THE TRANSFORMATION OF BASIC RESEARCH INTO COMMERCIAL VALUE: ECONOMICS ASPECTS AND PRACTICAL ISSUES

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Abstract

Basic research may be considered as the first step in the knowledge generation or innovation process. Knowledge is probably recognized as the most important factor in the development of national economies. Governments therefore have a role in ensuring and subsidizing the basic science to generate knowledge aimed to improve social welfare.

Since basic research is conducted mainly at universities nowadays, they should set to support all aspects of knowledge generation and transfer - from basic research (invention) to innovation and ultimately, to commercialization. The transformation of knowledge or innovation into commercial value depends primarily on efficient pathway(s) of technology transfer by universities' technology transfer organizations. Ideally, universities should seek to transfer technology to the private sector in order to capture the benefits of commercialization of their innovation. However, in circumstances where the innovation is at an early or premature stage, consequently far from materializing to a product, licensing to industrial enterprises is not (always) plausible, hence feasible alternatives should be sought. In this short review, we argue possible modi operandi to achieve these goals.

***Key words**: Basic Research; Knowledge; Innovation; IP; Technology Transfer; Licensing; Spin-off companies.*

Introduction

The purpose of this paper is to briefly discuss the potential contribution of universities applicable research to the achievement of economic growth. This paper is by no means an exhaustive review but rather aimed at bringing about a discussion on practicable avenues to commercially exploit scientific achievements and technological innovation from academia.

The rapid pace of technological advancement that has led many national economies forward for the past two centuries is not self evident. Indubitably, the growth of economies in industrialized countries has been driven mainly by the pursuit of scientific research, the implementation of innovative engineering solutions and a constant flow of technological innovation. It is now apparent that the knowledge base of modern economies has steadily increased, and the ability of a society to produce and commercialize knowledge is critical for sustained economic growth and improved quality of life.

Medical (and biomedical) research, for example, has certainly brought economic benefit and welfare. The increase in life expectancy in the twentieth century is generally attributed to improved drugs, vaccines, antibiotics, advanced diagnostic methods and other medical treatment breakthroughs. Silverstein et al. (Silverstein, Garrison, & Heinig, 1995) compiled data on cost savings from medical research. Following are few arbitrarily selected examples: polio vaccine saves $2 billion per year in the US; hip-fracture prevention in postmenopausal women at risk for osteoporosis saves $333 million annually. Kidney

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transplantation, improved efficacy and safety, save between 360-480 million per annum in reduced treatment costs and lost earnings. Treatment for testicular cancer has resulted in annual savings of 134.0-178.7 million from improved survival and reduced premature mortality.

The power of research is demonstrated not only by single innovations but by the ability to create entire new industries, such as *molecular biology* (genetic engineering), which in turn has led, among others, to new therapeutic modalities and the enormous growth of the biotechnology industry. The potential of these developments for healthcare is only beginning to be realized.

It is evident that universities have become more important players and scientists, researchers and engineers have played a critical role in driving technological progress. In order for the benefits of university research to be expressed in the economy, the universities have to find the way to effectively liaise with the industrial domain and explore efficient mechanisms for the transfer of technology to industry.

In this review we argue the role of basic research to generate knowledge which can be transformed into economic value. We discuss, among others, the common process and methodologies currently applied to the transfer of applicable scientific research and innovation from universities to the industry.

The Role of Basic Research in Generating Innovation

Basic research is conducted at universities and research institutions, and is primarily directed for the advancement of knowledge and scientific discoveries. Scientists often endeavor to solve scholarly problems without immediate expectations (or even interest) to utility implication. Consequently, basic research may produce results of vast scientific value, but not necessarily with plausible economical significance, if at all. Incontestably, universities' main goals are, *and should remain to be*, the discovery and dissemination of new knowledge, on one hand, and higher education teaching[2], on the other hand.

The increased importance of basic research is also the emergence of certain new technologies and knowledge (such as *biotechnology*, discussed hereinafter) which depends on and requires very basic research that might eventually materialize to marketable products.

