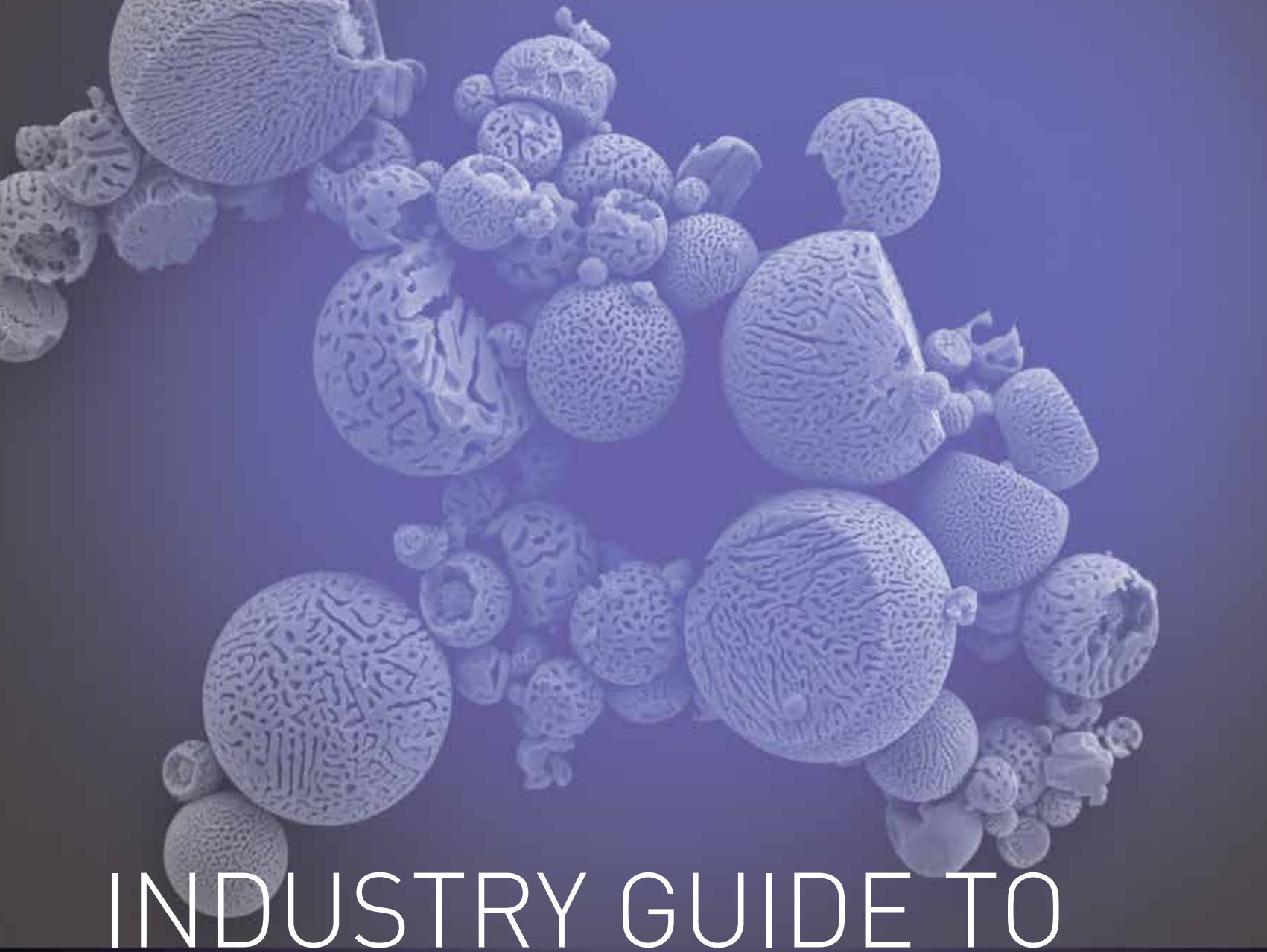

# INDUSTRY GUIDE TO THE TECHNION

Research Projects › Research Services › Technology Transfer

TECHNION
Israel Institute of Technology

*Cover:* Acquired using high resolution scanning electron microscopy

Maria Koifman Khristosov, Prof. Boaz Pokroy Group
Faculty of Materials Science and Engineering

# INDUSTRY GUIDE TO THE TECHNION

Research Projects › Research Services › Technology Transfer

TECHNION
Israel Institute of Technology

Produced by The Technion Research and Development Foundation (TRDF).

# Contents

From the very beginning, the relationship between the Technion and Israeli industry has been of prime importance. As early as 1925, Menachem Ussishkin, a mining engineer by profession, opened his keynote address at the opening ceremony of the Technion with the following words: "Basic research and applied research are the two sides of the same coin". Indeed, throughout its history the Technion has supported applied research, viewing its relationship with industry as being of prime importance. Technion graduates have been responsible for transforming the basis of the Israeli economy from agriculture to high-tech, and play a major role in the Start-Up Nation phenomenon.

Now that we are in the second century of its existence, the relationship between the Technion and industry is becoming even more important. In order to serve the Israeli economy effectively, it is vital that industry be aware of current research at the Technion, and the advanced facilities and services the Technion offers. The prime goal of this booklet is to make this kind of information easily available. For each Faculty we have given a short history and a summary of the main themes of its activities and links to the relevant topics and facilities, including QR Codes, names of staff, and contact details.

We hope that you will find this booklet informative and useful.

**Prof. Peretz Lavie**

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https://www.facebook.com/TechnionLive

https://www.linkedin.com/edu/school?id=13396

https://www.youtube.com/user/Technion

# ABOUT THE TECHNION

Technion - Israel Institute of Technology is a public research university in Haifa, Israel. Founded in 1912, it is the oldest university in Israel. The Technion offers degrees in science and engineering, and related fields such as architecture, medicine, industrial management, and education. It has 18 academic faculties and 60 research centers. Since its founding, it has awarded 110,634 degrees, and its graduates are cited for providing the skills and education behind the creation and defense of the State of Israel.

## Interesting facts:

- From 1995 to 2015, about 1,300 Technion graduates were involved in the setting up and management of 1,600 companies in Israel; about half of these are still active today. These companies generated revenues of over 30 billion dollars and created about 100,000 jobs in Israel.
- About 170 Technion graduates established or hold a senior position in overseas companies, and 134 companies were established on the basis of studies conducted by faculty members at the Technion.
- In the last 20 years more than 1,900 companies have been established in Israel and abroad, involving alumni, faculty members, and knowledge generated at the Technion.

**Source:** Examining Companies that are Based on Technion Knowledge, by Daphne Getz , Vered Gilad, Ella Barzani, Bella Zalmanovich, and Bahina Eidelman, S. Neaman Institute 2016

The Technion's 556 faculty members currently include three Nobel Laureates in chemistry.

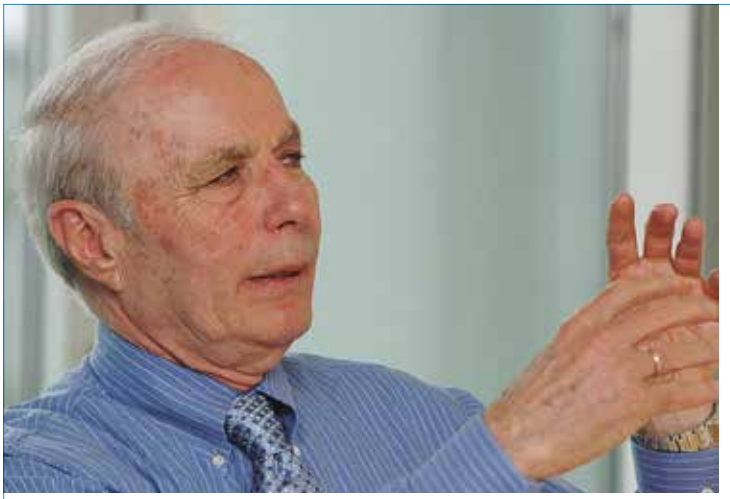
The 2016 Shanghai Ranking placed the Technion 69th in the index of the world's leading academic institutions, and the top position for any Israeli institute. Over the past five years the Technion has consistently ranked in the 15th-18th place in Computer Science and this year ranked 39th in the new specific Ranking for Electrical and Electronic Engineering.

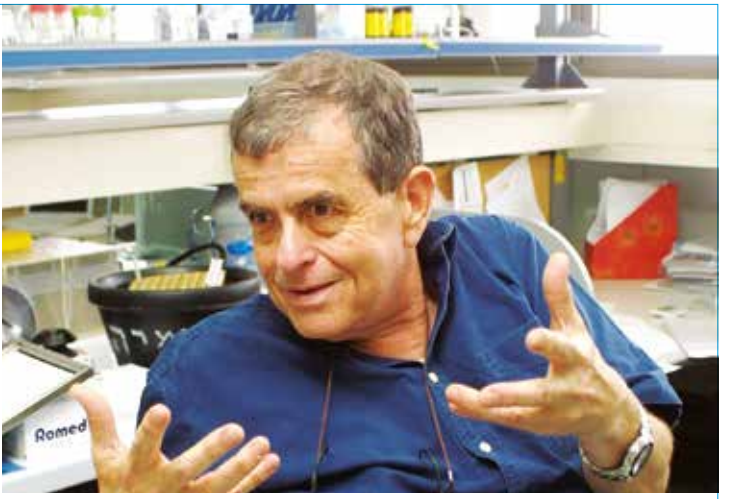
The Nature Index Ranking placed the Technion 26th in its 2016 list of Rising Stars, following a 40% increase in Technion's publications in leading scientific journals.

Recently the MIT/Skoltech Initiative ranked the Technion in 6th place worldwide for innovation and entrepreneurship.

In 2011, a bid by the Technion with Cornell University won a competition to establish an applied science and engineering institution in New York City – the Jacobs Technion Cornell Institute. The first class has graduated, making the Technion the first foreign university to award a diploma on US soil.

In 2013, the Technion signed with China's Shantou University to establish the Technion Guangdong Institute of Technology in China. In Israel, Technion International offers students from countries around the world an opportunity to join Technion academic programs in science and technology taught entirely in English.



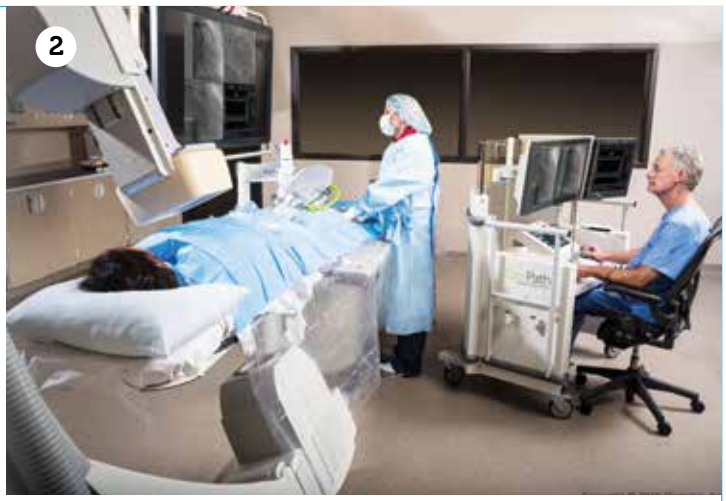



*(l-r)*
**Dist. Prof. Avram Hershko**
*Nobel Prize Laureate in Chemistry 2004*

**Dist. Prof. Aaron Ciechanover**
*Nobel Prize in Chemistry 2004*

**Dist. Prof. Emeritus Dan Shechtman**
*Nobel Prize Laureate in Chemistry 2011*

**Dist. Prof. Arieh Warshel**
*Nobel Prize Laureate in Chemistry 2013*




**1 ElMindA**
The ElMindA - Brain Networks Activation (BNA™) platform offers visualization and evaluation of complex brain networks.

**2 Corindus Vascular Robotics**
Corindus offers the CorPath® which is the first FDA-cleared robotic system for vascular interventions.

**3 AZILECT® (Rasagiline)**
Developed in collaboration with Teva Pharmaceutical Industries, AZILECT® is a revolutionary drug for Parkinson's disease.

**4 Pluristem Therapeutics**
Pluristem Therapeutics offers PLacental eXpanded (PLX) cells for tissue regeneration.

**5 Novocure**
Novocure's 2nd generation Optune® is an FDA-approved system that offers bioelectronic cancer therapy.

# RESEARCH COOPERATION WITH INDUSTRY

# RESEARCH PROMOTION UNIT

Contact
**David Shemtov**
Head
Tel. +972-4-829-5501
david.s@technion.ac.il

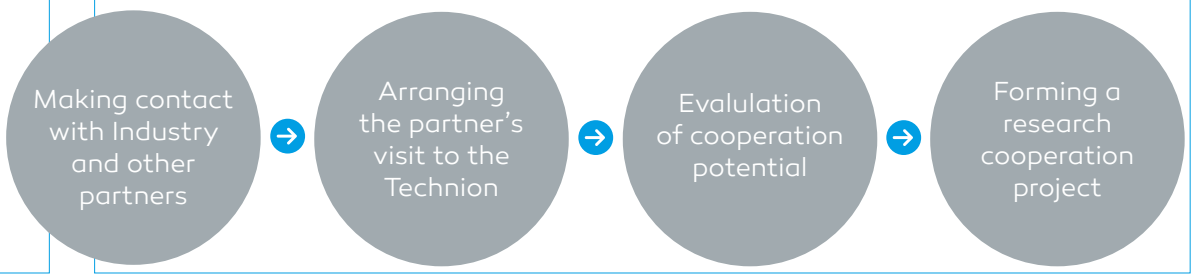
The Research Promotion Unit promotes research and development opportunities for Technion researchers and partners in Israel and around the World. The Research Promotion Unit offers a proactive and time-efficient interface for creating partnerships between Technion researchers and industries.
Upon receiving a list of an industry's technological needs, the Research Promotion Unit can identify the most suitable researchers and facilities, and promote customized cooperation. The Research Promotion Unit not only initiates the process of collaboration, but also closely follows the entire process, and assists in its various stages.

## Industry-Academia Cooperation and Services:

The Technion provides a wide range of R&D opportunities for national, international and global companies searching for a technological edge through collaboration. The combination of world-class researchers, a wide spectrum of state-of-the-art facilities and laboratories, research centers and institutes, together with extensive experience with industrial partners, ensure that the Research Promotion Unit offers the highest level of cooperation.

## Technion Research Promotion Unit Services for Industries:

- Translating industry's needs into scientific and technological requirements
- Coordinating campus resources with industry's technological needs
- Linking relevant researchers with industrial partners
- Coordinating visits, networking sessions and seminars with industries
- Mediating between industry and the researchers' needs and viewpoints
- Assisting in finding the appropriate financial tools for each project
- Providing assistance during all phases of the project



## Mutual Advantages of Industry-Academic Cooperation:

Risk and cost reduction of R&D ➔ Shortening time to market ➔ Access to research and industrial infrastructures ➔ Access to the wide range of resources of academic and industrial knowledge ➔ Direct access to future skilled employees ➔ A platform for upgrading and educating industrial staff ➔ Public awareness through high visibility collaboration ➔ Initiating research projects based on industrial needs

## Modes of Cooperation:

The Research Promotion Unit has extensive experience with European Union Framework programs, as well as programs of the Office of the Chief Scientist of the Ministry of Economy (OCS), and other relevant programs. The OCS programs are jointly funded by the OCS itself and by industry. The five main programs that deal with technology transfer are: Magnet, Magneton, Nofar, Kamin, and Meymad, described below.

### EU Framework Programs:

The Research Promotion Unit encourages and assists researchers and their partners in forming research consortia, preparing and submitting proposals and developing training and career development networks and individual excellence projects, all within EU Framework programs.

### Projects Directly Funded by Industry:

In this mode, the Technion carries out a research project that is guided by the industry's needs. Cooperation could be a fully-funded project, a combined industry and Technion research program, laboratory funding, a joint research center, or other arrangement. Terms of collaboration, including budget, duration, IP, or a combination with a framework agreement, would be adopted for each project. This is a flexible and pragmatic mode of operation.


# INDUSTRIAL AFFILIATES PROGRAMS

The Industrial Affiliates Programs (IAPs) are intended to facilitate direct ties between academia and industry. Supported by corporate membership fees, these programs provide access for industry to research in departments, and programs of interest. IAP members typically attend meetings, receive copies of reports and publications, and have opportunities to recruit students. Any interested company may join an affiliate program. This framework transcends traditional borders to form win-win relationships, while achieving and maintaining excellence.

# RESEARCH EQUIPMENT AND INFRASTRUCUTURE

## Accessing Information and the Use of Research Equipment and Infrastructure in the Technion:

The Technion is comprised of 18 faculties and a large number of research centers, institutes, and laboratories. The research performed by the Faculty, students and staff of these units is facilitated by the presence of hundreds of items of scientific and engineering equipment, in many cases with the most advanced capabilities in Israel, and in some cases in the world. For instance, in the field of visualization, Technion microscopes and other types of equipment allow researchers to see natural and synthetic materials, from atoms all the way up to industrial structures. The Technion's advanced equipment is available for use to outside researchers, including those from industry.

### Finding the correct equipment or infrastructure:

The Technion's website can aid industrial researchers and manufacturers in their search for specific equipment or other infrastructure that may be of assistance for their research requirements.

General research sites that are good starting points are:

**Research faculties and interdisciplinary research centers**

**Specific labs and equipment**

**Specific research centers, with sub-listings of equipment present in the centers**

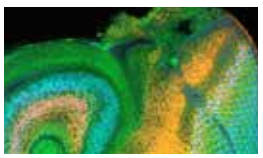
## Use of Technion equipment:

Scientific and engineering equipment can be found in the personal laboratories of Faculty members, as well as in Faculty Equipment Centers. Most of the larger and more expensive items of equipment can be found in the Technion's Interdisciplinary Research Centers. The regulations for each area are thus dependent on the responsible laboratory. The website links below can lead you to these centers, and include specific information on how to contact the responsible scientific team, as well as details of the capabilities of the equipment, requests for time, and costs. The teams responsible for the equipment are very knowledgeable about its performance, and will help in determining whether the equipment can perform your experiments, as well as how best to plan them.

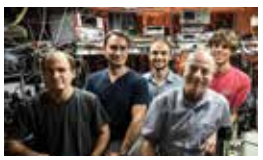
The major interdisciplinary infrastructure centers are:

Russell Berrie Nanotechnology Institute (RBNI)

Lorry I. Lokey Center for Life Science and Engineering



Faculty of Medicine Center for Interdepartmental Equipment



Solid State Institute

Faculty of Chemical Engineering

Schulich Faculty of Chemistry

**Virtual Facility Map**

# RESEARCH CONTRACTS

The Technion carries out various research activities with industry (both Israeli and multi-national), governments and public institutions.

Agreements (as opposed to grants) between the Technion and industry typically fall into one of the following categories:


Contractual arrangements depend on the parties' control over scope and timing of the activities, budgeting, the nature of the services provided or the research conducted, ownership in and to the intellectual property rights, and the relevant model of using thereof, type of research personnel involved, etc.

**Service Agreement / Laboratory Agreement:**
These agreements are typically used at the Technion in the following situations:

- Rendering standard services at the various Technion centers and laboratories: for example, providing proteomic analysis at the Smoler Proteomics Center, microscope work by the Titan Microscope at the Faculty of Materials Science and Engineering, or conducting preclinical trials at the Pre-Clinical Research Authority.

  For such services, standard agreements address industry's concerns and requirements, such as full ownership of the results, confidentiality obligations, etc.

- Technion personnel render a service based on specific equipment and expertise therein, providing the results to a client; while no intellectual input is required and no scientific publications are sought by Technion personnel.

  For such services we use our standard laboratory agreement appropriate to the industry/client's requirements.

**Research Agreements:**

Typically, industry from one side and Technion personnel from the other side, wish to conduct a specific research project, aimed at generating useful and valuable intellectual property. Such a project may be based on intellectual property or know-how originating from the Technion, the Industry, or even available in the public domain.

Research activities to be performed by Technion personnel vary. We at the Technion recognize that working with a large university can be challenging, and we are therefore committed to simplifying the process. We take a flexible approach, tailoring solutions to meet the specific needs of all parties, especially the need of industry to use the results of such a research project to improve its own capabilities. Each research agreement is unique, and receives our full attention.

Research agreements include many aspects, as specifically required for the related project, including the research scope and program, related budget and schedule of payments, reports, confidentiality obligations, academic publication issues, responsibility and liability, and intellectual property ownership and related terms for the right to the use thereof.

In general, the process begins with defining the scope of the work and the expected timeline and budget with the relevant Technion personnel. Research progress and related deliverables are reported in a timely manner, following a schedule agreed by the Technion and the industry.

Following the initiation of such agreements, the research authority and the legal department proceed as follows. The research authority will contact the industry asking for a representative to be responsible for all project-related matters, as well as a contact person responsible for payment by the industry. The legal department will handle the related agreement setting, negotiating all relevant terms, while balancing parties' requirements and expectations.

Some important issues will need to be addressed in the agreement:

### Academic Publication:

The research team varies from one project to another. It usually includes a Technion faculty member, senior research personnel, such as post-doctoral fellows, research assistants, professional engineers and technicians, and students. The research team is required to publish its work, even if it is part of a sponsored research project. SInce the project results may be more strategic and competitive in nature, we usually set a proper mechanism, granting the industry a reasonable time to review the draft of the publication and protect related intellectual property prior to publication. Of course, such publications will not include any confidential industry information.

### Intellectual Property Rights - Ownership and the Right to Use:

According to our standard model, any intellectual property rights arising out of a research project performed by a Technion research team are owned exclusively by the Technion. In the case that both parties have contributed to the generation of the intellectual property (i.e., inventorship contribution), the rights are jointly owned. The industry is granted the first option to receive an exclusive right to use the intellectual property (both the Technion's and the jointly-owned rights) for its own use, under commercial terms to be further negotiated with the Technion.

### Best Efforts - No liability for implementation of deliverables:

It is important to understand that funding a research project is different from hiring a commercial entity for up-scaling, improving, designing, or developing products. The Technion is an academic institution performing research work; hence we cannot guarantee the success of research projects and success in reaching the expected outcomes. The research activities shall be performed on a 'Best Efforts' basis, and the Technion shall release itself from any liability related to realizing the outcome in products or services.

### Conflicts of interest, ethics and regulations:

The Technion has established ethics, bylaws and other regulations which may influence research activities. For example, the principal investigator of a certain industry-funded research project that has also provided private consulting services to the industry in the past may have a conflict of interest.

It is not necessarily the case that all conflicts must be eliminated, but they must be disclosed and properly managed. Mechanisms exist for handling conflict situations.

**Umbrella Research Agreements:**
With large and frequent funding industrial partners, the Technion welcomes establishing framework agreements to which specific research projects are appended.

A framework collaborative research agreement involves a standard set of terms to apply to all research activities which the industry sponsors at the Technion. An agreed-upon Statement of Works (SoW) with the specific details is worked out on a case-by-case basis, and is subject to the framework terms.

A framework collaborative research agreement is usually tailored for the industrial partner's specific field, and may grant the partner more flexible terms that those in standard agreements.

Major Research Centers:
Such a center is established based on substantial industry commitment. The terms of use of a center's derived intellectual property are tailor-made on a case-by-case basis.

Summary:
The Technion is committed to building strong relationships with our industrial partners, contributing to their economic development and competitiveness. These valuable partnerships help boost the Technion's research excellence and deliver solutions to industry's current challenges and needs.

# TECHNOLOGY TRANSFER

TECHNION
Research and
Development Foundation

http://www.t3.trdf.co.il

Contact
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Tel. +972-4-829-4851
sofferb@trdf.technion.ac.il

Technion
Technology
Transfer

# TECHNION TECHNOLOGY TRANSFER - T³

Entrepreneurship and commercialization are at the core of Technion innovation. As part of the Technion R&D Foundation (TRDF), T³ is a one-stop-shop for innovation as a global hub for entrepreneurship startups and commercialization.

At T³, we commercialize cutting edge technologies developed by Technion researchers, students and alumni. T³'s mission is to facilitate and support the transformation of scientific discoveries into applied solutions. By creating optimal alliances between scientists, industrial partners, entrepreneurs, and investors, T³ enables a smooth transfer of technologies to the world.

Through its activities, T³ aims to ensure that Technion IP and knowhow will contribute to Israel's economy and will improve the quality of life for people worldwide.

## T³'s activities include:

- Analysis of new inventions and concepts developed at the Technion
- Protection and maintenance of IP
- Facilitation of government R&D incentive program grants
- Proof of concept and seed funding
- Negotiation and approval of the IP and business aspects of agreements with industry
- Licensing technologies developed at the Technion
- Incorporation of spin-off companies based on Technion IP
- Acceleration of Technion related spin-off companies
- Support and investments in Technion-affiliated companies


## PUBLICLY TRADED COMPANIES

Breathtec Biomedical
www.breathtecbiomedical.com

Corindus Vascular Robotics
www.corindus.com

Itamar Medical
www.itamar-medical.com

Mazor Robotics
www.mazorrobotics.com

Microbot Medical
www.microbotmedical.com

Novocure
www.novocure.com

OPKO
www.opko.com

Pluristem Therapeutics
www.pluristem.com

ReWalk Robotics
www.rewalk.com

## Into Business:

T³ takes a dynamic and flexible approach to commercialization in which deal structures are customized to real-time needs and long-term objectives; there is no "one size fits all". Industry collaboration ranges from joint R&D programs through licensing of technologies, products and services. These collaborative research, development and commercialization structures support the successful process of technology transfer.

### T³'s main commercialization avenues include:

- Licensing of Technion intellectual property (IP) to companies (with preference to companies based in Israel)
- Incorporation of startups based on Technion IP within the framework of incubators and seed investments
- Supporting Technion related innovation through dedicated infrastructure for project development: the Alfred Mann Institute at Technion (AMIT) dedicated to biomedical innovation; the Technion DRIVE Accelerator servicing non-life-science innovation

## Acceleration at Technion:

### Alfred Mann Institute at the Technion (AMIT):

Established in 2006, the Alfred Mann Institute at Technion (AMIT), aspires to bridge the gap between applied academic research and commercial success. AMIT is hub of innovation that is supporting biomedical company formation by Technion students, faculty and alumni.

### The Technion DRIVE Accelerator (The DRIVE):

The Technion DRIVE Accelerator is a Technion Accelerator focusing on ICT, Robotics, Materials, Digital Healthcare, Big Data, Artificial Intelligence and Cyber Security. Inviting students, faculty and alumni into an environment of creativity and entrepreneurship, the DRIVE facilitates the transformation of ideas into sustainable businesses at the forefront of Israel's economic development.

This infrastructure provides a spectrum of support and financing services from proof of concept (POC) funding, through to technology acceleration; follow-on funding; business premises; and mentoring to launch companies.

***http://economy.gov.il/RnD/OurArenas/TechnologyInfrastructure/Pages/default.aspx/***

## Entrepreneur in Residence (EIR) program:

The Entrepreneur in Residence (EIR) program invites entrepreneurs to commercialize groundbreaking technologies from the Technion. The program introduces entrepreneurs to the Technion research environment, offering support to identify promising technologies and to launch start-up companies.

## Technologies for commercialization:

### Available Technologies:

With over 650 granted patents and over 700 patents pending, T³ offers a comprehensive database of Technion technologies and know-how available for commercialization. To check our database for technologies available for commercialization and subscribe to technology updates visit: www.t3.trdf.co.il.

## Access to collaborative programs sponsored by the Israel Innovation Authority:

### Magnet:

This 3-5 year program supports the formation of industrial consortia with Israeli academic institutions, to perform joint generic pre-competitive research, technological development, and innovation in a particular topic, which may lead to a new generation of advanced products.

### Magneton:

This 1-2 year program supports transfer of technology from an academic institution to an Israeli industrial company, in all fields. The ultimate budget of Magneton is NIS 3,400,000 in total, for both academia and industry. The Chief Scientist of the Israel Innovation Authority funds 66% of this budget, and 34% is funded by the industrial partner. The academic institution is funded 100% through this budget.

### Nofar:

This program, lasting 12-15 months, supports advanced stages of applied academic research, not yet oriented towards a specific product, but already of interest to a business partner, and aims to bring the research to a mature phase. This program is limited to the feasibility phase. Later phases require other programs. This program enables an Israeli business partner (or an Israeli R&D subsidiary of an international company) to invest in it in the future, forming a cooperation based on the research achievements.

The Chief Scientist of the Israel Innovation Authority funds 90% of the budget (maximum NIS 495,000), and 10% is funded by the industrial partner. The partner has the first right to examine the research results.

### Kamin:

This is a 1-2 year program which bridges between basic and applied research that is not ready yet to be funded by industry. Kamin is open to all fields of science and technology. The maximum funding for a 1-year project is NIS 396,000, which is 90% of the requested budget. The maximum funding for a 2-year project is NIS 748,000, which is 85% of the requested budget. In special cases an additional year may be funded, the maximum funding being NIS 290,400, which is 66% of the requested budget.

### Meymad:

The program promotes creative and innovative dual-use technologies, particularly aimed at the international market. Governmental funding is at the level of 50%-66% of the approved budget. The projects adopt either the Magneton or Nofar scheme, according to the nature of the project. The maximum Magneton-based budget is NIS 5 million for a research period of up to 30 months. For a Nofar-based project, the maximum budget is NIS 550,000 for a research period of up to 15 months.

http://www.amitechnion.com

Contact
amitinfo@trdf.technion.ac.il

# ALFRED MANN INSTITUTE AT THE TECHNION (AMIT)

AMIT, the Alfred Mann Institute at the Technion is the Technion acceleration hub which supports the development and commercialization of exceptional biomedical innovations conceived by Technion students, faculty and alumni, with a mission to bring to market promising innovative biomedical technologies.

Established in 2006 by Dr. Alfred E. Mann, an American entrepreneur and philanthropist, and by the Technion - Israel Institute of Technology, a leading research university, AMIT aspires to bridge the gap between applied academic research and commercial success.

AMIT is an important part of the Technion entrepreneurial ecosystem, providing a unique platform for students, faculty and alumni to build sustainable biomedical companies. It provides the practical tools and the funding necessary to build and foster new biomedical ventures.

AMIT has a multidisciplinary core team of employees and consultants, led by Adv. Benjamin Soffer, CEO of T³ - Technion Technology Transfer office and a director of numerous high growth companies. It operates under the Technion and the Alfred E. Mann Foundation (AMF).

In 2015, AMIT invested in five new companies, totaling $1.9M. These ventures include: next-generation neurovascular treatments; hybrid catheters for interventional procedures; surgical robotics; anastomosis protection device for colorectal surgery and real time kidney monitoring. Companies that have been launched through AMIT include: Sealantis, offering an advanced biomimetic surgical glue; Accellta, commercializing stem-cell technologies; and Sanoculis, developing a new surgical technique for the treatment of Glaucoma.

DREAM
RESEARCH
INVENT
VENTURE
EXCEL

https://www.techniondrive.com

Contact
eisenmans@trdf.technion.ac.il

DRIVE
TECHNION ACCELERATOR

# TECHNION DRIVE ACCELERATOR

The Technion DRIVE Accelerator is a 9 month acceleration program for pre-seed and seed projects. The accelerator is located within the Technion campus and focuses on ICT, Robotics, Big Data, Autonomous Vehicles, Fintech, Augmented Reality, Materials and Digital Health.

The Technion DRIVE Accelerator's main goal is to capitalize on Technion's unique eco-system, innovative capabilities, and stellar human capital (researchers, students and most importantly alumni), by offering seed funding, business mentoring, office space, as well as access to Technion's resources, research facilities, infrastructure and equipment. It is a manifestation of Technion's vision to position itself not only as a leading research institution, but also as a generator of new ventures.

The Technion DRIVE Accelerator offers accepted companies a comprehensive service package which includes:

- Mentorship program
- Exchange program
- Entrepreneurship training program ("The DRIVE Academy")
- Beta-site support
- Fund raising support
- Support in accessing local and international grants
- 300 sq. meter office space
- Access to the Technion's labs and research centers
- Access to the Technion's talent pool and resources (such as specialized equipment)
- General support (administrative, business management, intellectual property, taxes etc.)

On top of the services package, companies accepted to the accelerator will be eligible for an investment of up to $100,000.

http://www.bio-rap.com

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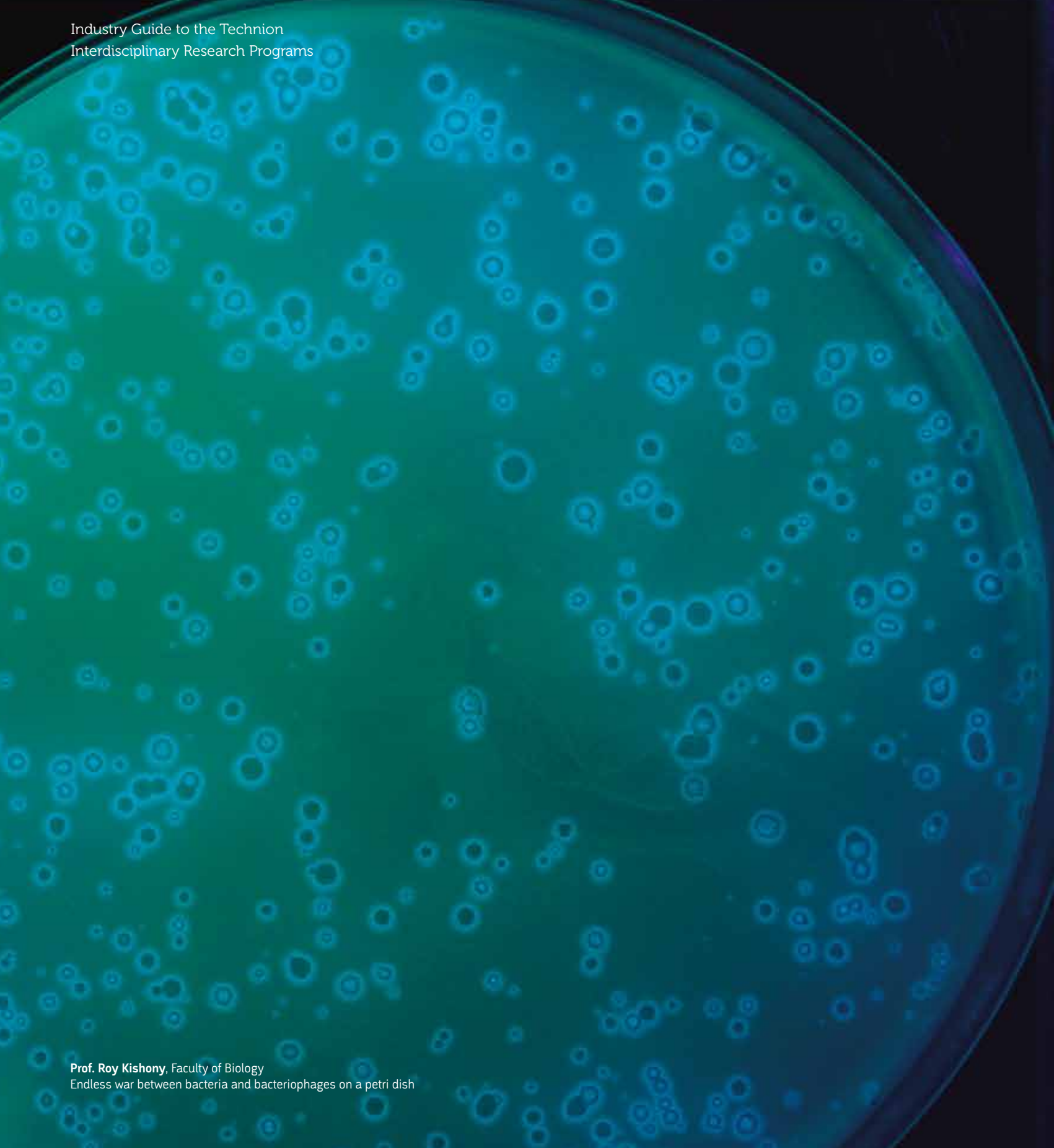
# BIORAP TECHNOLOGIES LTD.

BioRap Technologies Ltd. is a technology transfer company built upon patented technologies and creative innovations developed by the research scientists of the Rappaport Institute for Research at the Technion. Biorap Technologies provides a one-stop shop for advancing the development of groundbreaking discoveries by fostering strategic collaborations with industry through licensing, and new venture agreements. The Rappaport Institute, which is housed within the Rappaport Faculty of Medicine of the Technion-Israel Institute of Technology, consistently introduces promising new technologies, which can then be developed into products and services that benefit society and human health worldwide.

## BioRap Technologies encompasses two main areas of activity:

Technologies for licensing:

- Novel Molecules - For the treatment of inflammatory, autoimmune, renal, cardiovascular disease and cancer
- Medical Diagnostics - Novel markers for diabetes complications, cancer, autoimmune diseases, and both common and rare inherited genetic disorders
- Specialized Technology - Cell therapy using light-sensitive ion channels for cardiac and neurodegenerative modulation
- Therapeutics/Vaccines - Novel therapeutic vaccines for cancer treatment



**Prof. Roy Kishony**, Faculty of Biology
Endless war between bacteria and bacteriophages on a petri dish

# INTERDISCIPLINARY RESEARCH PROGRAMS

TECHNION CYBER SECURITY Research Center

GTEP Grand Technion Energy Program

Lorry I. Lokey Interdisciplinary Center for Life Sciences and Engineering

RBNI Russell Berrie Nanotechnology Institute
Technion - Israel Institute of Technology

TECHNION AUTONOMOUS SYSTEMS PROGRAM

TCE


# TECHNION CYBER SECURITY RESEARCH CENTER

TECHNION CYBER SECURITY
Research Center

http://cyber.technion.ac.il

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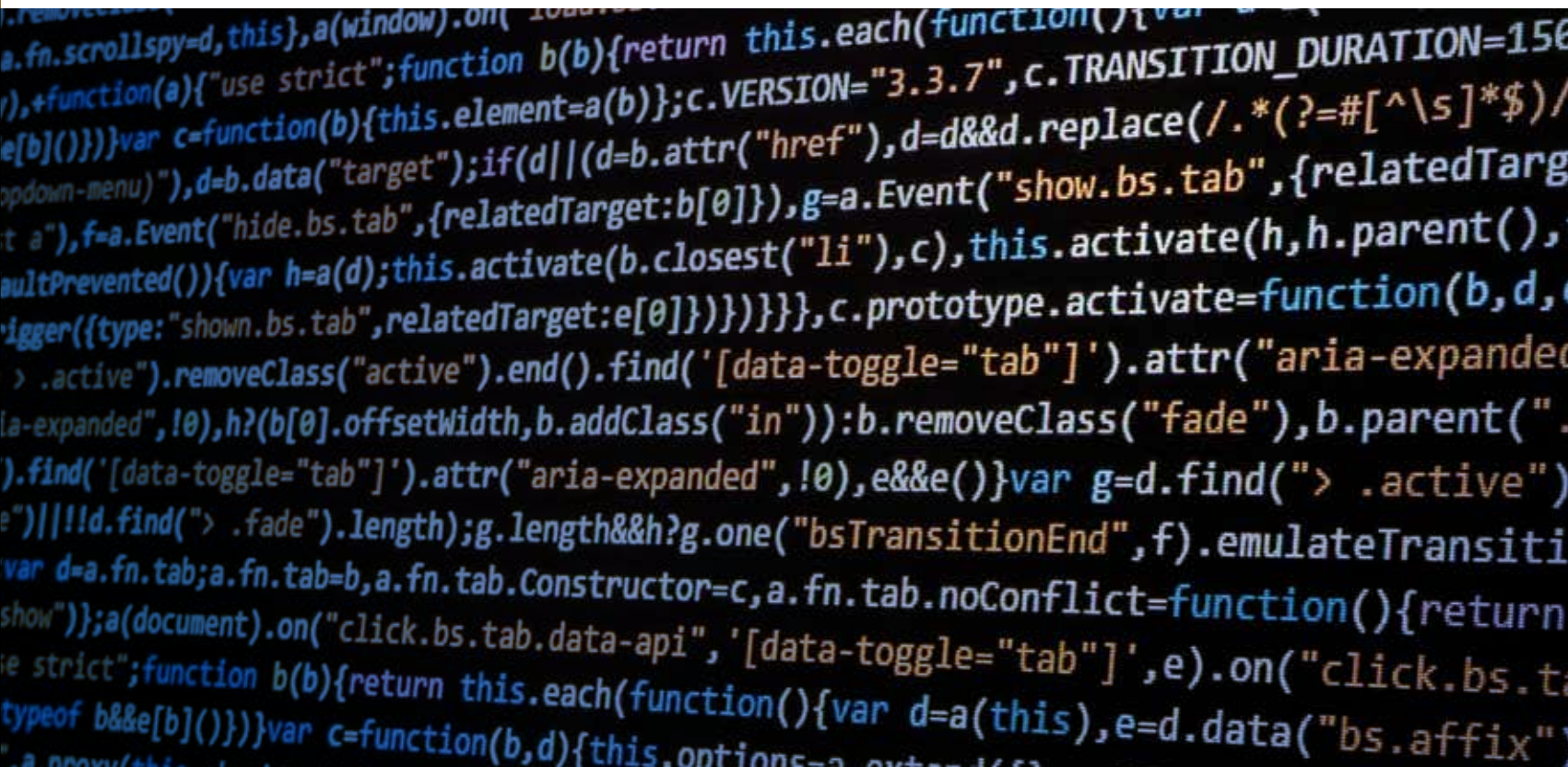
cyber@technion.ac.il

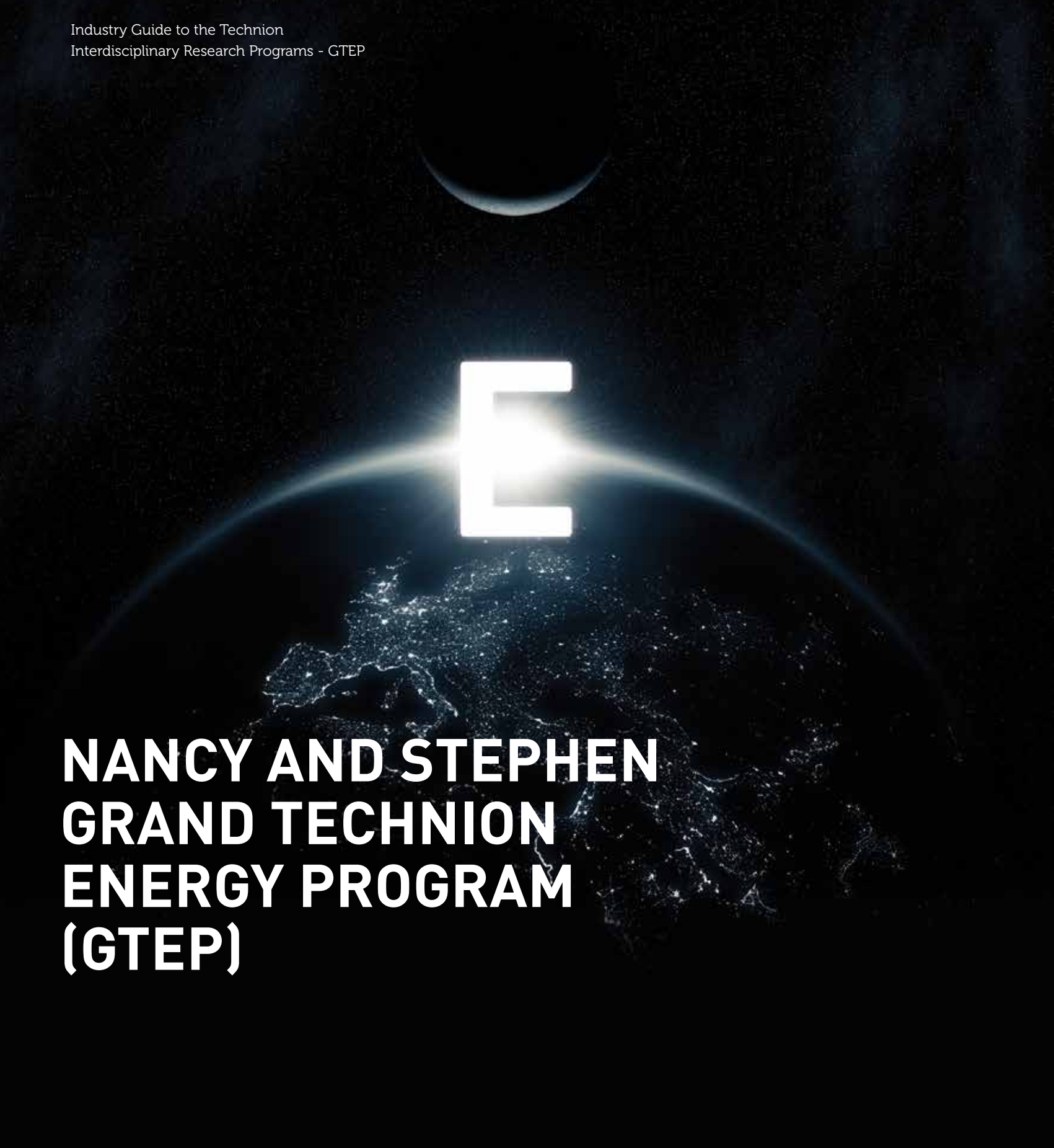
Cyber security is nowadays a vital area in computing, required for ensuring security and privacy of the computing systems, and of the data of users. The Technion cyber security research center collaborates dozens of researchers from various Technion faculties aiming to work on all areas related to the security of computer systems.

## Research Areas:

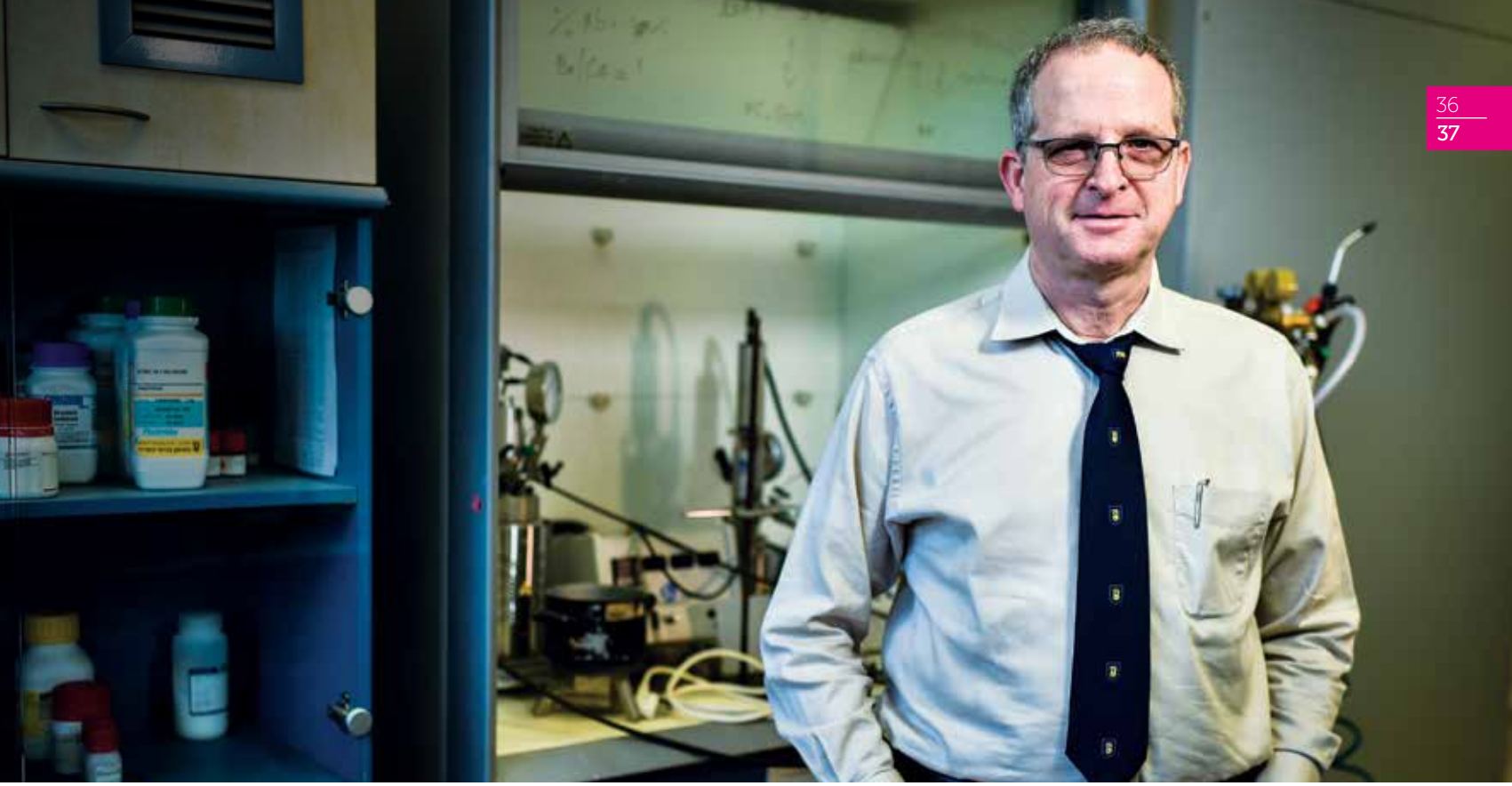
Network security ➲ Internet security ➲ Wireless security ➲ Ad-Hoc network security ➲ Electronic commerce ➲ Internet of Things ➲ Computer architecture ➲ Virtualization ➲ Cloud security ➲ Operating systems ➲ Parallel systems ➲ Hardware and software verification ➲ Computer vision for security ➲ Machine learning for security ➲ Cryptology and cryptanalysis ➲ Side-channel attacks ➲ Industrial control systems & SCADA ➲ Synthesis of secure software ➲ Autonomous systems security ➲ Privacy ➲ GPU and GPU security, etc.

The center is in collaboration with the national cyber bureau in the prime-minister's office.





# NANCY AND STEPHEN GRAND TECHNION ENERGY PROGRAM (GTEP)



Grand Technion Energy Program

http://gtep.technion.ac.il

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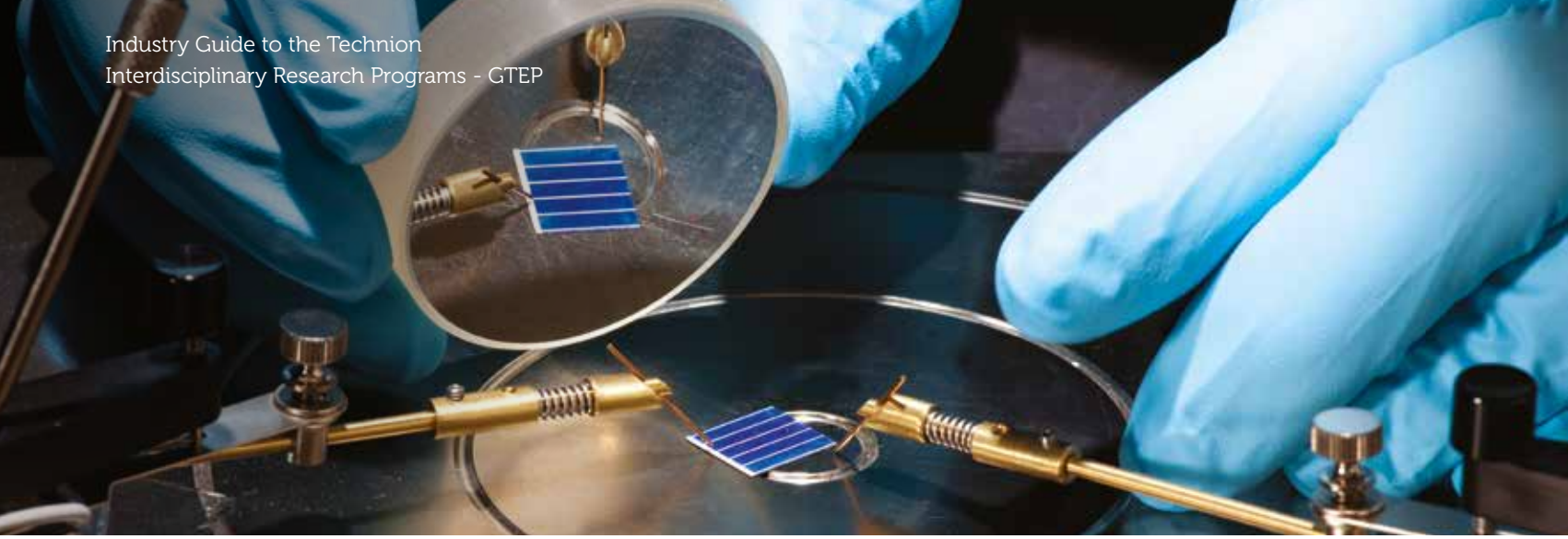
The Nancy and Stephen Grand Technion Energy Program brings the best science and engineering researchers together to work in a broad interdisciplinary track to discover and exploit alternative and renewable energy sources, to search for and develop alternative non-carbon-based fuels, to seek solutions for more efficient energy use, and to reduce the environmental damage caused by the production and burning of fossil fuels.

