הטכניון - מכון טכנולוגי לישראל
מזכירות הסנט

טל: 8292953, 8292643 - 04, פקס: 8293795- 04

אל : חברי הוועדה המרכזת
מאת : מזכירות הסנט
תאריך : 16 ביוני, 2014

הריני להזמינכם לישיבה של הוועדה המרכזת שתתקיים ביום א', 22.6.2014 בשעה 9:00 באולם הסנט.

על סדר היום:

		נספח מס'	עמ' מס'
1.	**הודעות היו"ר**	**בע"פ**	
2.	**דו"ח ועדת הערכה תקופתית של הפקולטה להנדסה ביו-רפואית** – <u>הוזמנו לדיון בשעה 9:00</u>: פרופ"ח אמיר לנדסברג, דיקן הפקולטה להנדסה ביו-רפואית, פרופ"ח שי שהם ופרופ"ח שולמית לבנברג, נציגי הוועדה המכינה היחידתית <u>יוצג על ידי סגן המשנה הבכיר לנשיא</u>	2	3-153
3.	**מינוי ראשי יחידות אקדמיות:** • **דיקן הפקולטה להנדסת מכונות** • **דיקן הפקולטה להנדסה ביו-רפואית** <u>יוצג על ידי היו"ר</u>	3א' 3ב'	154 155
4.	**תוכניות הלימודים היחידתיות לשנת הלימודים תשע"ה** – <u>המשך דיון</u> <u>יוצג על ידי דיקן לימודי הסמכה</u>	4	156-185
5.	**תוכניות "אפיק מעבר מן האוניברסיטה הפתוחה לטכניון" לשנת הלימודים תשע"ה** – <u>המשך דיון</u> <u>יוצג על ידי דיקן לימודי הסמכה</u>	5	186-192
6.	**שינוי תקנה 24.07 לתקנות בית הספר לתארים מתקדמים** <u>יוצג על ידי דיקן בית הספר לתארים מתקדמים</u>	6	193-194
7.	**מינוי חבר לוועדת סגל-סטודנטים כלל טכניונית** <u>יוצג על ידי המשנה הבכיר לנשיא</u>	7	195
8.	**אישור השתייכות משנית לפי סעיף 99.5 בתקנות וחברות בוועדה מכינה יחידתית לפי סעיף 165.2 ד'** <u>יוצג על ידי המנל"א</u>	8	196
9.	**דו"חות הישיבות של מועצות היחידות האקדמיות** – <u>לידיעה</u>	**בנפרד**	
10.	**שונות**		

בברכה,

אסף בינדר

הרכב הוועדה הוא:
החברים בתוקף תפקידם הם: נשיא (לביא) - יו"ר, משנה בכיר לנשיא (סידי), מנל"א (שוסטר), מנל"מ (שמואלי), משנה לנשיא ומנכ"ל (אנגלמן), דיקן לימודי הסמכה (כהן), דיקן בית הספר לתארים מתקדמים (לוי).
החברים הנבחרים הנותרים בוועדה הם: פרופ' אלי אלטוס (הנדסת מכונות), פרופ' זאב גרוס (כימיה), פרופ' דב זהר (הנדסת תעשיה וניהול), פרופ' ספי נאור (מדעי המחשב), פרופ' ברוך סולל (מתמטיקה), פרופ' איריס ערבות (ארכיטקטורה ובינוי ערים), פרופ' אדי קרניאלי (רפואה) ופרופ' משה שיינטוך (הנדסה כימית).
משקיף: סגן המשנה הבכיר לנשיא (ריטל).
חברי ועדת השבתון, תת ועדה של הוועדה המרכזת: מנל"א (יו"ר), מנל"מ, דיקן בית הספר לתארים מתקדמים ופרופ' איריס ערבות.

נספח 2

דו"ח ועדת הערכה תקופתית של הפקולטה להנדסה ביו-רפואית

<u>חומר רקע לדיון:</u>

- מכתבו של סגן המשנה הבכיר לנשיא, פרופ' דניאל ריטל, מיום 15.6.2014
- דו"ח ועדת הערכה תקופתית של הפקולטה להנדסה ביו-רפואית מחודש מאי 2013
- דו"ח מועצת הפקולטה להנדסה ביו-רפואית מיום 22.1.2014
- דו"ח הערכה עצמית של הפקולטה להנדסה ביו-רפואית מחודש מרץ 2013

הטכניון - מכון טכנולוגי לישראל
פרופסור דניאל ריטל
סגן המשנה הבכיר לנשיא

מס': ו. הערכה – 287

תאריך: 15.06.14

אל: פרופ' מ. סידי, משנה בכיר לנשיא

מאת: סגן המשנה הבכיר לנשיא

הנדון: **דו"ח ועדת הערכה תקופתית של הפקולטה להנדסה ביו-רפואית**

אבקשך להביא את דו"ח ועדת הערכה להנדסה ביו-רפואית לדיון בוועדה המרכזת, אשר יתקיים בנוכחות ראש היחידה ושני נציגים של הוועדה המכינה היחידתית (שייבחרו מקרב חבריה).

בברכה,

דניאל ריטל

העתק: ע"ד א. בינדר, מזכיר הסנט

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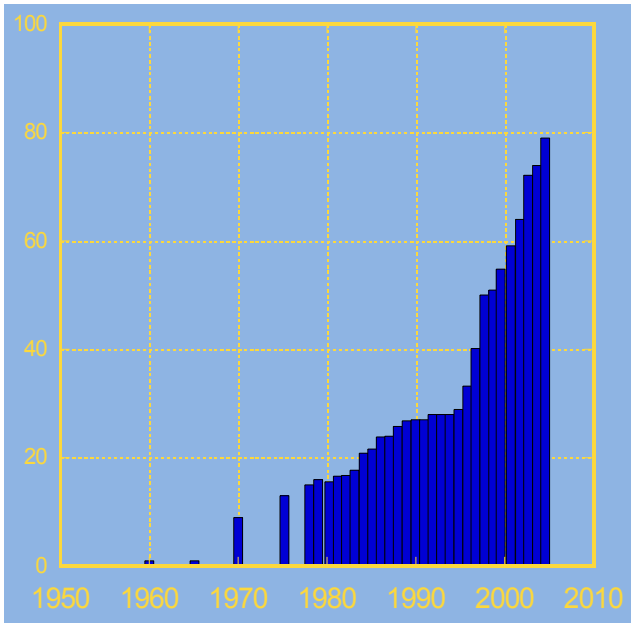
Report of the International Review Committee on the Biomedical Engineering Faculty

General

Biomedical Engineering is a rapidly growing field in the USA and Europe with predictions of continued growth over the next decade. A recent article[1] in Forbes Magazine reported on the analysis of 120 college majors and job growth projections through 2020 from the U.S. Bureau of Labor Statistics (BLS) and concluded that '*Biomedical Engineering is the major that is most worth your tuition, time and effort. Biomedical engineers earn a median starting salary of $53,800, which grows an average of 82% to $97,800 by mid-career. Moreover, the BLS projects a whopping 61.7% growth of job opportunities in the field.*' The growth of Biomedical Engineering in in American Universities has been extremely fast as shown in Figure 1 which shows the number of BME programs in the USA.[2] Also significant is the growth in applicants to BME programs which mirrors the growth in departments. At Berkeley, for example, the number of applicants to the Bioengineering Department has increased continuously since starting the program in 1999. The acceptance rate of Bioengineering at Berkeley is the lowest in the entire College of Engineering (~14%) and the entering students are the best in the College. Similar characteristics are seen at Universities across the USA including Caltech which just started their Undergraduate program 2 years ago. The Technion as a premier Biomedical Engineering Department in Israel has experienced a similar increase in the number and quality of their



Major institutional investments are being made across the nation in Bioengineering

[1] 'The 15 Most Valuable College Majors', Jenna Goudreau, *Forbes Magazine*, May 15th, 2012. Available online at: http://www.forbes.com/sites/jennagoudreau/2012/05/15/best-top-most-valuable-collegemajors-degrees/

[2] Source: Whitaker Foundation

applicants.

BME at the Technion

The committee was very impressed with the Biomedical Engineering Faculty at the Technion. The students at both the undergraduate and graduate levels are outstanding and enthusiastic about the field and program at the Technion. Overall the faculty members are very strong, each in their field. The BME Faculty is outstanding in terms of its funded research even compared to other leading programs at the Technion. Under the enthusiastic leadership of Prof. Landesberg, the BME Faculty is clearly working together to improve their department on many fronts. The passion, positivity, and collegiality of the whole BME program were clearly evident to the committee and this bodes extremely well for the continued excellence of biomedical engineering at the Technion.

However, the committee believes that the size of the Faculty is relatively small compared to leading departments in the US (Table 1), which may have resulted from the lack of growth over the last 10 years. For the Technion BME program to have significant impact it needs to grow. This can be done strategically by establishing a critical presence in a select number of these key areas. This does not imply duplication of faculty research areas, but rather to have complementary overlap in these areas. The committee identified the following areas, based on the existing program, which could be potential growth areas:

- Regenerative Medicine (Landesberg, Levenberg, Seliktar, Shoham, Sznitman, Weihs)
- Cardiovascular Systems (Landesberg, Haim, Daphne, Jousea)
- Diagnostic Technologies (Adam, Azhari, Meller, Mizrahi, Yelin + 1 new hire)
- Noninvasive Therapeutics, (Adam, Kimmel, Mizrahi, Shoham, Yelin +1 new hire)
- Medical Devices (Landesberg, Levenberg, Meller, Yelin)
- Drug delivery, (Seliktar, Weihs, + 2 new hires)
- Neural Systems (Shoham, Gur, + 3 new hires)

Obviously, Cardiovascular and Diagnostic Technologies are classical research areas that have been long-term strengths of the Department. Regenerative Medicine is a current thrust in the Department and also has great future potential with increasing investment by funding agencies. However, the lack of a strategic plan for growth could lead to missed opportunities to build a world-class department worthy of the Technion. The above list identifies upcoming retirements (underlined) and needed new faculty members.

This action will also resolve other critical issues for the program. High quality teaching and training is imperative for the program to be at the forefront of emerging and important BME areas while having strength in the basic tools of engineering needed for training. Also, the small

size of the department is noticeable in the ratio of graduate students to faculty which is 14:1. In addition, the teaching load of 3-4 courses per year is very high but these courses are necessary in order to provide the required classes for the major. Even with this high workload the department faculty cannot provide sufficient graduate-level classes.

The committee found a pronounced weakness in that the program is missing faculty who focus in theoretical and computational areas.

The committee recommends that a strategic plan be developed for the development and growth of the Faculty over the next 10 years. Based on the size of successful Biomedical Engineering programs in the USA, we recommend that a target size of 20 to 25 faculty be considered.

Table 1. Bioengineering Program Size Comparison

	2013 US News Rank Grad	Ugrad	NRC Ranking Graduate ('07)	Tenure–track Faculty* (2006)	Tenure-Track Faculty* (2012)	Target Faculty FTE
Johns Hopkins	1	1	8	25	33	
Georgia Inst. of Tech	2	2	9	24	27	42
UCSD	3	5	1	16	21	30+
U. Washington	6	10	3	16	23	30+
UC Berkeley	10	10	2	16	19	25
Stanford	6	10		7	16	25

*Source: ASEE (American Society of Engineering Education)

Research

The quality of research overall in the Faculty is on-par with the leading institutions in the USA. This is clearly demonstrated in the quality of their papers and their presentations in International Conferences and invited lectures.

It is hard to compare funding levels between the US and Israel. However, both the overall and per capita number of grants in the BME Department ranks very high relative to other departments at the Technion. There is a large disparity between grants from Israel (comparable to NSF) and the large ERC grants. The committee thinks that this could present a problem when ERC grants end because they are so large. It is not clear what the effect will be on researchers when they have to shift to smaller grant support and how faculty will be able to bridge between these vastly different grants. ERC funding is being used for infrastructure support and the committee is concerned what is going to happen to excellent on-going research programs if they cannot continue important laboratory support at the end of an ERC grant.

The committee was impressed that all of the faculty are excited about their work and are doing interesting research. The lack of 'unproductive' faculty is remarkable.

Curriculum

The curriculum in the BME program is formidable. At the undergraduate level, the BME students are currently required to take 165 points. This is a standard 'problem' in bioengineering programs because biology, chemistry, and physiology classes are added to an engineering curriculum. The Faculty has proposed moving to a 'Track' system which has been successful at other institutions including Berkeley. This can reduce the total number of classes because prerequisite courses can be tailored to the advanced classes in the focus area without major impact on 'breadth'. In the material supplied by the Faculty, both curricula were presented and the new Track system requires 5 fewer points. The new curriculum includes more laboratory class options: an initial introductory techniques lab followed by more focused, elective laboratory classes in one of three track areas. The laboratory classes the committee saw were extremely good. The two project classes provide unique opportunities where students can collaborate with industry on a year-long design project or spend a semester-long internship in a medical clinic.

The BME Faculty is encouraged to continue to work on their curriculum as the field matures. The "General Engineering" classes that make up the core of the curriculum tend toward biomechanics and cellular engineering and lacks offering an advanced course in signal processing that is required today in all fields of engineering-it is offered only in an alternative track. In addition the curriculum lacks offering a required course in basic statistics and bio-statistics.

It is unclear whether the reduction of points assigned to core class such as Biological Fluid Mechanics and Transport Phenomena in Physiological Systems (4 points to 3 Points) represents a readjustment associated with the actual workload or a change in the amount of material taught. In the higher level elective classes it is possible that there may be classes that could be combined but the committee cannot realistically make specific suggestions.

The committee did note that some of the problems brought up by the BSc alumni have been addressed by the Department and have been fixed in the current curriculum. The BME Faculty is clearly actively engaged in a continuous effort to improve their curriculum and this is seen by the Committee as an exceedingly positive demonstration of the investment that all of the staff have in the program.

Teaching and Students

The students with whom we spoke were very happy with the program and the attitude of the faculty. The students specifically mentioned that professors are very available and are positive

about talking with students. In addition, the committee saw that the BME faculty recognize that their students are among the best at the Technion.

While this is discussed below in the Industry section, it should be noted here that many undergraduate students work part-time in industry during their last two years in school. While some do this for financial reasons, several said that they worked so that they could get a job after they graduate. The new project design class is ideal for this problem because it is done in collaboration with industry. It may also be possible for students to do their final design project at a local company. This will provide students with both a design experience and exposure to BME industry. Students who are interested in research could similarly get credit for doing independent research in Technion faculty labs.

The Graduate students with whom we spoke were happy overall with the program. The completion times for graduate degrees does not seem to be an issue. The graduate students were, however, sensitive to the financial and space limitations of the BME Department. While there were no really critical problems, e.g. reduced library hours, it did demonstrate that the departmental resources are significantly limited especially in light of the desire to increase the number of international graduate students.

Overall, the graduate programs seem very good. The ratio of graduate students to faculty appears high relative to other programs at the Technion, but is close to programs in the US. The number of M.Sc. students relative to PhD students varies considerably at universities in the USA and is constantly changing with the wide-spread growth of 'Professional Masters' degrees, which are course-only degrees. However, from a faculty workload perspective, PhD students work more independently and produce more research results because of their increased training over 4 years.

The Faculty and the Technion

The BME Faculty would naturally have collaborative potential with ME in the area of biomechanics and microfluidics, with EE in the areas of medical imaging, signal processing, biosensors, and microfabrication, Biology in systems and synthetic biology, ChemE in biomedical sensors, MSE in biomimetic materials, and the Faculty of Medicine for clinical applications (where there are already significant research collaborations, n=41). These are areas where the expertise is limited in the BME department and would provide synergistic potential with little cost. Clearly the BME Department has not been sufficiently active in seeking out or responding to collaboration opportunities in the past. The Technion should consider methods of rewarding faculty who develop collaborations or promoting interdisciplinary efforts. These reward mechanisms could include fellowships and/or seed funding for

preliminary results needed for grant applications. As such, these efforts would be investments toward increased research grant support for the departments involved.

In our discussions it appears that at one time the Technion considered integrating BME into other departments. Institutions in the USA that have tried to include BME programs in other departments have not been successful. Therefore, the committee strongly recommends that the BME Faculty be strongly supported by the Technion Administration so that it can become an independent, self-sufficient program that can interact with other programs on equal terms. Collaborations require that both parties bring complementary strengths to the project.

The committee was asked if the BME Department should be combined with other departments into a SchooI similar to other Universities. This is a major change in the structure of the Technion and may be out of scope for this committee.

Infrastructure

Overall the existing space is reasonable for the current situation but is inadequate for the needed expansion of the program and Faculty. This does not include the need for social interaction space for faculty, undergraduate and graduate students. The classrooms are limited in size and will become inadequate when the student population increases.

The laboratory equipment is quite good. However, laboratory managers/support engineers are severely limited which impacts equipment down-time and ability to sustain continuous operation. The loss of institutional memory needed for advanced equipment as students matriculate, especially given the large number of ‘short-term’ master’s students, significantly increases the load on the faculty. The institution should provide half an engineer per lab.

The machine shop does not appear sufficiently staffed to provide faculty with research support.

Cooperation with Industry

The BME faculty seem to cooperate well with industry as evidenced by the large number of start-ups associated with the departmental faculty and alumni. A large number of undergraduate students work in industry while they are completing their last two years of their degree. While this can be needed for financial support, several students reported that they felt that this was necessary in order to get a job when they graduated. The committee is concerned because the students cannot perform at their best academically when they are committed to 15 to 20 hours per week at a company. It may be possible to get industry more involved in the final design projects of the students, even allowing them to do their design project at a company. This could allow the students an industry experience with less impact on their

academic performance. For students who are more interested in research, the Department could consider allowing students to complete an independent research project in faculty research laboratories. This would be an excellent experience and strengthen their graduate school applications.

The new Industrial and Clinical Affiliate Program seems to the Committee to be an excellent move to increase productive collaborations as well as industrial awareness of the outstanding BME graduates from the Technion.

Additional Comments

The committee recommends that the BME department form an Industrial Advisory Board which would meet on an annual basis. This could provide essential strategic curriculum advice for increasing interaction with multinational medical and pharma industries. Also, it would help to raise outside awareness of the Technion's BME program.

The BME Department is a rapidly changing and growing program. This requires resources for the leadership to provide opportunities beyond normal operational requirements to the student body and faculty. In general, rapidly growing departments in the US receive additional resources compared to established departments. The committee is very concerned that the BME has been depleting their endowment in order to meet standard operational expenses. This cannot continue if the Technion wants an elite BME Faculty because there is no discretionary money for new programs such as the ones mentioned in this report.

For example, the committee recommends that the BME start having annual retreats so that the faculty and students become more aware of the capabilities of other research groups. Faculty from other departments could attend the retreat and this would encourage collaborative research that would benefit the Technion as a whole. And lastly, the committee encourages the establishment of a visiting faculty program from abroad.

דו"ח ישיבה עם הנהלת הטכניון בנושא דו"ח ועדת הערכה – 22.1.14

משתתפים: פרופ' פרץ לביא - נשיא, פרופ' משה סידי- משנה בכיר, פרופ' גדי שוסטר – מנל"א, פרופ' עודד שמואלי – מנל"מ, פרופ' בועז גולני – סנק"צ, פרופ"ח אמיר לנדסברג – דיקן, פרופ"ח חיים אזהרי, פרופ"ח משה גור, פרופ"מ דפנה ויס, פרופ"ח דביר ילין, פרופ"ח שולמית לבנברג, פרופ"ח דרור סליקטר, פרופ"ח איתן קימל, פרופ"ח שי שהם, פרופ"מ יהושע שניטמן

נעדר: פרופ' עמית מלר – בחו"ל

הדיקן, **פרופ"ח לנדסברג**, פתח את הפגישה בהצגת החזון של הפקולטה - להיות הפקולטה המובילה בארץ בתחום ההנדסה הביורפואית. הדיקן הציג את תחום ההנדסה הביורפואית בעולם ואת הצמיחה של התחום בארה"ב ובארץ. הוצגה התפתחות הפקולטה מאז היווסדה.

לאחר תיאור כללי – הוצגו עיקרי הסיכום של דו"ח עדת הערכה, התרשמותה והמלצותיה עפ"י התחומים השונים.

הוועדה התרשמה מאוד לחיוב מהפקולטה: 1.רמת הסטודנטים בתואר ראשון ומסומכים מעולה. 2. יש בפקולטה חברי סגל חזקים. 3. חברי הסגל חדורי התלהבות בקידום הפקולטה, וקידום תוכניות מצוינות.

<u>חברי סגל ותקנים:</u>

הוועדה ציינה שהפקולטה קטנה ולא גדלה כנדרש לאורך 10 השנים האחרונות מאז הוועדה הקודמת.

הוועדה ציינה שקיים חוסר קריטי במספר חברי הסגל. המסה הקריטית של כ- 25 חברי סגל חשובה מאוד לפריצה ולהתפתחות של הפקולטה שתהיה בעלת השפעה עולמית. הוועדה ציינה זאת תוך מתן דוגמאות מפקולטות מובילות בארה"ב.

הוועדה ציינה שחסרים לפקולטה חוקרים העוסקים בתחומים תיאורטיים וחישוביים. הוועדה המליצה להרחיב את התחומים הבאים שבהם הפקולטה חזקה, תוך יצירת מסות קריטיות באותם תחומים. הוועדה ממליצה לגייס אנשים במיוחד בתחומים של: Diagnostic Technologies (1), Noninvasive therapeutics (1) Drug Delivery (2), Neural System (3) (בסוגריים – מספר חברי הסגל).

הוועדה העלתה את הצורך בגיוס – גם כדי לעמוד בדרישות ההוראה הנאותה בתחומי ההנדסה. הוועדה מציינת שהעומס על חברי הסגל גבוה, מספר משתלמים לחבר סגל 14:1 והוראה של 3-4 קורסים בשנה.

פרופ"ח שהם – ציין כי נקודה זו הודגשה מאוד ע"י חברי הועדה אשר ציינו שהסטטיסטיקה מראה כש- 25 הוא קו הגבול בין פקולטות שגדלות ופורחות ומצטיינות

במחקר ובין פקולטות שמדשדשות עם תפוקה נמוכה. ולמספר חשיבות גם בעמידה בתוכנית ההוראה.

פרופ' לביא - העלה את השאלה, האם העובדה שלאוניברסיטת ברקלי, שלהם מספר חברי סגל נמוך מ- 25 (19 חברי סגל) הפריעה להיות בין המובילים.

הדיקן ציין שאלו פקולטות יחסית חדשות (הנדסה ביורפואית בברקלי נוסדה ב-1998) והפקולטה שם בצמיחה, עם יעד של 25 לפי הטבלה. לעומת הפקולטות שבמקומות הראשונים כמו ג'ון הופקינס וג'ורג'יה עם 33 ו-27 חברי סגל.
הדיקן הציג את תהליכי הגיוס שנעשו בשנה האחרונה ואת פעילות הפקולטה לטובת גיוס חברי סגל.

<u>מחקר:</u>
הוועדה ציינה שהמחקר בפקולטה והמעבדות מתקדמות, כמו במוסדות מובילים בארה"ב. הפקולטה ממוקמת במקום נכבד בטכניון בנושא השגת מענקים, לעומת פקולטות אחרות בטכניון.
הוועדה ציינה שמענקים של ERC משמשים לתמיכה בתשתיות, והוועדה מודאגת מכך, שכן עם הפסקת המענקים יפלו התשתיות. הדבר מדגיש את הצורך במהנדסים ומנהלי מעבדות בפקולטה. כרגע ישנם 3 תקנים של מהנדסי מעבדה.

פרופ"ח שהם – הציג את הצורך והחשיבות במהנדסים ומנהלי מעבדה למעבדות המחקר, תוך הצגת הבעייתיות בהקמת מעבדה ללא עזרה של מנהל מעבדה ואת חוסר הברירה שהיתה לו, אלא להשתמש ב- ERC למימון מנהלת מעבדה.

<u>לימודים:</u>
פרופ"ח לבנברג הציגה את הערות והמלצות הועדה לגבי התואר הראשון ואת השינויים שנעשו בעקבות המלצות הועדה.

הוועדה ציינה שהסטודנטים מאושרים מתוכנית הלימודים ומהיחס. הסטודנטים ציינו שהמרצים זמינים. הוועדה ציינה את הבעייתיות שחלק ניכר מהסטודנטים בשנה שלישית כבר עובדים בתעשייה. **הוועדה דיווחה שהמשתלמים לתארים גבוהים ציינו שיש מחסור במקום ובמלגות** – ואכן הפקולטה מאוד מוגבלת במקום.

פרופ"ח לנדסברג – הציג את השינויים בתוכניות הלימוד, שהחלו עוד לפני הוועדה וקיבלו את תמיכתה. תכנית הלימודים בפקולטה היו בתהליכי שינוי כבר שהוועדה באה. **הוועדה ציינה שתוכנית הלימוד קשה ועמוסה ביותר.** למדו בה באותה תקופה 165 נקודות, והעומס הורד.

הפקולטה חזרה לתכנית על פי מסלולים, דבר שיש בו כדי לעזור ולהוריד את העומס ואת מספר הקורסים, ולהעלות את המקצועיות.
הוועדה ציידדה בתוכנית הפקולטה להעלות את מספר המעבדות (מ-2 בלבד ל-3 + 1 בחירה).
הוועדה ציינה שקורסי החובה נוטים לביומכניקה והנדסת-התא וחסרים קורסים בעיבוד אותות הנדרשים כיום.
הדיקן ציין שישנם שינויים משמעותיים לטובה בלימודים:

- **יש עליה בקבלה מזה שנתיים– ל-72 מתקבלים באוקטובר 2013.**
- **נפתחה תכנית ייחודית עם הפקולטה לרפואה, שתוכנית שיש בה 11 סטודנטים עתה במחזור הראשון, ותוכנית שמשכה מצטיינים לפקולטה.**
- **הוקמה תכנית מגמות, ורואים כבר את הצמיחה.**
- **הוכפלו מספר המעבדות.**
- **שודרגו נושאי פרויקטי הגמר והפרויקט הקליני.**
- **הורד עומס הלימודים**
- **חוזק הקשר עם הבוגרים ועם התעשייה (כנס שנתי בהנדסה ביורפואית, ערב בוגרים, ערב פרויקטים).**

פרופ"ח לנדסברג – הציג את הצרכים **ואת החוסר ביחידות תעסוקה בעקבות השינויים בתכנית הלימודים.** תוספת המעבדות, התרגולים במקצועות שלא היו תרגולים, והפרויקטים העלו ב-50% את יחידות התעסוקה מכ-14,000 נקודות שהיו נהוגים במשך כעשור לכ-21,000 נקודות לסמסטר, וזה לפי המפתח הנקבע בטכניון.

<u>קשרים עם הפקולטות.</u>
הוועדה המליצה לטכניון לחפש דרכים לעודד שיתופי פעולה ולעודד מאמץ בין-פקולטי-כולל מענקים בסיסיים. הדיקן הציג שחל שיפור ויש עדות לחיזוק שיתופי הפעולה עם פקולטות אחרות בטכניון ביחוד עם רפואה וחשמל. חיזוק שיתוף הפעולה הביא לכנס שנתי שרץ בפעם הראשונה ממש לפני בוא הוועדה, בשיתוף עם הפקולטה לרפואה וכל הפקולטות למדעי החיים והנדסה.

<u>תשתיות ובינוי</u>
הוועדה ציינה את מצוקה בכיתות הוראה ואת המצוקה בשטחים למעבדות מחקר לחברי סגל חדשים. הדיקן ציין שמאז שופרו מעט התשתיות: הוקם חדר ישיבות פקולטי ומרכז לימוד לתואר ראשון. וציין את עזרתה ודחיפה שנתנה הסמנכ"לית גב זהבה לניאדו.
הוועדה הדגישה שיש חוסר חמור במהנדסי מעבדה, מהנדסי תמיכה והדבר פוגע ביכולות. הוועדה המליצה לגייס חצי תקן מהנדס לכל חבר סגל !

פרופ"ח שהם – הדגיש שנית את החשיבות של איש עזר מהנדס/טכנאי במעבדות המחקר ובמיוחד לאור העובדה שהפקולטה היא אינטרדיספלנריות ועוסקת גם בהנדסה וגם במדעי החיים.

פרופ"ח לנדסברג – על מנת שהפקולטה תמשיך לצמוח, לגדול ולהתפתח יש צורך באפלייה מתקנת. הפקולטה ענייה בתקנים לעומת פקולטות אחרות. חשוב להבין שהפקולטה להנדסה ביורפואית היינו מנוע צמיחה בכל האוניברסיטאות בארה"ב. הצמיחה של הפקולטה תחזק ותשפיע על צמיחת הטכניון כולו.

לבסוף הוצגו הדרישות לעתיד:

<u>מחקר ותארים מתקדמים</u>

- הגדלת סגל הפקולטה ל-25 חברים בשנים הקרובות.
- גיוס מהנדסי מעבדה ומנהלי מעבדה – לפי מפתח של חצי תקן עד תקן לחבר סגל.
- הקמת מרכז תשתית פקולטי לצרכי כל חברי הסגל.
- הקמת מרכז תשתית במחקר בסיסי בהדמיה.

<u>הוראה לתואר ראשון</u>

- חיזוק התוכנית עם רפואה ופיזיקה.
- הגדלת מחזור המתקבלים, כאשר עד כמחציתם בתוכניות משותפות.
- הקמת מרכז הלימוד בקומת המקלט.
- הגדלת יחידות התעסוקה ל- 21000 לסמסטר (ולא 10300).

<u>סגל מנהלי</u>

- תוספת מזכירת דיקן וחצי תקן למזכירה פקולטית

<u>תשתיות</u>

- בניית עוד אגף או 2 קומות (תוספת 10 מעבדות מחקר+ 2 אולמות הרצאה).
- בניית מרכזי התשתית בקומה התחתונה
- טיפול במפגעי התחזוקה והבטיחות – מיזוג, מתזים, חשמל.

<u>תקציב</u> – <u>הגדלת התקציב ל-737,000 שקל (במקום 622,000) בעיקר בסעיפים של כוח אדם ארעי, ציוד לשימוש תואר ראשון, ואירוח.</u>

<u>הנושא נפתח לדיון:</u>

פרופ' סידי – קליטת 25 חברי סגל ב- 5 שנים אינה ריאלית. הטכניון והפקולטה לא יכולים לעמוד בכך.

פרופ' שמואלי,– בנושא הקשר עם התעשיה – מבחינת ERC ראוי לציין שיש לפקולטה בהחלט מקום יפה ומכובד. מה לגבי חוג ידידי הפקולטה. בפקולטות הנדסיות כמו בחשמל למשל, המנחים הם מהתעשייה, כמה מזה מתבצע פה?

פרופ"ח לנדסברג – התפרצת לדלת פתוחה, מאחר ונעשתה פעילות רבה בתחום חיזוק הקשרים עם התעשייה:

1. גייסנו מנהלת קשרי – תעשייה, שתפקידה יהיה לפתח נושא זה.
2. במהלך השנה עורכת הפקולטה שלושה מפגשים עם התעשייה\בוגרים: א. כנס שנתי בהנדסה הביו-רפואית בשיתוף האקדמיה-הרפואה והתעשייה (ביום חמישי האחרון של כל פברואר. הכנס הבא ב- 26.2.2015, ובכנס הקודם היו כ-700 משתתפים). ב. כנס פרויקטים של תלמידי שנה ד', שבו התעשייה גם מציגה הצעות לפרויקטים של שנה רביעית (ביולי – כל שנה). ג. כנס בוגרים (באוקטובר).
3. אנו התחלנו לקיים סדנאות לעשרה, בנושאים כגון הדמיה. לאחרונה נערכה סדנה למהנדסי חברת ביוסנס.
4. אנו מאפשרים לסטודנטים לעשות פרויקטים בתעשייה, בשיתוף עם הפקולטה. כ-70% מהפרויקטים בפקולטה בשנה רביעית נעשים בתעשייה, זה הרבה לעומת פקולטות הנדסיות בטכניון למיטב ידיעתי. בפרויקטים יש מנחה מהתעשייה, יש צוות סיוע ופיקוח בפקולטה.

פרופ' לביא – האם יש סטטיסטיקה כמה מהבוגרים עובדים בתעשייה הביו-רפואית? מבקש לדעת כמה בוגרים עוסקים ב- Medical Devices . יש לבדק האם לשוק יש דרישה למהנדסים ביו-רפואיים?

פרופ"ח שהם – הפקולטה בולטת בכך שהיא מלמדת כמה דיסציפלינות יחד , בניגוד לפקולטות כמו חשמל, מכונות, וששם אין אנשים רב גווניים כמו פה.
פרופ"ח לנדסברג – אין לנו עדיין סטטיסטיקה, אך כמו שהוועדה ציינה יש בעיה שהסטודנטים כבר בשנה שלישית ברובם עובדים ונחטפים. יש לציין שהשוק בארץ שמרני, והתואר יחסית חדש. למשל, בצבא יש תקנים ל-20 מהנדסים שעוסקים בביורפואה לפי הגדרת עיסוקם, אולם בשלישות התקנים מוגדרים למהנדסי חשמל או מכונות. דוגמה נוספת - בכל בית חולים יש מחלקה להנדסה ביורפואית. אולם התקנים מוגדרים לרוב למהנדסי חשמל. הדוגמאות רק ממחישות שהתחום חדש.
ברגע שפתחנו מסלולים – אנו מאפשרים לסטודנט להתמקצע בשני תחומים מתוך שלושה.

פרופ' לביא – אתם מציגים תוכנית גרנדיוזית לקליטת חברי סגל, אולם אי אפשר בתקופה כזו קצרה לגייס כזו כמות . אני צריך נתונים על הבוגרים. הנימוקים לפיתוח שיש לתת לות"ת הם : מה השוק דורש. מה קורה פה בארץ , האם לבוגרים יש תרומה משמעותית בתחום ההנדסה הביורפואית בארץ. הדרך לפתח את הטכניון זה להביא פרוייקטים. כמו פרוייקט מערכות אוטונומיות; פרוייקט מדעי החיים וההנדסה, פרוייקט הנדסת מחשבים.
יש לבוא עם תכנית ל- 5 השנים הבאות, תוכנית המציגה סדר עדיפויות, תוך ציון התחום המועדף שאותו שרוצים לפתח ואז ניתן יהיה לצאת להתרמה.
אני לא משוכנע שצריך 25 חברי סגל, גם 20 חברי סגל זה טוב.

פרופ' סידי – חושב שהנדסה ביורפואית זה תחום חשוב ומתפתח. בשנים האחרונות הפקולטה היתה רדומה, והוא מברך על השינוי, על העשייה ועל כך שיש פיתוח ופריחה. יחד עם זאת קליטת חברי סגל זה לא דבר פשוט וטרוויאלי, ישנם הרבה מכשולים בדרך ואת זה לומדים מהנסיון.
באשר למהנדסים – לפני כחודש קבלנו החלטה בועדת המשנים, שכל חבר סגל חדש שהוא נסיונאי יקבל בשנתיים הראשונות עזרה כספית שתאפשר לו לקלוט מהנדס בהיקף של 50%.
באשר ליחידות תעסוקה - 8000 יחידות שווה לרבע מיליון שקל. כך שמ- 13,000 יחידות תעסוקה להגדיל ל- 21,000 זה לא קל. הכפלת מספר המעבדות או הפרוייקטים, המשמעות שלה היא כסף, כך שלא פשוט לעשות שינויים בלי השיקול הכספי. חשוב להבין זאת.

פרופ' שוסטר - אני מברך על כך שהפקולטה מתעוררת משינה ארוכה, זו פקולטה חשובה . זו עדיין יחידה קטנה עם מעט סטודנטים. לא ברור כמה זה אפקטיבי הצורך במהנדס מחשבים לפקולטה כזו קטנה וצריך לחשוב על שיתוף עם פקולטות אחרות.
מברך על התוכנית המשותפת עם רפואה. מברך גם על הפעילות הגדולה בגיוס חברי סגל חדשים. המפתח להתפתחות הוא להביא חברי סגל מצוינים. הטכניון לא יגיד לא למועמד מצויין. זו הדרך להעלות את הרמה. אני לא אוהב את המינוח מסה קריטית. הטכניון בנוי על כך שחוקר אחד מצויין יותר טוב מ- 5 בינוניים. זה המפתח להעלאת מספר חברי הסגל.
צריך לפנות כל שטח למעבדות מחקר ולציוד אינטרדיסיפלינרי למחקר. תמשיכו בקליטה אנחנו נעזור לכם. באשר לתחומי המחקר, צריך להסתכל בהתסתכלות טכניונית ולא יחידתית, כמו למשל בנושא drug delivery זו קבוצה טכניונית העוסקת בתחום זה בכל הטכניון. לא חייבים מסה קריטית בתחום זה. צריך להסתכל בראייה של מדעי החיים וההנדסה בטכניון.

פרופ' שמואלי – מסכים עם דברי קודמי . מדגיש את החשיבות בפיתוח הקשרים עם התעשייה. בתוכנית האירופית החדשה ישנה אפשרות להשיג 1/2 מליון אירו למחקר, המשלב את האקדמיה עם התעשייה ולכן חשוב מאוד לקדם את הקשר מול התעשייה.
פרופ' לביא – לסיכום: עדיף להתמקח עם דיקנים רעבים מאשר להזיז ישנים. כשנכנסתי לטכניון החזון שלי היה הקמת בתי ספר, זה לא עבד. לפני כ- 4 שנים העליתי את הרעיון למשוך סטודנטים טובים לטכניון דרך רפואה, ואני שמח שסוף סוף הדבר קרם עור וגידים ביזמתו ובדחיפתו של אמיר.
כאשר אין בתי ספר, כל 18 הפקולטות מתנקזות להנהלה, וההיבט שלנו הוא כלל טכניוני, ולא לפי תחומים. כך שכולם נלחמים על אותה עוגה.
האמביציות טובות. גם 20 חברי סגל זה טוב בתנאי שהם מצוינים. אני משוכנע שתוספת של עוד 3 חברי סגל ובשלב הבא עוד 3 חברי סגל ייתן דחיפה רצינית לפקולטה.

חשוב מאוד לחזק את נושא התשתיות. נושא זה צריך להיות בראש סולם העדיפויות. נתנו את הדעת על הצורך בעזרה למעבדות מחקר ואכן צריך לשנות זאת, אולם מאחר והתקציב קשיח ואין לנו תקציב פיתוח, יש לנו קושי.
חשוב לתכנן תוכנית לתשתית בינוי. אם זה שתי קומות או בניין נמצא לכך פתרון.
את סכום הדו"ח והישיבה יש לדווח להנהלה, ההנהלה מדווחת לועדה המרכזת ולאחר שנתיים נערכת בקרה על מה שנעשה.

פרופ"ח שהם – בשנים האחרונות היו 4-5 מועמדים לחברי סגל שלא התקבלו בשל החשש לתקנים. אולי כדאי שההנהלה תמליץ על מינויים משותפים.
פרופ' לביא - מצד אחד לפקולטה יש אוטונומיה לקבל החלטות באשר למהות המינויים ומצד שני רוצים שההנהלה תנהל את נושא המינויים המשותפים. לדעתי, מינוי משותף יש לו מקום בייחוד אם יש תחומי עיסוק משותפים. המינוי המשותף צריך להיות כהחלטה ומו"מ בין הדיקנים לפקולטה.
פרופ' סידי - ההיסטוריה של מינוי משותף היא לא מוצלחת.
פרופ' שוסטר – הרבה דיקנים חוששים מכך שהמינוי המשותף יגרום לכך שאחד הצדדים יצא עם תחושת תיסכול. התחרות בין הדיקנים יכולה לגרום לכך שמינוי משותף אינו מוצלח.
פרופ' לביא – יש מקרים שמינוי משותף הוא טוב. אני חושב שמינוי כזה עם הפקולטה לרפואה והפקולטה לחשמל יכול להיות מוצלח ובעל חשיבות.

הישיבה הסתיימה ברוח אופטימית ועם תחושה שיש רצון מצד ההנהלה לקבל את מסקנות ועדת הערכה לפיתוח וקידום הפקולטה.

Technion – Israel Institute of Technology

Faculty of Biomedical Engineering

Review Report
2013

Submitted to the International Review Committee
March 2013

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1. Vision

To generate and advance knowledge in the field of Biomedical Engineering, to improve human health through excellence in research and education at the interface of engineering, science and medicine, and to lead the field of Biomedical Engineering discipline in Israel.

The Faculty places particular focuses on:

- Promoting and developing new technologies and methodologies.
- Advancing the research and understanding of various health problems and diseases, on various scales: from molecular and nanotechnological, sub-cellular, intercellular interactions, as well as whole organ or systemic.
- Developing novel diagnostic and therapeutic modalities, from the bench to the "mensch".
- Teaching budding biomedical engineers along the principles of: Knowledge, Experience, Creativity and Innovation.
- Training and educating graduate students (MSc and PhD) to become leaders in the academy and in the industry.
- Tightening collaboration with other faculties in the campus with the goal of advancing biomedical sciences and engineering.
- Strengthening interactions with the industry in Israel, to advance projects for the benefit of humanity and the state of Israel.
- Generating and intensifying international scientific collaboration though faculty and student exchange programs, funded research, consortia, and international conferences.

2. Introduction and Overview

2.1 General Description.

The Faculty of Biomedical Engineering at the Technion is involved in a wide range of basic and applied research and in teaching the challenging and expanding field of Biomedical Engineering to a top quality group of students.

The rise in life expectancy, alongside enhanced quality of life, has ushered in a growing demand for improved health-related products and services. Biomedical Engineering integrates traditional biology and engineering disciplines, as well as recent novel medical developments to advance clinical diagnosis and therapy options, and to investigate the physiological basis of diseases. Biomedical Engineering encompasses techniques in and study of tissue engineering, tissue regeneration, nanotechnology, intracellular physiological control mechanisms, drug regulation and drug delivery systems, rehabilitation engineering, signal processing, image processing, biomechanics and biofluids, and aids for the feeble and the disabled. The field of biomedical engineering is characterized by innovation and sophistication, and by the constant search for new challenges. It has provided the public with implant devices, cardiac assist devices, various neurological implants, diagnostics and therapeutics, minimal invasive treatment by catheterization and development of advanced imaging modalities.

The Faculty of Biomedical Engineering (BME) at the Technion was the pioneering and has been the leading Faculty in this field in Israel, since 1968/9. To date, the graduates of the Faculty of BME at the Technion comprise the majority of Israeli-educated scientists and engineers in this field.

The multitude of novel engineering techniques and state-of-the-art technological, scientific and medical know-how generated by the Faculty have, over the years, proved both useful and beneficial to the medical community, at large, and to the medical device industries, in particular. The Faculty was the first Israeli institute to establish an undergraduate program, offering a B.Sc. in this discipline since October 1999.

The Faculty's academic program provides high quality education in Biomedical Engineering at both the undergraduate and graduate levels; graduates are equipped to meet the diverse demands of biomedical research and to address industrial applications.

Our graduates have integrated remarkably well into Israel's biomedical industry and hi-tech industries, often in key positions in development, production, marketing, and medical applications.

2.2 Historical Background

Biomedical Engineering research at the Technion began as early as the mid 1940's, when bio-electric phenomena of the body were studied in the Department of Electrical Engineering. The interest and enthusiasm generated by this new field of study grew so rapidly that, by 1968, over forty biomedical projects were simultaneously evolving at various Technion departments.

The interdisciplinary program in Biomedical Engineering was formally established in 1968/9, and the Julius Silver Institute was set up to house all of the Technion's Biomedical Engineering research. The mission of the Julius Silver Institute was to provide graduate education in Biomedical Engineering, and essentially became the pioneering and leading program in this field in Israel. Prof. Zvi Karni was appointed the head of the program, which was initially hosted within the Department of Mechanics. At that time, all faculty members had secondary affiliations at other departments, and primary affiliation at the Biomedical Engineering Department. The department's only staff member was one secretary and there were no laboratory facilities.

The first MSc student graduated in 1972. Prof. Joseph Mizrahi and Dr. Alexander Vilensky, the Department's first PhD students, graduated in 1975.

In 1972 Prof. Yoram Lanir received the first academic appointment in the department, and subsequently, a limited number of additional positions, academic and technical, became available to ensure activity with the minimal available resources.

The cornerstone of the Julius Silver building was laid in 1973. The Julius Silver Institute of Biomedical Engineering was opened in 1976. The head of the department at that time was Prof. Amiram Carmon. With the opening of the institute, four additional staff members were recruited: Prof. Rami Seliktar, Dr. Shlomo Shalev, Assoc. Prof. Amnon Foux, and Prof. Uri Dinnar. Prof. Isak Gath joined the institute in 1974.

In 1979, the Department employed nine junior, eight technical and four secretarial staff members. At that time, the Department provided graduate studies only, and all faculty members with primary affiliation at the Department were required to have a secondary affiliation at other departments and to teach at least one course per semester in these departments. Hence, the number of courses the department could offer was limited.

It should be noted that the decision to establish the Faculty of Medicine at the Technion was influenced by the strong research ties that had developed between the then young Department of Biomedical Engineering and physicians working in the three major hospitals in Haifa. The Faculty of Medicine, which initially was intended (by the Haifa municipality) to be a part of the newly established Haifa University, was established in the Technion in 1969 and became an integral part of the Technion's teaching and research activities.

From 1969 to 1993, the Department of Biomedical Engineering (BME) at the Technion was the only Faculty in the field of Biomedical Engineering in Israel. A Department of BME was established in Tel-Aviv University in 1993.

In 1999, the Faculty, headed at that time by Professor Uri Dinnar, initiated an **undergraduate program,** by accepting 30 freshmen students into its academic program. In the spring of 2002, the degree of B.Sc. in Biomedical Engineering was officially approved by the Council for Higher Education in Israel. This was the first approved degree in Biomedical Engineering in Israel.

By the academic year 2002/3, the Department had all four undergraduate years active with a yearly enrollment of about fifty new students every year. In 2004 the first group of students (21 engineers) received, for the first time in Israel, a B.Sc. in Biomedical Engineering. The head of the Department at that time was Professor Joseph Mizrahi.

In 2004, the Department was officially recognized as a Faculty.

In 2007, a peak of 13 faculty members with primary affiliation in the Faculty, was reached. After Prof. Dan Adam's retirement in Oct 2012 the number declined to 12 faculty members.

The Faculty is currently staffed by six engineers, three of whom provide general support and assistance to the Faculty (one for the student lab courses, one is in charge of the computer services and one electrical engineer), while the other three engineers work in research labs.

As of 2002, staff members recruited to the Faculty received significant startup grants for their labs. The infrastructure and furniture of all other laboratories in the Faculty are 36-years old and require renovations. In the past year sections of the floor were replaced and the asbestos was removed from the wall of the auditorium.

A significant part of the running maintenance budget (46%, namely 288,650 NIS of 625,549 NIS, in the past year) is paid from faculty research money.

3. Basic Facts (2012/2013).

3.1 The Faculty

Staff:

Faculty	12 members (14 positions)
Engineers	6 engineers (5.5 positions, , Appendix A) 3 - fully employed engineers provide Faculty-wide services (Student Labs, Computers, Electronics) 1 - engineer services two research labs (two staff members) 2 - engineers (50% position), service an additional two labs.
Administrative & Technical staff	6 (only 5.6 positions, Appendix A) 3 - Secretarial staff, 2 - Technical staff, 1 - Building superintendent

Students:

Undergraduate Studies:

Began in 2012	55
Graduated in 2012	40
Currently enrolled in the program:	188

Graduate Students

MSc - Master's Degrees (with thesis):	55
ME - Master in Engineering (without thesis)	22
Technion's ME program in Tel Aviv	35
PhD - Doctoral Degrees:	24
MSc and PhD in other Programs as: Nanotechnology, Biotechnology and Autonomous Systems	22
TOTAL (2012):	158

Degrees Awarded (from 1972-2012, inclusive):

	Total	**Since**
MSc	**299**	1972
PhD	**110**	1975
ME	**16**	2004
Technion's ME program in Tel Aviv	**44**	2010
BSc in BME	**354**	2004
BSc & MD	**8**	2008
Total:	**831**	

12 Research Laboratories (alphabetic order)

Infrastructure

3 story-high building with built-up area of about 6500 square meters.

1 auditorium, capacity: 99 people

2 class rooms, capacity: 50 and 20 students

2 student labs

1 seminar room, capacity: 15 people

1 library

3.2 The field of BME in Israel and abroad

- The ***Israeli Council for Higher Education (MALAG)*** has authorized four additional accredited institutes to award an academic degree in Biomedical Engineering. These include:
    - Tel-Aviv University
    - Ben-Gurion University
    - Afeka – Tel Aviv Academic College of Engineering
    - Ruppin–The Academic Center (Medical Engineering)
- Additional institutes are pursuing the approval of the ***Israeli Council for Higher Education (MALAG)***:
    - Kinneret College on the sea of Galilee
    - Ariel University (currently within Mechanical Engineering and Mechatronics)
    - The Hebrew University of Jerusalem
    - Jerusalem college of Technology (Lev institute – JCT).
    - Hermelim College (Medical Engineering)

- About 10% of Israel hi-tech exports ($1.8B) are products of Biomedical Engineering, and consist mainly of medical devices (based on data from "***the Israel export and international cooperation institute, IEICI",*** Jan 2012). As a comparison, software exports (the largest hi-tech fraction of the Israeli exports) comprise about 21% of the country hi-tech exports.

- Nearly half of Israel's technological incubators focus on projects in the Life Sciences or Biotechnology disciplines. At the end of 2008, 41% of all incubated companies were involved in development medical devices, and 18% in biotechnology (IEICI). About 50% of startup companies around Haifa are based upon BME.

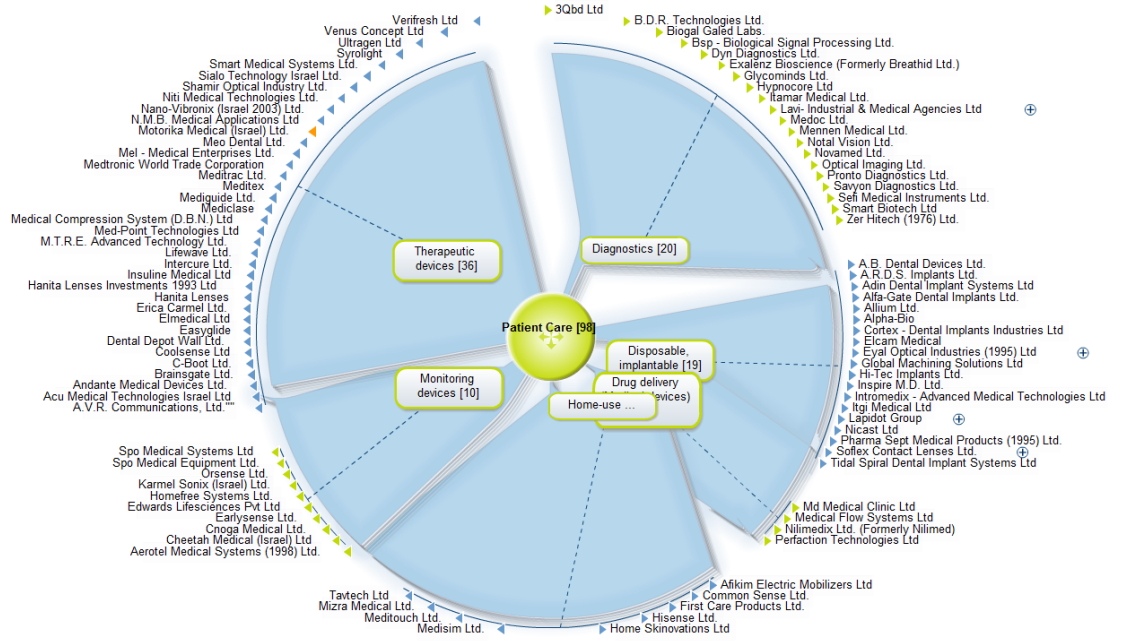
- Of the $360 million awarded to incubator companies by Israel's Office of the Chief Scientist in 2008, 25.4% was allocated to those involved in the medical devices/Life Sciences.

