Current Research Activities

The Weizmann Institute of Science

2009

About the Weizmann Institute of Science

Table of Contents

About the Weizmann Institute of Science

The Weizmann Institute of Science in Rehovot, Israel, is one of the world's top-ranking multidisciplinary research institutions. Noted for its wide-ranging exploration of the natural and exact sciences, the Institute is home to 2,500 scientists, students, technicians and supporting staff. Institute research efforts include the search for new ways of fighting disease and hunger, examining leading questions in mathematics and computer science, probing the physics of matter and the universe, creating novel materials and developing new strategies for protecting the environment.

Faculty of Biochemistry

Department of Biological Chemistry

Eitan Bibi, Head

The research activities of the Department of Biological Chemistry span several topics in the life sciences with overlapping interests. The common thread connecting these activities is the study of proteins in key biological processes ranging from transport across membranes and signal transduction, to gene expression and DNA repair. The department has more than 20 research groups whose activities are centered around the following six foci of interest:

1. Protein science, including protein-protein interactions, protein-ligand interactions, evolution of enzymes, and understanding the composition of large complexes.
2. Proteins involved in controlling DNA stability, repair and expression of genetic information.
3. Structure and function of membrane proteins including ion channels, pumps, transports, enzymes, and molecular motors.
4. Mechanisms by which proteins and lipids are transported from their point of synthesis, sorted, and inserted into various organelles.
5. Signal transduction processes in bacteria, vertebrate, and invertebrate organisms, as well as molecular pathogenesis, nerve growth and regeneration,and cell differentiation.

A variety of methodologies are being utilized, with an emphasis on biochemistry, biophysics, molecular genetics, advanced microscopy, computation methods, and structural biology tools (such as crystallography, atomic force microscope, mass spectrometry). Additional information can be obtained in the department's Home Page.

E. Bayer

Structural and functional aspects of the multi-enzyme cellulosome complex from cellulose-degrading bacteria.

1. The cohesin-dockerin couple - Protein-protein interactions that mediate recognition and specificity in cellulosome assembly.
2. Cellulose-binding domains as models for protein-sugar interactions.
3. Bioinformatics of cellulases and cellulosome components
4. Comparative genomics of cellulosome components.
5. Structure determination of cellulosome components.
6. Enzymology of cellulosomes for conversion of biomass to biofuels
7. Designer cellulosomes - Selective engineering of chimaeric cellulosome constructs for nanotechnology.
8. Avidin-biotin system - Mutated avidins and streptavidins

E. Bibi

Structure/function studies of the *E. coli* multidrug transporter, MdfA.
E. Bibi, N. Fluman and O. Tirosh

1. The multidrug recognition pocket of MdfA (genetic and biochemical studies)
2. 3D crystallization of MdfA
3. Mechanism of MdfA-mediated multidrug transport (proton/drug antiport)

The signal recognition particle (SRP) system in *Escherichia coli* and its role in membrane protein biogenesis:
E. Bibi, E.S. Bochkareva, A. Kinori, D. Ben-Halevy

1. FtsY, the essential prokaryotic SRP-receptor: its role in biogenesis of membrane proteins.
2. Structure-function studies on the GTPase (NG) domain of FtsY.
3. Membrane targeting and association of ribosomes in E. coli.
4. Membrane targeting and association of mRNAs encoding membrane proteins

Intra-membrane quality control
E. Bibi, E. Erez, I. Noach

1. Genetic screens aimed at the identification of intra-membrane quality control pathways and factors
2. Intra-membrane proteolysis by the rhomboid serine protease GlpG
3. Crystallization of a rhomboid-substrate complex

R. Dikstein

Transcription regulation: the mechanisms of basal and activated transcription

1. Molecular characterization of the general transcription factor TFIID
2. The mammalian core promoter diversity
3. Links between transcription and post transcriptional stages of gene experssion.
4. Mechanism of rapid transcriptional induction of NF-kappaB target genes.

Translation initiation

1. Mechanism of translation initiation from short 5'UTR mediated by TISU
2. Biological significance of TISU-mediated translation initiation

M. Eisenbach

Sperm guidance in humans

1. Molecular and behavioral mechanisms of sperm chemotaxis
2. Molecular mechanism of sperm thermotaxis

Chemotaxis of bacteria

1. Molecular mechanisms of sensing, signaling and response
2. Molecular mechanism of function of the switch of the bacterial flagellar motor

Z. Elazar

Molecular mechanisms of autophagy

1. Mechanism of autophagosomes biogenesis
2. Autophagy and neurodegeneration
3. Regulation of autophagy in yeast and mammals

Mechanism of intracellular protein trafficking

1. Regulation of intra-Golgi protein transport

M. Fainzilber

Molecular mechanisms underlying nerve growth and regeneration

1. Retrograde signaling mechanisms in healthy, diseased or injured neurons.
2. Molecular mechanisms of axonal communication and neuronal regeneration.
3. Death signaling in neural tumors
4. Size control mechanisms in neurons and other large cells.

