Biotechnology Policy in Egypt

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Abstract

In this article we present the policy designed by Egypt to develop biotechnological research. It is embedded in the national research system, and tangled in the working and living conditions of the researchers. Nevertheless, the state equipped itself with specific institutions, and it supports some big projects in an area announced as a priority. Results are very unequal. The interesting thing is that beyond this framework (conforming to world standards) the making of science depends much on the handling of resources, rules and controls. According to their access to foreign funding, and to political support different types of laboratories enter into very different levels of science. The article describes institutes of excellence, 'pharaonic' projects, autonomous laboratories and "normal" teams (the great number of them) which indulge in different styles of science, topics and publics. The "normal" teams in particular are little visible in bibliographic databases, which does not mean that they have no products and those are not tailored to certain needs of Egyptian people. One could then say that the results do not come up to expectations and investments. This is mainly due to the governance of research in practice. This remark could well apply to other fields of Egyptian science, and to other countries. Rather than to a scale of laboratories

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involved in higher or lower science, one should also pay attention to the various types of the scientific endeavour that co exist in one place.

Introduction

This article examines the subject of governance in biotechnology in Egypt as a case-study for developing countries. Biotechnologies are expected to play an important role in economic development, in domains such as agriculture and health. Like many other countries, Egypt entered the field some twenty years ago.

More than other sectors, the research sector requires close cooperation between many actors at several levels. Fundamental research concerning biotechnologies is necessary but it must be orientated to economic purposes and embedded in industrial processes. The state and its public research policies play an important role in involving and mobilizing private sector including foreign partners. Non Governmental Organisation's (NGO), lobbying groups, the media, farmer unions and public opinion; all have concerns about Genetically Modified Organisms (GMOs) and the related ethical issues. The management of biotechnologies involves many participants. Biotechnologies can be only developed within the framework of a well-planned strategy which associates and merges the interests of several actors.

In order to assess the achievements and understand its dynamic, interviews were conducted**,** during the period of 2005-2006, with researchers and heads of laboratories working at the main places producing results in this field. These belong to different research environments associated with biotechnology development in Egypt, namely the National Research Centre, several Universities (Ain Shams, Cairo University and the University of Agriculture), plus the two main Egyptian research institutes dedicated to biotechnology AGERI (Agricultural Genetic Engineering Research Institute) and GEBRI (Genetic Engineering an Biotechnology

Research Institute). We completed information with the most recent literature dealing with the subject (including internet websites).

The main conclusion that can be drawn from the study is that Egypt benefits from a privileged situation due to the very high level of support from other countries and from its research system that is one of the best in the Arab world. But the results obtained have been disappointing in terms of the investments put in. The main reason for this might be an inefficient governance of the whole research system rather than specific resource shortage or inadequate research. The Egyptian government is carrying out large scale reforms of its research system in order to address these problems. The first part of our study shows that Egypt has already at its disposal all the essential elements required for the development of a biotechnology sector. The second part describes the biotechnology research in Egypt and proposes a typology of Egyptian labs. The last part highlights elements that could explain inefficiencies of the research governance.

1 Egyptian research system and biotechnology

Overview of the research system

As well described by R. Waast, the higher education and research system in Egypt is the largest and the oldest one in Arab countries and also the most productive one (in terms of publications) (Waast, Rossi, 2010). The Al-Azhar University associated to the Al-Azhar mosque (built in 969 AD) is considered to be the oldest operating university is the world. The public University of Cairo was first created in 1908, as a private university. Of the five public universities and one private University (the American University of Cairo) available in 1957, the higher education system has grown up to 19 public universities and 13 private universities.

The research system has developed as early as 1928 with the creation of a Higher Council for Scientific Research and a budget attributed after the Second World War lead to the creation of the National Centre for scientific Research (NRC), the main research centre in basic science in Egypt.

Today, the Egyptian research system is characterised by its complexity. It is spread throughout many different Ministries (see table 1). The Egyptian government reports as many as 170 000 public agents working in the Research Development and Innovation process although most of the report on the subject (OCDE-World Bank 2009, Waast 2010; UNDP 2009) estimate approximately that the number of full time researchers is around 14 000. The Egypt research system functions through the Ministry of Higher Education (MOHE) which employed more than 60 000 public agents, and the Ministry of Scientific Research (MOSR) which employed almost 6000 public agents mainly at the NRC. Associated to these two main Ministries, the Ministry of Agriculture and Land and Reclamation and the Ministry of Petroleum and Mineral which employed respectively 86 669 and 2711 agents play also an important role in the Egyptian research system. Most of the other ministries (see table 1) have associated research centres. As a consequence, Egypt has a large amount of research centres, some sources (OCDE-World Bank 2009) report fourteen specialised government research centres, 219 research centres under the auspice of ministries and 114 centres at universities. Since 1993, Egypt has also developed a technological research city, the Mubarak City for Scientific Research and Technological Applications (MUSCAT).

In terms of funding, as in most Arab countries, the most significant proportion of funding comes from the state. Within the region, Egypt is characterised by the weakness of the resources devoted to research, with a budget that amounts to 0.2 per cent of the GDP. As a comparison Tunisia has reached 1.1 per cent of its GDP (Waast 2010).

