ACADEMIES OF SCIENCES AND THE SCIENTIFIC ENTERPRISE IN THE ISLAMIC WORLD AND THE WEST: A COMPARATIVE STUDY WITH REFERENCE TO SELECTED OIC AND WESTERN COUNTRIES

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ABSTRAK

Tesis ini adalah satu kajian pelbagai disiplin mengenai akademi sains dan kegiatan saintifik di Dunia Islam dan Barat. Ia menganalisis asal-usul, peranan, fungsi dan aktiviti-aktiviti akademi sains dari masa ke masa dan merentasi tamadun. Kerana terdapat pertalian yang rapat antara akademi sains dan zaman di mana mereka berkembang, tesis ini melangkaui penulisan yang sedia ada dan mencadangkan kronologi alternatif mengenai kebangkitan dan kemerosotan sains dalam tamadun Islam dan kebangkitan sains di Eropah. Ini adalah dianggap sebagai pra-syarat kepada pemahaman yang lebih baik mengenai kelemahan kegiatan saintifik di dunia Islam dan ketiadaan budaya sains , berbanding dengan Eropah dan Barat.

Akademi sains adalah organisasi yang mempunyai sejarah yang panjang. Bagi kebanyakan orang, mereka diselubungi misteri. Ciri-ciri institusi, peranan mereka, fungsi dan aktiviti-walaupun mungkin didokumenkan, adalah tidak diketahui umum.. Untuk menangani hal ini, ciri-ciri institusi beberapa akademi sains disiasat melalui kajian mendalam terhadap penerbitan, kajian silam dan melalui kaedah temubual.

Dalam usaha untuk membuat sumbangan asli untuk mempromosikan peranan mereka sebagai tonggak yang amat diperlukan di dalam sistem sains, teknologi dan inovasi (STI), khususnya dalam negara OIC, Tesis ini membahagikan aktiviti-aktiviti akademi sains kepada dua bahagian, iaitu: (i) komponen politik dan (ii) dasar-dasar. Bahagian pertama melibatkan peruntukan berasaskan khidmat nasihat sains, interaksi dengan kerajaan dan parlimen, diplomasi sains dan rangkaian antarabangsa manakala bahagian kedua termasuk pendidikan sains dan promosi penyelidikan saintifik, sedangkan isu wanita dalam bidang sains ditangani di bawah tajuk yang berasingan. Bab kajian perbandingan mengkaji 15 akademi sains dari seluruh dunia dan melibatkan juga kritikan terhadap statut akademi sains yang unggul seperti yang dirumuskan oleh Panel InterAcademy (IAP). Ini boleh membantu untuk menyebarkan amalan terbaik dalam

akademi sains yang sedia ada, dan boleh menggalakkan penggunaan dan penyesuaian model tersebut bagi keperluan negara tertentu pada masa akan datang.

Penemuan utama kajian menunjukkan bahawa walaupun laluan sejarah sains mereka telah pernah bertembung, hari ini terdapat jurang yang luas dalam bidang sains dan penginstitusiannya, di antara Dunia Islam dan Barat. Walaupun banyak inisiatif yang telah diambil dari pihak atasan dalam bidang sains di Dunia Islam, penggunaan S & T sebagai platform untuk pembangunan hanya dihargai oleh beberapa ahli-ahli sains dan beberapa orang pemimpin politik dan masyarakat. Kekurangan naungan politik dan sokongan sains, walaupun dengan adanya legasi kreativiti dan inovasi, adalah punca utama kekurangan sistem STI di dunia Islam. Kurangnya budaya sains dimanifestasikan juga oleh kewujudan sekitar hanya 26 akademi sains di 57 buah negara OIC. Selain itu, sebahagiannya merupakan akademi yang baru, beroperasi pada peruntukan belanjawan yang kecil dan menjalankan beberapa aktiviti yang terhad. Tiada setakat ini yang telah menghidupkan semula semangat yang wujud di zaman yang terdahulu; walau bagaimanapun terdapat pihak yang cuba mencontohi kejayaan rakan sejawat mereka di dunia Barat.

ABSTRACT

This Thesis is an interdisciplinary study of the academies of sciences and the scientific enterprise in the Islamic world and the West. It analyses the genesis, roles, functions and activities of academies of sciences over time and across civilisations, as well as contemporaneously. As there is a close nexus between academies of sciences and the milieus within which they flourish, the Thesis goes beyond existing literature and proposes an alternative chronology of the rise and decline of science in the Islamic civilisation and the ascendance of science in Europe. This is considered a perquisite to a better understanding of the current weakness of the scientific enterprise in the Islamic world and the relative absence of science culture within, compared to Europe and the West.

Academies of sciences are organisations that have a long history. For many, they are shrouded in mystery. Their institutional characteristics, roles, functions and activities – although plausibly documented- are not well known. To address this, the institutional traits of some academies of sciences are investigated by means of an in-depth review of published literature, earlier studies and interviews.

In order to make a bona fide contribution to promoting their role as indispensable pillars of science, technology and innovation (STI) systems, particularly in OIC countries, the Thesis streamlines the activities of academies of sciences into politics-oriented and policies-based components. The former include the provision of science-based advice, interaction with governments and parliaments, science diplomacy and international networking while the latter include science education and the promotion of scientific research, with the issue of women in science discussed under a separate heading. The comparative study chapter looks at 15 academies of sciences from around the world and includes a critique of the statutes of the model academy of sciences as adopted by the InterAcademy Panel (IAP). This may help to propagate best practices

within existing academies of sciences, and may prompt further work in adopting and adapting the model to individual country requirements in the future.

The main findings of the study reveal that although historically their paths of science have crossed, there is today a wide gap in science, and the institutionalisation thereof, between the Islamic world and the West. Despite many top-down initiatives in science in the Islamic world, the tool of S&T as *the* platform for development is prized only by some scientists and, at best, a few political and community leaders. Lack of political patronage and support of science, despite a legacy of creativity and innovation, is a major cause of the poor output of the STI system in the Islamic world but it is not the only quandary. The lack of a culture of science manifested by the existence of around 26 academies of sciences in the 57 OIC-member countries is another. Moreover, most such academies are new, operate on shoestring budgets, and undertake a limited number of activities. None has thus far captured the spirit that prevailed around their ancient predecessors; however, some are trying to emulate the success of their counter-parts in the West.

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Closer to home, I wish to express my thanks to my wife, Basma, whose encouragement and support have been a source of inspiration for me throughout my research and writing, and to our children Rafe', Sama and Rashed, who tolerated the long hours I had to spend doing my research.

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LIST OF SYMBOLS AND ABBREVIATIONS

AAS	Australian Academy of Science
AD	Anno Domini, a designation used to label years in the Julian and Gregorian calendars
AFRISTECH	African Organization for Science and Technology
AH	After Hijra
AKM	Academy of the Kingdom of Morocco
ALECSO	Arab League Educational, Scientific and Cultural Organization
ALLEA	All European Academies
ASADI	The African Science Academy Development Initiative
ASF	Academy of Sciences of France
ASIRI	Academy of Sciences of the Islamic Republic of Iran
ASM	Academy of Science Malaysia
ANSTS	Académie de Sciences et Techniques du Sénégal
BA	Bibliotheca Alexandrina (The Library of Alexandria)
BC	Before Christ
CAS	Chinese Academy of Sciences
CCA	Council of Canadian Academies
CDTI	Centre for the Development of Industrial Technology; Spain
CE	Christian Era
COMSTECH	OIC Ministerial Committee on Scientific and Technological Co-operation
COSTIS	Consortium on Science, Technology and Innovation for the South
EASAC	European Academies Science Advisory Council
EU	European Union
FAO	Food and Agriculture Organization
FASAS	Federation of Asian Scientific Academies and Societies
FTE	Full-Time Equivalent (related to the number of researchers)
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GNP	Gross National Product
HAST	Hassan II Academy of Science and Technology
IAC	InterAcademy Council
IAMP	InterAcademy Medical Panel
IAP	InterAcademy Panel on International Issues
IAS	Islamic World Academy of Sciences
ICSU	International Council for Science
ICT	Information and Communications Technology
ISESCO	Islamic Educational and Scientific and Cultural Organization
IDB	Islamic Development Bank
IDRC	Canadian International Development Research Centre
IF	Institute of France
IFS	International Foundation for Science
IFSTAD	Islamic Foundation for Science, Technology and Development
IPCC	Intergovernmental Panel on Climate Change
IRCICA	OIC Research Centre for Islamic History, Art and Culture
ISESCO	Islamic Educational, Scientific and Cultural Organization
IUA	International Union of Academies
KVA	The Royal Swedish Academy of Sciences
LAMAP	La main à la pate (The hands-on)

MDGs	Millennium Development Goals
NAM	Non-Aligned Movement
NASAC	Network of African Academies of Sciences
NASIC	Network of Academies of Sciences in OIC Countries
NGO	Nongovernmental organization
NSF	National Science Foundation of the United States
OECD	Organization for Economic Co-operation and Development
OIC	Organization of the Islamic Co-operation
PALAST	Palestine Academy of Sciences and Technology
PUIC	Parliamentary Union of OIC Member States
RAS	Russian Academy of Sciences
R&D	Research and Development
RS	The Royal Society of London
RSNZ	Royal Society of New Zealand
SciDev.Net	A free-access website that provides information about science and technology in the developing world
S&T	Science and Technology
SESRIC/ SESRTCIC	Statistical, Economic and Social Research and Training Centre for Islamic Countries
SET	Science, Engineering and Technology
SNAS	Singapore National Academy of Sciences
SREs	Scientists, Researchers and Engineers
STI	Science, Technology and Innovation
TÜBA	Turkish Academy of Sciences
TWAS	The Academy of Sciences for Developing Countries
TWNSO	Third World Network of Scientific Organizations
TWOWS	Third World Organization for Women in Science
UNCSTD	United Nations Commission on Science and Technology for Development
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNAS	Uganda National Academy of Sciences
UNU	United Nations University
US-NAS	United States – National Academy of Sciences
VISION 1441	VISION 1441 is a set of 4 goals, a number of targets and performance indicators in science and technology that OIC countries aim to achieve by the year 2020
WEHAB	Water, Energy, Health, Agriculture and Biodiversity
WHO	World Health Organization
WSSD	World Summit on Sustainable Development

CHAPTER ONE

INTRODUCTION: WHAT ARE ACADEMIES OF SCIENCES?

> *The functions of a sovereign of science, to the extent that it exists, will be vested in the academies (of sciences).* (Ravetz 1980).

1.1 Background and Research Aims

1.1.1 Background

What is an Academy? This question will appear repeatedly in this thesis. Definitions vary from an intellectual retreat that resonates from the ambience of Plato's ancient garden near Athens, to a school devoted to specialized training in art or music. In some parts of the world, academies carry a military connotation, largely because many of the United Kingdom's generals who oversaw the nation's 19^{th} century empire were educated at the Sandhurst Royal Military Academy. More recently, the word Academy has gained a 'star-struck' Hollywood image due to the Oscars that are awarded by the Academy of Motion Picture Arts and Sciences in the United States every year.

Often, to call a subject 'academic' is to dismiss its relevance to real life. Such judgments may conceivably apply to the rarefied musings of Plato and his dialogue partners, but not of the academies of sciences of today (McNeely 2007).

Although there is little that is stealthy about academies of sciences, only a limited number of studies of their origins and roles have been carried out (Ornstein 1964 cited in Evans 1980) and only a few studies have tried to unravel their 'clandestine' ways (Boffey 1975 cited in Evans 1980). Moreover, most of the accounts that have appeared in the scholarly literature on the work of scientific academies refer to the work of those in the West (Hall 1991; Eamon and Paheau 1984; Hunter 1989; Roberts 1991). Likewise, only a few studies on academies of sciences that are based in the member countries of the Organisation of Islamic Cooperation[1] (OIC) have been undertaken (Hassan 2005) (Khan 2005).

Only in 2009 did the Council of Canadian Academies and the Inter-Academy Panel[2] (IAP) come together to organize a workshop on *Best Practices in Advisory Roles and Fellowship Appointments (of Academies of Sciences).* The workshop[3] addressed common issues and challenges faced by academies of sciences such as outreach to society and roles in providing advice (IAP 2009). Furthermore, in 2009, the *International Journal of Technology Management* for the first time published a special issue that included a number of papers on 'academies of sciences' (Tan and Subramaniam 2009).

Today, even with the existence of many academies of sciences in the world, the understanding of the term 'academy of sciences' is lacking (Zou'bi 2003). Many people are ignorant of the fact that an academy of sciences' primary role is to act as the science advisory or *sovereign* (supreme authority) (Ravetz 1980) which actively promotes science and technology in the catchment[4] area where it operates and that it is a forum where scientific issues are debated, studied and communicated.

The Islamic world of today, as represented by the member countries of the OIC, has historically been a milieu within which the scientific enterprise bloomed for centuries, and the domicile of many famous academies and academy-type institutions. Cities such as Alexandria, Baghdad and Cairo bear witness to this fact (Serageldin 2006a) (Lumpkin and Zitzler 1987). In the Arab/Islamic civilisation, the concept of an academy of sciences may be traced back to the era of the 'Abbāsids which witnessed the birth of *Bayt al-Hikma* (House of Wisdom in Baghdad) in the 9th century, and the

1 The Organisation of Islamic Cooperation (OIC) (formerly Organization of the Islamic Conference) is the second largest inter-governmental organization after the United Nations. It has a membership of 57 states spread over four continents, and has been designated by some as the voice of the Muslim world.
2 The Inter-Academy Panel (IAP) is a global network of over 100 academies of sciences.
3 The workshop was held at the offices of the IAP in Trieste, Italy; 12-13 February 2009.
4 The catchment area of an academy of sciences may, for the purpose of this study, be defined as the geographic area in which the academy operates whether it is the country, the region or the world.

Nizamiyyah Academy of Baghdad in the 11th century (Hitti 2002: 410). At the latter institute, scientific matters were debated and discussed by *al-Ghazzālī*[5] and his dialogue partners (Ormsby 2007) (Nofal 1994). *Al-Tusi*'s and *Ulugh Beg*'s observatories in Maragha and Samarkand in the 14th and 15th centuries respectively are also outstanding examples of such institutions (Saliba 2002) (Morgan 2007). The existence of such institutions is one manifestation of the scientific supremacy that the Islamic civilisation enjoyed for centuries.

Such 'academies' –which were mostly founded by leaders rather than the science community- existed long before the first real European academy of sciences, the *Accademia dei Lincei*, which was founded in Italy in 1603 (McClellan 2003. Needless to say, the translation activity associated with Bayt al-Hikma and the educational functions of the Nizamiyyah did not take precedence in the role of their European successors which were mostly founded by amateur scientists –like Galileo- who were fascinated by science and appreciative of its pecuniary value (Saliba 2011).

Today, academies of sciences exist in over 100 countries (IAP 2010). They come in many forms. Some are only honorific societies while several are fully-fledged research organisations (de Góes 2009). Most are national. However, there exists a number of regional and global academies of sciences such as the Islamic World Academy of Sciences (IAS) based in Amman, Jordan, and the Trieste-based the Academy of Sciences for the Developing World (TWAS) (IAP 2010). In the OIC, the 26 academies that exist in the 57 OIC countries are 20th century phenomena, are small in size and operate on meagre budgets (Hassan 2009). Most –with varying degrees of success- are engaged in politics-oriented activities including interaction with governments and parliaments, international networking, the provision of science-based advice, science education and the promotion of scientific research (Hassan 2005).

[5] Ormsby's book profiles Abu Hamid al-Ghazzali (1058-1111), the foremost Islamic scholar and mystic of the medieval period who –at some point- headed the Nizamiyyah of Baghdad.

The main objective of Chapter One is to provide an overview of the rationale, significance and context of this Thesis. It begins with the background. This is followed by the aims of the research, including the research questions, and goes on to describe the significance of the research and its delimitations. This is followed by the self-standing literature review, which has been divided into four parts with the part on 'The Story of Islamic Science' intentionally coming last. As it turned out, that was the approach Diner adopted in his book; *Lost in the Sacred: Why the Muslim World Stood Still* (Diner 2009) where he follows a present-past timeline in addressing the question of what caused the Muslim world to lag behind. Diner presents a number of arguments[6] that need to be revisited and pinned against the local and global milieus in which they occurred as well as the external and internal factors that led eventual decline of the Arab/Islamic world.

The chapter then outlines the hypothesis, methodology and scope of the research and ends with an outline of the structure of the Thesis.

1.1.2 Aim of Research and Research Questions

The research aims to increase the understanding of the nature, functions and activities of academies of sciences in the scientific enterprise in the Islamic world and the West, historically and today.

Academies have been described as thoroughly European institutions (Yates 1983:6). This research will show that they are not. It will show that the Islamic civilisation was an inviting milieu for many famous academy-type institutions to rise within, and that it had a profound role in the assimilation, perfection and the transmission of ancient sciences. The research will also appraise the science landscape in the Islamic world

[6] Diner argues that the sacred in Islam suspends the acceleration of social time, hinders change, and circumvents secularization and modernity. He overplays the argument about the time-suspending impact of Arabic as a sacred language, the prevention of print, etc…

today and compare academies of sciences in the Islamic world to their counter-parts elsewhere.

The research questions thus are:

1) How has the scientific enterprise in the Islamic world evolved historically and how has science ascended in the West? What is the status of science in the Islamic world today?
2) How have academy-type institutions and academies of sciences evolved in Islam and the West?
3) What are the special features of academies of sciences today? How do they promote science nationally and globally and how do OIC academies of sciences compare to their counterparts in the West today? What are the characteristics of a 'model' academy of sciences?

1.1.3 Research Objectives

1) To examine the ancient and Islamic era history of academies of sciences;
2) To investigate how the scientific enterprise ascended in Islam and how it was transmitted into Europe and its ascendance within;
3) To examine the rise of European academies and their role in the scientific enterprise;
4) To appraise science in the Islamic world today; and
5) To scrutinize the role and functions of academies of sciences nationally and internationally and compare some OIC-based ones to their counterparts in the West.

1.1.4 Research Significance

This research was carried out at a time when the *politics* (governance) and *policies* (socioeconomic development) in the Islamic world are in turmoil. Despite massive investments in STI and higher education by a few monetarily rich ones such as Saudi Arabia and Qatar, OIC countries today are in a state of scientific and technological quiescence. Many are not clearly aware of their rich scientific heritage and how science was institutionalised within their societies in the Golden Age of their civilisation, or why it blossomed when it did. Most have not institutionalised science or the scientific enterprise nor see a need for such endeavours. And although some countries have considered academies of sciences as pillars of national STI systems, the concept of an 'academy of sciences' is not hitherto graspable by many decision-makers or the public in the OIC.

The significance of the research lies in its attempt to address historical aspects of the scientific enterprise with contemporary ones, in the process answering many of the questions being raised today about science in the Islamic world, the importance of institutionalising science for development, and the role that academies of sciences can play in such an endeavour. In today's turbulent milieu, this study attempts to be a timely investigation of the various interconnected elements outlined above.

1.1.5 Research Delimitations

Literature on the history, role and functions of academies of sciences is scarce; especially literature originating from or dealing with academies in OIC countries, where only a few national academies of sciences exists. Further, the fact that academies of sciences worldwide do not conform to a single model in terms of history, size or role; some being government research organisations while others are honorific non-governmental advisory bodies; makes comparing the various models no straightforward task. Collecting and analyzing data for the Islamic world, especially S&T indicators, proved – as usual – to be a cumbersome task. Not only is data normally at least four years old, but it often is incomplete and has to be compiled from a number of sources.

1.2 Literature Review

There are two types of literature review that are currently used in academic research (Patterson 2006). Firstly, there is the self-standing literature review, which takes the form of a chapter or a section of a chapter. Secondly, there is the integrated literature review where the literature is introduced where pertinent throughout the study.

Due to the nature of the research topic, both types are used in this Thesis. This section is the self-standing part and is organized broadly in line with the research questions. Literature related more specifically to the subject matter will be introduced in more detail where appropriate in the Thesis.

1.2.1 The Aim of the Literature Review

An undated document published by Loughborough University Library says that a literature review is a critical and evaluative account of what has been published on a research topic. Its purpose is to summarize and analyze the arguments of others. The researcher should describe the knowledge that exists and what gaps occur in research revealing in the process consistencies and controversies in previous research (Loughborough University Library, n.d.).

With this in mind, the literature review in this Thesis will focus on two main themes; (a) Academies of sciences as institutions: Aspects of the roles, functions and activities of academies of sciences historically and today, and (b) Science in societies where academy-type institutions existed in the past and exist today, including science in the Islamic world and its ascendance in the West.

The nexus between the two themes will be touched upon in this review and will be closely examined at various junctures throughout this Thesis, and eventually when academies of sciences in the Islamic world and other parts of the world are analysed.

Needleless to say, neither the history and function of science academies nor the scientific enterprise in the Islamic world today can be studied without looking back into the history of science and the history of Islam respectively.

1.2.2 Who's Who in Academe? Who's Who in Islamic Science?

Despite the fact that academies of sciences are among the oldest institutions in continuous existence that we find today, there is little organized information on their characteristics. Information on their activities is not normally readily available and rarely takes the form of specialized books, or articles in science or history of science journals. It often describes what an academy does without really going beyond the facade. It often appears in terms of a news item in bulletins, statements on scientific topics, press releases or through the web pages of academies or associations of academies.

The first attempt at a description of modern Academies that we know of belongs to Joseph C. Kiger, who in 1993, published an ‘International Encyclopaedia of Learned Societies and Academies’ that described Academies and Learned Societies of all kinds in over 50 countries. Kiger included both, Academies of Sciences as well as Academies and Learned Societies of many other kinds (Kiger 1993). Nonetheless, when the historical role and functions of science academies are discussed, the names of McClellan and Yates feature high on the list of academic authorities on the subject. The contemporary French Academician Yves Quéré can be designated as the ‘official’ spokesman on academies of sciences, today. Current and past presidents of academies such as Pieter Drenth, Bruce Alberts, M. H. A. Hassan, Aaron Klug, Michael Clegg, Lee Yee-Cheong, Leo Wee Hin Tan, Tore Frängsmyr and Robert May are normally considered voices for academies of sciences as well, especially in the international arena. Moreover, the work of scholars such Roger Hahn, Ian F. McNeely as well as Peter Collins is very much essential reading when the topic of academies of sciences is researched. Perhaps because he is a social scientist, Drenth, in particular, looks beyond the façade of science academies and analyzes the internal workings of academies of sciences in his book, *Walks in the Garden of Science* (Drenth 2006).

On the other hand, the topic of the rise of Islamic science, in its broadest context, has spawned a vast literature. To a lesser extent has the topic of academy-type institutions in Islam; the Bayt al-Hikma academies and the various observatories that have historically sprang up in various parts of the Islamic world.

The names of George Sarton, David Lindberg, S. H. Nasr, Z. Sardar, E. S. Kennedy, George Saliba, Ismail Raji Al-Faruqi, Toby Huff, Edward Grant, Dimitri Gutas, Roshdi Rashed, A. I. Sabra, Jamil Ragep, Salim Al-Hassani, Philip Hitti and David King (the astrolabist) spring to mind whenever the topic of Islamic Science is addressed. In the Islamic world, the list surprisingly is not that long. If however only those who have written on the topic in English are considered, names like M. M. Qurashi, Mehdi Golshani, Osman Bakar, Pervez Hoodbhoy, Abdus Salam[7], Ekmeleddin Ihsanoglu (of the OIC), Nidhal Guessoum as well Mohd Hazim Shah (of the University of Malaya) spring to mind.

In his book, *Science and Technology in the Middle East*, Sardar (Sardar 1982: 18) mentions a number of factors that have contributed to the rise of scientific consciousness among Muslims in the second half of the 20th century including the publication by S. H. Nasr of his book, *Science and Civilization in Islam* (Nasr 1968) and the publication by Fuat Sezgin, *Geschichte Des Arabischen Schrifttums* (Frankfurt-am-Main 1972-1976). Sezgin also produced a little known Arabic-language compilation of his lectures in a book entitled, *Muhadarat fi Tareekh il-'Uloom* back in 1979 that caused quite a stir (Sezgin 1979).

However, has this contemporary interest by Muslim scholars yielded an acceptable narrative for the historical rise of the Islamic Science and its eventual decline as there are still many unanswered questions related to the history of science in the context of the Islamic world? For example, the traditional narrative for the rise and decline of Islamic science does not tell us when it started to rise and when it started to decline. Nor do we know for certain why the scientific renaissance or the scientific revolution happened in Europe and did not occur in the Islamic world – in what may be described as another form of the Needham's grand question[8] (Needham 1969).

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7 Muhammad Abdus Salam (1926-1996), 1979 Physics Nobel Laureate, world famous scientist from Pakistan and founder of TWAS; the Third World Academy of Sciences.

8 'Needham's Grand Question', also known as 'The Needham Question', is simply …why China had been overtaken by the West in science and technology, despite its earlier successes.

There are unanswered questions too regarding academies of sciences and how and why they appeared in Europe when they did and why academies of sciences are today blooming in Europe and the US, unlike in the Islamic world. Drenth (2006:185) tells us that when universities became under the influence of the church or the state in the 16th and 17th centuries, academies ascended in Europe to provide venues where scientific matters could be discussed freely and safely. Are OIC-based academies fulfilling a similar role today? If so, how effectively?

1.2.3 Academies of Sciences: What are They? What do They do?

Notwithstanding a reference made by de Góes (2009) to the Confucian institutions of China in BC 400, the view of many science historians, including McClellan & Dorn (2006) as well as Chermiss (1980), that Plato created the first academy of sciences in BC 387 have been supported by Drenth (2006:197). The location of Plato's Academy was an orchard outside the walls of Athens where the legendary hero of Greek mythology *Akademos*[9] was honoured. In his youth, Aristotle went to Athens to study with Plato and became a member of Plato's Academy for 20 years until Plato's death in BC 347 (McClellan & Dorn 2006:203).

Winter (1952: 60) reported that the Academy of Athens was suppressed in AD 529. Drenth (2006: 219) tells us that this Academy was closed by the then Emperor Justinian almost a millennium after it was started, since the views it propagated were considered damaging to the state. That probably represented the first historical clash between academe[10] and government.

[9] A legendary hero in Greek mythology, Akademos was linked to the archaic name for the site of Plato's Academy, the Hekademeia, outside the walls of Athens.

[10] Academe in this context means the world of academies.

In 1949, Frances Yates delivered a lecture at the Summer School of the Society for Italian Studies at Magdalen College, Oxford, which she commenced as follows:

> *What is an academy? Let us think of a few familiar examples. The Royal Academy holds annual exhibitions of pictures and judges art by certain standards of its own. The British Academy awards distinctions to scholars for research in many branches of humane learning and organises lectures and publications. The Royal Society – the oldest of our true academies, though it does not use the word to describe itself – has been for centuries the centre and arbiter of scientific research.*
>
> (Yates 1983: 6).

She went on to describe academies in the following fashion:

> *The academy is thus not a school. Nor is it a university. It is an institution devoted to research, or to the perfection of some art. Moreover, it is a thoroughly European institution to be found in every country in Europe, and of fundamental importance in the development of the European mind.*
>
> (Yates 1984: 6).

A quotation from P. J. D. Drenth, which appears in his book *Walks in the Garden of Science* (2006), provides the matter-of-fact definition of an academy of sciences and can be the starting point of this section. It reads:

> *An Academy is basically a learned society, with (a restricted number of) members who are solely selected on the basis of their scientific or scholarly qualification and reputation… An Academy's main responsibility is the promotion of science and scholarship through independent research, reflection and discussion as well as evaluative and advisory activities, and the public disclosure of its opinions and judgements.*
>
> (Drenth 2006: 184).

Saliba, on the other hand, defined an academy of sciences and what it does indirectly when he claimed that there was a fundamental connection between the availability of resources and the production of science and the resulting 'sudden' rise in activities in Renaissance Europe. This definition is not only important when one tries to provide evidence that Bayt al-Hikma was an academy of sciences of its day (as will be outlined in section 2.7), but also when one tries to unravel the reasons behind the decline of Islamic science (as will be outlined in Chapter Two):

> *When you assemble a group of scientists to work in a relatively carefree environment (that is, an environment made free of care by the availability of capital), their collective activities are bound to make a difference in terms of scientific production. A good number of them may produce nothing of memorable importance, but the availability of resources to support the whole group will ensure that at least some of them make remarkable discoveries. Bayt al-Hikma of Harun al-Rashid and his son, al-Ma'mun, or the various institutions called Dar al-`Ilm all over the Islamic world, the Maragha Observatory itself, the Accademia dei Lincei and, more recently, the Institute for Advanced Study, have all acted in this same fashion.*
>
> (Saliba 2002).

Today, the word 'academy' has a different meaning to what it meant four centuries ago McNeely (2007) argues, when academies were blossoming in Italy. Today, an 'academy' is synonymous with an 'ivory tower,' a bastion of the scholarly establishment out of touch with common experience and common sense. Clark (2003) sarcastically describes academies of sciences as being part of the problem (of science) in that they represent 'old men's clubs for the preservation of traditional disciplines.'

The other component of academies, 'science' is a term that was coined in the 19th century from the Latin *scientia* meaning knowledge (Gribbin 2008: xiii). We can adopt the rather 'matter-of-fact' definition of science as a 'means of knowledge creation; that deals exclusively with evidence-based facts and yields results that can be confirmed' (Clegg 2003). It is also an 'end' as it is the 'organised body of knowledge achieved through research' (Popper 2002). Science is also fundamental to driving economic development in more sustainable ways and to improving the life of people everywhere (Alberts 1995a).

Drenth (2006:185) has suggested that historically there have been a number of characteristics that have made academies stand out, particularly their untiring endeavour to further critical scientific thinking, advance research and promote science's independence and freedom, which is *sine qua non* for its advancement. The French academician, Yves Quéré (2006a), stresses the international character of academies of sciences and the essential role they play in the development of science and technology worldwide. The importance of the academies emanates, he reiterates, from their prestige due to the scientific *excellence* that they reveal, *independence* vis-à-vis the various powers (political, economical, religious...), and *stabilit*y in time, which most other types of institutions (parliaments, boards of directors...) do not have.

In 1863 the US National Academy of Sciences, Alberts (2002) points out, was established by an Act of (the US) Congress to, upon the request of the government to 'investigate, examine, experiment, and report upon any subject of science or art.' Such a mandate highlights the role that academies of sciences were/are expected to play as science advisors of the government in their 'catchment areas.' An equally unambiguous view has been expressed by Wulf (1998) of the US National Academy of Engineering, who described the purpose of academies today as organisations that provide independent, balanced and authoritative advice to government on policy-based issues that have a strong technical component.

But, do governments seek advice from academies of sciences?

Academies are able to give advice on a variety of topics, Drenth (2002b) notes, including advice based on quality assessments of scientific programmes, on science policy, on political decisions that have a scientific element, as well as on ethical and social issues resulting from scientific research. The Australian Academy of Science has provided (unsolicited) advice to its government since 1957 (Lambeck 2008), when it advised on 'Scientific and Technological Manpower Supply and Demand' and mathematics education.

A legislative authority's view on the issue of scientific advice has been outlined in a British House of Commons Report (2006) entitled, *Scientific Advice, Risk and Evidence Based Policy Making,* which made more than 40 references to the role of the various Royal Societies (academies) in terms of advising the UK government on scientific issues. Further, it quoted the Vice-President of the Royal Society as saying 'We are a very great resource. We have not just got our fellowship that covers expertise in all science but also all our various contacts, networks, including networks overseas. This is something superb for the government to be able to draw from …'

Further evidence has been reported in the UN Millennium Project (2005: 143) on how policymakers in the UK seek advice on scientific and technological issues from a variety of sources, including the Royal Society and the Royal Academy of Engineering.

In a similar vein, Crawford (1989) reported on the attempt of the presidents of the three US National Academies to convince the US President to appoint a technology adviser in a senior staff status, describing in the process the advantages of a personal S&T adviser in the presidential administration, and the possible helpful influence of such a position on government and industry.

'Being 'at the service' of its patron or the community to which it belongs was how Cabibbo (2004: p. 117) described the advisory function of the Pontifical Academy of Sciences.

Global academies are also expected to engage in providing scientific advice. For example, one of the objectives of the IAS, Zou'bi (2008) has reported, has been to serve as the consultative organisation of the Muslim *Ummah* (nation) and institutions of OIC countries on matters related to science and technology.

The lack of advice-giving competence within the science academies of OIC countries has prompted their representatives, as reported in *Outlook on Science Policy* to discuss means to build their capacities so that they can provide advice to governments, the private sector and other stakeholders. (Cunningham and Dufour 2006). The Académie des Sciences et Techniques du Sénégal (ANSTS) (founded in 1999) seems to be an exception. It has been active in giving science-based advice to decision-makers and enhancing the contribution science makes to sustainable development, as reported by Sock (2006). Other African academies of sciences have voiced their willingness to provide advice to their governments on important topics including malaria, science and technology education, HIV, tuberculosis, nutrition, good governance, and education policy, as Scott (2006) has reported. In contrast to the useful yet dispersed African endeavours, there exists one example of an international advisory body that is composed of 24 representatives of European national science academies, the Academia Europaea, and the All European Academies Federation (ALLEA); namely the *European Academies Science Advisory Council*[11] (EASAC). This is an agency, according to Ramon (2006), through which academies work together to provide independent, expert, evidence-based advice about the scientific aspects of public policy to those who make or influence policy within European institutions.

[11] The aim of the European Academies Science Advisory Council (EASAC) is to provide authoritative scientific judgement to the policy makers of the European Union on a wide variety of topics (environment, agriculture, energy, fisheries, health and food safety). EASAC currently has a membership of 16 academies from the 15 EU member states, plus Academia Europaea and ALLEA.

The importance of national academies of sciences as providers of scientific advice to governments has led to governments taking the lead in establishing/re-establishing academies of sciences. This was the case in Canada, as reported in the UN Millennium Project (2005: 144). Juma and Lee (2005) cite the example of the Academy of Sciences Malaysia as a successful science advisory system that has not adhered to the 'established' principles of being independent of government, as it is associated administratively with the government (UN Millennium Project 2005: 147). In fact, it was the Malaysian Prime Minister's Science Advisor; Omar Abdul Rahman[12] and his compatriot Lee Yee Cheong, who were behind the creation of a new, independent advice mechanism that had government support; that evolved to become the Academy of Sciences Malaysia in 1996 (Lee 2002).

Providing scientific advice to all branches of government is a key function of academies of sciences. Alberts (2002), a former president of the US National Academy of Sciences, has often declared that politicians everywhere tend to focus on short-term gains, whereas on many issues, only a respected voice for local scientists (an academy of sciences) can provide the countervailing power needed to make wise long-term decisions. It is in this context that attempts by academies of sciences to build bridges with politicians become important. National science academies, according to Hassan (2004: 206), can play a role in providing credible and objective advice to governments on issues of local, national and international concern.

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[12] Tan Sri Dr Omar Abdul-Rahman is an eminent Malaysian scientist and administrator of science. He is the Founding President of Academy of Science Malaysia.

1.2.4 How do Academies of Sciences Promote Science?

The universities of the 16th and 17th centuries, Drenth (2006:188) tells us, were institutes of learning that had strong ties to the ideologies of the churches. Academies, on the other hand, were places where research was performed. In the 19th century, the nature of most academies changed resulting in the research function going back to universities. However, Drenth points out that the 20th century saw the academies of sciences of central and Eastern Europe in particular continuing to accommodate extensive research infrastructures, while the majority of other academies' involvement in research became less direct.

As well as providing advice to various stakeholders, some academies which have been modelled after the Soviet Union Academy of Sciences run and manage research centres. The Kazakhstan Academy of Sciences, with its world-famous space facility at Baikonur (RSW 2010), is a case in point as Ovchinnikov (1980) and Sievers (2003) outline. The Tatarstan Academy of Sciences in Russia, Mazgarov (2007) tells us, is the umbrella organisation of six institutes and six research centres including the Institute of Experimental Aesthetics and the Institute of Information Science. The Chinese Academy of Sciences is also of this type. Not only is it at the top of the Chinese scientific hierarchy but it also comprises over 140 research institutes scattered around China (Cao 1999). The InterAcademy Council report entitled, *Inventing a better future: A strategy for building worldwide capacities in science and technology***,** highlights the involvement of the Chinese Academy of Sciences (CAS) in the 'Pilot Project of the Knowledge Innovation Programme (PPKIP).' This is an ambitious project to enhance China's scientific capacity and output in fundamental research (IAC 2004: 37).

The *UNESCO Science Report 2005* (UNESCO 2005: 98) describes the scene in some Eastern European countries which originally had monolithic and hierarchical STI landscapes with powerful academies of sciences at their core. It highlighted that such structures were changed after the demise of the Soviet Union and aligned more to the 'Royal Society' model for the organization of research, with science academies assuming a less domineering role on the national S&T stage.

Nevertheless, evidence exists that the Soviet model of an academy of sciences is still in existence in many of the former Soviet republics (many of which are now members of the OIC) as reported in Nature (1997). Such academies were unable to adjust to the political changes that have taken place, although Afanasiev and Siscanu (1998) cite the exception of the Academy of Sciences of Moldova, which in 1997, was asked by the Moldovan President to undertake a thorough review of the country's S&T system that resulted in widespread reforms. In Latvia, on the other hand, the academy of sciences changed course and became an advisory body to the government on science policy, working on an honorary basis. Belarus decided to merge its many academies of sciences into a single bigger one, according to a report prepared by UNESCO and the IAP entitled *The Future Role of the Academies of Sciences in Countries in Transition* (Nechifor 2005).

The *Science and Technology Policy Infrastructure Guidelines and References* published by the United States Department of Commerce (USDC 2004) lists the Polish Academy of Sciences as a governmental scientific institution as well as an honorific society while the Czech Academy of Sciences is listed as the leading non-university basic research institution in that country. In Finland, with its geographical proximity to the Eastern Bloc yet a very dissimilar history, the academy of sciences has been the planning and funding agency for basic research, according to the UN Millennium Project (2005: 28). It has assumed the task of assessing the scientific and social impact of its research and evaluating the impact of its funding as well as that of the state's on the level of research, as outlined in *Outlook on Science Policy* (Cunningham & Dufour 2006).

In contrast to the Soviet model, academies modelled after the Royal Society focus on promoting, encouraging and sometimes funding research, but not running research centres. Collins (1998) points out that the Royal Society does not employ any research scientists, but is responsible for channelling funds allocated in the UK science budget to support researchers. Klug (2000) explains that the Royal Society acts as a research-funding agency that supports individuals to undertake imaginative research through research professorships and fellowships, conferences and research grants.

In 1941, in a speech at the Indian Academy of Sciences, Raman (1941) described how national academies serve the interests of science best when they undertake direct participation in research work of exceptional importance. He cited the 'great' national academies such as the Royal Society of London and the Academy of Sciences of Paris, as not acting merely as clearing houses for scientific information but also encouraging scientific research.

Encouraging and supporting scientific research is a key function for the majority of academies of sciences according to Bernard (1980). The distinction between honorific and research academies however holds true when assessing the nature of the involvement of an academy of sciences in research. Todd (1980), for example, does not embrace involvement in scientific research as a function of the Royal Society of the UK. However, Evans (1980), Ovchinnikov (1980) and Malone (1980) of the Australian, Soviet and American academies respectively, do, for their respective academies. Malone (1980), in particular, explains that the US National Academy of Sciences has a principal research arm associated with it; the National Research Council[13] (NRC).

[13] NRC's mission is actually to improve government decision making and public policy, increase public understanding, and promote the acquisition and dissemination of knowledge in matters involving science, engineering, technology, and health.

The idea of an academy of sciences supporting and streamlining research carried out at specialised research agencies, universities or industry, has been promoted in recent years in OIC countries, as mentioned by Hassan (2005) and Khan (2005). In his review of some of these activities, Hassan (2005) points out that support of high-quality scientific research and its applications should be a priority for such academies, including the awarding of competitive research grants and fellowships.

In many developing (including OIC) countries, much of the R&D capacity is scattered across many independent research institutions and universities. As a result, resources are not effectively utilized. One way to address this challenge is to pool resources to pursue research in priority areas identified by national governments (ESCWA 2000). This is one area where the national academy of sciences can play a role. The UN Millennium Project (2005: 132) refers to the example of the Israel Academy of Sciences and Humanities which operates a high-level advisory commission for the national R&D infrastructure made up of heads of major national research and funding organizations. The panel attempts to pool budgetary resources and direct major joint research initiatives in fields of national interest.

Clegg[14], cited by Guinnessy (2003), makes a special mention of the Indian and Chinese academies suggesting that they were making good progress in areas such as information technology and climate change research. Other academies, such as in Brazil and Chile, Clegg added, became successful by creating scientific reports that influence government policy, and by focusing on specific research areas.

[14] Michael Clegg is the Foreign Secretary of the US National Academy of Sciences.

Academies of sciences enhance their influence and credibility in science and technology issues by also organising specialised seminars and conferences that address important S&T topics. In this context, many science academies in developing (including OIC) countries organise this type of activity regularly. The IAS, as Zou'bi (2008) reports, organises an annual scientific conference in which scientists from developing and developed countries participate. The *UNESCO 2005 Science Report* (UNESCO 2005:82) makes a mention of the Caribbean Academy of Sciences which has organised an annual scientific meeting at which scientists present their research work, and has been successful also in arranging lectures that have attracted a number of Nobel Prize Laureates.

Of the various stakeholders in the S&T system in any country is industry -or what Léna describes as- the application of science (Pontifical Academy of Sciences 2004: 219). Collins (1998) in his overview of the role of academies of sciences, quoted the examples of the Czech and the Jordanian[15] academies of sciences as providing advice to industry on a number of issues. The Australian Academy of Science and the US National Academy of Sciences collaborate with industry through mechanisms such as the Science and Industry Forum and the Government-University-Industry Research Round Table respectively (Collins 1998). Needless to say, the relationship between academies of sciences and industry depends on the level of advancement of industry (and the academy) and industry’s S&T needs. On the other hand, Collins (1998) has noted that the Mexican Academy's linkages with industry are ‘non-existent,’ but it nevertheless runs programmes on university-industry-government linkages.

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[15] The Jordanian academy referred to here is the Royal Scientific Society, which is not an academy of sciences in the usual sense, but rather a semi-governmental scientific services and research centre.

A cautionary note on academe-industry relations has been expressed by Klug (2000) who warned that the policy of encouraging closer relations between academe and industry could lead to many scientists having commercial links while pursuing their publicly-funded academic research. Such links may hinder an expert from giving objective advice making the job of finding disinterested experts to serve on advisory panels much harder.

In Eastern Europe, academy[16]-industry relations are developing under pressure according to Balazs (2001) due to the lack of demand for R&D by the industrial sector. She mentioned attempts that have been made to address this mismatch, which she summed up in terms of R&D attempting to stay on course during times of economic decline! Lessons learnt from developed countries in academy-industry relations may be useful and could be adapted by other countries, she concluded.

As well as undertaking, supporting, publicising and managing scientific research, academies of sciences play a useful role in encouraging scientific excellence, reported Cunningham and Dufour (2004). Hassan (2005) suggests that recognition of scientific achievement and encouragement of the pursuit of scientific excellence, should be priority programme areas for academies in OIC countries. As is well known, awarding academic excellence has been a major activity of, for example, the Royal Swedish Academy of Sciences. It has been active in promoting excellence in basic research, and has become known as a result of its pivotal role in the creation and functioning of the Nobel Institution and its association with prizes (Hiebert 1989).

[16] The author uses the term 'academy' throughout her paper although the idiom 'academe' may be more linguistically correct.

1.2.5 What is the Story of Islamic Science, Past and Present?

Let me now look at some of the literature related to the rise and decline of Islamic science. This is a niggling question in the minds of science historians, policy planners and scientists in the Islamic world, today, and it is not possible to talk about academies of sciences in the Islamic world without addressing it. Addressing this question may help in understanding the reasons for the backward state of STI in the Islamic world today. Some of the knowledge that exists on the subject will be highlighted as well as the gaps and controversies that are there in previous research.

At the outset, it is important to define what 'Islamic Science' is in the context of this Thesis.

It is *not* the 'spiritual' definition proposed by Nasr in his book *Science and Civilisation in Islam* (Nasr 1968:30), also alluded to by Shah (2001) which says:

> *Islamic science seeks ultimately to attain such knowledge as will contribute toward the spiritual perfection and deliverance of anyone capable of studying it; thus its fruits are inward and hidden.*

Rather, it is the matter-of-fact definition, which is essentially based on the terminology that was discussed extensively by Sabra (1987), adopted by Saliba (2007c) and Abdalla[17] (2007):

> *Islamic science in this narrative means pure and applied science that was developed in the context of the Islamic civilization.*

[17] Abdalla (2007) gives the following detailed definition.: Islamic science here means the natural or exact sciences that originated in or were influenced by the Islamic civilization. Arabic was the main scientific language used, but not necessarily the native language of the scientists, who might have been Persian, Turkish, or of other origins. While the terms Islamic science and Arabic science are modern historical terms within the context of Islamic civilization, this science is Islamic in the sense that it suited the new and growing needs of the Islamic civilization; was available entirely in Arabic, which replaced Syriac; and was familiar to an increasing number of translators, students, and scientists. It is in this context that the term Islamic science is used in this Thesis.

The archetypal narrative says that interest in science reached a peak soon after the ‘Abbāsids ascended to power in AD 750 but does not tell us when it started and how it developed. Sabra (1987: 228) says that it was not until the ‘Abbāsid revolution ended and the ‘Abbāsid Empire established in Baghdad that we witness a cultural explosion of which the translation of ancient sciences and philosophy was a major feature.

The alternative narrative, which will be proposed in this Thesis, will show that interest in science started earlier, and that the Umayyads were instrumental in starting the scientific movement in the Islamic civilisation. It can even be said that the accumulation of scientific knowledge continued during early Islam and accelerated during the Umayyad era and then during the ‘Abbāsid era. Proponents of the traditional narrative such as Hoodbhoy (1992: 89) tell us that prior to AD 750, notwithstanding some attempts to translate alchemical, astrological, and medical works, there were no activities in science in the world of Islam to speak of. Gutas (1998: 11) suggests that after the culmination of the ‘Abbāsid revolution in AD 750, the ground was prepared for a flourishing translation movement under the ‘Abbāsid Caliph *Harun ar-Rashid* and his successors, and the process of Hellenisation of Islamic culture and the translation of the classical tradition from Greek and Syriac into Arabic was underway, according to Lindberg (2007: 169).

From other research, it becomes known that the archetypal narrative broadly defines the starting point for the ascendance of Islamic science as the start of the 9th century, i.e. a few decades into the ‘Abbāsid era – probably at the time of Harun ar-Rashid or his son *Al-Ma’mun*. It was at that time according to the archetypal narrative that Muslims began to study the *awā’il* (earlier) sciences.

In describing the scene on the eve of AD 750, Ghassib (2008a) notices that following the phenomenal territorial expansion that took place during the Umayyad rule, the ‘Abbāsids realised that military conquests into new territories were no longer rewarding, and they diverted their attention to building the agricultural infrastructure of the state –especially in Mesopotamia- in order to increase state revenues. They developed a keen interest in science to facilitate this expansion.

Gutas (1998: 12) supports the notion that the unification of the ‘East’ and the ‘West’ in a new state witnessed an increase in trade and ushered in an age of prosperity and the start of an agricultural revolution that took off due to heavy investments in irrigation systems, which was further augmented by the transfer of agricultural knowhow from one region to another. He cites the introduction of paper-making technology into the Islamic world by Chinese prisoners of war in AD 751 as a turning point in the chronology of events that enhanced the spread of knowledge. In terms of science patronage, Gutas (1998: 56) suggests that Harun ar- Rashid and his son al-Ma’mun were interested in aspects of Sassanian ideology including the recovery of knowledge through the translation of ancient works. Scholars such as Nasr (1968: 70) suggest that the real reason for the interest of Muslims in non-Islamic sciences at the beginning of the 9th century, compared to the sporadic interest they had in the earlier century, stemmed from the new ideological challenge that Islamic society was facing. This important challenge which rose as a result of interaction with Christian and Jewish theologians who would present strong arguments when debating principles of faith with their Muslim counterparts, which Muslims had to address.

Moreover, the important question of the decline of the scientific enterprise in the Islamic civilisation has spawned many theories. Most however, neither tell us when did the decline start nor the reasons which led to it, although such reasons may help explain the present state of science in the Islamic world.

Did the fall of Baghdad at the hands of the Mongols mark the abrupt end of five centuries of Islamic scientific enterprise? Was it what Sarton called 'scholasticism?' Was it al-Ghazzālī's influence and his classification of knowledge as revealed and non-revealed, which eventually led to reining in theoretical inquiry, as described by Sabra (1987)? What were the external and internal factors that led to this decline, if a decline did occur at all?

Nakosteen (1964: 173) suggests that the 8th and 9th centuries were the period which saw the introduction of classical learning; the 10th and 11th centuries were dedicated to the interpretation of classical thought; and the 12th and 13th centuries saw the gradual decline of Muslim creative scholastic distinction and the flow of accumulated knowledge into the Hebrew and Christian schools. Abdus Salam was also of the opinion that after AD 1100 science in Islam started to decline and by AD 1350 the decline was almost complete (Dalafi and Hassan 1994). Other scholars claim that despite the fact that learning and acquisition of knowledge were at the heart of the Islamic faith, there was a sudden decline after Muslim scholars and scientists reached the pinnacle of their scientific achievement in the 14th century, and that there has been an almost permanent stagnation since then (Mushatq 1995).

A comprehensive chronology of the historical development of Islamic S&T has been proposed by Al-Hassan and Hill (1986, cited in Bakar 2008: 204) who suggest that there were three distinctive periods in the evolution of Islamic science: the first was one of transition and assimilation which covered the 8th and 9th centuries; the second spanned the 10th and 11th centuries and was characterised by the prevalence of innovation; and the third, which lasted until the 16th century was of innovation in new areas of S&T.

Mursi (1982) has described the rise and fall of Islamic educational institutions in four stages as follows: the Building Stage (from the beginning of Islam to the end of the Umayyad reign in Damascus), the Golden Stage (the ‘Abbāsid dynasty), The Deterioration Stage (the Ottoman Era), and the Renewal and Re-building Stage (from the end of Ottoman rule to the present).

Some 19th century and a few contemporary scholars have suggested that the decline of science in Islam was caused by the negative attitude of Muslim theologians starting in the 4th Hijri century. They single out al-Ash’arī (AD 874-936) and al-Ghazzālī (1058-1111) as having a negative influence on the advancement of Islamic science (E.G. Browne[18] (1908) and Sayili (1981) cited in Al-Hassan et al. 2007a) (Ghassib 2008a). In his great philosophical work, *The Incoherence of the Philosophers*, al-Ghazzālī attacked ancient philosophy, especially the theories of Aristotle. He also regarded Greek theology and natural philosophy as dangerous to the Islamic faith (Grant 2007: 88), thus paving the way for a revival of Islamic orthodoxy. A similar point of view was adopted by George Sarton, who labelled the views of al-Ash’ari and al-Ghazzālī as ‘scholasticism,’ which ‘were obstacles to the progress of science in the Middle Ages’ (Sarton 1975:626). Sarton said that until the 16th century, developments in science were taking place both in the East and the West, but after that time Western science began to develop while Eastern civilization remained at a standstill, or even deteriorated. He concluded that the essential difference between the East and the West was that the latter overcame scholasticism, while the former did not (Al-Hassan et al. 2007a). This narrative attributed to Sarton (1975) has been questioned by some contemporary scholars who have suggested that since Sarton did not speak the language of Islamic science (Arabic), his ability to analyse and study Arabic manuscripts and thus make conclusive statements was limited (Saliba 2007a).

18 Browne, Edward Granville (1862-1926). British orientalist who published many books and articles on the Babi and Baha'i religions. He is best known to modern Baha'is for his description of his meeting with Baha'u'llah. Available at: http://www.northill.demon.co.uk/relstud/browne.htm [Accessed 20 November 2008].

In short, the traditional narrative answers the questions of when and why science in the Islamic world or Islamic science started to decline as follows: Firstly, the year AD 1350 marked the start of the decline of Arab/Islamic science, this is the year adopted by the UNESCO Science Report (UNESCO 2005: 159), and earlier by Abdus Salam (Dalafi & Hassan 1994); and secondly, the decline was mainly due to a change in the mindset of Muslim scientists and scholars as a result of –among other things– the negative influence of theologians, the introduction of the *Madrasa* (religious school) system, and political upheaval.

The above analysis leaves a number of questions unanswered. For example, why specifically the year AD 1350? Moreover, the idea that the revival of 'Islamic orthodoxy' led to the decline in Islamic science needs to be re-examined.

The 2010 UNESCO Report tells us that the challenges that face the Islamic/Arab World today lie in achieving socioeconomic advancement partly through S&T (UNESCO 2010). But, how do we assess the state of S&T in the Islamic world? Needless to say, the UNESCO Science Report itself is probably the world's best reference on the subject. In this Thesis, I will also talk about the work of Godin including his book, *Measurement and Statistics on Science and Technology: 1920 to the Present,* which has become a major reference on the subject (Godin 2000, 2002 and 2005).

In bridging the divide between the historical discourse on science and the contemporary quantitative one, it is important to take note of the research carried out by Shah, who, by studying two documents, has demonstrated how some agencies in the Islamic world have adopted a dichotomous stance on S&T (Shah 2003). The first document was published by the ISESCO and was called *Strategy for the Development of Science and Technology in Islamic Countries* (ISESCO 2000). The second document was by ISESCO and COMSTECH and was called *First Islamic Conference of Ministers* *of Higher Education and Scientific Research: Towards Mechanism for the Implementation of the Strategy for the Development of Science and Technology* (ISESCO and COMSTECH 2000 cited in Shah 2003). Shah concludes that OIC countries and organisations are aware of their S&T dilemma as manifested in the current state of S&T under-development. To boost morale, they leap over blindly to the historical narrative and highlight the scientific achievements of the Islamic civilisation at its heyday. In short, they are stranded between a glorious past and an uncertain future. OIC countries and organisations tend to pay lip service to the intellectual quality of the scientists of the past and the milieu in which they excelled (Shah 2003). At the same time, Shah complains that OIC countries by adopting purely quantitative measures to gauge their S&T status today are forsaking their cultural authenticity and becoming economically and politically paralysed (Shah 2003). Kessler puts forward a similar argument and claims that many contemporary Muslim neo-traditionalist ideologues boast about the achievements of the Islamic civilisation in science without actually commanding or embodying the scientific rationalism that was *sine qua non* for the ascendance of science in the Islamic civilisation (Kessler 1990).

Shah draws another comparison in his article entitled, *A Tale of Two Scenarios in the Development of Science and Technology in Malaysia.* Here, he explains the difference between the qualitative (philosophical) approach and the quantitative (indicator-based) approach of assessing the S&T status in Malaysia (Shah 2004). Shah says that the qualitative approach has supporters in a majority Muslim society like Malaysia where the proponents of this approach range from those calling for the Islamisation of science and those rejecting modern science outright, to those moderates who support keeping science at arm's length (Shah 2004). Shah is also critical of the quantitative approach as represented in the publications of the Malaysian Science and Technology Information Centre (MASTIC), which regularly publishes an assortment of STI indicators for

Malaysia. He claims that MASTIC's publications do not capture all the essential facets relating to S&T in the country nor do they reflect the sentiments and attitudes of religious thinkers towards science. Although the above study specifically addresses Malaysia, its conclusions are valid for the majority of OIC countries where decision-makers and the public are torn between looking at national S&T indicators to know where their countries stand in the domain of S&T, and looking beyond the numbers to perceive what or where science should take their countries in our globalised world.

An early contemporary pseudo-qualitative attempt to study Islamic science and civilisation was made by Seyyed Hossein Nasr who in 1968 published his famous book; *Science and Civilisation in Islam* (Nasr 1968: 30). It represented an early attempt to reintroduce the towering figures in science and philosophy of the Islamic civilization to a contemporary audience, and introduce Islamic science as an integral component of Islamic civilization and the Islamic intellectual tradition. On the other hand, Hakim Said's book *Personalities Nobel* published in 1981, contains the brief resumes of 26 historical figures in science and philosophy of the golden era of the Islamic civilization. It represents an attempt to introduce Islamic science to a younger audience (Said 2000) in contemporary parlance. The late M. M. Qurashi also attempted to bridge the divide between the qualitative and the quantitative in many of his works going as far as to apply modern statistical techniques to plot the frequency of the appearance of eminent scientists and philosophers from the Islamic civilization on the world stage (Qurashi 2008) (Qurashi 2008).

In one of the earlier publications of the Academy of the Kingdom of Morocco, Abdus Salam presented an important pioneering paper on how science can help in major problems such as: disease control, greening deserts, weather modification, energy use and earthquake mitigation, etc. It brought to light some indicators on S&T in the developing world. Interestingly, the paper was published before Salam founded TWAS in Trieste, Italy (Abdus Salam 1983). In addition, Salam gave a series of lectures along the same lines after he had won the Nobel Physics Prize of 1979. These lectures were presented in a book entitled *Renaissance of Sciences in Islamic Countries*, which was edited by H. R. Dalafi and M. H. A. Hassan (Dalafi and Hassan 1991). Another viewpoint on how science should be perceived has been presented by Pervez Hoodbhoy, whose mentor was the late Abdus Salam. He sees science as a universal phenomenon and as such views labels like 'Islamic science' or 'Christian science' to be misplaced, if not erroneous. For him, Islam is not intrinsically opposed to science. He suggests that Muslim countries should utilise science to achieve economic development and industrialisation but without sacrificing religion, as religion encompasses the elements of 'justice, beauty or feeling' (Shah 2001).

In his seminal book *Can Science Dispense with Religion?,* Mehdi Golshani, after surveying the opinions of more than 60 scholars of all persuasions, concludes that – despite areas and causes of conflict- an essentially harmonious relationship exists between 'Science' and 'Religion' (Golshani 2004:402-413).

This conclusion forms the underlying tone of this Thesis.

1.2.6 Conclusion and Implications

So, where does this Thesis stand in relation to the literature on academies of sciences, and the scientific enterprise in the milieus where such institutions existed including the Islamic and the West?

Only a few studies have been carried out on the role and functions of academies of sciences and it is fair to say that real interest in such institutions and their interaction with society nationally and with the international community, only surfaced in 1980s. Most studies understandably take a bird's eye view of science academies focusing on: the activities which they implement rather than their histories and the milieus within which they ascend, intrinsic strengths and their contributions to the scientific enterprise at many levels. Moreover, a few studies were carried out on academies of sciences in the Islamic world.

Although some eminent historians of science have acknowledged the contribution that Islamic science has made to world science, the calendar of science in the mind of many 'academicians' in particular starts with the birth of the Accademia dei Lincei in Italy in 1603. Rarely are the great academies of the Islamic civilization mentioned when the history of academies is discussed. Moreover, the flow of scientific knowledge from the Islamic civilization into Europe seems to be under-rated by the contemporary historical narrative despite its tremendous relevance to world political affairs today.

Muslims today are uncertain as to how they should perceive science. Should they look at as a tool for development or an enterprise that has bloomed in the past? Not many are aware of the reasons for the decline of the scientific enterprise in Islam historically and the implications of that on science in the Islamic world today. And although there are various schools of thought on 'Islam and science,' only a few outside academia agree that there is essentially a harmonious relationship between Islam and science. This renders promoting a culture of science a difficult task.

Naturally, this present research does not attempt to rework existing literature on all the above issues. Rather, it aims to fuse the two themes of academies of sciences and the scientific enterprise (particularly in the Islamic world) together for a more meaningful contribution to science policy in general, and particularly in the Islamic world.

1.3 Hypothesis

> *A hypothesis is a logical supposition, a reasonable guess, an educated conjecture. It provides a tentative explanation for a phenomenon under investigation.'*

(Leedy and Ormrod 2001).

The role, functions, and activities of academies of sciences are multifaceted and multilayered; at the heart of which lie the promotion of S&T and the application thereof to increase knowledge, improve socioeconomic conditions in society, create wealth; and make the world a better place. Appreciation of academies of sciences, it is proposed, is lacking in many countries –especially OIC countries- despite a rich heritage of science and the scientific enterprise including scientific institution building.

My hypothesis therefore is:

Despite a rich heritage in science and the scientific endeavour –still being uncovered- which witnessed the rise of many famous academy-type institutions in conducive milieus patronised by enlightened leaders, science academies in the Islamic world today are few and lack political and financial patronage, although internationally such bodies have a proven track record of over 350 years in the promotion of science and technology nationally and globally. Reinvigorating such institutions in the Islamic world will render the science, technology and innovation systems of OIC countries more effective in achieving socioeconomic development goals, and will contribute to a greater understanding between world cultures and civilisations.

1.4 Theoretical Framework

The theoretical basis for the Thesis will essentially be organised around two main themes within the domain of science institutionalisation: (a) Academies of sciences as institutions: Aspects of the roles, functions and activities of academies of sciences historically and today, and (b) Science in societies where academy-type institutions existed in the past and exist today including science in Islam and its ascendance in the West. Many studies have investigated the two themes independently from each other without aligning science academies and what they do against the science timeline, rendering the comprehensiveness of such studies limited.

By investigating the two themes and uncovering their points of convergence in different milieus, we can draw a better understanding of the 'institutionalisation of science' in general and in the Islamic world in particular.

1.5 Methodology, Evidence and Presentation

How can the status of science in the Islamic world today be assessed? To capture the complete picture, an in-depth look at the history of Islamic science, especially in the light of recently unearthed documentary evidence, is required as well as a quantitative look based on the latest STI indicators available. A better understanding of the history of Islam and how science was institutionalized within will not only tell us why science in the Islamic world is in its current state, but more importantly how it can be promoted, today. Can academies of sciences make a measurable impact on S&T? If so, how? What lessons can be drawn from international experiences in this field?

These are some of the issues that will be addressed in this Thesis.

There have been some constraints to what I set out to do in this Thesis. In particular, time constraints prevented a more thorough examination of the complex question of how science is perceived in the Islamic world today, and why it is generally not viewed as a means of attaining might and prosperity.

Secondly, there was the question of funding science, whether for R&D or for academies of sciences. It would have been interesting to study how the scientific enterprise has historically been financed and how academies of sciences can today come up with novel ideas to finance their existence and their activities without compromising their treasured independence and prestige.

1.5.1 Why a Comparative Study?

This Thesis is a multi-layered comparative study of history; the history of science in the Islamic world and the West, the history of academies of sciences as well as the roles and functions of such entities in the Islamic world and the West historically and contemporaneously. An advantage of such a comparative study –which inherently recognizes differences and contexts- is that it leads to a better understanding of contemporary problems in science and the scientific enterprise.

This would result in highlighting best practices in the institutionalisation of the scientific enterprise, particularly in the Islamic world, and to the development of a model academy of sciences, a model that can be put into practice because it is congruent to the realities of society.

1.5.2 Data Gathering Methods and Interviews

In order to make an unsullied contribution to the literature available of the subject of the Thesis, an attempt was made throughout to look for previously untapped or undocumented data from a variety of sources. The assessment of the academies of sciences was based on independent studies as well as through a comprehensive literature review of published material on the subject. Quantitative approaches (including surveys) were employed to set out a number of parameters related to the types of activities implemented by academies of sciences, as well as to present data on the status of science in OIC countries.

In addition, information was collected through direct enquiries and interviews with academicians within and beyond OIC-countries, as well as through participating in conferences and seminars on the subject.

A number of interviews were conducted to provide insights into aspects of the Thesis which could not be obtained from archival sources. These were conducted mostly face-to face and were of a semi-structured nature. They included questions on the themes of this Thesis depending on the interviewee. This interview strategy fits with general data gathering methods as Yin states in *Case study interviews are of an open-ended nature, in which you ask key respondents for the facts of a matter as well as for the respondents' opinions about events* (Yin 1994: 84).

In addition to the interviews, opinions expressed by politicians and science journalists, who gave presentations at a number of conferences, were included. A list of individuals either interviewed or listened to for this thesis is given in Appendix 1.

Insights from these interviews and presentations have been incorporated into the Thesis where appropriate.

1.6 Scope of the Research

The research will look at the historical evolution of some academies of sciences as documented in published literature. A conscious attempt will be made to benchmark the review to historical contexts that are particularly germane to the Islamic world in order to provide a novel outlook on the subject. The research will focus on academies of sciences in a cluster of OIC countries including Uganda and Senegal from the African OIC region, Morocco and Palestine from the Arab OIC region, and Turkey, Tatarstan, Pakistan and Malaysia, from the Asian OIC region. These academies vary in terms of history, mandates, and types of activities they implement, yet they share some common heritage. The OIC region from a historical viewpoint could be considered the modern day manifestation of the Islamic super-state that at times spanned from China to Spain.

Two regional academies of sciences would be studied: the Trieste-based TWAS, as well as the IAS, based in Amman, Jordan.

Moreover, the wealth of experience accumulated by some Western academies of sciences in promoting S&T would be analysed to draw possible parallels between such academies and OIC-based entities. These include the US National Academy of Sciences, the French Academy of Sciences as well as the UK's academy of sciences: the Royal Society, and the Royal Swedish Academy of Sciences.

Overall, the academies chosen include the world's richest and poorest academies (the US National Academy and the Academy of Senegal, respectively) and one of the oldest and most prestigious as well one of the youngest (the UK's Royal Society founded in 1660 and again, the Senegal Academy of Sciences launched in 1999, respectively). The Tatarstan Academy of Sciences was selected to represent Soviet-style academies of sciences and similar in set-up to the science academies of central Asian countries. The choice of the OIC-based academies covers the three regions of the Islamic world, which has often been described as spanning from Indonesia in the East to Senegal in the West, and from Uganda in the South to Kazan in the Republic of Tatarstan in the Russian Federation, in the North.

It will be assumed that the recently identified international development goals which have found a new expression in the UN Millennium Declaration will continue to be a priority on the international science agenda and for the countries considered in this study[19]. In the same perspective, reference will be made to the S&T parameters stipulated in *Vision 1441*, as formulated and adopted by the OIC in 2003.

1.7 Structure of the Thesis

This Thesis is essentially about academies of sciences and their role in science, technology and development in the Islamic world and the West. Unlike the approach Diner adopts in his book; *Lost in the Sacred: Why the Muslim World Stood Still* (Diner 2009) where he follows a present-past timeline, this main body of the Thesis –unlike the self-standing literature review- follows a past-present timeline. Yet, in addressing the research questions, it tries to highlight the alternative viewpoints to the traditional narratives on the various questions.

