סמינר אדאמס תשס"ז | ADAMS Seminar for 2007

In Honor of Mr. Marcel Adams
On the Occasion of his 87th Birthday

Guest Lecturer

Nobel Laureate and Academy Member
Professor Robert J. Aumann

Professor Robert J. (Yisrael) Aumann
Nobel Laureate and Academy Member

Robert Aumann was born in Frankfurt am Main, Germany, in 1930, to a well-to-do orthodox Jewish family. Fleeing Nazi persecution, he emigrated to the United States with his family in 1938, settling in New York. In the process, his parents lost everything, but nevertheless gave their two children an excellent Jewish and general education. Aumann attended Yeshiva elementary and high schools, got a bachelor's degree from the City College of New York in 1950, and a Ph.D. in mathematics from MIT in 1955.

He immigrated to Israel in 1956, joining the mathematics department at the Hebrew University of Jerusalem and has been there ever since. In 1990, he was among the founders of the Center for Rationality at the Hebrew University, an interdisciplinary research center, centered on Game Theory, with members from over a dozen different departments, including Business, Economics, Psychology, Computer Science, Law, Mathematics, Ecology, Philosophy, and others.

In many real-world situations, cooperation may be easier to sustain in a long-term relationship than in a single encounter. Analyses of short-run games are, thus, often too restrictive. Robert Aumann was the first to conduct a full-fledged formal analysis of so-called infinitely repeated games. His research identified exactly what outcomes can be upheld over time in long-run relations.

The theory of repeated games enhances our understanding of the prerequisites for cooperation: Why it is more difficult when there are many participants, when they interact infrequently, when interaction is likely to be broken off, when the time horizon is short or when others' actions cannot be clearly observed. Insights into these issues help explain economic conflicts such as price wars and trade wars, as well as why some communities are more successful than others in managing common-pool resources. The repeated-games approach clarifies the raison d'être of many institutions, ranging from merchant guilds and organized crime to wage negotiations and international trade agreements.

Aumann is the author of well over eighty research papers and six books, and has held visiting positions at Princeton, Yale, Berkeley, Louvain, Stanford, Stony Brook, and NYU. He is a member of the American Academy of Arts and Sciences, the National Academy of Sciences (USA), the British Academy, and the Israel Academy of Sciences; holds honorary Doctorates from the Universities of Chicago, Bonn, Louvain, City College and Bar-Ilan University and has received numerous prizes. He is the father of five and the grandfather of 18.

In 2005 Aumann was named as the co-winner of the Nobel Memorial Prize in Economic Sciences "for having enhanced our understanding of conflict and cooperation through game-theory analysis."

Greetings from

Professor Menahem Yaari,
President of the Israel Academy

Recognizing the pivotal contribution of top quality science training to Israeli society and its growth, security, and well-being, Mr. Marcel Adams has undertaken to establish a unique framework to assist outstanding young Israelis to pursue advanced training in the sciences.

Today, many of the top-rated Western universities offer their incoming graduate students guaranteed financial support for the entire duration of their studies towards the doctoral degree. Young people of outstanding talent are thus able to pursue their studies in these universities while maintaining a sustained focus on the academic tasks at hand, and to do so with the security of uninterrupted encouragement and support (as long as they remain students in good standing) and with no diversions to be dealt with along the way. This gives science training the best substrate on which to flourish, and Marcel Adams's idea is precisely that this should apply to science training also in Israel.

Marcel views young Israeli scientists as the key to the State's future, so a program to build a new cadre of scientists committed to remaining in Israel and advancing scientific knowledge and research, is the most worthwhile investment.

Adams Fellows enjoy sustained financial support for three to four uninterrupted years of Ph.D. study. As long as the Fellow maintains good standing in his/her training program, no further requirements are placed for continued support.

Adams Fellows enjoy two privileges, not normally available in graduate student support programs. First, each Adams Fellow is entitled to funding towards travel abroad to participate in international, scientific conferences or workshops. Second, Adams Fellows are given the opportunity to interact with one another and to form a small science community of their own. This will be achieved through initiatives such as invited lectures by renowned scientists and periodic seminars and retreats.

Adams Fellows are selected annually from candidacies received from Rectors of Israel's institutions of higher learning. We seek outstanding and highly motivated students, hoping to build their scientific careers in Israel. Only candidates from the natural sciences, life sciences, computer science and mathematics are eligible. The Program welcomes candidates from fields which transcend traditional disciplinary boundaries and conventional frameworks.

Since the Program's inauguration in May of 2005, 26 Adams Fellows, PhD Students of the highest academic standing have been been inducted. We are proud to introduce each one of them briefly in this brochure.

Tomorrow, August 2, 2007, will be Marcel Adams's eighty-seventh birthday. In Hebrew numerals, 87 is **פ"ז** and **פז** is the glow of gold. To our dear friend Marcel we say: May your initiative and generosity continue to glow as gold for many years to come.

Adams Fellowships Steering and Selection Committee

Professor Yoram Groner
Chairman

Professor Noga Alon

Professor Chaim Cedar

Professor Yigal Talmi

Professor Itamar Willner

Professor Jacob Ziv

Greetings from

Professor Yoram Groner,

Chair of the Adams Fellowships Steering and Selection Committee

Two years ago, the Israel Academy of Sciences and Humanities established the Adams Fellowships program for doctoral students in mathematics, the natural sciences, life sciences and computer science. This program was initiated by Mr. Marcel Adams of Canada and Prof. Menahem Yaari, President of the Israel Academy.

The Academy appointed a steering and selection committee of Academy Members to run the project and select the fellows. The Committee's members are: Profs. Yoram Groner (Chair), Noga Alon, Chaim Cedar , Igal Talmi, Itamar Willner and Jacob Ziv.

The Steering and Selection Committee's goal of nurturing the Adams Fellowships program until it becomes the leading fellowship program for science doctoral students in the higher education system has guided it in establishing the strictest criteria for the selection process. Adams Fellows are chosen solely on the basis of their excellence, without any institutional considerations.

During the two years of its operation, the Adams Fellowships program has attained prestige and won acclaim from the leaders of Israel's higher education system. I have no doubt that it will leave its mark on the training of Israel's research cadre for many years to come. Mr. Marcel Adams deserves our deepest appreciation for his initiative and generosity of heart.