## Research Areas:

Alternative Fuels ➔ Energy Storage and Conversion ➔ Renewable Energy Sources ➔ Energy Conservation.

Proposed research topics that these areas will address are: expanded uses for solar energy, including solar photo-voltaic cells, for the generation of electricity, solar-powered air conditioning and solar process heat; development of non-carbon-based alternative fuels; biomass generation of combustible gases; wind turbine design; energy storage; optimization of urban planning for energy conservation; improving engine performance by reducing friction and using advanced combustion processes; and the development of power sources for microelectronic devices.



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## Technion Photovoltaic Laboratory:

This is a central Technion facility established jointly by GTEP and RBNI to provide advanced tools for the fabrication and characterization of photovoltaic (PV) devices. The Photovoltaic Center comprises two laboratories; one for the fabrication of photovoltaic cells, and the other for the characterization of these cells.

Laboratory personnel offer both technical services and assistance in the design, fabrication, and characterization of organic, inorganic, and hybrid PV devices. The laboratory serves the PV community of the Technion and the broad optoelectronics community in Israeli academia and industry. Professionals from industry come to the Center for the characterization of devices and for support in fabrication.

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## Technion Hydrogen Technologies Research Laboratory (HTR):

This is a central Technion facility, established jointly by the Grand Technion Energy Program (GTEP), the ADELIS Foundation and the Solar Fuels I-CORE, to provide basic and advanced tools for developing technologies for low-cost, highly-efficient hydrogen production from diverse renewable sources.

Activities at HTRL focus on the development of new materials, photocatalysts, and innovative electrodes that will enhance photo-electrochemical and fuel processing systems using deposition methods, electronic characterization, and photoelectrochemical sample analysis. The advanced analytical equipment at the laboratory is unique in its flexibility and capacity to accommodate studies in hydrogen energy production as well as research in other fields.

The laboratory personnel offer both technical services and assistance in the design and characterization of hydrogen production technologies. The laboratory serves the general Technion community and Israeli academia and industry. Launched in August 2013, the HTR Laboratory is now fully active.

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## Leona M. and Harry B. Helmsley Charitable Trust Energy Storage Complex:

This complex was established by GTEP as the first academic complex for research into energy storage. Investigations are focused on advanced, rechargeable Li-ion and metal-air battery systems using high energy fuels such as lithium and silicon.

### The Energy Storage Complex includes four hubs:

- Powder Preparation Hub
- Electrochemical/Chemical Laboratory
- Analysis of Hub-battery Discharge and Characterization
- X-ray Diffraction Laboratory

Laboratory personnel offer both technical services and assistance in the design and characterization of energy storage technologies.

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## Satell Family Nitrogen-Hydrogen Alternative Fuels (NAHF) Reaction Research Laboratory:

The Center was established by GTEP to promote the development of non-carbon fuel technologies. Investigations focus on the reactions of nitrogen-based fuels commonly encountered in fertilizers. The challenges are to develop clean, efficient, and environmentally friendly combustion technology of these energetic materials.

### The Center includes the following facilities:

- High-pressure batch reactors
- High-pressure continuous reactors
- Chemical analysis and characterization units of the effluent gases

Laboratory personnel offer both technical services and assistance in measurements of effluent gasses from combustion processes.

# Lorry I. Lokey Interdisciplinary Center for Life Sciences and Engineering

***http://lokey.technion.ac.il***

## Contact

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The Lorry I. Lokey Interdisciplinary Center for Life Sciences and Engineering provides a unique opportunity to bring the worlds of medicine, life sciences, and engineering together. Where else but at the Technion, a leader in high-tech and innovation in fields of engineering and medicine, could such a center be created? Nobel Prize laureate Aaron Ciechanover had a vision of this Center, and it was adopted with enthusiasm by Lorry I. Lokey, a longtime supporter of research and educational institutions.

The Lokey Center brings together the diverse but related fields of systems biology, bioinformatics, proteomics, tissue regeneration and stem cell biology, genomics, imaging, bio-processing engineering, structural biology, metabolomics and information processing. The Center provides state-of-the-art equipment to a cadre of outstanding researchers, allowing inter-disciplinary exchange between scientists with various areas of expertise. The Center provides an environment of excellence to foster creative research in life sciences, with the complementary skills in engineering and technology. It offers these scientists tools to help solve problems associated with basic life sciences and biomedical engineering, create new diagnostic techniques in medicine, and extend the frontiers of knowledge in science and technology.

# LOKEY CENTER

**Research Areas:**
Systems Biology ➲ Genomics ➲ Proteomics ➲ Bioinformatics ➲ Tissue Regeneration and Stem Cell Biology ➲ Imaging and Microscopy ➲ Cell Analysis ➲ Bioprocess Engineering ➲ Information Processing ➲ Structural Biology ➲ Biological Networks ➲ Metabolomics ➲ Optical Nanoscopy

**Facilities at Emerson Life Sciences Building:**
National Proteomics Center ➲ Bioinformatics Knowledge Unit ➲ Technion Center for Structural Biology ➲ LS&E Infrastructure Unit ➲ Technion Genome Center

# LIFE SCIENCES AND ENGINEERING INFRASTRUCTURE CENTER

***http://isu.technion.ac.il***

## Contact

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## Services and Instruments:

Microscopy and imaging
Flow cytometry
Technion Genome Center
Real- time qPCR

The Life Sciences and Engineering (LS&E) Infrastructure Center was set up in 2007 as a collaborative venture between the LS&E at the Lokey Center and the Russell Berrie Nanotechnology Institute (RBNI).

The main aim of the Center is to provide state-of-the-art technology and expertise to researchers from diverse disciplines, including biology, biotechnology, bioengineering, chemistry, chemical engineering, food engineering, material engineering, optical nanoscopy and physics.

The Center serves researchers from the Technion, as well as from other academic institutions and industry. It organizes seminars and workshops on the most up-to-date technology and applications.

At the LS&E Infrastructure Center, users receive full training and support, from designing the experiments to data analysis. The Technion team includes scientists who are experts in their field to provide the best service.

The Center has 3 major divisions:

- Light Microscopy and Imaging Unit
- Flow Cytometry Unit
- Genomic facility services - the Technion Genome Center

The Center is open to all users at the Technion as well as other academic institutions and industry.

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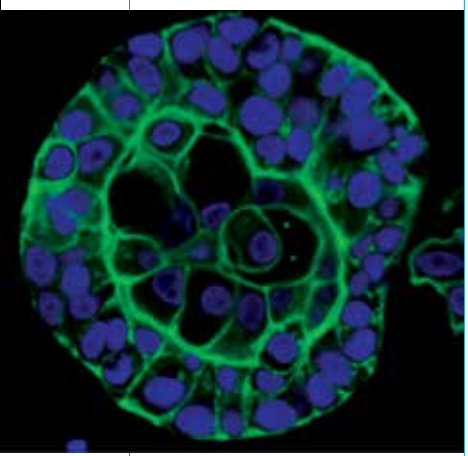

## Light Microscopy and Imaging Unit:

The Light Microscopy and Imaging Unit is headed by Dr. Nitzan Dahan, and offers advanced light microscopy equipment. The Unit supports researchers from diverse fields of life sciences, physics, chemistry, and engineering.

### The Unit's main equipment includes:

- 3 confocals fluorescence microscope, two of which are inverted and dedicated for live imaging and one with spectral detector (Zeiss LSM 700 and Zeiss LSE 710 with GaAsP Detectors)
- A multi photon confocal laser system (Zeiss LSM 510)
- 3 fluorescent inverted microscopes (Zeiss Cell Observer, Leica DMI8, Leica DMI2)
- Fluorescent binocular (Olympus and Leica)
- High-content-high-throughput imaging system (GE InCell Analyzer 2000)
- NEW Light sheet fluorescence microscope from Zeiss – new technology that enables live imaging of large 3D samples with 2 channels and multi-view (Zeiss Light Sheet Z1)
- Dedicated image analysis and processing software (Imaris, Image J, InCell Investigator, ZEN, Spotfire, Miner)

The Unit provides service and support, from designing the experiment to data analysis, with a full software range of: Imaris, Image J/FIJI, ZEN, AxioVision, and InCell Investigator.

### Applications include:

- Fast image acquisition for live cell imaging and time-lapse studies
- Z-Stacks for localization of cells in living tissues and 3-D reconstruction
- High-resolution localization of sub-cellular compartments and quantities co-localization
- Spectral imaging and detection
- Fluorescence resonance energy transfer – FRET
- Multi-channel fluorescence imaging
- Quantitative co-localization
- Fluorescence recovery after photo-bleaching – FRAP
- Multi-photon imaging
- Automated slide imaging
- Cell-based assays and detection, including: compound screening, Phenotypic profiling, RNAi screening, Whole organism imaging, Cell lineage studies, Cell cycle studies, Cell migration, Organelle and protein trafficking, Morphology analysis, DNA content analysis, and Apoptosis/cell viability


## Flow Cytometry Unit:

The Flow Cytometry Unit has two analyzers, a sorter and the ImageStream system:

- Analyzer: BD FACS Calibur - 2 lasers, 4 channels
- Analyzer: BD LSR-II - 4 lasers, 12 channels and High Throughput System (HTS)
- Sorter: BD FACS Aria-III - a four-laser sorter with 12 channels that can sort the analyzed particles or cells for further growing and analysis
- NEW – Image Stream – Imaging Flow Cytometer combines the speed, sensitivity, and phenotyping abilities of flow cytometry with the detailed imagery and functional insights of microscopy

The Unit serves all the Technion's units, as well as other academic institutions and industry. The Unit provides service, from designing the experiment to data analysis, with a full software range of FSC express and ModFit.

### Applications include:

- Functional analysis: Ionic Flux Determinations; Membrane Potential; Oxidative Reactions
- DNA analysis: Cell cycle and cell proliferation; Cell Viability; Apoptosis / necrosis (Cell death)
- Intracellular signaling: Cytokine production; Phagocytosis; Single cell analysis; Cell enrichment

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TechnionGenomeCenter

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## Technion Genome Center:

As part of the LS&E Infrastructure Center since 2009, the Technion Genome Center (TGC) is at the forefront of sequencing technology, providing state-of-the-art services to researchers from diverse disciplines. TGC plays a central role in enabling the Technion's researchers to find answers to the pressing questions of the 21st century develop genome technology. TGC offers a range of services from designing the experiment, through library preparation and sequencing, to bioinformatics analysis. The mission of TGC is to maintain and expand its role as Israel's leading sequencing facility, and therefore TGC continuously upgrades its equipment as new technology becomes available. TGC's team, located in the Technion's new Emerson Life Sciences Building, includes highly-trained and experienced scientists, bioinformaticians and molecular biology specialists who have a proven record of working together with researchers from the Technion, other universities, and industry. TGC's customers include all Israeli universities, research institutes, hospitals and genetic institutes, as well as industrial companies and start-ups. The TGC offers sequencing, library preparation and bioinformatics services.

### Available applications:

- RNA-Seq
- Low input and ultra-low input RNA sequencing
- Resequencing / de novo sequencing
- Amplicon sequencing
- Exome Sequencing
- ChIP-Seq
- CEL-Seq – single cell / low input RNA sequencing protocols
- Bioinformatics analysis
- Advanced molecular biology laboratory

### TGC's state-of-the-art equipment includes:

- Illumina HiSeq 2500
- Illumina HiSeq 2500 – 1Tera
- Illumina MiSeq
- MinIon - Nanopore Technology Sequencer
- Fluidgm C1 - Automated Single Cell Genomics
- Agilent Bravo automation system for sample preparation
- Agilent TapeStation 2200 - DNA and RNA quality control
- Covaris E220 - DNA shearing system
- Advanced molecular biology laboratory

TCSB
Technion Center for Structural Biology

# TECHNION CENTER FOR STRUCTURAL BIOLOGY

***http://tcsb.technion.ac.il***

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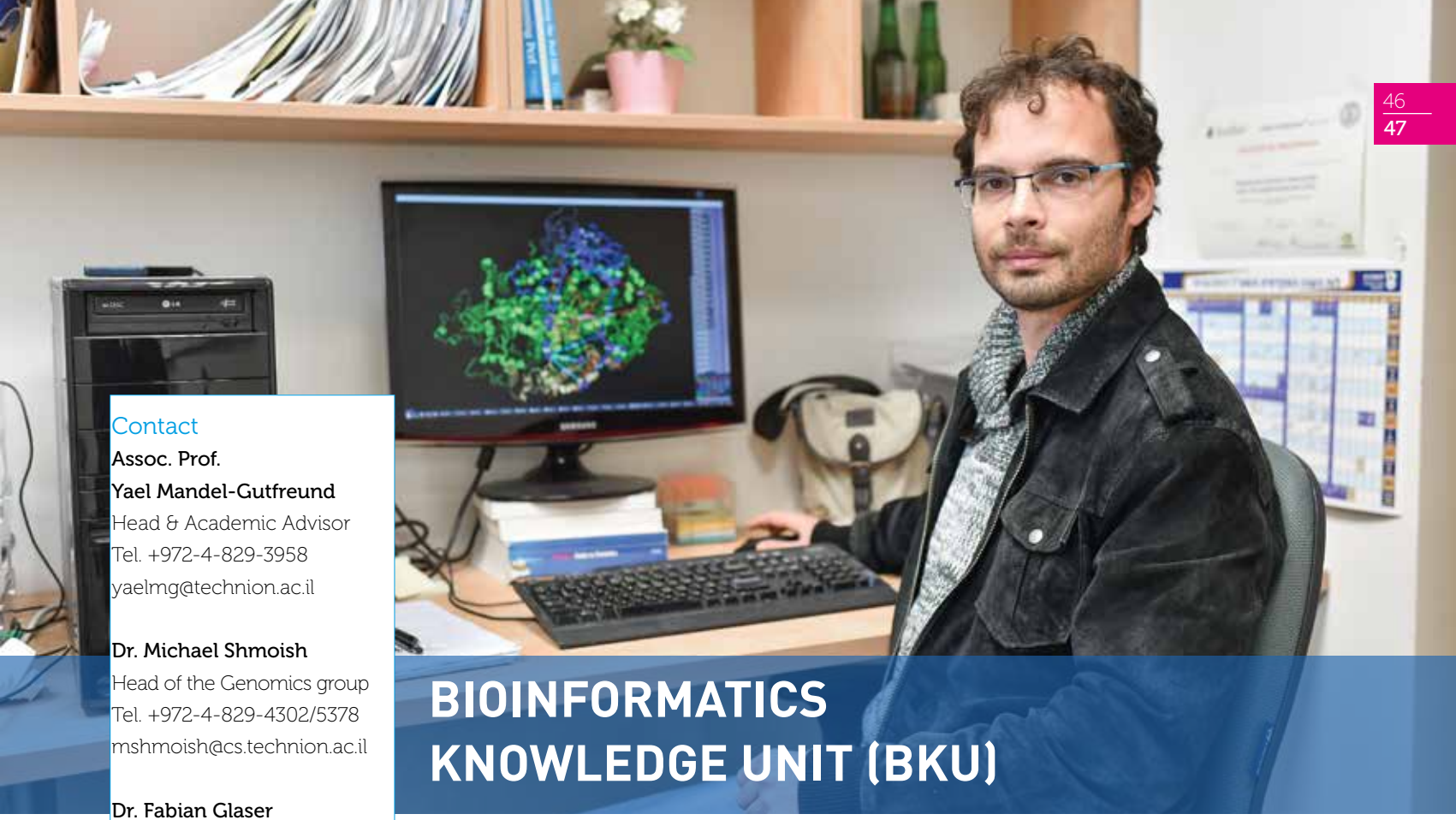
The center was jointly established by the Lorry I. Lokey Interdisciplinary Center for Life Sciences and Engineering (LS&E) and the Russell Berrie Nanotechnology Institute (RBNI). In order to enhance molecular-level biomedical research at the Technion, the LS&E took the initiative in establishing the Technion Center for Structural Biology (TCSB). Headed by Dr. Yael Pazy Benhar, the TCSB provides both expertise and infrastructure for macromolecular crystallography to enable state-of-the-art structural biology research on campus. TCSB is equipped with the most advanced infrastructure for macromolecular crystallography, including robotic and automation systems for high-throughput crystal growth and x-ray data collection. The Center is engaged in molecular studies of wide-ranging areas in life sciences, with an emphasis on functional and mechanistic understanding of the interaction between biological macromolecules, such as proteins and DNA. Dissecting biological processes with such high-resolution approaches is often crucial in unraveling the molecular basis of diseases and for rational development of therapeutics via structure-based drug design.



# BIOINFORMATICS KNOWLEDGE UNIT (BKU)

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The Bioinformatics Knowledge Unit (BKU) provides science researchers at the Technion and its affiliated hospitals with computational methods and tools to make their research more productive, saving time, effort and cost. BKU provides consulting to individual laboratories, arranges workshops and seminars for students, technical, and academic staff, and makes state-of-the-art computing tools, data resources, and computing power available to all. Consulting activities include help-desk services as well as involvement in research projects and grants.

## Research Areas:

The BKU provides consultation services to researchers and staff of the faculties of life sciences and exact sciences at the Technion and its affiliated hospitals. We aim to establish cooperation with researchers. Currently we support research in, amongst others, genomics and high-throughput data analysis (denovo genome sequencing, RNA-seq, ChIP-seq, CLIP-seq, etc.), application of R-system, phylogenetic analysis, protein-protein and protein ligand docking, molecular dynamics, structure-based mutational analysis, and novel gene annotation.

# RUSSELL BERRIE NANOTECHNOLOGY INSTITUTE (RBNI)

Russell Berrie Nanotechnology Institute
Technion - Israel Institute of Technology

http://rbni.technion.ac.il

Contact
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Supported by the Russell Berrie Foundation, the Government of Israel through TELEM, and the Technion; The Russell Berrie Nanotechnology Institute (RBNI) was established in 2005 and has since positioned the Technion and the State of Israel amongst the leading global academic institutes of Nanotechnology research and development. Vigorous recruitment of bright new faculty members from research laboratories around the world, extensive investment in infrastructure, new educational programs for training the next generation of scientists and engineers, and nurturing of multidisciplinary collaborations within campus, as well as with industry and other academic institutions, provide the vehicle for achieving the desired impact on the Technion, the State of Israel, and the well-being of humankind.

The research activities within RBNI cover a wide range of scientific and technological areas typifying the multi-disciplinary nature of the center. The activities can be divided into several broad fields that include: Nanophotonics, Quantum science matter and engineering, Nanoelectronics, Nanomed, Advanced Imaging, Nanotechnology for energy harvesting, Self-assembled materials and structures.

## Nanotechnology Infrastructure:

Over the past 11 years, RBNI has established several Nanotechnology Infrastructure centers across campus and significantly upgraded other centers in faculties associated with RBNI. Overall, RBNI invested in the past 11 years, over M$40 in upgrading nano related equipment, and continues to support 15 infrastructure centers on campus, serving Israeli researchers in academia and industry. Dozens of companies from the Israeli Industry and well over 100 research groups from Technion and other Academia institutes, use multiple services offered by the RBNI supported infrastructure centers.

### RBNI supports the following infrastructure centers:

Zisapel Nanoelectronics Center (MNFU) (Faculty of Electrical Engineering) ➲ Electron Microscopy Center (Faculty of Materials Science and Engineering) ➲ Electron Microscopy Center for Soft Matter (Faculty of Chemical Engineering) ➲ Center for Nano Photonics (Faculty of Electrical Engineering Fischbach Building) ➲ Joint GTEP and RBNI Technion Photovoltaic Laboratory (Zisapel Building) ➲ Joint Life Sciences and Engineering and RBNI Infrastructure Unit (Emerson Building) ➲ Smoler Proteomics Center (Faculty of Biology) ➲ Biomechanics and Tissue Engineering Center (Faculty of Bio-Medical Engineering)

Surface Characterization Center (Solid State Institute) Russell Berrie Nanoparticles and Nanometric Systems Characterization Center X-ray and Particle Characterization Facilities (Faculty of Chemical Engineering) Center for Computational Nanoscience and Nanotechnology (Computer Center) Joint Life Sciences and Engineering and RBNI Technion Center for Structural Biology (TCSB) The Biomedical Core Facility (Faculty of Medicine) The Chemical and Surface Analysis Lab (Faculty of Chemistry)

## RBNI Expertise:

The key expertise of RBNI are in four areas: Nano Photonics, Nano Electronics, Electron Microscopy and NanoMed.

**Nano photonics** is by far the largest and most famous activity and comprises some 27 faculty members across campus. The activity covers a wide range of topics from fundamental to very applied.

In the past five years, the applied activity was focused on a national project, Focal Technological Area - *Nanophotonics for Advanced Light Detection, Imaging, Inspection, Smart Sensors, Energy Conversion*.

Technion's Focal Technological Area in the area of Nano Photonics was selected for funding by the Israeli Government and was developed over the past 5 years by several Technion research groups. The focus of this activity is light nano-detectors, enhanced by nanophotonic structures and applications, including sensing and ultrahigh resolution inspection. The photonics-related industry in Israel is expected to be directly transformed by the project's technologies, detectors, sensors, modules, platforms, and systems.

The FTA enabled Technion to add to its infrastructure a major tool – a state of the art electron beam writing system with characteristics that are second to no other similar system in the world. The EBL was put into work in 2015 and is located in the Zisapel Nanoelectronics Center (MNFU) (Faculty of Electrical Engineering).

**Nano Electronics** activities involve many researchers who deal with issues of a very applied, yet futuristic nature. Silicon activities are often done in collaboration with industry. Research in III-V materials (mainly InP based) make use of local epitaxy capabilities, GaN research is done in collaboration with industry and foreign partners and super

conducting materials, organic semiconductors and Carbon nano tubes are fabricated on site. The activities take place in the Zisapel nano electronics center which comprises many faculty and a large, high level technical staff. Device processes are developed in house for internal and external users and a modern facility with state of the art equipment is available for academic as well as industrial users.

**Electron Microscopy** is another strength of the Technion. RBNI established and supports two microscopy centers, one for soft materials which is housed in the Chemical Engineering Dept. and a second which is at the Materials Science and Engineering Dept. Both centers have state of the art equipment, both purchased new HRTEM systems in 2016 which are available for use by everyone from academia and industry. The centers include high level technical and support staff and hence can provide a full line of services of the highest quality.

**NanoMed** is a field that lies at the interface of nanotechnology and the life sciences. It operates in close collaboration with the Center for Life Science and Engineering and in future will collaborate strongly with the newly established Cancer Research Center. The main participants in the NanoMed program come from the faculties of Biology, Biomedical Engineering, Biotechnology and Food Engineering, Chemical Engineering and Mechanical Engineering. The topics of research are very wide and cover diagnostic, therapeutic and medical imaging as well as fundamental life science research. Many of the researchers work closely with industry and the vast infrastructure established by RBNI is available for use by all academic and industrial researchers in Israel.

## Cooperation with industry:

The FTA yielded many potential commercial outlets. A large segment of the inspection and metrology industry in Israel will be directly up-graded by novel ultra-high-resolution methodologies and technologies. Other products expected to emerge from, or to be affected by, technologies developed in the framework of the FTA include: pillar-based NIR-SWIR-MIR sensors and imagers; imagers with plasmonics based smart pixel optics; miniature optical clocks and photonic based magnetometers; nanophotonic parametric oscillator-based sensors; plasmonic multispectral, polarization diversity functional imagers; extreme resolution inspection systems with emphasis on microelectronics and biomedics; efficient hybrid thin layer solar cells; efficient solar-electrochemical cells; nanophotonic-enhanced medical

probes: high-resolution OCT; plasmonic-enhanced medical Raman probes; micro-nano photonic circuit platforms and elements; flexible sensors; and integrated communication transceivers.

Cooperation already exists with SCD, Elbit, and Tower Jazz in novel detectors, 3G Solar in solar cells, and with Rafael in special sensors, amongst others.

While a significant portion of the research outcome is expected to be absorbed in the large industrial entities of defense, detectors, semiconductors, and inspection; in two evolving fields we expect to promote new initiatives and start-up activities: biomedical optical probing and diagnostics, and solar energy harvesting.

# TECHNION AUTONOMOUS SYSTEMS PROGRAM (TASP)


Quad-Copter


Snake Robot

Autonomous systems represent the next great step forward in the fusion of machines with sensors, computers, and communication capabilities. The objective is to develop intelligent systems that can interact dynamically with the complexities of the real world. These systems make independent decisions about how to act, even in groups, especially in unplanned, changing, or unexpected conditions. Autonomous system applications include performance-enhanced unmanned aerial vehicles (UAVs); swimming medical micro-robots that can travel through the human body; unmanned vehicles for underwater, land-based, and space exploration; environmental disaster cleanup operations; rescue operations; detection, identification, and neutralization of chemical and biological weapons and explosives; transportation and traffic control systems; communication networks; and a wealth of other applications that drive progress in defense, medicine, and industry. The Technion does research in all these areas

## TASP Centers:

- Arlene and Arnold Goldstein UAV and Satellite Center
- Unmanned Ground Systems Center
- Unmanned Marine Systems Center

## Two Centers under construction:

- Autonomous Medical Systems
- Autonomous Agent Systems

## Collaborations:

- Agreement with Israel Aerospace Industries (IAI) for NIS 1 million annual research support.
- Participation in ROBIL, a three-university project to design a humanoid robot, funded by the US Defense Advanced Research Projects Agency (DARPA) and the Israeli Ministry of Defense.

***http://tasp.technion.ac.il/index.php/en***

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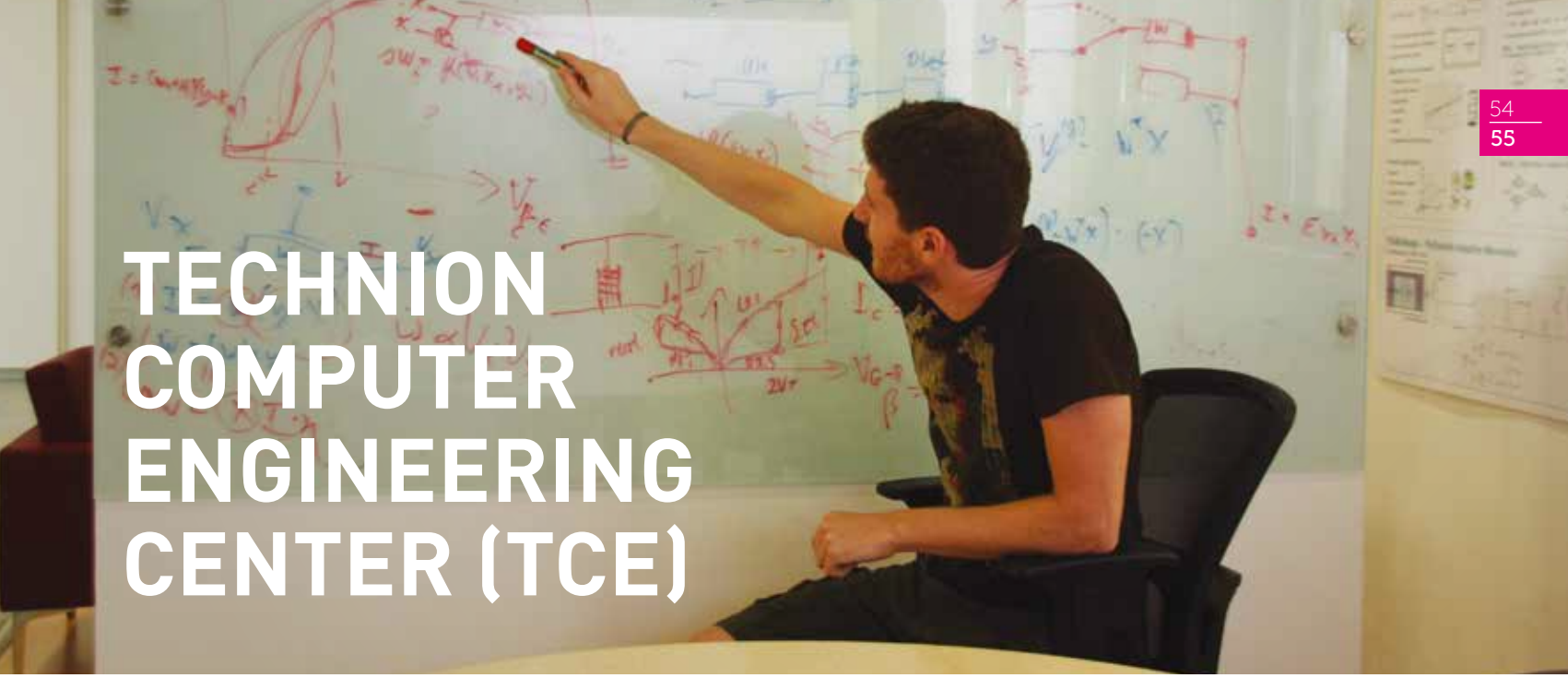

# TECHNION COMPUTER ENGINEERING CENTER (TCE)

***http://tce.technion.ac.il***

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The TCE Center is designed to lead worldwide computer engineering research and education, and to operate as a focal point for academic and industrial collaboration. Computer Science and Electrical Engineering are two of the Technion's leading faculties. With the TCE Center, these Faculties intend to take a national and international leadership role in cutting-edge research and development. The TCE Center provides the foundation and facilities for computer engineering research and education. Its unique model facilitates an unprecedented platform for industrial-academic partnership, and creates a novel eco-system beneficial to both.

## Research Areas:

Applied Computer Engineering domains, such as:
Computer Architecture and Systems ➲ Cloud Computing ➲ Communication and Networking ➲ Data Bases ➲ Data Processing and Data Mining ➲ Machine Learning ➲ Computer Graphics ➲ Computer Vision ➲ Cyber Security ➲ Social Networks ➲ Quantum Computer Engineering

## Industry-Affiliated Opportunities:

A major goal of the TCE Center is to bridge the academia-industry gap by encouraging academic members to contribute knowledge and experience in joint applied research with industry. The Center welcomes part- and full-time visitors from industry, interested in research collaboration or seeking expert help.

***http://icri-ci.technion.ac.il***

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Visitors may engage in research, education, and innovative projects. In order to create a suitable environment that will accommodate both TCE and industry, TCE has adopted an open IP policy to govern TCE activities, where all results generated in the scope of TCE activities are open to the public, and IP will be dealt with on a per case basis. TCE members need to sign the TCE Memorandum of Understanding (TCE MOU).

### Industry Members:

Check Point ➲ Yahoo! Labs ➲ EZChip ➲ HP ➲ IATI- Israel Advanced Technology Industries ➲ IBM ➲ Intel ➲ Matrix ➲ Marvell ➲ Mellanox ➲ Motorola Solutions ➲ Rafael ➲ Ravello Systems ➲ SAP ➲ EMC

### Intel Collaborative Research Institute - Computational Intelligence (ICRI-CI):

Intel Laboratories has launched Intel Science and Technology Centers and Intel Collaborative Research Institutes to foster collaboration of Intel and academia. Each research community is Intel-funded, jointly-led, and focused on a specific technology domain, bringing top researchers from academia and Intel together to explore and develop new answers to existing and new questions. The mission is to build global collaborations with academic pioneers to discover and utilize computing to enrich the human experience. The resulting insights are expected to bring in new technologies that will be used by Intel and the industry to build better, more exciting, products, and maintain Israel's leading position.

The Intel Collaboration Research Institute for Computational Intelligence (ICRI-CI) Center was inaugurated on May 22, 2012. It is focused on machine learning, brain-inspired computing, and heterogeneous computer architectures. ICRI-CI's vision is to deliver breakthroughs in architecture, algorithms, and usage models. The center carries out fundamental research in the above domains, as well as developing capabilities in the areas of learning audio/visual systems and intelligent agents.

In Israel the Institute is based at the Technion in Haifa and the Hebrew University of Jerusalem, and also includes researchers from Bar-Ilan University, the Weizmann Institute of Science, and Shenkar College of Engineering and Design. The Center is mainly connected with several Intel business units, in Israel and internationally.

# RESEARCH INSTITUTES

מיסודם של
משרד הבינוי והשיכון
הטכניון - מכון טכנולוגי לישראל
הפקולטה להנדסה אזרחית וסביבתית

המכון הלאומי לחקר הבנייה
National Building Research Institute

ASHER SPACE RESEARCH INSTITUTE

Solid State Institute
המכון למצב מוצק

THE STEPHEN AND NANCY
GRAND WATER RESEARCH
INSTITUTE

המכון לחקר התחבורה
TRI

# NATIONAL BUILDING RESEARCH INSTITUTE (NBRI)

***http://nbri.net.technion.ac.il***

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The National Building Research Institute was established in October 1988, as a joint venture of the Israeli Ministry of Construction and Housing and the Technion. It is based on the highly respected 50-year-old Building Research Station, and maintains its professional tradition. Its main objective remains advancement of knowledge in the building sciences, solution of long-range problems of the building sector through methodological research, as well as support in solving short-term needs, in areas where expertise is crucial.

NBRI members include the Civil Engineering Faculty, whose research is in the areas of Structural Engineering, Geotechnical Engineering, Building Materials, Performance and Technology and Construction Management and Economics, as well as researchers and graduate students in these areas. NBRI has a large laboratory hall with a massive testing floor and several specific laboratories in these areas.

NBRI has a long-standing collaboration with industry, assisting Israeli manufacturers and builders in the investigation of innovations, and in studying basic issues related to their products or processes. In addition to research collaboration, NBRI provides testing services when other laboratories are not equipped to do so. Reports include detailed description of the test and results. NBRI does not engage in standard testing and certification, or in providing expert opinions.
The price of the testing service includes manpower and use of equipment. It depends on the specific work, and comprises a set-up fee for the specific test plus the price per hour or part of an hour, according to the complexity, manpower, and type of equipment used for testing.

## Testing Hall and Structural Engineering Laboratory:

The main testing hall at NBRI includes several testing facilities for material and structural tests, as outlined below, and a strong test floor, which enables versatile arrangement of various set-ups for medium- to large-scale specimens of structural components, such as beams, columns, walls, etc. Part of this floor is dedicated to a permanent special steel frame, with a 500-kN, 150-mm stroke actuator, that enables testing of specimens with a height of up to 2 m. This actuator is connected to an MTS controller that enables testing with stroke control to a variety of static and dynamic loading programs.

Shaking Table

1000kN compression and tension machine and pulsators

The specific equipment in this laboratory includes:

- Shaking Tables: Large 1-DoF table, 3 x 3 m, up to 50 kN, 1-10 Hz, horizontal sway ±50 mm. Small 1-DoF table, 40 x 60 cm, up to 40 N.
- Compression and Tension Testing Systems: Manually controlled machines with capacities of 1, 100, 300, 1000, and 5000 kN
- Controllable Actuators: In compression and tension with capacities of 100 and 500 kN, and in compression with a capacity of 2000 kN
- Hydraulic Jacks: 25 jacks and a central control system. Force capacities are 160, 180, 320, 350, 420, and 500 kN, and maximum travels are 60, 100, 150, 380, and 450 mm
- Static and dynamic measurement laboratory: Includes data acquisition systems, and a variety of force, displacement, acceleration and strain transducers, as well as pulsators. Force transducers include compression of 100, 250, 500 and 5000 kN; tension 5 and 50 kN; tension and compression 5 and 50 kN; and hollow 500 kN

## Impact Laboratory:

The Impact Laboratory is built partly below ground. The space of this specially reinforced concrete laboratory comprises a control and operation room with a safety and operational controller, and various electrical, mechanical, and computational facilities.

The laboratory is used to test the impact response of structural elements and materials to low velocity and high velocity impact loads, penetration processes in structural and geotechnical systems, and the blast response of structural elements.

Air Gun

The laboratory floor includes two large isolated foundation blocks supporting a gun system and a target holder system. Specially constructed interior reinforced concrete walls provide separation of different safety zones.

The specific equipment in this laboratory includes:

- Air-guns for high-velocity impact, and a moderate-velocity air gun system
- Low-velocity impact system
- Small caliber shooting system
- High-speed cameras: A high-speed monitoring system.
- High-speed velocity measurement system
- Monitoring systems: For dynamic acceleration, pressure, strain, and displacement
- Blast shock tube: Under development

**Building Materials Laboratory:**

The laboratory is equipped with various accessories to test chemical, physical and mechanical properties of building materials, such as concrete (in both fresh and hardened states), gypsum, lime, masonry, plaster, grout, natural stone, metals, timber, fiber-reinforced materials, chemical and mineral admixtures for concrete, as well as industrial by-products, such as coal fly ash, chemical gypsum, recycled aggregates, recycled plastics, and rock waste. The laboratory facilities can be used to simulate behavior of various building materials under special environmental and loading conditions, and for testing strength, permeability, durability, shrinkage-induced cracking, corrosion resistance, water/gas/water penetration, sorptivity, resistance to salt attack, UV radiation, and thermal and hygric cycles. The laboratory is also equipped for non-destructive testing of mechanical properties.

The specific equipment in this laboratory includes:

- Climatic Rooms: Regulated temperature $\pm$0.5°C and humidity $\pm$5%
- Climatic Chambers: Temperature range: -10 to +150°C, RH = 25%-99%
- Carbon Dioxide Chamber: up to 5% of $CO_2$
- Ovens: For drying and heating
- Mercury Intrusion Porosimeter: up to 0.4 GPa
- Thermo-Gravimetric Analyzer TGS-2
- Scanning Electron Microscope (SEM)
- Small Wind Tunnel: 90x60 cm cross-section and 180 cm length, for testing building materials under drying conditions in hot climates

Climactic Chamber

- Uniaxial Restrained Shrinkage Apparatus: Closed loop system for measuring strains and stresses in early age concrete
- Chemical Shrinkage Measuring System
- Adiabatic and Isotheral Calorimeters: For measuring heat of cement hydration
- Rheometer: For measuring rheological properties of fresh concrete mixes
- Portable Non-Destructive Testing Instruments: For ultrasonic pulse, rebound, electro-magnetic, electrical conductivity, optical and other measurements
- Chloride and Water Penetration Measuring Systems
- Set-up for Testing Corrosion of Reinforcement Steel in Concrete

**Thermal and Energy Laboratory:**

The Thermal and Energy Laboratory is capable of testing the thermal conductivity of building materials, thermal and energy performance of wall specimens of surface area 1.2x1.2 m, and the air and water permeability and performance under a pressure difference of any vertical building envelope element, such as walls, windows and curtain-walls, with a surface area up to 4x4 m.

The equipment in this laboratory includes:

- Guarded hot plate: Thermal conductivity measurements of specimens up to 5 cm thick in the range 10°C to 50°C
- Hot box: For the investigation of steady-state thermal and energy performance of 1.2x1.2 m wall specimens
- Air and water permeability test facility: For investigating air and water tightness of vertical elements of up to 4x4 m. The nominal pressure difference capacity is up to 3000 Pa, and the air flow range is 210 $m^3 h^{-1}$

**Radiation Safety in Construction Laboratory:**

The laboratory can assist in measuring natural radionuclides in building materials, radon flux from soils and building materials, and perform continuous as well as long-term average radon monitoring in enclosed spaces.

The equipment in this laboratory includes:

- Scintillation gamma-spectrometers for measuring natural radionuclides in building materials
- Beta-spectrometer for measuring radon flux from soils

Air and Water Permeability Test Facility

- Continuous radon monitors and electrets
- Gamma dosimeters
- Radon permeability test installation for testing building materials and radon-barrier materials
- Radon exhalation testing chambers for measuring radon exhalation of building materials (6.5 and 85 L)

**Seskin Virtual Construction Laboratory:**

The primary foci of the Virtual Construction Laboratory (VC Lab) include Building Information Modeling (BIM), Lean Construction, and the synergies between the two. Its computing and virtual reality infrastructure enables tackling a wide range of topics, not only in Construction Management, but in diverse fields such as Architecture and Town Planning, Transport, Design Collaboration, and others.

The specific equipment in this laboratory includes:

- A CAVE (CAVE Automated Virtual Environment): the EON Mobile Icube, a reconfigurable 3-wall PC workstation-based immersive environment, in which participants are completely surrounded by virtual imagery and a sound system. The system has a DLP active stereo-projection system, 3D stereo rear-projection screens, a floor-mounted screen structure, EON Professional Software (EON Studio, Visual Effects, RPC, EON CAD, Raptor and Physics Engine as well as EON Server), a Natural-Point eight-camera wide field of view infrared wireless motion tracking system, and active stereo glasses.

- KanBIM™ mobile touch screen workstation: Includes a mounted PC workstation (Intel i7 950 6GB RAM DDR III NVidia GTX 460) and a 42" touch screen monitor (Elo Touch Systems 42" Model ET4200L-AUWA).

- Dual-screen BIM workstations: Five stations with a variety of BIM software tools.

# NORMAN AND HELEN ASHER SPACE RESEARCH INSTITUTE (ASRI)

ASHER SPACE RESEARCH INSTITUTE

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ASRI operates with a broad national perspective. It fosters interdisciplinary work and collaboration of Israeli researchers from all Technion departments, as well as from other universities, agencies, and industry. The ASRI has also established collaborative projects with institutions in other countries.

ASRI was established in 1984. Its members are professors in eight academic departments of the Technion (Physics, Aerospace, Mechanical, Chemical, Civil and Environmental, and Electrical Engineering, Computer Sciences, and Architecture).

Its research and technical staff are involved in various activities, including research and development of small satellites.

The Asher Space Research Institute has achieved global recognition, having succeeded in bringing space-related research activities to the forefront of science, technology, and academia, both nationally and internationally. The institute is now regarded one of the most prestigious research centers on campus, and attracts high-profile visitors.

## Laboratories:

In addition to its support of space-related research around the campus, ASRI is home to four leading laboratories.

### Distributed Space Systems Laboratory (DSSL):

The DSSL was designed and built in the Faculty of Aerospace Engineering, and is located in the Asher Space Research Institute. Research efforts are focused on dynamics and control of multiple spacecraft formation flying, a topic attracting much interest in the United States and Europe. The DSSL also serves as a resource for instruction and education.

***dssl.technion.ac.il***

### Electric Propulsion Laboratory:

The present-day stage in the development of worldwide spacecraft technology is characterized by the increasing use of electric propulsion (EP) for solving a broad spectrum of problems; from correction of a spacecraft position in orbit, to a radical change of its flight trajectory, and implementations of interplanetary missions. The application of electric propulsion allows a significant reduction of spacecraft mass as a consequence of propellant saving. This, in turn, provides substantial mission cost savings. ASRI researchers invented the patented CAMILA thruster that is now on track to commercialization.

***asri.technion.ac.il/node/148***

### Space Interferometry Laboratory:

The Space Interferometry Laboratory (SILy) seeks novel solutions for improving the angular resolution of telescopes for both astronomical and Earth observations from space. The resolution of a traditional telescopic imaging system is strictly limited by the size of the aperture and the color of light that is observed. Telescopes as large as 30 and 50 m are currently being designed, but in space, limitations on size and weight are severe. The Hubble space telescope, for example, has a mirror diameter of 2.4 m. In order to minimize aberrations, the mirror needs to be thick, which costs valuable space, and more importantly, weight, which the mission needs to launch into space. Telescopes much larger than Hubble, therefore, very quickly become far too heavy and expensive for space missions. Our laboratory is now involved in a project to develop a segmented telescope that will allow the optics to be deployed in space to be larger than the launcher.

***http://asri.technion.ac.il/node/149***

***http://asri.technion.ac.il/node/271***

***http://asri.technion.ac.il/node/219***

## Aerospace Plasma Laboratory (APL):

APL is part of the Faculty of Aerospace Engineering and is located in the Asher Space Research Institute, Technion. The lab is built for carrying out a program of research and development of innovative nanosatellite/CubeSat electric propulsion systems. The laboratory goal is to enable advanced understating of the plasma processes in these devices and enable their realization. The approach to research in APL involves a full set of activities: starting from a simplified physical-mathematical or phenomenological model, then development of a more realistic computer simulation and finally the design, implementation, and testing of a specific device.

## SAMSON Project:


The State of Israel is a proud member of the space club, which comprises fewer than ten nations that design, build, and launch their own satellites. As such, Israel's space industries are world-renowned, and have achieved their well-respected standing for the satellites they have built, and are building and selling today. In contrast, the research at the Asher Space Research Institute (ASRI) is mostly concerned with Israel's space technology a decade from now, and beyond. Small university-scale satellites, such as those of the Technion's SAMSON mission, are becoming the primary tool for training engineering students on a worldwide basis, as well as for testing novel applications in space before they can be implemented on large, commercial satellites. University space research, by its nature, is too far advanced for industries to immediately turn their concepts and designs into current business. Nevertheless, many industries do have vision, and realize that today's research is tomorrow's potential business.

Over the past two years, the Technion has claimed the role of spearheading small-satellite research in Israel, mostly owing to the SAMSON project. Under the leadership of ASRI, we have now built a diverse group of several dozen researchers and engineers from the Technion and collaborating Israeli industries. The industries work pro-bono, as they recognize the technological value of being part of a cutting-edge space mission. In the space business, where customers are few, SAMSON provides a rare opportunity for industry to be part of a novel, yet real, mission through which their people and hardware gain valuable prestige in the space industry.

### Current SAMSON Industry Partners:

The space division of Israel Aerospace Industries – MBT Space – is Israel's primary space contractor, and the home of Israel's highly successful Ofeq and Amos satellite lines. Once SAMSON was conceived, MBT Space volunteered to provide systems engineering services to the project, as well as their other expertise in satellite building, attitude and thermal control, thermo-acoustic testing, systems integration, etc. MBT Space has just developed a new "bus" (basic units) for nano-satellites. We are in the process of purchasing three such units for the SAMSON satellites, which will be one of the first test beds for the new bus.

Rafael Advanced Defense Systems Ltd. is the backbone of Israel's defense industries, and is probably its most profitable member. Rafael designs and builds thrusters and thruster components for most of Israel's satellites. Rafael was part of SAMSON early on, when one of its engineers instructed group student projects. Since SAMSON was conceived in 2011, these projects have been geared towards the SAMSON mission. Under the instruction of engineers from Rafael's Space Directorate, Technion students designed the thruster system of SAMSON that will be the key to the success of its formation flying and the geo-location missions.

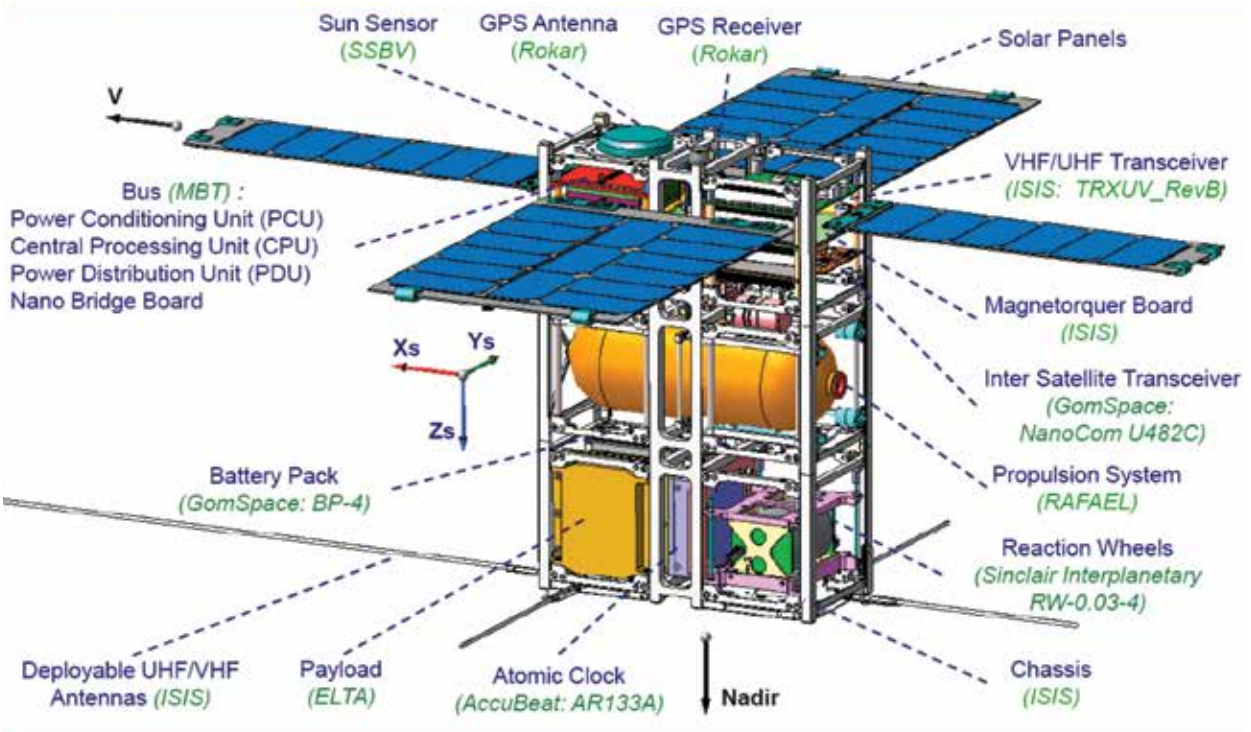


Image courtesy of Dr. Vladimir Balabanov (ASRI)

ELTA Systems Ltd., a subsidiary of IAI, is one of Israel's leading defense electronics companies. Several Elta engineers are core members of the SAMSON team, and are working closely with the SAMSON team to develop the geo-location payload.

Beyond all the above, several small and medium Israeli enterprises (SMEs) are important members of the SAMSON collaboration:

- **Spacecialist** - for its expertise in systems engineering and launch technologies
- **BAE Systems** - Rokar - for its GPS flight models
- **Accubeat** - for its atomic clock for high-precision time-keeping that is the key to the geo-location algorithm

# SOLID STATE INSTITUTE (SSI)

Solid State Institute
המכון למצב מוצק

***http://solid-state.technion.ac.il***

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The Solid State Institute is an interdisciplinary research center designated to house and serve scientists from various faculties who are interested in the study of solids and solid interfaces. Pure and applied research projects, some of which may ultimately be of use to industry, are being carried out at the Institute in many individual and/or collaborative research efforts. The physical proximity fosters cooperation between scientists from different disciplines and different faculties that otherwise would not take place.

## Service Laboratories:

Ion Implantation Laboratory ➲ Near Field Scanning Optical Microscopy and Raman Spectroscopy Laboratory ➲ Surface Science Laboratory ➲ Ultra-High Vacuum Surface Probe Microscopy Laboratory ➲ X- Ray Laboratory

## Individual Researcher Laboratory Functions:

Extreme non-linear optics ➲ Coherent electronic transport ➲ Non-linear optics ➲ Optically-detected magnetic resonance and near-field optics ➲ Quantum optics and time-resolved spectroscopy ➲ Photo-induced infrared spectroscopy ➲ Diamond-film deposition ➲ Electrical characterization, Electro-optical characterization and magneto-optical spectroscopy

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## Main service laboratories:

### Ion Implantation Laboratory:

The Ion Implantation Laboratory was established some 30 years ago. The facility is based on a 350 keV ion implanter, with the ability of utilizing many different ion species for implantation at multiple-charged ion states under different conditions, such as sample temperature, orientation, etc.). It can implant nearly any ion with isotopic resolution. In this respect it is unique in Israel, and is most useful for versatile research applications. The laboratory collaborates with many local industries, as well as worldwide.

Ion Implanter

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### Near Field Optical Scanning and Raman Microscopy Laboratory:

The laboratory is based on the Nanonics CryoView 2000™ set-up, purchased in 2007. It introduces integrated microscopy to low-temperature research. It is capable of simultaneous near-field scanning optical microscopy (NSOM and atomic force microscopy (AFM) or confocal imaging of surfaces in variable temperature environments.

The unit comprises a helium flow cryostat with optical access from above and below the sample. It is capable of simultaneous AFM and NSOM at temperatures down to 10°K. It provides high resolution photoluminescence measurements at a lateral scanning range of 50 by 50 µm and heights of about 10 µm.

NSOM apparatus

## Variable Temperature, Ultra High Vacuum, Scanning Probe Microscope (VT-UHVSPM) Laboratory:

The Laboratory is based on an Omicron Variable Temperature Ultra High Vacuum Scanning Probe Microscope system, purchased in 2005.