From the laboratory bench to the market place

A remarkable contemporaneous example to illustrate the long journey *'from the laboratory bench to the market place'* is the development of Copaxone®[3], among the most unique of modern drug discoveries, initiated at the Weizmann Institute of Science in Rehovot, Israel (WIS). It is a notable example of basic research with vast impact on human health and economic benefit. The roots of this drug are to be found in the research of Ephraim Katchalski Katzir[4], who, back in the 1940s, prepared synthetic polypeptides—long molecules resembling proteins. Ten years later, Katzir's student, Michael Sela, discovered that these synthetic polypeptides could activate the immune system. A decade later, Sela, together with his student Ruth Arnon and Dvora Teitelbaum were working to determine the minimum chemical

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[2] A rather important effect of basic research is the training that graduate students receive, which later enable them to engage in innovative firms. The movement of trained personnel into industry can be a powerful mechanism for the dissemination of scientific research thus affecting the efficiency of R&D – 'Human Capital'.

[3] Copaxone®, Teva's (see Footnote 5) first major innovative drug, is the leading multiple sclerosis treatment. Multiple sclerosis (MS) is a chronic disease of the central nervous system. Worldwide, MS is thought to affect more than 2.5 million people.

[4] Eminent scientist and the fourth President of the State of Israel (1973-1978)

constituents necessary to make a molecule immunogenic, that is, to give it the ability to elicit antibodies in an animal. Later, they began to examine possible applications for such molecules with interest in the immunology of lipids. They have made a serendipitous discovery of a drug (or 'therapeutic vaccine') for the exacerbating-remitting form of multiple sclerosis. The pathway of the drug discovery is vividly summarized in Michael Sela's presentation at the Plenary Session of the Pontifical Academy of Sciences on 'Paths of Discovery' which was held in November 2004 in the Vatican (Sela, 2006). These experiments eventually led to the development of Copaxone®. The active molecule was patented and licensed to Teva Pharmaceutical Industries (Teva)[5]. Clinical trials carried out by Teva showed its efficacy in treating MS. At the end of the process, in 1996, Copaxone® became the first original Israeli drug to be approved by the US Food and Drug Administration (FDA). Today, following fifteen years of active sales in the U.S. and 40 countries around the world, Copaxone® has made a significant contribution to the Israeli economy and to patients' wellbeing. Global market sales of Copaxone® reached a record $3,316 million in 2010[6]. The development of Copaxone® is not a single example whereby basic research has evolved to commercial products.

The role of basic research in 'knowledge-based economies'

It is generally accepted that basic research may be considered as the first step in the process of knowledge generation that might lead to discoveries and inventions that have a significant impact on society. To this end, scientific knowledge[7], resulting from basic research and inventions thereof has been long recognized to have characteristics of a pure public good (see for example, (Nelson, 1959) (Arrow, 1962)). Knowledge is accordingly recognized as a critical determinant of economic growth and standard of living. The role it plays in the process of innovation and economic growth has become even more central since the emergence of the so-called 'knowledge-based economies' - economies which are directly based on the production, distribution and use of knowledge (OECD, 1996). In fact, the science system carries out key functions in the knowledge-based economy, including knowledge production, transmission and transfer.

The characteristic of the knowledge-based economy has emerged with changes to the linear model of innovation (Figure 1: Linear Model of Innovation). This theory held that innovation is a linear process which begins with new scientific research, progresses sequentially through stages of product development, production and marketing, and terminates with the successful sale of new products, processes or services. However, innovation can assume many forms, including incremental improvements to existing products, applications of technology to new markets and uses of new technology to serve an existing market (see also Footnote 5). Therefore, it is argued now that the process is not completely linear, it rather requires extensive communication among the different players (OECD, 1996).

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[5] Teva Pharmaceutical Industries Ltd. is a global pharmaceutical company, based in Israel, specializing in the development, production and marketing of generic and proprietary branded pharmaceuticals as well as active pharmaceutical ingredients.

[6] Teva Annual Report 2010 (FORM 20-F (US Security and exchange Commission - SEC).