As stated earlier, the Egypt research system performance suffers from its complexity. Most of the Ministries tend to develop internally research activities related to their own needs instead of putting pressure on the Ministry of Scientific Research and Higher Education in order to open knew research fields. Table 1 indicates that at least 15 Ministries out of the Ministry of research and higher education undertake important research programs. In other respects, these Ministries exercise their administrative supervision on many research centres. The Ministry of Agriculture has at its disposal 16 specialised institutes under the supervision of the ARC (Agriculture Research Centre), 6 labs and 37 regional stations. The complexity of the system is increased due to the fact that some labs depending of one Ministry undertake research on subjects relevant to other Ministries. For example, the Ministry of research has 14 specialised councils. One of them concerns medical studies and overlaps with research carried out within the Ministry of Health. Some issues, irrigation for example, are at the intersection of several fields; water, public health, desertification, agriculture. Such issues may concern three of four Ministries. Therefore inter-sectors coordination and harmonisation of policy makers is strongly needed.

Biotechnologies are of course a small part of this system. But the institutional and professional framework is the same and determines the working conditions. The development of the biotechnologies sector is described in the following sections.

The government is politically committed to biotechnologies

At the beginning of the nineties, the Egyptian government recognised the importance of biotechnology as a tool for national development and set “excellence in biotechnology and

genetic engineering" as a national goal. A focal point for biotechnology was established in the Academy of Scientific Research and Technology in Cairo (Abdelgafar 2004).

In 1995, 'Egypt's National Strategy for Genetic Engineering and Biotechnology' was launched in order to implement a national biotechnology sector in Egypt. Egyptian expatriates and local experts were involved in its definition. The strategy aimed at acquiring capabilities that would permit Egypt to have a competitive edge and encouraging the private sector to invest in biotechnology-dependent industries. The original budget of 25 million US dollars was cut to 4 million US dollars before being approved. All the biotechnology centres and authorities operating in the field of genetic engineering were involved in the process (ISESCO 2004). This plan led to the introduction of biotechnology into universities and public research institutes.

Specific regulations and institutions for biotechnologies in Egypt

The government has also equipped the country with regulations and institutions necessary to the development of biotechnology products. They comply with world standards, and they help to earn the interest of foreign companies and funding. They regard notably biosafety and Intellectual property Rights (IPR). Special institutions are geared to popularizing biotechnologies and facilitating the spread of biotechnology products.

Biosafety in Egypt

A National Biosafety system is an important element of the national strategy to develop biotechnology products[1]. It is also instrumental in involving different stakeholders in the definition of the national project, and in facilitating collaboration with foreign countries.

The Egyptian National Biosafety Committee (NBC) was created in January 1995. Its members are representatives from the Ministries of Agriculture, Health, Industry and Education, from the Sector of Environmental Affairs and from the private sector. They include policy makers, experts and non-technical members. A series of Ministerial Decrees from March 1995 to August 1997, established the rules of Egyptian Biosafety.

NBC is in charge of establishing policies and procedures regarding biotechnology in the whole country. It is "the official body responsible for ensuring that biotechnology continues to be safe and facilitating access to modern biotechnology generated abroad"[2].

All organisations that undertake biotechnology research must establish an Institutional Biosafety Committee to organise the safety of their own activities. These committees report back to NBC and are supposed to carry out NBC's duties.

If an import permit is required, NBC notifies a secondary specialised agency (e.g. the Supreme Committee on Food Safety) before authorizing field tests. Once the authorisation is given, a team of NBC inspectors carries out the monitoring.

Foreign donors have been strongly involved in setting up the Biosafety system in Egypt[3]. The AGERI Institute also played a central role in building up institutional capacities for biosafety[4].

Intellectual Property Rights in Egypt

Intellectual property rights play an important role in the development of biotechnology as they protect the huge investments made by private companies. The protection of new products can

represent an incentive for the researchers. Having this protection is also necessary to obtain technological transfers from foreign companies. The previous Egyptian patent law dated back to 1949. It did not offer protection to food-related products and was not suitable for the new biotechnologies. Egypt also had to bring itself into compliance with its international agreements, notably the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs).

Members of AGERI were trained in issues related to IPR through different internship programs in collaboration with US universities. From 1993 to 1997 workshops financed by ABSP-USAID contributed to the training of Egyptian scientists in all aspects of Biotechnology IPR. These researchers (especially the AGERI ones) endeavoured to increase awareness of the biotechnology development conditions and helped the government to establish a comprehensive legal framework including IPR, Biosafety, and Information Centres.

The new IP Law 82/2002 consists of a comprehensive code for intellectual property including patents, design, integrated circuits, trademarks, geographical origin and trade statements. The second paragraph of the Law excludes plants and animals from the granting of patents, but the fourth chapter of the Law addresses plant variety protection. A period of protection of 20 or 25 years is granted to plant varieties, derived inside or outside Egypt, whether developed through biological or non-biological means. To be eligible for protection a variety must be new, distinct, uniform, stable and subject to a denomination. To complete the Law, the Agricultural Research Centre (ARC) has adopted a Technology Management and Commercialisation Policy which gives an inventor of ARC the possibility to share financial benefits in the ratio of 80 per cent for the institution and 20 per cent for the inventor.

Public awareness. Information Centres

One of the main obstacles to the development of Biotechnologies is the mixed or negative nature of public opinion regarding its benefits. Awareness of the possible dangers that GMO represents for health and environment lead to a cautious approach. Up until 2003, Egypt had been supporting the US by pursuing a WTO case against the European Union's policy on genetically modified food. In 2003, for example, Egypt dropped this case due to public concerns about GMO in Egypt. This change in Egyptian attitude delayed the negotiations on the US-Egyptian Free Trade Area.

One of the Egyptian initiatives largely supported by USAID was the establishment of the Biotech Information Centre. The Egyptian Biotechnology Information Centre (EBIC) is a joint non-profit organisation set up by the Egyptian Ministry of Agriculture and the International Service for the Acquisition of Agribiotech Applications (ISAAA). The latter is an international NGO, supported by USAID, public organisations and seed multinationals, and devoted to the promotion of agricultural biotechnologies in poor countries. Through its connection with this NGO EBIC belongs to a world wide network that facilitates the exchange of information and experiences between developing countries.