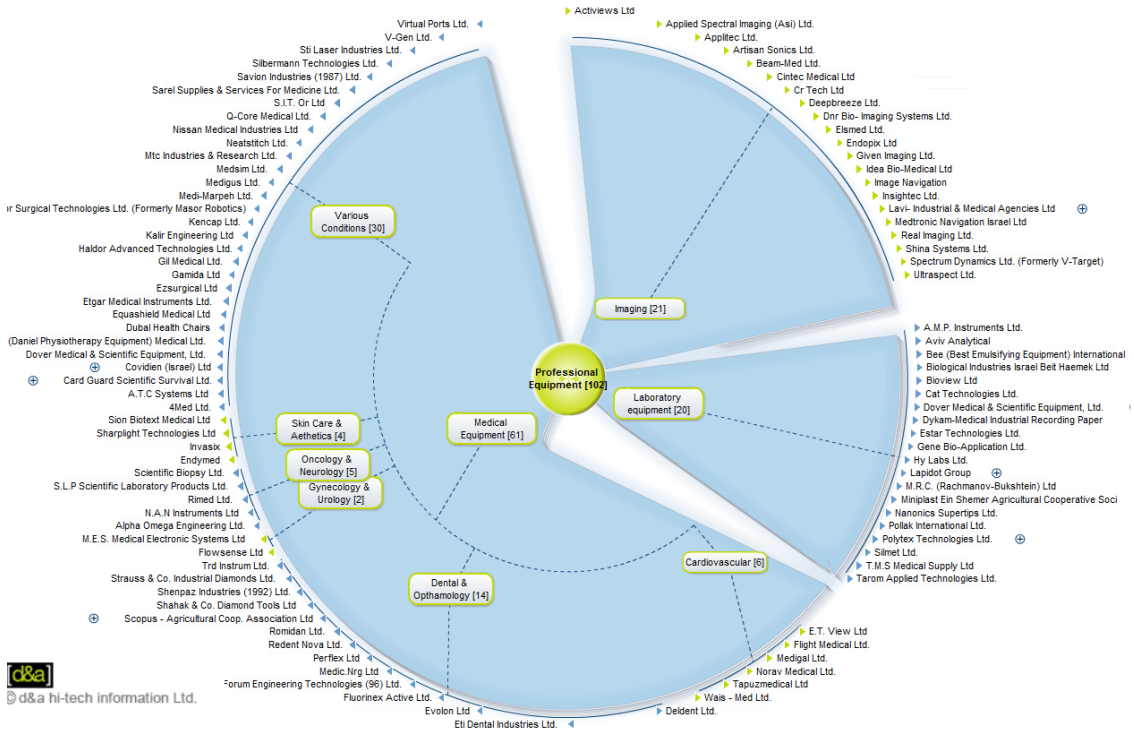
- The IEICI's Life Science Sector is the leader in business matching between the more than 1,200 companies in the Israeli Life Science industry and worldwide business partners at all levels.

- The number of BME-based startup companies increased 6-fold in the last decade, from 200, in 2002, to 1200 companies, in 2012 (IEICI 2012)

- Israel is world leader in the number of patents in the field of medical devices per capita.

- According to recent financial analyses, biomedical engineers in the USA are in the top of the best paying jobs of the future. "Between 2010 and 2020, the number of biomedical engineers is projected to rise by 61.7%, more than four times the projected growth rate for all jobs, which is 14%" (Wall street Journal, August 2012)





4. Achievements.

- **Internationally leading research Labs**

The research laboratories at the Faculty of Biomedical Engineering are listed below after the brief description of the activities of each staff member.

- **Leading in funded research grants**

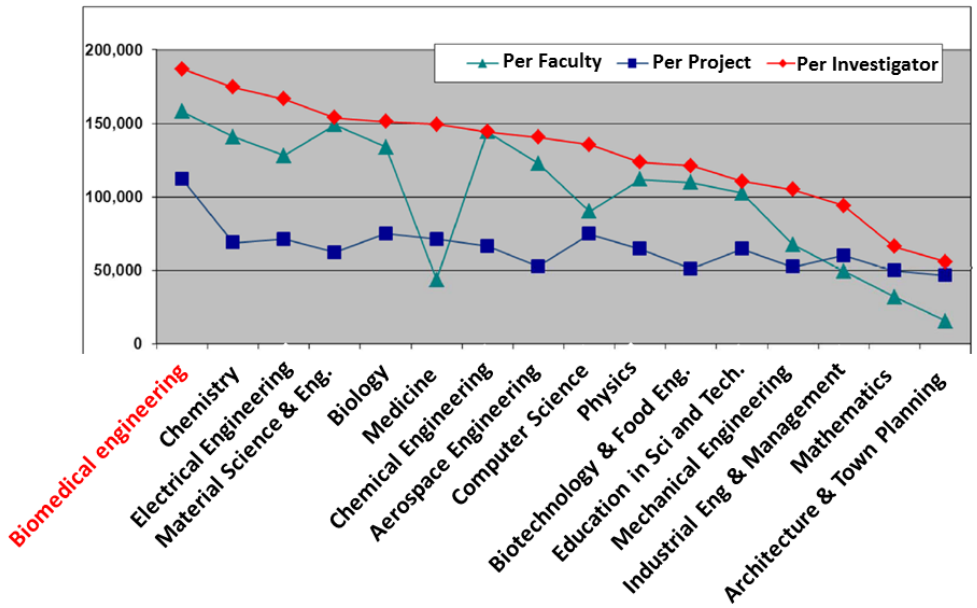
  - In 2013, a grant application of Prof Amir Meller, for the Center of Biophysics (I-Core) was granted by the Israel Science Foundation**;** "Physical Approaches to Quantifying Dynamical Processes in Living Systems" (Only two were approved at the Technion, Prof. Amit Meller and Prof. Motti Segev (Physics)).

  - Three "ERC starting grants" were awarded to three staff members in the Faculty: Shy Shoham, Shulamit Levenberg and Dvir Yelin. Although the Faculty of BME is one of the smallest faculties at the Technion, it is the only one that simultaneously has three ongoing ERC funded projects.

  - Multiple R&D funding for technological transfer to industry (e.g. Prof. Adam won 7 "magneton" funding projects with GE HealthCare Inc. (each >$1M)).

  - The Faculty is a leader, in the Technion, in the mean research funds per PI, the mean funds per research project and the mean Faculty research funds (based on a report from the office of the Executive Vice President for Research).

Compiled data for the years 2005-2010

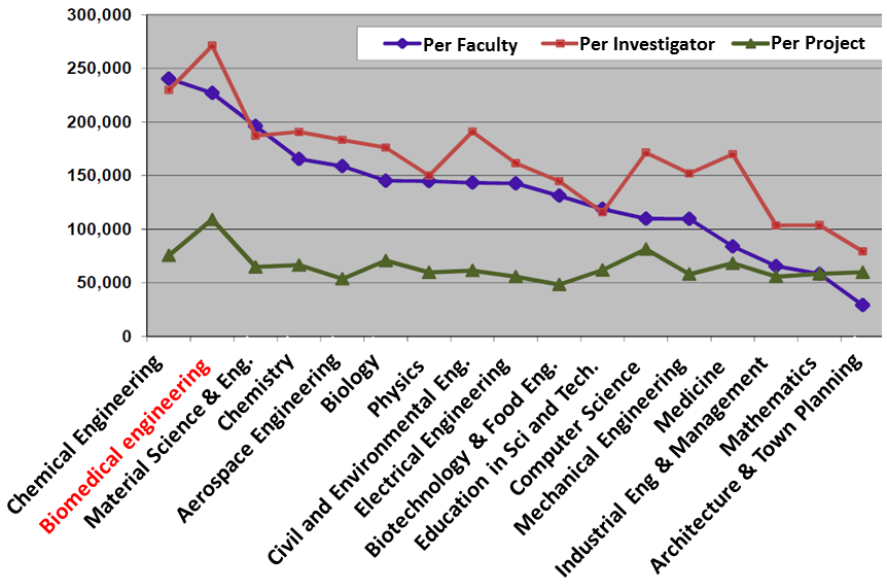


The Faculty of Biomedical Engineering

Research funds 2005-2010 18.1.2011

Year	Number of principal investigators	Funded research projects	Total external funds ($)
2005	8	13	595,070
2006	12	19	948,445
2007	12	23	1,391,158
2008	10	12	3,475,361
2009	11	22	3,999,155
2010	8	11	811,082

Compiled data for the years 2010-2012



The Faculty of Biomedical Engineering 4.11.2012

Funded research according to the date of the start of funding

Year	Department	Total ($)	Number of faculty members in department	Number of principal investigators	Number of grants in the department
2009	BME	1,595,986	11	11	27
2010	BME	3,746,461	13	9	19
2011	BME	1,856,838	13	10	31
2012	BME	3,919,304	12	11	25

Leading in Education.

- First established in 1969, as the first BME graduate program in Israel. Our graduates serve in the leading positions in the academy and the industry (e.g. in Biosense, Given-Imaging, GE, Philips)

- The first to establish a B.Sc. BME program in Israel, in 1999. The first graduates completed their studies in 2004. Altogether between the years 2004-2012, 354 graduates have gained a B.Sc. of BME at our Faculty.

- Prestigious programs for excellent students: a joint program (3 degrees: BA in Life Sciences, B.Sc. in BME, and M.D.) in "Biomedical Engineering and Medicine" and a dual (2 degrees) program in "Biomedical Engineering and Physics".

- Excellent teachers: Prof. Eitan Kimmel received the prestigious Yanai Prize for Excellence in Academic Education (2011). In 2011 average students rating of our Faculty's teachers (3.97) was close to the overall Technion lecture score (4.07). It is important to compare the scores to Faculties in similar engineering fields and with similar learn/work loads, since the learn/work loads and the demands may affect the student's satisfaction and rating! In the Technion's engineering Faculties, student lecture scores ranged between 3.78 and 4.21, in 2011.

- Our excellent students labs were used as a model for the development of similar labs at other academic institutes in Israel

- Leading in innovation

- High output of patents
- Numerous startup companies have originated from IP that was developed in the Faculty
- Strong collaborations with the industry, mostly funded by the office of the Chief Scientist in the Ministry of Industry Trade and Labor

5. Research in the Faculty

The strength of the Technion's Faculty of Biomedical Engineering lies in its high-level scientific research and experimental work backed by hi-tech infrastructure and multidisciplinary approach. The key advantages of the ongoing research at our Faculty include:

- **A multidisciplinary** approach, requiring unique skills and ability to integrate know-how from the following three main pillars: Exact sciences, Engineering and Medicine/Life Sciences. The research in the Faculty requires in-depth understanding of these disciplines and application of skills acquired from various fields of engineering toward investigating medical and biological phenomena and developing novel diagnostic technologies or therapeutic modalities.
- **In-depth investigation of physiological systems,** featuring and expertise unique to Biomedical Engineering, relative to other traditional engineering disciplines.

  When compared to adjacent engineering Faculties, the research conducted in our Faculty requires comprehensive investigation into the core of Life Sciences. In some cases, enhanced understanding of the physiological mechanisms underlying a given phenomenon will assist in development of novel diagnostic and treatment modalities.

  In comparison to other Faculties in the fields of life-sciences (Medicine, Biology) the Faculty of Biomedical Engineering employs engineering and quantitative tools for modeling, analysis and investigation of comprehensive biological problems.
- **Modern and well equipped laboratories** enabling study and investigation of novel technologies and scientific hypotheses that are at the cutting-edge of the life sciences.
- **High quality undergraduate and graduate students**, who are among the best of the Technion's student body.
- **Strong research ties with clinical departments** both within Haifa and throughout Israel, where part of the research takes place in hospitals.
- **Steady collaborations with the industry** in the field of Biomedical Engineering and consortium-based activities. A number of startup companies have been initiated by some of our graduates and faculty members.
- **Multiple international collaborations** with colleagues and research institutes around the world, as well as with leading clinical centers and global industries.

6. The Faculty

At present, the Faculty consists of 12 members: 2 full professors (Profs. Joseph Mizrahi and Amit Meller), 8 associate professors (Associate Profs. Haim Azhari, Moshe Gur, Eitan Kimmel, Amir Landesberg, Shulamit Levenberg, Dror Seliktar, Shy Shoham, Dvir Yelin), and 2 Assistant Professors (Daphne Weihs and Josue Sznitman). There are 6 professor emeriti (Profs. Dan Adam, Uri Dinnar, Isak Gath, Yoram Lanir, Noah Lotan, Alice Maroudas).

In addition, there are 6 faculty members (Profs. Rafael Beyar, David Durban, Alfred Bruckstein, Hillel Pratt, Abraham Marmur, Aharon Blank) with secondary affiliation in the Faculty. They mentor graduate students (no formal teaching) and participate in the Faculty council meetings.

The Faculty also employs 13 teaching adjuncts (Prof Avraham Shitzer, Dr. Alexander Vilensky, Dr. Yosef Andrei, Prof. Avraham Reznick, Assist Prof. Jonathan Lessick, Dr. Zvi Fridman, Dr. Sharit Sivan, Dr. Tamar Jehuda-Cohen, Dr. Mark Levy, Dr. Eugene Konyukhov, Dr. Roey Tzezana, Dr. John Kennedy), who share the heavy teaching load at both the graduate and undergraduate levels.

The Faculty has 14 tenured and tenure-track positions. A new faculty member is scheduled to join the Department in October 2013; an additional faculty member is currently being evaluated (waiting for letters from referees). A massive search is currently being conducted to recruit new staff members.

Enclosed is a list of faculty members, along with a summary of their research field and activities. Each faculty member has his/her own lab.

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Bio: Prof. **Azhari** received his B.Sc in Mechanical Eng. from the Technion in 1977, his M.Sc. (Cum Laude) in Biomedical Eng. from Tel-Aviv University 1984, and his D.Sc. in Biomedical Eng. from the Technion in 1987. From 1987 to 1990, he was on the staff of the Technion Department of Biomedical Engineering in a postdoctoral position. Prof. Azhari then received a double appointment as an International Research Fellow in both the Department of Radiology and the Division of Cardiology at the Johns Hopkins School of Medicine in Baltimore, Maryland. Upon his return to Israel in 1992, he joined the Department of Biomedical Engineering at the Technion-IIT as a staff member, where he is currently an associate professor. From 1999-2000, Prof. Azhari was on a sabbatical leave at Harvard Medical School in the Beth-Israel radiology department.

Research Interests: Prof. Azhari's research is focused on medical imaging, which includes Ultrasound, MRI (Magnetic Resonance Imaging), nuclear imaging (SPECT, PET), and hybrid scanners. His research group studies new imaging techniques and algorithms for improving the quality of medical images and for adding new features that will improve diagnosis. They also study methods for image guidance of minimal invasive intervention procedures.

Notable Activities: Prof. Azhari is an associate editor in two scientific Journals. In the past three years he was a Member of the Technion Senate. He is also a member of several committees for the Council of Higher Education. He is currently the president of the Israeli Society for Medical and Biological Engineering (ISMBE).

Publications:
Prof. Azhari has published nearly sixty peer reviewed papers and letters to the editor, two textbooks, eight chapters in books and about seventy abstracts and several patents.

Publications in the Past 5 years:
Textbook:
2010 "Basics of Biomedical Ultrasound for Engineers"
by: Haim Azhari. Hardcover: 371 pages, Publisher: John Wiley & Sons -IEEE Press; 1st edition (March 15, 2010)
Language: English

Peer Reviewed Articles:

- J.A. Kennedy, O. Israel, A. Frenkel, R. Bar-Shalom, and **H. Azhari**, "A Hybrid Algorithm for PET/CT Image Merger in Hybrid Scanners". Eur. J. Nucl. Med. Mol. Imaging, vol. 34, no. 4, 517-531, 2007.

- Yoav Levy and **Haim Azhari**: "Velocity Measurements Using a Single Transmitted Linear Frequency Modulated Chirp", Ultrasound in Med. & Biol., Vol. 33, No. 5, pp. 768–773, 2007
- John A. Kennedy, Ora Israel, Alex Frenkel, Rachel Bar-Shalom, and **Haim Azhari**: "Improved Image Fusion in PET/CT Using Hybrid Image Reconstruction and Super-Resolution," International Journal of Biomedical Imaging, vol. 2007, Article ID 46846, doi:10.1155/2007/46846, 10 pages, 2007.
- Yoav Levy, Yehuda Agnon and **Haim Azhari**: "Ultrasonic Speed of Sound Dispersion Imaging", Ultrasound in Medicine and Biology, Volume 33, Issue 5, Pages 762-767, May 2007.
- Kovalski, Gil, Attia Shai, Israel, Ora, Keidar Zohar **Azhari Haim**: " Correction of Heart Motion due to Respiration in Clinical Myocardial Perfusion SPECT Scans Using Respiratory Gating", The Journal of Nuclear Medicine, 48(4):630-636, 2007.
- John A. Kennedy, Ora Israel, Alex Frenkel, Rachel Bar-Shalom, **Haim Azhari**: "The reduction of artifacts due to metal hip implants in CT-attenuation corrected PET images from hybrid PET/CT scanners.", Med. Biol. Eng. Comput., vol. 45, no. 6, 553-562, 2007.
- **Haim Azhari**, Robert R. Edelman, and David Townsend: "***Editorial***: Multimodal Imaging and Hybrid Scanners". International Journal of Biomedical Imaging, Article ID 45353, 2 pages. doi:10.1155/2007/45353, 2007
- Gil Kovalski, Zohar Keidar, Alex Frenkel, Jonathan Sachs, Shai Attia, **Haim Azhari:** "Dual 'Motion-Frozen Heart' Combining Respiration and Contraction Compensation in Clinical Myocardial Perfusion SPECT Imaging", Journal of Nuclear Cardiology (JNC), 16:396–404, 2009.
- Gil Kovalski, Zohar Keidar, Alex Frenkel, Ora Israel, **Haim Azhari**: "Correction for Respiration Artefacts in Myocardial Perfusion SPECT is More Effective when Reconstructions Supporting Collimator Detector Response Compensation are Applied". Journal of Nuclear Cardiology, 16(6):949-955, 2009.
- Tanya Glozman and **Haim Azhari**: "A method for characterization of tissue elastic properties combining Ultrasonic Computerized Tomography with Elastography". Journal of Ultrasound in Medicine (JUM), (29): 387-398, 2010.
- Tamara Rothstein, Diana Gaitini, Zahava Gallimidi and **Haim Azhari**: ""Investigation of acoustic changes resulting from contrast enhancement in through-transmission ultrasonic imaging", Ultrasound in Medicine and Biology, 36(9), pp.1395-1404**,** 2010.
- **Haim Azhari**: "Feasibility Study of Ultrasonic Computed Tomography Guided High Intensity Focused Ultrasound", Ultrasound in Medicine and Biology, Volume 38, Issue 4, Pages 619–625, 2012.
- **Haim Azhari**: "Ultrasound: Medical Imaging and Beyond **(*An Invited Review*)**", Current Pharmaceutical Biotechnology, Volume 13, Number 11, pp.2104-2116, September 2012.
- Diana Gaitini, Tamara Rothstein, Zahava Gallimidi and **Haim Azhari**: "Feasibility study of breast lesion detection using computerized contrast enhanced through-transmission ultrasonic imaging", **In-Press**, Journal of Ultrasound in Medicine (JUM), 2013.

Research lab: Medical Imaging

- **Ultrasound** – Investigation of various applications of ultrasound in medicine. This includes development and implementation of new methods for ultrasonic imaging, mainly by using through transmission waves and particularly for breast imaging. Investigation of new applications for high intensity focused ultrasound (HIFU) and development of methods for noninvasive thermal monitoring.

- **Nuclear Medicine PET/SPECT** – Which includes investigation of methods for improving image quality, resolution or contrast.

- **Magnetic Resonance Imaging (MRI) -** Algorithms and methods for rapid image acquisition and reconstruction. Information extraction from images.

- **X-ray CT**- Image guided minimal invasive surgery using HIFU, RF and Microwave needles.

- **Multimodal imaging** – which includes the synthesis and fusion of information obtained from different imaging modalities in order to yield synergism by providing new improved images or measure noninvasively various tissue properties.

Gur Moshe Ph.D.

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Education:

Date	Institute	Degree	Area of specialization
1968-1974	University of Minnesota	Ph.D	Visual Physiolgy
1965-1968	Hebrew University	Bs.C	Biochemistry and Physiology

Employment:

Date	Institute	Title	Research area
1991 - present	Technion, Biomedical Engineering Department	Associate Professor	Physiology and Psychophysics of Vision; Modeling; fMRI; Eye Movements.
1980-1991	MIT, Chemical Engineering Department	Senior Lecturer	Physiology and Psychophysics of Vision; Modeling
1976-1980	Technion, Biomedical Engineering Department	Lecturer	Physiology and Psychophysics of Vision
1974-1976	Dept. of Physiology, Medical School, University of Minnesota.	Instructor	Color vision

Recent Grants

2004-2007 Chief Scientist, Ministry of Science – Smart sensors for space exploration. $70,000 (M. Gur, Principal Investigator; O. Yadid-Pecht, co-principal Investigator.)

2004-2008 Bi-National Science foundation - Pattern Adaptation: Studies using Human fMRI and Alert Monkeys. $120,000. (M. Gur, Principal Investigator; DM Snodderly, co-principal Investigator).

2009-2012 Israel Science Foundation — $110, 000

Research interests

Studying various aspects of the visual system using single cell recording in alert monkeys, psychophysical and fMRI experiments in humans, theoretical and experimental modeling of binocular eye movements.

Recent Invited Talks (International)

Center for Consciousness Annual Meeting, Tuscan, AZ, 2012; Plenary talk.
Boston University, 2012

Harvard Medical School, 2012
University of California, Berkley, 2011
University of Texas, Austin, 2011
Vision Science Society, Sarasota, Florida 2005, Invited speaker.

Selected Publications

Gur M, Kagan I, and Snodderly M**.** Orientation and direction selectivity of single cells in V1 of alert monkeys: functional relationships and laminar distributions. *Cerbral Cortex*, 15, 1207-1221, 2005.

Furman M, and Gur M. Alteration of the perceived path of a non-pursued target during smooth pursuit: Analysis by a neural network model. *Vision Research*, 15, 1207-1221, 2005.

Gur M and Snodderly DM. High response reliability of neurons in primary visual cortex (V1) of alert trained monkeys. *Cerbral Cortex*, 16, 888-895, 2006.

Tang Y, Saul A, Gur M, Goei S, Wong E, Ersoy B, and Snodderly DM Eye Position Compensation Improves Estimates of Response Magnitude and Receptive Field Geometry in Alert Monkeys. *J Neurophysiol* 97: 3439-3448, 2007.

Gur M and Snodderly DM. Direction selectivity in V1 of alert monkeys: Evidence for parallel pathways for motion processing**.** *J. Physiology (London)*, 585, 383-400, 2007. (*This paper has been chosen to be highlighted in the Perspective part of the Journal*)

Gur M and Snodderly DM. Physiological differences between neurons in layer 2 and layer 3 of primary visual cortex (V1) of alert macaque monkeys**.** *J. Physiology (London)*, 586, 2293-2306, 2008.

Kagan, I Gur, M, and Snodderly DM. Saccades and drifts differentially modulate neuronal activity in V1: effects of retinal image motion, position, and extraretinal influences. *J. Vision*, 8, 1-25, 2008.

Snodderly DM, Kagan I, Gur M. Linearity and selectivity of neuronal responses in awake visual cortex. Importance of the cell sample. eLetter to J. Vision. 2010
http://www.journalofvision.org/content/9/9/12.short/reply#jov_el_84

Forman, M and Gur, M. And yet it moves: perceptual illusions and neural mechanisms of motion processing during pursuit eye movements. *Neurosci. Biobehav. Rev.*, 36, 143-151, 2012 (Invited review).

Hendel, T and Gur, M. Evidence against the facilitation of the vergence command during saccade-vergence interactions. *Exp. Brain Res*., 223, 415-427, 2012.

Research Lab: Vision Research

Research Projects

Visual perception unity and the corpus callosum (CC)—an fMRI/DTI study

We perceive the world as a seamless whole even though its representation is split between the two cerebral hemispheres. Current explanation is that the CC that relays information between the two hemispheres is responsible for correlating, in time and space, visual information across the mid-line. To test this explanation, we used fMRI to map the exact location of the cortical representation and DTI (diffusion tensor imaging) to track the number of fibers that connect the two hemispheres at the central representation of the visual field where the scene is perceived with exquisite exactitude.

We found that contrary to current view, there are very few fibers that connect the central field representation and thus we are in support of the alternative hypothesis positing that the central field is represented twice in the two hemispheres.

How are binocular eye movements controlled?

A major component of binocular eye movements are saccades which are the fast and very accurate eye movements that are generated every few hundred msec. These movements are complemented by slow movements. How are the two types of movements controlled, and what are the physiological mechanisms generating them has been under debate. Using accurate measurements of eye movements we suggest a novel theoretical model and its physiological implementation whereby the superior colliculus in each hemisphere is generating a monocular command that are combined only by downstream mechanisms. Our findings and analysis offer an alternative to the current view of the superior colliculus issuing binocular commands.

Spatial resolution within the central visual field (fovea)

Anatomical structures within the retina, particularly in the fovea predict that visual acuity should be maximal at the very center of the fovea and would rapidly decrease as a function of distance from the center. Due to uncertainty induced by eye movements acuity is usually measured only at the visual field center so not much is known about our ability to resolve spatial information away from the very center. Furthermore, the all-important ability to resolve faces has not been studied at all. In this study we used very short exposure times and controlled eye movements to study acuity within the fovea. We found that there is indeed a deterioration in acuity as a function of eccentricity but it is less than predicted by the anatomy— probably due to miniature eye movements and repeated sampling. We have also shown for the first time that face recognition acuity is exquisite—on the order of 6 minutes of arc.

Parallel processing by the brain

Although information about the outside world is transmitted to the brain in parallel and many aspects of perception remain parallel (space perception is a prime example), current approach is strongly influenced by the computational view which is inherently serial. I conducted a series of perceptual experiments in the somatosensory, auditory and visual modalities and showed that we can perceive and process very short events taking place at separate cortical loci. I further showed that no convergent serial processing can account for those perceptual results. We can conclude that the brain has a unique ability to relate information located at disparate locations without sending it to a new locus for comparison. Our results stress the brain ability of parallel processing and suggest the existence of non-conventional interactive mechanisms.

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Education:

Date	Institute	Degree	Area of specialization
1984-1987	MIT	Post-Doctorate	Biomechanics
1981-1984	Technion	D.Sc.	Biomedical Engineering
1979-1981	Technion	M.Sc.	Biomedical Engineering
1969-1973	Technion	B.Sc.	Aeronautical Engineering

Employment:

Date	Institute	Title	Research area
2002 - present	Technion, Biomedical Engineering (BME) Department	Associate Professor	Cell biomechanics, therapeutic ultrasound, bubble dynamics, intra-membrane cavitation
2001-2002	Tel Aviv University, BME	Visiting Scientist	Therapeutic ultrasound, angiogenesis
1996-2001	Technion, Agricultural Engineering Department	Associate Professor	Aquaculture, ultrasound, drug delivery, lung mechanics
1987-1996	Technion, Agricultural Engineering Department	Senior Lecturer	Heat and mass transfer in animals,

Selected Honors and Awards

2004: The Henri Gutwirth award.
2011: The Daniel Shiran Memorial Research Prize for 2011 in the Field of BioMedicine
2011: The Yanai Prize for Excellence in Academic Education for 2011

Recent Invited Lectures (International)

ICSV19 international congress-Vilnius, Lithuania. July, 2012. Invited distinguished keynote speaker.
ECI conference- Ein Bokek, Dead Sea, Israel. March, 2012. Invited lecture.
Workshop on Micro-acoustics- Bergen, Norway. December 2011. Invited lecture.
ICSV18 international congress- Rio de Janeiro, Brazil. July 2011. Invited lecture and session chair.

Selected Publications (last 5 years)

- Naor, O., Y. Hertzberg, E. Zemmel, E. Kimmel, S. Shoham. Towards multifocal ultrasonic neural stimulation II: design considerations for an acoustical retinal prosthesis. **J. Neural Engineering** 2012. doi:10.1088/1741-2560/9/2/026006

- Mizrahi, N., E. Zhou, G. Lenormand, R. Krishnan, D.Weihs, J.P. Butler, D.A. Weitz, J.J. Fredberg, E. Kimmel. Therapeutic ultrasound perturbs cytoskeleton dynamics. **Soft Matter** 8:2438-2443, 2012.
- Krasovitski, B., V. Frenkel, S. Shoham, E. Kimmel. Intramembrane cavitation as a unifying mechanism for ultrasound induced bioeffects. **PNAS** 108(8):3258-3263, 2011.
- Oliven, E., R. Kaufman R. Kaynan, R. Oliven, U. Steinfeld , N. Tov, M. Odeh, L. Gaitini, A.R. Schwartz, E. Kimmel.. Mechanical parameters determining pharyngeal collapsibility in patients with sleep apnea. **J. Applied Physiology** 109:1037-1044, 2010.
- Krasovitski, B., A. Goldring, A. Harari, E. Kimmel. Growth and collapse of a vapor bubble and shock wave emission around a holmium laser beam: Theory and experiments. **Bubble Science, Engineering and Technology** 2(1):17-24, 2010.
- Hancock, H., L. Smith, J. Cuesta, A. Durrani, M. Angstadt, M. Palmeri, E. Kimmel, V. Frenkel. Investigations into pulsed high-intensity focused ultrasound–enhanced delivery: preliminary evidence for a novel mechanism. **Ultrasound in Medicine and Biology** 35(10):1722-1736, 2009.
- Or, M., E. Kimmel. Modeling linear vibration of cell nucleus in low intensity ultrasound field. **Ultrasound in Medicine and Biology** 35(6):1015-1025, 2009.

Research Lab: Biomechanics of Ultrasound Interactions with Cells and Tissues

THE INVESTIGATION OF INTRA-MEMBRANE CAVITATION

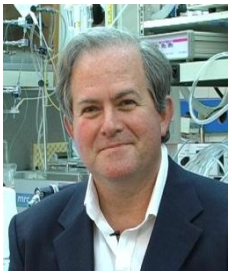
It all started from the mysteries of therapeutic ultrasound that I was trying to resolve in the last 17 years. The interaction of therapeutic ultrasound and biological tissues is known to induce a wide variety of non-thermal effects ranging from hemorrhage and necrosis to more delicate manipulations of cells and their membranes such as permeability enhancement and excitable tissue stimulation. Those cellular bioeffects are presumably associated with distortions of hundreds nonometers in the cell structure and current bio-acoustic physical models fail to explain how ultrasound induces those distortions unless extracellular gas bubbles are generated “somewhere” in the tissue and their pulsations in the ultrasonic field apply mechanical loads on the cells. However, these cellular effects of low intensity ultrasound, which occur at intensities comparable to ultrasound imaging and even much lower, and where cavitation in the body is purposely avoided. Finally, I believe that I have resolved this enigma, at least in theory. Some two years ago we (in collaboration with Prof. Shy Shoham and Dr. Boris Krasovitski, a research associate) proposed a unifying hypothesis of a bilayer sonophore (BLS) whereby ultrasound preferably induces bubble formation in the intra-membrane space between the two lipid leaflets by pulling away the two leaflets while dissolved gas is accumulating in the hydrophobic zone, creating pockets of gas. Stretching of the leaflets that follows the pocket formation was predicted to initiate mechano-transduction processes in the cell; induce pore formation in the membrane and permeability

changes, and might induce polarization in the membrane of excitable cells and affect voltage sensitive ion channels as well. The model suggests that the stretching level of the leaflets increase with ultrasound pressure amplitude and decrease with the frequency; membranes in cells in softer tissues and relatively closer to free surfaces can more easily open up, deform and stretch. This model, when extended by adding electric charge and voltage sensitive trans-membrane ion gates predicts the conditions for induction of action potential in a neuron cell (Michael Plaksin, doctorate student) - another potential applications of cell modulation. A spherical symmetry version of this model predicts the whereabouts of an artificial membrane that encloses a spherical liquid filled liposome under ultrasound– where the intra-membrane gas accumulates a spherical gas envelope. We have also developed a simplified liposome BLS model (Michael Assa, doctorate student). In the original BLS model, a flat and circular piece of cell membrane is surrounded by a constraining ring of trans-membrane proteins. The simplified liposome BLS model however, has spherical symmetry and uniform radial expansion and contraction of a spherical outer leaflet of a spherical bilayer membrane that surround a layer of gas that form the external layer to a spherical droplet of liquid with diameter of a couple of micrometers. This mechanism is easier to simulate and it contains less unknown parameters that could be determined only by experiments. The BLS model depicts the cell in an ultrasound field as made of a cluster of gas pockets that are not necessarily spherical in shape, yet it is expected that many of the features of bubbles in ultrasound field will be applicable to cells in ultrasound field. As such, cells in suspension will be attracted to each other and will cluster in node or antinodes. Cells will magnify the pressure signal nearby and induce a steady microstreaming flow field near them when they are near a wall. Clustering and rotation of RBC and microstreaming, production of blood cell stasis and endothelial damage in the blood vessels under low intensity ultrasound, cells clustered at nodes as gas-bubbles (Nesma Mazawim master student). Spectrum analysis of the scattered signal from cells should have subharmonics and ultraharmonics like for bubbles and a resonance frequency where all the bioeffects will be enhanced. Basically, any abrupt pressure change affects the BLS and thus affects cells, and this is demonstrated by a model for traumatic brain damage that is induced by a high energy explosion or by a violent mechanical impact We hypothesize that cells are affected by the pressure waves that develop in the skull after the impact to the head; mainly by the negative pressures that expand the intra-membrane spaces within the cells and in the membrane that surround it. Soft cellular tissues such as the brain, the lungs, the liver and the spleen are extremely sensitive to negative pressures and therefore are the first to damage in case of impact. It might happen, in our view that in such cellular tissues there will be cells that rupture while the extracellular matrix is left intact. This perception is very different from the common approach to mechanical failure/yield of living tissues. At this stage "intra-membrane cavitation" is merely a concept. In order to establish the theory as a scientific/engineering base for many applications, BLS dynamics should be investigated experimentally. The main reason we believe that such membrane response to ultrasound irradiation was not previously observed is that it involves both very tiny displacements between tens to hundreds nanometers and very rapid movements at typical time scale of less than ten microseconds. Some experimental observations provide an indirect evidence for the BLS theory. For instance, the observations of widened cavities coinciding with membranes

in and around cells, when we exposed a multi-layered epithelium to ultrasound *in vivo*. At this stage a rigorous experimental investigation of the BLS is needed when it is exposed to ultrasound or to other acoustic stimulation such as a shock wave. First, an experimental verification is required of the BLS theory and the best will be to observe the BLS in real time. At the same time, to find evidence for the BLS existence by other techniques such as acoustical methods is of great importance as well. In addition, there is a need to provide experimentally the relationship between the membrane properties and the parameters of the acoustic wave, and to compare to the theory on one hand, and to find missing parameters in the theory on the other hand. first as a direct experimental validation of the theory, and second, the theory has several unknown parameters that were guessed by us but need solid data to substitute for the guessed parameters. We will use Fluorescence Resonance Energy Transfer (FRET), a technique based on a distance-dependent interaction between two molecules in which excitation is transferred from a donor molecule to an acceptor molecule. Energy transfer from the donor to the acceptor occurs over distances of 1nm to 10nm, and is negligible at distances that exceed 10nm (the FRET signal decreases with the sixth power of the distance). Biological membranes are about 5nm in thickness, making them a suitable target for analysis with the FRET technique: intra-membrane thickness changes can be monitored by integrating a donor molecule into one leaflet and the acceptor molecule into the other leaflet (Carmel Zeltser, master student). Our model predicts that ultrasound treatment will dynamically modulate the intra- membrane space and increase the distance between the outer leaflet and the inner leaflet. Hence, under ultrasound treatment we expect to see reduction in the average FRET signal as the intra-membrane space swells. Regarding the "zero-state" of the bilayer membrane, we assume that gas pockets are continuously formed and disappear inside the bilayer membrane. The main parameters are the dissolved gas concentration and composition, and the properties of the membrane. Simulate the effect of the zero state on the response (especially, pressure threshold) of the BLS model to pressure changes. We intend to measure membrane configuration changes at the zero state and changes that follow the exposure of the BLS to US and to imbalance maneuvers using a method with ultra high spatial sensitivity to changes in the energetics at the molecular level in interfaces and rapid enough to follow microsecond changes in time (Einat Shapira, master student). Another interferometry technique (Wide Field Digital Interferometry – WFDI) will be used in collaboration with Dr. Natan Shaked, TAU. A label-free technique will be applied by Rasha Elaimy (master student) to provide quantitative measurements of optical path delays (OPDs) associated with optically transparent samples. By recording the interference pattern between the light that has interacted with the sample and the mutually coherent reference wave, WFDI captures the complex wavefront of the sample field, containing the quantitative phase profile of the sample. Using WFDI, we will study membrane dynamics and the pattern of movement of the two separate leaflets of the membrane according to optical path delays of light transmitted through membrane. WFDI is able to record the entire complex wavefront (amplitude and phase) of the light interacted with the membrane, and can digitally reconstruct the quasi three-dimensional distribution of the sample field.

Landesberg Amir M.D., D.Sc.

Associate Professor



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Education:

Date	Institute	Degree	Area of specialization
1996-1997	University of Calgary	Post-Doctorate	Cardiac Excitation Contracton Coupling
1994	Technion	D.Sc.	Biomedical Engineering
1986	Technion	M.D.	Medicine
1985	Technion	Bs.C	Electrical Engineering

Employments and Professional Experience

Date	Institute	Title	Research area
2012-	Technion, Biomedical Engineering Department	Dean	
2007-	Faculty of Biomedical Engineering, Technion	Associate Professor	Physiological Control System. Assist and Monitoring devices.
1998-2007	Departmnt of Biomedical Engineering, Technion	Senior Lecturer	Sarcomeric control of contraction
1996 - 1997	University of Calgary	Post-Doctorate	Cardiac Excitation Contracton Coupling
1994 - 1996	Rambam Medical Center	Residence (Physician)	Internal Medicine
1987-1992	Israel Defense Force (IDF)	Military Physician	
1987	Rambam Medical Center	Internship	General Medicine

Public Professional Activities

2008- Secretary /President, The International Society for Heart Research (ISHR) – Israel group.

2009-2012 Treasures and member of the Technion Association Organization

Professional Experience

2008- Pneumedicare. Chief scientific Officer. An innovation that emerged from the Faculty of BME Technion. Development of technologies for monitoring lung ventilation.

1999-2003 Levram – Medical Device Ltd. The Technion Entrepreneurial Incubator Co. Ltd. Project leader. Development of cardiac therapeutic devices for heart failure.

Selected Honors and Awards

- Hershel and Hilda Rich - Technion Innovation Award . "A device for continuous monitoring of lung ventilation". June 2012
- An Award for excellent research, from the International Dead Sea Symposium (IDSS)

on Cardiac Arrhythmia and Device Therapy. "Optimization of Cardiac Function After Acute Infarction, by Pacing at Various Sites". February 2010.

- The Neufeld Memorial Research Award, from the United State – Israel Binational Science Foundation (BSF), for the annually most outstanding and original BSF supported project in the health sciences. Sept 2004.
- Henry Neufeld Research Award Fund, Israel Heart Society together with the Israel Society of Cardiothoracic Surgery, "Circulatory Support in Acute Heart Failure by a physiological cardiac assist device that works synchronously with the heart" April 2003
- Excellence Award for outstanding project of the Technological "incubators" in Israel. The Chief Scientist of the Ministry of Industry & Trade. 2001
- Yigal Alon Award, The Israel ministry of Education, 1998-2001.

Research interests

- Control and modeling of biomedical system. Modeling whole heart function based on cellular mechanisms. Cardiac Mechanics. Whole heart, in-situ studies and isolated muscle fiber (trabeculae) studies.
- Excitation contraction coupling in the cardiac and skeletal muscle. Regulation of intracellular calcium transient and motor unit (Cross-bridge) dynamics. Biochemical to Mechanical energy conversion by the Sarcomere.
- Heart failure and Cardiac Assist devices. The aging heart. Development of new diagnostic and therapeutic modalities.
- Cardiac electrophysiology. Early detection of ischemia. The Mechanoelectrical feedback. Cardiac resynchronization therapy.
- Physiological Control systems. Early detection of complication and preventive medicine. Monitoring the ventilation in premature infants. Monitoring patients with heart failure.

Recent Invited Lectures

- "The Afterload Dependency of the Frank-Starling Law Reflects Cross-Bridge Dependent Regulation of Contraction". Thick and Thin Filament Regulation in Striated Muscle, Madison, USA, May 2008
- "Theories of Cardiac Sarcomere contraction and Implications to normal and failing heart function". Faculty of Engineering Science, Ben-Gurion University of the Negev. May, 2009.
- "Sarcomere velocity regulates the cross-bridge cycling rate in cardiac muscle: A novel theory for the muscle molecular motor". Myofilament Control Mechanisms, Madison, USA, May 2010.
- "Contraction kinetics and energy metabolism". Symposium on the myocardial fuel/work balance. The European Society of Cardiology. ESC conference 2010, Stockholm, Sweden, August 2010.
- "From the cross-bridge dynamics to cardiac function and energetics" Cardiac Sarcomere Function: An Integrative Approach. Satellite of the North American ISHR meeting, Banff, May 2012.

Selected Publications

1. Rappaport D., Konyukhov E., Shulman L., Fridman Z., Lysyansky P., **Landesberg A**., and Adam D. Detection of the cardiac activation sequence by novel Echocardiographic tissue tracking method. Ultrasound in Medicine & Biology, **33** (6) pp. 880-893, 2007.
2. Rappaport D., Konyukhov E., Adam D., **Landesberg A**. and P. Lysyansky. In-vivo validation of a novel method for regional myocardial wall motion analysis based on echocardiographic tissue tracking. Med Biol Eng Comput. 46; 131-137,2008.
3. ter Keurs H.E.D.J, Shinozaki T., Zhang Y.M., Zhang M.L., Wakayama Y., Sugai Y., Kagaya T., Miura M., Boyden P.A., Stuyvers B.D.M, and Landesberg A. Sarcomere

mechanics in uniform and non-uniform cardiac muscle: A link between pump function and arrhythmias. *Progress in Biophysics and Molecular Biology* 97; 312–331, 2008.
4. Yaniv T., Stanley W.C., Saidel G.M., Cabrera M.E. and Landesberg A. The Role of Ca2+ in Coupling Cardiac Metabolism with Regulation of Contraction, In Silico Modeling. Ann. N.Y. Acad. Sci. 1123: 69–78 (2008).
5. ter Keurs H.E.D.J., Shinozaki T., Zhang Y.M., Wakayama Y., Sugai Y., Kagaya Y., Miura M., Boyden P.A., Stuyvers B.D.M., and **Landesberg A.** Sarcomere mechanics in uniform and nonuniform cardiac muscle, a link between pump function and arrhythmias. *Annals of the New York Academy of Sciences*, vol. 1123, issue 1, pp. 79-95, 2008.
6. Sela G. and **Landesberg** A. The external work - pressure-time integral relationships and the afterload dependence of Frank Starling mechanism. *Journal of Molecular and Cellular Cardiology* 47; 544–551, 2009.
7. Yadid M. and **Landesberg A**. Stretch increases the force by decreasing cross-bridge weakening rate in the rat cardiac trabeculae. *Journal of Molecular and Cellular Cardiology* 49; 962–971, 2010.
8. Sela G. Yadid M. and **Landesberg A.** Theory of Cardiac Sarcomere Contraction and the Adaptive Control of Cardiac Function to Changes in Demands. *Annals of the New York Academy of Sciences*, vol. 1188, pp. 222-230, 2010.
9. Waisman D., Levy C., Faingersh A., Klotzman F.I.C., Konyukhov E., Kessel I., Rotschild A., and **Landesberg A.** A new method for continuous monitoring of the chest wall movement to characterize hypoxemic episodes during HFOV. *Intensive Care Medicine*, 37(7):1174-1181, 2011.
10. Yadid M., Sela G., Pavlov D.A., and **Landesberg A.** Adaptive control of cardiac contraction to changes in loading; from theory of sarcomere dynamics to whole-heart function. *Pflugers Archiv* 462(1);49-60,2011.
11. Koffler J., Francis K.K., Shandalov Y., Egozi D., Pavlov D.A., **Landesberg A.**, and Levenberg S. The relay race to integration of engineered vascularized graft. *PNAS*, 108(36):14789-14794, 2011.
12. Waisman D., Faingersh A., Levy C., Konyukhov E., Colman-Koltzman I., Rotchild A., and **Landesberg A**. Early detection of deteriorating ventilation by monitoring bilateral chest wall dynamics in rabbit. *Intensive Care Med* 38:120–127, 2012.
13. Waisman D., Faingersh A., Levy C., Colman-Klotzman I., Rotschild A., Lichtenstein O., **Landesberg A**. Transient decrease in PaCO2 and asymmetric chest wall dynamics in early progressing pneumothorax. *Intensive Care Med* 39:137-145, 2013.
14. Itzchaki I. and **A. Landesberg**. The role of the sarcoplasmic reticulum in mediating the effects of non-excitatory stimulation on cardiac mechanics. (In review)
15. Landesberg G., Jaffe A.S., Gilon D., Levin P.D., Goodman S., Beeri R., Weissman C., Sprung C.L., **Landesberg A**. The Role of Left Ventricular Diastolic Dysfunction and Right Ventricular Dilatation in Troponin Elevations and Mortality from Severe Sepsis and Septic Shock. (in review).

Research Laboratories: Molecular cardiology and cardiovascular system

- **Laboratory for isolated muscle fiber studies**. This laboratory includes state of the art equipment for the analysis of isolated muscle fiber (trabeculae) dynamics, utilizing the laser diffraction technique, and enables precise studies at the nano-scale spatial resolution.
- **Surgical facility for studying physiological systems and testing novel devices.** The only in-situ large animal facility at the Technion. It is used for whole heart studies, including functional ventricular studies, coronary flow dynamics, cardiac hemodynamics energetics and electrical activity. The lab enables testing new assist devices for the failing heart, novel therapeutic modalities as cardiac resynchronization, and the effects of new drugs.

- **The theory of cross-bridge dynamics (muscle contraction)**. Explanations for the basic muscle characteristics, such as the force–velocity relationship, the Fenn effect and the high contractile efficiency, are still vague. There is a gap between our knowledge of the molecular motor kinetics and the sarcomere dynamics. Three main models have been suggested in the past 60 years to describe the dynamics of the XBs. These studies suggest that XB kinetics is plausibly dependent on one of three mechanical variables: displacement, load or velocity, as depicted in Fig.1. The first theory postulates that XB attachment/detachment rates are determined by its displacement relative to an equilibrium position. This hypothesis was originally suggested by Sir A.F. Huxley. Load-dependent molecular motor kinetics was suggested by recent studies of single molecular motors. I have suggested that the XB kinetic rates, in the framework of an integrated sarcomere, are functions of filament sliding velocity. Specifically, it has been suggested that the XB reverse rate from the strong to weak conformation (weakening rate, g), is a linear function of the sliding velocity. Shortening increases whereas lengthening decreases the XB weakening rate.

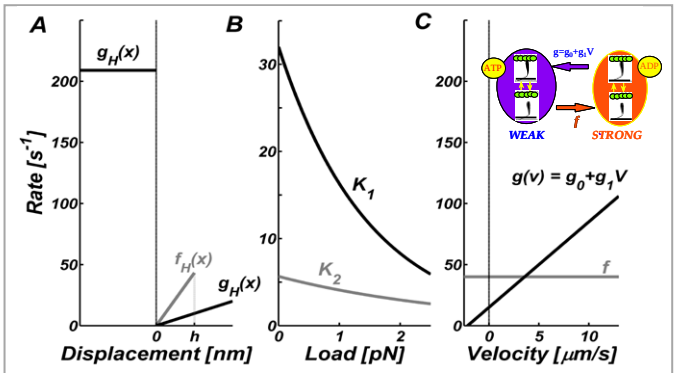

Fig.1: Three suggested dependencies of myosin kinetic rates on mechanical variables: displacement **(A)**, load **(B)** and velocity **(C)**.

The investigations reveal that: (1) Force enhancement during sarcomere lengthening is associated with a similar increase in stiffness (negates the displacement dependent hypothesis); (2) The apparent force per XB during sarcomere lengthening is constant and independent of stretch velocity, while there are overt velocity dependent changes in XB kinetics (negates the load dependent hypothesis). (3) The normalized stiffness difference between ramp perturbations and isometric regime is a linear function of ramp's velocity and duration (as predicted by the velocity dependent hypothesis); (4) Sarcomere velocity has an identical and symmetrical effect on the rates of change in normalized stiffness difference ($d\Delta K_N/dt$) during stretches and releases, as shown in the Fig. 2. Only the velocity-dependent theory suggests such symmetrical behavior.

This body of evidence strongly supports the velocity-dependent theory. The velocity-dependence hypothesis is appealing since it provides a simple explanation to all the described observations during both lengthening and shortening, as well as to other well-established phenomena. This theory provides an analytical derivation of Hill's equation for the force-velocity relationship and elucidates the Hill coefficients based on intrinsic XB properties. Additionally, it explains the relationships between oxygen utilization and mechanical energy output observed in both isolated fibers and whole hearts and enlightens the riddle of the high and load-independent contractile efficiency of the cardiac muscle.

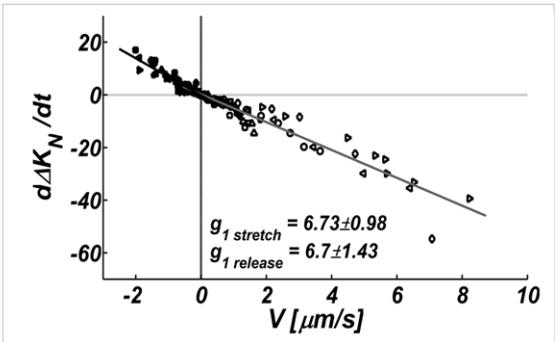

Fig. 2: The rate of change in normalized stiffness ($d\Delta K_N/dt$) is an identical linear function of the sarcomere velocity during lengthening and shortening (75 stretches, 72 releases, 8 fibers).

- **Excitation contraction Coupling**; Well-established phenomena describe the regulation of cardiac function by loading conditions: the Frank-Starling Law, the Fenn Effect and Suga's pressure-volume area (PVA) concept. The Frank-Starling mechanism provides crucially fast adaptation to changes in preload. Fenn has established the existence of an immediate control of energy consumption by the afterload. The sarcomeric control of contraction (SCC) schematically presented in Fig. 3, is based on coupling the kinetics of calcium binding to

troponin with XB cycling dynamics. The theory elucidates the main rate-limiting kinetics involved in regulation of the cardiac sarcomere. The regulatory units are distributed between four states (Fig. 3) that are determined by two kinetics: (i) calcium binding and dissociation from troponin and (ii) XB cycling between the weak and strong conformations. The SCC includes two major feedback loops: (1) The affinity of calcium binding to troponin is determined by the number of XBs in the strong conformation. This positive feedback is denoted as the cooperativity. (2) The rate of XB turnover from the strong to weak conformation is determined by the filament shortening velocity. This feedback is denoted as the mechanical feedback. The two feedbacks provide the adaptive control of cardiac function by the loading conditions. The cooperativity explains the following phenomena: (1) The steep cardiac force-length relationship. (2) The sigmoidal force-calcium relationship. (3) Length-dependent calcium sensitivity, (4) Modulation of the free calcium transient by the loading conditions. (5) Adaptive control of energy consumption by the loading conditions.

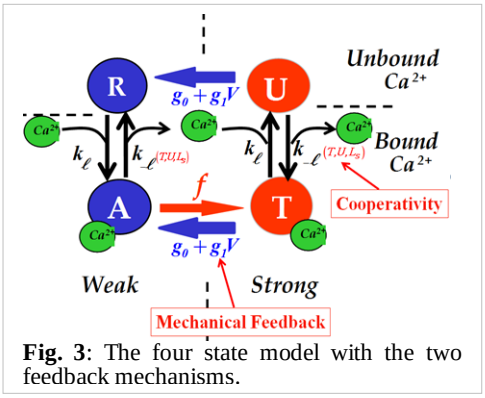

Fig. 3: The four state model with the two feedback mechanisms.

