



**Committee for the Evaluation of
Biotechnology & Biotechnology Engineering Study Programs**

General Report

February 2012

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Chapter 1 General Background

At its meeting on July 25, 2010, the Council for Higher Education (CHE) decided to evaluate study programs in the field of Biotechnology and Biotechnology Engineering during the academic year 2012.

Following the decision of the CHE, the Minister of Education, who serves ex officio as Chairperson of the CHE, appointed a Committee consisting of:

- **Prof. Moshe Rosenberg**, Department of Food Science & Technology, UC Davis, USA, Committee Chair¹
- **Prof. Gad Galili**, Department of Plant Sciences, Weizmann Institute of Science, Israel
- **Prof. Milica Radisic**, Institute of Biomaterials and Biomedical Engineering, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Canada²
- **Prof. Joseph Shiloach**, Biotechnology Core Lab, NIH- National Institutes of Health, USA

Ms. Yael Elbocher - Coordinator of the Committee on behalf of the CHE.

Within the framework of its activity, the Committee was requested to:³

1. Examine the self-evaluation reports, submitted by the institutions that provide study programs in Nutritional Sciences, and to conduct on-site visits at those institutions.
2. Submit to CHE an individual report on each of the evaluated academic units and study programs, including the Committee's findings and recommendations.
3. Submit to the CHE a general report regarding the examined field of study within the Israeli system of higher education including recommendations for standards in the evaluated field of study.

The entire process was conducted in accordance with the CHE's Guidelines for Self-Evaluation (of October 2010).

¹ During the first round of visits Prof. Carl Batt of Cornell University was Committee Chair. During the period between the two rounds of visits Prof. Batt resigned due to incomparable disagreements

² Prof Radisic joined the committee for its second round of visits, thus did not take part in the evaluation of Tel Hai College, ORT Braude College and The Hebrew University of Jerusalem

³ The Committee's letter of appointment is attached as **Appendix 1**.

Chapter 2 Committee Procedures

The Committee held its first meetings on March 14, 2012, during which it discussed fundamental issues concerning higher education in Israel, the quality assessment activity, as well as Biotechnology and Biotechnology Engineering Study programs.

In March 2012, the Committee held its first round of visits of evaluation, and visited Tel Hai Academic College (**THAC**), ORT Braude College (**OBC**) and the Hebrew University of Jerusalem (**HUJ**). In June 2012 the Committee conducted its second evaluation cycle, and visited Ben-Gurion University of the Negev (**BGU**), Hadassah Academic College Jerusalem (**HAC**), Tel Aviv University (**TAU**) and the **Technion**. During the visits, the Committee met with various stakeholders at the institutions, including management, faculty, staff, and students.

The Committee wishes to thank the management of the institutions and the Biotechnology and Biotechnology Engineering departments for their self-evaluation reports and for their hospitality towards the Committee during its visits. The Committee wishes to thank Ms. Yael Elbocher and staff of CHE for their efforts and dedication in assisting the Committee.

This report deals with the general state of Biotechnology (BT) and Biotechnology Engineering (BTE) Programs in Israel.

Chapter 3 Evaluation of Biotechnology and Biotechnology Engineering Study Programs in Israel

** This Report relates to the situation current at the time of the visit to the institution, and does not take account of any subsequent changes. The Report records the conclusions reached by the Evaluation Committee based on the documentation provided by the institution, information gained through interviews, discussion and observation as well as other information available to the Committee.*

3.1 Executive Summary

The Biotechnology (BT) and Biotechnology Engineering (BTE) study programs that have been evaluated by the committee are, in general, strong, competitive, and capable of providing the state of Israel with the knowledge and discovery platform as well as with education and training programs, that are needed in order to promote and support the field of BT/BTE in Israel. BT/BTE-related study programs or study tracks as well as research programs exist in many academic units outside the scope of the designated BT/BTE departments or faculties in Israeli institutions for higher education. The “national pool” of professionals (at all levels) that are trained in BT/BTE thus significantly exceeds the number of those graduating the designated BT/BTE undergraduate and graduate programs. Data highlighting the current and future needs of the Israeli Biotechnology Industry (IBTI) in terms of professionals (at all levels) does not exist and thus the growth of the “national pool” of BT professionals cannot be designed. An in-depth review, that is aimed at mapping and detailing **ALL** of the BT/BTE-related and relevant study and research programs in the Israeli academia, is needed. Credible information about the needs of the Israeli BT industry, in terms of professionals (at all levels) in the future decade and beyond, does not exist and has to be developed. BT/BTE curricula at the evaluated study programs are, in general, adequate, similar to those offered by similar programs in the US and other countries, and are effective in educating and training professionals in the disciplines associated with modern BT/BTE. Some needs for curricular modifications and/or enhancements have been identified and remedial measures have been recommended by the committee, in a program-specific manner. Research programs at the evaluated universities are of high quality and at the fore-front of the field. Faculty members of these programs are of high caliber, have established both individual and collective impressive and highly competitive record of discoveries and publications, and many of them have been recognized as authority in their respective field. The quality of the graduate study programs at the universities is very high, the curricula are rigorous and the