It includes an Atomic Force Microscope (AFM) and a Scanning Tunneling Microscope (STM) with the following technical capabilities:

- True sub-pA scanning tunneling microscopy and spectroscopy (STS)
- STS down to atomic scale
- True atomic resolution imaging in contact AFM mode
- Topography and Current mapping in contact AFM mode
- Non-contact AFM mode in frequency modulation regime and new PLL electronics
- Scanning Kelvin Probe Microscopy (SKPM) in frequency modulation regime
- *In situ* Auger electron spectroscopy (AES), *In situ* low energy electron diffraction (LEED), *In situ* cleavage, *In situ* sample heating up to 1500K, *In situ* Ar sputtering, *In situ* metal evaporation and *In situ* $H_2$ cracker
- Gate valve for analysis and preparation chamber isolation
- Basic vacuum in both preparation and analysis chambers, as obtained by ion pumps and Ti sublimator pumps, is 4x10-11mbar
- AFM beam deflection
- Direct and radiation sample heating up to 1500K
- *In situ* cooling and heating down to 25K and up to 1500K
- Sample introduction through fast entry lock chamber
- Scan size from sub-nano to 8 µm

The system has so far been mainly used for the following measurements:

- Imaging solid surface and nanostructures down to a vertical resolution better than 0.01nm and a lateral resolution better than 0.1nm
- Determination of local electrical, chemical and mechanical properties at atomic scale

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The UHVSPM apparatus in the VT-UHVSPM lab

## Surface Science Laboratory:

The Surface Science Laboratory, established in 1980, serves as a center for basic and applied research in the field of surface and thin film physics and chemistry.

The laboratory is equipped with a Time of Flight SIMS (ToF-SIMS) system, and an X-Ray Photoelectron Spectroscopy (XPS) system. These two powerful surface techniques are widely used by several academic research teams, making the Surface Science Laboratory a multi-disciplinary laboratory. The laboratory supports also hundreds of industrial companies in their R&D and Q&A ongoing activities.

The Laboratory specializes in three surface-sensitive analytical techniques:

### The XPS apparatus in the Surface Science Laboratory:

The X-Ray Photoelectron Spectroscopy (XPS) provides a quantitative chemical composition of solid surfaces with chemical bonding information for surfaces, thin layers, interfaces, bulk and powder materials.

The key features of XPS are:

- Identification of all elements except Hydrogen and Helium
  Surface sensitivity : probes between 2 to 8nm of the material
- Quantitative analysis with a 0.1% atomic sensitivity
- Chemical bonding information from core level energy shifts
- Depth profiling with a 3nm depth resolution
- Electronic structure information

The XPS activity is based on Thermo VG Scientific Sigma Probe, England purchased in 2000. The system is fitted with a monochromatic Al Kα (1486.6 eV) source. A 100W X-ray primary beam size can be varied from 400 to 15 µm diameter allowing a wide area or localized chemical characterization.

In early 2017 a new XPS system has been installed at the Surface Science laboratory. The scanning XPS microprobe VersaProbe III (PHI Physical Electronics, USA) system is equipped with the following features:

- An aluminum monochromated X-ray primary source with a beam size that can be varied from 300 to 10 mm diameter

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The XPS apparatus in the surface science laboratory

- Scanning X-ray beam induced secondary electron images (SXI) with a field of view of 700*700 $mm^2$
- An ability of chemical state imaging and mapping of surface sample (lateral resolution of 4-5 mm)
- An ultra violet integrated source allows ultra violet photoelectron spectroscopy (UPS) analysis for a direct measurement of valence band and work function of materials
- *In situ* sample cooling (down to -140°C) or heating (up to 800°C)

The Versaprobe III system presents also the ability for depth profiling materials by three different methods:

- An angle resolved XPS (AR-XPS) analysis to depth profile by tilting the sample without damaging the surface, till about 15nm depth.
- A monoatomic Ar+ ion gun used for depth profiling semiconductor materials or metal oxides
- A cluster Arn+ ion gun sputtering used for depth profiling organic based structures

The versatility of the VersaProbe III provides analytical and research services essential for progress of many academic research groups and industries ongoing activities in the means of surface science understanding.

The Surface Science Laboratory is equipped with a TOF.SIMS 5 from IONTOF GmbH (Germany) purchased in 2007:
Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) is a very sensitive surface analytical technique, well established for many research and industrial applications. It provides detailed elemental and molecular information about surfaces, thin layers, interfaces, and full 3D analysis of the samples.
Its design guarantees optimum performance in all fields of SIMS applications. The flexible, high precision sample manipulator well as the perfect charge compensation allows the analysis of virtually all kinds of samples. The TOF analyzer provides a high secondary ion transmission with high mass resolution and high lateral and depth resolution. The use is widespread, including semiconductors, polymers, paint, coatings, glass, paper, metals, ceramics, biomaterials, pharmaceuticals and organic tissue.

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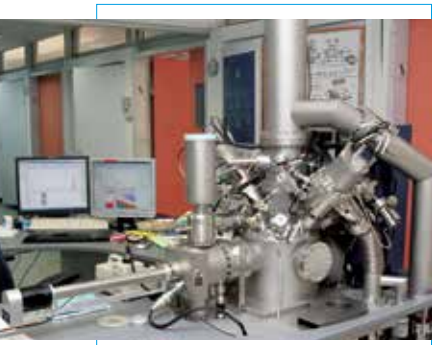


The TOF-SIMS apparatus in the surface science lab

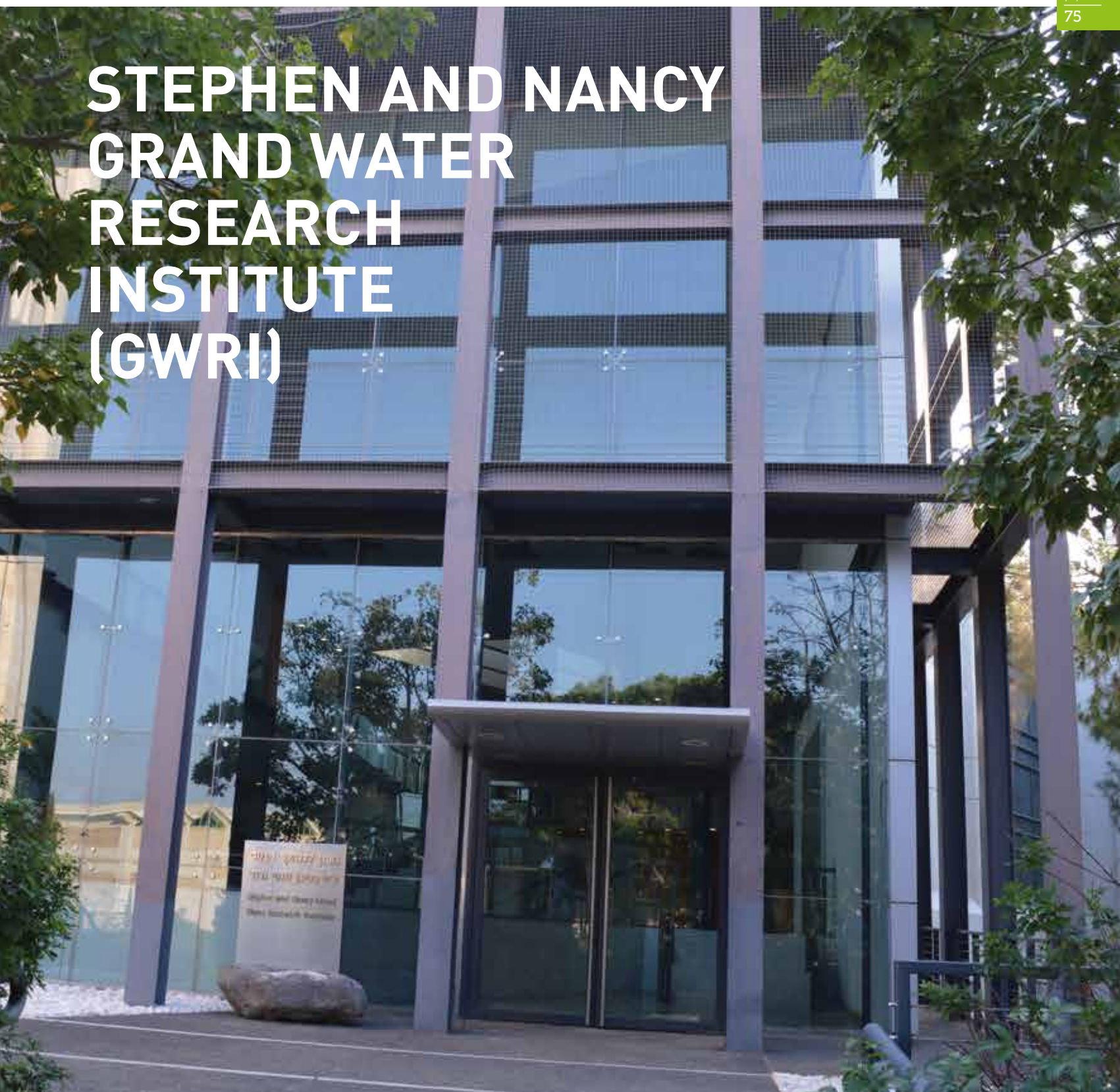
The key features of the TOF-SIMS are:

- Elemental and molecular chemical detection, including hydrogen, with a high sensitivity range (~1ppm)
- High mass range (up to 14000 au) with an option to simultaneously detect different ions, organic and inorganic (including hydrogen) materials, that allows retrospective analysis
- High mass resolution at full transmission (M/DM>8000) even for insulating materials
- High lateral resolution (<1 mm) with field of view from $mm^2$ to $cm^2$
- Depth resolution of about 1nm together with sputter speed of up to 10 mm /h
- 3D rendering software
- *In situ* sample cooling (down to 150K) or heating ( up to 900K)

The system has been so far used for:

- Detection and relative quantification of traces of metals, dopants, contaminants or diffusion profiles (down to $10^{15}$ at/$cm^3$)
- Chemical imaging and mapping of elements and molecules for investigation of layers, defects, grain boundaries and manufactured structures
- Reverse engineering and failure analysis

# STEPHEN AND NANCY GRAND WATER RESEARCH INSTITUTE (GWRI)



THE STEPHEN AND NANCY GRAND WATER RESEARCH INSTITUTE

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The Stephen and Nancy Grand Water Research Institute (GWRI) was established in 1993. Its mission is to promote and support research and management of Israel's water resources, maintaining the Technion's leading position and Israel's world leadership in the domain.

Technion, given its international and regional pre-eminence in science, engineering and technology, relies on the GWRI leadership to continue the line of research excellence that provides solutions to water-related problems.

GWRI emphasizes advancement of water science, engineering and management tools in Israel, the Middle East, and other water-sensitive regions worldwide. GWRI focuses on innovative and sustainable approaches, technologies and methods for overcoming water shortage and preserving the quality of water resources at the lowest possible cost, while saving energy and diminishing environmental and ecological impact. GWRI is committed to lead water research in Israel, while maintaining good working relations with the academic, research, and industrial sectors both locally and internationally.

## Research and Development Areas:

### Water treatment, desalination and treatment of wastewater:

Water treatment (physico-chemical, biological) ➲ Advanced desalination technologies ➲ Membranes: design-synthesis-modifications-testing-modeling ➲ Wastewater treatment: biological, chemo-physical, membranes, nanofilters / nanotubes / nanochannels ➲ Post-treatment of desalinized seawater ➲ Treatment of industrial wastewater ➲ Gray-water recycling and management aspects

### Preservation of water resources, hydrology - source quantity and quality, wastewater reuse and efficient irrigation:

Hydro-geophysics ➲ Hydrological processes, including climate change effects ➲ Monitoring and modeling at various scales ➲ Fluid dynamics of complex water systems ➲ Development of advanced analytical and monitoring tools ➲ Reuse of reclaimed wastewater for sustainable crop production ➲ Water use efficiency

### Water and environmental microbiology:

Applied Genomics and Water Microbiology ➲ Pathogen survival in water systems and in plants irrigated with reclaimed wastewater ➲ Advanced methods for bacterial detection ➲ Microfluidics for advanced bio-sensing

Management of urban water systems, water resources management and policy:
Water resource systems analysis ➲ Management of water distribution systems ➲ Multi-objective optimization models ➲ Security and reliability aspects ➲ Water resources under uncertainty and risk ➲ Water-sensitive planning ➲ Enviromatics: utilization of distributed multi-modal sensor networks for water sensing and decision-making

**Interaction with the water industry sector:**
GWRI members are deeply involved with the Israeli and international water industry through active participation in R&D projects, scientific/professional meetings, consulting to industry, and involvement in professional steering committees.

Research projects are conducted by GWRI researchers sponsored directly by various water industries, including SANOFI; Mekorot-Israel National Water Co.; Haifa Chemicals Ltd.; Maccabi Carasso Ltd; Agat Engineering Consulting and Design 2000 Ltd; Israel Electric Corporation; Hydranautics Inc.; and Oil Refineries Ltd.

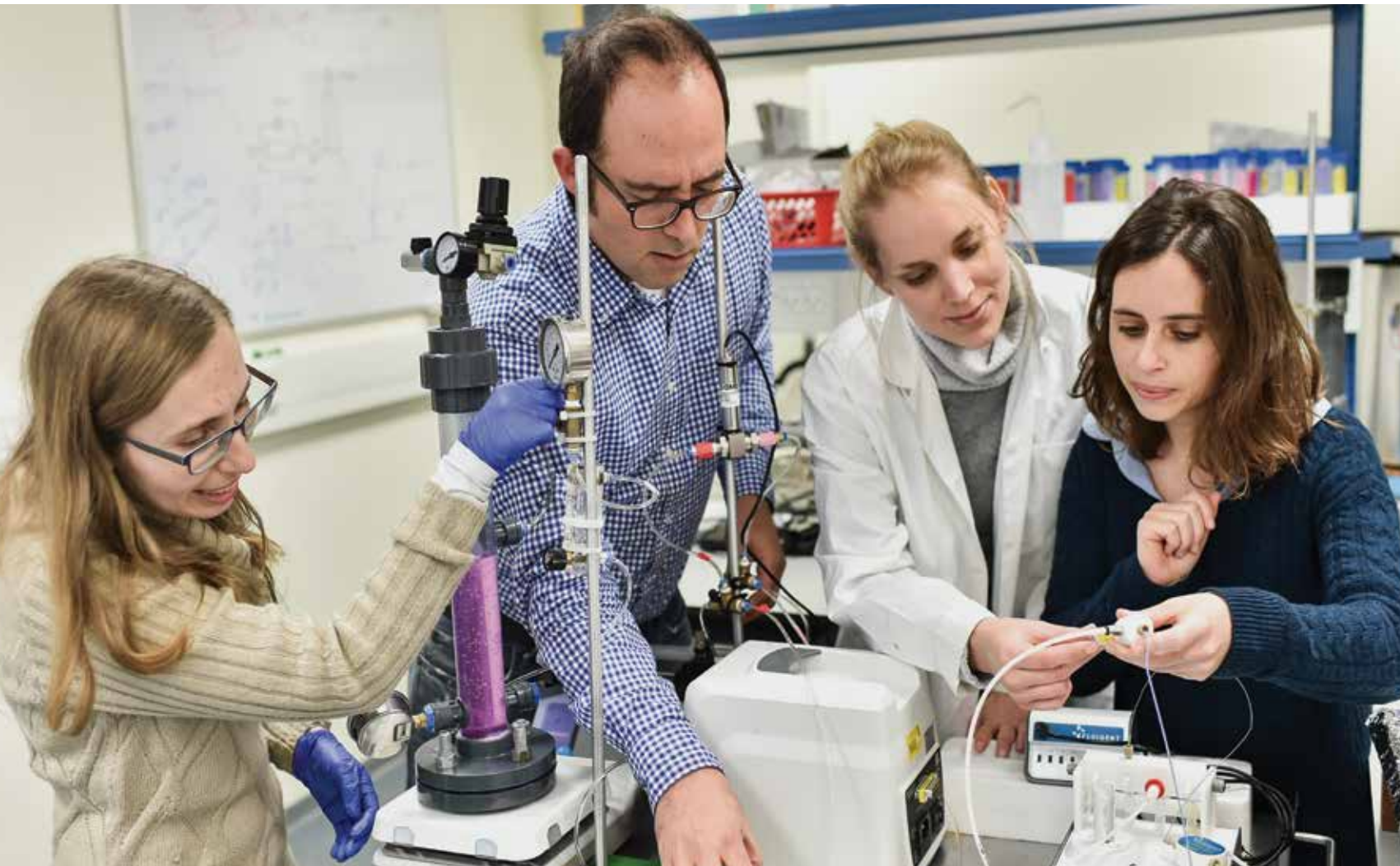
A significant portion of the research projects are funded by leading, competitive and prestigious local and international funding agencies (e.g., BSF, ISF, BARD, BMBF and DKFZ, Technion-Niedersachsen fund [Germany], US-AID/MERC, FP-7 [EU]).

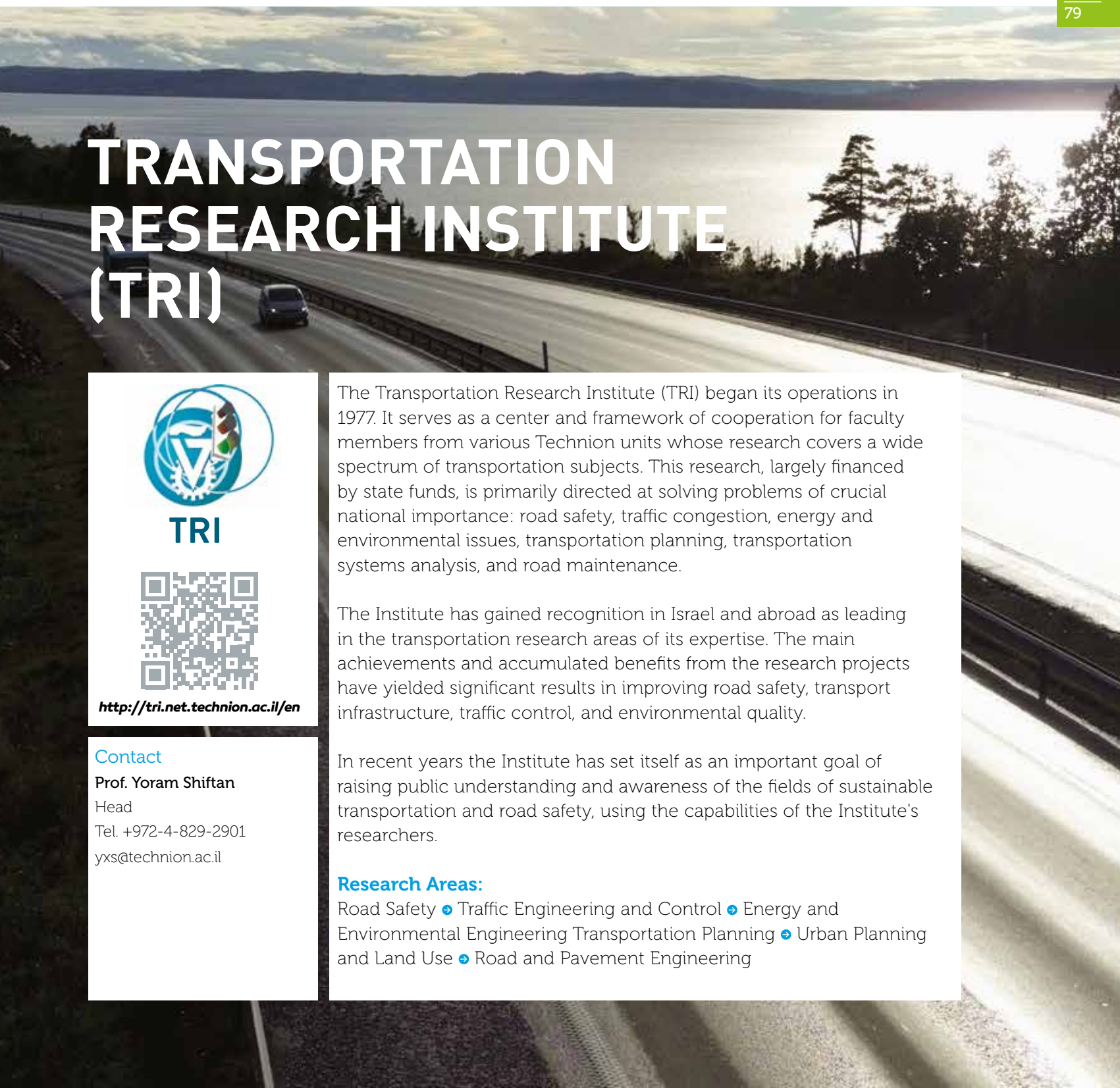
**Involvement and Interaction with Governmental Offices/Authorities:**
GWRI as an institute, as well as its individual members, are deeply involved with Israeli governmental offices and authorities. This activity includes interaction with: the Israeli Water Authority at various levels; and participation and/or chairing of Professional/Steering Committees at the Ministry of Infrastructures - Water and Energy, the Ministry of Environmental Protection, the Ministry of Science, and the Ministry of Agriculture. GWRI members also contribute to, amongst others, Israel's Institute of Standards and Water and Wastewater Corporations.

Research projects conducted by GWRI researchers are funded directly by governmental agencies/ministries, such as the Ministry of Industry, Trade and Labor, the Water Authority, the Ministry of Environmental Protection, the Ministry of Science, the Ministry of Agriculture, and the Standards Institution of Israel.

GWRI jointly organizes with the Samuel Neaman Institute for Advanced Studies in Science and Technology and the Water Authority "The Water Forum", with more than 100 participants, including leading researchers, water specialists, government officials and the Water and Energy Office of the Minister of Infrastructures. The forum's aim is to discuss and analyze key issues of Israel's water-related management problems in annual workshops.

GWRI members are also deeply involved in leading/chairing or participating as members of steering committees of the following professional societies: the Israeli Desalination Society - IDS, the Israeli Society of Soil Science - ISSS, the Israel Agricultural Engineering Society, the Israel Society of Ecology and Environmental Sciences, and the Israel Analytical Chemistry Society.





# TRANSPORTATION RESEARCH INSTITUTE (TRI)

TRI

http://tri.net.technion.ac.il/en

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The Transportation Research Institute (TRI) began its operations in 1977. It serves as a center and framework of cooperation for faculty members from various Technion units whose research covers a wide spectrum of transportation subjects. This research, largely financed by state funds, is primarily directed at solving problems of crucial national importance: road safety, traffic congestion, energy and environmental issues, transportation planning, transportation systems analysis, and road maintenance.

The Institute has gained recognition in Israel and abroad as leading in the transportation research areas of its expertise. The main achievements and accumulated benefits from the research projects have yielded significant results in improving road safety, transport infrastructure, traffic control, and environmental quality.

In recent years the Institute has set itself as an important goal of raising public understanding and awareness of the fields of sustainable transportation and road safety, using the capabilities of the Institute's researchers.

## Research Areas:

Road Safety ➲ Traffic Engineering and Control ➲ Energy and Environmental Engineering Transportation Planning ➲ Urban Planning and Land Use ➲ Road and Pavement Engineering

Contact

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## The Institute has three centers/labs:

### Mobility Management Research Center:

The Mobility Management Research Center (MMRC) was founded in 1994 as part of the Transportation Research Institute. The Center specializes in developing algorithms, methodologies, and systems for promoting sustainable urban mobility.

MMRC conducts multidisciplinary research, based on know-how and expertise in Transportation Engineering, Process Engineering, Operations Research, Statistics, Data and Text Mining, System Analysis, and Software Engineering.

MMRC works in close cooperation with all the major transport authorities in Israel, as well as with high-tech companies. Alongside the local cooperation, MMRC is also involved in international research projects through various research frameworks, such as the EU R&D Framework Program.

R&D examples:

AVIVIM:
AVIVIM is the Traffic Management and Control System of the municipalities of Tel-Aviv and Haifa. AVIVIM follows the classical approach of management and operational layers. MMRC has conducted research focusing on decision-support traffic management methodologies since 1994, funded originally by the Municipality of Tel Aviv and the Israeli Ministry of Transport. As a result of the success of the implementation of AVIVIM in Tel Aviv, it was adopted by the municipality of Haifa in 2006, who is now a partner in funding the ongoing development of the system.

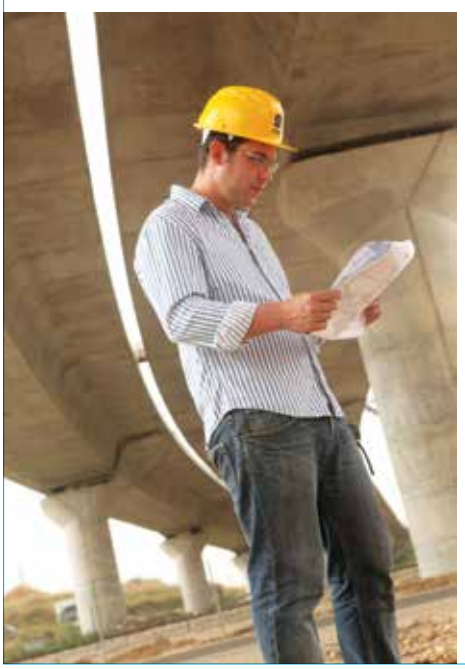
The research in this area continues to address the ever-growing mobility needs of public transit users, private vehicle users and pedestrians, and is reflected in new methodologies incorporated into AVIVIM.

The Municipality of Tel Aviv has chosen to present AVIVIM as the municipal state-of-the-art system in several benchmarking projects, and AVIVIM has been recognized as one of the most advanced Traffic Management and Control Systems in the world.

Harvesting the potential to achieve transport Policy Goals:
Harvesting transport information from social media is a new field, with the potential to improve the understanding of users' needs and as a basis for supporting the achievement of transport policy goals. An exploratory case study was conducted using authentic Twitter data, with the goal of associating Twitter postings with the one of three categories defined: Expressing a need for a transport service; Expressing an opinion regarding a transport service and Reporting a transport related incident or event. The case study targeted football matches in the UK, where an initial pool of candidate text posts were filtered from the stream of Tweets posted over a period of about one week around each match.

Automatic classification of Tweets as transport-related, as well as classifying them into one of the three categories, yielded high performance both in terms of coverage and relevance. Research results support the hypotheses that valuable information for transport policy makers exists on social media and that such information can be effectively harvested.

Social media, as a two-way communication arena between transport authorities and travelers, continue to be one of the research areas that researcher at MMRC are engaged in.



## Road Safety Research Center:

In the area of road safety, research activity started within the framework of the Road Safety Center in 1967 which was later incorporated into the TRI. The Road Safety Research Center (RSRC) was re-established in 2007 as a joint initiative by the Technion and the Or Yarok (Green Light) NGO. The RSRC mission was defined as conducting scientific research that should support the development of evidence-based road safety programs and interventions, in producing road safety knowledge fitted to Israeli conditions, in developing tools for professionals and decision-makers and in promoting research on a future vision for road safety. The RSRC research areas concern: Road safety policy and management; Monitoring road safety; Accident data analyses; Road user behavior analyses; Modeling safet; Safety impacts' evaluation; Safety performance indicators; Safer road infrastructure; Controlled field experiments; Self-explaining roads; e-safety; Vulnerable road users - pedestrians, bicyclists, motorcyclists, children, elderly; Public transport safety; Alternative transportation means.

The RSRC conducted research studies commissioned by the National Transport Infrastructure Company - Netivei Israel, Ministry of Transport, National Road Safety Authority, the Ran Naor Foundation for Road Safety Research and other local bodies, and is involved in European road safety activities. Examples of applied research results: establishing a national system for monitoring road user behaviours in Israel; a manual on infrastructure solutions for improving pedestrian safety in urban areas; safety performance functions and decision-support tools implemented in the Safety Management System of the Netivei Israel Company.

## Sustainable Mobility and Robust Transportation (T-SMART) Laboratory:

The Technion Sustainable Mobility and Robust Transportation (T-SMART) Laboratory was established in 2013 with the generous support of the Technion and the Israel Science Foundation (ISF) Lab equipment grant. The laboratory provides the tools and methodologies for advanced urban traffic management of autonomous and conventional vehicles in complex coexistent large-scale transport networks. The laboratory facilities have been utilized in a wide range of projects. The laboratory collaborates with traffic engineers, road authorities and municipalities in Israeli cities.

The laboratory has two main components: the T-SMART monitoring system and the autonomous vehicles setup. The T-SMART monitoring system includes advanced sensors and estimates the traffic flow performance in real-time, where currently more than 50 Bluetooth sensors are deployed in Tel-Aviv city center, Jerusalem, and along the Avalon Highway.  The lab provides a real large-scale sensory network to support theoretical research with real case studies, including calibrations and validations based on real traffic data. The laboratory also supports research on modeling and control of autonomous vehicles by the T-SMART autonomous experiment setup, which includes wheeled mobile robots, optical tracking camera system, and software which serves as the platform for design and deployment.

# FACULTIES


Moshe_063
Tango Explorer
Destroy the enemies before they catch you
Let your partner help you
Good luck!
√ Accept

# AEROSPACE ENGINEERING

***http://ae-www.technion.ac.il***

Dean's Office
**Prof. Jacob Cohen**
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The Faculty of Aerospace Engineering is a leading faculty in its field and the sole source of aerospace engineers in Israel. Faculty members conduct world-class (mostly sponsored) research, provide consultancy services to the Israeli aerospace industry in innovative technologies and challenging problems, and teach a wide range of aerospace disciplines.

The Faculty's research laboratories include: the Wind Tunnel Laboratory complex (comprising supersonic, transonic, subsonic, and turbulence laboratories), the Aerospace Plasma Laboratory, the Autonomous Navigation and Perception Laboratory, the Mechanics of Soft Materials Laboratory, the Aerospace Structures Laboratory, the Combustion and Rocket Propulsion Laboratory, the Turbo and Jet Engine Laboratory, the Flight Control Laboratory, the Distributed Space Systems Laboratory, the Cooperative Autonomous Systems Laboratory, the Computational Laboratory for Aerospace Structures, the Aeroacoustic Laboratory, the Turbomachinery and Heat Transfer Laboratory and the Turbulence and Complex Flow Laboratory.

The high quality of the academic work performed by Faculty members and graduate students is reflected, first and foremost, by the quality and number of scientific articles published in the best academic venues, but also in the appointments of these Faculty members to Israeli, American, and other international academies; their election to governing bodies of national and international professional associations, and their memberships on editorial boards of prestigious scientific journals. Thus far, three Faculty members have received the

prestigious Israel Prize, the highest national award, for their lifetime achievements in aerospace sciences research.

## Research and Consultancy Areas:

Fluid Mechanics and Aerodynamics ➲ Solid Mechanics ➲ Aerospace Structures ➲ Composites and Active Materials ➲ Guidance ➲ Navigation ➲ Control ➲ Estimation ➲ Dynamics ➲ Flight Mechanics ➲ Design Theory ➲ Jet and Rocket Propulsion and Combustion ➲ Electric Propulsion ➲ Aeroelasticity ➲ Aeroacoustics ➲ Trajectories ➲Thermodynamics ➲ Heat Transfer ➲ Optimization ➲ Flow Control ➲ Helicopters Rotorcraft and Rotary Wings ➲ Autonomous Systems ➲ Unmanned Aircraft Systems ➲ Space Systems and Space Mechanics ➲ Astrodynamics ➲ Sea Vehicles ➲ System Engineering

## Aerospace Engineering Industrial Affiliates Program (AE IAP):

The Aerospace Engineering Industrial Affiliates Program (AE IAP) was developed to strengthen and formalize the relationship between the Faculty and Industry.

This relationship works for the benefit of both sides by enabling the Faculty to be more exposed and more attuned to market needs, up to date with companies' R&D activities, and assists the Faculty in promoting academic research projects. At the same time, IAP members gain access to the Faculty's activities, its human capital – faculty members and students, and can be exposed to relevant research achievements that may assist in the development of new products or in upgrading existing products.

For companies that join the IAP, the Faculty offers a broad benefits package which includes components from the fields of Research & Development, Education & Teaching, Human Resources & Employment, and Public Relations & Marketing.

Benefits package components listed below are the fundamental platform for collaboration between the Faculty and the companies in the program. The companies are more than welcome to present new initiatives to enrich the relationship, according to the specific needs relevant to them.

Contact
**Mrs. Orly Reiss**
Industry Relations Coordinator
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### Research & Development:

- Option for joint research between industry and academia
- Confidential and reliable channel to interact with Faculty researchers
- Assistance in finding relevant research partners for joint participation in funded research projects (Chief Scientist, IMOD, European Community)
- Option for joint supervision of graduate students
- Option to conduct R&D projects in the "Design Project" and "Research Project" courses
- Invitation to participate in the Faculty's annual "Research Day"
- Invitation to attend in weekly Faculty seminars, as lecturers and listeners
- Option to have meetings with our researchers and to bring up acute engineering problems
- Option to include articles concerning R&D activities of the company in the Faculty newsletter
- Benefits on execution of company projects in Faculty labs

### Education & Teaching:

- Option to propose topics and candidacy for supervision of undergraduate student projects
- Option for company's employees to attend faculty courses, free of charge, without academic credit (advanced registration required)
- Option to offer guest lectures by company personnel as part of Faculty courses, coordinated with the course lecturers
- Option to offer mini-courses and extracurricular lectures on the technological topics the company specializes in

### Human resources & Employment:

- Option to hold an exclusive Student Recruiting Day
- Advertisement of job openings on the "Industry Relations" page on the Faculty website, Faculty's billboards, via social networks of Faculty's alumni, and via direct emailing to all students & alumni

### Public Relations & Marketing:

- Company name & logo will appear on the IAP page on the Faculty website
- Option to advertise company activities on Faculty's billboards, via social networks of Faculty's alumni and via direct emailing to all staff members & students
- Guided Tours: Option for students to have a guided tour at the company's facilities

- Option to sponsor conferences, ceremonies, scholarships, competitions and projects
- Option to advertise in the Faculty newsletter which is distributed to our graduates, industry seniors and Faculty staff & students

## Research Laboratories:

### Aerodynamics Laboratory:

The Wind Tunnel Complex in the Faculty of Aerospace Engineering consists of four tunnels: two in the incompressible subsonic range (Mach<0.3), one in the compressible transonic range (0.35<Mach<1.1), and one in the compressible supersonic range (1.6<Mach<3.5). In addition, the complex includes the Turbulence Laboratory, the water-tunnel facility and a transonic jet. While numerous incompressible subsonic wind tunnels can be found in the academic environment, the Technion is one of few universities in the world with such facilities. The wind tunnels are used for aerodynamic experimental research carried out by faculty members, graduate students and joint projects with the industry as well as for teaching undergraduate laboratory courses.
The instrumentation includes: Balances, manufactured in-house, for measuring forces and moments, a Schlieren system for visualization of flow where density gradients exist, Hot wire anemometer and dynamic pressure transducers for high-rate measurement of velocity and pressure, respectively, at a point and Particle Image Velocimetry (PIV) for measurement of a velocity field in a plane.

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### Computational Laboratory for Aerospace Structures:

The lab has three HP DL585 G7 servers, with 48 processors each, intended for CPU-intensive High Performance Computing (HPC). The research is numerical and involves, mainly, aerodynamic and aeroelastic simulations in designated codes.

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### Cooperative Autonomous Systems Laboratory:

The research performed in the Cooperative Autonomous SYstems (CASY) lab is in the general area of guidance of autonomous (especially aerial) vehicles operating individually or as a team. The scope of the research spans from the high-level cooperative team mission planning (task assignment), to motion planning (guidance) with regard to optimizing trajectories for the dynamical systems, to the problem of trajectory-following, and lastly to the low-level control of a single vehicle. In our research and experiments we seek to devise new algorithms and strategies for performing these cooperative or individual

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tasks and to gain insight into the interactions between the different levels of planning and control. The lab operates an indoor test-bed emulating real world complexities and constraints. It is composed of a motion capture system, providing in real-time 6-DOF estimates for tracked vehicles that include quadrotors and ground vehicles. CASY's architecture allows for the addition of vehicles in a short time at a low cost, since no embedded hardware is installed in the vehicles. This enables us to avoid being overly conservative during flight testing.

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## Philadelphia Flight Control Laboratory:

The Philadelphia Flight Control Laboratory serves the entire Guidance, Navigation and Control (GNC) research group of the Department of Aerospace Engineering. The scope of the interdisciplinary research performed in the lab includes high-level control objectives such as cooperative team mission planning (task assignment) and multi-vehicle coordination, motion planning (guidance) with regard to optimizing trajectories for dynamical systems, trajectory-following, low-level control objectives focused on the control of single vehicles and/or platforms and also vision-aided single- and multi-vehicle autonomous navigation in uncertain environments. Additional research topics pursued in the lab are advanced flight displays, pilot-vehicle modelling and active manipulators.

The lab operates an indoor test-bed emulating the complexities and constraints of real-world systems. Supporting hardware for this test-bed includes a motion capture system capable of providing real-time six degree-of-freedom estimates for tracked vehicles such as quadrotors and ground vehicles. A unique seven degree-of-freedom moving platform used to mount a variety of sensor payloads has also been built in-house. The platform, which moves freely through one of the rooms, is suspended from the ceiling by six computer-controlled wires. The 7th degree-of-freedom is required to allow all-attitude yaw motions. Two high-precision three-degrees-of-freedom flight tables complement the equipment needed for evaluating inertial and electro-optical sensor performance.

The lab is also home to a joint Aerospace Engineering and Mechanical Engineering Controls Teaching Laboratory, which operates eight identical test benches containing a rotational (Furuta) pendulum driven by a DC-motor and supporting computer software and hardware. The lab setup, designed by the Department of Mechanical Engineering, is a

flexible and modular apparatus that allows undergraduate and graduate students from both departments to explore various concepts related to dynamical systems and control theory.

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### Distributed Space Systems Laboratory:

Distributed Space Systems Lab (DSSL) is a research laboratory at the Technion, led by Professor Pini Gurfil and comprising an interdisciplinary group of faculty, staff, and graduate students from Aerospace Engineering, Physics, Computer Science, Autonomous Systems Program and other departments.

DSSL's vision is to generate knowledge and experience that will enable the launch of a multiple satellite formation flying mission into a low Earth orbit within the next 3 years. DSSL is committed to performing groundbreaking research in astrodynamics, navigation and data processing of multiple satellite systems, as well as related disciplines. DSSL's experimental facilities include a 4x4 meter air-bearing table, nanosatellite models, sensors, and optical telescopes.

### Contact

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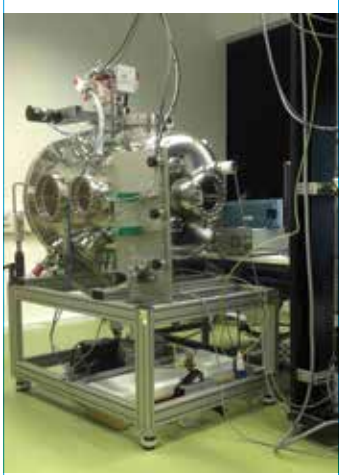
### Aerospace Plasma Laboratory (APL):

The Aerospace Plasma Laboratory (APL) was founded in 2015 by Asst. Prof. Igal Kronhaus for carrying out a program of research and development of innovative miniaturized plasma devices for propulsion applications. APL is currently active in two areas of research:

- Electric rocket propulsion for nanosatellite applications
- Plasma actuators for aeronautical flow manipulation



The laboratory goal is to enable advanced understating of the plasma processes in these devices and enable their realization. The approach to research in APL involves a full set of activities: starting from a simplified physical-mathematical or phenomenological model, then development of a more realistic computer simulation and finally the design, implementation, and testing of a specific device.

APL is part of the Faculty of Aerospace Engineering and is located in the Asher Space Research Institute, Technion. The centerpiece equipment in APL is the vacuum test facility, a cylindrical vacuum chamber 1.0 m long and 0.6 m in diameter with multiple viewing ports and access ports, capable of supporting background pressures down to 10-6 mbar. APL is equipped with gas and power supplies to generate both DC, pulsed, and AC and RF plasmas. A number of specialized diagnostic tools are

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available, including a micro-Newton thrust balance, a fast ICCD camera with a gating time below 5 ns, a spectrometer, various electrostatic probes, and linear stages for equipment positioning under vacuum conditions. In addition to the vacuum test facility and diagnostic equipment the laboratory is equipped with a large workbench area to support component level testing and assembly. The laboratory also serves as an office space for students and research staff.

## Krumbein Aircraft Structures Laboratory:

Lab Equipment:

- MTS Servo-Hydraulic Machine: Three loading rigs, with capabilities of 100, 250, 500 kN, each able to dictate a displacement up to 150 mm, and testing of structures up to 2 m. All the three systems can be controlled by force, strain or displacement of the hydraulic piston. The control is either manual or computerized and can include various types of functions like, random, continuously up to 20 Hz, etc. During the tests, the data in the form of forces, strains, displacements and temperatures can be stored for later use.

- Large Scale Test Servo-Hydraulic Machine: Another MTS type system is solely dedicated to special projects, which has special testing need and has to be clamped to the floor of the lab. The maximum applied load is: 100 kN.

- Impact Test Machine: Impact testing of structures for damage / destruction by shooting steel spheres having the diameter of 9 or 13 mm, with velocities up to 150 m/sec.

Capabilities:
FE simulations - NASTRAN, ANSYS, ABAQUS; Design and Performance of Structural Tests; Dynamic Loading; Static Loading; Impact Loading; Thermal Loading; Vibrations.

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**Dr. Dan Michaels**
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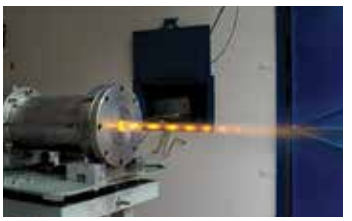
## Sylvia and David I.A. Fine Rocket Propulsion Center:

The Fine Rocket Propulsion Center accommodates research activities in rocket and ramjet propulsion, combustion, energy, and related areas and derivatives (e.g., gel fuels and propellants, energetic materials, two phase flows, and marine propulsion). It includes three faculty members, five scientists, about 15 doctoral and master students, and technical personnel. It has been hosting Visiting Professors, Visiting Scientists, Post-Doc Fellows, as well as foreign and Technion undergraduate research students. The Center has a number of reinforced test cells, specially built for static firing tests and for high pressure experiments, high pressure air and gas supply, high and low speed video cameras, computerized data acquisition systems, a Malvern-Spraytech particle and spray size measurement system, a DSC-TGA thermal analysis system, PLIF (planar laser induced fluorescence) of OH and $CH_2O$, Rayleigh thermometry, gas chromatograph, high frequency pressure and force sensors, and a number of specific setups such as a water tank for marine propulsion and bubbly flow research.



## Turbo and Jet-Engine Laboratory:

Development of low NOx Jet engine combustor, improving stability of gas turbine combustion system, the use of methanol as an alternative fuel, biofuels for aviation, development of acousto-optic interface for autonomous maritime vehicles, optimization of small wind turbines for urban environment, control system for small engines, compressor dynamics & aerodynamics, development of optical diagnostics, sensors design.

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## Turbomachinery and Heat Transfer Laboratory:

Turbomachinery and Heat Transfer Laboratory, supervised by Dr. Cukurel, is envisioned to be the main Israeli academic entity for aero-thermal research and advanced development in the field of turbomachinery applications. The center mainly focuses its effort on the hot gas section of a gas turbine, consisting of the high pressure turbine. The scientific contributions are primarily applicable towards small scale engines, which are commonly used in distributed power generation, business jets, unmanned air vehicles, auxiliary power units etc. In light of more stringent emission requirements, demand for increased power to weight ratio, the progressively augmenting durability requisites, and critical necessity to improve cycle efficiency, the laboratory develops technology at the frontiers of the current knowledge with advances in:

- Turbine Cooling in Mini and Micro Jet Engines
- Heat Transfer Enhancement in Hot Gas Section Coolant Coverage
- Thermal Management
- Aerodynamic - Thermal Coupling in High Speed Flows
- Novel Experimental Measurement Technique Development

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## Autonomous Navigation and Perception Laboratory (ANPL):

The Autonomous Navigation and Perception Laboratory (ANPL) investigates problems related to single and multi-robot collaborative autonomous navigation and perception, with a particular focus on online, accurate and reliable operation in uncertain and unknown environments. The lab was founded by Assistant Prof. Vadim Indelman in 2015.

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Research in the lab is highly multidisciplinary, involving topics such as sensor fusion, SLAM and navigation in GPS-deprived environments, robust perception, decision-making and belief space planning, both for single and distributed multi-robot autonomous systems. Applications span a wide range of problems in mobile aerial and ground (indoor and outdoor) robotics. ANPL's interdisciplinary research group comprises staff and graduate and undergraduate students from different departments, including Aerospace Engineering, Computer Science and the Technion's Autonomous System Program (TASP). Besides office space, ANPL also includes a high ceiling testing area that is equipped with a motion-capture system. This facility allows conducting experiments with ANPL's aerial (quadrotors) and ground robots to investigate various performance aspects of the approaches developed in the lab. The motion capture system is mainly used for providing ground truth information as inference/estimation is performed online, using onboard sensors (e.g. cameras, RGBD, laser, IMU). As such, the experiments are not limited to the testing area and can be also performed in other environments (e.g. outdoors).

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## Aeroacoustic Laboratory:

The Technion Aeroacoustic Laboratory carries out fundamental and applied research incorporating theoretical and experimental studies. The Laboratory aims to conduct cutting-edge research and advanced development in the field of aeroacoustics. The overarching theme of our laboratory is an experimental approach to understanding, predicting and controlling fluid flow and noise that are relevant to aerodynamic and aeroacoustic applications.

The laboratory provides advice, consultancy and contract research in all the following areas (this list is not exhaustive).

- Horizontal- and Vertical-Axis Wind Turbine
- Rotor noise
- Landing gear noise
- Feedback noise
- Duct acoustics
- Advanced acoustic measurements, including beamforming

We are pleased to assist in most areas of acoustics, noise, vibration, and audio communication.

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## Turbulence and Complex Flow Laboratory:

The Turbulence and Complex Flow Laboratory conducts fundamental research on large-scale turbulent flows as well as small-scale multi-phase flows, with emphasis on the coherent behavior of fluids along walls and at multi-fluid interfaces. The lab utilizes both high speed water channel facilities as well as confocal microscrope facilities to study these flows, and exploits techniques from both high- and low-Reynolds number research to better understand the flow physics. The primary applications of this research are aero- and hydro-dynamic drag reduction, smart surface coatings, particle dispersion, and reduced-order modeling of complex flows for use in computational simulations.

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## Laboratory of Mechanics of Soft Materials:

Our research focuses on the mechanics of soft materials including architectured functional materials, bio-inspired metamaterials, and biological tissues. We actively utilize the design rules observed in nature to develop bio-inspired materials with a large variety of functionalities. Our research profile includes the area of active materials for artificial muscles, actuators, sensors, and soft robotics; bio-inspired flexible armor; acoustic metamaterials; and light-weight composites with extreme mechanical properties. Our research bridges the gap between material microstructures and macroscopic properties. Our group uses a good mix of theory, simulations and experiments involving advanced 3D printing techniques. The laboratory is equipped with the new 3D printed Objet Connex 260 allowing us to fabricate architectured materials with resolution of 16 μm.

## Ties with Industry:

- Faculty members and their supervised graduate students perform industry-sponsored applied research.
- Faculty members provide consultancy services on a personal basis to the industry in their areas of expertise.
- Industry seminars are delivered by industry representatives as part of the Faculty seminar series.
- Leading experts from the industry supervise and mentor undergraduate final-year comprehensive student projects.
- Industry experts collaborate with Faculty members in advising MSc and PhD students.
- Industry and Faculty collaborate in organizing conferences and symposia in various fields of aerospace sciences.
- The Faculty's Research Laboratories provide various testing services to aerospace industries.

# ARCHITECTURE AND TOWN PLANNING

***http://architecture.technion.ac.il/en***

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The goal of the Faculty of Architecture, since it was established in 1924, has been to be the foremost professional body shaping the built image of Israel. Through education, research, and design leadership, the Faculty has successfully upheld this goal for the past 92 years, graduating thousands of professionals who literally designed and built the State of Israel. Led by a dedicated, fully-qualified, teaching staff of researchers and practitioners, the Faculty houses about 850 students (300 of whom are graduate students) in the fields of architecture, landscape architecture, planning, and industrial design. In addition, through its three research centers, the Faculty is also the primary locus of research and the generator of new design and planning knowledge in Israel. The Faculty offers post-professional, mid-career, and advanced degree programs in architecture, urban and regional studies, landscape architecture and industrial design. In 2014, in collaboration with the Faculty of Civil and Environmental Engineering, the Faculty integrated a new master's program in urban engineering.

In 2015, the Architecture program switched to its new 6-year, M.Arch. program, which is comprised of a 4–year undergraduate program in Architectural sciences, and a 2-year professional graduate program. This new combined approach is equivalent to how architects are educated in leading universities in USA and Europe. It provides graduates with both a broad theoretical base and deep professional knowledge, preparing them to an ever evolving profession. Students are encouraged to specialize in knowledge areas such as digital architecture, history- theory and criticism, sustainable architecture, conservation and urban design.

## Research Areas:

### Architecture:

Digital Architecture/Computer-Aided Architectural Design (CAAD) ➲ Design Research and Design Theory ➲ Sustainable Architectural Design ➲ Intelligent Buildings ➲ Computer-Aided Architectural Fabrication ➲ Urban Design ➲ Architectural Philosophy ➲ Architectural Education ➲ Design with Communities ➲ Art ➲ Architecture Theory and Criticism ➲ Deployable Structures, Spatial Structures and Shells | Design Research, Design Theory, Design Studies ➲ History, Theory and Criticism ➲ Biomimicry in Architecture ➲ GIS

### Urban and Regional Planning:

Housing and Urban Regeneration ➲ Social and Cultural Aspects of Planning ➲ Spatial Development and Planning ➲ Economic Aspects of Planning ➲ Planning Law and Property Rights ➲ Infrastructure ➲ Environment and Planning

### Industrial Design:

Design and Human Factors in Healthcare ➲ Personalized Design, Design for All (Inclusive Design) ➲ Human Factors and Design in Extreme Environments ➲ Evidence- Based Design (EBD) Methodologies ➲ Computer-Aided Architectural Fabrication ➲ Interactive Design and Responsive Environments ➲ Sustainable Materials ➲ Design Thinking

### Landscape Architecture:

History, Theory and Criticism of Landscape Architecture in Israel ➲ Cultural Landscapes ➲ Sacred and Symbolic Landscapes: Natural, Cultural and Visual Components

## Architecture and Town Planning Affiliates Program (ARAP):

The Architecture and Town Planning Affiliates Program (ARAP), established in 2013, is dedicated to the creation of cooperation between academia and leading industrial companies in Israel and worldwide. We believe that by establishing strong long-term relations between academia and industry we can promote important values, focusing on knowledge, development, innovation, leadership, and excellence. The ARAP stimulates and supports the needs of business, industry, and academia in applied research and development, teaching, human resources, public relations, and advertising.

## Research and Development:

- Professional interaction with Faculty researchers.
- Students' Final Project Course: subjecting proposals and assistant mentors provided by company for special student projects.
- Carrying out joint projects with research centers and laboratories.
- Use of Faculty Laboratories - Fabrication, Visualization, GIS, Climate and Energy, Experimental Art and Architecture.
- Identifying partners for joint research proposals to the Chief Scientist of the Ministry of Economy and the European Union.

## Teaching:

- Workshops, Seminars and Guest Lectures presented within the Faculty by representatives of suitable companies.
- Student competition themes by companies.
- Mini-courses, seminars, summer courses and professional graduate programs presented in the Faculty by Faculty researchers to company employees.
- Free Auditing: option for company employees to choose specified faculty courses.
- Industrial Advisory Board held once or twice a year to discuss teaching programs, research projects, laboratories, and Faculty equipment.
- Library Services: limited.
- Guided Tours: opportunity for students to have a guided tour of the company's facilities.

## Human Resources:

- Classified ad distribution by direct mailing, monthly Faculty newsletter, Faculty website and bulletin boards and plasmas.
- Announcements via professional conferences, seminars, awards, scholarships, and recruiting days.
- Student employment during summer projects, and hosting summer interns.

## Public Relations and Advertising:

- Increasing company's visibility: Company's name and logo presentation at the Faculty Academia Industry Affiliates program web page linked by the official Faculty website.
- Sponsorship opportunity for affiliate's conferences, seminars, competitions, projects, etc.
- Sponsorship advertising announcement in the Faculty newsletter, distributed to alumni, industry personnel, Faculty staff, and students.