- **A Physiological Cardiac Therapeutic Device.** To simultaneously assist the circulation and to facilitate the potential recovery of the failing heart a new method for assist was innovated, by an implanted device denoted as Physiological Cardiac Assist Device (PCAD). The device works in cadence with the dynamics of the failing heart in a synchronized manner. The device augments the cardiac stroke work by ejecting blood from the PCAD into the failing ventricle after the opening of the aortic valve. It allows unloading of the ventricle by withdrawing the same amount of blood from the ventricle into the PCAD, only during the diastole. Therefore, the device is equivalent to an implantation of "bionic" healthy cardiac tissue that does about 30% of the heart works. As a functional implanted cardiac cell – the device assists the contraction and blood ejection during the systole. However, unlike implanted cell that passively returns back to the initial length, the device also provides active refilling of the ventricle. A series of pre-clinical feasibility studies have established the utility of the device in the setting of severe acute cardiogenic shock (pigs) and severe end stage chronic heart failure (sheep). Figure 4 presents the utility of the device in the setting of chronic heart failure.

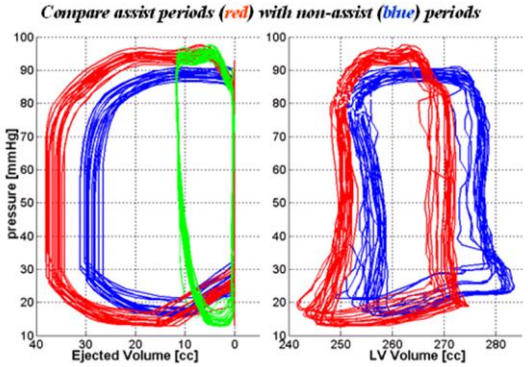

Fig. 4. The effects of PCAD (green) of the systolic and diastolic functions, in sheep with chronic heart failure.

- **Physiological Control System. Early detection of complications.** In spite of the currently used sophisticated monitoring systems, up to 45% of life-threatening events in the Neonate ICU go undetected, and are only recognized by attending staff inspection. However, when these do detect a complication, the baby is already in distress, and the situation can become life threatening. A novel modality for the monitoring the ventilation was developed, for early detection of deteriorating ventilation and characterization of the underlying problems. It facilitates the diagnosis and correct treatment before the patient suffers distress. The system is non-invasive and easy to understand. It consists of three very small motion sensors attached to either side of the chest and to the upper abdomen. Symmetry of lung ventilation, together with breathing effort are measured by the motion sensors. The Journal of Intensive Care Medicine, a leading professional journal in the field, published an editorial discussing this system: "Early detection of complication, prevention is better than cure." The editor of this esteemed journal also awarded the study as paper of the month.

Levenberg Shulamit Ph.D.

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Education:

Date	Institute	Degree	Area of specialization
1999-2002	MIT	Post-Doctorate	Tissue engineering
1993-1999	Weizmann Institute	Ph.D	Cell adhesion signaling
1989-1992	Hebrew University	Bs.C	Biology

Employment:

Date	Institute	Title	Research area
2011- 2012	Harvard Wyss Institute for Biologically Inspired Engineering	Visiting Professor	Bio-inspired materials for Tissue Regeneration
2009 - present	Technion, Biomedical Engineering Department	Associate Professor	Tissue Engineering, vascularization, stem cell differentiation, nanoliter droplet devices.
Summer 2006	MIT, Chemical Engineering Department	Visiting Scientist	Biomaterials and Tissue Engineering
2004-2009	Technion, Biomedical Engineering Department	Senior Lecturer	Stem cell Tissue Engineering
2002-2004	MIT, Chemical Engineering Department	Research Associate	Embryonic stem cells and vascular tissue engineering

Selected Honors and Awards

2012: Juludan Prize
2011: ERC starting grant
2009: TEVA Research Award
2009: "The Excellences of Israel" Prize, Italy
2008: France-Israel Foundation Prize for Scientific Excellence in Stem Cell Research
2007: List of 50 people of the year- Yediot Acharonot news paper
2007: The Henry Taub Prize for Academic Excellence
2006: 2006 Scientific American 50 Award- **Research Leader in Tissue Engineering**
2006: Krill Prize of the **Wolf Foundation** for excellence in scientific research
2006: Marie Curie International Reintegration Grant Leader in Engineering
2004: Landau Fellow, *Leaders in Science and Technology* program
2004: American Society for Artificial Internal Organs Willem J. Kolff Young Investigators Award
1999: European Molecular Biology Organization (EMBO) Long-Term Post-doctoral fellowship

Research interests

Vascularization of engineered tissues (Skeletal and cardiac muscle, pancreatic islets, spinal cord), Stem cell differentiation and organization in 3D, mechanical interplay between cells and scaffolds, controlling cellular microenvironments using nanoliter droplet devices.

Recent Invited Lectures (International)

TERMIS World Congress - Vienna, Austria. Sep 2012. Keynote speaker and session chair

TERM STEM Stem Cells and the Future of Regenerative Medicine, Guimarães, Portugal Oct 2012

Gordon meeting -Signal Transduction by Engineered Extracellular Matrices. USA, July 2012

Stem Cell and Cardiovascular Regeneration Symposium. Charleston, NC, USA, Nov 2011

Aegean Conference in Tissue Engineering. Crete, Greece, June 2011.

The Australian Health and Medical Research Congress. Melbourne, Australia, Nov 2010

Controlled Released Society. Oregon, USA, July 2010

Selected Publications (last 5 years)

Tzezana R., Reznik S., Blumental J., Zussman E. and Levenberg S. Regulation of Stem Cell Differentiation by Tight Control of RetinoicAcid Gradients in 3D scaffold. Macromolecular Bioscience.12(5):598-607.(2012)

Dado D., Sagi M., Levenberg S. and Zemel A. Mechanical control of stem cell differentiation. Regenerative Medicine. 7(1):101-16 (2012)

Kaufman-Francis K, Koffler J, Weinberg N, Dor Y, Levenberg S. Engineered vascular beds provide key signals to pancreatic hormone-producing cells. ***PLoS One***. 7(7) e40741. (2012)

Zoldan J., Anderson D., Langer R. and Levenberg S. The influence of scaffold elasticity on germ layer specification of human embryonic stem cells. ***Biomaterials***. 32(36):9612-21 (2011)

Koffler K., Francis K. Shandalov Y., Egozi D., Amiad Pavlov D., Landesberg A. and Levenberg S. Improved vascular organization enhances functional integration of engineered skeletal muscle grafts. ***PNAS.*** 108(36):14789-94 (2011)

Lesman A., Koffler J., Atlas R., Blinder Y., Kam Z. and Levenberg S. Engineering Vessel-Like Networks Within Multicellular Fibrin Based Constructs. ***Biomaterials.*** 32(31):7856-69 (2011)

Michael I., Walton D. and Levenberg S. Infantile Aphakic Glaucoma: A Proposed Etiologic Role of IL-4 and VEGF. ***Journal of Pediatric Ophthalmology***. May 28:1-10. (2010)

Shemesh J., Nir N., Bransky A. and Levenberg S. Coalescence-assisted generation of single nanoliter droplets with predefined composition. ***Lab on a Chip***. 11(19):3225-30 (2011)

Khoury M., Bransky A., Korin N., Chen Konak L., EnikolopovG., Tzchori I. and Levenberg S. A microfluidic traps system supporting prolonged culture of human embryonic stem cells aggregates. ***Biomedical Microdevices***. 12:1001-1008 (2010)

Shemesh J., Bransky A., Khoury M. and Levenberg S. Advanced microfluidic droplet manipulation based on piezoelectric actuation. ***Biomedical Microdevices***. 12:907-14 (2010)

Levenberg S., Ferreira L., Chen-Konack L., Kraehenbuehl T, and Langer R. Isolation, differentiation, and characterization of vascular cells derived from human embryonic stem cells. ***Nature Protocols***. 5(6):1115-26. (2010)

Dado D. and Levenberg S. Cell-scaffold mechanical interplay within engineered tissue. ***Seminars in cell and developmental biology***. Regenerative Biology and Medicine issue. 20:656-664 (2009)

Kaully, T., Kaufman-Francis,K., Lesman, A. and Levenberg S. Vascularization – The Conduit to Viable Engineered Tissues. ***Tissue Engineering Journal***. Part B Rev. Epub Mar 20 (2009).

Lesman A., Blinder Y. and Levenberg S. Modeling of flow-induced shear-stress applied on 3D cellular scaffolds for vascular tissue-engineering applications. ***Biotechnology and Bioengineering***. *105(3):645-54*. (2009)

Lesman A., Habib M., Gepstein A., Arbel G., Levenberg S. and Gepstein L. Transplantation of Tissue- Engineered Human Vascularized Cardiac Muscle. ***Tissue Engineering*** *Part A*. 16(1):115-25. (2009)

Bransky A., Korin N., Khoury M. and Levenberg S. A Microfluidic Droplet Generator Based on a Piezoelectric Actuator. ***Lab on a chip***. Feb 21;9(4):516-20. (2009).

Levy-Mishali M., Zoldan J and Levenberg S. Effect of Scaffold Stiffness on Myoblast Differentiation. ***Tissue Engineering***. Part A. Apr;15(4):935-44. (2009)

Tzezana R. Zussman E., Levenberg S. A Layered Ultra-Porous Scaffold for Tissue Engineering, created via a Hydrospinning Method. ***Tissue Engineering***. Part C. Dec;14(4):281-8. (2008)

Korin N., Bransky A., Dinnar U. and Levenberg S. Periodic "Flow-Stop" Perfusion Microchannel Bioreactors for Mammalian and Human Embryonic Stem Cell Long-term Culture. ***Biomedical Microdevices***. Feb;11(1):87-94. (2009).

Bransky A., Korin N. and Levenberg S. Experimental and theoretical study of selective protein deposition using focused micro laminar flows. ***Biomedical Microdevices***. 10:421–428 (2008)

Levenberg, S., Zoldan J., Bashevits Y. and Langer, R. Endothelial potential of Human Embryonic Stem Cells. ***Blood***. 110(3):806-14 (2007)

Korin N., Bransky A., Dinnar U. and Levenberg S. A Parametric Study of Human Fibroblasts Culture in a Microchannel Bioreactor. ***Lab on a Chip***, 7, 611 – 617. (2007)

Caspi O. and Lesman A., Basevitch Y., Gepstein A., Arbel G., Habib M., Gepstein L., and Levenberg S. Tissue Engineering of Vascularized Cardiac Muscle from Human Embryonic Stem Cells. ***Circulation Research***. 100(2):263-72. (2007)

Research Lab: Stem cell Tissue engineering

The rapidly increasing demand for organ and tissue transplantation has promoted tissue engineering and stem cell research as promising approaches. Tissue engineering combines cells, growth factors and 3D scaffolds for repair and regeneration of biological tissues. To advance tissue engineering research, scaffold properties must be optimized for a given application and cell type. External forces may also contribute to cell and tissue organization and require bioreactor design and modeling. In addition co-culture approaches to induce multicellular cell-cell interactions are required to allow organization of complex tissue structures.

As a postdoctoral fellow at Professor Robert Langer's group at MIT, Prof Levenberg's explored cell and tissue organization processes and designed human embryonic stem cell (hESC)-based models which focused on investigating vascularization invoked during tissue formation. Her studies demonstrated differentiation of hESCs into endothelial cells (EC) and vessel-structure formation in vivo, which appeared to integrate with host vasculature following implantation of EC-embedded polymer scaffolds. In addition, she engineered

human tissue structures by seeding differentiating hESCs onto biodegradable 3D polymer scaffolds.

Prof Levenberg's ongoing projects at the Technion encompass interdisciplinary research of tissue engineering, stem cells and biodegradable scaffolds.

In 2006, Prof Levenberg was nominated as a Research Leader in Tissue Engineering by the Scientific American Journal. This recognition as a research leader was given to Prof. Levenberg for her breakthrough in vascularization of engineered tissues; first published in Nature Biotechnology in 2005 and demonstrating engineering skeletal muscle tissue constructs that contain endothelial blood vessels. Upon implantation, this vascularization was shown to anastomose with the host vasculature and improve survival and perfusion of the engineered graft. This work was cited as a landmark paper in the field of Tissue engineering, showing the importance of co-cultures for engineering vascularized complex tissue structures. Her discoveries have laid the foundation for successful production of engineered vascularized cardiac muscle tissue and pancreatic islet constructs as well. Upon their implantation in rodent models, anastomosis of construct-host vasculature was observed and correlated with improved survival and perfusion of the grafts. Understanding these vascularization mechanisms is currently the focus of ongoing projects in her lab.

In parallel, some of Prof Levenberg projects focus on the impact scaffold mechanical properties bear on the fate of cell differentiation and organization. To this end, her group has developed scaffolds of varying elastic moduli and has demonstrated the effect of scaffold stiffness on organization and differentiation of embedded embryonic stem cells.

As a member of the Technion Interdisciplinary Nanotechnology program, Prof Levenberg continues to combine biology and engineering disciplines towards development of micro-bioreactors designed to support stem cell growth and manipulations. She focuses on utilizing microfluidics as a novel biotechnology platform for biomedical device and tissue engineering applications. Recently, a novel nanoliter droplet microarray which allows long culture of single cells was developed in her lab.

Description of Current projects in the lab:

Vascularization of engineered tissue constructs

This project focuses on characterizing the mechanisms of *in vitro* vascularization and vessel-network formation in multi-cellular tissue constructs by using defined biomaterials designed and mechanical stimulation similar to *in-vivo* settings. In addition, this study aim to elucidate the signaling effects and *in vivo* integration process of engineered vessel network with host vasculature. Several in vivo models are being used to investigate in real time the vascularization and integration of engineered vascularized constructs. **(Funding ERC starting grant)**

Engineering a vascular niche to support pancreatic islet survival and function and improve islet transplantation efficacy

The research focuses on induction and characterization of 3D vascular network formation in engineered 3D pancreatic tissues cultured *in vitro* and on evaluating the capacity of pre-vascularized islets to treat a Type 1 diabetes mouse model. **(Funding JDRF/ISF grant)**

Flow-induced vascularization in engineered tissue

This research focuses on the effects of interstitial flow on the self-assembly of endothelial cells into vascular networks in vitro. Using a combination of perfusion-bioreactor design, computational fluid dynamics (CFD) modeling, fluorescence microscopy image analysis and gene expression analysis, we are working to characterize and quantify these effects. (**Funding: Israel science foundation**)

Engineering vascularized cardiac tissue

Cardiac tissue engineering aims to create functional tissue constructs that can re-establish the structure and function of injured myocardium. Our goal is to create in vitro pre-

vascularized cardiac tissue using a multi-cellular seeding strategy. This strategy involves co-culturing 3 types of cells (i.e. cardiomyocytes, endothelial cells and fibroblasts) within a nano-patterned scaffold. In collaboration with Profs Gepstein, Geiger and Spaz) (Funding: **FP7-Europian Small Collaborative Project – Nano card project)**

Spinal cord injury regeneration

Among the strategies being investigated to promote spinal cord regeneration following injury is the transplantation of stem cells. We aims to exploit the supportive properties of Olfactory ensheathing cells (OECs) in combination a biodegradable scaffold, as a strategy to preserve spared neural tissue, and promote a more hospitable environment for vasculogenesis and neural regeneration. In our studies we implant OEC on 3D scaffolds and also investigate implants which include hESC- derived neural progenitors (in collaboration with Prof Reubinoff). These scaffolds are implanted in a spinal cord injury animal model and tested for their effect on spinal cord regeneration. (**Funding: Israel ministry of health, Israel foundation for spinal cord injuries, Shervington funds for spinal cord regeneration, Trudy Louis foundation**)

Cell mechanics in 3D constructs

In this project we investigate the mechanical interplay between cells and scaffold within 3D engineered constructs. We examine the influence of cells seeded within scaffold via measurements of contractile forces and the influence of mechanical constraints of the scaffold on cell behavior mainly focusing on embryonic stem cells differentiation (**Funding**: ISF Bikura, **FP7-Europian Small Collaborative Project)**

Droplet Based Microfluidics

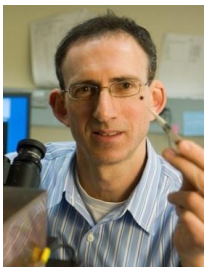
We have developed innovative methods to create and manipulate nanoliter volume droplets in microfluidic channels. We were able to achieve on demand generation of nanoliter droplets, purely hydrodynamic droplet sorting and accurate droplet composition control. In addition a novel nanoliter droplet microarray has been recently developed in the lab and is being used for studying single cell assays and biochemical reaction kinetics and further being developed as a microfluidic System-On-a-Chip platform for parallel single cell screening and analysis (collaborations with Profs Meller, Yosifun, and Peer). (**Funding: RBNI grant, Israel ministry of science- Tashtiot Grant**)

Prof Levenberg's work has been published in >50 peer-reviewed articles in leading international journals. She has presented her work in over 40 invited talks at leading international conferences (including the Gordon conferences), 10 of which as an invited keynote speaker. To date, her work has been cited 2283 times, excluding self-citations, with an h-index of 20. Levenberg et al. (PNAS, 2003) appeared in the list of 20 most-cited papers on human embryonic stem cells (hESC) throughout years 1998-2004. In addition, Levenberg et al. (Nature Biotechnology, 2005) was designated a landmark paper is Nature Biotechnology News and Views. Bransky et al. (Lab on a Chip, 2009) was highlighted as a "featured article" by the Lab on a Chip editors. Prof Levenberg was awarded over $5.5 million in research funds for her research group. Principal Investigator of an ERC grant worth over $ 2.5 M and Currently Principal Investigator and of 8 other active grants.

Today, as the head of the Technion's Stem Cell Tissue Engineering lab she supervise a group of, 12 graduate students, 2 undergraduate students , 2 research scientists, post-doctoratal fellow, lab engineer and a technician. Along the 8 years at the Technion, 10 students have already graduated from her lab and 5 Post doctorate fellows completed their training. Her research team is comprised of individuals of a broad range of academic backgrounds including Biomedical Engineering, Medicine, Biology, Physics, Materials Engineering, Chemical Engineering and Mechanical Engineering.

Meller Amit Ph.D.

professor



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EDUCATION:

1993 - 1998 *WEIZMANN INSTITUTE OF SCIENCE*, REHOVOT, ISRAEL. Ph.D. in Physics,
1990 – 1992 *WEIZMANN INSTITUTE OF SCIENCE*, REHOVOT, ISRAEL. M.Sc. in Physics,
1987 – 1989 *TEL AVIV UNIVERSITY*, TEL AVIV, ISRAEL, B.Sc. in Physics and Astronomy (*Cum Laude*).

APPOINTMENTS:

2010- Professor, Department of Biomedical Engineering, *Technion*, Haifa, Israel.
2010- Professor, Department of Biology, *Technion*, Haifa, Israel.
2010 - World-Class University Professor, Biophysics and Chemical Biology, *Seoul National University*, Korea.
2006 – Associate Professor, Department of Biomedical Engineering, *Boston University*, Boston, MA, USA.
2002-6 Rowland Senior Fellow, The Rowland Institute at Harvard, *Harvard University*, Cambridge, MA USA.
1998 - 2000 Postdoctoral Fellow, Departments of Molecular and Cellular Biology, *Harvard University*.
1998- Postdoctoral Fellow, Department of Molecular Genetics, *Weizmann Institute of Science*, Rehovot, Israel

OTHER ACTIVITIES:

2008- Scientific advisory board member of *Oxford Nanopore Technology*, Oxford, UK.
2010- Founder and acting Chief Scientific Officer of *NobleGen Biosciences, Boston, MA USA.*

HONORS AND AWARDS:

2013 Leader and the Principle Investigator of Center of Excellence (I-Core), "Physical Approaches to Quantifying Dynamical Processes in Living Systems"
2008 Finalist on the Keck Foundation Science and engineering and medical research grant.
2007 (1st) Early Career Research Excellence Award, College of Engineering, Boston University
2004 - 08 Fellow of *The Institute of Physics* (IoP, London)
2004 Winner of the Nano-Innovation award by Physik Instrumente
1994 – 97 Levy Eshkol Ph.D., scholarship in applied materials, Israeli Ministry of Sciences and the Arts.
1989 B.Sc. Tel Aviv University with excellence.

***Recent* Invited Lectures** (out of >120 since 2002)

(1) Gordon Research Conference "Nanostructure Fabrication", Biddeford, Maine, USA (2012);
(2) 2012 CECAM workshop on DNA sequencing and detection with nanoprobes, Scuola Normale Superiore, Pisa, Italy.
(3) Molecular Structure, Dynamics & Recognition of Biomolecules, Tel Aviv Univ. Israel;

(4) NHGRI 2012 meeting on Advanced Genome Sequencing Technologies, San Diego, CA, USA.
(5) Max Delbrück Center for Molecular Medicine (MDC), Berlin, Germany.
(6) Department of Electrical Engineering Seminar, Keio University, Tokyo, Japan.
(7) 4th International Symposium on NEMS and Nanofluidics, Tokyo, Japan.
(8) 2012 Zing International Conference on Nanopore science, Lanzarote, Spain.

JOURNAL (PEER REVIWED) PUBLICATIONS IN THE PAST 5 YEARS:

1. Anderson, B.N. Muthukumar, M. Meller, A. pH tuning of DNA translocation time through organically functionalized nanopores. *ACS Nano* (2013) DOI: 10.1021/nn3051677.
2. Dela Torre, R., Larkin, J., Singer, A., Meller, A. Fabrication and characterization of solid-state nanopore arrays for high-throughput DNA sequencing. *Nanotechnol.* **23**, 385308 (2012).
3. Lin, J., Fabian, M., Sonenberg, N. Meller, A. Nanopore Detachment Kinetics of Poly(A) Binding Proteins from RNA Molecules Reveals the Critical Role of C-Terminus. *Biophys. J.* **102**, 1427–34 (2012).
4. Singer, A., Rapireddy, S., Ly, D. H. , Meller, A. Electronic barcoding of a viral gene at the single-molecule level. *Nano Lett.* **12**, 1722–1728 (2012).
5. Sun, Y. Atas, E. Lindqvist, L. Sonenberg, N., Pelletier, J., Meller, A. The eukaryotic initiation factor eIF4H facilitates loop-binding, repetitive RNA unwinding by the eIF4A. *Nuc. Acid. Res.* (2012).
6. Kim, M.-C., Isenberg, B.C., Sutin, J., Meller, A., Wong, J.Y., and Klapperich, C.M. (2011). Programmed trapping of individual bacteria using micrometre-size sieves. *Lab Chip **11***, 1089-1095.
7. Singer, A., H. Kuhn, M. Frank-Kamenetskii, and A. Meller. (2010) Solid-State Nanopore based Detection of Urea-Induced Internal Denaturation of dsDNA. *J. Phys. Cond-Mat.* 22:454111.
8. McNally, B., A. Singer, Z. Yu, Y. Sun, Z. Weng, and A. Meller. (2010) Optical Recognition of Converted DNA Nucleotides for Single-Molecule DNA Sequencing Using Nanopore Arrays. *Nano Lett.* 10:2237-224
9. Lin, J., A. Kolomeisky, and A. Meller. (2010) Helix-coil kinetics of individual polyadenylic acid molecules in a protein channel. *Phys. Rev. Lett.* 104:158101-158104.
10. Di Fiori, N., and A. Meller. (2010) The effect of dye-dye interactions on the spatial resolution of single-molecule FRET measurements in nucleic acids. *Biophys. J.* 98:2265-2272.
11. Wanunu, M., W. Morrison, Y. Rabin, A. Y. Grosberg, and A. Meller. (2010) Electrostatic Focusing of Unlabeled DNA into Nanoscale Pores using a Salt Gradient. *Nature Nanotechnol.* **5**:160-165.
12. Viasnoff, V., U. Bockelmann, A. Meller, H. Isambert, L. Laufer, and Y. Tsori. (2010) Localized Joule heating produced by ion current focusing through micron-size holes. *Appl. Phys. Lett.* 96:163701-163703.
13. Soni, V. G., A. Singer, Z. Yu, Y. Sun, B. McNally, and A. Meller. (2010) Synchronous optical and electrical detection of bio-molecules traversing through solid-state nanopores. *Rev. Sci. Instru.* 81:014301-7.
14. Singer, A., M. Wanunu, W. Morrison, H. Kuhn, M. Frank-Kamenetskii, and A. Meller. (2010) Nanopore-based sequence-specific detection of duplex DNA for genomic profiling. *Nano Letters* 10:738-742.

15. Valencia-Burton, M., A. Shah, J. Sutin, A. Borogovac, R. M. McCullough, R. C. Cantor, A. Meller, and N. E. Broude. (2009). Spatiotemporal patterns and transcription kinetics of induced RNA in single bacterial cells. *Proc Natl Acad Sci* U.S.A **106**,16399-16404.
16. Wanunu, M., J. Sutin, and A. Meller, (2009). DNA Profiling Using Solid-State Nanopores: Detection of DNA-Binding Molecules. *Nano Letters* **9**, 3498-3502.
17. Wanunu, M. Sutin, J. McNally, B. Chow, A. and A. Meller, (2008) DNA Translocation Governed by Interactions with Solid State Nanopores, *Biophys. J.* **95**(10), 4716-25.
18. McNally, B. Wanunu, M. and A. Meller (2008) Electro-mechanical unzipping of individual DNA molecules using synthetic sub-2 nm pores, *Nano Lett.* **8**, 3418-22.
19. Wanunu, M. Chakrabarti, B. Mathe, J. Nelson, D. R. and A. Meller (2008) Orientation Dependent Interactions of DNA with an □-Hemolysin Channel. *Phys. Rev. E* **77**, 031904.

REVIEWS AND BOOK CHAPTERS IN THE PAST 5 YEARS:

1. Atas, E., Singer, A., Meller, A. (2012) DNA sequencing and bar-coding using solid-state nanopores. *Electrophoresis* **33**, 1-11.
2. A. Meller (2012) "Nanopores: Single-Molecule Sensors of Nucleic Acid-based Complexes". in *Advances in Chemical Physics*, **149**, (2012).
3. Singer, A. McNally, B. Dela Torre, R. and A. Meller (2011) DNA Sequencing by Nanopore Induced Photon Emission (SNIPE), in "Nanopore-based technology: Single molecule characterization and DNA sequencing", *Humana Press, Springer.*
4. Livingstone M., Atas E., Meller A., N. Sonenberg (2010) Mechanisms governing the control of mRNA translation. *Phys Biol.*, **7**, 021001.
5. Wanunu, M., Squires, A. and A. Meller (2011). Capture and Translocation of Nucleic Acids into Sub-5 nm Solid-state Nanopores. In: "Nanopores: Sensing Fundamental Biological Interactions at the Single Molecule Level", *Springer*.
6. Singer, A., and A. Meller. (2010). Nanopore-based Sensing of Individual Nucleic Acid Complexes. *Israel Journal of Chemistry* 49:323–331.
7. Wanunu, M. Soni, G. and A. Meller (2010) Analyzing Individual Biomolecules Using Nanopores, in the "Handbook of Nanophysics" Taylor & Francis Group.
8. Dudko O., Mathé, J., and A. Meller (2010) Nanopore Force Spectroscopy tools for analyzing single biomolecular complexes, Methods in Enzymology, *Elsevier*.
9. Dudko O. and A. Meller (2009) Probing Biomolecular Interactions Using Nanopore Force Spectroscopy, In the Encyclopedia of Analytical Chemistry, *John Wiley & Sons, Ltd.*
10. Branton, D. *et al.*, (2008) The potential and challenges of nanopore sequencing. *Nature Biotechnology* **26**, 1146-1153.
11. Wanunu, M, Soni, G. and A. Meller (2009) Single molecule studies of nucleic acids interactions using nanopores, In Handbook of Single Molecule Biophysics, *Springer*.
12. Wanunu, M. and A. Meller. (2008). Single Molecule Analysis of Nucleic Acids and DNA-protein Interactions using Nanopores. In Laboratory Manual on Single Molecules. *Cold Spring Harbor Press*.

Meller Lab: Single Molecule Bioengineering Laboratory
Nanoscale tools for single biomolecule genomics in vitro and in live cells

The activities in Meller's group involve two main areas: (1) The development of novel sensors and methods for single-biomolecule detection and characterization. (2) The application of single-molecule techniques for the study of gene expression and protein translation machineries *in vitro* and in *live cells*. Our work cuts across scientific disciplines, involving the development of novel materials, advanced optics and electronics, molecular and cellular biology, biophysics and bioengineering.

(1) Nanopore sensors for advanced single-molecule genomics

Nanopores have recently emerged as a prominent single-molecule analytical method, holding particular promise both for genomic applications such as direct DNA and RNA sequencing, as well as for the fundamental biophysical characterization of bio-complexes. Specifically, using advanced nanotechnologies our group has developed solid-state nanopores from inorganic materials (Figure 1) that offer chemical and physical robustness and can be tuned for an extremely broad range of sensing applications. Here I describe two prominent areas: (a) We introduced the use of sequence-specific Peptide Nucleic Acids (PNAs) in conjunction with solid-state nanopores for direct gene identification at the single-molecule level. We illustrated this method by directly discriminating between two genes of similar HIV subtypes having >93% sequence similarity. These studies open up new avenues for extremely fast pathogen detection and diagnosis and thus lead to better healthcare. (b) Since 2004 our group has developed a high-throughput, single-molecule nanopore based DNA sequencing method. The unique feature of our method is the use of optical sensing (rather than pure electrical one) which enables parallel detection of thousands of pores at an extremely small surface. Our method consists of two main steps: first, each nucleotide in the DNA undergoes a

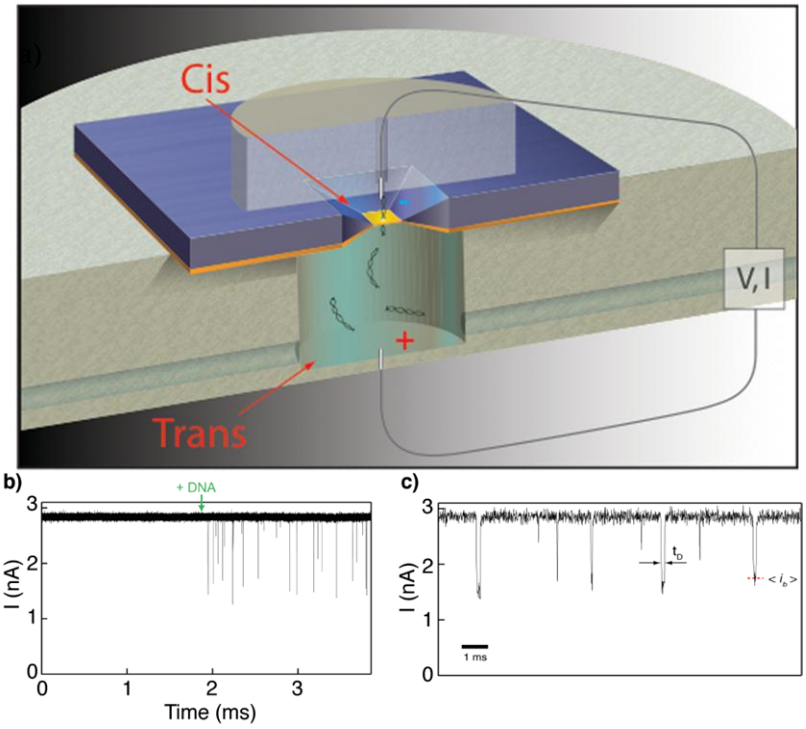

Figure 1 a) A schematic illustration of a solid-state nanopore sensor. A silicon chip where a single ~4 nm pore is fabricated is sandwiched between two tiny fluid chambers (*Cis* and *Trans*). A pair of electrodes immersed in these chambers is used to apply voltage and measure the ionic current through the pore. **b)** Ion-current trace just before and after the addition of double-stranded DNA molecules to the negatively biased

biochemical "conversion" process, whereby it is converted to one of four possible short oligos (15-mers). This circumvents the resolution limitation of nanopore sensing, removes readout issues associated with secondary structure (abounded in complex genomes such as the human genome), and facilitates an enzyme-free – purely "physical" sequencing. At the second step, the converted DNA strands are hybridized with a library of four different molecular beacons having fluorophores at four colors, and are read by threading the molecule through arrays of solid-state nanopores. As each of the strand is threaded through a ~4 nm pore the colored beacons are unzipped, one after the other giving rise to a sequence of photon bursts in four colors that represent the DNA sequence. Our technique has already passed a number of feasibility milestones, and is currently under process of commercialization by *NobleGen Biosciences* (Boston, MA). It is anticipated that it will become commercial within 24-36 months.

(2) Single-molecule biomolecular dynamics *in vitro* and in live cells.

Unraveling the dynamical processes controlling protein synthesis in Eukaryotic systems is the second focus area of the Meller group. Here we employ single-molecule techniques, such as Fluorescence Resonance Energy Transfer (sm-FRET) and nanopore force spectroscopy to probe the activity of eukaryotic translation initiation (TI) complex (*eIF*) known to regulate ribosome assembly. Specifically, we recently used sm-FRET to elucidate the unwinding helicase activity of the eukaryotic initiation factor 4A (eIF4A), and to probe the interactions of polyA binding proteins with the mRNA. These processes are essential for TI control and are implicated in a wide range of human diseases including cancer and neurodegenerative diseases. Currently we develop advanced real-time optical microscopy for live cell imaging using split GFP complexes.

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Professor Joe Mizrahi, a faculty member of the Technion BME since 1982, is the incumbent of the Pearl Milch Chair of Biomedical Engineering Sciences and Fellow of the AIMBE. He received his BSc in Aerospace Engineering (1967); MSc in Mechanics (1970); and PhD in Biomedical Engineering (1975), all from the Technion – IIT. Starting in 2004, he served as Dean of the BME Faculty for 5 years. He has also held positions with the Universities of the Witwatersrand Johannesburg, Cape Town, Harvard, Hong Kong Polytechnic, Drexel and has headed the Biomechanics Laboratory at the Loewenstein Rehabilitation Center in Ra'anana, Israel. His major research interests are in Orthopaedic Biomechanics and Rehabilitation Engineering. More specifically, his studies have include the mechanics of the musculo-skeletal system; muscle/bone interactions; muscle fatigue; Functional Electrical Stimulation (FES) of excitable tissues; musculo-skeletal redundancies and mechanical indeterminacies in healthy and deficient conditions. He presently heads of the laboratory for Biomechatronics, Orthopaedic and Rehabilitation Engineering.

Selected Recent Publications

- Langzam E., Nemirovsky Y., Isakov E. and Mizrahi J. (2007): Muscle enhancement using closed-loop electrical stimulation: Volitional versus induced torque, *J. Electromyography and Kinesiology*, 17:275-284.
- Terraciano, V., Hwang, N., Moroni, L., Park, HB., Zhang, Z., Mizrahi, J., Seliktar, D. and Elisseeff, J. (2007) Differential Response of Adult and Embryonic Mesenchymal Progenitor Cells to Mechanical Compression in Hydrogels, *Stem Cells*, First published online August 16, 2007; doi:doi:10.1634/*stemcells*, 2007-0228
- Suponitsky, Y., Verbitsky, O., Peled, E., and Mizrahi J. (2008) Effect of Force Imbalance of the Shank Muscles, due to Selective Fatiguing, on Single-Leg-Standing Control, *J. Electromyography and Kinesiology*, 18:682-689.
- Katz, A., Tirosh, E., Marmur, R. and Mizrahi, J (2008) Enhancement of muscle activity by electrical stimulation in cerebral palsy – a case control study, *J. Child Neurology*., 23:259-267.
- Preiss-Bloom, O., Mizrahi, J., Elisseeff, J. and Seliktar, D. (2009) Real-time monitoring of force response measured in mechanically stimulated tissue engineered cartilage *Artificial Organs*, 33(4):318-327.
- Appelman, T.P., Mizrahi, J. and Seliktar, D. (2011) A Finite Element Model of Cell-Matrix Interactions to Study the Differential Effect of Scaffold Composition on Chondrogenic Response to Mechanical Stimulation, *ASME J of Biomechanical Engineering*, 133:April2011, 041010-4.
- Peng, C.W., Chen, S.C., Lai, C.H., Chen, C.J., Chen, C.C., Mizrahi, J. and Handa, Y. (2011) Clinical Benefits of Functional Electrical Stimulation Cycling Exercise for Subjects with Central Neurological Impairments: Review, *Journal of Medical and Biological Engineering*, 31(1): 1-11.
- Roth, N., Seliktar, R. and Mizrahi, J. (2011) Mechanical Impedance Control in the Human Arm while Manually Transporting an Open-Top Fluid Filled Dish, *Appl. Bionics & Biomechanics*, 8:393-404.

- Mizrahi, J (Editor). Advances in Applied Electromyography, September 2011, InTech, Croatia (ISBN 978-953-307-382-8).

Research Lab: Biomechatronics, Orthopaedic and Rehabilitation Engineering

The Laboratory for Biomechatronics, Orthopaedic and Rehabilitation Engineering studies the mechanical function of the musculoskeletal system under normal and pathological conditions. Of special interest is the implementation of the results obtained in the field of rehabilitation for improved diagnostics, monitoring of functional progress, and indications for therapy. Intelligent electromechanical systems to support affected motor functions of the human body are also being studied. Of the research projects in the laboratory, the following are of special interest.

1. Restoration and/or augmentation of function in handicapped muscles by means of functional electrical stimulation (FES);

Two major issues are associated with FES: the mechanism of force generation by the recruitment of muscle fibers and the decay of muscle force with time as a result of muscle fatigue. Knowledge of the electric field distribution within the muscle as a result of stimulation is essential in determining which regions of the muscle have been excited and therefore take part in the force generation process. We have developed novel efficient procedures for solving the potential and current density distributions with arbitrary placement of electrodes, surface or intramuscular. Our work on muscle fatigue in FES is highlighted by the innovative integration of *in vivo* mechanical, myo-electric and metabolic factors of fatigue (through the spectra of the phosphorus metabolites as obtained from MRI) into a muscle model which allows predicting the muscle force under various activation conditions. The results of this work are significant in the design of strategies for the efficient activation of muscles resulting in optimal recruitment of the muscle and in reduction of muscle fatigue, thus simplifying the task of a feedback controller.

Our more recent efforts are being focused on the application of FES in partial muscle deficiency to augment muscle force. While in complete paralysis muscle activation is the result of electrical stimulation (ES) only, in partial deficiency muscle activation may generally result from the combined volitional and ES-induced activations. We coined for that purpose the term 'Hybrid Activation' of muscles. Depending on the level of stimulation, the proportion between volitional and induced activations will vary. In order to mathematically resolve the share of the volitional and electrically-induced torque components under hybrid activation from *in vivo* experiments we developed a computational algorithm, based on EMG signal processing and on pre-calibration of the dynamic system of the volitional torque versus EMG. The obtained results indicated the quantitative relations between decrease in the volitional torque and the required increase in ES enhancement. The developed method also demonstrated what ES intensity profile is necessary to produce a desired overall torque output. This provides the means for designing an adaptive rehabilitation device for the hybrid activation of deficient muscles.

2. Musculoskeletal interactions in able-bodied and disabled human individuals;

Muscle contraction is responsible for the generation of the driving forces and torques in body motion. Muscles are also a major source of shock absorption in the body. Thus, we have been investigating how muscle fatigue contributes to the aggravation of shock loads

along the skeleton and to activity imbalance of the lower limb muscles in human locomotion. The results obtained from our research shed light on the mechanisms of stress fractures and joint damage and allow the development of proper training procedures and exercises to reduce damage to the musculoskeletal tissues.

Another aspect of these studies dealt here is the mechanism by which the stiffness and damping of the upper limb are adjusted to accommodate changes taking place during manual transport of objects while walking, so as to ensure stability of the held object. Studying the coordination between reaching motion of the upper limb and body locomotion through the non-linear mechanical impedances of the joints provides an insight into the design of spring based artificial and robotic arms and man machine interfacing devices.

Neuromuscular redundancies and mechanical indeterminacies in the human body and their implications in the field of Rehabilitation.

A major and interesting question in human biomechanics and kinesiology is how many muscles are required for performing a given motor task? Not less intriguing is the question relating to the number of muscles actually engaged in performing this given motor task. It may be argued, though, that the involvement of all the muscles in the abovementioned walking task is not essential and that the locomotor system is neuro-muscularly redundant, with substantially more acting muscle groups than actually required. Mechanically, the consequence of this redundancy is that the number of unknown internal joint and muscle forces exceeds the number of mechanical equations, rendering the system highly indeterminate. The level of indeterminacy is expected to decrease with the reduction of redundancy. Complete paralysis is an extreme example to demonstrate this. Our study deals with the formulation of mechanical models at various degrees of redundancy and with analysis of their indeterminacies. This particularly becomes instrumental in resolving muscle and joint forces from the musculo-skeletal mechanical equations required identifying the effects of muscle deficiency on performance.

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Education:

Date	Institute	Degree	Area of specialization
2000-2002	ETH and University of Zürich	Post-Doctorate	Biomaterials
1994-2000	Georgia Institute of Technology	Ph.D	Bioengineering
1994-2000	Georgia Institute of Technology	M.Sc.	Mechanical Engineering
1990-1994	Drexel University	Bs.C	Mechanical Engineering

Employment:

Date	Institute	Title	Research area
2011- present	Nanotechnology Institute, National University of Singapore (NUS)	Visiting Associate Professor	Biomaterials and Tissue Engineering
2009 – Present	Department of Biomedical Engineering, Technion	Associate Professor	Biomaterials and Tissue Engineering
2004-2009	Department of Biomedical Engineering, Technion	Senior Lecturer	Biomaterials and Tissue Engineering
2002-2004	Department of Biomedical Engineering, Technion	Lecturer	Biomaterials and Tissue Engineering
2001-2002	Samuel Lunenfeld Research Institute, Mount Sinai Hospital, University of Toronto	Visiting Research Scholar	Biomaterials and Tissue Engineering
1994 - 2000	Georgia Institute of Technology	Graduate Research Assistant	Biomaterials and Tissue Engineering

Selected Honors and Awards

2008	Member, GT Council of Outstanding Young Engineering Alumni
2007	Dudi Ben-Aharon Award for Excellence in Research
2005	Salomon and Simon Mani Award for Excellence in Teaching
2005	Hershel Rich - Technion Innovation Award
2000	NSF International Research Fellow Post-Doctoral Award
2000	ISACB Young Investigator Award

Research interests

My research interests in tissue engineering and regenerative medicine include: 1. the design and development of semi-synthetic hydrogels for tissue engineering and regeneration; 2. the regulation of cellular morphogenesis via physical properties of the provisional extracellular matrix in three dimensional cultures; and 3. the use of mechanical stimulation for optimizing the development of tissue engineered constructs.

Recent Invited Lectures (International)

3rd TERMIS world congress, Vienna, Austria, September 5-8, 2012 – **Invited Keynote**
European Society for Biomaterials Annual Meeting, Dublin, Ireland, September 4-8, 2011- **Invited Keynote**
TERMIS-AP 2011, Singapore, August 3-5, 2011-**Invited Keynote**
ICCMB2, Singapore, August 2-4, 2010- **Invited Plenary**
TERMIS-EU 2010, Galway, Ireland, June 13-17, 2010- **Invited Keynote**.

Selected Publications (out of 53)

1. Seliktar D., "Designing Cell-Compatible Hydrogels for Biomedical Applications" ***Science***, 336(6085):1124-8, 2012.
2. Orbach, R., Mironi-Harpaz, I., Adler-Abramovich, L., Mossou, E., Forsyth, V.T., Gazit, E., Seliktar, D., "Unique Properties of Fmoc based peptide hydrogels and implications for the role of aromatic interactions in their self-assembly", ***Langmuir***, 28(4):2015-22, 2012.
3. Mironi-Harpaz, I., Wang, D.Y., Venkatraman, S., Seliktar, D. "Photopolymerization of Cell-Encapsulating Hydrogels: Crosslinking Efficiency Versus Cytotoxicity," ***Acta Biomaterialia***, 8(5):1838-48, 2012.
4. Frisman, I., Seliktar, D., Bianco-Peled, H., "Nanostructuring PEG-Fibrinogen Hydrogels to Control Cellular Morphogenesis", ***Biomaterials***, 32(31):7839-46, 2011.
5. Gonen-Wadmany, M., Goldshmid, R., Seliktar, D., "Biological and Mechanical Implications of PEGylating Proteins into Hydrogel Biomaterials", ***Biomaterials***, 32(26):6025-33, 2011.
6. Appelman, T., Mizrahi, J., Elisseeff, J., Seliktar, D., "Tissue Engineered Scaffold Alterations Affects the Biochemical Response of Chondrocytes to Dynamic Mechanical Stimulation", ***Biomaterials***, 32(6): 1508-1516, 2011.
7. Appelman, T., Mizrahi, J., Seliktar, D., "A Finite Element Model of Cell-Matrix Interactions to Study the Differential Effect of Scaffold Composition on Chondrogenic Response to Mechanical Stimulation", ***Journal of Biomechanical Engineering***, 133(4), 2011.
8. Oss-Ronen, L., Seliktar, D., "Polymer-Conjugated Albumin and Fibrinogen Composite Hydrogels as Cell Scaffolds designed with Affinity-Based Drug Delivery", ***Acta Biomaterialia***, 7(1):163-170, 2011.
9. Sarig-Nadir, O., Seliktar, D., "The Role of Matrix Metalloproteinases in Regulating Neuronal and Nonneuronal Cell Invasion into PEGylated Fibrinogen Hydrogels ", ***Biomaterials***, 31(25): 6411-6416, 2010.
10. Shachaf, Y., Gonen-Wadmany, M., Seliktar, D., "The biocompatibility of PluronicF127 fibrinogen-based hydrogels", ***Biomaterials***, 31(10):2836-47, 2010.
11. Frisman, I., Seliktar, D., Bianco-Peled, H., "Nanostructuring of PEG-Fibrinogen Polymeric Scaffolds", ***Acta Biomaterialia***, 6(7): 2518-2524, 2010.

12. Orbach, R., Adler-Abramovich, L., Zigerson, S., Mironi-Harpaz, I., Seliktar, D., Gazit, E., "Self-Assembled Fmoc-Peptides as a Platform for the Formation of Nanostructures and Hydrogels", ***Biomacromolecules***, 10(9): 2646-51, 2009.
13. Cheung, Y.K., Azeloglu, E.U., Costa, K.D., Seliktar, D., Sia, S.K., "Microscale Control of Stiffness in Cell Adhesive Substrate Using Microfluidics-Based Lithography", ***Angewandte Chemie***, 48(39):7188-92, 2009.
14. Sarig-Nadir, O., Livnat, N., Zajdman, R., Shoham, S., Seliktar, D., "Laser Engraving of Guidance Microchannels into Hydrogels Directs Cell Growth in 3-D", ***Biophysical Journal***, 3;96(11):4743-52, 2009.
15. Bitton, R., Josef, E., Shimshelashvili, I., Shapira-Schweitzer, K., Seliktar, D., Bianco-Peled, H., "Phloroglucinol-based Biomemtic adhesives for medical applications", ***Acta Biomaterialia***, 5(5):1582-7, 2009.
16. Appelman, T., Mizrahi, J., Elisseeff, J., Seliktar, D., "The differential effect of scaffold composition and architecture on chondrocytes response to mechanical stimulation", ***Biomaterials***, 30(4): 518–525, 2009.
17. Shapira-Schweitzer, K., Habib, M., Gepstein, L., Seliktar, D., "An Injectable Hydrogel for 3-D Culture of Human Embryonic Stem Cell-Derived Cardiomyocytes and Rat Neonatal Cardiac Cells", ***Journal of Molecular and Cellular Cardiology***, 46(2):213-24, 2009.
18. Peyton, S.R., Kim, P.D., Ghajar, C.M., Seliktar, D., Putnam, A.J., " The effects of matrix stiffness and RhoA on the phenotypic plasticity of smooth muscle cells in a 3-D biosynthetic hydrogel system", ***Biomaterials***, 29(17):2597-607, 2008.
19. Dikovsky, D., Bianco-Peled, H., and Seliktar, D., "Defining the Role of Matrix Compliance and Proteolysis in Three-Dimensional Cell Spreading and Remodeling", ***Biophysical Journal***, 94(7):2914-25, 2008.
20. Sarig-Nadir, O., Seliktar, D., "Compositional Alterations of Fibrin-Based Materials for Regulating In Vitro Neural Outgrowth", ***Tissue Engineering Part A***, 14(3):401-11, 2008, (Featured on the Cover).

Research Lab: Tissue engineering and biomaterials

The research in the Laboratory for Biomaterials & Regenerative Medicine is focused on rational design of cell-compatible hydrogels, with the goal of improving strategies in tissue repair, stem cell therapy, drug screening, and protein biotechnology. The focus of our applied research is on the design of semi-synthetic protein-polymer hydrogels that can influence specific interactions with cellular systems. These hydrogels have undergone extensive validation and testing in pre-clinical and clinical settings. In parallel, some of the more basic scientific aspects of our research focus on using these hydrogels to understand the impact of matrix properties on the fate of stem cells and metastasizing cancer cells in 3D culture (i.e. mechanobiology).Our main areas of research are (more information at http://brm.technion.ac.il)

Cell-Compatible Hydrogels

We design and validate semi-synthetic hydrogels made from protein-polymer adducts for various applications, including tissue engineering, cancer drug screening, and investigational mechanobiology. These cell-compatible hydrogels are constructed from water-soluble

polymeric building blocks in order to provide coordinated control over physical properties and bioactivity at a cell-material interface.

Three-dimensional (3D) Cellular Morphogenesis

We develop material-based approaches to study and elucidate how cells regulate morphogenesis via physical matrix properties in 3D culture. We use a model system premised on cell-laden hydrogel scaffolds arranged in a "gel-in-gel" configuration for studying three important agonists: matrix stiffness, ligand density, and proteolytic responsiveness

Cell Therapy (Skeletal, Muscle, Cardiac)

We are developing injectable hydrogels for better engraftment of cardiac and skeletal muscle stem cells in various muscle pathologies, including myocardial infarction, traumatic injuries, and muscular dystrophy. In these applications, our cell-encapsulating biodegradable hydrogels have been tested pre-clinically as cell carriers, effectively localizing the cell grafts, providing protection against inflammation and facilitating controlled integration with the host tissue

Tissue Repair (Cartilage, Bone, Nerve)

Our research in tissue repair is focused on engineering biomaterials that can harness natural cellular and molecular healing pathways to enhance functional in situ tissue regeneration, without the use of exogenous cell therapy. Although the healing process that leads to functional regeneration relies on numerous biological events, it can often be catalyzed and sustained by a single inductive factor. Our approach employs natural proteins and their degradation products to facilitate induction of tissue repair.

Stem Cell Mass Production

We are investigating the use of 3D encapsulating hydrogel biomaterials for human stem cell (hSC) bioprocessing. We address the principal requirements for 3D suspension bioprocessing of hSCs using semi-synthetic hydrogel milieus, mainly by developing methodologies for straightforward cell inoculation into microgels, in situ self-renewal and differentiation in a microgel culture system, and mild cell recovery into a solution phase.

Cancer Drug Screening and Diagnostics

We are working on establishing reliable assays for in vitro screening of cancer drug sensitivity based on a tumor culture model system that employs semi-synthetic hydrogels. The 3D culture conditions in the hydrogels better mimic the normal conditions of tumor growth in vivo, enabling more reliable testing methodologies for determining quantitative chemo-sensitivity and optimal drug dosing.

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Education:

Date	Institute	Degree	Area of specialization
1997-2001	University of Utah	Ph.D	Bioengineering
1995-1996	Hebrew University	Graduate Studies	Neural Computation
1991-1994	Tel Aviv University	B.Sc. (Honors)	Physics

Employment:

Date	Institute	Title	Research area
2010 - present	Technion, Biomedical Engineering Department	Associate Professor	Neural Engineering, Computational Neuroscience and Biomedical Optics and Acoustics.
2005–2010	Technion, Biomedical Engineering Department	Senior Lecturer	
2001- 2005	Princeton University, Molecular Biology.	postdoctoral fellow	Patterned uncaging and multiphoton microscopy.
1996–2001	University of Utah	Ph.D.	Advances towards an implantable motor cortical interface

Selected Honors and Awards

2012: Editorial Board Member, Translational Vision Science and Technology
2012: Daniel Shiran Memorial Prize for advances in biomedicine
2011: Editorial Board Member, Journal of Neural Engineering
2008: ERC starting grant
2006: "Promising Israelis under 40", De Marker magazine (Hebrew)
2006: Marie Curie International Reintegration Grant Leader in Engineering
2005-7: Irwin and Helgard Field Career Development Chair
2002-4: Lewis-Thomas Fellow, Princeton University

Research interests

Neural Engineering and Computational Neuroscience: development of an implant-less retinal prosthesis and other massively-parallel neural interfaces. Analysis and control of neural population signals.