research dissertations are excellent. The research infrastructure at the research universities has to be properly maintained and continuously updated in order to maintain the competitiveness of the programs. With the exception of one college, the BT/BTE programs in the academic colleges lack research infrastructure and, in most cases, research culture. Without such infrastructure, these BT/BTE departments should not offer graduate study programs. There is a need to establish a core research infrastructure to allow faculty members of BT/BTE programs in the academic colleges and some undergraduate students conducting a limited-scope research on campus. Colleges have to develop and introduce faculty member-specific job descriptions and promote their faculty members according to their success in meeting attainable objectives that are detailed in their job description. The growth and success of both the BT/BTE academic programs and the Israeli BT industry depend on establishing meaningful relationships between the academia and the industry. It is therefore strongly recommended that each of the BT or BTE programs will establish and interact on a regular basis with an effective and committed Industry Advisory Board.

3.2 Background

3.2.1 Biotechnology

Biotechnology, in the broadest sense, involves the use of living organisms or cell processes to make useful products and has been defined as “*the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services*”. Although biotechnological concepts (such as fermentation) have been utilized for thousands of years, biotechnology as a scientific field has gained a significant interest only about 40-50 years ago and has since exhibited a fast-developing rate. Biotechnology is interdisciplinary in nature and draws on the biological sciences, exact sciences, chemistry and physics as well as on different engineering and technological disciplines and concepts. In its convergence with information technology, biotechnology is also associated with bioinformatics, nanotechnology and biomanufacturing. Biotechnology is considered to be an essential enabling technology of the 21st century (the BioCentury) and is expected to offer a significant engine of economic growth in science- and technology-driven regions and societies.

Biotechnology carries a great promise in its potential ability to successfully address significant global challenges pertaining to (among other areas) human health, food security, renewable resources and environmental sustainability. Reflecting the latter, the Biotechnology Industry (BTI) spans across boundaries of many industrial sectors. More “traditional” sectors include: biopharmaceuticals, biologics, medical devices and equipment, nanotechnology, agriculture and food, chemicals and facilities & infrastructure management. In recent years, new industrial sectors related to information technology have emerged and include: digital healthcare, telemedicine, quantum computing, biological computing and optics. Molecular electronics is yet another emerging sector of the BTI.

3.2.2. The Israeli Biotechnology Industry (IBTI)

The excellence of Israel’s institutions for higher education and the quality of their study and research programs in areas relevant to modern BT and BTE offer an extremely fertile ground, knowledge foundation and pool of expertise for the creation of a vibrant and competitive BTI. In order to complement the report about the state of the BT and BTE academic programs, a short review describing the history and current state of the IBTI is provided.

The birth of the biotechnology industry in Israel predates the birth of the country. In 1936 Dr. Chaim Weizmann, later to be the country's first president, developed a fermentation process where *Clostridium acetobutylicum* was utilized for producing acetone. The modern IBTI was born in the 1990s, when government incentives assisted the creation of a large number of BT start-ups, and has demonstrated a significant growth over the last two decades. Recognizing the promising potential for biotechnology, the Israeli government has developed, over the years, different tools aimed at supporting the evolution of the IBTI. These included R&D grants from the Chief Scientist's Office; the Magnet framework (since 1994); a National Committee for Biotechnology (1995); Bioplan 2000, which created dedicated biotech incubators; identifying biotechnology to be a National Project (2002); and, most currently, a Grants Program administered by the Israel Investment Center; an Automatic Tax Benefits program administered by the Tax Authorities, and designating biotechnology a Preferred Sector (Biotech - Tailor made for Israel - Nov 2010: www.MFA.gov.il). However, it seems that

a strong national agenda for Biotechnology infrastructure and industry in the current decade and beyond has yet to be developed.

Reports that have commissioned by the Israeli government (for example: “Realizing our Potential”, 2001; “microeconomics of competitiveness”, 2006) indicated that success in creating and sustaining a thriving IBTI is dependent on a concerted effort by all stakeholders (government, academia, investors and entrepreneurs). A unique initiative, BioJerusalem, has been launched to help fuel the economic development of Jerusalem by leveraging the vast life sciences resources available in the city.

Current data (www.investinisrael.gov.il) indicates that the IBTI is the second largest sector of the Israeli Life Science Industry and consisted in 2012 of about 200 companies. Diagnostic kits, Biopharma compounds and Tissue Engineering & Cell Therapy are the major subsectors of the IBTI and represent (each) 13-17% of this industry (<http://www.iati.co.il>). Some 60 percent of Israeli biotech focuses on human therapeutics, including drug discovery, cell therapy and genetics; additional 20% of the industry develops and manufactures diagnostic kits (Biotech - Tailor made for Israel - Nov 2010: www.MFA.gov.il).

Although the IBTI has exhibited a very dynamic growth since the 1990s, only about 40% of the Israeli biotech companies generate revenues and only about 10% of the companies employ more than 50 employees (<http://www.iati.co.il>). The latter is a significant challenge when employment for those graduating the academic programs in BT and BTE is considered. The potential for a commercially successful and competitive IBTI exists however, the long awaited economical success of this industry is yet to occur. Similar to the evolution of BTI in the USA, most biotechnology companies in Israel are located around the major universities and about 90% of the sector’s activity takes place within the triangle of Jerusalem, Tel Aviv and Haifa.