EBIC is located at AGERI[5]. Among other activities, EBIC issues an Arabic newsletter called "Roayah" which includes local and international news on biotechnology. It holds conferences, workshops and supports the writing of articles on biotechnology. One of its first activities was to organise a workshop in February 2004 for Egyptian journalists, in order to provide an objective and scientific view on Biotechnology and to balance the negative public opinion towards GMO.

Egypt has all the basic elements necessary to build up a competitive biotechnology sector: A complete legal framework including property rights, safety institutions, an information centre, laboratories and trained researchers. The strong level of support from other countries and the quality of exchanges with foreign labs should guarantee good performance.

2. Organisation of Biotechnology –Three Sectors

Thanks to the priority given to them, biotechnologies have grown into key sectors for the Egyptian economy in agriculture, health and industry. After a description of the development of biotechnologies in these three different fields of application, we propose a typology of Egyptians labs based on our investigations.

Biotechnology research in the agricultural sector

Egypt is a large consumer of agricultural products (corn, soybeans and vegetable oils) derived through modern biotechnology and imported from the United States and Argentina. Genetic engineering programs started in 1990.

Today, universities conduct biotechnology research in the agricultural sector, but the leading research activity is concentrated in one place at the Agricultural Genetic Engineering Research Institute (AGERI). This institute, located within the Agricultural Research Centre (ARC) in Giza, was jointly established in 1989 by the Egyptian government and the United Nations Development Program. Until 2001, the US largely contributed to the development of this Institute as USAID has allocated $60 million to the Agricultural Technology Utilisation and Transfer (ATUT) program, which supports Egypt's efforts to commercialise agricultural biotechnology. This program, initiated in 1995, aimed at collaborative research between the

AGERI and Michigan State University to advance Egyptian agriculture using biotechnology. The program covered the development of tomatoes resistant to the tomato Yellow Leaf virus, potatoes resistant to potato Tuber Moth, and corn resistant to Stem Borer insects. Moreover, USAID has also funded several agricultural projects to the tune of $595 million including the Agricultural Policy Reform Program (APRP), the Technical Assistance for the Agricultural Policy reform Program (TA/APRP). These projects were designed to enhance the effectiveness of a wide range of public and private institutions in Egypt's agricultural development by focusing on agricultural research, technology transfer, and crop biotechnology.

Today, the AGERI institute is developing a number of GMO products for commercialisation by working with leading biotechnology companies and universities mainly in the United States. These crops are Tuber Moth resistant potatoes, virus-resistant squash and tomatoes, corn borer-resistant, maize and drought-tolerant wheat. Through collaboration with Monsanto, AGERI has developed an insect-resistant long staple GM cotton strain (USDA 2005). According to the Food Agriculture Organisation (FAO) database, in Egypt, 15 GMOs are under experimental phase, another 15 under field trial and one under commercial phase. (USDA 2009)[6]. Recently**,** the Egyptian Ministry of Agriculture had " approved the decision made by the national Biosafety Committee and Seed Registration Committee to allow for commercialisation of a genetically modified Bt corn Variety in 2008 (USDA 2008). The variety to be distributed, Ajeeb-YG, was developed by Monsanto scientists in South Africa, as a cross between MON 810 and an Egyptian maize variety. The Cairo based company Fine Seed International is partnering with Monsanto to distribute the variety in Egypt.

AGERI is considered a success story by the Egyptian Government and the international scientific community. It has indeed reached the best level in the Middle Eastern region and

diffuses information in Arabic all over the region. Of the ten biotechnology-related patents registered by Egyptians inventors at the US Patent and Trademark Office (USPTO) for 1990-2003 period, half of them were co-assigned with AGERI (Quach 2006). AGERI is also strongly involved in biotechnology training. Between 1990 and 2004, AGERI delivered 64 Masters of Sciences degrees, and 28 PhD (8 in collaboration with US and 2 with Germany). Research conducted at AGERI between 1992 and 2004, leaded to the publication of 109 papers, 60 in Egyptian publications (55 per cent), 32 in Arabic publications (29 per cent) and 17 (16 per cent) in international publications (16 per cent).

Biotechnology research in the Industrial sector

Biotechnology directed at the industrial sector is far less developed than towards the agricultural sector. In terms of research, the main structure is the Mubarak City for Scientific Research and Technological Applications (MUSCAT). It is situated at New Borg el Arab City, West of Alexandria where 40 per cent of the Egyptian industry is located. According to the MUSCAT web site[7]:

"the activity of this research institute is directed to the development and renovation of industry, as well as for solving specific problems facing the health, agricultural and environmental sectors. These objectives can be summarised as follows:

- Develop centres of scientific Excellency that aim to serve both economic and social developments of the Egyptian society.
- Develop new technologies and provide new scientific methods in different fields of industry in order to link research programs to national development plans.
- Provide training consulting and technology transfer to different production and services agents in Egypt.

- Conduct applicable projects to ensure better performance in different areas that can benefit the Alexandria region and the national economy.
- Cooperation with different national and international institutes in the various areas of technology".

MUSCAT was created following a decree issued by the President Hosni Moubarak in 1993. The 24 million dollar centre housed in three pyramid-shaped glass buildings was inaugurated in 2000. By then, it was composed of two of the ten originally planned institutes: the Genetic Engineering and Biotechnology Research Institute (GEBRI) and the Informatic Research Institute (IRI). Today it is also composed of the Advanced Technology and New Material Research Institute (ATNMRI), the Agricultural Research and Development Institute (ARADI) and the Technological Capabilities Development Centre (TCDC). MUSCAT has a "special status" with a budget of 9 millions EGP (2.64 millions USD) and is directed by a committee associated with the Ministry of Research. The main activity of GEBRI, the oldest institute, is directed towards biotechnology research serving different fields: Medical, Environmental, Industrial and Pharmaceutical areas. This centre has at its disposal fully sophisticated equipment (DNA sequencing machine, DNA arrays ….) with a highly skilled staff. 40 per cent of the 100 scientists working at the GEBRI are PhD holders who have been trained abroad mainly in the US and Germany, the main international collaborators.