Recent Invited Lectures (International)

NERF neurotechnology symposium (Belgium), April 2013
Optogenetics Workshop, Bordeoux, France, September 2012
Cornell NYCTech Healthy Living Hub (panelist), July 2012
CNS 2012 Workshop, Atlanta, GA, July 2012
FENS forum (Federation of European Neuroscience Societies), Barcelona, July 2012

AREADNE, Research in Encoding and Decoding of Neural Ensembles, Santorini, Greece, June 2012
Neural Engineering Summer School, Genoa, June 2012
Cleveland Neural Engineering Workshop, June 2011
Pittsburgh Neuroscience seminar series, June 2011
Spike-sorting workshop, Ski, Norway, May 2011
AREADNE, Research in Encoding and Decoding of Neural Ensembles, Santorini, Greece, June 2010
HHMI Janelia Farms, May 2010

Selected Publications (last 5 years)

Reutsky I, Golan L, Farah N, Schejter A, Tsur L, Brosh I & Shoham S, Holographic optogenetic stimulation of neuronal activity for vision restoration, ***Nature Communications*** (in press)

Dana H and Shoham S, characteristics of line temporal focusing in transparent and scattering media, ***Optics Express*** (in press)

Tankus A, Fried I & Shoham S, Structured neuronal encoding and decoding of human speech features, ***Nature Communications*** 3:1015 (2012)

Tankus A, Fried I & Shoham S, Sparse decoding of multiple spike trains for brain-machine interfaces, ***Journal of Neural Engineering*** 9(5):054001 (2012)

Dana H & Shoham S, Remotely scanned multiphoton temporal focusing by axial grism scanning, ***Optics Letters*** *37(14):2913-5* (2012)

Ma R, Söntges S, Shoham S, Ntziachristos V & Razansky D, Fast scanning coaxial optoacoustic microscopy, ***Biomedical Optics Express*** (2012)

Szameit A*, Shechtman Y*, Osherovich E*, Bullkich E, Dana H, Steiner S, Gazit S, Cohen-Hyams T, Shoham S, Zibulevsky M, Yavneh I, Kley EB, Eldar YC, Cohen O and Segev M, Sparsity-based single-shot sub-wavelength coherent diffractive imaging, ***Nature Materials***, 11(5), 455-459 (2012)

Naor O*, Herzberg Y*, Zemel E, Kimmel E and Shoham S, Towards multifocal ultrasonic neural stimulation: design and characteristics of an acoustic retinal prosthesis, ***Journal of Neural Engineering***, 9 026006 (2012)

Matar S, Golan L and Shoham S, Reduction of two-photon holographic speckle using shift-averaging, ***Optics Express*** 19, 25891-25899 (2011)

Dana H & Shoham S, Numerical evaluation of temporal focusing characteristics in transparent and scattering media, ***Optics Express*** 19(6), 4937-4948 (2011)

Krasovitski B, Frenkel V, Shoham S & Kimmel E, Intramembrane cavitation as a unifying mechanism for ultrasound induced bioeffects, ***PNAS***, (2011)

Shoham S, Optogenetics meets optical wavefront shaping (N&V), *Nature Methods* 7(10), 798-799 (2010)

Herzberg Y*, Naor O*, Volovick A and Shoham S, Towards multifocal ultrasonic neural stimulation: pattern generation algorithms. ***Journal of Neural Engineering*** 7 056002 (2010)

Shoham S & Deisseroth K, Special issue: advances in optical stimulation technology (Editorial), ***Journal of Neural Engineering*** 7 040201 (2010)

Krumin M, Reutsky I & Shoham S, Correlation-based analysis and generation of multiple spike trains using Hawkes models with an exogenous input, ***Frontiers in Computational Neuroscience***, 4:147 (2010)

Krumin M, Shimron A and Shoham S, Correlation-distortion based identification of Linear-Nonlinear-Poisson models, ***Journal of Computational Neuroscience*** (2010)

Golan L, Reutsky I, Farah N and Shoham S, Design and Characteristics of Holographic Photo-stimulation Systems, ***Journal of Neural Engineering*** 6:6, 66004. (2009).

Yaeli S*, Binyamin E* and Shoham S, Form-function relations in cone-tipped stimulating microelectrodes, ***Frontiers in Neuroengineering***, 2:13 (2009).

Sarig-Nadir O*, Livnat N*, Zajdman R, Shoham S and Seliktar D, Laser photoablation of guidance microchannels into hydrogels directs cell growth in 3-D, ***Biophysical Journal***,96, 4743-4752 (2009)

Golan L and Shoham S, Speckle elimination using shift-averaging in high-rate holographic projection, ***Optics Express*** 17, 1330-1339 (2009)

Krumin M and Shoham S, Generation of spike trains with controlled auto- and cross-correlation functions, ***Neural Computation*** 21:6, 1642-1664 (2009)

Bobrowski O, Meir R, Shoham S and Eldar Y, A neural network implementing optimal state estimation based on dynamic spike train decoding, ***NIPS*** 21, (2007)

Research Lab: Neural Interface Engineering

The lab deals with the development and application of diverse *physical and computational tools for interfacing with neuronal populations* (stimulation and recording). Central projects focus on advancing neurotechnologies for implant-less retinal stimulation using optics and acoustics and for monitoring how the retina and cortex respond to this stimulation. Another major theme is the analysis and control of neuronal signals, and their application in Brain Machine Interfaces for the paralyzed. The lab has three custom multiphoton microscopes and an inverted bio-microscope, integrated with a diverse array of customized photo-stimulation and electrophysiology systems.

Pattern photo-stimulation: An *optical photo-stimulation retinal prosthesis* for outer retinal degenerative diseases like Age-related Macular Degeneration (AMD) and Retinitis Pigmentosa (RP) potentially offers fundamental advantages because it can be non-contact and can leverage display devices for high-resolution spatial-temporal control of light patterns (Fig. 1). Neural photo-stimulation, primarily using optogenetic probes, is recently emerging as an alternative to electrical stimulation with significant potential benefits: it is non-contact, enables higher spatial resolution and can be genetically targeted. We focus on the

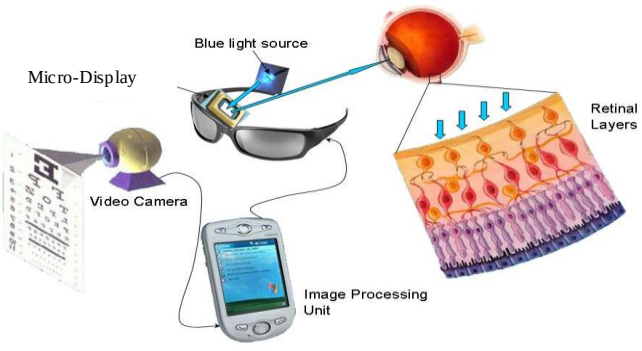

Fig. 1. Schematic of an artificial optical retinal interface

development and application of new pattern photo-stimulation systems for this application based on high-rate digital-holography. Our results demonstrate that using this technology we can accurately control the activity of many individual retinal ganglion cells both *in vitro* and *in vivo*. To achieve this, we developed unique technical tools for imaging and stimulating the retina *in vivo* at a cellular resolution (Fig. 2).

The lab is also developing related tools for patterned brain stimulation, and for patterned stimulation inside bioengineered brain-like neuronal networks that we introduced using ideas from neural tissue engineering.

Pattern acousto-stimulation: expanding ideas from diffractive optics, we showed how they can be adapted to the generation of holographically-structured ultrasound fields towards a new concept: patterned acoustic-stimulation of neural systems. In collaboration with Prof. Kimmel, a powerful model of acoustic-stimulation biophysics was introduced. With Insightech LTD., we are exploring the stimulation of retinal and other neurons using ultrasonic field patterns. This approach could potentially lead to a completely non-invasive (low-acuity) retinal stimulation interface.

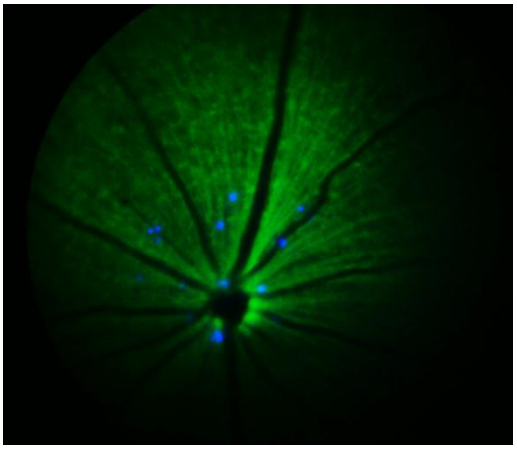

Fig. 2. Holographic pattern projection onto a ChR2-eYFP expressing mouse retina in vivo

Brain Machine Interfaces and Neural Signals: We have been working with neurosurgeon Itzhak Fried on a central BMI problem: how are speech features represented at the single unit activity level in the human brain, and can they be directly "read out" from neural activity. We identified medial-frontal neurons that are exquisitely tuned to individual vowels, and showed a structured organization of the neural representation that exactly matches the anatomy of speech production.

In another project we introduced a general "correlation distortion" computational strategy for generating multiple spike trains with exactly controlled mean firing rates and correlation structure, and for analyzing the underlying structure of such signals.

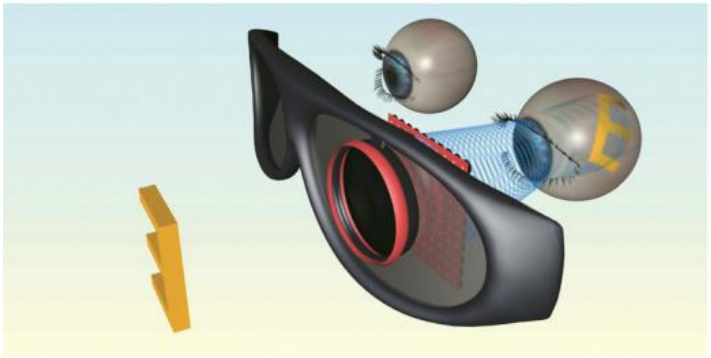

Fig. 3. Concept of an acoustic retinal prosthesis. A processed image is transmitted to the retina by an US-phased array

Sznitman Josué Ph.D.

Assistant Professor

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Education:

Date	Institute	Degree	Area of specialization
2003-2008	ETH Zurich	Dr. Sc.	Fluid Dynamics
2002-2003	ETH Zurich	Dipl.-Ing.	Mechanical Engineering
1998-2002	MIT	B.Sc.	Mechanical Engineering

Employment:

Date	Institute	Title	Research area
2010-present	Technion, Dept. of Biomedical Engineering	Assistant Professor	Biofluid dynamics, flow visualization, respiratory physiology, microfluidics
2009-2010	Princeton University Dept. of Mechanical Engineering	Lecturer, Research Associate	Fluid mechanics, flow visualization
2008-2009	University of Pennsylvania, Dept. of Mechanical Engineering	PostDoc	Biomechanics, animal locomotion, flow visualization

Selected Honors and Awards

2011 Bergmann Memorial Research Award (Binational Science Foundation)
2010 Marcella S. Geltman Memorial Academic Lectureship Fund
2010 - 2012 Horev Fellow, Leaders in Science & Technology (Taub Foundation)
2009 - 2011 Princeton Council of Science & Technology, PostDoctoral Teaching
2008 ETH Silver Medal for outstanding PhD thesis
2008 Research Award (PhD thesis) - Swiss Society for Biomedical Engineering
2007 Young Scientist, CNRS France (EE250 Conference)
2006 Young Scientist Award - 12th Inter. Symposium on Flow Visualization
2005 Young Research Award, Nestle SA - Swiss Paediatric Research
2004 ETH Medaille (outstanding M.Sc. thesis)
2002 Sigma Xi – The Scientific Research Society
2001 Tau Beta Pi – The Engineering Honor Society
2000 Pi Tau Sigma - International Mechanical Engineering Honor Society

Research interests

Biofluid dynamics; respiratory flows and physiology; particle inhalation, transport and deposition; flow visualization; computational fluid dynamics, microfluidics; microcirculation; biomechanics; animal locomotion; image processing and statistical learning methods

Invited Lectures

2012 Microfluidic designs of pulmonary acinar networks: CFD and experiment. *7th International Biofluid Mechanics Symposium*, March 25-30 2010, Israel.

2010 Convective gas transport in the acinus: revisiting the role of effective diffusivity, *6th World Congress of Biomechanics*, August1-7 2010, Singapore.

2010 *Department of Mechanical Engineering, McGill University, Canada*.

2009 *Department of Mechanical Engineering, Carnegie Mellon University, USA.*

2009 *Institute of Bioengineering, EPFL Lausanne, Switzerland.* March 2009.

2009 *School of Engineering and Applied Science, Harvard University, USA.*

2009 *Department of Mechanical Engineering & Materials Science, Duke University, USA.*

2009 *Department of Mechanical and Industrial Engineering, University of Toronto, Canada.*

Publications (last 5 years)

Sznitman J. Respiratory microflows in the pulmonary acinus. *Journal of Biomechanics* doi: 10.1016/j.jbiomech.2012.10.028 (2013).

Mahto SK, Tanenbaum-Katan J, and **Sznitman J**. Respiratory physiology on a chip, *Scientifica* ID 364054 (2012).

Ghosh R, and **Sznitman J**. Visualization of nematode *C. elegans* swimming in a liquid drop, *Journal of Visualization* 15: 277-279 (2012).

Sznitman J, Guglielmini L, Clifton D, Scobee D, Stone HA, and Smits AJ. Experimental characterization of 3D corner flows at low Reynolds numbers, *Journal of Fluid Mechanics* 707: 35-52 (2012).

Shen X, **Sznitman J**, Krajacic P, Lamitina P, and Arratia PE. Undulatory locomotion of *C. elegans* on wet surfaces, *Biophysical Journal* 102: 2772-2781 (2012).

Spycher B, Wildhaber JH, Frey U, and **Sznitman J**. Mathematical behavior of MEFV curves in childhood asthma and the role of curvature in quantifying flow obstruction, *ISRN Pulmonology* ID 305176 (2012).

Sznitman J, Shen X, Sznitman R, and Arratia PE. Flow behavior and force measurements of undulatory swimmers at low Reynolds number, *Physics of Fluids* 22: 121901 (2010).

Juarez G, Lu K, **Sznitman J**, and Arratia PE. Motility of small nematodes in disordered wet granular media, *Europhysics Letters* 92: 44002 (2010).

Sznitman J, Shen X, Purohit PK, and Arratia PE. The effects of fluid viscosity on the kinematics and material properties of C. elegans swimming at low Reynolds number, *Exp. Mechanics* 50: 1303-1311 (2010).

Sznitman J, Sutter R, Altorfer D, Stampanoni M, Roesgen T, and Schittny JC. Visualization of respiratory flows in reconstructed 3D terminal alveolar airspaces using X-ray tomographic microscopy, *Journal of Visualization* 13: 337-345 (2010).

Sznitman R, Gupta M, Hager GD, Arratia PE, and **Sznitman J**. Multi-environment model estimation for motility analysis of Caenorhabditis Elegans, *PLOS One* 5(7): e11631 (2010).

Sznitman J, Purohit PK, Krajacic P, Lamitina T, and Arratia PE. Material properties of Caenorhabditis elegans swimming at low Reynolds number, *Biophysical Journal* 98: 617-626 (2010).

Sznitman J, and Roesgen T. PIV investigation of low-Reynolds boundary driven cavity flows in thin liquid shells, *Journal of Visualization* 13: 49-60 (2010).

Sznitman J, Shen X, Purohit PK, Sznitman R, and Arratia PE. Swimming behavior of the nematode Caenorhabditis elegans: bridging small-scale locomotion with biomechanics. in CT Lim and JCH Goh (Eds.): IFMBE Proceedings 31, pp. 29-32, 2010.

Sznitman J. Convective gas transport in the acinus: revisiting the role of e_ec-tive di_usivity. in CT Lim and JCH Goh (Eds.): IFMBE Proceedings 31, pp. 370-373, 2010.

Sznitman J. Convective gas transport in the pulmonary acinus: comparing roles of convective and diffusive lengths, *Journal of Biomechanics* 42: 789-792 (2009).

Sznitman J, Heimsch T, Wildhaber JH, Tsuda A, and Roesgen T. Respiratory flow phenomena and gravitational deposition in a three-dimensional space-filling model of the pulmonary acinar tree, *Journal of Biomechanical Engineering* 131: 031010 (2009).

Sznitman J, and Roesgen T. Acoustic streaming visualization in elastic spherical cavities, *Journal of Visualization* 11: 347-355 (2008).

Sznitman J, and Roesgen T. Acoustic streaming flows in a cavity: an illustration of small-scale inviscid flow, *Physica D* 237: 2240-2246 (2008).

Sznitman J, and Roesgen T. Formation of negative buoyant vortex rings at an orifice opening, *International Journal of Transport Phenomena* 10: 37-45 (2008).

Wildhaber JH, **Sznitman J**, Harpes P, Straub D, Moeller A, Basek P, and Sennhauser FH. Correlation of spirometry and symptom scores in childhood asthma and the usefulness of curvature assessment in expiratory flow-volume curves, *Respiratory Care* 52: 1744-1752 (2007).

Sznitman J, Heimsch F, Heimsch T, Rusch D, and Roesgen T. Three-dimensional convective alveolar flow induced by rhythmic breathing motion of the pulmonary acinus, *Journal of Biomechanical Engineering* 129: 658-665 (2007).

Sznitman J, and Roesgen T. Optical density visualization and Abel reconstruction of vortex rings using background-oriented Schlieren, *Journal of Visualization* 10: 5 (2007).

Research Lab: Biofluids

Our research activities examine a broad range of fluid flows relevant to biomechanics, biology and physiology, a field often referred to as ***biofluid dynamics***. Our largest efforts pertain to the biofluid dynamics of the lungs, covering respiratory flows and physiology, and particle transport and depositon (detailed below). In parallel, a secondary research effort of ours is aimed at characterizing animal locomotion and motility phenotyping for the model organism nematode *C. elegans*, in relation to disease quantification and drug screening (not detailed).

Overall, our research strategy revolves around the use of both experimental and computational techniques, including high-speed imaging, microscopy, microfluidics (including cell cultures and cell biology), particle tracking and velocimetry (PIV) methods,

computer vision and statistical learning methods, image processing, and computational fluid dynamics (CFD) simulations.

Respiratory physiology and acinar flows: The human lung is a remarkable organ optimized for respiratory gas exchange, featuring a network of branched airways that connect hundreds of millions of micro-airspaces with the external environment. With each breath inhaled, millions of micron- and nano-particles are susceptible to deposit inside the airways of the lung, and in particular inside pulmonary alveoli, the basic units of the lung. How particles are effectively transported inside the lungs, and ultimately into the small alveolar regions, is of critical importance when considering inhaled pollutants or aerosolized drugs for inhalation therapy. Whether a health threat or a therapeutic solution, inhaled aerosols are influenced by respiratory flows and in particular the microflows that exist in the lung's alveolar region. Obtaining a detailed understanding of such flows is critical to predict local deposition patterns of inhaled particulate matter, with an outlook toward future drug targeting strategies.

Our work investigates the complex interactions that exist between respiratory flows and inhaled particles in the deep regions of the lung. On the one hand, we use CFD techniques to investigate locally the fluid mechanics of acinar flows. Concurrently, our experiments are based on fabricating in vitro models of pulmonary acinar airways –so-called artificial breathing lungs. Our microfluidic "chips" are constructed with soft-lithography methods, enabling us to recreate airway replicas at the real scale and visualize respiratory flows in real-time. With our microfluidic systems, we can integrate physical models with biological environments by growing cellular populations representative of the lung airways (i.e. confluent monolayers of alveolar epithelial cells). This strategy enables us to investigate simultaneously how flows influence basic physiological functions of airway cells, including the secretion of surfactant by alveolar epithelial cells.

Moreover, we are building microfluidic in vitro platforms of the corresponding alveolar capillary networks that line the alveolar walls. In this way, we aim to have a description of both airflows in the alveolar space, as well as capillary blood flows in the alveolar microvasculature. This latter work will help us uncover transport phenomena in the lung microvasculature and how ultrafine (nano-scale) particles, known to translocate into capillaries from the airspace, ultimately enter the systemic circulation.

Our research is currently supported by the Israel Science Foundation (ISF; 2012-216), the US-Israel Binational Science Foundation (BSF; 2012-2016), the European Career Integration Grant (CIG; 2011-2015), the Russel Berrie Nanotechnology Institute (RBNI, Technion,; 2012-2013) and the Technion Center of Excellence of Exposure Science and Environmental Health (TCEEH, Technion; 2012-2013).

Technion Biofluids Laboratory

The *Technion Biofluids Laboratory* was established in the Fall 2011 and features a wide range of experimental and computational facilities (approx. 110 m2). The main lab holds a **dark-room for microscopy**, equipped with an epi-fluorescence inverted microscope (Nikon Ti-Eclipse) with motorized stage and a caged incubator for live cell imaging (Okolab). The

setup is coupled for imaging with a high-speed (100 fps), high-resolution (2560x2160 pixels) sCMOS camera (Andor Technology). Our laboratory also features a designated "**wet bench**" area for cell biology and live organism manipulations, equipped with a biosafety cabinet, a chemical fume hood, a CO_2 incubator, a refrigerated centrifuge, as well as stereo and inverted microscopes.

For microfabrication rapid prototyping, our lab holds an oven, a spin processor (Laurell Tech.) and an oxygen plasma Treater (Electro-Technic) for surface bonding. For **microfluidic-related** experiments, including biology, our lab holds a number of programmable syringe pumps (e.g., PhD Ultra, Harvard Apparatus) as well as a pressure/volume-controlled ventilator (Inspira, Harvard Apparatus)

For flow visualization and velocimetry activities, our **laser room** is equipped with a fully-integrated micro-Particle Image Velocimetry (PIV) / micro-Particle Tracking Velocimetry (PTV) system (LaVision GmBH, Germany), constructed of a custom inverted epi-fluorescent microscope with motorized stage, two laser illumination setups (i.e., DPSS continuum laser or double-pulsed Nd:Yag laser), and two image acquisition systems (CCD double-frame camera or high-speed CMOS camera), depending on the temporal dynamics of the flows of interest.

Our lab's computational facilities gather a number of multi-core PC workstations as well as a dedicated SGI server (12 core Intel Xeon E5-2640 2.5 GHz; 64 GB RAM; 8 x 2TB 7200 RPM hard drive). We use a number of commercial (e.g., COMSOL Multiphysics, ANSYS, Fluent) and open-source (e.g. OpenFOAM) softwares to conduct computational fluid dynamics (CFD) simulations. For flow velocimetry, our lab holds a dedicate workstation with dual processor quad core processors.

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Education:

Date	Institute	Degree	Area of specialization
2000-2004	Technion-IIT	Ph.D. Chem. Eng.	Rheology and microstructure of complex fluids & crystallization of gallstons
1998-2000	Technion-IIT	M.Sc. Chem. Eng., Cum Laude	Microstructure development in complex fluids
1994-1998	Technion-IIT	B.Sc. Chem. Eng., Cum Laude	Chemical Engineering

Employment:

Date	Institute	Title	Research area
2006-present	Technion-IIT	Assistant Prof.	Cancer cell mechanics and bio-rheology
2004-2006	UCLA	Post-graduate researcher	Mechanics of living cells

Selected Honors and Awards

2009	Henri Gutwirth Research Grant awarded for project "Comparing micro- and macro-rheometry: operating windows and structuring of complex liquids"
2003	Best Paper award at the Israeli Society for Microscopy annual meeting
2000-2003	Eshkol Doctoral Scholarship, awarded by the Israeli Ministry of Science, Culture, and Sports for interdisciplinary research, awarded for 3 years
2000, 2002	Outstanding teaching assistant award
2000	Wolf Foundation national award for excellence in study and research
1999	Mitrani Family scholarship (including full tuition) during M.Sc.
1999	Technion scholarship for excellence, for first year M. Sc. students
1999	Outstanding undergraduate final-year project prize awarded at the 35th Annual conference of the Israeli Institute of Chemical Engineers

Research interests

Disease development and its influence on internal structure and mechanics of living cells; Diagnosis of cellular health through mechanical and micro-rheological properties; Cancer metastasis, physical and mechanical aspects and potential treatments; Molecular motor-mediated transport in living cells and in vitro; Cell adhesion and spreading on bio-surfaces as a function of external conditions and pre-stress; Computer simulations advancing understanding of mechanical and structural evolution of cell interiors, with application to microrheology.

Recent Invited Lectures (International)

10th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering (CMBBE), Berlin (April 2012).

Tissue Growth and Morphogenesis: from Genetics to Mechanics and Back, Workshop Series at the Banff International Research Station (BIRS), Banff, Canada (July 2012).

ECI conference: Biological & Pharmaceutical Complex Fluids: New Trends in Characterizing Microstructure, Interactions & Properties, Portugal (August 2012).

Binational meeting on Biomedical Engineering approaches in chronic diseases, Poland (September 2012).

32nd Israeli Conference on Mechanical Engineering, in mini-symposium on Mechanical Principles of Biological Cells, Tel Aviv (October 2012). Keynote speaker

Selected Publications (last 6 years)

1. Daphne Weihs, Thomas G. Mason, and Michael A. Teitell, "Bio-microrheology: A Frontier in Microrheology", *Biophysical Journal* **91**, 4296-4305 (2006). PMID: 16963507. Doi: http://dx.doi.org/10.1529/biophysj.106.081109 (*has 61 citations 10/2012*)
2. Daphne Weihs, Michael A. Teitell, and Thomas G. Mason, "Simulations of Complex Particle Transport in Heterogeneous Active Liquids", *Microfluidics and Nanofluidics* **3**, 227-237 (2007). Doi: http://dx.doi.org/10.1007/s10404-006-0117-4
3. Daphne Weihs, Judith Schmidt, Dganit Danino, Ilana Goldiner, Diana Leikin-Gobbi, Arie Eitan, Moshe Rubin, Yeshayahu Talmon, and Fred M. Konikoff, "A Comparative Study of Microstructure Development in Paired Hepatic and Gallbladder Biles", *Biochimica Biophysica Acta* **1771**, 1289–1298 (2007). PMID: 17913578. Doi: http://dx.doi.org/10.1016/j.bbalip.2007.07.006
4. Daphne Weihs, Thomas G. Mason, and Michael A. Teitell, "Effects of cytoskeletal disruption on transport, structure, and rheology within mammalian cells", *Physics of Fluids* **19**, 103102 (2007). (Also featured in: the Virtual Journal of Nanoscale Science & Technology -- October 22, 2007) PMID: 19816550. Doi: http://dx.doi.org/10.1063/1.2795130
5. Naama Gal and Daphne Weihs, "Experimental Evidence of Strong Anomalous Diffusion in Living Cells", Rapid Comm. in *Phys. Rev. E*. **81**, 020903(R) (2010). Also in the *Virtual Journal of Biological Physics Research* 19(4) (2010). ISSN: 1539-3755, PMID: 20365523. doi: http://dx.doi.org/10.1103/PhysRevE.81.020903
6. Itai Cohen and Daphne Weihs, "Rheology and Microrheology of Honey as a Model Newtonian Fluid", *Journal of Food Engineering* **100**, 366-371 (2010). ISSN: 0260-8774, http://dx.doi.org/10.1016/j.jfoodeng.2010.04.023
7. Maayan Lia Yizraeli and Daphne Weihs, "Time-Dependent Micromechanical Responses of Breast Cancer Cells and Adjacent Fibroblasts to Electrical Treatment", *Cell Biochemistry and Biophysics*, **61**, 605-618 (2011). ISSN: 1559-0283, doi: http://dx.doi.org/10.1007/s12013-011-9244-y
8. Daphne Weihs, Dror Gilad, Moti Seon, and Itai Cohen, "Image-Based Algorithm for Analysis of Transient Single-Particle Trajectories", *Microfluidics and Nanofluidics* **12(1-4)**, 337-344 (2012). ISSN: 1613-4982, doi: http://dx.doi.org/10.1007/s10404-011-0877-3
9. Natalya Mizrahi, Enhua Zhou, Guillaume Lenormand, Ramaswamy Krishnan, Daphne Weihs, James P. Butler, David Weitz, Jeffrey J. Fredberg, and Eitan Kimmel, "Low intensity ultrasound perturbs cytoskeleton dynamics", *Soft Matter* **8(8)**, 2438-2443 (2012). ISSN: 1744-683X, doi: http://dx.doi.org/10.1039/C2SM07246G

10. Sasuga, Sonoko, Weihs, Daphne, Talmon, Yeshayahu, Okabayashi, Hirofumi, O'Connor, C., "Aggregate Structures of Asymmetric Di-Alkyl Phosphate Anions and the Role of Conformations about the Polar Region: SANS, Cryo-TEM, Raman Scattering, ^{13}C NMR and Selective NOE Studies", *Journal of Physical Chemistry B* **116**, 3538-3550 (2012). ISSN 1520-6106, doi: http://dx.doi.org/10.1021/jp300019n
11. Moti Umansky and Daphne Weihs, "Novel Algorithm and MATLAB-Based Program for Automated Power Law Analysis of Single Particle, Time-Dependent Mean-Square Displacement", *Computer Physics Communications* **183**, 1783-1792 (2012). ISSN: 0010-4655, doi: http://dx.doi.org/10.1016/j.cpc.2012.03.001
12. Naama Gal and Daphne Weihs, "Intracellular mechanics and activity of breast cancer cells correlate with metastatic potential", *Cell Biochemistry and Biophysics* **63(3)**, 199-209 (2012). ISSN: 1559-0283, doi: http://dx.doi.org/10.1007/s12013-012-9356-z. Featured in: Mammary Cell News, Vol. 4.18 (May 10, 2012).
13. Shada AbuHattum and Daphne Weihs, "Cell-based coordinate system for intracellular location-dependent particle tracking analysis", In Press. Invited contribution to a Special Issue of *Computer Methods in Biomechanics and Biomedical Engineering* (Personal invitation by issue editors).

Submitted invited papers to special issues

1. Diana Goldstein, Tal Elhanan, Maria Aronowitz, and Daphne Weihs, "Role of Cytoskeleton and Molecular Motors in Breast Cancer Cell Structure, Activity, and Mechanics". Invitation to submit to Emerging investigators themed issue of Soft Matter (Personal invitation from journal editorial board)
2. Diana Goldstein, Naama Gal, and Daphne Weihs, "Particle Tracking in Living Cells: A Review of the Mean Square Displacement Method and Beyond", invited contribution to a special issue of *Rheologica Acta* (Personal invitation by journal editors).

Research Lab: Cellular Biomechanics and Bio-rheology

In her current position at the Faculty of Biomedical Engineering at the Technion, Dr. Weihs' research focuses mainly on the micro-mechanics of living cells in diagnosis, treatment, and prevention of breast cancer and its metastases. The research projects that were and are currently carried out at Daphne's Bio-Rheology Lab run along the following main directions: (1) Evaluating rheology and micro-mechanics of living cells for developing approaches for cancer diagnosis and testing of treatments; (2) Advancement of particle-tracking microrheology and general rheology; (3) Evaluate mechanisms of force application by cancer cells, especially during metastatic invasion; and (4) bio-rheological, micromechanical studies with collaborators. The various directions and the potential impact are detailed in the subsections below.

(1) Micro-mechanics of living breast cancer cells for diagnosis and treatment

The research has been focused on evaluating the mechanics of living breast cancer cells with the objective to reveal mechanisms driving activity in cells and their responses to treatment and perturbations. It has been shown in others' works in the past few years, by measuring external stiffness of cells, that metastatic breast cancer cells are softer than cancer cells, which are in turn softer than benign cells. The Weihs lab has recently been able to show that internal mechanics and activity levels of the cells also depend on their metastatic potential, yet in a different way. The group uses probe particle embedded deep within living cells to evaluate structural features and active transport. The work performed at the Weihs lab is unique in the ability to accurately track motion of small particles (200-nm diameter) at high

frame rates (60 frames-per-second) within living cells and perform accurate analysis. This is something only 2-3 other labs in the world are currently capable of doing. Using those approaches, the Weihs lab has shown that highly metastatic breast cancer cells are softer and more active than both low metastatic potential breast cancer cells and benign cells; the latter are in fact internally similar. Thus, highly metastatic cells require a combination of external and internal pliability as well as enhanced activity to perform metastatic functions. In addition, a newly applied analysis approach revealed that in metastatic cells, there are at least two concurrent active processes driving probe particle motion; that is, concurrent processes driving structural the mechanical changes in the cells. The mechanics of those cells provides targets for both diagnostics and treatments.

The Weihs lab have evaluated effects of various physical and chemical treatments on living cells. Low intensity, direct-current electrical fields have been applied to a model tumor environment, including highly metastatic breast cancer cells and fibroblasts (connective tissue cells) surgically obtained from a tumor adjacent region. The work has shown that the treatment specifically affects the cancer cells and not the benign fibroblasts. Many of the cancer cells were destroyed while others were perturbed for at least two hours. That time of effect could potentially provide a window for synergistic treatments. Another physical approach that was applied is low intensity, therapeutic ultrasound has prompted fluidization of a cell and dramatic acceleration of its remodeling dynamics when exposed to low intensity ultrasound. This is important in several aspects, a as use for treatment/modification of cells and as to reveal what ultrasound can do within the body on the cell level. The Weihs lab have also been applying several chemotherapeutics, some of which are clinical, to evaluate the origin of activity in cancer cells and differences relating to metastatic potential; this is part of a manuscript in preparation for an invited special issue paper of Soft Matter.

(2) Advancement of particle-tracking microrheology and general rheology

The Weihs lab has developed many approaches for measurement and analysis that have advanced particle tracking microrheology and general rheology. The group has developed an approach to detect different modes of active transport in particle tracking microrheology ((described above). The work presented with that approach was the first experimental proof of a phenomenon called weak self similarity, something that has only been described by theoretical and numerical works in the last 15 years. The group has also presented a novel algorithm to analyze particle tracking specifically in cells with consideration for their structure and orientation in the field of view. This approach uses image processing techniques to localize the nuclei of cells, approximate them to ellipses, and then correlate particle trajectories and transport properties with their location relative to the nucleus. The group has developed a general algorithm for automated slope detection in noisy, logarithmically scaled data of time-dependent power law data; this approach has been taken up by many labs of peers for particle tracking analysis and others. In addition, the group has developed an image processing based approach to segment transient particle-trajectories exhibiting alternating trapping and escape from local traps, regardless of their origin.

In macro-scale rheology research, the Weihs lab has evaluated operating windows for materials, rheological parameters, and is collaborating on development of a new in-line viscometer. Following contact with industry a work on honey was performed. This work provides the operation limits of microrheology (in a high viscosity non-transparent liquid) as well as an evaluation of the rheology of reduced calorie honey as a quality indicator, of great interest in industry. Dr. Weihs' expertise in rheology has been established and she has provided lab support and consultation to companies, such as Serafix, IonMed, Transpharma

Medical, Landa Corporation, and Orbotech. Currently, she is collaborating with Faculty from TAU and BGU in development of an in-line viscometer for industry. The first paper on this is under final revision, and the group has recently received a Kamin grant from the Min. of Commerce to facilitate instrument development.

(3) Mechanisms of force application by cancer cells during metastatic invasion

The Weihs lab has shown that metastatic cells have a more active and softer intracellular microenvironment than cancerous and benign cells. Interestingly, the groups' recent work also shows that the same metastatic cells are still stronger and more tenacious in applying forces to their environment, when attempting to invade it. The group has shown that metastatic cancer cells will attempt to penetrate, by indenting and actively applying force, an impenetrable substrate. The cells repeatedly apply forces to gels that are non-degradable and with impenetrable pores. The forces depend on metastatic potential of the cells, substrate stiffness, and attempt number; cells concede and displace after several tries. This phenomenon was unexpected and provides preliminary indication to mechanisms of force application by cells. The paper describing this work is currently under revision. The work has, however, been presented in international conferences in the past few months and has garnered great interest. It has led to establishment of 3 new collaborations with labs interested in performing theory and modeling of the novel results obtained at the Weihs lab. Future work at the lab includes combination of the force application measurements together with intracellular micromechanics approaches, which Dr. Weihs is already considered an expert on.

(4) Papers from collaborations

Dr. Weihs has several ongoing collaborations, some of which have already produced joint papers. Those include the work on cells with low intensity ultrasound, microstructural characterization of cell-membrane modeling materials, and design and implementation of a new in-line viscometer.

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Education:

Date	Institute	Degree	Area of specialization
1999-2002	Harvard Med. School	Post-Doctorate	Biomedical Optics
1993-1999	Weizmann Institute	Ph.D	Physics
1992-1995	Hebrew University	Bs.C	Physics

Employment:

Date	Institute	Title	Research area
2012 - present	Technion, Biomedical Engineering Department	Associate Professor	Biomedical Optics, clinical endoscopy, non-invasive imaging, nano-plasmonics for therapy.
2007-2012	Technion, Biomedical Engineering Department	Senior Lecturer	Biomedical Optics
2004-2007	Harvard, Wellman Center for Photomedicine	Instructor	Biomedical optical endoscopy

Selected Honors and Awards

2012: Hershel Rich Technion Innovation Award.
2011: The JULUDAN Research Prize Fund.
2010: ERC starting grant
2006: Career Development Award from the Center for Integration of Medicine and Innovative Technology (CIMIT).
1998: Excellence prize for M.Sc. thesis from the Feinberg graduate school of the Weizmann Institute.

Research interests

Clinical endoscopy, advanced optical microscopy, gold nanoparticles, applications of ultrafast lasers, laser therapy. Current projects include the study of new approaches for medical endoscopy, and the development of novel, minimally invasive therapeutic approaches, which utilize gold nanoparticles and high-power femtosecond pulses to selectively target and manipulate living cells.

Recent Invited Lectures (International)

- NATO-Advanced Study Institute in Optical Waveguide Sensing and Imaging, Gatineau, Canada, 2006.
- Photonics West, BIOS, 6433-26, San Jose CA, USA, January 2007.
- OSA Biomedical Optics (BIOMED), St. Petersburg, Florida, USA, March 2008.
- 2nd International Nanotechnology Conference, Tel-Aviv, Israel, October 2010.
- Focus on Microscopy 2012, WE-MO1-PAR-A, Singapore, April 2012.

Selected Publications (last 5 years)

1. "Volumetric sub-surface imaging using spectrally encoded endoscopy", D. Yelin, B. E. Bouma, and G. J. Tearney, Opt. Express **16**, 1748 (2008).

2. "Doppler imaging using spectrally-encoded endoscopy", D. Yelin, B. E. Bouma, J. J. Rosowsky, and G. J. Tearney, Opt. Express **16**, 14836 (2008).

3. "Spectrally-encoded color imaging", D. Kang, D. Yelin, B. E. Bouma, and G. J. Tearney, Opt. Express **17**, 15239 (2009).

4. "Theoretical analysis of spectrally encoded endoscopy", M. Merman, A. Abramov, and D. Yelin, Opt. Express, **17**, 24045 (2009).

5. "Multiple-channel spectrally encoded imaging", A. Abramov, L. Minai, and D. Yelin, Opt. Express, **18**, 14745 (2010).

6. "Flow cytometry using spectrally encoded confocal microscopy", L. Golan and D. Yelin, Opt. Lett. **35**, 2218 (2010).

7. "Effect of single femtosecond pulses on gold nanoparticles", O. Warshavski, L. Minai, G. Bisker, and D. Yelin, J. Phys. Chem. C. **115**, 3910 (2011).

8. "Dispersion management for controlling image plane in Fourier-domain spectrally encoded endoscopy", M. Merman and D. Yelin, Opt. Express **19**, 4777 (2011).

9. "Spectrally encoded spectral imaging", A. Abramov, L. Minai, and D. Yelin, Opt. Express, **19**, 6913 (2011).

10. "Optical nano-manipulations of malignant cells: controlled cell damage and fusion", L. Minai, D. Yeheskely-Hayon, L. Golan, G. Bisker, E. J. Dann, and D. Yelin, Small, DOI: 10.1002/smll.201102304 (2012).

11. "Controlled fabrication of gold nanoparticles and fluorescent proteins conjugates", G. Bisker, L. Minai, and D. Yelin, Plasmonics, in press (2012).

12. "Noble metal nanoparticles and short pulses for nano-manipulations – theoretical analysis", G. Bisker and D. Yelin", J. Opt. Soc. B, **29** 1383 (2012).

13. "Noninvasive imaging of flowing blood cells using label-free spectrally encoded flow cytometry", L. Golan, D. Y. Hayon, L. Minai, E. J. Dann and D. Yelin", Biomed. Opt. Express **3**, 1455 (2012).

14. "Controlled release of Rituximab from gold nanoparticles for phototherapy of malignant cells", G. Bisker, D. Yeheskely-Hayon, L. Minai and D. Yelin, J. Controlled Released, **162**, 303 (2012).

15. "Dual-channel spectrally encoded endoscopic probe", G. Engel, H. Genish, M. Rosenbluh, and D. Yelin, Biomed. Opt. Express, **3**, 1855 (2012).

16. "High-speed interferometric spectrally encoded flow cytometry", L. Golan, D. Yeheskely-Hayon, L. Minai and D. Yelin, Opt. Lett., **37**, 5154 (2012).

17. "Image transmission through an optical fiber using real-time modal phase restoration", A. Fertman and D. Yelin, J. Opt. Soc. Am. A, **30**, 149 (2013).

Research Lab: Biomedical Optics

At the Faculty of Biomedical Engineering at the Technion, Prof. Dvir Yelin research group studies and develops a novel approach for cancer therapy that treats cancer cells at nano-scale resolutions, with minimal toxicity and tissue damage. Briefly, when noble-metal nanoparticles interact with intense, short laser pulses tuned to their plasmonic resonance, nanometric cavitation bubbles are formed, affecting the nearby cellular environment. This process, which essentially involves no toxic agents, is at the basis of this approach, which includes nanoparticles targeting to cancer cells and irradiating the cells using fiber optics for light delivery and imaging. The various research projects in our group focus on three main aims: studying the interaction between gold nanoparticle and ultrashort pulses, affecting cancer cells using specific nanoparticle conjugates and short pulses, and developing minimally- or non- invasive endoscopic techniques for accessing the cells (or tumor) area.

Study the interaction between gold nanoparticles and short laser pulses: In a first experiment designed to elucidate the effect short laser pulses have on gold nanoparticles, we have found that a single resonance excitation pulse above a certain threshold (approx. 10 mJ/cm^2) induces noticeable changes in solutions containing various particle dimensions. We have conducted a theoretical study of the relative contributions of various pulse parameters, including duration, irradiance, and wavelength, as well as the particle's substance, size, and shape. We have shown that spatially confined local nanometric interactions between a particle and its near surroundings are feasible using 50 nm gold and silver nanospheres illuminated by laser pulses shorter than 70 fs and 90 fs, respectively, with no particle melting and minimal collateral damage. The results of this work could be useful for researchers in various fields, who aim at manipulating matter on the smallest possible scales, with high specificity and accuracy.

Targeting cancer cells and proteins using nanoparticles and ultrashort pulses: Specifically targeting and manipulating living cells is a key challenge in biomedicine and in cancer research in particular. Several studies have shown that nanoparticles irradiated by intense lasers are capable of conveying damage to nearby cells for various therapeutic and biological applications. In a recent paper we reported the use of ultrashort laser pulses and gold nanospheres for the generation of localized, nanometric disruptions on the membranes of specifically targeted cells. The high structural stability of the nanospheres and the resonance pulse irradiation allow effective means for controlling the induced nanometric effects. The technique was demonstrated by inducing desired death mechanisms in epidermoid carcinoma and Burkitt lymphoma cells, and initiating efficient cell fusion between various cell types (Fig. 1). Main advantages of this approach include low toxicity, high specificity, and high flexibility in the regulation of cell damage and cell fusion, which would allow it to play an important role in various future clinical and scientific applications.

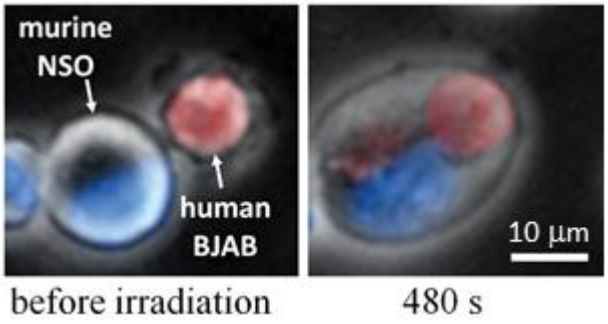

Figure 1: Formation of a hybridoma cell: time sequence of human BJAB cells (red nuclei) and murine myeloma (NSO) cells (blue nuclei) following irradiation by five pulses, in the

Recently, we have experimentally demonstrated the use of single femtosecond pulses at resonance wavelength for a controlled conjugation of gold nanoparticles and fluorescent proteins. This optically driven reaction was rigorously studied and analyzed using a variety of experimental techniques, and a

detailed model was proposed which describes the adsorption of the proteins onto the nanoparticles' surface, as well as their subsequent desorption by a reducing agent. Potential applications of the resulting nanoparticle–protein conjugates include controlled delivery of fluorescent markers and local sensing of various biochemical processes. This study had led to another set of experiments designed to better control the release of molecules from the particles' surfaces. We had utilized gold nanospheres conjugated to Rituximab, an anti-CD20 monoclonal antibody-based drug, for carrying and releasing the drug upon irradiation of specifically tailored femtosecond laser pulses. The released anti-CD20 molecules have retained their functionality and ability of triggering the complement-dependent cytotoxicity system. This effect comes in addition to cell necrosis caused by the plasmonic nanometric shockwaves emanating from the nanospheres and rupturing the plasma membranes.

Minimally- and non-invasive optical imaging techniques: Thanks to extremely high cell damage rates and low overall toxicity, our approach for damaging cells would be particularly attractive for targeting flowing blood cells and could assist in the diagnosis and treatment of hematological cancers, for example. We have demonstrated that spectrally encoded confocal microscopy is capable of imaging un-labeled flowing blood cells with submicron resolutions and high contrast. Recently, we had presented label-free *in vivo* flow cytometry of blood using a compact imaging probe that could be adapted for bedside real-time imaging of patients in clinical settings, and demonstrated subcellular resolution imaging of red and white blood cells flowing in the oral mucosa of a human volunteer. By analyzing the large data sets obtained by the system, valuable blood parameters could be extracted and used for direct, reliable assessment of patient physiology. We are currently establishing collaborations with experts in the field of hematological cancers to explore potential applications for this novel approach.

Spectrally encoded endoscopy (SEE), a variant of spectrally encoded confocal microscopy, allows significant miniaturization of clinical endoscopes, potentially allowing for minimally invasive imaging in hard-to-reach areas. Our group had established the theory behind image formation using SEE. We have then demonstrated several novel approaches for SEE, using multiple channels for speckle-free and fluorescence imaging, spectral imaging, i.e. capturing full spectra from each image pixel, depth-of-field scanning using external (out of the body) dispersion management, and measurement of acoustic vibrations in nanometric resolutions. Recently, we have presented a novel miniature SEE probe, which incorporates these recent advances into a compact and robust endoscopic system. Using a high-quality miniature diffraction grating that was laser-cut from a large bulk grating, as well as separate imaging and illumination fibers, the new system had large depth of field, negligible back reflections and well controlled speckle noise that depends on the core diameter of the illumination fiber. These developments are particularly important for clinical diagnosis, allowing the detection of specifically labeled targets and the diagnosis of various conditions such as small cancer tumors, internal infections and bleeding.

Adam Dan D.Sc.

Professor Emeritus

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Education:

Date	Institute	Degree	Area of specialization
1980-1983	Harvard-MIT Div Health Sc & Tech	Ass. Visiting Prof.	Cardiology Research & signal Processing
1978-1980	Tufts- N.E. Medical Center	Post-Doctorate	Cardiology Research
1974-1977	Technion – Biomedical Eng.	D. Sc.	Neuroengineering – Information Theory
1971-1973	Technion – Electrical Engineering	M.Sc.	Physiological modeling
1964-1968	Technion – Electrical Engineering	Bs.C.	

Employment:

Date	Institute	Title	Research area
2012-present	Technion, Dep. Biomed. Eng.	Prof. Emerit.	Ultrasound beam-forming and signal proc.
2009-2012	Technion, Dep. Biomed. Eng.	Dean	Ultrasound signal & Image processing
2006-2012	Technion, Dep. Biomed. Eng.	Professor	Ultrasound contrast agents, High Intensity Focused Ultrasound, signal & Image proc.
1993-2005	Technion, Dep. Biomed. Eng.	Assoc. Prof.	Ultrasound signal & Image processing
1992-1993	DCRT, NIH, Bethesda, MD	Sen. Researcher	3D Ultrasound vascular flow measurements
1987-1993	Technion, Dep. Biomed. Eng.	Senior Lecturer	Ultrasound signal & Image processing
1983-1987	Technion, Dep. Biomed. Eng.	Senior Res. Assoc.	Cardiac Electrophy.,processing & Ultrasound
1980-1983	Harvard-MIT Div Hth Sc & Tech	Ass. Visiting Prof.	Cardiac Electrophys., processing & Modeling
1978-1980	Tufts- N.E. Medical Center	Ass. Professor	Cardiac Electrophysiology & processing
1977-1978	Technion, Dep. Biomed. Eng.	Research Assoc.	ECG signal processing
1975-1975	Physiology Inst., U. Goettingen	Researcher	Animal Neurophysiology
1968-1971	Elscint Ltd.	Product manager	Mossbauer Effect Spectrometers

Dan Adam joined the Technion Faculty in 1977. He was at Tufts U., Boston, 1978-80. He joined MIT in 1980, teaching at the Harvard-MIT HST Program. He re-joined the Technion in 1983, and is now a Professor in Biomedical Engineering and Dean (2009-2012). He had a sabbatical at NIH, MD, 1992-3. He has been an IEEE member since 1964, elected to the IEEE-EMBS AdCom in 1999, and to the Board of Computers in Cardiology 1990-9. He serves on the Board of the Israel Society for Medical and Biological Engineering since 1988, and as its President till 2007, and its delegate to the International Federation for Medical and Biological Engineering (IFMBE), and as past-Chair, Academic Division and Council Member, European Alliance for Medical and Biological Engineering and Science (EAMBES). He was elected as EAMBES fellow. He advised 43 MSc students and 11 PhD students. Prof. Adam is leading a research group of 6-10 graduate students (3-4 PhD), 2-4 groups of 4th year students, 3 Research Scientists and an Electronic Engineer. His has research funding of over US$200,000 per year, plus ~US$150,000 per year royalties, mostly obtained from GE Healthcare.

Research interests

Development of signal processing tools and measurement procedures of ultrasound signals for modifying apodization parameters (e.g. by Sub Aperture Receiver technique), for reduced speckle noise and tissue characterisation. * Development of measurement methods and processing of signals and images (2 dimensional and 3 dimensional) of blood flow and flow velocity, using Doppler ultrasound technology (continuation of a R&D project which was initiated together with the Division of Computer Research and Technology - National Institutes of Health (NIH). * Development of tracking of tissue in ultrasound images and of parameters which allow description of stain development in the myocardium. Development of new 'strain imaging' process that provides the myocardial activation sequence. * Development of signal processing methods for detecting reverberations of ultrasound contrast agents (gas bubbles) for perfusion measurements and pressure measurements.