Sincerely,
Yoram Groner

Marcel Adams

Hebrew-speaking philanthropist Marcel Adams, who escaped from a forced-labor camp in Romania in 1944, fought in Israel's War of Independence and made his fortune in Montreal, has endowed the Adams Fellowship Program to support Israel's brightest doctoral students in the natural and exact sciences each year.

Marcel Adams (Abramovich) was born in Piatra-Neamt, Romania, in 1920. The anti-Semitic regime in Romania during the Holocaust interrupted his studies, triggering a lifelong quest for learning and a zest for the life of the mind. An active member of Hanoar Hazioni in Bucharest, Adams survived forced labor, food shortages and arbitrary harassment by the authorities.

After coming to Israel with the Jewish Agency's help in 1944, Adams settled in Pardes Hanna and participated in the War of Independence. He moved to Canada in 1951 and worked as a tanner before going into real estate. He eventually developed dozens of properties, mostly in eastern Canada, including Galeries de la Capitale, the largest shopping mall in the province of Quebec. With his late wife Annie, he established Tel Aviv University's Adams Institute for Business Management Information Systems and endowed the university's Adams Super Center for Brain Research. A Montreal resident, the proud father of four and grandfather of eleven, he remains full of energy, works a full week and looks at least a decade younger than his 87 years.

Adams officially signed an agreement to establish the Adams Fellowships with the Israel Academy of Sciences and Humanities in Jerusalem in May 2005. The fund is large enough to provide $1 million annually to outstanding Ph.D. students, covering their full tuition and living expenses throughout four years of study and including funds for attending scientific conferences abroad. Most recipients are aged 26 to 34.

The easy way would have been to hand over a check, but Adams wishes to pay back his 1944 debt to the Jewish people, which gave him a new identity and hope for rebuilding from the ashes of Europe. The fellowship helps young men and women thrive technologically, scientifically and intellectually. In turn, Adams believes they will carry the flag for the next generation and for future generations.

Academy President Prof. Menahem Yaari describes the agreement as one of the most important documents ever for the future of higher education in Israel. A professional committee at the Academy reviews applications from doctoral students and chooses the awardees, for study in such fields as organic chemistry, molecular biology, chemistry, mathematics, engineering, physics, genetics, computer science and brain research.

Marcel. Adams wishes to help the best and brightest academics, those with tremendous potential for growth, who have demonstrated excellence in both quality of mind and personal character.

(This article includes extensive quotes from an article by Judy-Siegel-Itzkovich in the Jerusalem Post, May 29, 2005)

Yael Eshed-Eisenbach

PhD student of Prof. Elior Peles, Molecular Cell Biology, Weizmann Institute of Science
Dissertation topic: Neuro-Glial Interactions

Yael joined the research group of Prof Elior Peles after completing her BSc in the Faculty of Medicine at the Hebrew University of Jerusalem, where she was at the top of her class. Prof. Peles describes her as an extremely bight individual, whose wide knowledge of different topics in biology, as well as her original thinking and creativity, continue to amaze him Her unique technical skills make her an exceptionally talented experimentalist.

In the course of her MSc studies, Yael discovered a new protein (gliomedin) that mediates communication between the two major cell types in the nervous system, neurons and glial cells. Later on, as a PhD student, Yael showed that the protein she discovered is important to the normal organization of nerve cell membranes. Gliomedin is important to the clustering of ion channels at specific locations along the nerves called the nodes of Ranvier. Her discovery was published in *Neuron* and is recognized as a major achievement in molecular and cellular neuroscience.

Yael continues to make outstanding contributions to our understanding of how functional nerves are built during development. She planned and performed several original and elegant experiments that reveal how gliomedin functions. Her results have opened some surprising new avenues of research.

2005-2006

Nathan Keller

PhD student of Prof. Gil Kalai, Mathematics, The Hebrew University of Jerusalem
Dissertation topic: Probabilistic Combinatorics and its Relations with Harmonic Analysis

Nathan's research is geared towards probabilistic combinatorics and its relations with harmonic analysis. Nathan's potential may be seen from his prior accomplishments. In high school, he won first prize in the Israeli Mathematics Olympiad and twice won bronze medals in the International Mathematical Olympiads. He is a gifted violinist and also pursued higher religious studies for several years at the Merkaz Harav Yeshiva.

Nathan completed his first degree at the Technion at the age of 17, and his second degree at the same institution during his military service. Results of his MSc thesis in matrix theory, and the subsequent outcome in the same area, form two of his published journal papers. In addition, Nathan has written more than twenty conference papers in cryptology, investigating design and analysis of various cryptosystems.

Nathan intends to continue his research in combinatorics under the supervision of Prof. Gil Kalai while simultaneously continuing his research in cryptanalysis with Dr. Orr Dunkelman and Prof. Eli Biham of the Technion. With Prof. Stephen Miller at Rutgers University and Ramarathnam Venkatesan of Microsoft Research in the United States, he wishes to extend his work to the more mathematical aspects of cryptology. He also intends to continue his work in matrix theory, on a smaller scale, with Prof. Daniel Hershkowitz of the Technion.

According to Prof. Kalai, Nathan has shown rare abilities and extraordinary potential as a mathematician.

Tal Lev-Ami

PhD student of Prof. Shmuel Sagiv, Tel-Aviv University
Dissertation topic: Efficient Transformers for the Verification of Heap Manipulating Programs

Tal completed his undergraduate degree in Computer Science at the Open University of Israel while still in high school in the United States. He went on to do his MSc in the same field at Tel-Aviv University while serving as a full-time army officer in a special unit for gifted soldiers.

In his MSc thesis, for which he received the Maus Prize, Tal developed TVLA, a tool for generating software verification algorithms that is already being used by researchers in leading universities worldwide. Parts of the thesis, which demonstrated his capabilities to tackle theoretically difficult problems and come up with ingenious solutions, were published in top-rated conference proceedings, and they formed the basis for over 12 papers by doctoral students. Profs. Alex Aiken of Stanford University and Tom Reps of the University of Wisconsin both evaluated his MSc thesis as the equivalent of a PhD dissertation at their universities.