According to the web site, more than 200 scientific papers were published in the international and local specialised abstracted Journal (MUSCAT 2004). Analysis of GEBRI production in the Thomson ISI database for the 1999-2007 period detects 90 papers, 53 per cent were published with international co-authorships (US (35 per cent) and Germany (33 per cent))[8]. In 2004, 11 patents have been submitted to the Egyptian patent office.

Although, MUSCAT has been slow to set up, this young research structure has a high-level personnel, perfectly well inserted in the international scientific community as the publication record shows.

Biotechnology research in the health sector

As in many developing countries, biotechnology research in the health sector is directed towards local needs. Notably, Egypt has to face a large Schistosomia infection in the rural population and an elevated infection rate of Hepatitis C in the population which has reached about12 to 20 per cent[9]. Non infectious diseases such as diabetes are also a public health concern. The Egyptian population counts 5-7 million diabetics out of its population of 74 million.

Biotechnology research in the health sector has been pushed after the 'Egypt's National Strategy for Genetic Engineering and Biotechnology' launched in 1995. Research using DNA-based technology is currently ongoing for disease diagnosis, therapy (drugs and other products development) and prevention (vaccines). Health biotechnology research laboratories are scattered around numerous universities or research centre departments, such as the biomedical or biotechnological research departments at the National Research Centre (NRC), the GEBRI or the Holding Company for Biological Products and Vaccines (VACSERA), the main Egyptian private company in the field. In contrast to biotechnology research in the agricultural sector, it seems that there is neither an institute dedicated to health biotechnology nor any leading governmental programs or funds.

Two interesting scientometric studies conducted in the fields of Genomics and Health Biotechnology in developing countries over a twelve years period (1990-2002) provide informations on the Egyptian health biotechnology research (Bertrand 2004, Thorsteindottir

2006). These analyses were conducted on several developing countries including Brazil, China, Cuba, Egypt, India, Republic of Korea and South Africa. Numbers of publications in health biotechnology in Egypt show a slight increased (1,6 fold) between 1991 and 2002 (papers recorded in Thomson ISI database) with 159 papers published in the field. The citation index analysis reveals a low visibility and a poor impact of the research. Authorship analyses indicate a high international collaboration rate in the field of Genomic and Health Biotechnology (74,5 and 68,8 per cent respectively in 2002) but also the lowest national collaboration rate (11 per cent and 12,5 per cent respectively in 2002). This highlights Egypt's scientific dependence on international partnerships in genome sciences and health biotechnology. The US, the main collaborator, features in more than 60 per cent of the collaborative papers. The main institutions contributing to genomic and health biotechnology publications come from universities and governmental sectors, with the most active cities being Cairo followed by Alexandria , Giza and Mansoura.

As pointed out by the scientometric analysis, research in biotechnology is mainly undertaken in the public sector. As a consequence, health biotechnology research suffers from a scarcity of resources and high budget constraints. Nonetheless, in the frame of international public health programs some structures associated with a group of strong leading scientist can emerged, as has for example, the Research and Training Center on Vector of Diseases. This centre, located at the Faculty of Medicine within Ain Shams University, works on issues such as Schistosomia infection supported by large international programs. It has an autonomous management with its own budget fuelled by international funding agencies such as World Health Organisation (WHO). The group leaders are integrated into the international network of their field of research and could be implicated in international projects such as the 'Filarial Genome Project'[10].

These elements indicate that Egypt is already engaged in a developing process regarding biotechnologies. Some of its laboratories benefit from an excellent standard that crosses its boarders.

A typology of a fragmented research system

One of the most striking characteristics of the Egyptian research system is its fragmentation. According to our observations we could establish a typology of the various types of laboratories based on two main criteria: the level of access to foreign resources and the level of government support obtained by the lab. By cross-referencing these elements, we obtain four ideal-types, representative of the actual situation.

Criteria	Large Government support	Small government support
Access to foreign funds	Centre of Excellence, ex. AGERI	Autonomous laboratory
Low access to foreign funds	Pharaonic Centre, ex ; MUSCAT	The standard Egyptian lab,

These elements increase or decrease along a sliding scale. For example, small labs without large government support can still rely on small public budgets and benefit from researchers who are state employees. Looking at these two elements is the key to understand the differences between Egyptian labs. The quality of the insertion within international networks, quality of the training and of the equipment, standards of publications, access to internet and on-line bibliographic resources all these elements seem highly interrelated and can be linked

back to one of the discriminative elements we looked at previously[11]. We will give examples of the various types of laboratories based upon our observations and interviews.

The classic academic laboratory

Standard Egyptian labs are generally very small. Their resources often depend upon the state budget. Their staff is provided by the university or the Ministry which supervises the lab. Their legal status defines them as administrative units without the right to act independently. They cannot, for example, freely establish contracts, engage staff or be autonomous in research fields. Their budget is part of the University budget or of the budget of the administrative body (Minister or Centre) that controls their activities.

This kind of lab undertakes research that fits within the research priorities of the Egyptian government. Most of the time, they carry out applied research related to specific Egyptian problems. Agriculture is a main area of research, especially concerning the improvement of crop-yields. These labs focus on local problems. They are not overly concerned with gaining international recognition. Most of the time, these labs adapt international standards to the local situation of the Egyptian research related to very practical issues.