Chapter One is the Introduction, which includes: Background and Research Aim; the self-standing Literature Review; Hypothesis; Theoretical Framework; Methodology, Evidence and Presentation; Scope of the Research and the Structure of the Thesis.

Although this Thesis is essentially about academies of sciences, particularly in the Islamic world, it was imperative that the research is put in the wider context of the history of science in the Islamic civilisation. This was investigated in **Chapter Two**.

[19] For an example of the quantitative and qualitative approaches to assessing the development of science and technology, see Mohd Hazim Shah and Phua Kai Lit, 2004, pp. 59-84.

Chapter Three tells the story of the European Renaissance. It describes the routes through which science from the Islamic world was transmitted into Europe and then proposes a chronology of the events that culminated in the scientific renaissance, the reorganisation of science, the Scientific Revolution, and the birth of scientific academies in Europe. It also talks about the Industrial Revolution and discusses the history of some famous academies of sciences that have appeared since then. **Chapter Four** marks a departure in the research approach as it describes contemporary events and milieus. To establish the proper context, the question of colonialism in the Islamic world is addressed. The methodology adopted in the chapter is similar to that adopted by Abdus Salam in his book *Renaissance of Sciences in Islamic Countries* (Dalafi and Hassan 1994), and Ziauddin Sardar (1977) in his book *Science, Technology and Development in the Muslim World*, which were early attempts to bring to present a contemporary outlook on S&T for development in the Islamic world.

Before comparing a number of academies of sciences from the Islamic world and the West in terms in their involvement in the scientific enterprise, the theoretical perspectives related to the nature, character, role and outreach activities of academies of sciences were investigated and analysed in **Chapter 5**. The same chapter includes a critique of the Statutes of the 'model' academy of sciences proposed by the IAP.

Chapter 6 comprises the comparative study of a sample of academies of sciences chosen from many regions of the world, while **Chapter 7** is the conclusion chapter that draws together the various findings of the study and attempts to answer the research questions. That is followed by a **Bibliography** and **Appendices**.

CHAPTER TWO

THE SCIENTIFIC ENTERPRISE AND ACADEMIES OF SCIENCES IN THE ISLAMIC WORLD: THE HISTORICAL CONTEXT

> *History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed. That image has previously been drawn, even by scientists themselves, mainly from the study of finished scientific achievements as these are recorded in the classics and, more recently, in the textbooks from which each new scientific generation learns to practice its trade.*
>
> (Kuhn 1996: 1)

2.1 Introduction

The aim of this chapter is to provide a short history of ancient and Islamic era academies of sciences. This will be carried out against the background of the narratives –traditional and alternative- of the rise and moot decline of Islamic science. An attempt will be made to link historical developments to the various manifestations of scientific distinction; be they the individual scientists and scholars, scientific institutions including academies and the patrons of the scientific enterprise.

To illustrate the Islamic tradition of institutionalisation and the patronage of science, the example of Bayt al-Hikma of Baghdad will be examined closely in the light of recently published literature. The perception that Bayt al-Hikma of Baghdad was an 'academy of sciences' of its day will be presented. In order to extract possible lessons for today's Islamic world, the chapter will question the classical narrative for the decline of Islamic science and suggest possible alternative causes for the decline in the light of recently published research.

Part I: Pre-Islamic Academies

2.2 Academies in Ancient Civilisations: A Snapshot

Ancient civilizations such as those that flourished in China, Mesopotamia and Egypt, witnessed in their heyday illustrious accomplishments in the domain we today call S&T. Some Middle Eastern historians claim that the Phoenicians too were interested in science and established sciences and law academies in Sidon and Beirut (in modern day Lebanon) respectively around BC 1000 (American Philosophical Society 1963). These claims however have not been published in scientific journals, and there is no widespread acceptance of their validity. The Phoenician civilisation, which succeeded in colonising the shores of the Mediterranean, has however been credited with inventing the alphabet (Wazen 2007).

The Academy of Athens was created by Plato in BC 387 (Drenth 2006:197). The century following its birth witnessed the rise and fall of Alexander the Great, and the end of the ancient Egyptian and Babylonian civilisations. However, the city founded by one of the most successful military commanders in history, Alexandria, witnessed the birth, around the year 290 BC of the Ancient Library of Alexandria. Established by Ptolemy I Soter[1], it was intended to be a meeting place for scholars (Serageldin 2006a), and the first research centre in the world expanding to comprise all forms of knowledge of the ancient world. At its peak, the Library may have held over 700,000 scrolls (BA 2004:7).

The establishment of the Library of Alexandria was a historical event (Serageldin 2006a). Alexander had managed to establish an empire that spanned from Taxila (in modern day Pakistan) to Byzance and Cyrene (in modern day Libya), thus facilitating the flow of knowledge between East and West. The ancient Library of Alexandria married Greek and Egyptian sciences and added some Asian elements. This produced

[1] Ptolemy I Soter (BC 323 –BC 283).

an explosion of knowledge unparalleled in history. The ancient Library was the academy *par excellence* of ancient times (Serageldin 2006a). By the 1^{st} century BC, Alexandria had become the centre of Greek science and philosophy (Nasr 1968: 30).

The idea that Muslims were responsible for the destruction of the ancient Library of Alexandria was posited initially by Abdel Latif Baghdadi (d. AD 1241/42) who visited Egypt in AD 1200 (Qasem 2006). Ibn al-Qifti[2] (b. AD 1172) provided a more detailed account of the alleged destruction of the Library. However, historians argued that his narrative was proposed to justify Salahuddin's closure of *Dar al-Hikma* on the basis that the earlier grander Library of Alexandria was destroyed upon the orders of the famous Caliph *Omar Ibn al-Khattab*. Thus, what Salahuddin did could be justified. The motive behind Ibn al-Qifti's narrative seems to have been the appeasement of Salahuddin (Qasem 2006).

Serageldin (2006) too refutes the claim made by Winter (1952) and Butler (1988) that the final destruction of the library came at the hand of the Muslims during their conquest of Egypt (AD 640) under *Amro Ibn al-'As*[3]. He stresses that the Library was destroyed long before. The same argument is offered by Daffa' (1998: 41) who provided evidence that the Library was burnt down by Julius Caesar in 48 B. C.

Moreover, the allusion to Amro Ibn al-'As in the context of the narrative is tantamount to falsification of history, for Ibn al-'As was an exceptionally progressive figure renowned for his military and political acumen as well as his exposure to and appreciation of non-Islamic cultures. Had the Library existed when he entered Egypt, it is almost certain that he would have preserved it.

2 A detailed account of the life of Ibn al-Qifti is given on website of ISESCO: http://www.isesco.org.ma

3 Amro Ibn al-As was a famous companion of the prophet Mohammad and the leader of the Muslim army that conquered Egypt.

The idea of Alexandrian-type academies resurfaced centuries later by the leaders of the Christian Church who founded similar institutions in Antioch and Nisibis (in modern-day Turkey) after AD 425 (Becker 2005). Although Greek served as the *lingua franca* for scholars at such (schools), many of the texts were translated from Greek to Syriac, and when these schools moved to Edessa (in modern-day Turkey) in AD 464, they became engrossed in the Syriac tradition.

Nestorians, named after the bishop of Constantinople 'Nestorius' (AD 381-451), who had settled in Edessa, eventually moved together with their Syriac traditions to the east in AD 457. The Syriac traditions survived for another century, for when the Persian leader Khosrau I established an Alexandrian-type 'academy' in Jundishapur[4] (in the south-western corner of modern-day Iran) around AD 560 (half a century before the birth of Islam in Mecca), instruction would be conducted in Syriac. This academy was a refuge for many Greek philosophers and Nestorian Assyrians fleeing religious persecution by the Byzantine Empire.

In his book, *History of Islamic Origins of Western Education,* Nakosteen (1964: vii) mentions the Academy of Jundishapur which flourished during the 6th century and was described as the greatest academy of its time. It lasted until after the establishment of the 'Abbāsid Caliphate, and became an important source of ancient learning in the Islamic world (Nasr 1968: 31).

2.3 Discussion of Part I

Academies are not new. Examples of such institutions exist from ancient times. Athens was one of three ancient cities that were the domicile of academies of sciences. The other two were Alexandria and Jundishapur, which are cities found in what we know today as countries of the OIC or the Islamic world: Egypt and Iran respectively. Athens

[4] Also written as Gundeshapur, Gondeshapur, Jondishapoor, Jondishapur, and Jondishapour, Gundishapur, Gondêšâpur, Jund-e Shapur, Jundê-Shâpûr. The city was the intellectual centre of the Sassanid empire and the home of the Academy of Gundishapur.

was the venue for Plato's academy (BC 387), followed historically by Alexandria, which boasted the ancient library named after it in BC 290 Jundishapur was home to an Alexandrian-type 'academy' established by Khosrau I around AD 560.

Was the Jundishapur academy the forerunner of the Bayt al-Hikma academy, which was founded two centuries later? This is likely because the 'Abbāsids, who established Bayt al-Hikma in Baghdad, may have become aware of Jundishapur and its rich academic heritage due to its proximity to the route that linked their first (AD 749-762) capital Kufa to Khorasan and its capital city Merv or Merw (a UNESCO World Heritage Site in today's Turkmenistan). Khorasan was the powerful province that first supported the rebellion of the 'Abbāsids against the Umayyads.

Secondly, the prestige of the Alexandrian-type institution in Jundishapur must have encouraged early 'Abbāsid Caliphs to establish Bayt al-Hikma in Baghdad, the city that was built by the second 'Abbāsid Caliph *al-Mansur* (the real founder of the 'Abbāsid Caliphate).

Thirdly, the reported direct contact established between Jundishapur and Baghdad in AD 765, when al-Mansur sought the help of Jundishapur's most famous physicians (Jirjīs Bukhtyishū), paved the way for a tradition of transfer of medical knowledge from Jundishapur to Baghdad that lasted for centuries (Nasr 1968: 193).

Fourthly, the link between the two academies manifested itself in the person of *Hunayn Ibn Ishaq* (AD 809-877?), the philosopher of Nestorian roots who became the curator of Bayt al-Hikma. According to Lindberg (2007: 171), Ibn Ishaq represented the Greco-Arabic translation movement at its best. He was a celebrated physician who mastered the language of the Greeks. He translated, as Sarton (1927-41) highlighted, the entire works of Galen, as well as Aristotle, Hippocrates, and other classics from Greek into Syriac. He wrote also the 'Ten Treatises of the Eye,' which later became known in the West as 'Johannitius.' In translating Galen's book, Ibn Ishaq wrote how the only reasonably complete copy he could find came from Alexandria (Mohaqqaq 2001).

Part II: The Rise of Islamic Science

When did Islamic science begin to ascend? Was it during the early ‘Abbāsid[5] period that started in AD 750? How significant was the pre-’Abbāsid translation movement? Was there a scientific movement to speak of during the reign of the Umayyads?

2.4 The Alternative Narrative

The archetypal narrative outlined in the literature review does not answer specifically the question of when science in the Islamic world started to ascend or when it started to decline (Saliba 2008).

The alternative narrative tells us that interest in science and the scientific endeavour started earlier than AD 750, as Umayyad Caliphs resorted to scientific methods to resolve everyday problems. The main reasons for the early Muslims’ interest in science were both religious and administrative: Religious in that the teachings of Islam encouraged Muslims to explore and study various phenomena; and administrative as they had large empire that they had to learn to administer (Golshani 2008) (Saliba 2008) (Saliba 2009).

[5] The ‘Abbāsid Caliphate ruled from AD 750 to AD 1258.

2.4.1 *Abd al-Malik Ibn Marwan:* Science Patron *Par Excellence*, and *Khalid bin Yazid*

Less than a century after the birth of Islam in Mecca in AD 610, and as a consequence of Arab conquests during the Umayyad reign, a vast new empire came into existence, a super-state that spanned from China to the Atlantic[6] (Rahman 1999). For this state to be governed effectively by its founder, Abd al-Malik *(*AD 646-705) (considered one of the greatest of the early Muslim Caliphs) from his capital Damascus, new mechanisms of government had to be developed which relied on scientific knowledge (Saliba 2007c). These included creating an elaborate postal system and instituting a mint that produced uniform currency. Knowledge of engineering and architecture had to be acquired to repair the damaged *Ka'aba* in Mecca, build the Dome of the Rock in Jerusalem (Morgan 2007: 222), and build other Umayyad desert palaces and retreats that are still standing today in Jordan and Syria.

One 'Abbāsid Caliph who –a century after Abd al-Malik- showed an interest in architecture was al-Ma'mun who followed in the steps of his distant cousin Abdel al-Malik by rebuilding the Dome of the Rock in Jerusalem. He however unscrupulously replaced the name of Abdel al-Malik with his own on the Kufic inscription on its walls but inadvertently forgot to change the date (Hitti 2002: 220). Thus, the caliphate of Abd al-Malik marked the start of an Islamic tradition in science. A tradition that has been described as developing its roots through the 'smart' appropriation of ideas from ancient civilizations – the Greeks in particular.

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[6] Rahman offers a factual description of the principal events which occurred between A D 570 and the year AD 1000. The book also contains maps showing the extent of the Byzantine and Persian empires in AD 600, the spread of Islam from AD 622 to AD 750, the extent of the Muslim world in AD 1000 and genealogical tables of the Umayyads (AD 661 - 750) and the Abbasids. (AD 750 - 1258).

Abd al-Malik himself sought scientific answers to the problems he encountered from his distant cousin, the Umayyad prince Khalid[7] bin Yazid bin Muawiya. This renowned scholar and alchemist had earlier discarded his own claim to the caliphate for the sake of scholarly pursuits (Daffa' 1991) (Saliba 2007c:50-51). Khalid bin Yazid became famous for inviting Greek philosophers from Egypt and commissioning them to translate books from Greek and Coptic into Arabic. Acknowledged by many Arab historians, he was also a scholar who was interested in medicine and astronomy, as well as being a renowned poet (Daffa' 1991). Many cite him as the initiator of Arab and Muslim interest in science (Batayneh 2008). It is startling how Khalid's scientific eminence totally escaped the eyes of Ulmann (1978) (cited in Gutas 1998: 24), who claimed that it was a total fabrication. It clearly was not. It escaped the attention of Ulmann and Gutas that the history of the Umayyad era was actually written during the 'Abbāsid Caliphate. Therefore, it is difficult to envisage how any historian of the 'Abbāsid era, let alone somebody of the stature of *Ibn al-Nadim* –the 10th century transcripter/historian- would conjure up a favourable impression of an Umayyad prince knowing the animosity that existed between the Umayyad and 'Abbāsid dynasties.

According to the account of Ibn al-Nadim[8], Khalid commissioned a number of Greek scholars who were well versed in Arabic from Egypt, to translate works on alchemy into Arabic. He had learnt the art of alchemy under Maryanus the Hermit. Maryanus was a pupil of Istfan (Stephanus) of Alexandria. The treatise *Liber de compositione alchimiae,* (The Epistle of Maryanus, the Hermit and Philosopher, to Prince Khalid bin Yazid) whose Arabic original became known recently, ' رسالة مريانس الراهب الحكيم للامير خالد بن

[7] The Umayyad Prince, *Khalid b. Yazid* (d. 84/704), who was the heir apparent to the throne. Khalid turned his attention to the occult and hermetic sciences in order to fulfill an inner satisfaction and ambition. We are told that he summoned to Damascus the monk, Marianos, an alchemist hermit from Alexandria, Egypt, who taught him the secrets of the art.[Online] Available at: http://www.islamset.com/heritage/pharmacy/alchemy.html [Accessed on 22 February 2008].

[8] Abu'l-Faraj Muhammad bin Ishaq al-Warraq (Arabic: ابو الفرج محمد بن إسحاق الوراق), commonly known as Ibn al-Nadim (Arabic: ابن النديم) (died 995 or 998) was a Muslim scholar and bibliographer of either Arab or Persian background. He is famous as the author of the *Kitab al-Fihrist*).

يزيد', gave a description of the encounter between Khalid and Maryanus and the discourse that ensued between the two (Al-Hassan 2004).

2.4.2 The *Fihrist* of Ibn al-Nadim and Beyond

The Fihrist of Ibn al-Nadim is the premier Arabic-language bibliographical book to survive to the present day. It includes a listing of all the books that were written in or translated into Arabic in all the fields of knowledge until the year AD 987. From a historical point of view, The Fihrist of Ibn al-Nadim, better known as the Index of *Nadim*, is one of the most important documents in Islamic culture (Nakosteen 1964: 29). It is an encyclopaedic work. It investigated all the sciences and catalogued all the well-known books that were written about them (Outba 1986).

The account of Ibn al-Nadim is often disregarded by modern Western scholars. Saliba (2007c) however, basing his verification on it, suggested that early translations from Persian and Greek sources outlining elementary scientific ideas for the use of rulers were the impetus for the development of the Islamic scientific tradition. These early translations were undertaken by scholars who were within the circles of government in the service of the Umayyad dynasty. They were required to translate Greek manuscripts, after Abd al-Malik and his caliph sons went about arabicizing the documents of the state. He concludes that the translation movement that ushered in the age of Islamic science did not start with al-Ma'mun and Bayt al-Hikma, but commenced during the reign of the enlightened and astute Abd al-Malik well over a century before al-Ma'mun became caliph.

The multi-volume book by Carl Brockelmann[9] (1868-1956) entitled *Geschichte der arabischen Litteratur* (1898-1902), *Ibn al-Nadim's Fihrist*, *al-Qift*i's *Ikhbar il-Ulama' bi-Akhbar il-Hukama'* [10] contain evidences that reinforce Saliba's argument of the existence of a strong scientific movement in an era earlier than often assumed. These contain details of the translations undertaken in the early days of Islam (Shalaby 1954: 98) (Outba 1986) (Qurashi and Rizvi 1996).

Further evidence to support the alternative narrative is illustrated by the scientific endeavours of another Muslim scholar, which took place well before the 'Abbāsids ascended to power. *Ja'far al-Sadiq*, a descendent of the fourth Islamic Caliph of Islam; *Ali Ibn Abi Taleb* (the cousin of the Prophet (pbuh), who is revered by Shia Muslims and immensely respected by Sunni Muslims), is known to have mastered both Islamic sciences, i.e. those related to teachings of the faith, and Islamic science –especially chemistry and medical sciences. Daffa' (1991) reported that among his religious disciples, were two of the founders of Islamic schools of thought (mazhab) (the theologians Malik b. Anas and Abū Ḥanifa), whereas Jabir b. Ḥayan (Geber) was his principal student of chemistry. Needless to say Jabir's role in the early ascendance of the Islamic scientific tradition cannot be under-estimated (Haq, 1995).

Moreover, Saliba (2008) cited Al-Mansur's invitation of astrologers around AD 762 to determine when and where his capital, Baghdad, should be built, as reflecting the advanced level of knowledge available at his astrologers' disposal to undertake the related complex calculations. This is decades before the reigns of both al-Rashid (786-809) and al-Ma'mun (813-833) during which the cultural explosion took place (Sabra 1987). Nawbakht and Mashallah consulted the heavens and offered the caliph

9 Carl Brockelmann (1868-1956), German Semiticist, was the foremost orientalist of his generation. He was a professor at the universities in Breslau, Berlin and, from 1903, Königsberg. He is best known for his multi-volume Geschichte der arabischen Litteratur (1898-1902)(History of Arab Literature) which included all writers in Arabic to 1937. (Wikipedia).

10 This book provides brief biographies of famous scholars of pre-Islamic and the early Islamic era and includes biographies of people such 'al-Hareth bin Kilda' who was a famous physician of the early Islamic era and 'Ibn al-Muqafa'' who was a man of letters from Basra who witnessed the transition of power from the Umayyad to the *'Abbāsid* dynasties.
The AH 1326 edition of al-Kifti's book is available online in PDF format: http://www.marefa.org

appropriate advice. He went on to order the construction of the city as a perfect circle in accordance with the teachings of Euclid (Lyons 2009:55).

2.5 Discussion of Part II

Islam is a set of values, laws and rituals that encompass all aspects of human life, the introduction of which triggered the rise of the Islamic civilization (Kettani 1984). Basic Islamic ideals are linked with each other through a system in which reason is given its full due. This led to the introduction of a value system that encouraged Muslims to explore and study nature as vividly outlined in the recommendations of the *Qur'an* and the *Sunnah* (Golshani 2008) and ultimately led to the rise of science in early Islam.

The Muslims of the 8th century were not only well versed with Islamic 'sciences,' which were primarily based on the teachings of Islam, but also developed a basic understanding of some scientific fields of knowledge; philosophy, astronomy, mathematics and chemistry. Evidence moreover exists that the early days of Islam witnessed speedy advancement in medicine primarily as a result of the teachings of the Islamic faith (Daffa' 1998). It would otherwise be difficult to imagine that an assemblage of Arab tribes from the Hijaz who essentially lead a nomadic existence at start of the 7th century would go on to establish a super-state in less than 100 years without having some knowledge capacity to begin with. Some researchers mention that they had a keen sense of observation, had some basic information about animals, were aware of their desert plants and their uses, and were aware of the fixed stars as well as the movements of the planets and the changes of weather (Qurashi and Rizvi 1996). However, was this knowledge enough?

In addition, early Muslims must have had the faculty and competence to master the art of nation building and the knowledge or 'science' required to achieve such a feat. Evidence of this exists from the era of the Caliphs –Abu Bakr, Omar, Othman and Ali- and the Umayyads.

Contrary to the accepted view, the foundations of Islamic scientific tradition were established well before Greek sources were formally translated into Arabic and disseminated in the 9th century (Saliba 2007c). Otherwise, it would be difficult to understand how the phenomenal growth of Islamic Science could have succeeded.

It was established that science in the Islamic world bloomed as a result of political patronage by leaders such as Abd al-Malik. He was an enlightened leader who appreciated science and what science could do for the state. Patronage of science, until today, remains a critical prerequisite for science to flourish.

Rereading the story of the rise of Islamic Science may help in highlighting many phenomena that are still in existence today. Phenomena such as the harmonious relationship that existed between Islam and science, the capacity of early Muslims to learn from others and adapt to the political realities that they became a part of, as well as the open-mindedness they had demonstrated in interacting with other cultures and civilisations.

Part III: Academies of the Islamic Era

Having established how science and the scientific enterprise developed during the first two centuries of Islam, in this section, some of the more famous academy-type institutions that appeared in the Islamic civilisation will be described. Distinction will be drawn between such institutions and those described by Makdisi (1981) in his book, *The Rise of Colleges: Institutions of Learning in Islam and the West.* An attempt will be made to establish that some of the great centres of learning of the Islamic world may rightly be considered as the academies of sciences of their day.

2.6 Bayt al-Hikma

In the literature review, I mentioned that Saliba has classified Bayt al-Hikma (House of Wisdom) and the Accademia dei Lincei, which came almost eight centuries later, in the same depiction; namely as institutions where scientists worked in a relatively carefree environment and whose collective activities were bound to make a difference in terms of scientific production. This is unusual, as Saliba is known to be of the opinion that Bayt al-Hikma was not a science academy, justifying his opinion on the valid grounds that no manuscripts have come to light to prove that it was (Saliba 2008).

The ‘Abbāsid Caliph al-Ma’mun (AD 786 –833), the son of *Harun ar-Rashid*, was an outstanding caliph who is best known for sponsoring the translation of Greek philosophy into Arabic and for promoting the activity of mathematicians, astronomers, engineers and physicians (Cooperson 2005). In his book, *Introduction to the History of Science: Vol. II,* Sarton (1927-41) declared that, during the reign of al-Ma’mun, new learning reached a climax that culminated in the founding in Baghdad of Bayt ul Hikma in AD 830 (Kirk 1964: 30) (Majeed 2005) or even before. Al-Ma’mun created in Baghdad a ‘regular school’ for translation that was equipped with a library. One of the translators at Bayt al-Hikma was Hunayn Ibn Ishaq[11] (AD 809-877) who was a gifted philosopher and physician of wide erudition, and one of the eminent figures of that century of translators. Sarton (1927-41) added that people later discovered from Ibn Ishaq’s memoir that he had translated practically the entire works of Galen.

As well as describing Bayt al-Hikma, Yazigi (1966: 72), suggested that one of its activities, was the intellectual debate that Harun ar- Rashid convened regularly. Shalaby (1954: 98) was certain that Harun ar- Rashid was the real founder of Bayt al-Hikma, an institute that gained its fame under the patronage of al-Ma’mun. Hitti (2002) however, in his *History of the Arabs*, argued that al-Ma’mun established Bayt al-Hikma in

[11] *Hunayn Ibn Ishaq* died in 873 according to Michael Hamilton Morgan's *Lost History*.

Baghdad as early as AD 814 as a combination of a library, an academy, and a translation bureau. The account of Syed Ameer Ali (1955: 278) of al-Ma'mun's reign as the most brilliant and glorious of all in the history of Islam reinforces Hitti's claim. Ali portrayed how al-Ma'mun collected the writings of the school of Alexandria and from Athens secured the best philosophical works of ancient Greece.

Many historians trace al-Ma'mun's interest in the science of earlier civilisations to the time he spent at Merv (in modern-day Turkmenistan). Merv has been a stopover town on the Silk Road and on the path of every conqueror and religion that has risen in Eurasia. Al-Ma'mun was influenced by the rich heritage that earlier cultures of the Greeks, Zoroastrians, Christians, and Buddhists had left (Morgan 2007: 55). Moreover, Merv, in Khorasan, had a great deal to do with the fortunes of the 'Abbāsids, who drew strong support from Khorasan. Moreover, the Barmakids, the family that later supplied the all-powerful ministers who guided and controlled the 'Abbāsid government, had its roots in that city (O'Leary 1979). However, the theory that the hard core of 'Abbāsid support from that city came from '*Ahl Al-Taqadum*, i.e. Arab settlers who had earlier settled in Merv, has been strongly questioned by Daniel (1996).

Modelled after the ancient Library of Alexandria, Bayt al-Hikma was a centre of scholarly activities where books from the Greek, Syriac, and Persian languages were translated into Arabic by expert Arabists (Lerner 1998: 69). Sabra (1987) takes the thoughtful view that it was a forum for translating and documenting the rational sciences which were called the 'sciences of the ancients' *(ulūm al-awā'il*) to distinguish them from disciplines that dealt with Islamic religion and Arabic language. Ahmed went as far as to describe it as the Baghdad Academy of Sciences (Ahmed 2008:10). Abdus Salam, on the other hand, described it as an institute of advanced study (Dalafi and Hassan 1994), while Youssef Eshe described it as a stronghold of Mu'tazelite Thought during the reign of al-Ma'mun (Al-Awady 1997: 80). At the time, al-Ma'mun supported theological positions many Muslims considered unacceptable (Cooperson 2005).

Although the second half[12] of the existence of Bayt al-Hikma (AD 990 – 1258) is not well documented, there is a general consensus among contemporary historians and scientists that what was left of the original grandiose Bayt al-Hikma eventually came to a violent end at the hands of the Mongols when they occupied Baghdad under Hulagu in AD 1258 (Mustafa 1988 cited in Jawahiri 2001). The last we hear of Bayt al-Hikma comes from Ibn al-Nadim (died AD 990) according al-Atrakji (2001), who also supports the view that Bayt al-Hikma was destroyed by the Mongols in AD 1258.

Notwithstanding the theory of Hamarneh (2004) that Bayt al-Hikma's holdings were transferred to the Nizamiyyah in the 10th century, it is not clear if the rise of the Nizamiyyah Academy of al-Ghazzālī in Baghdad in 1066 did have an adverse effect on Bayt al-Hikma as a beacon of translation and scientific research.

2.7 Discussion: Was Bayt al-Hikma an Academy of Sciences?

Notwithstanding the testimony of Hitti (2002) that Bayt al-Hikma was an academy as important as the Library of Alexandria, and Saliba's declaration that Bayt al-Hikma and the Accademia dei Lincei were carefree physical environments for the pursuit of science (Saliba 2002), questions were raised on the validity of this argument by Gutas (1998: 59) and later by Saliba himself (Saliba 2007a) (Saliba 2008). Gutas has according to Lindberg (2007: 171) debunked the theory that Bayt al-Hikma was a research institute.

[12] This period spans form the death of *Ibn al-Nadim* until the fall of Baghdad in 1258.

In what follows, an attempt will be made to show that Bayt al-Hikma was an academy of sciences *of its day*, and ought to be conceived as such. The evidence will – in part- follow an idea[13] Gribbin (2008: xiii) proposed in his book *The Fellowship: Gilbert, Bacon, Harvey, Wren, Newton, and the Story of a Scientific Revolution,* in which he claims that decades after Copernicus, Galileo and his contemporaries still viewed themselves as natural philosophers rather than scientists although what they were doing *was* science.

Firstly, there is the terminology. In his book, *Les bibliothèques arabes publiques et semi-publiques en Mésopotamie, en Syrie et en Égypte au Moyen-Age*, published by *l'Institut français de Damas* in 1967, extensively cited by Makdisi (1981: 24), Youssef Eche provides a description of the terminology used to explain 'academic' institutions that existed at the time of Bayt al-Hikma. Arabic terminology that describes locales: bait (room), khizana (closet), and dar (house) and terminology that describes activities: hikma (wisdom), 'ilm (knowledge), and kutub (books). Eshe claims that these terms refer to libraries. But, do they all have the same meaning? What does each term specifically mean?

It is likely that institutions that were identified as 'bait' were more than libraries, probably locales where science and scientific matters were discussed. Judging by how the term 'bait' appears in the *Qur'an*, it can be construed as a location where people assemble that has a patron or a master. If what Gutas (1998: 59) claims is correct, that is Bayt al-Hikma was a library that formed part of 'Abbāsid administration, a replica of the Sassanian model, then it would have been called *Dar at-Tarjamah* or *Dar al-Naql*, (both meaning 'House of Translation') or simply *Dar al-Kutub* (House of Books) and not Bayt al-Hikma. This latter term means the patronized location within which

[13] The idea is that 50 years after Copernicus, Galileo and his contemporaries became thoroughly familiar with the term 'knowledge' but still viewed themselves as natural philosophers rather than scientists, and as the heirs of Pythagoras and Aristotle. However, as the old saying goes, if it looks like a duck, flies like a duck, and quacks like a duck, then it *is* a duck. In other words, Galileo and friends were scientists and what they did was science; and only a doctrinaire would object to the use of the words science and scientists in this context.

intellectual matters are discussed. Moreover, the term *al-Hikma* is what linguists call an intangible, an attribute that cannot be measured or quantified. In a similar vein, Sabra (1987) proposes that al-Hikma or *al-'ulum al-hikmiyya* is 'the philosophical sciences.'

The linguistic argument highlighted above is in line with the pioneering (at the time) work of the prominent linguists *Ibn Fares*[14] (AD 940-1004) and *Ibn Al-Anbari*[15] (AD 886-940) both mentioned by Hasan (n.d.) who claimed that there is no synonymy in the Arabic Language[16] and that each word has a unique meaning. The same argument is put forward by Hamwi Duwaiji (2007).

Suffice to say that whenever we intend to define a term we have to take into account the time factor. That is to say that the definition of an academy today may not be applied to an academy twelve centuries ago.

Secondly, there is the research carried out by many contemporary scholars which shows that Bayt al-Hikma was not merely a translation bureau. It was more of a complex that had a large repository of manuscripts, with specialists employed to oversee their translation. Adjacent to it, a large observatory was built as well as a school that taught astronomy (Yawar 2001) (Rida cited in Yawar 2001). Researchers at Bayt al-Hikma studied a wide range of sciences such as medicine, chemistry, astronomy as well as other sciences mainly through experimentation (Yawar 2001). Bayt al-Hikma embraced many of the translated sciences and was domicile to many diverse activities including authoring, translating, transcription, studying, documenting, and hosting scientific and literary debates between its various patrons who included *al-Khawarizmi*, *al-Farra'*, *Hamzah al-Asfahani*, and Ibn al-Nadim (Khalaf 200: 223). Al-Hakim (2001) singled out scientific debates as a separate activity and described how it facilitated to

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[14] ابن فارس وهو أبو الحسين أحمد بن فارس بن زكريا القزويني الرازي (329 هـ-395 هـ / 940-1004 م) لُغَوِيّ أي إمام لغة وأدب. قرأ عليه بديع الزمان الهمذاني والصاحب بن عباد وغيرهما من أعيان البيان. أصله من قزوين ، وأقام مدة في همذان، ثم انتقل إلى الري فتوفي فيها وإليها نسبته. من مؤلفاته معجم مقاييس اللغة.

[15] ابو بكر محمد بن القاسم بن محمد بن بشار الأنباري ، المقرئ النحوي . من أعلام اللغة والتفسير والحديث ، ومن بحور العلم في التأليف والتصنيف . ولد سنة 272هـ وتلقى العلم عن أبيه وسمع في صباه من محمد بن يونس الكديمي ، واسماعيل القاضي ، واحمد بن الهيثم البزاز، وابي العباس ثعلب ، وخلق كثير . [Online] Available at: http://www.alrashead.net/index.php?manaerprev&id=41#نشأته_وحياته_ [Accessed on 9 May 2010]

[16] They argued that every word has a different meaning from the other. , القعود for example is different from الجلوس, because القعود (sitting down) means that the person had been standing before sitting, while الجلوس (sitting up) means that he had been lying down before he straightened his position to that of sitting. I think that what those linguists were trying to establish is that there is no absolute synonymy.

non-Muslims the opportunity to discuss and debate a wide range of issues. It is worth mentioning that the first curator of Bayt al-Hikma, according to Hamarneh (2004), was *Yohannah ibn Massawaih*, a Christian scholar, and that many of the eminent scholars who taught at Bayt al-Hikma were non-Muslims. Administrative affairs were carried out by directors who were of many origins, ethnicities and religious schools of thought. Together with the scientists and the researchers, they had to wear special clothes when working at the 'House' (al-Atrakji 2001). Within Bayt al-Hikma, the individuals responsible for the mathematical sciences, geometry, and music were the *Banu Shaker*; the eldest of whom was *Abu Ja'far Muhammad Bin Musa* (died AH 259). The translation department had many famous chiefs including *Omar Bin Farkhan al-Tabari*, as well as *Ibn Ishaq*.

Conclusive evidence is relayed by many researchers on the high-end research carried out at Bayt al-Hikma, particularly in the field of translation. In translating the original works of Aristotle to Arabic, careful examination of the contribution of many researchers reveals two types of translations: the actual works of Aristotle; and the works allegedly carried out by Aristotle. Over the years, some manuscripts of the works of Aristotle that have been translated at Bayt al-Hikma have appeared in libraries around the World and they were mostly of the first type. Al-'Assam (2001) has spent over 30 years examining the manuscripts that have appeared at various libraries and research institutes around the world which either originated or were based on studies carried out at Bayt al-Hikma. He made a special mention of manuscript number Arab. 2446 (at the French National Library), which during various periods in the 20th century was studied by J. T. Zenker (1846 & 2006) in his book 'Aristotelis Categoriae,' Ibrahim Madhkour (1944), and K. Djorr (1946), all of whom base their analysis on the work of the translators of Bayt al-Hikma. He cited numerous other examples of rare manuscripts that have appeared at various libraries around the world that were originally translated into Arabic by some of Bayt al-Hikma's more famous translators. These range in subject from Organon (Aristotle's works on logic), biology, theology, ethics and art.

Thirdly, there is the patronage and the Waqf. Although Bayt al-Hikma had its own Waqf (Trust to generate income) (Khalaf 2001: 227), accurate estimates are not available on the financial costs that were expended to run it although some scholars claim that 20,000 Dinars were expended on Bayt al-Hikma monthly. It is likely that such resources were afforded by the caliph, his ministers and advisors and it has been reported that al-Ma'mun, the patron of Bayt al-Hikma, would give Hunayn Ibn Ishaq the weight of the books he translated in gold. The fact that this institution was strongly patronised by the caliph supports the argument that it was an academy-type institution.

Various evidences thus exist that show that Bayt al-Hikma contained the treasures of Islamic and foreign sciences. It was a science academy, an observatory as well as a public library, and the greatest of cultural institutes after the Library of Alexandria (Brockelmann cited in Jawahiri 2001) (Durant[17] cited in Jawahiri 2001) (Hunke[18] cited in Jawahiri 2001). There is little doubt that Bayt al-Hikma was not merely a translation bureau. It was in part an Arabic language academy (majma') that made Arabic the most important scientific language of the world for many centuries, as well as being an international archive that preserved knowledge that might otherwise have been lost forever (Majeed 2005). Moreover, it was an academy of sciences *par excellence* of the ninth and tenth centuries (Hibbi 2001) (Al-Hashem 2001) (Qurashi and Rizvi 1996), not only owing to institutional set-up but also due to the fact that the majority of the subjects studied within its confines belong to what in modern parlance consist of basic sciences including; astronomy, mathematics and medicine as well as the main Greek works on philosophy (Al-Hassan et al. 2007a).

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17 William James Durant (November 5, 1885–November 7, 1981) was a prolific American popularizer in the fields of history, religion and philosophy. He is best known for the 11-volume *The Story of Civilization*, written with his wife Ariel and published between 1935 and 1975 (Wikipedia).

18 Sigrid Hunke (1913 - 1999) was a German author. She is known for her work in the field of religious studies (Wikipedia).

Based on the evidence presented, this Thesis proposes that there exists sufficient to demonstrate that Bayt al-Hikma was an academy of sciences *of its day*.

2.8 Other Academies in the Islamic Civilisation

The reign of the Umayyad prince (later caliph) *Abdel Rahman* III (AD 889-961) was an epoch that saw the Islamic presence in Spain reaching its peak. Cordoba was the most prosperous and sophisticated metropolis in Europe. It alone had 70 libraries, one containing between 400,000 and 500,000 volumes (McClellan & Dorn 2006:109). The status of Cordoba did not diminish under his son and successor; *al-Hakam* II (AD 961-976) who was a scholar and a patron of learning (Hitti 2002: 530). Al-Hakam established his own *Dar al-Hikma* in Cordoba which was modelled on Bayt al-Hikma of Baghdad (al-‘Atbi 2001).The founding of Dar al-Hikma in Cordoba was the culmination of vigorous scholarly exchanges that resulted in the transfer of linguistic, scientific as well as medical knowledge from Baghdad to Cordoba and then onto Europe (al-‘Atbi 2001). This is probably an early example of the early traffic (of knowledge) from East to West. A phenomenon that took many forms later on as Saliba (2007c: 226) explained in his book *Islamic Science and the Making of the European Renaissance*.

Within a few decades of the death of al-Hakam II (AD 961-976), Spain became the main conduit through which the accumulated knowledge of the Islamic world would flow into Europe.

Yazigi (1966: 72) speaks of another Dar al-Hikma that was established by *al-Hakim bi-Amrillah* in Cairo at the start of the 11th century, for the same purpose as the original Bayt al-Hikma in Baghdad. It was probably an attempt by its Fatimid founder to emulate al-Ma’mun, the patron of Bayt al-Hikma. Dar al-Hikma (or *Dar al-Ilm,* according to some sources) (the Hall of Wisdom or of Science), was a dynamic translation bureau, and a true science academy according to Lumpkin and Zitzler

(1987). Based in Cairo (1005), it was quite similar to the earlier Bayt al-Hikma but did not focus as much on translation. From North Africa, the most advanced mathematics, science, medicine were introduced to less developed Europe leading to the later flowering of science and culture in Europe known as 'the Renaissance.'

Rulers of the Fatimid dynasty, to which al-Hakim belonged, were munificent patrons of learning and science and established colleges, public libraries, scientific academies as well as astronomical observatories. Al-Hakim himself established Dar al-Hikma, which contained a library, meeting rooms and facilities for copying and binding books and manuscripts (Ali 1995). The programme of study of Dar al-Hikma did not only include religious subjects but also subjects such astronomy and medicine. Caliph al-Hakim also established an observatory near mount Al-Muqattam, which was equipped with the best available astronomical instruments of the day including the armillary sphere and the azimuth circle. Al-Hakim was a leader who appreciated science. He must have been encouraged to promote scientific knowledge by such towering figures as *Ali Bin Yunus*[19], *Ibn al-Haitham*[20], *Ali Bin Ridwan*[21] and others (Ali 1995: 72). A brief account of the end of Dar al-Hikma and how it was eventually closed and then converted into a religious school by Salahuddin was outlined in section 2.2.

In AD 1066, the Nizamiyyah was founded, which Yazigi (1966) described as one of the most famous scientific establishments in the whole of Islam. Ali (1955: 315) described *Nizam al-Mulk*, the minister of Malik Shah who founded the Nizamiyyah, as one of the ablest administrators that Asia had ever produced. Hitti (2002: 410) described the Nizamiyyah as the first real academy in Islam that made provision for the physical needs of its students and became a model for later institutions of higher

[19] Abu al-Hasan 'Ali abi Sa'id 'Abd al-Rahman ibn Ahmad ibn Yunus al-Sadafi al-Misri (c. 950-1009) was an important Egyptian Muslim astronomer and mathematician.
Wikipedia: http://en.wikipedia.org/wiki/Ibn_Yunus [Accessed 27 November 2008].

[20] Abu Ali al-Hasan ibn al-Hasan ibn al-Haytham was the first person to test hypotheses with verifiable experiments, developing the scientific method more than 200 years before European scholars learned of it—by reading his books. Born in Basra in 965, Ibn al-Haytham first studied theology. He then turned his attention to the works of the ancient Greek philosophers and mathematicians, including Euclid and Archimedes. Web site: http://www.ibnalhaytham.net/ [Accessed 27 November 2008].

[21] Abu'l Hasan Ali ibn Ridwan al-Misri (988–c. 1061) was an Egyptian Muslim physician, astrologer and astronomer, born in Giza. Wikipedia: http://en.wikipedia.org/wiki/Ali_ibn_Ridwan [Accessed 27 November 2008].

learning. It was where al-Ghazzālī[22] lectured for four years (1091-5) (Hitti 2002: 411).

Makdisi (1981) in his famous book '*The Rise of Colleges: Institutions of Learning in Islam and the West,'* discusses all aspects related to the founding of *al*-Nizamiyyah and asserts that it was a religious school advocating the brand of Ashʿarism (an Islamic theological school of thought) most favoured by its founder Nizam al-Mulk. He undermines the involvement of al-Ghazzālī in al-Nizamiyyah as not being indicative of its Ashʿarite leanings. He adds that al-Ghazzālī joined al-Nizamiyyah more than 25 years after its anti-Ashʿarite foundations were laid by Abu Ishaq ash-Shirazi.

Nakosteen (1964: 40) described al-Nizamiyyah as the most famous of the chain of madrasas (schools) that was built in Baghdad in 1065. The book *History of Muslim Education*, written by Shalaby (1954: 140-142) asserted that the Nizamiyyah of Baghdad and the Nizamiyyah-type system included schools of high standard that were staffed by the best scholars of the day including al-Ghazzālī. After extensive research, Shalaby (1954) discovered that al-Fairuzabadi (d. AH 817 or AD 1414) was probably the last of a long line of famous scholars to set foot at al-Nizamiyyah, which survived Hulagu's capture of Baghdad in AD 1258, and was later merged with *al-Mustansiriyah* in AD 1394. It is unlikely that either school survived the destruction of Baghdad in AD 1401 by the Mongol warlord Timurlane (ruled 1370-1405).

The fall of Baghdad at the hand of Hulagu in AD 1258 was a historical occurrence that had a profound and long-lasting effect on the Islamic civilisation. It had great cultural impact and symbolism (Morgan 2007: 146). Yet, it was an event that encouraged al-Tusi[23] (AD 1201-1274) to seek the consent of Hulagu, to start a grandiose astronomical project, namely the building of an observatory in Maragha (in

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[22] Abu Hamid al-Ghazzali, (AD 1058-1111 or 1128 according to Hakim Said's Personalities Noble) [aka: al-Ghazali , Algazel] is one of the great jurists, theologians and mystics of the 12th Century. He wrote on a wide range of topics including jurisprudence, theology, mysticism and philosophy.

[23] Nasir al-Din was one of the greatest scientists, philosophers, mathematicians, astronomers, theologians and physicians of the time. As the chief scientist at the observatory established under his supervision at Maragha, he made significant contributions to astronomy. Source: Said, Hakim, 2000. *Personalities Noble*, Amman, Jordan: Islamic World Academy of Sciences, 2nd Revised Edition.

modern-day Iran) that was completed in AD 1262. It is a historic irony that the might that destroyed Baghdad in AD 1258 was also the same that built Maragha Academy and its observatory. Maragha became the epicentre of scientific activity, witnessing an intellectual flow from China to the West as well from Arab and Islamic lands eastwards to China. It was where centuries of Greco-Arabic-Persian learning in astronomy was centralised by the Mongols, and sanctioned by scholars such as *Ibn al-Futi*[24] who eventually became the curator of the library of the Maragha Academy (Morgan 2007: 147).

Over the centuries, Institutions such as India's five Jantar Mantar observatories, built in the 18th century, would attempt to capture the grandeur of the Samarkand observatory (in modern day Uzbekistan), which specialized in the teaching of astronomy at the heart of what constituted the nucleus of a scientific 'academy' frequented by Ulugh Beg (1394-1449), who himself was a renowned mathematician and astronomer (Morgan 2007: 150).

> *At the time Ulugh Beg's observatory flourished, it was carrying out the most advanced observations and analysis being done anywhere. In the 1420s and 1440s, Samarqand was the astronomical and mathematical 'capital of the world.'*
>
> Kevin Krisciunas (1994) (cited in King 1999).

The Samarkand observatory was replicated in the 16th century in Istanbul, where *Taqī i-Dīn b. Marūf* [25] (of Damascus) (1525-85) founded an observatory in 1575 under the patronage of the Ottoman Sultan *Murad III*. This observatory seemed to have a promising future however an unfortunate astronomical prediction about a comet carried out by Taqī i-Dīn in 1577, as well as some resentment from rejectionist forces in Ottoman society, forced the Sultan to order its closure in 1580 (Bosworth et al. 1989).

[24] ابن الفُوَطي: عبد الرزاق بن أحمد بن محمد الصابوني، مؤرخ، يعد من الفلاسفة، مولده ببغداد 645هـ ووفاته ببغداد سنة 723هـ .أخذ عن محيي الدين يوسف بن الجوزي أستاذ الدار الذي قتله هولاكو سنة 656هـ ، لجأ إلى الطوسي فألحقه بتلاميذه، وباشر (خزانة الرصد بمراغة) زهاء عشرة أعوام، وهي أول أكاديمية في القرون الوسطى في العالم. الاعلام للزركلي و معجم الالقاب.

[25] See: Hassan, Ahmad Y., 1976. *Taqi al-Din and Arabic Mechanical Engineering*. Aleppo, Syria, Institute for the History of Arabic Science.

Not before the passing of three centuries would the Ottoman Empire witness the birth of a new academy of sciences, the Encümeni Danish in 1861, founded Sultan *Abd al-Majid* (AD 1824-1861) in Istanbul. In English, the name has been translated as the High Consultative Committee and in some references as the Turkish Academy of Sciences (University of Waterloo 2008). Its first lecture was on physics, which attracted hundreds (Masood 2009:191). It was abolished in 1862. The Institut D'Egypte in Cairo (1798), which was established by Napoleon Bonaparte during his Egyptian campaign, has been described as the first 'modern' academy outside Europe (Serageldin 2006b).

2.9 Summary and Discussion of Part III

A number of academies and academy-type institutions appeared after Bayt al-Hikma, such as Dar al-Hikma of Cairo (1005), al-Nizamiyyah of Baghdad (1065), the Maragha Academy and its observatory (1262), the Samarkand observatory (1420s), the Istanbul observatory which was closed in 1580, the Institut D'Egypte (1798) and the Encümeni Danish in 1861 (the Turkish Academy of Sciences of its day).

Nakosteen (1964: 40), Makdisi (1981) and to a lesser extent Hitti (2002: 410) agree that the Nizamiyyah of Baghdad was a teaching (rather than research) academy and the Nizamiyyah-type system included schools of high standard that were staffed by the best scholars of the day including al-Ghazzālī.

Saliba (2007a) is of the opinion that the Maragha observatory established under the supervision of al-Tusi was more of a (research) academy than its more famous predecessor, Bayt al-Hikma. The Maragha observatory/academy was equipped with the best possible instruments, including those collected by the Mongol armies from Baghdad and other Islamic centres. The work done at Maragha by al-Tusi and his group included drawing up astronomical tables that were based on original observations and became the most popular until the 15th century (Said 2000).

Ironically, the fact that the Istanbul observatory was closed down in 1580, after Taqī i-Dīn b. Marūf had ran out of favour the Ottoman Sultan *Murad III* owing to an astronomical prediction he had made (Bosworth et al. 1989), is perhaps proof that it was an advisory body performing one of the functions of an academy of sciences of its day.

Not before three centuries would the Ottoman Empire witness the birth of a new academy of sciences, the Encümeni Danish in 1861, founded Sultan *Abd al-Majid* (1824-1861) in Istanbul (see section 2.13).

The Institut D'Egypte in Cairo (1798), which was established by Napoleon during his Egyptian campaign, has been described as the first 'modern' academy outside Europe (Serageldin 2006b).

Three main conclusions could be drawn from this section. First, the scientific enterprise continued in the Islamic world after the Mongol destruction of Baghdad in AD 1258 although at a slower rate. This is manifested by the founding of academy-type institutions at various junctures. Second, the founding of such institutions –with the exception of the Maragha academy- was a result of initiatives by political figures (top-down) illustrating again the momentous role that central authorities played in the march of science in the Islamic civilisation. Third, there was relative scientific inactivity in the territories of the Ottoman Empire during the 17th and 18th centuries.

Part IV: Islamic Science: An Appropriator of Science, and its Moot Decline

Huff (2002) in his review article 'The Rise of Modern Science: A Reply to George Saliba' stated that:

> *The 'problem' of Arabic science, namely, the intellectual question of how it happened that scholars communicating mainly in Arabic excelled in scientific inquiries during certain periods of time and, yet, failed to continue those inquires so that there was a decline, indeed, such a steep and long-lasting decline that people in later centuries might conclude that the 'Arabs' had never been masters of science.*

2.10 The Marginality Thesis versus the Appropriation Thesis

In describing the milieu in which Islamic science evolved, or the impact this era, which spanned from 800 to 1600 had on world history, Fiorina (2001) portrayed the Islamic civilisation as one of the greatest in the world, one that provided its multitude of subjects with peace and prosperity. When other nations were afraid of ideas, this civilisation which was driven by invention thrived on them and passed the knowledge of the past to the others. She elucidated that Western civilisation was indebted to the Islamic world for its eventual development in S&T (Fiorina 2001).

Notwithstanding Fiorina's testimony, conflicting views exist on the contribution of the Islamic civilisation to humanity's scientific enterprise. Questions are often asked about that 'mysterious' bond between Islamic science and its Greek predecessor. Some scholars speak of the 'refrigerator hypothesis' which claims that the role of scientists from the Islamic civilisation was simply to preserve the Greek body of knowledge and then pass it on to the Europeans at the time of the Middle Ages or the European Renaissance. This is a hypothesis strongly debunked by Saliba, as reported by Anwar (2007) (Saliba 2011).

There are two theories about the acceptance of Greek science in Islam, the marginality thesis and the appropriation thesis. The 'marginality thesis' states that Greek science was unwelcome for religious reasons, and only survived on the margins of Islamic culture. In discussing this thesis, Golshani (2008) quotes Russell who had said that the 'Mohammadan' civilisation was admirable in the arts in many technical ways, but it showed no capacity for independent speculation in theoretical matters, and its importance lied in it being a transmitter. The 'appropriation thesis' however asserts that Greek science was warmly and universally embraced. Not only did scientists from the Islamic civilisation study and analyse Greek science but also added many completely new concepts unknown to their predecessors (Saliba 2008) (Saliba 2011).

The marginality thesis has many advocates, some of whom rejected Islamic accomplishments outright. One critic, the French physicist Pierre Duhem[26] (cited by Covington 2007) accused Muslims of trying to destroy classical science in his 1914–1916 historic survey entitled *Le Système du Monde* (The System of the World).

A contemporary example of unfavourable opinion of Islamic scientific accomplishments and the commandeering of earlier science comes from an expatriate Muslim engineer, Mohammad Gil[27] (2008). It appeared on Chowk[28], the Internet platform that publishes writings on issues that are important to the people of India, Pakistan, and other South Asian countries. One of its paragraphs reads as follows:

> *Science had entered the Muslim World from the outside (it did not evolve from within), and it remained as an external entity. It still is. Once it started to decline, it could not bounce back and rejuvenate because it did not have deep roots in the society.*

[26] Pierre Duhem (1861–1916) was a French physicist and historian and philosopher of science. Biodata available online: http://www.science.uva.nl/~seop/entries/duhem/ [Accessed 11 December 2008].

[27] A retired Detroit Water & Sewerage Department engineer whose professional publications are in Hydraulics, Sediment Transportation in Rivers and Open Channels. Has done some other light writing related to philosophical topics, also and considers writing as his pastime.

[28] http://www.chowk.com/ [Accessed on 24 February 2008].

Regardless of its scholarly value, the above statement probably reflects the opinion of many. It is certainly a negative over-simplification of the story of the rise and decline of Islamic science. Debunking this statement is probably beyond the scope of this Thesis, however by examining the alternative 'appropriation thesis' some answers may be gained. Many Western scholars such as Jean-Jacques Sédillot, Eilhard Wiedemann, Robert Briffault, and George Sarton (cited in Covington 2007), reflect favourable opinions of Islamic science and how it was linked to Greek science. In 1928, Briffault wrote the following paragraph in his book, *The Making of Humanity* (Briffault, 1928):

> *What we call science arose as a result of new methods of experiment, observation, and measurement, which were introduced into Europe by the Arabs. […] Science is the most momentous contribution of Arab civilization to the modern world, but its fruits were slow in ripening. […] The debt of our science to that of the Arabs does not consist in startling discoveries or revolutionary theories; science owes a great deal more to Arab culture, it owes its existence….What we call science arose in Europe as a result of a new spirit of inquiry, of new methods of investigation, of the method of experiment, observation, measurement, of the development of mathematics in a form unknown to the Greeks. That spirit and those methods were introduced into the European world by the Arabs.'*

Today, we are still unravelling many of the milestones in the evolution of science in the Islamic civilization. Many of the sources we rely upon need to be objectively re-examined in order to develop a clearer chronology of major historical events drawing up the storyline of the Islamic civilization and the still to be unearthed scientific component within.

2.11 Discussion of the Archetypal Narrative on Islamic Science: Late Decline Not Sudden Demise

Notwithstanding the extensive argument presented in the literature review, in what follows, I will attempt to examine the narrative usually proposed to describe the decline of Islamic science that has lasted to the present day.

By revising the traditional narrative, I am admitting that a decline took place but I am casting off the view of many historians that the golden age of Islamic science abruptly ceased to exist in the 10th ,13th or even the 14th century. It will be shown that the decline in Islamic science started gradually owing to external and internal factors. Scientific activities went on well into the 16th and 17th centuries but were more dispersed, less well documented and less sensational than what was happening in Europe at about the same time. Some of the factors that led to this decline are discussed below:

(i) The Crusades (*Huroob al-Firinjja*) and the Mongol Invasion

Of the external factors that have affected the wellbeing of the Islamic world –and the scientific activity within- were the Crusades (Huroob al-Firinjja), and the Mongol invasions. The Crusader Wars or the Crusades[29], which commenced in 1095, have been described as one of the great forces that affected the history of Europe (and the Middle East) between 1095 and 1400. The Crusades were a major cause of the decline of the forces of creativity in the Arab Islamic Civilisation, and the subsequent entry of the Arab region into a state of quiescence in all fields (Qasem 1990). A less critical view has been taken by a number of contemporary scientists who claim that the Crusades in the 12th and 14th centuries did more to energize Muslim science than retard it (Rashed cited in Covington 2007), as the Crusades encouraged Muslims to find out the secrets of their enemies' forces. This theory needs to be investigated further however as no evidence has been found in this current research to assess it.

That the 13th century was a turning point in the history of the Islamic civilisation cannot be denied. The first half of that century witnessed milestone events in the history of the Islamic civilisation. In AD 1246, the city of Cordoba in al-Andalus (Spain) fell.

29 The Crusades are often translated into Arabic as *al-Huroob al-Salibiyya.* A fairer translation has been promoted by a number of eminent political historians such as Ahmad Sidqi Dajani, who prefers the term *Huroob al-Firanja* (Franks), as the latter carries no religious connotation. Moreover, Dr Ayoub Isa Abu Dayyeh has written a comprehensive book entitled *Huroob al-Firrinj Huroob la-Salibiyya* (Wars of the Franks: No Crusader Wars) in which he refutes the traditional narrative that the Crusades were religiously motivated and presents a comprehensive argument that they were motivated by social, economical, and political reasons in Europe (Abu Dayyeh 2008).

That was followed in AD 1258 with the fall of Baghdad. Another event, which will prove particularly significant later on, was the formal establishment of the Ottoman Empire under Osman I, in AD 1299.

The traditional narrative maintains that the decline of Islamic science took place abruptly during the 14th century, perhaps as an outcome of the Mongol destruction of Baghdad, and the collapse of the ʻAbbāsid Caliphate. The Mongols, although inexhaustible warriors, seemed not to have a vision for the future of the countries they conquered, for after destroying Baghdad and its science and education infrastructure, they went on to commission al-Tusi to establish one of the most famous scientific institutes of the day (the observatory and academy at Maragha in modern-day Iran)(see section 2.8). Nevertheless the destruction that the Mongols caused was a devastating blow of historical proportions to the Islamic civilisation, and it took practically centuries for the population of the region to return to its pre-Mongol levels (Masood 2009: 91).

(ii) Lack of Patronage and Political Fragmentation

During the golden age of Islamic science, the centre of scientific activity and creativity in the Islamic world was not fixed. Centres of considerable scientific activity flourished at different times and were closely associated with the seat of power. During the Umayyad and ʻAbbāsid periods, the major urban centres of the Islamic world, namely Damascus, Baghdad, Cairo and Cordoba, were hubs of science. In modern parlance, there was a brain drain of scientific talent towards these cities once the seat of political power was established. An idiosyncratic feature of that golden age of Islamic science was that it was diverse, interdisciplinary, and enjoyed political patronage. Islamic science blossomed as a result of direct and indirect political patronage by the ruling dynasties. Umayyad rulers in Spain and ‘Abbāsid rulers in Baghdad were for the best part of two centuries in competition to capture the hearts and minds of the population.

The period after the 12th century witnessed an innovation fatigue that led to stagnation coupled with the demise of the Umayyad dynasty in Spain (AD 1041) and the end of the ‘Abbāsid dynasty in Baghdad (AD 1258). The Islamic super-state fragmented into smaller states, none of which has inherited the glory of their past imperial tradition, and was able to capture the strength or the glory of their predecessor.

(iii) The Milieu

Although certain sciences flourished in the two adversary Islamic states that inherited sizeable chunks of the earlier all encompassing Islamic empire; the Ottoman Empire and the Safavid Empire, a school of thought propagates that Islamic science, after the 14th century, lacked the zeal to produce revolutionary scientists (King 1999).

Until the end of the 15th century, scientific knowledge was dominated by few major systems which became dogmatic and static. The main ones were Aristotelian physics, Ptolemaic astronomy, Galenic medicine, and Jabirian alchemy. Science had reached a point where further progress became extremely difficult (Al-Hassan et al. 2007a&c). This explains the scarcity of important scientific progress both in Islam and in medieval Europe between the 13th and the 15th centuries. To achieve major breakthroughs in science, a revolution in science was necessary. Such a revolution required the existence of a large community of scientists working diligently within a flourishing economy and a stable atmosphere over a long period of time. This did not exist in the Islamic world at the time. Some scholars blamed the elaborate madrasa-system, which was launched with the founding of the Nizamiyyah School in Baghdad, outlined earlier, claiming that contributed to the decline of Islamic science (Golshani 2008) Sabra (1987). Although such schools did for some time teach and promote religious studies and Islamic jurisprudence, this was not really their core mission. It was the need of the time as Shalaby (1954: 56-57) outlined, as Syria, Iraq and Egypt were under the domination of the Buwayhids and Fatimids. The madrasa system was an unattractive predecessor to the university system that sprang up in Europe in the 14th century. For the universities were created to assimilate and utilise the new knowledge coming from the Islamic world unlike the system of madrasas was more restrictive in scope (Nakosteen 1964: 188-189).

It may be true that the latter expedited the flow of knowledge and enhanced interdisciplinarity between students of various subjects. But, it is true also that the former did not hinder such a process.

(iv) Demography

The advent of Islam in Arabia brought about a dramatic shift from a culture of warring tribes to an orderly, constructive way of living (Hussain and Qurashi 2002). Large urban centres such as Damascus and Baghdad appeared in the Umayyad and ‘Abbāsid eras respectively. The two dynasties developed irrigation systems to promote agriculture, an action that resulted in an agricultural revolution in the first centuries of the Islamic empire. The population of the Islamic world of the day grew very rapidly in the initial period to around 14 million in AD 650, 33 million in AD 750, peaking at around 50 million in AD 1100 (Hussain and Qurashi 2002).

The central authority in the Islamic world eventually became preoccupied with political strife that resulted in damage to the irrigation system, which together with other infrastructure were destroyed by the Mongol invasions. This led to agricultural lands suffering irreversible damage, and the economy of the region was destroyed (Al-Hassan et al. 2007a).

This – as well as natural disasters – contributed to dramatic decreases of the population of the – at the time – heartland of the Islamic civilisation (Egypt, Syria and Iraq) (Ashtor 1976 cited in Al-Hassan et al. 2007a) including the terrible famine of AD 968 resulting from the low level of the Nile. Another famine, which was caused also by a low level of the Nile, lasted seven years between 1066 and 1072.

AD 1350 witnessed the end of the plague of 1347- 1350, that was known in Europe as the Black Death, which swept across the Islamic world and Europe. The population of Egypt, Syria and Iraq was diminished by one third. The Black Death was followed by a series of plagues which continued into the 19^{th} century. These recurring famines and plagues were instrumental in diminishing agricultural production. Death wiped out a large proportion of peasants and domestic animals. Industry collapsed with the deaths of great numbers of skilled workers. This also had adverse effects on the administration and the government.

(v) The Islamic world Losing its Strategic Importance

AD 1492 was a momentous year in the history of humanity and the Islamic world. It witnessed the fall of the last Arab/Muslim bastion on European soil (Granada), and the naval expedition of Columbus to establish an alternative route to India that would circumvent Islamic territories where Ottoman power was on the rise. Columbus's discovery of the new world brought untold riches to Europe (Saliba 2007a). The centre of international trade thereby shifted from the Mediterranean and the Indian Ocean to the Baltic and the Atlantic.

Although the Ottoman Empire was disturbed by the changes resulting from the discovery of America, its reaction was lethargic at best. These changes ultimately affected the traditional structure of the Ottoman Empire as a centrally-administered military state (Diner 2009: 97). These developments were to the detriment of the

Islamic world because the trade routes were no longer passing through it. Soon, traders developed the capacity to circumnavigate Africa (Saliba 2007a) after Vasco da Gama's first expedition of 1497-1498. The Portuguese, seeking to bypass the Islamic lands to reach the East were able to occupy all the important Islamic trading posts in the East and to establish a number of colonies (Al-Hassan et al. 2007a) (Al-Hassan et al. 2007b) (Al-Hassan et al. 2007c) and as result became a huge commercial power of the day.

(vi) Patenting and Printing

Patenting is essentially a European invention. More than a century before the Accademia dei Lincei was launched in 1603, patent laws were adopted in the Republic of Venice, between 1450 and 1550 (Prager 1944) with some contemporary legal experts specifying that it was in 1474 that the first patent law was implemented (Çözüm Patents 2011).

In the Islamic world, the issue of patents is not straightforward with schools of thought on the subject ranging from outright rejection of copyright as a concept and a practice on religious grounds (Saliba 2011) to lukewarm acceptance. The fact that the Ottomans only adopted their 'Ottoman Invention Berat Law' in 1879 after translating the French Patent Law (Çözüm Patents 2011) reflects this fact. The concept of patenting may have been one of the major reasons for the decline of the Islamic scientific enterprise (Saliba 2011).

One year after Sultan Mehmet II conquered Constantinople in 1453, Gutenberg printed the Bible in Mainz in AD 1454 and the mass printing of books was underway. Ottoman/Muslims however had to wait until 1727[30] to get their first printing house which was established by Ibrahim Müteferrika (Devlet 2008). Thus, the dissemination

[30] M. Serpil Altuntek, "İlk Türk Matbaasının Kuruluşu ve İbrahim Müteferikka", *H.Ü. Edebiyat Fakültesi Dergisi*, X. No. 1 (July 1993), pp. 191-204.

of print and the associated dissemination of scientific knowledge among Ottoman Muslims commenced almost three centuries after it had started in Europe.

2.12 The Decline of Islamic Science: The Watershed

Although the number of historically renowned scientists in the Islamic civilisation seems to have declined after the 14th Century, upon careful re-examination we find that a number of eminent scientists appeared in or after the 14th century including the famous polymath, Ibn Khaldun (1332-1406). Other famous scientists in the 14th and 15th centuries include Ibn al-Shatir (1304-1375) and Baha al-Din al-‘Amili[31] (1547-1622), both of whom have been extensively studied by King (1999: 45) as well as many others. The 16th and 17th centuries witnessed a number of Iranian scholars who travelled to the courts of northern and central India including Mīr Fazl Allāh Shīrāzī, the polymath Ibn Khākūn (the nephew of Baha al-Din Amili) (Robison 1997).

In advocating that the decline in scientific activity in the Islamic world was not negatively influenced by al-Ghazzālī’s doctrines, Saliba mentioned that al-Khafri, and other eminent astronomers, revised the astronomical theories of the pre-Ghazzālī era and proposed new theories … ‘on levels that were much more sophisticated than the levels found in the earlier period of the Greek sources themselves’ (Saliba 2007a).

A careful look at the encyclopaedic *‘Mu’jam al-A’lam’* (Lexicon of Towering Figures or Biographical Dictionary as its publisher calls it) by Khayruddin al-Zerekly (2007) reveals that many prominent scientists and scholars in the Islamic world appeared in the 15th, 16th and 17th centuries. The fact that they were identified by the compilers of the lexicon indicates that some important documentary evidence of their work exists. Table 2.1 below is based on Zerekly’s book as well as the work of Manzoor-i-Khuda (1992).

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[31] Baha al-Din al-‘Amili was born in Lebanon in 1547. Moved to Iran and later rose prominence during the reign of Shah ‘Abbas I and died there in 1622.

