Response to the Committee for the Evaluation of Biotechnology & Biotechnology Engineering

Y. Shoham, Dean

Faculty of Biotechnology & Food Engineering

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The Faculty of Biotechnology and Food Engineering would like to thank the Committee for the thorough and praising evaluation report. Indeed, some of the issues raised by the committee were already addressed by the department self-evaluation report. However, we disagree with some of the statements and recommendations in the report.

The Faculty responses to the Evaluation Report consists of a summary of the Faculty response to each statement and recommendation raised by the committee (underlined), point by point, in the order of their appearance in the evaluation report.

Executive Summary

<u>The proportion of engineering courses in the curriculum has to be increased and the extent to which concepts pertaining to food- science, technology and engineering are being addressed by the curriculum has to be enhanced (page 5).</u>

The Faculty disagrees with this statement. The committee does not specify the engineering courses that should be added, and what courses should be removed. A short scan of many of the leading programs in biotechnology and food engineering (or science) will indicate that our program contains more engineering courses than these programs, as detailed in subsequent sections.

Specifically, the extent to which the research program addresses food-related issues has to be increased and more research effort has to be directed at addressing engineering and technology aspects of both biotechnology- and food science-related issues (page 5).

The Faculty disagrees with this statement. Most of the research carried out by the faculty members is highly related to biotechnology engineering, food sciences and food engineering (see Appendix 1).

Recommendations

Establish an effective Industry Advisory Board (page 6).

The Faculty agrees that an Industry Advisory Board is an important tool in maintaining crosstalk with industry. We are in the process of establishing an Industry Advisory Board which will include top research and management figures from the leading food and biotechnology companies in the country (many of which are graduates of the department!). However, we would like to emphasize that it is a long tradition of our department to constantly maintain strong and active ties with industry through frequent meetings, workshops and active mutual research projects, which increased significantly in recent years.

Enhance the engineering and technology components of the teaching and research elements of the program as well as better adjust the balance between food engineering and biotechnology engineering. Lower the proportion of electives in the curriculum (page 6).

The Faculty believes its curriculum is well balanced and provides excellent background for both Biotechnology and Food Engineers. It is not clear from this recommendation what engineering and technology components should be added and as a result, what components should be removed. The faculty invested many

hours in building our teaching program and we believe that the program is comparable, and in fact even better, than that of most leading universities in the world.

The proportion of electives (30 CP) in the curriculum is determined by the Technion's regulations and not by the Faculty. Effectively, the number of true electives in the faculty curriculum is much lower than maximal credit points (CP) allowed. Once a student commits himself to one of the two specialization tracks (Biotechnology Engineering or Food Engineering) he/she has to take additional mandatory courses (which are marked as electives). As for additional lab courses: the undergraduate curriculum already contains compulsory laboratories in the following areas: analytical chemistry, biochemistry and food chemistry, general microbiology, food microbiology, food and biological material analysis, bioprocess and food process engineering, and biotechnology or advanced technologies in food engineering (based on the chosen track). An elective lab course in molecular biology is also offered on a yearly basis. Some elective courses such as Emulsions, Sensory Evaluation or Food Packaging include lab exercises embedded within the courses. In addition, many of the students take research projects (8 CP). In the Technion's CP system, each hour in a laboratory course is counted for only 1/3 CP. Thus, laboratory courses which are extensively time consuming are inherently under weighted. As a result, it is not realistic or necessary to add new lab courses to the curriculum, which is already loaded with a significant number of essential laboratory courses.

<u>Make a 4th year undergraduate research project compulsory requirements in both study tracks (page 6).</u>

This issue is an ongoing debate in the Faculty. Historically (20 years ago), the undergraduate research project was compulsory. At that time, the ratio of 4th year students to faculty members was about 1:1, respectively. Today, this ratio is reaching 7:1 therefor it is practically impossible to provide high standard

research projects to so many students. However, we strongly encourage our students to take the undergraduate research project even in other Faculties. The students are also encouraged to do their research project in industry with mutual supervision.

Offer an upper division compulsory course where the student's skills to integrate knowledge derived from the exact sciences, engineering/technology and from biological/chemical sciences are challenged (page 6).

