

The Arab States

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Although Arab culture historically has contributed a great deal to the world's scientific development, the region today exhibits poor performance in science and technology (S&T). It is evident that the advances in S&T that have changed our lifestyle have been driven by exciting discoveries made by scientific laboratories in the West. These discoveries have transformed human behaviour by introducing new products, new processes and better services. This progress has been mainly due to the West's commitment to improving both the quality and relevance of education, particularly in basic and applied sciences. The West's investment in human resources has created a wealth of knowledge.

In the meantime, due to political turmoil, low-quality education and inadequate R&D infrastructure, the Arab region has failed to deliver the high-quality scientists it needs to build economic self-reliance and capacity for innovation in the region.

OVERVIEW

The Arab region has by no means a homogeneous social fabric. The region's peoples may share a commonality of language, history and religion, but their societies are at variance when it comes to governance, currency, traditions and socio-economic systems.

The region is home to 295 million people, representing 4.5% of world population, and boasts a workforce of 103 million. Scattered across 22 countries, the Arab region covers 10.2% of the world's land area.

The Arab region has one of the highest fertility rates in the world. It exhibits annual population growth of 2.3%, compared with averages of 0.6% for industrial countries and 1.9% for developing countries. The fertility rate is 3.7 children per woman, whereas the world average is 2.8. As a consequence, the Arab population is expected to reach 315 million by 2015. One feature of Arab demography is that 40% of the population are young people aged 15 or under. This puts growing stress on educational, health and social systems, a trend that may have an impact on economic growth in terms of eroding gains in gross domestic product (GDP) per capita.

Wealth varies greatly from one country to another. In Qatar, for example, GDP per capita is the highest in the world at US\$ 29 948. This contrasts strikingly with GDP per capita of only US\$ 334 in Mauritania, one of the poorest countries in the world.

The Arab region may be grouped into three categories. The first, characterized by dependence on natural resources, particularly oil, includes the Gulf States of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates – GDP per capita income being highest in Qatar and lowest in Oman (US\$ 7 933).

The second category encompasses Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia, where GDP per capita is highest at US\$ 4 552 and lowest at US\$ 1 180. Although the countries in this category possess modest natural resources – with the exception of Iraq and Libya, which have considerable oil resources – they are essentially rich in terms of human resources, which are underutilized.

The third group of countries is characterized by scant natural resources and an equally meagre supply of trained human resources. Countries in this category also possess some of the lowest GDP per capita incomes in the world, which classifies them as least developed countries (LDC). They are Djibouti (US\$ 819), Mauritania, Somalia, Sudan and Yemen.

Table 1 shows the average GDP per capita of Arab states in 2002 compared with 1995. Some countries have experienced economic growth; others have suffered a recession.

ARAB SCIENCE IN A HISTORICAL PERSPECTIVE

The history of science can be divided into four broadly defined eras. The Greeks made substantial contributions to science between 450 BC and about 200 BC. The Chinese made useful contributions during the period AD 600–700. The Arab golden era of science extends about 350 years, from AD 750 to 1100. Europe and the West come to the fore from AD 1350 onwards.

Between the seventh and fourteenth centuries, the Arab and Islamic region held the banner of civilization, learning,

Table 1
GDP PER CAPITA IN THE ARAB REGION, 1995
AND 2002
In ascending order (\$PPP*)

	1995	2002
Mauritania	463	334
Sudan	245	443
Yemen	332	508
Djibouti	858	819
Syria	1 163	1 180
Morocco	1 252	1 250
Egypt	1 053	1 286
Algeria	1 456	1 661
Jordan	1 568	1 744
Tunisia	2 015	2 367
Libya	6 340	3 292
Lebanon	3 178	4 552
Oman	6 477	7 933
Saudi Arabia	7 577	8 053
Bahrain	10 120	11 374
Kuwait	14 118	14 597
United Arab Emirates	17 755	20 509
Qatar	16 642	29 948
Average	2 144	2 430

* PPP = purchasing power parity.

Source: Arab Fund for Economic and Social Development (2003) *Unified Arab Economic Report 2003*.

science and philosophy. Arabs led the way in mathematics, astronomy, physics, chemistry and medicine, due to their drive and enquiring minds when it came to problem solving and seeking the truth. Luminaries of this era who laid the foundations of modern science include Jaber-bin-Hayan (chemistry), Al-Khawarizmi (mathematics), Al-Razi (chemistry and medicine), Ibn-Sina (medicine), Ibn-Alhaisam (optics) and Al-Bairuni (physics and medicine). It was during this period that an unprecedented unravelling of intellectual mysteries related to nature occurred. The critical and analytical approach that was developed at the time is inherent in today's science.

At the time of Arab greatness, other civilizations remained stagnant. Ekelund and Hébert (1990) wrote that 'The death of the last Roman emperor in AD 475 ushered in

a long period of secular decline in the West and a concomitant rise in the fortunes of the East.' By AD 730, the Moslem empire's reach extended from southern France to the borders of China and India, an empire of spectacular strength and grace. Islam led the world in power, organization and extent of government; in social refinements and standards of living; in literature and scholarship. The Arab world acted as a sort of conduit to the West for Hindu wisdom and culture. Cities of the Saracen world like Baghdad, Cairo and Damascus, and Moorish Cordova and Toledo in Spain, were growing centres of Arab civilization and intellectual activity. It was Moslem science that preserved and developed Greek mathematics, physics, chemistry, astronomy and medicine during this half millennium, while Europe sank into what historians commonly call the Dark Ages (AD 500–1100).

Perhaps the most significant single innovation that the eager, inquisitive Arab scholars contributed to the West was their system of writing numbers. This displaced the clumsy Roman numerals of the previous empire with the much more utilitarian Arabic numerals of today. One of the more eccentric Arab mathematicians, Alhazen, founded the modern theory of optics around the year AD 1000. But for our purposes, the most important contribution of Arab culture was its reintroduction of Aristotle to the West.

After the city of Toledo was recaptured from the Moors by Crusaders in 1085, European scholars flocked there in order to translate the ancient classics, from Greek (which Europe had forgotten) into Arabic and Hebrew, then into Latin, making that knowledge accessible to the West. From AD 1100–1350 – during the first half of the European Middle Ages (AD 1100–1543) – the names of a few European scientists appear in scientific literature alongside a string of Muslim scientists, whose numbers include Ibn-Rushd, Tusi and Ibn-Nafis.

In that era, the English scholar Roger Bacon (1214–1292) studied Arabic and Arab sciences. Bacon became an expert on Aristotle at Oxford University and lectured on his teachings both there and at the University

of Paris, where study of Aristotle had been banned for many years on the grounds that he was not a Christian. Bacon was to introduce the experimental method as the only way to true knowledge.

After AD 1350, the world's scientific honours go mainly to Western scientists. The year 1543, which marked the death of Copernicus – who established a mathematical-astronomical model of the Sun at the centre of the universe, and Earth and other stars rotating around it – was to signal the end of medieval times and superstition, and the dawn of the Renaissance and modern science in Europe.

Robert Briffault states that science arose in Europe as a result of a new spirit of enquiry, new methods of investigation – the experimental method and the use of observation and measurement – the development of mathematics in a form unknown to the Greeks and, last but not least, the introduction of those methods by Arabs into the European world. Since then, European domination of science has become more pronounced with the passage of time.