A. Futerman

The molecular mechanisms of sphingolipid storage diseases (Gaucher, Niemann-Pick, and Tay-Sachs disease).

The regulation of ceramide synthesis

Sphingolipid signaling during neuronal development.

H. Garty

Regulation of epithelial ion transport:

1. FXYD proteins as tissue specific regulators of the Na+/K+ ATPase.
2. Kinases mediating hormonal regulation of epithelial ion-transport.
3. Identification of aldosterone regulated genes involved in ionic homeostasis

S. Karlish

Crystalization and function of Na/K-ATPase.

Regulation of Na/K-ATPase by FXYD proteins.

Molecular mechanisms involved in generation of essential hypertension.

Development of isoform-selective drugs

Z. Livneh

Molecular and cellular analysis of error prone DNA repair (translesion DNA synthesis) in mammals

DNA repair biomarkers for risk assessment and early detection of cancer

DNA damage tolerance via homologous recombination repair in mammals.

Mechanisms and biomedical applications of DNA repair.

U. Pick

Regulation of massive -carotene synthesis in *Dunaliella bardawil* and its industrial utilization.

Cold acclimation and cold-induced proteins in Dunaliella.

Iron uptake by an algal transferrin.

Structure and function of salt-resistant proteins.

H^+ and Na^+ transporters in the halotolerant alga Dunaliella.

Z. Reich

Nuclear pore complex (NPC)-mediated macromolecular transport

1. Transport mechanics, dynamics and energetics.
2. Nuclear pore proteins: molecular and biophysical characterization.
3. Nuclear import of exogenous DNA: implications for human gene therapy.

E. Reuveny

Structural and functional studies of ion channels in health and disease

1. Biophysical analysis of the gating and permeation using electrophysiological approaches (patch clamp).

2. Regulation of cellular distribution and signaling specificity by ion channels-associated proteins using biochemical approaches.
3. Conformational dynamics of ion channels associated with activation using novel fluorescence-based measuring techniques.
4. The role of the G protein coupled potassium channel in insulin secretion.

G. Schreiber

Protein-protein interactions, from basic biophysical understanding to protein design and structure-function relation.

1. Rational design of faster associating and tighter binding protein complexes.
2. Evaluation of direct and cooperative contributions towards the strength of non-covalent protein-protein interactions
3. Structure-function studies of the interaction of interferon and its receptors, towards understanding the biophysical basis of heterogeneous receptor activation by a family of hormones.
4. Bioinformatics of Protein-Protein interactions

Y. Shai

Membrane-protein interaction and molecular recognition within the membrane milieu. Implication to the function and structure of membrane proteins.

1. Assembly and organization of pore forming toxins and ion channels in membranes: Studies with isolated fragments and intact proteins.
2. Molecular mechanism of membrane fusion and its inhibition: Studies with HIV and Sendai Virus.
3. Molecular basis for cell selectivity by cytolytic antimicrobial peptides.

E. Shapiro

Biomolecular computing and its medical applications

M. Sharon

Studying large protein complexes involved in the protein degradation pathway using a novel mass spectrometry approach.

1. Elucidating the subunit organization of the 19S complex
2. Structure-function relationship of the signalosome complex
3. Investigation of the 20S ubiquitin-independent degradation pathway

Y. Shechter

Mechanism of insulin action: Post-binding events in insulin action

1. Post-receptor agents mimicking insulin.
2. Effect of vanadium *in vivo* and *in vitro*.
3. Role of protein tyrosine kinases and protein phosphotyrosine phosphatases in insulin effects.
4. Inhibitors of tyrosine kinases.
5. Chemical modifications of peptides and protein drugs.
6. Novel technologies to prolong life time of peptide and protein drugs.

D. Tawfik

Evolution and mechanism of enzymes

1. Molecular evolution in man-made cell-like compartments.
2. Directed evolution of tailor-made hydrolases (esterases, phosphoesterases, organophosphate hydrolases, and amidases) and DNA-modifying enzymes.
3. Structure, mechanism and evolution of serum paraoxonases (PONs)
4. The role of promiscuity and conformational plasticity in protein evolution.
5. Directed evolution of DNA-methyltransferases and DNase inhibitors
6. The stability effects of mutations
7. Protein evolvability
8. Chaperones and protein evolution

M. Walker

Selective gene expression in pancreatic beta cells:

1. Role of specific transcription factors in expression of the insulin gene in pancreatic beta cells and in control of pancreatic development.
2. Novel beta cell specific genes: isolation, characterization and use as potential tools in diagnosis and therapy of diabetes.