The Faculty already offers compulsory and elective courses that require the integration of knowledge from the required curriculum. Such courses include Industrial Plant Design, Laboratory in Biotechnology, Advanced Technologies in Food Engineering, the iGEM project and more. Students who engage in projects are also required to demonstrate integration of various skills and knowhow. In general, all of our upper division courses require true integration of knowledge.

Introduce and implement the concept of Learning Outcome Assessment as the main tool for assessing the learning outcomes of all of the courses and learning experiences that are offered by the study programs (page 6).

The concept of Learning Outcome Assessment is being introduced nowadays on campus.

Mission, Goals and Aims

Recommendations (page 9)

The faculty response to the recommendations was given above.

The Study Program

The B.Sc. Program

More specifically, the extent to which engineering concepts (both general and discipline-specific) and topics related to food technology are addressed in the curriculum falls short of what is required in a well balanced curriculum (page 9).

The Faculty disagrees with this statement and cannot understand how the committee came to this conclusion based on our courses syllabi. In all of our advanced courses the engineering and technology concepts are well integrated.

The introduction of a 3-course series addressing fluid mechanics, mass transport and heat transfer and the intended course in Food Technology are likely to strengthen the program, however, additional courses addressing topics in food technology are needed (page 10).

The engineering courses and food technology courses were always in the Faculty curriculum and this past semester we reintroduced a basic Food Technology course which had been given in the past. The Faculty agrees that additional elective courses in food technology and also in biotechnology can improve the program. With that, it should be recognized that, effectively, the curriculum does not allow too many elective options.

Both the structure and the content of the curriculum have to be addressed while taking into account two important facts (page 10).

The Faculty holds the opinion that the current curriculum is well balanced and addresses very well the facts mentioned in the report.

The engineering-related courses included in the curriculum account for about 20 CP, which is significantly less than what is commonly included in similar programs at leading universities worldwide (page 10).

The Faculty disagrees with this statement. Examination of the programs at MIT (Biological Engineering), CalTech (Bioengineering), Cornell (Food Operation and Management), Rutgers (Food Science), UMASS (Food Science and Technology) and UC-Davis (Food Science and Technology) will indicate that our program provides equal if not surpassing credits in engineering courses!

The committee has identified an excessive degree of content redundancy among the elective courses (that are listed in the catalogue) and it seems that many of these courses are not offered regularly (page 11).

The Faculty acknowledges that the English list of the elective courses was not updated in the Self Evaluation Report (there is no such issue with the Hebrew catalog) and steps were taken to update the English list (see Appendix 2).

Among the critical skills that students in such a program need to acquire, is the ability to effectively and creatively integrate knowledge. An advanced course addressing this need is not included in the curriculum (page 11).

The Faculty offers many upper-level courses that require knowledge integration. These courses include for example, the 5 CP Advanced Technologies in Food Engineering course (mandatory for the food engineering track) that requires students to perform a product development and process-planning project. The 2 CP Food Plant Design course (mandatory for the food

engineering track and elective for the biotechnology track) requires a decision-making process towards plant erection, process and engineering flow-diagram, equipment specifications and the design of utility and process pipelines, as well as HACCP analysis. In the biotechnology engineering track the mandatory 3.5 CP Biotechnology Laboratory requires the students to integrate their knowledge in engineering for analyzing mass transfer requirements and correlations, together with molecular biology principles. The fermentation laboratory in the Faculty is one of its kind with 18 fermentation units (1 to 50 liter), fully computerized and with off gas analysis (CO_2 and O_2). The 2 CP Molecular Biotechnology laboratory integrates all of the knowledge in molecular biology for analyzing expression of proteins in mammalian cells using state of the art techniques. There are many more courses that demand true integration of knowledge. For example, in the Food Microbiology course the students are assigned a food product and they investigate the production stages and critical control points, they analyze the product in the lab for presence of pathogenic bacteria using classical and modern methods, and they write a report on their results including comparison to national standards, and present them to their peers and teaching staff. Likewise, in the compulsory course on Food Analysis, the students get unknown food samples (e.g. oil sample) which they have to analyze, characterize and compare to international and national standards. Moreover, electives such as Foodborne Pathogens even expose students to advanced topics such as grant writing. The Faculty acknowledges that the full integration requirements in these courses may not have been sufficiently clarified to the committee during their visit.