WHY SCIENCE HAS DECLINED IN THE ARAB REGION

Scientific failing in the Arab region after AD 1350 can be traced to its history of persistent political upheaval caused by loss of empire, subjugation and conflict within countries. Such turmoil led to the disappearance of intellectual activity – an absence of interest in reasoning and a lack of curiosity – and has resulted in the region's current totalitarian and dictatorial political power systems. Arab enquiry and analysis were ultimately replaced by dogma and ignorance, resulting in the erosion of the scientific approach, accompanied by the loss of freedom of expression and thought.

Science grew essentially as a scholarly pursuit in its own right. However, oppression and loss of free thinking as a result of political conflicts, instability and the demise of democratic governance have produced too rigid an environment for the inquisitive mind to study nature. Hence, the last few centuries of scientific innovation completely belong to Europe, and the contribution of Arabs has been close to insignificant.

The current failure of S&T in the Arab region can be attributed to several main factors. One is an overall lack of interest in science by political leaders, who devote minimal funds to education and science compared with those set aside for military expenditure. Another is the deteriorating education system, whose insistence on traditional religious teachings leaves little room for scientific enquiry, much less innovative thinking. These factors, along with the strait-jacket of inadequate infrastructure and R&D support systems, create an environment that is not conducive to research and development. They will be discussed in greater detail below.

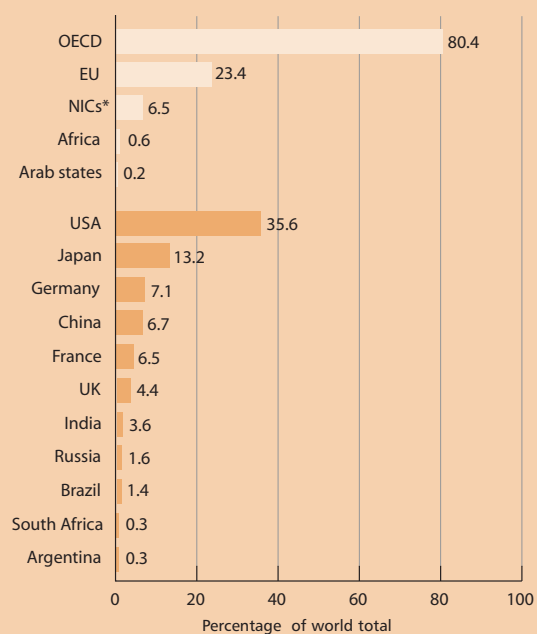
STATUS OF S&T IN THE ARAB REGION

Publications

One indicator of the region's poor performance is its low level of translation and publication of scientific papers. This falls within the general historical trend of few publications and translations in this region. For example, the cumulative total of translated books in the Arab world since the Caliph Maa'moun's time in the ninth century is about 100 000 books – equal to the volume Spain translates in one year (UNDP, 1999). The number of books currently translated into Arabic is about five books for every million Arab people. This compares with 920 books per million people translated into Spanish in Spain. To take another example, some 6 500 books are published by Arab writers every year in the Arab region, compared with 102 000 in North America.

Focusing on active research scientists, an indicator of the dynamism of research is the number of articles cited in reputable journals. The science citation index (SCI) is one measure of this activity. The number of frequently cited scientific papers per million inhabitants amounts to 0.02 in Egypt, 0.07 in Saudi Arabia, 0.01 in Algeria and 0.53 in Kuwait. Other Arab countries frequently have no cited publications to speak of. This compares with 43 in the USA, 80 in Switzerland, 38 in Israel, 0.04 in India and 0.03 in China. On a global level, the number of scientific publications originating in the Arab world does not exceed 1.1% of world production.

Figure 1
GERD IN THE ARAB REGION AS A WORLD SHARE, 2000



* NICs: Newly industrialized countries

Source: UNESCO (2003) *Global Investment in R&D Today*.

Patents

Technology output can be expressed in terms of the number of registered patents. Table 2 indicates the low level of innovative technology produced by the Arab region. Egypt, Kuwait and Saudi Arabia have been the Arab region’s main driving forces behind S&T output at the international level.

Investment in S&T

In terms of the ratio between gross domestic expenditure on R&D (GERD) and GDP, investment in the Arab world declined from a world share of 0.4% to 0.2% by 2000. Egypt, Jordan and Kuwait spend the most, devoting 0.4% of GDP to GERD. The figure for the remainder of the Arab region is as low as 0.1%. Total Arab GERD amounts to US\$ 1 100 million. As can be seen in Figure 1, the Arab region trails the developing countries in terms of GERD; this can be explained by a number of factors.

First, turnkey technology – which employs assembled products available for immediate use – is favoured in the Arab states to the detriment of endogenous technology, owing to contractual arrangements with foreign suppliers. In the past three decades, the Arab world has spent US\$ 1 000 billion on turnkey projects which is more than 20 times the amount spent within the Marshall Plan to

Table 2
PATENTS REGISTERED AT THE USPTO ORIGINATING FROM ARAB STATES, 1995–99
Non-Arab states are given for comparison

Year	1995	1996	1997	1998–99	Total
Bahrain	0	0	1	0	1
Egypt	7	6	2	7	22
Jordan	0	2	5	4	11
Kuwait	2	3	2	15	22
Oman	0	0	0	2	2
Saudi Arabia	11	12	14	30	67
Syria	0	0	0	1	1
United Arab Emirates	2	1	2	3	8
China	91	78	103	201	473
Republic of Korea	1 265	1 603	2 027	5 089	9 984
Israel	489	591	653	1 343	3 076

Source: United States Patent and Trademark Office: www.uspto.gov

rebuild Europe after the Second World War. The Arab states' dependence on such technology does nothing to help build domestic S&T capacity. The Arab region has maintained a strong role as a consumer of technology, totally dependent upon advanced countries for its own needs, be it in the form of chemicals, pharmaceuticals, engineering goods, transportation or defence equipment.

Second, S&T is not a priority item on the agenda of Arab political leaders – reflecting an absence of appreciation for the region's science and scientists. This has led to a situation where Arab economies dependent on oil and mineral resources will not be able to sustain development as resources become depleted. In spite of being blessed with 70% of the world's energy resources, the GDP of the entire Arab region is less than that of Italy.

In terms of overall investment, the amount spent in the Arab world on R&D, education and health combined amounts to less than expenditure on military needs imported from abroad (Table 3). Even though spending on defence has fallen recently, it still exceeds spending on education.

Generally speaking, expenditure on R&D by Arab countries is at best one-tenth of that spent in industrialized countries. According to UNESCO's 2003 report entitled *Global Investment in R&D Today*, some countries spend more than 3% of GDP on R&D, as in the case of Israel (4.4%) and Sweden (3.8%). The European Union spends 1.9% of GDP on R&D and has set a target of 3% by 2010. India spent 0.5% of its GDP on R&D in 2000 and has set itself a target of 2% by 2007. India's R&D indicators for 2003 have already shown the country's commitment as GERD has climbed to 1.08% of GDP.

Approximately 1.7% of world GDP was devoted to R&D in 2000, compared with 1.6% in 1997. The OECD reports a 2.4% share of GDP spent on R&D. Latin America spends an average of 0.6% of GDP on R&D, with Brazil and Costa Rica the greatest spenders at 0.9%, closely followed by Cuba at 0.8%. The Arab region remains by far the least R&D-intensive region in the world, devoting only 0.2% of GDP to R&D in 2000.