Selected Publications (last 5 years)

- Biedermann BC, Coll B, Adam D, Feinstein SB.: Arterial microvessels: an early or late sign of atherosclerosis? J Am Coll Cardiol. Sep 9; 52(11): 968; 2008.
- Adam D, Soqulin A, Coll B, et al. Quantitative contrast-enhanced ultrasound imaging of the carotid artery vasa vasorum: calibration and initial results. J Am Coll Cardiol;51 Suppl A:A318, 2008.
- Feinstein SB, Coll B, Staub D, Adam D, Schinkel AF, Ten Cate FJ, Thomenius K.: Contrast enhanced ultrasound imaging. J Nucl Cardiol. Vol. 17 (1), pp. 106-115; 2009.
- Leitman M., Lysiansky M., Lysyansky P., Friedman Z., Tyomkin V., Fuchs T., Adam, D., Krakover R., Vered Z.: Circumferential and Longitudinal Strain in 3 Myocardial Layers in Normal Subjects and in Patients with Regional Left Ventricular Dysfunction. J. of the American Society of Echocardiography, Vol. 23, (1), pp. 64-70, 2010.
- Bachner N, Tsadok Y, Adam D. Increase in endocardial rotation during doxorubicin treatment. Ann N Y Acad Sci, Feb;1188:128-32, 2010.
- Staub D., Schinkel, A.F.L., Coll B., Coli S., van der Steen A.F.W., Reed, J.D., Krueger C., Thomenius K.E., Adam D., Sijbrands, E.J., ten Cate, F.J., Feinstein S.B.: Contrast-Enhanced Ultrasound Imaging of the Vasa Vasorum: From early Atherosclerosis to the Identification of Unstable Plaques. JACC Cardiovasc Imaging, Jul;3(7):761-71, 2010.
- Becker M, Zwicker C, Kaminski M, Napp A, Altiok E, Ocklenburg C, Friedman Z, Adam D, Schauerte P, Marx N, Hoffmann R.: Dependency of cardiac resynchronization

therapy on myocardial viability at the LV lead position. JACC Cardiovasc Imaging, Apr;4(4):366-74, 2011.

- Becker M, Altiok E, Lente C, Otten S, Friedman Z, Adam D, Hoffmann R, Koos R, Krombach G, Marx N, Hoffmann R.: Layer-specific analysis of myocardial function for accurate prediction of reversible ischaemic dysfunction in intermediate viability defined by contrast-enhanced MRI. Heart. May; 97(9): 748-56, 2011.
- Becker, M., Altiok, E., Ocklenburg, C., Krings, R., Adam, D., Lysansky, M., Vogel, B., Schauerte, P., Knackstedt, C., Hoffmann, R.: Analysis of LV Lead Position in Cardiac Resynchronization Therapy Using Different Imaging Modalities. JACC: Cardiovascular Imaging; Vol. 3(5), pp. 472-481, 2010.
- Bachner-Hinenzon, N., Ertracht, O., Lysiansky, M., Binah, O., Adam, D.: Layer-specific assessment of left ventricular function by utilizing wavelet de-noising: a validation study. M Biol Eng Com. Jan; 49(1):3-13, 2011.
- Bachner-Hinenzon, N., Ertracht, O., Leitman, M., Vered, Z., Shimoni, S., Beeri, R., Binah, O., and Adam, D.: Layer-specific strain analysis by speckle tracking echocardiography reveals differences in left ventricular function between rats and humans. Am J Physiol Heart Circ Physiol 299: H664-H672, 2010.
- Winkler, I., and Adam D.: Monitoring Radiofrequency Thermal Ablation with Ultrasound by Low Frequency Acoustic Emissions: In-vitro and in-vivo study. Ultrasound Med Biol. May; 37(5): 755-767, 2011.
- Leitman, M., Bachner-Hinenzon, N., Adam, D., Fuchs, T., Theodorovich, N., Peleg, E., Krakover, R., Moravsky, G., Uriel, N., Vered, Z.: Speckle tracking imaging in acute inflammatory pericardial disease. Echocardiography, May; 28(5): 548-55, 2011.
- Hoogi, A., Adam, D., Hoffman, A., Kerner, H., Reisner, S., and Gaitini, D.: Carotid Plaque Vulnerability: Quantification of Neovascularization on Contrast-Enhanced Ultrasound With Histopathologic Correlation. Am J Roentgenol., Feb;196(2):431-436, 2011.
- Ertracht, O., Liani, E., Bachner-Hinenzon, N., Bar-Am, O., Frolov, L., Ovcharenko, E., Awad, H., Blum, S., Barac, Y., Amit, T., Adam, D., Youdim, M., Binah, O.: The cardioprotective efficacy of TVP1022 in a rat model of ischemia/reperfusion. Br J Pharmacol. 2011 Jun;163(4):755-769.
- Hersch A., Adam D.: Premature cardiac contractions produced efficiently by external high-intensity focused ultrasound. Ultrasound Med Biol. Jul; 37(7):1101-10, 2011.
- Lysiansky M., Bachner-Hinenzon N., Khamis H., Smirin N., Lysyansky P., Friedman Z., Shimoni S., Fehske W., Adam D.: Measurements of transmural strain variations by two dimensional ultrasound speckle tracking. Journal of Biomedical Graphics and Computing, Vol. 2, No. 1, pp. 1-16, June 2012.
- Bachner-Hinenzon N, Ertracht O, Malka A, Leitman M, Vered Z, Binah O, Adam D.: Layer-specific strain analysis: investigation of regional deformations in a rat model of acute versus chronic myocardial infarction. Am J Physiol Heart Circ Physiol. 2012 Sep;303(5):H549-58. Epub 2012 Jul 9.
- Hoogi A, Akkus Z, van den Oord SC, Ten Kate GL, Schinkel AF, Bosch JG, de Jong N, Adam D, van der Steen AF.: Quantitative Analysis of Ultrasound Contrast Flow Behavior in Carotid Plaque Neovasculature. Ultrasound Med Biol. Oct; 2012.

Research Lab: Ultrasound Images and Image Processing

43 MSc students and 11 PhD students have graduated from the lab. Research funding is of over US$200,000 per year, plus ~US$150,000 per year royalties, mostly obtained from GE Healthcare.

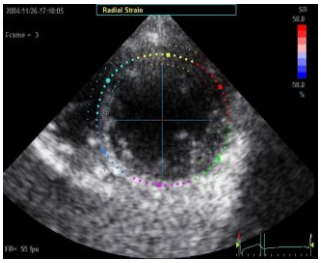
Lab facilities:

The lab is equipped with a specially modified GE VIVID III Ultrasound Imaging System, for direct output of the unprocessed RF data into a separate workstation. This imaging system can also be controlled from a different computer. Also, a VIVIDi is available, with several probes, including pediatric probe that allow image/data acquisition from small animals. The lab is also equipped with ultrasonic transducers high power amplifiers, receivers, function generators, digitizer cards and hydrophones. It also includes a X-Y-Z motorized system, degassing system, etc. The laboratory is equipped with highly sophisticated monitoring devices for measuring multiple sensors (various hydrophones, pressure, flow, electrograms, respiration etc.), and all necessary systems for running a well controlled experiments. Multiple workstations and software support are available.

Field of research:

Signal processing and image processing;
Ultrasound RF processing;
2 Dimensional Strain measurements in Echocardiography;
Layer-specific Echocardiographic strain mapping;
Multi-transducer phased array design;
Bean-forming design – Coded excitation
Perfusion measurements using Contrast Agents;
Pressure estimation using Contrast Agents;
Ultrasound control of thermotherapy - monitoring of thermal-cavitational therapy;
Measurement and analysis of body surface potential maps;
Determination of arrhythmic processes and their termination;
The forward and inverse problems in electrocardiography;
Study and analysis of non-linear processes in the cardiac system;
Cellular and subcellular processes generating arrhythmias and alternans;
Detection and manipulations of Contrast Agents;
High Intensity Focused Ultrasound;
Functional imaging;
Cardiac mechanics and Electrophysiology.

Research interests:



The lab's main activities are in ultrasound processing – design of multi-frequency phased array probes for the development of multi-frequency (spectral) imaging; ultrasound RF processing (Blind Deconvolution) for increased axial and 2D resolution;
Echocardiography Strain imaging, including Layer-Specific 2D Strain measurements as a diagnostic tool of myocardial pathologies – e.g. coronary artery disease, conduction system pathologies, congestive heart failure;

Mapping of flow indices as a measure of organ patency; Position/Orientation registration of probes for 3D quantification of measurements & visualization of flow in arteries – as well as in arterioles;
Quantification of neovasculature within plaques for estimating its vulnerability, using contrast enhanced ultrasound imaging; Monitoring neovasculature within cancerous lesions as a measure of its response to drug therapy, using contrast enhanced ultrasound imaging;

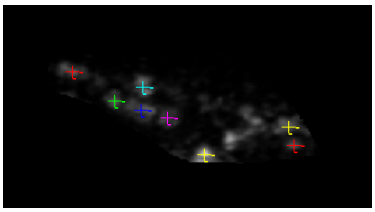
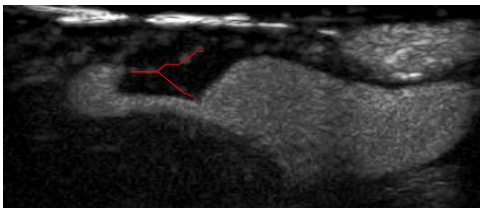
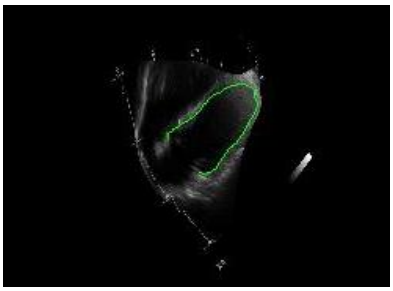
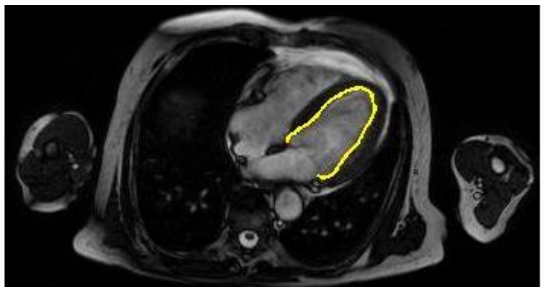



Image guided therapy/surgery;
Development of new applications for ultrasound Contrast Agents: Myocardial Perfusion estimation; flow within plaques by ultrasound using Contrast Agents, Pressure estimation using Contrast Agents;
Monitoring and control of thermotherapy by ultrasound: Treatment and initiation of apoptosis in cancerous tissue by localized heating – and control of the treatment by ultrasound measurements within the treated region and its surrounding areas;
Targeted drug or gene delivery using ultrasound and micro-bubbles (contrast agents);
Non invasive thrombolysis by focused ultrasound in acute ischemic stroke; Cardiac pacing by non-invasive high intensity focused ultrasound; Neural activation by non-invasive high intensity focused ultrasound;
Multi-modality cardiac imaging; cardiac-MRI and echocardiography image fusion, and functional data fusion.

Technology transfer:
Echocardiographic 2D strain imaging (AFI, GE Healthcare, Inc.)
Treatment of varicose veins by non-invasive high intensity focused ultrasound;
Removal of fat tissue/ cellulites by non-invasive high intensity focused ultrasound;

Dinnar Uri Ph.D.

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ACADEMIC DEGREES:

Ph.D. 1969 Engineering and Applied Physics, Harvard University, Cambridge,Mass. USA.
M.Sc.. 1968 Engineering and Applied Physics, Harvard University, Cambridge,Mass. USA..
B.Sc. 1964 Mechanical Engineering, Technion—Israel Institute of Technology.

ACADEMIC APPOINTMENTS- TECHNION:

1996- Henry Golberg Chair.
1990- Professor, Department of Biomedical Engineering,
1981 Associate Professor, Department of Biomedical Engineering.
1972 Senior Lecturer, Faculty of Mechanical Engineering.
1969 Senior Lecturer, Department of Applied Mathematics.

ACADEMIC APPOINTMENTS- OUTSIDE THE TECHNION

1976-1978	Visiting Associate Professor, Michigan State University, School of Osteopathic Medicine
1983-1984	Visiting Associate Professor, Drexel University, Faculty of Biomedical Engineering
1990-1991	Visiting Professor University of Houston, Faculty of Mechanical Engineering
1999-2000	Distinguished Visiting Professor, City College New York, Department of Biomedical Engineering
2003-2004	Visiting Professor Columbia University Department of Biomedical Engineering

TECHNION ACTIVITIES:

2004-	Member Technion's committee for development
2001-2003	Head Department of Biomedical Engineering
1994-1998	Head Department of Biomedical Engineering
1991-1992	Member Technion's committee for development
1998-1990	Head Department of Biomedical Engineering
1985-1987	Head Department of Biomedical Engineering

Supervision of graduate students and M.D Basic studies:

Till 2004 supervised 25 M.Sc. Students, 14 Ph.D. Students, 6 Basic studies

List of RECENT PUBLICATIONS

1. A. Morgenshtein, L. Sudakov-Boreysha, U. Dinnar, C.G. Jakobson and Y. Nemirovsky, "Wheatstone-Bridge Readout Interface for ISFET/REFET Applications", Sensors & Actuators: B. Chemical, Vol 98/1, pp 18-27, 2004
2. A. Morgenshtein, U. Dinnar, C.G. Jakobson and Y. Nemirovsky: CMOS Readout Circuitry for (ISFET Microsystems. Sensors and Actuators, BChemical, 97(1):122-131 Jan 1 2004.

3. Andrew Machauf (Prochaska, Yael Nemirovskyand Uri Dinnar : A membrane micropump electrostatically actuated across the working fluid. Journal of Micromechanics and Microengineering,Vol. 15, 2309-2315, 2005.
4. Bransky, N. Korin, Y. Nemirovski and U. Dinnar : An automated cell analysis sensing system based on a microfabricated rheoscope for the study of red blood cells physiology. Biosensors and Bioelectronics 22 (2) , 165-169, 2006.
5. Golan S., Elata D., Orenstein M. and Dinnar U.: Floating Electrode Dielectrophoresis. Electrophoresis 27 (4), 4919-4926, 2006.
6. A. Bransky, N. Korin, Y. Nemirovski and U. Dinnar, "A microfabricated biosensor for erythrocytes deformability and volume distributions analysis", SPIE vol. 6416, 64160O, 2006.
7. N. Korin, A. Bransky, U. Dinnar, S. Levenberg, "The culture of human embryonic stem cells in microchannel perfusion bioreactors", SPIE vol. 6416, 64160N, 2006
8. Bransky, N. Korin, Y. Nemirovski and U. Dinnar: Correlation of Erythrocytes deformability and size, a study using a micro-channel based rheoscope. Microvascular Research, 73(1), 7-13, 2007.
9. Korin N., Bransky A., Dinnar U., Levenberg S.: A Parametric Study of Human Fibroblasts Culture in a Microchannel Bioreactor. Lab on Chip, 7(5), 611-617, 2007.
10. Leshansky A.M., Bransky A., Korin N., Dinnar U.: Tunabale nonlinear viscoelastic "focusing" in a microfluidics Device. Physical Review Letters 98(23), Art: No. 234501, Jun, 8, 2007.
11. Bransky A., Korin N., Leshansky A., Dinnar U.,: The rheologic Properties of Erythrocytes: a Study Using an Automated Rehoscope. Rheologica Acta 46(5), 621-627, 2007.
12. Korin N., Bransky A., Dinnar U.: Theoretical Model and Experimental Study of Red Blood Cell (RBC) deformation in Microchannels. Journal of Biomechanics, 40(9), 2088-2095, 2007.

Recent Patents:

1. A. Morgenshtein, U. Dinnar and Y. Nemirovsky, "Method for ISFET measurements without readout circuitry and application to combined pH-image sensor", USA patent Application no 10/825,123, 2004.
2. S. Golan, U. Dinnar, D. Elata, M. Orenstein : Floating Electrode dielectrophoresis (FEDEP). USA Patent 31856, 2006.

Gath Isak D.Sc., M.D.

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ACADEMIC DEGREES

M.D. 1964 - Hadassah Medical School , Hebrew Univ., Jerusalem .
D.I.C. 1970 - Biomedical Eng., Imperial College of Science and Technology, London.
D.Sc. 1975 - Electrical Eng., Technion-Israel Institute of Technology, Haifa.

ACADEMIC APPOINTMENTS

1975 - Senior lecturer, Dept. of Biomedical Engineering, Technion, Israel.
1982 - Associate Professor, Dept. of Biomedical Engineering, Technion, Israel.
1991 - Professor, Dept. of Biomedical Engineering, Technion, Israel.
2001 - Professor, Secondary Affiliation, Dept. of Computer Science,
2005 - Professor Emeritus, Dept. of Biomedical Engineering, Technion, Israel.

Special Contribution To Teaching

Automatic Control - Man and Machine, a study program for science and technology for high school students. Has been distributed in 11 high schools in London and Southampton.
Development of 'CyberTest', the first computerized multipurpose exam system in Israel. Implemented for the undergraduate/ graduate course" Introduction to Biological Processes".

RESEARCH INTERESTS

Processing and pattern recognition of biological signals.

HONORS

- 1989-1990: Professor of Applied Mathematics, held a Chair *('ChaireMunicipale')* at the Dept. of Computer Science and Applied Mathematics, Joseph Fourier University, Grenoble.
- Sept 1999-Feb 2000 Professor (Invited), Machine Vision and Image Science Group, Oak Ridge National Laboratory, Oak Ridge.
- Feb. 2005-Sept. 2005 Professor (Invited) Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences, Warsaw.

PUBLICATIONS

Citation Classic

Paper No. 34 has been cited a great number of times and is still being cited, and was also included in the book 'Fuzzy Models for Pattern Recognition, a selected collection of the classical papers in the area.

66. Granovsky Ilana and Gath Isak. Hierarchical classification methods for biological patterns. Intelligent Systems for Molecular Biology Conference, Detroit, July 2005.

67. Mizrahi, N. and Gath I.: Detection of human skin using fuzzy clustering algorithm.

68. Lamash, Y. and Gath I. : A comprehensive feature selection method applied to pharmacokinetic data, the 2009 Intern. Conf. on Bioinformatics and Computational Biology, Las Vegas, 2009.

Lanir Yoram D.Sc.

Professor Emeritus

ACADEMIC DEGREES

1962: B.Sc., Technion-Israel Institute of Technology
1970: D.Sc., Technion-Israel Institute of Technology

ACADEMIC APPOINTMENTS

2008- Professor Emeritus, Faculty of Biomedical Engineering, Technion – I.I.T, Haifa, Israel.
2005 Visiting Professor, Department of Biomedical Engineering, The Johns Hopkins Medical Institutions, Baltimore, Maryland.
2004-2005 Visitting Professor, Institute of Bioengineering, University of Auckland, Auckland, New Zealand.
2004 Research Associate, Harvard School of Public Health, Harvard University, Boston, Massachusette.
2003-2004 Research Associate, Department of Biomedical Engineering, University of Pennsylvania, Philadelphia.
1998-1999 Visiting Professor, Department of Biomedical Engineering, Faculty of Engineering, Tel-Aviv University, Tel-Aviv, Israel
1988-2008 Professor, Faculty of Biomedical Engineering, Technion.
1998-2008 Holder, The Marcus Reiner Chair in Rheology
1986 Visiting Professor, Section of Cardiology, Department of Medicine, The Johns Hopkins Hospital, Baltimore, Maryland.
1981 - 1988 Associate Professor, Department of Biomedical Engineering, Technion - Israel Institute of Technology, Haifa, Israel.
1981 - 1988 Associate Professor, Faculty of Mechanical Engineering, Technion - Israel Institute of Technology (Secondary Appointment), Haifa, Israel.
1980 - 1981 Visiting Professor, Department of Biomechanics, College of Osteopathic Medicine, Michigan State University, East Lansing, Michigan.
1979 - 1980 Visiting Associate Professor, Department of Biomechanics, College of Osteopathic Medicine, Michigan State University, East Lansing, Michigan.
1973 - 1981 Senior Lecturer, Department of Biomedical Engineering, Technion - Israel Institute of Technology, Haifa, Israel.
1975 - 1979 Senior Lecturer, Faculty of Mechanical Engineering, Technion-Israel Institute of Technology (Secondary Appointment), Haifa, Israel.
1970 – 1973 NIH Post-Doctoral Fellow, Department of AMES – Bioengineering, University of California at San Diego, La Jolla, California.

TEACHING

Data Analysis, Parameter Estimation and Experimental Design (1987 - present)
Tissue Biomechanics (1995 - present)

RESEARCH AREAS

Tissue Mechanics and Structure
The Cardiovascular System
Flow and Control in Coronary Circulation
Tissue Growth and Remodeling

RESEARCH GRANTS

US – Israel Binational Science Foundation (BSF): Control of the Coronary Flow
2010-2014

RECENT PUBLICATIONS (5 years)

1. Wischgoll, T., Meyer, J., Kaimovitz, B., Lanir, Y., and Kassab, G.S.: A Novel Method for Visualization of Entire Coronary Arterial Tree. *Annals of Biomedical Engineering*, 35(5):694-710, 2007.
2. Guo, X., Lanir, Y., and Kassab, G.S.: Effect of Osmolarity on the Zero-Stress State and Mechanical Properties of Aorta in Various Species. *Am J Physiol Heart Circ Physiol.* 293(4):H2328-34, 2007.
3. Kaimovitz, B., Huo, Y., Lanir, Y., and Kassab, G.S.: Diameter Asymmetry of Porcine Coronary Arterial Trees: Structural and Functional Implications. *Am J Physiol Heart Circ Physiol* 294: H714–H723, 2008.
4. Jacobs, J., Algranati, D., and Lanir, Y.: Lumped Flow Modeling in Dynamically Loaded Coronary Vessels. E-publication, *J. Biomechanical Eng* 130: 054504-1-5, 2008.
5. Lokshin, O., and Lanir, Y.: Viscoelasticity and preconditioning of rat skin under uni-axial stretch: Micro-structural constitutive characterization. *J. Biomechanical Eng* 131(3): 031009-1-10, 2009.
6. Rakovsky, A., Marbach, D., Lotan, N. and Lanir, Y.: Poly(ethylene Glycol)-Based Hydrogels as Cartilage Substitutes: Synthesis and Mechanical Characteristics. *Journal of Applied Polymer Science* 112(1):390-401, 2009.
7. Lanir, Y., Mechanisms of residual stress in soft tissues. *J. Biomechanical Eng.* 131(4): 044506-1-5, 2009.
8. Huo, Y. Kaimovitz, B., Lanir, Y. Wischgoll, T., Hoffman, J.E.I., and Kassab, G.S.: A Biophysical Model of Spatial Heterogeneity of Myocardial Flow, *Biophysical Journal* 96(10):4035-43, 2009.
9. Lokshin, O., Lanir, Y.: Micro and Macro Rheology of Planar Tissues. *Biomaterials*, 30: 3118–3127, 2009.
10. Raz, E., and Lanir, Y.: Recruitment Viscoelasticity of the Tendon. *J. Biomech. Eng.* Vol. 131 / 111008-1, 2009.
11. Algranati D, Kassab G.S., Lanir Y.: Mechanisms of Myocardium - Coronary Vessel Interaction. *Am J Physiol Heart Circ Physiol.* 298: H861–H873, 2010. (First published December 4, 2009).
12. Kaimovitz B., Lanir Y., and Kassab G. S.: A Full 3-D Reconstruction of the Entire Porcine Coronary Vasculature**.** *Am J Physiol Heart Circ Physiol.* 299: H1064–H1076, 2010.
13. Hollander Y., Durban D., Lu X., Kassab G. S., and Lanir Y.: A Validated Micro-Structural 3D Constitutive Model of Coronary Arterial Media. *J. Biomech. Eng.*, Vol. 133 / 031007-1, 2011.
14. Algranati D., Kassab G. S., and Lanir Y.: Why is the Subendocardium more Vulnerable to Ischemia? A New Paradigm. *Am J Physiol Heart Circ Physiol*, 300: H1090–H1100, 2011.
15. Hollander Y., Durban D., Lu X., Kassab G. S., and Lanir Y.: Comparison of Constitutive Models for Coronary Arterial Media. *J. Biomech. Eng.*, Vol. 133 / 061008-1, 2011.
16. Reichenberg, Y., and Lanir, Y.: A flow bio-reactor for studying the effects of haemodynamic forces on the morphology and rheology of cylindrically cultured endothelial cells. *J. Medl Eng. & Tech.*, 35(3):231-238, 2011.

17. Chen, H., Liu, Y., Zhao, X., Lanir, Y., and Kassab, G. S.: A micromechanics finite-strain constitutive model of fibrous tissue. *Journal of the Mechanics and Physics of Solids,* 59: 1823–1837, 2011.
18. Lanir, Y.: Osmotic Swelling and Residual Stress in Cardiovascular Tissues. *J. Biomechanics (Special Issue on Cardiovascular Solid Mechanics),* 45:780-789, 2012.
19. Reichenberg, Y, and Lanir, Y.: Duration of microbead seeding on endothelial cells significantly affects their response to magnetic excitation. *Physical Review E,*85:041915, 2012.
20. Young, J.M., Choy, J.S,. Kassab, G.S. and Lanir, Y.: Slackness between vessel and myocardium is necessary for coronary flow reserve. *Am J Physiol Heart Circ Physiol* 302:H2230-H2242, 2012.

Research activity: Organ and Tissue Mechanics

- **Tissue Viscoelasticity**

There is still no agreement in the research community on the nature of tissues' viscoelasticity and on its reliable modeling. We speculate that disagreements between previous observations stem from difficulties of separating between viscoelastic and preconditioning effects, since both are manifested by similar response features. This and related issues are studied in the tendon as a prototype for other soft tissues.
A stochastic microstructural viscoelastic theory was developed based on the collagen fibers' properties and on their gradual recruitment with stretch. We are validating this model against experimental data. In parallel we are testing a new structure-based recruitment viscoelasticity (RVE) theory which was developed in our lab and compare it, both theoretically and experimentally, with Fung quasi-linear viscoelastic (QLV) theory.

- **Microstructural 3D Constitutive Modeling of Coronary Arteries**

The mechanical properties of arteries are of essential importance in hemodynamics and blood wave propagation along the arterial tree. These properties play a pivotal role in determining the local state of micro-stress, imposed on the vessel cells, which is converted by these cells via signal transduction into biological remodeling processes, including vascular pathologies. The wall is mechanically nonlinear, anisotropic and heterogeneous, and subjected in the unloaded state to residual stress and strain. Reliable model prediction of arterial response to physiological or pathological loads could help clarify their function, and shed light on the processes leading to initiation and progression of diseases and their clinical treatment. Most constitutive models of arteries in the literature are phenomenological, relying on significant simplifications and assumptions. They cannot predict the microscopic mechanical environment of the cells and fibers which are critical for understanding the mechano-transduction and disease processes. The wall properties depend on its microstructures, i.e., the elastin and collagen fibers and the cells in the wall's two major layers, the media and the adventitia. Yet, at present there is no constitutive model which adequately reflects the arterial wall realistic 3D structure. Such a micro-structure based model can provide a most reliable representation of the vessel properties and of the dynamics of its internal architecture, and most significantly, facilitate realistic analysis of the tissue micro-mechanical environment to which the cells are exposed and to which they react biologically. A model like that could help clarify important aspects of the initiation, progression, and clinical treatment of diseases like atherosclerosis. Our **general objective** is to develop a reliable three-dimensional (3D) mechanical model of the vessel wall based on its detailed heterogeneous microstructure and validate it against experimental data. The **research plan** employs advanced analytical tools drawn from finite strain non-linear

continuum mechanics, in conjunction with detailed micro-morphometry of the two arterial wall layers and modern computational capability.

- **3-D Geometric Reconstruction of the Coronary Network**

The temporal and spatial distribution of coronary blood flow, pressure, and volume are determined by the branching pattern and three-dimensional (3-D) geometry of the coronary vasculature, and by the mechanics of heart wall and vascular tone. Consequently, a realistic simulation of coronary blood flow requires, as a first step, an accurate representation of the coronary vasculature in a 3-D model of the beating heart. A large-scale stochastic reconstruction of the asymmetric coronary arterial trees (right coronary artery, RCA; left anterior descending, LAD; and left circumflex, LCx) of the porcine heart has been carried out to set the stage for future hemodynamic analysis. The model spans the entire coronary arterial, capillary and venous trees. The reconstructed RCA, LAD and LCx arterial trees and the corresponding venous trees show qualitative resemblance to native coronary networks, and their morphological statistics is being evaluated for its consistency with the measured data. The coronary model constitutes the first most extensive reconstruction of the entire coronary system which will serve as a geometric foundation for our future studies of flow in an anatomically accurate 3-D coronary vascular model.

- **The Coronary Dynamic Flow**

Ischemic heart diseases are a major cause of morbidity and mortality. Heart ischemia is caused by insufficient coronary blood supply. In spite of many years of intensive research efforts, the coronary circulation is not well understood. Three daunting dilemmas are subjects of long ongoing controversies in the research community: I) What is the nature of the dynamic vessel/myocardium interaction in the beating heart; II) Why is ischemia's onset transmurally heterogeneous, the subendocardium being more vulnerable than other myocardial layers, in spite of the fact that atherosclerotic stenosis (the major cause of coronary ischemia) afflicts solely epicardial arteries while intra-myocardial arteries (such as the subendocardial ones) are athero- protected; III) How reliable are stenosis severity indices currently used prior to catheterization procedures in predicting the flow improvement following treatment of the stenosis.

We are exploring these and related issues by means of large scale dynamic flow analysis of the coronary circulation which relies on realistic morphometry-based network anatomy, on detailed micro-mechanical fluid/structure analysis of the vessel/myocardium interaction, and on extensive sensitivity analysis by means of parametric investigation.

- **Regulation of the Coronary Flow**

The coronary circulation is regulated by a number of mechanisms responsible for the capacity of the network to respond to higher metabolic demand. This capacity is severely compromised in vascular pathologies such as hypertension and atherosclerosis. Despite significant progress, and due to experimental difficulties associated with confounding factors that cannot be separated, important clinical and research questions are not well understood. Our general objective is to develop and experimentally validate a theoretical platform for analyzing and predicting the effects of coronary tone regulating mechanisms and their interactions with other flow determinants. The long term impact of the research will be to establish an essential knowledge-base needed to understand coronary patho-physiological function. The research plan uses integrated bioengineering approach consisting of theoretical modeling and animal experiments.

Lotan Noah Ph.D.

Professor Emeritus

EDUCATION / TRAINING

1957 Chemical Engineer, Polytechnic Institute, Bucharest, Romania
1966 Ph.D. (with Distinction), Weizmann Institute of Science, Rehovot, Israel
1966-69 Postdoctoral Associate, Chemistry Dept., Cornell Univ., Ithaca, NY, USA

ACADEMIC APPOINTMENTS

1969-73 : Research Associate, Weizmann Institute of Science, Rehovot, Israel
1973-75 : Senior Scientist, Weizmann Institute of Science, Rehovot, Israel
1975-79 : Senior Scientist, Biochem.Eng.Group, Miles-Yeda Co., Rehovot, Israel
1979 : Senior Research Fellow (sabbatical), Israel Aircraft Ind., Lod, Israel
1979-80 : Senior Research Associate, Technion - Israel Inst.Technol., Haifa, Israel
1980-89 : Associate Professor, Technion - Israel Inst. Technol., Haifa, Israel
1989-03 : Professor, Technion - Israel Inst. Technol., Haifa, Israel
1994-95 : Visiting Scientist (sabbatical), Chem.Eng.Dept., MIT, Cambridge,MA, USA
1998-99 : Visiting Scientist (sabbatical), Chem.Eng.Dept., MIT, Cambridge,MA, USA
1995-03: Visiting Scientist , Chem.Eng.Dept., MIT, Cambridge,MA, USA
2003- : Professor Emeritus, Technion – Israel Institute of Technology, Haifa, Israel

HONORS, AWARDS AND FELLOWSHIPS

- Weizmann Fellowship for Postdoctoral Studies at Cornell University, Ithaca, N.U., U.S.A. (1966).
- Mif'al Hapais Award for Ph.D. Distinction, Weizmann Institute of Science, Rehovot, Israel (1966),
- Fulbright Fellowship of the U.S. Dept. of State, at Cornell University, Ithaca, NY, U.S.A. (1966-1969).
- NATO Fellowship at the Advanced Study Inst. on Reactive Polymers, Forges-les-Eaux, France (1975).
- Fellowship of the Centre National de Recherche Scientifique (CNRS), at Univ. Rouen, France (1976).
- NATO Fellowship at the Advanced Study Institute on Biopolymers, Izmir, Turkey (1984).
- Fellowship of the Enzyme Engineering Society, at the 9-th International Conf. on Enzyme Engineering, Santa Barbara, CA, U.S.A. (1987).
- Fellowship of the Ministry of Sciences, Lower Saxony, Germany, at the Israel - W. Germany Conference on "Frontiers in Biology, Chemistry and Physics", Braunschweig, Germany (1988).
- Lee Silver Friedman Award for Excellence, Technion-Israel Inst. Technol., Haifa, Israel (1991).
- Roy J. Matas/Winnipeg Chair in Biomedical Engineering, Technion-Israel Inst. Technol., Haifa, Israel(1999).

Membership, USA Federal Government Advisory Committee

Member, Special Emphasis Panel, Biomimetics and Tissue Engineering for the Restoration of Orofacial Tissues, Nat. Inst. of Dental and Craniofacial Research, NIH, Bethesda, MD, USA (1999).

Representative Recent Publications (Authored Books , Invited Chapters, Reviewed Articles, Patents**)**

- T.Gold, R.Azhari & **N.Lotan**: "Enzyme-promoted degradation of polymeric matrices for controlled drug delivery". In : *Degradation of Implant Materials*, N.Eliaz, Ed., Ch.8, pp.173-194, Springer (2012)
- O.Filo & **N.Lotan**: *" Information Processing by Biochemical Systems : Neural Network-Type Configurations"* , Wiley, USA (ISBN : 978-0-470-50094-1) (2010)
- M.Alagem, S.Sivan, M.Flugelman, R.Beyar, U.Dinnar & **N.Lotan**: "Targeted delivery at stent surface of in-situ produced drugs", Cardiovascular Revascularization, Geneva, Switzerland (2010)
- A.Rakovsky, D.Marbach, **N.Lotan** & Y.Lanir : "Poly(ethelene glycol)-based hydrogels as cartilage substitutes", J. Applied Ploymer Sci., 112, 390-401 (2009)

- D.Edwards, G. Caponetti, J. Hrkach, N. Lotan, J. Hanes, R. Langer, A. Ben-Jebria: "Porous particles comprising excipients for deep lung delivery". Mass. Inst. of Technology - MIT. US Patent 7,435,408 (2008)

Fields of Research

Physiology-Controlled Drug Delivery Systems: Most of available systems deliver drugs at a constant rate. This program considers the novel class of variable-rate devices, controlled by the physiological status of the disease and operating under the rules of biochemical logic (e.g., for treatment of diabetic patients).

Drug Targeting to Metastatic Cells: Theranostic modalities which combine diagnostic and therapeutic capabilities are assembled as macromolecular constructs, performing in an autonomous manner. They contain specific prodrug-activating enzymes, as well as guiding elements homing at metastatic cells.

Biosensors: These are hybrid devices that are critically required in the medical field (point-of-care diagnostics, therapy monitoring), as well as in biodefense applications (detection of anthrax). They are intended to perform autonomously and in real time. The activities carried out address particularly self-supporting devices.

Tissue Engineering: The production of substitute human organs and tissues is here addressed. The research program is particularly concerned with the development of scaffolding materials that provide temporary mechanical support to growing elements, and also release growth factors, each according to a predetermined schedule.

Biocompatible Metallic Implants: Some implants (e.g., vascular stents) are made of metallic alloys. This program addresses procedures for improving the biocompatibility of these implants by chemical modification, using particularly surface-immobilized enzymes which locally produce the required drugs.

Molecular Engineering: The program addresses procedures for the computer-assisted design of molecules and biomolecules, intended to perform a predetermined function. This activity relies on fundamental principles of thermodynamics and of biological recognition, as well as on molecular mechanics, molecular dynamics and molecular modeling.

Nanotechnology for Biomedical Applications: Nanotechnology is here applied towards developing sub-micron size particulate materials, intended for use as enzyme carriers, or for controlled release of bioactive molecules (drugs, growth factors, pest control materials).

Metabolic Support Systems: The modalities considered are aimed at supplementing impaired vital functions, by using extracorporeal or fully implanted blood-contacting bioreactors. These are active elements promoting specific enzymic reactions, and are particularly intended for use by patients with liver failure, or by dialysis patients treated for chronic kidney failure.

Maroudas Alice Ph.D.

Professor emeritus

DOB: 8.5.1933
Phone: 972-4-8294118, Fax: 972-4-8294599
Email: alice.maroudas@gmail.com
URL: http://www.bm.technion.ac.il/~alice

Education:

Date	Institute	Degree	Area of specialization
1961	University of London	D.I.C, Ph.D	Chemical Engineering
1951-1955	University of Witwatersrand, Johannesburg, South Africa.	B.Sc.	Chemical Engineering

Employment:

Date	Institute	Title	Research area
2001 - present	Dept. of Biomedical Engineering, Technion	Professor Emeritus	Studies of Connective Tissue and Joint Disease.
1982-2001	Dept. of Biomedical Engineering, Technion	Full Professor	Studies of Connective Tissue and Joint Disease.
1981-1982	Weizmann Institute, Rehovot	Visiting Scientist	
1976-1981	Biomechanics Unit, Imperial College.	Consultant	
1976-1981	The London Hospital Medical College.	Rheumatism Council Senior Lecturer	Bone & Joint Research
1970-1976	Mechanical Engineering Department, Imperial College.	Lecturer in Biomechanics	Physical Biochemistry of connective tissues
1966-1970	Department of Mechanical Engineering, Imperial College, London.	Research Fellow	

Selected Honors and Awards

2009: OARSI's, Lifetime Achievement Award.

2007: Elizabeth Winston Lanier Award Winner, Kappa Delta.

2001: Honorary Fellowship of the Israel Orthopaedic Society.
2000: Fellowship of the American Institute for Medical and Biological Engineering.
1999: OARSI International Award for Research in Cartilage and Arthritis.
1991: Lee Silver Friedman Award in Biomedical Engineering.
1988: Carol Nachman Prize for Research in Rheumatology.
1982: Pearl Milch Chair in Biomedical Engineering Sciences, Department of Biomedical Engineering, Technion.

Research interests

Biophysical Chemistry of Connective Tissues with special reference to cartilage and the intervertebral disc; Relations between functional properties and structure; Fluid and solute transport and equilibria in joint tissues; Biomechanics of cartilage and disc; Nutrition and Metabolism of cartilage and intervertebral disc; Aetiology of Osteoarthritis and low-back pain.

Selected Publications

- Sivan, S., Merkher, Y., Wachtel, E., Urban, JPG, Lazary, A., Maroudas, A. A needle micro-osmometer for determination of glycosaminoglycan concentration in excised nucleus pulposus tissue. ***Eur Spine J*** 2013. In Press.
- Sivan, S., Merkher, Y., Wachtel, E., Van El, B., Zuurmund, AM., Schmeltzer, C., Heinz, A., Varga, PP., Lazary, A., Brayda, M., Maroudas, A. 'Longevity of Elastin in Human Intervertebral Disc as Probed by the Racemization of Aspartic Acid'. ***Biochim Biophys Acta*** 1820(10):1671-7. 2012.
- Sivan, S., Schroeder, A., Rahamim, E., Diminsky, D., Priev, A., Yosef, A., Maroudas, A., Halperin, G., Nitzan, D., Barbur, A., Etsion, I., Barenholz, Y. 'Liposomes Act as Effective Biolubricants for Friction Reduction in Human Synovial Joints'. ***Langmuir*** 26(2):1107-16, 2010.
- Sivan, S., Wachtel, E., Tsitron, E., Sakkee, AN., van-der Ham, F., DeGroot, J.,Maroudas, A. Collagen Turnover in Healthy and Pathological Human Intervertebral Disc as Determined by the Racemization of Aspartic Acid. ***J Biol Chem*** 283(14):8796-801, 2008.
- Schroeder, Y., Sivan, S., Wilson, W., Huyghe, JM., Merkher, Y., Maroudas, A., Baaijens, FPT. Are Disc Pressure, Stress and Osmolarity Affected by Intra- and Extrafibrillar Fluid Exchange? ***J Orthop Res*** 25(10):1317-43, 2007.
- Johnson, WEB., Sivan, S., Wright, KT., Eisenstein, S.M., Maroudas, A., and Roberts, S., Human Intervertebral Disc Cells Promote Nerve Growth Over Substrata of Human Intervertebral Disc Aggrecan. ***Spine*** 3*1*(11):1187-93, 2006.
- Sivan, S., Wachtel, E., Merkher, Y., Maroudas, A. 'Correlation of Swelling Pressure and Intra-Fibrillar Water in Young and Aged Annuli of Human Intervertebral Discs'. ***J Orthop Res*** *24*(6):1292-8, 2006.
- Sivan, S., Tsitron, E., Wachtel, E., Roughley, P., Sakkee, AN., van-der Ham, F., DeGroot, J., Roberts, S., and Maroudas, A. Aggrecan Turnover in Human Intervertebral Disc as Determined by the Racemization of Aspartic Acid', ***J Biol Chem*** 281(19):13009-14, 2006.
- Merkher, Y., Sivan, S., Etsion, I., Maroudas, A., Halperin, G., and Yosef, A. A Rational Human Joint Friction Test using a Human Cartilage-on-Cartilage Arrangement. ***Tribology Letters*** 1-8, 2006.
- Sivan, S., Neidlinger-Wilke, C., Wurz, K., Maroudas, A., Urban, JPG. 'Diurnal Fluid Expression and Activity in Intervertebral Disc Cells. ***Biorheology*** 43(3-4):283-291,2006.
- Sivan, S., Tsitron, E., Wachtel, E., Roughley, P., Sakkee, N., van der Ham, F., DeGroot, J., Merkher, Y., Maroudas. A. Age-related Accumulation of Pentosidine in Aggrecan and Collagen from Human Intervertebral Disc. ***Biochem J*** 398(1):29-35, 2006.
- Barta E, Maroudas A. A theoretical study of the distribution of insulin-like growth factor in human articular cartilage, ***J. Theoretical biology*** 241 (3): 628-638, 2006.
- Wilke CN, Urban JPG, Roberts S, Maroudas A, Sivan S, Kletsas D, Videman T, Huyghe J. (Wilke, A.J. Ed.). Why Do Intervertebral Discs Degenerate? Presentation of the European Research Project EURODISC. (June 2006) Ergomechanics2 (English Version); Shaker- Verlag, Heidelberg ISBN 978-3-8322-5141-3. pp. 124-137.

7. The Faculty Plans

1. **To increase the number of admissions to our undergraduate program to 110 students per year,** including approximately 20 students to the joint BME-Medicine program and 10 students in the joint BME-Physics program, in response to increased student demand, as described in chapter 13.2. Approximately 300 candidates visited the Faculty on the recent "open day" at the Technion (31/1/2013).

   Currently, the number of Faculty graduates constitutes only about 2.2% of the Technion graduate populations, which is relatively low. However, the demand is expected to significantly grow: about 10% of the hi-tech exports are in the field of Biomedical Engineering, 25% of the hi-tech investments in Israel are in the field of Biomedical Engineering, and about 40-50% of the startups in Israel are in the field of Biomedical Engineering.

2. **<u>To recruit new core faculty members to reach a total number to 20 members (15 by 2015)</u>**

   Hiring new faculty member will take the newly developed areas of scientific research into consideration, with the increasing emphasis on life sciences, in accordance with global trends, in general, and the Technion's decision to promote life sciences research in particular.

   Additional core members focusing on the following fields which will be an asset to the Faculty:

   - Neurosciences: the sensory system, functional mapping, brain machine interfaces.
   - "Brain Engineering" – improving the diagnosis and treatment of brain-related diseases, e.g., monitoring and treatment of ischemia, microanalysis, deep brain stimulation, functional neural stimulation
   - Bioenergetics, mitochondrial functions, microcirculation.
   - Biomechanics - kinetics, structures and materials.
   - Numerical modeling of physiological systems.
   - Molecular bioengineering, molecular motors, DNA function and structure, molecular and cellular biophysics
   - System biology, computational biology.
   - Bioinformatics and computational biology
   - Molecular information processing, molecular complexity theory
   - Cardiovascular system, vascular system, autonomous system
   - Cancer cell characteristics, cell mechanics, therapeutic approaches

- Biodevices, nanotechnology, Lab on Chip (diagnostic),
- BioNEMS = Biomedical Nano-Electro-Mechanical-Systems.
- Control and complexity in biological networks (e.g. feedback between tissue mechanics and genetic expression).
- Medical Imaging
- Regenerative tissue engineering,

- One of our staff members retired (Dan Adam) and two will retire in the near future (Joseph Mizrahi (10/2013) and Moshe Gur (10/2014)). The Faculty is pursuing preservation of strength in their fields of expertise: Bioelectricity, Medical Imaging, Biomechanics (the skeletal system dynamics, Biodynamic), and Neuroscience and visual perception.

- We aim to provide high-level teaching for our undergraduate program. The current student-to-core faculty member ratio at the Technion is about 22:1. In order to provide high quality teaching and tutoring to the Faculty's 440 undergraduate students, we must increase our core faculty members to at least 20 members. In addition we are planning to expand our program to include at least 220 graduate students, a rise from the current 158 graduate students.

- A new faculty member, Assistant Prof. Yael Yaniv, will join the Faculty in October 2013. Her main research activities are in the fields of bioelectricity and bioenergetics.
- An additional faculty member has already been approved by the Faculty Preparatory Committee and we are awaiting letters from referees. This additional candidate specializes in Fluid Mechanics and Nanotechnology.
- During the next academic year, we plan to recruit at least two addition new faculty members.

3. **To recruit lab engineers for all research labs** Each research lab that applies in-vitro "wet" biological and in-vivo experiments should have a research assistant or engineer. Most of the research labs in the life science fields at Technion have a Technion-funded employee serving as a technician or lab engineer. Currently only 4 of the 13 labs in our Faculty have a research assistant whose salary is only partially supported by the Technion (50% position for each lab, Appendix A). While the technician:faculty

member ratio should be close to 1:1 to reach the full potential of the research labs, it currently stands at ~0.3:1 (4:13) in the Faculty of BME.

- This factor is especially critical in light of the mode of research in Israel. Unlike most of the labs abroad, where postdocs and PhD students stand at the forefront of the laboratory research, the research in Israel and at the Technion heavily leans upon MSc students and fewer PhD students. MSc:PhD student ratio at the Technion is larger than 3:1 (2977:871 in 2005). The lack of permanent technical staff in 8 Faculty laboratories causes discontinuity in the activity of these laboratories. Since activity relies primarily on graduate students, the knowledge gained is often lost upon the graduation of the student.
- There is a high turnover rate of MSc student, as they are required to complete their studies within 2 years, whilst spending approximately one year on the thesis. Moreover, this student population is less skilled than PhD/postdoc, and is very busy with a high load of theoretical courses. A steady staff research assistant/lab engineer in each laboratory would be responsible for teaching and supporting the MSc students, maintaining the experimental setup and promoting the research goals. In the current situation, the staff researcher in labs without research assistance is forced to engage himself in many administrative and maintenance tasks which consume precious time. Technical support is extremely important for young faculty members, who have to advance their academic career and establish new labs and experimental setups.
- **The lab engineers will also promote the undergraduate program.** Heightened availability of lab engineer/research assistants will enable exposure of the ongoing activity in the labs to the undergraduate students, and will provide support for performance of projects by undergraduates in the research labs. To date, the unavailability of research staff presents the main limiting factor to initiation of a research project program during undergraduate studies. However, the Faculty views the involvement of the undergraduate students in the research lab as extremely important, as a means of enriching their practical experience, exposing them to advance research, and promoting innovation and entrepreneurship. Experimental experience and promotion of entrepreneurship are probably the two most significant advantages that a teaching institute can provide to its students. This potential should be realized, and the Faculty acts to strengthen this advantages.

4. **To improve the current undergraduate programs and to promote high quality programs** in collaboration with the Faculty of Medicine and the Faculty of Physics. The programs are described in chapter 10.
5. **To improve the social (and physical) environments of the graduate students,** as described in chapter 15.
6. **To improve the teaching facilities in the Faculty**, as described in chapter 15.
7. **To improve the research infrastructure.** While all the labs in our Faculty are experimental laboratories, there are currently no shared facilities, and no physical space for such facilities. Shared facilities decrease the overall expenses, makes the Faculty more attractive for new staff members, facilitate staff member recruitment, and obviously promote research activity. Until 1998, the research activity in the Faculty primarily focused on modeling and simulation. However, today, all the faculty members are engaged in "wet" laboratory activities in addition to theoretical investigation. This need for the shared facility in the lower floor of the building was presented to and approved by Dr. Avital Stein, the previous Executive Vice President and Director General of the Technion. Dr. Stein authorized presentation of the project for funding by donation (project cost estimated at ~$1.5M, including construction), (see also chapter 15).
8. **To reach a realistic budget** that will support the running expenses, including the expected expansion of the Faculty. The budget is detailed in chapter 16.

Remark:

Prof. Adam ended his tenure as Dean of the Faculty on October 1st 2012 after which Prof Landesberg was elected the new Dean. The new dean established four new committees within the Faculty, in addition to the undergraduate and the graduate committees: (1) Infrastructure and resources, (2) Budget and future plans, (3) Promotion of programs, and (4) Industrial and clinical affiliates programs. Each committee consists of at least three staff members. Each committee has convened several times in the last three months, and has come to several significant decisions in all target areas, some of which are highlighted in this presentation. Some are currently under consideration and have not yet been finalized within the Faculty and summarizing them within the present report would be premature. These future plans that are being evaluated for approval within the Technion, are presented in this report (e.g. the changes in the undergraduate program, the changes in the joint programs with the Faculty of Medicine, the Budget).

8. Teaching at the Faculty

The undergraduate program (B.Sc.) is a four-year program and entitles its graduates to be registered in the 'National Registry of Engineering', and provides them with the qualifications to pursue higher degrees.

The program encourages the incorporation of three main features: knowledge, experience and creativity:

- **Knowledge** is provided through (a) in-depth courses in exact sciences, (b) courses in engineering disciplines that are essential for Biomedical Engineering and (c) courses in life sciences and medicine.
- **Experience** is provided by teaching numerous methods from various engineering and life sciences disciplines, and by performing dedicated lab experiments that expose the students to the various fields of Bioengineering. The Faculty has developed unique laboratory courses in the different fields of biomedical engineering for the undergraduate students, which are offered during the 3rd and 4th years of the undergraduate program. These courses aim to provide technical experience, develop technical skills, and to integrate the theoretical material that the students acquired throughout the four years in the Faculty. These laboratories were not available elsewhere and were designed from scratch.
- **Creativity and innovation** are pursued by encouraging students to participate in research labs (as an assistant or by taking the courses 334019 or 334020 "Advance Lab in Biomedical Engineering"), and by requiring them to conduct research and industrial projects during their last year of studies. Students are exposed to 'real-life' problems in their 4th year Industrial Project, usually mentored by either an experienced senior engineer from the industry or by one of the faculty members. The students are also exposed to the challenge of technical writing and data presentation, as they are required to submit reports and give presentations several times throughout their studies. Also, the students are exposed to the clinical environment, and to real-life clinical issues, while performing a Clinical Project, which is performed in one of the number of hospitals in the Haifa region. Here also, reporting and presentations are mandatory.

Three subspecialties are offered within the undergraduate curriculum: (A) Imaging and signal processing, (B) Biomechanics and biofluids, and (C) Tissue engineering and

biomaterials. The students are required to accrue 30 credit points within their subspecialty of choice.

The graduate programs (PhD, M.Sc. & M.E.) are intended to broaden and deepen the student's knowledge, as students specialize in a particular aspect of Biomedical Engineering. Graduates of other disciplines are welcome and encouraged to join these programs. The Faculty confers a Masters of Science (M.Sc.) degree in Biomedical Engineering sciences, for which a research thesis is required, as well as a Master degree in Engineering (M.E.) for which no thesis is required.
The Faculty encourages excellent students to pursue the PhD program, which prepares the student for a research career and to serve in leading technological and scientific positions in industry. Ph.D. candidates are expected to complete a research project representing an original scientific study bearing potential technological benefit.

The Faculty's well-established graduate program sharpens the student's insight and skills, as is required in order to provide effective solutions to current medical challenges. The high quality of the basic and applied research program contributes significantly to the know-how of the Biomedical Engineering sciences and of related and relevant fields of research and education. The research-oriented atmosphere also attracts clinicians to join research projects and provides them with up-to-date advances in physical sciences and technology.

Teaching and mentoring loads

- Most of our faculty members teach 3-4 courses each year, which exceeds the average teaching load at the Technion.
- Most faculty members mentor >6 graduate students. The annual productivity of the core faculty members in terms of the number of graduate students per supervisor completing research projects is at the top of the list at the Technion, and stands at 1 - 2 graduates per year.