<u>A course aimed at developing the technical writing skills, in both Hebrew and English, is missing from the curriculum (page 11).</u>

Historically such a course was given; however, the Faculty is in the opinion that the many requirements in the upper class courses fulfill this need and in such courses dedicated personal and professional development classes

are given (e.g. "how to give a seminar" lecture given in the course of Food Analysis).

Ethical issues are of critical importance to the field of Biotechnology; however they are not addressed by the curriculum (page 11).

The Faculty agrees with the committee. Ethics is a campus-wide subject of importance. A compulsory Ethical graduate course is given online starting this year.

Recommendations for the B.Sc. study program (page 12-13)

Develop more opportunities for students to have a summer internship (for credit) in the industry.

The curriculum allows the students to experience working in industry in several forms. The students have the option to carry out an 8 CP Research Project in industry with mutual supervision, they can also take a 1 CP Special Project course in industry (usually during the summer), or they can spend a complete term in doing practical work in the industry by taking the 8 CP Combined Studies (“Sandwich System”) course.

Eliminate content redundancy among courses and list only those elective courses that are offered at least every other year.

Done

Increase the proportion of engineering-related courses in the curriculum.

As explained above the Faculty does not share this opinion.

Lower the proportion of CP allocated to elective courses to accommodate needs for additional compulsory and laboratory courses

As explained above the number of elective CP is governed by Technion's guidelines and in practice our students have very few electives.

Include a research or design project as a compulsory requirement in both study tracks

Research and design projects are provided to our students in many courses as outlined above. These courses include for example, the Advanced Technologies in Food Engineering course, the Food Plant Design course, the Biotechnology Laboratory, the Molecular Biotechnology laboratory, the Biotechnology Enterprise course, the iGEM (International Genetically Engineered Machine) project in Synthetic Biology. Some of these courses are compulsory (at the different tracks). At this stage it will be impossible to provide an additional compulsory course due to Technion's regulations and the high student-to-faculty number ratio.

Instruct a course in "Ethics in Biotechnology".

An online compulsory graduate course in Ethics was recently opened at the Technion.

Instruct, during the first year of studies a compulsory course in technical writing in both English and Hebrew.

A 3 CP compulsory course in Technical English is given in the first year and various aspects of academic and technical writing are taught and practiced

throughout the compulsory laboratory courses. It is practically impossible to add compulsory courses in the first year due to the Technion's engineering compulsory requirements in Math, Chemistry and Physics.

Develop and introduce (to both study tracks) an upper division compulsory course where the student's skills to integrate knowledge derived from the exact sciences, engineering/technology and from biological/chemical sciences are challenged.

As explained above there are several courses in the curriculum that require true integration of knowledge. In the Biotechnology laboratory course there are 18 fully computerized bioreactors with CO_2 and O_2 off-gas analyzers that allow conducting experiments on carbon balance, mass transfer, high density cultures, enzyme overproduction purification and characterization, continuous cultures, gene regulation and more. In the Advanced Technologies in Food Engineering Laboratory the students are trained and operate various processing units (e.g. high pressure homogenizers) and advanced analytical tools such as laser-based particle sizers and analytical centrifugation and finally perform a product development and process-planning project. In the Food Analysis Laboratory students are required to analyze, identify and characterize different unknown food samples and to compare the quality with national and international standards. In the Food Microbiology course students analyze production lines with respect to HACCP. In the Food Packaging course students make a life cycle assessment of different packaging's (e.g. milk cartons vs. milk bottles vs. milk sachets) and utilize equipment for measuring strength and force of polymers. In the course on Emulsions, students employ their theoretical knowledge in the lab while making different foods under various conditions (e.g. crème Brule, marshmallow) to comprehend the influence of ingredient choice and processing conditions on the food texture. Therefore, we offer many opportunities for "hands-on" for our students, some of them are not evident from the course title.

The Graduate Studies Program

Recommendation (page 14)

Expand and develop the research program to include true cutting edge engineering and technology-related research directions.