- Advertising firms' activities/events: monthly Faculty newsletter, Faculty website, bulletin boards and plasmas.
- Exhibition presentations: in Faculty building.
- Links for selected web pages/company presentations to the Faculty Academia Industry Affiliates program web page.

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## Visualization Laboratory (VizLab):

The Visualization Laboratory (VizLab) was established in the Fall of 2013. The centerpiece of the Laboratory is a 3D immersive theater, consisting of a 2.4 x 7.0 m screen with a 75° field of view and three high-definition Projectiondesign® projectors. The laboratory was designed and installed by Antycip Simulation®. 3D capacities are enabled by VizTech XL software, which produces 3D images from software, including Rhino 3D, 3D Max// Vrml, Virtools, SketchUp, Google Earth, AutoCad, and ArcGIS. VizLab can host up to 20 people simultaneously for a 3D experience in which one participant, followed by tracking cameras, can "move" through the image, or manipulate a 3D object on the screen. VizLab is also equipped with a state-of-the-art sound system and advanced photography equipment.

The VizLab is available to users throughout the Technion and beyond.

The Laboratory serves a broad diversity of uses including:

- Investigating user experience in coastal environments under diverse physical and social conditions.
- Examining human behavior in interactive built environments (including historical settings).
- Stimulating dialogue and community participation in the future of their physical environment.
- Studying human cognition and perception during navigation and way-finding in urban environments and large internal spaces.
- Assessing the ecological, aesthetic and tourist value of open and forested landscapes.
- Empowering community stakeholders through the use of 3D visualization of urban development and architectural scenarios, thereby eliminating the gap between professional jargon and popular perceptions of development possibilities.
- Testing movement patterns in urban environments at different times.
- Participatory land use planning and architecture.
- 3-D study and design of objects, from as small as a pin to as large as a building, and from inanimate objects to complex living organisms
- Virtual tours of buildings and neighborhoods
- Land use and architectural scenario analysis

VizLab users receive the support of trained student technicians who accompany the user from data preparation to actual use within VizLab.

## Technion Computer Oriented Design and Manufacturing Laboratory (T_CODE):

The T_CODE is an experimental computer-oriented design research laboratory, which supports research and education in design computation and fabrication of new media and architecture. It includes a full spectrum of leading digital design and fabrication tools, such as 3D scanning, 3D printing, laser cutting, and a CNC milling machine. It supports design, rationalization, and preparation for fabrication of complex geometry, as well as 3D scanning and fabrication in various types of materials. It allows researchers and students to comprehend their designs more fully, as well as to conceive forms they would be unable to build on their own, thus unlocking their design creativity and productivity.

***http://tcode.net.technion.ac.il***

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## Center for Architectural Research and Development:

The Center for Architectural Research and Development (CARD) was established in the 1970s as the research arm of the Faculty of Architecture and Town Planning in areas including Sustainable Architecture (focusing on energy and lighting in buildings), Computational Design Methods, Digital Technologies, Advanced Building Simulation, Environmental Control, Urban Design, Housing, Morphology, Architectural Theory, Construction Technology, Building Technology, Re-Use of Buildings, and Work with the Community. Some 20 Faculty members and graduate students are affiliated with the Center, engaged in both basic and applied research. Examples of research performed at the CARD include development of the Israeli Standard for Energy Rating of Buildings (IS5282), which was adopted as part of the Israeli Standard for Green Buildings (IS5281). It will significantly help to reduce the energy consumption for air-conditioning and heating buildings, and will help reduce the dependence of Israel on imported energy resources. At the urban scale, many studies have been performed to develop design guidelines for solar and wind rights. The guidelines have been implemented in the curriculum, and published in books and papers available to the professional community. CARD researchers have developed novel tools, recognized nationally and internationally, for simulating future building behavior, which can forecast many performance aspects, including thermal comfort, lighting, heating, cooling, and people's behavior in buildings.

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## Center for Urban and Regional Studies (CURS):

The Center for Urban and Regional Studies (CURS) has traditionally been deeply involved in the planning field. The planning field is basically public, but involves numerous agencies and organizations, governmental and non-governmental; as well as private firms and a range of supporting services. CURS has made a major contribution over many years to the development of planning methodologies and tools for industry. In fact, CURS has been highly influential in the development of plans and planning policies at the national, regional, and local levels. CURS and the Faculty of Architecture and Town Planning have frequently initiated and coordinated major national planning efforts, including the 2020 Master Plan for Israel, the Northern District Outline Plan, local outline plans, and many policy documents dealing with tall buildings, affordable housing, and water conservation.

Its extensive research in planning and land legislation has been widely referred to in Supreme Court decisions and rulings, and has led to new legislation. CURS is now leading the preparation of the Marine Spatial Plan for Israel's Mediterranean Exclusive Economic Zone.

As a leading practice-oriented research center in the applied science of planning, CURS is a hub for professional discourse and innovation. It hosted the 2011 Annual Conference of the Israel Planners Association, and many professional seminars and symposia. Members of CURS often serve on public committees, both national and local. Their leading role as members in the National Council for Planning and Building has had a major impact on its decisions for many years.

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## Architectural Heritage Research Center:

The Architectural Heritage Research Center was established by Professor Gilbert Herbert in the 1980s. This Center was the first architectural archive in Israel, founded in order to establish a national basis for architectural research. Research in architecture is typological by nature, being based mostly on precedents.

The Technion's Architectural Heritage Research Center facilitates the study and documentation of Israel's built environment. It serves both as a world-class research center and as a guiding tool for architects and official planning bodies. The Research Center is a tribute to the founders of Israeli architecture, to their contemporary followers, and to Israeli society at large. The Center's major concerns are the preservation of cultural and historical heritage, urban renovation and regeneration, Israel's architectural development, heritage of the Arab sector in Israel, architectural international relationships between Mediterranean and Middle East countries, and its regional architecture and planning. Though housed within the Faculty of Architecture and Town Planning, the Architectural Heritage Research Center is multi-disciplinary in nature and national in scope.

Today aging architects and their families who wish to protect their architectural oeuvre bequeath them to historical heritage archives on the condition that the works will not only be protected, but will also be made available for active research that will keep their ideas alive.



# BIOLOGY

***http://biology.technion.ac.il***

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The Faculty of Biology started as a small department that split from the Faculty of Chemistry in 1971. During the first 25 years the Faculty of Biology developed slowly in terms of quality and quantity, focusing primarily on molecular and cellular biology research. After it became a Faculty, biology was not as dominant on campus as the biology departments at other universities. About ten years ago, the Technion management decided to establish strong and leading Life Science activities on the Technion campus by upgrading the Faculty of Biology to serve as the focal point for research into modern Life Sciences and teaching efforts. One of the tools for implementing this decision was the establishment of the of the Lorry I. Lokey Center for Life Sciences and Engineering, founded by Distinguished Professor and 2004 Nobel Prize laureate, Aaron Ciechanover. As head of this Center, Professor Ciechanover collected and implemented the essential resources and funds for the J. Steven and Rita Emerson Life Sciences Building adjacent to the Faculty of Biology to house modern infrastructure, technologies and facilities in Biology and Life Sciences.

## Research Areas:

Biochemistry ➲ Biophysics ➲ Biotechnology ➲ Cancer ➲ Cell Biology ➲ Computational Biology ➲ Development ➲ Drug Discovery ➲ Ecology ➲ Endocrinology ➲ Epigenetics ➲ Evolution ➲ Gene Regulation ➲ Genetics ➲ Genomics ➲ Immunology ➲ Microbiology ➲ Physiology ➲ Plant Biology ➲ Structural Biology ➲ Systems Biology ➲ Virology ➲ Zoology

**http://proteomics.net.technion.ac.il**

## Contact

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Head

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## Smoler Proteomics Center:

The Smoler Proteomics Center is the national infrastructure hub for proteome analysis. It was established by the Technion and the Ministry of Science to facilitate direct access to state-of-the-art technologies, instrumentation and knowhow in the fields of protein purification and analysis to researchers from universities, research institutes, hospitals, and biotechnology companies, from Israel and worldwide.

Activities in the Center range from identifying and quantifying proteins, to large-scale comparisons of proteins and their post-translational modifications in healthy and diseased states. The Center offers direct access to its technology and expertise, including protein and peptide mass spectrometry, micro-chromatography, two-dimensional chromatography, and electrophoresis, as well as in analyzing minute amounts of proteins. Three mass spectrometers are currently functional in the Center: Orbitrap, Orbitrap XL, and Q-exactive. All three are high-resolution, high-accuracy instruments enabling advanced proteomics. The mass spectrometers are fitted with nano-capillary HPLC, which enables the performance of very high-pressure and high-resolution chromatogaphy.

The Center provides services on a first-come, first-served basis, and also for research collaborations for complex projects. Services to biotechnology companies are performed both during the research and development phases, as well as the quality-control phase, and include consultation throughout the project.

### Quality Control:

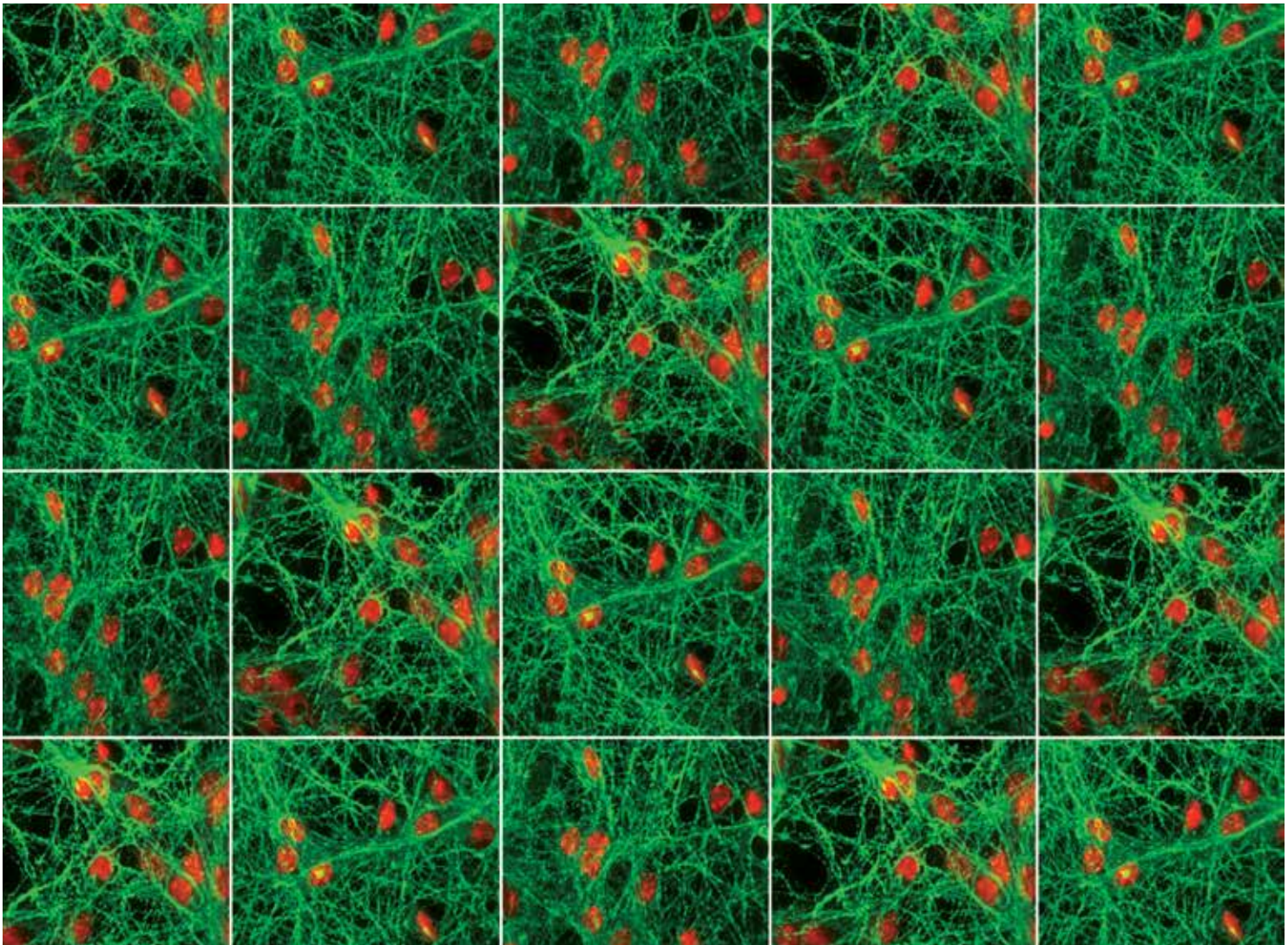
- Analyses of synthetic peptides - sequence validation and contamination analysis
- Protein identification
- Characterization of contaminated peptide
- Analyzing changes in a protein (company product)
- Stability tests of peptides and proteins
- Comparison of product purification in different production stages
- Comparison between different lots of products

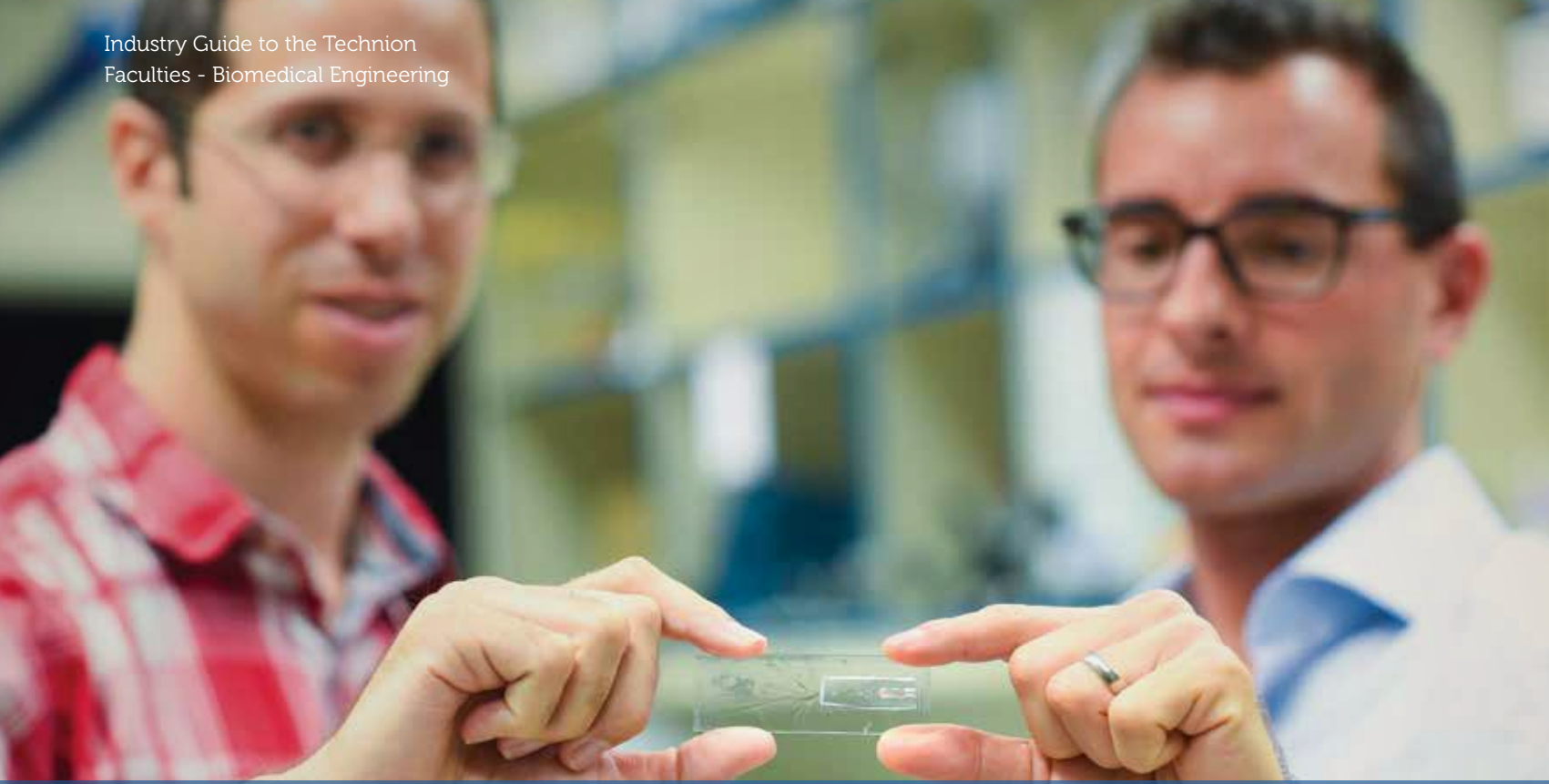
### Research and Development:

- Identification of the full repertoires of proteins (full proteomes, including many thousands of proteins) present in samples, such as cell lines, tissues, or microorganism cultures.

- Quantitative proteomics - definition of the relative levels of these protein repertoires in different cell types, and following the changes in these levels in response to treatments or mutations.
- Analysis of protein complexes - characterization of the interactions between different cellular proteins, and determination of their sub-cellular locations.
- Modifications - determination of post-translational modification patterns (including phosphorylation, ubiquitination, acetylation, etc.).
- Variations - determination of the differences between similar proteins.

In recent years more than 50 biotech companies, pharmaceutical companies, and startups have worked successfully with the Proteomics Center.





# BIOMEDICAL ENGINEERING

***http://bme.technion.ac.il***

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## Director of Industry and External Relations

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Biomedical Engineering (BME) at the Technion began as early as the mid-1940s, when the body's bio-electric phenomena were studied in the Department of Electrical Engineering. The interest and enthusiasm generated by this new field of studies grew so rapidly that by 1968 over 40 ongoing biomedical projects were under way at various Technion departments. In 1969, the Julius Silver Institute was set up to house all the Technion's biomedical engineering research, and the interdisciplinary Department of Medical and Biological Engineering was formally established, with the mission of developing a program for graduate studies.

Today, the Faculty of Biomedical Engineering is involved in wide-ranging research, both basic and applied. The varied novel engineering techniques and state-of-the-art technological, scientific and medical know-how generated by the Department have, over the years, proved both useful and beneficial to Israel's medical community.

| Contact | Research Groups: |
|---|---|
| **Prof. Amit Meller**<br>Tel. +972-4-829-3202/4143<br>ameller@technion.ac.il | Single Molecule Biophysics & Nano-biotechnology<br>Research interests:<br>➲ Biomolecular Engineering: Advanced molecular diagnostic systems; Microscopy, optical bioengineering and super-resolution methods; Nanopores and next generation DNA sequencing and genotyping<br>➲ Single Molecule Biophysics: Translational control in eukaryotic systems; Single molecule FRET and biomolecular dynamics; Live cell imaging and advanced microcopy |
| **Prof. Shulamit Levenberg**<br>Tel. +972-4-829-4810<br>shulamitl@technion.ac.il | Stem Cells Tissue Engineering Laboratory<br>The laboratory provides histology services for tissues and engineered tissues. It can assist in testing mechanical properties of tissues and scaffolds and in feasibility research for product development.<br>The laboratory is equipped with advanced equipment, and uses state-of-the-art assays for research in tissue engineering, 3D cultures, bioreactors, molecular biology, microscopy and biochemistry.<br><br>Research interests:<br>➲ Vascularization of engineered tissue constructs ➲ Engineering vascularized cardiac tissue ➲ Flow-induced vascularization in engineered tissue ➲ Engineering skeletal muscle tissue- as graft and flaps for reconstruction of abdominal wall tissue ➲ Engineering a vascular niche to support pancreatic islet survival and function and to improve islet transplantation efficacy ➲ Spinal cord injury regeneration ➲ Cell mechanics in 3D constructs ➲ Droplet Based Microfluidics ➲ The Rina & Avner Schneur Type II Diabetes center ➲ Lorry I. Lokey Tissue Regeneration Group in the Biomedical Engineering Laboratories |
| **Prof. Shy Shoham**<br>Tel. +972-4-829-4125<br>shy@technion.ac.il<br>***http://niel.net.technion.ac.il*** | Neural Interface Engineering Laboratory<br>Research interests:<br>➲ Design and application of optical and acoustic neural interfaces<br>➲ Computational Neuroscience: analysis and control of neural signals<br>➲ Biomedical Optics and Acoustics: wave propagation and tissue interactions |
| **Assoc. Prof. Amir Landesberg**<br>Tel. +972-4-829-4143<br>bmamir@technion.ac.il | Molecular Cardiology Laboratory<br>Research interests:<br>➲ Control and modeling in biomedical systems ➲ Intracellular control mechanisms ➲ Electro-mechanical coupling (Excitation-Contraction Coupling) ➲ Electrophysiology ➲ Electro-mechanical feedback |

| | |
|---|---|
| | ➲ Molecular cardiology, Motility assays ➲ Cardiac mechanics ➲ Regulation of energy conversion in muscles. Economy and Efficiency ➲ Isolated cardiac fiber studies ➲ Molecular motility assay. Image analysis ➲ Heart failure ➲ Cardiac assists devices |
| **Assoc. Prof. Dror Seliktar**<br>Tel. +972-4-829-4850<br>bmdror@technion.ac.il | Tissue Engineering and Biomaterials Laboratory<br>Research interests:<br>➲ Cell-Compatible Hydrogels ➲ Three-dimensional (3D) Cellular Morphogenesis ➲ Cell Therapy (Skeletal, Muscle, Cardiac) ➲ Tissue Repair (Cartilage, Bone, Nerve) ➲ Stem Cell Mass Production ➲ Cancer Drug Screening and Diagnostics ➲ Lorry I. Lokey Tissue Regeneration Group in the Biomedical Engineering Laboratories |
| **Assoc. Prof. Dvir Yelin**<br>Tel. +972-4-829-3832<br>yelin@technion.ac.il | Biomedical Optics Laboratory<br>Research interests:<br>➲ Miniature clinical endoscopy ➲ Advanced optical microscopy ➲ Gold nanoparticles ➲ Applications of ultrafast lasers ➲ Laser therapy |
| **Assoc. Prof. Eitan Kimmel**<br>Tel. +972-4-829-3857<br>agreita@technion.ac.il | Biomechanics of Ultrasound Interaction with Cell and Tissue<br>Research interests:<br>➲ Bio-heat and bio-mass transport ➲ Cell and tissue mechanics ➲ Nano-acoustics medicine: Ultrasound and opto-acoustics in medicine and biology as determined by intracellular; intra-membrane cavitation and bubble dynamics ➲ Acoustic neuromodulation. Biomechanics of trauma and decompression ➲ Acoustics of the inner ear |
| **Assoc. Prof. Haim Azahari**<br>Tel. +972-4-829-4145<br>azhari@technion.ac.il | Medical Imaging Laboratory<br>Research interests:<br>➲ Multimodal imaging including applications of Magnetic Resonance Imaging (MRI), Ultrasound, PET, SPECT and CT in medical imaging ➲ Development of new algorithms and methods for image reconstruction ➲ Image processing, information fusion and extraction from medical images ➲ Image guided intervention and therapy ➲ High Intensity Focused Ultrasound HIFU ➲ Thermal Tissue Ablation |
| **Assoc. Prof. Josue Sznitman**<br>Tel. +972-4-829-5678<br>sznitman@technion.ac.il | Technion Biofluids Laboratory<br>Research interests:<br>➲ Biofluid mechanics ➲ Physiological flows ➲ Pulmonary fluid dynamics ➲ Inhalation therapy ➲ Microcirculation ➲ Low Reynolds number flows ➲ Microfluidics ➲ Experimental flow visualization ➲ Particle image velocimetry (PIV) ➲ Particle tracking |

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## Mechanobiology of Cancer and Wounds

The lab provides services in experimental rheology and biorheology to characterize samples from water viscosity through gels. We specialize in working with gels, soft matter, and biological materials to evaluate effects of time, temperature, and additives. The lab also specializes in microscope-based particle-tracking microrheology, which can be used to determine the structure and dynamics of small samples.

Research interests:

➲ Mechanobiology of living cells in relation to cancer metastases and wound healing ➲ Cancer progression and predictive prognosis of cancer metastasis formation, through mechanobiology, structure and mechanics of living cells ➲ Cell adhesion, spreading, and force application on bio-surfaces as a function of external conditions, such as drug and chemotherapeutic treatments and applied mechanical deformations ➲ Computer algorithms, image processing, and finite element simulations to determine mechanobiology of cell interactions and intracellular mechano-structural evolution of cells

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## Cardiovascular NanoMed Engineering

Research interests:

➲ Cardiovascular Nano-medicine ➲ Microfluidics ➲ Hemodynamics ➲ Mechano-biology ➲ Vascular Diseases ➲ Lab on chip ➲ Thrombosis

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## Laboratory for Synthetic Biology & Bioelectronics

Research interests:

➲ Applying engineering to biology: Principles of genetic circuit design and synthetic biology ➲ Metabolic engineering ➲ Cytomorphic electronics; analog circuit design for modeling biochemical reactions and biological networks ➲ Bioelectronics -Whole cell biosensors for biomedical applications ➲ Bio-electrochemical systems for energy applications

**Asst. Prof. Yael Yaniv**
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## Bioenergetics and Bioelectric Systems

Research interests:

➲ Bioenergetics ➲ Calcium signaling ➲ Cardiac electrophysiology ➲ Cell Biophysics ➲ Heart rate variability analysis ➲ Mathematical modeling of the biochemical and bioenergetics signaling in the heart ➲ Mechanical interaction of the mitochondria and the cytoskeleton ➲ Sinoatrial node cells activity

| | |
|---|---|
| **Dr. Yoav Shechtman**<br>Tel. +972-4-829-1422<br>yoavsh@bm.technion.ac.il | Nano-bio-optics Laboratory<br>Research interests:<br>Nanoscale optical microscopy – method development and applications Three-dimensional imaging Computational imaging Localization microscopy Super-resolution microscopy Single particle tracking Single molecule measurements Signal-processing Phase-retrieval Chromatin structure |
| **Prof. Emeritus Dan Adam**<br>Tel. +972-4-829-4140<br>bmdan@technion.ac.il | Laboratory for Ultrasound Signals and Image Processing and Modeling<br>The lab provides services to ultrasound imaging and processing: Mapping of acoustic fields; Design and testing of novel beamforming; Acquisition of digitized RF data (either from single crystals or from imaging probes); Design and testing of transmit pulses; Ultrasound and echocardiographic applications using contrast agents.<br><br>Research interests:<br>Design of novel beamforming methods, including planar and diverging beams, multi-frequency phased array probes, etc. Automation of functional processing of echocardiography clips – selection of views, segmentation, strain measurements Echo ultrasound Strain imaging, including Layer-Specific 2D Strain measurements as a diagnostic tool of myocardial pathologies Contrast ultrasound super-resolution (spatial and temporal) for enhanced visualization of vasculature in tumors, plaques etc. Myocardial perfusion using contrast echocardiography Image guided therapy/ surgery High intensity focused ultrasound for cardiac pacing, fat tissue obliteration and other localized cavitation or heating based therapies |
| **Prof. Emeritus Noah Lotan**<br>Tel. +972-4-829-4135<br>noah@technion.ac.il | Biomaterials<br>Research interests:<br>Biomaterials : Medical and non-medical applications Intelligent systems for drug targeting: Cancer metastases and vascular lesions Immobilized enzymes and sorbents for biotechnological applications Extracorporeal and fully-implanted biosystems for metabolic support Bioengineering, biotechnology and artificial biological systems Separation and purification of biomaterials: Process engineering Multifunctional scaffolds for tissue engineering Molecular electronics and biochemical assemblies as neural networks Drug resistance: Metabolic reprograming and therapeutics |

**Prof. Emeritus Yoram Lanir**
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## Laboratory for the Mechanics and Function of Organs, Tissues and Cells

Research interests:

- Basic and applied quantitative analysis of the mechanics and function of cells, tissues and organs
- Theoretical and experimental studies range from cellular mechano-transduction, through the fundamental aspects of tissues' material properties, to pathophysiological processes
- Investigating the underlying morphological, mechanical, transport and physicochemical mechanisms, and their integration from the nano and micro scale into the overall macro behavior
- Interaction of blood flow with cardiac contraction, regulation of the coronary flow, analysis of pathophysiological cardiological events and of their diagnosis

## Dean's Office

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## The Rina and Avner Schneur Center of Diabetes Research:

The Rina and Avner Schneur Center of Diabetes Research lead by Prof. Levenberg, brings together top researchers from the faculty of Biomedical engineering and the Faculty of Medicine at the Technion-Israel Institute of Technology to seek for a cure to type II diabetes.

Type II Diabetes (DM2) is one of the most important public health challenges requiring a cure rather than preventive treatment. The current project (in collaboration with Prof. Eddy Karnieli) focuses on the development of a new cure for this important disease in the form of transplantation of engineered tissue, which will provide a useful tool to reach better systemic glucose homeostasis in DM2.

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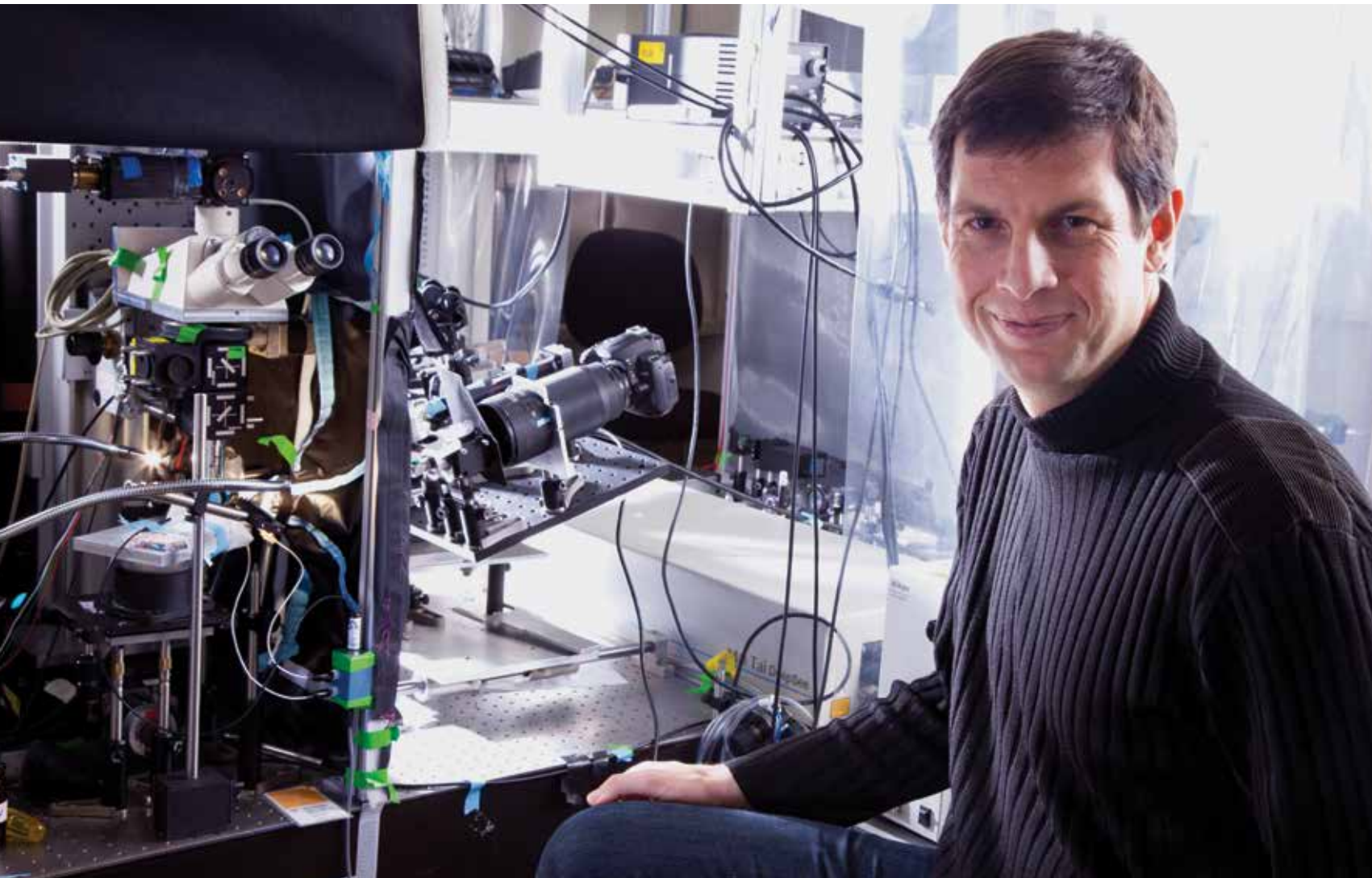
## Technion National Infrastructure Center for Advancing Brain Imaging (TELEM):

The TELEM lab is part of a distributed multi-university National Infrastructure Center for Advancing Brain Imaging supported by the council for higher education. This R&D branch was set up to develop and test high-resolution three-dimensional functional imaging and stimulation methods in rodents. The lab includes state-of-the-art multi-photon and opto-acoustic (photo-acoustic) systems for in-vivo imaging while a branch in the Technion medical school develops customized coils suitable for advanced functional MRI imaging.

This center enables advanced *in vivo* imaging and R&D in the field, accessible to both academic and industry researchers.



## The Industrial Affiliates Program (IAP):

The Technion Biomedical Engineering Faculty's Industrial Affiliates Program (IAP) is one of the faculty's flagship development projects. The program's goal is to provide a platform for structured interaction between the faculty and Biomedical Industry, to serve as a bridge to excellence and a stage for long-term affiliations and collaborations between academia and leading companies in the industry in the fields of research and development, human resources and employment, marketing and public relations, education and instruction.

The IAP Program enables the Technion community to become more attuned to industry needs and exposes the faculty members and students to a wide range of biomedical companies and their R&D activities. The program provides a platform for the IAP member companies, from which they can access to staff members and students, and influence the research, development and education of the biomedical engineering community.

Within the Industrial Affiliates Program any company, big or small, may gain equal access to the faculty's resources and carry out various activities which will expose the company's operations on all levels to undergraduate and graduate students, faculty alumni and academic faculty members. All company activities will be performed with the support of the Faculty's academic, administrative, and technical staff.

### IAP benefit package:

Following is the basic benefit package, which is the basis for discourse between academia and the industry. Companies may suggest more ideas and initiatives for collaborations according to their needs.

Research and Development:

- Participation in the "Research Day" in which faculty members and their advanced students present innovative research and developments
- Collaborating with students on projects for their Engineering Final Project Course and supervise students
- Coordination of joint projects with faculty laboratories
- Assistance in finding partners for submission of joint research proposals funded by the Chief Scientist and the European Union
- Examination of needs in the field of Research and Development among participating companies and creating connections to the existing capabilities of the faculty

Teaching:

- Participation in the industry leader advisory committee
- Participation in conferences and seminars held by the faculty
- Giving short seminars, courses and workshops exclusive to the company
- Possibility of company employees giving guest lectures at regular courses
- Possibility of company employees auditing regular courses

Human resources and employment:

- Possibility of having a student recruitment day that is exclusive to the company, once per semester
- Participation in a recruitment day held in the faculty building for several companies at once
- Sending e-mail messages to students studying all degrees regarding recruitment days, prizes and scholarships, conferences and seminars
- Sending company job opportunities to students via e-mail
- Publishing job opportunities on the company affiliation page (on the faculty website and Facebook)

Public relations and marketing:

- The company logo and a link to the company's website will appear on a webpage exclusive to the Industrial Affiliates Program (on the faculty website)
- Possibility of presenting technological exhibitions in the faculty building
- Company exposure to faculty members and students of all levels
- Option of publishing articles and advertisement in the faculty newsletter
- Sponsorship opportunity for the annual Biomedical Engineering Conference, alumni conferences, seminars, competitions, projects, etc.

## Alumni program:

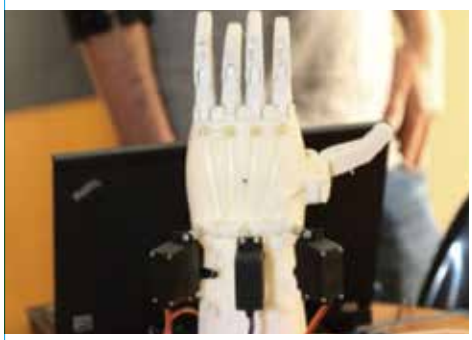
Our graduates have integrated remarkably well into Israel's biomedical industry. These, and other industries, have employed the department's graduates in key positions in research and development, production, marketing, and medical applications. In the past few years our graduates have become involved in many start-up companies, and more than 45% of Israel's start-ups are in this sphere.

In addition to the biomedical industry, the Department's alumni are found in the foremost research institutes and academic institutions, both in this country and abroad, where their know-how and expertise are highly valued.

The Department's program of studies provides high quality education in biomedical engineering at the undergraduate and graduate levels. Our graduates are equipped to meet the diverse needs of biomedical research and its industrial applications.

## Joint Activities with the biomedical industry:

1. Student Projects:



2. Student visits at the Industry:

3. Conferences:

- Annual Biomedical Engineering conference
  The annual conference of Biomedical Engineering is organized by the Biomedical Engineering Faculty at the Technion and the ISMBE organization. It is held at the Congress Center of Haifa and includes hundreds of participants from the biomedical community: academy, hospitals and industry. It includes various fields such as cancer detection, biomaterials and drug delivery, cardiovascular sessions, ultrasound (diagnosis and therapy), medical imaging, tissue engineering, biomechanics, mobile health, medical optics and Neuroscience.

- Project conference
  The annual Project conference is being held at the Technion at the end of the academic year. During the conference the students

present their work at a poster session and lectures. The industry sponsors the winning project's award. It is a great platform for the industry to present the project proposals for next year.

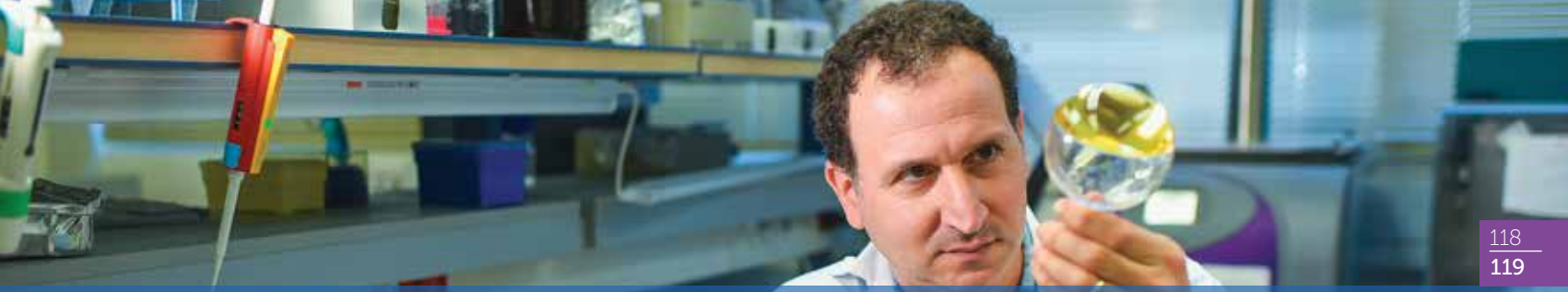
- Alumni conferences
  Our Alumni conferences discuss the future of biomedical engineering and medicine, the advances and strengths of biomedical engineering graduates in the industry and their integration in various biomedical industry fields.

- Entrepreneurship conferences
  A few conferences in the subject of innovation and Entrepreneurship are held at the faculty with the goal of promote and encourage students for innovation and creative thinking.

## Involvement of the industry in academic courses:

Biomed companies, and IAP companies in particular, are encouraged to take an active role in the department's academic courses.

The academic course of 4th semester undergraduates 'meeting the industry' is based on lectures of experts from the industry such as VP R&D, CEOs, CTOs, Product managers etc. It enables the undergraduate students to learn more about the different fields of biomedical industry and to be better prepared for their future options in the industry.





# BIOTECHNOLOGY AND FOOD ENGINEERING

***http://biotech.technion.ac.il/en***

Dean's Office

**Prof. Marcelle Machluf**

Dean

Tel. +972-4-829-3068/9

deanbfe@tx.technion.ac.il

The Faculty of Biotechnology and Food Engineering is unique in Israel, providing the highly skilled engineers needed for the country's expanding biotechnology and food industries. It offers a unique interdisciplinary blend of courses in engineering, food science and technology, life sciences, and biotechnology engineering. The Faculty has been transformed since a decision was made during the mid-1980s to focus on biotechnology. Accordingly, new Faculty members specializing in various aspects of biotechnology were recruited, and the teaching programs were revised to include a biotechnology specialization program, in addition to the existing food engineering specialization program. The integration is based on the biological material common to both fields, and fits well with the many changes in the traditional food industry, which is becoming more and more biotech-oriented. The Faculty's objectives are:

- To enhance the leadership status of the Faculty of Biotechnology and Food Engineering in Israel and among the World's top faculties in these fields.
- To attract the best Faculty members and students.
- To educate top-level engineers and scientists for the modern biotechnology and food industries.
- To maintain cutting-edge research, integrating scientific and engineering aspects related to biotechnology and food.

These objectives are in line with the Technion's vision of becoming one of the world's top ten universities.

The diverse activities of the Faculty of Biotechnology and Food Engineering combine a unique blend of engineering-technology research and aspects of life sciences and nanotechnology.

| Contact | Research Laboratories: |
|---|---|
| **Asst. Prof. Avi Shpigelman**<br>Head<br>Tel. +972-77-887-1867<br>avis@technion.ac.il | Novel Food and Bioprocessing Laboratory<br>Research Topics:<br>Food processing with emphasis on novel processing technologies. The effects of shelf life on food bioactives. Food polyphenols. The processing-structure-function relation in food systems. Food engineering towards food personalization. |
| **Dr. Maya Davidovich-Pinhas**<br>Head<br>Tel. +972-4-829-3346<br>dmaya@technion.ac.il | Lipids and Soft Matter Laboratory<br>Research Topics:<br>Structure-function relation of lipid based biomaterials, physical characterization of biopolymers and lipids, rheology and texture analyses. |
| **Asst. Prof. Roee Amit**<br>Head<br>Tel. +972-77-887-1895<br>roeeamit@tx.technion.ac.il<br>***http://roee-amit.technion.ac.il*** | Synthetic Biology Laboratory<br>Research Topics:<br>Decipherment of the regulatory and transcriptome codes using synthetic biology approaches, single molecule diagnostics. |
| **Prof. Dganit Danino**<br>Head<br>Tel. +972-4-829-2143<br>dganitd@tx.technion.ac.il<br>***http://dganitdanino.net.technion.ac.il*** | CryoEM Laboratory of Soft Matter<br>Research Topics:<br>Development of nanostructured carriers for drug delivery and nanomedicine; Structure-function of membrane-remodeling proteins; One-dimensional chiral self-assembly into ribbons and nanotubes; Thermodynamic and structural research of molecular assemblies; Milk proteins, Development of CryoEM methodologies. |

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|---|---|
| **Assoc. Prof. Ayelet Fishman**<br>Head<br>Tel. +972-4-829-5898<br>afishman@tx.technion.ac.il<br>***https://afishman.net.technion.ac.il*** | Molecular and Applied Biocatalysis Laboratory<br>Research Topics:<br>Engineering of enzymes for their use in the synthesis of chiral compounds and food ingredients, structure-function correlations of enzymes, enzymes in non-aqueous media |
| **Prof. Yechezkel Kashi**<br>Head<br>Tel. +972-4-829-3074<br>kashi@tx.technion.ac.il | Applied Genomics and Food Microbiology Laboratory<br>Research Topics:<br>Food and environmental microbiology, rapid detection of pathogens, typing of probiotics and pathogens, genome evolution, evolution of microsatellite DNA |
| **Assoc. Prof. Uri Lesmes**<br>Head<br>Tel. +972-77-887-1869<br>lesmesu@tx.technion.ac.il<br>***http://lesmesu.net.technion.ac.il*** | Chemistry of Foods and Bioactive Ingredients Laboratory<br>Research Topics:<br>Physicochemical basis of human digestion, food hydrocolloids, food delivery systems, encapsulation chemometrics and food personalization |
| **Prof. Ben-Zion Levi**<br>Head<br>Tel. +972-4-829-3345<br>blevi@tx.technion.ac.il<br>***http://levilab.net.technion.ac.il*** | Mammalian Cell Technology Laboratory<br>Research Topics:<br>Gene regulation in innate immunity, myeloid-leukemia, host-pathogen interactions |
| **Assoc. Prof. Yoav D. Livney**<br>Head<br>Tel. +972-4-829-4225<br>livney@technion.ac.il<br>***http://biopolymeric-nano-carriers-4-health.net.technion.ac.il*** | Food Physical Chemistry and Biopolymeric Delivery Systems<br>Research Topics:<br>Physical chemistry of macromolecules in food and other biotechnological systems, nano-delivery systems for health-promoting compounds |
| **Prof. Marcelle Machluf**<br>Head<br>Tel. +972-4-829-4916<br>machlufm@tx.technion.ac.il<br>***http://drugcelltherapy.net.technion.ac.il*** | Cancer Drug Delivery and Tissue Engineering Laboratory<br>Research Topics:<br>Tissue engineering and cell based delivery: Developing platforms for cell based delivery and tumor therapy. Developing scaffolds based ECM for tissue engineering of the pancreas, heart, and blood vessels.<br>Drug delivery: Development of micro and nano drug delivery systems for cancer and neurodegenerative disorders<br>Gene therapy: Delivery of cDNA and RNAi to cells and tissues using ultrasound energy and synthetic and natural nanoparticles |

| | |
|---|---|
| **Asst. Prof. Esther Meyron-Holtz**<br>Head<br>Tel. +972-4-829-3349<br>meyron@tx.technion.ac.il | Molecular Nutrition Laboratory<br>Research Topics:<br>Mechanisms and regulation of systemic and cellular iron distribution in mammals, in health and disease |
| **Prof. Emeritus Joseph Miltz**<br>Head<br>Tel. +972-4-829-2451<br>jmiltz@tx.technion.ac.il | Goldstein Packaging Laboratory<br>Research Topics:<br>Packaging (Active and Modified Atmosphere), suitability of packages for contact with food, suitability for dangerous materials and for fragile products, evaluation of gas (oxygen, water vapor and other gases) permeability, evaluation of mechanical and physical properties of packages and packaging materials |
| **Asst. Prof. Boaz Mizrahi**<br>Head<br>Tel. +972-4-829-2484<br>bmizrahi@technion.ac.il<br>***http://boazmizrahi.net.technion.ac.il*** | Biomaterials Laboratory<br>Research Topics:<br>Biologically inspired materials for reparative medicine, for improved bioavailability of drugs and food additives, and for separation processes, and the relationship between the molecular structure and functionality |
| **Prof. Amram Mor**<br>Head<br>Tel. +972-4-829-3340<br>amor@tx.technion.ac.il | Host Defense Peptides Laboratory<br>Research Topics:<br>Peptide-based drug design and delivery; non-specific mechanisms of action; structure-activity relationships |
| **Assoc. Prof. Ester Segal**<br>Head<br>Tel. +972-4-829-5071<br>esegal@technion.ac.il | Multifunctional Nanomaterials Laboratory<br>Research Topics:<br>Development of multifunctional nano-materials for sensing/ biosensing, drug delivery systems, intelligent and active packaging |
| **Prof. Yuval Shoham**<br>Head<br>Tel. +972-4-829-3072<br>yshoham@tx.technion.ac.il<br>***http://shoham.net.technion.ac.il*** | Protein and Enzyme Engineering Laboratory<br>Research Topics:<br>Gene regulation in Clostridium thermocellum and Geobacillus stearothermophilus, catalytic mechanism and structure function relationship of glycoside hydrolases and Amino peptides |

**Prof. Sima Yaron**
Head
Tel. +972-4-829-2940
simay@tx.technion.ac.il

## Molecular Biology of Pathogens Laboratory

Research Topics:
Food safety, molecular microbiology of food-borne pathogens, host-pathogen interactions, bacterial biofilms, gut microflora.

| CONTACT | EQUIPMENT | ITEM DESCRIPTION |
|---|---|---|
| **Prof. Dganit Danino**<br>Tel. +972-4-829-2143<br>dganitd@tx.technion.ac.il<br>***http://dganitdanino.net.technion.ac.il/equipment-2*** | CEVS | Manual system for cryo-TEM sample preparation in a controlled environment (temperature, humidity, vapor saturation) |
| | VITROBOT | Automatic system for cryo-TEM sample preparation in a controlled environment (temperature, humidity, vapor saturation) |
| | Light microscope | Olympus BX51 light microscope and Olympus DP71 digital camera |
| **Prof. Sima Yaron**<br>Tel. +972-4-829-2940<br>simay@tx.technion.ac.il | PERKIN ALMOR VICTOR | Fluorescence and luminescence plate reader |
| | BLOTEK | Fluorescence plate reader |
| | RT-PCR | Real-time PCR |
| **Prof. Ben-Zion Levi**<br>Tel. +972-4-829-3345<br>blevi@tx.technion.ac.il | Gel imager | Imaging lengths of DNA and RNA molecules |
| | Inverted fluorescence microscope | |
| | Nanodrop | |
| | Luminometer | |
| **Assoc. Prof. Uri Lesmes**<br>Tel. +972-77-887-1869<br>lesmesu@tx.technion.ac.il | LumiSizer LUM GmbH | Analytical centrifugation for analysis of stability and size of suspension and emulsions |
| | Titrando 902+TIAMO control software | Computer-controlled dual auto-titration unit |
| | Applikon MiniBioreactors and SCADA control software | Computer-controlled fermenters |
| | Bioreactors and Fermac peristaltic controllers | Simulated human colon fermentation |
| | Stomacker | Paddle homogenizer |
| **Assoc. Prof. Yoav D. Livney**<br>Tel. +972-4-829-4225<br>livney@technion.ac.il | Emulsiflex | High Pressure hemogenizer |
| | Postnova analytics, Germany. System includes: a 9 angle laser light scattering system (PN3609), refractive index (RI) detector (PN3150), a UV detector (PN3211) and a differential viscometer (PN3310) | Size exclusion chromatography (SEC) coupled to a mutli-detector system for molecular weight and particle size distribution & composition analysis |

| CONTACT | EQUIPMENT | ITEM DESCRIPTION |
|---|---|---|
| | Nicomp 380, PSS Santa Barbara, CA | Dynamic Light Scattering combined with zeta potential analyzer |
| | Ultrospec 3000, GE Healthcare | UV-VIS spectrophotometer |
| | DS5000 Anton Paar | Density & Sound velocity measurement in liquids |
| | Advanced instruments 3320 | Freezing point Osmometer |
| | Polytron | Benchtop Homogenizer |
| **Prof. Amram Mor**<br>Tel. +972-4-829-3340<br>amor@tx.technion.ac.il | Peptide synthesizer | Peptide synthesizer AB433A |
| | HPLC | Waters separation module Alliance |
| | Biotec Synergy | Biotec Synergy |
| **Prof. Marcelle Machluf**<br>Tel. +972-4-829-4916<br>machlufm@tx.technion.ac.il | Cell counter | |
| | FACS | |
| | Nikon T-2000E ECLIPSE<br>epifluorescence inverted microscope<br>with incubator setup for time-lapse imaging | |
| | Nano Sight 300 | |
| **Assoc. Prof. Ester Segal**<br>Tel. +972-4-829-5071<br>esegal@technion.ac.il | DSC- differential scanning-calorimeter | http://segallab.technion.ac.il - used for thermal characterization of materials, mainly polymers |
| | TGA Thermal gravimetric analyzer | http://segallab.technion.ac.il - used for thermal analysis of materials |
| | FTIR - Fourier Transform IR Spectrometer | http://segallab.technion.ac.il - spectroscopic technique to identify and study chemical composition |
| **Asst. Prof. Roee Amit**<br>Tel. +972-77-887-1895<br>roeeamit@tx.technion.ac.il | Optosplit | Splits microscope image for simultaneous imaging of different fluorescent channels |
| | Oscilloscope | Measurement and generation of voltage signals |
| | Fluorescence microscope | Measurement of microscopic samples (bacteria) that emit fluorescence |
| | Gel imager | Imaging lengths of DNA molecules |
| | Nanovue | Measures concentration of DNA in suspension |
| **Assoc. Prof. Ayelet Fishman**<br>Tel. +972-4-829-5898<br>afishman@tx.technion.ac.il | 2 Bioreactors (200 ml) - Applikon | Controlled growth of microorganisms |
| | HPLC-DAD and HPLC-UV (Agilent), HPLC -DAD (Dionex) | Separation of small non-volatile molecules |
| | GC-MS (Agilent) | Separation and identification of small volatile molecules based on their mass |
| | GC-FID (Agilent) | Separation of small and volatile organic molecules |
| | GC HEAD SPACE (THERMO) | Separation of small volatile organic molecules from liquid or head space |

| CONTACT | EQUIPMENT | ITEM DESCRIPTION |
|---|---|---|
| | EpMotion 5070 robotic system (Eppendorf) | Liquid handling system for 96-well plates |
| | AKTA Prime Plus | Protein purification |
| | Food Scan (Foss) | Analysis of fat, protein, water, collagen in meat samples |
| | Karl Fischer (Metrohm) | Moisture determination in samples |
| | Kjeldahl (Foss) | Protein determination in foods |
| | Polarimeter (Optical Activity) | Optical rotation measurement |
| | Microplate reader Synergy HT1 (BioTek) | Absorbance, fluorescence measurements |
| **Prof. Yechezkel Kashi**<br>Tel. +972-4-829-3074<br>kashi@tx.technion.ac.il | 3130 Genetic Analyzer - Applied Biosystems | DNA sequencing and genotyping - size determination of fluorenyl labeled products |
| | Microplate spectrophotometer | Absorbance microplate reader under temperature |
| | Eon-BioTek | control at selected wavelength (200-999 nm) |
| | Microplate reader Synergy HT - BioTek | Absorbance, fluorescence and luminescence measurements in microplate |
| | Step One Plus REAL TIME PCR-Applied Biosystems | Quantification and detection of DNA and RNA, gene expression analysis |
| | Nanovue plus | Determining DNA and RNA concentration |
| | Eclipse 5Oi - Microscope and micromanipulator - Nikon | Yeast tetratide dissection |
| **Prof. Yuval Shoham**<br>Tel. +972-4-829-3072<br>yshoham@tx.technion.ac.il | Dionex-Thermo Scientific Dionex Corporation | Chromatography |
| | GC-HP-GC 6890 | Gas chromatograph |
| | HPLC-HP 1100 | Liquid chromatograph |
| | Stopflow- Applied Photo Physics p*-180 | Spectrometer for nanosecond kinetics and CD-circular dichroism for protein studies; characterization, stability, formulation, structure, and more |
| | Akta Explorer- Pharmacia LKB (GE) | Protein chromatography system |
| | Akta Basic- Pharmacia LKB (GE) | Protein chromatography system |
| | Akta Avant - Pharmacia LKB (GE) | Protein chromatography system |
| | ITC- VP-ITC Microcal | Microcalorimeter |
| | DSC- VP-DSC Microcal | Microcalorimeter |
| | 2-, 10-, and 50-L fermenters (BRAUN-BIOSTAT MD) | Fermenter |
| | French Press-SPECTRONIC INSTRUMENTS | Cell homogenizer |

| CONTACT | EQUIPMENT | ITEM DESCRIPTION |
|---|---|---|
| **Prof. Yuval Shoham**<br>Tel. +972-4-829-3072<br>yshoham@tx.technion.ac.il | Anaerobic hood COY Laboratory Products Inc. | Anaerobic bacterial growth |
| | EMULSIFLEX C3-AVESTIN | Cell homogenizer |
| | BioTek- Synergy HT | Plate reader |
| **Asst. Prof. Avi Shpigelman**<br>Tel. +972-77-887-1867<br>avis@technion.ac.il | Agilent LS-MS (single quad) system | An analytical system for the detection, identification and quantification of compounds with Mw < 2000 Da |
| | Hydrostatic high pressure system (HHP), Stansted, up to 900 MPa temperature controlled vessel of ~300 ml | A processing system for the study of the effects of HHP |
| | Ultra-high pressure homogenizer, Stansted, up to 420 MPa, temperature controlled | A processing system for the study of the effects of UHPH on aqueous systems |
| | GPC-RI-UV-MALS-Viscometer quad detector system | For the studies of molecular weight and conformation of water-soluble macromolecules |
| **Asst. Prof. Boaz Mizrahi**<br>Tel. +972-4-829-2484<br>boazm@technion.ac.il | HPLC | Waters separation module Alliance |
| | Phenom ProX | SEM with EDX |
| | Fluorescence microscope | Nikon Eclipse Ti |
| | Mini Spray Dryer | Bucchi B-290 |
| **Dr. Maya Davidovich-Pinhas**<br>Tel. +972-4-829-3346<br>dmaya@technion.ac.il | X-ray diffractometer (Rigaku) | SmartLab 3kW instrument equipped with a high performance mid-low temperature control stage (-193 to 450˚C) |
| | Rheometer (Anton-Paar) | MCR302 rheometer equipped with a temperature control unit (-40 to 200˚C), tribology cell, couette cell, and additional measuring geometries |
| | Texture analyzer (Lloyd) | TA1 instrument equipped with 50N and 500N load cells with various measuring geometries |

| CONTACT | EQUIPMENT | ITEM DESCRIPTION |
|---|---|---|
| **Pilot Plant**<br>**(Food Technology)**<br>Tel. +972-4-829-2453<br>shazman@tx.technion.ac.il | Spray dryer (Niro; 10 kg/hr) | |
| | Drum dryer (Escher Wyss; 50 kg/hr) | |
| | Fluid Bed dryer (Aeromatic; 4 kg batch) | |
| | Tunnel dryer (up to 15 kg/batch) | |
| | Freeze dryer (Grenco; up to 15 kg/batch) | |
| | Agitated falling fFilm evaporator (Luwa; 25 L/hr batch type) | Boiling vacuum concentrator for viscous liquids |
| | Falling film evaporator (Niro; 50 L/hr continuous) | Boiling vacuum concentrator for liquids |
| | Centri Term evaporator (Alfalaval; 30 L/hr batch type) | Up to 2000 bar |
| | Kugel vacuum evaporator (up to 40 L) | Boiling vacuum concentrator reactor |
| | 2 Plate heat exchangers (Alfalaval and Niro; up to 6 L/min) | Pasteurization of liquids |
| | Still autoclave (Stork; with temperature and in package monitoring equipment) 50 L | |
| | Rotating autoclave (with temperature and in package monitoring equipment) 50 L | |
| | Blast freezer tunnel 80 L | |
| | Scraped surface freezer (Votator; 10 kg/hr continuous) 8 | |
| | Tweedy mixer for dough (up to 15 kg) | |
| | Controlled baking oven | |
| | Smoking cabinet | |
| | Stephan mixer | |
| | 2 Step Nozzle homogenizer (2 L/min) | Up to 300 bar |
| | Vacuum homogenizer (Herbot; 15 L batch) | |
| | Various high and low shear mixers and blenders | |
| | Various centrifuges(5 L/min) | |
| | Various grinders, crushers and Millers | |
| | Various screeners, sifters, filters | |
| | U.F filtration (0.54 square meter membrane) | |
| | FMC In-line-juice extractor | |

Industrial Relations Coordinator
**Prof. Marcelle Machluf**
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## Relations with Industry:

The Faculty of Biotechnology and Food Engineering is dedicated to the creation of mutual cooperation between academia and leading industrial companies, as part of our mission to promote mutually important values and needs of industry and academia focusing on knowledge, development, innovation, and excellence.