D. Wallach

Regulation of cell death and tissue damage:

1. Proteins involved in the signaling for the cell-killing (apoptotic and necrotic), immunoregulatory, and inflammatory functions of cytokines of the tumor necrosis factor (TNF) family, and in the regulation of these functions.
2. In vivo models for the functions of the signaling mechanisms activated by ligands of the TNF family and for their pathological aberrations.
3. Natural antagonists to ligands of the TNF family, for protection against the deleterious effects of these cytokines in autoimmune and infectious diseases.
4. Regulation of the activity of the NF kappa B transcription factors.
5. The caspases, their functions and mechanisms of activation.
6. Molecular mechanisms for chronic inflammatory skin diseases.
7. Contributions of aberrations in the function of signaling proteins activated by ligands of the TNF family to cancer

8. cancer-cells' survival factors

A. Yaron

Guidance mechanisms of sensory axons

Signaling mechanisms of repulsive axonal guidance cues

Department of Molecular Genetics

Yosef Shaul, Head

The molecular basis of genetics and related biological processes are under investigation in this Department. The investigators approach these processes from the most reduced and reconstructed systems up to more systemic and computational analyses. Different organisms are employed including virus, yeast, Drosophila, mouse and human. These animal models and cell culture systems are used to study the mechanisms of;
a. Basic processes in gene expression, such as transcription, translation and protein degradation.
b. Cellular responses to various stimuli, such as cytokines, growth factors and exposure to DNA-damage.
c. Regulation of cell growth, senescence, differentiation and death.
d. Development; Mechanistic view of zygote to embryo transition and development of various organs, such as brain, muscles, bones and pancreas.
e. Genetic and acquired diseases such as cancer and virus infection.
f. Computational and system biology. The function/evolution of genes and their diversification.

E. Arama

Genetic regulation of apoptosis and its molecular mechanisms.

Roles of caspases in conventional apoptosis and during cellular remodeling.

N. Barkai

Robustness and scaling of morphogen gradients .

System Biology: from functional genomics to network analysis

A. Elson

Regulation of physiological processes by protein dephosphorylation.

1. The role of PTPe in mammary tumorigenesis/breast cancer.
2. The role of tyrosine phosphatases in regulating bone mass and osteoporosis.
3. Roles of tyrosine phosphatases in regulating body mass.

4. Characterization of alternative isoforms of PTPe.
5. Identification of substrates and interactors of PTPe.

J. Gerst

Intracellular protein and mRNA transport in cell growth and disease

1. SNAREs and SNARE regulators in intracellular protein sorting
2. A yeast model for Batten disease
3. Targeted mRNA transport and the control of polarized cell growth
4. Genome-wide mapping of mRNA localization
5. Targeted mRNA transport and organelle biogenesis

Y. Groner

Positive and negative transcriptional regulation by Runx3

The Human Leukemia Associated Transcription Factor RUNX1/AML1 and Down syndrome leukemia

Biological function of the RUNX transcription factors

Molecular genetics of Down syndrome.

E. Hornstein

miRNA role in metazoan development and human disease

1. miRNA role in neuronal development
2. miRNA role in pancreas development
3. miRNA role in bone and cartilage development
4. miRNA stem cell differentiation

miRNA role in human disease

1. miRNA role in Diabetes Mellitus
2. miRNA role in neurodegeneration
3. miRNA role in DiGeorge syndrome
4. miRNA role in Tracheomalacia

C. Kahana

Characterization of the regulation and role of polyamines during growth of mammalian cells

1. Regulation of ornithine decarboxylase expression.
2. Polyamines and apoptosis.

Identification and characterization of regulatory and structural components of the polyamine

transport system.

1. Characterization of the proteolytic machinery.
2. Characterization of ornithine decarboxylase sequences that mediate its recognition by the proteolytic machinery.

Identification and characterization of functional domains of mammalian ornithine decarboxylase.

Characterization of ornithine decarboxylase degradation.

A. Kimchi

Programmed Cell Death: from single genes and molecular pathways towards systems level studies

1. Deciphering the roles of the DAP genes in programmed cell death
2. Systems biology analysis of the programmed cell death network
3. Functional annotations of a family of death-associated kinases: DAPk, DRP-1 and ZIPk
4. Protein translation control during cell death: structure/function analysis of the DAP5 gene

D. Lancet

Genomic and evolutionary analyses of molecular recognition systems.

1. Identification and molecular cloning of members of the olfactory receptor multigene family, including studies of their genome organization, evolution and polymorphisms in humans.
2. Computer analyses of structural models of olfactory receptors and other transmembrane proteins and of receptor affinity distributions.
3. Bioinformatics analysis of long-range DNA sequences and development of whole-genome databases.
4. Computer simulations of selection and evolution in current living organisms and at the origin of life.