The low figure recorded by Arab countries again reflects how Arab GDP is inflated by oil production, even though not all Arab states are oil producers. Arab researchers may not reach international standards in either quantity or quality, but their contribution to world R&D at 0.6% of the total is still three times that of the contribution of Arab GERD to world R&D.

Data shown in Figure 3 indicate disparities between developed and developing countries in terms of GERD per capita. In 2002, the Arab region spent US\$ 6 per capita on R&D, compared with US\$ 953 per capita in the USA, US\$ 779 in Japan, US\$ 465 in the European Union, US\$ 42 in Latin America and US\$ 40 per capita in China. The world average is US\$ 124 and the ratio of R&D spending by developing countries to that by industrialized countries is 1:15.

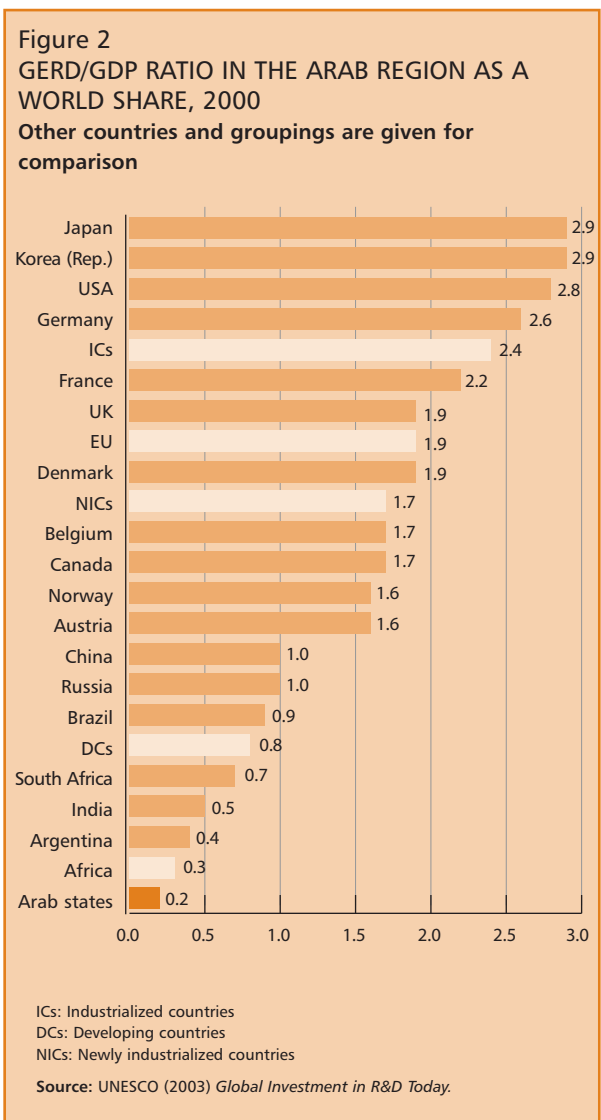
Information and communication technologies

Arab indicators show that S&T is in need of greater attention in terms of resources, institutional arrangements and

Table 3
MILITARY EXPENDITURE IN SELECTED ARAB STATES, 2001
As percentage of GDP, in descending order of GDP per capita

United Arab Emirates	2.5
Kuwait	11.3
Bahrain	4.1
Saudi Arabia	11.3
Oman	12.2
Lebanon	5.5
Tunisia	1.6
Jordan	8.6
Algeria	3.5
Egypt	2.6
Morocco	4.1
Syria	6.2
Djibouti	4.4
Yemen	6.1
Sudan	3.0
Mauritania	2.1

Source: UNDP (2003) *Human Development Report*.

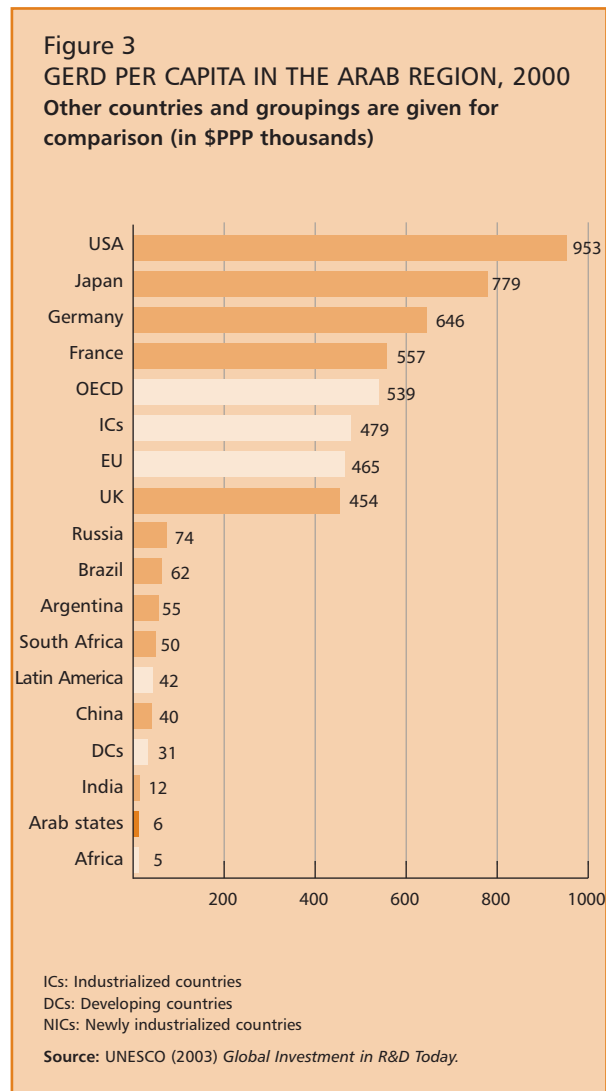


policy support. There are serious inadequacies, particularly where access to new technologies and information is concerned. Figure 4 shows that the Arab region has less than half the number of computers per 1 000 inhabitants than the average for middle-income countries. There are fewer than 25 computers per 1 000 population in the Arab region, compared to a global average of 78.3 (UNDP, 2003a). Similarly, there are only 109 telephone lines per 1 000 inhabitants in the Arab region, in contrast to an average of 561 in developed countries. That translates to one telephone for every ten Arab citizens,

against a ratio of one telephone for every 1.7 people in developed countries.

Some Arab countries, however, are catching up with the communications revolution. For example, a fibre-optics cable project covers 27 000km between Saudi Arabia, Egypt, the United Arab Emirates and Jordan. And in 1999, an Internet fair called Dubai Internet City displayed the UAE's progress in integrating information and communication technology (ICT).