[7] Knowledge in general, disregarding to its origin or the way is generated, is considered as a public good.

Figure 1: Linear Model of innovation

It should be further noted that knowledge can be non-excludable since, once it is made public, in the absence of clearly defined and protected property rights (e.g. patented), users cannot be prohibited from using it. Some forms of knowledge are (or can be made) excludable. For instance, it may be possible to keep new knowledge secret ('trade secret'), thereby excluding use by others. The most common way of excluding knowledge is by seeking protection through patents. Nonetheless, certain advances in basic knowledge, such as mathematical theorems, are not patentable despite their importance and their potential practical applications.

The Funding of Basic Research

Academia has traditionally been considered the primary producer of new knowledge, largely through publicly funded basic research at universities and academic institutions. Funding of university research, particularly applied research, by the private sector and industry is also considerable; however it will not be discussed in this paper. Justification for the public funding of basic research has been largely discussed in the literature; see for example (Scott, Steyn, Geuna, Stefano, & Steinmueller, 2001). It has been advocated that it should be governments' interest in funding basic research because of the potential benefits that it is perceived to bring to society. The justifications for funding basic research can be generally classified as instrumental, which often refers to direct or indirect economic benefits. To this end, Salter and Martin have classified six types of benefits: increasing the stock of knowledge; skilled graduates; new instrumentation and methodologies; networks and social interaction; technological problem-solving and creation of new firms. Consequently, they reasoned that no simple model of the economic benefits from basic research is possible (Salter & Martin, 2001). Though measuring rates of return to basic research may be particularly challenging, nonetheless, it is evident that the contribution of basic research to society is indisputable.

Another strong argument that public funds are needed to support the scientific research is the 'public good' argument, according to which there is a 'market failure' if the production of scientific knowledge is left to the private sector alone (Nelson, 1959; Arrow, 1962). This argument is increasingly being challenged and it is beyond the scope of this paper to further discuss it. We are, however, witnessing new arguments concerning the importance of science in the so-called '*knowledge-based economy*' used to justify the public support of basic research. This term emerged from recognizing the place of knowledge and technology in modern western countries economies. It became apparent that in the past few decades economies are more dependent on the production, distribution and use of knowledge than in previous times. In the knowledge-based economy, the science system contributes to knowledge production; knowledge transmission (i.e. educating and developing human resources); and knowledge transfer (i.e. disseminating knowledge). The government therefore has a role, or rather a duty, in ensuring and subsidizing the basic science to generate knowledge aimed to improve social welfare. Governments should therefore adapt their mechanisms and priorities for financing research.

It should be pointed out that research evaluation has emerged as a key science policy issue in most industrialized countries. Quantitative measures of the output of academic research seldom go beyond counts of research papers, patents, and royalty income, none of which directly correlates with the impact on industry[8]. Many countries have introduced procedures for the evaluation of university research (OECD, 1997). Challenges for the future include greater pressure from governments for demonstrable merit of the basic research it supports.

Most industrialized countries have publicly funded research-grant programs that attempt to channel public resources directly into R&D projects that are anticipated to have particularly large social benefits (Figure 2: Civilian R7D Expenditure as Percentage of GDP 2009). For instance, the US National Institutes of Health (NIH) invests over $31.2billion annually in medical research. More than 80% of the NIH's funding is awarded through almost 50,000 competitive grants to more than 325,000 researchers at over 3,000 universities, medical schools, and other research institutions in every state and around the world (NIH Budget, 2011). The EU's Seventh Framework Program for Research is the largest in the world with a budget of more than €50.5billion (excluding EURATOM), for 2007-2013 (EU Memo, 2010).

The necessity for and the significance of public funding is particularly relevant to biotechnology[9], which is an emerging field that remarkably illustrates a potential high return. It is incontrovertible that biotechnology is a vital key to enabling technology for the 21st century. The biological sciences have been adding value to an array of products and services, bringing forth the "*Bioeconomy*" and offering the potential to make major socio-economic contributions (Konde, 2002) , (JRC Reference Reports, 2007), (OECD, 2009) and (Levy, 2011). The bioeconomy will be influenced, among others, by public research support, regulations and intellectual property rights.