S. Pietrokovski

Developing computational methods for using and identifying protein motifs and applying them for the analysis of particular protein families.

1. Developing advanced methods for comparing protein motifs.
2. Applying protein motif comparisons for functional and structural predictions and to database annotation.
3. Analysis of inteins ("protein splicing" elements) and homing endonucleases.

Y. Pilpel

Systems biology of genetics regulatory networks

O. Reiner

Formation of the brain structure in human is a complex process. One of the most striking features of the human brain is characteristic convolutions. These convolutions are lacking in a severe human brain malformation known as lissencephaly (smooth brain).

1. Identification of genes that are downstream to Lis1 mutation using microarray technology.
2. Study of LIS1 and DCX functions through characterization of protein interactions
3. Analysis of the developmental function of LIS1, DCX and Doublecortin-like-kinase using gene targeting in the mouse.

Functional Analysis of Genes Involved in Lissencephaly.

M. Rubinstein

Role of cytokine-induced proteins in atherosclerosis

Cross-talk of transcription factors in interferon-induced genes

Evolution of the interferon alpha gene family

Cytokine receptors and binding proteins
M. Rubinstein, Daniela Novick

M. Schuldiner

Understanding the Molecular Mechanisms Driving Endoplasmic Reticulum Inheritance

Deciphering the Regulatory Mechanisms Driving Insertion and Maturation of Tail Anchored Proteins
M. Schuldiner, Prof. Blanche Schwappach

Y. Shaul

Study of proteasomal p53 and p73 degradation by a mechanism that does not involve ubiquitination.

The activation and the role of c-Abl-p73 signaling axis in response to DNA damage and cancer.

modulation of Hippo signaling by c-Abl; the role of Yap1 and TAZ transcription coactivators in cell proliferation and in apoptosis

the mechanisms of switching from tumor suppressor to oncogene.

Transcription regulation of the hepatitis B virus. The aim is to understand how overlapping promoters are autonomously functional.

The molecular basis of virus-host cell interaction. How HBV modifies cell behavior.

20S proteasome and degradation of unstructured proteines by default; the role of NQO1.

B. Shilo

Development of the *Drosophila* tracheal system.

Signaling by the Drosophila EGF receptor pathway during development.

R. Sorek

Computational discovery of novel natural antibiotics

Microbial genomics and RNAomics with Illumina sequencing

CRISPR, an antiviral microbial defense system

T. Volk

The molecular basis for muscle-tendon interactions during embryonic development

1. The mechanism by which the RNA-binding protein Held Out Wing (HOW) regulates tissue differentiation in Drosophila.
2. The mechansim of muscle attraction by tendon cells.
3. The mechanism of arrest of muscle migration.
4. Mechanisms regulating heart somatic and visceral muscle morphogenesis

The formation of the Blood Brain Barrier in Drosophila

1. 1. The contribution of HOW to BBB formation
2. 2. Control of the unique cytoskeletal organization during BBB formation by Moody
3. 3. Identification of additional components required for BBB formation.

E. Zelzer

the roles of the VEGF pathway in different steps during skeletal development.

Studying the role of mechanical load on embryonic bone development

Department of Plant Sciences

Avraham Levy, Head

Plants offer the world its only renewable resource of foods, alternative energy and biotherapeutic compounds. Plants have highly sophisticated short and long-term adaptive mechanisms to the environment as a result of the simple fact that they cannot alter their location during environmental change. Basic understanding of how plants react to the environment and why they grow the way they do are central to devising a rational approach to address three important global challenges, namely to secure more and healthier food, to develop novel plant-based products associated with biotherapeutics and to produce alternative energy resources in the form of biofuels. Research activities in the Department of Plant Sciences are associated with all of the above-mentioned global challenges and range from studies on the function and regulation of isolated genes to their interactive behavior in the context of the whole plant. We have developed extensive in-house genomic, bioinformatics and transgenic infrastructure that enables us to isolate novel genes by gene trapping, knockout or map-based cloning. Cloned genes are manipulated and studied by transgenic analysis to establish their potential in the whole plant. Our research as listed below integrates methodologies of molecular biology, protein modeling, genomics, metabolomics, bioinformatics, system biology, genetics, biochemistry and physiology.
Harnessing light energy and energy transduction in the plant cell: Research is carried out on the basic biophysical phenomenon of photon absorption by chlorophyll through transduction of this energy to ATP and the regulation of energy flux by the plant redox state.
Adaptive response in the plant to the biotic and abiotic environment: Molecular mechanisms that drive the cellular response are investigated under environmental perturbation. Research is directed in understanding the elements that play a role in the recognition of pathogens and the subsequent mounting of plant defense responses as well as in the response of plants to abiotic stresses, such as salt stress.
Plant metabolism and growth: Research is centered around elucidating regulatory metabolic networks for production of essential primary and secondary metabolites as well as understanding gene expression and hormonal networks that control plant metabolism, growth, reproduction and productivity.
Plant genome organization: Molecular tools have been developed to examine the fluidity of the plant genome, as described by transposon element, and the evolution of polyploid plants.