Moreover, a PhD dissertation by Jane Holt Murphy entitled *Improving the Mind and Delighting the Spirit: Jabarti and the Science in Eighteenth Century-Ottoman Cairo* examines the cultural and intellectual roles of the sciences in Cairo on the eve of direct European political involvement in the region. Murphy documents the activities of Egyptian religious scholars and military leaders in the domain of arithmetic, astronomy, astrology, the use of astronomical instruments, almanacs, aspects of number theory, medicine, divination, algebra and amulets, which were called the *gharib* (strange or foreign) science in local parlance (Murphy 2006). Another study (Haj Musa 2008) presented at a conference in Sharjah in 2008 documents the life and works of the extraordinary Algerian scholar and scientist *Muhammad Itfaysh Aljaza'eri*[32] (d. 1914).

This Thesis thus proposes an alternative watershed date for the *slowing down* of Islamic science – late in the 16th century, as many science historians advocate (King 2000) (Al-Hassan and Hill 1986 cited in Bakar 2008: 204) (Bakar 2008). This is after the exit of Muslims from Spain in 1492 and the discovery of America by Columbus in the same year. A more accurate date may coincide with the unfortunate closure of the Istanbul observatory of Taqī i-Dīn b. Marūf in AD 1580, an event after which conditions were no longer conducive to the advancement of science within the world of Islam. David King, in a paper entitled *Islamic world Maps Centred on Mecca: The Rediscovery of a Remarkable Tradition of Medieval Cartography*, declares unequivocally that there was no serious creativity in Islamic science after about 1600 (King 2000).

By contrast, the closure of the Istanbul observatory coincided with two remarkable events in the West: Copernicus' revelations in *De revolutionibus orbium coelestium* in 1543, and the founding of the Accademia dei Lincei in 1603, two landmark events in the ascendance of science in the West.

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32 *Muhammad Itfaysh Aljaza'eri* (d. 1914) was not an outstanding scholar of Islamic *'Aqeedah,* Arabic language and literature, but also a prolific scientists who wrote extensively on astronomy, medicine mathematics, botany as well as agriculture and irrigation. In astronomy, he wrote extensive commentaries on the work of *al-Mardini* and *al-Qulssadi* (Haj Musa 2008).

2.13 Science in the Ottoman Era

No state today can claim to be the sole inheritor of the 'Islamic Empire' of the Umayyads or the 'Abbāsids. Islamic countries such as Turkey and Iran can claim to be the successor-states –to use a term coined by Toynbee (1985) in his *Study of History*- of the Ottoman and Safavid empires respectively that rose after the demise of the earlier Islamic Empire. The two, together with Mughal India, were the three major powers in the Islamic world in the centuries that prevailed after the 'Abbāsid state; with Ottoman science being the most advanced (Bakar 2008: 205).

There was some intellectual interaction between the three empires. For example, Iranian skills in rational sciences were carried to Mughal India, and Indian achievements in rational sciences and mysticism were transferred to the Ottoman Empire, which, from the 17th century saw the ascendance of the transmitted rather than the rational sciences (Robinson 1997).

In the alternative narrative of the decline of Islamic science discussed earlier, the closure of the Istanbul Observatory in 1580 where Taqī i-Dīn b. Marūf worked, was the proposed alternative watershed date for the start of the decline. At the time[33], the Ottomans were the superior military power. Their artillery was unchallenged (Guilmartin 1974 cited in Al-Hassan et al. 2007a&c), and their technology in the 16th century represented the best that was known in that age, as manifested by the mechanical engineering books of Taqī i-Dīn b. Marūf. Ihsanoglu (1992, cited in Bakar 2008: 206) confirms that Ottoman science kept pace with economic, social, and cultural progress, however after the end of the 16th century it could not keep up with Europe in terms of development, scientific or otherwise. However, as any visitor to Turkey would observe, the Ottomans paid attention to architecture and construction as manifested by

[33] Remarkably, at about the same time, as an expression of its interest in cartography and navigation, Spain (which for 800 years was under Muslim dominance) in 1582 launched a particular brand of an Academy of Mathematics that was founded in Madrid by Philip II. It taught cosmography, navigation, military engineering, and the occult sciences. As a sign of the times, the engineering professor of fortifications received twice the salary of the leading university professor of philosophy (McClellan & Dorn 2006: 203).

the mosques built by Mimar (the architect) Sinan[34] (1489-1588 AD). Another exception to the general trend of stagnation was Ottoman medicine, which from the 14th to the 18th century was mainly a continuation of Islamic medicine based on the works of historically famous physicians. Ottoman doctors such as Shirvani (early 15th century) and Itaki (1642) were among the more notable (Sari 2008). The early 18th century witnessed a short-lived revival of interest in medicine with the appearance of a physician called *Ömer Şifai* who wrote a book on the use of chemistry in medical treatment, as well as *Nuh ibn Abdulmennan* and *Şaban Şifai* both of whom translated medical books that ushered in a new approach to medical practice (Lewis 1982: 230).

The first contact with Copernican astronomy by the Islamic world occurred around mid-17th century when the Ottoman astronomer *Tezkereci Kose Ibrahim Efendi* of Szigetvar translated a work by the French astronomer Noel Durret (d. ca. 1650). The introduction of Copernicus' new heliocentric concept into the Ottoman Empire did not cause a conflict between religion and science unlike in Europe. In fact, this concept was preferred to Ptolemy's geocentric system, and considered more suitable with respect to religion. However, the conflict between religion and science entered Ottoman intellectual life around the end of the 19th century with Western trends of thought such as positivism and biological materialism.

Although an extensive translation movement was underway during the reign of Sultan Ahmet III in 1720, the first 'academy-type' institution in the Ottoman state was only founded over a century and half later. The Ottoman state formally established an institution that was known as the 'Council of Sciences' in 1861. Loosely modelled after the *Académie Française* in terms of role and objectives, this institution was made up of notable state personalities, and enjoyed a special status (Ihsanoglu 1999). The 'Encümeni Danish' was the first incontestable formal learned society (academy) in the

[34] Koca Miʻmār Sinān Āġā (1489 - 1588) was the chief Ottoman architect and civil engineer for sultans Suleiman I, Selim II and Murad III. He was responsible for the construction or the supervision of most major buildings in the Ottoman Empire.

Islamic world (Clarence-Smith 2006). In English, the name has been translated as the High Consultative Committee, and in some references as the Turkish Academy of Sciences (University of Waterloo 2008). Its first lecture was on physics, which attracted hundreds (Masood 2009:191). It was abolished in 1862.

2.14 Summary of Chapter Two

In this chapter, I mentioned that Athens was one of three ancient cities that were the domicile of academies. The other two were Alexandria and Jundishapur, located in what we know today as countries of the OIC or the Islamic world. I also attempted to establish a link between Jundishapur and its successor Bayt al-Hikma to demonstrate how traditions of scholarly activities –like science- transcend civilisations.

In discussing the rise of Islamic science, I argue that science in the Islamic civilisation started to rise earlier than what the archetypal narrative tells us. The Umayyad reign –despite its eventfulness- was a milieu of dynamism and innovation that engendered the curiosity of Muslims to learn about the world. The foundations of Islamic scientific tradition were thus present well before Greek sources were formally appropriated into the Islamic knowledge pool during the reign of early the ‘Abbāsids. I discuss the history of Bayt al Hikma in Baghdad and –based on new evidence- argue that it was a care-free locality in which science was translated, debated, researched and documented, i.e. activities undertaken within the confines of science academies, and conclude that it was an academy of sciences of its day. The chapter then discusses other academies and academy-type institutions in Cordoba, the Nizamiyyah in Baghdad and the Maragha observatory/academy –this being considered by many as an academy of sciences *par excellence* of its day (Saliba 2007a).

By revisiting the narrative of the decline of Islamic science, I investigate a number of causes that led to the decline of the Islamic civilisation after the 11th century. However, I contest the claim that Islamic science came to a standstill in the 14th century and propose an alternative watershed for the *slowing down* of Islamic science, namely the closure of the Istanbul observatory of Taqī i-Dīn b. Marūf in AD 1580. From the 17th century onwards, conditions were no longer conducive within the realms of Islam (as represented by the Ottoman Empire) for the development of science. Reasons for this scientific quiescence include social and economic disruption resulting from the weakening of the central authority – not in a dissimilar fashion to what took place during the ‘Abbāsid Caliphate – dissolution of political stability, loss of territories and the diminishing revenues of the Empire (Ihsanoglu 2006).

Abdullah Schleiffer argues that history has compensated the Islamic world for the major setbacks it had inflicted on it. The destruction of Baghdad by the Mongols in AD 1258 was compensated by the invaders converting to Islam, while the Muslim exodus from Spain in 1492 was compensated by the capture of Eastern Europe by the Ottomans (Shleifer 2011). That may have been true on the two occasions. However, it is difficult to think today of an event that did compensate for the apparent divorce between state and science as manifested by the closure of the Istanbul observatory in 1580.

A closer look at the reasons outlined in this chapter for the gradual decline of Islamic science reveals that they are the same factors that are today holding back the collective scientific and technological advancement of OIC countries. They include; external military threats, strategic location (which is an advantage and a disadvantage), political fragmentation, poor rule of law, lack of patronage of science, out-of-date system of education, lack of human resources active in science as well as the lack of effective patenting regimes to unleash innovation. Understanding such reasons is important to understanding the reasons for the status of science in the Islamic world today.

Table 2.1 Some of the eminent scientists of the Islamic Civilisation who have appeared after the AD 1350 watershed.

No.	NAME	DATE	DISCIPLINE	LOCATION
1.	Lisan al-Din Ibn al-Khatib*	1313-1374	Medicine	Granada
2.	Abdullah Ibn Ali al-Kashani*	c. 1400	Chemistry	n.a.
3.	Al Ghernati	d. 1403	Arithmetic	n.a.
4.	Ibn Khaldun*	1332-1406	Alchemy, History and Sociology	Tunisia/Egypt
5.	Ibn Qunfudh	1340-1407	Astronomy	Algeria
6.	Ibn al-Hai'm	1352-1412	Mathematics	Egypt/Jerusalem
7.	Al Wanogi	1357-1416	Arithmetic	Tunisia/Mecca
8.	Al Tunsi	d. 1417?	Medicine	Tunisia
9.	Haji Basha	d. 1417	Medicine	n.a.
10.	Al-Ansari Haji Zainal-Din Attar*	b.1429	Pharmacy	n.a.
11.	Jamsheed Bin Masoud	d. 1429	Mathematics/Astronomy	Iran
12.	Ibn al-Karmani	1361-1430	Medicine	Cairo
13.	Qadi Zadah	d. 1436	Mathematics	Shiraz/Samarqand
14.	Burhanuddin Nafis	c. 1438	Medicine and Ophthalmology	n.a.
15.	Ulugh Beg	1394-1440	Astronomy/ Mathematics	n.a.
16.	Al Hijazi	d. 1445	Arithmetic	Cairo
17.	Al Nizam al-Nissabouri	d. 1446?	Mathematics	Iran
18.	Ibn al-Majdi	1366-1447	Mathematics/ Astronomy	Egypt
19.	Ibn Sharraf	1380-1448	Arithmetic	Jeusalem
20.	Al Tozari	d. 1454	Astronomy	Tunisia
21.	Ibn Khatima*	d. 1469	Medicine	n.a.
22.	Musa al-Kahhal	d. 1474	Medicine	n.a.
23.	Al-Koshaji	d. 1474	Astronomy/Mathematics/	Samarkand
24.	Ibn al- Attar	d. 1475	Arithmetic	n.a.
25.	Al Karadisi	1420-1482	Astronomy	n.a.
26.	Ibn al-Azraq	d. 1485	Medicine	Yemen
27.	Al-Qalaṣādī	1412-1486	Mathematics	Spain/Tunisia
28.	Ibn al-Amshati	1409-1496	Medicine	Egypt
29.	Sherfuddin Sabunjuglu	c. 1495	Medicine	n.a.
30.	Manzur bin Ahmed	c. 1496	Medicine/Anatomy	n.a.
31.	Al Yaldani	d. 1501	Medicine	n.a.
32.	Al-Khodiry	1466-1505	Medicine	n.a.
33.	Sabt al-Mardini	1423-1506	Astronomy / Mathematics	n.a.
34.	Al Sharwani	d. 1506	Medicine	n.a.
35.	Ibn Kadi-Zadah	d. 1524	Astronomy	n.a.
36.	Al Qosoni	d. 1525	Medicine	Egypt
37.	Al-Ghazzi	1458-1529	Alchemy	n.a.
38.	Shams al-Din al-Khafri (Saliba 2007c: 240).	d. after 1550	Astronomy	n.a.
39.	Abdul Fadl Allami	d. 1551	Geography	Cairo
40.	Ramadan al-Safty	d. 1554	Astronomy	n.a.
41.	Sulaiman al- Mahri	d. 1554	Geography/Astronomy	Yemen
42.	Al-Shifaai	c. AD 1556	Pharmacy	n.a.
43.	Ghars El Din Ibn el Naqib	1494-1563	Medicine/ Mathematics/ Astronomy	Syria/Egypt/Algeria
44.	Ibn Zourayk	d. 1569	Astronomy	Damascus
45.	Al Zammouri	d. 1570	Astronomy	Morocco
46.	Taḳī i-Dīn b. Marūf	1525-1585	Arithmetic	Damascus/Istanbul
47.	Al Hatab	1496-1587	Astronomy	n.a.

No.	NAME	DATE	DISCIPLINE	LOCATION
48.	Daoud al-Antaki	d. 1600	Medicine	Antioch/ Mecca
49.	Al Jaradi	d. 1600	Astronomy	n.a.
50.	Hakim Abdul Fatah Gillani	c. 16th/17th century	Pharmacy and Medicine	n.a.
51.	Al Mala Safi Aldeen	d. 1601	Medicine	n.a.
52.	Al Wazir Al Ghassani	1548-1611	Medicine	Morocco
53.	Al Rashidi	d. 1611	Astronomy	n.a.
54.	Ibn Ma'youb	d. 1613	Arithmetic	n.a.
55.	Al Boreiny	1556-1615	Mathematics	Ottoman Palestine/Syria
56.	Al Fardi	1546-1619	Arithmetic	n.a.
57.	Baha al-Din al-'Amili[35]	1547-1622	Mathematics and Algebra	n.a.
58.	Al Manashiri	1573-1630	Astronomy	n.a.
59.	Madin al-Qousi	1562-1634	Medicine	Egypt
60.	Bakatheer	d. 1635	Medicine	Yemen
61.	Al Awfi	d. 1635	Astronomy	n.a.
62.	Ibn al-Anz	1592-1641	Astronomy	Yemen
63.	Al Ghazzi	1592-1644	Arithmetic	n.a.
64.	Ibn Mutair	d. 1658	Arithmetic	n.a.
65.	Al Sabbagh	1582-1666	Arithmetic	Morocco
66.	Saleh Salloom	d. 1670	Medicine	Turkey
67.	Ibn Abdelhadi	1645-1676	Astronomy	n.a.
68.	Al Jilani	d. 1677	Medicine	Iran/India/Yemen
69.	Yahya Ben al-Hussein	1635-1679	Medicine	Yemen
70.	Ahmad al-Samlali	d. 1682	Medicine	n.a.
71.	Al Shilli	1621-1682	Astronomy	Hadhramaut/Yemen
72.	Al Rodani	1627-1683	Astronomy	Morocco
73.	Al Dadsi	d. 1683	Astronomy	Morocco/Egypt
74.	Al Safarjalani	1645-1700	Mathematics	Damascus
75.	Al Falaki	d. 1711	Engineering/Astronomy	Egypt
76.	Ibn al-Qasim	1652-1717	Medicine	Yemen
77.	Al Bathishi	1684-1734	Mathematics	Akka/(Ottoman Palestine)
78.	Al Sanaani	1655-1736	Medicine/Botany	Yemen
79.	Al Tarazi	1675-1747	Medicine	Damascus
80.	Al Jabarti	1698-1774	Astronomy/ Engineering	Egypt
81.	Al Kawazi	d. 1774	Medicine	n.a.
82.	Muhammad Itfaysh Aljaza'eri (Haj Musa 2008).	1821-1914	Medicine, Astronomy and Botany	Algeria

[35] Baha al-Din al-'Amili was born in Lebanon in AD 1547. Moved to Iran and later rose prominence during the reign of Shah 'Abbas I and died there in AD 1622.

CHAPTER THREE

THE MAKING OF THE EUROPEAN RENAISSANCE AND THE RISE OF ACADEMIES OF SCIENCES IN THE WEST

> *Compared with the East and with medieval Islam, Christian Europe at the turn of the first millennium AD was an 'empty quarter.' Latin Christendom numbered 22 million souls in 1000, versus 60 million in the heartlands of China, 79 million on the Indian subcontinent, and perhaps 40 million under Islamic governance. By the year 1000 the population of Rome had declined to 35,000 from its peak of 450,000 in antiquity; only 20,000 people lived in Paris, and only 15,000 inhabited London. In contrast, the population of Córdoba in Islamic Spain topped 450,000 (some estimates range as high as 1 million), Constantinople held 300,000, and the population of Baghdad—the largest city in the world—was nearly 1 million.*
>
> (McClellan & Dorn 2006: 203)

PART I: Renaissance in Europe

3.1 Raphael's Painting: A Misleading Picture of the Academy of Athens

The Academy of Athens is one of Raphael's most famous paintings. It depicts towering historical scholars. According to Pope Pius XII in his address to the Fellows of the Pontifical Academy in 1949, 'In those people you will have recognised your oldest predecessors in the investigation of both matter and spirit' (Pontifical Academy 2004).

Figure 3.1 The Academy of Athens by Raphael (1509-1510).
Source: http://en.wikipedia.org/wiki/Academy (Accessed 20 December 2008)

The magnificence of the Raphael's painting is undermined by the fact that it shows only one figure belonging to the Islamic civilisation: Averroes or *Ibn Rushd*. Historically, it is known that Raphael painted the 'Academy of Athens' in 1509-1510. Was Averroes the only figure known to the European intellectual community at the time to deserve a place in the portrait? Was he the only scholar who contributed to the renaissance, the scientific renaissance and eventually to the scientific revolution? What about those of the likes of *Ibn Sina* (Avicenna), *al-Khawarizmi* (Algorizm), *al-Razi* (Rhazes) and al-Tusi and his famous al-Tusi Couple[1]? In describing the ascendance of the European renaissance, which culminated in the Scientific Revolution and then the Industrial Revolution, it will be argued that there is a case to include many towering figures from the Islamic civilisation in the portrait in recognition of their contributions. The question of how science was transmitted from the Islamic civilisation into Europe will be discussed. Further, the rise of academies of sciences in Europe to become beacons of science and the scientific endeavour will also be addressed.

3.2 The Islamic Civilization and the Making of the European Renaissance

How did the Islamic civilization contribute to the European renaissance? The following quote from Nakosteen (1964: vii.) provides a lead:

> *If the inspiration for this renaissance came from within the Latin-Christian world, certainly its stimulation – to a large extent- its substance and intellectual direction came from the Muslim World, which gave the European revival its form as well as its content.*

Furthermore, Graham (2006) talks about the influence of the Islamic civilization on Europe in a more colourful narrative:

> *At the dawn of the Renaissance, Christian Europe was wearing Persian clothes, singing Arab songs, reading Spanish Muslim philosophy and eating off Mamluk Turkish brassware… It is the story of how Islam created the modern world.*

[1] Details about the al-Tusi Couple will be provided under a separate heading. http://en.wikipedia.org/wiki/File:Tusi_couple.jpg

By the close of the first millennium, Europe was set for a transformation manifested in revival of interest in science. Contact between Europe of the Dark Ages and the Islamic civilization was about to start.

Greek giants such as Aristotle were but a distant memory of Europe's classical past. Knowledge of mathematics was so basic that calculations were performed on the fingers of the hand, using the cumbersome Roman numerals. A glimpse of the sorry state of arithmetic in Europe is given in the memoirs of the medieval English scholar Aldhelm of Malmsbury, who lived in the late 7^{th} century. He recorded his 'near despair' in trying to 'grasp the most difficult of natural principles…what they call fractions.' Even into the late 10^{th} century, it was said that Northern Spain was the only place in Christian Europe where mathematics was taught (Burnett 2008). In what follows, a description of the various routes through which scientific knowledge flowed from the Arab/Islamic civilisation into Europe is presented.

3.2.1 The Andalucían Connection

At least a century before the Crusades, Gerbert of Aurillac (AD 948–1004), who became Pope Sylvester II in AD 999, was the first to introduce the Hindu-Arabic numerals into Christian Europe. Hindu-Arabic methods of calculation were later used by Fibonacci (Leonardo of Pisa) in his *Liber abaci* [Book of calculation] of 1202. His book contained the celebrated problem of the rabbits that led to the 'Fibonacci sequence' 1, 1, 2, 3, 5, 8, 13, 21,… in which each number after the first two is the sum of the previous pair (Wilson 2001).

Echoes of the scientific activities in al-Andalus were resonating in Barcelona, where scholarly monks in the late 10th century were writing the first Latin treatises based on Arabic/Islamic sources. Their texts contained portions translated from al-Khawarizmi's treatise on the use of the astrolabe, and two short fragments from Ptolemy's Planisphaerium, as well as writings on the subject based on Arabic sources (Kunitzsch 2007). The advancement of Muslim Spain in the sciences and the arts resulted in an influx of European scholars, especially to Toledo, which became a magnet for scholars intent on harvesting Arab and Greek science. There, more than 100 major scientific and philosophical essays were translated from Arabic into Latin and Hebrew between AD 1116 and AD 1187 (Djebbar 2007 cited in cited in Covington 2007). As the barrier of language dissolved, ideas born in the great Islamic cities began to filter into Europe, forever changing Western thought. Great translators appeared, such as Plato of Tivoli, who between AD 1116 and AD 1148 translated Arabic works on astronomy and astrology by al-Battani, Ibn al-Saffar and Ibn al-Khasib (Mushtaq 1990).

The most important reason for the development of Toledo as a centre of learning was the role played by the archbishops of Toledo, Raymond I (r. AD 1125-1152) and Rodrigo Jimenez de Rada (r. AD 1170-1247) (Mushtaq 1990). The appearance of what became to be known as the Toledo School of translators, which included scholars from all over Europe including Adelard of Bath and Robert of Chester is a manifestation of Toledo's importance. Two famous translators came from Flanders (Rudolf Bruges and Henry Bate), many came from southern France, (including Armengaurd son of Blaise, Jacob Anatoli, Moses ibn Tibbon) and from Italy came Plato of Tivoli, Gerard of Cremona, Aristippus of Catania, Salio and John of Brescia.

What was happening in Spain at the time was a repeat of what had taken place earlier during the early ʻAbbāsid Caliphate, between the Greek and Islamic cultures. Just as Baghdad had diligently sought to acquire Greek science, so Europe in the 12th century devoted great care to Islamic works on astronomy, arithmetic, trigonometry, optics, geometry, astrology and medicine (Mushtaq 1990).

Adelard of Bath, who travelled as far as Antioch in his quest for learning based on ‘reason rather than authority,’ (as he wrote in *Quaestiones Naturales)*, returned to the court of English King Henry I. There, he introduced Muslim research on trigonometry, botany, falconry and other subjects. His compatriot Daniel of Morley later lectured to his Oxford students that they should ‘not despise the simple and clear opinions of the Arabs.’ Although Daniel of Morley’s books from Spain were destroyed in the English religious wars, Oxford’s Bodleian Library later built up an important collection of medieval Arabic manuscripts of the 12th and 14th centuries Latin texts translated from Arabic sources (Covington 2007).

3.2.2 The Sicilian Connection and the Wallonia Conduit

The Italian theologian Thomas Aquinas[2] (d. AD 1274) used the writings of Averroes to justify the separation of faith and reason, an idea that formed the bases of scientific enquiry. This is perhaps the only justification of why only Averroes appears in Raphael’s classic painting, which was referred to earlier alongside Plato and Aristotle. Aquinas was born in Sicily, which in the 12th century had also become another centre of learning. Due its history and geography, Sicily, especially under the patronage of Norman kings, was a meeting point of East and West. During the Norman reign, Arabic was used alongside Greek and Spanish. Many Arabic manuscripts of science and mathematics were obtained and translated into Latin. This movement was greatly

[2] Thomas Aquinas (b. ca. 1225 in Sicily; d. 7 March, 1274) was an Italian Catholic priest, and an immensely influential philosopher and theologian in the scholastic tradition (Source: Wikipedia).

encouraged by the three Sicilian kings; Roger II (r. AD 1140-1154), Fredrick II (1194-1150) and Manfred (r. AD 1241-1266) (Mushtaq 1990). Al-Idrissi (Dreses) (AD 1099 - 1166), the famous geographer who was closely associated with the court of Roger II, made original contributions to geography and published a geographical encyclopaedia (Said 2000: 18).

The region of Wallonia (in modern-day Belgium) played a role in the evolution of S&T and dissemination of Islamic science in Europe. From the 10th century onward, it became the contact point between the waterways and major roads of France, Germany, the Rhine, and Holland. Thus, all the major currents which have shaped the landscape of S&T in Europe have crossed Wallonia (Halleux et al. 1995). Pope Sylvester II in 999, mentioned above, not only introduced Arabic numerals to Christian Europe, but apparently taught a generation of mathematicians at the school of Reims (in Wallonia) including Notger, the bishop of Liege (AD 972-1008) and the author of a commentary on the great treatise ‘Arithmetic of Boethius.’ Another of his students was Heriger, the bishop of Lobbes, who wrote the rules for using the abacus. Eventually, a homogenous network of men and manuscripts came into existence. It covered the Lorraine and beyond and included people like Notger of St. Gallen, Adelbold of Utrecht, Adelman, as well as Randolph and Hermann of Cologne, all of whom assimilated Islamic science filtering in from the South (Halleux et al. 1995).

In the 12th century, the district of Wallonia maintained its importance as a repository and clearing house of Arab/Islamic science (Sghaier 2008a). Arabic medicine entered Wallonia probably from Salerno in southern Italy, which was visited by Wibald, the abbot of Stavelot, in 1147. In the second half of the 12th century, Arab works on science arrived *en masse*, but the absorptive and development capacity of the region was insufficient to handle the flow. Science in the Lorraine developed slowly while in France, science flourished after AD 1200, thanks to the start of universities. However, Wallonia failed to provide new knowledge as it lacked the infrastructure of education and research, which would have allowed its development, and thus did not undergo a scientific revolution.

Moreover, there is evidence that precious Arab and Islamic manuscripts were purchased or otherwise obtained from various Andalucían cities (including Toledo and Cordoba), were transferred to Wallonia and then translated. Some of the genealogical tables kept at the monastery in Wallonia revealed that generations of European scholars had access to this wealth of accumulated information. These generations of scholars eventually taught such outstanding students as Copernicus (Sghaier 2008a). Sghaier (2008b) lists many names of scientists linked to Wallonia who were associated with Islamic science. These included Gerbert, Notger, Heriger and Adelbold. The subsequent generation of scientists included Fulbert, Radulph, Ragimbold, Falchanlin, Wazon, and Constantin the African.

3.2.3 Early Contacts in the East: The Crusades and Beyond

A phenomenon that contributed to the transfer of knowledge into Europe was the Crusades[3] (AD 1095-1270). Rashed (2007, cited in Covington 2007) explains that the Crusaders brought back into Europe a great deal of science, medicine, foods, etc. from the Middle East. Many invading soldiers, after they had finished doing their 'bloody work' according to Burnett (2008), settled in the Middle East and developed an interest in the Arab civilisation. This has resulted in many works of medicine and philosophy being translated and later made available to Europe in the 11th and the early 12th century (Burnettt 2008). Of the many European medical practitioners who decided to settle in the Middle East were Robertus Medicus and Magister Lambertus (Mitchell 2004).

[3] I have earlier referred to the Crusades as *Huroob al-Firinja.*

Mitchell (2004) left open the question of whether the advancement in medicine that took place at the time could be attributed to the exchanges between the Frankish medical practitioners who accompanied the Crusades and the local doctors. He however confirmed that such exchanges took place, and admitted that the crusaders acquired many books on medicine and other sciences from the region. By the 14^{th} century, most such scholars started enjoying the fruits of relative peace. A member of this group, a native of the area, was Theodore of Antinoch (in modern-day Turkey) who was a student of *Kamal al-Din bin Yunus* in Mosul (Mitchell 2004) (Burnettt 2008). He was later head-hunted by King Fredrick II of Germany and became his court philosopher.

The Crusades also intensified exchanges between Europe and the Levant, with Italian City Republics taking a great role in these exchanges.

3.3 Summary and Discussion of Part I

The period from 500 to 1000 in Europe was known as the Dark Ages (Wilson 2001). During this period, philosophical and scientific teaching in the old continent was based upon copies and commentaries of ancient Greek texts, which remained in Western Europe after the collapse of the Western Roman Empire in AD 476. At the turn of the first millennium, the time was ripe to witness the rise of a new dawn in Europe. The sun of the renaissance was rising from the East.

By describing some of the routes through which science was transmitted into Europe including the Wallonia connection, the idea that science has always been international and free flowing across civilisations and cultures was reinforced. Knowledge started to flow from the Islamic civilisation to the West where it was absorbed and then contributed to the rise of the scientific enterprise, firstly, as an intellectual linguistic movement and then as a scientific movement. The fact that universities were starting up in Europe played a significant role in appropriating Arab and Islamic science. Here, universities in Europe renaissance preceded academies as beacons of science and the scientific endeavour, unlike the Arab/Islamic civilisation where academies were the forerunners to the madrasas.

The main conclusion to be drawn from uncovering the Wallonia connection is that many of the routes that the flow of Islamic science took when it was spreading through Europe are still being discovered.

Most Western historians (with a few exceptions such as Lindberg) tend to ignore the fact that the re-discovery of Greek learning started in the 12^{th} century, or even earlier, through Spain and the other conduits of knowledge from Islamic sources (Lindberg 1978). Further evidence to confirm the early transmission of Islamic science into Europe stems from the fact that medieval European universities were established in the 12^{th} century primarily to assimilate the knowledge coming from Islamic sources (Nakosteen 1964).

Part II: The Seeds of the Scientific Revolution

> *In his seminal work, De revolutionibus orbium coelestium (On the Revolutions of the Heavenly Spheres), Copernicus proposed a sun-centred or heliocentric cosmology with a moving earth rotating once a day on its own axis and orbiting the sun once a year. In 1543, every culture in the world placed the earth instead at the centre of its cosmology. In breaking so radically with geocentrism, received astronomical wisdom, and biblical tradition, Copernicus launched the Scientific Revolution and took the first steps toward the formation of the modern scientific worldview.*
>
> (McClellan & Dorn 2006: 203)

3.4 The Copernican Connection Revisited

3.4.1 Saliba's Evidence

Saliba (2007b) claims rightly that Copernicus's work was based on Ibn al-Shatir's of Damascus (d. AD 1375), which in turn was based on the work of al-Tusi. He cited Neugebauer discovery of the similarity of Ibn al-Shatir's lunar model and that of Copernicus. This was documented in an *Isis* paper by Victor Roberts, entitled *The Solar and Lunar Theory of Ibn al-Shatir: A Pre-Copernican Copernican model* (Roberts 1957) (Roberts and Kennedy 1959). Saliba goes on to outline Hartner's remarkable discovery of the similarity of Copernicus's proof of the theorem of generating linear motion from circular motion; or what is known as al-Tusi Couple, and the original illustration of al-Tusi himself. Hartner, according to Saliba (2007c), discovered that the two proofs carried the same alphabetic designators for the essential geometric points, i.e. where al-Tusi's proof designated a specific point with the Arabic letter 'alif,' Copernicus's proof signalled that same point with the equivalent phonetic letter 'A,' where al-Tusi had 'ba,' Copernicus had 'B,' and so on, except in one case where al-Tusi had 'zay' and Copernicus had 'F.' That is to say that Copernicus must have misread the Arabic 'zay' (ز) as an Arabic (ف).

Both Hartner (and before him Neugebauer) investigated how Copernicus could have become aware of the original Arabic manuscript, but it was Saliba who eventually identified some individuals, such as Postel[4] who may have brought back such manuscripts from the East and deposited them in libraries in Europe including at the famous library of the Vatican (Saliba 2007c).

[4] Guillaume Postel (March 25, 1510 – September 6, 1581) was a French linguist, astronomer, diplomat, professor, and religious universalist. Postel is believed to have spent the years 1548 to 1551 on a trip to the East, travelling to the Holy Land and Syria to collect manuscripts (Wikipedia).

3.4.2 Burnett's Narrative

Al-Tusi (AD 1201- 1274) was a leading astronomer who, like Theodore of Antioch, studied under Kamal al-Din bin Yunus. He designed the construction of the Maragha observatory (academy) in modern-day Iran in the 13th century. He authored a memoir on Astronomy (*al-Tadhkira fi 'ilm al-hay'a*) that amended Ptolemy's work on the motion of spheres and led him to formulate the theorem known as a-Tusi Couple which states that linear motion can be derived from uniform circular-motion. Al-Tusi's manuscript contained a series of diagrams that show clearly one sphere rolling inside another of twice the radius. It has now been acknowledged that in his 'Revolutions,' Copernicus reproduced the al-Tusi Couple. Al-Tusi's original experiment as reported in his Arabic manuscript was the source – the contribution of Ibn al-Shatir (AD 1304 – 1375) notwithstanding – that enabled Copernicus to arrive at his heliocentric view of the solar system. Copernicus remained silent about his Arabic sources and it probably did not occur to his contemporaries to track the source of his inspiration to its Islamic origins (Burnett 2008). This may have been the beginning of the divide that has become ever wider as Europeans became increasingly unwilling to admit that they were indebted to the Islamic civilisation for ideas that caused them to look at the world in a new way.

3.5 The Chronology

A chronology of the history of scientific development in Europe over the last five centuries may include four historical milestones:

(i) The arrival of Arab (Islamic) science starting as early as the 11th century, followed by centuries of assimilation and appropriation;

(ii) The scientific revolution of the 16th and 17th centuries, which developed the heliocentric model, and laid the foundation for the establishment of academies of sciences (Mijnhardt 1987 cited in Noordenbos 2002);

(iii) The organisational and institutional character of science in the 18th century that developed from earlier antecedents, i.e. an 'organised revolution' that represented the second or institutional phase of the Scientific Revolution (McClellan 2003);

(iv) The industrial revolution of the 19th and 20th centuries; and the ongoing scientific research since (Halleux et al 1995).

For the purposes of periodisation, we can say that the integration of science with technology, as manifested in the use of the experimental method in determining the validity of propositions regarding the natural world, was gradually becoming the norm with Bacon (AD 1561-1626) and Galileo (AD 1564-1642). Both championed this anti-Aristotelian revolution (Shah 2006: 83), and started a new phase in the history of science for development.

3.6 Summary and Discussion of Part II

The year 1543 witnessed a radical change in man's understanding of nature with the publishing of Copernicus' *De revolutionibus orbium coelestium* in which he proposed to increase the accuracy of astronomical theory by transferring to the sun many astronomical functions previously attributed to the Earth. Before his proposal, the Earth had been the fixed centre about which astronomers computed the motions of stars and planets. A century later the sun had, at least in astronomy, replaced the earth as the centre of planetary motions and the Earth had lost its astronomical status. Although this new theory was initially opposed by the Catholic Church, there were practical reasons for its acceptance namely in terms of its value as a basis for the construction of almanacs and for navigational purposes (Kuhn 1985 and Cohen 1985 cited in Shah 2006: 85). Many principal achievements of modern astronomy depended on this transposition. Other radical alterations in man's understanding of nature followed, which culminated a century and half later with Newton.

The transmission of science from the Islamic civilisation over centuries has culminated in this new understanding, which was itself based on some original research by al-Tusi three centuries before, the contribution of Ibn al-Shatir notwithstanding. Al-Tusi had laid the foundation for the Scientific Revolution in Europe of the 16th century in 13th century Maragha.

This scientific revelation, which was partly behind the Scientific Revolution caused an organisational tremor in scientific circles, and led to science and the scientific enterprise becoming solidified, with some European governments, notably in France (Crosland 1975) increasingly supporting novel social institutions of 17th century science.

Part III: Rise of European Academies

Nakosteen (1964, pp. 188-189) claimed that the first European universities began to appear during the second half of the 12th century. He – quite surprisingly – described these institutions as not restrictive in scope as the Academy of Jundishapur, the Museum of Alexandria, the Bayt al-Hikma of Baghdad or that of Cairo, and the system of madrasas (schools and colleges) founded by Nizam al-Mulk. Nakosteen's claim that (Eastern) academies were quite restrictive has been addressed in Chapter Two, where it also was demonstrated based on new evidence, that they were not as restrictive.

Despite their obscure beginning, European universities developed rapidly and by the end of the 12th century, there were five of them in existence, two in Italy (the medical school of Salerno and the law school of Bologna), two in France (Paris and Montpellier) and one in England (the university of Oxford) (Nakosteen 1964). The greatest was the University of Paris, of which Oxford was an off-shoot that in turn gave birth to Cambridge in 1209 (Rashdall 1895).

Nakosteen (1964) asserted that European universities were primarily created to assimilate and utilise the new inflow of Greco-Arabic culture.

3.7 From Universities to Academies

By the 15th century, almost four centuries after the start of the flow of Arab/Islamic science from the South to the North (to use modern parlance), science and intellectual interaction started to take a more institutional posture, particularly in Italy in what has been described as the Italian renaissance. To understand the phenomenon of the development of academe, the history of academies in Italy has to be looked at. This has not been extensively documented, although McClellan provided a comprehensive chronology in the chapter entitled *Learned Societies* which appeared in the *Oxford Encyclopaedia of the Enlightenment* (McClellan 2002). A publication that is often also mentioned is Maylender's five-volume monumental work entitled *Storia delle accademie d'Italia* (Maylender, 1926-1931).The question however remains as to why a movement which started in Italy gave rise eventually to such phenomena as Newton and the Royal Society when it was transferred to other parts of Europe (Yates 1984:7).

The arrival of the Greeks in Italy for the Council of Florence in 1439 seems to have been a factor in the growth of academies in Italy (Yates 1984:8). In 1442, Ficino's *Accademia Platonica* was founded in Florence (McClellan 2002). This was no more than a country villa near Florence where Ficino pursued his research and translated the works of Plato and the Neoplatonists into Latin (Yates 1984:8). Soon, a number of such Renaissance academies were established in Florence, Rome, Naples and Venice – all devoted to the revival of classical learning, and other activities broad in scope (Yates 1984:10). These first groups were trying to reproduce the atmosphere in which Plato and his disciples carried out their intellectual discussions. Maylender (n.d. cited in McClellan 2002) singles out the *Accademia Aldina* (1495) which was founded by Aldo Manuzio (1450-1515) as the first formal 'Renaissance' academy.

From about the second quarter of the 16th century onwards, small academies began to spring up all over Italy. Of these, the *Intronati of Siena*, founded in 1525, was the first regular academy of Italy, and even the world. It was the first to call itself by a symbolical name, to elect officers, and to ordain for itself social laws (Yates 1983:13). Maylender (n.d. cited in McClellan 2002) lists approximately 2500 Renaissance academies appearing in the period 1500–1800, that were devoted to the study of subjects (not strictly sciences) such as art, music, language, architecture, history, archaeology, religion, as well as equestrian and military arts.

The discovery of America and the circumnavigation by the Portuguese explorer Vasco da Gama in AD 1497-99 began to render the Mediterranean ports less important. From that date, the primary route of goods from the Orient was through the Atlantic ports of Lisbon, Seville, Nantes, Bristol, and London. These areas quickly surpassed Italy in wealth and power. By the end of the 15th century, the Italian renaissance was fading and a number of Italy's greatest artists were choosing to emigrate. The most notable was Leonardo da Vinci (1452-1519) who left for France in 1516.

Despite the lull in the fortunes of Italy, or because of it, a new movement started to develop, and famous academies such as the *Accademia Fiorentina* began to appear after 1540. It was one of the early academies in Italy to receive official support from the rulers of Florence (Yates 1983:16). A similar academy was the *Academy of Alterati* which was founded in Florence around 1569. Among the many famous events associated with this academy was a speech by Filippo Sassetti[5] (AD 1540-1588), which included an exceptional account of academies of the time.

> *What is an Academy? Asks Sassetti; and replies it is an association of persons of good birth (nobilis) for the study of letters. How does a modern academy differ from an ancient one? Because all are equal in it, not subjected to a head or leader as were the academies of Greece. How is one to make an impresa[6] for an academy? In order to answer this question he discusses some examples of academic impresa. A good impresa in the case of his academy would be a wine vat…. For the intellectual exercises of the academicians are like the fermentation of the grapes in the vat, through which perfect wine is produced.*
>
> (Yates 1983:17)

The medieval university continued to provide the institutional basis for science and natural philosophy however, things began to change in the 17th century, primarily because of the Scientific Revolution (McClellan 1985). The fact that the Church and the state had an ever increasing influence on universities in the 16th and 17th centuries led to a growing need for the creation of 'societies' where science and scientific questions could be freely debated. Thus, academies came into existence, firstly in Italy and then across Europe (Drenth 2006:185).

Signs that universities were no longer the hubs of scientific novelty however appeared earlier. As early as 1610 – during the early days of the Accademia dei Lincei – the courts of Renaissance princes started to attract people like Galileo away from (in his case) the University of Padua. Other examples of luminaries who abandoned their university careers in search of scientific pursuits at princely courts include Copernicus, Tycho, Kepler, and Descartes (McClellan 2003). The 15th and 16th century academies provided a humanistic alternative to the pedantic university world, especially as they used languages such as Italian and French instead of the Latin of the Church. Rather than imparting dry textbook knowledge to the young, they engaged the imaginations of

5 Filippo Sassetti was a Florentine merchant who was born in Florence, Italy in 1540 AD. He travelled to the Indian subcontinent and studied Sanskrit. Writing in 1585, he noted some word similarities between Sanskrit and Italian. Sassetti died in Goa, India in 1588.

6 A device with a motto used in the 16th and 17th centuries; *broadly* **:** EMBLEM http://www.m-w.com/dictionary/impresa

mature men and (sometimes) women, bursting in the process the stale Aristotelian medieval curriculum (McNeely 2007).

3.8 The Birth of the Accademia dei Lincei, the Ascendance of Academies of Sciences and the Age of Academies

Evolving from the earlier learned associations devoted to language and literature, the *scientific* academies of Italy had the same roots as the Renaissance academies, but emerged comparatively late. Among the most famous of these are the Accademia dei Lincei[7] (Rome, 1603–1630), which was born more than eight centuries after the founding of Bayt al-Hikma in Baghdad, and the *Academia del Cimento* (Florence, 1637-1667). Both quickly become rallying points for their members.

New discoveries, made during the Scientific Revolution motivated governments of European monarchies to establish academies to stimulate the development of science. After the foundation of the *Academy dei Lincei* in Rome in 1603, the French followed with the Académie Française in 1635 in Paris, and England followed with the Royal Society in London in 1660 (McClellan 2003), while Germany followed in 1700 with the foundation of a regional academy, the *Akademie der Wissenschaften* in Berlin (Noordenbos 2002).

The Academia dei Lincei was the first 'academy of sciences' to be founded in modern times. Federico Cesi, a young Roman nobleman fascinated by science, together with a group of young men, founded the Academy (Quéré 2006b). The name of the Academy means 'Academy of Lynxes,' a name chosen by the founders because the lynx is renowned for its sharp eyesight. Evans (1980) cites Ornstein who described the Accademia dei Lincei as a scientific monastery with a fellowship when scientists were viewed with suspicion (Yates 1983:21) and in danger of condemnation.

[7] The researcher often cites this example to highlight the fact that institutionalisation of science in the Islamic civilisation took root centuries before the European civilisation although he acknowledges that it is not really apposite to compare the Accademia Nazionale dei Lincei in Italy to the Nizamiyyah Academy or Bait al-Hikma, both in Baghdad, despite an initial inclination to do so. The two institutions were quite different. For a comprehensive listing on academies of sciences the following website provides some useful information: http://www-history.mcs.st-andrews.ac.uk/Societies/Lincei.html

The founding of the Accademia dei Lincei marked a turning point in the European Renaissance. The Academy was supportive of Galileo's battle for the affirmation of the Copernican system. The Lynceans (members of the Academy) were firmly convinced, following the publication of *Sidereus nucios* (The Starry Messenger), that seeing 'the new things of the heavens' is 'truly the office of the Lynceans' (Vinti 2004: 44).

The founding of the Accademia dei Lincei ushered in the 'Age of Academies,' which started around 1590, when many learned societies in the form of private associations of men of learning who shared knowledge of nature, were founded (Hahn 1990). The Accademia itself was dissolved in 1640 after the death of its founder. It was revived again in the 19th century, and again in 1946 when it was relaunched as the Pontifical Academy of Sciences by Pope Pius XI, and continues to the present time (Ricardi 2004: 106). The *Accademia Nazionale dei Lincei*, which is the other successor of the original academy was granted its official status in 1986.

Vinti (2004: 26) suggests that it may be difficult to give a balanced judgement on the role played by the Accademia dei Lincei in the renewal of Italian and European culture, however he reiterated what Alessandrini (1965 cited in Vinti 2004) said when he claimed that the Accademia stood out as a new phenomenon for the originality of its formulation and the seriousness of its commitment.

A public, civic function for learned societies began to emerge with the establishment of the Académie Française (1635), and the foundation of the Royal Society of London (1660). The Royal Society of London was the earliest national academy of sciences 'to have taken on a form and status capable of surviving without interruption into modern times,' according to May (2005). Replicas of the Royal Society and the *Académie Royale des Sciences* in Paris formed the backbone of institutional science in 18th century (McClellan 2003). Hahn (1990) reported that Fontenelle labelled the 18th century 'The Age of Academies,' (Fontenelle was the almost perpetual secretary of the Académie

Royale des Sciences according to Heilbron (1990)) with the number of official scientific societies growing rapidly between 1650 and 1750. Then, national scientific societies such as the Royal Society in London (1660), and the Academy of Sciences in Paris[8] (1666), Berlin (1700), St. Petersburg (1724) and Stockholm (1749) were launched. After 1750, the rate of founding of academies doubled compared to the previous half-century. This enlargement continued until the French Revolution and affected the quality as well as the quantity of academicians (Frängsmyr et al. 1990a).

Several features distinguish these academies of sciences from previous organizational settings for science (McClellan 2002):

(i) Many had powerful patrons although the role of patrons eventually declined into merely a figurehead. European polities supported learned societies as they were deemed useful. In a *quid pro quo* exchange between state and institution, societies delivered technical expertise in support of governance, and, in return, societies received recognition, aid, and a margin of independence to govern their own affairs;

(ii) They were official corporate bodies with charters issued by the nation-state or other governing authority;

(iii) Many received financial support from the state, and reciprocally they performed official functions as part of formal or informal government bureaucracies;

(iv) The majority devoted themselves to research and to advancing their areas of expertise. The *Académie Française* regulated the French language and produced an official dictionary for example, while the Académie Royale des Sciences in Paris (1666) judged patent claims. The Royal Society of London provided occasional expert opinions to the British government on such matters as protecting buildings against lightning strikes;

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[8] In France, the Academy Française was founded in 1635, the Academy of Humanities in 1663, and the Academy of Sciences in 1666.

(v) As disseminators of knowledge, these famous academies encouraged their members to present the results of their research at society meetings. Their proceedings — typified by the *Histoire et Mémoires* of the Paris Académie Royale des Sciences and the *Philosophical Transactions* of the Royal Society of London – quickly became the primary vehicles for the publication of original research; and

(vi) Unlike universities at the time, their intellectual commitments were not undermined by other engagements, as they did no teaching.

Distinction can be drawn between societies *per se* and academies, as exemplified by the Royal Society of London and the Académie Royale des Sciences in Paris. Societies had a larger, less structured membership, received less government support, and thought of themselves as more independent than academies. Conversely, academies were more clearly institutions of state, with a smaller, more restricted, and often paid membership and with more explicitly defined official duties.

The Royal Society and the Académie des Sciences counted in their array of members such towering figures as Newton, Hooke, Boyle, Huyghens and Fontenelle[9]. Boyle's famous air-pump experiment, proving the existence of a vacuum, was demonstrated at the Royal Society (McNeely 2007). Thus, individuals such as the mathematical physicist Leonard Euler (1707–1784) spent their entire working life within the confines of the scientific academies, beginning at the Saint Petersburg Academy (1727–1741), continuing at the Berlin Academy (1741–1766), and ending back at Saint Petersburg (1766–1784). The case of Joseph-Louis Lagrange (1746–1814), who moved from academies in Turin to Berlin and then to Paris also shows how academies formed an institutional base for professional careers in science (McClellan 2002).While the number of learned societies continued to grow into the 19th and 20th centuries, the 'Age of Academies' ended with the French Revolution in 1789 (McClellan 2002). This is

9 Bernard le Bovier de Fontenelle (1657-1757) was a French author. He began as a poet, and more than once competed for prizes of the Académie Française.

highlighted by the relationship between the French National Assembly and the Paris Academy. Despite the many questions sent by the Assembly to the Academy; including one on the most useful division of weights, measures, and monies (the answer to which was that everything should be decimal), the two entities were clearly drifting apart (Frängsmyr et al. 1990a). The National Assembly issued an order on 8 August 1793 for the closure of the Paris Academy along with other unrepublican corporations. The suppression came only a week after the Assembly had given reassurance that the Academy's labours would protect it (Frängsmyr et al 1990a). Jean-Baptiste Biot wrote in 1803, when surveying the progress of science since the Revolution; 'if the reasons that the Academy presented to the Constituent Assembly were not altogether the true ones, that is because the sciences also have their politics: sometimes to serve men one must resolve to deceive them.' Biot gave as the hidden agenda the Academy's wish to settle the shape of the earth once and for all (Frängsmyr et al 1990a).

3.9 Summary and Discussion of Part III

For a century and a half, from their founding in 1660s through to the 1790s, the Royal Society of London and the Paris Academy of Sciences were the dominant institutions supporting research in their respective countries. They served as the models of institutionalised science in other European countries. Political events that swept through Europe during the last decade of the 18th century and through to 1840s led to the demise of many academies. The fate of the Paris Academy of Sciences during those turbulent times is a manifestation of this (Cahan 2003).

Europe’s academies, unlike Bayt al-Hikma and the academies of the Islamic world were founded from the very beginning to develop technological ideas of monetary value. Galileo, who joined the Accademia dei Lincei within two years of its establishment, spent two-thirds of his time building instruments for the commercial navy and one-third of his time teaching students (Saliba 2007a). The functions of 17th century academies were summed up by McNeely (2007) as propagating and validating the discoveries of the scientific revolution, citing in this context the publishing by the Accademia dei Lincei of some of Galileo’s work, and its open defending of his Copernicanism.

After 1800, national and regional academies continued to be valued for their prestige, and continued to function as social, political and intellectual centres of scientific elites. However, many gradually lost much of their influence due the rising importance again of universities. Academies in places such as Berlin, Gottingen, Vienna, Bologna and Edinburgh owed a great deal of their well-being to the professors at the local universities who published in the journals of the academies.

While 19th century academies were waning in terms of research, they principally served to communicate results and distribute awards and their importance for scientific research was thus primarily indirect (Cahan 2003).

Part IV: Beyond the Industrial Revolution

3.10 The Industrial Revolution: Science and Academe Elements

The Industrial Revolution, which took place during the latter part of the 18th century, had a dramatic impact on society and science in Europe and the world. It was the transformation of an economy based on manual labour to one dominated by industry and machinery. From Britain, the first country to witness the Industrial Revolution, this major shift of technological, socioeconomic and cultural conditions of the late 18th century and early 19th century spread to the rest of the world.

Musson & Robinson (1969) attempted to establish that link between the Scientific Revolution of the 16th Century and the Industrial Revolution in their book *Science and Technology in the Industrial Revolution*. They concluded that the Industrial Revolution was not the result of uneducated empiricism, but was an intellectual movement. Moreover, it was much more than one of the outcomes of the Scientific Revolution (Musson & Robinson 1969). They observed that possible links between the Scientific Revolution and the Industrial Revolution were at best tenuous, mentioning that even in Newton's days science brought no practical results and the 'revolutionary scientific discoveries of Gilbert, Harvey, Galileo and Kepler, like the new mathematics of Descartes, Fermat and Pascal, were of no immediate practical importance' (Nef 1958) (Nef 1958 cited in Musson and Robinson 1969: 12).

On the other hand, the 16th and 17th centuries prestige was conferred by distinction in *techné* (technoscience in modern parlance) rather than excellence in theology as was the case earlier, and soon all over Europe the practical applications of science became evident. A new movement of collaboration of men of study and men of the workshop or the dockyard was underway which was highlighted by Francis Bacon treatise's *The Usefulness of Experimental Natural Philosophy* (Barrington 1951, 1963 & 1964 cited in Musson and Robinson 1969: 16).

The integration of S&T evolved gradually. It first manifested itself in the use of experimental techniques to determine the reliability of new ideas regarding the natural world (Shah 2006: 82). Francis Bacon, who predicted the rise of the modern age, helped to bring it about by attacking Aristotelian epistemology. He was witnessing the dawn of modernity (Shah 2006: 83). Bacon's ideas profoundly influenced the Royal Society which was concerned with the practical applications of natural philosophy and its members keen to improve the 'mechanick arts' such as building, 'chymical' operations, as well as shipbuilding and agriculture (Sprat 1734 cited in cited in Musson and Robinson 1969: 18). Fellows including Robert Hooke, Wren, the architect, and Petty who worked on statistics and navigation (Musson & Robinson 1969: 20) shared these practical interests which were also encouraged by the Society's patron.

A distinction was appearing between 'pure' and 'applied' science as manifested by the Royal Society and the appearance of the Society of Arts in 1754 (Hudson and Luckhurst 1954 cited in Musson and Robinson 1969: 30). The period spanned by the Industrial Revolution varies from one historian to another._Hobsbawm (1996) declares that it 'broke out' in the 1780s and was not fully felt until the 1840s. According to Hobsbawm, the period from 1789 to 1848 was marked by two watershed events; the twin upheavals of the British Industrial Revolution, and the contemporaneous French Revolution.

In her book *Scientific Culture and the Making of the Industrial West*, Jacob (1997) links the Scientific Revolution to the Industrial Revolution. Hahn (2000) supports this viewpoint and explains in that Jacob relates material transformations of the late 18th century to the new scientific setting, however, he questions her argument that scientific thinking was influential in industrialisation projects in England.

The period of extreme French revolutionary fervour in the early 1790s was followed by political instability until Napoleon seized power in November 1799 (Crosland 2006). After his crowning as Emperor Napoleon I in 1804, France became a dominant military and cultural power and the leading country in science at the time, rivalled only by Britain. Although academies of sciences became less prominent as centres for research, they nevertheless retained some prestige. In his book, *Science Under Control: The French Academy of Sciences 1795-1914*, Crosland (2002), in demonstrating the importance of the French Academy during the 19th century, claimed that the greatest ambition of any moderately successful 19th century French scientist was to become a member of the elite Academy of Sciences.

Germany, which interestingly boasts the most advanced science base in Europe, missed the great age of national academy formation. This legacy has left it with many regional academies, often with distinguished and enthralling histories, but with no unambiguously defined national academy of sciences (May 2004). It had to wait for over a century after the death of Bismarck to witness her Science Minister Annette Schavan declare in 2006 that the *Leopoldina* would serve as the new German Academy of Science and science adviser to the federal government (Vogel 2007).

3.11 Discussion of Part IV

The Organisational Revolution, which coincided with the Scientific Revolution, saw the rise of ‘Baconian’ academies of sciences at the expense of universities, which took a secondary role in the assimilation and dissemination of science. New discoveries made during the Scientific Revolution motivated polities of centralistic monarchies to launch and support science academies to stimulate the development of science in their countries. The first national academies were founded in southern European countries, but when the centre of the development of science shifted to northern European countries, the northern countries too initiated the foundation of national science academies (Chambers & Quiviger 1995 cited in Noordenbos 2002).

Ample evidence exists that early in the 19th century universities were revitalized as centres of research and were back at the forefront of scientific endeavour, at the expense of learned societies and academies of sciences. The process of knowledge production and utilisation was changing and so were the roles of universities and science academies. After 1815, specialized societies and professional organizations such as the British Association for the Advancement of Science (1841), superseded the learned societies as active centres for the production of knowledge (McClellan 2002). Many renowned scientists of the 19th century such as Michael Faraday and John Dalton did not create research schools as Justus von Liebig and Friedrich Wöhler and others did in Germany (Murmann 2002:12). Britain excelled in producing a large number of excellent private scientists, who were often associated with learned societies and academies, but did not develop the institutional framework for producing a large number of qualified students who could be employed by industry (Murmann 2002).

In France, the difficulties were of a different kind. Published literature by the French Academy of Sciences admits that at the beginning of the 20th century, the Academy witnessed a decline in activity and influence. It took almost a century (2002) for the Academy to embark upon a far-reaching reform of its statutes, its membership, and its mission. Bernard (1980) however claims that reforms at the French Academy of Sciences started in 1976.

De Faria (2004) explains that the Royal Portuguese Academy of Sciences, established in 1779, co-operated too closely with the university and become entangled in the political strife of the 19th century, thereby losing sight of its scientific purpose.

Moreover, in his review of the book, *Science in Sweden: The Royal Swedish Academy of Sciences, 1749-1989*, Hiebert (1989) explains that starting in 1780 the Swedish Academy, and with it Swedish science (and in general science in Europe) went through a period of decline. This was due to a less utilitarian culture prevailing at the time that was in search of 'imagination and joy, song and music' rather than 'devoutly preached economy and material benefit.'

Across the Atlantic, the *Archives of the US National Academy of Science* (NAS 2008) show that the US government continued to find a need for the young scientific academy it earlier founded. However, the most significant act that the Academy undertook during that period was to recommend the establishment of the US Geological

Survey, and to assist in setting up a national forest service. Malone (1980: 77) goes as far as to say that between 1864 and World War I, requests from the government to the US Academy were infrequent.

The oft-repeated but apocryphal story[10], cited by Silverstein (1999), that the Head of the US Patent Office in the middle of the 19th century quit his job and recommended that the Patent Office be closed 'since soon there would be nothing left to invent,' is a reflection of the state of things at the time.

Based on the above, together with other evidence, it may be concluded that the 19th century, which Rhodes (1999), D'Souza (2000) and others described as the century of Chemistry, was a relatively dormant period of academies of sciences' role and impact on society.

3.12 Summary of Chapter Three

Increased contact with the Islamic world in Spain and Sicily, the Crusades, as well as increased contact with Byzantium, allowed Europeans to acquire and translate the works of Hellenic and Islamic philosophers and scientists, especially the works of Aristotle, Euclid, Ptolemy, Geber, al-Khwarizmi, Rhazes (al Razi), Abulcasis (Abul Qasem Al Zahrawi), Alhacen (Al Hassan Ibn Al Haitham), Avicenna (Ibn Sina), and Averroes (Ibn Rushd), among others. The development of medieval universities allowed them to aid materially in the translation of these texts, and started a new infrastructure needed for scientific communities. Unlike the rise of science in the Islamic civilization, science in the European civilization was slowly assimilated and built up over centuries without much political patronage. Only in the 17th century can evidence of strong patronage of science by the kings of Europe be seen.

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[10] Daniel E. Koshland Jr (Science, cclxvii (1995), 1575) and others have repeated this story, but Eber Jeffery has shown in 'Nothing left to invent' (Journal of the Patent Office Society, July 1940, 479–81) that the account is not accurate. Henry Ellsworth, the Patent Office head, actually said in Congressional testimony that, 'The advancement in the arts, from year to year, taxes our credulity and seems to presage the arrival of that period when human improvement must end.'

Renaissances were many. First, there was the 12th century renaissance in Europe that was triggered by the recovery of ancient learning and the discovery of the Arabic/Islamic knowledge. The 14th century witnessed the new literarily and artistic movement. In the late 15th century, there began the Italian renaissance which has been described as the rediscovery of ancient art, architecture, sculpture and literature. Finally in the 16th century and 17th century, there began a change in scientific concepts with the appearance of Copernicus and Galileo, and the beginning of the new renaissance of science (Haskins, n.d. cited in Burnett 2008).

Any fair historian of science would notice that European culture tended to deny the Islamic sources of European science. Even Copernicus and his compatriots fail to mention the Islamic origins of many of the famous scientific theories they promulgated.

Unlike academies in the Islamic civilization, academies in the European civilization – especially the early ones – were founded by the scholars themselves not by heads of state (bottom-up). Only in the 17th century did European monarchs become interested in patronising academies of sciences. The example of the Royal Society receiving its Royal Charters in 1661 and 1663 is an example of this.

Another major difference between the famous academies of the Islamic era and their European successors lies in that the latter ones were inclined to focus on the application of science rather than theoretical studies of science. Galileo's instrument-making endeavours while a member of the Accademia dei Lincei is proof of this approach to science adopted by those early European science academies. It was such Baconian ideas that influenced science academies such as the Royal Society, and enticed its members to begin to look at the practical applications of natural philosophy to improve certain engineering practices as well as shipbuilding and agriculture, establishing the footing of the Industrial Revolution that was soon to follow. In Europe, science academies bloomed when universities were losing their freedom to indulge in the scientific enterprise. When universities started to regain their prominence, science academies' started to diminish. Academies of sciences started to regain their prominence in the 20th century.

In his book entitled, *The Virtue of Prosperity: Finding Values in an Age of Techno-Affluence*, D'Souza (2000) talks about American dominance during the last decade of the 20th century stressing that technology (and science) has simply consolidated America's military, political, and cultural hegemony worldwide. He adds that domination by a leading world power was not new; the 20th century belonged to America in much the same way that the 15th century belonged to the Portuguese, the 16th to the Spanish, or the 19th to the British. In the case of the British, it can be argued that their dominance of the 19th century can partly be attributed to the advancement they made earlier in the domain of science[11].

[11] *See* Banks, Joseph, 1998. *Science in the Service of Empire*. Cambridge: Cambridgr University Press.

CHAPTER FOUR

TWELVE CENTURIES AFTER *BAYT AL-HIKMA*: S&T IN THE POST-COLONIAL ISLAMIC WORLD

> *With more than a trillion dollars in cash and a population of over a billion people, the Muslim world should be poised for a remarkable scientific explosion. Yet despite some very high-profile projects in the Gulf, including the building of massive state-of-the-art facilities for research ..., the reality is that Muslim countries tend to spend less on scientific research itself, as distinct from buildings and equipment, as compared to other countries at the same income scale. Furthermore, even where funding for science has been available, the results in terms of output–research papers, citations, and patents–are disappointingly low. Why?*
>
> Ismail Serageldin (2008)

4.1 Introduction

This chapter will not attempt to answer the question that Serageldin raises above. However, by partly looking at the indicators he mentions, it will describe the current S&T landscape in the Islamic world.

Earlier, it was shown that the Islamic world was once home to a great civilisation that cultivated science. An explanation was offered as to why the Islamic civilisation did not undergo a scientific revolution similar to that witnessed in Europe in the 16^{th} and 17^{th} centuries, one that eventually led to the industrial revolution of the 19^{th} century.

In order to understand the complete picture today, this chapter will resort to quantitative tools such as input and output STI indicators to describe the current S&T landscape in the Islamic world.

Part I: The Colonisation of the Islamic World

In this section, the question of how colonisation affected some OIC countries will be addressed.

4.2 Pseudo-Colonisation and Colonisation

The Ottoman Empire was the main power that dominated a sizeable area of the Islamic world including the Middle East. For four centuries (1517-1917) it was the ruling authority in Lebanon, Palestine, Jordan, Syria, Saudi Arabia, Iraq and North Africa. The Ottomans stepped in to fill the power vacuum by the Mamluk Sultanate which had ruled in Egypt and Syria since the 13th century (Lewis 2000: 111) while Great Britain became the *de facto* occupier of Egypt in 1882.

After World War I ended in 1918, the Ottoman Empire and Iran, which for centuries had disputed the hegemony of the region, were in danger of losing their independence. The Ottoman Empire was in ruin with its capital occupied and its enemies appropriating its territories. Iran, despite its neutrality, had served as the battleground for foreign forces including the Turks, Russians, Germans and British (Lewis 1995: 344). The territories of the Middle East were carved up between Britain and France after World War I with Britain taking control of Palestine, Jordan and Iraq and France dominating Lebanon and Syria. By the end of World War II, Arab and Islamic nation states came into being. So did Israel, which came into existence in 1948 on territories that formerly constituted most of historical Palestine. The countries of the region then embarked on pursuing socioeconomic advancement with no resources, high illiteracy and no education or S&T infrastructure, and more importantly a complete break of three centuries with a glorious past. The discovery of oil in the Middle East early in the 20th century rejuvenated the strategic importance of the Middle East that it had lost five centuries earlier. Other parts of the Islamic world were subject to systematic conquests for colonies by European powers that began in the late 18th century and lasted until World War I. In the early 1800s, the Industrial Revolution was beginning and Great Britain needed raw materials to feed its growing industry and began to colonize India for economic profit. British presence in India lasted until 1947. The modern state of

Pakistan, which was established on 14 August 1947, was carved out of the two Muslim-majority wings in the eastern and north-western regions of British India. East Pakistan –Bangladesh- was established with the partition of Bengal and India in 1947. It became independent in 1971. Malaysia –which was also under British rule- achieved its independence in 1957.

Other European players that had colonial encounters with the Islamic world included Austria, the Papacy, Portugal, Venice, Russia (Masood 2009: 188), Holland –colonizing Indonesia for centuries until the latter achieved its independence in 1949- as well as Italy which for over three decades colonised Libya (1911-1944).

Colonialism included different practices. Spanish colonizers conceived their 'territorial empire' in the New World as kingdoms joined in a greater federated monarchy. The Portuguese and Dutch viewed their colonies as 'trading-post empires.' Other Europeans practiced ethnic cleansing by replacing natives with settlers from Africa (Curtin 1990 cited in Schiebinger 2005).

As with other major powers of the time, France controlled numerous colonies and dependencies between 1500 and 1950 including most of West and North-West Africa as well as Algeria. By 1900, the geographic extent of the French empire was second only to that of England. After World War II however, the French empire contracted in rounds of decolonization (Osborne 2005). The process, inscribed in the French consciousness by the 1954 defeat at Dien Bien Phu (in Vietnam), stripped France of Vietnam, Laos, and Cambodia, followed by Morocco and Tunisia, and ultimately Algeria in 1962 (Osborne 2005). The countries that colonized vast areas of the Islamic world were, to a large extent, the same ones that constituted the early home of modern science in the 16^{th} and 17^{th} centuries, such as Italy, France, England, the Netherlands, Germany, Austria and the Scandinavian countries (Basalla 1967). These countries were home to the science that would eventually diffuse from Western Europe to the rest of the world.