9. The Undergraduate Program.

The undergraduate program in Biomedical Engineering was established in October 1999, as the first program in Biomedical Engineering in Israel. After four years of careful examination of the suggested curriculum and Technion commitments, a B.Sc. in Biomedical Engineering was approved by the *Israeli Council for Higher Education (MALAG)*, in 2002.

Since initiation of the program, the students applying to the program have been among the very top applicants to the Technion. Moreover, they have a high grade point averages, despite the intensity of the program, which includes courses in multidisciplinary fields (exact sciences, biology and engineering), and the strongest series of courses in mathematics throughout the engineering programs at the Technion.

The curriculum is a four-year program that incorporates:

A. **A mandatory program** (125 credit points), that includes:

- Top level courses in Exact Sciences: Mathematics and Physics.
- Essential courses in Life Sciences: Chemistry and Medicine
- Basic courses in engineering, in three main areas: Electrical Engineering, Mechanical Engineering and Chemical Engineering.
  - ❖ Basic courses in Biomedical Engineering (e.g. Basic bioelectrical design, Basic biomechanical design, Introduction to material engineering, Biological fluid mechanics, Transient phenomena in physiological system).
  - ❖ Advanced laboratory course in the various fields of Biomedical Engineering.
  - ❖ Biomedical Engineering Project (2 courses) and Clinical Engineering Project.

  The current mandatory program is depicted in **Appendix B**.

B. **An elective program** (30 credit points)

   The elective program includes advanced courses in Biomedical Engineering, in the following three main fields: (1) Tissue engineering and biomaterials, (2) Bio-mechanics and biofluids and (3) Imaging and signal processing.

C. Mandatory selection of general courses (10 credit points).

The current program (until March 2013) requires 165 credit points (125.0 mandatory credit points, 30.0 elective points and 10 points is general courses) and is the only Technion program requiring so many credit points. The average course load in other Technion engineering departments is below 160 credit points.

9.1 Tracks

In all the engineering departments at the Technion, students are required to accrue at least 30 elective course credits.

The three elective tracks in the department are:

Imaging and Biomedical Signals

Diagnostic and treatment equipment, Non-penetrating techniques, Imaging techniques, Signal processing, Image processing in medicine, Physiological control, Biomedical optics and photonics, Ultrasound in imaging and treatment, Bioelectrical phenomena.

Biomechanics and Biofluids.

Fluid Mechanics, Mechanics of posture and gait, Orthopedic biomechanics, Orthopedic implants, Rehabilitation engineering, Biomechatronics, Systems and accessories for the handicapped, Artificial limbs and neural prostheses, Heat transfer, Intracellular structure and mechanics, Rheology.

Tissue Engineering and Biomaterials

Tissue engineering, Biomaterials, Stem-cells, Biochemical engineering, Molecular engineering, Bio-sensors, Controlled release of drugs, Nano-particles.

The elective courses offered for each of the three tracks, are listed in **Appendix C**.

Core Courses. A list of the "Core Course" at our Faculty is provided below:

336020	Bioelectrical Phenomena	2.5 pt
336023	Biomedical Optics	2.5 pt
336208	Analysis of Biological Signals	2.5 pt
336325	Ultrasound in Medicine	2.5 pt
335522	Introduction to Control in Biomedical systems	3.0 pt
336021	Nano-Particles in Biology, Mechanics and rheology	2.5 pt
336506	Rehabilitational Biomechanics	2.5 pt
336517	Bioengineering in Cell	2.5 pt
336518	Heat Transfer in Biological Systems	2.5 pt
336405	Engineering principles in Biology and Biotechnology	2.0 pt
336529	Tissue engineering and biological substitutes	2.5 pt

Appendix D describes the syllabi of all the courses.

Present Curriculum

- During the first and second years of study (semesters 1 - 4), students primarily participate in courses in both engineering and medical/biological sciences. These courses are taken at the relevant Technion departments, alongside students studying other disciplines, thus exploiting the highest standard of teaching and resources available. All the courses in these two years are part of the mandatory program (Appendix B and the table below).
- In the last two years of studies (years 3 and 4 /semesters 5 - 8) mandatory **Biomedical Engineering** courses are taken; these mandatory courses provide basic knowledge in the three main tracks of Biomedical Engineering.

Current Elective Courses Program

- From Semester 5, students must choose their elective courses.
- Students are required to accrue 30 credits in elective courses.
- Students must accrue **at least 13 points from the list of "core courses"**, i.e. about 5 courses from the above list.
- The additional credit points (up to 17 points) should be taken from the **list of the elective courses (Appendix C).**
- Although there are 3 tracks, the students can choose any course from the three tracks.

Recent developments

- **Learning/working loads**

  An updated program was recently submitted for approval (next page). It includes a reduction of the number of required points to 160 and an increase in number of elective points to 33.5 . (This program also includes more laboratories in BME).

- **"Core Courses" versus Tracks**

  The Faculty is considering switching from a list of "core courses" and "elective courses" to Tracks.

  1. The first tracks will be in the three main BME fields: (1) Tissue engineering and biomaterials, (2) Bio-mechanic and biofluids and (3) Imaging and signal processing.
  2. Additional tracks in physics and medicine will be available in the future.
  3. The students will be encouraged to **specialize in two of the Tracks** by taking **at least 5 courses** in each Track.

Required Courses for the Program of Studies for the **B.Sc. in Biomedical Engineering 2013-14 (160.0 pts)**

Mandatory Courses: 116.5 pts, Elective Track Courses: 33.5 pts, General Course: 10 pts.

Semester	Mathematics		Physics		Chemistry	Life Sciences		General Engineering				Elective	General Courses	Points
1	Algebra 1 Expanded 104016 5.0	Calculus 1 Expanded 104012 5.5			General Chemistry 125001 3.0			Intr. to Comp C + Lang. 234112 4.0				Direction in BME 334021 General elective 1.0	Physical Education 394800 1.0	18.5
2	Ordinary Diff. Eqs 104135 2.5	Calculus 2 Expanded 104013 5.5	Physics 1 Expanded 114071 3.5		Organic Chemistry 1B 124801 2.5	Biology 1 134058 3.0							Technical English 324012 3.0	20.0
3	Complex Func. & Integral Transf. 104221 4.0	Partial Diff. Eqs & Fourier Series 104223 4.0	Physics 2 114052 3.5	Physics Lab 1H 114032 1.0	Physical Chemis. 1B 124503 2.5	Macro. & Micro. Anatomy 274001 2.0	Introd. to Biochem. & Enzymology 134019 2.5						Physical Education 394800 1.0	20.5
4						Intro. To Biological Processes 336004 2.5	Biophysics and Neuro-physiology 336537 3.0	Electrical Engineering Expanded 044105 4.0	Motion Biomechanics 335334 4.0	Solid Mechanics 084505 3.5	Intro. To Materials Engineering 314221 2.5			19.5
5						Physiology of the Body Systems for Engineers 276011 3.0	From Cells To Tissues 336022 2.5	Signals And Systems 044130 4.0	Basic Bio-Electric Design 334011 3.0	Biological Fluid Mechanics 334009 3.0		Meeting the Biomedical Industry 334331 General elective 1.0		15.5
6			Fund of Biomd Optics & Photonics 336533 3.0					Basic Bio-Mechanical Design 334010 3.0	Transport Phenomena in Physiol. systems 337403 3.0	Laboratory In Biomed Eng. 1 335001 2.0	Clinical Eng. Project 334016 1.5	Elective		12.5
7										Laboratory In Biomed. Eng. 2 335002 2.0	BME Project 1 334014 3.0	Elective		5.0
8										Laboratory In Biomed. Eng. 3 335003 2.0	BME Project 2 334015 3.0	Elective		5.0
Total	26.5		11.0		8.0	18.5		47.5					5.0	116.5

9.2 Labs and Projects

BME Projects (4 Pts). During the final year of study, students are required to undertake a year-long project, carried out in collaboration with the industry. The project provides the students with the opportunity to directly apply their skills through the creation of an innovative product. Aside from providing the student with real-life experience in the process of product development, students benefit from the possibility of providing a truly marketable invention (One startup company has already emerged from this project).

The Clinical Project. A one-semester-long internship at hospitals that are affiliated with the Faculty of Medicine, provides students with firsthand experience in application of engineering knowledge in the medical field, ranging from data processing to patient handling, to discovering the needs for new technologies and providing solutions.
Starting in March 2013, the clinical project will be performed before the BME project, so that ideas raised by the physicians or the students may be carried over to the above BME project, promoting innovations and strengthening interactions between the Faculty of Medicine and the Faculty of Biomedical Engineering.

Laboratory Courses in BME

To increase exposure of the undergraduate students to hand-on procedures in the field, a major change in lab courses was recently approved (**from Spring 2013**). Two additional lab courses were added, and the four new labs will replace the presently offered two labs.
This will allow one basic laboratory in methods and then three elective laboratories, one in each of the three main BME fields: (1) Tissue engineering and Biomaterials, (2) Bio-mechanic and biofluids, and (3) Imaging and signal processing. The students will be required to choose two out of these three labs. The labs will provide extensive experience in various procedures and techniques in each of the fields.

The table below presents a list of the experiments performed in the four laboratory courses:

335001 - **Laboratory in BME 1**
Methods and basic equipment

1 Error calculation
2 Microscopy and spectrophotometry
3 Data acquisition principles
4 Electrical measurements 1
5 Electrical measurements 2
6 Analog Amplifiers
7 Digital systems

Laboratory in Biomedical Engineering 2, 3 and 4 are in the following fields:

	Biomechanics and flow	**signals and imaging**	**tissue and biomaterials**
1	Tensile and bucking of materials	Acquisition and processing of medical signals	Scaffolds in tissue engineering
2	System with one degree of freedom	Ultrasound imaging of anatomy and flow	Electrophoresis and protein analysis
3	In vitro model of pulsatile flow	Medical imaging	Histology
4	Motion analysis	Tissue optical imaging	Immune staining for cell and tissue characterization
5	Mechanical properties of tissue	Brain computer interphase	Methods in molecular biology
6	Biomedical control	Implementing CT using ultrasonic waves	Slow release of molecules from nanoparticles
7	Microcirculation	Biomedical control	

10. Excellent Undergraduate Programs

Dual degree: Physics-Biomedical Engineering

This program is designated for a limited number of excelling students who wish to enhance their biomedical engineering education with a more thorough scientific understanding of physics.

These students, by completing a combined study program, earn both a BSc in Physics and a BSc in BME. The students in the program must acquire 182.5 points (142.5 points in mandatory courses, 30.0 in elective courses and 10.0 points in general courses).

Trio degree: Medicine -Biomedical Engineering (BA in Life Sciences, BSc in Biomedical Engineering and Medical-Doctor)

The Faculty of Medicine and the Faculty of Biomedical Engineering have established an integrated program for excelling students who were accepted to the School of Medicine. The program is designated for a limited number of students. The duration of studies is eight academic years.

The program aims to educate leading scientists\researchers and physicians and equip them with critical skills in both Biomedical Engineering and Medicine, required for research and development leader in the expanding Life-Sciences and technology disciplines, in the academy and industry.

In the first four years of study, the students accrue 191.5 points (26 points above the required course load in the undergraduate BME program) that include all the courses required by the Faculty of BME and the two first years of course requirements at the Faculty of Medicine. Thereafter, the students join the Faculty of Medicine and continue four years of clinical studies, with students in the Faculty of Medicine.

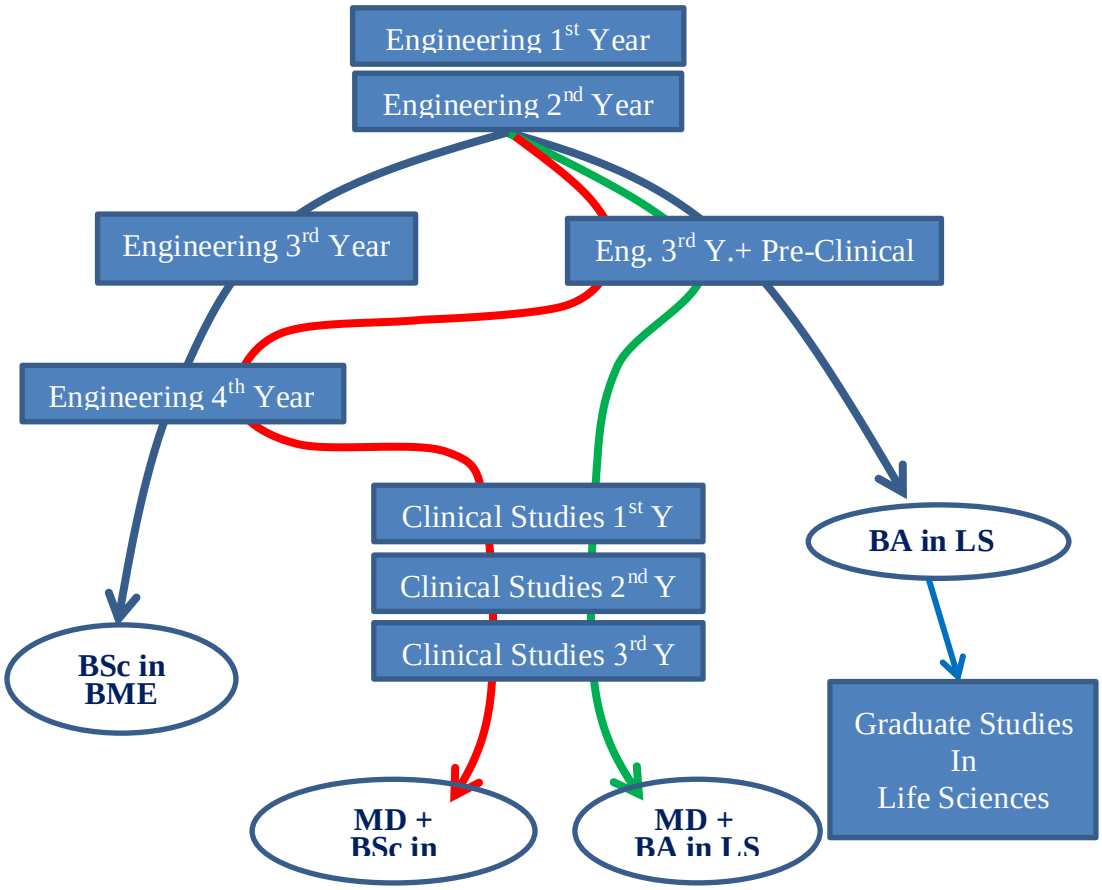
Recent decisions and development:

- **The course load in the first four years of study was significantly reduced**, from 191.5 to 172 (only 12 above the required for BSc in BME).
- **The length of the clinical studies** program was shortened by half a year to 3.5 years.
- All the **required preclinical courses**, from the first two years of course work in the School of Medicine, will be studied within the first three years of the integrated program (not within four years, as is the current setup)

- The fourth year of studies will only include courses from the Faculty of Biomedical Engineering, mainly elective courses, laboratories and projects.
- A student who wishes to leave the BME program and to complete the requirement for an MD dissertation within 7 years will be able to continue to the clinical studies after completing the third year of the Trio-degree program. Such students will receive BA in Life Sciences (and not a B.Sc in Biomedical Engineering).
- Excelling students who were not accepted to the School of Medicine but who have high scores ("SECHEM" above 90) will be also able to begin this Trio-degree program in the Faculty of Biomedical Engineering. After the second year, and after learning the Life-Science courses together with students from the Faculty of Medicine, they will able to apply (again) to the Faculty of Medicine. They will be accepted to the School of Medicine based on their academic achievements in the first two years at the Technion.

All the above resolutions were approved by the councils of the Faculty of BME and the Faculty of Medicine.

The two Faculties are working on a new and shorter program that is schematically presented in the figure below:



11. Graduate Programs

The Faculty's graduate program is open to graduates of all engineering departments, as well as to graduates of Exact Sciences, Life Sciences as well as to physicians. The Faculty takes pride in the continuously growing number and quality of students in its graduate program.
Current admittance into the program calls for a grade point average of 83 as the minimal acceptance level.

The majority of students is enrolled in full-time programs and receives a graduate school fellowship. The Faculty, through the staff members is committed to provide about 30% of the fellowship. The Faculty budget provides an additional teaching assistantship for teaching (tutorials) in our Faculty. Currently there are 136 graduate students in the Faculty that will receive their degree from the Faculty.
In addition, 22 graduate students currently perform their research activity under the supervision of our faculty members and use the laboratories and facilities of the Faculty of Biomedical Engineering, but are formally registered in other programs, such as Nanotechnology (n=11), Biotechnology (n=9) and Autonomous Systems (n=1) along with one PhD student in Life Sciences in the Faculty of Medicine.
Students entering our graduate program from other Faculties are required to take a number of complementary pre-requisite courses as preparation for the graduate curriculum. All engineering students are required to take four pre-requisite Life Sciences courses (11 points). Students from the Exact Sciences and Life Sciences are required to take an individually tailored complementary program (6 to 13 courses, 15 to 30 Pts) in Engineering and Basic sciences.

The staff members of the Faculty currently supervise a total number of 101 graduate students in the thesis tracks (MSc and PhD).
During the course of the graduate program, each student must complete a research project under the supervision of a member of the Faculty.
The table below presents some strengths of our Faculty. The table is based on data from the years 2001-2005, but we are of the impression that the trends have been preserved. The strength of the Faculty can be summarized as follow:

- We have a relatively large number of graduate students per faculty member, a ratio of more than 6:1 (The graduate school recommends no more than 6)!
- The productivity of the Faculty of Biomedical Engineering is very high. Although the supervisor:student ratio is high (more students per supervisor) and the duration of the studies is as in other faculties, the number of graduated students per faculty member per year stands at the top of all the Technion's faculties. Each year, about 1.44 students

graduate from each research lab, while the average at the Technion is about 0.86 . For example, Prof. Dan Adam has recently retired, after teaching in the Faculty for about 26 years (1986 - 2012); 55 MSc and PhD were graduated under his supervision, more than 2 per year.

Faculty	**No. Staff Members**	**# graduates within 5 years**	**Average per Staff Member / year**
Mathematics	51	72	0.28
Aerospace Engineering	27	60	0.44
Physics	42	133	0.63
Material Science & Engineering	17	64	0.75
Mechanical Engineering	35	148	0.85
Computer Science	51	218	0.85
Civil and Environmental Eng.	62	275	0.89
Chemical Engineering	18	80	0.89
Chemistry	27	129	0.96
Biotechnology and Food Eng.	14	71	1.01
Biology	22	116	1.05
Electrical Engineering	49	268	1.09
Industrial Eng. & Management	50	294	1.18
Architecture and Town Planning	32	210	1.31
Biomedical Engineering	**11**	**79**	**1.44**
Total (mean)	**508**	**2217**	**(0.87)**
BME in %	**2.2**	**3.6**	

11.2 Technion's ME Program in Tel Aviv

Our program of Masters in Engineering in Tel Aviv was initiated 7 years ago. We see this program as a service to the community; means of spreading Biomedical Engineering know-how to seasoned professionals, thereby strengthening the growing biomedical industry.

The program was especially designed for graduates of engineering faculties from universities all over Israel. In addition to engineering graduates, the program also admits graduates of Life Sciences, Physics and Mathematics, provided they complete some basic engineering courses, such as linear systems, electrical circuits, etc.

The 5th class is about to graduate, the 6th began in October 2012, and the 7th will begin the program in October 2013. About 25 students enroll in the program each year.

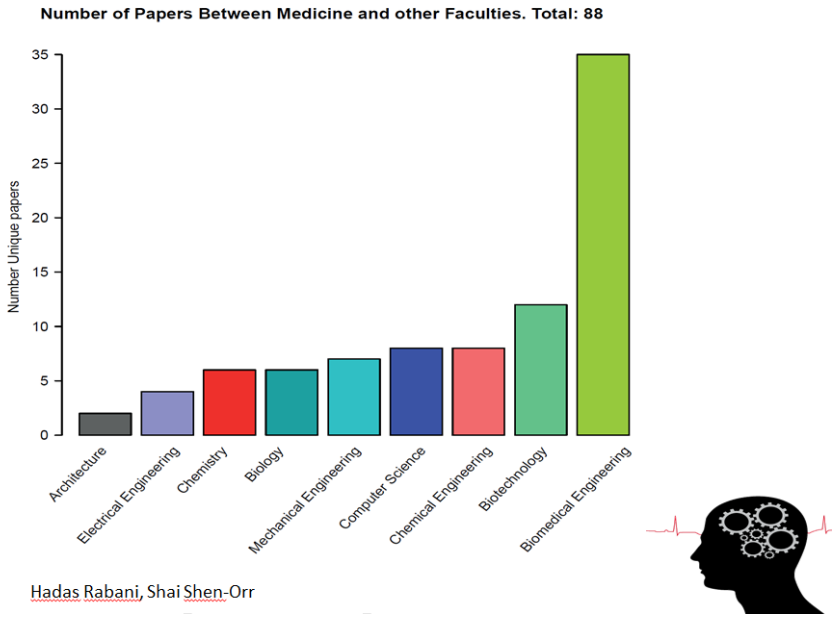
The ME course load is spread out over 5 semesters, delivered in 8 hour weekly sessions. This arrangement is very convenient for students who work full-time and have families. It is conveniently located near a train station thereby accessible to people from all over the country, including students from Beer Sheba, Jerusalem and Haifa.

12. Interactions with Other Faculties

The Faculty is seeking to promote interactions and collaborations with all Technion faculties, ranging from Engineering, Exact sciences and Life sciences. The Faculty also encourages and is actively pursuing tightening collaborations in the various teaching and learning programs.

The Faculty benefits from strong interaction with the Faculty of Medicine, which has performed the largest number of joint projects and research activities (35 joint researches, based on the presentation of the Dean of the Faculty of Medicine, below) with our Faculty. The close relations and the interaction with the Faculty of Medicine have generated a substantial number of joint research projects and joint supervision of graduate students.

Interactions also exist with most academic departments at the Technion, including Biology, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Aerospace Engineering, Material Sciences and Engineering, and others. The fact that faculty members from these departments hold a secondary affiliation appointment in our Faculty fosters joint research and supervision of graduate students.



13. Industrial & Clinical Affiliate Programs

13.1 General description

The Technion's Biomedical Engineering Industrial & Clinical Affiliates Program was launched in October 2012. The program serves as a bridge for the exchange of ideas and knowledge and as a framework for a long term relationship and collaboration between the Faculty and leading industrial companies in the field of Biomedical Engineering, clinical institutions and the Faculty's alumni. The program goal is to provide win-win solutions for the short and long term needs and to pave the way for consolidation of strategic ties, focusing on securing the best outcomes for our graduates, the Technion and the Faculty of Biomedical Engineering.

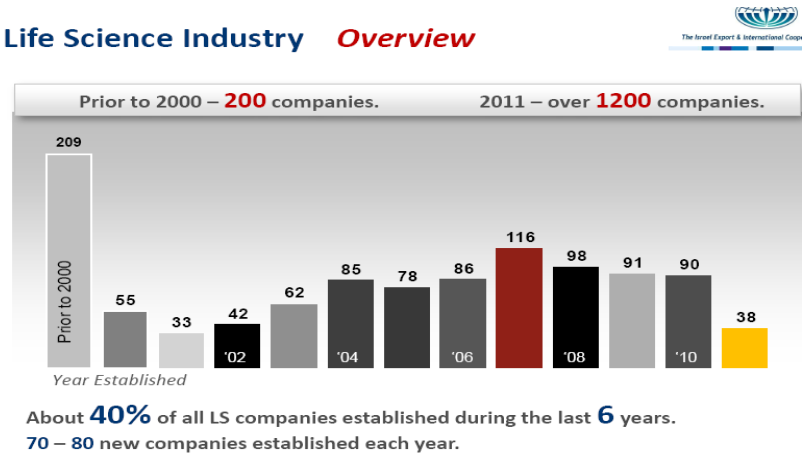
The program seeks to maintain the Faculty's status, as comprehensively reviewed by the Faculty's students and alumni and the biomedical industry, with respect to the following issues:

1. The Technion's Biomedical Engineering is Israel's leading academic Biomedical Engineering establishment and training institute of the next generation of biomedical engineers. The Faculty trains highly skilled students with a multidisciplinary as well as innovative and entrepreneurial approach; equipped with the potential of staffing leading position in the industry.
2. A gathering of the best and brightest engaged in cutting-edge research and technology of the leading fields of Biomedical Engineering
3. A vast platform and a lead to excellent human resources and influence of new developments and research directions
4. A platform enabling the industry to gain updated knowledge and state of the art research which can enrich the leading research and development teams in Israel and support the "startup Nation".

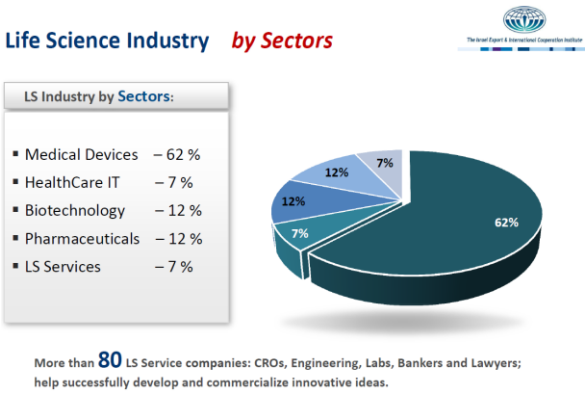
The Faculty will establish a new network to include all Faculty alumni and all the individuals currently pursuing Biomedical Engineering. This network will offer a vast variety of shared activities for the industry and the academy in the fields of research and development, education and teaching, human resources, employments and public relations. Through the program, industrial companies, of all sizes, will implement a range of activities to expose the various levels of their company's activities.

13.2 The Biomedical Industry in Israel

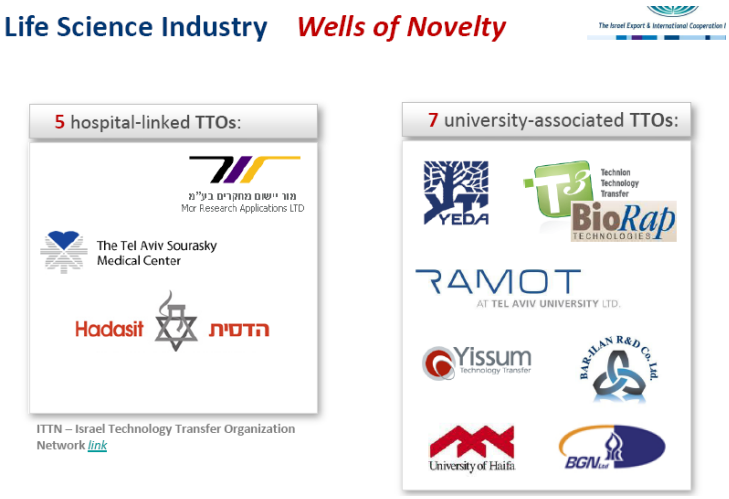
- Israel ranks **fourth** in the world in the per capita number of registered patents and **first in medical device patents per capita**.
- The biomedical segment leads the field of Life Science industry and is considered its growth engine. In 2010, the total Israeli exports reached a total of $1.8 billion; in the field of medical devices, exports had grown by 10% growth, in comparison to the previous year.
- An estimated 70 - 80 new life science startups emerge each year. The number of Israeli Life Science companies grew from 186 in 1996 to over 1000 in 2008, an increase of almost 600%. More than 1/3 of these companies now generate revenues.



- 40% of the total number of Israel's Life Science companies were established in the last 6 years.
- There are more than 20 incubators in the field of Biomedical Engineering, with an average 15 companies per incubator.
- Life science companies in Israel can be categorized as: 62% Medical Devices, 12% Biotechnology, 12% Pharmaceutical, 7% HealthCare IT, 7% Life-science services and regulation .



- Both the number and activities of hospital- and university–linked technology transfer organizations, summarized in the figure below, demonstrate the expanse of the novel technologies generated in these institutes.



13.3 Goals

- To increase the Faculty visibility to the industry: exposure of the excellent human resources available in the Faculty, including students, at all levels, and staff.
- To position the Faculty as a suitable partner for the industry for long-term relationships in various fields
- To pave a fast track for graduate students to the industry
- To strengthen the importance of our "Industrial Project" course in the eyes of both students and industry.
- To maintain long-term relationships with the Faculty alumni.

13.4 Strengths and Challenges

Faculty strengths:

1. A **research** institute engaged in dealing with the state-of-the-art Biomedical Engineering tracks
2. Leading research projects exploiting dealing with cutting-edge Bioengineering **technologies.**
3. A diverse teaching program enabling **multidisciplinary and independent studies.**
4. Brilliant students, among the top applicants to the Technion.
5. High graduate student enrollment rates; the highest graduate students to staff ration within the faculties of engineering.
6. Advanced labs with state-of-art equipment.

Faculty opportunities:

1. Multiple hi-tech companies in the Haifa region (e.g. GE, Philips, Mediguide)
2. Establishment of the Bio-Science Park in Haifa, a novel center dedicated to promotion of Life Science technologies.
3. Potential collaborations with strong engineering Faculties.
4. Collaboration with strong faculties in Exact Sciences and Life Sciences, the Faculty of Medicine and the affiliated hospitals.

Challenges:

1. The BSc degree in Biomedical Engineering is relatively new in Israel (since 2004). The industry is led by professionals who are not familiar with the BME program.
2. The current BSc program is heavily loaded (165 points) and limits specific tracks and elective courses. Changes are being made to rectify these points in the current program, as described above.

13.5 Plan of operations to strengthen Faculty visibility.

1. Annual conference of the Israeli Society for Medical and Biological Engineering (ISMBE)- led by both the Society and the Faculty, calling for participation of leading physicians and R&D executives.
2. Participation of the industry in the Faculty "project presentations day", held once a year, in which students present the final results of their "Industrial project", designed to tackle issues at the forefront of research.
3. Increase company visibility within the Faculty by holding dedicated events during which each company presents its R&D activities
4. Establishment of a specialized program to link Faculty alumni with Faculty students.
5. Host company-specific recruitment events, within the faculty.
6. Organize tours in industry for students and graduates, to familiarize them with the local opportunities.
7. Organize technological exhibitions within the Faculty.
8. Establishment of a special ‘Faculty Council' meeting to address curriculums, research and Faculty labs. The Council will include our staff members, alumni and key opinion leaders in the field.
9. Participation in the Technion Alumni Mentors program.
10. Organization of seminars to be delivered by Faculty members.
11. Open registration to academic courses to company employees, through the Technion's official registration office (Continuation Studies).
12. Host guest lectures within the Faculty.
13. Assistance with the execution of projects in Faculty labs, through the office of the Technion's Research and Development Foundation.

14. Infrastructure

The available teaching and learning facilities:

1 Auditorium, capacity: 99 people.

2 small teaching rooms, capacities: 50 and 20 students.

2 student labs, capacities up to 40 students working simultaneously.

1 computer farm for the undergraduate students, with 30 computers.

Shared Research Facilities:

The "cold room" is the only available shared facility.

15. Needs and work in progress

I. Lab Engineers

Four labs (staff members) have a research assistant/engineer on staff. Eight labs (staff members) have no research assistant/engineer and urgently need this essential assistance.
The lack of permanent technical staff in 8 laboratories causes discontinuity in the activity of these laboratories. Since research activity currently heavily relies on graduate students, the knowledge gained is often lost with the graduation of the student.
This urgent need was described and detailed in Pages 85-86.

II. Administrative Staff

The Faculty is understaffed in all areas. The personnel and administrative staff are described in Appendix A. The administrative, technical and building maintenance staff is short of meeting the Faculty needs.
In 1979, with a Department of five tenure-track members and only a handful of graduate students, the administrative staff consisted of 4 secretarial staff and 8 technical staff members (12 positions). Today, with the addition of 7 tenure-track members and the undergraduate program we have only 10 administrative and technical positions + 3 lab engineer positions.

- There is no Dean Secretary. Consequently, the Faculty employs students to assist in the dean's office.
- The Faculty has one Computer System Manager, who isn't physically capable of serving the undergraduate and graduate students, and all the 400 users within the building, who require real-time solutions in the research labs, student labs and computer farm. Therefore the Faculty employs two computer technicians (student's wages) for assistance.
- The Faculty employs only one person who serves as the building superintendent and manager. To execute all the activities there is a dire need for a full-time assistance. The Faculty employs one house manager assistant.

  All salaries for these temporary employees, required to support the ongoing Faculty activities, **are only partially (about 20% !!!) covered** by the Faculty operating budget. The cost of hiring these temporary assistants (3 part time and 1 full time employees) sums to 204,240 NIS, while only 44,100 has been approved, and the rest is paid from the Faculty Research Funds.

III. Infrastructure

The status of the Faculty's infrastructure has been stagnant for many years except for the new labs that were developed for the recruited staff members, in 2002.

Only two facilities have been added since the establishment of the new undergraduate program in 1999: the computer farm (30 computers) and the undergraduate student lab (for up to 40 students).

A. Teaching and learning facilities

- **Study space for B.Sc. students**. There is no such space available to date for the undergraduate or graduate students. The undergraduate students are forces to seek places in other neighboring faculties in order to prepare the assignments and to discuss their studies. The current set-up impacts their ability to communicate and alienates them from the atmosphere at the Faculty and from the research labs.
- **Study space open in the evenings and weekends**, time slots when the Faculty is currently closed. Currently the Faculty is closed in the evenings and from Thursday evening to Sunday morning.
- **Expansion of student teaching labs**. The current teaching labs can only fit about 40 students at once. Only two lab courses are currently incorporated in the curriculum but the Faculty wishes to add 2 lab courses to the curriculum, to enrich student experience.
- **Addition of a lecture room**. There are currently only two rooms (for 99 and 50 students) and one small room for small study groups (up to 20 students).
- **Meeting room for staff members, employees and graduate students**. There is currently no such gathering place in the Faculty.

B. Shared Research Facilities.

Recruitment of new faculty members is difficult due to lack of infrastructure. Each new staff member is forced to buy basic lab equipment, which is shared in other Life Science faculties. There is an urgent need for a small center for Shared Facilities to house essential equipment, such as deep freezers (-86^0C), liquid nitrogen storage dewars, water purification systems, centrifuges, and autoclaves.

C. General housing and maintenance

- Addition of two floors to the building/new structure – for essential future expansion. The current Faculty building can incorporate up to four more laboratories only. Recruitment of additional staff members will require expansion of the building. A plan for addition of two more floors has been weighed. Evaluation of the building's capacity to withstand an earthquake was due to be delivered to the Faculty by 31.01.2013.
- Basic construction work has not been performed in the building for 36 years, aside from the recent replacement of the floor in some of the corridors; basic maintenance work is critical.
  - 36-year-old heating pipes, which are corroded and insufficient. Air conditioners are 36-years-old and decaying.
  - Some laboratories are furnished with 36-year-old furniture.
  - Staff offices and labs contain furniture and PVC floors that have not been renovated in 36 years
  - Safety hazards, such as bomb shelters used as storage rooms, chemical storage room near the bomb shelter, etc.

D. **Work in progress**

- Construction of a study center (work space) for undergraduate students that will be accessible in the evenings and on weekends has received the general authorization from Dr. Avital Stein, the previous Executive Vice President and Director General of the Technion, who visited the Faculty in Nov. 2012. The site will be linked to the computer farm on the first floor. A number of meetings have been held with the Coordination Committee on this topic. Construction plans have been submitted (Appendix E).

- Construction of a gathering and discussion site for staff members, employees and students, has also received general authorization from Dr. Stein, the previous Executive Vice President and Director General of the Technion. The site will replace the library hall, and the library space will be reduced. Staff members have held a number of meetings with the Coordination Committee on this topic. Construction plans have been submitted (Appendix E).

- A center for infrastructure equipment. The site will be established on the lowest floor, in place of the storage rooms. As per the decision of Dr. Stein, this plan will be submitted for funding by donations (Appendix E).

- Construction of a storage room for maintenance equipment near the machinery room (in place of using the bomb shelter and many other areas).
- Initiation of evaluations essential for establishing the possibility of adding two floors to the current Faculty building.

16. Budget for 2012/2013

There is a dire need to balance the running expenses of the Faculty.

- A significant portion of the running budget (**46%**, 288,650 NIS out of 625,549 NIS, in the last year) is paid from the Faculty research money.
- Most of the salaries (**78%,** 160,140 NIS out of 204,240 NIS, in this year) of the temporary assistants, that mainly serve the basic needs of the undergraduate program, as explained above in chapter 15-II, are not covered by the proposed operating budget for this year, and fall on the Faculty research money.
- Most of the computer and software expenses (**88%**, 108,992 NIS out of 123,392 NIS, in the last year, chapter 16), basic needs of the Faculty, that also serve the undergraduate program, are not covered by the proposed operating budget for this year and fall on the Faculty research money.
- Most of the maintenance expenses (furniture and insurances) (**82%,** 113,893 NIS out of 139,393 NIS, in this year (Chapter 16, Technion's code 403 and 404)), that mainly serve the basic needs of the undergraduate program, are not covered by the proposed operating budget and fall on the Faculty research money.

- The operating budget has remained the same for the more the 10 years (around $ 100 K), and was not increased, despite initiation of an undergraduate program. (In 2002, the Faculty got a single push of money, to build the student labs).
- The operating budget is mainly allocated toward the maintenance of the building and the Undergraduate program (computer assistance, student lab disposables, wear and tear of the furniture in the class rooms, etc.) The Faculty wishes to use the research funds for advancing research, supporting postdocs and research assistants and for the renewal of the equipment, and not for the basic needs of the undergraduate program.

Budget for 2012/2013

Code	Type of expenditure	Approved (NIS)	Details		Required (NIS)
102	Salaries for temporary assistants	44,100	**Huge Shortfall**		204,240
			Technical support for all the computer systems. 2 student positions. 120 hr/mo.	56,160	
			Technical support for the students' labs. 2 students. 24 h/mo.	10,080	
			Assistance in the Dean office. 1 student. 100 hr/mo.	42,000	
			Assistant the house manager	96,000	
108	Transportation	4,200			6,000
114	Short time guests	3,800			10,000
201	Consumable supplies	61,000	For the student labs. The number of laboratories will increase from 2 to 4!		73,950
203	Printing, photocopiers	20,700			36,000
204	Office expenses	11,400			11,400
205	Mail Postage	13,800			13,800
206	Telephone	44,900			44,900
207	Hospitality	8,200	Faculty events, Conferences, For years this item is in deficit.		26,000
208	Central computer services	7,800			7,800
209	Miscellaneous	66,000	Awards, Advertisement, Seminars, Public Relation – Promotion, Internet services.		82,000
301	Equipment	8,600	Printers, screens, Security Cameras		50,000
302	Computers and Software	14,400	**Huge shortfall**		123,392
			Computers and Screens (n=8/y)	34,560	
			Licensing for 280 computers + special SW as Solideworks, SAP	25,000	
			Backup services	10,523	
			Required renewal of main server + mail & web server (5 years program)	16,500	
			Switching panels, Communication, Support for 10GB	17,130	
			Addition of wireless and internet points	9,600	
			Storage facilities (Five Y program)	6,080	
			Repair of various equipment	4,000	
303	Furniture	2,500	Student Labs, Staff member offices.		14,400
403	Maintenance (pipe lines, furniture….)	14,200	**Huge shortfall**		89,000
			Repair of the drainage lines, Hot and cold water lines, Teaching rooms, Renewal of the staff offices.*		
404	Maintenance (Insurances..)	11,300	**Huge shortfall**		50,393
			Insurance for the servers, Control system for the doors, refrigerators, communication systems,		
	Total:	**336,900**			**843,275**

Appendix –A
Administrative and Technical Staff

Secretarial Staff		
Baumel Zahava	Administrator	100%
Segev Haviva	Graduate Studies Secretary	80%
Felixbrodet Smadar	Undergraduate Studies Secretary	75%

Engineers		
Anne Weill	Computer system Manager	100%
Alfassy Aharon	Electrical Engineer	100%
Lichtenstain Oscar	Students Laboratories Engineer	100%

Lab Engineers		
Ben-David Galia	Bio-Materials Laboratory Engineer	100%
Adi Guterman	Nanotechnology & Biophysics Laboratory Manager	100%
Limor Minai	Bio-Medical optics Laboratory Manager	100%

Technical Staff		
Cohen Rachel	Purchasing	100%
Revach Ronit	Librarian	30%

Building Maintenance		
Boukai Izak	Building Superintendent	100%

Appendix –B

Required Courses for the Program of Studies for the **B.Sc. in Biomedical Engineering 2012 (165.0 pts),** In addition: Track Courses: 30 pts.

Semester	Mathematics		Physics		Chemistry	Life Sciences		General Engineering				Elective	General Courses	Points
1	Algebra 1 Expanded 104016 5.0	Calculus 1 Expanded 104012 5.5			General Chemistry 125001 3.5			Intr. to Comp C + Lang. 234112 4.0				Direction in BME 334021 General elective 1.0		18.0
2	Ordinary Diff. Eqs 104135 2.5	Calculus 2 Expanded 104013 5.5	Physics 1 Expanded 114071 3.5	Physics Lab 1H 114032 1.0	Organic Chemistry 1B 124801 2.5	Biology 1 134058 3.0							Technical English 324012 3.0	21.0
3	Complex Func. & Integral Transf. 104221 4.0	Partial Diff. Eqs & Fourier Series 104223 4.0	Physics 2 114052 3.5		Physical Chemis. 1B 124503 2.5	Macro. & Micro. Anatomy 274001 2.0	Introd. to Biochem. & Enzymology 134019 2.5						Physical Education 394800 1.0	19.5
4						Intro. To Biological Processes 336004 2.5	Biophysics and Neuro-physiology 336537 3.0	Electrical Engineering Expanded 044105 4.0	Motion Biomechanics 335334 4.0	Solid Mechanics 084505 3.5	Intro. To Materials Engineering 314221 2.5		Physical Education 394800 1.0	20.5
5	Introduction to Probebility H 104034 3.5					Physiology of the Body Systems for Engineers 276011 3.0	From Cells To Tissues 336022 2.5	Signals And Systems 044130 4.0	Basic Bio-Electric Design 334011 4.0	Biological Fluid Mechanics 334009 4.0		Meeting the Biomedical Industry 334331 General elective 1.0		21.0
6			Fund of Biomd Optics & Photonics 336533 3.0					Basic Bio-Mechanical Design 334010 4.0	Transport Phenomena in Physiol. systems 337403 4.0	Laboratory In Biomed Eng. 1 334012 2.0	Principle of Medical Imaging 336502 2.5	Elective		15.5
7										Laboratory In Biomed. Eng. 2 334013 2.0	BME Project 1 334014 3.0	Elective		5.0
8									Clinical Eng. Project 334016 1.5		BME Project 2 334015 3.0	Elective		4.5
Total	30.0		110.		8.5	18.5		52.0					5.0	125

Appendix –C

The list of courses in the current Tracks

Imaging and Medical Signal	pts
336020 **Bio-Electrical Phenomena**	2.5
336208 **Analysis of Biological Signals**	2.5
336325 **Ultrasound in Medicine Principles Applications**	2.5
336522 **Introduction to Control In Bio-Medical**	3.0
334303 **The Brain and the Computer**	2.0
336023 **Biomedical Optics**	2.5
336214 **Process Analysis in the Visual System**	2.5
336326 **Data Analysis and Parameter Estimation**	2.5
336504 **Principles f M.R. in Medical Imaging**	2.0
336521 **Engineering Aspects in the Cardiovascular System**	3.5
336523 **Medical Instrumentation, Standards, Safety**	2.5
034033 **Numerical Analysis M**	3.0
044198 **Introduction to Digital Signal Processing**	3.0
044202 **Random Signals**	3.0
046197 **Computational Methods**	3.0
046200 **Image Processing and Analysis**	3.0
046201 **Introduction to Random Signal Processes**	3.0
046332 **Visual and Auditory Systems**	3.0
046041 **Biological Neural Networks: Computation**	3.0
094423 **Introduction to Statistics**	3.5

Tissue Engineering and Biomaterials	Pts
336021 **Nano-Particles in Biology, Mechanics and Rheology**	2.5
336405 **Engineering Principles in Biology Biotechnology**	2.5
336517 **Bioengineering of The Cell**	2.5
336529 **Engineered Tissue Substitutes**	2.5
336214 **Process Analysis in The Visual System**	2.5
336326 **Data Analysis and Parameter Estimation**	2.5
336401 **Biomaterials**	2.0
336508 **Connective Tissue Biophysics**	2.0
336509 **Tissue Biomechanics**	2.5
336520 **Orthopedic Implants and Tissue Substitutes**	2.5
336521 **Engineering Aspects in the Cardiovascular System**	3.5
336526 **Artificial Metabolic Organs**	2.0
336528 **Controlled Drug Delivery**	2.5
336531 **Principles of Biochemical Sensors**	2.5
336538 **Single Molecule Approaches**	2.5
035021 **Micromechanic Devices-Design and Fabrication**	3.0
094423 **Introduction to Statistics**	3.5

Bio-Mechanics	pts
336021 **Nano-Particles in Biology, Mechanics and Rheology**	2.5
336506 **Rehabilitational Biomechanics**	2.5
336517 **Bioengineering of the Cell**	2.5
336518 **Heat Transfer in Biological Systems**	3.0
336522 **Introduction to Control in Biomedical Systems**	3.0
336305 **Flows in Biological Systems**	2.0
336326 **Data Analysis and Parameter Estimation**	2.5
336509 **Tissue Biomechanics**	2.5
336520 **Orthopedic Implants and Tissue Substitutes**	2.5
336521 **Engineering Aspects in Cardiovascular Systems**	3.5
336526 **Artificial Metabolic Organs**	2.0
336530 **Eng. Analysis of Respiratory Systems**	2.5
336535 **Therapeutic Ultrasound**	2.5
336539 **Respiratory Flows Inhalation Therapy**	2.5
034033 **Numerical Analysis M**	3.0
035001 **Introduction to Robotics**	2.5
035021 **Micromechanic Devices-Design and Fabrication**	3.0
036049 **Neural Networks for Control/Diagnostic**	2.5
086574 **Finite Elements in Aeronautical Engineering**	3.0
094423 **Introduction to Statistics**	3.5

Medical Track omaterials	Pts
134020 **General Genetics**	3.5
134082 **Biochemistry of Intermediary Metabolism**	2.5
134121 **Microbiology and Virology**	3.0

Appendix –D
Syllabi

334009 - BIOLOGICAL FLUID MECHANICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	3	2	0	0

Credit points
4.0

This is an introductory course describing the concept of continuum, applied to biological substance. Topics will cover: the concept of continuum, fluid properties, stress and pressure. Hydrostatics. Descriptions of motion, streamlines. Application of the principles of conservation of mass, momentum, and energy to fluid systems. Rheological properties that characterizes cells, fluids and tissues, boundary conditions. The Navier-Stokes flow equations. Newtonion and non-newtonion flows.

334010 - BASIC BIOMECHANICAL DESIGN

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	3	2	0	0

Credit points
4.0

Failure criteria, stress fatigue, stress concentration. Tolerances, material selection, production stages. Analysis and design of: joints (bonding, bolts), springs, bearings, transmissions, clutches. example: bearing and locking of a joint in external prostheses. Design of simple mechanisms and transducers. Motorized systems and energy sources: types and characteristics of electric motors, hydraulic and pneumatic systems. Examples: design of transmission and motorized systemes for wheel chairs and dynamic imaging systems. Computer applications for drawing and design.

334011 - BASIC BIOELECTRICAL DESIGN

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	3	2	0	0

Credit points
4.0

Static and dynamic characteristics of transducers used in medicine, shielding, measurement noise and drift. Equivalent circuits, transfer function and measurement errors. Semi diode, bi-polar, FET CMOS transistors. Design of linear circuits, amplifiers, recorders. Specifications and data sheets. Design of analog filters. Gates and digital circuits. Design of medical instrumentation, impedance matching, signal-to-noise, signal processing and safety considerations.

334012 - LAB. IN BIOMEDICAL ENGINEERING 1

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	4	0

Credit points
2.0

Electronic instrumentation, measurement and confirmation of network laws, digital electronics, data acquisition and computer system control. Membranes, chromatrography, potentiometric titration. Mechanical testing equipment, load and deflection measurements, beam vibrations, mechanical behavior of viscoelastic materials, pressure and flow in pulsating flow.

334013 - LAB. IN BIOMEDICAL ENGINEERING 2

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	4	0

Credit points
2.0

The laboratory provides knowledge on bio-medical equipment and techniques and experience in basic clinical equipment: transducers in circulatory systems, voltage sensors (EEG, ENG, ECG) data acquisition and analysis, feedback control system, posture and kinematics, tissue engineering, excitable tissue (muscle, nerve), bio-materials, medical imaging. A lecture is given within the first two weeks on: ethics, safety and basic equipment. Passing an examination on these topics, based on distributed reference, is mandatory.

334016 - CLINICAL ENGINEERING PROJECT

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	1	0	3	0

Credit points
2.0

The student will meet a number of clinical departments in the hospital. The clinical and engineering problems associated with the implementation of devices in the patient-device-operator system, and the required qualifications for operating the device will be demonstrated. The project will be assigned to small groups within the regular clinical system.

334019 - ADVANCED LAB. IN BIOMEDICAL ENGINEERING

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	6	0

Credit points
2.0

Excellent students will learn research methods and critical thinking in an active research laboratory in fields such as tissue engineering, biomaterials or bio-signals. The planned research has to be approved by the laboratory faculty member. The activity in the laboratory will be summarized in a written report and a seminar.

334020 - ADVANCED LAB. IN BIOMEDICAL ENGINEERING .2

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	6	0

Credit points
2.0

Excellent students will learn research methods and critical thinking in an active research laboratory in fields such as tissue engineering, biomaterials or bio-signals. Students will study the background and submit their labotatory plan for approval. The activity in the laboratory will be summarized in a written report and a seminar.

334021 - DIRECTIONS IN BIOMEDICAL ENGINEERING

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	1	0	0	0

Credit points
1.0

The course aims to expose before the students the various activities in the field of biomedical engineering and the topics that they will study in depth in advance semesters. The lectures present the research and the academic activities in the department in the three main directions: 1. Imaging and medical equipment. 2. Biomechanics systems. 3. Biomaterials and biotechnology. The course is designated to students from biomedical engineering program.

334221 - FUNDAMENTALS OF MEDICAL MATERIALS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Introduction to the different classes of materials for biomedical applications including synthetic and natural polymers, hydrogels, ceramics, glasses, composites and metal alloys. Measurement of mechanical properties, simple models of viscoelastic behavior, creep and stress relaxation, fracture and fatigue failure modes, challenges in characterization and modeling biomaterial behavior, surface properties of materials, surface modifications, degradation of biomaterials, simple mathematical degradation models, biocompatibility to biomaterials, controlled drug release system and mathematics of release.

334303 - THE BRAIN AND THE COMPUTER

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Human and artificial intelligence - Turing's definition and operational definitions. Evolution of biological intelligence, principles of structure and organization of the nervous system, the mind-body problem. Digital computers and algorithmic solutions to cognitive processes. AI and the brain. The Chinese room and algorithmic solutions. Neural nets and parallel processing in visual cortex. Brain versus computer- advantages and disadvantages. Could machines think. Tutorial in principles of operations of neural networks.

334331 - MEETING THE BIOMEDICAL INDUSTRY

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	1	0	0	0

Credit points
1.0

Experts from the biomedical industry will lecture on their areas of activity while presenting in detail some hi-tech solutions of medical needs. Emphasis will be paid to scientific/ technology aspects, and on regulatory demands and innovation in the development of the biomedical industry.

335001 - LABORATORY IN BIO-MEDICAL ENGINEERING 1

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
2.0

final grades will be given based upon final exam, reports and performance during the experiments. the laboratory provides basic knowledge on bio-medical equipment and techniques in the fields of bio mechanics, bio materials and electronics. each student has to complete 7 experiments. each experiment include: a 4 hour meeting, preparatory tasks and a report.

335002 - LABORATORY IN BIO-MEDICAL ENGINEERING 2

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
2.0

final grades will be given based upon final exam, reports and performance during the experiments. the laboratory focuses on one of the following field: biomechanics and flow, tissue and biomaterials or signals and imaging. each student gas to choose 6 experiments that belong to one of the fields. each experiment include: a 4 hour meeting, preparatory, tasks and a report. part of the experiments consist in two meeting of four hours each.