A. Aharoni

Genetic Regulation of Metabolic Pathways and its Co-ordination with Developmental and Stress Response Programs in Plant Biology

1. The Primary-Secondary Metabolism Interface
2. Regulation of Plant Surface Formation
3. Regulation of Secondary Metabolism Associated Metabolic Pathways
4. Plant and Yeast Metabolomics
5. Riboswitches in Plants: Post Transcriptional Regulators of Metabolic Pathways

A. Danon

Mode of action of redox-signal transduction factors.

Redox-signaling controling light-regulated translation. Mechanisms of disulfide bond formation and isomerization in the chloroplast.

RNA-binding proteins controling light-regulated translation.

R. Fluhr

Role of reactive oxygen species in pathogen defense and signal transduction.
R. Fluhr, A. Mor, N. Alkan, D. Prusky (ARO)

Transcriptome dynamics in plant growth and environmental response.
R. Fluhr, O. Davydov, D. Volodarsky, M. Sagi (BGU)

Plant resistance genes and their role as receptor-like proteins for pathogen generated factors. Their role in innate resistance, their architecture, structure-function relationships and evolution.
R. Fluhr, Y. Zohar, N. Lampl, H. Saboni, T. Shachar

Dynamics of alternative splicing during stress and development
R. Fluhr, Noam Leviatan

Control of protease pathways
R. Fluhr, N. Lampl, Anna Propp

G. Galili

Association of metabolism and cell biology with plant development and response to stress
G. Galili, Zevulun Elazar, Aviah Zilberstein, Rachel Amir, Yoram Kapulnik, Alisaider Fernie

1. Gene expression programs and metabolic networks associated with seed maturation and germination
2. Metabolic engineering of high-lysine plants
3. Genetic, genomic and bioinformatics approaches to elucidate metabolic networks in plants
4. Regulatory interactions between primary and secondary metabolism of plants
5. Cell biology and physiology of autophagy-associated processes in plants

A. Levy

DNA recombination and repair in plants

1. DNA mismatch repair and recombination between divergent sequences
2. Chromatin remodelling and homologous recombination
3. Gene targeting in plants
4. Meiotic recombination

Functional genomics in tomato: linking between genes and functions through mutants analysis

Genetic changes during wheat domestication

A. Levy, M. Feldman, S. Weiner

The impact of polyploidy on genome structure and expression
A. Levy, M. Feldman

R. Milo

Design principles in photosynthesis and carbon fixation

Optimality in Carbon Metabolism

Synthetic carbon fixation pathways

D. Noy

Photosynthetic protein maquettes

1. Complexes of water-soluble and transmembranal *de novo* designed proteins with bacteriochlorophyll derivatives
2. Self-assembly and function of minimal transmmebranal analogs of purple bacterial light-harvesting complexes
3. Coupling energy and electron transfer protein maquettes

Engineering guidelines for energy and electron transfer in plants, algae and photosynthetic bacterial photosystems

A. Scherz

Quantification of atoms, groups and molecules electronegati using metal substituted bacteriochlorophylls and application to chemical reactivity.

Resolving the forces which drive membrane protein assembly.

The mechenism behind generation of reactive oxygen species (ROS) by illuminating novel bacteriochlorophyll derivatives and their application in photodynamic therapy (PDT) of tumors.

Faculty of Biology

Department of Biological Regulation

Nava Dekel, Head

The research in the department of Biological Regulation is concentrated on molecular, cellular and physiological studies of processes that collectively control the action of cells, tissues, organs and the entire body. Extensive efforts are directed to the elucidation of the regulators and pathways of the transmission and translation of signals evoked by hormones, as well as growth and death signaling factors. These studies include: (i) characterization of interactions between growth factors, hormones and extra cellular matrix components with specific receptors; (ii) induction and mechanisms of action of programmed cell death, necrosis and cell survival; (iii) mediation of intracellular signaling via second messengers protein kinase cascades or through lipid mediators and (iv) mechanisms of angiogenesis and oncogenesis. The results of these investigations advance our basic understanding of phenomena related to reproduction as well as tumor and vascular biology. In addition, it enables us to develop useful applications that intend to improve patient management.