Publication strategies are clearly local. An international visibility through publication in international reviews would not be an advantage as it would not raise more funds or improve the career prospects of researchers.

At the risk of generalizing, equipment and staff training within these labs are limited and old-fashion. The staff lack experience in international networking and the students often have limited access to internet and on-line bibliographic resources.

The autonomous lab

Autonomous laboratories operate according to a different logic. They are often created by highly trained and efficient researchers who have had the opportunity to study abroad and who bring back to Egypt technical know-how and management expertise learned in these other countries. They can capitalise on their contacts with foreign partners and networks which allow them to raise funds and to be associated with international consortia. They can rely on their publications in international peer-reviewed journal to be eligible for external funds. Autonomous labs have control over their own budgets, opening up opportunities to recruit high potential young researchers who benefit in turn from the international networks and the possibility of being trained abroad. To a certain extent, these laboratories are set free from the constraints of the Egyptian administration.

The legal status adopted by those laboratories is called a 'special status' and the labs are called 'special units'. It is different from the usual administrative status mentioned previously. The special status offers more autonomy to the laboratory regarding its relations with the administrative supervisor. They are not controlled by the decision making process of the University or the Ministry. They benefit from a corporate body status. They are free to sign contracts within the private sector. They are free to choose their own fields of research. They can employ or dismiss their own staff.

One of the main advantages that a lab can have, considering the scarcity of funds, is the ability to make contract within the private sector. It can sell products developed from its research activities to the local private sector. In turn, it must pay a quota of the raised funds or of the obtained contracts to its administrative umbrella. In the Health field funds are raised from international donors on public Health research calls ie. WHO, UNDP or USAID. One of the examples is the *Research and Training Centre on Vector of Diseases*, which has become one of the associated laboratories of the WHO. When we interviewed researchers from this lab about the huge scientific reforms Egypt was about to launch, one of them answered: 'It's

not our business, that's politics'. There is no better way to demonstrate how autonomous they are.

Except for their location in Egypt, these laboratories are run just like standard labs in developed countries. The funds come from abroad, the publications are mainly oriented to international peer reviews, a large part of the training is done abroad. Their location in Egypt gives them a comparative advantage over the international competition due to specific access to a local field.

The 'pharaonic' lab

The third kind of laboratory in Egypt is strongly supported by the government. We have labelled that kind of laboratory a 'pharaonic' laboratory not just as a reference to ancient Egyptian history but to make reference to the inclination of implementing huge and costly projects that tend to last long before delivering valuable results. 'Pharaonic' is an appropriate term for the MUSCAT centre with its architecture in the form of a pyramid. The Nile University is another example of a 'pharaonic project' (Sawahel 2004). These huge institutions are expected to fill a gap or loosen a bottleneck identified at the highest level. They attract a large chunk of the public resources. They benefit from up-to–date equipment that would make many laboratories in western countries envious.

As we mentioned before, MUSCAT has been developing the most up-to-date areas of research and is equipped with up-to-date equipment and qualified researchers. These do not seem to be sufficient to create an actively productive research sector linked to users, as was the initial intention of this centre. Developing large cooperative projects and involving both public and private players should be a major prospect. This was precisely the intention for MUSCAT, which is located in an industrial region that gathers almost 40 per cent of the

industrial companies in Egypt. But few if any seem interested in biotechnologies. Moreover, its location, far away from an urban centre, with poor public transportation and employees that carry out an 'uninterrupted working day', leads to the fact that after 3 o'clock in the afternoon, these big buildings are empty[12]. A lot of effort seems necessary to develop the appropriate linkages with the industrial actors that would benefit from the kind of high-end research that is developed into the laboratories of MUSCAT.

The 'excellence model' lab

This is another kind of laboratory which is supported both by the public authorities and by external donors. We call them "excellence labs". They benefit from international cooperation decided between Egyptian authorities and important donors. The best example of this kind of laboratory is AGERI. It was designed to become an excellence centre not only for Egypt but for the whole Arab World. It is the result of a close cooperation between the Ministry of Research and USAID. It was directed for many years by Magdy A Madkour who has always been a strong supporter of biotechnology research. The US support leaded to the creation of a very high standard level research institute. Today, the AGERI institute is composed of 16 laboratories and 3 Service Units which dispose of the most recent facilities to develop research including genomic, proteomic and bioinformatics facilities. A BioComputing & Networks Unit provides the Information Technology (IT) infrastructure required for genetic engineering research one hundred scientists are working in the institute.

This Institute benefits from many advantages. It is endowed with huge levels of public funds and its openness to international laboratories and close links with foreign universities allows high standards of training for young researchers. The staff has access to on-line bibliographic

resources and well maintained laboratory equipment. Regular trips abroad by local researchers and visits by foreign colleagues to the lab facilitate access to spare parts and supplies.

The typology of different Egyptian labs is a key to understand their functioning. This proposal of classification completes the presentation of sectors of activities we made before. They both indicate that strong positive elements exist to establish a dynamic biotechnology research system. In spite of these positive elements, results are very limited. It is then necessary to examine the point.

3.The making of science at laboratory level.

Egypt is still a developing country. But it has already of a substantial sector in the field of biotechnology. Research actors are available: a government which has given biotechnology high priority in its research policy, a research system, mainly public which includes numerous institutions: biological labs whose many of them are engaged in biotechnologies. In other respect, Egypt has implemented a legal framework and the required institutions for the development of biotechnologies.

After twenty years of effort Egypt is still an emerging country as far as biotechnologies are concerned. This is mainly due to inefficient governance rather than scarcity of researchers. Most of the features of the biotechnology governance are also true for the whole research sector and in some respects for the whole Egyptian economy.