In general, however, the lack of computers and limited Internet penetration in the Arab region are serious obstacles to online learning and to gaining access to information and knowledge databases in the vast array of scientific research

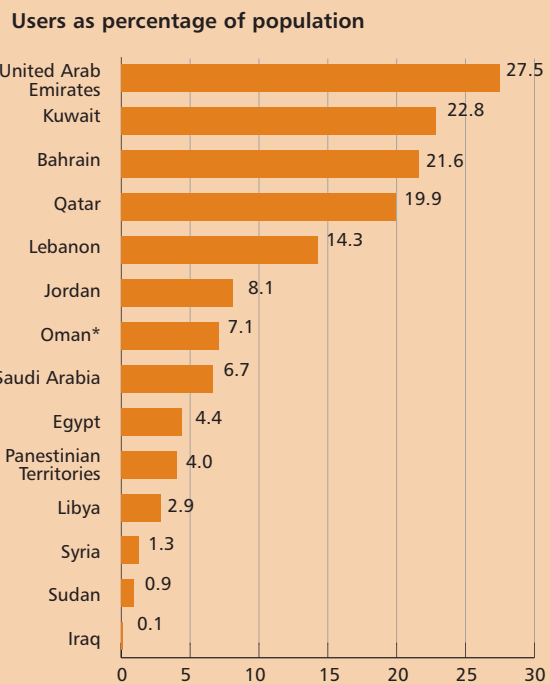


networks, universities, libraries and learning resources throughout the world. Developing into a knowledge society cannot be achieved without the appropriate infrastructure and relaxation of governmental bureaucracy concerning the acquisition of computers and related software technologies. Customs barriers and political protection in Arab countries hinder free communication and access to knowledge through networks.

Indicators show there were 4.2 million Arab Internet users in 2000, representing 1.6% of the Arab population (UNDP, 2003a); this figure compares with 30% of the population in the USA. These low numbers are a result both of the factors already mentioned and of the high cost of telephone lines, computers and subscriber fees. The small number of Internet service providers in the Arab region means there is little competition, and costs remain steep.

However, Figure 5 demonstrates that some Arab countries are making considerable progress in Internet penetration. Fibre optics and wireless networks are being established within and between university campuses to help pool resources in teaching, research and access to information. Many Arab universities, particularly in Egypt, Jordan, Lebanon and the Gulf states, have created online education and open

Figure 5
INTERNET PENETRATION IN THE ARAB REGION, 2003

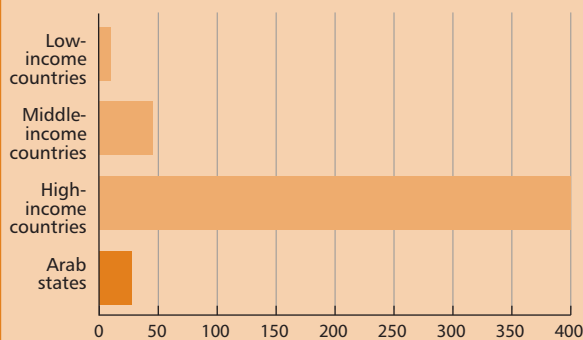


* 2002

Source: http://unstats.un.org/unsd/mi/mi_series_results.asp?rowID=605

Figure 4
PERSONAL COMPUTERS PER 1000 POPULATION IN THE ARAB REGION, 2001

Other groupings are given for comparison



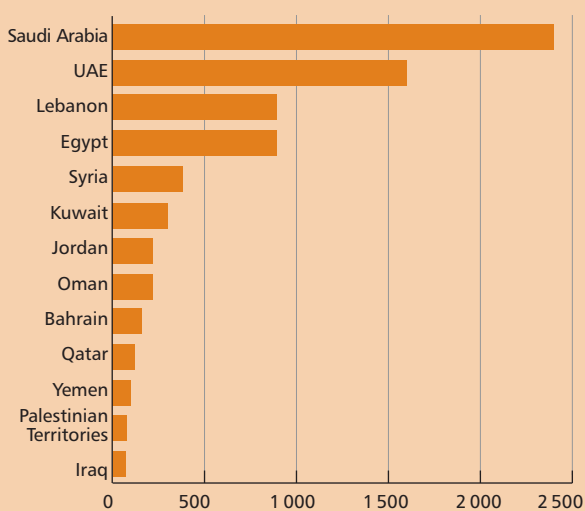
Source: World Bank (2002) *World Development Indicators*; UNDP (2003a) *Arab Human Development Report*.

university systems to link up to open universities in the UK, as well as to European and American universities. Libraries are also being linked to each other through a National Information Centre (NIC), in order to create an intranet electronic library system and Internet online library.

Increasingly, universities are providing more education in hardware and software technology, in addition to training courses in software programmes. Of all the countries in the region, Jordan has the highest computer literacy, thanks to the implementation of training programmes leading to an inter-national computer driving licence (ICDL). The programme content is supervised by UNESCO and meets European standards.

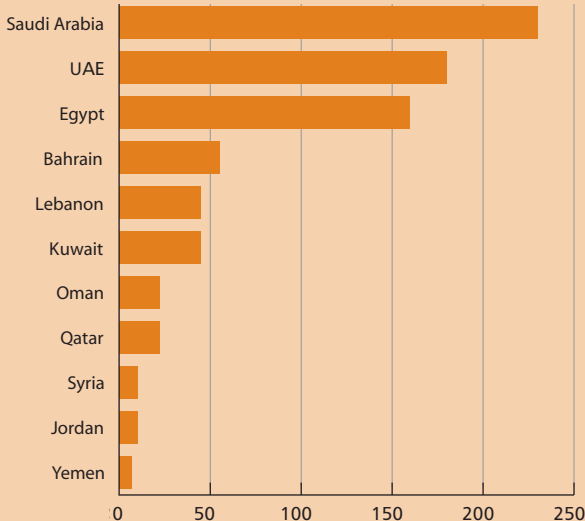
Table 4 shows the the position of Egypt, Jordan and Tunisia on the Networked Readiness Index (Harvard University, 2003), compared with sample countries from three other

Figure 6
VALUE OF CONTRACTS INVOLVING TRANSFER IN ICT, SELECTED ARAB STATES AND TERRITORIES, 1992–98
US\$ million



Source: Middle East Economic Digest (MEED) 1999.

Figure 7
TOTAL VALUE OF CONSULTANCY CONTRACTS IN SELECTED ARAB STATES, 1992–98
In millions of \$PPP



Source: Middle East Economic Digest (MEED) 1999.

regions. The index ranks countries on their preparedness to participate in the networked world and potential to participate in future. The highest ranking country has the most highly developed ICT networks and greatest potential to exploit them.

The total spent on ICT transfer by Arab countries between 1992 and 1998 amounted to US\$ 161.3 million on IT and US\$ 6.8 billion on communications. Figure 6 shows the value of contracts involving transfer of ICT over this period.

Consultancy as a tool for technology transfer

Consultancy contracts can be useful as an indicator of how know-how is oriented toward various economic activities, and this information can help in identifying areas for building endogenous S&T institutions that may target the transfer of know-how from contracting bodies to enhance national strategic plans. Figure 7 shows the value of consultancy contracts in S&T concluded by the Arab region from 1992 to 1998 for a total of US\$ 726 million. Egypt, Saudi Arabia and the United Arab Emirates account for about 78% of the total. In reality, the transfer of S&T depends largely on how these contracts are managed and what sort of a relationship is established between local teams and the consultants in terms of training, bridging and capacity building.

Table 4
THE DIGITAL DIVIDE IN SELECTED ARAB STATES, 2002
Other countries are given for comparison

	Score	Position in Networked Readiness Index
Tunisia	4.16	34
Turkey	3.57	50
Jordan	3.51	63
Egypt	3.13	64
Finland	5.92	1
Malaysia	4.28	32
Nigeria	2.62	74

Source: Harvard University (2003), *Global Information Technology Report 2002–2003*.