### Research and Development:

- Professional interaction with Faculty researchers
- Students' Final Project Course: topic proposals and mentors are provided by companies for 4th-year students
- Joint Projects: laboratory services are provided by Faculty members and their research facilities for the food industry and for the biotech / biomedical companies
- The Goldstein Packaging Pilot Plant Laboratory offers unique instruments for assessing and designing packaging systems

### Teaching:

- Workshops, seminars, and guest lecturers
- Free Auditor: options for company employees to choose specified Faculty courses
- Industrial Advisory Board: held once a year to discuss teaching programs, research projects, laboratories, and faculty equipment

### Human Resource:

- Recruiting day: an opportunity to hold an exclusive student-recruiting day
- Announcements via professional conferences, seminars, awards, scholarships, and recruiting days
- Student employment during summer projects and hosting summer interns

### Public Relations and Advertising:

- Increasing companies' visibility: companies' names and logo presentations on the Faculty web page
- Sponsorship opportunity for alumni conferences, seminars, competitions, projects, etc.


# CHEMICAL ENGINEERING

***http://chemeng.technion.ac.il***

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grader@technion.ac.il

Industrial Relations Coordinator
**Asst. Prof. Avi Schroeder**
Tel. +972-77-887-1953
avids@technion.ac.il

**Mrs. Hemda Tal**
Tel. +972-4-829-2829
hemda.t@technion.ac.il

The Faculty of Chemical Engineering at Technion is highly multidisciplinary, including researches that work on a broad spectrum of fields. The research areas include nano materials, drug delivery, advanced polymers, ceramics and biomaterials, reaction engineering, simulations, water desalination, fuel cells hydrogen generation and other energy related topics.

The faculty members engage in cutting edge research in the areas above and more. A testament to the level of excellence of our faculty members is that the department traditionally receives amongst the highest funding per faculty member in the whole Technion. It should be mentioned that beyond the research, our department scores very highly in student-faculty relations. Many of our faculty win the Technion excellent of teaching award. Finally, the department is growing in number of faculty members, expanding into new territories such as oil and gas in general and particularly into natural gas downstream processing. The growth of the department into the natural gas processing area is strategic, aiming to provide the engineering and research manpower that will be needed in Israel given that the gas sector will flourish here in the coming years.

Our faculty has four main research fields which our members are specialize in them:

Bio-systems and Bioengineering:
Prof. Hossam Haick ➔ Prof. Havazelet Bianco-Peled ➔ Assoc. Prof. Naama Brenner ➔ Asst. Prof. Avi Schroeder

Chemical Processes, Catalysis, Advanced Materials and Non-carbon Energy Sources:
Prof. Gideon Grader ➔ Prof. Daniel Lewin ➔ Prof. Yaron Paz ➔ Prof. Raphael Semiat ➔ Prof. Dario R. Dekel ➔ Assoc. Prof. Slava Freger ➔ Assoc. Prof. Yoed Tsur ➔ Asst. Prof. Oz M. Gazit ➔ Prof. Emeritus David Hasson ➔ Prof. Emeritus Ephraim Kehat ➔ Prof. Emeritus Moshe Sheintuch

Polymers Science and Engineering:
Prof. Yachin Cohen ➔ Assoc. Prof. Simcha Srebnik ➔ Dr. Tamar Segal-Peretz ➔ Prof. Emeritus Moshe Narkis

Fluid Systems, Colloid and Interface Science:
Prof. Simon Brandon ➔ Assoc. Prof. Slava Freger ➔ Assoc. Prof. Alexander Leshansky ➔ Asst. Prof. Ofer Manor ➔ Prof. Emeritus Abraham Marmur ➔ Prof. Emeritus Avinoam Nir ➔ Prof. Emeritus Yeshayahu (Ishi) Talmon

| Contact | **Bio-systems and Bioengineering:** |
|---|---|
| **Prof. Hossam Haick**<br>Head<br>Tel. +972-4-829-3087<br>hhossam@techunix.technion.ac.il<br>***http://lnbd.technion.ac.il*** | Laboratory for Nanomaterial Based Devices (LNBD)<br>Research Topics: Sensors, Volatolomics, Advanced materials<br>Facilities: TD-20-GC2010-GCMS-QP2010 system<br>TD-20 includes an auto sampler capable of holding up to 48 sample tubes. Batch processing is automatic. The samples are heated and transferred through the gas chromatograph colon (GC2010) into the mass spectrometer for identification of the volatile components. Company: Shimadzu. |
| **Prof. Havazelet Bianco-Peled**<br>Head<br>Tel. +972-4-829-3588<br>bianco@tx.technion.ac.il | Polymeric Biomaterials: Structure - Function relations<br>Research Topics: Biosystems<br>Facilities: HTBioTek Spectrophotometer Synergy™®; Lloyd mechanical testing machine equipped with a 50-N load cell |

**Assoc. Prof. Naama Brenner**
Head
Tel. +972-4-829-2933
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***http://biophysics.net.technion.ac.il***

### Theoretical Biophysics

Research Topics: Exploratory adaptation in cellular networks; Phenotypic variability in cell populations; Social interactions of bacterial cells in droplets; Statistical properties of synapses in neural networks; Psychophysics of visual perception

**Asst. Prof. Avi Schroeder**
Head
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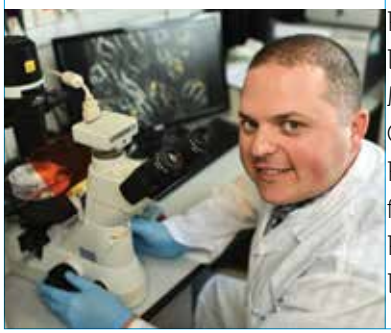
***http://nanodrugs.net.technion.ac.il***



### Targeted Drug Delivery and Personalized Medicine

Research Topics: Personalized medicine; liposomes;nanoparticles; drug delivery; bio-surgery; barcoded nanoparticles;protein producing particles.
Facilities: Dynamic light scattering (DLS) (Malvern) - particle characterization (size, zeta potential, protein mobility); High Pressure Liquid Chromatography (HPLC) (Agilent) - separation, analytical; Fast Protein Liquid Chromatography (FPLC) (Akta)- protein purification; Differential Scanning Calorimetry (DSC) (TA) – Tm; Gas Chromatography-Mass Spectra (GC-MS)(Agilent)- separation, identification; Inductively Coupled Plasma (ICP)(Agilent) - trace elements analysis; Inverted Fluorescent Microscope (Nicon); Plate reader (Tecan)-absorbance, fluorescence, FRET, luminescence, controlled environment; PCR;Incubators; Biohood;Chemical Hood;Lyophilizer; Centrifuge;SDS and DNA gels running equipment; -80 refrigerator; Shaker; Sonicators

Contact

## Chemical Processes, Catalysis, Advanced Materials and Non-carbon Energy Sources:

**Prof. Gideon Grader**
Head
Tel. +972-4-829-2008
grader@tx.technion.ac.il
***http://ceramicenergy.technion.ac.il***

### Advanced Ceramics and Non-carbon Fuels for Energy Applications

Research Topics: Sol-Gel ceramic films, ceramic nanofibers and non-carbon fuel combustion
Facilities:

- Thermal Analysis: Simultaneous Thermogravimetric Analysis and Differential Thermal Analysis (TGA/DTA) in different atmospheres; Setaram TG92 (RT-2400°C), Setaram SETSYS Evolution (RT-1700°C).
- Thermo-Mechanical Analysis -Dilatometry (TMA): Setaram Setsys Evolution (150-1700°C)
- Surface and Pore Size Analysis: Pore Size Distribution; Specific Surface Area; Chemisorption Analysis;ASAP 2010; Micromeritics Specific Surface Area, (BET), FlowSorp II, 2300, Micromeritics
- Thermal treatment: High temperature synthesis and sintering in oxidative, reduction and inert atmospheres (RT – 1650°C), box and tube furnaces with flowing gases and complicated thermal profile (CM Rapid and Carbolite furnaces)

**Prof. Daniel Lewin**
Head
Tel. +972-4-829-5672
dlewin@technion.ac.il
***http://tx.technion.ac.il/~dlewin/pse.htm***

## Process Systems Engineering

Research Topics: Heat Exchanger Network Synthesis

**Prof. Yaron Paz**
Head
Tel. +972-4-829-2486
paz@tx.technion.ac.il
***https://pygroup.net.technion.ac.il***

## Photo Catalysis and Thin films

Research Topics: Photocatalysis; Advanced materials; Environment, water and alternative energy; Thin films

Facilities:

- FTIR, Bruker Vertex 70V. KBr BS: Detectors: DTGS, MCT; Characteristics: Optical path under vacuum, Step-Scan option; Accessories: vertical ATR, circle cell ATR, KBr pellets press, diffuse reflectance, thin films grazing angle reflectance (homemade), in situ sample illumination (UV/VIS) (homemade), temperature controlled sample holder (homemade), in-situ photocatalytic reactor (homemade)
- FTIR, Bruker Equinox55. KBr BS: Detectors: DTGS, MCT; Sources: MIR, NIR; Accessories: IR Microscope A590, vertical ATR, circle cell ATR, KBr pellets press, diffuse reflectance, thin films grazing angle reflectance (homemade), variable angle specular reflectance, variable distance liquid cell, multiple pass gas chamber, photoacoustic detector, in-situ sample illumination (UV/VIS) (homemade), temperature controlled sample holder (homemade), in-situ photocatalytic reactor (homemade)
- UV-Vis spectrophotometer, UV-2600, Shimadzu: Accessories: Integrating sphere; Measures: absorption/transmission, reflection in liquid and solids
- AFM, PicoPlus, Molecular Imaging: Modes of measurements: contact, non-contact, magnetic, current sensing, STM; Accessories: Environmental chamber, in-situ UV-light effect (homemade)
- HPLC, Agilent 1100 equipped with quaternary pump, column compartment, DAD detector and auto sampler; Accessories: a variety of columns
- GC-MS, GC Hewlett Packard, GC HP6890; MS 5973: Detectors (GC): FID, TCD; Accessories: a variety of columns
- Q500 Sonicator, Qsonica (USA): Powerful ultrasonic processor, Effective for many popular applications nanoparticle dispersion, creating emulsions, cell lysis and homogenization; Power rating: 500 watts; Frequency: 20 kHz, Programmable Timer: 10 hours
- Electrospinning apparatus (Homemade)

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| | ⊛ Surface Plasmon Resonance (SPR) apparatus (homemade)<br>⊛ High Pressure reactor / hydrothermal reactor: Parr Ltd.<br>⊛ A variety of photocatalytic reactors (homemade) |
| **Prof. Raphael Semiat**<br>Head<br>Tel. +972-4-829-2009<br>cesemiat@tx.technion.ac.il | Desalination and Water Treatment<br>Research Topics: Desalination and water treatment<br>Facilities:<br>⊛ Pilot scale membrane systems: Flat sheet, tubular and spiral wound Reverse Osmosis; Nano-filtration and Ultrafiltration. Porous media for filtration and salt dissolution, etc.<br>⊛ Laboratory analysis equipment: ZetaSizer Nano S90 (Malvern, UK) - measure size and zeta-potential in a solution and in a dispersion; Mastersizer 2000 (Malvern, UK) Measures size from 0.02µm to 2000µm a solution and in a dispersion; Multi N/C 2100 total organic carbon (TOC) analyzer (Analytik Jena, Germany); ContrAA®700 Atomic Absorbance (Analytik Jena, Germany) |
| **Assoc. Prof. Dario R. Dekel**<br>Head<br>Tel. +972-4-829-1792<br>dario@technion.ac.il | Technion Electrochemical Energy based on Membranes<br>Research Topics: Fuel Cells – membranes, catalysts and full electrochemical devices; anion exchange membranes (AEM); Catalysis Research; Energy Materials Engineering; Flow Batteries<br>Facilities:<br>⊛ Fuel Cell Test Station – Greenlight Innovation Inc., G-20, capable of measuring EIS and DC performance of FC with $H_2/O_2/N_2$/air, in variety of temperatures, pressures and flows<br>⊛ Membrane test system – MTS 740 – Scribner Associates Inc.; measures the EIS response (including conductivity) of membranes in $H_2/N_2$ and in a range of temperatures and humidity levels<br>⊛ VTI-SA – Thermogravimetric analysis (TGA) with variable humidity - TA Instruments, Q series – up to 150°C, 90% RH, with sensitivity down to ~10 microgram<br>⊛ Ultra-microbalance – Radweg – Large diameter pan, extra-sensitive microbalance, with sensitivity down to 0.1 microgram; total max. mass- 2.1 gram<br>⊛ Tape Caster – MTI, USA – heated from below and above the casted film, equipped with Dr. Blade, variable speed.<br>⊛ Hot Rolling Press – 4" width, up to 100°C, variable speed |

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| **Assoc. Prof. Slava Freger**<br>Head<br>Tel. +972-4-829-3578<br>vfreger@technion.ac.ilr<br>***http://freger-membrane.net.technion.ac.il/facilities-and-resources*** | Membranes for Water and Energy<br>**Research Topics:** Membrane Technology; Desalination and Water Purification; Physical Modeling of Membranes; Fuel Cell Membranes<br>**Facilities:** Membrane test cells (dead-end and cross-flow filtration modes); Research potentiostat for electrochemical tests and impedance spectroscopy |
| **Assoc. Prof. Yoed Tsur**<br>Head<br>Tel. +972-4-829-3586<br>tsur@technion.ac.il<br>***http://electroceramics.net.technion.ac.il*** | Electroceramics<br>**Research Topics:** Electroceramics; Point defect chemistry of oxides; Flash sintering; Impedance spectroscopy; Development of ceramic inks<br>**Facilities:** Impedance Spectroscopy, AC-measurements, DC-measurements: Agilent 4294A - Precision Impedance Analyzer; Agilent 4284A - Precision LCR Meter; PS300 High Voltage Power Supply - Stanford Research System; Biologic SP-200 Potentiostat/Galvanostat; Biologic SP-240 - Potentiostat/Galvanostat with Booster; Biologic SP-300 Potentiostat/Galvanostat; Gamry Reference-3000 Potentiostat/Galvanostat; Keithley 2700 Multimeter/20 Channel Multiplexer; Keithley 2400 SourceMeter; Keithley 2400 SourceMeter; Keithley 2635A SourceMeter; Keithley 2260B-800-2 720W Power Supply; Dilatometer DIL801; Dilatometer DIL802; Carbolite Furnace Tmax = 1500; Brookhaven ZetaPALS for particle size and zeta potential measurements |
| **Asst. Prof. Oz M. Gazit**<br>Head<br>Tel. +972-4-829-3562<br>Ozg@technion.ac.il | Laboratory for Heterogeneous Catalysis and Advanced Materials<br>**Research Topics:** Heterogeneous catalytic materials; Solid adsorption materials; Composite materials. Methane activation reactions to fuels and chemicals; Upgrading of biomass derived molecules<br>**Facilities:** Setaram Labsys Evo TGA/DSC (RT-1500°C) coupled to a Hiden QGA-MS; Chemisorption Micromeritics ASAP 2920 coupled to a Hiden QGA-MS; Physisorption (Micromeritics 3Flex); In-situ high temperature (900°C) gas phase FTIR; Shimadzu HPLC with RI and PDA detectors; Supercritical $CO_2$ dryers (25 ml) |
| **Prof. Emeritus David Hasson**<br>Tel. +972-4-829-2936<br>hasson@technion.ac.il | Membrane Separation Processes, Desalination and Water Treatment Technologies |
| **Prof. Emeritus Ephraim Kehat**<br>Tel. +972-4-829-2935<br>cerekek@technion.ac.il | Analysis of Industrial Processes |

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| **Prof. Emeritus**<br>**Moshe Sheintuch**<br>Head<br>Tel. +972-4-829-2823<br>cermsll@technion.ac.il | Chemical Reaction Engineering and Environmental Catalysis<br>Research Topics: Membrane reactors; Pure hydrogen production; Engines powered by reforming products; Reactor dynamics<br>Facilities: AutoChem 2920 – Automated Catalyst Characterization System (micromeritics): Analysis types:Temperature Programmed Desorption, Temperature Programmed Reduction, Temperature Programmed Oxidaiuon, Pulse Chemisorption Analysis, Langmuir Surface Area analysis, Total Pore Volume Analysis, Additional Uses of AutoChem 2920: Catalyst pretreatment, Temperature programmed Reaction, Isothermal Reaction; GC Trace Ultra- Gas Chromatography |

| Contact | **Polymers Science and Engineering:** |
|---|---|
| **Prof. Yachin Cohen**<br>Tel. +972-4-829-2010<br>yachinc@technion.ac.il | The Relation between Processing, Microstructure, Properties and Function in Polymer Systems, in the Solid, Gel, Colloid and Solution States<br>Research Topics: Cellulose processing: hydrogels, aerogels, emulsions and hydrolysis; Conversion of biomass to bio-fuels; Dispersion and processing of polymer-nanoparticles composites, including: carbon nanotubes, graphene and metals and metal oxides; Ultra-light-weight foams and nanocomposite foams; High performance composite materials by fiber compaction; Organized microstructure in amphiphilic systems and polymer-surfactant interactions; Block copolymer structure and deformation<br>Facilities: Simultaneous small- and wide-angle x-ray scattering (SAXS/WAXS): [Rigaku-Molecular Metrology] comprised of a sealed tube generator with microfocus graded mirror optics [Philips-Osmic] and 3-pinhole collimation with a 2 dimensional wire detector [Gabriel] for SAXS and image plate [Fuji] for WAXS; Sample holders available for solids, liquids and gels, with temperature controllers covering ranges from liquid nitrogen to 300°C |
| **Assoc. Prof. Simcha Srebnik**<br>Head<br>Tel. +972-4-829-3584<br>simchas@technion.ac.il | Polymer and Biopolymer Science<br>Research Topics: Epoxy composites; Molecular imprinting; Protein folding<br>Facilities: Computational polymer physics lab |

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| **Dr. Tamar Segal-Peretz**<br>Tel. +972-4-829-3565<br>tamarps@technion.ac.il | Laboratory of Functional Nanostructures and Advanced Imaging<br>Research Topics: Polymer-based functional nanostructures; Block copolymers self-assembly and directed-self assembly for advanced lithography and nanofabrication; Three-dimensional characterization of nanostructures using TEM tomography; Growth processes of inorganic materials inside polymer films<br>Facilities: Atomic layer deposition; Glove box; Polymer synthesis and thin film fabrication facilities; Work closely with the Electron Microscopy Center-FEI Talos TEM with room temperature and cryo tomography capabilities and low dose imaging |
| **Prof. Emeritus Moshe Narkis**<br>Head<br>Tel. +972-4-829-2937<br>narkis@tx.technion.ac.il<br>***http://plast.technion.ac.il*** | Polymers and Plastics<br>Research Topics: Polymer science and technology<br>Facilities: TA 2050 Thermal Gravimetric Analyzer (TGA); Mettler DSC-30 differential scanning calorimeter; Dynamic mechanical thermal analysis (DMTA – Perkin Elmer series 7); AR 1000-N TA Instruments parallel plate rheometer; Arburg injection molding; Brabender plastograp; Brabender twin-screw extruder; Instron 2050 tensile machine |

| Contact | **Fluid Systems, Colloid and Interface Science:** |
|---|---|
| **Prof. Simon Brandon**<br>Tel. +972-4-829-2822<br>cersbsb@technion.ac.il | Computational Analysis of Transport and Interfacial Phenomena<br>Research Topics: Crystal growth science and technology; Electrochemical systems; Wetting phenomena |
| **Assoc. Prof. Slava Freger**<br>Head<br>Tel. +972-4-829-3578<br>vfreger@technion.ac.ilr<br>***http://freger-membrane.net.technion.ac.il/facilities-and-resources*** | Membranes for Water and Energy<br>Research Topics: Advanced Characterization of Membranes; Novel and Modified Membranes for environmental and energy applications; Fouling and Biofouling Phenomena<br>Facilities: Fourier Transform InfraRed (FTIR) equipped with ATR (Diamond and Ge crystals); Atomic Force Microscope (AFM), max scan range 90X90 micrometers; Electrokinetic analyzer for solid surface analysis (SurPass, Anton Paar); Quartz Crystal Microbalance with dissipation (QCM-D); Optical Microscope; Drop shape analyzer (Contact angle) – DI water only |
| **Assoc. Prof. Alexander Leshansky**<br>Head<br>Tel. +972-4-829-3502<br>lisha@tx.technion.ac.il<br>***https://chemeng.technion.ac.il/alexander-leshansky-2*** | Complex Fluids and Microflows<br>Research Topics: Fluid dynamics; Transport phenomena; Complex fluids; Microfluidics; Colloids and Interfaces |

**Asst. Prof. Ofer Manor**
Head
Tel. +972-77-887-1734
manoro@technion.ac.il
***https://chemeng.technion.ac.il/small-scale-transport***

## Small Scale Transport

**Research Topics:** Colloid and Interface Science; Catalysis; Process system engineering; Transport phenomena

**Facilities:** Scanning Laser Doppler Vibrometer MSA-500 Micro System Analyzer; Upright Microscope Eclipse Ni-E; Nikon; Inverted Microscope Eclipse TI-S/L, Nikon; HAMEG HMO3000 Digital Oscilloscope, Rohde & Schwarz; RF and Microwave Signal Generator, Rohde & Schwarz; BSA 500 kHz... 1000 MHz Solid State Amplifiers, BONN Elektronik; Expanded Plasma Cleaner, Harrick Plama; Q500 Sonicator, Qsonica (USA); QCA 15Pro Video-based angle optical contact angle measuring instruments, Dataphysics company

**Prof. Emeritus Abraham Marmur**
Head
Tel. +972-4-829-3088
marmur@tx.technion.ac.il

## Interfacial Phenomena

**Research Topics:** Colloid and Interface Science; Thermodynamics

**Prof. Emeritus Avinoam Nir**
Head
Tel. +972-4-829-2119
avinir@tx.technion.ac.il

## Multiphase Dispersed Fluid Systems

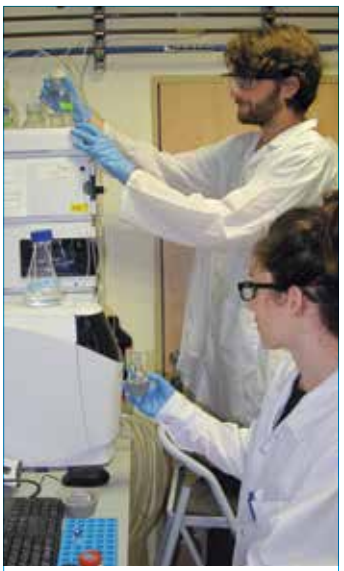
**Research Topics:** Fluid mechanics; Transport phenomena

**Prof. Emeritus Yeshayahu (Ishi) Talmon**
Head
Tel. +972-4-829-2007
ishi@tx.technion.ac.il
***http://talmon.net.technion.ac.il***

## Complex Liquids, Nanostructure and Macromolecules

**Research Topics:** Research Topics: Complex Liquids; Soft Materials; Nanostructured Biosystems; Colloid and Interface Science

**Facilities in the Laboratory for Electron Microscopy of Soft Materials:** an FEI Talos 200C, a new high-resolution, field-emission gun (FEG)-equipped cryo-TEM, with a demonstrated resolution of 0.12 nm; FEI Tecnai T12 G2 cryo-transmission electron microscope; Zeiss Ultra plus cryo-high-resolution scanning electron microscope (HR-SEM) with a Bruker EDS system; Olympus BH2 light microscope with a Nikon DS-F12 CCD camera; CEVS - Controlled Environment Vitrification System for cryo-EM specimen preparation; Leica EM BAF 060 Freeze-Fracture-Replication and cryo-SEM specimen preparation system, Leica EM UC7 cryo-microtome system



## Relations with the Chemical Industry:

The researchers of the Faculty of Chemical Engineering are involved in various ways and in all aspects with the Israeli chemical industry, and also with companies abroad. The cooperation includes research programs in direct cooperation with a wide range of companies, indirectly with the help of governmental institutions, start-up companies that were founded by our Faculty members, services based on available equipment, and consulting on a personal basis by individuals.

The range of companies involved is wide, and includes companies in the petrochemical and polymer industries, minerals, energy, agrochemical and fine chemicals, pharmaceuticals, biotechnology and biomedicine, water and desalination, electronics and advanced materials, and the security industry. Our former students are active in all these industries.

# CHEMISTRY

***http://chemistry.technion.ac.il***

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**Prof. Noam Adir**
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chdean@ch.technion.ac.il

***http://chemistry.technion.ac.il/deans-message***

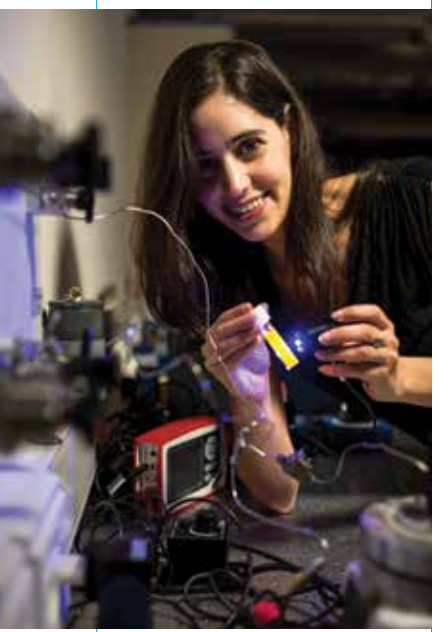
Industrial Relations Coordinator
**Ms. Meytal Bar-On**
Tel. +972-4-829-3727
meital.b@ch.technion.ac.il

The Faculty of Chemistry is a vibrant academic unit, with dynamic research and teaching programs, active Faculty members, and modern research laboratories and facilities. It spans the full spectrum of disciplines within chemistry – physical, analytical, inorganic, organic, biochemical, and theoretical; and overlaps the associated fields of physics, materials sciences, biology, medicine, electronics, and nanotechnology.

**The Faculty is divided in two divisions:**

The Division of Organic and Inorganic Chemistry comprises 11 research groups. Their scientific interests and activities encompass general fields of organic, inorganic, bio-organic, bio-inorganic, catalytic, theoretical, supramolecular, polymer, and materials chemistry.

The Division of Physical, Theoretical and Analytical Chemistry comprise 14 research groups that apply a variety of theoretical and experimental techniques to elucidate the molecular nature of materials. Many of the studies carried out in these laboratories are interdisciplinary in nature, belonging to the overlapping realms of materials science, life sciences, energy research, solid state, and nanomaterials.



## Ties with Israeli Industry:

The interaction between the Faculty and industry may be divided into:

- Direct sponsored research of Faculty members by industry
- Sponsored research of joint projects between academic groups and industry by governmental institutions
- Start-up companies in which academic staff are involved
- Consultancy work provided to industry by some of our Faculty members
- Patent applications and commercialization
- Service provided to industry by our general service research laboratories

Some Faculty members have research directly sponsored by Israeli industries, such as Teva Pharmaceutical Company, and SCD Semiconductor Devices. In these cases, very focused applied research is carried out in collaboration with industrial programs, with financial support provided from the industrial side.

Some academic staff members are associated with large government-sponsored academic-industrial research through various programs, such as Magnet, Nofar, and Magneton. In these cases, several industrial partners and academic groups join a large project that has several research and development aspects. Industrial partners in these large projects include, for example, Intel, Tower, SCD, Rafael, Teva, ELOP, 3GSolar, and others.

Several academic staff members have founded start-up companies based on research and patents developed within the Technion. Several of these start-up companies were successful.

All our general service research laboratories (NMR, MS, XRD, and the Surface Analysis and Characterization Laboratory) provide service work for various industries (mostly chemical and pharmaceutical) and research laboratories within and outside the Technion. In these cases, the service is carried out at predefined rates. Finally, our glassblowing workshop and machine shop also do occasional work for external users at predefined rates.

## Technical Services:

The Faculty's technical services are organized in the machine, electronic, and glassblowing units. Our machine shop provides design, manufacturing, and technical support services for the Faculty's laboratories, for other Technion faculties, and for external clients.

Our highly skilled technicians possess extensive experience in manufacturing prototypes of experimental apparatus and separate precision parts according to special specifications, using diverse materials including plastics, stainless steel, aluminum, brass, and refractory metals. The machine shop also provides repair, maintenance, and modernization services for existing scientific instruments and experimental equipment in research laboratories. The scope of the shop's facilities allows the production of a wide range of components, from precision parts to large experimental apparatuses for many important applications, such as cryogenics, processes in high and ultra-high vacuum, optical and laser spectroscopy, chemical reactors, and systems and components for nanotechnology research and magnetic resonance.

***http://chemistry.technion.ac.il/faculty-units-and-services***

## General Research and Service Laboratories:

### Chemical and Surface Analysis Laboratory:

The Chemical and Surface Analysis Laboratory offers a wide range of characterization techniques, together with highly skilled expert personnel. This facility serves all Technion researchers, and other research institutes (universities and colleges), as well as industry.

The Laboratory's main equipment includes:
Horiba (LabRAM HR) micro-Raman system ➔ Veeco (Dimension 3100) Atomic Force Microscope (AFM) ➔ ESCAN (Vega-II) Scanning Electron Microscopy (SEM) ➔ Thermo Scientific CHNS Analyzer (Flash2000) ➔ Bruker (Tensor 27) Fourier Transform InfraRed (FTIR) ➔ Shimadzu (UV-1800) Spectrophotometer ➔ Jobin Yvon (Fluorolog-3) Fluorometer for monitoring fluorescence of samples at wavelengths of 280 to 900 nm, and temperatures from -170°C to 90°C ➔ CEM Cop. (Discover) microwave reactor

The Laboratory is managed by a PhD engineer in physical chemistry.

***http://nmrlab.technion.ac.il***


## Nuclear Magnetic Resonance Laboratory:

The goal of Technion's High-Resolution Magnetic Resonance Center (HR-MRC), housed in its natural place within the Schulich Faculty of Chemistry, is to provide service via its modern instrumentation to more than half-a-dozen Technion departments covering a wide scope of multi-disciplinary research interests. This first-rate facility provides access to modern NMR spectrometers, five Bruker Avance spectrometers with proton operating frequencies ranging between 200 to 600 MHz, including fully automated 400 MHz Bruker Avance-III spectrometer with a sample changer. The instrumentation available is capable of running most experiments of interest to the research chemist. The broad range of experiments including 1D and 2D NMR for multiple nuclei (1H ,2H, 13C, 15N, 19F, 31P, 29Si, 103Rh ...), high and low temperature measurements, kinetics, diffusion, etc. The Laboratory is managed by two full-time, professional, PhD-level spectroscopists. Graduate students and post-docs are trained and independently operate the spectrometers. Researchers have 24-hour open access to the MRC and can reserve instrument time via an on-line scheduling system, or opt for the fully-automated spectrometer with sample changer which delivers the results over the network. In addition, spectrometer time is allocated in favor of the hundreds of undergraduate students going through the Faculty of Chemistry teaching laboratories.

The Faculty of Chemistry is also the home of the research laboratory of Prof. Schmidt whose scientific activity centers on solid state NMR spectroscopy of materials and biomaterials. This lab operates three solid state NMR spectrometers [Bruker Avance-III 300 and 500 MHz and a Chemagnetics-Agilent 300 MHz] which are equipped with a variety of triple- and double-resonance MAS (magic angle spinning) probes, including high- and ultrahigh-speed capable of sample spinning up to 60 kHz exhausting state-of-the-art NMR capabilities. Through the support of a professional PhD spectroscopist this research lab allocates part of the time to assist Technion labs as well as out-of-Technion organizations.

## Positions Available:

***http://chemistry.technion.ac.il/vacant-positions***

## Mass Spectrometry Laboratory:

The Mass Spectrometry (MS) Laboratory provides method development and consultation services for elemental analysis for research faculty, staff members, and students at the Technion.

The laboratory has several state-of-the-art instruments:

- Waters Micromass LCT Premier (TOF) coupled to an HPLC.
  The instrument is an easy to use bench-top mass spectrometer that utilizes a high-resolution time-of-flight (ToF) analyzer to enable exact automated mass measurements. The ToF analyzer utilizes W-Optics, a novel method for enhancing resolution, which provides up to 10,000 FWMH resolution.

- Waters MALDI-TOF MS System, featuring the MALDI micro-mass spectrometer, offers automated sample processing and MALDI target spotting, allowing for unattended operation and increased throughput and reproducibility.

- Waters AutoSpec Premier™ is the latest development in magnetic sector technology. It incorporates the Waters unique EBE, double-focusing geometry with extra wide gap magnet of the proven Ultima NT system, providing an unmatched combination of high sensitivity, high resolution, and low background noise. The AutoSpec Premier forms a powerful platform for high-resolution selected ion recording applications, such as dioxin, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), or drugs of abuse analysis.

- Bruker-QTOF-II, enabling techniques of LC-MS, GC-MS, MS-MS, high-resolution MS with various modes of ionization.

## X-ray Crystallography Laboratory:

This laboratory has two X-ray machines, including a Nonius KappaCCD diffractometer. The services are provided by a PhD-level professional.

In addition, we post classified ads for open positions (industrial and academic) on our website.

# CIVIL AND ENVIRONMENTAL ENGINEERING

***http://cee.technion.ac.il/eng/index.asp***

## Dean's Office

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Dean
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deansecr@technion.ac.il

## Industrial Affiliates Program

Director
Tel. +972-4-829-2363

The Faculty of Civil and Environmental Engineering in its current structure was established in 2002 by the merger of two veteran academic units, the Faculty of Civil Engineering and the Faculty of Agricultural Engineering. The Faculty of Civil Engineering was the first academic unit of the Technion when it opened its doors in 1924. The Faculty of Agricultural Engineering was established in 1952 by Professor Walter Clay Lowdermilk. Both faculties were inspired by the vision of settling Israel and developing the science and technology required for its transformation into a modern country. At this time, the country had a pronounced need for the housing and infrastructure that would support its economic growth and quality of life, while preserving its natural resources.

The Faculty is committed to providing high-level engineering support for projects. As a result, a range of support units, such as service units and testing laboratories, were developed and accredited as national laboratories. These laboratories have since made impressive achievements, recognized in Israel and abroad, and support Israeli industries. Further, the Faculties of Civil and Agricultural Engineering have thrust Israel to the forefront in fields such as housing, water supply and management, and advanced agriculture and environmental issues.

The 2002 union, and the subsequent founding of the unified Faculty of Civil and Environmental Engineering, was accompanied by structural changes and modernization of educational programs.

Several research centers were established or upgraded, including the National Building Research Institute, the Transportation Research Institute, the Grand Water Research Institute, and the Agricultural Engineering Research Center, in which faculty members play a major role. Together with addressing industries and national needs, these centers have enhanced the opportunities and activities available to MSc and PhD students.

The faculty is composed of three autonomous divisions. This structure enables a reasonable balance between the need to specialize in the various disciplines of civil and environmental engineering, and maintaining a mechanism that can foster cooperation across divisions in research and teaching.

## Structural Engineering and Construction Management Division:

### Research Areas:

Structural Engineering ➲ Construction Management ➲ Building Materials and Technology ➲ Physical Performance ➲ Geotechnology

Many Faculty members of the Division conduct research within the framework of the National Building Research Institute (NBRI).

### National Building Research Institute (NBRI):

NBRI research and development activity is based mainly on sponsored research, and covers the four main domains mentioned above, and interactions between them.

Research areas include:
Structural earthquake resistance, impact and blast response of structures, penetration processes in structural and geotechnical systems, innovative methods for structural repair, structural behavior of repaired structures, building information modeling, lean construction, safety in the construction process, forming systems and equipment for construction, quality assurance and control, utilization of industrial by-products in building materials, durability of building materials, microstructure of cementitious materials, energy in buildings, heat and mass transfer in buildings, integrated performance of the building envelope, sustainability of the built environment,

***http://cee.technion.ac.il/eng/Templates/showpage.asp?DBID=1&LNGID=1&TMID=84&FID=302***

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earthquake engineering and seismic behavior of soils, and soil-structure interaction.

NBRI has a long-standing collaboration with industry, assisting Israeli manufacturers and builders in the investigation of innovations, and in studying basic issues related to their products or processes. It provides testing services when other laboratories are not equipped to do so, but does not engage in standard testing and certification.

NBRI facilities include a large testing hall with a massive and strong test floor and, in addition, the following specific main laboratories: Testing Hall and Structural Engineering Laboratory ➔ Impact Laboratory ➔ Building Materials Laboratory ➔ Thermal and Energy Laboratory ➔ Radiation Safety in Construction Laboratory ➔ Seskin Virtual Construction Laboratory

## Environmental, Water and Agricultural Engineering Division:

Research Areas:
Water resources ➔ Hydraulic engineering ➔ Environment ➔ Air quality ➔ Agriculture

Laboratories at the Agricultural Engineering Complex:
Agricultural Machinery Laboratory ➔ Agricultural Materials Laboratory ➔ Control and Automation Laboratory ➔ Sensing of Natural Materials Laboratory ➔ Soil Chemistry and Fertility Laboratory➔ Agro-biology, Soil Chemistry, and Soil Physics Laboratory ➔ Seidel Flow Measurement Laboratory ➔ Subsurface Hydrology and Hydrogeophysics Laboratory ➔ Irrigation Laboratory ➔ Environmental Fluid Mechanics Laboratory ➔ The Ecological Garden ➔ Technion PIV Laboratory at the IUI in Eilat

Environmental Laboratory Complex (Grand and Sherman Buildings):
The Environmental Science and Engineering Teaching and Research Laboratory Complex is a recent collaborative effort of the Faculty of Civil and Environmental Engineering and the Grand Water Research Institute.

Laboratories within this complex:
Environmental Chemistry Laboratory ➔ Environmental Biotechnology Laboratory ➔ Aquatic Chemistry Laboratory ➔ Molecular Microbiology Laboratory ➔ Analytical Water Chemistry Laboratory ➔ Environmental Microbiology Laboratory

***http://cee.technion.ac.il/eng/Templates/showpage.asp?DBID=1&LNGID=1&TMID=84&FID=220***

Faculty members conduct their research
in one of these research centers:

- Environmental and Water Resources Engineering Research Center
- National Center for Research in Coastal and Marine Engineering- CAMERI
- Research Center in Agricultural Engineering

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### Environmental and Water Resources Engineering Research Center:

Water is at the core of the human activity, and as such receives the highest attention in the division of water, environment, and agricultural engineering. Key activities are related to understanding and development of processes for treatment of drinking or irrigation waters from various natural and artificial sources, and the treatment of domestic and industrial effluents. This includes primarily chemical and biological processes related to treatment of water and wastewater.

The core business of this center is the study of the dynamics of water flow through natural and artificial conduits, and the engineering of efficient water delivery systems and marine structures, which are all related through the general field of fluid mechanics.

A variety of tools (analytical and computational) are used to study source apportionment identification transport, and deposition of atmospheric particles. Advanced electron microscopy techniques have been developed and applied to characterize individual atmospheric particles, using morphology and elemental composition of single particles.

Research Areas:
Water and Wastewater Processes • Water and Marine Systems • Environmental Microbiology • Water Resources Systems • Aquatic Chemistry • Air and Atmosphere • Computational Fluid Dynamics • Air-Sea Interaction • Enviromatics • Sustainable Water and Energy

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### CAMERI – Coastal and Marine Engineering Research Institute:

The main objectives of CAMERI are to provide applied research services, basic know-how and model testing of coastal and marine structures and facilities; and to advance knowledge and technological expertise in the various disciplines of marine engineering. CAMERI operates as a business company, which belongs to the Technion and to the Israel Ports Company. The Board of Directors of CAMERI includes representatives form the Technion and from the Israel Ports Company.

The staff of nine includes six research engineers, technicians, a secretary, and an accountant.

CAMERI performs basic and applied research projects in areas of coastal and marine engineering, such as: wave measurements and processing, near shore wave transformation, sand transport and beach morphology, harbor agitation and ship mooring studies, marine and coastal structures model testing, and towing tank model testing.
Some of the projects carried out during the last few years are physical and mathematical models for the development of Haifa (Carmel) and Ashdod (Hayovel) ports (Israel Ports Company), cooling water circulation mathematical modeling (Israel Electric Corporation), Sand transport and beach morphology numerical modeling for Artificial Islands study (Ministry of Infrastructures).

CAMERI measures waves offshore Haifa and Ashdod (directional measurements) continuously since 1992 and holds the major processed database of wave climate along the Israeli cost.

Laboratories:
Wave Basin 53x24x0.9m equipped with wave generators ➔ Towing tank ➔ Wave Flume 45x2.4x1.5m equipped with wave generator

The laboratories are equipped with computerized control for real sea simulation, ship models for mooring tests, wave gages, and high sampling rate pressure gages.

Agricultural Engineering Research Center:
Modern agriculture is no longer limited to the development of cultivation tools, but focuses on automation and control, advanced local and remote sensing, precision, post-harvest treatment of biological materials, machine-soil interaction, energy-efficient development, and other topics. The Agricultural Engineering group deals with various topics related to mechanics and sensing in classical agricultural engineering, and all fields of environmental engineering and water systems.

Research Areas:
Automatic Control in Environmental, Water, and Agricultural Engineering ➔ Monitoring of Agro-Biological Systems ➔ Post-Harvest and Biomaterial Properties ➔ Machine-Soil Interaction ➔ Off-road Mobility ➔ Field Machinery ➔ Robotics in Agriculture and Civil Engineering

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## Transportation and Geo-Information Division:

### Research Areas:

Road Safety ➲ Road and Pavement Engineering ➲ Transportation, Land Use Planning and Transportation Economics ➲ Traffic Engineering and Control ➲ Surveying and Geodesy ➲ Cartography and Mapping ➲ Photogrammetry and Remote Sensing

### Laboratories:

Intelligent Transportation Systems (ITS) laboratory:
The immense advancements in surveillance and communication technologies in recent years increasingly make ITS applications, which rely on these technologies, essential and central tools to improve road safety, environmental impacts, management of transportation systems operations, and efficient use of infrastructure.

The ITS research laboratory focuses on the development, testing and evaluation of various innovative technologies in these application areas. The laboratory includes three main components that supplement each other in the types of data that can be acquired and the research to be supported by it: (i) A driving simulator that can collect detailed information on the vehicle control and driving behavior of individuals in a wide range of scenarios and conditions and simulate the performance and efficiency of ITS technologies. (ii) Dynamic spatial sensing equipment that collects data on the higher-level travel behavior decisions and spatial distributions of activities of individuals. (iii) Advanced traffic management test bed that receives data from the real-world surveillance system the same way these inputs are received at the actual traffic management center (TMC). The information that arrives in a TMC commonly covers an entire metropolitan area, and so this testbed is useful for development and testing of ITS applications at the system level.

Road and Soil Laboratory:
The laboratory is used for research and teaching in the fields of rigid and flexible pavements, and testing pavements materials and structures. The lab is equipped with several instruments for conducting materials characterization tests. In addition, a hydraulic instrument was installed in the lab for advanced tension, pressure, and period loading tests. Several specialized software systems, which are used by students in advanced courses, are available in the computer laboratory.

Geographic Information Systems Laboratory:
Geographical Information Systems, also known nowadays as Geographical Information Sciences (GIS), is a computer-based information technology that acquires stores, analyzes, and retrieves geographic or spatial information. The goal is achieving accurate and up-to-date data that describes the real world. GIS has been successfully used for many years in a wide number of professional contexts, in planning, infrastructure, environment, transport, communications, land-ownership, cartography, location-based services and route optimization.

Many computer geospatial databases that can be directly entered into a GIS are being produced by governmental agencies as well as by private companies and nonprofit organizations. One of the main issues in GIS is how to collect the geospatial information from the different sources (field surveying, aerial or satellite imagery, aerial or terrestrial laser scanning, existing maps and digital files, and more) and fuse them into a unified, accurate, and updated database.

GIS has traditionally dealt with data in the two-dimensional plane, but in recent years there have been significant developments in the direction of three-dimensional data handling, representation, and analysis.
By combining layers of spatially referenced data within Geographic Information Systems with aerial or satellite images obtained via remote sensing, computer mapping technology has become a powerful decision-making tool. From military planning to natural resource management to civil engineering projects, geospatial technologies have changed the face of mapping and broadened job prospects across public and private sectors. The Faculty of Civil and Environmental Engineering have trained most GIS experts in Israel.

Photogrammetry Laboratory:
Photogrammetry is a measurement technology in which the three-dimensional coordinates of points on an object are determined by measurements made in two or more photographic images taken from different positions. The technique is used in different fields, such as topographic mapping, architecture, engineering, police investigation, geology and by archaeologists to quickly produce plans of large or complex sites. For many years photogrammetric research has focused primarily on exact mathematical modeling of the geometry of imaging systems. With recent development in digital imaging – terrestrial (consumer cameras), aerial (costumed high performance imaging

systems), and spaceborne – photogrammetry is witnessing a resurgence. Nowadays, exact modeling of the new imaging systems is only one aspect in the broad spectrum of domains photogrammetry studies. Recent activities focus on the automation of mapping processes, particularly of autonomous interpretation of images for the extraction of three-dimensional geospatial information such as building outlines, road networks.

Laser Scanning Laboratory:
The emergence of new mapping and geo-information technologies is expanding teaching and research possibilities. One of the newest technologies is laser altimetry, known as Light Detection and Ranging (LiDAR) technology. LiDAR works by transmitting laser signals using all light ranges (ultraviolet, visible, infrared) out to a target. The transmitted light interacts with and is changed by the target. Some of this light is reflected / scattered back to the instrument where it is analyzed. The change in the properties of the light enables some property of the target to be determined. Commercially such systems can be aerial or terrestrial, and it is clear that this is the technology of the future. Providing direct 3-D information has versatile uses; a few examples include city modeling on a large scale, biomass estimation, or terrain analysis.