The professional framework

In Egypt a large number of researchers might be concerned by biotechnologies. Some reports have proposed that 10 per cent of Egyptian researchers are working in the field (de Beauvais 2005). This figure might be optimistic, but a circle of researchers trained according to international standards does exist.

Our interviews indicate that scientific training followed in English is mainly theoretical and that no practical courses are organised at the university. This can easily be explained by the high costs of the practical courses in the domain of biotechnology, the elevated numbers of students and probably the lack of qualified teachers in the discipline. As a consequence the practical training in biotechnology relies on laboratories.

On the other hand, the career of a researcher in a public institution starts very early. Graduate students can be integrated in a laboratory as a laboratory assistant under the supervision of the senior researcher overseeing their Ph.D. In this context, the quality of the training will depend on the resources available at the laboratory (human, equipment, financial). Moreover, working in a laboratory which develops international collaboration will give access to training in a foreign country.

In the case of the new centre dedicated to biotechnology (AGERI and GEBRI), a large part of its researchers' training is done overseas. Most of AGERI researchers have been trained in the US. Today this institute has at its disposal a body of well-trained researchers with the most recent equipment in the field of genomics. Foreign training is well appreciated and encouraged. As one young researcher told us: "in foreign countries we learn how to think and perform experiments". In 1993, during the first phase of the foundation of GEBRI, the NRC recruited undergraduate students and sent them to the US and Germany to be trained in order to establish a qualified team of researchers. As a result, nowadays, most of the researchers at GEBRI have obtained their Ph.Ds overseas. Foreign training is strongly supported by the successive strategic plan to reinforce the competence of Egyptian researchers.

The recurrence of training in other countries raises the double problem of brain drain and of the local working conditions. The wages of researchers in Egypt are very low generally speaking. A technician working in an academic laboratory earns only 150 to 250 EGP (around 25 euros). A doctoral candidate can hope to earn around 400 EGP (50 euros). A PhD researcher begins at 1000 EGP (120 euros) and a confirmed professor can expect 3000 EGP (360 euros) at the end of his career if he relies only on his official public wage. Compared to Mediterranean countries, and even sub-saharian countries, Egyptian researcher's income level is extremely low. As a comparison a young assistant working in Tunisia earns around 1000 euros.

Due to this very low level of income, research will be only one part of a researcher's activities. First of all, many of them have a heavy teaching load and must spend a large amount of their time in lecturing. Secondly, a public agent in Egypt usually works from only about 9:00 to 2:00 and even less during Ramadan or summer. Most public agents usually have a second or even a third job.

Researchers' careers come up against many characteristics that hinder high standard development. This is much worse for the biotechnology sector which requires dynamic teams able to adapt quickly to a competitive changing environment. The career begins soon before the PhD and according to criteria that are sometimes related to favouritism. Students owe allegiance to their tutor. They maintain loyalty to their institution which depends on different administrative bodies[13]. Therefore, the movement of researchers between laboratories is low. The career path is similar to a country like France but the capacity to build up research programs and networks or to raise fund in an autonomous way require to have reached at least the status of professor.

Hypertrophy and weakness

The Egyptian research sector is characterised by complexity and hypertrophy. Egyptian administration has a tendency to implement new bodies instead of re-arranging what already exists (Moisseron 2007). This is done to avoid affecting the existing decision processes and disturbing the balance of power between departments.

However, adding new research structures instead of reorganizing existing ones leads to an increase in the complexity of information and decision making circuits. This is the main reason for inefficiency in the research system.

In the Egyptian research system, the Ministry of research only controls a small part of the national research budget. This part represents only a fifth of the total budget, according to 1997 figures, equivalent to the research budget of the Ministry of petroleum or the Ministry of Health. It is less than the research budget of the Ministry of Agriculture which attracts 28 per cents of the total budget.

These figures show how research resources are spread out amongst autonomous decision makers who each have their own particular strategy. Other Ministries devoted to the production of goods and services (the Ministry of Petroleum for example) supervise research activities through their affiliated research centres rather than to making use of the Ministry of research.

Biotechnology in Egypt suffers greatly from this lack of coordination. For example, a Paleogenetic laboratory of the University of Mansourah, built up with the support of INSERM[14] and IRD[15] in 2007 was under the supervision of the Supreme Council of Antiquities rather than the Ministry of Research. This lab was devoted to DNA analysis but most of the problems encountered by the cooperation had to do with political issues rather than scientific challenges.

Survival in a constrained environment

Except in the supported laboratories, one of the main problems encountered by Egyptian researchers is the scarcity of resources. Budget constraints are a common complain in every countries but for Egypt shortage of funds affects both wages and operating budget.

Researcher can hardly survive with their 'discount wages'. A second job is not a luxury, it is a necessity. It is a matter subsistence. The survival of the laboratory likewise depends on external resources. Therefore researchers intend to promote generating cash know-how even on a small scale rather than non-profit research.

Competing for international funds is a good strategy to deal with resource shortages but the channels used to raise these funds have to be closely examined. These external funds can have a very positive effect if they contribute to building up scientific capacities. Funding calls may help already existing research teams that are forced to rethink their own strategy during the competition process and to clarify their position in the scientific field. Funding calls can be also a good incentive to establish durable networks that have long term positive effects.

The external funding of the biotechnology sector in the field of Agriculture is organised differently. The funds are not provided according to a competitive process but through regular international grants related to US foreign policy towards Egypt in the context of the Camp David agreements. As an example, USAID initiated one of the largest Agriculture project supported by a foreign donor in Egypt, The NARP (National Agriculture Research Project). Conducted from 1990 to 1994, it consisted in using tissues culture techniques in order to produce virus-free seed potatoes. USAID and the International Potato Centre (CIP) provided technical assistance to NRC which received an annual allowance of US$40 million US dollars

which is equivalent to 28 per cent of the total Egyptian research budget. Such a big allowance, because of its proportional weight, creates a distortion in the research system.