Arab scientists and engineers

Figure 8 shows that, with 124 full-time equivalent (FTE) research scientists and engineers per million population, the Arab region surpasses only Africa. The Arab figure is far lower than the average of 313 for developing countries.

If we compare the Arab region with the Russian Federation, which has a population of a similar size, we find that the number of Arab researchers per million inhabitants amounts to only 0.5% that of the Russian Federation.

GERD per researcher is extremely low in the Arab region (Figure 9). However, owing to the fact that low GERD is spread over fewer researchers, GERD per researcher in the Arab region is actually higher than the corresponding figure in the Russian Federation, despite the fact that total GERD in the Arab region represents only 12% that of the Russian Federation.

Research groups are made up of MSc and PhD holders. Figure 10 gives R&D expenditure per FTE researcher in some Arab countries. It should be interpreted with caution, since the high figures for some countries reflect the fact that GERD is spread over a small pool of researchers. A large amount of GERD is spent on salaries and wages for researchers and support staff. Note also that the Gulf States pay higher salaries to researchers than do other countries.

Of the 20 000 research scientists and engineers in the Arab region, more than half (56%) are found in Egypt (Table 5). Some 66% of Arab researchers work in the public sector (for the government), 31% in the university sector and only 3% in the private sector. Nearly half (44%) of all Arab researchers work in water and agriculture (UNESCO, 1998).

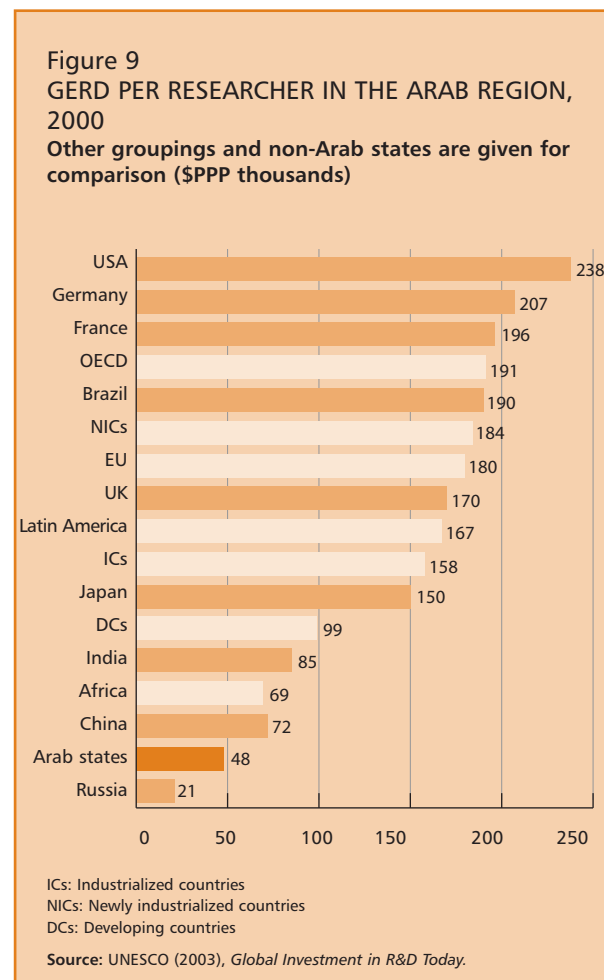
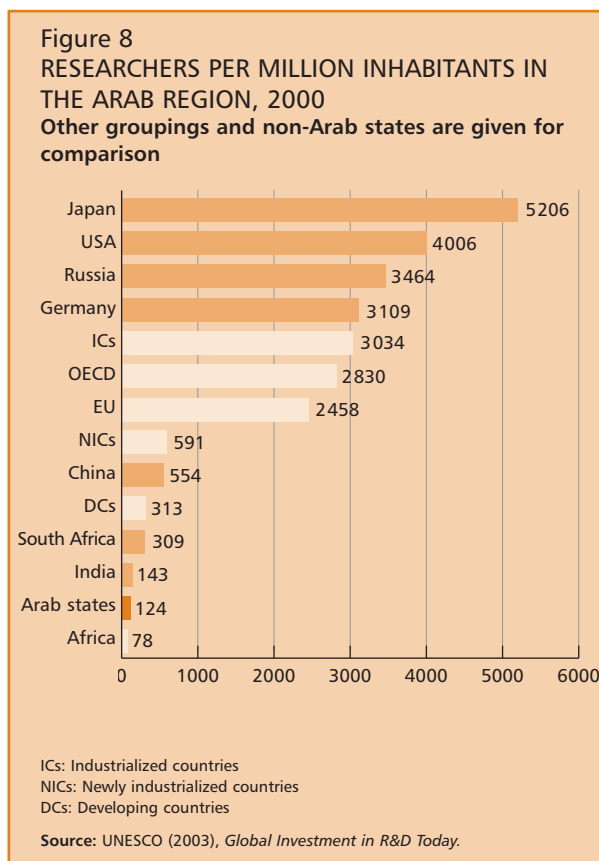
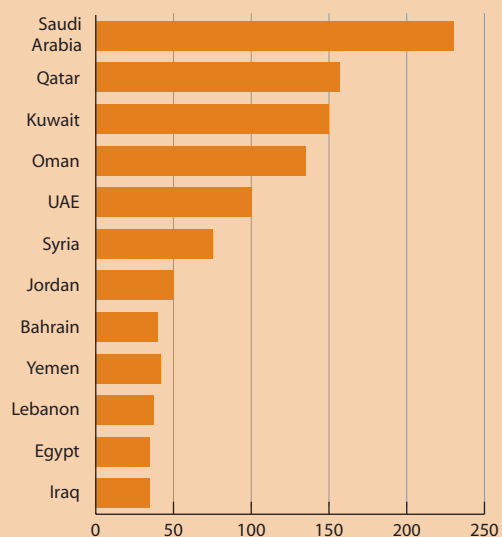


Figure 10
GERD PER FTE RESEARCHER IN SELECTED ARAB STATES, 1996

US\$ thousands



Source: adapted from UNESCO-ESCWA (1998a) *R&D Systems in the Arab States: Development of Science and Technology Indicators*.

Most scientists in the Arab region are working in the agriculture and health sectors, suggesting that they are still concentrating in the area of basic needs in order to secure food and health for their populations. Scientists have not yet been able to leapfrog to the third wave of the brain-intensive knowledge economy but remain in the agricultural and industrial stages. The IT revolution has not yet fully taken place for them.

Who funds what in R&D?

Indicators on who finances R&D reflect how each country deals with problem-oriented research. Many countries are moving towards a model where greater private funding is playing a major role in the performance of R&D. According to UNESCO's report *Global Investment in R&D Today* (2003), 70% of all OECD R&D was performed by the enterprise sector in 2000, compared with 10% by the government sector and 17% by universities. The remaining 3% was carried out by private non-profit institutions. As much as 78% of Sweden's R&D is performed by enterprises; this proportion is matched by Israel and the USA (both at 75%), Switzerland (74%), Japan (72%), the Russian Federation 71% and the Republic of Korea (76%).