Remote Sensing Laboratory:
Remote sensing is the technique of acquiring information about an object without actually being in contact with it. This is usually done by sensing and recording electromagnetic radiation and processing, analyzing, and applying that information. Remote sensing is used in resource management, agriculture, mineral exploration, and environmental monitoring. Satellite and airborne sensing systems have rapidly progressed to mapping infrastructures and built-up areas as well as monitoring physical, biological, and chemical properties, but these advances need considerable scientific and technical knowledge.

Hyperspectral imaging, also known as imaging spectroscopy, is a key element in remote sensing. It is a type of multispectral imaging that records many tens of bands of imagery at very narrow bandwidths. Spectrometers can "see" ranges of wavelengths greater than the human eye. Depending on the target of interest, sensors can be optimized to detect specific areas of the electromagnetic spectrum, such as the shorter ultraviolet wavelengths or the longer infrared wavelengths.

The main advantage of hyperspectral is the ability to measure many, contiguous bands of wavelengths simultaneously, which provides a broader base from which to analyze a scene.

Research and instruction in Remote Sensing incorporate three integrated directions: expanding our knowledge regarding spectral signatures of wide variety of surface/environment materials and types; developing algorithmic methods for objects recognition belonging to Artificial Intelligence including Knowledge Based Systems; studying the relationships between remote sensing indicators and the surface conditions.

Survey Engineering Laboratory:
The Surveying Engineering Laboratory houses surveying equipment that is used for both basic and advanced training for students and academic staff research. The current lab is equipped with many types of surveying instruments: geodetic GPS receivers, total-stations, precise and conventional theodolites and levels, gyro-theodolite, rotating laser level, straight-line laser pointer, optical tooling kit, and tape surveying instrumentation and communication equipment. The equipment is mostly used in the open field around the campus; only calibrations and limited work are being done indoors.

The Surveying Engineering Laboratory is unique in type, quantity, and variety of instrumentation among academic institutions in Israel and the only lab of its type being used for high level academic research, much of which is later applied by government organizations and public companies.

## Undergraduate Office

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Undergraduate Office:
For the last ten years the Undergraduate Office has conducted a special one-day "Fair Employment" event. About 50 to 60 companies participate in this event every year. The Fair Employment day creates opportunities for meetings between infrastructure companies and students.

The Undergraduate Office keeps an open channel with industry, and advertises a Jobs List for students on the Faculty website and special board.

All undergraduate students take the "Introduction to Civil and Environmental Engineering" course in their first year. In this course, key persons from the infrastructure industry present their experience, and there are field trips to several companies, exposing our students to the profession in the real world.



# COMPUTER SCIENCE

***http://www.cs.technion.ac.il***

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The Faculty of Computer Science is the second largest academic unit in the Technion. It comprises about 50 Faculty members of international repute with expertise in a wide variety of fields. It is the largest department of computer science in Israel, and supplies the Israeli hi-tech industry with the highest caliber manpower. The Faculty engages in a wide range of research and teaching activities, and constitutes a unique meeting point between science and technology.

## Research Areas:

### Theory of Computer Science:

Automata and Formal Languages ➲ Coding ➲ Complexity ➲ Computational Geometry ➲ Cryptology ➲ Distributed Computing ➲ Logic and Semantics ➲ Theory of Algorithms

### Systems:

Databases and Data Mining ➲ Distributed and Parallel Systems ➲ Hardware ➲ Networks, Communication and Systems ➲ Programming Languages ➲ Software and Hardware Verification ➲ Software Engineering

***http://www.cs.technion.ac.il/iap***

***http://www.cs.technion.ac.il/iap/list.html***

## Artificial Intelligence:

Learning ➔ Reasoning

## Intelligent Systems and Scientific Computation:

Geometric Modeling ➔ Graphics ➔ Image Processing and Computer Vision ➔ Robotics and Complex Systems ➔ Scientific Computation and Numerical Analysis

## Technion Computer Science Industrial Affiliates Program – IAP:

The primary objective of the Technion Computer Science Industrial Affiliates Program (IAP), established in 2001, is to provide a platform for structured interaction between the Computer Science Department and the hi-tech industry in Israel and worldwide.

The program provides a solid bridge between academia and industry, from which both sides benefit significantly. On one hand, it has enabled the Technion community to become more attuned to industry needs, and exposed Faculty and students to a wide spectrum of companies and their R&D activities. On the other hand, it has given the IAP member companies a platform through which they can gain access to Faculty and students, and influence computer research, development, and education.

Some 30 companies of all sizes are now members of this club
*see list of IAP members:*

## IAP Program Benefits:

The IAP program offers many benefits to its members in return for a modest annual membership fee. The most important advantage is the opportunity to influence computing research and education.

## Research and Development:

- Attend the faculty's annual Research Day.
- Participate in the Industrial Project course.
- Carry out joint software projects with the Faculty laboratories.
- Match partners for joint research proposals to the Chief Scientist and the European Union.
- Interact professionally with Faculty researchers.
- Participate in the Industry Advisory Board.

## Human Resources:

- Hold company recruitment events and technological exhibitions in the Faculty's lobby.
- Advertise job openings by email to interested students; Advertise job openings on the IAP website, and on the electronic board in the Faculty lobby.
- Employ graduate students for summer internships.

## Teaching:

- Attend faculty seminars, conferences and symposia (as auditors and as lecturers, if suitable).
- Offer mini-courses focusing on soft skills or technological topics.
- Offer guest lectures in academic courses.
- Send company employees to attend academic courses as free auditors.
- Access Faculty library.

## Public Relations:

- Increase company visibility within the Faculty - company logo on the Industrial Affiliates web page and on a plaque in the Faculty lobby.
- Distribute announcements on company events (recruiting days, mini-seminars, etc.) to students.
- Advertise in Homepage – the Faculty's semi-annual magazine.

## Involvement of Industry in Academic Courses:

IAP companies are encouraged to take an active role in the Faculty's academic courses, by teaching, designing, or creating such courses.

## Such involvement may take one of three forms:

- An expert from industry teaching a course or part of it, in order to bring a unique specialty that our Faculty lacks.

- Projects guided by representatives from industry, either with one of the Faculty's laboratories, or directly through the Industrial Project course. The latter is a regular course given twice a year, with nearly 15 projects each semester. The projects are proposed and guided by interested companies.

- In addition, a specialist from industry may teach a mandatory or elective course in his/her area of expertise.

In all cases, there is academic supervision of these courses, to ensure their academic quality, and a proper grading procedure.

### Extra-curricular Support for Students:

The Industrial Affiliates Program sees it as one of its tasks to provide counseling and assistance services to students and graduates, with emphasis on extra-curricular courses on soft skills, and more directly, obtaining information on job opportunities.

### Teaching and Research Laboratories:

There are 12 teaching and research laboratories in the Faculty, many working closely with industry, carrying out projects and research led by Faculty members, engineers, graduate students, and undergraduate students.

***http://www.cs.technion.ac.il/research-labs***

More information about channels for collaboration is available in the laboratory's website.


# EDUCATION IN SCIENCE AND TECHNOLOGY

***http://edu.technion.ac.il/?lang=en***

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The Faculty of Education in Science and Technology contributes to the Israeli educational system by preparing prospective science and technology teachers for high schools and colleges, and by encouraging its graduate students to contribute to Israel's formal and informal education, higher education, the hi-tech industry, and the public sector.

The Faculty's teaching and R&D activities are varied, and focus on science and engineering education, the learning sciences, educational technologies, neuro-education, science communication, and pre- and in-service teacher education in a variety of subjects: biology, chemistry, computer science, electrical and mechanical engineering, environmental sciences, mathematics, and physics. These topics are offered as part of the BSc, MSc, and PhD programs. The Technion is the only university in Israel offering undergraduate programs in technology or engineering education.

## In addition to these programs, we offer the Views (MABATIM) program:

### Views I:

Views I program, for Technion graduates from other units who return to the Faculty of Education in Science and Technology for four semesters to become high school teachers.

### Views II:

Views II program, with admission requirements that are higher than those for Views I, lasts six semesters, and has three streams within the program:

- Master's degree and teaching diploma without thesis;
- Master's degree and teaching diploma including a final project; and
- Master's degree and teaching diploma including a thesis.

## Research and Development:

Biology Education • Chemistry Education • Computer Science • Education • Electrical Engineering • Environmental Sciences Education • Mathematics Education • Mechanical Engineering • Neuro-education • Physics Education • Formal and Informal Education • Learning Technologies • Project Assessment • Science Communication

## Affiliation Programs:

Our vision is to be a leader in science, technology, engineering, and mathematics (STEM) education research and practice in many contexts, including schooling, higher education and the hi-tech industry, providing learners with a stimulating environment for intellectual and creative activities. Our strategic plan aims at strengthening connections and collaborative activities in the education system, industry, and the Technion.

## STEM education as a core resource for all:

The Faculty contributes to the Israeli educational system, not only by preparing prospective high school STEM teachers, but also by encouraging its graduates to take leadership roles in the educational system and contribute to Israel's higher education, the hi-tech industry, and the Third Sector.


The Faculty recognizes the importance of teaching skills and learning processes in these sectors, and believes that all Technion students should acquire the skills and ability to communicate effectively.

**To these ends:**

The Faculty launched the Views program five years ago, with the objective of offering Technion graduates a unique opportunity to obtain a second BSc degree or MSc in Science and Technology Education that fulfills the requirements for a teaching certificate in their subject area. Study scholarships are available for four semesters (for Views I) to six semesters (for Views II), and Technion graduates who join the program are not required to commit themselves to teaching in the education system. As of November 2016, more than 100 graduates of the Views programs are teaching in middle and high schools in Israel. Many combine their studies with work in industry and teaching in high schools.

**Research and Development:**

Our collaboration with government, NGO organizations, and industry includes:

- Professional interaction with Faculty researchers
- Projects with research centers and laboratories for the benefit of both partners, to advance mutual interests
- Research proposals submitted to different funding resources and funded (e.g., ISF, the EU, Trump Foundation, Ministry of Education)
- Organization of international research conferences on topics that bridge STEM education and technological development

In addition:

- Faculty members from the Faculty give lectures in industry.
- Projects in educational technology, developed by students and Faculty, are presented at the national and international exhibitions, and participate successfully in international science or design competitions.
- Leading role holders from industry and Ministry of Education visit the Faculty and share their experience.


# ELECTRICAL ENGINEERING

***http://webee.technion.ac.il***

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The Faculty of Electrical Engineering is ranked in the top tier of electrical engineering and computer science departments in the World. The Faculty is the major source of engineers leading the development of advanced Israeli technology in the fields of electronics, computers, and communications. It is the largest academic unit in the Technion, with over 2,000 students. An international evaluation committee, chaired by the current President of MIT, concluded that "the graduates of this Department, whether with a B.Sc., M.Sc., or Ph.D., are as well prepared (if not better prepared) as EE graduates of any top ranked institution anywhere in the world".

The Faculty acts as a center of excellence in applied and theoretical research, contributing to the advancement of knowledge in electrical and computer engineering in Israel and throughout the World. The Faculty's activities constitute an important component of the technological and scientific infrastructure of the State of Israel. Additionally, the department has extensive, multi-faceted relations with industry.

***http://webee.technion.ac.il/Research/Labs-and-Centers***

***http://webee.technion.ac.il/Industrial-Relations/Mission-and-Activities***

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## Research Areas:

Computer architecture ➲ Parallel and distributed computing and systems ➲ Computer communication networks ➲ Electronic systems and devices ➲ Computer-aided design ➲ Very large scale integration (VLSI) ➲ Signal processing ➲ Image processing ➲ Computer vision ➲ Communication and information theory ➲ Automatic control ➲ Wave propagation and electromagnetic engineering ➲ Nano- and micro-electronic devices ➲ Solid-state electronics ➲ Electro-optics and opto-electronic systems ➲ Biological signals and systems ➲ Machine learning

## Laboratories and Centers at the faculty of Electrical Engineering:

The experimental and applied research activities are supported by advanced laboratories, some of which are also used for our highly acclaimed student project activity. There are 8 centers and over 20 laboratories.

### Irwin and Joan Jacobs Center for Communication and Information Technologies (CCIT):

Overview:

The Faculty of Electrical Engineering at the Technion has extensive relationships with dozens of companies, mostly through its research and teaching activities, but also directly. Its Industrial Liaison Program (ILP) includes some 30 member companies, from multi-nationals to startups. They are invited to attend special symposia and short courses, hold recruiting days, meet with faculty and students, and explore other avenues of contact. They are also invited to participate in the Industrial Advisory Board of the faculty, which convenes semiannually in order to receive updates and, more importantly, offer advice. This is also the venue for discussing high-level issues such as the professional longevity of engineers. The ILP is administered by the Center for Communication and Information Technologies (CCIT).

The Electrical Engineering Faculty's relationship with industry is very diverse, both in the area of activity and in the nature of the relationship, reflecting the interests and needs of both sides.

To this end, we have identified several needs and potential benefits for all involved, which guide us in exploring opportunities and setting up mechanisms.

These include:

The Faculty's objectives and needs:

- Obtaining support (funding, equipment, etc.)
- Obtaining access to information, platforms, and special equipment available in industry
- Awareness of needs and interesting problems
- Collaboration in complementary-capability situations (feedback and advice, teaching, project supervision and graduate-student supervision)
- Help in developing advanced technologies
- Visibility for our graduate students and, through that, convincing our best students to pursue advanced degree studies
- Visibility for our research, both in order to advance recognition of the Faculty in Israel and abroad, and to increase the impact of our research results, including commercialization of Technion IP.
- Receiving feedback and guidance from the field pertaining to both our curriculum and research directions

Industry's objectives:

- Quick access to expertise and knowledge (depth)
- Better solutions for specific problems
- Guarding the flanks (trying alternatives; becoming aware of dead ends)
- Guidance and feedback
- Using Technion IP in products in order to obtain a competitive advantage
- Company personnel: recruiting, retaining, developing (keeping current, adapting, etc.). Increasing professional life expectancy ("early burnout" stands to become a critical national socio-economic problem)
- Influencing our curriculum so as to better prepare our graduates for the industry's needs, and especially to ensure coverage of emerging fields

Following are some modes of collaboration with industry, with representative examples.

Teaching:

- A select group of instructors from industry teach courses. In some cases this assists in reducing class sizes by holding parallel sessions; in others, these are specialized graduate courses in the instructor's area of expertise, which enrich our curriculum.

- Undergraduate student projects are the strongest and most highly acclaimed elements in our curriculum, but are also quantitatively the most challenging teaching undertaking (more than 300 projects per year!). Here, the contribution of industry comes in various forms: equipment donation, financial sponsorship of projects, and project supervisors. Many of the supervisors have carried out projects as students in the same laboratories, and having them as supervisors is a true joy for all involved. Numerous companies are involved in the various modalities, ranging from large multi-nationals, through established Israeli companies, all the way to start-ups. One recent prominent example is a project in whichstudents in the Communications Laboratory developed a sophisticated antenna that is dramatically smaller than the prior art. This project won the student project competition, and is being commercialized.

**Participation in Government-Sponsored R&D Consortia ("Magnet"):**

These consortia are funded in large part by the Office of the Chief Scientist of the Ministry of Economy, and are aimed at promoting collaboration between Israeli companies and universities at the generic research and development stage in new, promising fields in which relevant expertise exists in Israel and there is a major export growth opportunity. This program, which started in 1990, fosters collaboration, with both research and product benefits. It also brings people together, giving faculty members and graduate students an opportunity to get to know the relevant industry, and vice versa.

Recent examples include:

- Tera Santa: developing the required components and system architecture for a Terabit (one million megabits) per second optical communication link with the ability to add and drop 10 Gbit/sec sub-channels. Five Technion Electrical Engineering Faculty members and their graduate students, and three of its laboratories are involved, covering optical devices, optical communication algorithms, and high-speed signal processing architectures.
- CORNET: cognitive radio networks
- RESCUE: disaster handling technologies

**Direct Funding of Research:**
This entails funding the research of individual faculty members by specific companies, often with some IP arrangements. Two recent examples are in the areas of machine learning and compressed sensing.

Establishment of Research Centers:
The most prominent recent example is the funding by Intel of the ICRI-CI, Intel Collaborative Research Institutes – Computational Intelligence. This center, based at the Technion and at the Hebrew University, brings together computer architecture and machine learning (two very active areas of research in the Faculty of Electrical Engineering) in order to address the issue of "intelligent computing": using machine learning to help optimize computer systems in general, as well as developing computer architectures that are well matched to the computing needs of machine-learning applications. This center is unique in that it brings together different fields within the Faculty of Electrical Engineering, and also funds Intel personnel who work in it.

The Technion Computer Engineering Center (TCE) established jointly by the Electrical Engineering and Computer Studies faculties, offers yet another platform for industry-Technion collaboration by permitting industry personnel to spend time at the Technion on joint research.

Multi-prong Championed Relationships:
This refers to a situation wherein a specific person in a company explores opportunities and establishes relationships with our Department. One such effort has, over the past two years, involved student project funding, consulting by faculty members, and Summer Internships for our students, as well as research collaboration that very recently resulted in a best paper award.

Commercialization of Technology Developed or Seeded in the Faculty:
This takes place in various fields, and is rather challenging, as it is important to find the appropriate mechanisms that fairly reward all those involved, yet are also well matched to the proper structure of a company in the relevant area.

Providing Services to Industry:
In the micro- and nano-technology fields, we often require the help of industry, for example, fabrication facilities. However, the reverse

is sometimes true, especially when it comes to test equipment, microscopes and the like. Here, companies (often small ones) pay a fee and use our advanced equipment. Such equipment thus becomes a national resource of sorts, with priority given to use for Technion research. This helps us fund the equipment and the personnel who operate it, while assisting industry.

### Consulting and Individual Involvement of Faculty Members with Industry:

Many faculty members are personally involved with companies, mostly Israeli, through consulting and otherwise. This, even when carried out individually and not on behalf of the Technion, serves both to help Israeli industry and to open and maintain channels and a network that helps Technion-industry relations. Areas include optical components, chips for satellites, communications, signal processing, and computer engineering.

Some of the aforementioned activities can be viewed as 'bottom-up', namely a collection of individual 'sporadic' undertakings. These are complemented by 'top-down' activities, mostly through the ILP, which are aimed at facilitation of the individual engagement by reactive as well as proactive undertakings. The reactive undertakings include helping faculty members find industrial partners, and helping interested companies identify the relevant faculty members. Also, advice is offered regarding modes of collaboration based on cumulative experience. The proactive undertakings are aimed at planting seeds that will hopefully benefit us in the future, and maintaining continuity of contacts with companies.

In summary, the Faculty of Electrical Engineering has extensive and extremely diverse relationships with industry, corresponding to the diverse set of needs and opportunities, in line with the Technion's charter.

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## The Micro Nano Fabrication and Printing Unit (MNF&PU) at the Sara and Moshe Zisapel Nanoelectronics Center and the Wolfson Microelectronics Center:

The MNF&PU is a national infrastructure for micro and nano device engineering. It consists of a highly experienced team of 12 technicians and engineers running an R&D FAB that spreads across 700m$^2$ of clean rooms space (Class 100). The unit hosts a wide range of tools associated with fabrication at micro and nano scale, and printing technologies, thus allowing a full process flow to be designed and implemented. The MNF&PU offers high development flexibility and enables fabrication of various high-quality devices (electrical, optical, mechanical) based on a variety of materials. Hands-on courses and trainings are available for undergraduate, master, Ph.D. students and engineers that fuel the high-tech industry and eventually lead the advanced Israeli technology.

Technion president Prof. Peretz-Lavie (right) visiting the MNF&PU with the center head Prof. Nir Tessler (middle) and the chief engineer Yacov Shneider (left)

### Modes of collaboration with the MNF&PU:

- Our team can perform fabrication processes according to your specifications.
- You or your engineers can be trained to use the facility and register as a user. As a registered user you have access to a web-based booking system that operates on a first come, first served basis.
- You can ask us to perform a prototype development and then to produce at small volume.
- Based on our positive experience, we welcome mutual partially subsidized development projects (Magnet, Magneton, Meymad).

- If you need a unique tool that requires a dedicated clean room environment, you can rent space in our facility, and we will help you to connect your tool to the supporting infrastructure.

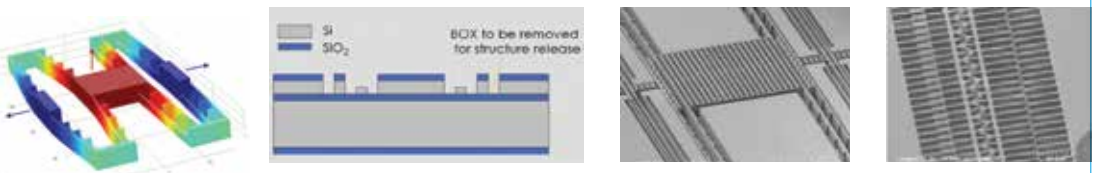
## Collaborations with Industry:

## The MNF&PU provides support in the following eight areas:

### Process Integration and Device Prototyping:

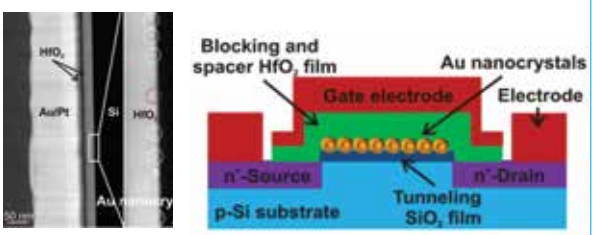
Once a need (feature of structure) is defined, our team will perform (or assist in) solution design, full process integration, prototype, and small scale production. Examples:

- MEMS devices: Selective stiffening for producing a mass-fabrication compatible mechanism that converts in-plane to out-of-plane motions




I. (Hotzen) Grinber et al., J. Microelectromech. Syst., vol. 24, no. 6, pp. 2101-2108, 2015

- NVM transistors based on High-K dielectrics and Au/Pt nanodots: A non-volatile low-voltage memory transistor based on $SiO_2$ tunneling, blocking and Au nano-particle charge storage layers




V. Mikhelashvili et al., Appl. Phys. Lett., vol. 98, p. 212902, 2011

Micro-patterning (photolithography):

- Stepper Lithography: I-line; Sub-micron resolution; Gray scale lithography
- Laser writer: Direct maskless lithography; Mask fabrication (includes automatic development and chrome etching); Sub-micron resolution
- Mask aligners: Resolution up to 1 micron; Backside alignment; For small pieces and wafers up to 6"
- Photo resist types: 4562, 4533, 1512, 1529, LOR (lift-off resist) 5214, negative 2070, dry-film resists (with laminator), SU-8 (accomplished with flood exposure tool)
- Coaters: Manual coaters, high uniformity automatic spin coaters with gyrset
- Miscellaneous: HMDS vapor prime, automatic developer and hot plates, wet benches with developers, resist strip solutions, lift-off, plasma ashers for descum, $NH_3$ oven for image reversibility

Nano-patterning (e-beam lithography):

- E-Beam writer EBPG 5200: State-of-the-art tool that has the capabilities to write features size down to 8nm and over areas of up to 6" in reasonable time scale

Pattern Transfer (etching):

- Reactive Ion Etching (Fluorine Chemistry): Si, $SiO_2$, $Si_3N_4$, TiN, Ti, W, Mo, Nb, Au, Pt, $TiO_2$, $HfO_2$, Polymers, Diamond, SiC
- Deep Reactive Ion Etching (Fluorine Chemistry): Si. Basis in fabrication of MEMS devices, Si templates for PDMS soft lithography, microfluidic devices, various patterned Si structures for biological research
- Inductively Coupled Plasma (Chlorine Chemistry): III-V alloys
- Wet benches: RCA clean, Buffered oxide etch, Isotropic Silicon etch, Aluminium etch, $Si_3N_4$ etch, Anisotropic Silicon etch (KOH), Chromium etch

Material Deposition and Annealing:

- E-Beam Evaporators: Al, Al / Si / Cu, Ti, Ti/W, Si, Cr, Ni, NiCr, Pt, Au, Ta, Hf, TiW, Ge, Co, Fe, $SrF_2$
- Thermal Evaporators: Ag, Au, Pd, Cu, Ge, Al, Cr, Sn, In
- Plasma Assisted Atomic Layer Deposition: $Al_2O_3$, $HfO_2$, $TiO_2$, AlN, TiN, metals (like Pt, W)
- Plasma Enhanced Chemical Vapor Deposition: $SiO_2$, $Si_3N_4$, low stress $Si_3N_4$, $SiO_xN_y$
- High Temperature Furnaces: Oxidation, Annealing, Phosphorous diffusion

Deposition tools

- Molecular Vapor Deposition: Teflon (anti-sticking coating for PDMS soft lithography), $Al_2O_3$, ZnO
- Sputter deposition: $Al_2O_3$, $Cu_2O$, $Fe_2O_3$, $Ga_2O_3$, $In_2O_3$, ITO, $Nb_2O_5$, $SiO_2$, $SnO_2$, $Ta_2O_5$, $TiO_2$, ZnO, $HfO_2$, $ZrO_2$, $InGaZnO_4$, $CuInO_2$, AZO, Al, Cr, Au, Cu, Fe, Sn, W, Pd, Nb, Co, Ta, Hf, Ti, Pt, Ag, Mo, BN, TaN, TiN, AlN, Si (undoped), Ge, $NiSi_2$, $W_5Si_3$
- Low Pressure Chemical Vapor Deposition: $SiO_2$, $Si_3N_4$, poly-Silicon
- Rapid Thermal Annealing: $N_2$, $O_2$, Forming gas, Up to 1200°C

Printed silver mesh on curved surface

Printing:

- Pad Printer: Offset printing (as gravure); Direct patterning on curved surfaces; Silver conductive inks, photo-resists, polyimide; The printer has been modified to achieve 10 micron resolution

Inspection and Characterization:

- Optical Microscopy: Inspection, CDs measurements, step depth measurements
- Surface Profilometry: Step height, surface roughness, surface waviness
- Electrical Probing: C-V plotter, I-V station, Four Point Probe
- Film Thickness Measurement: Elipsometers, Nanospec
- High Resolution Scanning Electron Microscopy
- Atomic Force Microscopy: Surface topology, surface electrical and mechanical properties
- Wetting properties: Drop shape analysis

Packaging:

- Dicer: Silicon, sapphire, ceramics
- Bonder: Au wires

New state of the art tools have been recently purchased (2015-2016) to face growing demands and technological challenges:

E-BEAM Lithography: RAITH, Model EBPG 5200

- High performance nanolithography system
- Minimum feature size of less than 8 nm
- Thermal field emission gun for operation at 20, 50 and 100 kV
- Rapid exposure with up to 50 MHz pattern generator
- Wafers up to 8" and masks up to 6"

E-BEAM Evaporator: EVATEC, Model BAK501A

- Precise thin metal films and multilayer deposition
- E-gun evaporation of metal source

- Special holders for coating of 3D objects
- Wafers up to 6"

Laser Lithography System: Heidelberg Instruments, Model DWL 66+

- High precision maskless photolithography
- Applicable for direct writing and mask production
- High accuracy overlay and Mix&Match with other lithography tools is possible
- Minimum feature size: 0.6 microns
- Substrates up to 8"x 8"

PE-CVD: Plasma-Therm, Model Vision 410

- High quality films with isothermally heated wall technology
- Deposition of $SiO_2$, $Si_3N_4$, $SiO_xN$, low-stress $Si_3N_4$
- Temperatures 80-350°C
- Wafers up to 16"

Atomic Layer Deposition: Ultratech/Cambridge Nanotech, Model Fiji G2

- Plasma assisted atomic layer deposition of ultrathin dielectric layers
- Substrate temperatures up to 500°C
- Deposition of oxides and nitrides: $Al_2O_3$, $HfO_2$, $TiO_2$, AlN, TiN, and metals (like Pt, W)
- Wafers up to 8"

Atomic Force Microscope: Asylum Research/Oxford Instruments, Model MFP-3D Infinity

- Variety of modes: Tapping, Contact, AM-FM Viscoelastic Mapping, Fast Force Mapping, ORCA Conductive AFM, Tunneling Microscopy, Electrochemistry, Microwave Impedance Microscopy
- Environmental Controller -30° to 120°C
- Closed Fluid Cell. Up to 80mm sample size

Dicer: Disco, Model DAD3350

- Automatic dicing saw
- Hard and brittle materials such as silicon and ceramics can be processed
- Wafers up to 6"

Pad Printer: Teca-Print, Model TPX301

- High quality, multi-color printing
- Patterning of curved surfaces
- Multiple printing to desired paint thickness

# INDUSTRIAL ENGINEERING AND MANAGEMENT

***http://ie.technion.ac.il***

The concept of Industrial Engineering and Management was first conceived by the founding fathers of our Faculty in the mid-1950s. The founders, a mixed group of industrial engineers and operations researchers, identified a need to educate engineers who would have basic management education in addition to engineering skills and knowhow. This new breed of engineers became a great success story in Israel, and similar programs were later opened in other universities and colleges. The demand for IE&M graduates is constantly on the rise, and their impact is felt across all economic and industrial sectors.

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Like all other engineering disciplines, IE&M is a dynamic entity. New areas of interest frequently appear, while mature areas that were exhaustively investigated gradually give way. Thus, there is no longer a need to only compress management education into the undergraduate degree. In IE&M we aim to provide our students with the tools necessary in order to face the challenges that are posed by the ever-increasing presence of large and complex systems in every aspect of today's reality and the vast amounts of data that are readily becoming available in the modern digital era. This means augmenting IE&M with industrial and systems engineering (I&SE) and recently also Data Science and Engineering (DS&E). Indeed, the IE&M faculty continues our tradition of leading the academic community in Israel and beyond towards the challenges that await us as we start to implement the necessary changes in our research and teaching focus.

## Research Areas:

Data Science and Engineering ➲ Information Systems Engineering ➲ Industrial Engineering ➲ Entrepreneurship ➲ Innovation ➲ Behavioral Sciences and Management ➲ Economics and Finance Reliability and Quality Assurance ➲ Operations Research ➲ Probability and Statistics

## Industrial Engineering and Management Affiliates Program (IE&M AP):

The Industrial Engineering and Management Affiliates Program (IE&M AP) is dedicated to the creation of mutual cooperation between academia and leading industrial companies in Israel and worldwide. We believe that by establishing strong long-term relations between academia and industry, we can promote mutually important values focusing on knowledge, development, innovation, leadership, and excellence. The Program (IE&M AP) was established in 2010. The IE&M AP stimulates and supports the mutual needs of business, industry and academia in applied research and development, teaching, human resources, public relations, and advertising.
Below we demonstrate the vast scope of activities in the IE&M faculty, emphasizing our activities in the field of data science, Innovation and Entrepreneurship.

## Research and Development:

- Professionally interaction with Faculty researchers
- Students Project Course: subject proposals and mentors given by companies for 4th-year students and MBA
- Faculty Newsletter issue: dedicated to company research and development program
- Faculty Newsletter distribution: for company employees
- Joint projects: with research centers and laboratories
- Identification of partners for joint research proposals: to the Chief Scientist and European Community

## Teaching:

- Workshops, seminars and guest lecturers: presented within the faculty by representatives of suitable companies
- Mini-courses, seminars, summer courses and Professional Graduate Programs: presented within the faculty by Faculty researchers to company employees
- Free Auditor: option for company employees to choose specified Faculty courses
- Industrial Advisory Board: held once a year to discuss teaching programs, research, laboratories and Faculty equipment
- Library Services: limited
- Guided Tours: opportunity for students to have a guided tour at company facilities

## Human Resources:

- Recruiting day: opportunity to hold an exclusive student recruiting day
- Classified ad distribution by direct mailing, monthly Faculty newsletter, Faculty website, and bulletin boards and plasmas
- Announcements via professional conferences, seminars, awards, scholarships, and recruiting days
- Student employment during summer projects and hosting summer interns

## Public Relations and Advertising:

- Increasing company visibility: Company name and logo presentation at the Faculty Academia Industry Affiliates Program web page linked to the official Faculty website
- Sponsorship opportunity for alumni conferences, seminars, competitions, projects, etc.

- Sponsorship advertising announcement in the monthly Faculty newsletter, distributed to 4,000 alumni, industry personnel, Faculty staff and students
- Advertising company activities/events: monthly Faculty newsletter, Faculty website, bulletin boards and plasmas
- Exhibition presentations: in Faculty building
- Links for selected web pages/company presentations to the Faculty Academia Industry Affiliates Program web page

**Faculty laboratories:**

Enterprise Systems Modeling Laboratory:

The Enterprise Systems Modeling Laboratory (ESML) specializes in modeling complex systems and systems of systems via advanced modeling methodologies and languages, primarily Object-Process Methodology (OPM) ISO 19450 Standard and Publicly Available Specification. Conceptual modeling is the process of constructing a model of a system in order to design, understand, and communicate its function, structure, and behavior. An enterprise model is a conceptual representation of the function, structure, and behavior of an enterprise system. The enterprise model facilitates understanding of the business processes of the extended enterprise and relations that extend across its boundaries.

Business Intelligence Laboratory:

The research conducted in the Business Intelligence lab in the Faculty of Industrial Engineering and Management at the Technion is aimed at developing mathematical and computational tools addressing (separately and together) three grand tasks in which computationally automated tools can greatly assist human decision makers are as follows:

- Obtaining information relevant to the decision task at hand helping the human decision maker identify the actual space of alternatives.
- Modeling and reasoning about likelihood and desirability of various outcomes of alternative decisions.
- Assisting the user to plan the actions needed to implement her decision.

Max Wertheimer Minerva Center for Cognitive Processes and Human Performance:

The Max Wertheimer Minerva Center for Cognitive Processes and Human Performance was established in 1996. It is a joint center that combines the activity of seven senior researchers from the

University of Haifa and the Technion. The center's main purpose is to foster collaborative research projects between the two groups of the Israeli scientists and between the Israeli scientists and their German colleagues, working in the area of human cognition and human performance. The center was established with the support from the prestigious Minerva foundation and the Max Planck Society.

### Project Management Research Center:

The project management research center is involved in three types of activities:

- Development of new methodologies, tools and techniques for project management
- Supporting industry apply the knowledge developed at the center on real projects
- Supporting industry by workshops and seminars on advanced topics in project management

### The Research Center for Work Safety and Human Engineering:

The Research Center for Work Safety and Human Engineering at the Technion was established in 1974 as a joint, endeavor of the Faculty of Industrial Engineering and Management and the Faculty of Medicine, funded by a grant from the Committee for Research and Prevention in Occupational Safety and Health. It is a pivot of interdisciplinary research and teaching activities on topics of behavioral, physiological, medical and engineering aspects of safety at work, as well as general studies on human factors and ergonomics in engineering systems. It focuses on the capabilities and well being of human operators in the work environment.

### Service Enterprise Engineering (SEE) Laboratory:

The goal of SEE is to become a worldwide hub for research and teaching in Service Engineering and to develop principles and tools that are data- and science-based which support and balance service quality, efficiency and profitability, from the likely conflicting perspectives of customers, servers, managers, and often also society. Successful design, analysis and management of services must often be multi-disciplinary, fusing ingredients from Operations Research, Statistics, Industrial Engineering; Game Theory, Economics; Sociology, Psychology; Management Information Systems, Computer Science, and even more.

## Statistics Laboratory:

The Statistics Laboratory operates within the Technion Research and Development Foundation Ltd. and is part of the Faculty of Industrial Engineering and Management. The projects that are carried out can be divided into several categories according to their topics. The ones that are the most frequent are:

- Medical research
- Survival Analysis; Assessment of newly-developed medical devices and diagnostic tools; Data analysis of clinical trials
- Organizational Behavior
- Assessment of agreement, Hierarchical linear models, Mixed models, Generalized linear mixed models, Classification and regression trees
- Transportation
- Before vs. after analysis, Assessment of intervention, Bayesian methods
- Environmental Studies

## Technion Optimization Laboratory:

The major goals of TOC are:

- Fundamental research in the area of Continuous Optimization and its applications, with emphasis on developing novel optimization methodologies, models and algorithms
- Applications of optimization models and techniques in Engineering, Medicine, Industry, etc.
- Supervising and supporting graduate research projects in the area of Continuous Optimization
- Disseminating advances in optimization techniques via organizing workshops, schools, seminars, etc.

## Data Science and Engineering:

Historically, the Davidson Faculty of Industrial Engineering and Management (IEM) was the first of its kind in Israel, and most likely worldwide. So, it is no surprise that IEM is again pioneering the way: Providing multidisciplinary training to engineers for the burgeoning field of Big Data, or Data Science and Engineering (DSE). With the accelerated quantity of data being created, improved communications capabilities, and the increased amount of information being stored, the DSE program, conceived and developed at IEM, reflects the shifting ground rules in the world in general, and in the world of computing in particular: Data, information, and knowledge have become an essential part of organizational operations and business strategy.

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The multidisciplinary nature of the IEM faculty - with expertise in high-level statistics, operations research, computation and economics, artificial intelligence, cognitive science, and more enables the broad education of our BSc Data Science and Engineering students. Our academic program is supported by our policy of "hands on data" from day one of education.

The local industry is already on board with our new degree, partnering in providing weekly lectures in our Data Club, undergraduate projects, our summer internship project and even in provision of full courses for students under our "Bring Your Own Data" policy for data courses. Joint academic-Industry research is significantly enhanced when proprietary data becomes part of the collaboration platform. As such the faculty of IEM has vast experience in data-based joint ventures and has developed collaboration mechanisms, and data sharing facilitation capabilities that enable such research to exist. One such example of the many available is the T-PADS - Technion Poalim Data Science Center.

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## T-PADS - Technion Poalim Data Science Center:

The Technion-Bank Hapoalim Data Science Center was established in August 2016, and is located at the faculty of IEM on the Technion campus. The highly secured data center will promote basic research in areas of Data Science, machine learning, games theory, service system engineering, psychology, NLP and more - intertwining the different disciplines to perform state of the art research in the financial sector. The research is a joint collaboration between Technion researchers and Bank analysts and experts thus combining the Bank's knowledge, experience and data and the Technion's knowledge and expertise. Through a five-year joint research partnership, the center will help define future banking and financial services.

Projects:

- Modeling and predicting events in a customer journey
- The Influence of customer engagement and empowerment in the transition to a digital bank
- Searching for clusters of clients over ontologies
- Anomalies in trading rooms
- Customer sentiment analysis via financial data
- Creativity under the radar
- Data-driven models for the connection between operational load, customer emotions, and profitability in multi-channel service systems

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Head of the KCI activities

**Talli Zahavi**
Leads the "Seeds of Innovation" program and is responsible for managing innovation workshops for overseas delegations

## Knowledge Center for Innovation (KCI):

Technion Research and Development Foundation Ltd.

### Introduction:

Founded in 2008, the KCI vision is to enhance innovation by promoting research of knowledge on innovation, disseminating it among researchers, students, managers and practitioners, as well as implementing it in organizations to enhance economic growth, personal growth and well-being.


The Innovation Center aims to serve as a provoking factor that impacts the joint collaboration of research institutes, industry, and policy-makers for enhancing innovation initiatives. KCI initiates and supports innovation programs to enhance innovation at all levels - individual, team, organization, national and global levels.

### The Journey of the Idea:

The KCI model for stimulating and managing the innovation process follows the journey of ideas. It is a multi-phase, non-linear process for progressing from the ideation phase to the implementation phase until market penetration. Along the journey of the idea innovation may take the form of new technology, products, processes, business models or management. This model serves as a guide for KCI initiatives

### Major Innovation Enhancement Initiatives led by the Innovation Center:

The KCI initiatives encompasses four major tracks: research, knowledge transfer from academia to Industry via educational programs to industry leaders in managing the generation of creative ideas and their implementation, a website that serves as a database of knowledge methods, tools and best practices to enhance innovation, and an active role in working with Policy Makers to develop tools for enhancing Innovation initiatives.

## Research:

The KCI leads national and international studies, including a longitudinal study for identifying factors that inhibit or facilitate innovation of small and medium size enterprises in peripheral areas, as well as a multi-national study on the effect of multicultural teams on innovation. KCI collects and develops case studies of success stories of Israeli companies.

## Knowledge transfer from academia to industry:

### Managing Innovation Forum:

Senior managers from more than 50 leading Israeli companies meet once a month at the Technion to listen to lectures by senior Israeli managers, acquire the latest academic knowledge, learn a variety of methods for enhancing innovation in organizations, and most importantly, to share and create an innovative and synergistic network which crosses industrial sectors.

### Seeds of Innovation:

This program initiated and led by KCI, with the support of the Chief Scientist of Israel at the Ministry of Economics and the Council for Higher Education, serves for developing and guiding teams of Industrial engineering students from leading faculties who work on innovation related final projects in the classical industry companies.

### Organizational Innovation Management Course:

KCI initiated the first Israeli "organizational innovation management course". A comprehensive professional training for organizational innovation leaders, built on advanced academic knowledge and rich practical knowledge on innovation management in organizations.

### Innovation Starts Inside:

KCI experienced professional team offers organizational consulting on promoting innovation in organizations, tailored to each organization's structure and innovation challenges.

### Israel Innovation Workshop:

The KCI conducts innovation workshops for overseas' delegations of senior executives. The workshop content is built upon a strong academic basis and industrial expertise, and the tools and practices are derived from proven models that served for driving innovation across industries and cultures. The workshops are tailor-made per delegation, based on the specific interests of the participants.


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Policy Making:
The KCI developed the "managing innovation Standard" for the Standards Institution of Israel, and provided the guidelines for managing innovation in organizations. These guidelines offer a written methodology for introducing innovation into organizations. The KCI has an active role in government and national committees for the development of policies and incentives for innovation in the industrial sector.

Online Knowledge Base:
The KCI website is a unique knowledge base, containing articles and studies on innovation, innovation-promoting methods and online lectures on innovation. The website features workrooms for participants in the various training programs, such as an innovative interface for idea management through crowd sourcing. It also serves as an Information Center for the P^3 MAGNET Consortium, sponsored by the Israeli Chief Scientist and aimed at promoting innovation in the plastic industry.

**Bronica Entrepreneurship Center:**
The Bronica Entrepreneurship Center is the focal point of entrepreneurship at the Technion. We provide the education, expertise, and connections that Technion students and alumni need to become effective entrepreneurs. We offer a variety of academic courses, workshops, hackathons, competitions, training, and consultations to students from all faculties and degree levels. We have both academic and extracurricular activities.

Academic:
We offers formal and informal frameworks, with almost 20 academic courses, a minor in entrepreneurship, free sessions that are open to the public, private workshop that provide hands-on experience, and more. Our courses allow students to learn the theoretical and practical aspects of the entrepreneurial process, from the stage of identifying needs/opportunities through ideation to setting the foundations of a venture.

Extracurricular:
We offer a host of activities, including workshops, hackathons, competitions, lectures, and meetups. In all our activities, we collaborate heavily with industry.

Sample activities include:

Technion 3DS:
3 Day Startup are intensive, exciting workshops in which students transform ideas into companies in just three days. Our participants are very diverse, hailing from a variety of disciplines, degree levels, countries, and professional backgrounds. Over 3 intensive days, we guide them through the early stages of starting a technology company. They brainstorm ideas, conduct market validation, develop business models, create brands, and pitch to investors and successful entrepreneurs. The result is an experience that challenges participants to innovate, create, and launch real companies.

BizTEC:
BizTEC is Israel's top technological entrepreneurship program led by the Bronica Entrepreneurship Center at the Technion. BizTEC's mission is to accompany early-stage entrepreneurs through their first venture. Founded in 2004, it includes students and alumni of more than 20 campuses across Israel. BizTEC creates the next generation of technology entrepreneurs. It caters to hundreds of entrepreneurs annually and is the starting point for many successful startups and entrepreneurs in many different verticals. We achieve this by creating a thriving learning environment and providing an extensive network of partners, mentors, and alumni that leads the teams from ideas to commercial realization. BizTEC ventures have raised more than $200M.

Dream Factory:
The Technion Dream Factory is an idea-generating, problem-solving program of the Bronica Entrepreneurship Center (BEC) at the Technion. Dream Factory brings together Technion innovation and real-world challenges as the basis for startups.  Selected companies challenge Technion students, who in turn compete to find the best solution. The program goals are to introduce Technion students to current industry problems and needs, and to increase the founding rate of enterprise-oriented startups that address real world problems with validated customer needs and market.

Prizes:
We offer annual prizes which encourage and advance breakthrough ideas. Prizes are awarded for technologies with commercialization potential as well as innovation within established companies. Prizes are awarded to Technion students and faculty members.

Brightest talent.
Deep technologies.
Breakthrough innovations.

## International Collaboration:

We offer two types of international programs.

- The first type of program is hosting of international delegations interested in learning about entrepreneurial activities at the Technion Our experienced staff arrange tours and design workshops that give visitors a taste of the Israeli entrepreneurial ecosystem as well as training on our educational programs in entrepreneurship. Moreover, we incorporate international visitors in our activities such as 3 Day Startup, exposing them to both our methodologies and the Technion's brightest talent.

- The second type of program focuses on exposing Technion students interested in entrepreneurship to international markets. We send delegations of students to workshops, hackathons, competitions, and other events across the world.

## Industry Collaborations:

We have multiple forms of collaborations with industry, including startup partnerships, hackathons, meet-ups and networking, pitching events, workshops, and industrial-challenge competitions. Our industry partners gain access to the finest technological minds in Israel. They are at the beginning of their journey, so relationships formed at this stage are especially meaningful and long lasting. Our past partners have remained in contact with our entrepreneurs for years on, as mentors, services providers, employers, and partners.

## Selected success stories:

PolyTouch Medical

WINDWARD

LifeBond
Life Saving Biomaterials

BreezoMeter
Because Breathing Matters

HEALTHY MIZE

AUGmedics

AerialGuard

# MATERIALS SCIENCE AND ENGINEERING

***http://materials.technion.ac.il***

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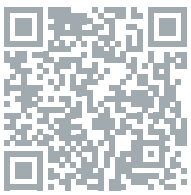
The mission of the Faculty of Materials Science and Engineering is to serve as the national center of teaching and research, by educating world-class scientists and engineers, and conducting research in specific fields of materials science and engineering.
The research activities of the Faculty cover most of the important and advanced topics in materials science and engineering. The Faculty includes a broad range of research centers and laboratories for processing and characterization of materials, equipped with a wide range of advanced facilities, supported by experienced staff.



***http://materials.technion.ac.il/Access-to-Research-Facilities***

## Research Areas:

Metals and Alloys ➲ Ceramic Materials ➲ Polymers ➲ Nano-materials ➲ Biomaterials ➲ Electronic Materials ➲ Functional Materials ➲ Materials for Energy Conversion and Storage ➲ Interfaces in Materials ➲ Microstructural Characterization

## Research Facilities Providing Services to Industry:

| Contact | Materials Characterization: |
|---|---|
| **Dr. Alex Berner**<br>Tel. +972-4-829-4568<br>berner@technion.ac.il | Scanning Electron Microscopy:<br>Imaging, chemical mapping (EDS, WDS), crystallographic analysis (EBSD) |
| **Dr. Yaron Kauffman**<br>Tel. +972-4-829-4567<br>mtyaron@technion.ac.il | Transmission Electron Microscopy:<br>High-resolution imaging (atomic scale), crystallographic analysis (electron diffraction), chemical mapping (EDS, EELS), *in situ* heating and cooling experiments |
| **Mr. Joshua Schecter**<br>Tel. +972-4-829-4566<br>chuly@technion.ac.il | X-ray Diffraction:<br>Phase identification, strain analysis, *in situ* heating experiments |
| **Eng. Michael Kalina**<br>Tel. +972-4-829-4795<br>mkalina@technion.ac.il | Atomic Force Microscopy:<br>Surface topography and related parameters |
| **Mr. Ronen Aviram**<br>Tel. +972-4-829-4289<br>ronenmt@technion.ac.il | FTIR:<br>Chemical bonding<br><br>Dilatometer:<br>Elongation measurements as a function of temperature, useful for sintering. Analysis and measurement of coefficients of thermal expansion. Temperature range: room temperature to 1600°C<br><br>Thermal Gravimetric Analyzer (TGA):<br>Weight loss as a function of temperature. Temperature range: room temperature to 1100°C<br><br>Differential Scanning Calorimeter (DSC):<br>Measures the amount of heat required to increase the temperature of a solid. Used mainly for identifying the type of reaction (endothermic/exothermic). Temperature range: room temperature to 1400°C |

| | |
|---|---|
| **Mr. Ronen Aviram**<br>Tel. +972-4-829-4289<br>ronenmt@technion.ac.il | Mechanical Properties:<br>Evaluation of mechanical properties of materials and components using tension, compression, flexure, fatigue, impact, and torsion tests<br><br>Hardness and Micro-Hardness:<br>Surface hardness and related mechanical properties |
| **Dr. Galit Atiya**<br>Tel. +972-829-5125/5144<br>gatiya@technion.ac.il | Dual-Beam Focused Ion Beam:<br>Used for nanometer length-scale fabrication, 3D characterization, and TEM specimen preparation |
| | Specimen Preparation: |
| **Mr. Ronen Aviram**<br>Tel. +972-4-829-4289<br>ronenmt@technion.ac.il | Metallographic Laboratory:<br>Cutting, hot mounting press, grinding, and polishing systems<br><br>Furnace Laboratory:<br>Carbolite air furnace (R.T-1100°C), electric arc furnace |
| **Eng. Michael Kalina**<br>Tel: +972-4-829-5795<br>mkalina@technion.ac.il | Conventional TEM specimen preparation |
| **Dr. Eugene Konyukhov**<br>Tel: +972-4-829-4597<br>eugene@technion.ac.il | Magnetron Sputtering:<br>Thin-film depositions |

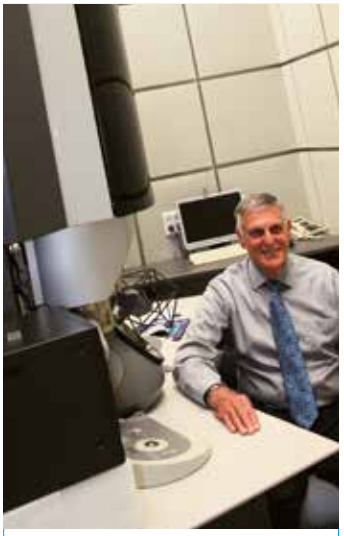
***http://mtrmika.technion.ac.il***

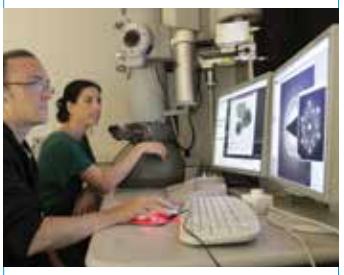
## Electron Microscopy Center:

The Electron Microscopy Center, located at the Faculty of Materials Science and Engineering, serves Faculty and students within the Technion, as well as from other institutions and local industry. The Center provides services on all the microscopes, and trains students and scientists for independent use of the equipment.

The facilities are run by five staff members, and include computerized light microscopy (LM), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). In addition, a complete specimen preparation laboratory is included within the framework of the Electron Microscopy Laboratory.


FEI COMPANY





## The Main Microscopes in the Center:

### FEI Titan Cubed Themis G2 300:

The Titan Themis G2 300 (FEI) is the world's highest resolution commercially available Transmission Electron Microscope (TEM) and Scanning Transmission Electron Microscope (STEM) microscope with a high-tension voltage range of 60-300kV, yielding powerful sub-Ångstrom (atomic scale) imaging and analysis for a broad range of materials (metals, semiconductors, ceramics, polymers and organic materials). The Titan's dedicated platform for correctors and monochromator technologies and their applications is designed for a high degree of automation, and provides ultimate stability, performance, and flexibility. The microscope transfers information deep into sub-Angstrom resolution, providing the highest performance available in both TEM and STEM modes, enabling extraordinary new scientific opportunities for direct observation aimed at enabling analysis of individual nanostructures at an unprecedented resolution of 0.8Å, which is approximately one-third the size of a carbon atom.