The Faculty recently recruited Dr. Boaz Mizrahi, currently a postdoctoral fellow at MIT in the laboratory of Prof. Robert Langer. Dr. Mizrahi has a strong background in pharmaceutical chemistry and will cover the area of powders, emulsions, pharmacokinetics, as well as food toxicology. In addition, the Faculty secured two tenure-track positions for two excellent PhD graduates that are currently being trained as postdoctoral fellows at two world leading research laboratories; Dr. Avi Shpigelman, our graduate, that is training in non-thermal processing with Prof. Marc Hendrickx, head of the Laboratory of Food Technology (Leuven Food Science and Nutrition Research Centre, LFoRCE, Belgium), one of the leading groups in the world in this field, and Dr. Maya Davidovich-Pinhas, a chemical engineering graduate, being trained in soft material science with emphasis on functional fats and oils at the laboratory of Prof. Alejandro G. Marangoni, a Professor and Canada Research Chair Food and Soft Materials Science at the University of Guelph. We expect these two candidates to join the department within 1-2 years. Taken together, we believe that these three new recruits will further enrich our teaching program.

Teaching & Learning Outcomes

Recommendations (page 15)

Introduce and implement the concept of Learning Outcome Assessment.

As mentioned above the concept of Learning Outcome Assessment is being introduced nowadays on campus.

Human Resources

Recommendations (page 16)

In order to assist junior faculty members in successfully meeting expectation for promotion, assign to each of them senior faculty member who will serve as his/her mentor.

The Faculty totally agrees with this recommendation and will act accordingly.

Include a document highlighting the among-disciplines differences in impact factors in promotion dossiers of the program's faculty members.

The Faculty totally agrees with this recommendation and will act accordingly.

Research

Recommendations (page 20)

Develop and introduce research programs aimed at addressing the engineering and technology related deficiencies that have been identified by the committee.

The committee's report does not mention any specific research deficiencies. It is clear that 14 faculty members cannot cover all aspects of Food and Biotechnology Engineering.

Appendix 1

Research Activities at the Faculty of Biotechnology and Food Engineering

The research activity of the faculty may be classified into two groups:

1) Food Technology and Food Engineering
2) Biotechnology

Obviously, there is some overlap between the two, especially in food related biotechnology. Table 2.1 provides a quick overview of the research areas and activities.

Table 2.1: Research Areas of Faculty Members

Faculty Member	Research Area	Research Topics
Roee Amit	Synthetic Biology & Single Molecule Imaging	Decipherment of the regulatory and transcriptome codes using synthetic biology approaches, single molecule diagnostics
Dganit Danino	Nanostructured Molecular Assemblies	Nanoencapsulation and drug delivery, physical chemistry of soft matter, lipids and vesicles, self-assembly and nanostructure of complex fluids, Cryo-TEM: development and application
Ayelet Fishman	Molecular and Applied Biocatalysis	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
Yechezkel Kashi	Applied Genomics & Food Microbiology	Food and environmental microbiology, rapid detection of pathogens, typing of probiotics and pathogens, genome evolution, evolution of microsatellite DNA
Uri Lesmes	Chemistry of Foods and Bioactive Ingredients	Physicochemical basis of human digestion, food hydrocolloids, chemometrics and food personalization

Faculty Member	Research Area	Research Topics
Ben-Zion Levi	Mammalian Cell Technology	Gene regulation in innate immunity, myeloid-leukemia, host-pathogen interactions
Yoav Livney	Biopolymers and Nano-Biotechnology	Physical chemistry of macromolecules in food and other biotechnological systems,nano-delivery systems for health-promoting compounds
Marcelle Machluf	Cancer Drug Delivery & Tissue Engineering	Tissue engineering based ECM platforms, cell encapsulation and drug delivery systems, ultrasound technology for DNA delivery to cells and tissues
Esther Meyron-Holtz	Molecular Nutrition	Mechanisms and regulation of systemic and cellular iron distribution in mammals, in health and disease
Amram Mor	Host Defense Peptides	Peptide-based drug design & delivery; Non-specific mechanisms of action; Structure-activity relationships.
Ester Segal	Functional Nanomaterials, Biosensors, and Sensors	Development of multifunctional nanomaterials for sensing/biosensing, drug delivery systems, intelligent and active packaging
Eyal Shimoni	Functional Foods, Nutraceuticals, and Food Nanoscience	Micro and nano encapsulation, food grade delivery systems, structuring food using self-assembly phenomena, starch based food ingredients
Yuval Shoham	Protein and Enzyme Engineering	Gene regulation in *Clostridium thermocellum* and *Geobacillus stearothermophilus*, catalytic mechanism and structure function relationship of glycoside hydrolases
Sima Yaron	Molecular Biology of Pathogens	Food safety, molecular microbiology of food borne pathogens, host-pathogen interactions, bacterial biofilms, gut microflora