In his PhD dissertation, Tal attacks the problem of automatically verifying computer programs operating on the heap, which is the dynamically-allocated memory used by programs to store information. He uses the theory of "abstract interpretation" to conservatively approximate the runtime behavior of a program. One of the major challenges in this framework is the development of efficient and precise "abstract transformers" that capture the effect of each program statement. The provision of such transformers will allow the verification of larger programs that have thus far been too complex for the current systems.

Raz Palty

PhD student of Dr. Israel Sekler, Physiology, Ben-Gurion University
Dissertation topic: Characterization of the Novel Exchanger NCLX – a FLJ2233 Gene Product

Dr. Israel Sekler describes Raz as an extraordinary PhD student, as reflected both in his scientific achievements and in his intellectual ability. Raz is working on three major scientific projects: intracellular Na+/Ca2+ transport mediated by a unique Na+/Ca2+ exchanger that he cloned; the oligomeric structure of this novel exchanger; and the molecular identification of a novel Na+/Zn2+ exchanger.

In the first project, Raz and his colleagues identified a novel Na+/Ca2+ exchanger that is localized to intracellular organelles and controls cellular Ca2+ homeostasis. Even subtle changes in intracellular Ca2+ transport play a fundamental role in critical cellular processes ranging from aging to cell death. Therefore, the identification of this exchanger represents a novel and major contribution to understanding basic and fundamental issues of cellular Ca2+ homeostasis.

In the second project, Raz found a unique structural and functional interaction between two subunits of the exchanger. This is the first demonstration that subunits of a protein from this family can interact, a finding that may have important physiological implications, since the interaction between these proteins may greatly diversify their activity and regulation in native tissues such as muscle.

In his third project, Raz identified a novel transporter of zinc. This protein, a Na/Zn exchanger, is able to lower the intracellular concentration of zinc, a finding that has both scientific and medical implications, because zinc rise in neurons is a key factor in neuronal death and brain damage encountered during brain stroke. Raz's finding may pave a new way to the treatment of this devastating disease.

Raz is the leading author of several full-length articles in the prestigious periodicals Journal of *Biological Chemistry* and *Biochemistry* and is recognized by his mentors as one of the brightest and most promising young scientists in Ben Gurion University.

Sharon Shwartz

PhD student of Prof. Moti Segev, Physics, The Technion
Dissertation topic: Nonlinear Optics in CZT:V

In the framework of the Technion's direct PhD program in physics, Sharon is conducting research on fundamentally new effects in a family of cubic nonlinear crystals. He has made a profound discovery that, according to Prof. Segev, has the potential of creating a mini-revolution in what is known about such materials, opening up new opportunities for important all-optical beam steering and control, beam scanning, detection and other applications that may lead to many patents.

Sharon discovered that under some conditions of light illumination and applied electric field, a class of material (cubic crystals with a low concentration of foreign atoms at energy level deep in the forbidden gap) becomes highly polar and greatly modifies its properties. The atoms making up the crystalline lattice move considerably, greatly distorting the electronic orbitals, enhancing all the nonlinear properties of the medium in real-time. He measured enhancements of the electro-optic effects by 3 orders of magnitude, more than any other electro-optic index change ever measured in an inorganic bulk medium. He also measured a factor 1000 enhancement of the piezo-electric and electrostriction effects. These are clear indications of a major change in the crystalline structure of the material. Sharon went on to carry out sophisticated x-ray diffraction experiments with Prof. Zolotoyabko, Dean of the Materials Engineering Department at the Technion, and Prof. Steve Forrest of Princeton University, leading to the discovery that their "educated guess" was correct: The light moves the atoms in an orderly manner, determining the crystalline structure.

Sharon continues to make important progress in his research, exploring the microscopic origins of the light-induced crystalline symmetry-breaking effects he has discovered. Prof. Segev's predictions have been borne out by the publication of solid results in the journals *Optics Letters* and *Optics Express*.

Haim Beidenkopf

PhD student of Prof. Eli Zeldov, Physics, Weizmann Institute of Science
Dissertation topic: Vortex Thermodynamics in High-Temperature Superconductors

During his MSc studies, Haim built a unique experimental setup, carrying out local magnetization measurements of vortex matter in high-temperature superconductor single crystals in the presence of a "shaking" AC magnetic field. The unique precision of his measurements and his exceptional insight and perceptiveness enabled Haim to discover a new thermodynamic phase transition of the vortex matter in high-temperature superconductors, one that questions some of the fundamental concepts in vortex matter physics.

As a first step in his PhD work, Haim expanded his studies to a range of different samples with various degrees of anisotropy and disorder, carrying out theoretical analysis in collaboration with some of the leading theoreticians in the field. He summarized his findings in an excellent paper published in *Physical Review Letters*, received the best poster award at an international workshop on vortex dynamics held in India, and participated in schools in France and Brazil, where he attracted much attention. He has given invited talks at the Israel Physical Society, at conferences held in Poland, Germany and Brazil, and at an Israeli-German Minerva workshop, where he proved himself exceptionally eloquent. Haim was also invited to visit the Max Planck Institute in Stuttgart for purposes of scientific collaboration, and he has given seminars at Ben Gurion and Bar Ilan Universities.

Additional exciting research directions that Haim is exploring are the dynamics of vortex flow in the vicinity of the discovered phase transition and in ion- and proton-bombarded samples; the thermal flow of vortices; and the occurrence of superconductivity in monolayers. Haim's results have given definitive answers to some long-standing, controversial puzzles, and they establish new scientific questions that theoreticians will have to address.

Liat Benmoyal Segal

PhD student of Prof. Hermona Soreq, Biological Chemistry, and Prof. Hagai Bergman, Physiology, The Hebrew University of Jerusalem
Dissertation topic: The Role of the Cholinergic System in the Pathogenesis of Parkinson's Disease

Liat is focusing on the involvement of the cholinergic system in the progression of Parkinson's Disease (PD), particularly from the genetic perspective. Although PD was first described in 1815 by Dr. James Parkinson, its etiology is incompletely understood, and no cure has been found.

In her MSc project, Liat discovered a novel association between genetic polymorphisms in Acetylcholinesterase (AChE, a key enzyme in the cholinergic system) and the occurrence of PD under chronic exposure to organophosphate insecticides (OPs). OPs, commonly used as agricultural pesticides, have been shown to increase the risk of developing PD. Their main target is the inhibition of AChE. Assessment of the environmental risk of neurodegeneration associated with exposure to pesticides is of great importance. Liat's study added important information on such risks and how they can be avoided.