The Titan Themis features:

- A monochromator for sub-eV energy resolution (60-300kV)
- A double corrector system (CEOS) for both TEM and STEM modes enabling sub-Ångstrom resolution
- A high-resolution energy filter (Gatan Quantum ER965), for sub-eV EELS and energy filtered TEM (including ultrafast dual-EELS capabilities)
- Dual-X detector (Bruker) with an effective Solid Angle of 1.76sr for fast and precise local (atomic) chemical analysis
- A high-resolution BF/DF/HAADF STEM system
- Ceta2 4Kx4K ultra-high-speed CMOS camera (for *in situ*)
- Lorentz mode for mapping magnetic materials
- A DensSolutions double tilt hot stage (up to 1300°C) for *in situ* studies
- A Gatan double-tilt hot stage (up to 1000°C) for *in situ* studies
- A Gatan double-tilt cryo-stage (liquid N2) for life-science and CBED/EELS analysis
- A Fischione single-tilt tomography holder for EDX TEM and STEM 3D reconstruction

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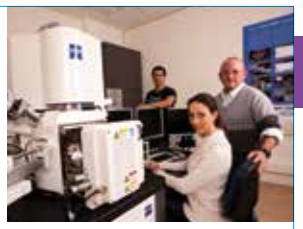

FEI Tecnai G2 T20 S-Twin TEM:
200keV (or 120keV) TEM with a LaB6 electron source and an FEI Supertwin Objective Lens.
This microscope is equipped with:

- BF and DF STEM detectors
- EDS detector (EDAX)
- Plate camera and a 1x1K Gatan 694 retractable slow scan CCD
- DensSolutions double tilt hot stage (up to 1300°C) for *in situ* studies
- Gatan double-tilt hot stage (up to 1000°C) for *in situ* studies
- Gatan double-tilt cryo-stage (liquid N2) for life-science and CBED/EELS analysis

FEI Helios NanoLab Dual Beam FIB G3 UC:
The dual-beam focused ion beam (FIB) at the Technion was purchased with the support of the Russell Berrie Nanotechnology Institute. The Helios NanoLab G3 series DualBeam systems integrate ion and electron beams for FIB and SEM functionality in one machine. It enables switching between the two beams for quick and accurate navigation and milling. Convergence of the SEM and FIB at short working distance. The FEI Helios NanoLab DualBeam allows fastest TEM sample preparation performance and allows highly flexible failure analysis capability and "slice-and-view" cross-sectioning at high resolution. This SEM/FIB combines the most advanced scanning electron microscope (SEM) and focused ion beam (FIB) technologies with innovative gas chemistries, detectors, and manipulators. Featuring unsurpassed SEM resolution, image quality and Tomahawk™ FIB performance, imaging, milling, or preparing samples is fast and easy for semiconductor and data storage labs, research facilities and industrial applications. The Helios NanoLab G3 is equipped with EDS and EBSD and enables 3D tomography.

The Helios NanoLab G3 features:

- Ultra-high resolution Elstar™ electron column with the UniColor source mode
- High-resolution Tomahawk™ ion column with ICE (in chamber electronics) ion detector
- The chamber and stage accommodate up to 100 mm samples.
- The high accuracy five-axis X, Y, Z, Rotation, Tilt) stage provides full coverage of 100 mm samples with computer control and automation of all axes for precise sample manipulation.

- The FEI EasyLift NanoManipulator supports higher yields for TEM sample lift-out through an intuitive, integrated user interface and attachment to a TEM grid for further analysis. It allows for final thinning of the sample to be accomplished after attachment to the TEM grid holder.
- Gas Injection System (GIS) – Advanced control of gas chemistries including FEI proprietary gases for enhanced precision deposition or bulk material removal.
- Auto Slice & view software provide a fully automated recipe for accurate slice and view.
- NanoBuilder allows the creation of structures that are not possible with other lithographic methods. Users can modify their designs faster and resulting in quicker iteration than traditional lithography process.

Zeiss Ultra-Plus FEG-SEM:

A high-resolution Schottky field emission gun SEM (FEG-SEM).
The Zeiss Ultra-Plus features:

- A heating stage (Kammrath & Weisse) for *in situ* heating up to 1050°C
- A Picoindenter (model PI85, Hysitron) for *in situ* mechanical testing
- An 80 $mm^2$ active area Oxford SDD EDS detector with an energy resolution of 127 eV
- An EBSD (Electron BackScattered Diffraction) & TKD (Transmission Kikuchi Diffraction) system for orientation mapping of crystalline materials

Contact
**Mr. Joshua Schecter**
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- A unique combination of detectors:
  - > Everhart Thornley chamber secondary electron detector
  - > In-lens secondary electron detector
  - > In-lens energy selected back-scatter detector
  - > Four-quadrant angular selected back scatter detector, allowing imaging in orientation, topographic, or composition modes
  - > Transmission electron detector for STEM operations, allowing bright and dark field imaging modes

FEI SEM Quanta 200:
A variable pressure SEM enabling characterization of non-conducting materials without a conductive coating, equipped with EDS (light element), WDS and EBSD.

## X-Ray Diffraction Laboratory:

The Rikagu SmartLab high-resolution diffraction system available in this laboratory represents the state of the art in fully-automated modular XRD systems. The system incorporates a high-resolution theta/theta closed loop goniometer drive system, CBO, an in-plane scattering arm, a 9.0 kW rotating anode generator, and a fully-automated optical system to make advanced measurements possible for both expert and novice users of the system.

This diffractometer allows for the investigation of the preferred orientation of individual crystallites, and residual stress analysis of powders, polycrystalline materials, and polycrystalline thin films, as well as single crystalline films. With this system it is also possible to measure the rocking curves of the samples in the sample-detector decoupled mode, and to take diffraction profiles in grazing incidence. In addition it is equipped with an automatic sample changer, a capillary module for small amounts of powdered samples, and a hot stage operated in various inert environments (up to 1100°C). Another available mode of the system's operation is glancing angle X-ray reflectivity, which provides information on surface roughness and electron density variations beneath the surfaces and buried interfaces of various crystalline and non-crystalline materials, including glasses and polymers.

# MATHEMATICS

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The Faculty of Mathematics was founded in 1950. Today it is one of the leading mathematics departments in Israel. The Faculty is engaged in world-class research in both pure and applied mathematics. The research interests of the Faculty include Algebra, Representation theory, Number theory, Analysis (Asymptotic Geometric analysis, Complex analysis, Differential equations, Functional analysis, Non-linear analysis, Operators theory and Banach Algebra), Applied Mathematics, Discrete Mathematics, Ergodic theory and Dynamics, Math Physics, Probability and Stochastic process, Topology and Geometry.

The Center for Mathematical Sciences (CMS) was founded at the Faculty in 1988. Since then it has supported a large variety of research activities, conferences, special lecture series, workshops, etc.

## Industrial Activity at the Faculty of Mathematics:

The Faculty of Mathematics has been involved in applied mathematical research for many years and in many capacities:

- Startup companies: A number of successful companies were founded by the Faculty members and graduates in different areas, including optics, image processing, and signal processing.
- Consulting to industry: Our Faculty members are engaged in various consulting activities, covering a wide range of areas, including optimization, optics, mechanics, control, fluid mechanics, and 'big data'.
- In-house inventions: A number of innovative technologies and algorithms were invented in the Faculty and patented by the Technion.

## Student Projects:

A number of industrial projects were carried out by our undergraduate students as part of a special training course.

# MECHANICAL ENGINEERING

***http://meeng.technion.ac.il***

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Industry Relations Director
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The Faculty of Mechanical Engineering at the Technion is the major source of high-level mechanical engineers for Israeli industry and R&D. Graduates of the Faculty of Mechanical Engineering fill senior positions in Israeli industry, particularly in the high-tech and defense industries. The Faculty's facilities include advanced teaching and research laboratories, a computer facility, and a spacious well-equipped library.

The Faculty of Mechanical Engineering at the Technion has been recognized as one of the leading departments in its field. The research in the faculty is diverse, highly multi-disciplinary, and is at the forefront of science and technology. Research in the Faculty is carried out through research centers. The centers provide Faculty members and their students with the facilities, manpower and support to conduct their projects.

**Research Areas:**
Biomechanics ➲ CAD ➲ Control ➲ Design and Production ➲ Design in Marine Environment ➲ Dynamical Systems ➲ Energy ➲ Flow-Structure Interaction ➲ Fluid Mechanics and Transport Phenomena ➲ Mechanics of Materials ➲ Mechatronics ➲ Micro-systems ➲ Nano-Mechanics ➲ Optical Engineering ➲ Reliability ➲ Robotics ➲ Surface Engineering

***http://meeng.technion.ac.il/research-centers-and-labs***

***http://rittel.net.technion.ac.il***

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Contact
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yossifon@technion.ac.il

## Research Centers and Laboratories:

### Materials Mechanics Center:

The Materials Mechanics Center specializes in the mechanical testing of materials at low strain rates and in the fatigue regime. The Dynamic Fracture Laboratory (DFL), part of the center, specializes in high rate testing of the deformation and fracture mechanics of materials (metals, polymers, ceramics, and composites). Our dedicated equipment includes several Split Hopkinson tension and compression bars, shear experiments, a materials characterization facility (optical and SE microscopy), and numerical simulations capability (Abaqus, Ansys). Moreover, we have a high-speed camera (Kirana), with a 6 million fps frame rate, total 180 high resolution pictures. The DFL is a unique facility in Israel, at the forefront of the research in the field of dynamic failure of materials.

### Computational Fluid Dynamics Laboratory (CFDLAB):

The Computational Fluid Dynamics Laboratory (CFDLAB) specializes in high-fidelity modeling and simulation of turbulent flows, with applications in aerodynamics, aeroacoustics, biological/cardiovascular, combustion, microfluidics, and multiphase flows. Specifically, we focus on advanced numerical methods and models related to applying the large eddy simulation technique for turbulent flows. We employ high-performance parallel computing, and feature a 768 core dedicated Linux cluster computer for our work.

We also feature the use of open-source codes, such as OpenFOAM, and commercial packages, such as Star-CCM+, depending on the problem.

### Multiphase Flow and Thermal Management Laboratory:

The Multiphase Flow and Thermal Management Laboratory specializes in all forms of boiling and multiphase flow phenomena, in particular as related to thermal management of electronic and optical components, such as high power computer chips, signal amplifier lasers, and the like. Our dedicated equipment includes high-speed video, as well as all the standard thermal-laboratory equipment.

***https://meeng.technion.ac.il/internal-combustion-engines-laboratory***

## Contact

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***http://ncds.technion.ac.il***

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## Internal Combustion Engines Laboratory:

The Technion Internal Combustion Engines Laboratory (TICEL) specializes in the development, testing, and modeling spark ignition and diesel engines for UAV and automotive applications, as well as advanced hybrid propulsion systems. TICEL is equipped to study engines and propulsion systems fueled with both conventional and alternative fuels. The TICEL staff has gained a rich experience in development, modeling, and testing 4-stroke, 2-stroke, and rotary internal combustion engines; road tests of motor, hybrid, and electric vehicles; and assessment of energy and environmental impacts of vehicles and transportation systems.

Our dedicated equipment includes several engine dynamometers, including the dyno with transient capabilities; facilities for mechanical loss measurement; engine indicating; measurement of fuel consumption, gaseous and particle emissions; a high-speed camera; and a facility for flame velocity studies. Our numerical simulation capabilities include GT-SUITE software. The TICEL is a unique knowledge center in Israel, at the forefront of the research in the field of UAV and automotive propulsion.

## Nonlinear and Chaotic Dynamical Systems (NCDS) Laboratory:

The Nonlinear and Chaotic Dynamical Systems (NCDS) Laboratory specializes in the analysis and characterization of nonlinear materials and structures. The focus of the NCDS Lab includes both identification of complex material properties that cannot be obtained by standard linear analysis, and investigation of unstable and non-stationary structures that are subject to severe and unsteady environmental conditions. We make use of multiple-scale asymptotics and numerical bifurcation analysis to resolve nonlinear spatio-temporal interactions; and employ chaos theory to determine instabilities governed by sensitivity-to-initial-conditions. We are thus able to derive consistent model-based estimation procedures for validation of combined geometric (large deformation) and material (thermo-visco-elastic) nonlinearities from experiments that exhibit self-excited modulation and multiple coexisting solutions (hysteresis) due to parametric and internal resonances. The NCSD Lab includes both non-intrusive (high-speed cameras) and intrusive (strain/acceleration) capabilities to conduct experiments in high vacuum (and thus isolate the influence of internal thermo-elastic damping from air drag).

The NCDS lab, located within the Material Mechanics Center at the Technion, is a unique facility in Israel that is at the forefront of the research in the field of nonlinear dynamical systems.

## William and Sophia Shamban Tribology Laboratory:

The Shamban and Tribology Laboratory specialize in science and technology of interacting surfaces in relative motion. Our research, both theoretical and experimental, is in contact mechanics, adhesion, friction, wear, and lubrication related to fields ranging from mechanics to biology. We consult and help to solve problems related to wear reduction, energy conservation, and increasing reliability and service life of mechanical components and systems. Our dedicated equipment includes optical and scanning electron microscopy, surface profilers and hardness testers, and 15 various custom-built tribometers capable of working in different contact schemes, motion types, and wear modes.

## Micro- and Nano-Fluidics Laboratory (MNFL):

The Micro- and Nano-Fluidics Laboratory (MNFL) specializes in studying transport processes of electrolyte/colloids/cells/biomolecules within micro- and nano-fluidic devices. We target a number of application areas, involving primarily electrokinetic actuation, such as energy (e.g. electro-chemo-mechanical energy-conversion, heat management), healthcare (e.g. Lab-on-a-chip) and environmental (e.g. desalination) applications. Fabrication of the devices is done either within the Technion's shared micro-fabrication facilities (photolithography, E-Beam, FIB) or in our own Class 1000 clean room.

The MFNL laboratory has state-of-the-art imaging and electronic sensing instruments. The key to studying electrokinetic phenomena in micro- and nano-fluidics is to have an exquisite control over the generated AC/DC electric field, together with high-precision current and impedance measurements. The laboratory contains the following main equipment: spinning-disk confocal and epi-fluorescence imaging microscopes, Andor's latest sCMOS and EMCCD high-sensitivity camera, TSI μ-PIV, impedance and current meters, function generators, and power supplies.

## Contact

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## Technion - Mechanical Engineering Industrial Affiliates Program (IAP):

The Technion's Mechanical Engineering Industrial Affiliates Program (IAP) was launched in 2009 to serve as a bridge between the Faculty and leading industrial companies in Israel and worldwide for the exchange of excellence, and as a framework for relations and collaboration in the fields of Education and Teaching, Human Resources & Employment, Research & Development, and Public Relations & Marketing. Program components were constructed to bypass obstacles to collaboration, provide win-win solutions to short- and long-term needs, and pave the way to the consolidation of strategic ties, focusing on securing the best outcome for the State of Israel and its future.

Through the IAP, industrial companies of all types and sizes, both domestic and foreign-based, can gain equal access to Faculty resources, and implement a range of activities to expose the various levels of company activities to Faculty staff and alumni, and undergraduate and graduate students in all tracks. All company activities within the framework of the program are performed with the full support of the Faculty's academic, administrative, and technical staff.

### Members' Benefits:

Companies joining our IAP are awarded access to a comprehensive benefits package, including components from the fields of Education and Teaching, Human Resources and Employment, Research and Development, and Public Relations and Marketing. The backbone of the program consists of package components, listed below. Companies are always welcome to offer the Faculty new initiatives that enrich the dialogue, and deepen common grounds and utilization of growth opportunities to extend the existing benefits package.

Access to Faculty members and students at all levels, with the following options:

### Education and Teaching:

- Offering suggestions for students' final projects
- Collaboration with the Faculty-led Technion Formula SAE Initiative
- Collaboration with the Faculty-led Technion PACE Initiative
- Collaboration with the Faculty's annual Women's Day Initiative
- Participation in a special annual 'Faculty Council' meeting open to industry

- Giving short courses or seminars
- Giving guest lectures within the Faculty's TechTalk Framework
- Organizing mini-courses, seminars, summer courses, or advanced degree programs for company employees (additional payment)
- Attending free Faculty courses for company employees (advance notice required)
- Access to Faculty library services (advance notice required).

### Human Resources and Employment:

- Holding an exclusive Student Recruiting Day twice a year
- Participating in a Student Recruiting Day held once a year in the Faculty building for several companies at a time
- Advertising open positions to all Faculty students and alumni through the Faculty's Newsletter
- Awarding scholarships to Faculty students
- Sponsoring Faculty alumni reunions
- Sponsoring Faculty graduation ceremonies
- Sponsoring Faculty seminars, conferences, and symposia

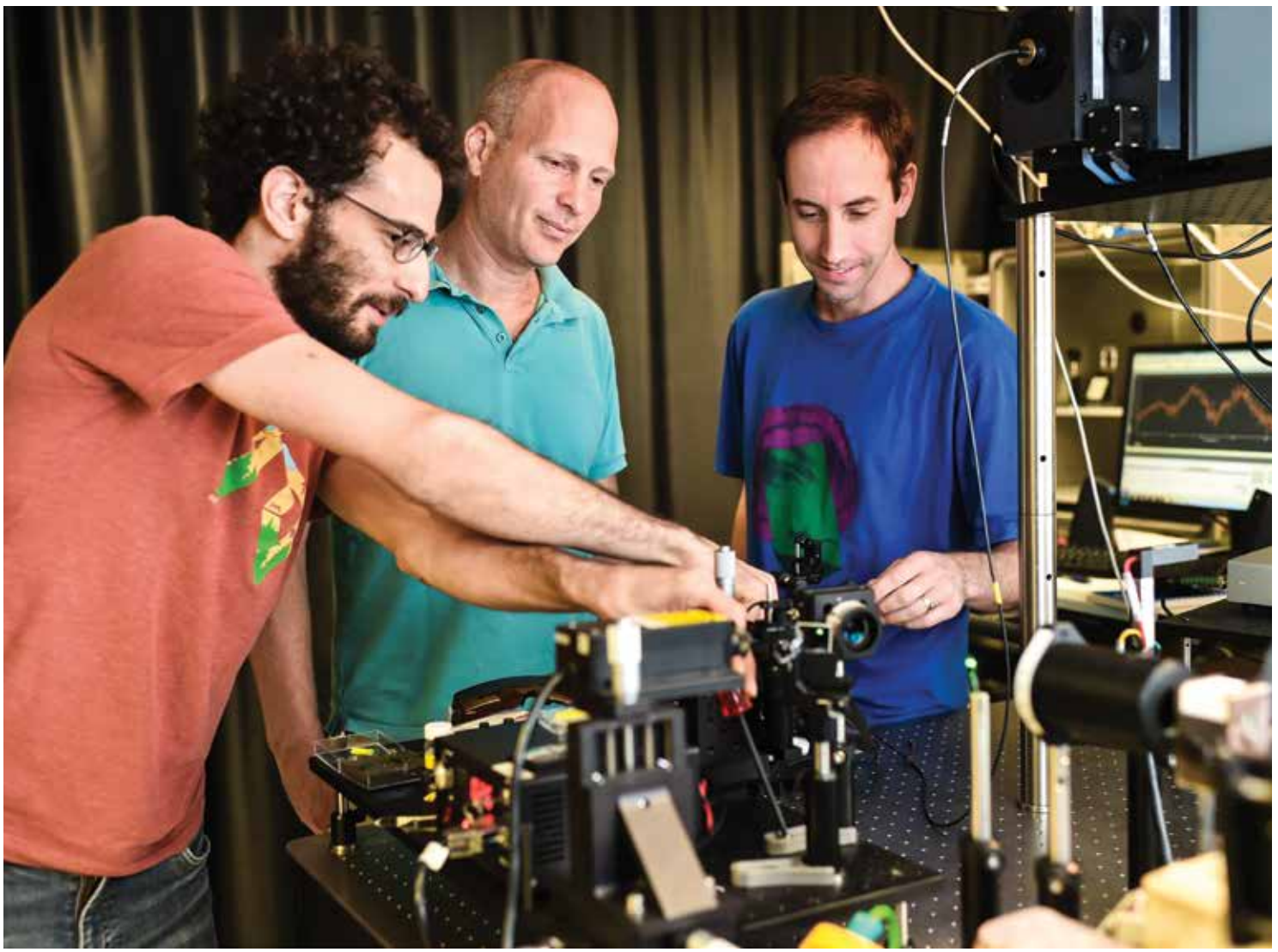
### Public Relations and Marketing:

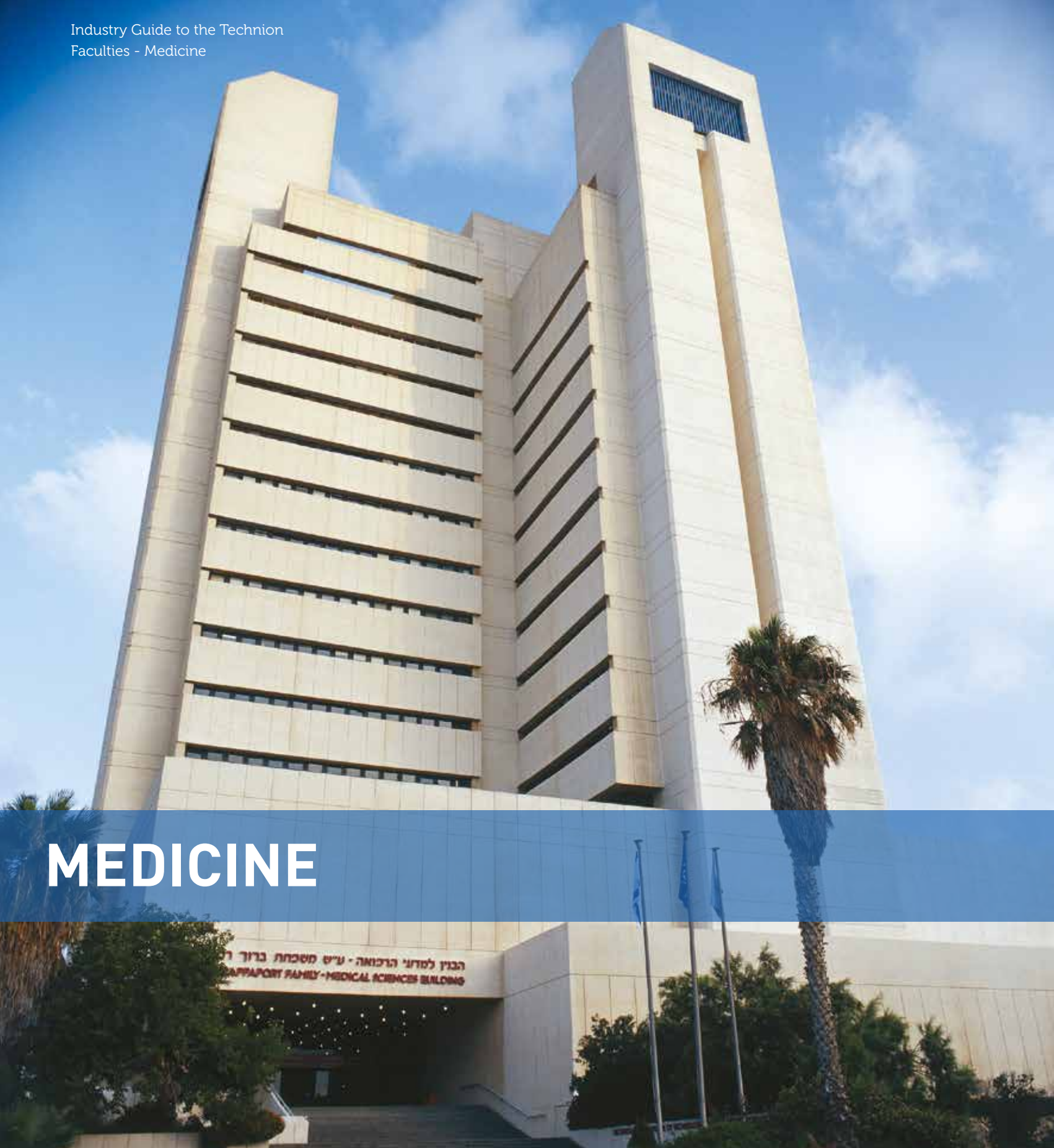
- Company name and logo on a special "Industrial Affiliates" website linked to the ME Faculty website
- Company name and logo on a special "Industrial Affiliates" board in the ME building lobby
- Advertising company activities at the Faculty on electronic boards located in main entrances to Faculty building
- Linking selected company web pages to the Faculty IAP website.
- Presenting exhibitions in the Faculty building
- Advertising articles and advertisements in the Faculty's Newsletter sent to all students, staff and alumni (about 6,000 recipients)

### Research and Development:

- Participation in the annual ME "Research Day", held once a year, in which graduate students present their research to Faculty students, staff, Faculty alumni, Technion Management, and senior industry executives
- Participation in the annual Project Expo, where Faculty undergraduates in their 4th year present projects they have designed and built in collaboration with leading industrial companies
- Confidential and reliable channel to Faculty researchers.

- Receiving copies of publications and annual activity reports produced by the Faculty
- Organizing visits to selected Faculty laboratories
- Organizing round-table meetings with staff operating in fields of mutual interest
- Access to the list of courses and research topics of graduate students
- Listing company R&D needs, and making connections to Faculty capabilities
- Discount on execution of company projects in Faculty laboratories




הבנין למדעי הרפואה - ע"ש משפחת בריך ר
APPAPORT FAMILY - MEDICAL SCIENCES BUILDING

# MEDICINE

***http://md.technion.ac.il***

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Clinical Professor of Plastic Surgery
Holder of the David Erlik Chair in Surgery
Vice Dean for Strategic Development

The Faculty of Medicine is one of the few medical faculties worldwide integrated in a technological institute. Research in the Technion Faculty of Medicine has made impressive achievements.

In the short time since its establishment in 1969, the Faculty has earned the scientific community's highest respect in several research areas.

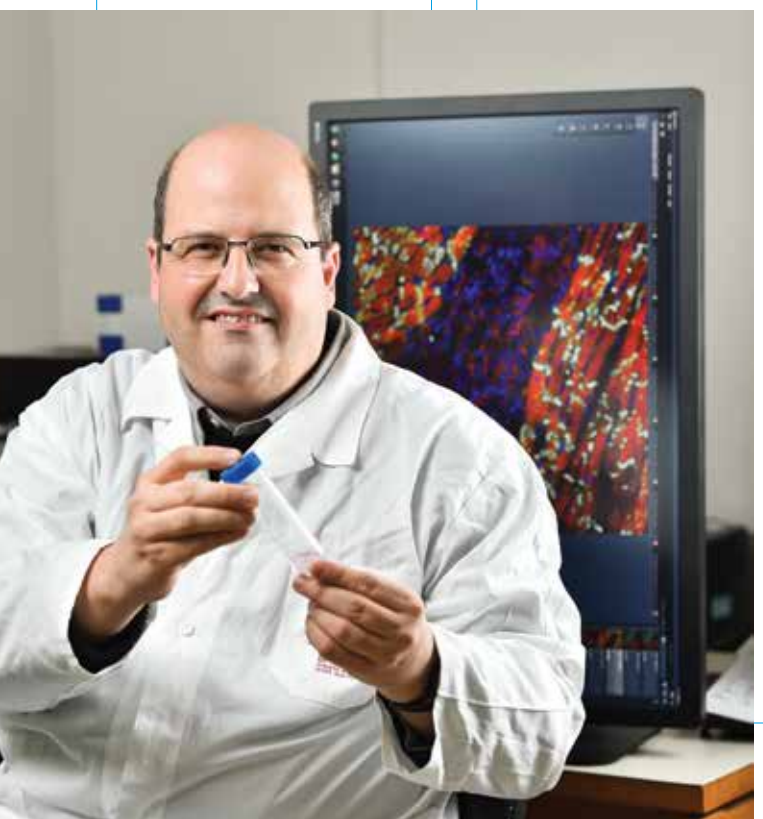
Two of our Faculty members, Distinguished Professors Avram Hershko and Aharon Ciechanover, were awarded the Nobel Prize in Chemistry in 2004 for discovering the Ubiquitin system and its crucial role in protein degradation and cell cycle. The Faculty Center for Degenerative Brain Diseases is world-famous, and has brought about the development of new medicines for protection against brain degeneration. Our stem cell scientists are well known as pioneers in their field. Technion Faculty members have contributed to the understanding of "crush syndrome" that has enabled the rescue of thousands of earthquake victims around the world. The Faculty Centers for Cardiovascular Diseases and Cancer Research have made important discoveries in the growth of blood vessels and future pharmacological treatment of patients with vascular disease and cancer. These most impressive achievements are only the tip of the iceberg, and have already earned our Faculty a reputation for being at the forefront of medical research.

## Teaching Hospitals:

Rambam Health Care Campus ➔ Bnei Zion Medical Center ➔ Carmel Medical Center ➔ Hillel Yaffe Medical Center ➔ Emek Medical Center ➔ Shaar Menashe Mental Health Center ➔ Tirat Hacarmel Mental Health Center ➔ Mental Health Center Mazra ➔ Fliman Geriatric Center ➔ Shoham Geriatric Center ➔ French Hospital - Nazareth ➔ Sanz Medical Center - Laniado Hospital, Netanya

## T2Med Program - 3 Day Startup Event (3DS):

The 3DS Program, established at Nov. 2013, is an annual program takes place over the course of three days during which 70 students divided into 7-8 groups from different faculties at the Technion (medicine, computer science, biomedical engineering, electrical engineering, mechanical engineering, etc.) collaborate to create healthcare startups. During these days the students learn to identify unmet needs in healthcare and medicine, devise technological solutions to these needs, learn to write a business plan and experience market validation by physically talking to potential customers and users. They manage to do all this with the help of the intensive mentorship they receive from physicians, engineers, researchers, VCs and other experienced entrepreneurs. At the third day of the program (finals) each group presents a short presentation of which they elaborate the need, the market potential, and the solution and establish the budget and miles stones to proceed. The three winning teams that show a potential for commercialization, which are chosen by prestigious referees from the medical and biotech disciplines, get the chance to participate in the Technion's BizTec accelerator program as well as the opportunity to fly to Boston as part of the Technion-BWH Exchange program and meet with several VCs groups and other entrepreneurs.



In addition to the above three-day T2Med program, the Faculty of Medicine at the Technion offers a semester elective medical entrepreneurship course at the Rappaport Faculty of Medicine in which 30 students attend lectures on innovating medical technologies. The lectures present needs assessments, pre-clinical testing, prototyping, IP, writing a business plan, funding and VC, regulatory issues, product design and materials, and marketing, as well as a visit to a Cardiac Cath lab and an innovation workshop.

## Biomedical Core Facility:

The Biomedical Core Facility (BCF), headed by Dr. Ofer Shenker, is your one-stop shop for state-of-the-art technology and expertise. Over the years the Faculty of Medicine, together with the Rappaport Research Institute, has been committed to providing excellent resources to our scientists, and has invested in both advanced instruments and highly-trained personnel to operate the instruments and support the science. At the BCF we help with all stages of the experiment – design, execution, and data analysis. Our services include microscopy, imaging, whole-animal imaging, flow cytometry, mass cytometry, molecular biology, genomics, biostatistics and bioinformatics, supported by miscellaneous research equipment. Access to these resources is available to all researchers in industry and academia at affordable prices. Our team of scientists and trained technicians works in close collaboration to advance your science seamlessly in different fields and technologies.

### Bioimaging Applications

- Widefield microscopy
- High speed & high resolution confocal microscopy
- Live cell high throughput imaging
- Automatic whole slide digitization
- Rodent bioluminescence, fluorescence & X-RAY
- High resolution micro ultrasound
- Structural 1T micro MRI
- Functional 9.4T micro MRI
- Functional rodent cardiac imaging
- Functional rodent brain imaging
- *In vivo* body fat and lean composition
- Personalized image analysis services

### Genomic Applications

- RNAseq
- DNAseq
- BiSseq
- miRNAseq
- ChIPseq
- Real-Time PCR
- Single-cell gene expression
- Digital PCR
- DNA methylation
- SNP genotyping
- CNV analysis
- CRISPR-Cas6 knockout in cell lines
- Human cell line authentication
- Sanger sequencing
- STR fragment analysis

### Flow Cytometry

- Polychromatic staining
- Functional assays, including calcium flux, proliferation, DNA content, etc.
- Phospho-flow
- Multiplexing samples (barcoding)
- Rare event detection
- Small particle analysis
- mRNA detection
- Precision and enrichment sorting
- Single cell sorting into 96-384 well plates
- Mass cytometry
- Magnetic bead–based immunoassays with MAGPIX

### General Services

- Isothermal Titration Calorimetry
- Freeze-drying
- Fluorescence, transmitted, luminescence plate readers
- Spectrophotometry
- Centrifuges
- Scanners (Phosphor Imager, Odyssey)
- Gamma & Beta radiation counters
- Film Development
- Sonicators & high pressure homogeniser
- Bio-safety virus room

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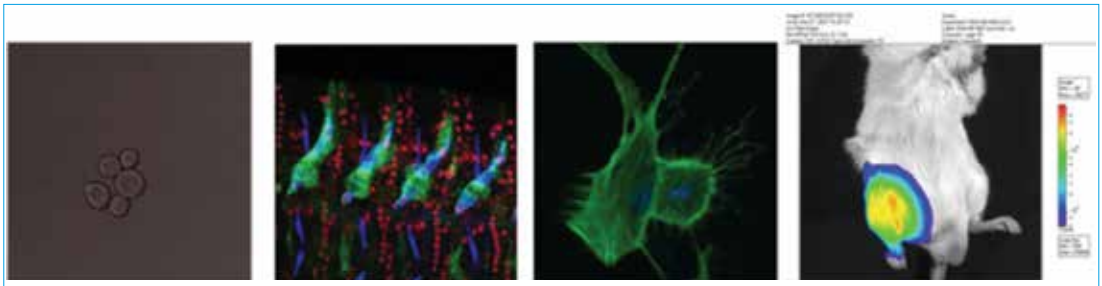

## Imaging and Microscopy Center:

The Bioimaging Center, headed by Dr. Edith Suss-Toby, offers state-of-the-art technologies enabling visualization, digitization, and image analysis from subcellular resolution up to whole animal (rodent). Our team supports researchers with new technologies, protocols implementation, system operation, image acquisition, result interpretation and image analysis solutions. We have broad experience with biomedical research imaging applications. We offer annual workshops and academic courses for training and education, presentations of new technologies and a technological information exchange mailing list. We support researchers from a variety of life science fields, such as cancer, angiogenesis, atherosclerosis, cardiac stem cells, development, neurobiology, behavioral research, and more. Our *in vivo* imaging unit enables performing longitudinal multimodality noninvasive imaging; in combination with viral/genetic manipulations & cellular validation, it creates a unique research platform.
Our imaging and microscopy center is capable of bridging the gap between cellular information and in-vivo operational mechanisms. Below we describe our technologies and applications.

### Cellular Microscopy:

The microscopy unit offers transmitted & fluorescence wide field microscopes, high speed & high resolution laser scanning confocals and high throughput automated fluorescence digital scanner and live cell imaging systems. These technologies enable the visualization and digitization of molecules, proteins, and organelles in live cells, fixed 3D matrices, tissues. We offer short or long-term live cell time-lapse imaging systems, and high-resolution large-scale whole slide imaging. Among the feasible applications are protein expression, protein co-localization, tube formation, wound healing, cell population interactions, calcium imaging, FRAP, FRET, photo activation, and more. For more information and image gallery please enter our site.

Our services have expanded to two new units: 1. Histopathology unit for automated paraffin and cryo section slide preparation (Leica equipment) 2. Electron Microscopy (EM) biological specimen preparation unit.

*In vivo* Imaging Unit:

The *in vivo* imaging unit provides an optical high throughput imaging system for tumor progression screening with fluorescence and bioluminescence detection, IVIS 200, a fluorescence stereoscope for ex-vivo metastasis imaging, a high-resolution micro-ultrasound system (US), Vevo-2100, equipped with acquisition modules suitable for vascular, cancer, contrast agent application, high resolution cardiac US imaging and US guided injection. We run an *in vivo* NMR analyzer, providing *in vivo* fat/lean ratio suitable for brain, diabetes, behavioral research, an Aspect 1T MRI system suitable for 2D & 3D whole body anatomical imaging, matrix implants, tumor and metastasis progression (lung, brain, spinal cord, and pancreas), contrast agent applications, histology ex vivo MR imaging. Our 9.4T Bruker high-resolution functional MRI system is suitable for functional kidney imaging, functional 3D cardiac imaging, functional brain imaging, high resolution brain anatomy and diffusion tensor imaging (DTI).

Our *in vivo* imaging unit is a unique research platform enabling multimodality imaging, data co-registration, and combination with behavioral studies.

Computational Image Analysis Unit:

We strive to advance research by developing quantitative image analysis methods for multimodality imaging applications in multiple research areas. Additionally, our mission is to familiarize our medical and engineering students with image analysis methodologies to provide image-based quantitative analysis services for both clinical and basic research using advanced computer-aided methods.

Our unit is equipped with advanced image analysis software: Imaris 8.3, AutoQuant Deconvolution, Zeiss ZEN, Image Pro Premier 9.2, FIJI, Photoshop, Living image, and a custom made MRI tool. We provide data visualization, rendering, deconvolution, segmentation, quantitative data analysis, including phase contrast image analysis for wound healing, tube formation, immunochemistry, big data analysis, data co alignment and co registration, cellular component relationships, personalized image analysis solutions, including macro, batch and GUI software programming. For more information and image gallery please enter our site.

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***http://bcf.technion.ac.il/genomics***

## Genomics Center:

The Genomics Center is headed by Dr. Liat Linde, and provides cutting-edge technologies and applications. We have been supporting research along the entire project trajectory, from initial experimental design through high-quality experimentation and finally customized data analysis. Our service is comprehensive, reliable and attentive manner. Our team is comprised of highly trained and experienced scientists, experts in all aspects of genomic analysis and bioinformatics. We aim to function as one stop shop offering user-friendly and personalized genomic solutions to our ever growing clientele. We can deal with large-scale projects with hundreds of samples, as well as small highly-tailored projects with a few samples. In addition to our in-house comprehensive technologies, we work closely with you and can direct you to the very best affiliated facilities for all your needs. Among our customers are several pharmaceutical and biotech companies from across the country.

### Next Generation Sequencing:

The Genomics Center offers next generation sequencing (NGS) application in large-scale and small-scale. Every new project starts with a kick-off meeting where research question is clarified, bioinformatics data analysis pipeline suggested, and statistical analysis tools proposed. Using our extensive genomics knowhow we offer an assortment of solutions, from basic to cutting-edge projects, using tools from the public domain as well as in-house customized scripts. We also offer meaningful interpretation of gene lists using several tools such as Ingenuity Pathway Analysis (IPA), FGNet and iPathwayGuide. Here comes a list of different types of analyses we can perform, among others:

- Gene expression, microRNA and alternative RNA splicing profile (RNAseq)
- Single base and structural variant detection (DNAseq, exome sequencing)
- Low frequency variant detection (Cancer samples)
- DNA methylation profile (Bisulfite DNAseq)
- Identification of novel transcripts (De-novo RNAseq assembly)
- 16S rRNA profiling (Microbiome sequencing)
- DNA-protein interaction analysis (ChIP-seq and more)
- RNA-protein interaction analysis (RIP-seq, CLIP, etc.)
- DNA conformation profile (Hi-C, ATAC-seq, etc.)

CRISPR Genome Editing:
The center offers CRISPR knockout in mammalian cells (using the NEPA21 Electroporator), in two modes of service:

- Full- from design step to knockout cells. At the end we will provide two freeze vials of knockout clone.
- Consultation- includes sgRNA and primers' design together with guidance along the process (PCR for screening, Sanger) and reagents for start. It is for researchers who wish to perform CRISPR in their own lab.

Gene Expression:
The center offers a range of gene expression platforms from whole genome expression profile by illumina, through 48/96 transcripts format by Fluidigm, to single transcripts by qPCR.

SNP and CNV:
The center offers detection of SNPs and copy number variations (CNVs) using Illumina BeadChips for human and agriculture products. Additionally, more focus formats for validation and screening are available, either at 48-96 SNPs format (Fluidigim BioMark HD) or less (Ion Torrent PGM).

DNA methylation:
The center offers the Illumina EPIC Methylation panel which allows researchers to interrogate over 850K methylation sites quantitatively across the genome at single-nucleotide resolution. Additionally we offer amplicon based focused formats using the Ion Torrent PGM technology.

Real Time PCR:
The center offers large scale PCR reactions with high sensitivity, single cell gene expression and digital PCR (dPCR) which is useful for absolute quantification and rare allele detection.

Human cell line authentication:
The center offers human cell lines authentication to ensure that you are working with the correct cell line.

Sanger sequencing:
The center offers Sanger for long contiguous DNA sequences (~900 nucleotides). We perform hundreds of Sanger sequencings each day, and provide the results within two working days. We perform QC for all reactions before uploading the results.

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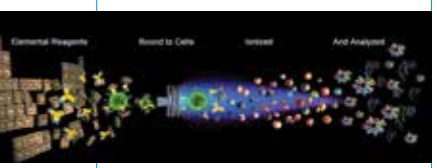
***http://bcf.technion.ac.il/flow-cytometry***



DNA/RNA extraction:
The center offers automated purification of DNA and RNA on the QIAcube from cells and tissues. Protocols are available for a wide range of organisms such as cells and tissues of human and other animals, plant, yeast, bacteria and cyanobacteria.

DNA/RNA quality and quantity:
The center offers TapeStation automated electrophoresis to determine the quality of DNA or RNA sample. In addition, we offer several methods for determining nucleotides acid concentration, such as Qubit Fluorometer, Picogreen dye. Quality and precise quantity of DNA and RNA are essential factors in the success of genomic protocols.

## Flow and Mass Cytometry Center:

The Flow and Mass Cytometry Center is headed by Dr. Amir Grau, and is dedicated to provide a suite of services for state-of-the-art flow and mass cytometry. Our expert team will support your research with experiment design, instrument operation, data analysis, interpretation and in developing of novel cytometry-based techniques.

Fluorescence Activated Cell Sorting:
We operate four advanced cell analyzers:

- A 16 channels Stratedigm S1000EXi High Throughput System (HTS) with four lasers, including a 561 laser line
- A 16 channels BD LSR Fortessa with four lasers, including a UV laser line
- A 11 channels Dako CyAN ADP with three lasers
- A 4 channels BD FACS Calibur with two lasers

All parameters measured at a single cell level. Over the years our team has developed expertise in various assays, including polychromatic staining, functional assays, phospho-flow, multiplexing samples, rare event detection, and small particle analysis.

For cell sorting, we offer:

- A 14 channels BD FACSAria IIIu Cell Sorter with five lasers, including near-UV and Yellow/Green lasers.

We provide expertise in rapid enrichment sorting, precision sorting and single cell sorting into 96-384 well plates.

Mass Cytometry:
The Cytometry Center operates Israel's first mass cytometry instrument – the CyTOF – which can measure up to 100 parameters on every cell by using antibodies (as in FACS) labeled with metal isotopes. Mass cytometry allows ground-breaking science for discovery, diagnostics, and high-throughput screening. To support researcher, we have established a metal-conjugated antibody bank consisting of about 380 antibodies against mouse or human. Our team will be happy to introduce you to the technology and its utility for your R&D.

MAGPIX Multiplex Reader:
We can support your research with our magnetic bead–based immunoassays MAGPIX reader that measures up to 50 analytes per sample in a single reaction volume. This multiplex reader is capable of both qualitatively and quantitatively analyze proteins, including phosphoproteins, and nucleic acids in a variety of samples in a simple and convenient ELISA-like workflow.

## Preclinical Research Authority:

For the last three decades the Experimental Surgery and Laboratory Animal Unit, or in its current name, the Preclinical Research Authority has been a leading research facility, supplying quality preclinical study services to leading biomedical and start-up companies, and providing a superior platform for academic research.

Our main expertise lies in preclinical study design and conduction of efficacy and safety studies. Over years of activity we have acquired experience in product development studies, and servicing leading and pioneering researchers and companies in fields of cardiology, invasive cardiology, cardiovascular surgery, orthopedics, orthodontics, gastroenterology, obstetrics, and imaging. Expertise gained through years of research, combined with constant input in structure and equipment, enables conduction of top quality animal studies in our unit.

### Advanced research environment and up-to-date medical equipment:

Digital Fluoroscopic machines ➲ X-ray ➲ Echocardiography ➲ ICUS ➲ IVUS ➲ Endoscopy and Laparoscopy platform ➲ By-pass machine ➲ Orthopedics equipment ➲ Microsurgery tools ➲ In-house laboratory including blood gas analysis, CBC, and ACT ➲ Availability of CT and MRI screening

***http://pcra.technion.ac.il/en/Homepage***

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## Animal Enrollment:

All animals are obtained from approved suppliers, and are recruited after health screening. A period of acclimatization or isolation and animal preparation is mandatory for all participating animals.

- In-house recovery and hospitalization
- Long term maintenance, at a secluded farm under PCRA supervision
- Full monitoring and record-keeping
- Conduction of all studies requires the approval of the Technion Institutional Animal Care and Use Committee, and is carried out in strict compliance with international guidelines.

## Facility Description:

Two buildings one at the upper campus and the other at the faculty of medicine comprise a total of 3500sqm including 2 SPF rodent facilities, NONSPF rodent rooms, a biohazard ward, PDX section, rodent imaging area, five large animal surgery rooms, a large animal section, and a service area.

The SPF rodent section is a self-contained section of the Unit with animal maintenance and isolation rooms, and has its own separate service area and surgery room. Animals are maintained in individually ventilated cages (IVCs), and rooms are equipped with laminar flow work stations. Isolation rules apply to this section, and it has separate entrance and exits. All rooms have air filtration, and positive air pressure gradient is maintained and monitored. Access is restricted to authorized researchers, and dedicated personnel are assigned specifically to this section in order to ensure strict separation from the rest of the unit.

The Multidisciplinary Laboratories of the Bruce Rappaport Faculty of Medicine and those of Life Sciences in the main campus offer advanced imaging equipment:

MRI 9T ➔ MRI1T ➔ Micro US-Vevo 2100 (Visualsonics) ➔ IVIS 200 ➔ NMR ➔ Stereoscopes ➔ Fluorescent Stereoscope ➔ Laser Doppler - Moor Inst

The large animal surgery section comprises five modern, fully-equipped surgery rooms and an X-ray room located together in an isolated area. All rooms are equipped with anesthetic machines and PP ventilators, monitoring equipment, ceiling-mounted surgery lights, and central gas supply and evacuation systems. The rooms have air filtration by Hepa-filters, and positive air pressure is maintained and monitored. All rooms, doors and windows are x-ray shielded.

Technion Integrated Cancer Center

***http://ticc.technion.ac.il***

Contact

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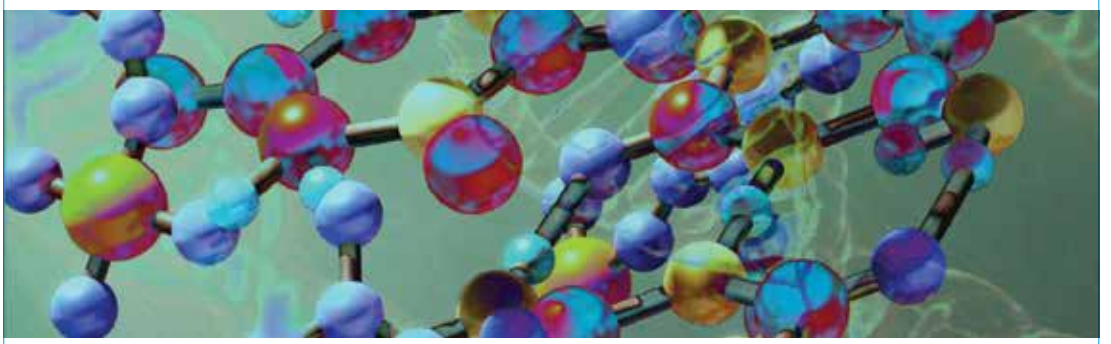
## Technion Integrated Cancer Center (TICC):

Cancer is a collection of complex diseases and is the leading cause of death in the Western world. Whereas some cancers have been partially defeated, mostly due to early diagnosis and the development of novel therapeutic modalities, others have become more common and more aggressive. Cancer originally stems from a mutated normal cell, but in the course of treatment, many more mutations develop that make the tumor more aggressive and resistant to treatment.

From being initially isolated, the tumor soon develops a symbiotic network between the cancer cells and the surrounding normal tissue. In order to sustain itself and grow, a tumor must continuously recruit new capillary blood vessels. These abnormal blood vessels have malignant characteristics and, in addition to providing nourishment to the cancerous cells, serve as a gateway for tumor cells to enter the circulation and disseminate as metastases to distant sites.

The Technion has established the Technion Integrative Cancer Center (TICC) to enable interdisciplinary teams of doctors and scientists – including clinicians/oncologists, protein chemists, structural biologists, organic synthetic chemists, computational chemists, bioinformaticists and data set analysts – to collaborate with engineers from a variety of disciplines on developing sensitive diagnostic sensors to diagnose the disease at an early, treatable stage, and creating guiding devices to selectively carry drugs to the disease site. TICC will combine basic discovery with clinical research, leveraging the Technion's expertise and resources to carry out clinical and translational research, culminating in clinical trials. As an integrative comprehensive cancer center, TICC will exploit the Technion's unique strengths and bring together interdisciplinary teams of leading doctors and scientists to work together to combat cancer.

The TICC cores (which will include Histopathology; Chemical Genomics & Drug Discovery; Imaging; Genomics / Epigenetics / Bioinformatics; Personalized Medicine; Single Cell Tumor Heterogeneity) will coordinate the efforts of outstanding researchers and fully exploit the interdisciplinary nature of TICC.



## About the TICC:

Battling cancer begins with the understanding that the disease is driven by a combination of genetic and epigenetic changes; the latter dynamic modifications are part of cancer's adaptation to the microenvironment and response to therapy. Breast or prostate cancer tumor cells, for example, not only differ from patient to patient, but also differ within the tumor of an individual patient. This makes the therapeutic approach especially challenging, requiring a multidisciplinary approach to developing diagnostic and therapeutic modalities.

To address unmet clinical needs, drive new discoveries, and evaluate future medicines requires the concerted, focused efforts of experts from areas such as biology, chemistry, physics, engineering and computer science, working together with oncologists.

The Technion is ideally positioned to pursue multidisciplinary cancer research because it has all three of the essential elements necessary for success: basic research (the Rappaport Faculty of Medicine); clinical and translational research, along with clinical trials (the Rambam Health Care Campus and four other hospitals affiliated with the Technion); and strong science- and engineering-based faculties on the main campus. The vision of the TICC is to combine basic discovery with clinical research, leveraging the Technion's expert facilities and resources to create an integrative comprehensive cancer center.

The Technion is the only institute in Israel with expertise in the diverse disciplines required to conduct both modern cancer research and clinically oriented work. The Technion's strong Faculties of Chemistry, Mathematics, Materials Science & Engineering, and Biology, as well as the Russell Berrie Nanotechnology Institute, are renowned for their innovation in computational analysis of complex networks operating in cancer cells, and for development of new drugs using advanced chemistry. Technion researchers in the fields of materials science and nanotechnology have made significant advances in formulating new drugs and devising ways to deliver them to tumor sites.

As part of TICC, the Technion is establishing a basic drug discovery unit in the Rappaport Faculty of Medicine. This unit, which will be the heart of TICC, is where new targets of future medicines, unidentified biomarkers for prevention or diagnosis of tumor growth, unknown paradigms of cancer development, and novel therapies will be discovered. These discoveries will be advanced in preclinical studies via collaborative projects among experts working in the specialized departments mentioned above.

A crucial part of TICC consists of a network of five hospitals affiliated with the Technion. Those include facilities in Hadera in the south and Afula in the north, plus three additional hospitals in Haifa. (The Rambam Health Care Campus is located just across the street from the Rappaport Faculty of Medicine, making such collaborations particularly efficient.) This network covers the northern half of Israel, consists of

3,500 beds, and treats 2 million patients. It will not only provide a valuable resource of human tissue samples for assessment in TICC laboratories, but also the infrastructure essential to carry out clinical trials driven by TICC discoveries.

## TICC Mission:

Despite recent advances in cancer therapy, with targeted therapies becoming more prevalent and immune-based therapies paving new roads for prolonged tumor-free survival, there is still no solution to some of the most critical problems in today's cancer therapy.

The TICC will focus on these unmet clinical needs in order to deepen our understanding of cancer biology, the complexity inherent in tumor heterogeneity and plasticity, the propensity of tumors to metastasize, and tumors' ability to establish resistance to targeted therapies.

TICC will be equally positioned to address fundamental processes now recognized as underlying the promotion (advancement) of cancer, including obesity, inflammation, diabetes and related metabolic stress syndromes. These processes implicitly affect the gut microbiome and the immune system, and consequently, the tumor microenvironment, with direct implications for tumor dormancy. TICC will address each of these unmet clinical needs by establishing a critical mass of leading scientists with complementary expertise, thereby allowing interdisciplinary collaborations, cross fertilization and the advancement of research toward treatments.