A third drawback might be the dependence upon external funds. In case the fund source dries up, the laboratory would have to face a serious crisis. This has been the case since 2001 when USAID funding for biotechnology research stopped[16]. At the end of the NARP project, NRC contributions to the project felt to US$15,000 including wages. With such a change in the budget, the very existence of the project is put in jeopardy (de Hoop 1996).

One further issue related to relying on foreign donors is that it may lead to less effort being made to identify local problems and local needs. It is difficult for researchers to escape the influence of the foreign donors on their choices in terms of research topics.

Scarcity of resources and low wages force researchers to carry out consultancy work. This is common for researchers in developing countries specially so when crisis situations in the public sector imply loss of budgets. But at the same time, this provokes competition between researchers that is not always of a positive nature. The prospect of "selling" ones knowledge as consultants forces to avoid sharing knowledge in order to keep a monopoly of this particular piece of information, even if its a small and very specialised area. Cooperation is seen as detrimental and in our interviews we repeatedly had complains about the reluctance of researchers to cooperate and to establish networks. Scarcity forces the labs to withhold information and to implement 'niche strategies'. We witnessed the failure of an ambitious research program, which included an international cooperation with Egyptian laboratories dealing with a worrying pest that destroys date palms although large levels of funding were available. The various diverging interests of different organisations (labs, departments of ministries, safety organisation) finally paralyzed the project. This might explain why numerous small labs, focusing on small-scale projects, tend to adopt a low profile strategy as

a way to survive. This lack of cooperation has also been observed in scientometric studies (Bertrand 2004, Thorsteindottir 2006).

The incentives to concentrate on profit-oriented activities could be considered as a boosting element for research. But funding needs are such that labs try to internalise the production and distribution of the products they supply. For example, one lab in Alexandria which specialises in lactic fermentation produces and markets its own cheese. The government also lobbies to encourage the commercial activities of the labs. AGERI has established two units, BIOGRO and GESU (Genetic Engineering Service Unit) in order to develop commercial products and encourage market-oriented research. GESU is described as "the commercial arm of the institute'(Madkour 2000b). It was established in 1994 to facilitate interactions between the private and public sector. It provides reagents, kits and diagnostics produced by genetic engineering and molecular biology for agricultural production and sells state-of-the-art services and products produced by the institute. BIOGRO is a local company with an international branch in the US. It aims to develop commercial products based on the application of research results to real situations and to market these products internationally.

The inclination to focus on market-oriented research is a survival strategy to relieve the pressure on budgets. But that leads to activities that have little to do with research. Survival strategies divert labs from their original purpose. Large amounts of resources and time are diverted away from research towards quasi-industrial and often low-standard activities. It creates a bias towards research likely to make a short-term profit. As a result, laboratories may loose efficiency and become less specialised.

The weakness of the Egyptian private sector

The Biotechnology sector is the sector which needs the largest amount of investment devoted to research and development. In developing countries, the private sector is the major investor in biotechnologies as biotechnologies have a lot of business potential in both the pharmaceutical and the agricultural fields. Some international companies can mobilise research budgets which exceed by far the whole public research budget of a country like Egypt.

In many developing countries, the development of a biotechnology sector depends largely on the size of the private sector in general. For example, in India more than 328 companies and 241 organisations use biotechnology. 96 private companies are exclusively concerned with biotechnology (Kumar 2004). In Brazil as well, a biotechnology sector is emerging with many small and medium sized companies in the agricultural and Health sectors (Rezaï 2008).

From this point of view Egypt is lagging behind. In 2005, there where no existing biotechnology companies in the Health sector and it was difficult to find any in the Agricultural sector (Abdelgafar 2004) Even if the Egyptian pharmaceutical sector is well developed and cover more than 93 per cent of the local needs, this sector appears poorly developed in recombinant technologies field. Egyptian companies report local production of interferon α-2B, a treatment of Hepatitis C, or the local production of recombinant insulin for diabetes treatment but the local production is restricted to packaging or local formulation of imported unfinished products (Abdelfagar 2004). This situation reflects the weakness of the private sector in Egypt and also the Venture Capital Industry[17].

'The Venture Capital/Private Equity Industry in Egypt is still in its early stages' (Heywood Miller, 2006, p.2). This can be explained by the legal and regulatory environment, which is considered as a major impediment for the growth of Venture Capital/Private Equity Industry. The second reason for the weakness of Joint venture in Egypt is the scarce management resources and the need for better human capital. But encouraging entrepreneurship is also

critical. “Without entrepreneurs there is no need for a VC Industry” (Heywood Miller, 2006, p.2). This is true for biotechnology.

The private sector is also very important for the day to day functioning of the labs. Access to specialised companies for the maintenance of sophisticated machines can avoid interruptions in research activities. Specific suppliers are needed for chemical products or equipments that are used in labs. In Egypt, such companies do not exist. If a laser is out of order or defective, it is almost impossible to find somebody able to repair it. When a public lab needs to order products, it can take many weeks or months to be delivered. We were personally witness to the delays of several months endured by the director of the Paleogenetic lab previously mentioned, just to import donated equipment from France. Local taxes and administrative costs for importing those equipments were beyond the means of the Egyptian lab.

