature of the project is the role of in-country partners. By working closely with national research partners, national governments, universities and other stakeholders throughout the process, our aim will be to build up a cadre of

86 OIC (2008). *Eleventh Session of the Islamic Summit Conference (13–14 March 2008). Resolution No. 2/11-S&T*, held in Dakar, Senegal. Organisation of the Islamic Conference: Jeddah, Saudi Arabia.

trained research analysts in each country studied who can then become the kernel of a wider pan-OIC/European/North American network and take forward the learning and recommendations of the project. Each country report will be jointly authored by an experienced international analyst of national science and innovation systems, with a national researcher partner, ideally placed in a recognised or emerging centre of excellence within the country of focus.

We have only just begun. Country studies are now underway in Malaysia, Qatar, Pakistan, Jordan and Egypt, with national research partners including the University of Malaya, the Lahore University of Management Studies, the Faculty of Islamic Studies in Qatar and the Princess Sumaya University of Technology in Jordan. Starting with the release of the Malaysia case study at the OIC Meeting of Higher Education and Scientific Research Ministers in Kuala Lumpur in October this year, a steady flow of country reports will then be released throughout 2011 and early 2012.

Already our networks and understanding of the complexities facing scientific progress across the Islamic world have grown exponentially, as has our appreciation of the importance and timeliness of such projects. For organisations like the Royal Society and other international partners, this project is also important because it engages a range of countries that have been largely ignored by international science and innovation policy. As a result, there is a substantial gap in knowledge and awareness of how far and fast things may be changing.

As one of the oldest scientific academies in the world, a priority of the Royal Society since 1660 has been to map and make sense of international developments in science and innovation. Today, the Islamic world represents one of the most important arenas within which to undertake this task. This project, therefore, has great potential to bridge the knowledge gap that has grown, to support new collaborations and to improve learning about what constitutes effective policy for science and innovation between OIC countries, and between the OIC and the wider world.

As this paper highlights, there is much to suggest that a new renaissance of Islamic world science could be occurring. And there are also many challenges. If the Islamic world is to again prosper and flourish, far greater investment—in people, cultural attitudes as well as in physical and intellectual infrastructure must be encouraged. It must also be underpinned by greater international outreach and collaboration. The Atlas project is a small step amongst many in this process, but great leaps are required.

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- COMSTECH (the OIC's Standing Committee on Scientific and Technological Cooperation)
- Nature
- The Islamic Development Bank
- ISESCO (The Islamic Educational, Scientific and Cultural Organisation)

Further information on The Atlas of Islamic-World Science and Innovation is available online at: http://royalsociety.org/aiwsi or by contacting:

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Appendix 1 The status of science and research within the membership of the Organisation of the Islamic Conference

Name of the country	Region	Researchers in R&D (per million population)*	Expenditure on R&D (% of GDP)*	Tertiary gross enrolments ratio (% of relevant age group)*	Total number of journal papers published (2004–2008)**	Total number of citations (2004–2008)**	Average number of citations per paper (2004–2008)**	Field-weighted relative impact (2004–2008)**
Afghanistan	Asia	N/A	N/A	1 (2005)	103	358	3.476	0.949
Albania	Europe	N/A	N/A	20 (2005)	270	706	2.615	0.683
Algeria	Africa	N/A	0.19 (2004)	20 (2005)	6489	10519	1.621	0.505
Azerbaijan	Asia	1203 (2006)	0.25 (2005)	15.0 (2005)	2000	1626	0.813	0.189
Bahrain	Asia	N/A	N/A	33.1 (2005)	1006	1326	1.318	0.322
Bangladesh	Asia	77 (1996–2004)	0.62 (2000–2004)	6 (2005)	4358	12144	2.787	0.710
Benin	Africa	N/A	0.7 (2006)	3 (2001)	733	1947	2.656	0.707
Brunei Darussalam	Asia	274 (1990–2005)	0.01 (2003)	15 (2005)	277	653	2.357	0.657
Burkina Faso	Africa	19 (2006)	0.20 (2006)	2 (2005)	979	3167	3.235	0.781

Continued

Name of the country	Region	Researchers in R&D (per million population)*	Expenditure on R&D (% of GDP)*	Tertiary gross enrolments ratio (% of relevant age group)*	Total number of journal papers published (2004–2008)**	Total number of citations (2004–2008)**	Average number of citations per paper (2004–2008)**	Field-weighted relative impact (2004–2008)**
Cameroon	Africa	28.31	N/A	6 (2005)	2384	6958	2.919	0.695
Chad	Africa	N/A	N/A	1 (2005)	102	333	3.265	0.770
Comoros	Africa	N/A	N/A	2.3 (2004)	12	21	1.750	0.410
Cote d'Ivoire	Africa	N/A	N/A	6.5 (1999)	962	2833	2.945	0.652
Djibouti	Africa	N/A	N/A	2.2 (2005)	26	72	2.769	0.654
Egypt	Africa	493 (1990–2005)	0.49 (1995)	33 (2005)	21246	47682	2.244	0.577
Gabon	Africa	109 (1996–2004)	N/A	7.10 (2005)	439	2526	5.754	1.067
Gambia	Africa	N/A	N/A	1 (2005)	458	4015	8.766	1.565
Guinea	Africa	342 (1996–2004)	N/A	3 (2001)	115	503	4.374	0.963
Guinea Bissau	Africa	N/A	N/A	0.4 (2005)	101	640	6.337	1.110
Guyana	South America	N/A	N/A	10.8 (2005)	104	180	1.731	0.365
Indonesia	Asia	207 (1990–2005)	0.1 (2006)	17 (2005)	4186	14335	3.425	0.859
Iran	Asia	1279 (2006)	0.59 (2006)	24 (2005)	44703	87132	1.949	0.611
Iraq	Asia	N/A	0.5 (2004)	15.0 (2005)	1001	1374	1.373	0.385