A diversity of experimental methodologies is used in these projects. In particular unique non invasive methodologies of Magnetic Resonance Imaging (MRI) and Spectroscopy (MRS) are being developed in this department. The research groups include students from life sciences and chemistry, residents, physicians, and guest researchers from Israel and abroad. Several projects have already incorporated clinical assessment of experimental drugs and new diagnostic methods.

H. Degani

Estrogen regulation of angiogenesis and perfusion of breast cancer; from molecular mechanisms to functional MRI of the microvascular physiology

Hyperpolarized magnetic resonance spectroscopy and imaging of cancer metabolism; searching for novel metabolic markers of cancer
H. Degani, Professor Lucio Frydman, Weizmann Institute

Renal function through sodium grandients; Non-invasive, high resolution sodium MRI.
H. Degani, Dr. Edna Haran, Weizmann Institute

Mechanisms of lymphatic metastasis in breast cancer; In vivo fluorescence and magnetic resonanc imaging

Advanced non invasive MRI methods for breast cancer detection and diagnosis ; clinical investigations
H. Degani, Dr. Myra Shapiro, Meir medical Center

1. 3D Tracking of the mammary tree using diffusion tensor magnetic resonance imaging
2. Advanced methods for analysis of dynamic contrast enhanced MRI based on a combined model free and model based method.

Molecular magnetic resonance imaging of the estrogen receptor
H. Degani, Professors David Milstein and Joel Sussman, Weizmann Institute

1. Synthesis of new, high affinity ligands of the estrogen receptor as probes for molecular imaging
2. Structuaral studies (x-ray crystalography and NMR) of the estrogen receptor - targeted ligands complex
3. Functional activities and molecular imaging of the new targeted ligands in estrogen receptor positive huaman breast cancer cells

Perfusion and angiogensis in lung cancer: The role of the bronchial and pulmonary vascular network using Fluorescence and magnetic resonance imaging methods

N. Dekel

Regulation of the meiotic cell cycle: use of rodent oocytes as a model system.

Cell-to-cell communication: regulation of expression, posttranslational modification, degradation and function of the gap junction proteins, Cx43 and Cx37.

Mechanisms involved in successful implantation.

Molecular characterization of the ovulatory cascade

L. Gilboa

Soma - germ line interactions and germ line stem cell establishment in Drosophila melanogaster

1. Formation of the somatic niche for germ line stem cells.
2. Establishment of germ line stem cells from primordial germ cells.
3. Understanding how somatic cells determine the number of germ line stem cells.
4. Uncovering new genes that affect germ line stem cell maintenance and differentiation.

A. Gross

Mitochondria in apoptosis: Mechanisms of action of the BCL-2 family members

Mitochondria Carrier Homolog 2: role and function in embryogenesis, apoptosis and cancer

The response of cells to DNA damage: The role of ATM-mediated BID phosphorylation

M. Neeman

Targeted imaging of angiogenesis
M. Neeman, Helena Sheikhet Migalovich, Sefi Addadi

Multimodality imaging
M. Neeman, Alon Harmelin, Inbal Biton, Vyacheslav Kalchenko

Angiogenesis in ovarian cancer
M. Neeman, Gila Meir, Sefi Addadi, Yael Tzuman, Helena Sheikhet Migalovich

1. The role of fibroblasts and myofibroblasts in tumor growth, angiogenesis, vascular permeability and vascular maturation
2. MR labeling and tracking of cell migration during angiogenesis
3. Development of a contrast material for MR mapping hyaluronidase activity

Regulation of lymphangiogenesis.
M. Neeman, Batya Cohen, Gila Meir, Stav Sapoznik

1. The role of VEGF-A and Akt/PKB in interstitial convection and lymphatic drain
2. In vivo imaging of lymphatic drain and lymph node metastasis
3. The role of VEGF family members and microenvironmental stress in tumor lymphangiogenesis

Development of a reporter gene for MRI
M. Neeman, Batya Cohen

1. Ferritin expression in endothelial cells
2. Ferritin expression in liver hepatocytes

Imaging of apoptosis
M. Neeman, Atan Gross, Natalie Yivgi-Ohana, Michal Eifer

Y. Salomon

Anti-cancer treatments :

1. Development of novel bacteriochlorophyll-based drugs for photochemotherapy.
2. Boron neutron capture therapy.

Reactive oxygen species, their generation by bacteriochlorophyll and light, their role in signal transduction and mechanisms of cell and tumor destruction.

Vascular biology and vascular destruction.

R. Seger

MAPK signaling in proliferation and oncogenic transformation

1. The nuclear translocation of MAPKs - characterization and molecular mechanisms.
2. The role of non-alpha Importins in regulating nuclear effects of MAPKs.
3. Structure-function relationships of ERK and MEK.
4. The effect of calcium on the ERK1/2 and ERK5 signaling cascades.
5. Protein-protein interaction in the MAPK cascades.
6. Alternative splicing in determining signaling specificity of ERKs.