4.3 Colonizer-Colonized Interaction: The Basalla Model Expanded to Education and Academe

The American historian of science George Basalla published his model of the transmission of science from a small circle of Western European countries including Italy, France, England, the Netherlands, Germany, Austria and the Scandinavian countries to the Colonies (the non-European world) during the 16th and 17th centuries, in 1967 (Basalla 1967). The three basic phases of the model have been studied by Shah (2003: 133), however in summarising them, I will use Basalla's terminology to describe the phases and add comments from Shah in brackets.

During 'phase 1' the non-scientific society or nation provides a source for European science (during the 16th through to the 18th century, Europeans were surveying the world for flora and fauna, which they were bringing back into Europe). 'Phase 2' is marked by a period of colonial science (total dependence of the colonial scientist on the Metropolis for his education, training, institutional affiliation, even tools), while 'Phase 3' witnesses the completion of the science transplantation process in the colonies and the start of their attempt to establish their independent scientific enterprise. Basalla's model has come under some criticism as being too Eurocentric, indifferent to the reverse knowledge transfer from the colonised to the colonial power and its indifference to the characteristics of the recipient milieu of the transmitted science (Raina 1999). Furthermore, the Basalla model seems to ignore how modern science was integrated into non-Western cultures (Petijean 1992 cited by Raina 1999).

For former colonies, difficulties appeared in or after phase three, i.e. when they tried to establish their independent scientific enterprise. They either faced opposition due to philosophical or religious reasons, or attempted to indigenise science by going back to their cultural roots and the sciences which their ancient cultures practised such as in the case of India and China (Goonatilake 1984 cited in Shah 2003: 122).

In his analysis of the Basalla model, Shah mentions two significant points that are relevant to this Thesis. The first relates specifically to academies of sciences, the Royal Society in particular. The second relates to the second phase of the Basalla model above. It describes how the spectrum of scientific activities related to this phase tended to broaden to include subjects other than biodiversity and natural history by referring to an example of colonial astronomy in one part of the Islamic world (Indonesia). They are:

(i) The link between Francis Bacon’s philosophy of science especially the exhortation to collect and classify data to gain practical understanding. Given Bacon’s influence in the launch of the Royal Society, it is not surprising to find many Royal Society Fellows becoming involved in the first phase of the Basalla Model, described above, namely that of surveying the world for flora and fauna.

(ii) Pyenson (1989 cited in Shah 2003) mentions astronomical observatories, meteorological stations and technical colleges that were built in Indonesia by the Dutch and managed by Dutch scientists.

Using the Basalla model as a basic template, I will argue that aspects of Western traditions in science and academe were also transplanted in the colonies as most of the colonies –especially in the Islamic world- had lost touch with their past traditions in education and academe, and found in Western traditions a model that they adopt.

Through military conquest, colonization, imperial influence, commercial and political relations and missionary activity, Western nations passed on their scientific heritage to the rest of world. During this era of Euro-colonialism, Muslims rediscovered the importance of education when they encountered ‘modernity’ and Westernization (Abdalla et al. 2006: 6), and had to come to grips with Western military, political, and economic superiority. Many colonial powers established educational and research institutions in the countries and territories they colonised. The British, who ruled the

Indian subcontinent, established a number of schools in which English was the medium of instruction for teaching such subjects as science and mathematics. As a result, the number of traditional Islamic schools *(madaris)* was gradually reduced (Abdalla et al. 2006). Starting from 1835, Arabic and Persian schooling was gradually phased out in the Indian subcontinent (Masood 2009:199).

Egypt was the first among Arab countries to borrow the French system of education by sending students to study in France and establishing modern schools (Mursi 1984: 457), particularly in the fist half of the 19th century. Muslim intellectuals and reformers of the late 19th and early 20th century, such as Jamaluddin al-Afghani and Mohammed Abdu, considered education a key component in their programmes of socio-religious reforms (Saqib 1983 cited in Abdalla et al 2006: 7). The influence of Al-Afghani and Abdu led to the rise of many eminent scientists, including Ali Mustafa Mosharrafa, the Egyptian physicist (Dhaher 2008). Mosharrafa (1898- 1950) became a Fellow of the Royal Society in 1921- the year Einstein won the Nobel Prize. At the time, he was working at the edge of quantum physics, exploring mathematically the ramifications of the Zeeman and Stark effects (Reid 1990: 101). Mosharrafa actively lobbied for the founding of the Egyptian Academy of Sciences in 1944 (Reid 1990).

Education was also the medium through which the Ottoman Empire enhanced its contacts with the West. By 1900, the Ottomans were allowing around 700 international missionary organisations to build schools and universities within their territories including the Middle East. Part of the incentive for locals was the capacity of such institutes to provide health facilities to their clients (Masood 2009:195). As a result of and as a reaction to this wave, the first university of the Ottoman Empire came into existence at around 1900 after a long struggle (Masood 2009).

During the 17th and 18th centuries, the organization of science throughout Europe – and its ever expanding assortment of colonies – was varied. Science was funded by states and trading companies, such as the British East India and Dutch East India companies (Saliba 2011). The latter group hired physicians to keep voyagers healthy in unknown lands. They also doubled as medical botanists and naturalists. Furthermore, science was financed by academies of sciences such as the Parisian Académie Royale des Sciences, and by the Royal Society (indirectly) whose president; Sir Hans Sloane (1660-1753), was involved in several schemes to search for new and profitable drugs in the American states of Virginia and Georgia. (Schiebinger 2005).

Despite this, France and Britain, the leading scientific powers in the 19th century, did not implant the learned society or academe traditions in their colonies. The founding of the *L'institut De L'Egypte* by Napoleon in 1798 was the exception. The other, which came much later, being the founding of the three Indian academies of sciences during 1930s when India was under British rule.

In the case of Egypt, Napoleon was accompanied by 167 scientists who went on to create the *Description De L'Egypte* (the main academic fruit of his campaign); which was published in Europe in 1809. The new *Bibliotheca Alexandrina* published the Description again in digital format in 2006 (Serageldin 2006a). Serageldin (2006a) claims that L'institut De L'Egypte was the first academy to be founded outside Europe, and modelled on the Institut de France. It is not linked to the more traditional Egyptian Academy of Sciences of Ali Mustafa Mosharrafa, which was launched in 1944 (Fayez 2005).

In 1919, French-controlled Damascus witnessed a short-lived attempt to establish an academy – albeit an academy of Arabic language with certain scientific elements. It was founded by the nationalist Arab government and called the Arab Scientific Academy. It was quickly converted into a language academy (Tammam 2009).

In British-India, the National Academy of Sciences of India is the oldest Science Academy of the country, founded in 1930 and is based at Allahabad. The second oldest is the Indian Academy of Sciences which was founded in 1934 to promote the cause of science in pure and applied branches. The National Institute of Sciences of India, which later on became the Indian National Science Academy (INSA), was inaugurated on 7 January 1935 (Jairajpuri 2009: 455-456).

In the republics of Central Asia, which after the demise of the Soviet Union joined the OIC, the central government in Moscow founded national academies of sciences in Uzbekistan (1943) and Kazakhstan (1946). This was a manifestation of the interest of the central government in developing science in rural areas; 'to a degree unknown in any colonial environment, the USSR attempted to level the playing field between the capital and remote territories' (Sievers 2003). Until 1945, there were only two countries that are today OIC-Members that had 'functioning' academies of sciences: Uzbekistan (Uzbekistan Academy of Sciences founded in 1943 in what was at the time the Soviet tradition), and Egypt (which established its Academy of Sciences in 1944). The idea of establishing the Pakistan Academy of Sciences (PAS) was mooted in November 1947, soon after the establishment of Pakistan. PAS was inaugurated officially in 1953.

4.4 OIC Countries after Colonisation: In Search of a Model

After the Second World War, a strange mutant type of society appeared in the majority of Muslim states that was partially Muslim in tradition and values but occidental in behaviour, thought and outlook (Sardar 1977: 11). The colonial domination of the Islamic world had not only altered the character of Muslim societies but also caused a lasting political, social, economic, demographic as well as changes in the science landscape of the colonised societies. The countries of the Maghreb; Algeria, Morocco and Tunisia are today still deeply intertwined with France and are struggling to define the gaps in their culture that resulted from the colonialist era. Although French colonialism ended decades ago, its effects are still evident throughout the Maghreb (Tarwater 2005). Economically for example, only since the late 1980s have countries in the Middle East and North Africa managed to shrug off the heavy burden of colonialism imprinted on their economies at their 'rebirth' or decolonisation (Abderrezak 2004).

Colonialism left OIC countries in a predicament. It resulted in the severing of ties between contemporary Islam and the golden age of scientific and technological advancement that the Islamic civilisation enjoyed between AD 700 and 1600. The towering figures of the golden age in science in the Islamic civilisation were all but a distant memory. The impact was huge. It changed the way people perceived their 'ideal society.' This 'society' was no longer an extension of traditional values of culture and religion, nor was it in harmony with the standards of the modern 'Western' civilisation (Shah 2003: 135).

Shah (2003) draws a comparison between this and what Thomas Aquinas had to endure in the 13th century after the influx of Arab/Islamic science into Europe. Aquinas had to rediscover Aristotelian corpus in 12th century Europe and come to terms with 'pagan' knowledge in the form of Greek philosophy and science in a mainly Catholic society. He had to harmonise Catholic philosophy with Aristotelian philosophy to pacify any confrontation between the new science and Catholicism (Grant 1977 cited in Shah 2003). Many centuries later, and in many parts of the Islamic world, post-colonial reconciliation between the ruling ideas of the coloniser and indigenous knowledge and culture has not been possible. The relatively smooth landing of science that had occurred in Western culture – and the accommodation of science within – did not happen in the Islamic world in the same way. Some former colonies –in today's Islamic world- adopted Western development planning models. Due to the quantitative means that were adopted to gauge development, many were classified as developing countries.

This made some feel inferior. Other countries perceived this classification to mean more foreign aid or as Shah (2003) calls it ‘playing dumb could be smart.’ Today, the Islamic world comprises 57 countries. There are noticeable differences in their educational and scientific systems as a result of occurrences during the colonial and postcolonial eras. The political, social, and economic peculiarities of each state have played a role in the policies they adopted to develop their educational and scientific systems (Abdalla, et al 2006: 7). Some factors can be signalled out as playing a role in the evolution of post-colonial modernization in OIC–member countries (Fazlur Rahman 1984: 43). They are:

(1) The degree of relative sovereignty retained by the country vis-à-vis the European political expansion and whether it was dominated and governed *de jure* or *de facto* by a European colonial power;
(2) The influence of the religious establishment, or religious leadership, and the character of their relationship with the governing institution before the colonial encroachment;
(3) The state of Islamic education and its accompanying culture immediately before the colonial encroachment; and
(4) The ‘flavour’ of the colonizing power—British, French, or Dutch etc.

4.5 Discussion: How is Science perceived in the Islamic World Today?

In the literature review, I mentioned that some Muslim scholars and OIC science organisations today adopt a dichotomous stand vis-à-vis science and the scientific enterprise. A stand which is a hybrid of a qualitative historical component –that lacks real depth (Kessler 1990) – and a quantitative indicator-based component. Today, the science scene in the Islamic world is blurred, rendering efforts to rejuvenate the scientific enterprise within, futile. A divide exists between essentially two schools of thought. Each, as Shah[12] outlines (Shah 2001), has its proponents who adopt differing views within the same school of thought they represent.

The first school of thought is the 'modernist' school which believes that S&T is *the* means to realize socioeconomic development, without delving too much into the spiritual and ethical features of science. Decision-makers of this inclination such as Atta-ur-Rahman[13] (Pakistan) accept quantitative techniques as the main means by which S&T is gauged. They are in harmony with the pragmatic approach, which seeks to promote pure and simple 'science,' as pursued by most science academies, national S&T agencies and bodies such COMSTECH and the ISESCO (Hoodbhoy 1992). Proponents of this school include Pervez Hoodbhoy (Pakistan) who shares this view with his mentor the late Abdus Salam. In this group, Nasr also puts people like Jamaluddin al-Afghani and Muhammad Abdu (Nasr, n.d. cited by Guessoum 2011: 108), the two influential reformers, in this category.

The other is the 'conservative' school of thought as represented by Seyyed Hossein Nasr (Iran/US), which argues that there is more to science than numbers, and that modern science has its own worldview. It is not at all value free, nor is it a purely objective science of reality irrespective of the subject studied (Nasr, n.d.). Nasr believes that 'only a science that is from the source of all knowledge, from the Knower –and cultivated in an intellectual universe in which the spiritual and the ethical are not mere subjectivisms but fundamental features- can save humanity.' He suggests that Islamic science has the potential to help the Muslim world and create a science for 'those who seek a science of nature and a technology which could help men and women to live at peace with themselves, with the natural environment, and above all, with that Divine Reality Who is the ontological source of both man and the cosmos' (Nasr 2006).

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[12] In a paper entitled *The Encounter Between Islam and the West: Changing Relationships in Knowledge and Power, with Special Reference to the History of Science*, Shah (2001) discusses the views of Syed Naquib al-Attas, Seyyed Hossein Nasr, Ziauddin Sardar, Pervez Hoodbhoy and others on the subject.

[13] Professor Atta-ur-Rahman is the Co-ordinator General of COMSTECH, former Minister of S&T of Pakistan and former Minister in-charge of Higher Education in the country.

Guessoum (2011) mentions other schools of thought including the *I'jazi* (miraculous scientific facts in the Qur'an) school –which Sardar calls Bucaillism after Maurice Bucaille,[14] and the creationist school, led by Harun Yahya, the Turkish thinker and writer.

In short, after colonisation, many OIC countries – and scholars- found themselves in a real predicament. How to develop a viewpoint on modern science that is in harmony with Islam yet projects the capacity of modern science to address problems and catalyse socioeconomic development. Needless to say, the process of rationalisation and institutionalisation of science took several centuries in Europe (Ben-David 1971 quoted in Shah 2004). Therefore, it should not surprise anybody if it takes a long time for it to happen in the Islamic world. The process however may be easier than in Europe if Muslims again realise that they have been down that road before. Contemplating on how to bridge the divide between the modernists and the conservatives is beyond the scope of this Thesis. However, such a task could be an activity that academies of sciences can be involved in, particularly in the Islamic world. However, contemporary Muslims must take a bold approach to modern S&T, work out how best to respond to the challenge the 'tool' of S&T presents and determine how this tool can be utilised to address contemporary challenges that require contemporary thinking and problem solving (Shah 2001). Some of these contemporary challenges are development-related and will be described in Part II of this chapter, which will also highlight S&T as the means to address them (See section 4.8).

[14] Maurice Bucaille, a French doctor who in the 1970s wrote an influential book entitled, *The Bible, The Qur'an and Science: The Holy Scriptures Examined in the Light of Modern Knowledge*.

Part II: S&T and Higher Education Landscape in the Islamic World Today

For two millennia, science was mostly documented in the form of scrolls and manuscripts. The ancient Library of Alexandria, in its heyday, held 700,000 scrolls (Serageldin 2006a). Only a fraction of the Islamic scientific texts produced during the golden age of Islamic science have been published, and most remain in manuscript form (McClellan & Dorn 2006: 105). Copernicus first proposed heliocentrism in an anonymous manuscript tract, the *Commentariolus*, which he circulated among professional astronomers after 1514 (McClellan & Dorn 2006: 209). Kepler worked fervently on mathematical problems for years, leaving behind some 900 manuscript pages of calculations, testimony to a heroic endeavour without the benefit of calculators (McClellan & Dorn 2006: 219). The precise role of experiment in Galileo's science and the reality of *how* Galileo came to reject Aristotle did involve considerable experimentation that was documented in voluminous manuscript records (McClellan & Dorn 2006: 239).

As contemporary quantitative tools will be used in this chapter to assess the current S&T landscape in the Islamic world, a brief overview of the documentation of science is outlined in section 4.6.

4.6 On the Documentation of Science

Many references exist that talk about the history of statistics and statistical theorems in the 18th and the 19th centuries including two books by Stigler (1986) and Hald (1998). In the 18th century, scientists began to portray science as a source of progress, mainly to encourage funders to finance their work. Their discourse was determined by the arguments that science inculcates intellectual virtues such as objectivity, logic and rationality in individuals (Turner 1980 cited in Godin 2000); and that science drives socioeconomic progress (Stewart 1992; Golinski 1992 cited in Godin 2000). Statistics were developed by the state and were driven with a view to population control and social intervention (Hacking 1986; Desrosieres 1990; Porter 1997; Brian 1994; cited in Godin 2000) and to boost a ruler's prestige as population numbers reflected the strength of the state (Heilbron 1990). However, during the 20th century, the measurement of S&T has taken on a new form with the appearance of S&T indicators. This can be attributed to the US's National Science Foundation (NSF) and the Organisation of Economic Cooperation and Development (OECD) when the latter decided, in 1962, to produce a manual on R&D statistics based on the concepts developed by the NSF. This led to appearance of the Frascati Manual in 1963 (Godin 2001).

In OIC countries, apart from a few national agencies such as MASTIC[15] in Malaysia and pan Islamic ones such SESRIC[16] in Ankara, agencies involved in measuring S&T components are non-existent. Normally, heavy reliance is made on the statistics produced by the UNESCO Institute of Statistics.

To introduce this part, the following modern definition of S&T indicators is proposed. Indicators for S&T may be defined as '*statistics which measure quantifiable aspects of the creation, dissemination and application of science and technology. As indicators, they should help to describe the science and technology system, enabling better understanding of its structure, of the impact of policies and programmes on it, and of the impact of science and technology on society and the economy*' (Wilk, n.d. quoted in Shodjai 1996).

As I have indicated in the literature review, some researchers remain critical of the quantitative approach that produces publications containing assortments of STI indicators. Shah (2004), in Malaysia, does not feel that they capture all essential facets relating to S&T in the country.

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15 The Malaysian Science and Technology Information Centre. [Online]. Available at http://www.mastic.gov.my/ [Accessed 16 May 2010].

16 The Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC), was founded as a subsidiary organ of the Organisation of the Islamic Co-operation (OIC). The Centre started its activities in Ankara on 1 June 1978. [Online] Available at: http://www.sesrtcic.org/sesric-about.php [Accessed 16 May 2010].

4.7 What constitutes the Islamic World today?

The above question was posed by Sardar (1977) in his book *Science*, *Technology and Development in the Muslim World*. Since then, the Cold War has ended but many hot wars have erupted in what is known today as the Islamic world. The term 'Islamic world' was coined by the American political theorist and anti-immigration advocate Lothrop Stoddard (1883-1950) (Dajani 2000). It has become internationally accepted term to describe the group of countries where the majority of the population follow the Muslim faith. These countries today belong to the OIC (Nature 2006). The OIC was founded in 1969, after the infamous arson attack at the *Aqsa* Mosque in Jerusalem. It is the second largest inter-governmental organization after the United Nations and its membership is comprised of 57 states spread over four continents. Unlike the G77 or the Non-Aligned Movement (NAM), the OIC has a broad multi-faceted mandate that is similar to that of the United Nations'.

The OIC started out as a political forum. However, it quickly embarked on economic programmes. This was evident in its charter of 1972, which reiterated the necessity for co-operation for community-wide economic progress as well as individual and collective economic capacity (Hassan & Islam 2001). Twelve years after its founding, the OIC established three ministerial committees: Information and Cultural Affairs (COMIAC)**,** Economic and Commercial Co-operation (COMCEC) and the Standing Committee on Scientific and Technological Co-operation (COMSTECH), the latter of which is based in Islamabad (Pakistan), and is active in the field of S&T.

The Islamic world occupies an area of 26.6 million square kilometres (km^2), which is equivalent to 19.9% of the total global land area (Daghestani and Altamemi 1991). It extends from Indonesia in the east to the Atlantic Ocean in the west, and from the city of Kazan in the Russian republic of Tatarstan in the north to the source of the Nile in Uganda, in the south. OIC countries – together with Muslims in India, Russia and China

– account for a population that exceeds 1.6 billion (Table 4.1) (SESRIC 2009a). In general, terms, Muslims are young. This is both an opportunity and a challenge, as young populations can stimulate growth and create dynamic societies but they need good schools, universities and jobs. Although they make up 22% of the global population, the 57 OIC countries account for only 6.8% of the world total output (GDP) and 9.8% of world total merchandise exports (SESRIC 2009a). OIC countries are well endowed with high economic potential in different sectors such as energy and mining (mainly oil and gas), agriculture and arable land and human resources. Although they occupy a vast strategically-located trading region, they do not make up a homogeneous economic group in terms of economic development levels and economic performance (SESRIC 2009a). Table 4.2 shows the average GDP per capita of OIC countries in 2006.

The high HDI group of OIC countries are characterized by small population and almost total economic dependence on natural resources, particularly oil. It includes Brunei Darussalam, the Gulf States of Kuwait, Qatar, the United Arab Emirates, Bahrain, Oman and Saudi Arabia. The Science, Technology and Innovation (STI) and higher education systems in these countries are new but expanding rapidly due to sizeable investments by heads of state and governments (UNDP 2007). 32 OIC countries feature in the medium category according to the 2007/2008 UNDP Human Development Report (UNDP 2007), while 11 have been grouped under the 'low human development' category with Sierra Leone occupying the lowest rank. Over the last decade, the level of human development in the OIC region has risen.

Sub-Saharan Africa witnessed an economic boom during the middle of the decade which, according to the 2006 World Bank Development report (World Bank 2006), was remarkable. It culminated in five years of growth after two decades of decline. Among the OIC countries of this group, Chad's economy grew by more than 10% per year and

Nigeria’s by 6% (Butler 2006). However, economic levels remain poor, with growth rates usually far below the 7% minimum considered necessary to begin meeting the MDGs. Several countries, including Côte d’Ivoire and Gabon, still show negative growth.

In the majority of OIC countries, governance is in a state of turmoil. Many regimes are torn between upholding security –as they perceive it- on the one hand, and adopting good governance practices on the other, including: promoting accountability, transparency and combating corruption. Table 4.3 shows military expenditures in a number of OIC countries as a percentage of GDP. They remain the highest in the world. The top seven per capita military spenders in the world are Middle Eastern countries (six belong to the OIC); Oman, Qatar, Saudi Arabia, Iraq, Jordan, Israel and Yemen (CIA 2008).

Notwithstanding the security issue, OIC regimes can still create milieus that can help knowledge and knowledge-based industry to flourish. By allowing citizens to enjoy basic freedoms, they may mitigate the brain flight of scientists and intellectuals.

Table 4.1 Population of OIC countries in 2005

Countries	Population (2005)	Countries	Population (2005)	Countries	Population (2005)
Arab Countries		**African**		**Asian**	
1. Algeria	32.9	1. Benin	8.5	1. Afghanistan	…
2. Bahrain	0.7	2. Burkina Faso	13.9	2. Azerbaijan	8.4
3. Egypt	72.8	3. Cameroon	17.8	3. Bangladesh	153.3
4. Iraq	N/A	4. Chad	10.1	4. Brunei Darussalam	0.4
5. Jordan	5.5	5. Comoros	0.8	5. Indonesia	226.1
6. Kuwait	2.7	6. Cote d'Ivoire	18.6	6. Iran	69.4
7. Lebanon	4.0	7. Djibouti	0.8	7. Kazakhstan	15.2
8. Libya	5.9	8. Gabon	1.3	8. Kyrgyzstan	5.2
9. Mauritania	3.0	9. Gambia	1.6	9. Malaysia	25.7
10. Morocco	30.5	10. Guinea	9.0	10. Maldives	0.3
11. Oman	2.5	11. Guinea-Bissau	1.6	11. Pakistan	158.1
12. Palestine	3.8	12. Mali	11.6	12. Tajikistan	6.6
13. Qatar	0.8	13. Mozambique	20.5	13. Turkey	73.0
14. Saudi Arabia	23.6	14. Niger	13.3	14. Turkmenistan	4.8
15. Somalia	N/A	15. Nigeria	141.4	15. Uzbekistan	26.6
16. Sudan	36.9	16. Senegal	11.8	**Total**	**773.1**
17. Syria	18.9	17. Sierra Leone	5.6	**Other**	
18. Tunisia	10.1	18. Togo	6.2	1. Albania	3.2
19. United Arab Emirates	4.1	19. Uganda	28.9	2. Guyana	0.7
20. Yemen	21.1	**Total**	**323.3**	3. Suriname	0.5
Total	**279.8**			**Total**	**4.4**

UNDP Human Development Report 2007-2008.

Table 4.2 GDP per capita in OIC Countries in 2006

HDI Rank 2008	COUNTRY	(US$PPP)	HDI Rank 2008	COUNTRY	(US$PPP)
	1. Afghanistan	…	52	29. Libya	13,362[m]
69	2. Albania	5,884	63	30. Malaysia	12,536
100	3. Algeria	7,426[m]	99	31. Maldives	5,008
97	4. Azerbaijan	6,172	168	32. Mali	1,058
32	5. Bahrain	34,516[f]	140	33. Mauritania	1,890
147	6. Bangladesh	1,155	127	34. Morocco	3,915
161	7. Benin	1,259	175	35. Mozambique	739
27	8. Brunei	49,898[d]	174	36. Niger	612
173	9. Burkina Faso	1,084	154	37. Nigeria	1,852
150	10. Cameroon	2,043	53	38. Oman	20,999[f]
170	11. Chad	1,470	139	39. Pakistan	2,361
137	12. Comoros	1,152	106	40. Palestine	…[aa]
166	13. Cote D'ivoire	1,632	34	41. Qatar	72,969 [d,f]
151	14. Djibouti	1,965	55	42. Saudi Arabia	22,053
116	15. Egypt	4,953	153	43. Senegal	1,592
107	16. Gabon	14,208	179	44. Sierra Leone	630
160	17. Gambia	1,152		45. Somalia	…
167	18. Guinea	1,118	146	46. Sudan	1,887
171	19. Guinea Bissau	467	89	47. Suriname	7,268[m]
110	20. Guyana	2,782[m]	105	48. Syria	4,225
109	21. Indonesia	3,455	124	49. Tajikistan	1,609
84	22. Iran	10,031	159	50. Togo	792
	23. Iraq	….	95	51. Tunisia	6,958
90	24. Jordan	4,654	76	52. Turkey	11,535
71	25. Kazakhstan	9,832	108	53. Turkmenistan	4,826 [f,m]
29	26. Kuwait	46,638 [d,f]	156	54. Uganda	888
122	27. Kyrgyzstan	1,813	31	55. United Arab Emirates	49,116 [d,f,m]
78	28. Lebanon	9,757	119	56. Uzbekistan	2,189[m]
			138	57. Yemen	2,262

UNDP Human Development Report 2007/2008, Human Development Index.

c. For purposes of calculating the HDI, a value of 99.0% was applied.
d. For purposes of calculating the HDI, a value of 40,000 (Purchasing Power Parity (PPP) US$) was applied.
f. Data refer to a year other than that specified.
m. World Bank estimate based on regression.
aa. An estimate of 2,073 (PPP US$) was used, derived from the value of GDP in US$ and the weighted average ratio of PPP US$ to US$ in the Arab States.

Table 4.3 Military expenditure in Some OIC countries in 2005

COUNTRY	Military expenditure (% of GDP)	COUNTRY	Military expenditure (% of GDP)
1. Albania	1.4	25. Libya	2.0
2. Algeria	2.9	26. Malaysia	2.4
3. Azerbaijan	2.5	27. Mali	2.3
4. Bahrain	3.6	28. Mauritania	3.6
5. Bangladesh	1.0	29. Morocco	4.5
6. Brunei Darussalam	3.9	30. Mozambique	0.9
7. Burkina Faso	1.3	31. Niger	1.2[e]
8. Cameroon	1.3	32. Nigeria	0.7
9. Chad	1.0	33. Oman	11.9
10. Cote D'ivoire	1.5[e]	34. Pakistan	3.5
11. Djibouti	4.2[b]	35. Saudi Arabia	8.2
12. Egypt	2.8	36. Senegal	1.5
13. Gabon	1.5	37. Sierra Leone	1.0
14. Gambia	0.5[e]	38. Sudan	2.3[b]
15. Guinea	2.0[e]	39. Syria	5.1
16. Guinea Bissau	4.0	40. Tajikistan	2.2[e]
17. Indonesia	1.2	41. Togo	1.5
18. Iran	5.8	42. Tunisia	1.6
19. Iraq		43. Turkey	2.8
20. Jordan	5.3	44. Turkmenistan	2.9[e]
21. Kazakhstan	1.1	45. Uganda	2.3
22. Kuwait	4.8	46. United Arab Emirates	2.0
23. Kirghizstan	3.1	47. Uzbekistan	0.5[e]
24. Lebanon	4.5	48. Yemen	7.0

b: Data are for an earlier year
Source: UNDP (2007/2008): *Human Development Report*.
http://hdr.undp.org/en/reports/global/hdr2007-2008/chapters/

Table 4.4 OIC countries that have/host academies of sciences

	Country	Academy of Sciences	
1.	Afghanistan	Afghanistan Academy of Sciences	1969
2.	Albania	Albanian Academy of Sciences	1972
3.	Azerbaijan	Azerbaijan National Academy of Sciences	1945
4.	Bangladesh	Bangladesh Academy of Sciences	1973
5.	Cameroon	Cameroon Academy of Sciences	1990
6.	Egypt	Academy of Scientific Research and Technology (ASRT)[17]	1948
		Egyptian Academy of Sciences	1944
		Institute D'Egypte	1798
7.	Indonesia	Indonesian Academy of Sciences (AIPI)	1990
8.	Iran	Academy of Sciences of the Islamic Republic of Iran	1987
9.	Iraq	Iraq Academy of Sciences	1947
10.	Jordan	Islamic World Academy of Sciences (IAS)	1986
11.	Kazakhstan	National Academy of Sciences of the Republic of Kazakhstan	1946
12.	Kyrgyzstan	Academy of Sciences of the Kyrgyz Republic	1993
13.	Lebanon	Arab Academy of Sciences (AAS)	2002
		Académie des Sciences du Liban (ASL)	2007
14.	Morocco	Hassan II Academy of Sciences and Technology	2006
15.	Malaysia	Academy of Sciences Malaysia (ASM)	1995
16.	Nigeria	Nigerian Academy of Sciences	1977
17.	Palestine (West Bank)	Palestine Academy of Sciences and Technology (PALAST)	1997
18.	Senegal	Academy of Sciences and Techniques of Senegal.	1997
19.	Sudan	Sudan National Academy of Science	2006
20.	Tajikistan	Academy of Sciences of the Republic of Tajikistan	1951
21.	Turkmenistan	Turkmenistan Academy of Sciences	…
22.	Turkey	Turkish Academy of Sciences (TÜBA)	1993
23.	Uganda	Uganda National Academy of Sciences (UNAS)	2000
24.	Uzbekistan	Uzbekistan Academy of Sciences	1943

Source: Compiled by Zou'bi, M. R. from personal contacts and interviews and the InterAcademy Panel website. [Online] Available at: http://www.interacademies.net/CMS/2950/4016.aspx [Accessed 4 April 2010].

4.8 S&T in the Islamic World

In the 57 OIC countries, S&T is the responsibility of a variety of departments, depending on the country. In some, ministries of higher education and scientific research are responsible for R&D activities. Councils and governmental academies are responsible for the same in countries of central Asia. Universities and research centres are responsible for R&D activities in four Arab OIC countries, ministries of education in three Arab OIC countries while in one OIC country, the ministry of planning is responsible for R&D activities at the national level (Saleh 2008). In Malaysia, the Ministry responsible for S&T was recently renamed MOSTI; the Ministry of Science, Technology and Innovation.

[17] The Egyptian Academy of Sciences and Technology (ASRT) is a fully fledged S&T department under the Minister of State for R&D.

The existence of a national academy of sciences in a country is an expression of the country's commitment to S&T. In 2008, only 24 OIC countries out of 57 had national academies of sciences or played host to one (Table 4.4). This is a surprising fact as academies of sciences, as advocates of science and advisory bodies have been at the vanguard of the scientific endeavour in advanced countries such as the United Kingdom, and France; as well as in rising economies such as China, India, Mexico, Brazil and Malaysia.

Interest in S&T in the majority of OIC countries began to develop after World War II, when most of the OIC countries became independent. Universities and research centres were founded mostly by central governments from the 1960s onward.

Only a few OIC countries today have national policies for S&T. Many are still in the process of formulating S&T policies/strategies. Jordan, for example, founded its main national university – the University of Jordan – in 1962, and its main industrial research centre –the Royal Scientific Society in 1970- yet only adopted its National S&T Policy in 1995 (HCST 2005). Saudi Arabia only adopted its national S&T policy in 2003 (al-Athel 2003). Where S&T policies exist, they are either too ambitious or ambiguous. Further, with the exception of Malaysia, which has assigned the ministry of S&T the responsibility, innovation has not yet become a part of the S&T parlance in many OIC countries. This may be attributed to the weak linkages between industry and R&D organizations. This is also evident from the low patent output.

In 2003, Tunisia carried out an innovation survey as a first step towards remedying this situation. Tunisia ranks 40th in terms of its capacity for innovation out of 133 economies covered by the Global Competitiveness Report of the World Economic Forum. Qatar is the leading OIC country in the survey (22nd), United Arab Emirates (23rd), Malaysia (24th), Saudi Arabia (28th), Brunei Darussalam (32nd), Bahrain (38th), Kuwait (39th), Oman (41st) and Jordan (50th) (World Economic Forum 2010).

Recent developments include the establishment of science parks in Bahrain, Morocco, Qatar, Saudi Arabia, Tunisia and the United Arab Emirates represents a move towards partnerships in innovation between private and public R&D. In 2009, Jordan launched El-Hassan Science Park as part of a major science project in Amman, and Egypt was setting up its own science park (UNESCO 2010: 73-101).

But why should any OIC country have an S&T policy in the first place? What would the objective of such a policy be? Dr Mahathir Muhammad, the former Prime Minister of Malaysia, stated back in 1992 that the basic objective of the Malaysian S&T policy was to help Malaysia to become fully developed by the year 2020 (IAS 1994b). President Kennedy, in a presidential address in 1961, said that the objective of the US space programme (part of the US S&T policy) was to put a man on the moon before the end of the decade (the 60s) (IAS 1994b). It is critical that the objectives of any S&T policy are clearly stated – and understood by the executive branch of the government – as a foundation for its implementation and the public comprehension of it. For any OIC country, for instance, is the objective of its S&T policy to roll society into a fully industrialized one that nourishes an export-oriented economy? It would be beneficial if reasonable targets were set at the outset, as this would provide the implementing agencies with the capacity to appraise their policy and overcome any shortcomings in implementation.

Knowledge is necessary to address problems and generate wealth. Historically, progress in many walks of life has been associated with the output of research activity, i.e. knowledge and its effective utilisation (ESCWA 2003). The conversion of R&D findings into innovation-based products, processes and services is essential to ensure that economic benefit from scientific research is realised (Thiruchelvam 2003). Notwithstanding Baconian influences on science in the 17th century, there is evidence that science, engineering, technology and innovation have a direct effect on economic growth and development in both developed and developing nations (Ward et al. 2009). The ability of nations to solve problems and initiate and sustain economic growth depends partly on their capabilities in science, technology, and innovation (Chen and Feng 2000 & Wang and Yao 2004 cited in UN Millennium Project 2005). S&T are linked to economic growth, and scientific and technical capabilities determine the ability to provide clean water, good health care, adequate infrastructure, and safe food.

Development trends around the world highlight the role that science, technology, and innovation play in economic transformation in particular and sustainable development in general (Juma et al. 2001 cited in UN Millennium Project 2005).

The Millennium Development Goals (MDGs) –adopted in 2000- are development 'yardsticks' to which politicians can relate when formulating/evaluating policies. The MDGs are set of 8 goals, 18 targets, and 48 performance indicators relating to poverty reduction, including income and non-income measures of well-being (UNDP 2008).

Achieving the MDGs will require the implementation of development policies that promote economic growth, including those associated with new and established scientific and technological knowledge and related institutional adjustments. To promote the use of science, technology, and innovation for development, countries need to adopt strategies for technological learning at the national and international levels and promote interactions between government, industry, academia, and civil society (UN Millennium Project 2005: 144).

At the 2002 UN World Summit on Sustainable Development (WSSD) former Secretary-General Kofi Annan outlined five key priority areas that have a profound effect on the way humans live. The concept of 'WEHAB' covering Water, Energy, Health, Agriculture and Biodiversity, encapsulated the areas where action was needed (Anan 2002). In WEHAB, OIC countries have priority areas to address. Other priorities that should be addressed include wealth creation for their nations and contribution to world civilisation in all fields.

OIC countries have been –throughout the 1980s and 1990s- making an effort to enhance their S&T capabilities. Some have managed to implement a number of major programmes. Countries such as Malaysia, Pakistan, Jordan, Egypt, Tunisia and the UAE reacted promptly to the ICT revolution and made up for lost development opportunities. The 2003 OIC Summit adopted a yardstick to measure development in the domain of S&T to which policy-makers and the public can relate: Vision 1441, which is a set of goals, and a number targets and performance indicators relating to the S&T status that OIC countries have to achieve by the year 2020. These indicators stipulate that by 2020, each OIC country should spend 1.4% of its GDP on R&D, that the OIC community of countries should contribute 14% to the world's output of publications, and that the number of Full Time Equivalent (FTE) researchers and engineers should become 1441 per million of population. It manifests a commitment by OIC-Member countries to doing all they can to achieve these targets by 2020 (Nor and Zou'bi 2008). Unlike the MDGs – which lack the clear S&T component- Vision 1441 serves as a visionary challenge to help galvanize new energy for the S&T development agenda.

4.9 R&D Inputs: Researchers and GERD

Estimating R&D personnel is a difficult task as counting only individuals whose primary function is to perform R&D would result in underestimating the national effort. On the other hand, to do a headcount of everyone spending some time on R&D would lead to an overestimate (UNESCO 2010). The number of individuals engaged in R&D must, therefore, be expressed in full-time equivalents (FTE) of the time spent on R&D, both in the government and private sectors. The FTE researchers per million population figures for some OIC countries are shown in Table 4.5. The figures for Algeria, Mauritania, Morocco and Oman include FTE researchers at government universities, while the figures for the other countries do not (Saleh 2008). The numbers for the majority of OIC countries are small if compared for example to Chile which has 832 FTE Researchers per million population, 1,301 in Israel and 2,681 in Ireland (World Bank 2008). The number of researchers per million population among OIC member countries, according to Shah and Thiruchelvam (2006) is about one-sixth that of the world average. For the majority of OIC countries, the professionalization of S&T has not taken root.

Research scientists working in oil rich countries such as Saudi Arabia, Qatar, Oman, Kuwait and UAE are mostly expatriate foreign scientists. This reflects the failure on the part of these governments to attract local students to take up careers in science and engineering (Naim and Rahman 2008). Poor prospects have led to the loss of thousands of highly qualified citizens of OIC countries who are now working in the developed world. This ‘brain drain’ could be turned into a ‘brain gain’ if OIC governments engaged their highly qualified expatriate citizens in domestic R&D programmes. Partnerships, rather than repatriation efforts, should be the focus among member countries to harness their expatriates’ talents (Shah and Thiruchelvam 2006). The ‘brain drain’ is a serious problem that has been plaguing many OIC countries – especially African countries. In 2009, the Network of African Science Academies (NASAC), urged the governments of the G8+5 grouping (the G8 plus Brazil, China, India, Mexico and South Africa) to help Africa rebuild its university sector and facilitate training programmes that would discourage African students from leaving Africa to rich counties where they would be more likely to stay (Nording 2009).

Only a few researchers from the Islamic world have been internationally recognised. Out of the 60 women honoured with the L'Oreal-UNESCO Awards for Women in Science from 1998-2009, nine represented OIC countries: Nigerian Biochemist Grace Oladunni Taylor (1998), Nigerian Molecular Geneticist Adeyinka Gladys Falusi (2001), Egyptian Geneticist Nagwa Meguid (2002), Egyptian Physicist Karimat El- Sayed (2003), Turkish Physicist Ayse Erzan (2003), Tunisian Physicist Zohra Ben Lakhdar (2005), Habiba Bouhamed Chaabouni (Tunisia) who was awarded the Prize in 2007, Lihadh al-Gazali **(**United Arab Emirates) who won the Prize in 2008, and Rashika El Ridi (Egypt), who was awarded the Prize in 2010 (L'Oreal 2010).

Furthermore, the list of the world's top 100 highly cited scientists only included four scientists from OIC countries in 2009; Prof. Boudjema Samraoui, a biologist at the University of Annaba in Algeria; Prof. Jawad Salehi (Iran); Prof. Shahid H. Bokhari (Pakistan) in the field of computing; Prof. Halil Mete Soner who is a mathematician from Turkey (ISI 2009). The name of IAS Fellow; Mohammad Sajjad Alam also appeared on the list. He is an American physicist of Pakistani roots. Moreover, only three scientists who trace their roots to the Islamic world have won Nobel Prizes in scientific streams. The first was Abdul Salam who the Nobel Prize in Physics in 1979. The second was Ferid Murad, a second generation American medical doctor of Albanian roots who was awarded the Nobel Prize in medicine in 1998. The third Nobel laureate from the Islamic world in a scientific discipline was Egyptian-born Ahmed Zewail. He received the distinction for chemistry in 1999 while working at the California Institute of Technology in the USA (Nobel Prize 2010). It is worth noting that none of the three scientists actually worked in OIC countries, and were mostly based in the west where the research environment is more attractive.

Average Gross Expenditure on Research and Development (GERD) expenditure in the majority of OIC countries stood at around 0.42% of GDP (Naim and Rahman 2008) whereas advanced countries spend over 2.5% of GDP on R&D. Table 3.6 shows the Gross Expenditure on R&D (GERD) as a percentage of GDP for some OIC-Member countries in 2006. Countries such as Egypt, Qatar and Tunisia have set themselves ambitious targets for GERD. In November 2006, Qatar announced that it was boosting its GERD to 2.8% of GDP over five years (Shobakky 2007). Since then, Qatar has launched a number of initiatives in S&T and education and is approaching this figure for GERD (Weingarten 2009). The figure for Egypt climbed to 0.24% of GDP in 2008 and plans are under way to raise it to 1% of GDP over the next five years. Tunisia's spending on R&D has been climbing steadily since 2000. In 2006, it was the leading OIC Arab country in terms of its R&D effort, which stood at more than 1% of GDP. The government's objective is to reach a GERD/GDP ratio of 1.25% by 2009, of which 19% would be funded by the business sector (Arvanitis and Mhenni 2007). Jordan has recently invoked a law whereby 1% of the net profit of public shareholding companies is transferred to a special R&D fund to finance research. Another law was introduced that compels public and private universities to allocate 5% of their budgets annually for R&D. These measures have raised Jordan's GERD in 2009 to around 0.55% of GDP (Badran 2010).

Out of 131 countries studied, Tunisia ranked 36th in terms of private sector expenditure on R&D, Qatar and the UAE both ranked 42nd, Jordan 96th, Egypt 99th, Syria 108th and Bahrain 119th (Waast 2008).

4.10 R&D Output: Publications and Patents

An indicator of particular interest to academies of sciences in OIC countries reflects the number of publications from a country/research institution/scientist appearing in internationally recognized journals.

The total scientific and technical publications of OIC countries between 1996 and 2005 stands at 275,999 (Table 4.7). The total number of articles published during the ten years 1996-2005 varies from 16 in Somalia to 87,629 in Turkey. On the other hand, two prestigious American universities, MIT and Stanford, published 99,644 articles in the same period. When we compare the OIC regional groups, OIC Asia ranks first with 147,494 articles, followed by the OIC Arab countries (105,218) and the OIC African countries (24,287) (SESRIC 2009). Table 4.8 shows the latest available data for the number of scientific and technical articles published by OIC countries published in 2000 and 2006. Turkey, Iran and to a lesser extent Egypt have made marked progress in terms of the number of scientific publications in 2000 and 2006. Table 4.9 shows that there has been an increase in the number of patents acquired by OIC countries from 2004 to 2008, however the fact remains that a country such as South Korea, which in the 1960s was on level par with Egypt in terms of S&T output, acquired an astonishing 8,410 patents in 2008, compared to the total for OIC countries which stood at 317 (USPTO 2009).

OIC countries contributed just 0.05 percent to the share of patents granted in the United States during 1963- 2007**.** Patent statistics from the World Intellectual Property Organisation (WIPO) for applications filed by residents and non-residents during 1997-2006 show just a 0.56 percent contribution in the patent applications filed by residents and 2.12 percent from non-residents of OIC countries (USPTO 2009 and WIPO 2009 cited in Naim and Rahman 2008).

Table 4.5 FTE Researchers/million population for some OIC countries in 2006

Country	FTE Researchers / million population 2006
Jordan	588
Qatar	588
Tunisia	555
Egypt	451
Libya	361[b]
Oman	252
Sudan	252[c]
Kuwait	240
Morocco	186
Algeria	179
Mauritania	156
Yemen	23

Source:
Saleh, Nabiel (2008): S&T Indicators in the Arab States (2006). UNESCO/ALECSO/AAS, Cairo.
B indicates Human Development Report 2007.
C The World Bank Website: Knowledge for Development Scoreboard [Online] Available at: http://info.worldbank.org/etools/kam2/KAM_page3.asp?default=1 [Accessed 13 December 2008].

Table 4.6 Gross Expenditure on R&D (GERD) as a percentage of GDP for some OIC Countries and Comparators in 2006*

Country	GERD as % of GDP	Country	GERD as % of GDP
Algeria	0.22[c]	Oman	0.17[c]
Azerbaijan	0.30 [e]	Pakistan	0.22
Bahrain	0.04[d]	Palestine (West Bank)	…
Bangladesh	0.62 [e]	Qatar	0.33[c]
Brunei Darussalam	0.03 [e]	Saudi Arabia	…
Burkina Faso	0.17 [e]	Sudan	0.3
Egypt	0.19[b]	Syria	0.12[d]
Indonesia	0.05[e]	Tunisia	1.03
Jordan	0.55[f]	Turkey	0.66 [e]
Kazakhstan	0.22[e]	Uganda	0.81[e]
Kuwait	0.18	United Arab Emirates	0.1[d]
Kyrgyzstan	0.20[e]	Israel	4.5
Libya	…	United States	2.7
Malaysia	0.69[e]	South Korea	2.6
Mauritania	0.5[c]	China	1.4
Morocco	0.75	India	0.8
Mozambique	0.59 [e]	Ireland	1.2

Source:
a The World Bank Website: Knowledge for Development Scoreboard Available online: http://info.worldbank.org/etools/kam2/KAM_page3.asp?default=1 (Accessed 13 December 2008).
B Human Development Report 2007.
C Saleh, Nabiel (2008): *S&T Indicators in the Arab States (2006).* UNESCO/ALECSO/AAS, Cairo, Egypt.
D Waast, Roland (2008): Draft Regional Report on Arab Countries. UNESCO.
E The Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC) http://www.sesrtcic.org/stat_science.php
f Badran, A. & Zou'bi, M. R.: Personal interview with Prof. Adnan Badran, former Prime Minister of Jordan; 20th February 2010.
* Data for 2006 or latest available up to 2006.

Table 4.7 Scientific and Technical articles published (1996-2005)

Country	Scientific and Technical Journal Articles Published (1996-2005)	Country	Scientific and Technical Journal Articles Published (1996-2005)
Turkey	87,629	Gabon	619
Egypt	27,247	Mali	592
Iran	21,596	Niger	590
Saudi Arabia	16,840	Libya	586
Malaysia	10,894	Albania	456
Morocco	10,045	Togo	422
Lebanon	9,149	Mozambique	416
Nigeria	8,774	Kyrgyzstan	407
Pakistan	7,844	Yemen	496
Tunisia	7,454	Brunei	475
Jordan	6,514	Palestine	264
Kuwait	5,900	Tajikistan	176
Indonesia	5,087	Guinea-Bissau	175
Algeria	4,984	Guyana	151
Bangladesh	4,686	Mauritania	148
Uzbekistan	4,725	Chad	111
Oman	2,499	Sierra Leone	108
Cameroon	2,451	Turkmenistan	94
Kazakhstan	2,242	Afghanistan	59
Uganda	2,025	Suriname	48
Azerbaijan	2,010	Maldives	25
Senegal	2,004	Djibouti	24
UAE	1,961	Comoros	18
Syria	1,424	Somalia	16
Benin	1,264		
Guinea	1,107	**OIC Total**	**275,999**
Sudan	1,070		
Côte d'Ivoire	1,015	Finland	86,608
Burkina Faso	970	Greece	65,107
Bahrain	840	Ireland	60,609
Iraq	772	Hungary	48,842
Gambia	745	Stanford University	59905
Qatar	746	MIT	49,748

Source: ISI Web of Knowledge Database, which presents all articles covered by Science Citation Index Expanded (SCI-EXPANDED), Social Science Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI). SESRIC Website (Accessed 1 October 2007).

Table 4.8 Scientific publications by OIC countries; and scientific publications in collaboration, 2000-2006.

COUNTRY	Scientific publications 2000	Collaborative scientific publications 2000	Scientific publications 2006	Collaborative scientific publications 2006		COUNTRY	Scientific publications 2000	Collaborative scientific publications 2000	Scientific publications 2006	Collaborative scientific publications 2006
Afghanistan	…	…	11	9	30.	Malaysia	854	376	1,836	876
Albania	31	18	33	28	31.	Maldives	1	1	4	2
Algeria	412	256	950	568	32.	Mali	32	31	98	89
Azerbaijan	161	46	232	107	33.	Mauritania	16	15	20	17
Bahrain	54	10	119	57	34.	Morocco	1,052	611	990	578
Bangladesh	373	197	594	421	35.	Mozambique	28	24	65	56
Benin	65	45	116	96	36.	Niger	42	29	66	52
Brunei-Darussalam	35	15	28	23	37.	Nigeria	794	214	1,159	329
Burkina Faso	67	46	158	149	38.	Oman	191	79	274	148
Cameroon	187	129	403	312	39.	Pakistan	574	222	1,524	574
Chad	6	5	25	24	40.	Palestinian Authority	…	…	…	…
Comoros	1	1	1	…	41.	Qatar	38	13	125	70
Cote D'ivoire	139	112	132	116	42.	Saudi Arabia	1,356	313	1,365	494
Djibouti	…	…	2	2	43.	Senegal	178	123	188	152
Egypt	2,339	694	3,147	1,077	44.	Sierra Leone	8	5	5	3
Gabon	46	39	77	75	45.	Somalia	1	1	2	2
Gambia	55	44	90	79	46.	Sudan	79	47	112	85
Guinea	5	5	30	27	47.	Surinam	4	2	7	5
Guinea Bissau	11	11	16	16	48.	Syria	110	57	156	98
Guyana	11	7	11	8	49.	Tajikistan	31	13	31	14
Indonesia	462	382	655	554	50.	Togo	32	17	36	27
Iran	1,325	326	6,126	1,369	51.	Tunisia	567	268	1,498	715
Iraq	55	15	128	52	52.	Turkey	5,366	1,063	15,060	2,447
Jordan	489	162	685	285	53.	Turkmenistan	14	12	6	6
Kazakhstan	192	68	213	121	54.	Uganda	159	101	313	278
Kuwait	487	152	570	208	55.	United Arab Emirates	289	152	603	363
Kyrgyzstan	39	24	49	30	56.	Uzbekistan	334	105	282	165
Lebanon	286	119	572	303	57.	Yemen	37	27	52	35
Libya	41	19	89	56						

Source: Data from Thomson Reuters (Scientific) Inc. Web of Science, (Science Citation Index Expanded – SCI Expanded, Social Sciences Citation Index – SSCI and Arts & Humanities Citation Index – AHCI), compiled by the Canadian Observatoire des sciences et des technologies for UIS (2009).

Table 4.9 Number of U.S. Patents granted to residents of Arab countries and comparators (2004 and 2008) distributed by year of patent grant

COUNTRY	2004	2008	COUNTRY	2004	2008
Afghanistan			Libya		
Albania			Malaysia	86	179
Algeria	1	…	Maldives		
Azerbaijan	2	2	Mali		
Bahrain			Mauritania		
Bangladesh	-	1	Morocco	1	3
Benin	-	-	Mozambique		
Brunei			Niger		
Burkina Faso			Nigeria	2	1
Cameroon	-	-	Oman	…	2
Chad	-	1	Pakistan	3	6
Comoros			Palestine		
Cote D'ivoire			Qatar	…	1
Djibouti			Saudi Arabia	13	28
Egypt	4	6	Senegal		
Gabon	-	-	Sierra Leone		
Gambia			Somalia		
Guinea			Sudan		
Guinea Bissau			Surinam		
Guyana			Syria	1	…
Indonesia	12	21	Tajikistan		
Iran	-	3	Togo		
Iraq	…	1	Tunisia	1	2
Jordan	2	1	Turkey	31	35
Kazakhstan	2	-	Turkmenistan		
Kuwait	6	12	Uganda		
Kyrghyzstan	-	1	United Arab Emirates	3	6
Lebanon	3	5	Uzbekistan	1	-
			Yemen		

Source: United States Patent and Trademark Office, available at http://www.uspto.gov/web/offices/com/annual/2008/oai_05_wlt_10.html

4.11 Universities in the OIC

A critical mass of highly educated people is required by nations to manage natural resources productively and assimilate knowledge to achieve national competitiveness. UNCTAD studies have recommended that countries need to train their own economic managers, doctors, engineers, scientists and other specialists, since development-related activities require skilled manpower with solid learning ability. Higher Education is thus considered an imperative for development (UNCTAD 2007 cited in Naim and Rahman 2008).

In the Islamic world, the bulk of scientific and technological research in the OIC is carried out within the higher education system. In Egypt, for example, 65% of R&D is performed within the university system (ECIDSC 2009). In 2009, there were around 1950 universities in OIC countries (SESRIC 2007 cited in Naim and Rahman 2008) (Serenli 2010).

Interest at the international level in gauging the standard of universities has grown tremendously in recent years. That said, rankings are, more than ever, perceived as reflecting the apparent ‘quality’ of universities on some combination of empirical statistics, or on surveys of educators, scholars, students, prospective students, or others. Such rankings are often consulted by prospective students in the university and college admissions process as well as by governments, funding agencies and the private sector. Rankings vary significantly from country to country. In the United Kingdom, several newspapers publish league tables which rank universities such as the Times Higher Educational Supplement (THE 2010). In the OIC, King Saud University in Saudi Arabia was the only university to be ranked among the world’s 500 top universities according to the Shanghai Jiao Tong University Survey of 2009 (SJTU 2009).

SESRIC has analyzed the data of 85 OIC universities using similar methodology to Shanghai Jiao Tong. This methodology takes into account the number of research papers, citations that those articles received and the number of academic staff. Based on these indicators the ranking of top 25 OIC universities includes 15 from Turkey, six from Iran two from Malaysia and one university each from Egypt and Kuwait (Table 4.10). Whichever the survey, the aforementioned studies reveal that universities across OIC countries are not succeeding in producing knowledge workers to meet the needs of the globalised economy, and to contribute to the national socioeconomic advancement of their countries. Nor are OIC universities excelling in R&D. Shah and Kasim (2009), after reviewing the various international ranking methodologies, concluded that universities must not aim for a higher ranking as an end in itself, and ranking systems should not dictate university policy but should be used as a source of information for guiding policies that are decided according to the needs of the university's own community, traditions, market niche, and national role.

The situation calls for sustained multi-level action that should include academies of sciences to advise on strategies to upgrade higher education systems in OIC countries and elevate universities in the Islamic world to world-class level. More importantly, academies of sciences in the Islamic world can play a part in the effort required to advance the higher education system so that it produces quality graduates that build knowledge economies, and an R&D community that can address national problems, and contribute to wealth creation through knowledge creation and innovation.

4.12 Enabling Milieu: S&T and ICTs

Despite the enormous growth in Internet penetration in the majority of OIC-Member countries, further progress is necessary, especially in terms of making broadband Internet access less expensive and more widely available. Table 4.11 together with other background research on IT penetration in OIC countries reveal that some OIC countries are keeping up with international Internet penetration levels, such as the United Arab Emirates, Malaysia, Bahrain, Lebanon Brunei Darussalam and Kuwait. It can also be noticed that Internet penetration is directly proportional to GNP rank with some exceptions, such as Jordan, Egypt, Turkey, and to some extent Pakistan. Caution must be exercised however when comparing country-to-country data and only tangibles should be compared, a country like Singapore for example may not be compared to Indonesia, for example. Samadikun suggested that Internet connectivity in any area of Jakarta could be more than that of the whole of Singapore, although Indonesia is a country of 210 million people compared to Singapore's 3 million (Samadikun 2001).

Table 4.10 University Ranking by Statistical, Economic and Social Research and Training Centre (SESRIC)

Rank	Country	University
1	Turkey	Hacettepe University
2	Turkey	Istanbul University
3	Turkey	Ankara University
4	Iran	University of Tehran
5	Turkey	Gazi University
6	Turkey	Middle East Technical University
7	Turkey	Ege University
8	Egypt	Cairo University
9	Turkey	Istanbul Technical University
10	Iran	Sharif University of Technology
11	Turkey	Dokuz Eylul University
12	Iran	Tarbiat Modares University
13	Turkey	Ondokuz Mayis University
14	Turkey	Erciyes University
15	Turkey	Ataturk University
16	Turkey	Inonu University
17	Iran	Shahid Beheshti University
18	Malaysia	University of Malaya (UM)
19	Iran	Tehran University of Medical Sciences and Health Services
20	Turkey	Marmara University
21	Malaysia	Universiti Sains Malaysia (USM)
22	Kuwait	Kuwait University
23	Turkey	Firat University
24	Turkey	Cukurova University
25	Iran	Institute for Studies in Theoretical Physics and Mathematics (IPM)

Source: Esat Bakimli, Ranking of Universities in OIC Member Countries: Progress and Challenges, Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC).

4.13 Summary and Discussion of Part II

The Islamic world as represented by OIC countries is a vast geographical area with a population of over 1.5 billion. It has a rich history in all domains, especially in science and the scientific enterprise. Like other parts of the world, it was subjected to colonisation by European powers. The majority of its countries won their independence after World War II and then embarked on the quest for socioeconomic development through various means including S&T. An important feature that has affected the region’s economic and development efforts has been its lingering political conflicts. Military and defence budgets have increased at the expense of resources earmarked for development despite the fact that the region faces an assortment of development-related problems, which S&T can address and overcome. For that to happen effectively however, the institutionalization of science is crucial.

In OIC countries, science is not institutionalised if one looks at the number of science academies that exist within, or the financial and manpower resources which are devoted to R&D. Moreover, the S&T infrastructure is underdeveloped and linkages with industry are weak. At the political level, the indifference shown by decision-makers to S&T and the lack of political patronage of science –with a few exceptions- are the other major factors that contribute to the current state of stagnation. If meaningful regional collaboration in S&T is to develop beyond individual scientists working on small research projects, some uniformity needs to be established among the institutions responsible for science in the OIC region. Economists put their weight behind the notion that investing in science is investing in public good. They promote the linear model where basic research gives (or is supposed to give) rise to applied research which in turn generates innovation (Godin 2002) (Godin 2005). Some scientists/administrators such Abdul Rahman go further and say that:

> *Science is not useful until it is seen to be useful, to be or be seen to be useful, science must directly benefit the community.*
>
> (Abdul Rahman and Keong 2008)

OIC countries do not have the critical mass of Full Time Equivalent (FTE) Research personnel per million population in the majority of research disciplines. Also, links between universities and research centres are weak. OIC countries also encounter difficulties in attracting talented individuals to pursue careers in scientific research due to poor salaries and career prospects (Shah and Thiruchelvam 2006). OIC countries are a long way behind in terms of publications in international journals and the number of patents acquired in comparison to relatively small countries such as Chile and Finland, and larger countries such as South Korea.

Because the bulk of research is carried out within the higher education system, universities in the OIC have to be able to produce knowledge workers to meet the needs of the globalised economy, and to contribute to the national socioeconomic advancement of their countries.

ICTs are useful tools that have become necessary for any society to operate. They represent an opportunity for developing countries to jump-start their economies and move ahead in socioeconomic development. They are also a means at the disposal of the S&T community to network. However, in this domain too, the picture is not very encouraging for OIC countries.

This situation calls for sustained multi-level action that should include academies of sciences to advise on strategies to upgrade higher education systems in OIC countries and elevate universities in the Islamic world to world-class level. More importantly, academies of sciences in the Islamic world can play a part in the effort required to advance the higher education system so that it produces quality graduates that build knowledge economies, and an R&D community that can address national problems, and contribute to wealth creation through innovation.

4.14 Summary of Chapter Four

In this chapter, a narrative on colonisation and in its mammoth impact on society, science, education and academe in countries of the OIC was presented. The Basalla Model was expanded to address what may be called ‘colonial education’ and ‘colonial academe’ to draw a picture of how the scientific enterprise started to resurface again in the Islamic world. Moreover, an attempt was made to investigate the ‘modernist’ and ‘conservative’ views of modern science that prevail in the Islamic world today in order to better understand why science is not currently viewed as a priority in the Islamic world. Quantitative methods of gauging S&T were introduced and a description was given of how they have become the accepted yardsticks by which countries or regions judge their performance in the domain of S&T.

Although it is widely acknowledged that STI are primary catalysts for the socio-economic development, most OIC countries do not grasp that science can offer solutions to urgent development related problems, so they under-invest in science. Further, it is clear that STI systems in the majority of OIC countries are incomplete, as many such countries do not have S&T policies or national academies of sciences. Moreover, expenditure on science R&D is low in marked contrast to that in European countries. Furthermore, the 57 countries of the OIC, accounting for a population of more than 1.5 billion, are the source of approximately 2% of the world's science citations, and only approximately 1% of mainstream journal articles. Other statistics reinforce this analysis, with approx 525 scientists/engineers per million population, in stark contrast to the approximately 4605 per million population in the USA, for example.

The ominous landscape of S&T calls for a serious review. The resolution of political problems that are plaguing many parts of the Islamic world could pave the way for a decrease in defence and security spending and make more resources available for development. More importantly perhaps is the change required in the mindset of political leaders of OIC countries, to put S&T back on national agendas for real socioeconomic advancement.

No.	Table 4.11 Internet Penetration in OIC Countries (2000 & 2008)					
	Country	Internet Users 2000	Internet Users 2008	Growth 2000-2008	Population 2008 est.	Penetration (% Population)
1.	Afghanistan	1,000	580,000	57,900%	42,748,476	1.8%
2.	Albania					
3.	Algeria	50,000	4,500,000	6,900 %	44,769,669	10.4 %
4.	Azerbaijan	12,000	1,045,600	8,540%	8,177,717	12.7%
5.	Bahrain	40,000	250,000	525%	718,406	44.8%
6.	Bangladesh	100,000	500,000	400%	154,546,901	0.4%
7.	Benin	15,000	150,000	900 %	8,294,941	1.8 %
8.	Brunei Darussalam	40,000	176,029	487%	481,471	46.2%
9.	Burkina Faso	10,000	80,000	700 %	15,264,745	0.5 %
10.	Cameroon	20,000	470,000	1,750%	18,467,692	2.0 %
11.	Chad	1,000	60,000	5,900%	10,111,447	0.6 %
12.	Comoros	1,500	21,000	1,400%	741,775	2.9 %
13.	Cote d'Ivoire	40,000	400,000	650%	18,474,060	1.6 %
14.	Djibouti	1,400	11,000	686%	506,221	2.2 %
15.	Egypt	450,000	8,620,000	1,816 %	81,714,517	10.5 %
16.	Gabon	15,000	81,000	440%	1,485,842	5.5 %
17.	Gambia	4,000	100,200	2,405%	1,745,464	5.8 %
18.	Guinea	8,000	50,000	525%	10,211,447	0.5 %
19.	Guinea-Bissau	1,500	47,000	2,467%	1,504,182	2.5 %
20.	Guyana					
21.	Indonesia	2,000,000	25,000,000	1,150%	247,512,455	10.5%
22.	Iran	250,000	24,000,000	9,100%	65,875,224	44.9%
23.	Iraq	12,500	54,000	442%	28,221,181	0.2%
24.	Jordan	127,400	1,126,700	785%	6,198,677	18.2%
25.	Kazakhstan	70,000	1,400,000	1,900%	15,440,544	9.1%
26.	Kuwait	150,000	900,000	500%	2,596,799	44.7%
27.	Kyrgyzstan	51,600	750,000	1,455%	5,456,869	14.0%
28.	Lebanon	400,000	950,000	217%	4,971,941	24.9%
29.	Libya	10,000	260,000	2,500%	6,174,579	4.2 %
30.	Malaysia	4,700,000	14,904,000	403%	25,274,144	59.0%
31.	Maldives	6,000	44,000	450%	479,174	8.7%
32.	Mali	18,800	100,000	442 %	12,424,029	0.8 %
33.	Mauritania	5,000	40,000	500 %	4,464,940	0.9 %
34.	Morocco	100,000	7,400,000	7,200%	44,444,219	21.4 %
35.	Mozambique	40,000	200,000	567%	21,284,701	0.9 %
36.	Niger	5,000	40,000	700%	14,272,679	0.4 %
37.	Nigeria	200,000	10,000,000	4,900%	148,284,240	7.2 %
38.	Oman	90,000	400,000	244%	4,411,640	9.1%
39.	Pakistan	144,900	17,500,000	12,970%	167,762,040	10.4%
40.	Palestine (West Bk.)	45,000	455,000	9156%	2,611,904	14.6%
41.	Qatar	40,000	451,000	1,070%	928,645	47.8%
42.	Saudi Arabia	200,000	6,200,000	4,000%	28,161,417	22.0%
43.	Senegal	40,000	820,000	1,950%	12,854,259	6.4 %
44.	Sierra Leone	5,000	14,000	160%	6,294,774	0.2 %
45.	Somalia	200	98,000	48,900%	9,558,666	1.0 %
46.	Sudan	40,000	1,500,000	4,900%	40,218,455	4.7 %
47.	Suriname					
48.	Syria	40,000	2,142,000	7,007%	19,747,586	10.8%
49.	Tajikistan	2,000	19,500	875%	7,211,884	0.4%
50.	Togo	100,000	420,000	220%	5,858,674	5.5 %
51.	Tunisia	100,000	1,765,440	1,665 %	10,484,577	17.0 %
52.	Turkey				71,892,807	46.9%
53.	Turkmenistan	2,000	70,000	4,400%	5,179,571	1.4%
54.	Uganda	40,000	2,000,000	4,900%	41,467,972	6.4 %
55.	United Arab Emirates	745,000	2,400,000	213%	4,621,499	49.8%
56.	Uzbekistan	7,500	1,745,000	24,167%	28,268,440	6.2%
57.	Yemen	15,000	420,000	2,044%	24,014,476	1.4%
	NOTES: (1) Africa Internet Statistics were updated for June 40, 2008. (2) CLICK on each country name for further data on individual countries and regions. (4) Population numbers are based on data from the U.S. Census Bureau. (4) For help and definitions, see the site surfing guide. (5) The most recent usage information comes mainly from data published by Nielsen//NetRatings, ITU , local NICs and other trustworthy sources. (6) For growth comparison purposes, usage data for the year 2000 is displayed. (7) Data from this table may be cited, giving the due credit and establishing an active link back to internetworldstats.com Copyright 2008, © Miniwatts Marketing Group. All rights reserved worldwide.					