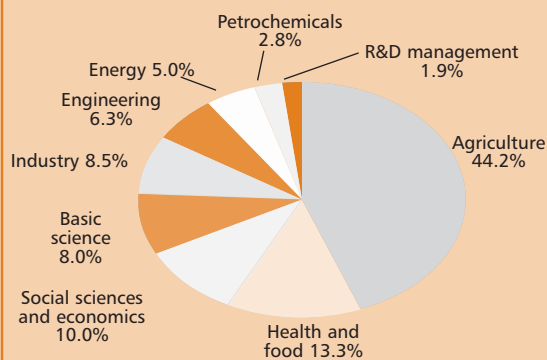
THE STATE OF SCIENCE IN THE WORLD

Table 5
DISTRIBUTION OF FTE RESEARCHERS IN ESCWA ARAB STATES, 1996-98
By sector of employment

	Public sector			University			Private sector			Total
	PhD	MSc	Total	PhD	MSc	Total	PhD	MSc	Total	
Bahrain	5	22	27	29	30	59	0	0	0	86
Egypt	4 708	3 366	8 074	1 627	757	2 384	114	172	286	10 744
Iraq	189	540	729	366	296	662	0	0	0	1 391
Jordan	86	129	215	98	42	140	15	31	46	401
Kuwait	117	217	334	81	2	83	8	15	23	440
Lebanon	28	65	93	65	47	112	0	0	0	205
Oman	17	39	56	19	7	26	0	0	0	82
Qatar	2	2	4	18	12	30	0	0	0	34
Saudi Arabia	84	224	308	363	175	538	0	0	0	846
Syria	95	115	210	109	37	146	0	0	0	356
United Arab Emirates	12	44	56	26	25	51	0	0	0	107
Yemen	115	89	204	44	22	66	0	0	0	270

Source: ESCWA-UNESCO reports.

Figure 11
RESEARCHERS IN THE ARAB REGION, 1996
By sector of activity



Source: UNESCO-ESCWA (1998a) *R&D Systems in the Arab States: Development of Science and Technology Indicators*.

Although university research is particularly important in the area of basic research, it corresponds to only 15–20% of the total R&D performed in major economies like France, Germany, Japan, the UK and the USA. It should be noted that only 60% of university research in the USA is financed with federal funds, the remainder stemming from university partnerships with industry.

The largest divergences between national R&D systems in the OECD countries are to be found in the least economically advanced economies, including the former Eastern bloc countries with traditionally agricultural economies and low levels of industrial activity. Here, R&D draws heavily on public expenditure.

Likewise, in the Arab region, most R&D is supported essentially by the public purse, the private sector lacking the appropriate infrastructure and budget to undertake R&D itself. R&D expenditure can be broken down as follows: 1% by enterprises, 30% by universities and the remainder by government.

It could be concluded that the Arab region is dominated by public sector economies. Some countries, however, have recently taken energetic steps to privatize major public sectors. The real obstacle in involving enterprises more in the funding and performance of R&D is a policy

question of how to move from 'big government', or the government handling of all economic activities, to 'small government', with greater involvement in R&D by enterprises. Until governments change their policies towards R&D, government incentives could be used in the meantime to achieve some growth among enterprises.

R&D units in the Arab region

In industrial countries, most R&D units belong to enterprises. Even universities and research institutes are contracted by the private sector to conduct R&D on their behalf. In the Arab countries, on the other hand, most R&D units belong to the government and public sectors, and conduct little contractual research work. The distribution of R&D units by sector is shown in Table 6, and it highlights the prevalence of research units specializing in agriculture and related fields.

Of the total of R&D units in the region, 36.3% are in agriculture. The health sector comes second to agriculture, with units specializing in health making up 18.3% of the total. R&D units involved in industry and engineering and related areas such as computer engineering and microelectronics comprise 20.2% of the total, and energy units 8.7%.

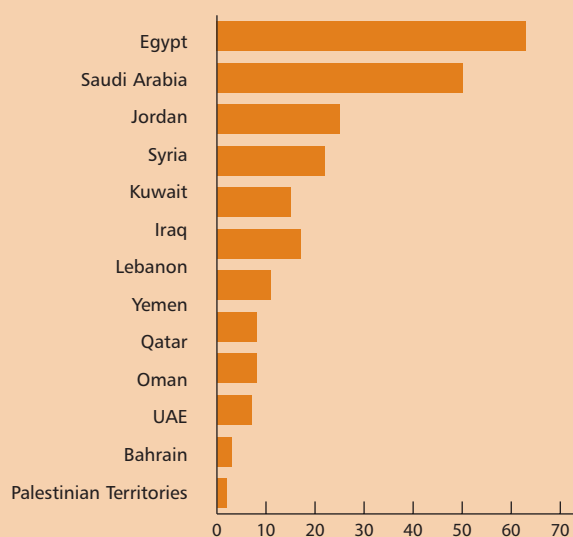
Research in basic sciences is performed by government and universities and represents only 6.2% of the total R&D in the region. This reflects the region's inattention to basic science, which is the backbone of all applied sciences.

Egypt leads the Arab countries within the United Nations Economic and Social Commission for Western Asia (ESCWA) in terms of the number of R&D units, followed by Saudi Arabia and Jordan (Figure 12). Governments fund about 75% of these R&D units. Universities trail far behind with only about 19%, the private sector funding the remainder (Table 6).

HIGHER EDUCATION: DEVELOPMENT OF HUMAN RESOURCES IN S&T

Arab countries have made great strides in expanding higher education. Some 200 Arab universities today have a roll of 3.6 million students taught by 140 000 faculty members. In addition, there are 600 community or intermediate colleges, which award diplomas rather than university degrees,

Figure 12
NUMBER OF R&D UNITS IN SELECTED PARTS OF THE ARAB REGION, 1999



Source: ESCWA (1999) *Science and Technology Policies in the Twenty-first Century*.

distributed throughout the Arab region. With the high population growth rate (2.3%), which means that young people make up a large proportion of Arab populations, it is expected that tertiary enrolment will climb to 5.6 million students by 2015.

Teaching such a cohort will require a quarter of a million faculty members, nearly double the current number.

In the Arab region, average government expenditure on higher education per student amounts to about US\$ 2 400, far less than that spent on a university student in Spain (US\$ 14 200). Table 7 shows average expenditure on education in Arab states from 1996 to 2001, expressed as a percentage of GDP and as a percentage of total public expenditure. There are large variations in expenditure on higher education by Arab governments. Some countries have achieved a rate of expenditure comparable to that of industrialized countries, whereas others have maintained a rate that is lower even than the average for developing countries.

The Arab region spends 5.4% of GDP per year on public universities and colleges, compared with 5.0% in industrialized countries and 3.8% in developing countries. It has been calculated that 20% of Arab total spending on education goes towards public higher education.

Indicators show that tertiary students in the Arab region (including those enrolled in colleges) represent 25% of the eligible population, which is high when compared with developing countries. Table 8 shows that, in the great majority of Arab countries, there is now a gender balance in higher education. In several countries, there is even an

Table 6
R&D UNITS IN THE ARAB REGION, 1996
By economic sector

	Government	University	Private	Total	% of total
Agriculture	97	19	1	117	36.3
Health	43	16	0	59	18.3
Industry	34	2	16	52	16.1
Energy	27	1	0	28	8.7
Basic science	12	8	0	20	6.2
Social science	13	7	0	20	6.2
Petrochemicals	11	2	0	13	4.1
Engineering	6	7	0	13	4.1
Total	243	62	17	322	100
% distribution	75.4	19.3	5.3	-	100

Source: UNESCO-ESCWA (1998b) *Higher Education in the Arab States: Development of S&T Indicators*.