In her PhD research, Liat initiated experiments to test the working hypothesis that aberrant control of AChE gene expression can influence susceptibility to PD. These tests are performed on transgenic mice that constitutively over-express different AChE variants. Because of their inherited imbalance, applying state-of-the-art techniques in molecular biology to such transgenic models can enable evaluation of the role of specific AChE isoforms and explain the intriguing mechanisms underlying the imbalance between cholinergic and dopaminergic signaling that initiates PD progression. This study will offer a new perspective on the involvement of the failing cholinergic system in the development of PD. EN101 (a specific antisense to AChE) or novel mRNA splicing modulators may become candidate drugs for attenuating the levels of circulating AChE, which may play a role in neurodegenerative diseases such as PD.

Liat's dream is to find a treatment that would either prevent PD or attenuate its progression. Her findings may also have implications for other neurodegenerative diseases, such as Alzheimer's and Huntington's.

Yael Elbaz

PhD student of Prof. Shimon Schuldiner, Biological Chemistry, Hebrew University of Jerusalem
Dissertation topic: Structure-Function Study of Multidrug Transporters

Multidrug transporters are ubiquitous proteins. Based on amino acid sequence similarities, they have been classified into several families. The smallest multidrug resistance proteins belong to the Smr family; they are about 110 amino acids long and extrude various drugs in exchange for protons. EmrE is a multidrug transporter from E. coli that belongs to the Smr family. EmrE serves as a good model system to investigate the mechanism of multidrug transporters and has been extensively characterized.

In her research on EmrE, Yael studied its topology in the membrane and also investigated the role of Tryptophan residues on the function of the protein. She then succeeded in expressing EmrE in a cell-free system, in a fully functional state and in amounts large enough to perform biochemical and structural studies. The results of her work were published in three papers, and Yael presented her work at the prestigious Gordon Conference on Membrane Transport in New Hampshire in June 2007, greatly impressing several prominent figures in the field.

The understanding of the mulitdrug-transporter mechanism has profound medical and biotechnological implications. Novel insights into its function should pave the way for better treatment of infectious diseases and will enable the design of new and effective chemotherapy drugs.

Apart from being an outstanding student, Yael is has dedicated herself to several extracurricular projects. She works as a tutor of adolescents resident in an institution for children from problematic backgrounds. At the Hebrew University's Institute of Life Sciences, she coordinates the very successful "Life Beyond the Life Sciences" series, in which guests from other disciplines are invited to discuss various topics.

Olga Khersonsky

PhD student of Dr. Dan Tawfik, Chemistry, Weizmann Institute
Dissertation topic: Mechanistic Enzymology: From Classical Tools to Directed Evolution

Olga served in the IDF's atuda program for four years as an officer and analytical chemist, heading an army research lab. She completed her first year of MSc studies simultaneously with her last year of army service. Through structure-reactivity studies, she revealed that serum paraoxonase is actually a lactonase. She performed mechanistic studies and deciphered the catalytic mechanism for lactones hydrolysis. Paraoxonases (PONs) are a family of HDL ("good cholesterol")-associated enzymes with anti-atherogenic functions and organophosphate (pesticides, nerve agents) degrading activity. In her MSc research Olga concentrated on serum paraoxonase 1 (PON1), and now she is working on PON3, a much less studied member of the paraoxonase family. She has published papers in *Biochemistry*, the *Journal of Biological Chemistry*, and *ChemBioChem*.

Olga is also working on the directed evolution of enzymes with novel activities. She aims to combine the classic tools of enzymology with a directed evolution strategy in the study of enzymatic mechanisms. She is developing substrates for high-throughput screening – a key process of directed evolution experiments.

Olga is interested in the interface between enzymology and medicinal chemistry. Most currently used medicines are compounds that interact with various enzymes, serving primarily as inhibitors. Several enzymes have been developed to serve as drugs. Olga believes that much progress can be achieved by using the potential of the directed evolution strategy, which is a powerful method for generating enzymes with tailor-made properties. Olga wishes to combine her skills in enzymology, molecular biology and synthetic organic chemistry to contribute to the development of novel therapies.

2006-2007

Dana Moshkovitz

PhD student of Prof. Ran Raz, Mathematics, Weizmann Institute
Dissertation topic: Probabilistically Checkable Proofs

The Probabilistically Checkable Proof (PCP) theorem is one of the most important and influential theorems ever proven in theoretical computer science. It states that any mathematical proof can be written in a different format, such that the proof can be (probabilistically) verified by reading only a constant number of its symbols (e.g., 10 bits). The PCP theorem implies hardness of approximation problems, and it yields constructions of codes with local testing and decoding properties. Two central parameters of a PCP are its size and its probability of error.

In 1997, researchers managed to construct PCPs with polynomial size and a sub-constant probability of error. In the last 6 years, many researchers have become extremely interested in PCPs of almost linear size and have managed to construct such PCPs, but these have achieved only constant (not sub-constant) probabilities of error. The bottleneck for constructing PCPs with both sub-constant error and almost linear size was the construction of low-degree tests that having both these properties. Dana and her advisor devised such a construction, as well as a corresponding PCP theorem. This breakthrough was presented in their joint papers "Sub-Constant Error Low Degree Test of Almost Linear Size" and "Sub-Constant Error Probabilistically Checkable Proof of Almost Linear Size", at STOC 2006 (one of the two best conferences in theoretical computer science).

According to Prof. Raz, Dana has an excellent background in theoretical computer science and a global research perspective. She is an outstanding student with outstanding research results.

Ariel Procaccia

PhD student of Prof. Jeffrey S. Rosenschein, Computer Science, Hebrew University of Jerusalem
Dissertation topic: The Theoretical Foundation of Multi-agent Systems (MAS)

Although multi-agent systems is a new discipline, it already includes a multitude of research fields. Ariel is working on the theoretical foundations of reputation systems (such as the one used in eBay). It is possible to show that in a peer-to-peer network, information can be aggregated very efficiently using "gossip-based" algorithms. This can be used to determine an agent's overall reputation before striking a deal, but raises many interesting questions with respect to defending the system against possible cheaters.