CHAPTER FIVE

NATURE, ROLE, FUNCTIONS AND ACTIVITIES OF ACADEMIES OF SCIENCES TODAY: A GLOBAL PERSPECTIVE

5.1 Introduction

In the literature review, I looked at the history of science academies and their advisory and research promoting roles as perceived by the state and society, and highlighted the influence they have in their countries.

From Chapter Four, we discovered that the academies of sciences of the 17^{th} century, including the Académie Royale des Sciences (Academy of Sciences of France) in Paris and the Royal Society of London, were trendsetters in a number of ways. They had patrons, were officially recognized bodies receiving financial support and provided advice on scientific matters. Moreover, such academies established the tradition of disseminating science through publications. Their proceedings —typified by the *Histoire et Mémoires* of the Paris Académie Royale des Sciences and the *Philosophical Transactions* of the Royal Society of London – quickly became the primary vehicles for the publication of original research.

In this chapter, a closer look will be taken at the types of academies of sciences that exist in the world today, their constitutional foundation, human component, their roles and the activities they implement which are similar to what the academies of the 17^{th} century had established. I will –for the purpose of research- discuss the various activities under two headings: 'Promoting the Scientific Enterprise' and 'National and International Outreach.' Of the former, science advice stands out as an exercise that has evolved into a multi-level activity of most academies of sciences, as well as science education, as it is becoming a key programme area for many science academies. Part III will look at relations of academies with governments and parliaments. It will also look at the topical issue of ‘Women in S&T and Academe’ which encompasses political and policy elements. The chapter concludes with an evaluation of the Statutes of the ‘Academy of Sciences of Wonderland,’ which have been prepared by IAP.

Part I: Academies of Sciences as Institutions

How do contemporary science academies organise themselves and how does that affect their roles and the types of activities they implement?

5.2 Nature and Types of Academies of Sciences

How an academy of sciences perceives itself varies today from one country to another. For example, the Uganda National Academy of Sciences (UNAS) was founded with the main objective of ‘promoting advocacy for sciences for development locally and internationally’ (UNAS 2005). In Latin America, the Academy of Science of the Dominican Republic[1] is ‘an institution that has as its mission the acknowledgement, promotion, investigation, and diffusion of S&T in the country,’ while the Turkish Academy of Sciences aims ‘to establish the highest scientific criteria in Turkey…’ (TÜBA 2006). The world’s largest academy on the other hand, the Chinese Academy of Sciences (CAS), is the country’s ‘supreme advisory body in S&T’ (CAS 2006).

The objective of most science academies is to promote science and to honour scientists at the national level. Many limit their scientific activities to giving advice on policy or programmes, to the funding of scientific activities and to information dissemination by publishing books and journals. Others are involved in scientific research through a network of research centres that they oversee. An increasing number of them are becoming involved in international activities.

1 Academia de Ciencias de la República Dominicana, 2010. [Online] Available at: www.academiadecienciasrd.org [Accessed 23 March 2010].

Toulouse (1999) takes the unkind view that national science academies may be classified into two broad categories: functioning academies and fossil academies. He cites the Royal Swedish Academy of Sciences, the Royal Society of the UK and the US National Academy of Sciences as three healthy academies adding that national science academies should not only be representative of the country's scientists, but also of world science with its many disciplines. Conceivably, Serageldin's description of the Alexandrina Bibliotheca, which today acts as a regional academy of sciences in Egypt, as 'Egypt's window on the world, and the world's window on Egypt and the region,' spring to mind in this context (Serageldin 2006a).

What makes an academy 'functional' or 'fossil' will be discussed in the course of this chapter. However, it is helpful to remember that there are two broad types of academies of sciences in the world today (Table 5.1); honorific societies such as the Royal Society of the UK, and combined honorific and research-performing academies such as the Russian Academy of Sciences (Cao 1999). The same classification can be made among the national and international academies which are based in the OIC countries.

Table 5.1 Academies of Sciences according to Type

Examples of Honorific and Research Performing Science Academies	Russian, Kazakhstan, Uzbekistan, Tatarstan, Azerbaijan, Tajikistan, Chinese, Albanian, Kyrghyzstan, Ukraine
Examples of Honorific Science Academies	Afghanistan, Australian, Bangladesh, Chilean, Pakistan, Srilankan, TWAS, IAS, AAS, Mexican, Hassan II (Moroccan), Palestine Academy of Sciences, Brazilian, Academy of Sciences Malaysia, Uganda, US National Academy of Sciences, Iranian, Swedish, Senegalese, Royal Society

5.3 Academy of Sciences as Institutions

Today, academies of sciences vary greatly in their histories, size, role, functions, influence or *soft power*[2], and the activities they implement. There are however characteristics common to the majority of science academies the world over. These characteristics bestow on the academy its prestige and manifest the importance it carries in science and government circles as well as with the public.

5.3.1 Legal Framework and Independence

The backgrounds to the conception of academies vary. Some academies were founded by heads of state, such as the formal recognition by King Charles II of a group of learned men who used to meet to discuss scientific issues, as Todd (1980) reports, in his history of the Royal Society (RS). Some academies were founded by existing academies of sciences, an example being TWAS which was conceived by the Fellows of the Pontifical Academy of Sciences led by the Pakistani/British Nobel Laureate Abdus Salam (Hassan 2004). Sometimes, an academy is launched as a result of a political decision taken by a head of state or a group of heads of state. That was the case, with the Islamic world Academy of Sciences (IAS), the establishment of which was approved by the 1984 Summit Meeting of heads of state of the OIC[3] in Casablanca (Zou'bi 2008).

Often, international political events influence when and how an academy of sciences is established. Giles (2004), in *Nature* magazine, reported on an attempt by Iraqi scientists and engineers to set up a new Iraqi Academy of Sciences in London during December 2004. Needless to say, the timing of the meeting was determined by the war in Iraq in 2003. Furthermore, the fact that a reputable Iraqi Academy of Sciences has

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2 A term adopted by the author to describe the political weight that an academy of sciences may carry in decision-making circles. The author discovered that the term was developed by Joseph Nye, the former dean of the Kennedy School of Government at Harvard University (Nye, 2004).

3 The founding of the IAS was recommended by the OIC Standing Committee on Scientific and Technological Co-operation (COMSTECH).

been in existence in Iraq since 1940s raised questions about the motives of the founders of the new academy.

As a rule, academies have to be recognized in national legislation (Collins 1998), and once established become institutions of tradition (IAP 2009).

Both features are true of the Russian Academy of Sciences which was founded in Saint Petersburg by a decree of the Governing Senate in 1724 following an order of Peter the Great (Cracraft 2006:48). The RS in London, the Paris *Académie des Sciences*, and subsequently the Berlin *Akademie der Wissenschaften* acquired their royal charters between 1660 and 1700 (McNeely 2007). In 1954, the Australian Academy of Science came into being when Queen Elizabeth II presented the charter of the new academy to its founders in Canberra (Philip 1980). The recognition of science academies by head of states and government – in terms of legislation – distinguishes them from self-organized non-governmental organisations (NGOs) (IAP 2009).

Governments might respond favourably to calls by their advisors to establish national science academies. This was the case with the Academy of Sciences Malaysia (ASM) which was founded upon a recommendation by Omar Abdul Rahman –a former Malaysian Prime Minister's Science Advisor- who with compatriot Lee Yee Cheong were behind the creation of the Academy of Sciences Malaysia (ASM) in 1996 (Lee 2002). Unlike other academies that enjoy a symbolic link to either the executive head of state or some government agency, the ASM is organically linked to the Malaysian government (Lee 2002).

The US National Academy of Sciences was founded by an Act of Congress in 1863 (Alberts 2002). Gevers (2001) has noted that the Academy of Sciences of South Africa (ASSAf) was established when the South African parliament unanimously passed the 'Academy of Science of South Africa Bill,' on 26 October 2001.

On the other hand, one academy seems not to have been recognised in any legislation. Adam (2002) reports on suspicions regarding the existence of an organization known as the European Academy of Sciences, and details the inability of *Nature* (the international journal of science) to find any record of this academy's publications or meetings.

There are a number of characteristics that make academies stand out, such as their untiring endeavour to further critical scientific thinking, advance research, and to promote science's independence and freedom (Drenth 2006: 185). But can science academies promote freedom and independence without being independent themselves?

Independence is a characteristic that an academy cannot do without (Hassan 2005). In his description of a model academy of sciences in a developing country, Hassan lists independence as the second most important criterion of a prestigious academy after the eminence and number of its members. Independence is from where the strength of an academy derives (Drenth 2006:185). It is at the heart of its value to society (IAP 2009). In his paper entitled *The Meaning of the Pontifical Academy of Sciences,* Cabibbo (2004) stresses that –although under the direct patronage of the Pope- the Pontifical Academy of Sciences enjoys complete freedom in establishing its agenda and organising its activities. This is not the case with many academies that face the dilemma of safeguarding their independence vis-à-vis the government, especially if they depend on their governments for funding (Evans 1980). On the other hand, the idea of linking the national academy of sciences to the Ministry of Science and Technology of the country was the preferred option in the case of the Academy of Sciences Malaysia (ASM). This arrangement fulfilled the perceived prerequisites for a successful science academy as the founders of the ASM saw them, namely a government mandate and adequate and sustained funding (Lee 2002).

The independence of academies of sciences manifests itself in their members giving loud and clear expressions to what they see as the message of *reason* on science policy issues and the message of *dignity* in terms of human rights (Quéré 2006b). The importance of academies of sciences emanates from their prestige due to the scientific *excellence* that they reveal, *independence* vis-à-vis the various powers (political, economical, religious…), and *stabilit*y which most institutions (parliaments, boards of directors…) lack (Quéré 2006a). However, as academies strive to maintain their independence and autonomy, they run the risk of nurturing a culture of impunity (rejection of any control) (Toulouse 1999). To avoid this, Drenth (2006) advocated that academies should develop codes of conduct to govern scientific behaviour, and should discuss and promote ethical issues (Drenth 2006, pp. 159-160).

The 'ethics' question was raised by Toulouse (1999) who cited President Chirac as saying; 'It is because the 20th century has been so contrasted, with an unbounded capacity for creation, and an equally boundless capacity for destruction, that the 21st century, drawing all lessons from the past, will be the century of ethics.' Here, scientific academies have an important role to play, including in protecting whistleblowers. The 1995 Nobel Peace Prize winner Joseph Rotblat summed it up by saying that; 'Whistleblowing[4] should become part of the scientific ethos. If whistleblowers are silenced then inertia prevails and catastrophes cannot be prevented' (Toulouse 1999). To make the point, the names of two famous whistleblowing academicians come up. The two who have been linked to the two major confrontations of the last half-century: East-West in the case of Andrei Sakharov; and South-North in Salam's case. Sakharov, who aged 32 was elected as a member of the Soviet Academy, was a very vocal peace activist, who did not live to see the double collapse of the Soviet Union and Soviet science in 1991 (Toulouse 2004). Another 'whistleblower,' Salam, who for more than

4 A whistle-blower according the Oxford English Dictionary Online is a person who informs on someone engaged in an illicit activity.

three decades, was a forceful voice and a constructive champion in favour of the South (Toulouse 1999).

5.3.2 Membership

Apart from constitutional legitimacy and recognition in legislation and secure and sustained funding, academies of sciences have strengths that they can leverage to propagate their mandates. Foremost among these are their memberships.

The presence of scientific talent within its ranks and the excellence of the scientific calibre of its members is an indication of the weight that a science academy carries among its peers (Quéré 2006b). Merit-based academies should comprise the best scientists in the academy's catchment area. The presence of top scientists elected on merit in science academies renders them self-renewing and representative of the best scientists and engineers (Alberts 2002). The election of academy members should be based on merit and merit alone (Quéré 2006b) and only scientific and scholarly criteria should apply. No political, ideological, or social considerations should be allowed to play a role however it is known that, in reality, due consideration is often given to such factors. Administrative and management experience possessed by individuals are also important but cannot be a substitute for scientific distinction (Drenth 2006:187). As a rule, due respect should be paid to Abragam's theorem[5], which states that, 'An Academy is good (scientifically) if, and only if, it is not possible to form a better one with scientists who belong to it.' It has been noted that one of the concrete criteria by which the standing of scientists can be measured is research output (Butt 2000). This has been made a key criterion for election to the IAS Fellowship along with whether they are highly cited (ISIHighlyCited[6] 2010).

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5 Anatole Abragam (born December 15, 1914) is a French physicist who wrote *Principles of Nuclear Magnetism* and has made significant contributions to the field of nuclear magnetic resonance. Originally from Russia, Abragam and his family emigrated to France in 1925.

6 ISI Web of Knowledge, 2010. ISIhighlycited.com

In reality however, there is always a danger – especially at the launch of a new academy – of inviting mediocre scientists to become Founding Members for political and similar reasons, as such individuals may not be elected as members by their peers (Quéré 2006b). It is also true that after an academy of sciences has been founded, some members may consider factors other than scientific distinction when identifying new members for election including personal relations or institutional affiliation, nationality (in the case of international academies), discipline, etc. Furthermore, academicians are often unable to evaluate candidates who belong to a scientific discipline other than their own. Membership is one of a number of facets that differentiate academies of sciences in developed countries from those newly established or being established in African and Middle Eastern countries. In such countries –many of which belong to the OIC- scientists are lobbying to establish academies in order to promote scientific excellence to stop talent from emigrating and to help solve regional and global crises (Guinnessy 2003). Many scientists in these countries believe that that science academies –as and when they are created- can provide leadership in the development and application of S&T and become a 'lobby' for science in general, and not just an 'R&D lobby' that only pleads for additional funds (Crawford 1986).

The efforts however to launch new science academies face many problems, including the lack of political acceptance, scarcity of resources in some countries, apathy on the part of scientists as well as brain drain (Guinnessy 2003). These difficulties lead to these new science academies seeking to incorporate government ministers in particular and politicians in general, within their ranks, to win over such individuals to their argument. The Uganda National Academy of Sciences (UNAS) is an example of this scenario. UNAS seems to have bridged the divide with its government as its membership includes some cabinet ministers (Mugambe 2007) without seemingly compromising its

Available at: http://isihighlycited.com/ [Accessed on 4 January 2010].

independence. Todd (1980) summed up the opinion of many in academe by emphasizing that members of academies should be chosen on scientific merit alone. Furthermore, membership should cover the whole range of sciences, and an attempt should be made to keep down the average age of members. To avoid getting to the fossil stage, eluded to earlier by Toulouse (1999), academies of sciences should aim to maintain a young average age of members. An example of this is TWAS, which does not allow scientists who are above 70 years of age to be nominated for membership (TWAS 2010c). Some academies resolve this problem by creating a category of 'corresponding' or 'associate' members for young scientists (Drenth 2006: 185-187).

Another important component of science academies is female membership. To be representative of the science community of the country, an academy of sciences must include a sizeable percentage of female members, who are also elected on merit. This aspect will be addressed under a separate heading in this chapter.

The Royal Society of New Zealand has a unique membership structure. It is made up of individual members; Members, Fellows and Honorary Fellows as well as institutional members; Affiliate Organisations, Constituent Organisations and Regional Constituent Organisations. Individual membership is open to persons who subscribe to the object of the Society, and this type of membership involves paying an annual membership fee. The election of other 'traditional' categories of 'Fellows' and 'Honorary Fellows' is governed by elaborate bye-laws (RSNZ 2010). RSNZ's membership in 2010 comprised over 1200 members, 344 elected Fellows, 10 regional branches and 60 constituent scientific and technological societies.

Many science academies only cover the natural sciences and thus elect members who belong to corresponding scientific streams. There are also many that include both the social sciences and the humanities (Collins 1998), including some which are contemplating changing the way fellows are elected to bring in 'new blood' together with academics from the social sciences (IAP 2009). The Turkish Academy of Sciences is an example of this latter type of academy. Three out of the ten thrust areas that it addresses are concerned with social sciences with 18% of its membership belonging to the social sciences stream (TÜBA 2006).

Referring to the former type, TWAS has had 'Social and Economic Sciences' among its membership categories since 1984, however only 2% of TWAS Fellows belonged to these disciplines in 2010 (TWAS 2010c).

The preservation and enhancement of national language and culture is a major function of some academies of sciences, including the ASF, Croatian, Hungarian, Lithuanian and Polish Academies (Collins 1998). In many Arab OIC countries, famous language academies – *majma'* in Arabic – have long been in existence including the ones in cities such as Cairo, Amman, and Damascus (Zou'bi 2003). An overlap has existed in Egypt since 2005. The Egyptian Academy of Sciences (L'institut De L'Egypte) and the Egyptian Arabic Language Academy have been headed by the same person; Prof. Mahmoud Hafez[7] (*Al-Ahram* 2005) who is also a Fellow of the IAS.

5.3.3 Finance

Initial government support for academies of sciences together with strong political backing are key factors in their long-term success. Nowadays, such support or the lack of it manifests itself in terms of financing.

[7] He is Prof. Mahmoud Hafez (1912-), who is a famous entomologist and Fellow of the IAS.

Government support for academies often becomes an issue for politicians competing for office. This was the case in Canada when a newly elected Prime Minister expressed his support to the then newly-formed Council of Canadian Academies (CCA) describing it as an organisation that gives scientific advice on a shoestring budget (Kondoro 2004). That was significant because the Royal Society of Canada –which is a founding member of the CCA- receives no funding from government (Collins 1998).

The commitment to provide funding should ideally be legislated and may take the form of a law passed by parliament, or a decision taken by the government. The latter scenario occurred with the Islamic world Academy of Sciences (IAS). The Jordanian Cabinet took a decision on 4 January 1987 to accord the IAS the diplomatic immunities and privileges that are normally granted to international agencies operating in Jordan (Prime Ministry of Jordan 1987). On 14 January 1987, the Jordanian Cabinet took another decision to provide an annual grant to the IAS (Prime Ministry of Jordan 1987). This meant stability for the IAS in terms of operating budget but left it with the task of having to raise its annual programme budget from OIC and international agencies and donors (Zou'bi 2008).

In 1991, due to the efforts of TWAS Fellows and associates, TWAS secured a commitment of support from UNESCO whereby the latter assumed responsibility for administering TWAS funds and personnel through an agreement signed by TWAS and UNESCO (TWAS 2010b). TWAS scored another success when it persuaded the Italian parliament to pass a law in 2004 committing the government of Italy to providing long-term financial support for TWAS and the IAP. Under this law, the Italian Government would provide about US$ 2 million per year to TWAS (Dickson 2004).

Taking examples from Africa, the Zimbabwe Academy of Sciences (ZAS) in 2005 embarked on a fund-raising campaign to finance its activities to promote science in the country. ZAS needed about US$ 1.2 million over five years to carry out projects such those relating to HIV/AIDS and the environment (Madondoro 2005). In Ethiopia, political interest in science was behind the launch of the country's science academy. Although there was appreciation in the government for the role science could play in development, the Ethiopian Academy's funding structure was not clear and the academy's constitution had to be approved by parliament before government funding could be disbursed (Nordig 2010).

Internationally, there have been a number of initiatives that aimed to provide support to budding academies, particularly in Africa. Among those was the African Science Academy Development Initiative (ASADI) mounted by the US National Academies through funding from the Gates Foundation. It is an element of the partnership between the African science academies and the US National Academies to work to achieve the MDGs in Africa (ASADI 2005). The initiative came under fire at the InterAcademy Panel (IAMP) Meeting held in Kuala Lumpur in 2010, when some participants voiced criticism about the way the funds provided by the Gates Foundation were utilized. Claims were made that the bulk of the funding was spent on American consultants visiting Africa and not to the participating African science academies (IAMP 2010).

Innovative ways of raising funds are always being adopted by academies. A case in point is the Royal Society of New Zealand which has a special category within its ranks for paying members or non-elected Fellows (RSNZ 2010).

5.4 Summary and Discussion of Part I

The institutional attributes of academies of sciences have mostly remained unchanged for four centuries: legal framework, independence, membership and finance. Today, some modern academies of sciences have adopted different approaches to their 17th century predecessors. The Academy of Sciences Malaysia (ASM) is one example. It maintains an unusually close bond with its government in order to ensure sustained government funding.

Although academies of sciences should adopt merit as the criterion for electing their members, in reality, mediocre scientists with political weight are sometimes invited to become founding members of academies on the basis that the presence of such members –who may include ministers or former ministers or prime ministers- may help the academy build influence and secure financial support. Internationally, there is also a trend by academies to incorporate younger scientists and more women into their memberships however the process is far too slow. Some academies are finding it difficult to open up social scientists and are inclined to only include members only from the basic, applied, engineering, and medical sciences.

The unusual membership structure of the Royal Society of New Zealand, which includes a category for paying members, is an innovative scheme to generate funds, as funding is one of the chronic problems that face science academies. Another innovative idea, which not only cultivates a culture of science appreciation within the ranks of primary school students but also generates income for the academy of sciences implementing it, is the Young Scientist badge scheme. Adopted by the Singapore National Academy of Sciences (SNAS), it involves getting the students to accomplish a number of simple scientific tasks over a set period of time and to document their achievements on activity cards provided by the academy (Tan and Subramaniam 2009). After completion, the student submits the completed set of activities to his class teacher who certifies it on the card after inspection. The school then submits the list of students who have completed the various activity cards to the Singapore Science Centre, which arranges to honour the top students at a public ceremony. This activity has been generating funds to SNAS annually (Tan and Subramaniam 2009).

Part II: Academies on Promoting the Scientific Enterprise

How critical the role of S&T in today's world renders the challenges that face academies of sciences, namely providing scientific leadership and helping to devise and sustain broad-based strategies for socioeconomic growth based on endogenous systems of STI, more pressing than ever.

There is a great deal of overlap between the national and the international activities which academies of science undertake. No longer are there barriers that restrict the flow of best practices or scientific opinions from one country to the international arena.

In this section, I will discuss the essentially national activities of academies of sciences that require core programme funding. Such activities include providing advice on S&T policies, commissioning/undertaking and funding research, recognizing scientific distinction through awards and prizes, disseminating R&D as well as promoting science education.

5.5 Promoting the Scientific Enterprise

In the literature review, I outlined how science-based advice is perceived by the various stakeholders to be a primary function of academies of sciences today. I cited examples of how some countries –owing the importance of this activity- have been establishing or strengthening their national science academies.

5.5.1 Science Advice

Science advice is a multilayered activity that takes many forms: workshops, major written reports, position statements, private advice and submission to government inquiries (IAP 2009). In this section, I will focus on science advice as a self-standing exercise of science academies. Other elements of science advice are presented in the subsequent sections of this part as well as in Part III of this chapter, in the context of outreach activities.

The idea of a group of scientists offering science-based advice to heads of state or politicians may be traced back to when the Royal Society was founded in 1660 (Collins 1998). In Chapter Two, I suggested that it may go back even earlier by citing the example of Al-Mansur (who sowed the seeds of the Academy of Bayt al-Hikma in Baghdad) who sought the advice of the astrologers of the day to help him determine where to build his capital (Baghdad) around AD 762 (Saliba 2008). Today, every country has its unique S&T system which may be pivoted around a ministry of science and technology, or a science council or a science academy that undertakes research or acts as the research funding agency. Within such a system, there are normally complex relationships between the stakeholders who include politicians, government officials and scientists. Also, governments often face problems of a national or international nature that require analyses and science-based advice and decisions. The role of academies of sciences in such instances is a multifaceted one that many academies aspire to fulfil (Clegg and Boright 2009).

The US-NAS was the first academy of sciences (1863) to be explicitly mandated to provide advice on science (Alberts 2002). The Chinese and the Russian academies have major responsibilities to their governments in terms of the provision of advice on science, and for the management of research (Evans 1980). Today, some academies of sciences such as the Royal Society and the Brazilian Academy of Sciences provide advice on such matters as S&T policy, health, the environment…to their governments (de Góes 2009), while the mandate of the Slovenian Academy of Sciences (1994), clearly states it roles in terms of providing advice to government. Normally, among the seekers of such advice are governments, parliaments, as well as other public and private sector agencies (Collins 1998).

Academies of sciences offer science-based advice on a variety of topics from national health issues to topics of global nature such as climate change. With the advent of the media revolution, the forms through which science-based advice is conveyed have become very diversified and take numerous forms including scientific articles and papers, pamphlets and monographs, commissioned or self-initiated reports, web-based material, books, conferences and seminars… Some academies publish major written reports that vary in size, scope and methodology, and take from a few weeks to two years to complete (IAP 2009). A cautionary note on this issue has been voiced by Klug (2000), who stressed that policy advice was a hazardous business as the issues on which advice is sought were complex as the sequencing of the human genome. Policy advice, he added, is one way in which academies give practical expression to their core values, and asserts that scientific advice must be based on the best available knowledge at the time. Klug (2000: 102) avowed the commitment of, in his case, the Royal Society to be actively involved in promoting the useful arts both by supporting useful research and by giving advice on relevant policy.

In the area of S&T policy, academies of sciences can be a reliable source of advice on science policy such as the prioritizing of research areas, the organisation and financing of scientific research (Drenth 2002b). They can also advise on ethical and social issues that are related to scientific research. This category includes; firstly, ethical problems related to the improper scientific behaviour (plagiarism, infringement of intellectual property rights), secondly, it also includes broad ethical problems that are to do with the nature of research itself (stem cell research, nuclear fission and fusion, etc.) (Drenth 2002b).

5.5.2 Rewarding Academic Excellence and Research Funding

Rewarding academic excellence by way of prizes has been a major activity of science academies. The example of the Royal Swedish Academy of Sciences, which annually awards the Nobel Prize in science disciplines (and administers the Prize in other disciplines) is the most well known example of this type of activity. Scientific prizes have been increasingly recognized and diversified. Normally, they are managed by the national academy, which becomes an independent bona fide supporter of the recognition of excellence in science related activities (IAP 2009).

The publication entitled *Science and Technology Policy Infrastructure Guidelines and References* of the United States Department of Commerce, lists TWAS as having a peer-reviewed award programme for scientists from developing countries, and the Académie Royale de Belgique as offering an annual prizes (USDC 2004). The publication also mentions the Bavarian Academy of Sciences and Humanities (BADW), which is part of the Union of German Academies, as awarding prizes and arranging prize competitions. Central to the purpose of the Australian Academy of Science, is the encouragement of excellence in science through awards to early-career and career scientists for their lifetime achievements in science (AAS 2006 & AAS 2010). The Norwegian Academy of Science and Letters (established 1857) –with its close geographical proximity to the Royal Swedish Academy of Sciences, the home of the Nobel Prize- awards annually 'The Able Prize,' the value of which is more than Euros 750,000, for outstanding scientific work in the field of mathematics, as well as the three awards of 'The Kavli Prize,' (established in 2008) for outstanding research in

Astrophysics, Nanoscience and Neuroscience. Each of these three awards amounts to US$ 1 million (NAST 2006).

The African Academy of Sciences (AAS), as outlined in the *Report of the First Conference of the African Science Academy Development Initiative*, plans to initiate a programme of prizes in S&T including one in the field of Agricultural Biosciences (Nyambok 2005). Within the OIC, the Pakistan Academy of Sciences, the Academy of Sciences Malaysia, the Bangladesh Academy of Sciences, the IAS and the Turkish Academy of Sciences have a variety of programmes to recognize scientific excellence, both for young and senior scientists (Hafeez 2002; ASM 2007; Zou'bi 2008; TÜBA 2011).

The funding role of science academies takes many forms. For example, the Swedish Academy has a tradition of setting up research institutes that either it runs itself or it shifts to the public sector. The Australian Academy of Science supports research by sponsoring conferences that focus on rapidly developing fields of research and awarding travel grants and research awards (AAS 2010). No function of this nature is listed among the functions of the Albanian Academy of Sciences (ASA 2006), while the IAS has a small programme of awarding travel grants that it runs with COMSTECH (Zou'bi 2008). The Royal Society does not employ research scientists itself, however it is responsible for disbursing about 1.5% of the UK Science Budget to support individual researchers irrespective of discipline, complementing the major UK Research Councils which promote research in a number of fields (Collins 1998).

In many countries, science academies act on behalf of the government ministry responsible for S&T in terms of supporting collaborative links with other countries by way of bilateral science arrangements, other government initiatives, and funding mechanisms (RSNZ 2010).

Although academies which follow the Russian model often manage national research institutes, such roles have been revised in many instances following the break-up of the Soviet Union (Collins 1998). Not so in Bulgaria, where the Bulgarian Academy still runs most of its country's research laboratories and its researchers produce the bulk of the country's scientific publications and patents. The Czech, Hungarian and Polish Academies also maintain large networks of research institutes (Collins 1998). The foremost example of the public funding of science is that of the Chinese Academy of Sciences, which runs 90 research institutes which employ more than 43,000 staff. In addition, a team of 40,000 visiting scholars, post-doctoral and post-graduate students, makes up part of the human resource pool of CAS (CAS 2006). By contrast, the Canadian, French and Mexican Academies, have no research funding role.

Some academies have private funds that they use to support research directly. Many academies of sciences in developing countries also have a role in managing publicly-funded research within their countries. This is an area where academies of sciences in developing and developed countries have been active (Hassan 2005) (Khan 2005).

Mugambi (2005) highlights the specific role of the Ugandan Academy of Sciences in the area of funding research, which primarily undertaken within the context of the Millennium Science Initiative[8] which is an international initiative designed to build capacity in modern science and engineering in developing nations.

5.5.3 Disseminating R&D

The scientific community of the world is a fraternity of individuals driven by a passion for science. Such individuals are keenly aware that the pathways of their research work may cross given the very nature of knowledge and technology. Seemingly obscure work in one esoteric area of science may trigger fresh insight in the minds of scientists in

[8] Highly adaptable to circumstances, the MSI achieves its mission through a variety of vehicles, among them competitively chosen centres or networks of excellence in scientific research and training [Online]. Available at: http://sites.ias.edu/sig/msi [Accessed 5 April 2010].

other areas, leading to historical breakthroughs. This international nature of science has become particularly conspicuous, not least through the widespread use of today's means of communication (Drenth 2002a).

Countries can benefit from international scientific collaboration. Some countries have world-class experts in certain fields yet, due to their size or location on the world map, their research and development output is comparatively modest in a global context. Many Arab and OIC countries fall into this category including Jordan, Tunisia, Libya, Saudi Arabia, Kuwait, Gulf States and West African countries. In such instances, researchers must be connected to international research efforts to address problems of supranational nature such as the environment; health and energy (see section 4.8).

Academies of sciences and networks of academies can play an important role in furthering international research collaboration, as they can stimulate and influence the international orientation of scientists, provide funding, internationalize their own research, and facilitate interaction with many international agencies (c.f. Drenth 2006: 193).

The leading science academies of developed countries, both at the individual level and at the pan-national bodies' level have been actively promoting science in –for example- sub-Saharan and central Africa with support from the Gates Foundation. However, such initiatives were criticized at the IAMP Meeting of Kuala Lumpur in 2010 by some participants who claimed that the bulk of the funding was spent on to cover the expenses of American consultants (IAMP 2010). For international collaborative research to succeed according to Ward et al. (2009), more coordination is required among the national academies of the USA, UK, Canada and the Netherlands, as the major benefactors in this area, to identify some of the major initiatives that could be implemented. These include highlighting the contribution that science, engineering, technology and innovation can make to growth; calling for the launch of new science academies in sub-Saharan Africa; and building links between scientists in developed countries and in sub-Saharan nations.

The 2005 UNESCO Science Report (UNESCO 2005: 54) acknowledged that academies of sciences in poor developing countries have stepped up their researcher exchange programmes and have launched joint projects with institutions in other countries, in particular with the US National Academy of Sciences, the UK Royal Society and other European institutions. Some academies have also done much to promote horizontal cooperation through the establishment of regional or sub-regional federations, such as the recently formed Caribbean Scientific Union (CSU).

Scientific publishing or disseminating new science, is an area in which academies of sciences have been active for centuries. Science academies represent a very significant fraction of science publishing in the world (Guédon and Hagemann 2003). The Royal Society of London publishes one of the world's oldest journals in continuous existence (Klug 2000). The Indian Academy of Sciences has co-published a science journal since 1932 (Current Science 2010). The IAS has been publishing a Journal since 1988 (Zou'bi 2008) as have many other academies which publish proceedings, including one of the OIC's oldest academies, the Egyptian Academy of Sciences which was established in 1944 (Fayez 2005). The US-NAS is a world leader in terms of publications including dissemination of information through the Internet. It offers its scientific journal, the *Proceedings of the National Academy of Sciences*, at no cost over the Internet to 140 developing countries (Alberts 2004). The approach adopted by the US-NAS is not common practice, but allows the cost-effective and virtually instantaneous dissemination of new research. Peer-reviewed journals are expensive. Fortunately, this scenario is changing and scientists from the developing world can now access some of these journals without charge (Ogodo 2007). The unhindered access to scientific information from peer-reviewed journals –as pioneered by the US-NAS- helps to elevate the quality of research work globally. It encourages researchers to aim for a high standard in their work and in the papers they publish. Researchers on the receiving have the opportunity to become acquainted with the latest research output. This ‘open access’ activity is of great value to developing countries, as advocated by Doyle (2004) in an article in *SciDev.Net*[9] which itself was founded on the premise of open access.

Opposing stands have been taken by academies of sciences on open access publishing[10]. The Royal Society has expressed serious doubts about open access on several occasions (Pincock 2006). This is a stance which was deplored by Arunachalam (2004), who applauded the stance of the Indian National Science Academy (INSA) (ironically presided over by a fellow of the UK Royal Society) on this issue. The INSA’s journals are all open access journals. Of the few journals originating from OIC countries that are available through open access is the Medical Journal of the IAS (Zou’bi 2008).

5.6 Science Education

Science education is a key activity which academies of sciences must be involved in (IAP 2009). It is an activity that can encourage students to opt for scientific educational streams, and engender science appreciation within society by demonstrating how science can be used to address societal problems.

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9 http://www.scidev.net

10 Open Access publishing is an exciting departure from the traditional subscription-based model of scientific publishing, a system that often frustrates the attempts of scientists, clinicians, and other interested users to search, read about, and share important scientific discoveries. While the prospect of free, comprehensive Internet archives of scientific literature is compelling, the logistics of open access remain a source of uncertainty for some stakeholders in scientific publishing. The United Nations has championed the need to promote open access to information and technology. It can play a critical role in promoting the concept of open access.

Léna (2004) summed the interest shown by academies of sciences and academicians in science education in a paper he presented at the Pontifical Academy of Sciences entitled: *Much More is Required: Science Education in the 21st Century: A Challenge:*

> *This preoccupation (with education) was present, as shown in the vigorous summary of the 2000 Budapest World Conference on Science given by Werner Arber or the plea for responsibility given by André Blanc-Lapierre. With great foresight, Ahmed Zewail, writing on the 'New world disorder', and Paul Germain underlined the importance of education in science as a fundamental need of modern societies to achieve peace, justice and a sustainable development.*

In general, building science capacity is a major function of science academies. At the heart of science capacity building is science education which has been described by Park and Han (2002) as a fundamental issue to improve the economic growth and the living standard of countries. Science education is an activity to which academies pay a special interest, because according to W. C. Clark (2003), 'young people do not see science careers as a way of helping to solve social problems so they seek other professions.' Science education curriculum development has been an area that has too attracted the attention of the Israel Arts and Science Academy (Erez 2004). It is an area that the political leadership in many countries rightly considers important. Cherry (1996), for example, described how (former) South African President Mandela challenged the country's academy of sciences to inspire the country's youth to seek careers in science, engineering and technology. Some African OIC academies such as the UNAS view science education as the single most important activity in which an academy of sciences can become involved (Mugambi 2006). Similarly, the ANSTS lists among its objectives the promotion of S&T education (Sock 2006). Some Asian OIC academies of sciences are active in the domain of science education, such as the ASM, which is pursuing a lecture series programme, science education evaluation activities, as well as reviewing proposals to launch mathematics and sciences teacher training institutes (Ong and Abdul Rahman 2002). Other OIC academies are also involved in promoting science education programmes, including the Bangladesh Academy of Sciences, the Afghanistan Academy of Sciences and the Pakistan Academy of Sciences (Ali 2002) (Rashed 2002) (Riazuddin 2002).

5.7 Summary and Discussion of Part II

In Part II, some of the questions raised in the literature review concerning the role of science academies were addressed.

The provision of science advice has often been signalled out as the one of the major functions of academies of sciences. Today, this is a broad domain that is interwoven with the existence of an academy and takes numerous forms, some of which were highlighted in this part. With the internationalisation of the scientific enterprise, this has developed into an outreach activity. Essentially, for the advisory process to work, lines of communication between the user of the service and the service provider (the academy) have to be in place. As a rule, academies of sciences should aim to offer the kind of advice that is neither ignored by the government nor one that rubberstamps its wishes (Lambeck 2008).

Rewarding excellence is another important activity of science academies. It is an activity that has become closely associated with the Swedish Academy of Sciences demonstrates (see section 6.17). There seems to be a trend internationally to award younger scientists and not only scientists who are at the end of their careers.

Funding research is a function that some academies of sciences are involved in– especially in the West- as science budgets in developing countries are mostly meagre, and the funding role is normally controlled by other agencies.

In Chapter Four, it was mentioned that OIC countries have set themselves quantitative targets including collectively producing 14% of the world's scientific publications. If this particular target is to be achieved, then science academies need to assume an even bigger role in increasing scientific output. 'Open access' is one means through which academies of sciences can increase scientific output. It is a means that science academies in the Developing world and more importantly in the West have to support.

Science education is today one of the most important activities of science academies. Due to the activities implemented by many Western academies of sciences, this has become a key activity of some science academies in the OIC. In general, the interest shown by the academies of sciences of OIC countries in promoting science education does not match that of the world's leading academies of sciences. This is disappointing as implementing activities in science education is not a costly endeavour, as Prof. Shamsher Ali (Bangladesh) noted at the 1999 IAS Conference;

> *A pond with which students in many parts of the Muslim world are so familiar can be shown to be a living laboratory containing some of the local flora and fauna. Many biological lessons can be driven home to the students by simply analysing the happenings in the pond.*
>
> (Ali 2000: 237).

Part III: Academies National and International Outreach

In this part, I will look at another aspect of 'science advice,' namely the interaction between academies of sciences and the executive and legislative branches of government, an interaction that is not always harmonious. I will also analyze the efforts of academies on the international arena and how they interact with the international community and act as a voice of science on issues of international nature.

5.8 Academies and *Realpolitik*

The statement below was issued by the IAP at the conclusion of a workshop it organized in Trieste during February 2009 on 'Best Practices in Advisory Roles and Fellowship Appointments…'

Academies need to be politically astute, use a variety of means to engage decision makers and take advantage of all opportunities including 'quiet diplomacy' to ensure that the voice of science is included at the decision-making tables.

(IAP 2009).

Science academies are responsible for analysing and presenting complex science-related transnational issues to decision-makers. Such issues include shared water resources, global warming, climate change, food security, etc. A prerequisite for such interaction between science academies and governments is the existence of a good rapport between the two. This would persuade governments to base their long-term decisions on the science-based advice offered by academies of sciences. Historically, such a rapport has not always been there.

The first reported spar between academe and government took place about 15 centuries ago (AD 529) and resulted in the closure of Plato's Academy by Justinian (Drenth 2006: 219), who proclaimed that the views the academy propagated were damaging to the state. Today, many science academies label themselves as non-political such as the IAS (Zou'bi 2008). Yet, it is impossible to disassociate academies of sciences from engaging in national, regional or international politics, sometimes to their detriment. On occasions however –due to their prestige- academies of sciences prevail.

Quiet diplomacy was absent when the Belgian government wanted to evict the Royal Flemish Academy for Science and Arts and the Royal Academy of Science, Literature and Arts from the Palace of the Academies in Brussels (Shiermeier 2001). The eviction would have had serious implications on the status of the academy and its members. Ultimately, the government had to back down. During the 1980s, the Academy of Sciences of the USSR refused to expel dissident physicist Andrei Sakharov from its ranks, despite the strong pressures exerted on it by the political powers of the day (Quéré 2006b). Ironically, after the end of the Cold War and the collapse of the Eastern Block, the academies of sciences of Eastern Europe and the former Soviet Union found themselves close to collapse themselves due to lack of government support (Nechifor 2005). In one of the former republics; Turkmenistan, the government was even more hostile when, in 1997, it decided to abolish its academy of sciences (Holden 1998). This stance however was reversed later (Ilolov 2010).

A more recent example also comes from Russia when, in 2004, members of the Russian Academy of Sciences reacted angrily to a government plan to slash their research budget (Allakhverdov and Pokrovsky 2004). As a result of the Russian government’s interference in its affairs, the academy was set to lose its autonomy and be renamed as the state academy of sciences. Because of the proposed change, the academy would no longer be permitted to allocate funds to research projects, but rather ‘manage’ funds as the government dictated (MacWilliams 2006). At the end of the day the Russian government had to back down.

In one OIC country; Kazakhstan, disagreements arose some years ago between the National Academy of Sciences and the leadership of the country that resulted in the latter slashing the Academy’s research budget (Ilolov 2010).

An extreme action was reported by Rich (1994) who described the capture by Serbian authorities of the building of the Kosovo Academy of Sciences and Arts in Pristina, Serbia; and handing it over to the Deaf and Dumb Association of Kosovo.

Today, there seems to be a divide also between academies and parliaments.

Earlier, McNeely was quoted as saying that … an ‘academy’ is synonymous with an ‘ivory tower,’ a bastion of the scholarly establishment out of touch with common experience and common sense (McNeely 2007). This is the case in some countries, where a gap exists between the science community and parliament.

This has been described by Gascoigne (2007) as follows:

> *There is a problem when it comes to the relationship between science and members of Parliament. Few Parliamentarians understand the possibilities of science. They do not understand the limitations of science, or the long time scales it can take to develop an idea into something that will benefit the community. Nor do scientists understand the work of members of Parliament. They do not have a clear idea of the political processes. They do not appreciate the pressures or the time scales Parliamentarians work to… there is no natural dialogue between the two sides, because they come from different worlds.*

However, some examples exist that illustrate how science academies interact with parliaments. One such example comes from the US where, in 1974, the US-NAS re-endorsed the scientific 'underpinnings' of the 1974 Endangered Species Act, which was criticized by Congress as being based on 'faulty science' and as 'trampling the constitutional rights of the individual' (Reichhardt 1995).

Realizing that greater understanding and synergy between scientists and parliamentarians would benefit the decision-making process (Rees 2005: 2), the Royal Society launched the Scientists/Members of Parliament pairing programme to engender dialogue between research scientists and Members of Parliament. Similar notions were expressed by Badrawi (2007) and Oboyi (2007) at the Budapest World Science Forum of 2007, hosted by the Hungarian Academy of Sciences. Both are members of their respective parliaments in Egypt and Uganda. The fact that both participated in a discussion of this nature at the 'Hungarian Academy of Sciences' is proof that there is a willingness on the part of politicians in developing countries to interact with scientists in their countries, and internationally, a willingness that science academies should cultivate.

5.9 International Outreach and Science Diplomacy

Quoting the former British Prime Minister Gordon Brown (Brown 2009):

> *Many of the challenges we face today are international and – whether it's tackling climate change or fighting disease – these global problems require global solutions… That is why it is important that we create a new role for science in international policy-making and diplomacy… to place science at the heart of the progressive international agenda.*

Science is a vehicle *par excellence* to build bridges between cultures (Drenth 2004). Governments must not ignore how science academies can help improve and assess policy decisions taken at the international level although they do, as was demonstrated by the absence of science academies from the agenda for the African Union Summit on science and technology in January 2007 (Scott 2006).

Science academies have often demonstrated their capacity to bridge political divides between nations as Jamgotch (1985) documents in the book: *Sectors of Mutual Benefit in US-Soviet Relations,* where it is reported that the US and Soviet academies agreed to conduct joint activities despite the atmosphere of hostility and distrust that existed between the two countries at the political level. Earlier, in 1981, at the height of Soviet military involvement of Afghanistan, the Soviet Academy of Sciences signed a wide-ranging agreement with the Afghanistan Academy of Sciences to organise training for Afghan scientists and engineers and establish a National Sciences Centre of the Afghanistan Academy of Sciences (Sardar 1982: 120).

Mervis (1997) has reported on a thawing of relations in 1997 between the US National Academy of Sciences and the Chinese Academy of Sciences after ten years of embargo. This was manifested in meetings between the two academies and the signing of a number of agreements, and eventually contributed to improvement of political relations between the US and China.

Some academies including the US-NAS, the RS and the IAS have individually implemented a number of activities that aimed to bridge the divide between the Islamic world and the West. Moreover, the US-NAS has been actively engaging Iran through organising visits and joint seminars and conferences yet such engagement has not resulted a political breakthrough between the two adversaries (Schweitzer 2008). Two years earlier, Schweitzer (2006), in his book *America on Notice*, argued that realistic modification to US foreign policy could change hostile attitudes toward the US. Such changes might include a new emphasis on job creation, foreign aid, expanding educational opportunities and encouraging the adoption of modern university curricula. These issues apply especially in the Muslim World.

The world today is dominated by S&T. These twin pillars of the modern world have the capacity both for good and for harm (Barker & Peters 1993). In Chapter Three, the problems that science should address including those related to WEHAB (Water, Energy, Health, Agriculture and Biodiversity) were outlined. With population growth as the driver, academies have identified these areas, together with education, as the most important issues to be analysed at the present time (Lee 1999).

In 1994, the IAS organised a conference in Sudan on the controversial topic of 'water' at which issues related to regional water 'hot-spots' including water sharing arrangements between Egypt and Sudan; Turkey, Syria and Iraq; as well as Jordan, Palestine and Israel, were considered (Ergin and et al. 1995).

Whenever the question of food security arises, the question of GMOs surfaces. The *Times* (cited in AgBioWorld 2003) reported on a meeting that involved the academies of sciences of Brazil, China, India, Mexico, the US, the RS and TWAS, which produced a report expressing worries about the safety and the possible environmental impacts of GM crops. A viewpoint to the contrary was expressed later by Jeffrey Sachs at the First Annual Conference of the African Science Academy Development Initiative (ASADI) held in Nairobi, Kenya, in 2005, when he called on African governments to adopt promptly the use of transgenic crops to boost food security on the continent (Nyambok 2006).

The controversial issue of cloning has been of concern to many academies of sciences. While the UN embarked on formulating a global convention on cloning in 2004, the world's science academies, including the Australian Academy of Science (AAS 2004), have been intensifying their efforts to lobby their respective governments in support of an international treaty that does not ban cell nuclear replacement for therapeutic purposes.

In 2005, the science academies of Brazil, Canada, China, France, Germany, India, Italy, Japan, Russia, the RS and the US sent a letter to world leaders, specifically those meeting at the Gleneagles G8 Summit in July 2005, advocating a number of policy actions on climate change (Pielke 2005). In 2010, TWAS decided to launch a mega project on climate change at its Hyderabad Meeting (Padma 2010). Other national academies of sciences have earlier joined the controversial debate on global warming. In an editorial in *Human and Ecological Risk Assessment*, it was reported that the US-NAS and the UN have concluded that a strong relationship exists between human activity and observed temperature increases (M. Clark 2006).

Human rights issues have not escaped the attention of academies of sciences. In 2001, the *International Human Rights Network of Academies and Scholarly Societies*[11] (2005) was launched to assist scientists and scholars who are 'subjected to repression for having non-violently exercised their rights as promulgated by the Universal Declaration of Human Rights.' However, when a petition was published in the scholarly journal *Nature* urging a European boycott of research and cultural links with Israel until the Israeli government 'abides by UN resolutions and opens serious peace negotiations

11 International Human Rights Network of Academies and Scholarly Societies, Proceedings, Symposium and Seventh Biennial Meeting, London, May 18-20, 2005, The National Academies Press, Washington D. C., USA.

with the Palestinians,' the Royal Society through the (same) *International Human Rights Network of Academies and Scholarly Societies* responded that any such action, 'although surely well-intentioned, is misguided and inevitably counterproductive' (Mantell 2002).

Upon a proposal by its then Secretary General the late Ali Kettani, the IAS issued a strong statement during its 1992 Conference in Kuala Lumpur condemning violence against civilians in Bosnia-Herzegovina at the time (Daghestani and Al-Athel 1994). In neighbouring Croatia, the Croatian Academy of Sciences has been active in mine clearing operations (RSSA 2002). This Zagreb-based academy is a learned society of 150 fellows that hosts a research centre employing over 100 researchers (UNESCO 2005: 109). In 2006, the IAS issued a statement at its Ankara conference condemning the killing of Iraqi scientists (Ergin and Zou'bi 2009).

5.10 Networking and Communication

The communication function is one of the essential *raisons d'être* of academies and association of academies (Drenth 2002a). Exchange of ideas by academicians takes place at scientific meetings, international conferences, workshops, reciprocal visits of scholars, and through exchanges of publications as well as membership of international organizations (Drenth 2002a). Despite the divergent viewpoints that may arise at such gatherings, the fact that academies of sciences are involved is reassuring. Firstly, differences in opinion seldom coincide with divisions between continents, nations or political alliances. Secondly, in most scientific discussions the differences are amenable to reason. Thirdly, it is the scientists themselves that decide what is scientifically right or wrong, not politicians (Drenth 2002b). The IAS organizes scientific conferences at which specialists from the Islamic and Developing worlds address contemporary scientific topics, and the results of their deliberations are then disseminated through declarations, newsletters and conference proceedings (Zou'bi 2008). The Swiss

Academy of Sciences sees itself as a science broker that mediates dialogue with society through the establishment of interfaces (Kissling-Naf 2009). The manner and platforms used for engaging the public offer useful pointers for other academies to promote public understanding and awareness of science.

Networks of academies are not new. The first such network, the International Union of Academies (IUA[12]) was launched in 1919. At the level of the OIC, the idea of establishing an association of science academies was brought discussed by the IAS Council in 1992 and 1993 (IAS 2003). Such a body was to be called the Association of Academies of Sciences (ASA) however, the idea was not implemented at that time as the then IAS President Dr M. A. Kazi felt that the Federation of Science Academies of Asia (FASAS) –established in 1984- was already shouldering some responsibility of coordinating the work of science academies in the region.

In 1993, the Inter-Academy Panel (IAP) was conceived as a global network of the world's science academies that aims to advise citizens and public officials on the scientific aspects of global issues. The IAP is particularly interested in raising the public profile of young academies and enhancing their influence among policy makers (IAP 2010). Through the IAP, academies of sciences produce global statements that they issue ahead of political summits. Many also are involved in the reports prepared by various UN agencies and the InterAcademy Council (IAC).

The IAC was established in May 2000 by 15 of the world's leading national academies of science, from Brazil, China, France, Germany, India, Israel, Japan, Malaysia, Mexico, Russia, South Africa, Sweden, the UK, the USA as well as TWAS, to provide high quality advice to international bodies – such as the United Nations and the World Bank – as well as to other institutions (IAC 2010). An important collaborative effort by the IAC has been the publication of the report entitled; *Inventing*

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[12] IUA (The Union Académique Internationale or the International Union of Academies), 2010. [Online] Available at: .http://www.uai-iua.org/english/description_en.asp [Accessed on 9 October 2010].

a better future: A strategy for building worldwide capacities in science and technology in 2004 (IAC 2004). The report concluded that people in most societies throughout the world are falling behind in their capacity to master the new knowledge and benefit from its fruits. The IAC has been responsible for publishing three further reports including one entitled *Lighting the way: Toward a sustainable energy future*, which came out in 2007. In 2010, the IAC released its much-anticipated review of the Intergovernmental Panel on Climate Change, recommending a beefed-up management infrastructure as well as various reforms for reviewing science, managing potential conflicts of interest and injecting fresh blood into the process. The review was requested jointly by the IPCC and the United Nations (Nature 2010).

ALLEA, founded in 1994, is the Federation of 53 National Academies of Sciences and Humanities in 40 European countries. Its member academies are self-governing communities of scientists and scholars, and operate as learned societies, think-tanks, grant givers, and research performing organisations. ALLEA itself promotes the exchange of information between academies and brings together the sciences and the humanities academies with policy-making instruments across Europe (ALLEA 2010).

The European Academies Science Advisory Council (EASAC), which includes representatives from 16 national European science academies, carries out studies for some European agencies. In one study in 2004, commissioned by the European Parliament Industry Committee, it claimed that Finland and Sweden spent 3.4 and 4.3%, respectively of GDP on R&D, higher than the target of 3% set by the EU as the target by 2010 (KVA 2011). The other regional networks IANAS, NASAC and NASIC have been active in implementing scientific activities with and under the sponsorship of the IAP, particularly in the field of science education.

Together with the IAP and the IAC, international associations of science academies such as ALLEA, EASAC, IANAS, NASAC and NASIC are potential key players in fostering international collaborative activities of scientists. Some have been established to embody the international dimension of providing science-based advice while others organise capacity building activities or science education programmes. Such networks can stimulate and influence the international orientation of scientists, provide funding, internationalize research and facilitate interaction with a host of international agencies such as UNESCO, ICSU, TWAS and others (c.f. Drenth 2006:193).

Nowadays too, e-mail and the Internet have become the most favoured means of communication. E-mail tops the list of all the technologies used. It is fast becoming expected for any business to have an internet presence that can be as simple as a one page 'About Us' to an elaborate multimedia production. The Internet offers another channel for science academies to increase their visibility and to promote their missions. By building an online community through the use of discussion forums, e-mailed newsletters and so on, academies' websites become powerful media to reach out to the public through cyberspace (Bowen and Borda 2009).

Many science academies have elaborate and informative web sites. Of particular note are the web sites of the US National Academy of Sciences, the RS, TWAS, the ASM, the IAS (which also has a 'Facebook' page and a 'Wikipedia' presence) and the Bibliotheca Alexandrina. However, the majority of science academies of the OIC hardly have any web presence to speak of.

Awareness by the media of academy activities is important for enhancing impact, and this is a weakness generally (IAP 2009). If science academies of the OIC are to fulfil their communication responsibilities, they must build informative multi-language web sites and engage more with science journalists. That was a major recommendation to come out from the 2008 IAS Conference in Kazan, Tatarstan, Russia (IAS 2008).

5.11 Promoting Women Scientists

The following quote from McClellan and Dorn (2006:254) sets the historical context for this section.

> *Whereas upper-class women reigned in the literary and intellectual salons of the 17th and 18th centuries, the world of science and the learned society remained largely a man's world. The French marquise Madame du Châtelet (1706–49) is a notable exception, being a member of several academies and Newton's underrated French translator.*

5.11.1 The Issue

In the above quote, McClellan and Dorn describe the role of women on the academies scene in France in the 17th and 18th centuries, when monarchies, motivated by the impact of the Scientific Revolution, were establishing academies to stimulate the development of science: Lincei (1603), Académie Française (1635); and the Royal Society in London (1660) (Noordenbos 2002).

Although none of these academies had statutes excludes women, hardly any were elected as members in the 17th, 18th or 19th centuries (Schiebinger 1989: 23 cited in Noordenbos 2002). The case of Maria Winkelmann at the Academy of Sciences in Berlin was the exception. She –in 1712- lost her year-long battle to become the Academy's astronomer in what turned out to be a decisive case in the rise of women academicians (Schiebinger 1987). Only well into the 20th century did an increase in the numbers of female members in science academies become apparent (Noordenbos 2002).

At present, only 58 of the 1285 members of The Royal Society in the UK are women. The Accademia Nazionale dei Lincei in Italy has less than 30 women among its 540 members, and the Brazilian Academy of Sciences, with a total membership of nearly 600, has just 60 women (Hassan and Schaffer 2009).

To explain this low percentage of women, theories about subtle forms of exclusion have been offered including the theory of social closure (Murphy 1988 cited in Noordenbos 2002) which says that the in-group (male academics) creates barriers for the out-group (female academics) to prevent the latter's members from joining. The network theory, on the other hand, shows that high-prestige male scientists have greater professional contact with other male rather than female scientists (Van Balen 2001 cited in Noordenbos 2002) and this leads them to nominate males rather than females to various memberships.

At the practical level, a billion women in rural areas and in the slums of megacities in the developing world are responsible for health care, water, food, shelter, education, and for development. Female engineers and scientists are needed to transfer technology to their sisters at the 'grass roots' (Sengers 2009).

Most planners in developing countries seem to be indifferent to the advantage of having a specific policy for the development of the women sector. In the areas of 'Environment and Health,' for example, it is obvious that a pre-requisite for the success of any policy would be to take measures to minimize the number of illiterate women in society. This would positively affect the environmental and health state of affairs in many developing countries (IAS 1992) (IAS 1994a). The pivotal role women have as stakeholders in sustainable development and better community health was highlighted at the two IAS Conferences in 1992 and 1993 on 'Environment and Development' and 'Health and Nutrition,' 1992 and 1993 (Daghestani and Al-Athel 1994) (Bor et al. 1996).

5.11.2 Affirmative Action by Academies of Sciences

The UNESCO and the IAC have both published highly-publicised recommendations on Women and Science. The 1999 World Science Conference held in Budapest under the title *Science for the Twenty-First Century* called for increased access within the education system for girls and women to pursue scientific education, and for raising awareness of the contribution of women to S&T (UNESCO 1999). In 2006, the IAC published a report entitled *Women for Science* that called on the world's academies of sciences to help remedy the underrepresentation of women in scientific and technical fields. It concluded that the disproportionately small number of women in the scientific enterprise, particularly in leadership positions, is a major hindrance to strengthening science capacity worldwide (IAC 2006). The underlying theme in the IAC Report is that academies of sciences –because of their influence in society and the prestige they enjoy- must take the lead in this area so that the S&T community can follow (Sharma and Sengers 2006). The IAC Report recommended a number of 'affirmative action' measures to raise the profile of women scientists including increasing the number of female academy members, nominating female scientists and engineers for prestigious awards, and ensuring that there is gender balance on decision-making juries.

Utilization of the talents of women should not be viewed only from the perspective of gender equity; it must be understood that the full involvement of women in scientific and technological efforts is essential today for rapid economic development and sustainable happiness (Sharma 2007).

5.12 Summary and Discussion of Part III

Relations between academies of sciences and governments have not always been harmonious. The opinions of academies are mostly science-based –or should be- while the essence of political thinking is short-term with measurable impact. Thus, clashes between the two are inevitable. The bottom-line is that academies need to be politically astute constantly engaging decision makers and use gentle persuasion to ensure that the voice of science is heard within decision-making circles.

Scientists are distant from their national parliaments. This was evident from the discussions that took place at the InterParliamentary Forum on Science, Technology and Innovation Policy for the Mediterranean Region, hosted by UNESCO in 2010 (UNESCO 2010). Greater understanding and synergy between scientists and parliamentarians would benefit the decision-making process (Rees 2005: 2). And although the RS of London has encountered some success in engaging the British House of Commons, as well as some African science academies with their respective parliaments, attempts by the IAS to engage the Parliamentary Union of the OIC Member States[13] (PUIC) have not been heeded.

Academies of sciences have a role in addressing contemporary problems that are international in nature such as combating violence. This was suggested by Drenth (2004) in the wake of the Madrid attacks in 2004, and earlier by the US-NAS after the attacks of 11 September, which caused a fundamental cleavage between the US and the Islamic world and redefined the roles of science academies on the international arena. Academies should lobby for more collaboration with scientists from Islamic countries as a means to bridge philosophical and cultural divides and contribute to better understanding (Drenth 2004). Many academies of sciences –especially the US-NAS- have been actively engaging the science community in the Islamic world. It was no

[13] www.puic.org [Accessed 31 December 2011].

coincidence that when US President Barack Obama made his defining speech in Cairo in 2009 in his first major attempt to engage the Islamic world, one of the key concepts he advocated was S&T. He followed it up with the appointment of three high-profile science envoys to strengthen contacts with the OIC countries including the former president of the US-NAS: Bruce Alberts.

The IAS, although mandated as a non-political organisation but convinced that the communication function is one of the essential *raisons d'être* of academies, has often addressed politically sensitive issues and issued statements on political events in the Islamic world. As scientific meetings are good milieus for exchanging views, the IAS has attempted to bridge the divide between the scientists of the Islamic world and the West by focussing on scientific issues of mutual interest.

Academies of sciences should be the democratic voice of science. They rightly take the moral high ground on a number of controversial issues. Issues of concern to humanity such as: the WEHAB components, global warming, stem cell research, etc. They not only have to answer to the public on such issues but also have to get their message across to decision-makers. The impact of such activities can be gauged through letters that academies receive, press releases, news articles as well as enquiries that they receive about certain positions that they take. The IAS for example received enquiries from a number of organisations in Philippines on that position it adopts on GMOs.

As many regions of the world face similar science-based problems, academies of sciences can join efforts and form groups or networks to organise regional activities to address such problems. Over the years, a number of networks of academies of sciences sprung up. They act collectively to give advice or issue statements on topical issues to major world agencies although some networks such as IANAS –the grouping of South American science academies- are also involved in science education.

How to increase the participation of women in science is a challenge for academies that most have not really been able to address, notwithstanding the limited success of some academies in this domain. This issue is both political and policy-based in nature. Greater female involvement will ensure that academies draw on the largest possible pool of talent. It will also help shift the focus of science to issues directly related to critical socioeconomic needs (A World of Science 2008). Science academies in the Islamic world, where they exist, have a particularly challenging responsibility in terms of the inclusion of female scientists in S&T for development activities.

Part IV: The IAP's Model Academy of Sciences

5.13 The Academy of Sciences of Wonderland (ASW)

The mission statement of the InterAcademy Panel on International Issues (IAP) states that it aims to serve as platform for member academies to develop mutual collaboration as well as common positions and activities. IAP aims to help member academies to improve their capacity to advise governments and societies. IAP will also support scientists with the creation of academies where none exist.

To help achieve these objectives, the IAP has prepared and published the 'Statutes of the Academy of Sciences of Wonderland,' to provide a guide to scientists who wish to establish a national science academy in their country. This was done after reviewing the statutes of over 40 academies of sciences worldwide. The Statutes of the Academy of Sciences of Wonderland were thus prepared by the IAP and published in 2006.

Article 1 of the Statutes describes the academy as an autonomous body, which is founded by scientists (Founding Fellows). It describes the various scientific disciplines that it will encompass including basic and applied sciences, engineering sciences as well as *interestingly* social sciences. It further outlines the legal status of the academy.

Article 2 of the Statutes details the objectives of the academy, which include awarding scientific excellence, networking between scientists, promoting national research, advising the national government on scientific issues, lobbying for science and streamlining scientific research to meet national interests.

Article 3 of the Statutes talks about the activities of the academy which include providing a forum for discussion of scientific issues, representing local scientists at international meetings, awarding grants and medals, scientific publishing, organising conferences and symposia and managing and supporting research institutions nationally.

Article 4 of the Statutes comprehensively addresses the question of the membership of the academy and proposes five categories of membership: Founding, Active, Emeritus, Foreign, and Honorary. It also emphasizes that all members are elected on merit and in accordance with the procedure outlined in the Statutes. It outlines that Active members automatically become Emeriti members upon reaching the age of 70, and are then no longer eligible to hold office within the Academy. Article 7 explains that in order to enable the Academy to offer Membership to scientists from other countries who have made real contributions to science in the country of the Academy or to scientists born in the country but working abroad, the category of Foreign members was introduced. The Honorary membership category does not stipulate that the member should be a scientist however he/she has to have made outstanding contributions to the objectives of the Academy.

Article 5 of the Statutes outlines the procedure for the election of new members including inviting nominations from Members. It assigns the President with the task of appointing Membership Advisory Committee for each discipline, or group of disciplines, to assist him/her with the selection of the candidates to be proposed by him/her to the Board. Article 5 further stipulates that if there is a limit on the number of new Members that can be elected, the Board shall consider not only the individual qualifications of the candidates, but also the overall balance between disciplines, age and gender in the Membership of the Academy. Once the final list of candidates is drawn up by the Board, voting is carried out by all Members through a secret ballot. If that number of respondents is less than two-thirds of all Members, the Board shall declare the ballot void and initiate a new ballot for which the required number of responses shall be reduced to one-half of total Membership. A candidate is elected when he/she receives the support of at least one-half of the Members that have responded and if no more than one-fourth of the responding Members oppose his/her election.

Articles 6 of the Statutes describes the duties and responsibilities of the General Body (General Assembly) of the Academy. The General Meeting shall, in particular, receive and approve the annual report of the Academy, issue overall policy guidelines to the Board, review the activities of the Academy, elect the Officers of the Academy; elect the Ordinary members of the Board, appoint the auditors of the financial administration of the Academy and approve reports and accounts submitted to it and award medals, prizes and other honours on behalf of the Academy.

Article 7 of the Statutes firstly describes an elaborate procedure for the election of Board members including the President who is allowed to hold the post for three consecutive terms while other Board members are only allowed to hold office for two consecutive terms. The Article details the duties of the Board including managing the affairs of the Academy and its finances, preparing for and convening the sessions of the General Meeting, appointing standing and temporary committees as and when necessary, considering all reports and accounts to be submitted to the General Meeting for review and approval by that Meeting and proposing medal winners and prise awardees to the General Meeting.

Article 8 of the Statutes outlined the duties of the President, the Vice-President, the Secretary General and the Treasurer of the Academy. It clearly states that the President is the principal officer of the Academy who represents it externally and presides over all its meetings. The Vice-President takes the place of the President if the President is unable to attend meetings and may be discharged other responsibilities as the President assigns to him/her. The Secretary General shall be responsible for all official records, including the Register of Members, of the Academy and for all official correspondence of the Academy, except that which relates to finance. He shall preside at meetings of the Board and at sessions of the General Meeting if the President and Vice-President are unable to attend. The Treasurer shall be responsible for the financial records and administration of the Academy and for the management of all its financial resources and other assets. The Treasurer shall report annually, and at such times as the Board may determine, to the Board on the finances and accounts of the Academy. He shall present a report to each Ordinary Session of the General Meeting on the audited accounts of the Academy.