## TICC Goals:

- Establishing multidisciplinary, state-of-the-art laboratories for basic cancer research
- Translating basic discoveries into new medicines
- Developing clinical trials of translational discoveries at one of five Technion-affiliated medical centers (Rambam, Carmel and Bnei Zion Medical Centers in Haifa; the Emek Medical Center in Afula; and Hillel Yafe Medical Center in Hadera)
- Training the next generation of physicians and scientists
- Advancing outreach, education and cancer control programs

## Leadership:

TICC will expand on existing expertise at the Rappaport Faculty of Medicine and the main campus to address each of the major subjects highlighted in our critical "unmet clinical needs" diagram. Our existing expertise in biochemistry, led by TICC Co-director and Nobel Laureate, Distinguished Professor Aaron Ciechanover, will be augmented by cell biologists and signaling experts who use genetic models to address problems associated with metabolic stress, tumor dormancy, tumor metastasis and resistance to therapy.

Prof. Ze'ev Ronai, a world-renowned expert in cancer biology and signal transduction pathways, has been recruited as the Co-director to lead the TICC, along with Prof. Ciechanover. Prof. Ronai has studied fundamental mechanisms underlying tumor adaptation to stress, including metabolic stress, which are often seen in response to therapies and harsh micro-environmental conditions, such as a low level of oxygen (hypoxia).

## Scientific Focus:

The leadership of Prof. Ciechanover and Prof. Ronai has enabled the Technion to recruit Prof. Eyal Gottlieb, a world leader in the field of metabolism, to the Rappaport Faculty of Medicine. Prof. Gottlieb brings critical expertise that has already become fundamental in understanding important aspects underlying tumor ability to reorganize metabolic networks to enable its sustained growth and metastatic potential, as well as resistance to therapy.

Additional leaders will be identified and recruited to enable support of the key components listed in the matrix. These include experimental and system biology experts who study tumor heterogeneity and its propensity to adapt to different growth conditions (also appreciated as tumor cell plasticity), experts in analysis at the single cell level, and experts with extensive computational ability in complex networks.

Likewise, TICC will be making efforts to identify experts in the tumor microenvironment who use advanced genetic models, which will allow TICC to integrate tumor-stroma interactions, cross-talk with the immune system and the effects of the physiological environment, including that of hypoxia.

A key component in TICC's ability to develop tomorrow's medicines is the establishment of a robust drug discovery program and the development of a pipeline. This will be accomplished through the recruitment of expert(s) in structural biology and medicinal chemistry, who are experienced in developing and performing screens for small molecule inhibitors in cell-based phenotypic assays. This expertise will enable the translation of TICC's fundamental discoveries at the level of small molecules that will be evaluated as candidates for preclinical and clinical trials.

# PHYSICS

***http://phys.technion.ac.il/en***

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During the first 30 years of its existence, the Technion had no separate science departments, although a basic education in physics was considered important, and was included in the curriculum of the Technion from the outset. In 1948 after the War of Independence the Technion started expanding, and in 1952 a Faculty of Science was established. A Department of Physics was formed as a part of the Faculty. The first Department chairman was Prof. Nathan Rosen, Einstein's last assistant.

The first class of six students graduated in 1956. Since then the Faculty has kept growing, and today maintains a vigorous research program in all the major fields of physics, including astrophysics, high-energy physics, condensed matter physics, and biophysics. Research programs in experimental physics include high energy physics, bioelectronics, plasma physics, semiconductors and quantum structures, nonlinear optics, magnetism, and superconductivity.

The Faculty has a strong teaching program both at the undergraduate and graduate levels. Along with the regular undergraduate program in Physics, the Faculty currently emphasizes the development of interdisciplinary undergraduate programs. These programs lead to a double degree in Physics and in Electrical Engineering, Physics and Materials Engineering, Physics and Mathematics.

The Faculty also has a joint program with Mechanical Engineering for Opto-Mechanics. The graduate program offers both courses and thesis research projects in all the above-mentioned subjects. Over the years the Faculty's graduates have taken leading positions both in industry and in academic institutions, and they continue to be in strong demand.

The Faculty has been responsible for teaching physics to all Technion students. Approximately 4,000 students from all departments take physics courses each semester. Due to this fact, the Faculty of Physics has a great advantage, as almost every student in the Technion goes through our Faculty, thus giving us full access to them all.

The Faculty of Physics is all about research. Nevertheless, we are dedicated to interfacing with the world of industry, and we see the importance and strength of the connection between both worlds. We do our best to give our students the knowledge and tools that they need to advance in both the research and industrial sectors. Our main goal is to further enhance the mutual contribution and benefit of both sides.

## Research Areas:

Astrophysics and General Relativity ➲ Atomic and Molecular Physics ➲ Biophysics and Non-Equilibrium Statistical Mechanics ➲ Condensed Matter and Materials Physics ➲ High-Energy Physics ➲ Mathematical Physics ➲ Nanoscience and Nanotechnology ➲ Non-linear Optics ➲ Plasma Physics

## Research Groups:

Astrophysics ➲ Atomic Physics ➲ Computational Physics ➲ Electron Spectroscopy ➲ Extreme Nonlinear Optics Group ➲ Experimental High Energy Group ➲ Magnetism ➲ Optics ➲ Plasma Physics ➲ String Theory ➲ Theoretical Particle Physics

***http://phys.technion.ac.il/en/research/research-groups***

List of people by research topic can be found in:

***http://phys.technion.ac.il/en/people/by-topic***

## Physics Industrial Affiliates Program:

### Research and Development:

- Professional interaction with Faculty researchers
- Departmental colloquia
- Joint projects: with research centers and laboratories
- Sponsoring laboratory sets/experiments/equipment

### Teaching:

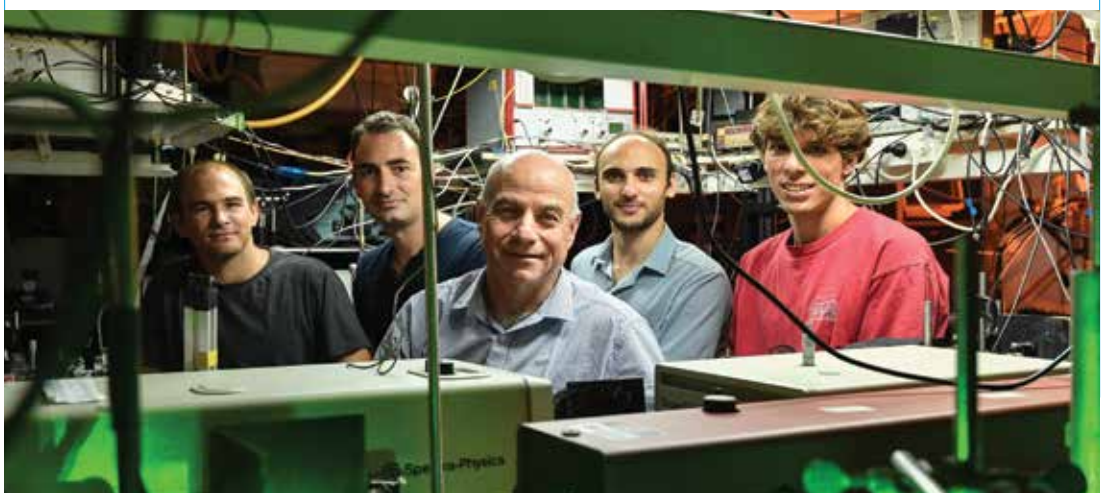
- Workshops, seminars and guest lectures: presented in the Faculty by representatives of suitable companies
- Mini courses, seminars, summer courses and professional graduate programs: presented in the Faculty by Faculty researchers to company employees, and vice versa

### Human Resources:

- Recruiting day: company recruitment events: company's R&D fields and technology
- Announcements via professional conferences, seminars, awards, scholarships, and recruiting days

### Public Relations and Advertising:

- Increasing a company's visibility: company's name and logo presentation at the Faculty Academia Industry Affiliates program web page linked from the Faculty official website
- Classified ads distribution by direct mailing, faculty website and bulletin boards; Sponsorship opportunity for alumni conferences, seminars, competitions, projects, etc
- Advertising company's activities/events: Faculty monthly newsletter, Faculty website, bulletin boards to staff and students
- Sponsoring academic contest for graduate/undergraduate students



# SERVICE UNITS

# RUSSELL BERRIE NANOPARTICLES AND NANOMETRIC SYSTEMS CHARACTERIZATION (NNSCC)

***http://nnscc.net.technion.ac.il***

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The Russell Berrie nanoparticles thermal and mechanical characterization center was established by the Russell Berrie Nanotechnology Institute, in the Faculty of Biotechnology & Food engineering. This center was founded in order to provide accessibility and support for variety of facilities and techniques for Nanoparticles and Nano systems and for thermal and mechanical properties of complex system.

This center is aimed to serve the Technion users as well as other academic or industrial users.

## Facilities:

### Spectroscopy:

The center is equipped with a FluoroLog 3-22 Spectrofluorometer that provides fluorescence measurements with very high sensitivity, allowing the detection of very low intensities of fluorescence. Moreover it can scan samples in a very fast way.

A unique 3D capability enables scanning of both excitation and emission spectra for locating optimal fluorescent response wavelengths.

## Nanostructure Analysis:

### Atomic Force Microscope (AFM):

The NanoWizard® II BioAFM measures topography with nanometric resolution. Other sample characteristics originating from probe-surface interactions, are acquired simultaneously with the topography in the different imaging modes, and are demonstrated as images. This AFM is also able to perform measurements in a controlled liquid environment (flow, temperature), which can be critical for living cell experiments. Measurements can be made in the temperature range from 0 to 100°C.

### X-ray Diffraction (XRD):

X-ray diffraction (XRD) is a non-destructive experimental technique aimed for all kinds of matter—ranging from fluids, to powders and crystals. This type of technique provide advanced, versatile, and cost-effective diffraction solutions for wide range of users from research, development, and quality control.

XRD is a scientific tool used in order to identify the atomic and molecular arrangement of crystalline molecules within the crystal structure. This molecular arrangement is determined by measuring the diffraction pattern obtained after the interaction of x-ray beam with a crystal structure. By measuring the diffraction angles and intensities, one can determine the mean positions of the atoms in the crystal.

The Russell Berrie Nanoparticles and Nanometric Systems Characterization Center is equipped with Rigaku SmartLab 3kW diffractometer instrument. The Rikagu SmartLab high-resolution diffraction system represents the state of the art x-ray diffraction instrument with fully automated modular systems. The system incorporates a high-resolution theta/theta closed loop goniometer drive system, cross beam optics (CBO), a 3.0 kW sealed tube anode generator, and D/tex Ultra 250 1D silicon strip detector. The instrument optical systems are fully automated thus providing advance measuring ability for both expert and novice users.

Our instrument is equipped with an Anton Paar TTK 450 mid-low temperature chamber providing sample cooling and heating in the range of -193°C to 450°C using liquid nitrogen. Such apparatus offers large temperature range and ease of use for a wide range of applications for liquid to solid materials. Vacuum ($10^{-2}$ mbar) conditions could also be used in this setup.

## Nanotechnology:

Particle size analyzer based on the laser diffraction technique:
The center is equipped with a new Mastersizer 3000 (Malvern Instruments Ltd) that provides particle size distribution in the range of 10 nm to 3.5 mm. This instrument is working using Hydro MV sample dispersion unit that is a fully automated for medium volume wet sample dispersion unit.

Particle size analyzer based on dynamic light scattering DLS:
We operate Vasco (Cordouan) that can be used to determine particle size distribution in the range of few nanometers to few microns in relatively concentrated solutions, in Dark/Opaque dispersions/emulsions, up to 40%V solids (and even more as long as we have Brownian Motion) with no need of dilution. Setting sample temperature 15°C-70°C. The sample volume is only ~75µl and the system has no consumables.

## Mechanical Properties:

EZ Series EZ50 Universal Materials Testing Machine LLOYD INSTRUMENTS:
This instrument is used to characterize the mechanical properties of materials, include fixtures for different tests (tension, compression, bending, fracture) load cells (1kN, 50 kN), and extensometers.

TA - HR-2 Discovery Hybrid Rheometer:
In this instrument rheological characterization can be performed on a wide variety of materials including polymer melts, soft solids, suspensions and emulsions. The HR-2 model is capable of applying torques range of 2 mNm to 200 mNm , high angular velocity up to 300rad/s, and normal force up to 50N. The HR-2 It includes popular patented Smart Swap® geometries, a new TRIOS Software for performing Flow, Step Transient (Creep and Stress Relaxation), and Oscillation experiments.

The system is equipped with DHR Electrically Heated Plate System (EHP) that provides active heating and cooling rate of parallel plate and cone and plate geometries up to 30°C/min and maximum temperature of 400°C.

## Thermal Analysis:

### Thermogravimetric Analysis (TGA):

We use in our center thermal gravimetric analyzer (Q5000 IR, TA Instruments). It provides superior temperature resolution of thermal events. By analyzing the weight changes in a material as a function of temperature (or time) under a controlled atmosphere of N2. It can be used to understand the thermal stability and composition up to 1000°C, (Top of specification: auto sampler – 25 sample Included ,weight Range 100 mg, Sensitivity < 0.1 µg Linear Heating Rate (°C/min) 0.1 to 500).

### Differential Scanning Calorimetry (DSC):

Measures the heat flow associated with phase transitions or reactions, such as melting, crystallization, solid phase transition, glass transition, curing, sorption, etc. We have HP-DSC 1 Mettler which can use both as a regular DSC and as a high pressure DSC. The high-pressure DSC cell is based on the successful Thermal Analysis DSC 1 technology and guarantees outstanding performance thanks to its FRS5 and HSS7 DSC sensors. The HP DSC 1 operates at overpressures from 0 to 10 MPa and from room temperature up to 700°C.

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# FERMENTATION AND PROTEIN PURIFICATION CENTER

The fermentation and protein purification center is located, in the Faculty of Biotechnology & Food engineering. The center provides aerobic and anaerobic fermentation facilities for up to 75 liter, anaerobic chamber and downstream processing for protein purification including continuous flow centrifugation, cell homogenizers and several FPLC chromatography systems.

## Bioreactors:

### BioEngineering 75 liter:

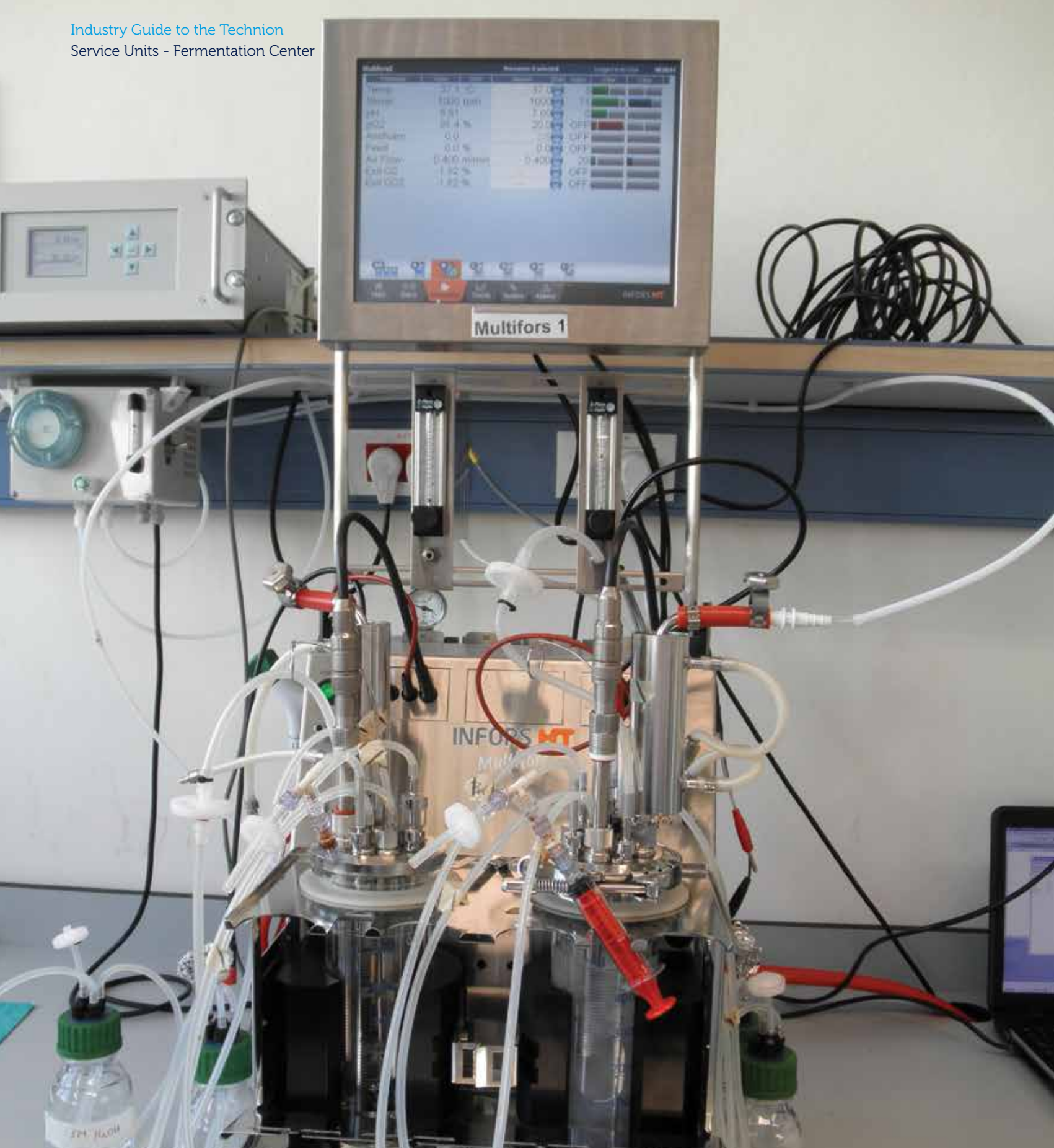
The fermenter system consists of 75 liters (working volume), pre-assembled unit, control cabinet mounted on a stainless steel frame, supplied with all necessary piping, valves. The system is fully suitable for inline CIP and SIP.

### UD 50 liter fermenter:

The system includes pH and $O_2$ electrodes, antifoam level controller.

### Solaris M series 30.0:

The system consists of 30 liters fermenter (working volume), pre-assembled unit, control cabinet mounted on a stainless steel frame, supplied with all necessary piping, valves and instruments, automation, control panel (HMI). The system is designed for aerobic and anaerobic fermentations, closed aseptic operations. The skid hold all the piping and all utilities need to be connected at one point of the skid. The control is based on a PLC-SCADA control system.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## Anaerobic Hood:

The Coy Vinyl Anaerobic Chambers provide a strict anaerobic atmosphere of 0-5 parts per million (ppm) using a palladium catalyst and hydrogen gas mix of 5%. The heavy duty vacuum airlock allows sample transfer without changes to the internal atmosphere.

## Cell Homogenizers:

The Micro DeBEE laboratory homogenizer is an air powered unit with a capacity of 15 liters per hour. This instrument is suitable for a broad range of applications  such as cell disruption, particle size reduction, nano/mico emulsions and dispersions.

### EmulsiFlex®-C3 Avestin:

A high pressure pump pushes the product through an adjustable homogenizing valve. The product can also be passed through a membrane. It can be collected or recycled to the reservoir via tubing/ pipes or heat exchanger.

### Continuous flow centrifugation:

The CEPA high-speed centrifuge Z41 is widely used in a variety of biological processes from cell harvesting and clarifying to separations of chemicals, foods, blood and pharmaceuticals. High performance is consistently achieved in continuous, semi-continuous or batch operations. Ruggedly built the centrifuge provide an efficient, cost-effective technology for research through production applications. The CEPA Z41 centrifuges efficiently separate from 1-200 liters of biological cultures and other mixtures.

## Fast Protein Liquid Chromatography Avant/Explorer/Basic/Start:

The center has several ÄKTA chromatography systems that can handle simple and complex protein purification methods in different scales, accelerating daily routines. In addtion or easy-to-use chromatography system that automates manual purification procedures using for example HiTrap columns. All systems are controlled by UNICORN, a common software platform that guides users through different purification scales and applications.

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# ISRAEL INSTITUTE OF METALS (IIM)

The Israel Institute of Metals is a research institute operating under the Technion umbrella in full cooperation with the scientists and researchers of the Technion. The Institute was founded in 1963 to serve as a bridge between the academic community of the Technion and traditional Israeli industry. The Institute leads in engineering, scientific, and technological innovations. Its activities include the industrial application of advanced capabilities stemming from cutting-edge technology. In order to fulfill its mission, the Institute is involved in national and international research activities, as well as cooperating with leading global research institutions in bilateral and multilateral research frameworks.

The Institute's researchers are served by the wide range of the Technion's laboratories and state-of-the-art facilities.

In order to provide efficient coverage of metals-related issues, the Institute operates the following professional laboratories:

- Additive Manufacturing (3-D Printing) Laboratory
- Metallurgical Engineering and Powder Technology
- Foundry Technology
- Corrosion Prevention, Surface Treatment, and Laser Technology

The Institute is certified under ISO 17020 (Inspection Activity) and ISO 17025 (Testing Laboratory), and is well known for its highly professional staff and operation.

### Metals Additive Manufacturing (3-D Printing) Center:

Additive manufacturing (AM) technology is an innovative field that has come to be known as the "third industrial revolution". The technology enables the production of components with complex geometry and high mechanical properties. This technology is predicted to become an integral part of research and production in aerospace and healthcare industries.

Metallurgical Engineering
**Dr. Jean Ramon**
Head of Metallurgical Laboratory
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Two types of additive manufacturing systems are used in our center:

- Electron Beam Melting system, utilizing high power electron beam that generates the energy needed for melting of metals from Aluminum up to Tungsten
- Laser Melting system, manipulating high power laser beam for high capacity production

The AM laboratory is well connected to both leading industries and R&D entities. This allows the laboratory to stand at forefront of industrialization and development in this area in Israel. Surrounded by the Technion's and the IIM's facilities and expertise, the AM lab is not only utilizing its own technological advantage but also preforms developments of AM complementary technologies such as surface polishing, ISO approved mechanical testing, alloy composition adaptation, corrosion tests and biological integration.

## Metallurgical Laboratory:

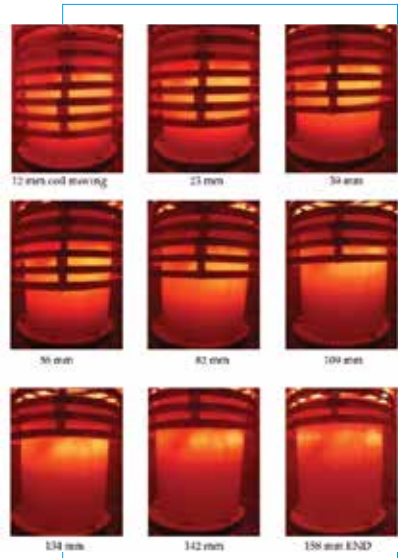
The Metallurgical Laboratory is intimately linked to industrial development projects, as well as trouble-shooting and failure analyses. Its excellent reputation stems from a continuous creation of innovative applications and meticulous routine work.

The Laboratory usually handles three or four major long-term projects concurrently, lasting 1 to 2 years. The laboratory addresses a wide range of topics, generating innovative technological research results. The team works in a highly collaborative manner, with all staff members being involved.

Being an ISO/EURO 17025 accredited laboratory is evidenced in all operations, including an orderly decision-making process, and clear development status reporting. Laboratory equipment is continuously tested and certified to leading national and international testing standards.

### Mechanical properties testing:

- Tensile, bend and compressive testing at room and elevated temperatures
- Fatigue endurance testing of materials and end/final products/implants
- Fracture toughness K1c and J-integral testing
- Impact test at room and low temperatures



Foundry Technology
**Dr. Alex Fleisher**
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## Materials characterization:

- Hardness measurement: HRC, HRB, HRA, HRV, Brinell, micro Vickers and Knoop methods
- Scanning electron microscopy (SEM) and EDS characterization
- Coefficient of thermal expansion measurement
- Surface roughness measurement
- Glow discharge optical emission spectrometry
- Thermal conductivity measurements
- X-ray diffraction
- High resolution scanning electron microscopy (HRSEM)
- Fracture expertise: fractographic analysis

## Technological expertise:

- Materials choice and selection, choice and tailoring of surface treatments, and manufacturability counseling
- The lab is accredited according to ISO 14801 for fatigue testing of dental implants

## Foundry Technology Laboratory:

The Foundry laboratory has accumulated expertise in the field casting and processing of advanced materials (metals, MMC, CMC, nanoparticles composites, amorphous metals). The Laboratory staff carries out numerous industrial R&D projects including national and international projects (as FP7 "THERMACO", H2020 "NOVAMAG", bilateral and direct funding projects).

## Fields of Activity:

Development of new Ferrous and non-ferrous casting processes ➔ Magnesium and Aluminum alloys processing and applications ➔ Metal Matrices Composites (MMCs) and improved properties by reinforcements with Nano and micro particles ➔ Thermal management of castings by implementation of MMC inserts in castings ➔ Ceramic Matrix Composites (CMC) ➔ Integration of steel/copper inserts into aluminum HPDCparts ➔ Integration of metal foam inserts into HPDC parts ➔ Refractory High entropy alloys and Ni-base superalloys ➔ Micro-alloying of Iron and Steels ➔ Rapid solidification by melt spinning (amorphous and Nano-structures) ➔ Low cost refining processes of Metallurgical Grade Silicon for Solar Grade Silicon production ➔ Permanent magnets ➔ Recycling of metals

Corrosion Prevention
**Eng. Daniel Safranchik**
Head of the Corrosion Prevention, Surface Treatment, and Laser Technology Laboratory
danis@trdf.technion.ac.il


### Semi-industrial on-site facilities:

High-vacuum unidirectional solidification casting machine, Semi-industrial press for hot and cold sintering, pressing, extrusion, drawing, etc., Die-casting/ sand-casting/investment casting/permanent-mold casting machines, Low-pressure and vacuum-casting machine, Melting/ induction/electrical resistance furnaces, Melting under protective atmosphere, Heat treatment with protective atmosphere or vacuum, Semi-solid casting machines, Powder injection molding machines, Melt-spinning technology.

### Analytical Equipment:

Optical Emission Spectrometer (OES), X-Ray Diffractometer (XRD), Scanning Electron Microscope, including high resolution (SEM/HRSEM), Transmission Electron microscope, including high resolution (TEM/HRTEM), Differential Scanning Calorimeter (DSC), Thermal Gravimetric Analyzer (TGA).

## Corrosion Prevention, Surface Treatment and Laser Technology Laboratory:

The Corrosion Prevention, Surface Treatment and Laser Technology Laboratory has accumulated many years of experience in the field of corrosion prevention and surface treatment of materials, especially metals and metal matrix composites (MMC's). The laboratory has the metallurgical facilities needed to deal with industrial challenges. The staff comprises a group of highly-qualified specialists with wide scientific and technological knowledge.

### Main Fields of Activity:

Corrosion testing and prevention, including corrosion failure analysis ➲ Corrosion measurements and tests ➲ Electrochemical corrosion measurements ➲ Development of coolants ➲ Surface treatment including electroless coating deposition and electrodeposition of metal alloys and metal/particle composite coatings ➲ Electrophoretic deposition for the formation of ceramic coatings ➲ Electropolishing ➲ Conversion coatings ➲ Laser Technology: including laser surface treatment (hardening, texturizing, etc.), laser welding, laser cladding ➲ Corrosion tests for medical devices according to ASTM standards.

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Facilities:

Electrochemical measurement systems, potentiostats, impedance electrochemical spectroscopy (EIS) instruments with suitable software, scanning electrochemical work station SVP and SECM micro- corrosion measurement system. Zetasizer for measurement of nano-particle size and stability of suspensions, programmable power supplies, micro-hardness tester (Vickers and Knoop), optical microscopes, salt spray (fog) chamber, chemical laboratory facilities, metallographic cross-section preparation equipment, TABER abrasion test, Nd: YAG laser: pulse laser working at wavelengths of 1064 nm, 532 nm, and 266 nm, with pulse duration of 7 ns (or long pulse 3 ms), 10 Hz, 10 W with computerized table, Diode laser: CW laser, 2 kW with the following heads: welding, surface treatment and cladding, including computerized table (x-y-z and spindle, SEM and EDS, HRSEM, GDEOS, XRD, mechanical characterization (e.g. hardness testers, INSTRON for tensile strength measurements, etc.), TEM, HRESEM, GDA, Auger, and XPS spectroscopy.

**Cooperation with industry:**

- Improvement of current production processes, and development of new production processes
- Development of new products, and improvement of existing products
- Applicative research and follow-up research for the development of new technologies
- Investigation of product properties, failure analysis, supporting and guiding factories in various processes
- Training/guidance, courses, and metallurgical support for plants and factories
- Initiation of industrial collaborative development projects between Israeli and international partners
- Technical and formal support for funding application in national industrial development projects (Israel Innovation Authority)



# AZRIELI CONTINUING EDUCATION AND EXTERNAL STUDIES DIVISION

***http://cont-edu.technion.ac.il***

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The Azrieli Continuing Education and External Studies Division has developed study programs over the years in professional academic disciplines for industrial organizations and institutions, including the senior teaching staff of Technion faculties.

By virtue of belonging to an academic institution of global standing and reputation, the Unit is required to meet strict standards, and provide study programs at the highest level of quality.

The study programs develop through learning the needs of the organization, and examining the challenges it faces.

The programs combine academic knowledge with applied tools for translating theory into practice, and include managers from the organization.

The programs are conducted according to organizational needs - seminars, workshops, and courses at the client's site, at the Technion in Haifa, the Technion campus at Sarona in Tel Aviv, and the Technion annex in Jerusalem.

# RESEARCH EQUIPMENT LIST

| SUBJECT | INSTRUMENT | LINK |
|---|---|---|
| Light Microscopy | ⊛ Inverted / Upright Light Microscopy (LSE, BCF, Materials Eng.)<br>⊛ Fluorescent light microscopy (LSE, BCF)<br>⊛ Confocal laser scanning microscopy (LSE, BCF)<br>⊛ Light Sheet Fluorescence microscope (Zeiss Z1) (LSE)<br>⊛ High throughput automated slide scanner (BCF)<br>⊛ High throughput High Content Imaging System with dedicated analysis software (GE InCell 2000) (LSE)<br>⊛ High throughput live cell imaging & analysis (Incucyte ZOOM) (BCF)<br>⊛ Histopathology slide preparation unit (BCF)<br>⊛ Electron microscopy biological specimen unit (BCF) | Life Science and Eng.<br>Biomedical Core Facility<br>Materials Science and Eng. |
| *In Vivo* Imaging | ⊛ *In vivo* high throughput luminescence & fluorescence & X-RAY Perkin Elmer IVIS Lumina XRMS) (BCF)<br>⊛ *In vivo* ultra sound - VisualSonics Vevo 2100 (BCF)<br>⊛ *In vivo* anatomical MRI - Aspect M2 1T (BCF)<br>*In vivo* functional MRI - Bruker Biospec 9.4T (BCF)<br>⊛ *In vivo* NMR - Bruker Minispec body composition analyzer (BCF) | Biomedical Core Facility |
| Image analysis and processing support | ⊛ 4D analysis software: Bitplane IMARIS, image J, Image Pro, InCell Investigator, Miner, ZEN, LSM (LSE, BCF)<br>Personalized image analysis solutions, batch & macros, custom-made software (BCF, LSE) | Biomedical Core Facility<br>Life Science and Eng. |
| Electron Microscopy | ⊛ SEM (+ with EDS, WDS and EBSD) (Materials Eng.)<br>⊛ High resolution cryo-SEM (+EDS) (Chemical Eng.)<br>⊛ Dual beam FIB (Materials Eng.)<br>⊛ S/TEM (+EDS, EELS) (Materials Eng.)<br>⊛ TEM (Materials Eng.)<br>⊛ Cryo-TEM and HR-cryo-TEM (Chemical Eng.)<br>⊛ Scanning Electron, Microscopy (SEM), TESCAN Vega-II (Chemistry)<br>⊛ HRSEM (+EDS, STEM and EBSD) (Materials Eng.)<br>⊛ HR-SEM Hitachi S-4700 and S-4800 (MNF&PU) | Materials Science and Eng.<br>Chemical Eng.<br>Chemistry<br>Micro Nano Fabrication and Printing Unit |

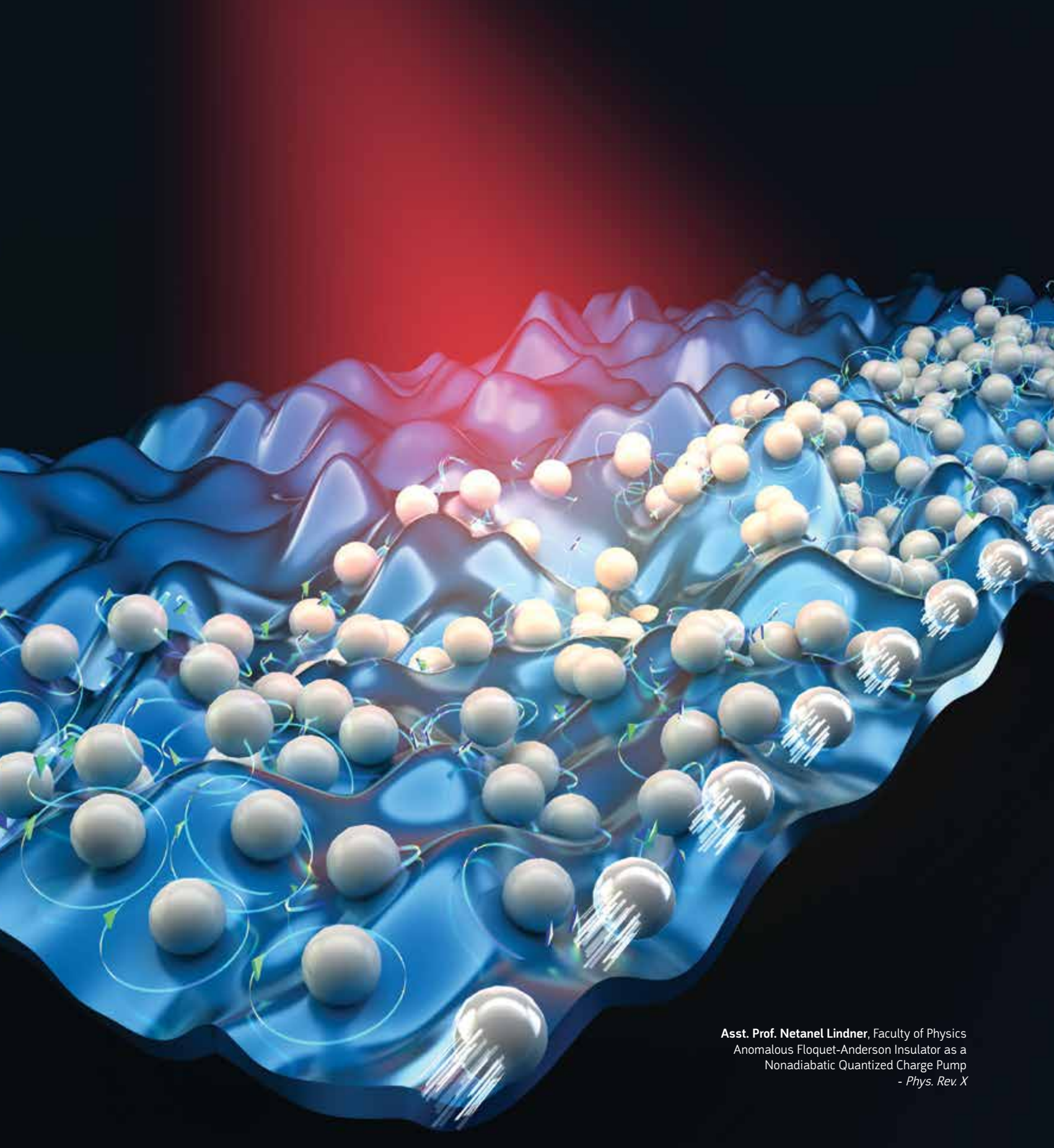
| SUBJECT | INSTRUMENT | LINK |
|---|---|---|
| Scanning Probe Microscopy | ⊛ AFM NSOM/AFM (STM/AFM) (Materials Eng.) (Solid State Ins. / Physics)<br>⊛ BioAFM (Biotech. Eng.)<br>⊛ Atomic Force Microscope (AFM), (Veeco/Bruker, Dimension 3100) (Chemistry)<br>⊛ AFM Veeco DI-3000 (MNF&PU)<br>⊛ AFM Asylum Research/Oxford Instruments MFP-3D Infinity (MNF&PU) | Materials Science and Eng.<br>Solid State Inst. Physics<br>Biotechnology & Food Eng.<br>Chemistry<br>Micro Nano Fabrication and Printing Unit |
| Flow Cytometry | ⊛ FACS Calibur (2 lasers) (BCF) (LSE)<br>⊛ BD LSR II with High Throughput system (4 lasers) (LSE)<br>⊛ BD FACS Aria-IIIu-sorter (5 laser) (BCF) (LSE)<br>⊛ Image Stream - Flow Imager (LSE)<br>⊛ CyAn ADP (3 lasers) (BCF)<br>⊛ BD FACS Fortessa (4 lasers) (BCF)<br>⊛ High-Throughput Stratedigm S1000EXi (4 lasers) (BCF)<br>⊛ Luminex MAGPIX (BCF)<br>⊛ Mass cytometry - CyTOF (BCF)<br>⊛ Analysis: Cytobank, FCS Express, FlowJO and ModFit data analysis software (LSE) (BCF) | Life Science and Eng.<br>Biomedical Core Facility |
| Genomics | Sequencing and Genotyping:<br>⊛ llumina HiSeq 1-Tera (TGC)<br>⊛ Illumina HiSeq 2500 (TGC)<br>⊛ Illumina NextSeq500 (BCF)<br>⊛ Ion Torrent PGM (BCF)<br>⊛ Illumina MiSeq (TGC)<br>⊛ Microarray- Illumina HiScan (BCF)<br>⊛ 3500XL Genetic Analyzer (BCF)<br>⊛ MinIon - Nanopore Technology sequencer (TGC)<br>⊛ Fluidigm C1 - Automated solution for single cell genomics (TGC)<br>⊛ Agilent Bravo sample-preparation automation system for NGS (TGC)<br>⊛ Covaris - high throughput shearing system (TGC) (BCF) | Biomedical Core Facility<br>Life Science and Eng.<br>Technion Genome Center |

| SUBJECT | INSTRUMENT | LINK |
|---|---|---|
| | Real-Time PCR:<br>⊛ Fluidigm BioMarkHD (BCF)<br>⊛ Qiagen Rotor Gene (BCF)<br>⊛ ABi 7300 (TGC)<br>⊛ BioRad CFX96 (TGC)<br><br>⊛ CRISPR Genome Editing NEPA21 Electroporator (BCF)<br>⊛ Automated Electrophoresis-2200 TapeStation (LSE) (BCF)<br>⊛ DNA/RNA automated extraction: Qiacube (BCF) | |
| Spectroscopy / Spectrometry | ⊛ Mass Spectroscopy (Chemistry)<br>⊛ Micro Raman Spectroscopy (Solid State Ins. Physics)<br>⊛ XPS-X ray Photoelectron Spectrometry (Solid State Ins. Physics)<br>⊛ TOF-SIMS Time of Flight Secondary Ion Mass Spectrometry (Ion ToF TOF SIMS V) (Solid State Ins. Physics)<br>⊛ Micro Raman (Chemistry) (with: hot/cold stage, poloraizers, UV laser), Horiba Jobin Yvon<br>⊛ Materials Characterization (Solid State Ins. Physics) | Chemistry<br>Solid State Inst. Physics<br>Chemistry |
| X-ray | ⊛ HR XRD-High Resolution (RBNI)<br>⊛ X-ray Diffraction (Solid State Ins. Physics)<br>⊛ X-ray Diffractometer (Materials Eng.)<br>⊛ Solid Identification by X-ray (Physics)<br>⊛ Small-angle X-ray scattering (SAXS) (Chemical Eng.)<br>⊛ X-Ray Single Crystal Diffraction (Chemistry) | Russel Berri Nanotech. Inst.<br>Solid State Inst. Physics<br>Materials Science and Eng.<br>Physics<br>Chemical Eng.<br>Chemistry |
| NMR | ⊛ NMR computer cluster | Chemistry |
| Computation | ⊛ TAMNUN | TAMNUN |
| Bioinformatics & Biostatistics | ⊛ Bioinformatics & Biostatistics (BKU) (BCF) | Biology<br>Biomedical Core Facility |
| Proteomics | ⊛ Q-Exactive Plus<br>⊛ LTQ Orbitrap XL | Biology |
| Elemental Analysis | ⊛ Thermo Scientific CHNS Analyzer | Chemistry |

| SUBJECT | INSTRUMENT | LINK |
|---|---|---|
| Micro Nano Fabrication and Printing Unit (MNF&PU) | Photolithography:<br>⊛ i-line Stepper GCA Autostep 200<br>⊛ Laser Writer Heidelberg Instruments DWL 66+<br>⊛ Contact Mask Aligner with BSA system KARL SUSS MA6<br>⊛ Contact Mask Aligner KARL SUSS MJB3<br>⊛ Contact Mask Aligner KARL SUSS MJB3 with BSA<br>⊛ Automatic Coater Suss MicroTec Delta 80 RC<br>⊛ Automatic Developer Suss MicroTec Delta 8+<br>⊛ Vacuum Oven with NH3 YES-310TA(E) for reversal image<br>⊛ Dry Film Laminator JSE JSL-1200<br>⊛ Flood Exposure Tool OAI-150<br>⊛ Wet benches for resist coating, bakes and development<br>⊛ Wet benches for resist stripping and cleaning<br>⊛ Plasma Asher Axic HF-8<br>⊛ Plasma Asher YES G-1000<br><br>Nanopatterning:<br>⊛ E-Beam Lithography Raith EBPG 5200<br><br>Etching:<br>⊛ Reactive Ion Etching (RIE) Plasma-Therm 790 (Fluorine Chemistry)<br>⊛ ICP Deep RIE Plasma-Therm Versaline (Fluorine Chemistry)<br>⊛ ICP Etcher Plasma-Therm Shuttleline (Chlorine Chemistry)<br>⊛ Wet etching benches (RCA clean, Buffered Oxide etch, Isotropic Silicon etch, Aluminium etch, $Si_3N_4$ etch, Anisotropic Silicon etch (KOH), Chromium etch)<br><br>Material Deposition and Annealing:<br>⊛ Tube Furnaces BTI-Bruce RTRI-878 for Silicon Oxidation, Annealing, Phosphorus Diffusion, Low Pressure CVD of $Si_3N_4$, Poly-Si and $SiO_2$<br>⊛ E-beam Evaporator Evatec BAK501<br>⊛ E-beam Evaporator Airco Temescal BJD 1800<br>⊛ E-beam Evaporator Airco Temescal FC 1800<br>⊛ E-beam Evaporator VST TFDS-184<br>⊛ Thermal Evaporator Vinci Technologies<br>⊛ Thermal Evaporator Edwards E306A<br>⊛ Sputter Deposition AJA International Inc. ATC 2200<br>⊛ Plasma-Assisted Atomic Layer Deposition Ultratech/Cambridge Nanotech Fiji G2<br>⊛ Plasma-Enhanced Chemical Vapor Deposition (CVD) Plasma-Therm Vision 410 | Micro Nano Fabrication and Printing Unit |

| SUBJECT | INSTRUMENT | LINK |
|---|---|---|
| | ⊛ Molecular Vapor Deposition AMTS 100E<br>⊛ Rapid Thermal Annealing Jipelec JetFirst 200C<br><br>Printing:<br>⊛ Pad Printer Teca-Print TPX301<br>⊛ Wet benches for ink preparation with stirring plate and mixers<br>⊛ Viscometer Viscotech Myr VR 3000<br><br>Characterization and Analysis:<br>⊛ HR-SEM Hitachi S-4700<br>⊛ HR-SEM Hitachi S-4800<br>⊛ Atomic Force Microscope DI-3000<br>⊛ Atomic Force Microscope Asylum Research/Oxford Instruments MFP-3D Infinity<br>⊛ Surface Profiler KLA Tencor P-6<br>⊛ Surface Profiler KLA Tencor 500<br>⊛ Surface Profiler KLA Tencor 200<br>⊛ Film thickness measurement Nanometrics AFT 2100 Nanospec<br>⊛ Ellipsometer Rudolph AutoEL II<br>⊛ Ellipsometer Gaertner L117<br>⊛ Ellipsometer Woollam VASE. Multi-layer measurements wave length 193-2500nm<br>⊛ Ellipsometer Woollam M-2000UI<br>⊛ Film stress measurement Tencor FLX-2320<br>⊛ C-V Plotter MDC<br>⊛ Four Point Probe Veeco FPP 5000<br>⊛ I-V probe station, Keithley 2400 I-V metter<br>⊛ CDs Optical Measurements Vickers micro-system<br>⊛ Optical Microscope Nikon Eclipse L200 with a camera<br>⊛ Optical Microscope Nikon with a camera<br>⊛ Optical Microscopes Olympus BX-60, SZ-11 with a camera<br>⊛ Optical Microscope Zeiss Axiotron<br>⊛ Contact Angle Goniometer Ramé-hart 200<br><br>Packaging:<br>⊛ Dicer Disco DAD3350<br>⊛ Wire Bonder TPT HB16 | |
| Nanomaterial Based Devices | Probe Station<br>Kelvin Probe | Laboratory of Nanomaterial Based Devices |

| SUBJECT | INSTRUMENT | LINK |
|---|---|---|
| | ⊛ QCM<br>⊛ Spectrophotometer<br>⊛ Elipsometer | |
| Research devices - production and repair | ⊛ Machine Workshop<br>⊛ Electronics Workshop | Physics<br>Physics |
| Low temperature | ⊛ Cryogenic Plant | Physics |
| Magnetism | ⊛ SQUID magnetometer | Physics |
| Other | ⊛ Laser Microdissection Optical Tweezers (Chemical Eng. / RBNI)<br>⊛ Solar simulator (Materials Eng.)<br>⊛ Fermentors (Biotech. Eng.)<br>⊛ Isothermal titration calorimeter (ITC & DSC) (BCF)<br>⊛ Fluorescence transmited luminescence plate readers (BCF)<br>⊛ UV-Vis Spectrophotometer & Nano Drop (BCF)<br>⊛ Lyofilizer (BCF)<br>⊛ Sonicators & High-Pressure Homogenizer (BCF)<br>⊛ Centrifuges & Ultra centrifuges (BCF)<br>⊛ Incubator-Innova 4335 (BCF)<br>⊛ Phosphor Imager, Odyssey scanner (BCF)<br>⊛ Fourier Transform InfraRed (FTIR) with ATR Bruker Tensor 27 (Chemistry)<br>⊛ Fluorometer (with chiller) Jobin Yvon Fluorolog-3 (Chemistry)<br>⊛ Spectrophotometer (with chiller) Shimadzu UV-1800 (Chemistry)<br>⊛ Spectrophotometer (with chiller) Varian Cary 50 Bio (Chemistry)<br>⊛ Elemental CHNS Analyzer Thermo Scientific Flash2000 (Chemistry)<br>⊛ Curing UV lamp RunWing Co. RW-UV.3BP (Chemistry)<br>⊛ Microwave reactor CEM Cop., Discover (Chemistry)<br>⊛ Light microscop with camera, Olympus BH2-UMA (Chemistry)<br>⊛ Oven (250 C) Fisher Scientific Ecocell (Chemistry)<br>⊛ Sputter coater Polaron (Chemistry)<br>⊛ Micro Balance Mettler Toledo Excellence Plus (Chemistry)<br>⊛ Laue camera (Chemistry)<br>⊛ Film Development (BCF)<br>⊛ Gamma & Beta radiation counters (BCF)<br>⊛ Imaging documentation system, Image Quant LAS4010 (BCF)<br>⊛ Bio-safety virus room (BCF) | Chemical Eng.<br>Biomedical Core Facility<br>Materials Science and Eng.<br>Biotechnology & Food Eng.<br>Chemistry |

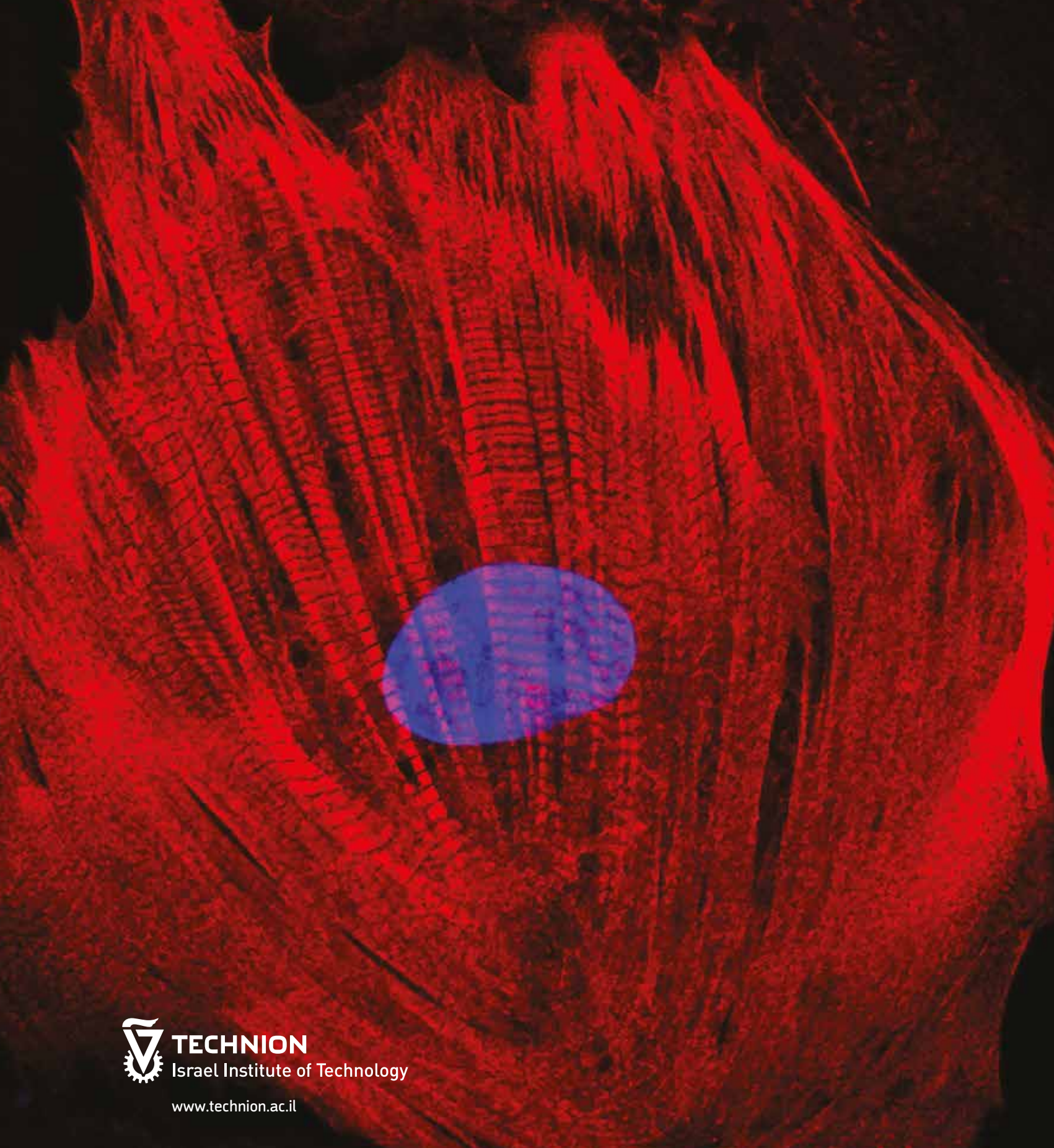


**Asst. Prof. Netanel Lindner**, Faculty of Physics
Anomalous Floquet-Anderson Insulator as a
Nonadiabatic Quantized Charge Pump
- *Phys. Rev. X*

*Back Cover:* Human Heart Cells Derived From Pluripotent Stem Cells.
Immunoflurescene image acquired using confocal microscopy.

The Gepstein laboratory.
Rappaport Faculty of Medicine.

From *LABSCAPES* exhibition at Technion, created and curated by Anat Har-Gil.



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