3.3 - Academic Programs in Biotechnology (BT) and Biotechnology Engineering (BTE)

The academic institutions, offering programs in BT or BTE, that have been evaluated by the committee, fall into two significantly different categories: research universities (Technion, BGU, HUI and TAU) and academic colleges (OBC, THAC and HAC) that are not research-oriented institutions and thus do not have research infrastructure. The BT and BTE

programs at the research universities have both study and research programs while, with one exception (THAC), the programs at the academic colleges are mainly directed at providing the undergraduate study programs, with only marginal research activities.

Two of the research universities (Technion and BGU) offer B.Sc., M.Sc. and Ph.D. in BTE, one university (HUJ) offers only M.Sc. in BT and one university (TAU) offers a B.Sc. in biology with emphasis on BT and M.Sc. in BT. One college (OBC) offers a B.Sc. in BTE and has recently launched a Master program (M.Sc. without thesis), two colleges (HAC and THAC) offer B.Sc. in BT. The THAC also offers M.Sc. in BT. The undergraduate study programs in BTE are 4-year programs while those in BT are 3-year programs. It has thus to be noted that, with the exception of the program at TAU, undergraduate study programs in BT reside (almost exclusively) in academic colleges (THAC and HAC). This undergraduate study programs distribution places a very significant responsibility in the hands of the academic colleges. The undergraduate programs in BTE reside in research universities (BGU and the Technion) and in one college (OBC).

It has to be noted that in addition to the undergraduate study programs in BT and BTE that have been assessed by the committee, different faculties and/or departments within the host institutions (of the evaluated programs) as well as at other institutions of higher education in Israel also offer study programs or at least study tracks related to BT and/or BTE. The latter can be found at the different constituent departments and programs of faculties of biological sciences, departments or programs of: chemical engineering, environmental engineering, agriculture, biological- and/or medical-engineering, material sciences, and chemistry as well as at the different constituent departments of the schools (or faculties) of medicine and pharmacy. Yet additionally, undergraduate and graduate students that pursue degrees in these different disciplines are being trained, in most cases, in concepts that are relevant to biotechnology. Although the committee has not reviewed graduate study programs other than the 7 designated BT/BTE programs, a significant number of Ph.D. students that are enrolled in different faculties or departments of the research universities, are being trained in BT-related concepts and conduct research that addresses research objectives and questions that are directly related to BT/BTE.

It is thus clear that the “national pool” of professionals (at all levels) that are trained in BT or BTE is much larger than the number of those graduating the designated BT and BTE undergraduate and graduate programs. Hence, although the number of those graduating every year the designated BT/BTE study programs is impressive, it falls short of being relevant and does not allow assessing the extent to which needs of the BT industry in Israel are being met.

Information included in Chapter 3.2.2 of this report indicates that about 90% of the biotech companies employ less than 10 employees. Employment opportunities for those graduating the B.Sc. study programs in BT or BTE are thus very limited. Many of the biotech companies are engaged in discovery and early concept development, where, in potential, employment for those holding advanced degrees in BT/BTE is likely to be available. Information that has been presented to the committee indicated that a significant number of those graduating the BT/BTE programs, especially at the B.Sc. level, become employed by industries such as the food industry. Some of the graduates of the BT/BTE programs (at all levels) become employed by the Pharma industry. Data highlighting the current and future needs of the IBTI in terms of professionals (at all levels) does not exist and thus the growth of the “national pool” of BT professionals cannot be designed.

In order to properly review and assess the scope, state and quality of Biotechnology-related study and research programs in the Israeli academia, a “system-wide” in-depth survey and review process, that is aimed at mapping and detailing ALL of the BT/BTE –related and relevant study and research programs, at both an institution-specific and national level is needed. Among other things, results of such effort will allow establishing credible and relevant information about the “national pool” of professionals that are trained in concepts and disciplines that are directly related to BT and BTE.

The committee reviewed the mission statement and strategic plan of the evaluated programs and provided detailed recommendations, when needed. However, the afore-described existence of BT-related study and research program outside the confines of the designated BT or BTE programs, at a given institute calls for establishing (in such cases) an institute-specific, **“institution wide”** biotechnology-related mission statement and strategic

plan. The recommended process will allow to effectively developing an integrated plan where the needs and strength of all the constituent departments/programs are properly addressed. The committee holds the opinion that developing an institute-specific, focused BT/BTE mission statement is of prime importance to quality, efficiency and competitiveness of the institute. Such mission statement should reflect the collective vision of the departments, programs and the faculty members that are involved in BT-related teaching or research activities.

The unique and extreme interdisciplinary nature of biotechnology does not allow a single program or institution to excel in all of the related disciplines and concepts. The latter suggests that the institutional BT/BTE-related mission statement should be focused on developing and supporting specific inherent strengths in biotechnology-related areas that the institution would like promote. Building the institute-specific BT/BTE platform in a way that specifically highlights the unique excellence of the constituent faculties/departments and their researchers is critically important to the success, competitive edge and attractiveness of the system-wide biotechnology program. Once such a mission statement has been developed, a detailed strategic plan, that is carefully designed and aimed at meeting the BT-related mission statement of the institution, has to be developed. This plan has to consist of tangible and specific long- and short-term objectives addressing all of the academic- , organizational- and infrastructural- aspects of the system-wide program.