Article 9 of the Statutes describes the duties of the Executive Director of the Academy who is the highest administrative officer of the Academy who, subject to the guidelines and instructions of the Board, is responsible for the administration of the Academy and for the management of the office of the Academy, including the appointment of staff, the setting of salaries and other benefits and the general conduct of the staff. He is also required to support the Board in formulating and implementing the policies of the Academy and he/she shall maintain working relationships with all organizations that pursue objectives similar to those of the Academy.

While Article 10 addresses the Financial Management aspects of the Academy, Article 11 stipulates that the publications and the statements of the Academy shall not be made public until their public release is approved by the Board. The President may decide on urgent matters of this nature provided that its content is in line with standing policies of the Academy.

5.14 A Critique

Albert Koers, who drafted the Statutes of the Academy of Sciences of Wonderland, admits that it is impossible to draft model statutes that meet the needs of each and every country. He admits however that there is great deal of overlap between the issues that must be included in the statutes of any academy of sciences including objectives, activities, membership, governance, finances, administration, etc. As Koers is a lawyer by profession, the Statutes have a distinctly legal proclivity.

The Statutes state that the Academy should be autonomous but do not indicate whether an attempt should be made –for example- to link it to the executive head of state although they mention that an attempt should be made by the founding members to ensure that its is registered an a non-profit organisation for tax purposes. This together with other provisions need to be checked in the light of national law. This bond between the academy and the executive head of state is important to ensure the financial security of the academy. So is the issue of the premises of the Academy –understandably not mentioned in the Statutes- but nevertheless an important feature that symbolises a country's commitment to the continuity of the academy.

Koers suggests that the Statutes are intended for a medium-size academy with a total of, say, 100 to a 500 members. An academy of this size can have a structure with: (a) A general meeting of all members that sets the general policies of the Academy (b) A *smaller* governing board of elected members that is charged with day-to-day management; and (c) A secretariat with professional staff to support the elected officials of the academy.

The question of the size of the academy has been discussed often in academe circles. An academy like TWAS with over 1000 Fellows (members) would find it difficult to convene a General Meeting in which the majority of Fellows can participate.

The questions of the age of Fellows has been partially addressed in the Statutes as it is stipulated that Active Fellows automatically become Emeriti members upon reaching the age of 70. However, no provisions were made to ensure that the average age of members remains reasonably low. Moreover, the category of associate members is dubiously missing from the statutes, as well as the category of 'fee-paying institutional members.'

Furthermore, it is known fact that most academies rely heavily on the existence of a strong efficient secretariat to run their day-to-day affairs. The Statutes seem to centralise decision-making powers in the hands of the Board and the President. In reality, this is a recipe for ineffectiveness as presidents of academies are normally senior figures with a multi-faceted public role and cannot devote a lot of time to running the secretariat. Presidents of academies as well as their boards should focus on broad policy issues and more importantly on raising funds for programmes and activities, as well as building its Trust Fund.

From Albert Koers' introduction, a reasonable conclusion may be drawn, namely that when an academy is governed by wise men and women, statutes will most likely live out their lives on the bottom of a drawer. And, if an Academy's leadership is incompetent, no statutes can really remedy that situation. But, good statutes like good laws – may help the wise and stop the not-so-wise.

5.15 Summary of Chapter Five

Chapter Five tells us that today, academies of sciences perceive themselves in a variety of ways, depending on whether they are honorific or honorific and research-performing academies, with an increasing number of both types becoming involved in international activities of a political nature. Academies have to be recognized in national legislation yet 'independent-enough' to offer science-based advice. The US-NAS was the first academy of sciences (1863) to be explicitly mandated to provide advice on science (Alberts 2002). The Chinese and the Russian academies have major responsibilities in this domain as well as in the management of research. The chapter argues that the provision of science-based advice has evolved into a multilevel outreach activity.

Independence is a characteristic that an academy cannot do without, and is the most important criterion of a prestigious academy together with the eminence and number of its members. The membership of academies of sciences is discussed and the innovative membership scheme of the Royal Society of New Zealand is highlighted. The question of whether academies should incorporate members from the social sciences and humanities is also discussed. Moreover, to be representative of the science community of the country, an academy of sciences must include a sizeable percentage of female members who are also elected on merit.

The chapter highlighted that scientific publishing or disseminating new science is an area in which academies have been active for centuries and that the US-NAS is a world leader in terms of publications including dissemination of information through the Internet. Although, the unhindered access to scientific information from peer-reviewed journals elevates the quality of research globally, yet, opposing stands have been taken by academies of sciences on open access publishing.

Science education is today one of the most important activities of science academies. The chapter acknowledges that it can become even more a key activity of science academies in the OIC where it is needed most. In general, the interest shown by the academies of sciences of OIC countries in promoting science education does not match that of the world's leading academies of sciences especially the French and the US academies.

Academies of sciences and networks of academies can play an important role in furthering international research collaboration and promoting science in scientifically lagging regions such as Africa. For international collaboration to succeed, stakeholder academies have to agree to achieve tangible objectives that are understood by all those involved.

Science academies are responsible for analysing complex transnational issues and presenting science-based opinions to decision makers on such issues including water resources, global warming, climate change, food security etc. A prerequisite for such interactions is the existence of a good rapport between the two, as this would convince governments to base their long-term decisions on science-based advice. This requires academies to be politically astute to ensure that the voice of science is heard at decision-making tables. Greater understanding and synergy between scientists and parliamentarians would also benefit the decision-making process.

The chapter talks about science diplomacy, which is a tool at the disposal of academies that helps them to address contemporary problems that are international in nature such as combating violence. After 11 September 2001 (9/11), many academies of sciences –especially the US-NAS- have been actively engaging the science community in the Islamic world, while academies based in the Islamic world such as the IAS have been furthering their scientific engagements with Western academies.

As many regions of the world face similar science-based problems, academies of sciences can join efforts and form groups or networks to organise regional activities to address such problems. Over the years, a number of networks of academies of sciences sprung up that act collectively to give advice or issue statements on topical issues to major world agencies.

The chapter then discusses the Statutes of the Academy of Sciences of Wonderland, and concludes that they present a good template to build upon for a country aspiring to establish a national academy of sciences, although they seem to centralise decision-making powers in the hands of the Board or the President. In reality, this is a recipe for ineffectiveness as presidents of academies are normally senior figures with a multi-faceted public role and cannot devote a lot of time to running the secretariat.

CHAPTER SIX

ACADEMIES OF SCIENCES IN THE ISLAMIC WORLD AND IN THE WEST: A COMPARATIVE STUDY

6.1 Introduction

This chapter will study the academies of sciences in Morocco and Palestine from the Arab OIC region, Uganda and Senegal from the African OIC region, and Tatarstan, Turkey, Pakistan, Iran and Malaysia from Russia and the Asian OIC region. The US National Academy of Sciences (US-NAS), the Academy of Sciences of France, the Royal Swedish Academy of Sciences, as well as the UK's Royal Society, will also be considered together with two global academies: the Trieste-based TWAS and the IAS, based in Amman, Jordan.

The aim of this analysis is to discover how academies from both regions function and draw possible lessons from the experience of academies of sciences in the West.

Part I: Two Academies of Sciences from the OIC Arab Region

Since the end of World War II, the OIC Arab region has been a hotspot of political and military conflicts that have adversely affected the limited efforts to institutionalise STI initiatives for development. This is clearly reflected by the STI indicators of the region (highlighted in Chapter Four) and the fact that today, science academies exist only in seven out of 22 Arab states –Morocco, Sudan, Egypt, Lebanon, Jordan, Iraq and Palestine. These academies are new and are still establishing a footprint on the national and regional S&T scene. Language academies, on the other hand, exist in almost every Arab country. The following section will look at two science academies from Arab OIC countries.

6.2 Palestine Academy of Sciences and Technology (PALAST)

> *What is it like to operate in a war zone? There is the fear and tension, and constant worry about being caught in the wrong place at the wrong time.*
>
> (TWAS 2010a)

Palestine was under British mandate until 1948. After their departure, and in the establishment of the Israeli state, Jewish military forces occupied the majority of Palestinian territories apart from the West Bank of the River Jordan (which makes up about 1/6th of historical Palestine) which remained under Jordanian rule until 1967, when it was occupied by, although not incorporated into, Israel.

Although the British paid some attention to education and the development of infrastructure, British influence on Palestine during their presence was mostly political.

The Palestinian National Authority (PNA) was established in the 1990s on parts of the West Bank and Gaza. The Palestine Academy for Science and Technology (PALAST) was first established in 1992 by the Palestine Liberation Organization (PLO) to nurture STI in the Palestinian society (Khatib 2008), but was formally launched in 1997 as an autonomous public, non-profit organization with its headquarters in Jerusalem and branches in Ramallah and Gaza.

Constituted as the umbrella organisation for S&T in the West Bank and Gaza, it is mandated to be the primary S&T body in Palestine in charge of providing advice on policies, programmes and projects. PALAST promotes national development and participates in the coordination of S&T activities. Of its special features is the presence of a powerful standing council made up of a number of government ministers. This council operates alongside a scientific council of elected members (PALAST 2009).

The founding of PALAST was by no means an easy feat. This is manifested by the fact that this academy was founded even before a State of Palestine proper.

The objectives of PALAST include promoting S&T and scientific research to meet national priorities, developing tools and services that meet the needs of the institutions and the researchers working in the field of science; and lastly *but most importantly* to provide advise to the government, parliament, universities and research institutes, and the private sector, as well as donors and international organizations in the field of S&T (PALAST 2009).

PALAST fellowship totalled 61 Fellows in 2009 (PALAST 2009). PALAST Fellows are associated with 12 different universities and organizations within the Palestinian territories. The majority of the Fellows belong to the sciences and engineering disciplines. Among the Fellows however are two Arabic literature specialists and one Islamic Studies specialist. PALAST has another category of membership, that of Honorary Membership. This is one of the highest honours that the PALAST can bestow upon a person. Honorary Members are encouraged to use their influence to advance the Academy's role in S&T and facilitating networking and cooperation between PALAST and foreign institutions. The list of PALAST's Honorary Fellows includes Professors A. S. Majali (IAS and TWAS), M. H. A. Hassan (IAS and TWAS), M. Clegg (US-NAS), F. El-Baz (IAS and TWAS) and Y. Quéré (ASF) among others.

PALAST has undertaken a number of activities since it was founded. In 2001, PALAST launched a project to assess the state of scientific research in Palestine. That was followed by a workshop on 'Basic Scientific Research in Palestine,' which was held simultaneously at the PALAST offices in Ramallah and Gaza. In November 2002, PALAST initiated a ten-month UNDP-funded environmental awareness project that aimed to raise environmental awareness and promote community involvement in tackling environmental issues (PALAST 2009), while in 2004, it launched the first Palestinian Environmental Field Centre (EFC) in Jericho, which aims to promote awareness of ecological diversity and eco-tourism. PALAST's Gaza Branch established the first natural history museum in Palestine, at about the same time.

As water is one of the crucial and sensitive regional issues that needs to be addressed scientifically as well as in the context of hydro-politics and rights, PALAST acted as scientific partner in the Global Change of the Water Cycle project (GLOWA) with the Potsdam Institute of Climate Impact, Germany. Moreover, in 2005, it initiated the international conference 'Water: Values and Rights' in cooperation with the Palestinian Water Authority (PWA) and UNDP. The conference aimed to provide scientists, researchers and decision-makers with a platform to introduce the latest research in the fields of water management and rights.

Figure 6.1 The Main Building of PALAST in Ramallah (after an attack by Israeli Forces).

Also in 2005, PALAST was commissioned by the EU to participate in a project called ASBIMED; *Assessment of the bilateral scientific co-operation between the European Union Member States, the Accession Countries and the Associated Countries, and the Mediterranean Partner Countries.* The project aimed at analysing the results of bilateral co-operation in the fields of S&T between each of the 25 EU-Member States on the one hand, and Morocco, Algeria, Tunisia, Egypt, Syria, Jordan, Lebanon and Palestine on the other (Khatib 2008).

In 2006, PALAST was commissioned by the EU to undertake a survey of research institutions in Palestine. The survey contributed to a report on the research system in Palestine that also drew information from interviews as well as historical, social and political sources (Khatib 2008).

Realizing that ICTs are a powerful means of activating, developing and promoting STI, PALAST has implemented several activities in this field in partnership with national and international institutions. During 2003-2005, PALAST participated in the Euro-Mediterranean project entitled *Enhancing the Environmental Management System (EMS) in Small and Medium Enterprises using Information Technology*. In 2007, PALAST was commissioned by the EU to participate in the Euro-Mediterranean Programme to build a national Scientific Research Agenda (SRA) in the field of ICT. PALAST went on to prepare the national ICT-SRA in collaboration with the relevant government department (Khatib 2008).

PALAST is active internationally. It is a member of the IAP, IAMP and NASIC, International Human Rights Network of Academies and Scholarly Societies (HRN), Consortium on Science, Technology and Innovation for the South (COSTIS), and the Mediterranean Inter-Academy Network.

PALAST has an informative English/Arabic web site[14], which lists its previous activities since 1999 and the various initiatives it is engaged in. It also gives some background information about PALAST, its Fellows and Honorary Fellows.

6.3 The Academies of Morocco: AKM and HAST

Morocco has two academies. The first, the Academy of the Kingdom of Morocco (AKM) was established following a Royal Decree by King Hassan II issued in 1977. It is an intellectual forum that addresses diverse fields including philosophy, law, letters,

14 http://www.palestineacademy.org/main/

the fine arts, town planning, education, health, science, applied technology, defence, agronomy, industry, economics, social sciences and international relations. The AKM was designated by its founder King Hassan II as an independent, financially autonomous body, composed of 80 members, 40 of whom are Moroccans and the remaining 40 are non-Moroccans (Associate Members). The Associate Membership included such eminent figures as Abdus Salam (who in 1983 founded TWAS), A. M. Mbou (the former Director General of UNESCO), Neil Armstrong (the astronaut), the Arab historian and politician Ahmad Sidqi Dajani and the eminent Jordanian scholar Nasseruddin El-Assad.

The AKM is a modern day Moroccan replica of the *L'Académie Française* the pre-eminent French learned body that was established in 1635 by Cardinal Richelieu, the chief minister to King Louis XIII. Although it is independent, the AKM enjoyed the strong patronage of King Hassan II who often attended its meetings, interacted with its Fellows and proposed themes for their deliberations. It was the King who decided that the AKM Fellows should be paid monthly stipends and granted diplomatic Moroccan passports.

In October 1993, sixteen years after the founding of the AKM, a royal decree was issued by Morocco's then King Hassan II establishing the Hassan II Academy of Science and Technology (HAST). That was followed on 19 May 2000 by another royal decree ratifying the earlier decree. On 21 July 2004, Prof. Omar-Fassi-Fehri was nominated by King Mohammed VI as Permanent Secretary of HAST. The king also nominated a five-member founding committee of HAST.

HAST's objectives include promoting research, setting the general orientation for S&T development, making recommendations regarding the national priorities in terms of research, evaluating research programmes and contributing towards networking Moroccan S&T and R&D activities with their national and international counterparts.

HAST is composed of 90 members: 30 of these are national members, 30 are foreign scientists who qualify as associates, and 30 are corresponding members who are both national and foreign scientific personalities.

HAST enjoys the support of King Mohammed VI of Morocco who inaugurated its first session in May 2009. In his speech on that occasion, he described an ambitious role for HAST in terms of helping the country to rise to the challenges of development, especially those relating to human development. He emphasized that scientific research, technological advancement, innovation and creativity must contribute to upgrading the living conditions of citizens and promote their integration into the knowledge-based society which itself should be open to modern science and technology (Maghreb 2010).

HAST organizes a plenary session annually, to which the public is invited. This plenary session assembles the resident, associate and corresponding members, and is intended to be a forum for local scientists to present their research findings.

Figure 6.2 Hassan II Academy of Sciences and Technology, Rabat.

Ordinary sessions are also held among the resident members in which submitted reports and projects are evaluated and various problems are discussed including those related to the national priorities in research and technology (HAST 2011).

HAST publishes an open-source electronic journal the objective of which is to provide a medium of exchange of high quality research papers in science and engineering. The journal which is called ‘Frontiers in Science and Engineering’ covers a wide array of subjects including: Materials Science, Mathematics, Physics, Chemistry, Computer Sciences, Energy, Earth Science, Biology, Biotechnology, Life Sciences, Medical Science, Agriculture, Environment, Water, Science Education as well as Strategic and Economic Studies (FSE[15] 2011).

Since it was founded, HAST has financed many long-term research projects which are undertaken by Moroccan scientists. In 2008, it was supporting over 30 projects in a variety of scientific domains (HAST 2011).

HAST has a basic French/Arabic web site[16] which provides background information about the Academy and its activities, while most the publications of HAST are in French including its proceedings.

6.4 Summary and Discussion of Part I

PALAST and HAST are the only *national* science academies that are active in the OIC Arab region today, as the Sudan and Lebanese academies are new and still establishing a footprint. The PALAST –founded in 1996- is a unique academy that was launched in a country under military occupation. The fact that a science academy exists in such difficult circumstances is remarkable, although the occupying power, Israel, boasts an academy of sciences of repute that was founded in 1959.

Despite such difficulties, PALAST has been able to implement a number of activities as well as to engender the sympathy of the international scientific community. Further, the volatile politics of the region consigns PALAST the added responsibility of speaking out against military aggression by Israel. On one occasion, in December 2008,

[15] Frontiers in Science and Technology is published online. It is available at: http://db.ah2st.ma/Home.php [Accessed 10 June 2011].

[16] http://www.academie.hassan2.sciences.ma/an/index.php

the Human Rights Committee of PALAST strongly condemned the Israeli military aggression against the Gaza Strip and called on the international community to act swiftly to put an end to such aggression. Regional co-operation for PALAST is imperative. Without outside help, PALAST would not be able to undertake many activities. PALAST as well as the scientists of the Middle East moreover have the responsibility of reaching out to academies of sciences in the West to provide a reasoned discourse on political issues. Strengthening academies such as PALAST should be a high priority for the international science community. Foreign scientific organizations should include academies such as PALAST in their activities in order to enhance their stature and encourage their roles as independent conveners and sponsors of cooperative scientific research (Greene 2007). PALAST has an untapped resource at its disposal, namely the Palestinian and Arab scientific diaspora, and must establish strong academic links with this community which has a strong presence in Europe and the US.

HAST was born in Rabat in 2006, 29 years after its prestigious predecessor, the AKM. It will take some time for HAST to build up a reputation for distinction similar to that of the AKM. Moreover, HAST needs to expand its international activities and engage the sizeable expatriate Moroccan science community in Europe and North America. HAST needs to consider opening up its membership structure so that new members are elected every year, and not follow the 'closed' model where new members are only elected when a member passes away. As with the majority of scientists from the Maghreb countries, HAST adopts French as the language of correspondence and publications. This narrows the list of possible collaborators with which HAST can fully interact to France and Francophone countries. HAST has to adopt the three working languages of the OIC; Arabic, English and French, if it is to fully realise its potential as one of the leading academies of sciences of Africa.

For both PALAST and HAST, no record was found of any collaboration between either academy and the private sector in Palestine and Morocco respectively. PALAST may find it easier to collaborate with the private sector in Palestine and among expatriate Palestinian business community, however HAST may find that somewhat difficult as an academy that enjoys royal patronage.

Part II: Five Academies of Sciences from Russia and the OIC Asian Region

6.5 The Tatarstan Academy of Sciences (TAS)

The following quote from Mintimer Shaymiev, the former President of Tatarstan (IAS 2009) sets the context for this section:

> *In 922 AD, our ancestors adopted Islam due to the active efforts of envoys of the Baghdad caliph al-Muqtadir Billah to Volga Bulgaria. Because of its advantageous geographical position, Volga Bulgaria had a wide range of contacts with Arab countries in the Middle East. Islamic civilization became a foundation for spiritual and material development of Tatars and many Turkic peoples in Eurasia.*

For two centuries, Kazan (the capital of Tatarstan, a small autonomous republic within the Russian Federation) has been a leading scientific centre. By 1917, Kazan was the third most important scientific centre of Russia; after Moscow and St Petersburg. During World War II, the USSR Academy of Sciences was evacuated to Kazan and in 1945, the Kazan Branch of the USSR Academy of Sciences was established. This led to founding many scientific institutions that used to serve the enormous military industries of the USSR. In 1991, after the demise of the USSR, TAS was born as a research academy in the Russian tradition. As such, TAS has a broader mandate than purely honorific academies of sciences. TAS aims to develop the fundamental sciences in Tatarstan, to solve important problems, upgrade the national economy, and coordinate the research work in academic, trade institutes and higher schools. The main function of the Academy is to ‘increase the level of fundamental research in the most important trends of natural, technical sciences and humanities.’

In 2008, TAS had 40 Full Members, 71 Corresponding Members, 18 Honorary Members and 2 Foreign Members. TAS consists of seven departments covering different scientific trends as well as the Ulyanovsk branch. It has six research institutes, scientific centres and laboratories. TAS members are part of the state hierarchy and many occupy positions of executive responsibility within government.

Figure 6.3 Academy of Sciences of the Republic of Tatarstan, Kazan, Tatarstan (Russia).

Since 2001, TAS researchers have acquired 242 patents and licenses and introduced 108 inventions. These achievements have generated an income of 500 million roubles. In addition, 62 doctoral students and 1301 postgraduate students have studied at TAS Institutes with the total number of doctoral theses defended in 2002-2006 – under the guidance of TAS members – rising to 25 and the number of PhD theses rising to 197. Further, TAS has collaborative agreements with research institutes in more than 40 countries and other regions of Russia.

Russia is a multi-ethnic country where Tatars constitute the second population group after Russians. Tatars are trying to preserve their language and develop their national culture with the help of TAS, which has implemented a number of programmes in this domain including the publication of the six-volume Tatar Encyclopaedia (Mazgarov 2008). Another important project is the seven-volume Tatar National History, which covers the history of the Tatar people from the earliest times to the present, including the role of Tatars in the history of the Islamic world as well as their interaction with Turkic and Russian peoples (Mazgarov 2008). TAS furthermore intends to open a museum of Tatar and Arabic manuscripts that have been accumulated for over a millennium.

6.6 The Turkish Academy of Sciences (TÜBA)

TÜBA is an Ankara-based scholarly society attached to the office of the Prime Minister of Turkey. It has administrative and financial autonomy although it is almost totally funded by the government. TÜBA is responsible for elevating the level of science in the country. It also addresses the critical issues that polity and society face and their social implications, and it is under this heading that the function of the Academy vis-à-vis scholarly ethics emerges. The Academy promotes excellence in science and scholarly ethics and social values. TÜBA is responsible for investigating critical problems, and strives to fit the solutions it derives into a framework of scholarly and ethical principles. Moreover, it serves as a platform for debate on the problems the country faces and, in this context, acts as a consulting institution for Turkey.

TÜBA’s main objectives include stimulating science and research, awarding scientific distinction, disseminating scientific methods and thinking, upgrading the social status and prestige of scientists and researchers and *appropriately* convincing the government to achieve such aims and objectives. Interestingly, the primary activity of offering science advise to the various national stakeholders is conspicuously absent from the main objectives of TÜBA, although the consulting role appears in the literature.

TÜBA has three categories of membership, namely Principal Members, Associate Members and Honorary Members. Only Turkish citizens can become Principal Members or Associate Members of TÜBA. Honorary membership is open to foreign scientists. TÜBA’s bylaws stipulate –unusually- that the number of the Principal Members cannot exceed 2% of the number of professors in Turkey and the number of Associate Members cannot exceed threefold the members. There is no limit on the number of Honorary Members.

Figure 6.4 Turkish Academy of Sciences Building in Ankara.

A Principal Member is elected from among the distinguished scientists of Turkey. The conditions for being elected are stipulated thus: 'to have received awards or medals from respectable national or international institutions; to have discoveries, inventions, theories and models named after himself or herself, and/or to have been cited in textbooks or review articles and to have a high number of accepted cited references in international science citation indices.' Principal Membership continues until the age of 70 when it automatically becomes Honorary Membership. Associate Members are elected for a period of three years from among the talented young scientists of Turkey. They are among candidates for Principal Membership further on in their careers. Principal and Honorary Memberships are lifelong. TÜBA had 135 members in 2010 (TÜBA 2009). They belong to a number of scientific disciplines as shown in Table 6.1 below.

TÜBA has signed protocols on scientific collaboration with the Austrian Academy of Sciences as well as the Hungarian and the Albanian Academies of Sciences. In 2002, cooperation agreements were signed with the Israel Academy of Sciences and Humanities and with the Romanian Academy. Those were followed by an MOU with the National Academy of Science and Technology of the Philippines. An agreement was signed with the National Academy of Sciences of Azerbaijan and another with the Korean Academy of Science and Technology (KAST) in 2003.

Table 6.1 TÜBA Members according to discipline

Scientific Domain	Honorary Members	Principal Members	Associate Members	Total
Medical Sciences (W/M)*	12 (3/9)	15 (3/12)	5 (1/4)	32 (7/25)
Basic and Engineering Sciences (W/M)	11 (1/10)	60 (5/55)	8 (1/7)	79 (7/72)
Social Sciences (W/M)	14 (2/12)	8 (2/6)	2 (1/1)	24 (5/19)
Total (W/M)	37 (6/31)	83 (10/73)	15 (3/12)	135 (19/116)

(female members account for 14.1 % of the membership)
* W/M women/men

TÜBA is active within the All European Academies (ALLEA), the Network of the Academies of Mediterranean countries, TWNSO, the International Human Rights Network of Academies and Scholarly Societies, IAP, AASA and International Social Science Council (ISSC), given that it has a strong social sciences contingent.

The fact that TÜBA was founded only in 1994 is surprising when one remembers that the Encümeni Danish was founded in Istanbul as the Turkish Academy of Sciences (University of Waterloo 2008) of its day in 1861. It is equally surprising to note that the Turkish science community waited for 70 years after Turkey was proclaimed a republic to establish its national academy of sciences especially as the existence of such an institution is a viewed as a symbol of erudition in the 20th century. Since becoming a republic in 1924, Turkey has adopted its own brand of secularism. Throughout the 20th century, Turkish republicans have identified certain groups including the military and the science community as the 'guardians' of Turkey's secularism. Ample evidence exists that this phenomenon has found its way into the ranks of the academicians as the majority of the members of the Turkish Academy of Sciences are ardent secularists with a few if any who have religious leanings. This is probably the reason why in 2011, the Turkish Government with its religious leanings decided to transfer TÜBA to the Ministry of Science, Industry and Technology and raise the number of full members to 150, one-third of whom will be appointed by the government and one-third by YÖK, the Higher Education Council, most of whose members are in turn appointed by the government (Nature 2011). To TÜBA's credit, female membership within its ranks at 14% is among the highest in the world.

6.7 Pakistan Academy of Sciences (PAS)

The idea of establishing PAS[17] was considered in November 1947, soon after the creation of Pakistan. Subsequently, nine scientists were elected as Foundation Fellows of the proposed Academy. One of the Foundation Fellows, Dr M. Raziuddin Siddiqi (who later on became a Fellow of the IAS) drafted PAS' constitution, and PAS was inaugurated by the then Prime Minister of Pakistan, Khwaja Nazimuddin, on 16 February 1954.

PAS is a non-governmental and non-political scientific body of distinguished scientists in Pakistan. The Government of Pakistan has given PAS a consultative and advisory status 'on all problems relating to the development of scientific efforts in the country,' and 'on such matters of national and international importance in the field of science.' The affairs of PAS are regulated by its Charter and By-Laws. PAS is governed by a *rather large* 17-member Council, headed by the President.

Funding for PAS comes mainly from the Pakistani Government. The Ministry of Education has been providing a grant-in-aid regularly to the Academy since its inception to carry out scientific activities. Occasionally, the Ministry of Science and Technology of Pakistan provides financial support. The Fellows also make annual voluntary contributions to the Academy. PAS also receives yearly grants from the Higher Education Commission of Pakistan and the Pakistan Science Foundation.

PAS literature makes no mention of support from the private sector, however the privately-owned Hamdard Foundation provides regular grants to PAS, which also occasionally receives grants from the private sector to help it organize some international activities. This was evident when PAS hosted the annual conference of the IAS in 2002.

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17 http://www.paspk.org/

The objectives of PAS include promoting pure and applied sciences, disseminating scientific knowledge, formulating standards of scientific effort and achievement in Pakistan and recognizing outstanding contributions to the advancement of science. The information dissemination component of PAS's objectives is achieved by publishing scientific proceedings, journals, books and other scientific literature. Of the important objectives of PAS is the outreach component that includes maintaining relations with Pakistani and overseas scientists. The advisory function of PAS is highlighted in PAS's objectives, as it is expected to offer advice to the government on S&T matters, and to represent the science community of Pakistan in the international arena.

PAS consists of Foundation Fellows, Fellows and Foreign Fellows. Fellows are Pakistani scientists eminent for their original contribution to science. Not more than five Fellows may be elected in any one year until the total number of Fellows reaches the limit of 100. Foreign Fellows are scientists who are nationals of countries other than Pakistan and who are eminent for their contributions to science. Not more than three Foreign Fellows may be elected in any year until the total number of Foreign Fellows reaches the limit of 30.

In January 2008, PAS had 87 Fellows, 22 Foreign Fellows and 8 Members. This is a very small number for a national science academy in a country that has a population of over 150 million. However, the number of Fellows is not expected to rise markedly as PAS has a limit on the number of Fellows it can have at one time, namely 100.

Figure 6.5 Pakistan Academy of Sciences, Islamabad, Pakistan.

Since 2000, PAS has organized seminars and conferences annually with the help and support of many international agencies. In 2000, it organized an international seminar on 'Prospects for Saline Agriculture,' in Islamabad. In 2005, PAS co-organized an international conference on S&T together with NASIC, COMSTECH, the Higher Education Commission of Pakistan and TWAS. In addition, PAS organizes monthly seminars in Islamabad/Rawalpindi, Lahore, Peshawar and Karachi, as well as occasional film shows and lectures by international speakers.

In 2002, under the leadership of Dr A Q Khan, PAS, with the support of a number of international agencies such as COMSTECH, hosted the 12th IAS Conference on 'Materials Science and Technology,' and 'Culture of Science' in Islamabad, whilst in 2004, PAS hosted the launch meeting of the Network of Academies of Science in Countries of the OIC (NASIC) in collaboration with COMSTECH and the IAP.

Due to political turmoil in the country, PAS was unable to host a number of international meetings, including the 18th TWAS General Meeting of 2007.

6.8 The Academy of Sciences of the Islamic Republic of Iran (ASIRI)

Iran, historically, has been home to the Jundishapur Academy (AD 560) which predated Islam, and the Maragha Observatory/Academy established by al-Tusi seven centuries later (AD 1262). It is thus not surprising that it today boasts a number of prestigious science academies that are active nationally and internationally. The literary movement which developed in Iranian academic circles throughout 1930s resulted in the establishment of the Academy of Iran in 1935. The mission of that academy was to preserve Persian language and literature. The Academy of Iran survived until 1968 when the idea of establishing new academies surfaced (ASIRI 2010).

Having studied the strengths and drawbacks of previous Iranian academies, as well as the achievements of the prestigious academies of the world, experts developed the constitutions of the present three Iranian academies in the 1980s and 1990s: ASIRI (1988), the Academy of Persian Language and Literature (1990) and the Academy of Medical Sciences (1991).

The academies have one board of trustees which is under the authority of the President of Iran and presided over by the First Deputy of the President. The board is composed of the following members: the Minister of Science, Research and Technology, the Minister of Health, the Presidents of the three academies and six eminent scholars (two members proposed by the President of each academy) approved by the Supreme Council of the Cultural Revolution. The major duties and responsibilities of the board are: the election and recommendation of the new heads of academies to the President of Iran for appointment; the approval of administrative, organizational, financial and employment regulations; the recommendation of the membership of academies in international organizations, societies, etc.; and the ratification of the standards for awarding scholarships, fellowships, grants, prizes, medals, badges, and rewards to scholars (ASIRI 2010).

ASIRI's objectives include helping Iran attain scientific and cultural independence, promoting S&T, encouraging the spirit of research and accessing the latest scientific findings and innovations through teamwork, and absorbing, encouraging and supporting eminent researchers and scholars. To help achieve its objectives, ASIRI has drawn up a number of functions for itself which include surveying and analyzing the status of S&T, education and research as well as giving advice to relevant authorities. The provision of academic counselling, research on matters requested by government departments and carrying out studies on the experience of other countries in the development of S&T and its application are among ASIRI's objectives. ASIRI moreover provides material and spiritual support for scholars to create scientific, literary and artistic works.

Other elements of ASIRI's functions include establishing links with the academies of the Islamic and the Third world countries in particular and other countries in general; evaluating and organising seminars, congresses and conferences at the international level and disseminating scientific information by publishing journals and books on the latest national and international scientific achievements. ASIRI's functions also include awarding prizes to distinguished scholars and researchers.

ASIRI[18] has an elaborate membership scheme and has three types of members in the Academy: fellows, associates and honorary members. All members are elected by secret ballot and need a majority of votes. Fellows are required to be full professors, to have published outstanding articles and books, to have carried out valuable research and to have Iranian nationality. In some cases, particularly within the Department of Islamic Studies and Department of Arts and Architecture of ASIRI, eminent scholars who do not hold academic ranks may become Fellows if they have equivalent qualifications.

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18 http://www.ias.ac.ir/

Figure 6.6 The Academy of Sciences of the Islamic Republic of Iran (ASIRI).

Eligible scholars become Fellows upon the recommendation of the President of the Academy or at least five General Body members (Fellows) and the approval of the General Body and the issued order of the President of the country. Fellowship is lifelong. According to the statutes, the number of Fellows should not exceed 43. Although no explanation is given in the literature for this limitation, this ceiling may be raised upon the approval of two-thirds of the Fellows in the General Body. Associates are chosen from among prominent Iranian scholars who are at least at the rank of professor and have published extensively and undertaken important research. In some cases, scholars who are associate professors are eligible for membership if they have similar qualifications. The number of associates should not exceed 157. This brings the total number of Fellows and associates to 200. Honorary Members can be national or international scholars elected by the General Body on the basis of their scientific activities and prestige in academic circles (ASIRI 2010).

ASIRI is active internationally and has signed MOUs with many academies of sciences throughout the world including the Romanian, Finnish, US, Austrian, Hungarian, Korean, and Sri Lankan academies and the Siberian Branch of Russian Academy of Sciences. Other agreements exist with the Croatian, Polish, Chinese, and Albanian academies, as well as the Academy of Sciences of the Czech Republic.

6.9 Academy of Sciences Malaysia (ASM)[19]

In 1992, the proposal to establish an independent yet government-linked Malaysian Academy of Science, Engineering and Technology was approved by the Malaysian National Council for Scientific Research and Development (NCSRD). The draft Bill to establish the ASM was tabled in Parliament in July 1994. The draft Bill, which was largely modelled on the constitution of the Australian Academy of Technological Sciences and Engineering, was passed by parliament unanimously (Lee 2002).

The 'Akademi Sains Malaysia' (ASM) –as it was subsequently called- was established by the Academy of Sciences Act (1994) and was officially inaugurated by Dr Mahathir Mohamad, the then Prime Minister of Malaysia, on 8 September 1995.

Of the features of the ASM (ASM 2005) is the fact that it is directly linked to the Ministry of Science, Technology and Innovation (MOSTI). This association literally prevents the Academy from taking any major decision without referring beforehand to the Minister of S&T.   ASM's objectives include providing advice to the government on STI, fostering a culture of excellence, upgrading the technological capability of Malaysian industries, promoting public awareness and understanding of STI, enhancing international collaboration and scientific literature. The functions of the ASM include the promotion of science, engineering and technology (SET) and their role in human progress as well as the promotion of creativity among scientists, engineers and

[19] http://www.akademisains.gov.my/

technologists. Further, ASM aims to promote national self-reliance in SET and to raise the awareness of the government of the significance of SET and identify where SET can contribute to the solution of national problems.

ASM further proposes to prepare reports on national SET policy; encourage research, development, education and training of the appropriate SET manpower; establish and maintain relations between the Academy and similar overseas bodies and provide advice on matters related to SET as requested by the Government.

The election of Fellows to the ASM takes place at its Annual General Meeting. Fellows are elected by a majority of two-thirds of the Fellows present and voting. Candidates are nominated every year by at least two Fellows. A Membership Committee recommends the names of nominees to the Annual General Meeting (ASM 2010). The ASM stipulates a number of criteria for fellowship nominees namely: outstanding individual achievement or leadership in SET; innovative management or development of technological industries, or of technological operations within non-technological industries, or of government or non-government organisations or institutions dealing with SET; or outstanding contributions at the interface between SET and society. It further provides some guidelines as to the attributes that nominees should possess, including: academic qualifications, research, innovative design, published papers, application of new and existing technology with end users, demonstrated management ability, recognition in Malaysia by peers, recognition overseas, recognition by the community, value to the Academy, personal knowledge of the candidate's character (ASM 2010). The 'ordinary' Fellows of the ASM belong to the following streams; Medical and Health Sciences, Engineering and Computer Sciences, Biological, Agricultural and Environmental Sciences, Mathematical and Physical Sciences, Chemical Sciences, and S&T Development and Industry. In 2010, the ASM had four

Honorary Fellows, five Senior Fellows and 77 Fellows of whom 50 were Founding Fellows.

Figure 6.7 Academy of Sciences Malaysia (ASM), Kuala Lumpur.

To promote excellence in research, the ASM has been organizing annual orations by Nobel laureates since 1996. It also initiated a series of public lectures by renowned overseas scientists as well as inaugural lectures by its own Fellows beginning 2002.

The ASM has been organising conferences with the objective of providing a platform for science and mathematics educators to share innovative teaching and learning practices. Beginning in 2004, the ASM started sponsoring the participation of young scientists in the annual Lindau event in Germany where Nobel Laureates in physics, chemistry and physiology/medicine annually convene in informal settings with students and young researchers from around the world (ASM 2010).

ASM took part in the national initiative to organize a national innovation summit that aimed to develop a functioning National Innovation System to optimize SET initiatives for national development. Of the outcomes of the Summit has been the establishment of the National Innovation Council and the Centre for Creative Ideas.

To recognize and reward excellence, the Scientific Excellence Award in honour of Tun Dr Mahathir Mohamad was launched in 2004. The award is given to researchers who have gained international recognition in the areas of Tropical Medicine, Tropical Agriculture, Tropical Architecture and Engineering, and Tropical Natural Resources Management. The recipient may be an individual or an institution and the first award was bestowed in 2005. The ASM also manages the Dr Ranjeet Bhagwan Singh Medical Award and the MAKNA Cancer Research Award (ASM 2010).

The imperative to learn from other academies and outstanding individuals was high on ASM's agenda in its initial years. ASM Fellows visited leading research institutes and academies to familiarize themselves with the role of scientific academies in development. This has led to ASM establishing linkages with a vast network of academies as well as international organizations such as ICSU, IAP, FASAS, TWAS, Sciences Council of Asia (SCA) and the IAS.

The ASM has been involved with the Malaysian Antarctica Research Programme since 1998, mainly in the three areas that were identified for Malaysia's involvement: Atmospheric and Earth Sciences; Ocean Science; and Terrestrial Science and Biodiversity. ASM helped arrange a 3-day workshop which brought into focus the nation's research interest in Antarctica. In 1999, also under the leadership of ASM, the first team of Malaysian scientists successfully concluded a number of research projects in Antarctica. In order to strengthen the Antarctica Research Programme and raise the awareness of the public and the scientific community of its importance, an international seminar on 'Antarctica Research: Challenges and Experiences' was organized with the objective of inviting research proposals from among the scientific community. An important outcome of the seminar was an invitation from the Australian Antarctica Division for two Malaysian scientists to participate in a voyage to their base in Antarctica. The two scientists successfully concluded their research work on board the

Australian Polar Bird and produced a video presentation that served to promote public awareness of the research potential in the continent (ASM 2010).

6.10 Summary and Discussion of Part II

The Tatarstan Academy of Sciences is a successful model of a young honorific and research-performing academy of sciences, in the Russian tradition. It enjoys the strong patronage of the leadership of the country and has an extensive mandate that it is trying hard to fulfil. It is evident that TAS is a pivotal organisation within the academic, and research infrastructure as well as the industrial sector of the country.

Apart from its scientific mission, TAS plays a national cultural role and acts as a focal point for the Tatar people whose ethnic, cultural and religious identity was suppressed during the Soviet era. It also tries –with the blessing of Russian politicians- to reach out to OIC countries and the scientific community within. During the last decade, TAS began to view its role as a bridge between the Republic of Tatarstan/Russia and the Islamic world. Close collaboration with Islamic countries will also facilitate studying the philosophical, theological, literary and scientific heritage of Tatar people.

Although Turkey became a republic in 1924 and underwent a number of reforms under Ataturk – the republic's founder – during the 1920s and 1930s, it only launched a fully fledged Turkish Academy of Sciences in 1994(TÜBA 2009). Seven decades after Ataturk declared that *Science is the only true guide in* life (The Quotations Page 2011). Although Turkey is an OIC country that has gradually been building strong influence within the organisation, TÜBA seems to be more active within European academe circles with little or no interaction with other OIC academies.

In Asian OIC countries, a wide variety of academies exists. Countries previously colonised by Britain, such as Pakistan and Bangladesh, have followed the British Royal

Society model of a science academy. Although PAS is well known among the intellectual elite of Islamabad and other major Pakistani cities, it has been powerless to influence the science and development domains in the country, and has remained aloof with little or no involvement in public-oriented programmes that other large academies have implemented. PAS seems to be distant from the government in Pakistan despite short spells of proximity when President Musharraf was in power. It has enjoyed periods of prominence under some of its past presidents including the late M. A. Kazi (also the founding president of the IAS), A. Q. Khan (the famous nuclear scientist) and Atta-ur-Rahman FRS (the organic chemist and Co-ordinator General, COMSTECH); who were keen to see PAS prosper and reach out locally and internationally. PAS has also benefited from the individual efforts of some its more eminent Fellows; M. D. Shami and the late M. M. Qurashi, the former as an institution-builder and the latter as a prolific author and specialist on Science and Religion.

Another large OIC country that has also been afflicted by politics and natural disaster is Iran. Nevertheless, Iran has been enjoying a relative boom in STI and higher education especially during the last decade. This is reflected by its rising research output in terms of scientific papers. This boom can be attributed to sustained government interest in STI and higher education and not directly to the activities or programmes of ASIRI. However, ASIRI's role at the international level, particularly its collaboration with TWAS, US-NAS and at some point with the IAS, has made the Iranian science community more spirited, and has contributed to the international science community becoming aware of and supporting national Iranian efforts in S&T.

Despite the strong influence that the government of Iran has on the ASIRI, the academy and its Fellows follow an independent line, especially at the international level as they for example collaborate extensively with the US-NAS and have implemented a number of programmes with their American counterpart (Shweitzer 2008). ASIRI's collaboration with the US-NAS culminated in an international workshop held in France to discuss issues concerning the role of science in the development of modern societies (Shweitzer 2008). Very little is documented in ASIRI's literature on collaboration with private sector in Iran.

The Malaysians have gone their own way in establishing a merit based academy that is directly linked to the Malaysian Ministry of Science, Technology and Innovation (MOSTI). Nevertheless, the ASM implements a number of innovative programmes such as the National Nobel Laureate Programme which was established to raise the standard of scientific research and produce a Malaysian Nobel Prize winner by 2020 (ASM 2005).

The ASM has become an efficient contemporary promoter of STI over the years however its close association with the government and sometimes powerful ministers of STI is a cause for concern particularly against the background of the party-politics scene in Malaysia. This is the main strength and the main weakness of the ASM. As a result of this close association between the ASM and MOSTI, the ASM is almost always financially secure, yet it is almost never free to object or take a different line of thinking to the incumbent minister. For example, ASM stayed away from a scientific activity organised by the IAS in Malaysia in 2009 as the local counterpart was a State government that was dominated by an opposition party and not the government party to which the minister belonged.

A special feature of ASM is the strength of the 'engineering' component within its membership and its programmes as it has a large number of engineers as members. Furthermore, a closer look at ASM's membership reveals that it represents all the multi-ethnic multi-religious components of Malaysia unlike –for example- TÜBA in Turkey, which has mainly inducted members that belong to the secular school of thought.

Part III: Two Academies of Sciences from the OIC African Region

> *Thirty-five of the world's forty-nine least developing countries are located in Africa. Nearly 70% of Africa's people live on less than US$2 a day.*
>
> (Hassan 2008)

6.11 Introduction

In Africa, because most national S&T systems are weak, the establishment of functioning national science academies is an essential element of the process of development. There are however particular institutional traits related to African science academies, such as their small memberships, poor finances, little experience with policy advice that makes their roles even more difficult. Because of these factors, these institutions must find suitable activities that allow them to leverage the limited resources at their disposal to become effective policy advisors to governments (Michelson 2006).

Economically, Africa witnessed impressive economic growth during 2006-2008 which was driven by high commodity prices as well as low inflation, low fiscal deficits, rising oil production in the continent, increased in-flow of private capital, debt relief by international agencies and an increasing volume of non-fuel exports (Barugahara and Tostensen 2009). This performance however has not translated into gains in terms of social development, job creation has been sluggish and the agricultural sector has been lagging behind with no major dent recorded in the poverty problem.

At the academe level, the African Science Academy Development Initiative (ASADI) is one initiative of note. It is an intensive decade-long restructuring initiative that was launched in 2005 and funded by the Gates Foundation, to strengthen science academies and enable them to provide neutral advice on politically-charged science issues (Scott 2007). ASADI activities have shown that some of Africa’s science academies were engaging more with policymakers who in-turn were expecting more from their poor academies. On the other hand, the academies of Cameroon, Senegal, South Africa and Uganda were trying to engage policymakers and the public in intensive brainstorming sessions but without much success. For harmony between the science policy promoted by academies and politicians to be realised, African academies should prioritise the issues most relevant to the public, including food security, the provision of clean water and combating disease, in line with the parameters proposed in the MDGs (Scott 2007). In the following section, the OIC African science academies of Uganda and Senegal will be discussed.

6.12 Uganda National Academy of Sciences (UNAS)

The Uganda National Academy of Sciences (UNAS) was launched on 20 October 2000 (IAP 2010).

UNAS is an eminent body of scientists offering independent merit-based advice to state agencies in Uganda. It consists of three organs: the General Assembly consisting of all members; the Executive Council and the Secretariat, which is responsible for implementing the programme and running the day-to-day affairs of UNAS (UNAS 2009). The objectives of UNAS include acting as an independent forum through which scientists can exchange ideas and experiences; promoting and fostering the growth of the scientific community in Uganda; stimulating and coordinating scientific research and development; contributing to the planning, convening and co-ordination of science education programmes and the nurturing of high-level S&T manpower. UNAS also recognises national scientific distinction through the awarding of prizes that promote the safe and ethical exploitation of S&T in national development.

Figure 6.8 Uganda National Academy of Sciences, Kampala.

UNAS brings together a diverse group of scientists from the physical, biological and social/behavioural sciences who aim to promote excellence in science. The strength of UNAS lies in the eminence of its membership and its ability to mobilize scientific experts to advise policy makers and other stakeholders. UNAS had 118 members in 2010 (UNAS 2010) including membership by the Prime Minister and the Minister of Information and Communications Technology (Mugambe 2007).

One of the primary functions of UNAS is to promote and boost science education in Uganda (Mugambi 2007). With support from the IAP, UNAS held an international workshop in 2005 on *Best Practices in Science Education in Africa*. Subsequently, UNAS collaborated with NASAC and the IAP to organize a workshop to promote *Best Practices in Science Education in Sub-Saharan Africa*. The workshop, held in 2008, was a joint effort with the Kenya National Academy of Sciences (KNAS), the Academy of Science of Senegal (ANSTS), and the Academy of Sciences of South Africa (ASSAf), under the theme *Promoting Good Practices in Science and Technical Education* (UNAS 2010). UNAS has been involved in the IAP science education project through a local working group that comprises experts from the Ministry of Education of Uganda as well as local specialized agencies. During 2010, UNAS convened a workshop that generated a policy brief to the Ministry of Education regarding the status of science education in Uganda and has prepared a report on the topic that was presented to the IAP and circulated to governments in sub Saharan Africa.

UNAS has followed in the footsteps of the UK Royal Society in launching an MP-Scientist pairing scheme to assess how effectively the Parliament of Uganda deals with S&T issues. To this end, it embarked on a study to establish the relevance, quality and quantity of policy briefs available to parliament; to analyze how committees handle S&T issues, focusing on the work of the parliamentary Standing Committee of Science and Technology; and to analyze parliamentary debate on S&T. The study was carried out by social scientists from Makerere University, and parliamentary researchers with guidance from UNAS and the Parliament of Uganda.

6.13 The Senegal Academy of Sciences and Techniques (ANSTS)

Two global academies have been associated with the ANSTS; the IAS and TWAS. During a conference organised by the IAS in Dakar in 1993; a discussion took place between IAS officials and the then President of the Republic of Senegal at which he indicated that he was keen to see a national academy of sciences established in his country. Envisioned as a learned society and placed under the patronage of the President of the Republic, the ANSTS was launched on November 25, 1999, in the presence of representatives of the IAS, TWAS, TWNSO, and AFRISTECH. The ANSTS is composed of the following bodies: the General Assembly, which includes regular members and associate members; three main sections each headed by a Vice-President: Science and Technology, Health Science, and Agricultural Science; the Executive

Office, which is composed of the President, three Vice-Presidents, a Permanent Secretary, an Assistant Secretary, a Treasurer, an Assistant Treasurer, four members of the Academy and the immediate outgoing President (Sock 2006).

Interestingly, the first objective of the ANSTS is to assist and advise the Senegalese State in drawing up and implementing a national S&T policy. Other objectives include initiating, recommending, and developing programmes in the fields of S&T; encouraging scientific research; bestowing awards and recognition upon individuals who have made significant contributions to science; (and importantly) creating job opportunities in science for young men and women; and contributing to the development of a culture of science and closer interaction between science and society.

The ANSTS is composed of permanent members, corresponding members, associate members, honorary members, and emeriti members. In 2005, the Academy had 45 permanent members who were elected by a merit-based process, four associate members and 15 honorary members.

Compared to more established academies, the ANSTS is composed of members who are relatively young, given that 75% of the members are still professionally active. In addition to their scientific activities, several members of the ANSTS hold political responsibilities as ministers, advisers to the President of the Republic or the Prime Minister, or ministers of government and heads of universities. As a result, the scientific opinions expressed by the Academy through its studies are respected by political authorities.

As a developing country, Senegal faces the problem of incorporating S&T into its development policies. The fact that Senegal needed to integrate S&T in its economic development strategies was an incentive that led to the creation of the ANSTS. The integration of S&T into economic, social, and cultural policies will help Senegal in facing the challenges of globalization (Sock 2006).

Figure 6.9 Académie des Sciences et Technique du Senegal, Dakar, Senegal.

Since its creation, the ANSTS has been providing science-based advice to decision makers by way of activities including annual opening ceremonies, public lectures, national and international conferences as well as studies and inquiries.

The annual ceremony is one of ANSTS' most important events. It is chaired by the Senegalese President and is a platform for communication and dialogue between the nation and its decision makers on S&T topics. In 2004, the ceremony dealt with the topic 'Development of Science and Technology Education in Senegal.' The ANSTS drew the attention of the President to the fact that Senegal needed to implement educational policy which incorporated S&T education. Subsequently, the Minister of Education created a 'National Steering Committee for the Development of Science and Technology Education,' to develop a national programme for S&T education.

The activities that the ANSTS initiated on 'Science Education' in 2004, led to the convening –in March 2005- of an international symposium on 'Science and Technology Education in Africa,' an activity which was supported by the IAP and NASAC. As a result of this symposium, the ANSTS was given the responsibility of coordinating a regional programme to implement an 'Inquiry Based Science Education' (IBSE) model at elementary schools in Senegal and other parts of Africa.

The ANSTS has also addressed problems that are more practical in nature such as 'Flood Management: The Case of the Town of Saint-Louis.' Due to the recurring floods in Saint-Louis, the ANSTS sent a scientific expedition to the city to study the problem and presented a number of recommendations to the Minister of Agriculture on how to address the problem.

At the policy level, the ANSTS organizes monthly open public lectures on a variety of topics including Political Science in Senegal, Public Health Policy in Senegal and the Introduction of New Communication and Information Technologies in West Africa.

The ANSTS also publishes studies such as the one emanating from the workshop on 'Biotechnologies: Potentials, Stakes, and Prospects: The Case of Senegal,' which was held in 2004.

There is a strong international element in ANSTS' activities which started in 1999 when the Senegalese President launched the academy at an international conference in Dakar. Since then, the ANSTS has developed associations with several international networks including the IAP, NASAC and NASIC. It cooperates with the academies of sciences in France, the United States, Canada, China, Kenya, and Uganda; as well as international organizations such as the International Centre for Development Research (IDRC) and the Agency for French-Language Universities (AUF).

6.14 Summary and Discussion of Part III

Both Uganda and Senegal belong to the OIC, but they have very different histories. Uganda was a British colony while Senegal was under the French. This is to some extent reflected in the paths the two academies have followed –UNAS has adopted many of the programmes initially developed by the UK's Royal Society, while ANSTS' administrative set-up as well as some of its programmes are similar to those of the Académie des Sciences of France (ASF). In general, UNAS has been more interactive with English-speaking academies around the world, while ANSTS has been collaborating with French-speaking ones. Like the majority of African science academies, UNAS and the ANSTS are new and have small memberships as well as limited resources despite being well linked to their governments. Both academies have made a steady start and both are active on the international arena. UNAS has benefited from the international ASADI Initiative, while ANSTS has been particularly visible on the OIC scene.

The objectives of the ANSTS give priority to its advisory role. That clearly reflects its proximity to the government and the head of state. Moreover, ANSTS' mission includes the objective of creating job opportunities in science for young men and women. This is an objective that the ANSTS is trying to achieve, and it should be commended for targeting a problem of this nature. UNAS, on the other hand, has been a pioneer in science education as can be seen from the number of activities it has implemented nationally and internationally in this important field. It has also been able –through its membership- to interact with the decision-makers of the country.

As with most academies of sciences, both UNAS and the ASTS have no links to speak of with the private sector in their countries.

Part IV: Four Academies of Sciences from America and Europe

> *The prosperity the United States enjoys today is due in no small part to investments the nation has made in research and development at universities, corporations, and national laboratories over the last 50 years.*
>
> (COSEPUP 2007).

The above quote is from a famous report by the US National Academy of Sciences (US-NAS) called; *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (COSEUP 2007). Not only does it highlight the importance of R&D as a means to achieve national prosperity but it also reflects – together with the report proper- the role that the US-NAS has in putting science on the national agenda of the US. In this part, a number of world famous academies of sciences including the US-NAS will be investigated to see how they have been promoting science and the scientific enterprise.

6.15 US National Academy of Sciences

The United States National Academies' setup comprises four organizations: the National Academy of Sciences (US-NAS), the National Academy of Engineering (NAE), the Institute of Medicine (IOM) and the National Research Council (NRC).

The US-NAS is an honorific society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of S&T and its use for the general welfare. The US-NAS is the world's wealthiest science academy with an annual budget that exceeds US$ 200 million (NAS 2010). It was signed into existence by President Lincoln on 4 March 1864, at the height of the American Civil War. The US-NAS was mandated to 'investigate, examine, experiment, and report upon any subject of science or art' at the request of the government. To keep pace with the growing roles that S&T would play in public life, the National Academies' system eventually expanded to include under its umbrella the National Research Council in 1916, the National Academy of Engineering in 1964 and the Institute of Medicine in 1970.

The membership of the US-NAS is comprised of approximately 2,100 members and 350 foreign associates, of whom more than 200 are Nobel Laureates. Members and foreign associates of the US-NAS are elected in recognition of their scientific distinction. US-NAS membership is one of the highest honours that can be presented to a scientist or an engineer. The US-NAS is governed by a Council comprised of 12 members and five officers, elected from among the membership.

US leaders have often turned to the National Academies for advice on S&T issues. The NRC conducts most of the institution’s science policy and technical work through committees. Some such deliberations have inspired some of the US’s most significant and lasting efforts to improve the health, education, and welfare of the population. The US-NAS’s service to government has become so essential that the US Congress and the President have issued legislation over the years reaffirming its unique role.

Internationally, the US-NAS played an important role in a seminar which was organised in Trieste in 2003 that saw scientists from Muslim countries committing themselves to creating or strengthening science academies for the benefit of their countries and humanity at large (Alberts 2004). Since then, the US-NAS has been participating in the international conferences organized by the IAS in the various countries (Zou’bi 2008). The US-NAS has also been active in the Middle East, and has participated in a number of activities in the domain of science education for children held at the Bibliotheca Alexandrina. It has also participated in water-related activities involving Jordan, Palestine and Israel; documented in the book *Water for the Future* published by the National Academy Press (NRC 1999). The US-NAS also collaborates with a number of countries such as Brazil, China, Korea, India, France, the Netherlands, the United Kingdom, Belgium, Switzerland, Germany, Italy, Canada and Mexico. At the institutional level, the US-NAS collaborates with ICSU, and was one of the founders of the InterAcademy Council (IAC), which was created to provide science advice to the world using study panels and review mechanisms. One of the IAC's studies was requested by the then UN Secretary General Kofi Annan and focused on harnessing S&T to increase food productivity in Africa (Alberts 2004).

Figure 6.10 The US National Academy of Sciences Building, Washington DC.

All of the international efforts in which the US-NAS engages are designed to create a higher profile for S&T and S&T institutions in both national and international affairs.

According to Alberts:

As scientists, we have the advantage of sharing a common set of values: Whether from China, India, Russia, or the United States, we are all passionate about basing decisions on evidence that uses rational analysis. And we all recognize that our governments need help in focusing on policies with long-term benefits.

(Alberts 2004).

The US-NAS too has been active in promoting science education (Clegg 2003). In response to the objective the US had set for itself that all students should achieve scientific literacy, the US-NAS has played a major role in developing National Science Education Standards, which were designed to make scientific literacy a reality in the 21st century (Alberts 1995a). A turning point in the interest that the US as a country and the US-NAS had in science education and indeed in science in general, came with the publication in 2007 by the academy of its famous report; *Rising Above the Gathering*

Storm: Energizing and Employing America for a Brighter Economic Future (COSEUP 2007). Not only did this publication address the S&T future of America, specifically, in the context of science education, it also presented four basic recommendations that focus on the human, financial, and knowledge capital necessary for US prosperity. The four recommendations, which are encapsulated in catchy phrases, focus on actions in K–12 education (*10,000 Teachers, 10 Million Minds*), research (*Sowing the Seeds*), higher education (*Best and Brightest*), and economic policy (*Incentives for Innovation*) (NAP 2010).

6.16 The Académie des Sciences of France (ASF)

The Institute of France, which has been described as the Parliament of the Learned, aims to improve the arts and sciences in a multidisciplinary fashion, and manage the donations, legacies, and foundations that it has been entrusted with to carry out its primary task. It brings together five Academies: the French Academy (established in 1635), the Academy of Inscriptions and Belles-Lettres (established in 1663), the Academy of Sciences (ASF) (established in 1666), the Academy of Fine Arts (established in 1816) and the Academy of Ethics and Political Science (established in 1795, abolished in 1803, and re-established in 1832) (IF 2011).

In his book *Science Under Control: The French Academy of Sciences 1795-1914*, Crosland (2002), claims that the greatest ambition of any moderately successful 19th century French scientist was to become a member of the ASF, this elite institution which had historically boasted the membership of figures such as Laplace, Cuvier and Louis Pasteur. Although for the duration of this period the French government exercised some control over the ASF, it continued to play its role in evaluating all serious scientific output. Only with its approval could the work of French scientists win acceptance.

The ASF is also important internationally, primarily for establishing certain procedures which are now considered basic to the organization of modern science.

Unlike the objectives of other academies of sciences, the objectives of the ASF include clear social sciences components. The revised objectives of the ASF were ratified on 31 January 2003. Articles 3 and 4 (ASF 2010) in particular define the objectives of the ASF as: (1) Encouraging scientific life, and contributing to progress in the sciences and their applications; (2) Studying social questions associated with the development of the sciences and formulating recommendations; (3) Developing international scientific relations; (4) Monitoring the quality of the teaching of the sciences; (5) Encouraging the diffusion of science among the public; and *interestingl*y (6) Upholding the role and the quality of the French scientific language.

Article 1 of the Statutes of the ASF states that 'the Academy of Sciences of the Institute of France brings together French scholars, and forms associations with foreign scholars, where both the former and the latter are selected from among the most eminent. By their involvement, they contribute to accomplishing the mission of the Academy' (ASF 2010).

In October 2011, the ASF had 251 Members, 140 Associate Members and 102 Corresponding Members.

The ASF monitors the level attained by research undertaken in France on the world stage. It also contributes to the organization of research and to directing scientific programmes. ASF is also involved in technology development and the application of science (ASF 2010). It carries out such activities on its own initiative or at the request of international, national or regional bodies. The ASF moreover publishes reports and takes a public stand on social problems that have a scientific component. The ASF plays an active role in the development of international scientific relations, notably in Europe, by establishing relations with foreign academies and as a result of representing France in the activities of ICSU.

The ASF plays a role in monitoring scientific and technical research policies and regularly publishes reports, articles and review articles on such matters in its *Comptes rendus de l'Académie des science.* This is bilingual multidisciplinary journal that was launched in 1835, and now comprises seven series: Mathematics, Mechanics, Physics, Geosciences, Paleontology- Evolution, Chemistry and Biology. It includes both articles on original works and thematic issues, many of which are made available on the website of the ASF and on the Elsevier website: www.elsevier.fr.

Numerous colloquia are organized by the ASF on topical subjects (in 2002 for example, Stem Cell Research, and Energy and Climate Change). The deliberations that take place at such colloquia are also published in the *Comptes rendus.*

Figure 6.11 Palais de L'Institut de France which houses the Academy of Sciences of France (ASF), Paris.

The ASF closely collaborates with the Academies of the Institute of France and the National Academy of Medicine, the French Academy of Agriculture and the Academy of Technologies. In 2001 for example, it addressed civil nuclear energy in the context of climate change. Reports on S&T are also presented to the government upon its request by groups of experts designated by the ASF.

At the weekly public sessions talks are given on topical questions, sometimes grouped together into mini-colloquia or conference discussions. There are exchanges of lecturers with a number of foreign academies including the UK's Royal Society, the Royal Dutch Academy in Amsterdam, and the *Academia dei Lincei* in Rome.

The archives and heritage service of the ASF conserves, enriches and enhances the academy's vast archive which includes documents from the 18th century. The ASF moreover awards prizes to researchers including an international 'gold medal.'

The ASF has an interesting scientist/parliamentarian pairing scheme that it organises with the French Parliamentary Office for Scientific and Technological Assessment, the objective of which is to build bridges between Members of Parliament, from both the Lower and the Upper French Chambers, and scientists, namely Members of the Académie and young researchers. The Delegation for International relations under the responsibility of ASF's Foreign Secretary manages international activities. Geographical groupings such ALLEA and EASAC or global groupings such as the IAP and IAC as well as the IAMP are among many with which the ASF collaborates (ASF 2002). Prof. Yves Quéré, the internationally famous Fellow of ASF, served for some time as co-chair of the IAP.

The ASF has over 40 agreements with the academies of sciences of other countries. These agreements provide for the exchange of high-level scientists between the two countries and for the organization of colloquia on subjects of common interest. Numerous inter-office visits enable the ASF to benefit from direct information about the operation and activity of other academies.

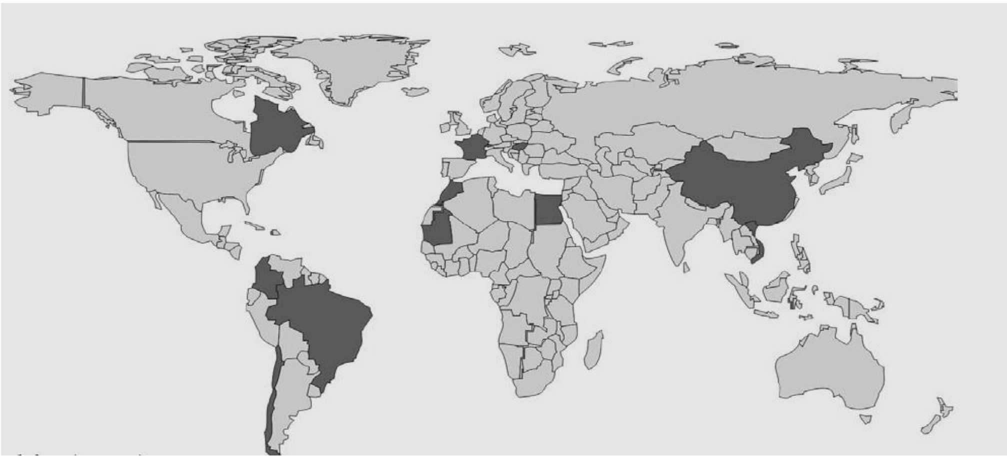

Figure 6.12 Worldwide distribution of *La main à la pâte* and its *Hands-on* partners.

The ASF is a world leader in science education as a result of an initiative by three of its members: Charpak (d. 2010), Quéré and Léna. This activity which is called *La main à la pâté* [20] (the hands-on or the hand in the paste) has become a model for the involvement of academies of sciences in science education of children at the world level (Descamps-Latscha 2003). Often described as an experiment in the renovation of science teaching, the La main à la pâte programme aims to encourage children to participate in the discovery of natural objects and phenomena in their milieus directly through observation and experimentation and to stimulate their imagination. Not only did the ASF initiate, develop the programme and prepare the course material and the web site, but also it promoted it internationally in cooperation with governments, educational institutes and science academies throughout the world. Following the

[20] Launched in 1996, the French La main à la pâte programme aims to renovate and revitalize the teaching of science in primary schools. Supported by the Académie des sciences, and in close collaboration with the Ministry of Education, it has developed a new approach of science education, that has been recently integrated in national French curricula.

success of the programme, a number of countries adopted and adapted the La main à la pâte programme as a key activity to improve science education at their national level (Figure 6.12).