Table 7
AVERAGE EXPENDITURE ON EDUCATION IN
THE ARAB REGION, 1996–2001

	Expenditure as % of GDP	As % of total expenditure
Saudi Arabia	9.3	22.8
Yemen	7.0	–
Tunisia	6.7	19.9
Egypt	5.2	14.7
Morocco	5.2	20.9
Algeria	5.1	16.4
Jordan	5.1	24.2
Kuwait	4.7	14.0
Mauritania	4.5	19.1
Oman	4.5	9.1
Bahrain	3.7	12.0
Syria	3.5	13.6
Djibouti	3.4	–
Lebanon	1.9	8.2
United Arab Emirates	1.8	16.4
Sudan	0.9	–

Source: UNESCO (1999) *Statistical Yearbook*; Arab Fund for Economic and Social Development (2002) *Unified Arab Economic Report*.

imbalance in favour of women, as in Saudi Arabia and the Gulf States.

Recent data for enrolment in natural sciences in the Arab region are hard to come by, but 2001 data are available for Lebanon and the Palestinian Territories. According to the UNESCO Institute for Statistics, the percentage of young people studying disciplines in the natural sciences is on a par with countries such as Australia, Germany and Mexico, at 15.8% for Lebanon and 13.2% for the Palestinian Territories. Among those studying natural sciences, a high proportion are women in both Lebanon (41.1%) and the Palestinian Territories (46.9%).

Public expenditure on higher education is complemented by the private sector. Jordan and Lebanon, for example, have launched numerous community colleges and universities financed solely by the private sector. This initiative has spread quickly all over the Arab region. Jordan boasts 11 private universities, a figure that is expected to increase within two years; its public universities number

only nine. Lebanon has expanded into private colleges and universities, which now number 34. However, 70% of all students at these private institutions are enrolled in disciplines that fall under the humanities and social sciences, and the quality of education has not always lived up to expectations. Indicators show that the education environment is still not sufficiently stimulating to produce entrepreneurs and spark creativity and innovation.

It should be noted that quality education does not depend totally on the availability of financial resources. The results of the Trends in Mathematics and Science Study (TIMSS) – an assessment of primary and secondary pupils in math and sciences around the world – have shown that the quality of education in the Republic of Korea, for example, has surpassed that of the USA, although the latter spends four times as much on education.

Table 8
STUDENT ENROLMENT IN HIGHER EDUCATION
IN THE ARAB REGION, 2000
Percentage of age cohort

	Males	Females	Total
Libya	51.7	50.6	51.2
Lebanon	35.2	38.2	36.7
Jordan	26.8	30.6	28.6
Qatar	13.7	46.2	27.7
Bahrain	19.6	31.1	25.2
Palestinian Territories	29.2	17.9	24.0
Egypt	27.1	17.8	22.4
Saudi Arabia	19.6	25.4	22.4
Kuwait	13.0	30.0	21.1
Tunisia	19.6	19.0	19.3
Algeria	15.8	11.0	15.0
Iraq	17.5	9.5	13.6
United Arab Emirates	4.9	20.7	12.1
Yemen	16.7	4.6	10.8
Morocco	10.6	8.0	9.3
Oman	8.8	7.1	8.0
Sudan	7.1	6.6	6.9
Syria	17.6	12.6	6.1
Mauritania	6.6	1.3	5.6
Somalia	3.6	1.1	2.3
Djibouti	0.4	0.3	0.4

Source: Arab Fund for Economic and Social Development (2002) *Unified Arab Economic Report*; Database 2003.

Three Arab countries out of 39 total participants took part in the 1999 edition of the TIMSS. In mathematics, Tunisia was ranked 29th with 448 points, Jordan was ranked 32nd with 428 points and Morocco came 37th with 337 points (Singapore was top with 604 points). In

science, Jordan was ranked 30th with 450 points, Tunisia 34th with 430 points and Morocco 37th with 323 points. Taiwan of China came first on the science list with 564 points. This demonstrates that the quality of education does not depend solely on resources or quantitative

Two Millennium Initiatives in the Arab World

ARAB ACADEMY OF SCIENCES

The Arab Academy of Sciences is domiciled in Beirut, Lebanon. A non-political, non-governmental and non-profit-making scientific organization, the Academy was established by a group of Arab scientists at the initiative of UNESCO in 2002.

The Academy supports and promotes excellence in research by Arab scientists and encourages problem-solving R&D of relevance to the Arab world. The Academy also acts as a consultative body on scientific issues related to the Arab world. In its three years of existence, it has organized two international conferences, the first in Beirut in 2003 on Bioethics: How to Adapt Biotechnology to Culture and Values; and the second, in Amman, Jordan, in 2004 on Drug Biotechnology and Medicinal Plants.

In a drive to create linkages between scientists and governance, the Academy co-organized with UNESCO and ISESCO a meeting on Science, Technology and Innovation Policy: A Parliamentarian Perspective, in Cairo, Egypt, in December 2004. The Academy promotes cooperation both among researchers in Arab countries and between the latter and the international scientific community. Notably, it is a founding member of the Arab Network for Women in Science and Technology.

In a region where there is little scientific awareness, the Academy also promotes public understanding of science and respect for science.

The pet project of the Academy in 2004–05 has been the production of an *Arabic Encyclopedia on Knowledge for Sustainable Development* supported by UNESCO. Once completed, the Encyclopedia will comprise four volumes covering the environmental, social and economic aspects of sustainable development. Contributions from experts in the Arab world were still being sought in 2005.

The Academy's flagship product will be a profile of S&T and higher education in the Arab region. This will be published on-line in 2006 and updated annually.

The Academy is governed by a General Assembly comprising all its members and by an Executive Council headed by Professor Adnan Badran, President of Philadelphia University in Jordan. The Academy's activities are sponsored by international and regional organizations that include UNESCO, the Islamic Educational, Scientific and Cultural Organization (ISESCO), the Arab League Educational, Cultural and Scientific Organization (ALECSO), the Standing Committee on Scientific and Technological Cooperation of the Organization of Islamic Conference (COMSTECH), the Third World Academy of Sciences (TWAS) and the Commission on Science and Technology for Sustainable Development in the South (COMSATS) founded under the aegis of TWAS in 1994.

See: www.arabacas.org or write to: a.academy@unesco.org

factors, but on the educational process and the means of delivery and evaluation.

Although expanding opportunities in education is essential for an Arab population of 295 million people (Japan, for example, has 1 000 universities – 120

in Tokyo alone – for a population of 127 million), the decline in quality now observed undercuts a basic goal of S&T development, namely that of enhancing the quality of life and moving the Arab region towards a knowledge society.

ARAB SCIENCE AND TECHNOLOGY FOUNDATION

The Arab Science and Technology Foundation (ASTF) was launched in 2000 to enhance the productivity and quality of Arab research by pooling the talents of Arab scientists living in both the Arab region and beyond through the combination of a connectivity network and collaborative research in strategic areas. Although water desalination is an area of obvious interest, for instance, the Solar Water Desalination Project launched by the Foundation in 2004 with funding from the National Bureau of Research and Development in Libya has proved to be the first collaborative research of its kind in the region.