Ariel intends to extend his previous work on computational social choice in many directions. One is designing a voting protocol that is hard to manipulate. He would also like to extend his work on multi-winner voting protocols by investigating the computational complexity of vote elicitation, examining questions in the context of party systems, which heretofore have not been considered, and studying communication complexity issues.

Ariel would like to obtain a generalization of his theorems on learning in games with fallacious rewards to stochastic games, since a large portion of multi-agent learning research focuses on them. Among the intriguing questions that he intends to study are the definition and analysis of a concept akin to the well-known "price of anarchy" in the framework of multi-agent systems; and the computational aspects of interactive knowledge (one of the disciplines developed by the 2005 Nobel laureate in economics, Prof. Yisrael Aumann).

Ariel's research is already gaining notice in the MAS community, with almost 20 research papers published (most of them in the field's leading conferences and journals) or in preparation.

Carmel Rotschild

PhD student of Prof. Moti Segev, Physics, The Technion
Dissertation topic: Soliton Interactions in Nonlocal Nonlinear Media

Carmel is currently participating in a direct PhD program at the Technion and has laid the foundations for a new direction in soliton science. As he described in *Physical Review Letters*, he is exploring the interactions between and among solitons from very far away and the remote control of soliton dynamics. He also discovered that if you take solitons that orbit about each other and move them apart while maintaining the launch trajectories, and the nonlinearity is fixed, the tangential velocity of their motion is unchanged even though the distance between them is increased by a factor of 5. Prof. Segev describes this as a ground-breaking result and foresees that Carmel's forthcoming paper in Nature-Physics will be viewed as a milestone and become a standard reference.

Recently, Carmel has found a new kind of solitons that arise in instantaneous response media. This breakthrough in soliton science is expected to have a great impact on observed nonlinear phenomena in astrophysics and other fields of science.

Carmel is now working on sub-wavelength solitons, which are solitons that are narrower than a single wavelength of the light beam that carries them. He has found a medium with an extremely large nonlinearity (where light pressure is used to modify the refractive index). His experiments in this new medium are very encouraging and have the potential to create the first "nano-scale soliton".

Another project Carmel is pursuing for ideological reasons is the generation of electricity by transporting water through osmotic pressure. He has constructed a small-scale model of the Dead Sea and linked it to a reservoir of ordinary sea-water (or purified sewage water), for the purpose of attempting to use the salinity difference between them to transport water in such a way as to produce electricity. His project has impressed and excited several prominent scientists at the Weizmann Institute.

Ofer Shayevitz

PhD student of Prof. Meir Feder, Electrical Engineering, Tel-Aviv University
Dissertation topic: Universal Communications with Feedback

Ofer's MSc research was at the crossroads of information theory and digital communications, focusing on the design of practical universal decoders for unknown frequency-selective fading channels. Such decoders had been suggested in the literature as an optimal method for decoding in unknown channels, but only random codes with an infinite block size had been considered, and no practical universal decoder had been proposed. Ofer described an explicit algorithm for selecting the optimal (in a minimax sense) universal decision rule out of a family of quadratic decision rules. The resulting universal decoder was shown to outperform the common approach of joint equalization/decoding, also known as the Generalized Likelihood Ratio Test (GLRT), while maintaining the same computational complexity. This result has many potential applications in wireless communications, some currently under investigation.

Today, Ofer's research focuses mainly on communications over unknown two-way channels, with specific interest in the role of feedback for boosting performance. By defining the notion of an "empirical capacity" for a channel, Ofer has demonstrated how a feedback link can be utilized in order to opportunistically attain positive communication rates over channels that, even with feedback, have zero classical capacity. Recently, he has also described a general feedback transmission scheme that, in a simple algorithmic fashion, attains a rate equal to the mutual information for any memoryless channel and any desired input distribution. This result provides a new unified framework for several feedback schemes previously suggested for specific channels.

Aside from the main theme of his dissertation, Ofer has recently presented some new results on the fundamental tradeoff between delay and redundancy in lossless source coding. He also has a keen interest in the growing field of quantum information theory, and he has put together and taught a graduate course on that subject.

2006-2007

Amir Shlomai

PhD student of Prof. Yosef Shaul, Biochemistry, Weizmann Institute
Dissertation topic: Metabolic Alterations in the Liver and Hepatitis B Virus Gene Expression

Amir graduated from the Hebrew University's Medical School in 2001, ranked third in his class. Following his internship at Hadassah, he decided to devote some time to research in the laboratory of Prof. Yosef Shaul at the Weizmann Institute, where he was exposed to basic science and the theoretical and practical aspects of molecular biology. After receiving his MSc, he returned to Hadassah as a resident physician in the Department of Medicine, but, following two years of clinical work, he returned to basic science and PhD studies in Prof. Shaul's lab.

Within a year, Amir succeeded in setting up a system to investigate the interplay between nutritional signals and the Hepatitis B Virus (HBV) life cycle. He first found that the metabolic coactivator Pgc1, a key component in the glucose production process (gluconeogenesis), plays a central role in HBV transcription and replication. He then used a new technique to deliver HBV DNA into a mouse liver, resulting in efficient liver-specific HBV gene expression and replication. Then, by changing the animal's food consumption, he showed that HBV production is dramatically increased by starvation, a condition that supports gluconeogenesis. By knocking down Pgc1 in the liver cells, he was able to demonstrate that this coactivator is responsible for the high HBV production, a conclusion that was further supported by other molecular techniques. These findings may explain for the first time why HBV is more prevalent in poor countries and may also promote a nutritional approach to fighting the virus.

Amir has proven himself to be not only an innovative physician, but also a leading force in the lab and the department. After receiving his PhD, Amir intends to become a physician-scientist by completing his residency in Internal Medicine.

Noam Stern

PhD student of Prof. Ofer Mandelboim, Immunology, Hebrew University of Jerusalem
Dissertation topic: Natural Killer (NK) Cells

The mechanisms controlling the killing of tumor and virus infected cells by NK cells are mostly unknown, and the identification of such mechanisms is one of the most important issues in the field of NK biology and in tumor and virus spread.

As an MSc student, Noam discovered a mechanism used by tumor cells to evade NK cell attack. These novel findings, which were published in the *Journal of Immunology*, have immediate clinical implications, as drugs can be developed to tackle the evading mechanism of the tumor cells, enabling the elimination of these cells by NK cells. Noam received the prestigious Wolf award and was invited to present her data at the international Carcino-Embryonic Antigen (CEA) conference in Germany.