Conclusion

Biotechnology has taken the first step in its emergence. To use an appropriate image, basic ‘cells’ or building blocks of the system are now available. Egypt has at its disposal a significant number of trained researchers, labs that are considered as ‘models’ in the Arab world, and that have obtained consistent results in the areas of agriculture, health and industry. The general framework required for managing biotechnology is also now available in Egypt. Biotechnology has been a high priority for the Egyptian government for twenty years and the government has gradually implemented an institutional framework regarding property rights, safety and information.

Even though the building blocks are now available, it is necessary to improve the way these blocks are arranged in order to ensure a dynamic development of the whole system. Egypt suffers as much from a lack of governance as it does from a lack of funds.

The Egyptian government is very aware of the issues surrounding the management of biotechnologies and a large reform process is on the way. In 2005, a national strategic plan for scientific and technological research was launched by the new Minister of Research and Higher Education (Koenig 2007).

To address many of the challenges and impediments highlighted in this paper, the Egyptian State Ministry for Scientific Research has launched an ambitious new strategy for Research and Technology in 2007. Two major institutions have been created: The Higher Council for Science and Technology (HCST) and the Science and Technological Development Fund (STDF). The former is supposed to provide the basis for a better prioritisation of R§D regarding the national research strategies. The latter improves incentives for researchers and represents a new instrument to strengthen the links between research and industrial needs.

This obvious willingness to boost the S§T in Egypt was embedded in the 'President Moubarak Initiative for a Decade for Science and Technology'. International cooperation of Egypt is no longer mainly directed to the US but also with Europe. EU has granted 11 millions euros to implement an EU-Egypt Innovation Fund, a RDI Network and to finance policies for monitoring and evaluation of RDI initiatives[18].

The National strategic goals developed by the Academy of Scientific Research and Technology (ASRT) in its Roadmap aimed to overhaul S§T by acting in three fields: Firstly, a specific attention is drawn to young scientists. Secondly, research activities should be translated into final products and services. Main support will be focused on applied science. Thirdly, incoming and outgoing fellowships and visits, conference attendance and international cooperation will be supported in order to achieve excellent researches regarding

international standards and high level of publications in the best international peer-reviewed journals. To achieve these goals, the ASRT will establish centres of excellence and incubators and will offer funds for innovative research projects. The priorities on thematic areas include: biotechnology, renewable energy, health, pharmaceutical science, food and agriculture, water as well as information and communication technologies.

It is too early to assess the results of such a reform. It seems however that S§T is not yet completely integrated in the global development strategy of Egypt. As quoted by the OCDE/World Bank Report: "Two important dimensions are noticeably absent from this economic development plan (i.e, the Five Years Plan 2007-2012), (i)harnessing and augmenting research and development to support the prioritised areas of economic growth and innovation, and (ii) engaging purposefully through international collaborations to expand Egypt's capacity and networks for sustaining its competitiveness"(OCDE/World Bank 2010, p.72).

This means that if Egypt is largely conscious of the necessity to implement the required institutions of a knowledge-base economy, the transition process will be long and must deal with many characteristics of the research system. An ambitious scientific policy focusing on Biotechnology must take into account the general constraints of the research system as a whole.

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Number and affiliation of RDI workers in Egypt

	Ministry	Number of Research Center and Institutes	Number of RDI workers
1	Universities (Ministry of Higher Education MOHE)	19 (public + Al Azhar) + 13 private universities	63174
2	NRC and misnistry of Scientific Research (MOSR) Institution	13	5768
3	M. of Industry and Trade	24	1287
4	M. of Agriculture and Land Reclamation	29	86669
5	M. of Military Production	na	26
6	M. of Petroleum and Minerals	25	2711
7	M. of Information	na	30
8	M. of Communication	na	105
9	M. of Investment	19	561
10	M. of Housing and Urban Communities	na	599
11	M. of Education	na	190
12	M. of Culture	10-12	455
13	M. of Environment	na	60

14	M. of Administrative Development	na	182
15	Health and Population	28	2527
16	M. of Manpower and Immigration	na	106
17	M. of Water Ressources and Irrigation	29	632
18	M. of Transportation	24	656
19	M. of Planning	10-12	261
20	M. of Civil Aviation	24	170
21	M. of Electricity and Energy	24	4275

Source: OCDE-Worldbank, 2010, p.225 and Eskandary 2007.

[1] For a full study, see (Madkour 2000)
[2] The scope of the NBC activities and/or responsibilities include: Formulating, implementing and updating safety codes; risk assessment and license issuance; providing training and technical advice; reporting annually to governmental authorities; coordinating with national and international organisations. »
[3] Through ABSP 2 under a world-wide IFPRI program (Brenner 2004)
[4] AGERI webSite: http://www.ageri.sci.eg/topic7/biostat.htm
[5] EBIC web site : http://www.egypt-bic.com/whoarewe_eng.htm
[6] http://www.fao.org/biotech.
[7] http://www.mcsrta.sci.eg
[8] Data from P.L. Rossi, IRD, from the Thomson ISI database
[9] Data WHO
[10] http://www.nematodes.org/fgn/net/fgplabs.html
[11] A similar approached has been proposed by Crow and Bozeman (1987) but the main criteria where rather proximity to markets.
[12] The 'uninterrupted working day' means a working day without lunch break. The employees leave the job earlier.
[13] 'We start and we end at the NRC' told us a NRC researcher.
[14] French Health Research Institute
[15] French Research Institute for Development
[16] The new programs of USAID after 2001 for Egypt are dedicated to education and Human rights. Biotechnology sector is not a priority anymore for USAID.
[17] The share of the private sector in GDP decreased from 70,7 to 62,3 per cent from 2003 to 2005 (Moisseron 2007)

[18] http://www.delegy.ec.europa.eu/en/EU_EGYPT_Cooperation/EC_Bilateral_Cooperation_new.asp