Research Activities in Food Engineering and Technology

The term food engineering is used here in the general sense to include all areas that deal with the different scientific and engineering aspects of food processing. These areas include the "traditional" fields, namely food technology, food engineering, food chemistry and biochemistry, food microbiology, nutrition, and food packaging. In addition, there are new research activities in less "traditional" fields such as food nanotechnology, food biotechnology, functional food, nutraceuticals, food structuring, molecular nutrition, intelligent packaging and molecular aspects of food safety. These new research fields were introduced by the young faculty members recruited over the last decade. These areas are in line with the slow yet steady shift from the traditional food industry toward a more biotech-oriented industry. A detailed list of research activities appears below.

1. Physical Chemistry of Foods

Prof. Dganit Danino

- Self-assembly of casein proteins

Dr. Yoav D. Livney

- The effects of low molecular weight co-solutes on water-structure and on protein solution behavior
- The effects of low molecular weight co-solutes on polymer phase behavior and on swelling of polymer gels
- Physical chemistry of milk proteins
- Self-assembly of proteins, and their co-assembly with hydrophobic nutraceuticals

2. Food Engineering and Technology

Prof. Eyal Shimoni

- Mechanisms affecting the crispness of RTE pre-fried food heated by microwave
- Increasing viability of probiotic bacteria in dairy products by the addition of tailored prebiotic resistant starch

- Development of V-amylose glycerol monostearate complexes in gum base system

3. Functional Foods and Food Ingredients

Prof. Eyal Shimoni

- Microcapsules and food grade enteric coating for the protection and controlled release of probiotics
- BioCurcumin – Platform for enhanced bioavailability and smart delivery of biologically active ingredients

Dr. Yoav D. Livney

- Nature-inspired biopolymeric systems for delivery of nutraceuticals for enrichment of staple foods and beverages

Dr. Uri Lesmes

- Bovine lactoferrin as a novel functional ingredient
- Engineering functional food grade proteins via the Maillard reaction

4. Food Biotechnology

Dr. Ayelet Fishman

- Biotechnological production of 2-phenylethanol, the rose fragrance

Dr. Uri Lesmes

- Understanding human digestion of proteins and lipids using *in vitro* models and physicochemical fingerprinting

Prof. Yuval Shoham

- Enzymatic treatments of natural juices

5. Food Nanotechnology

Prof. Eyal Shimoni

- Developing nano-sized molecular vehicles based on tailored oligosaccharide and polysaccharide derivatives by organic and enzymatic synthesis
- Molecular inclusion based nanocapsules for oral delivery and controlled release
- NANOFOODS – Nanoencapsulated functional foods
- Molecular and nano scale structural studies of amylose-polyphenol

Dr. Uri Lesmes

- Structure-function relationships for hydrocolloid delivery systems
- Development of nano-laminated emulsions and sub-micron particles complexes

Dr. Yoav D. Livney

- Nanoencapsulation of hydrophobic nutraceuticals (e.g., vitamin D, Omega 3 fatty acids) within reformed casein micelles
- Nanocomplexes of beta lactoglobulin and pectin for delivery of hydrophobic nutraceuticals (e.g., DHA)
- Heat-modified beta-lactoglobulin nanovehicles for delivery of hydrophilic nutraceuticals (e.g., EGCG from green tea)
- Maillard-reaction-based nanocapsules for enrichment of clear drinks with lipophilic nutraceuticals