Similar to what has been identified by different national and international BT assessment committees all over the world, the growth and success of academic programs in BT/BTE and that of the IBTI depend on establishing meaningful relationships between the academia and the industry. The success of the so called “Boston biotechnology cluster” or that of the California cluster makes it clear that both universities and industry benefit immensely from establishing true collaboration and partnership. The committee has strongly recommended that each of the BT or BTE programs will establish and interact on a regular basis with an effective and committed Industry Advisory Board (IAB). The committee would like to also recommend that for institutions where significant BT-related programs and/or study tracks exist outside the designated BT/BTE department or faculty, a system-wide Institutional

Biotechnology Industry Advisory Board (IBIAB), consisting of representatives of the top administration, leaders of the relevant departments/programs and leaders from the BT industry will be established. This Board can provide the institution with a comprehensive feedback about its relevance and adequacy and can partner with it in shaping its BT-related scope, competitiveness and growth.

3.4. Undergraduate Study Programs in Biotechnology and Biotechnology Engineering.

The interdisciplinary nature of biotechnology, and the need to significantly educate and train students in exact sciences, chemistry, biological sciences as well as in engineering and technological concepts and disciplines **before** specific topics in BT/BTE can be introduced to the curriculum, present some serious challenges to those who attempt designing “an optimal curriculum” in BT/BTE. An effective curriculum of an undergraduate study program has to be designed to educate and train its students to either successfully assume positions in the biotechnology and related industries or continue their studies towards graduate degrees (M.Sc. and Ph.D.). In addition to the acquired theoretical knowledge, it is imperative that the practical skills (at the bench) of students of BT/BTE programs will be well developed. A significant laboratory component has thus to be included in the curriculum. It is of critical importance that the curriculum will allow students to effectively develop their critical thinking, communication, and knowledge-integration skills.

The interdisciplinary nature of biotechnology requires offering several study tracks however, the number of such tracks (in a given institution) and their curricula have to be carefully designed. In all cases, a study track has to be offered only after a series of pre-requisites has been met; it has to consist of a defined sequence of compulsory and elective courses. It is imperative that among-tracks redundancy in content will be kept at the bare minimum. The curriculum of the BTE undergraduate study programs should provide students with tools and opportunities to be trained and educated in all of the engineering and technological aspects that are associated with BT-related processes and should also be trained in developing their process design skills. In all cases, the BT/BTE curriculum should include

components addressing ethical and legal aspects of modern biotechnology as well as study modules addressing experimental design and quality control.

Reviewing the BT/BTE curricula indicated to the committee that, in general, the undergraduate curricula are rigorous, adequate and effective in training and educating the students according to the afore-stated principles. The evaluated curricula are similar to what is common in BT/BTE programs in the USA and provide the students with appropriate opportunities to develop both their knowledge foundation and practical skills. However, it is noted that unlike in the US and other countries where the B.Sc. study program in BT is a 4-year program, the equivalent programs in the assessed institutions are 3-year programs. The latter presents a significant challenge.

The committee has identified program-specific deficiencies and challenges and recommended on remedial measures, on a case-specific basis.

Curricula of study tracks in BT/BTE span across a wide spectrum of scientific fields and disciplines and thus, when applicable, their constituent courses should not be limited to those offered by the BT/BTE programs, but rather include courses that are offered by different relevant programs on campus. The extent to which the latter is implemented by the evaluated programs is less than desired and has to be enhanced in order to limit waste and redundancy (at the institution level) and to allow students to enjoy the true inherent interdisciplinary nature of BT/BTE.

Laboratory courses are of critical value to the training of competitive professionals in BT/BTE and have thus to be properly included in the curriculum. The committee has found that in most cases an appropriate effort to accomplish the latter is made and provided recommendations when deficiencies have been identified. Biotechnology is an extremely dynamic field employing a broad array of analytical and research tools. It is thus important that the BT/BTE programs will be provided with appropriate tools to continuously update the content of the laboratory courses and maintain it current with the developments in the field.

The committee holds the opinion that undergraduate research/design project is of critical importance to the quality and merit of a high quality curriculum in BT/BTE and thus recommended that it should constitute a compulsory requirement. The duration of the

project varies among the institutions and ranges from a few weeks to a full time, almost one year long effort. There is a need to “standardize” the duration of the research project in a way that provides a real opportunity to become trained and engaged in research without compromising other needs of the curriculum.

Undergraduate students of the BT/BTE programs in research universities can conduct their research/design project in the laboratories of the faculty members. Students of the academic colleges face a very significant challenge when their undergraduate research is considered. The academic colleges do not have a research infrastructure, their faculty members do not have research laboratories and thus undergraduate research has to be carried out, in most cases, at an off-campus location (industry, non-academic research institute, research university (in Israel or abroad), etc). An exception in this regard is the BT program at THAC, where students can conduct research at MIGAL - Galilee Research Institute (where many faculty members of the BT program hold research positions and have research laboratories). The committee considers this aspect of the BT programs of the colleges a weakness that has to be addressed at two levels:

- 1) Establishing an on-campus **limited-scope core research infrastructure** (see 3.7) that will allow conducting some of the undergraduate research projects on campus.
- 2) Establishing conditions and incentives to facilitate opportunities for college students to carry out their research projects in laboratories of faculty members of relevant programs at research universities, preferable, in the vicinity of the college.