The biotechnology industry has emerged as a major growth area in the global healthcare industry. Since its emergence in the 1970s, the biotechnology market has shown tremendous growth, reaching approximately $128 billion in 2009 (Biotechnology Industry Yearbook, 2010). Today, there are more than 250 biopharmaceuticals and vaccines, with hundreds more in the pipeline. In 2009, 14 million farmers in 25 countries planted 134 million hectares of transgenic plants. Industrial biotechnology supports a growing US$2.9 billion global market for industrial enzymes (Greenwood, 2010).

The biotechnology industry survived tough times to a large extent because of the remarkable value it adds to society health, renewable energy sources and sustainable industrial processes and providing crops.

Further indicators for economical impact and valuation of biotechnology industry include the NASDAQ Biotechnology Index (see Figure 3, Endnote[i]) and the industry's collective market cap of $405 billion, as of July 2011 (Burrill & Company, 2011).

In summary, we should bear in mind that biotechnology requires a strong academic environment and must be nurtured carefully by an often long, laborious and costly basic research. The later development and implementation is also an extensive and expensive process (see discussion hereinafter). The public sector is, and should remain to be, a major player in nurturing biotechnology and accounts for a notable share of research.

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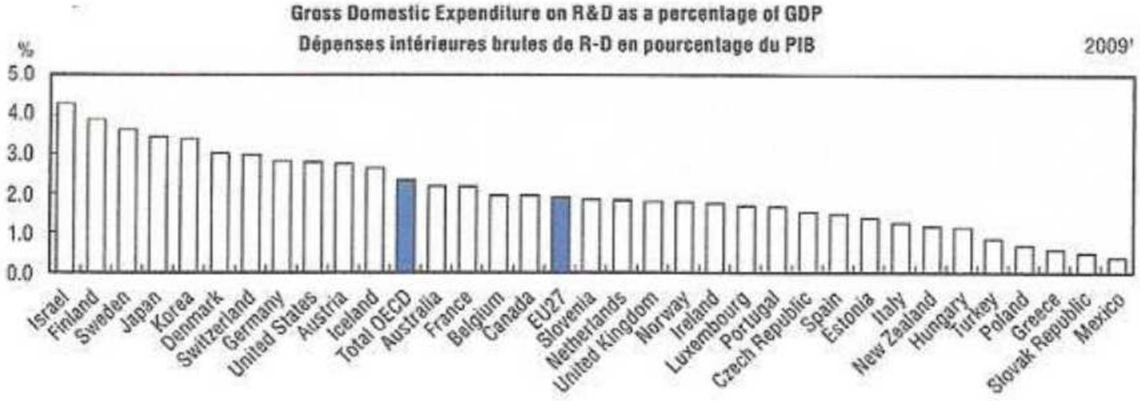
8 While industrial performance can be measured by shareholder value, employment growth, market share, technical advances and other factors.

9 Modern biotechnology applications are mainly related to the following areas: human and animal, primary production/agro-food, industrial processes and environment and energy. The term BioMed is also used with respect to life sciences and medical devices medical devices.

Figure 2: Civilian R&D Expenditure as Percentage of GDP (2009)



Source: OECD© (2011), "Gross domestic expenditure on R&D", Science and Technology: Key Tables from OECD, No. 1.

Commercialization of Innovation – Mechanisms of Transfer from Academia to industry

Technology transfer may be generally described as the mobility of knowledge or technology from one entity to another, including private firms, government agencies, government laboratories, universities and even entire nations. More practically, it is defined as the process by which a developer of technological innovation and owner of IP right (IPR) avails it to a business partner for commercial exploitation. In this paper we limit the scope of our discussion to the transfer of university-based innovation to the industrial sector.

A solid foundation of academic excellence and cutting-edge basic and applicable research, in conjunction with appropriate funding, are a fundamental prerequisite for beneficial commercial exploitation of universities and research institutes innovation. Ideally, university structures should be able to support all aspects from basic research (invention) to innovation and eventually to commercialization. In order to capture the benefits of commercialization, universities should seek to transfer their technology to the business sector. That can be achieved via a number of different mechanisms, as discussed hereinafter.