Prof. Dganit Danino

- Casein assemblies for enrichment of foods, beverages and soft drinks
- Lipid mesophases and nanoparticles for encapsulation and delivery of nutraceuticles

6. Food Microbiology

Prof. Yechezkel Kashi

- Epidemiologic study of bacterial pathogen
- Genome sequencing of new probiotic strain of *Lactobacillus johnsonii*
- Isolation, genomic typing and biodiversity study of new Lactobacillus strains
- Pathogenic strain of *V. vulnificus*

Prof. S. Yaron

- *Salmonella enterica* Serovar Virchow: Molecular and epidemiological characterization of an emerging foodborne pathogen
- Mechanisms of resistance of *Salmonella enterica* in biofilm to biocides and antibiotics
- Persistence of *Salmonella enterica* in fresh, ready-to-eat foods

7. Health, Nutrition and Nutritional Biochemistry

Prof. Eyal Shimoni

- QTL detection for mastitis resistance and milk nutritional aspects in dairy cattle populations

Dr. Esther Meyron-Holtz

- The mechanism and regulation of iron transport through the blood testis barrier
- The mechanism and regulation of ferritin trafficking in kidney proximal tubules
- The role of transferrin mediated iron transport and transferrin receptor regulation in the kidney
- The role of the iron regulatory protein 1 on iron homeostasis in the intestinal epithelium during inflammatory bowel disease
- The effect of targeted deletion of the iron regulatory protein 2 (*Irebp2*) and the hemochromatosis gene (*Hfe*) on the intestinal microflora
- The mechanism of ferritin secretion from macrophages and the role of secreted ferritin in tissue iron distribution
- Characterization of senescent macrophages in vivo produced with a hypertransfusion model
- Subcellular localization and orientation of heme-oxygenase
- Trafficking of heme-oxygenase 1 following erythrophagocytosis
- The effect of erythrophagocytosis on macrophage function

Prof. S. Yaron

- Evaluation of the effect of milk based infant formula with prebiotic and probiotic supplements on the intestinal microflora

8. Intelligent and Active Packaging

Dr. Ester Segal

- Development of optical biosensors for pathogen detection and their integration in food packaging platforms
- Novel antimicrobial polyolefin/clay hybrids by reactive compounding

Prof. Eyal Shimoni and Prof. S. Yaron

- Active multilayer packaging based on optimized PLA formulations for minimally processed vegetables and fruits

Research Activities in Biotechnology

The faculty recruitment strategy in biotechnology is less straightforward than that for food engineering. Biotechnology research is very heterogeneous, and therefore, the recruitment plan is based on three parameters; academic excellence, new research field not yet existing in the faculty and the Technion, and research areas that are associated with other research activities in the faculty. The philosophy is that each new faculty member will have a common research interest(s) with at least one more person. A detailed list of research activities appears below.

1. Directed Evolution and Biotransformation

Prof. Yechezkel Kashi

- Development of new sexual breeding procedure for rapid evolution and genetic improvement of *Saccharomyces cerevisiae*

Prof. Yuval Shoham

- Engineering glycoside hydrolases for novel applications

Dr. Ayelet Fishman and Prof. Yechezkel Kashi

- Biotransformation of organic components using improvement isolates of *Saccharomyces cerevisiae*

Dr. Ayelet Fishman

- Directed evolution of tyrosinases towards controlling catalytic activity and specificity
- Directed evolution of mono- and di-oxygenases for enantioselective synthesis of chiral sulfoxides
- Combining protein engineering approaches for evolving toluene 4-monooxygenase for the synthesis of hydroxytyrosol, a potent antioxidant
- Tailoring lipase from *Geobacillus stearothermophilus* for biodiesel production

2. Genomics and Metagenomics

Prof. Yechezkel Kashi

- Genome sequencing of emerging new pathogenic strain of *Vibrio vulnificus*
- Sequence periodicity in microorganism's genomes

3. Evolution

Prof. Yechezkel Kashi.