The committee reviewed samples of final reports of undergraduate research and has found that in most cases the research is hypothesis-driven, and appropriate research and data processing methodologies are used. Some of the reviewed reports meet requirements for M.Sc. research dissertation in reputable universities in the US and other countries.

Critical thinking and communication skills of the students are developed and challenged, in most cases, in a satisfactory manner. More than in many other scientific fields, professionals in the field of BT/BTE are required to integrate knowledge and concepts that are derived from different scientific and technological disciplines. The extent to which

curriculum of the undergraduate studies includes modules aimed at challenging and training students in “integration of knowledge” has to be enhanced.

3.5. Graduate Study Programs in Biotechnology and Biotechnology Engineering

All of the evaluated research universities offer M.Sc. in either BT or BTE; THAC offers M.Sc. (both with and without thesis) and OBC has recently launched a program offering M.Sc. without thesis in BTE. Both BGU and the Technion offer a Ph.D. program in BTE, while the evaluated research universities do not offer a designated Ph.D. in BT.

The committee holds the opinion that the first and most important objective of an academic college is to be focused on developing, maintaining and delivering excellent undergraduate study programs that effectively educate and train students to either assume positions in the industry or pursue higher degrees at research universities. The committee strongly believes that the main effort of the college and its programs should be aimed at disseminating existing knowledge rather than at developing new knowledge. An effective, high quality and relevant graduate studies program has to be built on strong foundations of research culture. The latter requires, as a pre-requisite (among other things), faculty members (at all ranks) who are actively and continuously engaged in research as well as an elaborate, properly equipped and well maintained physical research infrastructure. At present, with the aforementioned exception of THAC, these foundational infrastructures to support a graduate studies program do not exist at the evaluated colleges. The committee thus holds the opinion that academic institutions where the above pre-requisites are not fully met should not offer graduate study programs in BT/BTE. The committee thus strongly recommends that, with the afore-mentioned one exception, and as long as the afore-described situation exists, colleges will not offer graduate degrees in BT/BTE.

The curricula of the graduate study programs are rigorous and allow students to develop their knowledge base at a level that is appropriate to the graduate studies level. It is important that electives that are included in the curriculum of the graduate study programs will offer real new learning experiences, even to those who had their undergraduate studies in the same program. The scope and content of the courses should be designed to truly advanced the knowledge of the students, beyond what they have acquired in their undergraduate studies, while also provide them with enough opportunities to become enrolled in

courses that are relevant to their specific research interest. The committee believes that the “institution wide” approach that has been recommended in previous parts of this report will provide means to successfully meet these objectives.

The committee reviewed Master and Doctorate research theses from the different programs. This sample indicated high scientific merit and research quality; in all cases, the research addressed relevant topics and knowledge challenges and in most cases the research was hypothesis-driven. The committee holds the opinion that the academic and intellectual challenge, experimental approaches, relevance and the scientific depth that are reflected in these theses indicate the high caliber of the research component of graduate study programs in BT/BTE in general, as well as of the excellence of the faculty members and graduate students. The technical details of these theses indicate adequate application of advanced methodologies, current analytical tools and approaches and thus reflect on the high quality of the research programs. In many cases, the scope and depth of both M.Sc. and Ph.D. dissertations significantly exceed those from reputable research universities in the US.

The field of biotechnology is uniquely driven by a very aggressive and fast pace inter- and multi-disciplinary research. The competitive nature and success of an academic program in BT/BTE is thus critically dependent on the scientific merit, level, and success of its research programs. A major part of a research program in an academic institute is its Ph.D. programs, where highly motivated and skilled young researchers are committed to the process of developing new, cutting edge knowledge and discovering new horizons. The committee has identified the fact that the BT graduate study programs (TAU, HUI) offer only a Master degree in BT as a significant weakness and holds the opinion that developing a Ph.D. program in biotechnology (in each of the offered study tracks) is imperative and critically important to the competitiveness and success of the research universities as well as to the field of BT in Israel. Proper recommendations to this effect have been included in the program-specific report. The “institution wide” approach that has been recommended earlier can also allow developing appropriate platforms where BT-designated Ph.D. programs are offered across the departmental of faculty boundaries.

Developing and sustaining successful BT industry requires well educated and trained management, at all levels. The knowledge-based nature of this industry and its complexity

requires management with a broad training base in both BT-related and common managerial skills. The committee recommends establishing a graduate study program in biotechnology management. Such program can best be approached by academic institutions that can establish collaboration between their BT/BTE and MBA programs.