6.17 The Royal Swedish Academy of Sciences[21] (KVA)

> *The (Nobel) prize is such an extraordinary honour. It might seem unfair, however, to reward a person for having so much pleasure over the years, asking the maize plant to solve specific problems and then watching its responses.*
> (Barbara McClintock, the 1983 Nobel Laureate in Physiology or Medicine, (Wilford 1983)).

The Royal Swedish Academy of Sciences or *Kungliga Vetenskapsakademien* (KVA), founded in 1739, is the institution that annually awards the Nobel Prizes for Physics and Chemistry. It is a relatively small institution which has built tremendous influence on the contemporary global scientific scene. The Karolinska Institutet has been designated to award the Nobel Prize in Physiology or Medicine while the Swedish Academy awards the Nobel Prize in Literature, and a Committee of five individuals elected by the Norwegian Parliament awards the Nobel Peace Prize. In 1968, the Sveriges Riksbank established the Sveriges Riksbank Prize in Economic Sciences, and in 1969, the Royal Swedish Academy of Sciences was given the task of selecting the Laureates in Economic Sciences. The KVA is an independent organisation, the motto of which is *to promote the sciences and strengthen their influence in society'* (KVA 2010). It is interesting to note that Francis Bacon's model for new academies which eventually sprang up all over Europe during the 17th century was the same model adopted by the KVA's founders in 1739, who were politicians, scientists and natural historians (Frängsmyr 1990b: xxi).

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21 http://www.kva.se

The KVA seeks to be a forum where researchers can meet across subject borders and promote international scientific networking. Its other objectives include supporting young researchers and offer unique research environments rewarding prominent contributions to research, acting as a voice of science, influence research policy priorities and disseminate scientific and popular-scientific information through the media and promoting science and mathematics education in schools.

Being elected a member of the KVA constitutes exclusive recognition of an individual's successful achievements, which can take the form of prominent research in mathematics, natural science, engineering, social science or humanities, or outstanding services to science. The KVA currently has about 420 Swedish and 175 foreign members. Since the founding of the KVA in 1739, about 1,600 Swedish Fellows have been elected (KVA 2010). The KVA's work is based upon its ten classes (each representing a scientific subject field) at its six research institutes. Committees, such as the Environmental Committee and the Energy Committee, work with issues requiring a broad scientific competence. It administers a researcher exchange programme with other academies and publishes six scientific journals.

The KVA is famous for the variety of prizes it offers, foremost among which is the Nobel Prize in the branches of Physics, Chemistry and Medicine. The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel was instituted in 1968 (KVA 2010) while the Anna-Greta and Holger Crafoord prize, which was awarded for the first time in 1982, is intended to promote international basic research in the disciplines of Astronomy, Mathematics, Geosciences, Biosciences and Polyarthritis. The KVA also administers the Rolf Schock prize in the fields of logic and philosophy, mathematics, the visual arts and music, while the Aminoff Prize is intended to reward a documented individual contribution in the field of crystallography. In 2008, the Tobias Foundation started awarding the Tobias Prize, which consists of a personal prize and a research grant for five years. The prize, which is administered by committee appointed by the KVA's Class for medical sciences, aims to give the laureate the means to carry out high-class research concerning problems of importance for cell therapy in blood-related disorders (KVA 2010).

Figure 6.13 The Royal Swedish Academy of Sciences Headquarters, Stockholm.

The KVA is active internationally, and annually organizes seminars that address scientific issues that are international in nature. In 2002 for example, it hosted an international seminar on the future research policies of the European Union (EU), in which experts in science and science policy from most of the EU member countries met to discuss the future science policy of the EU (KVA 2011). In 2003, the KVA elected professors Ahmed Zewail, Professor of Chemistry at Caltech, California, USA, and Nobel laureate in Chemistry 1999; and Rita Colwell, Director of the NSF in Washington DC, as foreign members (KVA 2011). Since then, foreign members of similar stature have been elected annually. Other international activities include the travelling exhibition which is organized by the Nobel Museum. The exhibition presents the entrepreneur and innovator Alfred Nobel, and informs the visitor about his life, how he built up his industrial empire and how he got the idea to donate money for an international prize.

6.18 The Royal Society (RS) of London

The origins of the RS lay with a group of scientists who started holding regular meetings in Oxford, England, at the end of 1640s (Gribbin 2008: 125). Its official foundation date is 28 November 1660, when a group of scientists met and decided to found 'a Colledge for the Promoting of Physico-Mathematicall Experimentall Learning.' This group included Christopher Wren, Robert Boyle, John Wilkins and Sir Robert Moray (RS 2011a). News of the Society's meeting was reported to King Charles II who granted his approval. At first apparently nameless, the name 'The Royal Society' first appears in print in 1661, and in the second Royal Charter of 1663, the Society is referred to as 'The Royal Society of London for Improving Natural Knowledge.'

In 1663, The Royal Society of London for the Improvement of Natural Knowledge was granted its Arms and adopted the motto 'Nullius in verba,' (on the words of no one) an expression of its commitment to empirical evidence as the basis of knowledge about the natural world (RS 2010a). The RS is the grandmother of science academies in the world today and has in 2010 celebrated 350 years of existence. It is independent of government by virtue of its Royal Charters.

In 2010, the RS had around 1,450 Fellows (only 5% of them are women) and Foreign Members, including more than 75 Nobel Laureates (RS 2010b).The Fellows[22] of the RS are eminent scientists, engineers and technologists from the UK and the Commonwealth. They are elected for life on the basis of excellence in science through a peer review process, which culminates in a vote by existing Fellows. Each year 44 Fellows, eight Foreign Members and up to one Honorary Fellow are elected from a group of over 700 candidates who are proposed by the existing Fellowship. Fellows are invited to fulfil a range of responsibilities for the Society on a voluntary basis. Many are members of awards or grants committees, editorial boards, research panels or other

[22] Prof. Atta-ur-Rahman, who is both a Fellow of the IAS and the Pakistan Academy of Sciences, was elected a Fellow of the RS in 2005.

bodies, which oversee the work of the RS. The RS has five members of the British Royal Family as Royal Fellows while Queen Elizabeth II is the Society's patron (RS 2010b). Recently discovered evidence revealed that the RS had three Arab/Muslim Fellows during the 17th and 18th centuries: The first was Muhammad ibn Haddu the Moroccan ambassador to England in 1682, the second was Mohammed Ben Ali Abgali the Moroccan ambassador to England in 1726 and the third was Cassem Algiada Aga the ambassador of Tripoli to England in 1728 (RS 2011b).

The RS combines three different functions (Klug 2000). First, it is a learned society which promotes the values of modern science and the notion that knowledge about the natural world is best obtained by careful observations and by controlled experiment. It does this by identifying and honouring high achievement, disseminating new science through meetings and publications, and maintaining a famous library and archive on the history of science. Its function as a learned society is the foundation of everything it does, since it is the standing of the Fellows and their expertise, which gives the society its international standing.

Second, it is a funding body, using public and private monies to support the best individuals to undertake imaginative and far-reaching research. It does this through Research Professorships and Fellowships, conference and research grants.

Third, it is the UK's Academy of Science, leading the UK scientific community in its relations with UK society, government and the scientific communities of other countries. In the context of the relationship between science and politics which is often uneasy, the RS takes credit for the scheme –mentioned earlier- called the MP-Scientist pairing scheme, which it started in 2001 to help build bridges between politicians and the best researchers in the UK. By linking scientists with policy makers, often from the same locality, the scheme engenders beneficial longstanding links between the two communities (RS 2010a).

Advances in science have relied for a long time on the international flow of people and ideas. Moreover, during the Cold War days, scientific organisations and academies were important conduits on nuclear and other scientific issues. In the same spirit, the RS today believes that science offers an alternative channel of engagement with countries such as Iran, Saudi Arabia and Pakistan (RS 2010b). Not wanting to be left out, the RS, after 11 September 2001, decided to join the international scientific bandwagon which was interested in and working with developing and Muslim countries, partly within the context of its 'Science Diplomacy' programme.

Of the projects that the RS has launched in the Islamic world has been the 'Atlas of Islamic-World Science and Innovation,' which is a three-year project that aims to explore the landscape of science in a number of OIC countries including Egypt, Iran, Jordan, Qatar, UAE, Pakistan, Malaysia, Nigeria and Turkey (RS 2009).

Figure 6.14 The Royal Society of London.

The RS has been publishing scientific journals since 1665 when *Philosophical Transactions* was founded after Henry Oldenburg, the RS's first secretary, invented what we now call the 'peer-review' process. The discoveries reported in *Philosophical Transactions* served to establish an author's claim to that discovery, in effect laying the principle adopted by peer-reviewed journals today. *Philosophical Transactions* is still published today and is the world's longest-running scientific journal (RS 2010c). The RS today publishes six internationally peer-reviewed scientific journals and a further journal chronicling the history of science as influenced by the Society and its Fellows.

Apart from *Philosophical Transactions of the Royal Society* and *Proceedings of the Royal Society* (each published in two parts: one covering the physical sciences and the other biological sciences), the two latest journals to be launched are *Biology Letters* and the *Journal of the Royal Society Interface* (RS 2010c). It is worth noting that the reports which the Royal Society prepares for the benefit of various agencies are also peer reviewed before being submitted to the RS Council for approval (Collins 1998).

The RS has an elaborate 'open access' website that is not actually 'open' if compared to the system adopted by the US-NAS. It collaborates however with some UN agencies and the WHO to make scientific journal articles available online free of charge to the world's poorest nations (RS 2010c).

6.19 Summary and Discussion of Part IV

As a leading science publisher, the US-NAS has made available its library of publications on its website where the complete text of more than 2,800 books is displayed. It annually makes over its scientific journal, the *Proceedings of the National Academy of Sciences*, available online to developing nations (Alberts 2004). Since 11 September 2001 (9/11), the US-NAS –under Bruce Alberts (US-NAS President, 1993-2005) and his colleagues- has undertaken an extraordinary effort to promote scientific collaboration with OIC countries in Asia and Africa. Unlike other American agencies, the US-NAS has succeeded in engaging the science community within the OIC.

The US, French and British academies have been leaders in developing a 'role of science in foreign policy' and 'science in diplomacy' and in 'using science to strengthen scientific relations with Islamic world.' Because such academies are important to their governments, the standpoints they take are important internationally. If they happen to change their position on certain issues – as happened- with the RS in 2010 when it changed its position on the issue of 'Climate Change,' they become the subject of criticism (Henningsen 2010).

Of the major projects that the RS has launched in the Islamic world has been the 'Atlas of Islamic-World Science and Innovation.' This is a three-year project that aims to explore the changing landscape of science and innovation across a diverse selection of OIC countries including Egypt, Iran, Jordan, Qatar, UAE, Pakistan, Malaysia, Nigeria and Turkey (RS 2010c). It is interesting to note that the RS has no science academies from the Islamic world as partners in this project although Malaysia, Pakistan, Turkey and Nigeria have academies that can play a useful role in its implementation. One possible reason for this could be that the initiators of the project felt that such academies did not have the capacity to help.

France's ASF established many important precedents in the development of modern science. One of these has been the prize system, which originally involved the conferral of a few highly-prestigious prizes. Yet the advance of experimental science in the 19^{th} century demanded the availability of funds to carry out future research. The ASF gradually transformed its traditional system of prizes into a less prestigious but more widely shared system of monetary awards, which finally led to a system of grants for younger researchers of promise (Crosland and Gàlvez 1989). It is worth pointing out that Yves Quéré, during his tenure as IAP Co-Chair lobbied for a similar scheme. Although the Institut of France model was adopted by other countries (the Institut D'Egypte, the Encümeni Danish in Turkey in 1860s and the Academy of the Kingdom of Morocco in 1980s) the ASF itself is not as prominent internationally as its British or American counterparts nor does it have a large membership like the RS, the KVA or the US-NAS. Moreover, not many members of the French Academy of Sciences are as well known internationally as the Fellows of the two other academies apart from Yves Quéré, Pierre Léna and George Charpak (1924-2010). On the other hand, the UK's Royal Society has been headed at some point by well-known scientists; Sir Michael Atiyah, the famous mathematician of Lebanese extraction; and Martin Rees, the cosmologist and astrophysicist. Further, many from academic circles will be familiar with the current and previous presidents of the US-NAS; Professors Ralph Cicerone and Bruce Alberts respectively, while not many can name the current or former president of the ASF. Needless to say that neither the ASF or the RS have been as successful as the US-NAS in building bridges with the Islamic world through S&T.

Sweden is a relatively small country, yet it has one of the most prestigious and famous science academies of the world, and one with a large membership compared to the country's population. The fact that the Nobel Prize has been awarded by the KVA for over a century is a manifestation of the continuity and stability of the academy. The fact that the King of Sweden annually attends the Nobel Prize is a manifestation of the importance he attaches to the event, which has metaphorically become bigger than the country itself. The Prize, which has gone to such scientists as Albert Einstein, Marie Curie, Alexander Fleming and Ahmed Zewail, has had a huge impact on interest in scientific research in the 20^{th} century (Barany 2008). The fact that a movies have been made centring on events related to the Nobel Prize [including 'The Prize' (1963) (IMDB 2010a) and 'A Beautiful Mind' (2001) (IMDB 2010b)] is testimony to the Prize's prominence at the international level.

The KVA has successfully engaged the science community internationally by arranging a travelling Nobel Prize exhibition that has visited a number of countries (KVA 2010).

Part V: Two Global Academies of Sciences

6.20 Islamic World Academy of Sciences (IAS)

The glories of academies in the ancient Islamic world have been lost to history. Since the closure of the Istanbul observatory in AD 1580 (Bosworth et al. 1989) where Taqī i-Dīn b. Marūf (1525-85) worked, the concept of a fellowship of scientists dedicated to the advancement of knowledge has remained absent from the Islamic landscape.

The birth of the OIC in 1969 witnessed the start of a new phase in joint Islamic action, following the independence of OIC countries from colonial domination. The birth of COMSTECH in 1981 marked the start of a new phase in S&T cooperation between OIC countries. The establishment of the IAS was recommended by COMSTECH, and approved by the Fourth OIC Summit, Casablanca 1984. In October 1986, 38 eminent scientists from many Islamic countries established the constitutional and academic foundation of (what was called then) the Islamic Academy of Sciences as its Founding Fellows. This Founding Conference was patronised by His Royal Highness Prince El-Hassan bin Talal of Jordan and His Excellency General Zia Ul-Haq, the (late) President of Pakistan. The IAS, which commenced its activities in 1986, is a non-political, non-governmental independent organisation affiliated to the OIC. The Jordanian government provides the IAS with its main funding. The Sultanate of Oman, Qatar and the Malaysian State of Sarawak have also provided some support to the IAS in the past. The IAS enjoys international status comparable to other international learned bodies in the world. Prince El-Hassan described the IAS as:

The Islamic World Academy of Sciences provides an institutional umbrella for the utilisation of S&T in the development of Islamic countries and humanity at large. The IAS programme addresses many contemporary issues with a view of benefiting, not only the Islamic world, but all mankind through a knowledgeable, cooperative, pragmatic and humanitarian approach to scientific and technological development, changing ignorance and the lack of vision into global responsibility and awareness.

(El-Hassan 2008)

IAS's main purpose is to increase interaction among scientists from member states of the OIC, and facilitate the exchange of views on major contemporary issues affecting the development of the Islamic world (Zou'bi 2008). The main objectives of the IAS include serving as a consultative organisation of the member states of the OIC on S&T; initiating S&T programmes and activities and encouraging co-operation among research groups in the various Islamic countries on projects of common interest. The IAS also aims to encourage and promote research on problems facing Islamic countries and to identify future technologies of relevance for possible adoption and utilisation. It is also mandated to formulate standards of scientific performance and attainment, and to award prizes and honours for outstanding scientific achievements to individuals and to centres of excellence in all S&T disciplines.

Figure 6.15 The Islamic World Academy of Sciences Headquarters in Amman, Jordan.

The membership of the IAS is made up of Founding, elected Fellows and Honorary Fellows. IAS Fellows are eminent scientists and supporters of science with sizeable contributions to the development of S&T in their countries and internationally. The Academy organises an election every year through which existing Fellows nominate and elect new members to the Academy Fellowship. Since its establishment in 1986, over 100 Fellows have been elected through annual postal ballots, the results of which are ratified by the IAS General Assembly. IAS Fellows (male and female members) are of more than 40 nationalities, and represent numerous educational, scientific as well as R&D institutions. The number of Fellows stood at 106 on 1 November 2011, including 8 women (Zou'bi 2011). The Honorary Fellowship of the IAS is awarded by the Academy to eminent personalities outstanding in their fields, who have promoted S&T in the Islamic world and internationally. As of November 2011, the IAS had 14 Honorary Fellows from Kazakhstan, Turkey, Sarawak/Malaysia, Egypt, Saudi Arabia, Switzerland, North Cyprus, Kuwait, Tatarstan (Russian Federation), the USA, Qatar and Malaysia (Zou'bi 2008).

Since its founding, the role of the IAS has evolved into four different functions. The first is that of a learned society that promotes modern science, honours high achievement and disseminates the latest scientific achievements internationally through meetings and publications. A second function of IAS –still to be realised- is that of a funding agency that supports promising researchers. Thirdly, the IAS leads the scientific community of the OIC in its relations with governments and academies of sciences worldwide. Fourthly, the IAS often acts as forum for discussion on important issues such as the 'History of Islamic Science,' and 'Science and Spirituality.' Despite shortage of funding, the IAS has succeeded in building a presence among the academies of sciences in the world, and the membership of the IAS has become a sought after goal of many scientists from the OIC.

Since 1986, the IAS has been involved in the majority of international S&T activities that concern OIC countries and has been designated by many as the voice of S&T in the Islamic world. As with other science academies, it shoulders the primary responsibility for convincing decision-makers, parliamentarians and the public of the strong relationship that exists between science and sustainable economic growth.

The IAS has, since 1986, been promoting joint Islamic action in S&T through scientific conferences, which aim to nurture S&T relations between the science community in the host country and the international scientific community. As of 2011, the IAS has convened 18 such conferences which addressed important scientific topics such as Information Technology, Biotechnology, Nanotechnology, Energy and Higher Education as well as policy-based themes such as the 'Role and Function of Academies of Sciences' as well relations between the 'Islamic World and the West.'

The IAS publishes the proceedings of its conferences and has – as of 2011- published a total of 15 volumes of proceedings.

Since 1988, the IAS has published the *Journal of the Islamic Academy of Sciences* (ISSN 1016-4460), which aims to be a similar quality publication to other international scientific journals. In response to the large number of medical articles that it normally receives, the Journal was relaunched in 2000 as a medical publication –the *Medical Journal of the Islamic World Academy of Sciences*[23]- which is also available in an 'open-access' electronic version.

An award was instituted by the IAS in the name of Prof. Mohammed Ibrahim, Founding Fellow and eminent endocrinologist from Bangladesh, which is awarded biannually to young scientists active in the medical field.

[23] The Medical Journal of the Islamic Word Academy of Sciences is published online at http://www.medicaljournal-ias.org/

Furthermore, the IAS has built up scientific relations with a number of international governmental and non-governmental organisations which include: COMSTECH, IDB, UNESCO, ISESCO, TWAS, IAP, IAMP and the IUA. Such relations have helped the IAS and S&T community of the OIC to reach out and interact with the S&T community worldwide.

The IAS has collaborated with and received support from a number of private sector companies in Jordan, Turkey, Saudi Arabia, Kuwait and Malaysia.

6.21 The Academy of Sciences for the Developing World (TWAS)

Prof. Abdus Salam –the founder of TWAS- was the first scientist from the Islamic world to win a Nobel Science Prize (Physics; 1979). After winning the prize, he was invited by the King of Morocco to become a Fellow of the Academy of the Kingdom of Morocco (AKM) in 1980. It was at the meetings of the AKM in the early eighties that he contemplated founding the 'Afralasian' or 'Asialafrica' Academy of Sciences (Dajani 2003) (Schaffer 2005). When the academy was finally established, he decided to call it the 'Third World[24] Academy of Sciences (TWAS)' after the countries of South America had decided to join. TWAS changed its name to 'the Academy of Sciences for the Developing World' in 2004, but retained the 'TWAS' acronym.

TWAS is an autonomous international UNESCO-affiliated organization dedicated to building scientific capacity in the developing world. It was founded in Trieste, Italy, in 1983, by a distinguished group of scientists from the South, and officially launched by the UN Secretary General in 1985.

The UNESCO is responsible for the administration and the staff expenses of TWAS following an agreement between the two organizations. The Italian government provides TWAS with its main funding. TWAS collaborates closely with the UNESCO's

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[24] The term, 'Third World,' was coined by the French economic historian Alfred Sauvy in 1952. Sauvy, Alfred, 1952. *Trois Mondes, Une Planète*. *L'Observateur*. 14 August 1952.

Natural Sciences Sector, ICSU and United Nations University Institute of Advanced Study (UNU/IAS). TWAS and UNESCO co-sponsor a number of other programmes including the joint visiting scientist programme implemented by TWAS (TWAS 2010).

The objectives of TWAS include recognizing, supporting and promoting excellence in scientific research in the Developing world; responding to the needs of young scientists in S&T-lagging countries; promoting South-South and South-North cooperation in science, technology and innovation; encouraging scientific research and the sharing of experiences in solving major problems facing developing countries (TWAS 2010b).

The Membership of TWAS is composed of 999 (2010) distinguished scientists worldwide. On average, up to 50 new Members are elected every year. The main criterion for election as a TWAS Member is scientific excellence. Scientists who have attained the highest international standards and have made significant contributions to the advancement of science can be nominated as Fellows (who live and work in developing countries) or Associate Fellows (who live and work in developed countries). Other criteria for nomination of candidates are age (under 70 at nomination) and membership in a recognized national science academy if such a body exists in the candidate's country. Only TWAS Members can nominate candidates for election. The nomination must be made in writing on a form called 'Certificate of Election.' Completed 'Certificates of Election' are evaluated by Membership Advisory Committees and then submitted to the TWAS Council. The Council recommends a final list of candidates for election which is communicated to the Fellows and Associate Fellows attending the General Meeting. Candidates receiving a favourable vote by the majority of Fellows and Associate Fellows present at the General Meeting are elected (TWAS 2010c). Recently, the TWAS secretariat in Trieste established a new category of affiliated membership for young scientists that will permit those selected to be associated with the Academy for a five-year period. This is part of a larger campaign to encourage university students to pursue careers in science.

TWAS's most significant activity is the South–South fellowship programme it operates with the governments of Brazil, China, India, Mexico and Pakistan. The programme is open to young scientists from developing countries who are pursuing doctoral degrees and postdoctoral studies in a wide range of scientific disciplines. TWAS pays the cost of travel and provides a small stipend; local universities and research centres hosting the students cover the cost of food and lodging. This programme is one of the largest and most effective programmes for South–South cooperation in science. With more than 200 fellowships available each year, it represents a channel for collaboration between more scientifically proficient and less scientifically proficient developing countries.

TWAS also oversees a research grants programme largely for young and mid-career scientists in the developing world, and visiting scientist programmes that foster South–South and South–North scientific exchanges.

Figure 6.16 TWAS is housed at the Enrico Fermi Building which is part of the ICTP Complex, Trieste, Italy.

In 2002, TWAS launched a programme targeting funds for scientific groups and research centres in sub-Saharan Africa and the least developed countries. The programme offered annual grants of up to US$ 40,000 for three consecutive years. It is designed to provide significant resources to research groups and institutions in very poor developing countries that are doing excellent work under trying conditions.

TWAS also provides small sums of money for scientific meetings in the Developing world. It holds a general meeting once every two to three years which assess the state of science in the developing world. Brazil, China, India, Iran, Kuwait and Senegal are among the countries that have hosted Academy meetings. TWAS also supports scientific capacity-building at the regional level, largely through its offices in Brazil, China, Egypt, India and Kenya. A key focus of these regional offices is the organization of symposia and the awarding of prizes for young scientists.

As for collaboration with the private sector, TWAS has –since 2004- secured funding from illycaffè for the Trieste Science Prize under which two prizes of $ 50,000 each are given to science researchers from the developing world.

TWAS provides administrative support for several international scientific organizations including the IAP, IAMP and the Consortium on Science, Technology and Innovation for the South (COSTIS), the new organisation which replaced TWNSO in 2006.

6.22 Summary and Discussion of Part V

In this part, two global science academies were analysed: the IAS and TWAS. The two academies have some features in common. Both were founded by top Pakistani scientists (M A Kazi and Abdus Salam respectively) who were educated in the West, and who were keen to see countries of the South achieve advance in the domain of science and technology for development (Figure 6.16). Both Salam and Kazi had acquired a leaning for the Western model of science institutionalisation as manifested by academies of sciences.

Although many of the members of the IAS are also members of TWAS, the IAS has no institutional backing to speak of while TWAS enjoys the moral and material support of UNESCO.

The strength of the IAS lies in its ability to address heads of state and top politicians in the Islamic world especially those who host or participate in its meetings, and through its powerful Council. Yet the very same Council –which at some point included two former prime ministers of Jordan- has not been able to build up a sizeable Trust Fund (Waqf) for the IAS.

At times of international tension and Islamophobia, the IAS has been able to weather many storms and maintain an open minded and proactive posture and engage academies outside the Islamic world including the US-NAS, the Royal Swedish Academy of Sciences as well as networks of academies such as the IAP and the IUA.

The IAS has been described as being carefully silent about certain controversial issues such as the teaching of evolution (Léna 2009). This may be true and is justified on the grounds that the IAS has taken the middle ground between those blindly supporting science and those considered as its foes, and its continuous attempt to build consensus on many down-to-earth issues that science addresses. The IAS has succeeded in raising the profile of STI in decision-making circles in many countries. It has addressed many important themes at its international conferences including the so-called transformational technologies of ICTs, Biotechnology and Nanotechnology. IAS has succeeded in bringing many issues to the attention of decision-makers in OIC countries including food security, water issues, higher education standards and energy. It was among the first group of organisations to highlight that many OIC countries do not have S&T policies, or science academies and was among the first to publicise that no university in the Islamic world was ranked among the world's top 500 universities. The IAS was able to persuade some decision-makers in the OIC to pay more attention to STI, and to get a number of countries to invest more in STI including Jordan which raised its GERD from 0.33% in 2005 to 0.55% in 2010 partly as a result of efforts by IAS Fellows from the country.

The IAS –like many scientific organisations operating in the Islamic world- has also occupied itself with the history of science in the Islamic civilisation. It has developed an interest in this subject as a means to engage the science community in the West, for it is in the West that the majority of the experts on Islamic Science reside. Yet, some people in the West have certain trepidations about the IAS as they perceive it as an organisation with heavy religious leanings. This despite the efforts of many people who are associated with the IAS to explain that it is basically an academy of sciences of the countries of the OIC open to people of all colours, faiths, political beliefs and nationalities. TWAS, on the other hand, does not have the same problem.

The Islamic world does not have many active science academies that collaborate with the IAS. TWAS, on the other hand, is based in Europe, has international staff and operates on budget almost twenty times as big as that of the IAS (US$ 12 million compared to around US$600,000, respectively). It moreover has strong links with a number of well established academies in the developing world that appear to be competing for influence within TWAS' ranks (these include the Chinese, Indian, Brazilian and Mexican academies of sciences).

The IAS has just over 100 Fellows while TWAS has around 1,000. Judging by the number of Fellows who participate in their general meetings, the percentage of Fellows active in both academies is similar – around 30-40%. TWAS's strength and its evident success in establishing itself on the international S&T arena and implementing numerous S&T programmes lies in a number of factors including the fact that it is based in Trieste and financed by Italy, and has been organically linked to UNESCO which pays the salaries of its international-level staff. TWAS is practically a department of UNESCO except for the fact that it may have a bigger budget. TWAS moreover is seen by many as a competition playing field between India, China and South American countries such as Brazil and Mexico. This has worked to TWAS' advantage over the years. Furthermore, TWAS has enjoyed remarkable continuity manifested by the presence of Dr M H A Hassan as executive director for over 27 years.

Figure 6.17 A rare photo of Abdus Salam and M. A. Kazi in 1980s.

6.23 Summary of Chapter Six

Chapter Six looks at the academies of sciences of Palestine and Morocco from the Arab OIC region, Uganda and Senegal from the African OIC region, and Tatarstan, Turkey, Pakistan, Iran and Malaysia from Russia and the Asian OIC region. The US National Academy of Sciences (US-NAS), the Academy of Sciences of France, the Royal Swedish Academy of Sciences, as well as the UK's Royal Society are discussed as well as two global academies: the Trieste-based TWAS and the IAS, based in Amman, Jordan. By comparing academies of sciences; their successes, failures and the best practices that some have developed, we can draw possible lessons for the academies of

OIC and developing countries. This will be further detailed in the answers to the research questions (pp. 272-298).

Since the end of World War II, the OIC –particularly Arab region- has been a hotspot of military conflicts that have adversely affected the already few efforts to institutionalise STI initiatives for development. This is clearly reflected by the STI indicators of the region (highlighted in Chapter Four) and the fact that today, science academies exist only in seven out of 22 Arab states –Morocco, Sudan, Egypt, Lebanon, Jordan, Iraq and Palestine. The Palestine Academy of Sciences and Technology (PALAST) and the Hassan II Academy of Science and Technology (HAST) are the only active *national* science academies in the region today.

The chapter tells us the most academies of sciences in OIC are new, have small memberships, and are still trying to find niche areas in which they can excel. Of PALAST's special features is the responsibility it has to address contentious politically charged issues related to the Arab-Israeli conflict. HAST on the other hand has the reputation of its elder sister, the AKM to live up to. The Tatarstan Academy of Sciences (TAS) is a successful model of an honorific and research-performing academy in the Russian tradition that has an extensive mandate which is both scientific and political. TÜBA is a relative new comer on the international scene that should try to include all shades of political opinion and religious persuasion prevalent in Turkey in its membership if it is to avoid criticism. Although PAS is well known among the intellectual elite of Islamabad, it has been powerless to influence the science and development domains in the country, while ASIRI must try to enhance its international outreach with all international science academies. The ASM should consider redefining its role vis-à-vis the national government so that it is more independent and more effective in its advisory role. ANSTS seems to enjoy good rapport with its government and should use such influence to lobby for more resources for science while UNAS' niche activity seems to be the very important area of science education, which is also the niche activity of the ASF.

Unlike other American agencies trying to engage OIC countries, or indeed the RS, the US-NAS has succeeded in ‘getting to know’ the science community within the OIC, and is able to provide advice to a variety of stakeholders in the US on such matters.

The Royal Swedish Academy of Sciences has become associated with the Nobel Prize. This has done a lot not only for Sweden and the Swedish Academy but for academies of sciences worldwide including the IAS and TWAS. The strength of the former lies in its ability to address heads of state and top politicians in the Islamic world especially those involved in its meetings, whilst TWAS has succeeded in establishing itself on the international S&T arena and implementing many S&T programmes.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS: ENHANCING THE ROLE OF ACADEMIES OF SCIENCES IN THE ISLAMIC WORLD

Tore Frängsmyr (1990: xi) starts the introduction of the book, *Solomon's House Revisited: The Organisation and Institutionalisation of Science*, with the following statement

> *In his Utopian New Atlantis (1627), Francis Bacon*[25] *described the building that was to incorporate all the ambitions of the ideal society that Bacon visualised: He called it Solomon's House. It illustrated how science could be efficiently organised to benefit humanity.*
>
> Frängsmyr adds:
>
> *This was the first description of a modern scientific academy. We all know that academies had been formed before, especially in Italy, but not one before Bacon had such clear ideas on the organisation of science.*

7.1 Introduction

This concluding chapter draws together the salient findings of this Thesis and their implications for better context and understanding of the scientific enterprise in Islam and the role and functions of academies of sciences in the scientific enterprise, particularly in the Islamic world. The main findings and conclusions are presented as responses to the research questions, or as part of the self-standing conclusion which is entitled 'From Utopia to Pragmatism.' A number of areas for further research are suggested.

[25] Francis Bacon (1561 – 1626) was an English philosopher, statesman, scientist, lawyer, jurist, author and pioneer of the scientific method.

7.2 Summary of the Chapters

The main issues and Research Questions of this Thesis as well as the self-standing Literature Review, Hypothesis, Theoretical Framework, Methodology, Evidence and Presentation, Scope of the Research and the Structure of the Thesis are presented in **Chapter One.**

In **Chapter Two,** I start by providing a short history of the academies of the ancient era in Athens, Alexandria and Jundishapur, and in the process proposing a link between the Academy of Jundishapur and its successor, Bayt al-Hikma of Baghdad. This is followed by an attempt to show that contrary to the archetypal narrative, the scientific enterprise was on the rise well before Bayt al-Hikma was established in Baghdad around the beginning of the 9th century.

Many contemporary scholars disagree with the view that Bayt al Hikma was an academy of sciences of its day due to the lack of documentary evidence. In the light of recently published literature, the idea that Bayt al-Hikma of Baghdad was indeed an 'academy of sciences' of its day is presented. This is followed by a look at some of the more famous academy-type institutions that had appeared in the Islamic civilisation after Bayt al-Hikma including the Cordoba, Cairo and the Maragha observatory/academy of al-Tusi.

In order to extract possible lessons for today's Islamic world, the archetypal narrative for the decline of Islamic science is investigated and reasons for the general decline of the Islamic civilisation are outlined. To propose a new watershed for the decline of Islamic science, a thorough survey of the encyclopaedic *'Mu'jam al-A'lam'* (Lexicon of Towering Figures or Biographical Dictionary as its publisher calls it) by Khayruddin al-Zerekly revealing the names of many eminent scientists who have appeared in Islam after the 14th century. The closure of the Istanbul observatory of Taqī i-Dīn b. Marūf in AD 1580 is proposed as an alternative watershed for the *slowing down* of Islamic science. This view is supported by the narrative on Ottoman science, at the end of the chapter, which tells us that in general conditions after the end of the 16th century were no longer conducive to science in the world of Islam.

Chapter Three firstly describes Europe at the turn of the first millennium which was –with the exception of Al-Andalus- in a state of social and scientific backwardness. By describing some of the routes through which science was transmitted into Europe including Andalucía, Sicily and the Wallonia conduits, I am presenting another example of the transmission of science, and highlighting how early the translation movement in Europe started. After discussing the work of Copernicus and how it was based on earlier Islamic works, the dynamics of the renaissances in Europe and the rise of scientific academies in the 17th century are discussed.

The role of early science academies within the 'Age of Academies' is discussed leading to the Industrial Revolution. I allude briefly to the idea that studying how the Industrial Revolution came about in Europe will lead to a better understanding of why such a revolution did not take place in the Islamic civilisation. I suggest that the inability of science to reinvent/re-innovate itself as *techné* (craftsmanship) in the Islamic civilisation may have been a factor in the Industrial Revolution not taking place in the Islamic world.

In **Chapter Four,** a narrative on the colonisation of the Islamic world is presented and in particular its mammoth impact on society, science, education and academe in countries of the OIC. The Basalla Model for the 'Spread of Western Science' is expanded to address what may be called 'colonial education' and 'colonial academe' to draw a picture of how such enterprises resurfaced again in the Islamic world after an absence of two centuries. Moreover, an attempt is made to investigate the 'modernist' and 'conservative' views on modern science that prevail in the Islamic world today in order to better understand why science is currently not viewed as a priority. Quantitative methods of gauging S&T are introduced and a picture of the S&T landscape is drawn using the latest available data on the subject from a number of unusual sources.

In **Chapter Five**, a closer look is taken at the types of academies of sciences that exist in the world today, their constitutional foundation, human component, their roles and the activities they implement which are essentially similar to what their predecessors of the 17th century had instituted. The role, functions and activities of academies of sciences are described under two headings: ‘Promoting the Scientific Enterprise’ and ‘National and International Outreach.’ Of the former, science advice stands out as an exercise that has evolved into a multi-level activity of most academies of sciences, as well as science education, as it is becoming a key programme for many science academies. The chapter also investigates the relations of academies with governments and parliaments and analyses the topical issue of ‘Women in S&T and Academe,’ which encompasses political and policy elements. A critique is included of the Statutes of the ‘Academy of Sciences of Wonderland’ (the model academy) which have been drafted by the IAP to help guide countries planning to establish national academies of sciences.

Chapter Six looks at the academies of sciences of Palestine and Morocco from the Arab OIC region; Uganda and Senegal from the African OIC region; and Tatarstan, Turkey, Pakistan, Iran and Malaysia from Russia and the Asian OIC region. The US National Academy of Sciences (US-NAS), the Academy of Sciences of France, the Royal Swedish Academy of Sciences, as well as the UK’s Royal Society are discussed as well as two global academies: the Trieste-based TWAS and the IAS, based in Amman, Jordan. The analysis includes a look the founding of each academy and its constitutional structure, its membership and the types of programmes it undertakes as well as niche areas for which it has become well-known.

By comparing academies of sciences; their successes, failures and the best practices that some have developed, we can draw possible lessons for the academies of OIC and developing countries.

7.3 The Research Questions Revisited

In **Chapter One**, I listed three research questions that were to drive my research effort. It is time to return to those questions and provide answers.

1) **How has the scientific enterprise in the Islamic world evolved historically and how has science ascended in the West? What is the status of science in the Islamic world today?**

The Muslims of the 8th century were not only well versed with theological Islamic 'sciences' which were based on the teachings of Islam, but had also developed an understanding of some scientific fields of knowledge such as astronomy, mathematics, chemistry and medicine. Otherwise, it is difficult to imagine how an assemblage of Arab tribes from the Hijaz –who essentially lived a nomadic existence at start of the 7th century- would succeed in establishing a super-state in less than 100 years without having some knowledge capacity to begin with. The favourable milieu for science they had is due to the nature of Islam which encouraged Muslims to explore and study nature as outlined in the recommendations of the *Qur'an* and the *Sunnah* (Golshani 2008). Moreover, early Muslims must have quickly acquired the faculty and competence to master the art of nation-building and appreciated the knowledge or 'science' required to achieve such a feat.

The first century of Islam –notwithstanding some major political events- represented a period of not only military conquest[26] exposing Muslims to new cultures and civilizations, but also one of tremendous dynamism and innovation within a milieu of curiosity to learn about the world.

The foundations of Islamic scientific tradition were thus present well before Greek sources were formally appropriated into the Islamic knowledge pool and disseminated in the 9th century (Saliba 2007c). Science in the Islamic world started to flourish early as a result of patronage by leaders such as Abd al-Malik *(*AD 646-705) who was an enlightened leader who appreciated science and what science could do for the state. Political patronage, until today, remains a critical prerequisite for science to bloom.

The birth of Bayt al-Hikma early in 9th century Baghdad was not an event that occurred suddenly. It was the culmination of at least a century and a half of a movement to Arabicize science which was started by Abdel al-Malik. The seeds of the Golden Age of Islamic science were sowed then, probably even before. The ʻAbbāsids were institutionalisers of science. They were followed historically by the Umayyads of al Andalus, and the Fatimids in Egypt. It was al-Andalus – especially the city of Toledo – that became the main conduit through which Islamic science flowed into Europe as early as the turn of the first millennium.

The Golden Age of Islamic Science lasted for the best part of a millennium (AD 700 to 1600) in a milieu that warmly and universally embraced science. Not only did scientists from the Islamic civilisation study and analyse Greek (and other) sciences but also added many completely new concepts unknown to their predecessors (Saliba 2008) (Saliba 2011). It is true that Islamic science peaked early, probably in the 10th century, but scientific activities continued in the Islamic world to the end of the 16th century. Since the 11th century, the Islamic civilisation has practically been under attack. The

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26 Historians claim that more than 90% of the military expansion of the Islamic state took place within the first 100 years of Islam.

Crusades and Mongol invasion did not have had an immediate impact on science and the scientific enterprise (Saliba 2011) in Islam, but they had a mammoth impact on the milieu within which Islamic science flourished, which became starved of wealth and energy, busy attempting to repel the invaders and rebuild its devastated infrastructure. Of the effects of foreign invasion of the Islamic world has been the political fragmentation of the single powerful Islamic state as manifested earlier by the Umayyad and ʻAbbāsid Caliphates.

Although the number of historically renowned scientists in the Islamic civilisation seems to have declined after the 14th century, upon careful re-examination we find that many eminent scientists appeared in or after the 14th century including the famous polymath, Ibn Khaldun (AD 1332-1406). Other famous scientists in the 14th and 15th centuries include Ibn al-Shatir (AD 1304-1375) and Baha al-Din al-ʻAmili[27] (1547-1622), to name but a few.

By revising the traditional narrative for the decline of Islamic science, this Thesis casts off the view that the Golden Age of Islamic science abruptly ceased in the 13th or the 14th century. It is evident that the decline of the Islamic civilisation –including Islamic- started gradually owing to a series of external and internal factors including; the Crusades and the Mongol invasion, political fragmentation of the state and lack of patronage of science, an unappealing milieu, demographic considerations as well as strategic factors resulting in a decline of trading activities. Other factors that have contributed to the slow decline of Islamic science include; the absence of a patenting culture at a time when Europe was discovering patents, the slow introduction of printing and –quite possibly- the gradual abandonment of the Arabic language as the *lingua franca* of science, as it had been for centuries.

[27] Baha al-Din al-ʻAmili was born in Lebanon in 1547. Moved to Iran and later rose prominence during the reign of Shah ʻAbbas I and died there in 1622.

From the beginning of the 17th century, conditions were no longer conducive within the realms of Islam (as represented by the Ottoman Empire) for the development of science although the appropriation of technology continued. Reasons for this scientific quiescence that prevailed during the Ottoman era include social and economic disruption resulting from the weakening of the central authority – not in a dissimilar fashion to what took place during the ‘Abbāsid Caliphate in the 13th century – dissolution of political stability, decreasing conquests, loss of land and the diminishing revenues of the state (Ihsanoglu 2006).

This Thesis thus proposes an alternative watershed for the *slowing down* of Islamic science which coincides with the unfortunate closure of the Istanbul observatory of Taqī i-Dīn b. Marūf in 1580; that is almost a century after the exit of Muslims from Spain in AD 1492 and the discovery of America by Columbus in the same year. Moreover, the closure of the Istanbul observatory nearly coincided with remarkable events in the West: Copernicus’ revelations in *De revolutionibus orbium coelestium* in 1543, and the founding of the Accademia dei Lincei in 1603; two events that mark the start of the ascendance of science in the West. Needless to say Copernicus’ work was based on some original research by al-Tusi three centuries before, the contribution of Ibn al-Shatir notwithstanding. Al-Tusi had laid the foundation for the Scientific Revolution in Europe of the 16th century in 13th century Maragha.

For five centuries before Copernicus, Europe was on the receiving end of a massive surge of science from the South that started in al-Andalus around the turn of the first millennium and continued for the best part of five centuries through a number of conduits including Andalucía, Sicily and Wallonia (in modern-day Belgium).

The infusion of Islamic science into Europe at the time was a repeat of what had taken place earlier during the early ‘Abbāsid Caliphate, between the Greek and Islamic cultures. Just as Baghdad had diligently sought to acquire Greek science, so Europe in the 12th century devoted great care to Islamic works on astronomy, arithmetic, trigonometry, optics, geometry, astrology and medicine (Mushtaq 1990).

By describing some of the routes through which science was transmitted into Europe including the Wallonia connection, the idea that science has always been international and free flowing across civilisations and cultures was reinforced. Knowledge started to flow from the Islamic civilisation to the West where it was absorbed and then contributed to the rise of the scientific enterprise, firstly, as an intellectual linguistic movement and then as a scientific movement. The fact that universities were starting up in Europe played a significant role in appropriating Arab and Islamic science. Here, universities in Europe renaissance preceded academies as beacons of science and the scientific endeavour, unlike the Arab/Islamic civilisation where academies were the forerunners to the madrasas. The main conclusion to be drawn from uncovering the Wallonia connection is that many of the routes that the flow of Islamic science took when it was spreading through Europe are still being discovered.

Most Western historians (with a few exceptions such as Lindberg) tend to ignore the fact that the re-discovery of Greek learning started in the 12th century, or even earlier, through Spain and the other conduits of knowledge from Islamic sources (Lindberg 1978). Further evidence to confirm the early transmission of Islamic science into Europe stems from the fact that medieval European universities were established in the 12th century primarily to assimilate the knowledge coming from Islamic sources (Nakosteen 1964). The development of medieval universities allowed them to aid materially in the translation and propagation of these texts, and started a new infrastructure needed for scientific communities.

Unlike the rise of science in the Islamic civilization, which was rapid and well patronized by leaders, science in the European civilization was slowly assimilated and built up over centuries without much political patronage. Only in the 17th century can evidence of strong patronage by the kings of Europe of science and the scientific endeavour be found. That is almost six centuries after the first contacts between the Europe of the middle ages and the Islamic civilization. Rereading the story of the rise of Islamic Science may help in a better understanding of; the harmonious relationship that exists between Islam and science, the capacity of early Muslims to learn from others and adapt to the political realities that they became a part of and the open-mindedness they demonstrated in interacting with other cultures and civilisations. Furthermore, a closer look on the reasons outlined for the gradual decline of Islamic science reveals that they are as valid today as they were when they occurred. They are the same factors that are today holding back the collective scientific and technological advancement of OIC (including) Arab countries. These include; external military threats, strategic location (that is an advantage and a disadvantage), lack of patronage and political fragmentation, the system of education, and demography, manifested today by the lack of human resources active in science.

Science and the scientific enterprise have not been among the priorities of the Islamic world during the last century. The manifestations of interest in S&T and education by the Ottoman Empire and Egypt –particularly in 19th century- were incomparable to what was happening in Europe at about the same time. Omar Abdul-Rahman[28] suggests that the golden age of Islamic science triggered the renaissance in Europe that eventually led to the Industrial Revolution, while the scientific enterprise in the Islamic world went into a state of quiescence towards the end of the 16th century and has not really picked up since.

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[28] For sometime the science advisor of the Malaysian Prime Minister.

Colonisation represented the last stage of an epoch that spanned for almost two centuries in which the Islamic world was dormant, and had a mammoth impact on society, science, education and academe in countries of the OIC.

Today, the science scene in the Islamic world is blurred, rendering efforts to rejuvenate the scientific enterprise within, futile. A divide exists between the 'modernist' school which believes that S&T is *the* means to realize socioeconomic development, and the 'conservative' school of thought which propagates a more philosophical/mystical role for science.

Most OIC countries do not grasp that science can offer solutions to urgent development related problems, so they under-invest in science. Further, it is clear that STI systems in the majority of OIC countries are incomplete, as many such countries do not have S&T policies or national academies of sciences. Moreover, expenditure on science R&D is low in marked contrast to European countries. Furthermore, the 57 countries of the OIC, accounting for a population of more than 1.5 billion, are the source of approximately 2% of the world's science citations, and only approximately 1% of mainstream journal articles. Other statistics reinforce this analysis, with approximately 525 scientists/engineers per million population, in stark contrast to the approximately 4605 per million population in the USA, for example.

For countries to utilise S&T for development and prosperity, a critical mass of scientists and technologists, or a sizeable science community, is required. Such a community –often manifested by a national academy of sciences- is a multipurpose resource that not only carries out research but also interprets and communicates knowledge.

The above ominous landscape of S&T calls for a serious review. The resolution of political problems that are plaguing many parts of the Islamic world could pave the way for a decrease in defence and security spending and make more resources available for development. More importantly perhaps is the change required in the mindset of political leaders –and the public- of OIC countries, to put S&T back on national agendas for real socioeconomic advancement.

2) How have academy-type institutions and academies of sciences evolved in Islam and the West?

Appreciating the history of Islamic science is impossible without studying the institutions that were at its core such as academies and academy-type institutions. Such institutions mirrored the interest of leaders and society in science and the scientific enterprise.

Athens was one of three ancient cities that were the domicile of academies. The other two were Alexandria and Jundishapur, located in what we know today as countries of the OIC or the Islamic world: Egypt and Iran respectively. Athens was the venue for Plato's academy (BC 387), followed historically by Alexandria, which boasted the ancient library named after it in BC 290. Jundishapur was home to an Alexandrian-type 'academy' established by Khosrau I around in AD 560. With the exception of Plato's Academy of Athens, ancient Academy-type institutions in the Middle East were founded mostly by leaders and monarchs at the height of their political power such as Ptolemy I (Alexandria), Khosrau I (Jundishapur) and Al-Ma'mun (Bayt al-Hikma). The founding of each represented an early milestone in the respective histories.

Recently unearthed evidence shows that Bayt al-Hikma may be considered as an academy of sciences of the 9th and 10th centuries, an observatory, a public library as well as an international archive of knowledge that might otherwise have been lost. It was also an Arabic language academy (*majma*') that made Arabic the language of science for centuries. Not only did its institutional set-up reinforce the claim that Bayt al-Hikma was an academy of sciences, but also the fact that the majority of the subjects studied within its confines belong to what is called –in modern parlance- basic sciences including; astronomy, mathematics and medicine as well as the main Greek works on philosophy. By transposing Bayt al-Hikma against the definitions of an 'academy of sciences' that were outlined in the literature review, namely a care-free environment where scholars engaged in scientific pursuits, and arguing that it was an academy of sciences of its day, this Thesis opposes the opinion of Yates, mentioned in the literature review, that academies were essentially an European invention.

Spain, which was destined to become the conduit of Islamic science into Europe, was the home of Dar al-Hikma of Cordoba, which was modelled on Bayt al-Hikma of Baghdad, in another manifestation of the flow of the scientific enterprise from East to West. Dar al-Hikma in Cordoba was the culmination of vigorous scholarly exchanges that resulted in the transfer of linguistic, scientific as well as medical knowledge from Baghdad to Cordoba and then onto Europe. The other Dar al-Hikma, which was based in Cairo (AD 1005) was a science academy similar to the earlier Bayt al-Hikma but did not focus as much on translation. The programme of study of Dar al-Hikma did not only include religious subjects but also subjects such astronomy and medicine. Al-Hakim was a leader who appreciated science, and must have been encouraged to promote scientific knowledge by such towering figures as Ibn al-Haitham and others. In AD 1066, the Nizamiyyah was founded. Considered as the first real academy in Islam that made provision for the physical needs of its students, it became a model for later institutions of higher learning. It was where al-Ghazzālī[29] lectured for four years (AD 1091-5). Whether it was an academy-type institution of the type of earlier ones needs to be investigated further. However, al-Nizamiyyah has been described as the most famous of the chain of madrasas (schools).

The fall of Baghdad at the hand of Hulagu in AD 1258 was a historical occurrence that had a profound and long-lasting effect on the Islamic civilisation. Yet, it was an event that encouraged al-Tusi[30] (AD 1201-1274) to seek the consent of Hulagu, to build an observatory in Maragha (in modern-day Iran) in AD 1262. The Maragha Observatory/Academy became the epicentre of scientific activity. It was where centuries of Greco-Arabic-Persian learning in astronomy was centralised, and was according to many contemporary scholars a true science academy of its day.

The Samarkand observatory (in modern day Uzbekistan) specialized in the teaching of astronomy at the heart of what constituted the nucleus of a scientific 'academy' frequented by Ulugh Beg (1394-1449). In AD 1420s and AD 1440s, it was at the heart of the astronomical and mathematical capital of the world; the city of Samarkand.

The Samarkand observatory was replicated in the 16th century in Istanbul, where Taqī i-Dīn b. Marūf (of Damascus) (1525-85) founded an observatory in 1575 under the patronage of the Ottoman Sultan Murad III. This observatory seemed to have a promising future however the Sultan ordered its closure in 1580. Not before the passing of three centuries would the Ottoman Empire witness the birth of a new academy of sciences, the Encümeni Danish in 1861, founded Sultan Abd al-Majid (1824-1861) in Istanbul. In English, the name has been translated as the High Consultative Committee and in some references as the Turkish Academy of Sciences (University of Waterloo

[29] Abu Hamid al-Ghazzali, (AD 1058-1111 or 1128 according to Hakim Said's Personalities Noble) [aka: al-Ghazali , Algazel] is one of the great jurists, theologians and mystics of the 12th Century. He wrote on a wide range of topics including jurisprudence, theology, mysticism and philosophy.

[30] Nasir al-Din was one of the greatest scientists, philosophers, mathematicians, astronomers, theologians and physicians of the time. As the chief scientist at the observatory established under his supervision at Maragha, he made significant contributions to astronomy. Source: Said, Hakim, 2000. *Personalities Noble*, Amman, Jordan: Islamic World Academy of Sciences, 2nd Revised Edition.

2008). It was abolished in 1862. The Institut D'Egypte in Cairo (1798), which was established by Napoleon Bonaparte during his Egyptian campaign, has been described as the first 'modern' academy outside Europe.

It was in Europe that in the 15th century, almost four centuries after the start of the flow of Arab/Islamic science into Europe, that science and intellectual interaction started to take a more institutional posture, particularly in Italy in what has been described as the Italian renaissance. In 1442, the Accademia Platonica was founded in Florence, which was no more than a country villa near Florence where Ficino pursued his research and translated the works of Plato and the Neoplatonists into Latin. Soon, a number of such academies were established in Florence, Rome, Naples and Venice – all devoted to the revival of classical learning.

From about the second quarter of the 16th century onwards, small academies began to spring up all over Italy. Of these, the Intronati of Siena, founded in 1525, was the first regular academy of Italy, and even the world. It was the first to call itself by a symbolical name, to elect officers, and to ordain for itself social laws. Renaissance academies appearing in the period 1500–1800 were devoted to the study of subjects (not strictly sciences) such as art, music, literature, language, architecture, poetry, history, archaeology, religion, as well as equestrian and military arts.

The discovery of America and the circumnavigation of Africa by the Portuguese explorer Vasco da Gama in AD 1497-99 began to render the Mediterranean ports less important. From that date, the primary route of goods from the Orient was through the Atlantic ports of Lisbon, Seville, Nantes, Bristol, and London. These areas quickly surpassed Italy in wealth and power. By the end of the 15th century, the Italian renaissance was fading however a new movement started to develop, and famous academies such as the Accademia Fiorentina began to appear after 1540.

The medieval university continued to provide the institutional basis for science and natural philosophy however, things began to change in the 17th century, primarily because of the Scientific Revolution. The fact that the Church and the state had an ever increasing influence on universities in the 16th and 17th centuries led to a growing need for the creation of 'societies' where science and scientific questions could be freely debated. Thus, academies came into existence, firstly in Italy and then across Europe.

Evolving from the earlier learned societies devoted to language and literature, the *scientific* academies of Italy emerged comparatively late. Among the most famous of these was the Accademia dei Lincei[31] (Rome, 1603–1630), which was born more than eight centuries after the founding of Bayt al-Hikma in Baghdad.

New discoveries, made during the Scientific Revolution motivated governments of European monarchies to establish academies to stimulate the development of science. After the foundation of the Academy dei Lincei in Rome in 1603, the French followed with the Académie Française in 1635 in Paris, and England followed with the Royal Society in London in 1660, while Germany followed in 1700 with the foundation of a regional academy, the Akademie der Wissenschaften in Berlin (Noordenbos 2002).

The Academia dei Lincei was the first 'academy of sciences' to be founded in modern times. Federico Cesi, a young Roman nobleman fascinated by science, together with a group of young men, founded the Academy (Quéré 2006b). The founding of the Accademia dei Lincei marked a turning point in the European Renaissance. The Academy was supportive of Galileo's battle for the affirmation of the Copernican system and ushered in the 'Age of Academies,' which started around AD 1590, when many learned societies in the form of private associations of men of learning who shared knowledge of nature, were founded.

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[31] The researcher often cites this example to highlight the fact that institutionalisation of science in the Islamic civilisation took root centuries before the European civilisation although he acknowledges that it is not really apposite to compare the Accademia Nazionale dei Lincei in Italy to the Nizamiyyah Academy or Bait al-Hikma, both in Baghdad, despite an initial inclination to do so. The two institutions were quite different. For a comprehensive listing on academies of sciences the following website provides some useful information: http://www-history.mcs.st-andrews.ac.uk/Societies/Lincei.html

A public, civic function for learned societies began to emerge with the establishment of the Académie Française (1635), and the foundation of the Royal Society of London (1660). The Royal Society of London was the earliest national academy of sciences 'to have taken on a form and status capable of surviving without interruption into modern times,' according to May (2005). Replicas of the Royal Society and the Académie Royale des Sciences in Paris formed the backbone of institutional science in 18th century (McClellan 2003). After 1750, the rate of founding of academies doubled compared to the previous half-century. This enlargement continued until the French Revolution and affected the quality as well as the quantity of academicians (Frängsmyr et al. 1990a).

Several features distinguish these academies of sciences from previous organizational settings for science including having powerful patrons, being officially recognised, receiving monetary support with the majority devoting themselves to research..

While the number of learned societies continued to grow into the 19th and 20th centuries, the 'Age of Academies' ended with the French Revolution in 1789 (McClellan 2002).

Unlike academies in the Islamic civilization, academies in the European civilization – especially the early ones – were founded by the scholars themselves not by heads of state (bottom-up philosophy of science institutionalisation). Only in the 17th century did European monarchs become interested in patronising academies of sciences. The example of the Royal Society receiving its Royal Charters in 1661 and 1663 is an example of this. Another major difference between the famous academies of the Islamic era and their European successors lies in that the latter ones were inclined to focus on the application of science rather than theoretical studies of science. Galileo's instrument-making endeavours while a member of the Accademia dei Lincei is proof of this approach to science adopted by those early European science academies. It was such Baconian ideas that filtered into the realms of academe that profoundly influenced science academies such as the Royal Society, and enticed its members to begin to look at the practical applications of natural philosophy to improve certain engineering practices as well as shipbuilding and agriculture. Fellows including Robert Hooke, Wren, the architect, and Petty shared these practical interests, and in doing so, were building the foundation of the Industrial Revolution that was soon to follow.

3) What are the special features of academies of sciences today? How do they promote science nationally and globally and how do OIC academies of sciences compare to their counterparts in the West today? What are the characteristics of a 'model' academy of sciences?

Essentially, the academies of sciences of the 17th century, including the Académie Royale des Sciences (Academy of Sciences of France) and the Royal Society of London, were trendsetters in many ways; they had patrons and were officially recognized and supported. Their functions included providing advice on scientific matters including, for example, patent claims in the case of the former and in the case of the Royal Society by advising the government on such matters as 'protecting buildings against lightning strikes.' Moreover, both had established the tradition of disseminating science through publications. Their proceedings —typified by the *Histoire et Mémoires* of the Paris Académie Royale des Sciences and the *Philosophical Transactions* of the Royal Society of London – became primary vehicles for the publication of original research.

Today, academies of sciences perceive themselves in a variety of ways, depending on whether they are honorific academies such as the Royal Society, or honorific and research-performing academies such as the Russian Academy of Sciences, although some cynics classify science academies as either 'functional' or 'fossil' depending on their activity/inactivity. The objective of most science academies is to promote science and to honour scientists. Many limit their scientific activities to giving advice on policy or programmes, to funding scientific activities and to information dissemination by publishing books and journals. Others are involved in scientific research through research centres that they oversee. An increasing number of them are becoming involved in international activities, of a political nature.

What makes an academy 'functional' or 'fossil' is in no small part a reflection of its relations to its government. For a start, academies have to be recognized in national legislation, yet 'independent-enough' to offer science-based advice to the government and others. Independence is a characteristic that an academy cannot do without, and is the most important criterion of a prestigious academy together with the eminence and number of its members. Independence is from where the strength of an academy derives and is at the heart of its value to society. The independence of academies of sciences should manifest itself in their members giving clear expressions to what they see as the message of *reason* on scientific issues and the message of *dignity* on human rights issues. In reality however, there is always a danger – especially at the launch of a new academy – of inviting mediocre scientists to become members for political reasons or in the hope that having influential members –who may be below par scientifically- may eventually help to address the chronic problem that almost all science academies face: funding.

Relations between academies of sciences and governments have not always been harmonious. The opinions of academies are mostly science-based –or should be- while the essence of political thinking is short-term with measurable impact. Thus, clashes between the two are inevitable. The bottom-line is that academies need to be politically astute constantly engaging decision makers and use gentle persuasion to ensure that the voice of science is heard within decision-making circles. The first reported spar between academe and government took place about 15 centuries ago (AD 529) and resulted in the closure of Plato's Academy by Justinian who proclaimed that the views the academy propagated were damaging to the state. Today, many science academies label themselves as non-political such as the IAS. Yet, it is impossible to disassociate such academies from engaging in regional, or international issues that have a political component, sometimes to their detriment. On occasions however –due to their prestige- academies of sciences prevail.

However, the domineering role of government in many OIC and developing countries –manifested by the top-down philosophy of decision-making in science and otherwise- renders independence by science academies difficult to acquire. In the case of Malaysia, the idea of linking the academy of sciences to the Ministry of Science and Technology of the country was the preferred, probably the only, option of the founders of the Academy of Sciences Malaysia (ASM). This arrangement fulfilled the perceived prerequisites for a successful science academy as the founders of the ASM saw them, namely a government mandate and adequate and sustained funding.

Initial government support for academies together with strong political backing are key factors for their long-term success. The commitment to provide funding should ideally be legislated and may take the form of a law passed by parliament, or a decision taken by the government, as in the case of the IAS. Internationally, there have been a number of initiatives that aimed to provide support to budding academies, particularly in

Africa. Among such initiatives has been the African Science Academy Development Initiative (ASADI) mounted by the US National Academies through funding from the Gates Foundation to help African academies to work to achieve the MDGs in Africa. To be effective, such initiatives have to be carefully implemented and closely monitored to mitigate any misuse of funds. Innovative ways of raising funds should be developed by academies as in the case of the Royal Society of New Zealand, which has a special category within its ranks for paying members. Another innovative idea, which not only generates income for the implementer academy but also cultivates science appreciation in primary school students in the country is the Young Scientist badge scheme, adopted by the Singapore National Academy of Sciences (SNAS). It involves getting the students to accomplish simple scientific tasks and to document their achievements on activity cards provided by SNAS. After completion, the student submits the activity card to his school for inspection, which in turn submits the list of the successful students to the Singapore Science Centre, which arranges to honour the top students at a public ceremony. This activity has been generating funds to SNAS annually.

The question of membership is often discussed within academies' circles with emphasis placed on merit –or scientific excellence- as the main criterion that should apply when electing members. Many academies of sciences are contemplating incorporating members from the social sciences and humanities, within their ranks. This is also an issue that academies of sciences have to address, as there is need today to integrate the 'traditional' basic and applied sciences with the social sciences and humanities in a manner similar to what the Turkish Academy of Sciences (TÜBA) has done, with 18% of its membership belonging to the social sciences stream. The preservation and enhancement of national language is another function of some academies of sciences, including the Croatian, Hungarian, Lithuanian and Polish Academies. In many Arab OIC countries, famous language academies – *majma'* in

Arabic – have long been in existence in cities such as Cairo, Amman, and Damascus. However, most have been dormant for some time. Academies of sciences –particularly in OIC and developing countries- should try to develop innovative membership schemes that can help them raise funds by incorporating fee-paying members and affiliated organisations into their ranks. The experience of the Royal Society of New Zealand (RSNZ) is a note-worthy one in this area. Of course, there is always a danger of rejection by academy members when such schemes are proposed for fear that their introduction may undermine the prestige of the academy.

Another important component of science academies is female membership. To be representative of the science community of the country, an academy of sciences must include a sizeable percentage of female members, who are also elected on merit. The problem of the under-representation of women in science and science academies has a long history. Today, it has been called the 'leaking pipeline,' i.e. more women than men abandon careers in science after obtaining their PhD, few women become tenured professors in science, engineering and medical faculties and science academies on average have about 5% female members. How to substantially increase the participation of women in science is a challenge for academies that most have not really been able to address notwithstanding the success of the Turkish Academy of Sciences (TÜBA). Greater female involvement will ensure that academies draw on the largest possible pool of talent and shift the focus of science to issues directly related to critical socioeconomic needs. Science academies in the Islamic world, where they exist, have a particularly challenging responsibility in terms of the inclusion of female scientists in S&T for development activities.

Membership of science academies is itself a sought after honour by scientists. Rewarding academic excellence by way of prizes is another. The example of the Royal Swedish Academy of Sciences, which annually awards the Nobel Prize in science disciplines (and administers the Prize in other disciplines), is the most well known example of this type of activity that has not served Sweden and its academy, but brought academies of sciences worldwide into the limelight. Recognising scientific distinction is an activity that many academies undertake however, they are often criticised for honouring scientists who are at the end of their careers. This has enticed many academies including TWAS and the IAS to introduce prizes for working scientists.

The funding role of science academies takes many forms. For example, the Swedish Academy has a tradition of setting up research institutes that either it runs itself or it shifts to the public sector. In other countries, science academies act on behalf of the government department responsible for S&T to enhance links with other government initiatives, funders as well as other countries. The foremost example of the public funding of science is that of the Chinese Academy of Sciences –which is very well patronised by the Chinese government- which runs 90 research institutes with over 43,000 staff, 40,000 visiting scholars, post-doctoral and post-graduate students.

Like the Royal Society, scientific publishing or disseminating new science is an area in which academies of sciences have been active for centuries, and they represent a very significant fraction of science publishing in the world. The US-NAS on the other hand is a world leader in terms of publications including dissemination of information through the Internet. Unlike other Western academies, it offers its scientific journal, the *Proceedings of the National Academy of Sciences*, at no cost over the Internet to developing countries. The unhindered or ‘open access’ to scientific information from peer-reviewed journals –as pioneered by the US-NAS- helps to elevate the quality of research work globally, yet, opposing stands have been taken by academies of sciences on open access publishing. Despite its long tradition in publishing, the very Royal Society has expressed serious doubts about open access on several occasions, a stance which was deplored by many in the developing world.

Science education is today one of the most important activities of science academies. Due to the activities implemented by many Western academies of sciences, this has become a key activity of many science academies in the OIC, perhaps where it is needed most. In general, the interest shown by the academies of sciences of OIC countries in promoting science education does not match that of the world's leading academies of sciences especially the French and the US academies. This is disappointing given that implementing activities in the domain of science education is not a costly endeavour, and may contribute –in the long run- to cultivating the much-needed culture of science appreciation in OIC countries and perhaps mitigate the problem of brain drain which is affecting almost all developing countries.

Having discussed the institutional characteristics of academies of sciences, let me now turn to some of their functions nationally and internationally.