The Foundation provides financial and technical support for innovative research projects in the form of direct grants or fundraising on their behalf. The Foundation's budget originates from various sources, including an annual US\$1 million endowment from Abdul Latif Jameel Co., Ltd for scientific research in the Arab world under the supervision of the ASTF.

A founding member of the Arab Union of Venture Capital and of the Gulf Venture Capital Association, the Foundation seeks to forge the missing link in the Arab world between the research community and business. To this end, the Foundation organized the first Investing in Technology Forum in April 2004 and a second six months later. With the slogan of 'Innovating locally, competing globally', the Forum acts as go-between for start-ups within the Arab scientific

research community and the corporate business and investment sectors.

The Foundation has also organized three Scientific Research Outlook symposia in 2000, 2002 and 2004, to catalyse and support development-oriented collaborative research among scientists from 22 Arab countries.

In 2003, the ASTF conducted a needs survey among more than 400 scientists in Iraqi universities within 12 sectors of priority importance, namely: health; water resources; environment; engineering; energy; agriculture; veterinary sciences and livestock; biotechnology and genetics; communication; applied material science; basic sciences; and information technology. The findings of the survey were published in a 2004 report entitled *The Priorities of the Iraqi S&T Community*.

The Board of Directors is made up of the ten elected members of the ASTF. All are Arab scientists hailing from the institutional, business and academic sectors of countries in the Arab world, the USA and UK. One of the founders, Dr Abdalla Abdelaziz Alnajjar, is also President of the ASTF, in parallel to his functions as Director of the Research Centre at the University of Sharjah in the United Arab Emirates. A driving force behind the ASTF, his vision became reality thanks to the early financial backing of H.H. Sheikh Dr Sultan Bin Mohammed Al Qassimi, ruler of Sharjah.

See: www.astf.net or write to: info@astf.net

Quality of higher education

Many features of higher education in the Arab region contribute to the low academic standards. These are summarized below.

- Universities in the Arab region lack autonomy – the platform of freedom of expression and freedom of thought – and they suffer from political and ideological stress imposed by government. They are controlled both by their national political systems and social systems, whether tribal, ethnic, religious or another.
- Without a clear admissions policy, universities admit students to various disciplines on the basis of criteria other than merit or excellence. For political reasons, there are often higher-than-expected admissions from the provinces, for example.
- The universities lack quality faculty members. Many university professors come from a single university system, having obtained their undergraduate and graduate degrees from the university that employs them. As a consequence, their academic vision in teaching and research often does not extend beyond the university border. Moreover, some faculty members are political appointments forced upon the university without any regard for the requisite qualifications for the post.
- Rigid curricula are unable to meet changing needs in a global knowledge economy. The curriculum is obsolete in some universities, the professors hardly having time to update their skills either in the library or by making use of information networks to structure knowledge derived from new databases on the topics they are teaching. Textbooks are outdated and sometimes unavailable or too expensive for students. Lectures become dull without the help of computer-aided instruction or updated reference material and learning resources.
- There is a shortage of e-learning and distance education. The development of self-learners (teaching people how to learn) and continuous education have not taken hold in Arab universities.
- It is uncommon to see the learning process bridged with

professional experience and training in the private and public sectors. This is due to the increasing number of students, which has resulted in a recourse to traditional lecturing as the only way of establishing contact between professor and student.

- There is a lack of an R&D environment on campus. This is the fault of a heavy teaching load for faculty members and a lack of learning resources, equipment and facilities.

Bridging university and industry

The relationship between university research, teaching and industry is a three-way divorce in the Arab States. There is a lack of contractual research between industry and the universities. Although some universities have started up technology incubators and business parks with industrial partners, the majority of universities have yet to follow suit.

National universities are beginning to network among themselves, but they need to expand these efforts to incorporate regional and international cooperation, in order to introduce interactive learning, multimedia and online education.

PROSPECTS FOR THE FUTURE

Over the past three decades, major achievements have been made in the Arab region, primarily in education, food production, pharmaceuticals and health. However, there is a long road ahead.

The Arab region is at a crossroads economically, politically, scientifically and technologically. To thrive, it must become part of the global knowledge and information society. And to do so, it must first invest heavily in improving the quality and relevance of education from primary to tertiary levels.

Educational reform is badly needed to prepare people for the knowledge economy and globalization, which are knowledge-driven and interdependent. It is education which will add value to human capital, allowing the region to strengthen its capacity in science and move from turnkey technology to home-grown innovation.

Such reform will need first to focus on wiping out the

illiteracy that affects 68 million people in the region – 38% of all Arab adults (2000). The growth of illiteracy is considered to be responsible for the degradation of science and for high population growth. The Arab illiteracy rate is higher than both the average for developing countries (27%) and the world average (25%), and it stands in stark contrast to illiteracy in industrialized countries (1.1%).

Second, education should be science-based, competitive, flexible and relevant and, above all, it should deliver quality output. Reform should emphasize building skills in mathematics, science and IT. Schools should offer training in ethics, teamwork, discipline, dialogue and respect for differences, and they should be places of creativity, innovative thinking and enquiry, and lifelong learning.

Such an education would prepare individuals to absorb the avalanche of information required to construct knowledge. Youth need to be exposed to a challenging educational environment to unleash their creativity in finding novel solutions to difficult problems. They should not be expected to memorize and reproduce facts in examinations without enquiring about scientific principles and their application to real-life situations.

Turning to research, the goal of reform must be to upgrade Arab universities and research centres to the point where they are compatible with centres of excellence of an international standard, in order to develop world-class researchers for the creation of new knowledge. Basic science and basic research should be emphasized to absorb and develop emerging frontier technologies.

The Arab region must draw on its legacy of cultural achievement and reintroduce a system based on merit at all levels to nourish creativity and innovation. It goes without saying that suitable government policies and positive legislation relaxing bureaucracy should be implemented to create a stable, enduring environment for S&T. Confidence must be established between universities and research centres on the one hand, and universities and industry on the other. Last but not least, interaction between scientists and economists would optimize the growth process.

Most crucially, the region needs reforms that will help build societies that promote tolerance, allow freedom of expression, encourage free thinking and respect human rights if the Arab States are to develop fully their potential in S&T.

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Adnan Badran has been Prime Minister of Jordan since April 2005. He first served his country as Minister of Agriculture then as Minister of Education before joining UNESCO in 1990 as Assistant Director-General for Natural Sciences. Six years later, he was named Deputy Director-General of UNESCO, a post he occupied until August 1998.

Adnan Badran received his undergraduate and graduate education in the USA, culminating in a PhD from Michigan State University in 1963. He then spent three years conducting basic research in plant physiology and biochemistry in the USA before returning home to take up the post of Professor of Biology at the University of Jordan. He was later appointed Dean of the Faculty of Sciences of the same university, then founding President of Yarmouk University, also in Jordan, from 1976 to 1986.

In the course of his career, Dr Badran has published several books and articles on the life sciences. He is also the author of articles on science policy and higher education in the Arab region. At the time of his nomination as Prime Minister, he was President of Philadelphia University in Jordan and of the Arab Academy of Sciences in Beirut.