Jordan	Asia	1927 (1990–2005)	0.43 (2002)	39.0 (2005)	5379	9984	1.856	0.493
Kazakhstan	Asia	786 (2006)	0.28 (2006)	53 (2005)	1370	2017	1.472	0.367
Kuwait	Asia	242 (1996–2005)	0.2 (2006)	18.0 (2005)	3508	8740	2.491	0.558
Kyrgyzstan	Asia	397 (2007)	0.22 (2005)	41 (2005)	278	453	1.629	0.437
Lebanon	Asia	N/A	N/A	51.0 (2005)	3703	9662	2.609	0.647
Libya	Africa	361 (1990–2005)	N/A	56 (2005)	551	772	1.401	0.395
Malaysia	Asia	509 (2006)	0.63 (2006)	32 (2005)	14731	28124	1.909	0.584
Maldives	Asia	N/A	N/A	0.2 (2004)	28	53	1.893	0.546
Mali	Africa	N/A	N/A	3 (2005)	512	2137	4.174	0.946
Mauritania	Africa	N/A	N/A	3 (2005)	104	201	1.933	0.501
Morocco	Africa	782 (1996–2004)	0.75 (2006)	11 (2005)	6513	13740	2.110	0.516
Mozambique	Africa	132 (1996–2004)	0.52 (2006)	1 (2005)	422	1914	4.536	1.168
Niger	Africa	N/A	N/A	1 (2005)	278	669	2.406	0.638
Nigeria	Africa	800 (2007)	1 (2004)	10 (2005)	11105	14303	1.288	0.325
Oman	Asia	3.43 (2006)	N/A	15.0 (2005)	2014	3845	1.909	0.489
Pakistan	Asia	350 (2007**)	0.9 (2007**)	5 (2005)	12516	23151	1.850	0.503
Palestine	Asia	N/A	N/A	41.1 (2005)	781	1518	1.944	0.490

Continued

Name of the country	Region	Researchers in R&D (per million population)*	Expenditure on R&D (% of GDP)*	Tertiary gross enrolments ratio (% of relevant age group)*	Total number of journal papers published (2004–2008)**	Total number of citations (2004–2008)**	Average number of citations per paper (2004–2008)**	Field-weighted relative impact (2004–2008)**
Qatar	Asia	N/A	N/A	18.6 (2005)	1213	2285	1.884	0.514
Saudi Arabia	Asia	140 (1996–2004)	N/A	28.0 (2005)	10299	20550	1.995	0.469
Senegal	Africa	1.34 (2006)	0.11 (2005)	5 (2005)	1326	4474	3.374	0.750
Sierra Leone	Africa	N/A	N/A	2 (2005)	67	88	1.313	0.373
Somalia	Africa	N/A	N/A	2.5 (1997)	9	18	2.000	0.674
Sudan	Africa	252 (2006)	0.4 (2006)	6.2 (2000)	942	2025	2.150	0.541
Suriname	South America	N/A	N/A	12.4 (2002)	58	197	3.397	0.722
Syria	Asia	29 (2006)	0.2 (2006)	14.8 (1997)	1050	2328	2.217	0.579
Tajikistan	Asia	N/A	0.10 (2006)	17 (2005)	224	241	1.076	0.225
Togo	Africa	102 (1990–2005)	N/A	3.6 (2001)	239	432	1.808	0.439

Tunisia	Africa	1460 (2006)	1.35 (2006)	29 (2005)	9941	16881	1.698	0.463
Turkey	Asia	476 (2006)	0.79 (2006)	31.0 (2005)	93910	225708	2.403	0.588
Turkmenistan	Asia	N/A	0.6 (2006)	19.5 (1997)	34	68	2.000	0.512
United Arab Emirates	Asia	N/A	N/A	22.0 (2005)	4324	10824	2.503	0.686
Uganda	Africa	37 (1996–2004)	1.25 (2006)	3 (2005)	2061	9612	4.664	1.057
Uzbekistan	Asia	1754 (1990–2005)	0.3 (2006)	15 (2005)	1735	3426	1.975	0.454
Yemen	Asia	N/A	0.28 (2005)	9.0 (2005)	387	728	1.881	0.447

* Data were reproduced from: UNESCO (2009). *Occasional Paper No 17. Mapping scientific research in member states of the Organization of Islamic Conference (OIC). Research Summary.* United Nations Educational, Scientific and Cultural Organization: Paris, France.

** Data provided by Elsevier from its Scopus Database. **Total number of journal papers published** includes all articles, reviews and conference proceedings papers published in core Scopus journals in 2004–2008 inclusive, where at least one author address lists the named country. **Average number of citations per paper** is the ratio of the total number of citations and the number of publications. **Field-weighted relative impact** allows countries with very different research profiles to be readily compared. The average citations per journal paper are weighted by the typical citation rate of the journal's subject field to account for differences in citation practices between fields. The indicator is a ratio, such that 1.000 indicates citation rates in line with the expectation for those fields in which the country has published, where values higher or lower than 1.000 indicate greater or lesser citation impact after accounting for field differences.

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