Having moved to a direct PhD program, Noam is currently studying the mechanisms used by tumors and viruses to evade NK cell killing. She discovered a way by which NK cells are inhibited and demonstrated that tumor cells expressing the "famous" Carcino-Embryonic Antigen (CEA) are protected from killing by NK cells. Additionally, Noam has discovered a fascinating mechanism used by the Human Cytomegalovirus (HCMV) to avoid NK cell attack. She showed that the virus encodes a specific viral micro-RNA that down-regulates a host immune system gene crucial for NK killing of infected cells. These new findings are forthcoming in the prestigious *Science Journal*. Noam will continue to work on these important issues, as understanding the mechanisms by which tumors and viruses evade NK cell attack not only will contribute significantly to the basic understanding of NK cell biology, but may also enable the development of new drugs for treating cancer and virus spread.

Avraham Ben-Aroya

PhD student of Dr. Oded Regev and Dr. Amnon Ta-Shma, Computer Science, Tel-Aviv University
Dissertation topic: Quantum Computation and Quantum Information

Research in the upcoming field of quantum computation is concerned with the power of computing devices based on the laws of quantum physics, which are the laws that govern our universe on a microscopic scale. These quantum computers, once built, will be able to break almost all known cryptographic systems in use today, thereby affecting all electronic financial transactions. Constructing these amazingly powerful computers is a highly complicated engineering task, one that many labs and governments around the world are currently attempting to accomplish.

Avi's research is concerned with some of the core questions surrounding quantum computation, such as its limitations and abilities. He has investigated and described a new quantum primitive known as a quantum expander, which already has applications in quantum complexity theory, with more expected in the future.

In his research, Avi looked for a quantum analogue of expander graphs – a super-operator (i.e., an operator that maps one quantum state to another) having one eigenvector of eigenvalue one (the completely mixed state), with all its other eigenvalues bounded away from one. His goal is for the "degree" (which in this case is the amount of entropy created in the process) to remain constant. This construction has a potential for many applications in quantum computational complexity.

Other topics on which Avi is focusing are quantum error-correcting codes, quantum random access codes and classical encryption against quantum adversaries. Avi has come a long way since the beginning of his academic studies at the age of 14 and his BSc at 18. It is evident that he is putting his exceptional analytical abilities to good use.

Shai Carmi

PhD student of Prof. Shlomo Havlin, Physics, Bar-Ilan University
Dissertation topic: Complex Systems

Shai has already made significant contributions to the very active field of complex networks. He related the topological properties of the network of interacting proteins to the protein levels and suggested a model of protein complex formation to explain the results. Shai also developed a new algorithm for efficient routing in communication networks, based on physical methods and novel ideas. He investigated a variety of transport problems of model and real networks. He also suggested a new model for the Internet topology based on a new approach to network decomposition, fractal analysis and percolation theory. Shai's *Medusa* model for the Internet is much cited and has proved interesting and useful for understanding the complex topology of the Internet and improving its transport. Shai is also developing a model for the dynamics of systems (such as proteins or glasses) with complex energy landscape structure.

Shai plans to extend his projects and initiate new ones. In the protein networks project, he plans to integrate some new data sets of dynamically varying protein levels with protein interactome and transcriptome data. In the network transport project, he is developing a unifying theory for the various kinds of transport such as electrical conductance, max-flow and multi-commodity flow, as well as a new model for transport with priorities. He is also considering possible applications for network design and optimization.

Shai's advisor describes him as outstanding in the fields of mathematics, physics and computers. Since commencing research for his doctoral degree, Shai has published many of his findings in top journals, won many prestigious awards, including the Wolf Prize, and presented his work at prominent international conferences. Some of his results have recently caught wide media attention. Shai plays a leading role in developing theory for transport in complex networks.

2007-2008

Chen Davidovich

PhD student of Prof. Ada Yonath, Structural Biology, Weizmann Institute of Science
Dissertation topic: Ribosome Structure and Function

Chen is concerned with the increasing danger of antibiotic resistance, one of the more serious problems in modern medicine. All pathogenic bacteria acquire resistance to antibiotics in a relatively short time, leading to an alarming decrease in the usefulness of many antibiotics.

Owing to the fundamental role of ribosomes in the life cycle of bacteria, many antibiotics target them. Elucidation of the structural basis for antibiotic activity requires determination of the structures of ribosomal particles in complex with their antibiotics. Chen determined the three-dimensional structures of three ribosomal complexes with antibiotics from the pleuromutilins family. These antibiotics had not previously been characterized structurally, even though they are the object of great interest, since they bind to the ribosomal active site, which is highly conserved; yet not only do the pleuromutilins discriminate between eubacteria and eukaryotes, but resistance to this family is also acquired rather slowly by mutations, allowing peptide bond formation.

Chen has resolved this puzzle! He concluded that the accommodation of these antibiotics occurs by induced fit that utilizes the ribosomes' inherent functional flexibility and selectivity, and that resistance to pleuromutilins is based on remote interactions in the vicinity of the active site and not within it. Chen's study of pleuromutilins has thus provided unique information about ribosome function and invaluable data for future clinical applications, including possibilities for future drug design and cross-resistance. His study and creative interpretation were published in *PNAS*.

Simultaneously, Chen has designed a computational procedure for searching for ribosomal RNA regions suitable for antisense targeting. He examined these regions theoretically for their functional significance and produced antisense DNA fragments that complement these selected regions, as a potential basis for novel drugs. Chen presented this work at the 2007 International Ribosome Conference.

Shahar Dobzinski

PhD student of Prof. Noam Nisan, Computer Science, Hebrew University of Jerusalem
Dissertation topic: The Power of Approximations in Mechanism Design

Shahar's research is in Algorithmic Mechanism Design, an interdisciplinary area dealing with computerized markets and auctions. This area combines issues and techniques from computer science, game theory and economic theory. In mechanism design one doesn't just look at a game and try to understand what will happen. One designs the game in a way that will lead to the desired result, even with selfish players. Shahar is doing his PhD in conjunction with the new elite PhD program of the Rationality Center.