Apoptotic MAPK and PKB signaling

1. Mechanism of PKB inactivation upon stimulation.
2. Inter-relationship between the PKB, JNK and ERK cascades.
3. Scaffold proteins in the PKB cascade.
4. Mechanism of GPCR signaling to MAPKs and PKB.

PEDF phosphorylation: role in angiogenesis and cancer.
R. Seger, Teva

1. Development of the phospho-mimetic mutants of PEDF as anti angiogenic drugs.
2. Signaling by PEDF and its phospho-mimetic mutants.
3. Study the phosphorylation of PEDF as a model for extracellular phosphorylation.

E. Tzahor

Head muscle patterning and differentiation

1. Characterization of head muscle derived satellite cells
2. Dissecting the myogenic programs in head muscle progenitors
3. Involvement of p53 in cranial myogenesis

Cardiac and skeletal muscle progenitors during vertebrate embryogenesis

1. Studying the crosstalk between BMP and FGF signaling pathways in cardiac progenitors
2. Regulation of Islet1 gene expression using novel imaging techniques in live embryos
3. The origin of the heart endocardium: Focus on the role of endothelial cells in cardiogenesis

Y. Yarden

Roles for growth factors in cancer progression, focusing on epithelial cell migration and metastasis.

Feedback regulation of growth factor signaling, concentrating on receptor phosphorylation, ubiquitination, and endocytosis. Transcription-mediated control is studied at the level of mRNA and microRNA.

Molecular targeted therapy of cancer, including monoclonal anti-receptor antibodies, kinase inhibtors, soluble receptors and emerging technologies.

Roles for EGFR and HER2 in carcinoma development, resistance to conventional therapy and potential for future drug development.

Research on biomarkers based on detailed characterization of signal transduction and feedback regulation.

Brain tumors, pancreatic, breast and other types of cancer: molecular mechanisms underlying aggressiveness and resistance to therapies.

Department of Immunology

Yair Reisner, Head

Research topics of our Department span the wide range from basic mechanisms in the development, recognition, inter-cellular communication, trafficking, and effector functions of the immune system to the role of these processes in autoimmune disorders, allergies and cancer. Special attention is given to the studies of immunomodulation and immunotherapy of these diseases leading to the development of specific vaccines to viruses, parasites, cancer and autoimmune diseases. Specific projects include production of specific antibodies for targeting of drugs and effector lymphocytes; raising of catalytic antibodies; studies of the repertoire and specificity of the T-cell receptor in autoimmune models for multiple sclerosis, diabetes, arthritis, and myasthenia gravis; definition of antigen recognition and mode of action of killer lymphocytes in allograft and tumor rejection; understanding the developmental process of leukemias and treating them; use of cytokines for immunotherapy of metastases and immunomodulation of lymphocyte migration; immune cell adhesion and migration; the control of inflammatory processes; development of hematopoietic stem cells and T-cells activity during aging as well as understanding antigen recognition mechanisms by their receptors and its coupling to cellular response in mast cells as a model.

R. Alon

Biophysics of selectin and integrin-mediated rolling adhesions in shear flow.

Chemokine regulation of integrin adhesiveness and cell motility.

Intracellular regulation of integrin functions implicated in lymphocyte adhesion to vascular endothelium and migration to target tissues.

A. Ben-Nun

Demonstration of new primary target antigens (MOG, MOBP, ...) in multiple sclerosis and the implications for pathogenic processes and immune-specific therapy.

Epitope-directed immune-specific therapy of MOG-induced EAE mediated by altered peptides. Mechanisms of T cell modulation.

T cell receptor and ligand interaction in autoimmune disease.

Non-superantigenic bacterial toxins, T cell subsets and autoimmune disease.

Effect of encephalitogenic myelin-specific T cells and demyelinating antibodies on nerve conduction in the central nervous system in vitro.

G. Berke

Cancer Immunity: a) Tetrameric MHC-peptide complexes in cancer detection and as cancer vaccines, b) Fas/Fas-L in tumor immunity c) Tumor escape mechanisms.

Immunological memory in cancer.

Apoptosis of the heart muscle.

L. Eisenbach

Indentification of human TAA peptides through differential display methods (DNA chips, SAGE) and HLA transgenic mice.