335003 - LABORATORY IN BIO-MEDICAL ENGINEERING 3

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
2.0

final grades will be given based upon final exam, reports and performance during the experiments. the laboratory focuses on one of the following field: biomechanics and flow, tissue and biomaterials or signals and imaging. each student has to choose 6 experiments that belong to one of the fields that was not included in previous labs he was registred to. each experiment include: a 4 hour meeting, preparatory, tasks and a report. part of the experiments consist in two meeting of four hours each.

335004 - LABORATORY IN BIO-MEDICAL ENGINEERING 4

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
2.0

final grades will be given based upon final exam, reports and performance during the experiments. the laboratory focuses on one of the following field: biomechanics and flow, tissue and biomaterials or signals and imaging. each student has to choose 6 experiments that belong to one of the fields that was not included in previous labs he was registred to. each experiment include: a 4 hour meeting, preparatory, tasks and a report. part of the experiments consist in two meeting of four hours each.

335009 - BIOLOGICAL FLUID MECHANICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
3.0

Overlapping courses: 334009 - BIOLOGICAL FLUID MECHANICS

This is an introductory course describing the concept of continuum, applied to biological substance. Topics will cover: the concept of continuum, fluid properties, stress and pressure. Hydrostatics. Descriptions of motion, streamlines. Application of the principles of conservation of mass, momentum, and energy to fluid systems. Rheological properties that characterizes cells, fluids and tissues, boundary conditions. The Navier-Stokes flow equations. Newtonion and non-newtonion flows.

335011 - BASIC BIOELECTRICAL DESIGN

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
3.0

Overlapping courses: 334011 - BASIC BIOELECTRICAL DESIGN

Static and dynamic characteristics of transducers used in medicine, shielding, measurement noise and drift. Equivalent circuits, transfer function and measurement errors. Semi diode, bi-polar, FET CMOS transistors. Design of linear circuits, amplifiers, recorders. Specifications and data sheets. Design of analog filters. Gates and digital circuits. Design of medical instrumentation, impedance matching, signal-to-noise, signal processing and safety considerations.

335014 - BIOMEDICAL ENGINEERING PROJECT 1

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	9

Credit points
3.0

Project 1 is conducted by groups of students. Each group chooses a topic from a list published early in the semester. The project consists of design of an instrument or a system for diagnosis or treatment in the medical field. The work includes: literature survey and gathering of pertinent information. Analysis of needs and optional solution. Economic analysis including market research. Survey of possible technical solutions. Functional analysis of solution options. Decision on optimal solution and preparation of preliminary design.

335015 - BIOMEDICAL ENGINEERING PROJECT 2

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	9

Credit points
3.0

Project 2 follows project 1. The course includes design analysis, choice of materials, detailed design of instrument's parts and related accessories, design of control, command and operation units, preparation of production file, construction of prototype, its testing and design review.

335016 - CLINICAL ENGINEERING PROJECT

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	1	0	2	0

Credit points
1.5

The student will meet a number of clinical departments in the hospital. The clinical and engineering problems associated with the implementation of devices in the patient-device-operator system, and the required qualifications for operating the device will be demonstrated. The project will be assigned to small groups within the regular clinical system.

335334 - INTRODUCTION TO MOTION BIOMECHANICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	3	2	0	0

Credit points
4.0

Representation of the human body as a multi-segmental system of rigid bodies. Anthropometric data. Kinematics and dynamics of a segment. Newton-Euler and lagrange equations for a multi-segmental system. Torques and forces in joints. Indeterminate systems. Axial vibrations and application to biomechanical impedances.

336004 - BIOLOGICAL PROCESSES

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Matabolism synthesis and degradation of biological building block molecules, catabolism and anabolism, energy transfer processes, photo-biological processes, signal transduction, biological clocks and aging.

336017 - ADVANCED TOPICS IN BIOMEDICAL ENGINEERIN

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

An advanced course which allows specialization in a specific topic. Detailed sylabus will be announced at the time the course is offered.

336020 - BIO-ELECTRICAL PHENOMENA

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

engingeering aspects and models of membrane properties, action potential,the hodgkin-huxley and liu-rudy models. numerical solutions of action potential propagation in nerve axon and 2d tissue.definition of electrical sources, dipole and monopole source models.gauss theory, green theory. volume conductor. the forward problem and inverse problem. biological effects of non-ionizing electro-magnetic, low frequency and high frequency fields (measurement,cellular and whole- body effects, therapeutic effects). electrophoresis-field effects on the membrane, transport of molecules, drugs and genetic materials, utilization in the laboratory and tissue.

336021 - NANO-PARTICLES IN BIOLOGY, MECHANICS AND

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

nano-particles and molecules as markers in biology. various kinds of nano-particles, fabrication processes, composition and surface chemistry, biological compatibility. nano-particles as carriers and targets for medical treatments. forced transport and termal- fluctuation in solution. introduction to rheology and constitutive equations. nano-particle mediated mechanical and rheological measurements on the single cell level.

336022 - FROM CELLS TO TISSUES

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

differentiated cells and the structure of tissues. cell mobility and cell-cell adhesion. the extracellular matrix. receptors and signal transduction. life and death of cells in tissues. cell and tissue differentiation during embryonic development.

336023 - BIOMEDICAL OPTICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Light propagation in tissue, numerical simulation methods, diffuse optical tomography, optical tomography, applications of lasers in biomedicine, photodynamic therapy, neural stimulation, three-dimensional microscopy, super-resolution, coherence in optics, nonlinear microscopy, optical coherence tomography, optical coherence microscopy, endoscopy and miniature, endoscopy, spectrally encoded endoscopy.

336208 - ANALYSIS OF BIOLOGICAL SIGNALS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	2	0	0

Credit points
3.0

Molecular aspects : diseases as metabolic malfunctions. Modes of drug action. Drug and prodrugs: molecular design, dosage and blood concentration copolymers and polymer-drug conjugates. Drug-carrying micro - and nanoparticles. Enzyme related aspects. Pharmacokinetics and biodistribution. Drug targeting. Operating systems : concepts and principles. Mechanisms of action. Physioligically-controlled systems. Engineering aspects. Applications.

336214 - PROCESS ANALYSIS IN THE VISUAL SYSTEM

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

The retina, LGN, and visual cortex: structure and function. Signals in the visual system, slow and fast potential changes. The electroretinogram. Origin and production, spatial and temporal analysis of the signals. Spatial and temporal transfer functions - physiological and psychological. Comparison of visual information processing in various animals.

336305 - FLOW IN BIOLOGICAL SYSTEMS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Analysis of flow in different physiological systems. Among the topics: flow in the microcirculation, multiphases flow, transition of matter across the capillary wall, control systems, the respiratory system, pressure and flow in the respiratory system, interactions between cardiac and pulmonary performance, lubrication in joints, cardiac assist devices, hemodialysis and peritoneal dialysis, flow in microchips for medical diagnosis (Lab on chip).

336325 - ULTRASOUND IN MEDICINE PRINIPLES APPL.

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

The wave phenomena. Propagation of acoustic waves in liquids and solids: longitudinal and shear waves. Reflections and refraction from boundaries. Transducers. Acoustic fields. Acoustic mirrors and lenses. Acoustic properties of tissues. Measurement techniques. Acoustic imaging. Tissue characterization and therapeutic techniques.

336326 - DATA ANALYSIS AND PARAMETER ESTIMATION

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Model classification, estimation as an optimization, errors and residuals, standard statistical assumptions, linear regression - ordinary and weighted least squares estimators, expectation and variance for parameters and predictions, multiple linear regression, multicolinearity - detection and treatment, non-linear regression-search methods, constraints. Standard dynamic models - sensitivity equations. Optimal experimental design. Interpretation of the estimates.

336401 - BIOMATERIALS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Materials for medical applications: polymers, ceramics, metals. Chemical and physico-chemical aspects. New structural materials in medicine: porous and composite materials. Biomaterials under physiological conditions: biocompatibility. Separation of biomaterials. Drug-carrying polymers. Drugs provided with homing devices. Controlled-rate drug delivery systems. Insoluble adsorbents and biocatalysts. Biosensors. Devices for blood purification from toxins and undesired matabolites.

336405 - ENGINEERING PRINCIPLES IN BIOLOGY BIOTEC

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Biotechnology: An integrated biological, physiochemical and medical engineering endeavor. Fields of application. - The enzymic reaction as unit operation in biotechnological-biomedical processes. - Bioreactors for medical applications: principles of design and operation. - Immobilized enzymes: preparation and characterization. - Inactivation of biocatalysts: its mechanisms, and approaches to prevent it. -Control systems for biotechnological-biomedical processes. Biochemical sensors. -Separation and purification of biologically active materials from biomass.

336501 - CLASSIFICATION AND CLUSTERING IN BIOLOGI

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Pattern recognition of biological signals. Classification and clustering. Supervised and unsupervised learning. Data scales, normalization and proximity indices. Hierarchical and partitional clustering of biological signals. Fuzzy clustering and cluster validity. Data analysis from cardiology, EEG, central nervous system (vision) etc.

336502 - PRINCIPLES OF MEDICAL IMAGING

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Introduction: clinical and scientific needs in medical imaging. X-ray imaging and medical radiology. Computerized tomography and applications. Radioisotope imaging. Ultra-sound imaging. Nuclear magnetic resonance (NMR) principles and applications, spectroscopy. Medical thermography. Surface potential mapping and biomagnetic imaging. Near-infrared transillumination.

336504 - PRINCIPLES OF M.R. IN MEDICAL IMAGING

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

The magnetic resonance phenomenon, magnetic gradients, the relation between the free induction decay and the spatial frequency domain, 2-d and 3-d image encoding, imaging modes and pulse sequences, tagging and spatial modulation of magnetization and their applications in cardiology, contrast materials for medical imaging, hardware concepts, velocity imaging, applications in medicine.

336506 - REHABILITATIONAL BIOMECHANICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Methods of functional evaluation of limbs: standing and gait analysis, forces and moments in muscles and joints, electromyography. Pathophysiology of limbs in amputations, cranial and spinal injuries, stroke. Skeletal muscle fatigue. Design principles of aids for the disabled, artificial limbs and joints. Functional electrical stimulation of paralyzed muscles, hybrid walking systems.

336508 - CONNECTIVE TISSUE BIOPHYSICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Analysis of the physical environment of cells in different tissues - bone, cartilage, intervertebral disc, blood vessel wall. Role of the extracellular matrix in modulating the forces and the transport of stimuli in vivo. Influence of physical environment on cell metabolism in health and disease. Concepts used to assess the relationship of mechanical environment and cell response.

336509 - TISSUE BIOMECHANICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Prerequisites: (334010 - BASIC BIOMECHANICAL DESIGN)

The course deals with engineering methodology of stress analysis in biological tissues. Structure, function and mechanical characteristics of tissues. Review of basic concepts in linear elasticity, anisotropy in bones. Non-linear elasticity under large deformations, constitutive equations for tissues. Structure-function relationships, strss analysis in tissues. Viscoelastic models, linear, quasilinear and nonlinear viscoelasticity in connective tissues preconditioning. Mechanics of cartilage and disc as swelling multiphasic materials.

336517 - BIOENGINEERING OF THE CELL

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Cell types,cellular structure, mechanical environment of flowing and immobile cells, cell-matrix interactions, mass transport across cellular membrane, mechanical signal transduction in cells, effect of loading on cellular response, engineering aspects of cell mobility, morphogenesis and cytokinesis, mechano-chemical coupling and force generation, mechanical properties of blood cells, effect of flow on blood cell structure and function, implications for design of bio-materials, implants and artificial organs.

336518 - HEAT TRANSFER IN BIOLOGICAL SYSTEMS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	2	0	0

Credit points
3.0

The first law of thermodynamics, steady-state and transient heat conduction, natural and forced convection, radiation heat transfer between black and gray surfaces, the bioheat equation, homeostasis, thermal regulation of the body. Analog models for the calculation of heat transfer in tissues. Clinical application of thermography. Practical use of bioheat principles-hyper-and hypothermia.Cryosurgery. Students will be expected to participate in model development through homework problems and literature review reports.

336520 - ORTHOPEDIC IMPLANTS ” TISSUE SUBSTITUTES

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Mechanical failure of joints, artificial joints: biomechanical design configurations in the upper and lower limbs, fractures in long bones and their fixations using various methods. Two-material structures in bones and joints, undeterminate problems in different loading configurations. Composite stresses, material substitutes for bones, ligaments and blood vessels.

336521 - ENGINEERING ASPECTS IN CARDIOVASULAR

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	3	1	0	0

Credit points
3.5

Methods of cardiovascular research. Excitability : voltage-gated Ion channels, gap junction. Excitation-contraction coupling. Sarcomere dynamics and energetics. Laser trap. Frank-Starling law. Relaxation and diastolic function. Coronary circulation : thrombosis and thrombolysis. Heart rate variability, Baroreflex control of the circulation. Arrhythmias : reentry after depolarization. Heart failure. Methods to assess cardiac function and viability. Artifical heart.

336522 - INTRODUCTION TO CONTROL IN BIO-MEDICAL

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	2	0	0

Credit points
3.0

System presentation, control system characteristics, stability, Pid controller. Non-linear system analysis : phase plane analysis, limit cycles. Linearization and local stability. Lyapunov theory. Adaptive control : Model-reference adaptive system, self tuning regulators. Chaos in biological systems. Applications : heart rate variability, stimulated muscle function, arrhythmogenic activity, control of blood pressure and drug delivery.

336523 - MEDICAL INSTRUMENTATION, STANDARDS, SAFETY

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Safety and standards, single fault design, indentifying safety hazards, conformity assessment procedures, selection of components, construction details, safety and EMC tests, radiation and immunity testing. User and patient concerns, certification procedures (FDA and EC) as part of the design process. Performance standards for medical implants (ISO TC-150) and of medical devices. Exercises of design methods according to safety requirements.

336526 - ARTIFICIAL METABOLIC ORGANS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Artificial metabolic organs are therapeutic devices, intended to support metabolic functions which fail as a result of illness, or are missing due to inborn genetic defects. Blood detoxification pathways. Extracorporeal and fully implanted systems. Absorption- type and reaction-type devices. Enzymic bioreactors: enzyme immobilization, diffusion limitations, effects of ligands and enzyme inhibitors, analytical models, expert systems. The approaches involved are extended to "intelligent" drug delivery systems that act in accordance with the status of the disease.

336527 - INTRO. TO THE CARDIOVASCULAR SYSTEM

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	2	0	0

Credit points
3.0

physiology and pathology of the cardiovascular system. quantification of cardiac function. regulation of the intracellular excitation contraction coupling. models of cardiac muscle. electrocardiogram. properties of the blood. analog models of the circulation. coronary circulation. ischemic heart disease . fluid statics. conservation laws. pulsatile flow. propagation of waves in arteries. microcirculation. cardiac assist.

336528 - CONTROLLED DRUG DELIVERY

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Molecular aspects : diseases as metabolic malfunctions. Modes of drug action. Drug and prodrugs: molecular design, dosage and blood concentration copolymers and polymer-drug conjugates. Drug-carrying micro - and nanoparticles. Enzyme related aspects. Pharmacokinetics and biodistribution. Drug targeting. Operating systems : concepts and principles. Mechanisms of action. Physioligically-controlled systems. Engineering aspects. Applications.

336529 - ENGINEERED TISSUE SUBSTITUTES

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Integration of principles of engineering and life sciences as related to development of biological substitutes. Cells and biomolecules: control of cell proliferation and differentation, stem cells, gene transfer, growth factors, and morphogenic proteins. Biomaterials : synthetic, biological, and decellularized bioscaffolds as well as biomimetic materials. Engineering : bioreactor technology preservation of cells and engineered tissues, mass transport and biomechanics issues. Clinical applications: tissue and cell transplantation, bioartificial organs, in vivo tissue regeneration.

336530 - ENG. ANALYSIS OF RESPIRATORY SYSTEMS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

Models and simulations in the respiratory system: continuous and lumped parameter models for fluid and solid mechanics, and gas distribution in the lungs. Airflow in the airways. Parenchymal elasticity and viscoelasticity, hysteresis. Surface tension and stability, gas dispersion in bronchi and alveoli. Mucus film. mechanics of epithelial cells and smooth muscle cells. Acoustical diagnostic methods, breathing wheezes. Respirators.

336531 - PRINCIPLES OF BIOCHEMICAL SENSORS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	0

Credit points
2.0

Body fluids-key vehicles for diagnosis and their limitaions. principles in diagnostics-choosing the biological signal (metabolic, immunological, signal molecules) and its Parameters, Sensitivity, Specificity, positive and Negative predicitve value. Measuring levels of a biological component using Biochemical and Biological processes. Sensors - Transferring biological into mechanical/electrical signals. One time and continuous measurements. Qualitative and Quantitative measurements, possible deviations in sensors measurement/output. Biosensors and new tools in diagnostics-exaples form cutting edge Technologies E.G. Glucose monitoring, antibody and antigen detection. Hormone levels.

336533 - FUND. OF BIOMED. OPTICS ” PHOTONICS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	2	0	0

Credit points
3.0

electromagnetic waves, geometrical optics, refraction, light interaction with biological media, atomic and molecular models, scattering and absorption in biological media, fluorescence, photodynamic therapy, lasers in biomedicience, laser surgery, fourier optics. fresnel and fraunhofer diffraction, optical components. image formation, microscopy, confocal microscopy, imaging system design, optical contrast in biological microscopy, nanoparticles in biophotonics, light propagation in optical fibers. medical endoscopy, single fiber endoscopy.

336535 - THERAPEUTIC ULTRASOUND

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

topics: bubble dynamics and cavitation. ultrasound induced second order, steady streaming and microstreaming, radiation pressure. high intensity ultrasound and nonlinearity. shock waves. beam focusing. applications. bioeffects - the response of cells and tissues.

336537 - BIOPHYSICS AND NEROPHYSIOLOGY

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	2	0	0

Credit points
3.0

topics: diffusion, osmosis, ionic equilibrium, ionic flow through membranes, bioelectric phenomena, excitable membranes, the nerve impluse,hudgkin huxley equations,action potential simulation, synaptic transmission, neurotransmitters, neuromodulators, electrical and mechanical activity of muscle cells, organizational principles of the brain, sensory systems - transduction principles and central representation of information,the visual system, the autidory system, working principles of the motor system, functional imaging.

336538 - SINGLE MOLECULE APPROACHES

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

introduction, review of the physical biology of the cell, single molecule (sm) methods (in vitro), applications of sm in biophysics, biomolecules detection in live cells, nanobiotechnology and detection of single molecules with applications for dna sequencing (nbt).

336539 - RESPIRATORY FLOWS INHALATION THERAPY

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

discusses respiratory airflows and fundamentals of inhalation therapy in treating airway diseases. topics covered: fluid mechanics of respiration, oxygen transport, and the role of surface tension, the governing mechanisms for particle transport and deposition in airways (impaction,sedimentation,diffusion),and designs of medical devices for inhalation.emphasis is put on dimensional analysis and parameter estimation to gain physical understanding of flow and particle transport in the lungs.

336540 - DESIGN OF MEDICAL INSTRUMENTATION

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	1	0	0

Credit points
2.5

design of computer-based (virtual) medical instruments. introduction to labview programming. additional pc-instruments interfaces (gpib, rs232, usb). synchronization methods for parallel threads (sampling,data analysis, storage and display) design of virtual instrumentation for monitoring of physiological and medical parameters.

337403 - TRANSPORT PHENOMENA IN PHYS. SYSTEMS

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	0

Credit points
3.0

Basic laws of mass momentum and heat transfer. Principles of similarity in laminar and turbulent systems. Carrier-assisted and enzyme-promoted mass transport in membranes. Convective mass transfer, dialysis, ultrafiltration. Pharmacokinetics of drug and poison, tracers in blood flow. Compartmental analysis. Models of mass transfer between the body and extra-corporal systems. Artificial kidney and artificial liver.

338212- BIOLOGICAL SIGNAL PROCESSING LABORATORY

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	0	4

Credit points
2.0

Teaching the use of computers for processing analog signals, data acquisition, statistical analysis and display. 1. Sampling: quantization and sampling errors, finite length data, buffer length and chaining, interpolation and decimation. 2. Continuous wave analysis: sampling and filtration, FIR, band-reject FIR, peak detector comparison to ECG detector, averager. 3. Windowing, correlation estimation, use of FFT, filtration, estimation of power spectrum. 4. Random signal analysis: conversion to time series, power spectrum estimation, windowing, histograms, scatter diagram and time dependencies.

338319–BIOMEDICAL ENGINEERING PROJECT

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	0	0	8	0

Credit points
5.0

The course allows specialization in a given discipline of biomedical engineering, summarization of the know-how in writing and, usually, presentation of it in a formal seminar.

338328– ADVANCED METHODS OF ULTRASOUND IN MEDICINE

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	3	0

Credit points
2.0

Scattering in heterogeneous media: scattering, speckle statistics, methods of properties, size filtering and tracking, phased array imaging: transmit, receive focusing, synthetic aperture. Backscatter imaging: spatial resolution , speckles and beam density , inverse filtering and image reconstruction. Estimation of blood velocities: from doppler signals, color Doppler mapping (noise, sources and system performance), spectrum density. Effects of system parameters on estimation. Second-order effects: non-linear ultrasound: non-linear phenomena, distortion and scattering in the focused beam, scattering from ultrasound contrast agent, therapeutic methods (Hifus) and measuring non-linear distortions.

338515 – EXCITATION CONTRACTION COUPLIND IN THE SKELETAL AND THE CARDIA MUSCLE

	Lecture	Tutorial	Laboratory	Project/Seminar
Weekly hours	2	0	0	

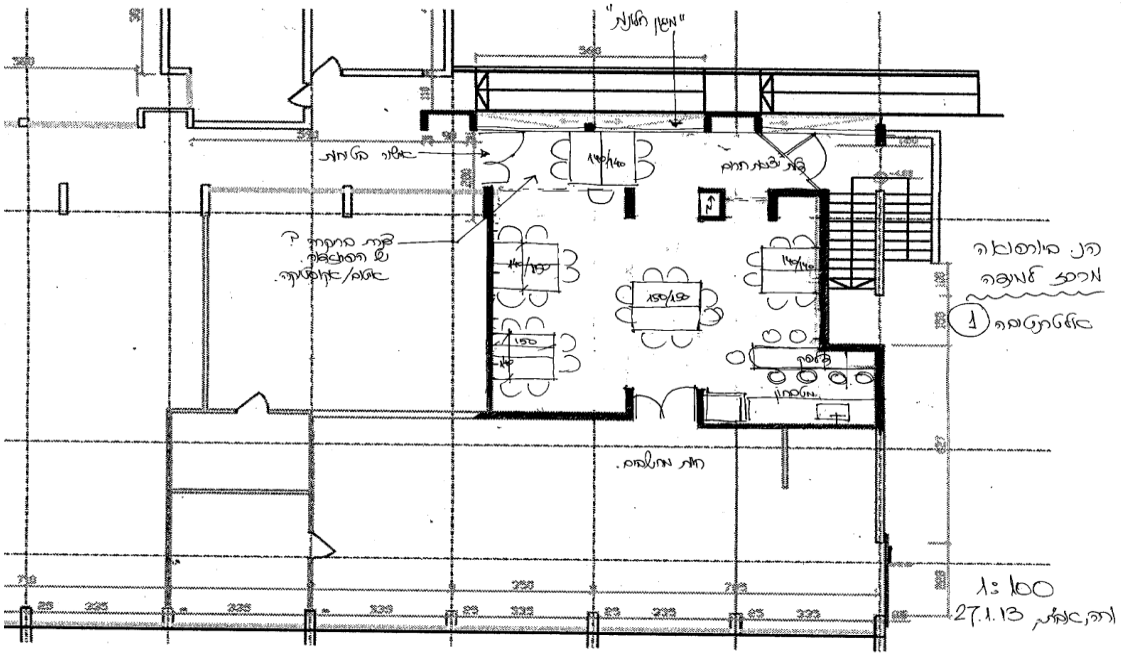
Credit points
2.0

Cardiac and skeletal muscle physiology and the intracellular control of the excitation contraction coupling.Left ventricle function myocyte structure. The contractile filaments structure. Motility essay studies. Huxley's model and biochemical models of crossbridge Dynamics. The sarcoplasmic retuculume. Force-length relationship. Frank-Starlind law. Regulation of shortening velocity and force- velocity relationship. Regulation of biochemical to mechanical energy conversion. Contractile property of the failing heart. Structure, dynamics and regulation of various muscle types. Neural and humoral regulation.

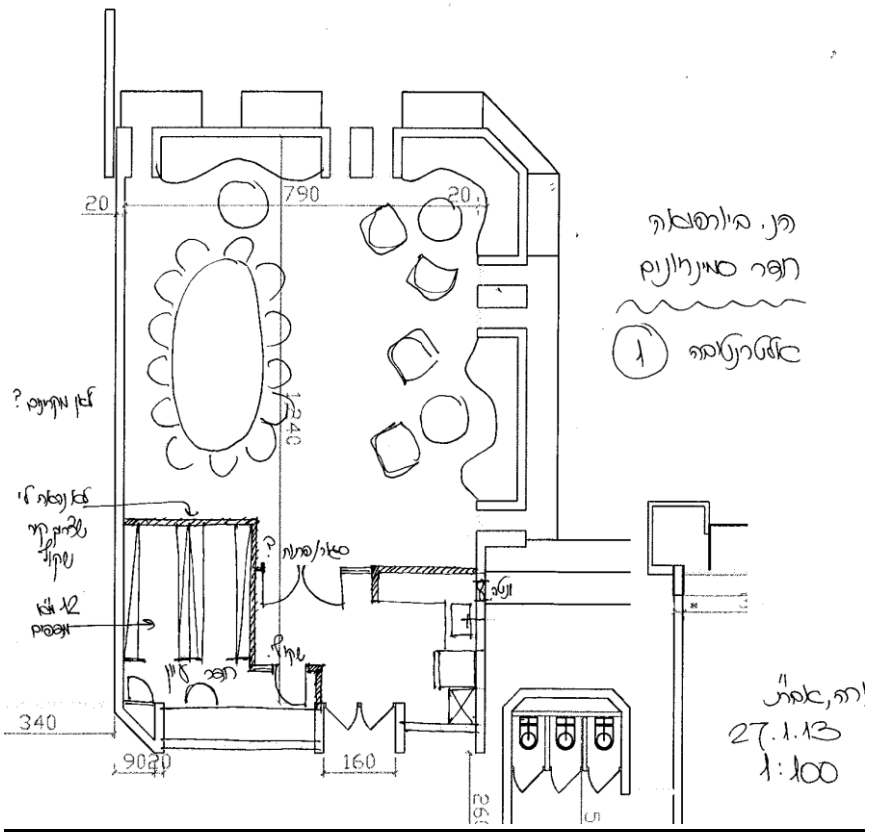
Appendix –E:

Constructions at the Faculty of BME

The Study Space for the undergraduate students.



The gathering space for staff members, employees and graduate students



נספח 3א'

תאריך: 25.5.14

אל: פרופ' פרץ לביא, נשיא
מאת: פרופ' פנחס בר יוסף, דיקן הפקולטה להנדסת מכונות

שלום רב,

הנדון: **<u>בחירת דיקן הפקולטה להנדסת מכונות</u>**

הריני להודיעך כי בישיבת מועצת הפקולטה להנדסת מכונות מיום 22.5.2014 נערכו בחירות לתפקיד דיקן הפקולטה.

הישיבה נוהלה על ידי פרופ' משה שפיטלני ופרופ' מיילס רובין.

הוצג מועמד אחד, פרופ' יורם הלוי שהגיש את מועמדותו לתקופת כהונה ראשונה מיום 1.10.2014 ועד יום 31.12.16.

בהצבעה השתתפו 33 בעלי זכות בחירה.

תוצאות ההצבעה: 31 בעד, ללא מתנגדים, 2 נמנעים.

נא הבא את תוצאות ההצבעה לאישור הוועדה המרכזת והסנט.

ב ב ר כ ה ,

TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY
Faculty of Biomedical Engineering
The Julius Silver Institute.

טכניון-מכון טכנולוגי לישראל
הפקולטה להנדסה ביו-רפואית
המכון ע"ש יוליוס סילבר

נספח 3ב'

15.6.2014

אל: פרופ' פרץ לביא, נשיא

מאת: פרופ"מ יעל יניב, מזכיר מועצת הפקולטה להנדסה ביו רפואית

שלום רב,

הנדון: <u>בחירת דיקן הפקולטה להנדסה ביו רפואית</u>

הריני להודיעך, כי בישיבת מועצת הפקולטה להנדסה ביו רפואית מיום 15.6.2014 נערכו בחירות לתפקיד דיקן הפקולטה.

הישיבה נוהלה על ידי.

הוצג מועמד אחד , פרופ"ח אמיר לנדסברג שהגיש את מועמדותו לתקופת כהונה שנייה מיום 1.10.2014 ועד יום 31.12.2016.

בהצבעה השתתפו 9 בעלי זכות בחירה.

תוצאות ההצבעה: 9 בעד (פה אחד).

אנא הבא את תוצאות ההצבעה לאישור הוועדה המרכזת והסנט.

בברכה

פרופ"מ יעל יניב

מזכיר מועצת הפקולטה

העתק:

- פרופ"ח אמיר לנדסברג, דיקן הפקולטה להנדסה ביו רפואית

נספח 4

תאריך: 15/6/2014

אל: פרופ' פרץ לביא, נשיא הטכניון

מאת: פרופ' יכין כהן, דיקן לימודי הסמכה

הנדון: **<u>תכניות לימודים לתשע"ה (המשך)</u>**

מצ"ב תכניות הלימודים הנוספות לתשע"ה ,שהתקבלו לאחר מועד כינוס הוועדה המרכזת שהתקיימה ביום 25/5/2014 . ואלה המסלולים המצורפים:

הנדסת חשמל
הנדסת מחשבים ותכנה
הנדסת מחשבים
הנדסת חשמל-פיסיקה
רפואה – תכנית אמריקאית
הנדסת חומרים-פיסיקה
הנדסת חומרים-כימיה
הנדסה ביו-רפואית-פיסיקה (תואר כפול)
הנדסה ביו-רפואית (התקבל ברגע האחרון, לא כלול בדו"ח המצורף).

אני מבקש להביא את התכניות לדיון בועדה המרכזת בתאריך 22/6/2014 ,ולאישור ועדת הקבע ללימודים אקדמיים בתאריך 22/6/2014.

הערה: לא התקבלה תכנית הלימודים במסלול הנדסה ביו-רפואית-רפואה.

בברכה,

יכין כהן

העתק:
פרופ' משה סידי, משנה בכיר לנשיא
עו"ד אביבה דרוגן, מזכירת הסנט

תכניות לימוד לתשע"ה (בהשוואה לתשע"ד) – שלב 2 (תכניות שהתקבלו באחור)

תכניות לימודים לפי מסלולים	עמ'	אופי השינוי
תכניות הפקולטה להנדסת חשמל	1-2	ריכוז שינויים לתשע"ה
הנדסת חשמל (ארבע שנתית)	3	היקף הנקודות בתכנית עלה בנקודה אחת: מ- 158 נק' ל- 159 נק'. היקף מקצועות החובה עלה ב- 2.5 נק' (מ- 105.5 נק' ל- 108 נק') היקף נקודות הבחירה ירד בנקודה וחצי (מ- 42.5 נק' ל- 41 נק'). השינוי עקב החלפת המקצוע מש.דיפ. רגילות ת' – 2.5 נק' במקצוע מש.דיפ. רגילות ואינפי 2ח – 5 נק'. חדו"א 1ת הוחלף באינפי 1מ' (ללא שינוי בניקוד). מקצועות בחירה חדשים. מקצוע מוסמכים הפך למשותף. התאמה לסמסטרים של 13 שבועות: התאמת סילבוסים ב-12 מקצועות חובה. מתוכננים שינויים בכ- 80 מקצועות בחירה שאינם מתבטאים בשינוי מהותי בקטלוג.
הנדסת מחשבים ותכנה (הנ. חשמל – ארבע שנתית)	4	היקף הנקודות בתכנית עלה בנקודה אחת : מ158 נק' ל- 159 נק'. היקף מקצועות החובה עלה ב- 2.5 נק': מ- 109.5 נק' ל- 112 נק'. היקף נקודות הבחירה ירד בנקודה וחצי. השינוי עקב החלפת המקצוע מש.דיפ. רגילות ת' – 2.5 נק' במקצוע מש.דיפ. רגילות ואינפי 2ח – 5 נק'. חדו"א 1ת הוחלף באינפי 1מ' (ללא שינוי בניקוד). מקצועות בחירה חדשים. מקצוע מוסמכים הפך למשותף. התאמה לסמסטרים של 13 שבועות: ב-15 מקצועות חובה ו-8 מקצועות ליבה הותאמו סילבוסים. מתוכננים שינויים בכ- 55 מקצועות בחירה שאינם מתבטאים בשינוי מהותי בקטלוג.
הנדסת מחשבים חשמל+מדעי המחשב (ארבע שנתית)	5-7	**הוסכם בין הפקולטות להנדסת חשמל ולמדעי המחשב כי בשנת תשע"ה התכניות לא תהיינה זהות.** תכנית חשמל: היקף הנקודות בתכנית עלה בנקודה: מ- 157 נק' ל- 158 נק'. היקף מקצועות החובה עלה ב- 2.5 נק': מ- 107.5-110 נק' ל- 110-112.5 נק' . היקף נקודות הבחירה ירד בנקודה וחצי: מ- 26-30.5 נק' ל- 24.5-29 נק'. השינוי עקב החלפת המקצוע מש.דיפ. רגילות ת' – 2.5 נק' במקצוע מש.דיפ. רגילות ואינפי 2ח – 5 נק'. התאמה לסמסטרים של 13 שבועות: ב-8 מקצועות חובה הותאמו סילבוסים. מתוכננים שינויים בכ- 40 מקצועות בחירה שאינם מתבטאים בשינוי מהותי בקטלוג. תכנית מדעי המחשב: היקף הנקודות בתכנית עלה בנקודה: מ- 157 נק' ל- 158 נק'. היקף מקצועות החובה עלה מ- 107.5-110 נק' ל- 111-113 נק'. היקף נקודות הבחירה ירד מ- 26-30.5 נק' ל- 24-28 נק'. הקורסים חדו"א 1ת חדו"א 2ת' יוחלפו בקורסים אינפי 1מ' 5.5 נק' ואינפי 2מ' – 5 נק'. נוסף קורס חדש אנליזה וקטורית 2.5 נק' שמכיל חומר החסר עקב המעבר מחדו"א לאינפי. הקורס מד"ר א' יילמד במקום מד"ר ת'.
הנדסת חשמל – פיסיקה (תלת שנתית)	8-13	היקף הנקודות בתכנית עלה בחצי נקודה : מ- 179 נק' ל- 179.5 נק'. היקף מקצועות החובה עלה מ- 134.5-134 נק' ל- 135.5 -137 נק'. היקף נקודות הבחירה הכללי ירד מ- 34.5 נק' ל- 32.5 נק' בהתאם לחלוקה הבאה: בחירה פיסיקה ירד מ- 9-12נק' ל- 8-11 נק'. בחירה חשמל ירד מ- 22.5-25.5 נק' ל- 21.5-24.5 נק'. להלן פרוט השינויים: אינפי 1מ מחליף את חדו"א 1ת, ללא שינוי במספר הנקודות.

		מש. דיפ.רגילות ת' 2.5 נק' הוחלף במקצוע מש. דיפ.רגילות ואינפי 2ח' – 5 נק'. אלקטרומגנטיות ואלקטרודינמיקה – תוספת 1 נק' פיסיקה סטטיסטית ותרמית – תוספת 1 נק' מעבדה לפיסיקה 4מח 1.5 נק' מחליפה את מעבדה לפיסיקה 4מח 2.5 נק' . כימיה כללית 3 נק' הוחלף בכימיה לפיסיקאים 3.5 נק' נוסף מעבדהל פיסיקה 3 – 1.5 נק' מעב לפיסיקה 5ת' ופרויקט ת' – כ"א 3 נק' - הועברו מחובה לבחירה, במסגרת מקצועות הבחירה מפיסיקה. מקצועות חדשים. התאמה לסמסטרים של 13 שבועות: בחשמל הותאמו 12 סילבוסים במקצועות חובה, מתוכננים שינויים בכ- 80 מקצועות בחירה. בפיסיקה 4 שינויים מהותיים, 3 שינויי ניקוד, התאמת סילבוסים בחלק גדול ממקצועות החובה.
רפואה- תוכנית אמריקאית	14-15	ללא שינוי.
הנדסת חומרים/פיסיקה (ארבע שנתית)	16-18	היקף נקודות החובה עלה בחצי נקודה (מ-142 נק' ל- 142.5 נק'), היקף נקודות הבחירה ירד בחצי נקודה (מ- 27.5 נק' ל- 27 נק'). להלן פרוט השינויים: מעבדה לפיסיקה 3 – מעבדה חדשה, תוספת 1.5 נק' פיסיקה סטטיסטית ותרמית – תוספת 1 נק' אלקטרומגנטיות ואלקטרודינמיקה – תוספת 1 נק' זרימה צמיגה ומעבר חום (3.5 נק') הוחלף במעבר תנע חום ומסה (4 נק') שינויים במקצועות המתמטיקה: חדו"א 1ת יוחלף בחשבון אינפי 1מ. מד"ר ת' יוחלף במד"ר ואינפי 2ח'. התאמה לסמסטרים של 13 שבועות: 2 שינויים מהותיים, 2 שינויי ניקוד. חומרי הלימוד בקורסים הותאמו לסמסטרים המקוצרים.
הנדסת חומרים/כימיה (ארבע שנתית)	19-21	היקף נקודות החובה עלה בנקודה וחצי (מ- 140.5 נק' ל- 142 נק'). היקף נקודות הבחירה ירד בנקודה וחצי (מ-29 נק' ל- 27.5 נק'). פרוט השינויים : במקצועות המתמטיקה : תוספת חצי נקודה עקב השינוי באלגברה לינארית (4.5 נק' במקום 4 נק'). תוספת חצי נקודה עקב השינוי במד"ח ח' – 2.5 נק', שהוחלף למד"ח מ' 3 נק'. זרימה צמיגה ומעבר חום (3.5 נק') הוחלף במעבר תנע חום ומסה (4 נק'). התאמה לסמסטרים של 13 שבועות: חומרי הלימוד בקורסים הותאמו לסמסטרים המקוצרים.
הנדסת חומרים/ביולוגיה	-	טרם הוגש
הנדסה ביו-רפואית (ארבע שנתית)	-	הוגש ברגע האחרון – לא כלול בחומר .
הנדסה ביו-רפואית – רפואה (תואר כפול) הנ. ביו-רפואית+ רפואה	-	טרם הוגש
הנדסה ביו-רפואית – פיסיקה (תואר כפול) הנ. ביו-רפואית+פיסיקה	22-26	היקף הנקודות בתכנית עלה מ- 176.5 נק' ל- 178 נק'. היקף נקודות החובה עלה מ- 136.5 נק' ל- 140 נק'. היקף נקודות הבחירה ירד מ- 30 נק' ל- 28 נק'. שינויים במקצועות חובה: אינפי 1מ (5.5 נק') מחליף את חדו"א 1ת (5.5 נק') מד"ר ואינפי 2מ (5 נק') מחליף את מד"ר ת (2.5 נק') התווספה מעבדה לפיסיקה 3 – 1.5 נק' אלקטרומגנטיות ואלקטרודינמיקה – תוספת 1 נק'

		פיסיקה סטטיסטית ותרמית – תוספת 1 נק' נקודות בחירה: מעבדה לפיסיקה 4מח 2.5 נק' הפכה למקצוע בחירה – 1.5 נק'. המעבדה היא חובה למי שבוחר פיסיקה של מצב מוצק. התאמה לסמסטרים של 13 שבועות: 5 שינויים מהותיים, 4 שינויי ניקוד,4 התאמות סילבוסים.

(ג)

ריכוז השינויים לתשע"ה דגבני - הני חשמל

תכנית הנדסת חשמל, הנדסת מחשבים ותכנה

1. המקצועות : "חדו"א 1ת" (104012) – 5.5 נק' ו"מש. דיפ. רגילות ת" (104135) – 2.5 נק', הוחלפו בהתאמה ל- "אינפי 1מ" (104031) – 5.5 נק' ו- מש. דיפ. רגילות ואינפי 2ח" (104035) – 5 נק'. המקצועות הישנים יינתנו בפעם האחרונה בסמסטר חורף תשע"ה, לצורך תיקון/שיפור.
2. לאור זאת, עבור הלומדים לפי התכנית החדשה, מספר נקודות החובה עלה ב- 2.5 נקודות, כאשר הקף הנקודות לסיום התואר עלה ב- 1 נק' (מ- 158 ל- 159) ונקודה וחצי תהיינה ע"ח נקודות הבחירה הפקולטיות.

תכנית תואר משולב חשמל–פיסיקה

1. זהה לשינויים במקצועות המתמטיים במסלול "הנדסת חשמל" כמצוין מעלה.
2. המקצוע "כימיה כללית" (125001) – 3 נק', הוחלף במקצוע "כימיה לפיסיקאים" (124108) – 3.5 נק' והוא הועבר לסמסטר 7.
3. המקצוע "מבוא להסתברות ח'" (104034) הוקדם לסמסטר 3
4. המקצוע "מעב. לפיסיקה 2מח'" (114030) הועבר לסמסטר 4
5. המקצוע "תורה אלקטרומגנטית" (114245) – 4 נק', הוחלף במקצוע חדש "אלקטרומגנטיות ואלקטרודינמיקה" (114246) – 5 נק'.
6. המקצוע "פיסיקה סטטיסטית ותרמית" (115211) – 4 נק', הוחלף במקצוע "פיסיקה סטטיסטית ותרמית" (114036)–5נק'
7. המקצוע "מעבדה לפיסיקה 4מח'" (114031) – 2.5 נק', הוחלף במקצוע "מעבדה לפיסיקה 4מח'" (114037) – 1.5 נק' והוא מומלץ לסמסטר 6
8. נוסף מקצוע חדש : "מעב. לפיסיקה 3 – גלים" (114035) – 1.5 נק' והוא מומלץ לסמסטר 5.
9. "מעב. לפיס. 5ת (114250) ו"פרוייקט ת'" (114252) הוצאו מאמסגרת מקצועות החובה והועברו למסגרת 8–11 נק' הבחירה מפיסיקה.
10. לאור זאת, עבור הלומדים לפי התכנית החדשה, הקף נקודות החובה עלה ב- 1.5 נקודות, כאשר הקף הנקודות לתואר עלה ב- 0.5 נק' (מ- 179 ל- 179.5) ונקודה אחת תהיה ע"ח נקודות הבחירה הפקולטיות של פיסיקה.

(2)

תכנית הנדסת מחשבים

1. יהה לשינויים במקצועות המתמטיים במסלול "הנדסת חשמל" כמצויין מעלה.
2. לאור זאת, עבור הלומדים לפי התכנית החדשה, הקף נקודות החובה עלה ב- 2.5 נקודות, כאשר הקף הנקודות לתואר עלה ב- 1 נק' (מ- 157 ל- 158) ונקודה וחצי תהיינה ע"ח נק' הבחירה הפקולטיות.
3. המקצוע "אלגברה מוד. ח'" (104134) הועבר לסמסטר 3.

כללי:

נוספו מקצועות בחירה חדשים:

1. "מבוא למערכות הספק ורשת חכמה" (044195) – לקב. התמחות "בקרה" במסלול הנדסת חשמל, הנדסת מחשבים ותכנה, וחשמל-פיסיקה.
2. "מאירי מתח מיתוגים" (044139) – לקב. התמחות "מעגלים אלקטרוניים ומערכות VLSI" במסלול הנדסת חשמל וחשמל-פיסיקה
3. "הנדסת מעבדי מחשב" (046268) – לקב. התמחות "מחשבים" במסלול הנדסת חשמל וחשמל-פיסיקה
4. "עבוד אותות מרחבי" (046743) – לקב. התמחות: "תקשורת", "אותות ומערכות ביולוגיים", "עיבוד אותות ותמונות" במסלול הנדסת חשמל, הנדסת מחשבים ותכנה, וחשמל-פיסיקה
5. "אלגו' לעריכת ובדיקת מעגלי VLSI" (046918) – לקב. התמחות "מחשבים" ו"מעגלים אלקטרוניים ומערכות VLSI" במסלול הנדסת חשמל וחשמל-פיסיקה

ובנוסף, עודכנו השם, הסילבוס ומקצועות הקדם של המקצוע "תכן בעזרת מחשב של VLSI" (046880)
ל- "תכן לוגי של מערכות VLSI"

הסילבוסים של המקצועות 044195 ו- 044139 מצ"ב

כ"כ, בוטל מקצוע הצמד "גלים ומערכות מפולגות" (044148) למקצוע "אלקטרואופטיקה 1" (044339)

(3)

נספח 2: טופס הגשת תכנית לימודים

יחידה: **הנדסת חשמל**

מסלול הלימודים: **הנדסת חשמל תשע"ה**

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס בהדפסה בלבד (ולא בכתב-יד). לנוחיותכם, המסמך נשלח אליכם בפורמט של WORD. ואולם, נא לא להתזירו ללימודי הסמכה בדואר אלקטרוני.

1	האם יש שינוי בהיקף הנקודות בתכנית?	כן
	פירוט: **עקב החלפת המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק' במקצוע "מש. דיפ. רג. ואינפי 2ח" (104035) – 5 נק', נוספה נקודה אחת לסך הנקודות לתואר – סה"כ 159 נקודות ונקודה וחצי תהיה ע"ח בחירה פקולטית**	
2	האם יש שינוי במקצועות היסוד? פירוט: **המקצוע "חדו"א 1ת" (104012) הוחלף ב"אינפי 1מ" (104031), ללא שינוי במספר הנקודות.** **המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק', הוחלף במקצוע "מש. דיפ. רג. ואינפי 2ח" (104035) – 5 נק'**	כן
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	לאור הנ"ל, היקף נק' החובה עלה ב- 2.5 נק'	
4	האם יש שינוי בהיקף מקצועות הבחירה? **41 נק' במקום 42.5 נק'**	כן
5	האם התכנית מכילה מקצועות לימוד חדשים?	כן
	פירוט: **כנ"ל ובנוסף -** **1. מקצוע מוסמכים "אלגו' לעריכת ובדיקת מעגלי VLSI" יהיה משותף גם להסמכה ומספרו - 046918** **2. מקצועות בחירה חדשים : "מבוא למערכות הספק ורשת חכמה" – 044195, "ממירי מתח ממותגים" - 044139, "הנדסת מעבדי מחשב" – 046268, "עבוד אותות מרחבי" - 046743** **המקצועות הנ"ל שובצו בקב. ההתמחות כמפורט בתכנית המצורפת.**	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע. **כנ"ל. הפקולטה למתמטיקה – פרופ' רון אהרוני**	כן
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	לא
8	הערות נוספות: **נעשתה התאמה של התכנית לסמסטרים של 13 שבועות : אין מקצועות שעברו שינוי מהותי או ששונה בהם הניקוד.** **בתאום עם אנשי התחום בכ"א מהמקצועות ובתאום עם המרצים במקצועות ההמשך, ב-12 מקצועות חובה הסילבוסים הותאמו ל- 13 שבועות ובמקצועות הבחירה (כ- 80), מתוכננים שינויים שאינם מחייבים שינוי מהותי בקטלוג.**	

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נספח 2: טופס הגשת תכנית לימודים

יחידה: **הנדסת חשמל**

מסלול הלימודים: **הנדסת מחשבים ותכנה תשע"ה**

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס בהדפסה בלבד (ולא בכתב-יד). לנוחיותכם, המסמך נשלח אליכם בפורמט של WORD. ואולם, נא לא להחזירו ללימודי הסמכה בדואר אלקטרוני.

1	האם יש שינוי בהיקף הנקודות בתכנית? פירוט: **עקב החלפת המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק' במקצוע "מש. דיפ. רג. ואינפי 2ח" (104035) – 5 נק', נוספה נקודה אחת לסך הנקודות לתואר – סה"כ 159 נקודות ונקודה וחצי ע"ח בחירה פקולטית**	כן
2	האם יש שינוי במקצועות היסוד? פירוט: **המקצוע "חדו"א 1ת" (104012) הוחלף ב"אינפי 1מ" (104031), ללא שינוי במספר הנקודות.** **המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק', הוחלף במקצוע "מש. דיפ. רג. ואינפי 2ח" (104035) – 5 נק'**	כן
3	האם יש שינוי בהיקף מקצועות החובה? **לאור הנ"ל, היקף נק' החובה עלה ב- 2.5 נקודות**	כן
4	האם יש שינוי בהיקף מקצועות הבחירה? **37 נק' במקום 38.5 נק'**	כן
5	האם התכנית מכילה מקצועות לימוד חדשים? **כנ"ל ובנוסף -** **1. מקצוע מוסמכים "אלגו' לעריכת ובדיקת מעגלי VLSI" יהיה משותף גם להסמכה ומספרו - 046918** **2. מקצועות בחירה חדשים : "מבוא למערכות הספק ורשת חכמה" – 044195, "ממירי מתח ממותגים" - 044139, "הנדסת מעבדי מחשב" – 046268, "עבוד אותות מרחבי" - 046743** **המקצועות הנ"ל שובצו בקב. ההתמחות כמפורט בתכנית המצורפת.**	כן
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע. **כנ"ל. הפקולטה למתמטיקה, פרופ' רון אהרוני**	לא
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	לא
8	הערות נוספות: **נעשתה התאמה של התכנית לסמסטרים של 13 שבועות : אין מקצועות שעברו שינוי מהותי או ששונה בהם הניקוד.** **בתאום עם אנשי התחום בכ"א מהמקצועות ובתאום עם המרצים במקצועות ההמשך, ב-15 מקצועות חובה ו- 8 מקצועות הליבה הסילבוסים הותאמו ל- 13 שבועות ובמקצועות הבחירה (כ- 55), מתוכננים שינויים שאינם מחייבים שינוי מהותי בקטלוג.**	

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הטכניון - מכון טכנולוגי לישראל

הפקולטה למדעי המחשב

הפקולטה להנדסת חשמל

9.6.14 (22.5.2014)

אל: פרופ' יכין כהן – דיקן לימודי הסמכה
מאת: פרופ' עירד יבנה – דיקן הפקולטה למדעי המחשב
פרופ' אריאל אורדע – דיקן הפקולטה להנדסת חשמל

הנדון: **תכניות לימודים משותפת לתואר ראשון במסלול להנדסת מחשבים - תשע"ה**

מצורפים טפסי פירוט השינויים במסלול להנדסת מחשבים מוגשים על ידי שתי היחידות (המערכת המומלצת מעט שונה בשתי היחידות). כמו כן מצורפים דפי התכנית המעודכנים.

בברכה,

פרופ' עירד יבנה

פרופ' אריאל אורדע

אישור מועצת פקולטה מדעי המחשב: 10.6.14 - כפוף לאישור מועצה
אישור מועצת פקולטה הנדסת חשמל: 21.5.14

אושר בקבלה אלקטרונית
8.6.14

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נספח 2: טופס הגשת תכנית לימודים

יחידה: מדעי המחשב והנדסת חשמל
מסלול הלימודים: הנדסת מחשבים – הפקולטה הנדסת חשמל - תשע"ה

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד)**. לנוחיותכם, המסמך נשלח אליכם בפורמט של WORD. ואולם, **נא לא להחזירו ללימודי הסמכה בדואר אלקטרוני**.