3.6. Teaching and Learning outcomes

The quality of teaching in courses offered by BT/BTE programs is high and a consistent effort is being made to maintain both breadth and depth of teaching. The satisfaction of students with the quality of instruction is assessed and monitored regularly and the level of satisfaction is, in most cases, high. The universities and colleges offer effective tools to enhance the teaching capabilities of both young and senior faculty members. The extent to which information and teaching technology tools are utilized by the programs is adequate and enhances the quality of teaching and training.

The Final grades of students in both undergraduate and graduate study courses are relatively high and similar to what is accomplished by students at high quality programs in Northern America.

Currently, the learning outcomes of the BT/BTE program are being assessed solely based on student grades. In recent years it has been recognized that grades alone cannot serve as effective tools in assessing learning outcomes. Institutions of higher education in North America and Europe have recognized that a full commitment to teaching and learning must be based on assessing and documenting what and how much students are learning and on using this information to improve the educational experiences. A detailed implementation of this Learning Outcome Assessment has been developed and introduced in numerous academic programs. This concept allows defining desired learning outcomes (for each course) and quantifying the success with which these outcomes have been acquired by students. This approach has not yet been introduced to the BT/BTE programs at Israeli institutes of higher education

3.7 Research and Research Infrastructure

Similar to what has been described for the study programs, BT/BTE-related research

is conducted by faculty members and their students and trainees in departments or programs that are both within and outside the “boundaries” of the designated BT/BTE programs. The committee assessed only the research that is conducted by faculty members that are directly affiliated with the BT/BTE programs and their students. The scope, depth and quality of research that is conducted at the research university are very impressive and in many cases the PIs are considered authority in their field. Researchers at the evaluated programs are engaged in a competitive, cutting edge research addressing a very broad, diverse, relevant and current biotechnology-related objectives and challenges. An appropriate balance between basic and applied research is maintained and results are published in reputable peer-reviewed journals of the relevant disciplines. Researchers of the evaluated programs have successfully secured significant research funds from national and international competitive funding agencies and have established and maintained meaningful and productive collaborations with researchers from all over the world. In most cases, both productivity and publication record of the researchers are highly competitive. The committee holds the opinion that “national pool” of researchers and their research programs can successfully provide the field of BT in Israel with a very sound and competitive discovery and development platform.

Overall, research in the BTE programs leans towards the biological sciences; There is a need to enhance the extent to which advanced topics related to process technology and engineering are addressed. Proper recommendations to meet this need have been made and are included in the institution-specific reports.

The rate and scope at which BT-related discoveries are made by researchers at the universities is among the highest in the world. The committee holds the opinion that the research infrastructure that is needed to allow advancing the field of BT/BTE in Israel exists, in most cases, at the evaluated universities. Maintaining this competitive edge is of a national importance and thus proper investments in updating the physical infrastructure have to be continuously made. Biotechnology is a field with an inherent high risk yet opportunities for a high return rate. Success in advancing the field of BT/BTE in Israel is critically dependent on the extent to which researchers can explore new horizons and address long-term knowledge goals, challenging both basic and applied questions and objectives. It is thus imperative that proper investments, to complement research grants that are awarded to the researchers, will

be made. Significant investments in advanced research tools have to be made in order to secure and maintain the competitive edge of BT-related research in Israel. Research infrastructure of BT/BTE programs at research universities are adequate and, if properly and continuously updated, provide the physical platforms that are needed in order to meet the afore-stated goals.

The committee has identified a need to establish research and development platforms, in the form of modern pilot plants. Such facilities do not exist at the evaluated programs and thus capabilities to seriously and competitively address and develop process-related concept are significantly compromised. Such facilities should allow addressing research questions related to propagation processes as well as to processes aimed at preparation, recovery and purification of biologically active molecules. Once such facilities are established, universities can better become engaged and collaborate with the IBTI in research beyond the discovery stage.

The research infrastructure-related needs have to be met by a collective effort of all who are involved in developing the strength of the BT/BTE field in Israel. These include the administrations of the academic institutions, governmental agencies and ministries, the BT/BTE industry as well as VC and investment entities.

The committee believes that involvement of faculty members of BT programs in academic colleges in research, **to a limited extent**, carries value and is likely to positively impact the teaching quality and the professional development of faculty members. No core infrastructure to support even a limited-scope research program of the faculty members exists at the facilities of BT/BTE programs in the academic colleges, and thus, involvement of faculty members in research is highly dependent on collaborations with researchers from other institutions. In most cases, such research activities are not carried out on a regular basis. The lack of research infrastructure also dictates that all the activities related to Research Projects of the undergraduate students will be conducted at off-campus facilities.

The committee has identified a critical need for the **colleges together with the relevant governmental agencies** to launch an effort aimed at establishing on-campus **core research facilities** that will allow faculty members and students to conduct **LIMITED SCOPE** research activities on campus.

3.8 Students

The committee met with both undergraduate and graduate students and was very impressed by their maturity, determination and competitiveness. The academic level of incoming undergraduate students is high and students are well prepared to succeed in their academic studies. In all cases the population of students is diverse and includes students from underprivileged segments of the society, minorities and new immigrants. In most cases, both the admission and attrition rate of the undergraduate programs is acceptable and similar to what is common in similar programs in the US and other countries. In one college, the committee identified a need to address an extremely high attrition rate and specific recommendations have been made. The committee applauds efforts made by both colleges and universities to provide candidates to the BT/BTE programs, with less than desired academic record (from high school) with remedial programs that are aimed at enhancing their knowledge base to the extent that they can be admitted to the program. The committee was impressed by the extent to which special needs of students are met.