Today, because people use online auction services like eBay and corporations run their supply chains using the Internet, complicated computer-based mechanisms to handle huge amounts of data need to be designed. The basic computing unit is the Internet, consisting of many players, and a classic algorithm alone does not suffice for the task. The strategic behavior of the bidders must be handled in a computationally efficient way. Classic mechanism design offers solutions, but it suffers from certain drawbacks, such as computational hardness and the consequent inapplicability of game-theoretic tools. The field of Algorithmic Mechanism Design attempts to develop new tools that take into account both strategic considerations and computational efficiency.

Shahar's research is aimed at bridging the gap between what is possible from a game-theoretic perspective and what is possible from a computational point of view. His main research question is: Is it possible to design truthful mechanisms that provide good approximations for combinatorial optimization problems? How much additional burden do strategic constraints impose beyond the computational ones?

Shahar has had an impressive number of papers published in the proceedings of the most prestigious conferences (STOC, SODA, EC), "each one," according to Prof. Nisan, "containing significant and ingenious novel results." In terms of the quality and quantity of research performed, Shahar has already produced enough for an excellent PhD dissertation!

Moshe Goldstein

PhD student of Prof. Richard Berkovits, Physics, Bar-Ilan University
Dissertation topic: Interference Effects in Interacting Mesoscopic Systems

Prof. Berkovits describes Moshe as "a rare talent of the kind that appears only once in a decade. Not only does he have exceptional grades and a long list of prizes; he has also distinguished himself by his deep, penetrating questions and lively discussions."

Moshe completed his MSc thesis on properties of interacting disordered mesoscopical systems with the highest distinction and a perfect score of 100. Problems in this field involve mastering complicated mathematical techniques and physical ideas related to many body quantum mechanics. Moshe mastered these techniques, completing his thesis within a year. He clarified the influence of weak electron-electron interactions on localization length using numerical calculations and analytical approaches based on the random matrix theory, an issue relevant to the hot topic of two-dimensional metal insulator transitions. He also considered the influence of temperature on the magnetic susceptibility of mesoscopic systems and found surprisingly strong temperature dependence. His thesis resulted in two papers in *Physical Review B*, a leading international scientific journal that publishes only papers containing significant new results of interest to the international physical community.

Concurrently with his demanding military service in the Israel Aerospace Industries, Moshe unofficially continued his scientific research in Prof. Berkovits's lab, working on problems related to the coupling of nano-structures (such as quantum dots) to external leads. These studies could lead to the discovery of new physical phenomena, such as quantum phase transitions, and they are also relevant to practical applications such as quantum computing. Despite his limited time, they resulted in five papers!

Following his military service, despite attempts to persuade him to continue his work in the Aerospace Industries, Moshe returned to Bar-Ilan University to work on his PhD dissertation, on topics related to correlated electron physics in meso- and nano-systems.

Amir Goren

PhD student of Prof. Gil Ast, Human Genetics and Molecular Medicine, Tel-Aviv University
Dissertation topic: Inferring Regulatory Elements of Splicing Using Comparative Genomics

Amir's work in Prof. Ast's lab has been remarkably successful. He is making significant inroads into crucial biological questions, including the significance of alternatively spliced exons containing Alu elements and how alternative splicing of these exons is regulated. Amir's work led to the development of a computational method based on the conservation level of wobble positions and the overabundance of sequence motifs. It has demonstrated the importance of exonic splicing regulatory sequences (ESRs) on alternative splicing regulation.

Amir's major scientific discovery was that the same DNA fragment can either enhance or suppress alternative splicing, depending on its location in the exon. This is a revolution in the way researchers think about such elements. A paper describing this breakthrough was published in *Molecular Cell*.

Amir is also involved in a second paper in which the evolution of alternative splicing is considered. He has identified a novel evolutionary pathway to create transcriptomic diversification. He was further involved in the bioinformatics analysis which demonstrated that constitutive exons have become alternatively spliced during evolution. He is currently working to correlate between SNPs and aberrant splicing. He examined rare nucleotide variants that are located in genes associated with extreme BMI and revealed they tend to affect ESRs, leading to aberrant splicing. This work is soon to be published in *Genome Research*. Amir has also just finished writing a review dealing with current perspectives on alternative splicing for *BioEssays*. This is outstanding for a PhD student.

Prof. Ast describes Amir as "unquestionably one of the most brilliant and productive graduate students" that he has ever worked with and an "outstanding addition" to his laboratory. Amir's work is laying foundational elements in genomic biology.

2007-2008

Dan Hermelin

PhD student of Prof. Gad M. Landau, Computer Science, Haifa University
Dissertation topic: Algorithmic Challenges in RNA Comparative Analysis

In his career as a professor of computer science in Israel and the USA, Prof. Landau has never come across a student as exceptionally bright and hard-working as Danny. In just three semesters, he completed all the courses and requirements for his Master's degree and produced four innovative papers as well. During his first three semesters as a PhD student, he wrote six more papers.

Danny is interested in designing and analyzing combinational algorithms for computational problems that have real-world applications, as in computational biology. This includes designing fixed-parameter and approximation algorithms for NP-hard problems, and faster algorithms for polynomial-time solvable problems. He is also interested in general computer science theory, particularly complexity theory, and in specific areas of combinatorics and discrete mathematics, such as graph theory and discrete geometry, which have applications in computer science.

Working in the area of approximation and exact algorithms for combinatorial problems, Danny presented six of his ten papers at top international conferences (SODA, ICALP, ESA, WG, CPM and SPIRE). Danny's papers so far have presented many new results on graph theoretical algorithms and optimization. He has developed many novel techniques for studying the complexity of a variety of problems involving 2-interval patterns, multiple-interval graphs and biological RNA sequencing. In most cases, he has filled in empty slots, answering several open questions in these settings. The new algorithmic procedures that he developed are considered a significant scientific advancement.

Prof. Landau places Danny among the top 1% of doctoral students in computer science in Israel.

Yoav Lahini

PhD student of Prof. Yaron Silberberg, Physics, Weizmann Institute of Science
Dissertation topic: Disordered Nonlinear Systems

Yoav's MSc research involved nonlinear physics of periodic media, investigated through nonlinear optics of waveguide arrays. He identified two previously unappreciated effects, one related to polarization properties of the band structure and the other to a nonlinear self-tuning effect. His work led to several papers in prestigious journals, including *Physical Review Letters, Physical Review* and *Optics Express* – an impressive achievement at this early stage in his career.