- Evolutionary function to SSR, as a major mutational source of quantitative genetic variation
- Biodiversity study in a natural population of the yeast *Saccharomyces cerevisiae*
- Evolution Study of food pathogens
- Overlap of transcription and DNA repair in stationary phase yeast

4. Environmental Microbiology

Prof. Yechezkel Kashi

- The role of insect, Chironomid, as a natural reservoir and carriers of *V. cholerae*

Dr. Ayelet Fishman

- Development of new methods for agricultural soil disinfection

5. Bacterial Diagnostics and Infection Therapy

Prof. Yechezkel Kashi

- Bacterial strains typing based on SSR (Simple Sequence Repeats or microsatellite DNA).
- Development of high-throughput SNP genotyping array for bacterial typing and evolution study of the human pathogens
- Environmental monitoring of *Vibrio cholerae* using Chironomids

Prof. Yechezkel Kashi and Prof. Eyal Shimoni

- Development of oral rehydration therapy for cholerae-infected based on bacterial adherence to starch grains

Prof. Amram Mor and Prof. Yechezkel Kashi

- Bacterial capture by peptide-mimetic oligoacyllysine surfaces

6. Host-Pathogen Interactions

Prof. Ben-Zion Levi

- The role of IRF-8 in innate resistance to intraphagosomal pathogens
- Nramp1 mediated innate resistance to intraphagosomal pathogens is regulated by IRF-8, PU.1 and Miz-1

Prof. Yechezkel Kashi

- Effect of the host genetics on levels of *Lactobacillus*

Prof. S. Yaron

- Regulation of the AvrA effector protein of *Salmonella enterica*.
- New insights on the interactions between *Salmonella enterica* serovars and plants

7. Innate Immunity

Prof. Ben-Zion Levi

- The role of IRF-8 in the pathogenesis of myeloid leukemia
- Lineage specific expression of IRF-8 during myeloid cell differentiation and myeloid leukemias
- Molecular mechanisms of IRF-8 gene silencing in myeloid leukemias

Prof. Amram Mor

- OAQ-based chemical mimics of host defense peptides as a novel approach to overcome multidrug resistance in bacteria

8. Cell and Tissue Engineering

Prof. Marcelle Machluf

- Developing extra cellular matrix (ECM) isolated from porcine organs as a platform for engineering organs ex-vivo

9. Gene Regulation

Prof. Ben-Zion Levi

- New isoforms of VEGF: role in regulated expression and biological activity
- Crohn's Disease and SLC11A1 promoter polymorphism
- Identification of IRF-8 and IRF-1 target genes in activated macrophages

Prof. Yuval Shoham

- Gene regulation of the cellulolytic system of Clostridium thermocellum
- Gene regulation of the hemicellulolytic system of *Geobacillus stearothermophilus*

Dr. Roee Amit

- Synthetic enhancers

10. Gene Therapy

Prof. Marcelle Machluf

- Developing non-viral technologies for pcDNAs transfection in vivo based on ultrasound waves and Polymeric nano-particles and demonstrating their efficacy in the field of cancer therapy

11. Microencapsulation, Nanoencapsulation and Drug Delivery

Dr. Yoav D. Livney

- Polysaccharide-based nanovehicles for targeted delivery, and target activated release of chemotherapy
- Casein-based nanocapsules for oral delivery of hydrophobic anti-cancer drugs
- Protein-polysaccharide conjugate based nanovehicles for targeted theragnostics

Prof. Eyal Shimoni

- Solid system for oral delivery of proteins – insulin
- A system for oral delivery of insulin

Prof. Dganit Danino

- Cubic micellosomes and micelles for controlled release of active agents
- Nanoencapsulation of drugs and therapeutic bioactive agents in κ-casein assemblies for oral delivery

Prof. Marcelle Machluf

- Developing polymeric system that can entrap stem cells that are engineered to secret anti-cancer drugs for tumor therapy
- Designing drug delivery system, which can deliver cancer therapeutics particularly for brain tumors

- Designing liposome-like vesicles that are produced from the cell membranes of stromal mesenchymal stem cells as targeted tumor drug delivery system

12. Biosensors and Sensors Technology

Dr. Ester Segal

- Label-free optical biosensors based on porous Si nanostructures for detection of chemical and biological targets