The academic level of students that are admitted to the graduate study programs is high and students are excited and dedicated to their research. There is a very significant level of inbreeding and a significant number of students to remain at the same institution or even the same department for both undergraduate and graduate degrees. Inbreeding is unhealthy and compromises the professional and academic development of students. It has to be noted that in many cases graduate students in Israel are older than those in other countries (due to the mandatory military service) and many of them have already established families and thus moving to another university (and city) is complicated. However, whenever applicable and possible, students are to be encouraged to pursue graduate degree in programs other than that from where they obtained their undergraduate degree.

3.9. Faculty members

The academic level of the faculty members at both universities and colleges is high and they are dedicated and passionate about their teaching and research activities and programs. The committee is impressed with the competitiveness of the academic staff of the BT/BTE programs and with the efforts made by faculty members in meeting needs and ensuring the

success of students. The ranks distribution of faculty members at the research universities is adequate and the ratio of senior-to-junior faculty members is appropriate.

The academic promotion process at the research universities is rigorous and is designed to maintain a high competitive nature of both the program and the university. The promotion procedure at the universities is clear and adequate and faculty members are well informed about the process. In general, both senior and junior faculty members of the programs at the research universities are satisfied with the process. For both colleges and universities, the ratio of FTE-to-students is adequate, in most cases, and comparable to that at public universities in the US.

3.9.1 Faculty members at the academic colleges

The rank distribution of faculty members in BT/BTE programs at the academic colleges is skewed and in most cases the proportion of senior faculty members is very small. In most cases, colleges employ a significant number of adjunct faculty members. Meetings with faculty members at the colleges indicated a noticeable dissatisfaction with the heavy teaching load and the limited opportunities for promotion to the professorial rank.

Information included in the self evaluation reports (SERs) prepared by the BT/BTE programs of the colleges indicates that the general guidelines for promotion (including tenure) take into account both research and teaching activities of faculty members. The SERs also detail the mechanisms and procedures associated with the faculty promotion process. The committee recognizes the fact that the inability of the faculty members of BT/BTE programs at the academic colleges (with some exceptions in the case of THAC) to conduct research significantly impairs their promotion to the professorial rank, where evidence of significant research accomplishments is required. The committee is concerned by the fact that some of the junior faculty members have not been promoted for many years, in part, because they could not establish the required research and publication record.

The committee strongly believes that the way in which faculty members of the BT/BTE programs of the academic colleges are assessed for their accomplishments and, consequently, promoted, has to be modified significantly. The committee's opinion is that promotion of

these faculty members should be based on assessing their success in meeting attainable objectives defined by an individual-specific job description.

It is imperative for the programs (and the Colleges) to develop and introduce, without delays, faculty member-specific job descriptions where the proportion of effort, to be directed at each of the academic activities (teaching, research and community service), are clearly defined. The individually-tailored job descriptions have to be developed through a dialogue with each faculty member and should include only attainable goals. This will allow better and more flexible distribution of teaching load among faculty members and will also allow tailoring individual-specific activity profiles that reflect the capabilities and aspirations of individual faculty members. Once the concept of individual-specific job description has been defined and accepted, a clear set of guidelines that identify and specify, for each promotion step in a given academic rank, the requirements for successful promotion, should be developed and published. The committee is aware of the fact that introducing this concept calls for a dialogue between the faculty members, the departments, the colleges and relevant governmental agencies. The committee strongly believes that such a dialogue has to be initiated by the colleges and CHE as soon as possible.

The committee would like to highlight the fact that the concept of introducing faculty member-specific job descriptions is common in many highly reputable universities all over the world.

Chapter 4 - Recommendations

Recommendations to CHE

- Appoint an *ad hoc* committee, consisting of academicians from the BT and related programs at the Israeli institution of higher education, to be charged with the task of:
 - Mapping and detailing **all** the Biotechnology- and Biotechnology Engineering-related study programs and/or tracks, curricula and research programs at all the institutions for higher education in Israel.
- Appoint an *ad hoc committee* of leaders from the Israeli Biotechnology and related industries charged with the task of :
 - Assessing and quantifying the current and future (at least 10 years) needs of the Israeli biotechnology industry (IBTI) in terms of professionals at all levels (B.Sc., M.Sc. and Ph.D.).
- Once the two *ad hoc* committees have met their objectives, appoint a planning committee charged with the tasks of:
 - Developing a strategic plan to address the anticipated needs of the IBTI.
- Do not approve opening new or expanding existing undergraduate study programs (in terms of number of enrolled students) in BT or BTE pending the development and approval of the strategic plan.
- Do not approve graduate study programs in BT/BTE in institutions of higher education where well established research infrastructure and culture does not exist.

Recommendations to universities and academic colleges

- Each university or college, where programs related to BT and/or BT exist, should review, map and detail **all** the Biotechnology- and Biotechnology Engineering-related study programs and/or tracks, curricula and research programs at all of its constituent faculties, departments and programs.