The idea of a group of scientists offering science-based advice to heads of state or politicians may be traced back to when the Royal Society was founded in 1660 or even earlier to when Al-Mansur (who sowed the seeds of the Academy of Bayt al-Hikma in Baghdad) sought the advice of the astrologers of the day to help him decide where to build his capital (Baghdad) around AD 762 (Saliba 2008). Today, science-based advice is perceived by society to be a primary function of academies. Science advice is a multilayered activity that no longer takes the single form of a scientific discussion within the ambiance of academies, but has evolved into a 'multi-media' outreach exercise. The US-NAS was the first academy of sciences (1863) to be explicitly mandated to provide advice on science. The Chinese and the Russian academies have major responsibilities in this domain as well as in the management of research. Academies of sciences offer science-based advice on a variety of topics from national health issues to topics of global nature such as climate change. Science advice is a hazardous business as the issues on which advice is sought are becoming ever more complex, but it is also one way through which academies can express their opinion on issues related to S&T policy, ethical and social issues that are related to scientific research. Essentially, for the advisory process to work, lines of communication between the user of the service and the service provider (the academy) have to be established. As a rule, academies of sciences should aim to offer the kind of advice that is neither ignored by the government nor one that rubberstamps its wishes.

Scientists in general, and science academies in particular, are distant from their national parliaments. This was evident from the discussions that took place at the UNESCO InterParliamentary Forum on Science, Technology and Innovation Policy for the Mediterranean Region in 2010. The forum called for closer co-operation between science policy-makers, scientists, parliamentarians, journalists, industry (public and private) and civil society; and called for strengthening the capacity of parliamentary science committees. Greater understanding and synergy between scientists and parliamentarians would benefit the decision-making process, and science. This is why science academies must try to engage parliaments despite the difficulties associated with such a task. Although the Royal Society of London has encountered some success in engaging the British House of Commons, as well as some African science academies with their respective parliaments, attempts by the IAS to engage the Parliamentary Union of the OIC Member States (PUIC) have not developed. This highlights the difficulties that many international groupings such as the PUIC face in building up a consensus on vital science-related issues.

S &T collaboration internationally is imperative for the progress of the scientific enterprise. Academies of sciences and networks of academies can play an important role in furthering international research collaboration as they can stimulate and influence the international orientation of scientists, provide funding, internationalize their own research, and facilitate interaction with international agencies. The leading science academies of developed countries, both at the individual level and collectively, have been actively promoting science in –for example- sub-Saharan and central Africa with support from the Gates Foundation. However, the science academies at the receiving end of this initiative have not been able to measure the impact that their activities have had in the recipient milieus. For international collaboration to succeed, stakeholder academies have to agree to promote tangible objectives that are understood by all those involved. Such objectives must include highlighting the contribution that STI can make to economic growth, underscoring the importance of starting new national science academies and establishing scientific links between developed and developing countries.

Science academies are responsible for analysing complex transnational and international issues, and presenting science-based opinions to decision makers on such issues including water resources, global warming, climate change, food security etc. A prerequisite for such interactions is the existence of a good rapport between the two, as this would convince governments to base their long-term decisions on science-based advice. This requires academies to use a variety of means to engage decision makers to ensure that the voice of science is heard at decision-making tables.

Nina Federoff, Science and Technology Adviser to the US Secretary of State (RS 2010b) defined 'Science Diplomacy' as follows:

> *Science diplomacy is the use of scientific interactions among nations to address the common problems facing humanity and to build constructive, knowledge based international partnerships.*

Science diplomacy is a tool at the disposal of academies of sciences that helps to them to fulfil their role in addressing contemporary problems that are international in nature such as combating terrorism. This was highlighted in the wake of the Madrid terrorist attacks in 2004, attributed to Muslim extremists. Academies should not contribute to the creation of a mistrustful atmosphere vis-à-vis scientists from Islamic countries by excluding them from the international scientific arena. On the contrary, Western academies should lobby for more collaboration with scientists from Islamic countries as a means to bridge philosophical and cultural divides –even political divides- and contribute to global tolerance. It is ironic that newspaper headlines in the US on the morning of 11 September 2001 (9/11) were highlighting a statement by the US-NAS on GMOs. This was in stark comparison to the headlines carried by newspapers on subsequent days. The attacks of 11 September shocked the world, including science academies, resulted in a fundamental rift between the US and the Islamic world and redefined the role of the science community including science academies on the international arena.

After 2001, many academies of sciences –especially the US-NAS- have been actively engaging the science community in the Islamic world. It was no coincidence that when US President Obama made his defining speech in Cairo in 2009 in his first major attempt to engage the Islamic world, one of the key concepts he advocated was S&T. He followed that up by appointing three high-profile science envoys to strengthen contacts with OIC countries including the former president of the US-NAS: Bruce Alberts.

The IAS, although mandated as a non-political organisation but convinced that the communication function is one of its essential *raisons d'être*, has often addressed politically sensitive issues, and tries to inform the science community in the West about the Islamic world by addressing themes, such as the history of Islamic science, which encapsulate messages of universality and harmony within its folds.

Academies of sciences should be the democratic voice of science. They rightly take the moral high ground on a number of controversial issues of concern to humanity such: the (Water, Energy, Health, Agriculture and Biodiversity) WEHAB components, global warming, stem cell research etc. They not only have to answer to the public but also develop an academy-wide perspective on such matters to get the message to decision-makers. The impact of such activities can be gauged through letters that academies receive, press releases, news articles as well as enquiries that they receive about certain positions that they take.

As many regions of the world face similar science-based problems, academies of sciences can join efforts and form groups or networks to organise regional activities to address such problems. Over the years, a number of networks of academies of sciences sprung up that give advice or issue statements on topical issues to major world agencies.

As institutions that have stood the test of time, academies of sciences must become more relevant to the society of the 21st century, not by addressing problems affecting the welfare of humanity, but by being seen to be addressing such problems and overcoming them.

Let me now turn to comparing some academies of sciences in OIC to some academies of sciences in the West.

1200 years ago, the Islamic world witnessed the founding in Baghdad of Bayt al-Hikma as the science academy of the day. In the Islamic world today, around 26 academies of sciences of different models exist in the 57 countries of the OIC. Most such academies operate on shoe-string budgets and undertake only a limited number of S&T activities, including offering science advice. None has captured the spirit that prevailed around their ancient predecessors. It is ironic that none of the wealthiest OIC (Arab) countries of today has an academy of sciences, yet Yemen –which is among the poorest- contemplated such plans in 1990s but shelved them as it felt that launching such an organisation was too early. The existence of the critical mass of S&T human resources is naturally a factor when such ideas are contemplated by any country.

Since the end of World War II, the OIC region has been a hotspot of political and military conflicts that have adversely affected the already few efforts to institutionalise STI initiatives for development. This is clearly reflected by the STI indicators of the region and the fact that today only a few science academies exist in the Islamic world.

The science academies which exist in OIC countries often rely on the efforts of individual 'S&T Champions' who believe in their value as propagandists for S&T and who spare no effort to ensure that such academies prosper and succeed. Most have a small number of Fellows who, although elected on merit, may no longer be practising scientists. In the West, science academies are institutionalised, and enjoy tremendous prestige and secure funding, and have each found a niche in which they excel. Whether, it is prize awarding as is the case with Sweden's KVA, or advice to government as is the case with the US-NAS, or science education in the case of France's ASF, there is normally one aspect in which an academy excels. Academies of sciences in OIC countries are smaller and poorer than their well-established and prestigious Western counterparts in terms of financial and human resources.

In the Islamic world, Malaysia's ASM is among the leading science academies although it –most of the time- acts as a secretariat to the Malaysian Ministry of Science, Technology and Innovation. The ASM together with the IAS and TWAS are among the more active academies in terms of South-South collaboration in S&T. This is a reflection of the fact that the sense of kinship shared by many developing countries drives them to pool their efforts, especially if they are wedded by comparable levels of skill and circumstances. This cooperation can be enhanced by the presence of science academies, as they can help in enhancing co-operation not only with other developing nations but also with developed countries which may be eager to help. In such an environment, 'cooperation' replaces 'aid' as the primary driver of development. This co-operation, together with the principle that science is universal, has probably been the driving force behind the interest that some Western science academies have shown in the Islamic World and the academies within. South–South cooperation does not in any way preclude South–North cooperation. In fact, South–South cooperation could well improve the effectiveness of South–North cooperation, through the successful building of trilateral arrangements in which developing countries with less scientific capacity interact with developing countries with greater scientific capacity, especially in the same region. The more scientifically proficient developing countries, in turn, could interact with developed countries. A variety of critical issues, for example, climate change, energy research and development, and curbing the spread of infectious diseases, could lend themselves to such an approach, thereby creating a truly global network of scientific research.

In answering the question, 'What is a Model Academy of Sciences?' a number of factors have to be taken in account.

Firstly, it must be acknowledged that the Statutes of the 'Academy of Sciences of Wonderland' as published by the IAP (Appendix 2) represent a good template that can be used by countries planning establish independent merit-based science academies. The Statutes cover the objectives, activities, membership, governance, finances, administration, etc. in a very comprehensive manner. The fact that an academy should be autonomous but preferably linked to the executive head of state, and having the legal status of a non-profit organisation for tax purposes, are two further criteria that need to be present in the Statutes. The bond between the academy and the executive head of state is important to ensure the financial security of the academy, and the freedom to speak out on science and scientific issues. So is the issue of the premises of the Academy –understandably not mentioned in the Statutes proposed by the IAP- but nevertheless an important feature that symbolises a country's commitment to the continuity of the academy.

A medium size Academy can have a structure with: (a) A general meeting of all members that sets the general policies of the Academy (b) A *small* governing board of elected members that is charged with day-to-day management; and (c) A secretariat with professional staff to support the elected officials of the academy.

The question of the age of members has been partially addressed in the IAP Statutes as it is stipulated that active members automatically become Emeriti members upon reaching the age of 70. However, no provisions were made to ensure that the average age of members remains reasonably low. Moreover, the category of associate members is dubiously missing from the Statutes, as well as the category of 'fee-paying institutional members.' Needless to say, fee-paying members may include, individuals, corporate entities, educational organisations and government departments etc. Although this is not the common practice in science academies today, it is certainly something to think about for the future.

Furthermore, it is known fact that most academies rely heavily on the existence of a strong efficient secretariat to run their day-to-day affairs. The IAP Statutes seem to centralise decision-making powers in the hands of the Board and the President. In reality, this is a recipe for ineffectiveness as presidents of academies are normally senior figures with a multi-faceted public role and cannot devote a lot of time to running the secretariat. Presidents of academies as well as their boards should focus on broad policy issues and more importantly on raising funds for programmes and activities, as well as building its Trust Fund.

7.4 Conclusion: From Utopia to Pragmatism

An in-depth investigation of the historiography of science –particularly Islamic science- is undoubtedly a valuable academic exercise that may disentangle many questions troubling the science community today. However, its real value may not be appreciated by science technocrats who are in the business of drawing up S&T policies for development or running science institutions. On the other hand, a study of academies of sciences as a stand-alone topic without any historical context renders it alien to academicians and may not have powerful policy implications for science practitioners – particularly in the Islamic world. To make a bona fide contribution to the study of science institutionalisation, it was deemed innovative and appropriate that this Thesis tries to marry the above components in one study.

The Thesis firstly reiterates that world civilisations have been/are interdependent. The scientific enterprise is a trans-civilisational phenomenon and science has historically flowed from one civilisation (normally the more advanced) to another. So have forms of science institutionalisation such as academies and academy-type institutions. Within the framework of this Thesis, science has flowed from the Greeks to the Arabs and Muslims where it was embraced, assimilated and revamped. It was then transmitted into Europe over centuries contributing in no small part eventually to the Industrial Revolution. Over the last 200 years, it has been slowly finding its way back from Europe and the West into the Islamic and Developing worlds through contact with colonial powers. Yet, because the Islamic milieu that encouraged innovation and creativity in science was/is but a distant memory, S&T today are not viewed by many as a tool of might and affluence or as a means to address immediate day-to-day problems that Islamic societies face. This absence of innovation culture –unlike the early days of Islam- and the prevalence of a spirit of apathy and submissiveness to destiny are partly due to the incorrect interpretation of certain aspects of faith.

Contrary to the archetypal view, there was some scientific capacity at the dawn of Islam. A capacity that started to expand with the founding of the Umayyad state and Islamic interaction with the other civilisations, then reached a climax at the time of the 'Abbasid Caliph: Al-Mamun. Despite a variety of opposing currents, the scientific enterprise in Islam prevailed for the best part of a millennium and continued until the end of the 16th century when it became too dispersed, after most of the assimilated and self-generated knowledge had been transmitted to Europe, initially as a trickle of translated texts and later a deluge of knowledge.

Today, we are still rediscovering the features of the Islamic scientific contribution to humanity's science. These have been hidden for the best part of two centuries, and hundreds of manuscripts on Islamic science and technology still lie on shelves throughout the Islamic world waiting to tell yet a new story about the achievements of the scientists and technologists of the Islamic civilisation of the past.

The reasons that led to the decline of the scientific enterprise in the Islamic world the past are multi-layered and multi-faceted. They are a combination of military, economic, demographic, theological as well strategic phenomena. Such phenomena have caused a shift in the centre of gravity of science from the Islamic world to Europe, eventually leading to the Scientific Revolution occurring in Europe and not in the Islamic world.

I am therefore proposing an alternative answer to Needham's Grand Question, 'Why did Modern Science develop in Europe and not elsewhere?' I am proposing that because scientific knowledge is progressive and accumulative across civilisations, the paradigm shift in science as manifested by the 'Scientific Revolution' had to happen eventually, and eventually it did, not in China, India or the Islamic world, but in Europe. In other words, I am looking at the history of science within the context of the history of humanity as a whole, in the process acknowledging the contribution of the Chinese and Islamic civilisation in the making of modern science. In doing so, I am taking Bala's argument[32] that ‘traditional cultures (Chinese, Arab and Indian civilisations) deserve praise for making discoveries that contributed to modern science, even if they assumed the blame for failing to reach modern science,’ further, and basing my argument on a universal rather than a Eurocentric hypothesis.

During and after colonisation, science and the institutionalisation thereof were reintroduced to an Islamic world that had lost touch with its glorious past. However, it was only after World War II that we began to see countries espousing S&T as a tool of might, advancement and affluence, and academies of sciences appearing in the Islamic and Developing worlds. A closer look at the reasons for the gradual decline of Islamic science historically reveals that they are –in part- the same factors that are today holding back the collective scientific and technological advancement of OIC countries. They include; external military threats, strategic location (which is an advantage and a disadvantage), political fragmentation, poor rule of law, lack of patronage of science, out-of-date system of education, lack of human resources active in science as well as the lack of effective patenting regimes to unleash innovation. Understanding such reasons is important to understanding the reasons for the status of science in the Islamic world today.

Historically, we do not know why academies have emerged. Perhaps it was humans’ desire for thoughtful interaction or a reflection of the ascendance of the incubating milieu. In Islam, the Islamic world scientific boom led to the founding of academy-type institutions among which was Bayt al-Hikma – by leaders, in a top-down manner that has characteristically been the trade-mark of decision-making processes in many including the Islamic culture. In the West, the rise of science academies such as the Accademia dei Lincei and the Royal Society of London was initiated by scientists and intellectuals –in a bottom-up manner- contributing eventually to the Scientific

[32] Bala, Arun, 2006. *The Dialogue of Civilisations in the Birth of Modern Science*. New York: Palgrave Macmillan.

Revolution, demonstrating an essential difference in decision-making philosophies between the Islamic world and the West that has ramifications on societies even today.

The history of academies is inextricably linked to the political history of the world. They are sometimes born when a nation is at the height of military might, and in some instances when a nation or a civilisation is at an historical low. Some are created by scientists themselves but most are created by the state, or even the head of state, perhaps as a manifestation of power. The underlying commonality among academies throughout history – whether intentionally or otherwise – is that they have converted science from a strictly private pursuit to a more public, even global phenomenon.

Academies of sciences are organisations that have withstood the test of time. The fact that the Royal Society of the UK celebrated its 350th anniversary in 2010 is proof of this. Today, academies of sciences in the world are many. Some are old and well established but most –in the Islamic and Developing worlds- are new and still finding their place within the variety of STI systems that exist, despite the fact that the Islamic world of today, as represented by the member states of the OIC, has historically been home to many famous academies, and academy-type institutions.

Of the various components of any national science, technology and innovation (STI) system; academies of sciences, where they exist, stand out as organizations with multifaceted roles. Today, they not only provide advice on scientific matters but are also viewed as propagandists for S&T in decision-making circles. Most have the capacity to be decision support units, especially on matters related to S&T policy formulation and monitoring as well as science education. They can have a significant role to play in the organisation and pursuit of S&T, which is a tool that is not considered *the* platform for sustained socioeconomic development in many developing countries. Unfortunately, it is a tool that is only prized by the scientists and academics and, at best, a few of the political and community leaders.

Academies of sciences of the various models are engaged in promoting science and the scientific enterprise and are trying to advocate S&T as a means to overcome the array of problems faced by humanity. In the West, they have reached the post-industrial stage, enjoy prestige and are trying to influence the state of science and technology in the world, while academies of sciences in the Islamic world are mostly new, small and inadequately funded and have little impact within national STI systems. Most such academies of sciences are not clear as to how they should deal with their national governments. They either tag the government line on science or they remain aloof with little or no interaction with government and most are in no position to make an impact on science in society except keep up the profile of science especially internationally as nationally little could be achieved until S&T appear on the national radar of development, and are integrated with the nation's overall development strategy.

The strength of an academy of sciences is proportional to the calibre of its members, and their ability to generate new ideas and programmes. Scientists and technologists are almost never satisfied with the amount of financial support they get from their patrons or governments. History has proven that the financial security of an academy-type institution is of paramount importance if academies are to fulfil their mandates successfully. Because governments and parliaments question the level of support they need to provide to science, scientists need to try harder to justify to the public why they indulge in science and why science is useful. The challenges faced by academies of sciences today are multifaceted. At the institutional level, science academies must become more dynamic, and incorporate younger and more women members. At the same time, it is a concern for academies the world over that the proportion of young people coming to science appears to be declining. Administration is a key to the success of an academy of sciences. Administrators of academies of sciences have to be committed to the goals and objectives of their institution and have an appreciation of its unique nature. Academic work that many may not see as useful or effective in terms of addressing real life problems is the norm of academies of sciences.

In terms of activities, science academies must engage the S&T community in which they are based to help develop scientific solutions to global/national development challenges including achieving satisfactory progress in the areas of Water, Energy, Health, Agriculture, Biodiversity (collectively known as WEHAB) as well as create wealth and –as history has demonstrated time and gain- contribute humanity reservoir of knowledge. These issues, together with climate change, must be addressed within the next 50 years. Climate change requires scientists to continue their research on climate in order to anticipate what kinds of changes climate will bring in terms of extreme weather phenomena.

Science academies have a role in building partnerships between the science communities in the developed and the developing world (Clegg and Boright 2009). Furthermore, it is essential that more academies in the developed world support their counterparts in the developing world.

Although many countries nowadays can pride themselves on having a science academy, there is still room for improvement, especially in the Third world where difficulties of the lack of political stability and lack of resources have certainly not changed. Today, most rulers and governments understand the utility of science in, for example, agriculture, medicine and technology. One would imagine that they are more easily convinced of the usefulness of a science academy than they were 300 years ago (Roinila 2009) to contribute to addressing a range of ‘soft security’ challenges. In the Third world however, only hard (military) security is appreciated. Food, water and energy security is in general not on the radar. Further, launching an academy of sciences with the expectation of quick results is a gross miscalculation. However, when all these are being addressed, an academy of sciences can be an invaluable source of knowledge and cultural enlightenment for any country (Roinila 2009), and a key player in achieving socioeconomic progress.

I started this Thesis with the following quote:

> *The functions of a sovereign of science, to the extent that it exists, will be vested in the academies (of sciences)*
>
> (Ravetz 1980).

Having traversed through the study, I would assert that the above statement held true during certain periods in history however, in the future, in Developing and OIC countries in particular, academies of sciences have to assume the functions of an *executive monarch* of science to address the variety of problems humanity faces. Do they retain their 'ivory tower' status or reinvent themselves as propagandists for science, in touch with people, and using science for the benefit of all?

7.5 Further Research

In order to understand the underlying reasons for the current state of science in the Islamic world, an attempt was made in this Thesis to investigate the reasons for the rise and decline of Islamic science. This subject requires further investigation in order to answer the question of why many decision-makers in the OIC do not today see science as a means to achieve socioeconomic advancement and why so few academies of sciences exist in the Islamic world. For the same reasons, public perception of science needs to be further investigated otherwise the long sought culture of science in the Islamic world will not prevail.

Academies of sciences in the West are mostly financially secure and follow a well-tried business model. Those that exist in the Islamic world do not. Ways of generating income for academies of sciences to ensure physical continuity and the implementation of more scientific programmes need to be researched further.

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APPENDICES

APPENDIX 1: LIST OF INDIVIDUALS EITHER INTERVIEWED OR LISTENED TO FOR THIS RESEARCH

Most of those interviewed were/are involved in some capacity with the academies of sciences chosen for the comparative study: Prof. M. H. A. Hassan, former Executive Director of TWAS; Prof. Michael Clegg, Foreign Secretary of the US National Academy of Sciences; Prof. Bruce Alberts, former President of the US National Academy of Sciences; Prof. Yves Quéré, Member of the Académie des Sciences in France and former co-chair of the InterAcademy Panel on International Issues; Prof. Paul E. Mugambe, President of the Ugandan Academy of Sciences; Academician Dato Lee Yee Cheong, Senior Fellow of the Academy of Sciences Malaysia (ASM); Prof. Akhmet Mazgarov, President of the Tatarstan Academy of Sciences; Prof. Eduardo Krieger, former President of the Brazilian Academy of Sciences and former IAP Co—Chair; Prof. Mamadsho Ilolov, President of the Tajikistan Academy of Sciences; Prof. Hisham Ghassib, former President of Princess Sumaya University of Technology in Jordan; Prof. Abdel Latif Ibrahim FIAS and Emeritus Professor at UNISEL, Malaysia, and the late Prof. Ahmad Sidqi Dajani, the Arab politician, historian/academician and Member of the Academy of the Kingdom of Morocco (AKM), and the Royal Academy for Islamic Civilisation Research in Jordan.

In addition to interviews, a number of conference presentations provided useful insights, notably by Prof. Yves Quéré on the history of science academies (Alexandria 2006), Prof. M. H. A. Hassan on the role of academies of sciences in achieving the Millennium Development Goals (MDGs) (Budapest 2007); and presentations by Prof. George Saliba on the alternative narrative of the rise of Islamic science (Kazan 2008), Prof. Charles Falco on ‘Ibn al-Haitham’ (Kazan 2008) and Prof. Mehdi Golshani and Prof. M. M. Qurashi on the decline of Islamic science (Kazan 2008).

APPENDIX 2: STATUTES OF THE ACADEMY OF SCIENCES OF WONDERLAND

STATUTES
OF THE
ACADEMY OF SCIENCES OF
WONDERLAND[*Φ]

Ideas to assist with the establishment of an academy of sciences

Foreword

The Statutes of the "Academy of Sciences of Wonderland" presented in this document are intended as a source of inspiration and ideas for individuals who may wish to create a new Academy of sciences or engineering or medicine. They were developed for the IAP as part of a larger project to prepare a publication with the (working) title "Organizing Science Academies" on the organizational and managerial aspects of Academies.

Although the Statutes of about 30 real Academies were reviewed to generate input for the "Wonderland Statutes", these Statutes do not represent a model proposed by IAP, nor is there any suggestion that for IAP they set a norm that should be followed. It is up to the local organizers of a new Academy to decide what to take from the Statutes, what to change and what to ignore.

We are most grateful to Albert Koers for his efforts in drafting these texts. We hope, and expect, that Statutes of an imaginary Academy in an imaginary country may be useful to scientists considering the question of how to establish a real Academy or who are already involved in the drafting of statutes for such an Academy. If necessary, the IAP stands ready to provide further assistance to these scientists.

The mission of the IAP is to help with establishing new Academies and with strengthening the capacities of existing Academies, particularly in developing countries. We consider the "Wonderland Statutes" part of that mission.

Yves Quéré
IAP Co-Chair

Chen Zhu
IAP Co-Chair

[*] An imaginary country with an equally imaginary Academy of Sciences - where Alice is in charge of all discoveries, scientific or otherwise.

[Φ] UNESCO BRESCE (UNESCO Regional Office for Science and Culture in Europe), 2008. Model Statutes for a Medium-Size Academy of Sciences with comments and alternatives In: *Academies of Sciences and the Transition to Knowledge Societies.* Venice: UNESCO BRESCE.

Introduction

It is of course quite impossible to draft model statutes that meet the needs of each and every science Academy: each Academy is unique and wants to be unique. However, fact is that at a more abstract level there is a great deal of overlap between the issues that must be dealt with in the statutes of any science Academy: all such statutes must deal with objectives, activities, membership, governance, finances, administration, etc. The model statues presented here aim, first, to identify those issues and, second, for each issue to present a possible arrangement to deal with it. However, for a specific Academy there may be additional issues, some issues raised in the model statutes may not be relevant at all in a specific situation and for any given issue other arrangements are not only be possible, but may even be preferable considering the local conditions.

- Accordingly, for each and every provision presented below, the first question should be whether or not, in the light of the local situation, it is really necessary to deal with that provision’s subject matter in the statutes that are being drafted.
- If this initial question is answered in the positive, then the next question should be whether or not the text of the provision presented below meets the local needs or desires and, if not, how it should be re-drafted, in whole or in part.

Not only Academies are unique, but so are the legal systems within which an Academy’s statutes are to function. Not all provisions suggested below need to be checked in the light of national law, but there are some for which this. Mostly, this applies to the legal status of an Academy under national law, but – more practically – also to its status under local tax laws. Input for these model statutes was sought - and found - in the statutes of a number of real Academies of sciences. Apart from a great deal of similarity in terms of the issues addressed, as well as much variety in the arrangements to deal with them, there also is a great deal of difference between these real statutes in the level of detail. Some Academies have very general statutes, while other Academies have statutes that go into extreme detail.

The statutes presented below try to strike a balance: they do not aim to cover every contingency in detail, but they do try to address all likely contingencies that may occur in the normal life of an Academy. For the sake of clarity it was also decided to present only a set of statutes. However, in reality it may be advisable to move some provisions to bylaws, rules of procedure or standing orders. This not only makes the statutes as such much more simple, but it also gives more flexibility when changes are needed.

Overall, the statutes that follow are intended for a medium-size Academy with a total of, say, 100 to a 500 members. An Academy of this size can have an structure with: (a) a general meeting of all members that sets the general policies of the Academy (b) a smaller governing board of elected members that is charged with day-to-day management; and (c) a bureau with professional staff to support the elected officials of the Academy.

- In a much larger Academy total membership will most likely be split up in sections, each with a governance structure of its own – which implies that the overall structure outlined in the preceding paragraph no longer fits for the Academy if that size.
- In a smaller Academy the general meeting can make detailed policy decision itself and charge one or two members with day-to-day operations. Clearly, for such a small Academy a much simpler subset of the model statutes would suffice.

The importance of statutes should not be underestimated, nor should it be overestimated. The quality of the individuals involved – elected officials and staff – and of the organization as a whole, is much more important. When an Academy is governed by wise men and women, statutes will most likely live out their lives on the bottom of a drawer. And if an Academy’s leadership is incompetent, no statutes can really remedy that situation. But good statutes - like good laws - may help the wise and stop the not-so-wise.

All this confirms what was said earlier by the IAP Co-Chairs: the Statutes of my imaginary "Wonderland Academy" should be seen as a source of ideas and inspiration in drafting a unique set of provisions that really meet the specific needs of the Academy-to-be. The Wonderland-Statutes are a starting point for discussion – not the outcome.

Albert Koers

STATUTES

Whereas science, in all its aspects and in all its forms, enriches our understanding of the world around us and of ourselves;

Whereas the contributions of science are essential for the advancement of our nation and its growth and development;

Whereas the values of science and of the scientific method enhance the quality of the decisions-making processes to chart the nation's future;

We, the Undersigned, have agreed to establish an Academy of Science.[1]

ARTICLE 1: ESTABLISHMENT[2]

1.1 The Academy of Sciences of Wonderland, hereinafter referred to as the "Academy", is an autonomous science[3] organization established by a group of scientists, hereinafter called "Founding Members"[4], to pursue the objectives set out below.

1.2 The Academy shall be concerned with the natural sciences, mathematics, medicine and other life sciences, the engineering sciences, social sciences and the humanities.[5]

1.3 The Academy has legal personality under the laws of Wonderland, it may receive and dispose of property, monies and other assets and it is capable of sueing and being sued under its own name.[6]

ARTICLE 2: OBJECTIVES[7]

2.1 The objectives of the Academy are:

- 2.1.1 To recognize, support and promote excellence in scientific research performed by scientists who are citizens of Wonderland[8];
- 2.1.2 To promote contacts among scientists who are citizens of Wonderland and between them and the world scientific community;
- 2.1.3 To strengthen the global position and role of scientific research performed by

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[1] Such a Preamble is of course optional, but it may be used to present, as concisely as possible, to the outside world the reasons of the "Founding Members" to set up the Academy.

[2] In addition to the Statutes, there also may be enabling legislation, adopted by the parliament and/or government to recognize the Academy and its statutes as a public organization. However, such legislation should not impede the ability of the Academy to arrange its own affairs as this may raise questions in relation to the Academy's independence.

[3] The term "science" appears more appropriate than "scientific" as the work of the Academy relates to science, without that work being done "scientifically".

[4] If a new Academy is to be credible, it is of course essential that the Founding Members themselves are eminent scientists. One or more well-established Academies or the IAP - as the organization representing all leading science Academies of the world - could be engaged on an ad hoc basis to vouch for the qualifications of the Founding Members.

[5] Here, a choice has to be made: all these disciplines or fields or just a subset? Also, in some cases it may be advisable to be more detailed, while in other cases just the opposite may be true. Lastly, is it desirable to mention explicitly that the Academy is concerned both with basic sciences and with applied sciences?

[6] Depending on the existence and the content of enabling legislation, additional provisions may need to be added here to meet specific requirements of the law of the country in which the Academy is established. There also may be certain procedures to register the organization. A specific issue in many countries is how to ensure that for tax purposes the Academy is classified as a non-profit or even as a charitable organization

[7] Objectives should give direction and identity, but it is not advisable to make them so specific as to force the Academy into a straightjacket. However, even if the objectives remain general, important choices need to be made between three different sets of objectives: (a) those dealing with the Academy as a learned society (here the provisions 2.1.1 to 2.1.3); (b) those dealing with the Academy as an adviser to the nation and the government (here the provisions 2.1.4 to 2.1.6); and (c) those dealing with the Academy as a manager of research institutions (here the provision 2.1.7). The role of learned society is inherent to all Academies, implying that objectives such as 2.1.1 to 2.1.3 should always find their way into statutes. But if, for some reason, an Academy does not have, or does not wish to have, a role as adviser to the nation/government or as manager of research institutions, objectives such as set out in 2.1.4 to 2.1.7 have no place in the statutes of that Academy.

[8] There are several alternatives here: (a) not link membership to any nationality so that members may come from all countries of the world, strictly on the basis of scientific eminence; (b) to refer to "scientist working in Wonderland", or "scientist with residence in Wonderland", but then the terms "working" or "residence" should be defined more precisely. Is a two-week visit enough? And does "residence" relate to a factual or to a legal status?

scientists who are citizens of Wonderland;

2.1.4 To advise the government on the quality of science in Wonderland, as well as on scientific aspects of social and economic issues in Wonderland;[9]

2.1.5 To provide information on science to, and build support for science with, the general public in Wonderland;

2.1.6 To advise the government on all issues related to science teaching and science education in the country;

2.1.7 To ensure that in Wonderland research is conducted in areas or on questions of special importance to science or the nation.

2.2 In pursuing these objectives the Academy shall ensure the highest standards of independence and impartiality. Any recommendations or advice emanating from the Academy shall be merit-based and be made public unless exceptional circumstances make this impossible.[10]

ARTICLE 3: ACTIVITIES[11]

3.1 In pursuing the objectives set out in article 2, the Academy may undertake, *inter alia*, the following activities:[12]

3.1.1 Present a platform for discussion and dialogue to all scientists from Wonderland and elsewhere on issues of common interest;

3.1.2 Elect into the Membership of the Academy scientists who have made outstanding contributions to their respective field(s) that meet the highest internationally accepted standards;

3.1.3 Represent and promote the interests of science in Wonderland in national, regional and international organizations and decision-making bodies;

3.1.4 Conduct studies and publish reports and statements on themes and topics that relate to science in Wonderland or to scientific aspects of social and economic issues in Wonderland;

3.1.5 Award competitive research grants to scientists who are citizens of, and to research organizations established in, Wonderland, either from its own financial resources of from financial resources made available to it;

3.1.6 Award medals, prizes and other honours to scientists from Wonderland or elsewhere who have made outstanding contributions to their respective field(s) or to the objectives of the Academy;

3.1.7 Publish journals, other periodicals and books, both for the community of scientists and for the public at large;

3.1.8 Manage, or support the management of, scientific research institutions or departments of such institutions in Wonderland;

3.1.9 Organize conferences, workshops and symposia on themes and topics that fall within its objectives and undertake such other projects and activities as it deems appropriate for achieving its objectives.

3.2 In carrying out these activities the Academy shall endeavour to contribute to the social and economic development of Wonderland. It shall also endeavour to increase awareness in society of the values represented by science and the scientific method.[13]

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[9] This phrase implies that the Academy is concerned both with "policy for science" and with "science for policy" issues. However, in a concrete situation one of these two perspectives may be less (or more) relevant than the other.

[10] This provision clearly reflects an ideological position. Yet, it also articulates a core-feature of an Academy of science if that Academy is to express the values of science.

[11] As with the article on objectives, the article on activities should not deny an Academy the flexibility to adapt to changed conditions. Hence, the "inter alia' in de chapeau of this article and the open formulation on other activities in provision 3.1.9.

[12] Of course, not all activities need to be mentioned. However, it is important that the list of activities is consistent with the list of objectives. If, for example, provision 2.1.6 is deleted from the list of objectives, then the corresponding provision 3.1.8 on activities should also be deleted. As a rule, it should be possible to link each activity to one or more of its objectives.

[13] This provision may not be without controversy as it also reflects an ideological position on the value and values of science.

3.3 In carrying out these activities the Academy shall maintain effective cooperation and coordination with other organizations or institutions, national or international, that have similar objectives.[14]

ARTICLE 4: MEMBERSHIP[15]

4.1 The Membership of the Academy shall consist of the following categories:

- 4.1.1 Founding Member;[16] 1
- 4.1.2 Active Member;[17]
- 4.1.3 Emeritus Member;[18]
- 4.1.4 Foreign Member;[19]
- 4.1.5 Honorary Member.[20]

4.2 Active Members shall be elected from amongst active scientists who are citizens of Wonderland[21] and who have, according to internationally accepted standards, made outstanding contributions to their respective field(s) of science. Active Members enjoy all the rights and have all the obligations of Membership.

4.3 An Active Member shall become an Emeritus Members at the end of the year in which he/she reaches the age of 70 years. Emeriti Members shall have the same rights and obligations as Active Members, except the right to be elected Officer of the Academy.[22]

4.4 Foreign Members[23] shall be elected from amongst scientists who are not citizens of Wonderland, but who have made significant contributions to science in Wonderland. Foreign Members shall meet the same criteria for Membership as Active Members. Foreign Members shall have the same rights and obligations as Active Members except the right to vote in the General Meeting or to be elected Officer of the Academy.[24]

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[14] This clause has been formulated here in general terms. In a specific situation it may be wise to add the most relevant organizations by name.

[15] The issues associated with membership are perhaps the single most important (legal) factor in determining the (future) viability and credibility of an Academy, both nationally and internationally. Accordingly, they need very careful consideration.

[16] For mechanisms to ensure the standing of the group of Founding Members, see footnote 4. It is if course a closed group once the Academy has become operational.

[17] Active Members are the core of the Academy. Their qualities determine the viability and credibility of the Academy as a whole. Hence, the requirement of provision 4.2 that they must be eminent scientist <u>in the light of internationally accepted standards</u>.

[18] It is of course possible not to make a distinction between Active and Emeriti Members, implying that all Members stay in the category "active" until their Membership ends, presumably by death. However, this creates a serious risk that over the years the average age of the Members increases, especially if there is a limit on total Membership and/or recruitment of younger Members is not very successful. The transition from Active Member to Emeritus Member can of course also be set at another age, but 70 seems a good balance.

[19] Having Foreign Members enables an Academy to offer Membership to scientists from other countries who have made real contributions to science in the country of the Academy or to scientists born in the country but now working abroad.

[20] Introducing a category of "Honorary Member" is not necessary, but it enables an Academy to engage individuals who have helped the Academy in the past – and may do so again in the future. This background also explains why the criteria for Membership are different from those for the other categories.

[21] But see the discussion of footnote 8. It is conceivable not to link Membership to any nationality at all or to link it to being a resident, rather than a citizen. If Membership is not linked to citizenship, the category of "Foreign Member" should be dropped.

[22] Here, "only" the right to be elected Officer of the Academy is withheld from Emeriti Members, but it is of course possible to withhold more (the right to vote, for example) or less (for example, the right to become President of the Academy). However, there always should be some sort of distinction.

[23] But see footnotes 8 and 21, suggesting that there may be no Foreign Members.

[24] Like in footnote 22: more, but also less may be withheld from Foreign Members. However, it seems logical to differentiate in relation to the two issues mentioned so that it is clear that the Academy of Wonderland is indeed under the control of scientists from Wonderland.

4.5 Honorary Members shall be elected by the General Meeting from amongst persons of eminence who have made outstanding contributions to the objectives of the Academy. Honorary Members shall have the same rights and obligations as Active Members.[25]

4.6 The General Meeting may, on a proposal from the Board, divide the Academy's total Membership in Classes based in discipline.[26] It may also set an upper limit to the number of Members that may be elected each year into a Class or, in the alternative, it may set an upper limit to the total number of Members in each Class.[27]

4.7 Members of the Academy shall uphold the Statutes of the Academy and they shall contribute to the achievement of the objectives of the Academy.[28]

4.8 Membership ends if a Member withdraws from the Academy, provided he/she has met all financial obligations to the Academy.[29] Membership also ends when a Member is convicted of a crime or other serious offence, is declared a bankrupt or is declared to be of unsound mind, each of these decisions to be made by a competent court of law or other legally designated authority.[30]

4.9 A Member may be expelled from the Academy when that Member has acted in manifest contravention of these Statutes or has otherwise prejudiced the good name or interests of the Academy. Expulsion shall be a decision of the Board, shall be a last resort and shall be based on grounds that are communicated to the Member. Before taking a decision on expulsion, the Board shall give the Member concerned the opportunity to defend him/herself.[31]

ARTICLE 5: ELECTION OF MEMBERS[32]

5.1 Nominations for election into the Membership of the Academy shall be made in writing by two Members of the Academy. A nomination shall be personally addressed to the President of the Academy.[33]

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[25] Again: local circumstances may suggest another approach. However, assuming that there will be only a few Honorary Members and that they will be persons of the highest standing, why take away from the honour to be given to them by withholding from them at the same time any of the rights and obligations of Membership?

[26] In some cases – especially for larger Academies with, say, more than 300 Members – it may be better if the Statutes themselves already divide Membership in "Classes" – or "Colleges", "Divisions" or "Sections", etc. Indeed, in many Academies this is established practice. However, for new Academies it may be wise to see how Membership develops before considering the creation of Classes. If Classes are created, either directly in the Statutes or later when Membership grows, one of the consequences is that special rules and arrangements need to be introduced on the governance of these Classes. Such arrangements may be minimal in nature (making a Class primarily a meeting place for related disciplines), but they may also be more far-reaching (even to the point of making a Class in fact a mini-Academy of its own). In the latter situation, it is likely that the statutes of the Academy will have to differ on essential points from the statutes presented here.

[27] First, reason that the provision requires the Board and the General Meeting to work together is that the Membership provisions are of such a crucial process that both bodies must support any decision. Second, it is for each Academy to decide whether or not in wishes to set an upper limit on Membership. However, fact is that such a limit may make the recruitment of younger Members more difficult – if not impossible – unless there are strict rules on retirement as well. An alternative to a limit on Membership would be a limit on the number of new Members that are accepted every year, either in total or for each Class. In this respect it may also be wise for a new Academy to see how Membership develops before making a definitive choice.

[28] An alternative approach would be a set of detailed provisions on the rights and obligations of Members - even to the point of specifying the hours during which they have access to the library – but a general provision as suggested here should suffice in most situations.

[29] Members should have the right to withdraw at all times, for example if they disagree fundamentally with a position taken by the Academy. However, any financial obligations should be met.

[30] Overall, same observation as in footnote 28: these clauses appear to suffice in most situations.

[31] Expulsion is a serious matter, both for the Member concerned and for the Academy. It should therefore be strictly limited to a set of pre-defined conditions – here: contravention and prejudice - and there should be strict procedural guarantees against arbitrariness. In most cases a general provision like this should be sufficient.

[32] Like article 4, this is a most crucial set of provisions for the future viability and credibility of the Academy – perhaps even more so as these provisions should make it clear to everyone that it is the Academy that elects new Members solely on the basis of their contribution to science. The various provisions of this article could go in much more detail, but what is suggested here appears to cover all essential elements.

[33] Two seems a reasonable number, but a higher number is of course possible. It is suggested to send nominations personally to the President so that he/she may intervene immediately (and with a minimum of loss of face for the nominators) if a nomination is clearly out of order.

5.2 Nominations for election may be submitted at all times, but nominations received less than six month prior to the next General Meeting shall not be considered at that Meeting, but at a later General Meeting.[34]

5.3 A nomination shall consist of the following documents: (a) a statement of at most 50 words on the most significant contribution to science of the candidate; (b) a statement of at most 500 words giving the reasons why the candidate should meet the criteria for Membership; (c) the names of five referees with the widest possible geographical distribution who may be consulted by the Academy; (d) a list of what are considered the 12 most outstanding publications of the candidate; and (e) a full CV of the candidate including a list of all his/her major publications.[35]

5.4 For each round of elections the President shall appoint a Membership Advisory Committee for each discipline, or group of disciplines, to assist him/her with the selection of the candidates to be proposed by him/her to the Board. The list of candidates to be submitted to the Board shall be drawn up in a meeting of the Chairpersons of the Membership Advisory Committees, chaired by the President of the Academy.[36]

5.5 If there is a limit on the number of new Members that can be elected, the Board shall consider not only the individual qualifications of the candidates, but also the overall balance between disciplines, age and gender in the Membership of the Academy.[37]

5.6 The Board shall draw up a Final List of candidates to be elected into the Academy. It shall send this list to all Members for a secret ballot. This ballot shall be held as follows:[38]

5.6.1 If the Board has placed more candidates on the Final List than there are vacancies to be filled, it shall indicate its own order of preference;

5.6.2 When sending the Final List to the Members the Board shall include two envelopes, one marked with the name of the Member, the other blank and without any markings;

5.6.3 The Board shall indicate to Members the deadline on which all replies from Members must have been received by it;

5.6.4 The Member shall indicate for each candidate on the Final List whether he/she supports the election of that candidate, opposes election or abstains;

5.6.5 The Member shall then place the Final List in the unmarked envelope and place that envelope in the envelope marked with his/her name;

5.6.6 The Board shall verify that all replies received come from a Member of the Academy and it shall then put all unmarked envelopes in a sealed ballot box;

5.6.7 When the deadline has passed, the Board shall open the ballot box and count the number of Members that have responded;

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[34] An alternative would be to specify cut-off dates and deadlines. The advantage of this provision is that it is self-policing. Note that nominations are "considered at" the General Meeting – and not "approved by" the General Meeting. This as the election as such is done earlier by secret ballot.

[35] Again, the precise requirements may vary, but these elements seem to cover the essentials.

[36] Such Committees not only enhance the quality of the information and spread the workload over a larger number of people, but they may also act as a buffer to protect the President if, for some reason, a particular nomination becomes controversial at a later stage. The Chairpersons of the various Committees receive of course all sorts of input from Committee members, but it is they and the President of the Academy that integrate all this input into a single consolidated list.

[37] If there is no such limit, this provision can be deleted. However, even in that case a balanced Membership remains an important issue. The provision also suggests that it is the Board that should consider the overall picture, including aspects that do not relate to individual qualifications.

[38] The arrangements that follow are fairly typical for the election procedures of many existing Academies. They are designed to make quite clear that it is the Membership that decides, not through a collective raising of hands at a meeting, but through the considered decision of each individual Academy member. An alternative for smaller academies could be to take the vote, also in the form of a secret ballot, at a General Meeting. The reference to a ballot by e-mail in provision 5.6.10 should need no further explanation.

5.6.8 If that number is less than two-thirds of all Members, the Board shall declare the ballot void and initiate a new ballot for which the required number of responses shall be reduced to one-half of total Membership;

5.6.9 A candidate is elected when he/she receives the support of at least one-half of the Members that have responded and if no more than one-fourth of the responding Members oppose his/her election;[39]

5.6.10 The above arrangements may also be implemented by e-mail provided that their intent and purpose is respected.

5.7 The President shall present each candidate that has been elected into the Membership of the Academy to the next General Meeting and he/she shall state the grounds for election. Membership becomes effective once the candidate has stated before the General Meeting that he/she accepts all rights and obligations of Membership.[40]

5.8 All information obtained by the President, the members of the Membership Advisory Committee(s), the members of the Board or the staff of the Academy on persons considered for election shall be treated as confidential to protect their privacy.[41]

ARTICLE 6: GENERAL MEETING[42]

6.1 The General Meeting is the highest body of the Academy and it is composed of all Members of the Academy. It shall meet at least once every year in an Ordinary Session at the offices of the Academy. All Members are expected to attend Ordinary Sessions.

6.2 The General Meeting may convene in an Extraordinary Session by decision of the President, the Board or at the written request of at least 1/5 of total Membership.[43]

6.3 The venue and dates of Ordinary and Extraordinary Sessions of the General Meeting shall be determined by the Board.[44] Sessions of the General Meeting shall be convened by a written invitation, including a proposed agenda, to be distributed to all Members of the Academy at least one month prior to the Meeting.

6.4 The General Meeting shall make, in particular, the following decisions:

6.4.1 Receive and approve the Annual Report of the Academy;

6.4.2 Issue overall policy guidelines to the Board;[45]

6.4.3 Review the activities, present and future, of the Academy;[46]

6.4.4 Elect the Officers of the Academy;

6.4.5 Elect the Ordinary members of the Board;

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[39] This particular provision is designed to ensure that only candidates are elected who enjoy general support and not much opposition.

[40] Essentially, this provision is not about electing candidates into the Membership of the Academy, but about confirming the election results before the highest organ of the Academy: the General Meeting of all Members. For that reason, the candidate-elect also has to formally accept Membership before that body, either by making a brief statement or by a solemn vow or oath.

[41] This provision could be made much more elaborate, but it covers what needs to be said.

[42] There is an important overall choice to be made here: (a) either the General Meeting has essentially a supervisory role with the Board acting as the main decision-making body on all operational affairs of the Academy; or (b) the General Meeting is the body that takes most of the decisions with the Board charged with their implementation. The statutes presented here opt for the first approach: operational management is in the hands of the Board subject to supervision and guidance by the General Meeting. If the other choice is made – quite feasible for smaller Academies – the provisions on the powers of General Meeting and of the Board need to be reshuffled substantially as what are now powers of the Board need to be transferred to the General Meeting.

[43] Extraordinary sessions may be convened for celebrations, but also to settle serious disagreements. For that reason, the provision as drafted allows all potential sides in a possible disagreement to convene an Extraordinary Session of the General Meeting so that no side can block the other.

[44] Even in situations of conflict the Board is still the Board, implying that it is the duty – "shall" - of the Board to make appropriate arrangements (including the allocation of funds) for all General Meetings.

[45] See footnote 42. This provision is inappropriate if the General Meeting is in charge of operational management.

[46] See footnote 42. If the General Meeting would be in charge of operational management this list should also state explicitly that the General Meeting decides on budgetary matters.

6.4.6 Appoint the auditors of the financial administration of the Academy;[47]
6.4.7 Review and approve reports and accounts submitted to it;
6.4.8 Award medals, prizes and other honours on behalf of the Academy.

6.5 The General Meeting may make formal decisions only if at least one-half of the Membership of the Academy is present. If within one hour after the scheduled opening of a General Meeting less than one-half of the Membership is present, the session shall be adjourned. In that case the Board shall invite all Members to a second session that may make formal decisions without a quorum requirement provided that there are no changes in the agenda and provided that at least two weeks have lapsed after the adjournment.[48]

6.6 Unless provided otherwise, decisions of the General Meeting shall be taken by a majority vote, abstentions not considered a vote. Decisions shall be made by a show of hands unless the General Meeting decides to vote by secret ballot. In case of a tie the President shall have a second vote.
6.6.1 Voting on the election of the Officers of the Academy and of the Ordinary members of the Board shall always be done by secret ballot;
6.6.2 If there is more than one candidate for a specific position as Officer of the Academy or as Ordinary member of the Board, the candidate who receives one-half of the votes, abstentions not considered a vote, shall be elected. If no candidate receives one-half of the votes, the candidate with the fewest votes shall be withdrawn from the list of candidates. Voting shall then be repeated for the remaining candidates until a single candidate obtains a majority of the votes, abstentions not considered a vote.[49]

ARTICLE 7: BOARD[50]

7.1 The Board shall consist of the Officers of the Academy and three Ordinary members, all elected from among the Members of the Academy.[51]

7.2 The members of the Board shall be elected by the General Meeting on the basis of a proposal from an *ad hoc* Nominating Committee appointed by the Board at least 12 months prior to the expiration of the terms in office of the incumbent Academy Officers and Ordinary Board members.[52]
7.2.1 The Nominating Committee shall consist of Members of the Academy that have been active in activities of the Academy and that do not seek election into the new Board. In the composition of the Committee there shall be balance between disciplines, age and gender;
7.2.2 The Nominating Committee shall request all Members of the Academy to submit candidates for election as Academy Officer and/or Ordinary Board

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[47] Although it is very specific, it is best to entrust the General Meeting with this decision to ensure a maximum of transparency and credibility. After all, the decisions of the Board and of the Executive Director are the objects of the audit.

[48] The precise details of this provision need to be determined in the light of the local situation. A quorum of one-half may be too high for one Academy and it may be too low for another. Also, it may be preferable to mention a precise number rather than a percentage. However, one aspect holds true in all situations: the quorum required goes up whenever the decision-making powers of the General Meeting increase. Otherwise, a relatively small group of Members may be able to hijack the decision- making process of the Academy. See also footnote 84.

[49] Clearly, this provision can be made much more elaborate, but this should suffice for a General Meeting without managerial tasks. Special provisions are needed for the election of Academy Officers and other Board members as there may be several candidates competing for the same position.

[50] To repeat the message: this particular provision also reflects the choice of having a General Meeting with an overall supervisory role and a Board charged with all tasks of operational management, including financial and budgetary matters.

[51] Local preferences should determine the precise numbers. Also, the number of Officers can be enlarged (more Vice-Presidents?) and that of the Ordinary members reduced.

[52] An independent Nominating Committee (or Search Committee) is essential as Board members may be up for re-election, which precludes a formal role for the Board itself. In this provision size and composition of the Nominating Committee are left to the Board, but any statutes can of course easily provide guidance or even instructions on these issues.

member. Self-nominations shall not be considered;

7.2.3 The Nominating Committee shall request incumbent Academy Officers and Ordinary Board members who are eligible for a second term to indicate whether or not they seek such a second term;

7.2.4 At least one month prior to the General Meeting where the election is to take place, the Nominating Committee shall inform the Board in the strictest confidence of the proposed slate of new Academy Officers and Ordinary Board members;[53]

7.2.5 All information obtained by the members of the Nominating Committee, the members of the Board or the staff of the Academy on persons considered for election shall be treated as confidential to protect their privacy.[54]

7.3 The Officers of the Academy and the Ordinary members of the Board shall be elected for a term of three years and shall be eligible for re-election for one additional term, either in the same position or in another.[55] However, if a member of the Board is elected President, he/she may have a total of three terms as member of the Board.[56]

7.4 For the purpose of continuity, during the second and final term of an incumbent President the Nominating Committee may recommend a President-Elect who shall be, or become, a member of the Board.

7.5 The Board shall fill any vacancy caused by death, resignation or incapacity of any of its members for the remainder of his/her term. A person filling a vacancy shall be eligible for election, thereafter, for two normal terms.

7.6 Subject to overall policy guidelines of the General Meeting, the Board shall be empowered to make decisions on all matters affecting the Academy. In particular, the Board shall make the following decisions:[57]

7.6.1 Manage, coordinate and supervise all affairs of the Academy, including its financial resources and other assets;

7.6.2 Convene the sessions of the General Meeting and distribute invitations, including an agenda, to the Members of the Academy;

7.6.3 Prepare a draft Annual Report of the Academy and submit it to the General Meeting for approval;

7.6.4 Appoint standing and temporary committees as and when the Board deems such committees necessary;[58]

7.6.5 Consider any reports and accounts to be submitted to the General Meeting for review and approval by that Meeting;[59]

7.6.6 Prepare decisions of the General Meeting to award medals, prizes and other honours to scientists for outstanding achievements;

7.6.7 Adopt bylaws to give effect to the provisions of these Statutes. The

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[53] This provision is designed to ensure that the incumbent Board can live with the proposal of the Nominating Committee and to minimize the chance of controversy at the General Meeting. It is best if the Nominating Committee were to present a full slate of new Officers and other Board members to the General Meeting so that the Meeting can say yes or no to the group as a whole. However, this may not be possible, in which case the General Meeting must choose between candidates. See the provisions of 6.6.2.

[54] Same comment as in footnote 41.

[55] A term of four years (maximum eight) would also be okay, but a term of two years (even when it becomes four years) seems too short to be effective. Experience shows that most newly elected officials without much relevant background need at least a year or so to come to grips with the job, then need several months to develop their own plans and initiatives plus another year at least to implement these plans and initiatives. Accordingly, a two year term invites a wait-and-see attitude, as well as a risk of inaction, particularly when re-election for a second term is not certain.

[56] Continuity is especially important for the President, both within the Academy, but also in respect of its external relations. Hence, the option to extend the President's terms in office.

[57] Again: all this applies only to a Board with managerial responsibilities.

[58] Most existing Academies have a range of committees, such as: Finance Committee, Awards Committee and Foreign Relations Committee. Whenever such a Committee is established, it is appropriate for the Board to also adopt special bylaws to govern its operation.

[59] This also implies that no reports will go the General Meeting without having been considered first by the Board – which is as it should be.

Board shall inform all Members of the Academy of any bylaws it may adopt.[60]

7.7 The Board may only take formal decisions if there is a quorum of at least four members. The Board shall decide by a majority of votes, abstentions not considered a vote. In case of a tie, the President shall have a second vote. Decisions shall be made by a show of hands unless the Board decides to vote by secret ballot. In the interval between meetings of the Board a vote may be taken by email.[61]

7.8 The Board shall meet at least four times a year[62] and the Minutes of its meetings shall, when confirmed, be sent to all Members of the Academy.

ARTICLE 8: OFFICERS[63]

8.1 The Academy shall have the following Officers: a President; a Vice-President; a Secretary General; and a Treasurer.[64]

8.2 The President shall be the principal officer of the Academy and he/she shall represent the Academy externally.[65] The President shall preside over all meetings of the Board and all sessions of the General Meeting. He shall present reports on the Academy's activities to the Board and to General Meetings.

8.3 The Vice-President shall take the place of the President if the President is unable to attend meetings of the Board or sessions of the General Meeting or is unable to represent the Academy externally. The Vice-President may discharge such other responsibilities as the President assigns to him/her.[66]

8.4 The Secretary General shall be responsible for all official records, including the Register of Members, of the Academy and for all official correspondence of the Academy, except that which relates to finance. He shall preside at meetings of the Board and at sessions of the General Meeting if the President and Vice-President are unable to attend.

8.5 The Treasurer shall be responsible for the financial records and administration of the Academy and for the management of all its financial resources and other assets. The Treasurer shall report annually, and at such times as the Board may determine, to the Board on the finances and accounts of the Academy. He shall present a report to each Ordinary Session of the General Meeting on the audited accounts of the Academy.

8.6 Any Officer of the Academy or an Ordinary member of the Board who behaves in a

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60 There is quite a range of possible bylaws. Some may be needed to add detail to the provisions of these statutes – for example, in relation to the administrative aspects of the membership election procedure. Other bylaws may cover aspects not dealt with in these statutes at all – such as the operation of newly created committees. One other possible topic for bylaws is Membership fees: level or levels, method of payment, consequences of non-payment, etc.

61 The provisions on decision-making by the Board can be simpler than their equivalent for the General Meeting, not because Board decisions are less important, but because the Board is a much smaller body. For obvious reasons a provision on e-voting has been added. Again, the provision may have to be adapted to local conditions, especially when it is decided to have a larger or smaller Board.

62 But in many situations that may be on the low side.

63 Of course, every Academy will have a President and should have a Vice-President, but a Secretary General and a Treasurer are not strictly necessary, while putting them collectively in the category "Officers of the Academy" is also a matter of choice. However, having Officers elected from among the Membership conveys the message that the Academy is truly managed by the Members themselves. Also and more practically: even if here is no Secretary General or Treasurer, their work has to be done anyway.

64 The number and type of Officers is a matter of choice as well. For example, many of the larger academies have a special Foreign Secretary to strengthen the position of the Academy in international relations. There also may be more Vice-Presidents, which makes it possible to assign specific responsibilities to them (such as: Membership issues, Science education, Awards, etc.).

65 The term "representation" here refers to flying the flag – it does not refer to entering into financial or legal commitments. See the provisions on Financial Management.

66 This should also make clear that ultimately there is only one boss: the President.

manner that is incompatible with the responsibilities of his/her office or who accepts a position that is in conflict with those responsibilities, including a paid position at the Academy, shall resign his/her office. If he/she refuses to do so, the Board shall propose to the General Meeting to remove him/her from office.[67] If an Officer is expelled as a Member of the Academy, his/her term in office ends automatically.

ARTICLE 9: EXECUTIVE DIRECTOR[68]

9.1 The Board shall appoint an Executive Director of the Academy as the highest administrative officer of the Academy for a term in office set by the Board, but not less than three years, and for a salary and other benefits also set by the Board.[69]

- 9.1.1 Not later than 12 months prior to the end of his/her term in office the Board shall request the incumbent Executive Director to indicate whether or not he/she seeks appointment for another term in office;
- 9.1.2 If the Executive Director seeks another term, the Board shall decide whether or not to re-appoint the incumbent Executive Director;[70]
- 9.1.3 If the incumbent Executive President is not available or if the Board decides that a new Executive Director needs to be appointed, the Board shall appoint a Search Committee from among its members;
- 9.1.4 The Search Committee shall publicly advertise the vacancy, as well as the criteria for appointment. It shall also seek input from Academy Members;[71]
- 9.1.5 The Board shall appoint a new Executive Director not later than two months before the end of the term of the incumbent Executive Director.

9.2 The Executive Director is accountable to the President of the Academy.[72]

9.3 Subject to guidelines and instructions of the Board, the Executive Director shall be responsible for the administration of the Academy and for the management of the office of the Academy, including the appointment of staff, the setting of salaries and other benefits and the general conduct of the staff.[73]

9.4 The Executive Director shall support the Board in formulating and implementing the policies of the Academy and he/she shall maintain working relationships with all organizations that pursue objectives similar to those of the Academy.[74]

9.5 If the Executive Director behaves in a manner that is incompatible with the responsibilities of his/her office, he/she shall resign his/her office. If he/she refuses to do so, the Board shall remove him/her from office.[75]

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[67] That is: he/she may stay on as Member. Strictly speaking, the last sentence is not needed as all Board members must be Academy Members. However, in case of conflict ….

[68] Again the observation that this position assumes that the Academy has a certain size. For smaller Academies it may just not be realistic to have a salaried Executive Director, not even part-time. In that case, one or more of the members of the Board have to do the work – as volunteers.

[69] Accordingly, the Executive Director is a paid employee of the Academy, full-time or part-time. This is not only a matter of expediency, but it also is a matter of principle to make clear how the position of Executive Director relates to the elected positions of the Officers of the Academy.

[70] It is only fair that an incumbent Executive Director has the right of first refusal, especially when he/she does a good job.

[71] In most cases a maximum of transparency is best.

[72] The Executive Director can also be made accountable to the Board as a whole, but this may cause confusion if the Board is divided.

[73] No doubt, a more detailed and elaborate provision can be formulated, but this describes clearly two important components of the job: administration and office management. Accordingly, the Secretary General and the Treasurer may have ultimate responsibility for the correspondence and the finances of the Academy respectively, but it is the Executive Director who does most of the actual work.

[74] A good Executive Director may do much more than administration and office management – if an Academy lets him/her, as all larger Academies should. Based on his/her specific role as the highest administrative officer of the Academy, he/she can also have a voice in the decision-making processes of the Academy and in the contacts with other organizations. Presidents and Board members may come and go, but a good Executive Director is essential to bring a degree of continuity and stability to an Academy.

[75] The Board appointed the Executive Director and so the Board should fire him/her.

ARTICLE 10: FINANCIAL MANAGEMENT[76]

10.1 The Academy is authorized to accept and receive grants, donations, gifts, bequests, trust funds and prizes from national or international entities, public or private, or from individuals, as well as fees from its members or for any services it may render. Acceptance of such financial contributions shall be affected by the Executive Director under guidelines issued by the Board.

10.2 The Officers of the Academy, the Ordinary members of the Board and other Academy officials elected from amongst the Members shall not receive any salaries or other honoraria or fees. However, they shall be reimbursed for any personal expenses made in performing their duties, while the Academy may compensate, in whole or in part, the organization where they work for the costs of their salary.[77]

10.3 The Academy shall enter into financial obligations in relation to third parties only on the basis of an explicit decision of the Executive Director. The Executive Director shall enter into such financial obligations only for expenditures that are included in a budget approved by the Board.[78]

10.4 The Academy may borrow money from established financial institutions and it may invest any funds it does not need to disburse. Investments shall be made only in financial instruments that carry a minimum of risk. Transfer of Academy funds for investment purposes shall be affected by the Executive Director upon a written instruction from the Board signed by the President.[79]

10.5 The accounts of the Academy shall be audited in accordance with generally accepted accounting and auditing standards.[80]

ARTICLE 11: PUBLICATIONS AND STATEMENTS[81]

11.1 Publications or statements on behalf of the Academy shall not be made public until their public release is approved by the Board. In particularly urgent matters the President of the Academy may decide on the public release of a publication or statement provided that its content is in line with standing policies of the Academy.

11.2 The Board shall appoint an Editor or Editorial Committee of the Academy, preferably from amongst its members, to supervise the preparation of publications for public release on behalf of the Academy.[82]

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[76] This provision aims to set out some general principles. More detailed provisions may be needed, but these could be adopted as part of the Academy's bylaws.

[77] In most situations it may be appropriate to provide that any work for the Academy is done on a pro bono basis and not for a salary or honorarium. However, the home-organizations of an Academy Officer may be compensated for the time "lost" by that organization to the Academy. There also may be situations where the position of Academy Officer should carry a salary. Accordingly, this provision needs to be adapted to the local situation.

[78] One (intended) result of the way this provision reads is that the Executive Director will have considerable discretion in entering into financial obligations if the Board adopts a budget with only a few very broad categories. If the Board does not wish to give so much freedom to the Executive Director, it should adopt each year a comprehensive budget for all major (categories of) activities of the Academy. An alternative would be to stipulate that the Executive Director needs approval from the Board (or the Treasurer) for every transaction or for transactions that exceed a certain amount. However, such an arrangement appears feasible only for smaller Academies.

[79] No speculation with Academy funds on the stock market.

[80] With the auditors being appointed by the General Meeting. See provision 6.4.6.

[81] A provision on publications and statements may not be necessary for all Academies. However, in view of the impact a publication or statement may have on the reputation of an Academy, it may be wise to set out some basic principles in the statutes.

[82] Note that the Editor or the Editorial Committee is charged with supervising the preparation of a publication for public release and not with the task of preparing it for publication. If the Editor/Editorial Committee is recruited from among Board members, there is

11.3 If the Editor or the Editorial Committee considers a publication ready for release, he/she/it shall submit a proposal to the Board on the manner and mechanisms of publication and dissemination.[83]

11.4 The President or the Vice-President shall supervise the preparation of all Academy statements. If the President or Vice-President considers a statement ready for release, he/she submits a proposal to the Board on the manner and mechanisms of dissemination.

ARTICLE 12: FINAL PROVISIONS

12.1 Amendments to these Statutes may be made by the General Meeting on the basis of a proposal from the Board. Proposed amendments shall be put to a vote only if at least two-thirds of the Members of the Academy are present at the General Meeting. Approval of a proposed amendment shall require a two-thirds majority vote, abstentions not considered a vote.[84]

12.2 The Academy may be dissolved at an Extraordinary General Meeting, especially convened for that purpose. A proposal to dissolve the Academy shall include arrangements to dispose of the assets of the Academy.

12.2.1 The proposal to dissolve the Academy shall be put to a vote only if at least two-thirds of the Members of the Academy are present at the Extraordinary General Meeting. Approval of the proposal shall require a two-thirds majority vote, abstentions not considered a vote.[85]

12.2.2 If within one hour after the scheduled opening of the Extraordinary General Meeting less than two-thirds of the Membership is present, the President shall adjourn the session. He/she shall then invite all Members to a second session that may take the decision to dissolve the Academy without a quorum requirement and by a majority vote, abstentions not considered a vote

less need for formal reporting and consultation.

[83] This implies that the Board is not asked to approve the contents of the publication or statement. In essence, the approach suggested here is that any publication or statement must meet strict (methodological) quality standards, but that within an Academy there is no room for censorship.

[84] For such an important decision Board and General Meeting should be required to work together, while the decision should not only require a two-thirds majority, but also a higher quorum. This to prevent a relatively small group of Members to amend the statutes for their own purposes, in effect hijacking the Academy. By way of example: if an Academy has 200 Members, provision 6.5 sets the regular quorum of a General Meeting at 100 Members, implying that as few as 51 Members could change the statutes. With the increased quorum requirement of two-thirds, these numbers become 134 (quorum) and 90 (vote), which are better thresholds for these (potentially) crucial decisions.

[85] For quorum and voting requirements, see the previous footnote. However, in case of dissolution the actual number of Members participating in the decision may be quite small.