The Role of TTO

Strong technology transfer organizations[10] (TTO) combined with a solid IPR protection capacity is crucial for successful consummation of technology transfer transactions. TTOs are thus considered to be a valuable instrument for screening and assessing innovative applicable research projects in-campus, on one hand, and connecting researchers with the industry, on the other hand. A diligent evaluation process is essential for the selection of the most appropriate projects representing a significant commercial potential and commercialization opportunity. Basic criteria determining the viability of the outcome of applicable basic research include, among others: (i) market potential; (ii) competitiveness and (iii) patentability of the results/invention. The latter is of particular significance in view of the costs involved and the importance of creating a strong IPR position, which is a vital factor for decision making by licensees. Moreover, the most efficient and pertinent way of commercialization of each particular innovation (project) should be determined specifically for and in accordance with the case, as it may be.

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[10] TTO also refers to technology transfer offices or technology transfer companies. Not to be confused with 'brokerage' activity.

We reason that in order to achieve these goals, each university (or such other academic institution) should establish its own TTO designated to commercialize its innovation. The TTO should be an independent, yet controlled by the university, legal entity or agent, engaged exclusively with the commercialization of the university's inventions and authorized to conclude technology transfer transactions, aiming at generating revenue to support further research and education[11].

It is therefore advisable that TTOs recruit experienced people, possessing international business experience, and retain competent consultants to proficiently carry out the assessment process. Strong IPR protection should be duly obtained for elected inventions which demonstrate high commercialization potential. An appropriate patent application policy (taking into consideration that it is a vast financial burden) should be therefore determined and applied by the TTO.

Ownership of IP

Ownership of the IPR presents an additional material issue which should be addressed. It is now a common policy and practice in developed countries that universities claim and retain title to inventions made by their faculty scientists during the course of their research. This is implemented either by legislation or contractually (i.e. employment contracts). In the US, for example, the Bayh-Dole Act[12] created a uniform patent policy among the many federal agencies that fund research, enabling also universities, to retain title to inventions made under federally-funded research programs. In our opinion, a more general strategy should be endorsed, according to which the ownership of IPR should neither depend on the source of funding (e.g. governmental) nor on the nature of the employer (e.g. public, NGO's etc.), but rather should be determined by and depend on the employer-employee labor relations in general. Such policy is implemented, for instance, in the Israel Patent Law[13] and the UK Patent Act[14]. In accordance with Section 132 (Chapter Eight, Service Inventions) of the Israel patent Law, an employee must notify his employer of any invention which he made in consequence of his service or during the period of his service, as soon as possible after he invented it. An invention made by an employee, arrived at in consequence of his service and during the period of his service (designated as '*Service Invention*') shall, in the absence of an agreement to the contrary between him and his employer, become the employer's property, unless the employer waives the ownership to the invention[15].

In absence of appropriate legislation, universities may contractually stipulate title to so-called 'Service Inventions' in the employment agreement.

Incentives to Scientists

Scientists are unlikely to be experts in legal and business domains and therefore their cooperation with the TTO officers may facilitate the commercialization of their inventions. TTOs must seek scientists' cooperation in order to successful commercialize their inventions. Such cooperation will mainly depend on trusting the competence and performance of the TTO officers. To achieve this goal, *ex ante* incentives for scientists to disclose their inventions and *ex post* incentives upon the beneficial commercialization of their innovation, should be sincerely considered. We propose possible *modi operandi,* which are based on our experience

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[11] It is anticipated that the academic institutes provide initial finance to the TTO and later on the TTO should obtain certain management fees.

[12] P.L. 96-517, Patent and Trademark Act Amendments of 1980.

[13] The Israel Patents Law (5727-1967)

[14] See, among others, also The UK Patents Act (1977).