Yoav is now focusing on direct observation and characterization of the interplay between disorder and nonlinearity. This interdisciplinary field, involving concepts from nonlinear science, solid-state physics and ultrafast optics, is very hard to approach theoretically. Yoav developed a new, exciting experimental approach that enables direct investigation of these factors. His experimental setup allows an excellent control of experimental parameters that is practically impossible in other realizations of this problem. His work has already attracted considerable interest among scientists working in solid state physics in nonlinear science and optics.

Yoav's important breakthrough is in the area of discrete X-wave solitons. This effort is expected to open a new area of study. In his experiments, Yoav has demonstrated for the first time efficient two-dimensional nonlinear X-wave generation in optical waveguide lattices, by using discrete effects in a bidispersive system. He has also worked in the area of nonlinear selection rules and nonlinear induced relaxation processes.

Yoav is regarded as one of the top research students in nonlinear optics and complex dynamics. His results are considered a true first in nonlinear science and are expected to have a lasting impact for many years to come.

Guy Ron

PhD student of Prof. Eliezer Piasetzky, Experimental Physics, Tel-Aviv University
Dissertation topic: Measurement of the Proton Elastic Form Factors at Low Q2

Guy's choice to pursue his PhD in the field of high-energy nuclear physics (the boundary between high-energy/particle physics and the more traditional nuclear physics) stems partly form a scholarship awarded him by the US Department of Energy during his BSc studies, allowing him to spend a summer working in the Thomas Jefferson National Accelerator Facility – JLAB, a leading research institution in the US. His BSc was sponsored by the Israeli government through the IDF, where he served for twelve years in the Military Intelligence Signals Regiment. He is now in a direct-track PhD program.

Guy completed his analysis of proton electromagnetic form factors in only three months, with excellent results: the first definitive finding that the electric and magnetic structures of the proton differ significantly when probed at low-momentum transfer. This is very suggestive of a behavior in the ratio of electric to magnetic structure unanticipated by any of the existing theories or descriptions of the proton electromagnetic structure. These intriguing results have already led to the proposal of a detailed follow-up experiment. Guy is the first PhD student to defend an experimental proposal before the International Program Advisory Committee (PAC) at JLAB and the first graduate student spokesperson of an approved experiment.

Guy's findings have a potentially high impact. The new measurements improve our understanding of the proton electromagnetic structure and also have the potential to resolve a discrepancy in understanding hyperfine splitting in the hydrogen atom. They may also impact a modern technique that uses virtual Compton scattering to measure what are called generalized parton distributions of the proton, as well as parity violation experiments that measure the strange quarks in the proton.

Avraham Saig

PhD student of Prof. Ehud Ahissar and Dr. Amos Arieli, Neurobiology, Weizmann Institute of Science
Dissertation topic: Guiding Principles for Sensory Substitution: From Vision to Touch

Avi completed his MSc in chemistry with seven publications in such prominent international journals as the *Journal of Physical Chemistry, J. Phys. Chem Solids, Langmuir*, and *J. Chem Phys*. However, spurred by a wish to move to a more "virgin" scientific field in which he could benefit society more directly, he switched to brain research, focusing on helping the blind and visually impaired.

Avi is researching the field of sensory-substantiation, the attempt to substitute one sensory modality (e.g., touch) for another (e.g., vision). This field has practical implications as a means to alleviate sensory deficits in clinical populations – such as the blind and the deaf – who may be able to rely on an alternative sensory modality to gain missing information about the outside world. There are also interesting fundamental issues involved in mapping one sensory modality onto another: Does the learning process depend on active participation, or can it occur passively? What are the dynamics involved? What strategies can the substitution use? These issues can teach us a lot about the way the human brain represents the outside world through the senses - one of the fundamental questions facing brain research.

Sensory substitution is usually carried out using electronic systems converting data-signals arriving from an artificial sensor (e.g., a camera) to activation-signals directed to a stimulator activating sensory receptors (e.g., skin receptors). Although existing sensory substitution devices take advantage of available knowledge about peripheral tactile receptors, they are not sufficiently successful. Accumulating evidence suggests that part of this failure stems from the non-optimal way, from the point of view of central tactile processing mechanisms, that these devices stimulate peripheral tactile receptors. Avi is working on the development of scientific guidelines for optimization. His aim is to reveal the guiding principles for efficient design of vision-to-touch substitution systems.

2007-2008

Alexander Sodin

PhD student of Prof. Vitali Milman, Mathematics, Tel-Aviv University
Dissertation topic: Probabilistic Methods in Asymptotic Geometric Analysis

Sasha's research is part of an area called Asymptotic Geometric Analysis, which has emerged in the last few decades at the border between Functional Analysis and Convex Geometry. Deep and multifarious connections have been discovered between this area and Probability Theory, Mathematical Physics, Combinatorics and Theoretical Computer Science, and methods from Asymptotic Geometric Analysis have found numerous applications. On the other hand, methods from Probability Theory, Classical Analysis and so on appear to be useful for solving purely geometric problems.

In his research, Sasha hopes to promote the interconnections between Asymptotical Geometric Analysis and the above subjects. Methods from Probability Theory have been applied in Analysis for many years. Recently, a new level of connection has appeared, focusing, on the one hand, on the study of probability measures of geometric origin (such as uniform distribution in a convex body) and, on the other, on the study of natural classes of probability measures (such as s-concave measures) from a geometric point of view. Using the geometric and analytic tools he has learned from Prof. Milman and the techniques in Probability Theory that he learned from Professors Barthe, Bakry and Ledoux in Toulouse, Sasha hopes to contribute to this research direction, which introduces a new approach to several problems.

Additional challenging subjects that Sasha plans to research are; the interconnection between Geometric Asymptotic Analysis and several areas of Mathematical Physics, especially Statistical Physics and Random Matrix Theory; and the connections between Geometric Asymptotic Analysis and Graph Theory.

Only one year after completing his army service, Sasha has already written eight papers and presented his results at the international conference on Gaussian measures in Convexity Theory in the US. Sasha received a Wolf Fellowship for MSc students for this work, which he did during his army service.