- Once the information detailed in the previous recommendation has been established, each institution should develop its institution-wide BT/BTE-related mission statement and strategic plan
- For institutions with significant BT-relevant programs, study tracks and research platforms, establish an Institutional Biotechnology Industry Advisory Board.
- Encourage incorporating in the study tracks that are offered by the BT/BTE study programs relevant courses that are offered by other programs/faculties on campus.
- Establish a committee, consisting of representatives of CHE, administrators and program leaders from research universities and colleges with BT/BTE programs, charged with the task of negotiating and developing opportunities for students of the BT/BTE programs in the academic colleges to conduct their research project in the research laboratories of relevant PIs at research universities. Once the latter has been agreed upon, negotiate with the relevant governmental agencies the financial tools to cover some of the direct cost of the research.
- Enhance the extent to which students are trained and challenged in “knowledge integration” by developing and introducing study modules where senior-year students will be engaged in problems solving, process development and/or product design projects where knowledge derived from the exact sciences, chemistry, biological sciences and biotechnology-related concepts and methodologies, will be integrated.
- Continuously update scope and content of laboratory courses to maintain them current with the developments in the field.
- Develop and offer a designated graduate study program (M.Sc.) in biotechnology management, either as a study track of the BT/BTE program or as a joint program with a business management school or department (when applicable).
- Introduce and implement a Learning Outcome Assessment program as the main tool for assessing the learning outcomes of all of the courses and learning experiences that are offered by the study programs.

Recommendations to the universities

- Enhance the extent to which research addresses topics related to the engineering and technological aspects of BT.
- Maintain the competitive edge of the research infrastructure and keep it current at the fore-front of the field.
- Develop and offer designated Ph.D. in BT
- Develop and install research BT/BTE pilot plants

Recommendations to the academic colleges and CHE (and other relevant government agencies)

- Pending the introduction of tangible opportunities for conducting research, as part of the criteria for promotion, and until the concept of individual-specific job description has been implemented, base the promotion of faculty members, at all ranks, only on their accomplishments in teaching, community service (committee and other administrative tasks) and outreach activities.
- Develop and introduce the concept of faculty-member-specific job description, where the proportion of effort to be allocated to each of the academic and administrative activities of the faculty member is clearly defined.
- Once the concept of individual-specific job description has been established and defined, develop and implement a clear set of guidelines that identify and specify, for each promotion step in each of the academic ranks, the requirements for a successful promotion.
- After establishing and introducing the revisions, as described above, fully implement a promotion process that is based on assessing success in meeting the criteria and objectives that are stated in the individual-specific job description.
- Include in the promotion process of faculty members (at all ranks) with a significant research component (more than 20%), and faculty members that are considered for

promotion to the professorial rank, a dossier evaluation by 3 outside reviewers, to be solicited from relevant academic programs abroad.

- Together with relevant government agencies develop and install an on-campus core research infrastructure to allow developing limited scope BT-related research program.

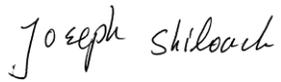
Signed by:



Prof., Moshe Rosenberg,
Chair



Prof. Gad Galili



Prof. Joseph Shiloach



Prof. Milica Radisic

Appendix 1: Copy of Letter of Appointment



May, 2012

שר החינוך
Minister of Education
وزير التربية والتعليم

Prof. Moshe Rosenberg
Department of Food Science & Technology
University of California, Davis
USA

Dear Professor Rosenberg,

The State of Israel undertook an ambitious project when the Israeli Council for Higher Education (CHE) established a quality assessment and assurance system for Israeli higher education. Its stated goals are: to enhance and ensure the quality of academic studies; to provide the public with information regarding the quality of study programs in institutions of higher education throughout Israel; and to ensure the continued integration of the Israeli system of higher education in the international academic arena. Involvement of world-renowned academicians in this process is essential.

This most important initiative reaches out to scientists in the international arena in a national effort to meet the critical challenges that confront the Israeli higher educational system today. The formulation of international evaluation committees represents an opportunity to express our common sense of concern and to assess the current and future status of education in the 21st century and beyond. It also establishes a structure for an ongoing consultative process among scientists around the globe on common academic dilemmas and prospects.

I therefore deeply appreciate your willingness to join us in this crucial endeavor.

It is with great pleasure that I hereby appoint you to serve as Chair of the Council for Higher Education's Committee for the Evaluation of Biotechnology and Biotechnology Engineering Studies.

The composition of the Committee will be as follows: Prof. Moshe Rosenberg (Chair), Prof. Gad Galili, Prof. Milica Radisic, Prof. Joseph Shiloach.

Ms. Yael Elbocher will coordinate the Committee's activities.

In your capacity as Chair of the Evaluation Committee, you will be requested to function in accordance with the enclosed appendix.

I wish you much success in your role as Chair of this most important committee.

Sincerely,

Gideon Sa'ar
Minister of Education,
Chairperson, The Council for Higher Education

Enclosures: Appendix to the Appointment Letter of Evaluation Committees

cc: Ms. Michal Neumann, The Quality Assessment Division
Ms. Yael Elbocher, Committee Coordinator

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