[15] Section 132 in Chapter eight: Service Inventions of the Israel patent Law (5727-1967), as amended.

in Israel. Award of compensation to the inventors should be such as will secure a fair share of the benefit which the university has derived. We believe that the award should be allocated mainly to the inventor(s)[16] himself, however part of the award should be allotted to support the scientist ongoing research. Under appropriate circumstances[17], TTOs should consider offering licensing the IP to the inventors themselves or in certain cases even assigning the IPR to pertinent scientists, who can demonstrate the competence to effectively commercialize it[18]. That should be in return for sharing future proceeds (i.e. by way of royalties) and/or equity shares in the Spin-off Company established by such scientists.

Technology Transfer Transactions – Licensing vs. Spin-Off companies

For universities, technology transfer by way of licensing out can successfully and effectively bring their innovation through to the market place. The license is a permission granted to licensee by licensor to use the patent(s) for the development, manufacturing and sale of the 'licensed product', in return for royalties (a certain percent) of revenues from sales of the licensed product. Royalties can be considerable and reach millions of dollars per year. According to the Association of University Technology Managers, universities' total royalty income on patents in the US has exceeded $1 billion per year. Interestingly, much of that income is from biomedical patents (AUTM, 2005). To this end, some remarkable licensing instances of basic research in the medical field from academia in Israel to industry are shown in Table 1: List of Licensed Innovative Drugs from Universities in Israel.

TTO's should seek to license their IP to appropriate commercial entities, which are financially, technologically and operationally competent to develop, manufacture and market the university innovations. However, in circumstances where the innovation is at an early stage and far from materializing to a product, licensing is not (always) plausible; TTO's should therefore explore alternative avenues. This is particularly applicable to new drug discovery (see below) and innovation in biomedical area. For illustration purpose (and interest) we will contemplate the pharmaceutical domain.

Applicable basic research results in medical sciences may be regarded as the "discovery stage" (early stage) of a potentially new drug or medical technology. It is a common knowledge that the development of new drugs (and medical innovations in general) requires massive long term investments in R&D, expertise in pharmaceuticals development, obtaining regulatory approval, production and marketing capacities. On average, developing an innovative new drug takes about 12 years. A recent estimate of the average cost of developing an innovative new drug is over $800 million, including expenditures on failed projects and the value of forgone alternative investments (DiMasi, Hansen, & Grabowski, 2003). Hence, due to the unpredictability of innovative biomedical developments, pharmaceutical companies diverse R&D to divide risk across many projects. Large pharmaceutical companies find viable innovation to be much more difficult to accomplish internally (Christensen, 1997). The challenges, including, among others, lack of in house basic research set-up and activities, encourage large Pharmaceutical firms to pursue collaborative alliances. Pharmaceutical executives seem to recognize that collaborative arrangements provide a vital mechanism enabling to expand product pipeline. Nonetheless, most of the pharmaceutical companies (and to a certain extent, medical device companies) tend to refrain from engagement in an early stage of the discovery, namely in the basic research stage. Often they are willing to become involved after preclinical and toxicology

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[16] The practice in Israel is that universities share royalties received at least 60:40 with the scientists/inventors.

[17] i.e. in the event of establishing a spin-off company.

[18] The author of this paper was personally engaged in the two instances.

studies have been satisfactory[19]. Indubitably, preclinical and toxicology studies, which are costly and may require expertise unavailable on university campus, are not within the scope of academic research and therefore are not presumed to be carried out at universities. We surmise that under these circumstances, licensing to third parties (e.g. pharmaceutical companies) would be impractical, and that the formation, by the TTOs or otherwise, of independent new spin-off entities, that would be dedicated and focused on the completion of preclinical and toxicology studies[20], would be a more proper technology transfer avenue.

Successful technology transfer by universities to spin-off companies depends, among others, on cutting edge innovation, a strong IPR position, entrepreneurial spirit, competent management, appropriate long term financing, significant competitive edge and market growth, a supportive board of directors and a viable business strategy. The role of spin-offs to economy growth, in general and for the benefits of universities, in particular, is addressed by the author elsewhere (Levy, 2011).