13. Nanobiotechnology and Functional Nanomaterials

Dr. Ester Segal

- Biodegradable porous Si-based nanomaterials for drug delivery
- Biosensor-based micro-affinity purification assays to recover peptide fragments for downstream proteomics analysis. Lab-on-chip devices integrating high-throughput sensing and purification

14. Physical Chemistry of Molecular Assemblies

Prof. Dganit Danino

- Chiral self-assembly of peptides into ribbons and nanotubes
- Mechanisms of amyloid formation by proteins and peptides
- Structuring lipids
- Membrane fission and fusion
- Nanostructure and dynamics of molecular assemblies
- Origin of the viscosity peak in viscous micellar solutions

Dr. Yoav D. Livney

- Low-molecular-weight molecules effect on protein self-assembly and co-assembly

15. Synthetic and Quantitative Biology

Dr. Roee Amit

- Synthetic enhancer, synthetic gene regulatory circuits, reduced noise in poised transcription. The intracellular detect circuit

- Live dynamical imaging of RNA molecules; synthetic RNA probes and coupled imaging apparatus. Single molecule diagnostics. The intra-cellular detect gene regulatory circuit

Appendix 2

Table 3A.3 – Undergraduate elective courses

Cat. No.	Course	Credit
064001	Undergraduate Research 1	4.0
064002	Undergraduate Research 2	4.0
064003	Practice in Food Industry	1.0
064005	Special Project	1.0
064071	Technical Report	1.0
064119	Food Plant Design	4.5
064209	Advanced Technologies in Food Engineering	5.0
064210	Food Technology 3	2.0
064211	Food Technology 4	2.0
066112	Evaporation and Dehydration of Foods	2.0
066217	Packaging at Food Drugs and Biological	3.0
066226	Technology of Winemaking	2.0
066230	Principles of Sensory Evaluation of Food	2.5
066237	Shelf Life of Foods and Drugs	2.5
066241	Advanced Chapters in Packaging	2.5
066243	Powder- Science and Technology	2.5
066328	Micro, Nano encapsulation	3.0
066329	Emulsions in Food and Biotechnology	2.5
066418	Microbiology of Pathogens	2.0
066505	Downstream Processing in Biotechnology	2.5
066513	Biotechnology of Animal Cells	2.0
066516	Molecular Biotechnology Laboratory	2.0
066517	Advanced Genetic Technologies	3.0

066524	Biotechnology of Antimicrobial Peptides	2.0
066525	Biotechnology Enterprise	2.0
066605	Preventive Nutrition Health Aspects	2.0
066613	Functional Food and Nutraceuticals	2.0
068006	Special Project	1.0
068509	Process Biotechnology	3.0
068521	Tissue Engineering	2.0

Elective Courses in other Faculties		
014917	Principles of Quality Engineering	2.5
014919	Quality Control Engineering in Production	2.5
014920	Standards and Standardization Systems	1.0
017002	Physical Properties of Natural Products	2.5
054350	Polymers 1	2.5
054351	Polymers 2	2.5
054413	Polymers and Applications in Biotechnology	2.5
094591	Introductory Economics	3.5
094607	Organizational Sociology and Ind. Relationship	3.5
094616	Human Resource Management and Labor Relationship	2.5
094821	Financial and Managerial Accounting	3.5
094831	Principles of Marketing	2.5
096410	Statistical Quality Assurance	2.5
096475	Design and Analysis of Experiment	3.0
126304	Structural Biology for Bioinformatics	2.0

134020	General Genetics	3.5
134055	Endocrinology	2.0
134117	Physiology	3.5
134118	Physiology of Plants	4.0
134119	Regulation of Gene Expression	2.5
134128	Cell Biology	3.5
136007	Ecology	3.0
236523	Introduction to Bioinformatics	2.5
274215	Molecular Genetics and Human Inheritance	3.5
276413	Basic Immunology	4.0
276424	Selected Chapters in pharmacology	2.0
277006	Introduction to Sensory Systems	3.0
314007	Structure and Properties of Eng. Mat	4.0
314532	Corrosion & Corrosion Protection	2.5
314535	Introduction to Materials Engineering	2.5
315018	Biomaterials	2.0
324648	Report & Expression	1.5
336022	From cells to Tissues	2.5