1	האם יש שינוי בהיקף הנקודות בתכנית?	כן
	פירוט: **158 נק' במקום 157 נק'**	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: **המקצוע "חדו"א 1ת" (104012) הוחלף ב"אינפי 1מ" (104031), ללא שינוי במספר הנקודות.** **המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק', הוחלף במקצוע "מש. דיפ. רג. ואינפי 2ת (104035) – 5 נק'**	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	פירוט: **110-112.5 במקום 107.5-110**	
4	האם יש שינוי בהיקף מקצועות הבחירה? פירוט: **24.5-29 במקום 26-30.5**	כן
כנ"ל	האם התכנית מכילה מקצועות לימוד חדשים?	כן
	פירוט: **כנ"ל**	
6	האם יש בתכנית מקצועות תדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	כן
	פירוט: **כנ"ל. הפקולטה למתמטיקה, פרופ' רון אהרוני**	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו ת השינוי.	לא

8	הערות נוספות: **א. הוסכם בין הפקולטות להנדסת חשמל ולמדעי המחשב כי בשנת תשע"ה, התכניות לא תהיינה זהות.** **ב. נעשתה התאמה של התכנית לסמסטרים של 13 שבועות – אין מקצועות פקולטיים שעברו שינוי מהותי או ששונה בהם הניקוד. בתאום עם אנשי התחום בכ"א מהמקצועות ובתאום עם המרצים במקצועות ההמשך, ב-8 מקצועות חובה הסילבוסים הותאמו ל- 13 שבועות ובמקצועות הבחירה (כ- 40), מתוכננים שינויים שאינם מחייבים שינוי מהותי בקטלוג.**	

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טופס 2: טופס הגשת תכנית לימודים

יחידה: מדעי המחשב והנדסת חשמל
מסלול הלימודים: הנדסת מחשבים - הפקולטה למדעי המחשב - תשע"ה

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד)**. לנוחיותכם, המסמך נשלח אליכם בפורמט של WORD. ואולם, **נא לא להחזירו ללימודי הסמכה בדואר אלקטרוני**.

1	האם יש שינוי בהיקף הנקודות בתכנית?	כן
	פירוט: 158 נק' במקום 157 נק'.	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: הקורסים חדו"א 1ת' וחדו"א 2ת' בסמסטרים 1 ו- 2 יוחלפו בקורסים חדשים חשבון אינפיניטסימלי 1מ' (104031) 5.5 נק' וחשבון אינפיניטסימלי 2מ' (104032) 5 נק'. נוסף קורס חדש אנליזה וקטורית (104033) 2.5 נק' שמכיל את החומר החסר עקב המעבר מחדו"א לאינפי וילמד בסמסטר השלישי.	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	פירוט: 111 – 113 נק' במקום 107.5 -110 נק'.	
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	פירוט: 24 – 28 נק' במקום 26 – 30.5 נק'.	
5	האם התכנית מכילה מקצועות לימוד חדשים?	כן
	פירוט: ראה סעיף 6.	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	כן
	פירוט: ראה סעיף 2 לעיל לגבי סמסטרים 1 ו- 2. בסמסטר 3 אנליזה וקטורית (104033). בסמסטר 3 ילמד הקורס מד"ר א (104285) במקום מד"ר ת' (104135). תואם עם הפקולטה למתמטיקה.	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתה תואם השינוי.	לא
	פירוט:	
8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - מס' המקצועות בהם שונה ניקוד - מס' המקצועות בהם הותאם הסילבוס – מס' המקצועות ללא שינוי – אחר (פרט) – ראה דוח בטופס המסלולים הכלליים של מדעי המחשב לגבי מקצועות הפקולטה להנדסת חשמל–ראה דוח שלהם.	כן
9	הערות נוספות: הקורס תכן לוגי 234262 עובר מסמסטר 3 לסמסטר 4 עקב הוספת אנליזה וקטורית 104033 בסמסטר 3. הוסכם בין הפקולטות למדעי המחשב והנדסת חשמל כי בשנת תשע"ה התכניות לא תהיינה זהות.	

הפקולטה להנדסת חשמל
אלקטרוניקה
מחשבים
תקשורת

הטכניון - מכון טכנולוגי לישראל

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לשכת הדיקן

תאריך: 26.5.2014

אל: פרופי י. כהן, דיקן לימודי הסמכה

מאת: פרופי נ. סוקר, דיקן הפקולטה לפיסיקה

פרופי א. אורדע, דיקן הפקולטה להנדסת חשמל

הנדון: **תוכנית לימודים משולבת חשמל-פיסיקה**

לשנת תשע"ה

מצורפת תוכנית הלימודים חשמל-פיסיקה לשנת תשע"ה לאחר אישור מועצת הפקולטה של פיסיקה מיום 8.5.2014 ומועצת הפקולטה של הנדסת חשמל מיום 21.5.2014.

השינויים מצורפים בתכנית.

בברכה,

פרופי נ. סוקר

פרופי א. אורדע

קרית הטכניון, חיפה 32000, טל: 04-8294680, פקס: 04-8323041, www.ee.technion.ac.il

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נספח 2: טופס הגשת תכנית לימודים

יחידה: הנדסת חשמל
מסלול מועדפים: משולב : חשמל - פיסיקה

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס <u>*מהמחשב בלבד*</u> (<u>ולא בכתב-יד</u>). לנוחיותכם, המסמך נשלח אליכם בפורמט של WORD. ואולם, נא *לא* להחזירו ללימודי הסמכה בדואר אלקטרוני.

1	האם יש שינוי בהיקף הנקודות בתכנית? פירוט: **בעקבות המפורט מטה, מספר הנקודות לסיום התואר עלה בחצי נקודה ל- 179.5** **א. המקצוע "חדו"א 1ת" (104012) הוחלף במקצוע "אינפי 1מ" (104031), ללא שינוי במספר הנקודות** **ב. המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק', הוחלף במקצוע "מש. דיפ. רג. ואינפי 2ח" (104035) – 5 נק'** **ג. המקצוע "תורה אלקט. מגנטית" (114245) – 4 נק', הוחלף במקצוע "אלקטרומגנטיות ואלקטרודינמיקה" (114246) – 5 נק'** **ד. המקצוע "פיסיקה סטטיסטית ותרמית" (114036) – 5 נק' מחליף את המקצוע "פיסיקה סטטיסטית ותרמית" (115211) – 4 נק'** **ה. המקצוע "מעב. לפיס. 4מח" (114031) – 2.5 נק', הוחלף במקצוע "מעב. לפיס. 4מח" (114037) – 1.5 נק'** **ו. המקצוע " כימיה כללית" (125001) – 3 נק', הוחלף במקצוע "כימיה לפיסיקאים" (124108) – 3.5 נק'** **ז. נוסף מקצוע חדש "מעב. לפיס. 3-גלים" (114035) – 1.5 נק'** **ת. המקצועות "מעב. לפיס. 5ת" (114250) והחילופי "פרויקט ת" – כ"א 3 נק', הועברו מחובה לבחירה, במסגרת מקצועות הבחירה מפיסיקה**	כן
2	האם יש שינוי במקצועות היסוד? **כנ"ל**	כן
3	האם יש שינוי בהיקף מקצועות החובה? **ההיקף עלה מ- 134-134.5 ל- 135.5-137**	כן
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	היקף נק' הבחירה הכללי ירד מ- 34.5 ל- 32.5, בהתאם לחלוקה הבאה: **היקף נק' הבחירה מפיסיקה ירד מ- 12-9 ל- 11-8** **היקף נק' הבחירה מחשמל ירד מ- 22.5-25.5 ל- 21.5-24.5**	
5	האם התכנית מכילה מקצועות לימוד חדשים? **כנ"ל ובנוסף -** **1. מקצוע מוסמכים "אלגו' לעריכת ובדיקת מעגלי VLSI" יהיה משותף גם להסמכה ומספרו - 046918.** **2. מקצועות חדשים : "מבוא למערכות הספק ורשת חכמה" – 044195, "ממירי מתח ממותגים" – 044139,**	כן

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	"הנדסת מעבדי מחשב" – 046268, "עבוד אותות מרחבי" - 046743	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע. **כנ"ל. הפקולטה למתמטיקה – פרופ' רון אהרוני, הפקולטה לכימיה**	כן
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	לא
8	הערות נוספות: **נעשתה התאמה של התכנית לסמסטרים של 13 שבועות : אין מקצועות מחשמל (04) שעברו שינוי מהותי או ששונה בהם הניקוד.** **בתאום עם אנשי התחום בכ"א מהמקצועות הפקולטיים ובתאום עם המרצים במקצועות ההמשך, ב-12 מקצועות חובה הסילבוסים הותאמו ל- 13 שבועות ובמקצועות הבחירה (כ- 80), מתוכננים שינויים שאינם מחייבים שינוי מהותי בקטלוג.**	

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נספח 1: טופס ריכוז שינויים בתכנית לימודים (תשע"ה)

יחידה: פיסיקה
מסלול הלימודים: פיסיקה - חשמל

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד).**

		נא לרשום "כן" או "לא"
1	האם יש שינוי בהיקף הנקודות בתכנית?	כן
	פירוט: תשע"ד – 179 תשע"ה – 179.5 א. המקצוע "חדו"א 1ת" (104012) הוחלף במקצוע "אינפי 1מ" (104031), ללא שינוי במספר הנקודות ב. המקצוע "מש. דיפ. רג. ת" (104135) – 2.5 נק', הוחלף במקצוע "מש. דיפ. רג. ואינפי 2ח" (104035) – 5 נק' ג. המקצוע "תורה אלקטרומגנטית" (114245) – 4 נק', הוחלף במקצוע " אלקטרומגנטיות ואלקטרודינמיקה" (114246) – 5 נק' ד. המקצוע "מעב. לפיס. 4מח" (114031) – 2.5 נק', הוחלף במקצוע "מעב. לפיס. 4מח" (114037) – 1.5 נק' ה. המקצוע " כימיה כללית" (125001) – 3 נק', הוחלף במקצוע "כימיה לפיסיקאים" (124108) – 3.5 נק' ו. נוסף מקצוע חדש "מעב. לפיס. 3-גלים" (114035) – 1.5 נק' ז. המקצועות "מעב. לפיס. 5ת" (114250) והחילופי "פרויקט ת" – כ"א 3 נק', הועברו מחובה לבחירה, במסגרת מקצועות הבחירה מפיסיקה ח. 114036 פיסיקה סטטיסטית ותרמית (5.0 נק') מחליף את 115211 פיסיקה סטטיסטית ותרמית (4.0 נק')	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: כמפורט מעלה	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	פירוט: תשע"ד: 134-134.5 נק' תשע"ה: 135.5-137 נק'	
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	פירוט: תשע"ד: 34.5 נק' תשע"ה: 32.5 נק'	

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	היקף נק' הבחירה מפיסיקה ירד מ- 9-12 ל- 8-11 היקף נק' הבחירה מחשמל ירד מ- 22.5-25.5 ל- 21.5-24.5	
5	האם התכנית מכילה מקצועות לימוד חדשים?	כן
	פירוט: כמפורט בסעיף 1 + כמפורט בטופס חשמל.	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	כן
	פירוט: הפקולטה למתמטיקה- פרופ' רון אהרוני הפקולטה לכימיה – פרופ' אורי פסקין	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	כן
	פירוט: *פירוט:* *סמסטר 4:* *114245 תורה אלקטרומגנטית 3 הר', 1 תר' שונה ל-* *114246 אלקטרומגנטיות ואלקטרודינמיקה 4 הר', 2 תר', 5 נק'* *115211 פיסיקה סטטיסטית ותרמית 3 הר', 2 תר',4 נק' שונה ל-* *114036 4 הר', 2 תר',5 נק'.* *סמסטר 5:* *נוספה מעבדה חדשה 114035 מעבדה לפיסיקה 3 1.5 נק'.* *סמסטר 6:* 114031 מעבדה לפיסיקה 4מח' (2.5 נק') הועברה לסמסטר 6 ומספרה שונה ל-114037 (ירדה הרצאה) (1.5 נק'). המקצועות "מעב. לפיס. 5ת" (114250) והחילופי "פרויקט ת" – כ"א 3 נק', הועברו מחובה לבחירה, במסגרת מקצועות הבחירה מפיסיקה.	
8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - 4 מס' המקצועות בהם שונה ניקוד - 3 מס' המקצועות בהם הותאם הסילבוס – חלק גדול מקורסי החובה. מס' המקצועות ללא שינוי – כל השאר אחר (פרט) – מקצועות מפיסיקה בלבד	כן
9	*הפקולטה לפיסיקה בוחנת את תוכניות הלימוד כל 3 עד 10 שנים.* *מקצועות רבים הותאמו לשינוי בידע קודם של מתקבלים ובתרבות המשתנה של הסטודנטים, לדוגמא: קורסי המתמטיקה היסודיים חונקו מאד לפני שנתיים. כמו כן, קורסים מתקדמים נשנה אחרונה בתואר, הכוו בחלקם לבחירה,*	כן

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	כדי לאפשר נוכחות מכסימלית לסטודנטים. לאור האמור, לא נדרשו לשינויים מרחיקי לכת עם המעבר ל- 13 שבועות לסמסטר.	

Technion – Israel Institute of Technology
American Program
Ruth and Bruce Rappaport
Faculty of Medicine

הטכניון מכון טכנולוגי לישראל
תוכנית אמריקאית
הפקולטה לרפואה ע"ש
רות וברוך רפפורט

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19.05.2014

לכבוד
פרופ' יכין כהן
דיקן לימודי הסמכה
הטכניון

שלום רב,

<u>הנדון : תכנית לימודים TeAMS רפואה לשנת תשע"ה (2014/2015)</u>

<u>מצ"ב תכנית הלימודים לשנת תשע"ה</u>

סה"כ הנקודות לתואר נשאר ללא שינוי משנה קודמת והוא 162.5 נקודות.

המקצועות בשנים הפרה קליניות – נשאר ללא שינוי 90.5 נק'

המקצועות בשנים הקליניות – נשאר ללא שינוי 72.0 נק'

בכבוד רב,

Andrew P. Levy MD PHD FACC
Professor
Vice Dean
Director Technion American Medical Program

פרופ' אנדרו לוי
ראש התוכנית האמריקאית

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נספח 1: טופס ריכוז שינויים בתכנית לימודים (תשע"ה)

יחידה: רפואה
מסלול הלימודים: TeAMS

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד).**

		נא לרשום "כן" או "לא"
1	האם יש שינוי בהיקף הנקודות בתכנית?	לא
	פירוט:	
2	האם יש שינוי במקצועות היסוד?	לא
	פירוט:	
3	האם יש שינוי בהיקף מקצועות החובה?	לא
	פירוט:	
4	האם יש שינוי בהיקף מקצועות הבחירה?	לא
	פירוט:	
5	האם התכנית מכילה מקצועות לימוד חדשים?	לא
	פירוט:	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	לא
	פירוט:	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	לא
	פירוט:	
8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - מס' המקצועות בהם שונה ניקוד - מס' המקצועות בהם הותאם הסילבוס – מס' המקצועות ללא שינוי – אחר (פרט) -	כן
9	הערות נוספות:	

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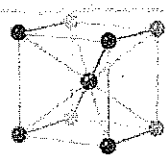

הפקולטה למדע והנדסה של חומרים
DEPARTMENT OF MATERIALS SCIENCE & ENGINEERING

תאריך: 25 במאי 2014

אל : פרופ' יכין כהן, דיקן למודי הסמכה

מאת : פרופ' וויין קפלן, דיקן הפקולטה להנדסת חומרים
פרופ' נועם סוקר , דיקן הפקולטה לפיסיקה

הנדון: **<u>תכנית למודים תשע"ה</u>**

מצורפת בזאת תכנית הלמודים לשנה"ל תשע"ד המשותפת לפקולטה להנדסת חומרים ולפקולטה לפיסיקה.

התכנית אושרה במועצת הפקולטה להנדסת חומרים בתאריך 22.5.14 ובמועצת הפקולטה לפיסיקה בתאריכים 8.5.14

ב ב ר כ ה,

פרופ' נועם סוקר
דיקן הפקולטה לפיסיקה

פרופ' וויין קפלן
דיקן הפקולטה להנדסת חומרים

קרית הטכניון, חיפה Technion City, Haifa Israel.32000
טלפון Telephone: +972-4-829-4591/2, פקסימיליה: Fax: +972-4-829-5677
http://www.technion.ac.il/technion/materials

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נספח 1: טופס ריכוז שינויים בתכנית לימודים (תשע"ה)

יחידה: הפקולטה למדע והנדסה של חומרים
מסלול הלימודים: הנדסת חומרים ופיסיקה

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד).**

		נא לרשום "כן" או "לא"
1	האם יש שינוי בהיקף הנקודות בתכנית?	לא
	פירוט:	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: קורס 104012-חדוא 1 ת' יוחלף בקורס 104301 חשבון אינפיניטסמילי 1 מ'. קורס 104135- מד"ר ת' יוחלף בקורס 104035- מד"ר ואינפי 2ח'.	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	מ-142 ל-142.5. פירוט: <u>קורסים חדשים:</u> 114035- מעבדה לפיסיקה 3. <u>קורסים מחליפים:</u> 115211 פיסיקה סטטיסטית ותרמית 4נק' הוחלף בקורס 114036- פיסיקה סטטיסטית ותרמית של 5 נק'. קורס 114245 תורה אלקטרומגנטית של 4 נק' הוחלף בקורס 114246 אלקטרומגנטיות ודינמיות של 5 נק'. קורס 084314 זרימה צמיגה ומעבר חום(3.5 נק) הוחלף בקורס 315039- מעבר תנע חום ומסה(4 נק). הקורס ניתן בעבר ע"י הפקולטה ורק במשך השנתיים האחרונות הוחלף בקורס של אווירונאוטיקה. <u>קורסים שיוצאים מתוכנית הלימודים:</u> 114037- מעבדה לפיסיקה 4 מח' עובר לקורסי הבחירה בפיסיקה. 124417- ספקטרוסקופיה מולקולרית- עבר לקורסי הבחירה מפקולטות אחרות.	
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	פירוט: מ-27.5 ל-27.0.	
5	האם התכנית מכילה מקצועות לימוד חדשים?	
	פירוט: 114035- מעבדה לפיסיקה 3.	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	לא

	פירוט:	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	לא
	פירוט:	
8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - 2 מס' המקצועות בהם שונה ניקוד - 2 מס' המקצועות בהם הותאם הסילבוס – מס' המקצועות ללא שינוי – אחר (פרט) – חומרי הלימוד בקורסים הותאמו לסמסטרים המקוצרים.	כן
9	הערות נוספות:	

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הפקולטה למדע והנדסה של חומרים
DEPARTMENT OF MATERIALS ENGINEERING

תאריך: 25 במאי 2014

אל : פרופ' יכין כהן, דיקן למודי הסמכה

מאת : פרופ' וויין קפלן, דיקן הפקולטה להנדסת חומרים
פרופ' אלון הופמן , דיקן הפקולטה לכימיה

הנדון: **<u>תכנית למודים תשע"ה</u>**

מצורפת בזאת תכנית הלמודים לשנה"ל תשע"ה המשותפת לפקולטה להנדסת חומרים ולפקולטה לכימיה.

התכנית אושרה במועצת הפקולטה להנדסת חומרים בתאריך 22.5.14 ובמועצת הפקולטה לכימיה בתאריך 24.3.14.

ב ב ר כ ה,

פרופ' אלון הופמן
דיקן הפקולטה לכימיה

פרופ' וויין קפלן
דיקן הפקולטה להנדסת חומרים

קרית הטכניון, חיפה Technion City, Haifa Israel.32000
טלפון Telephone: +972-4-829-4591/2, פקסימיליה: Fax: +972-4-829-5677
http://www.technion.ac.il/technion/materials

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נספח 1: טופס ריכוז שינויים בתכנית לימודים (תשע"ה)

יחידה: הפקולטה למדע והנדסה של חומרים
מסלול הלימודים: הנדסת חומרים וכימיה

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד).**

		נא לרשום "כן" או "לא"
1	האם יש שינוי בהיקף הנקודות בתכנית?	לא
	פירוט:	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: 104009- אלגברה ליניארית מ' של 4 נק' הוחלף בקורס 104019 –אלגברה ליניארית מ' של 4.5 נק'.(נוספה חצי שעת הרצאה). 104218- מד"ח ח' של 2.5 נק' הוחלף בקורס 104228- מד"ח מ' של 3 נק'. (נוספה שעת תרגול).	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	מ-140.5 ל-142.(1 בגלל השינויים בקורסי מתמטיקה שתוארו לעיל ו0.5 נק בגלל המפורט מטה). קורס 084314 זרימה צמיגה ומעבר חום(3.5 נק) הוחלף בקורס 315039- מעבר תנע חום ומסה(4 נק). הקורס ניתן בעבר ע"י הפקולטה זרק במשך השנתיים האחרונות הוחלף בקורס של אווירונאוטיקה.	
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	פירוט: מספר נקודות הבחירה ירד מ-29 ל-27.5 עקב השינוי במספר נק החובה. כימיה וחומרים- ללא שינוי, לפחות 11.5 מכל פקולטה. מרשימת הקורסים מפקולטות אחרות יש ללמוד-4.5 נק'.	
5	האם התכנית מכילה מקצועות לימוד חדשים?	לא
	פירוט:	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	לא
	פירוט:	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	לא
	פירוט:	

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8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - מס' המקצועות בהם שונה ניקוד - מס' המקצועות בהם הותאם הסילבוס – מס' המקצועות ללא שינוי – אחר (פרט) – נעשתה התאמה של חומרי הלימוד לסמסטרים המקוצרים.	
9	הערות נוספות:	

Technion
Israel Institute of Technology
Department of Physics
Office of the Dean
Tel: 972-4-829-3902 :טל

deanphys@ph.technion.ac.il

הטכניון
מכון טכנולוגי לישראל
הפקולטה לפיסיקה
לשכת הדיקן
FAX: 972-4-829-5755 :פקס

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תאריך: 18.5.2014

אל: פרופ' יכין כהן , דיקן לימודי הסמכה
מאת: פרופ' נועם סוקר, דיקן הפקולטה לפיסיקה
פרופ' אמיר לנדסברג, דיקן הפקולטה לביו-רפואה

הנדון: <u>תוכניות לימודים לשנת תשע"ה – תואר משולב פיסיקה – ביו-רפואה</u>

מצורפות תוכניות הלימודים לשנת תשע"ה, לתוכנית לתואר משולב בפיסיקה – ביו רפואה
לאחר אישור מועצת הפקולטה לפיסיקה מיום ה' 8.5.2014 והפקולטה לביו-רפואה מיום 18.5.2014.

בברכה

פרופ' נועם סוקר

פרופ' אמיר לנדסברג

Technion City, Haifa 32000, Israel

קרית הטכניון, חיפה 32000

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נספח 1: טופס ריכוז שינויים בתכנית לימודים (תשע"ה)

יחידה: הנדסה ביו-רפואית
מסלול הלימודים: מסלול משולב עם פיסיקה

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד).**

		נא לרשום "כן" או "לא"
1	האם יש שינוי בהיקף הנקודות בתכנית?	כן
	פירוט: מספר הנקודות עלה מ-176.5 נק' ל-178.0 נק'	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: סמסטר 1: 104031 אינפי 1מ' (5.5 נק') מחליף את 104012חדו"א 1ת' (5.5 נק') סמסטר 2: 104035 מד"ר ואינפי 2מ' (5.0 נק') מחליף את 104135 מד"ר ת' (2.5 נק')	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	פירוט: סמסטר 4: התווסף 114035 מעבדה לפיסיקה 3 (1.5 נק') סמסטר 6: 114246 אלקטרומגנטיות ואלקטרודינמיקה (5.0 נק') מחליף את 114245 תורה אלקטרומגנטית (4.0 נק') 114036 פיסיקה סטטיסטית ותרמית (5.0 נק') מחליף את 115211 פיסיקה סטטיסטית ותרמית (4.0 נק')	
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	פירוט: סמסטר 7: 114031 מעבדה לפיסיקה 4מח' בוטלה כחובה מסמסטר זה ומספרה שונה ל-114037 (ירדה הרצאה). מעבדה זו הועברה למקצועות בחירה בפיסיקה רק למי שלומד את 116217 פיסיקה של מצב מוצק. אחרים לא רשאים לקחת את המעבדה.	
5	האם התכנית מכילה מקצועות לימוד חדשים?	כן
	פירוט: כמפורט בסעיפים 2 ו-3	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	כן
	פירוט: סמסטר 1: 104031 אינפי 1מ' (5.5 נק') סמסטר 2: 104035 מד"ר ואינפי 2מ' סמסטר 4: 114035 מעבדה לפיסיקה 3 (1.5 נק') סמסטר 6: 114246 אלקטרומגנטיות ואלקטרודינמיקה (5.0 נק') 114036 פיסיקה סטטיסטית ותרמית (5.0 נק')	
7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת	לא

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	ושם איש הקשר איתו תואם השינוי.	
	פירוט:	
8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - 5 מס' המקצועות בהם שונה ניקוד - 4 מס' המקצועות בהם הותאם הסילבוס – כ-4 מס' המקצועות ללא שינוי – כל השאר אחר (פרט) -	
9	הערות נוספות:	לא

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נספח 1: טופס ריכוז שינויים בתכנית לימודים (תשע"ה)

יחידה: פיסיקה
מסלול הלימודים: תואר כפול הנדסה ביו רפואית פיסיקה

הנחיות:

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים במקרה של תשובות חיוביות.
- במידת הצורך נא להוסיף דפים נוספים.
- נא למלא את הטופס **בהדפסה בלבד (ולא בכתב-יד).**

		נא לרשום "כן" או "לא"
1	האם יש שינוי בהיקף הנקודות בתכנית?	כן
	פירוט: מספר הנקודות עלה מ-176.5 נק' ל-178.0 נק'	
2	האם יש שינוי במקצועות היסוד?	כן
	פירוט: סמסטר 1: 104031 אינפי 1מ' (5.5 נק') מחליף את 104012חדו"א 1ת' (5.5 נק') סמסטר 2: 104035 מד"ר ואינפי 2מ' (5.0 נק') מחליף את 104135 מד"ר ת' (2.5 נק')	
3	האם יש שינוי בהיקף מקצועות החובה?	כן
	פירוט: תשע"ד: 136.5 נק' תשע"ה: 140 נק' סמסטר 4: התווסף 114035 מעבדה לפיסיקה 3 (1.5 נק') סמסטר 6: 114246 אלקטרומגנטיות ואלקטרודינמיקה (5.0 נק') מחליף את 114245 תורה אלקטרומגנטית (4.0 נק') 114036 פיסיקה סטטיסטית ותרמית (5.0 נק') מחליף את 115211 פיסיקה סטטיסטית ותרמית (4.0 נק')	
4	האם יש שינוי בהיקף מקצועות הבחירה?	כן
	פירוט: תשע"ד: 30.0 נק' תשע"ה: 28.00 נק' סמסטר 7: 114031 מעבדה לפיסיקה 4מח' בוטלה כחובה מסמסטר זה ומספרה שונה ל-114037 (ירדה הרצאה). מעבדה זו הועברה למקצועות בחירה בפיסיקה רק למי שלומד את 116217 פיסיקה של מצב מוצק. אחרים לא רשאים לקחת את המעבדה.	
5	האם התכנית מכילה מקצועות לימוד חדשים?	כן
	פירוט: כמפורט בסעיפים 2 ו-3	
6	האם יש בתכנית מקצועות חדשים הניתנים ע"י יחידה אחרת? אם כן, פרט את המקצועות, שם היחידה הנותנת כל מקצוע, ושם איש הקשר ביחידה שאיתו תואם מתן המקצוע.	כן
	פירוט: סמסטר 1: 104031 אינפי 1מ' (5.5 נק') סמסטר 2: 104035 מד"ר ואינפי 2מ' (5 נק') ניתנים ע"י הפקולטה למתמטיקה.	

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7	האם יש בתכנית שינויים (סילבוס, הסמסטר בו הקורס ניתן וכו') במקצועות קיימים המיועדים ליחידה אחרת? אם כן, נא לפרט את המקצועות, שם היחידה האחרת ושם איש הקשר איתו תואם השינוי.	כן
	פירוט: *פירוט:* *סמסטר 4:* *נוספה מעבדה חדשה 114035 מעבדה לפיסיקה 3 1.5 נק'.* *סמסטר 6:* *114245 תורה אלקטרומגנטית 3 הר', 1 תר' שונה ל-* *114246 אלקטרומגנטיות ואלקטרודינמיקה 4 הר', 2 תר', 5 נק'* *115211 פיסיקה סטטיסטית ותרמית 3 הר', 2 תר',4 נק' שונה ל-* *114036 4 הר', 2 תר',5 נק'.* *סמסטר 7:* 114031 מעבדה לפיסיקה 4מח' (2.5 נק') בוטלה כחובה מסמסטר זה ומספרה שונה ל-114037 (ירדה הרצאה) (1.5 נק'). מעבדה זו הועברה למקצועות בחירה מפיסיקה והיא חובה רק למי שלומד את 116217 פיסיקה של מצב מוצק. אחרים לא רשאים לקחת את המעבדה.	
8	האם נעשתה התאמה של התכנית לסמסטרים של 13 שבועות? מס' המקצועות שעברו שינוי מהותי (איחוד, ביטול וכו') - 5 מס' המקצועות בהם שונה ניקוד - 4 מס' המקצועות בהם הותאם הסילבוס – כ-4 מס' המקצועות ללא שינוי – כל השאר אחר (פרט) – מקצועות ממתמטיקה ופיסיקה	כן
9	*הפקולטה לפיסיקה בוחנת את תוכניות הלימוד בכל 3 שנה 10 שנים.* *מקצועות רבים הותאמו לשינוי בידע קודם של מתקבלים ובתרבות המשתנה של הסטודנטים, לדוגמא: קורסי המתמטיקה היסודיים חוזקו מאד לפני שנתיים. כמו כן, קורסים מתקדמים בשנה אחרונה מתואר, הפכו מחלקם לבחירה,* *כדי לאפשר גמישות מכסימלית לסטודנטים. לאור האמור, לא נדרשנו לשינויים מרחיקי לכת עם המעבר ל- 13 שבועות לסמסטר.*	כן

נספח 5

תאריך: 15/6/2014

אל: פרופ' פרץ לביא, נשיא הטכניון

מאת: פרופ' יכין כהן , דיקן לימודי הסמכה

הנדון: <u>תכניות "אפיק מעבר" מהאוניברסיטה הפתוחה תשע"ה - המשך</u>

מצורפות תכניות "אפיק מעבר" לתשע"ה שהתקבלו לאחר מועד כינוס הוועדה המרכזת ביום 25/5/2014. ואלה המסלולים המצורפים :
הנדסת חשמל
כימיה
ביוכימיה מולקולרית

אודה לך אם תביא את התכניות הנ"ל לדיון בועדה המרכזת בתאריך 22/6/2014 , ולאישור ועדת הקבע ללימודים אקדמיים בתאריך 22/6/2014 .

הערה: תכניות אפיק מעבר במסלולים חומרים-כימיה, חומרים-פיסיקה טרם הוגשו.

בברכה,

יכין כהן

העתקים: פרופ' משה סידי, המשנה הבכיר לנשיא
עו"ד אביבה דרוגן, מזכירת הסנט

נספח: תכנית "אפיק המעבר" מהאוניברסיטה הפתוחה תשע"ה

יחידה: הנדסת חשמל
מסלול הלימודים: "אפיק מעבר" – תשע"ה

- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים כנדרש.
- נא למלא את הטופס בהדפסה בלבד (ולא בכתב-יד). לנוחיותכם, המסמך נשלח אליכם בפורמט של WORD. (ואולם, נא לא להחזירו ללימודי הסמכה בדואר אלקטרוני).

		נא לרשום "כן" או "לא"
1	האם יש שינויים מהתכנית שאושרה לתשע"ד? בעקבות השינויים בקורסים "אינפי 1" ו"אינפי 2", מועצת הפקולטה מיום 9.4.14 אישרה את השינויים המוצעים ע"י דיקן לימודי הסמכה	כן
2	לפי הכללים כל מועמד חייב להשלים מסגרת לימודים של 30 נקודות טכניוניות, בציון ממוצע של 80 וציון מינימלי של 70 בכל מקצוע. האם יש חריגה מכללים אלה?	לא

נספח: תכנית "אפיק המעבר" מהאוניברסיטה הפתוחה תשע"ה

יחידה: כימיה
מסלול הלימודים: כימיה

הנחיות:
- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים כנדרש.
- נא למלא את הטופס בהדפסה בלבד (ולא בכתב-יד).

		נא לרשום "כן" או "לא"
1	האם יש שינויים מהתכנית שאושרה לתשע"ד?	כן
	אם כן "פרט": הקורס אלגברה לינארית (104006) הוחלף בקורס אלגברה לינארית מ' (104019) בהיקף של 4.5 נק')	
2	לפי הכללים כל מועמד חייב להשלים מסגרת לימודים של 30 נקודות טכניוניות, בציון ממוצע של 80 וציון מינימלי של 70 בכל מקצוע. האם יש חריגה מכללים אלה?	לא
	אם "כן", נא לפרט, ולהוסיף נימוקים:	

הפקולטה לכימיה

על הסטודנטים לסיים באוניברסיטה הפתוחה, בציון ממוצע 80 ומעלה, מקבץ קורסים מתוך הרשימה אשר סך הניקוד עבורם בטכניון מצטבר ל- 30 נקודות (כולל נקודות הבונוס). ציון המעבר לקורס בודד הוא 70

האוניברסיטה הפתוחה		הטכניון		
שם הקורס	נ"ז	שם הקורס	נ"ז	בונוס
כימיה כללית (20437) (1) + מעבדה כימיה כללית (202234)	6 2	יסודות הכימיה א' (124117) + יסודות הכימיה ב' (124118)	3 3	- -
כימיה אורגנית (20456)	6	כימיה אורגנית 1 מורחב (124708)	5	-
ביוכימיה א' (20204)	3	מבוא לביוכימיה ואנזימולוגיה (134019)	2.5	-
התא: מבנה ופעילות (20214)	6	נושאים בביולוגיה מודרנית (134127)	2	1
תרמודינמיקה (20217) (2)	3	כימיה פיסיקלית – תרמודינמיקה כימית (124415)	4	-
אלגברה 1 (20109)	6	אלגברה לינארית מ' (104019)	4.5	-
חדו"א א' (20406) (3)	6	חדו"א 1 (104003)	5	-
חדו"א ב' (20423) (4)	6	חדו"א 2 (104004)	5	-
מבוא למדעי המחשב - JAVA(20441) (5)	6	מבוא למחשב – שפת C (234112) או מטל"ב (234127)	4 4	- -
מכניקה (20215)	6	פיסיקה 1ל' (114078) או פיסיקה 1 (114051)	2.5 2.5	1 1

1. או קורסי כימיה כללית (20487, 20477) שאינם מוצעים עוד באו"פ. במקום הקורס כימיה כללית אפשר ללמוד באו"פ את צמד הקורסים כימיה כללית א' (20470, 4 נ"ז) + כימיה כללית ב' לביולוגים (20490, 2 נ"ז), או את צמד הקורסים כימיה כללית א' (20470, 4 נ"ז) + כימיה כללית ב' (20480, 4 נ"ז)
2. קורס האו"פ יפטור את הסטודנטים מלימוד הקורס הטכניוני המקביל, אך יקנה בטכניון 3 נקודות צבירה. את הנקודה החסרה יש להשלים במסגרת נקודות בחירה פקולטית.
3. במקום חדו"א א' אפשר לבחור באו"פ את אינפי 1 (20106), שיקנה גם נקודות בונוס אחת.
4. במקום חדו"א ב' אפשר לבחור באו"פ את צמד הקורסים אינפי 2 (20212) + אינפי 3 (20224), שיקנה גם 3 נקודות בונוס.
5. נדרש ציון 80 ומעלה בקורס של האו"פ.

- 1 -05- 2014

22 במאי 2014

אל: פרופ' י. כהן, דקן לימודי הסמכה
מאת: דיקן הפקולטה לביולוגיה
דיקן הפקולטה לכימיה

<u>תוכנית הלימודים בביוכימיה מולקולרית ותוכנית "אפיק מעבר" מהאו"פ לשנת תשע"ה</u>

מצורפת תוכנית הלימודים במסלול ביוכימיה מולקולרית לשנת תשע"ה.

התוכנית אושרה פה אחד במועצת הפקולטה לביולוגיה בתאריך ה-21.3.2014 ובמועצת הפקולטה לכימיה בתאריך ה- 24.3.2014

בכבוד רב,

פרופ' יהודה אסרף
דיקן הפקולטה לביולוגיה

פרופ' אלון הופמן
דיקן הפקולטה לכימיה

נספח: תכנית "אפיק המעבר" מהאוניברסיטה הפתוחה תשע"ה

יחידה: כימיה וביולוגיה
מסלול הלימודים: ביוכימיה מולקולרית

הנחיות:
- יש לרשום "כן" או "לא" משמאל, ולהוסיף הסברים כנדרש.
- נא למלא את הטופס בהדפסה בלבד (ולא בכתב-יד).

		נא לרשום "כן" או "לא"
1	האם יש שינויים מהתכנית שאושרה לתשע"ד?	כן
	אם כן "פרט": הקורס אלגברה לינארית (104006) הוחלף בקורס אלגברה לינארית מ' (104019) בהיקף של 4.5 נק')	
2	לפי הכללים כל מועמד חייב להשלים מסגרת לימודים של 30 נקודות טכניוניות, בציון ממוצע של 80 וציון מינימלי של 70 בכל מקצוע. האם יש חריגה מכללים אלה?	לא
	אם "כן", נא לפרט, ולהוסיף נימוקים:	

הפקולטה לכימיה

הפקולטה לביולוגיה

מסלול: ביוכימיה מולקולרית

על הסטודנטים לסיים באוניברסיטה הפתוחה, בציון ממוצע 80 ומעלה, מקבץ קורסים מתוך הרשימה אשר סך הניקוד עבורם בטכניון מצטבר ל- 30 נקודות (כולל נקודות הבונוס). ציון המעבר לקורס בודד הוא 70

האוניברסיטה הפתוחה		הטכניון		
שם הקורס	נ"ז	שם הקורס	נ"ז	בונוס
חדו"א א' (20406) (1)	6	חדו"א 1 (104003)	5	-
חדו"א ב' (20423) (2)	6	חדו"א 2 (104004)	5	-
אלגברה 1 (20109)	6	אלגברה לינארית מ' (104019)	4.5	-
מכניקה (20215)	6	פיסיקה 1ל' (114077) או פיסיקה 1 (114051)	2.5 2.5	1 1
כימיה כללית (20437) (3)	6	יסודות הכימיה א' (124117) + יסודות הכימיה ב' (124118)	3 3	- -
כימיה אורגנית (20456)	6	כימיה אורגנית 1 מורחב (124708)	5	-
ביולוגיה כללית א' (20118) + ביולגיה כללית ב' (20119)	6 6	ביולוגיה 1 (134058) + זואולוגיה (134111)	3 3	1
ביוכימיה א' (20204)	3	מ בוא לביוכימיה ואנזימולוגיה (134019)	2.5	-
מבוא למדעי המחשב – JAVA(20441)	6	מבוא למחשב שפת C(234112)	4	

1. במקום חדו"א א' אפשר לבחור באו"פ את אינפי 1 (20106), שיקנה גם נקודת בונוס אחת
2. במקום הקורס חדו"א ב' אפשר לבחור באו"פ את צמד הקורסים אינפי 2 (20212) + אינפי 3 (20224) שיקנה גם 3 נקודות בונוס.
3. או קורסי כימיה כללית (20477, 20448), שאינם מוצעים עוד באו"פ. במקום הקורס כימיה כללית אפשר ללמוד באו"פ את צמד הקורסים כימיה כללית א' (20470, 4 נ"ז) + כימיה כללית ב' לביולוגים (20490, 2 נ"ז), או את צמד הקורסים כימיה כללית א' (20470, 4 נ"ז) + כימיה כללית ב' (20480, 4 נ"ז).

11 יוני 2014

אל: פרופ' פרץ לביא, יו"ר הוועדה המרכזת

מאת: דיקן ביה"ס לתארים מתקדמים

נספח 6

הנדון: <u>בקשה לשינוי סעיף 24.07 – העברה למסלול ישיר לדוקטורט</u>

בהתאם לתקנות הנהוגות כיום, סטודנט שעובר למסלול הישיר לדוקטורט נשאר במעמד של סטודנט לתואר מגיסטר עד למעבר בחינת המועמדות. רק לאחר שעמד בבחינת המועמדות מוסב מעמדו לזה של סטודנט לתואר דוקטור. הדבר ייצר עיוות פסיכולוגי ועיוות כלכלי.

מניסיוני, ובמענה לפניות של עמיתים וההנהלה, אני מציע להסב את מעמדו של הסטודנט מהיום שבו הוחלט להעבירו למסלול הישיר למעמד של דוקטורנט. הדבר יתרום לתחושת ההערכה העצמית של הסטודנט, ובנוסף ישווה את מעמדו לזה של דוקטורנט מכל הבחינות האחרות, כמו זכאות להגשה לפרסים, תגמול עבור תרגול וכו'. בהתאם לניסיון המצטבר, רק אחוז זעום של הסטודנטים אינו עובר את בחינת המועמדות, ומחיר השינוי מראש של מעמדו של סטודנט שעשוי להיכשל בבחינת המועמדות הוא זניח.

לאור זאת, אני מבקש לשנות את סעיף 24.07 בתקנות בית הספר לתארים מתקדמים כמפורט בעמוד הבא.

אודה לך אם תביא נושא זה לדיון בוועדה המרכזת.

בברכה,

בן-ציון לוי

העתק:
המשנה הבכיר
מזכיר הסנט

בל/יג
שינוי סעיף 24.07 – לועדה המרכזת

Technion city, Haifa 3200003, Israel
Churchill Building, Room 205
Tel. 972-4-829-2478, Fax. 04-829-5635
Email: tgs-dean@technion.ac.il

קרית הטכניון, חיפה 3200003
בניין צ'רצ'יל, חדר 205
טל' 04-829-2478, פקס. 04-829-5635
דוא"ל: www.graduate.technion.ac.il

24.07 העברה למסלול ישיר לדוקטורט – סעיף קיים	24.07 העברה למסלול ישיר לדוקטורט – סעיף מוצע
הדיקן רשאי להעביר סטודנט לתואר מגיסטר המבצע מחקר, למעמד של סטודנט לתואר דוקטור במסלול ישיר, אם הסטודנט הוכיח תוך כדי מחקרו כשרון והישגים המצדיקים העברה כזאת. על הסטודנט למלא את התנאים הבאים:	הדיקן רשאי להעביר סטודנט לתואר מגיסטר המבצע מחקר, למעמד של סטודנט לתואר דוקטור במסלול ישיר, אם הסטודנט הוכיח תוך כדי מחקרו כשרון והישגים המצדיקים העברה כזאת. על הסטודנט למלא את התנאים הבאים:
א. השלים לפחות סמסטר אחד שלם לאחר אישור נושא המחקר. במקרים מיוחדים רשאי הדיקן לקצר תקופה זו בהתאם להמלצה מנומקת של הוועדה. ב. השלים לפחות מחצית ממכסת נקודות הלימוד אשר חויב בה, והשיג רמת ציונים טובה מאד (ציון ממוצע 90 לפחות). ג. הוועדה השתכנעה כי המועמד מתאים לתואר דוקטור ונושא מחקרו למגיסטר ניתן להרחבה להיקף הנדרש מעבודת דוקטור. ד. על סטודנט בוגר תואר ארבע שנתי בטכניון שסיים את לימודיו לתואר ראשון בהצטיינות (ממוצע 85 לפחות) או שהיה מצטיין נשיא בארבעה הסמסטרים האחרונים, וכן סטודנט בוגר תואר ראשון שלוש שנתי בטכניון או באוניברסיטה שסיים את לימודיו בהצטיינות יתרה (מצטיין נשיא או מקביל) - יחולו התנאים המופיעים בסעיפים א' ב' ג' לעיל, למעט ההקלות הבאות: הוא יוכל לבקש לעבור למסלול הישיר לאחר סמסטר אחד, ולאחר השלמת לפחות שליש מהנקודות הנדרשות (אך לא פחות משמונה). סטודנט משלים שנדרש בהשלמות יצטרך בנוסף לסיים את כל מקצועות ההשלמה.	א. השלים לפחות סמסטר אחד שלם לאחר אישור נושא המחקר. במקרים מיוחדים רשאי הדיקן לקצר תקופה זו בהתאם להמלצה מנומקת של הוועדה. ב. השלים לפחות מחצית ממכסת נקודות הלימוד אשר חויב בה, והשיג רמת ציונים טובה מאד (ציון ממוצע 90 לפחות). ג. הוועדה השתכנעה כי המועמד מתאים לתואר דוקטור ונושא מחקרו למגיסטר ניתן להרחבה להיקף הנדרש מעבודת דוקטור. ד. על סטודנט בוגר תואר ארבע שנתי בטכניון שסיים את לימודיו לתואר ראשון בהצטיינות (ממוצע 85 לפחות) או שהיה מצטיין נשיא בארבעה הסמסטרים האחרונים, וכן סטודנט בוגר תואר ראשון שלוש שנתי בטכניון או באוניברסיטה שסיים את לימודיו בהצטיינות יתרה (מצטיין נשיא או מקביל) - יחולו התנאים המופיעים בסעיפים א' ב' ג' לעיל, למעט ההקלות הבאות: הוא יוכל לבקש לעבור למסלול הישיר לאחר סמסטר אחד, ולאחר השלמת לפחות שליש מהנקודות הנדרשות (אך לא פחות משמונה). סטודנט משלים שנדרש בהשלמות יצטרך בנוסף לסיים את כל מקצועות ההשלמה.
במקרים כאלה יכולה הוועדה להמליץ בפני הדיקן על המעבר. להמלצה יצורפו חוות-דעת של המנחה ושל ממליץ נוסף, וכן סיכום תמציתי של עבודתו לתואר מגיסטר עד אותו מועד, ושל תכנית המחקר לתואר דוקטור.	במקרים ~~כאלה~~אלה (סעיפים א-ד) יכולה הוועדה להמליץ בפני הדיקן על המעבר. להמלצה יצורפו חוות-דעת של המנחה ושל ממליץ נוסף, וכן סיכום תמציתי של עבודתו לתואר מגיסטר עד אותו מועד, ושל תכנית המחקר לתואר דוקטור.
לאחר אישור המעבר על-ידי הדיקן, יגיש הסטודנט תיאור תמציתי של הצעת המחקר וייגש לבחינת המועמדות תוך שישה חודשים ממועד ההודעה על ההעברה למסלול הישיר (ראה סעיף 36.01). במקרים מיוחדים רשאי הדיקן להאריך תקופה זו בהתאם להמלצה מנומקת של הוועדה.	לאחר אישור המעבר על-ידי הדיקן, ~~יגיש הסטודנט~~יוסב מעמדו של הסטודנט למעמד של סטודנט לתואר דוקטור. משך השתלמותו יוארך בעוד שמונה סמסטרים, והוא יחויב ללמוד מקצועות מתקדמים נוספים הנדרשים מסטודנטים לדוקטורט בהיקף שייקבע על-ידי היחידה, ולא פחות מ- 5 נקודות. הסטודנט יגיש תיאור תמציתי של הצעת המחקר וייגש לבחינת המועמדות תוך שישה חודשים ממועד ההודעה על ההעברה למסלול הישיר (ראה סעיף 36.01). במקרים מיוחדים רשאי הדיקן להאריך תקופה זו בהתאם להמלצה מנומקת של הוועדה.
אם ימלא הסטודנט את התנאים, יוסב מעמדו למעמד של סטודנט לתואר דוקטור. משך השתלמותו יוארך בעוד שמונה סמסטרים, והוא יחוייב ללמוד נקודות מתקדמים נוספות בהיקף שייקבע על-ידי היחידה, ולפחות 5 נקודות. בנוסף, יהיה הסטודנט זכאי לתעודת מגיסטר (ראה סעיף 21.04) לאחר שעמד בהצלחה בבחינת המועמדות, ולאחר שהשלים את כל דרישות הקורסים שהוטלו עליו בעת הקבלה לתואר מגיסטר, ביחידות שיבחרו להפעיל הסדר זה.	~~אם ימלא הסטודנט את התנאים, יוסב מעמדו למעמד של סטודנט לתואר דוקטור. משך השתלמותו יוארך בעוד שמונה סמסטרים, והוא יחוייב ללמוד נקודות מתקדמים נוספות בהיקף שייקבע על-ידי היחידה, ולפחות 5 נקודות. בנוסף, יהיה הסטודנט זכאי לתעודת מגיסטר (ראה סעיף 21.04)~~ לאחר שעמד בהצלחה בבחינת המועמדות, ולאחר שהשלים את כל דרישות ~~הקורסים~~המקצועות שהוטלו עליו בעת הקבלה לתואר מגיסטר, ~~ביחידות שיבחרו להפעיל הסדר זה~~.יהיה זכאי הסטודנט לתעודת מגיסטר (ראה סעיף 21.04).
אם נכשל הסטודנט בבחינת המועמדות, יוכל לבקש להמשיך את השתלמותו לתואר מגיסטר עד סיומה.	אם נכשל הסטודנט בבחינת המועמדות, ~~יוכל לבקש להמשיך את השתלמותו~~יוחזר למעמדו הקודם לתואר מגיסטר~~ עד סיומה~~..

נספח 7

מינוי חבר לוועדת סגל-סטודנטים כלל טכניונית

בוועדה **מקום פנוי אחד.**

דיקן הסטודנטים מציע למנות את פרופ"ח אלון וולף (הנדסת מכונות), בהסכמתו, לוועדה.

הרכב הוועדה הוא:
חברים בתוקף תפקידם: שלושה חברי סגל אקדמי בדרגת פרופסור מן המניין או בדרגת פרופסור מן המניין קליני, או בדרגת פרופסור חבר, שאינם ראשי יחידות אקדמיות; דיקן הסטודנטים; ארבעה נציגי סטודנטים בלימודי הסמכה; נציג אחד של הסטודנטים בתארים מתקדמים; ארבעה משקיפים ללא זכות הצבעה: דיקן לימודי הסמכה, דיקן בית הספר לתארים מתקדמים, ראש היחידה לקידום סטודנטים שישמש גם כמרכז הוועדה, וסיו"ר אגודת הסטודנטים.
החברים המכהנים כיום בוועדה הם: פרופ"ח אברהם דנציגר – יו"ר (הנדסה אזרחית וסביבתית), פרופ"ח נעמי ביטרמן (ארכיטקטורה ובינוי ערים), פרופ' מיילס רובין (הנדסת מכונות – עד חודש יולי 2014).

משך המינוי הוא שנתיים והוא ניתן להארכה לתקופה נוספת של שנתיים ולאחר מכן שנת "צינון".

המינוי לעיל הוא בסמכות הוועדה המרכזת ובאישור המליאה האקדמית (קטגוריה 2 של מינויים).

נספח 8

הטכניון – מכון טכנולוגי לישראל
TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY
המשנה לנשיא לעניינים אקדמיים
EXECUTIVE VICE PRESIDENT FOR ACADEMIC AFFAIRS

אישי-סודי

תאריך: 25 במאי 2014

אל: פרופ' פרץ לביא, נשיא

מאת: פרופ' גדי שוסטר, המשנה לנשיא לעניינים אקדמיים

הנדון: אישור השתייכות משנית לפי סעיף 99.5 בתקנות וחברות בוועדה מכינה יחידתית לפי סעיף 165.2 ד'

על פי בקשתם של הפרופסורים הלל פרת מהפקולטה לרפואה, אברהם מרמור מהפקולטה להנדסה כימית, דוד דורבן מהפקולטה להנדסת אוירונוטיקה וחלל ופרדי ברוקשטיין מהפקולטה למדעי המחשב ובהסכמת דיקני הפקולטות ובאישור הוועדה המכינה של הפקולטה להנדסה ביו-רפואית, הנני מעביר לאישור הוועדה המרכזת את הבקשה להשתייכות משנית לפקולטה להנדסה ביו-רפואית כלהלן:

שם	השתייכות ראשונית	השתייכות משנית	תקופה
פרופ' הלל פרת	רפואה	הנדסה ביו-רפואית	לתקופה נוספת מ-1.3.2014 עד 30.9.2016.
פרופ' אברהם מרמור	הנדסה כימית	הנדסה ביו-רפואית	לתקופה נוספת מ-1.3.2014 עד 30.9.2015.
פרופ' אלפרד ברוקשטיין	מדעי המחשב	הנדסה ביו-רפואית	לתקופה נוספת של 3 שנים, החל מ-1.3.2014.
פרופ' דוד דורבן	הנד. אוירונוטיקה וחלל	הנדסה ביו-רפואית	לתקופה נוספת מ-1.3.2014 עד 20.10.2014.

בברכה,
גדי שוסטר

העתקים: עו"ד אביבה דרוגן, מזכירת הסנט.
עו"ד אסף בינדר, מזכירות הסנט.

תיקיית נשיא/השתיכות משנית - 2014/גש/אא.

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