Table 1: List of Licensed innovative Drugs from Universities in Israel

Product	Indication	License	Sales in 2009 (in millions)	Licensor
Copaxone	Multiple Sclerosis	Teva	$2,826	Weizmann Institute (WIS)
Rebif	Multiple Sclerosis	Merck- Serono	€1,537	WIS
Exelon	Alzheimer	Novartis	$954	Hebrew University Jerusalem (HU)
Doxil/Caelyx	Cancer	Schering-Plough	$295	HU and Hadassah Hospital, Jerusalem
Aziltec	Parkinson	Teva	$243	Technion medical School (Haifa, Israel)
Erbitux	Cancer	Merck- Serono	€697	WIS

Sources: Companies' Annual Reports 2009

Conclusion

It is evident nowadays that basic research creates knowledge that may lead to discoveries and inventions that have a significant impact on society. Basic research may be therefore considered as the first step in the knowledge generation or innovation process. The ability of a society to produce and commercialize knowledge is critical for sustained economic growth and improved quality of life. Recent policy statements from the OECD, the World Bank, and others, clearly echo that knowledge is the most important factor in economic development. The role it plays in the process of innovation and economic growth has become even more central since the emergence of the so-called 'knowledge-based economies' - economies which are directly based on the production, distribution and use of knowledge. Governments therefore have a role in ensuring and subsidizing the basic research to generate knowledge aimed to improve social welfare.

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[19] This is also based on the author's personal experience.

[20] In certain cases, even conclude phase I clinical studies [Phase I: researchers test an experimental drug or treatment in a small group of people for the first time to evaluate its safety, determine an appropriate dosages, traces what happens to the compound in the body, and begin to identify side effects].

The transformation of knowledge or innovation into commercial value depends primarily on successful transfer of the technology. Ideally, university structures should support all aspects from basic research (invention) to innovation, as well as commercialization. Universities should seek to transfer technology to the private sector in order to capture the benefits of commercialization of their innovation. To this end, TTOs are expected to play a crucial role and should be therefore structured and managed accordingly. For universities, technology transfer by way of licensing out can successfully and effectively bring their innovation through to the market place. However, in circumstances where the innovation is at an early stage and far from materializing to a product, licensing is not (always) plausible; TTO's should therefore explore alternative avenues, such as formation of spin-off companies. Not least, scientists (inventors) should be properly compensated for their contribution to economic profits of the universities.

In summary, successful commercialization of applicable discoveries and inventions may well serve the interests of the university, the scientific community and society in general.

Figure 3: NASDAQ BIOTECHNOLOGY INDEX*(five years, as of July 18, 2011)

Source: NASDAQ*

*The NASDAQ Biotechnology Index includes securities of Nasdaq-listed companies classified according to the Industry Classification Benchmark as either Biotechnology or

Pharmaceuticals which also meet other eligibility criteria. To be eligible for inclusion in the Index, the security must have, among others, a market capitalization of at least $200 million.

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Abstrakt

Badania podstawowe mogą być traktowane jako pierwszy krok w tworzeniu wiedzy lub procesu innowacji. Wiedza jest uznana współcześnie za najważniejszy czynnik w rozwoju krajowej gospodarki. Rządy pełnią zatem ważną rolę w zapewnianiu i dofinansowaniu badań podstawowych, których celem jest do tworzenie wiedzy w celu poprawy opieki społecznej. Badania podstawowe prowadzone są głównie na uniwersytetach, w dzisiejszych czasach, powinny one mieć wsparcie we wszystkich aspektach generacji i transferu wiedzy - od badań podstawowych (wynalazek) do innowacji i ostatecznie do komercjalizacji. Przekształcanie wiedzy i innowacji w wartość handlową zależy przede wszystkim od efektywnego transferu technologii przez organizacje transferu technologii. Uczelnie powinny dążyć do transferu technologii do sektora prywatnego w celu uzyskania korzyści z komercjalizacji ich innowacyjności. Jednak w sytuacji, gdy innowacja jest na wczesnym etapie, w konsekwencji też daleko jej do materializacji w postaci produktu, otrzymanie licencji dla przedsiębiorstw przemysłowych nie jest nierzadko możliwe.