Antigen presentation by engineered MHC molecules
L. Eisenbach, Dr Gideon Gross

tumor escape and tolerance

cryoimmunotherapy

the role of small interferon induced genes in tumorigenicity and apoptosis

TCR evolution

Autoimmunity and immunotherapy
L. Eisenbach, Dr Ilan Volovitz, Prof. Irun Cohen

High throughput analysis of antibody response to tumor development
L. Eisenbach, Prof. Irun Cohen

Z. Eshhar

Adoptive Cellular Immunotherapy of Cancer and Inflammatory Diseases
Z. Eshhar, T. Waks, Dr A. Maliar, Dr C. Mavor-Servais, A. Globerson, A. Macus, D. Blat

1. Adoptive immunotherapy of breast cancer
2. Adoptive immunotherapy of pancreatic cancer
3. Adoptive immunotherapy of prostate cancer
4. Adoptive immunotherapy using allogeneic cells

Genetic Programming of the Recognition of T-Cells (Treg
Z. Eshhar, Dr E. Elinav, T., D. Blatt

1. Redirecting Treg to colitis
2. Redirecting Treg to arthritis and EAE

Genetic Signature of Prostate Cancer Metastases and Resistance to Irradiation
Z. Eshhar, Prof. E. Domany, Dr I. Kela, Dr A. Harmelin

Modulation of Allergic Responses
Z. Eshhar, Dr G. Gross, T. Waks

Genetic predisposition of protate cancer to irradiation
Z. Eshhar, Prof E. Domany, Dr A. Harmelin, Dr L. Agemy

N. Friedman

Studies of intercellular cytokine comunication networks in T-cell development and differentiation

Modeling hepatitis induced tumorigenesis at the single cell level
N. Friedman, Y. Ben-Neriah (Hebrew University), E. Pikarsky (Hebrew University)

S. Jung

Structure/Function analysis of the CX3C chemokine receptor family

Dendritic cell functions in the Maintenance of Gut Homeostasis and Development of Inflammatory Bowel Disease (IBD)

Monocyte functions in Inflammation and Tissue repair

The Bone Marrow Immune Niche
S. Jung, I. Shachar, G. Shakhar

T. Lapidot

Stem cell regulation via dynamic interactions of the nervous and immune systems with the microenvironment.

1. The interplay between chemokines, cytokines, proteolytic enzymes adhesion molecules, osteoblasts and osteoclasts in regulation of the stem cell niche and blood formation.
2. Mechanism of stress induced mobilization and recruitment of stem cells from the bone marrow into the circulation.
3. Steady state homeostatic release and function of blood circulating stem cells.
4. SDF-1 / CXCR4 axis as a major regulator of hematopoietic stem cells retention and egress.
5. Bone remodeling and hematopoietic stem cell regulation by their niche.
6. Hematopoietic stem cell regulation by the nervous system.
7. Regulation of niche cells by cell contact.

Y. Reisner

The role of megadose stem cell transplants in overcoming MHC barriers in sublethally irradiated recipients: A new approach for tolerance induction.

Mechanism(s) of tolerance induction by different veto cells.

Human/mouse chimera: New models for human antibody production and for induction of human CTLs against human tumors.

M. Sela

Monoclonal antibodies (mAbs) to ErbB-1 and ErbB-2 receptors and their role in potential anti-tumor strategy.
M. Sela, Y. Yarden

Synergistic effects of combinations of mAb against distinct epitopes on EGFR/ErbB-1 and ErbB-2 receptors: accelerated receptor aggregation, down regulation and inhibition of tumor growth.
M. Sela, Y. Yarden

Effective synergism by anti ErbB-2 mAb combinations comprising one mAb against the dimerization site of ErbB-2.
M. Sela, Y. Yarden

Mechanism of action of Copolymer 1 (Copaxone), a therapeutic vaccine against multiple sclerosis.
M. Sela, R. Arnon

I. Shachar

Determine the mechanisms regulating peripheral B cell maturation and survival in health and disease.

Follow the mechanisms controlling homing of immune cells in health and disease.

Analyze the pathway regulateing the survival cascades in Chronic lymphocytic leukemia
I. Shachar, Dr Michal Haran, Kaplan Medical center

Department of Molecular Cell Biology

Varda Rotter, Head

The molecular mechanisms underlying cell structures, dynamics and fate, and their involvement in embryonic development and cancer are among the primary topics of interest of the Department. These include studies on the mode of action of growth factors and the nature of signals triggered by them in target cells following binding to specific surface receptors. Growth regulation is also approached through the study of suppressor genes encoding such proteins as p53, which inhibit proliferation and drive cells towards differentiation or apoptosis. These studies, focusing on the mechanisms stimulate cell proliferation, differentiation, or death, can elucidate the basis for cancerous transformation in a large variety of systems. Overproduction or hyperactivation of growth-promoting systems

was shown to have an oncogenic (cancer-causing) effect, and a similar process may be induced when growth-suppressor or apoptosis-inducing genes fail to function. The levels at which cell structure, activity and fate are studied in this department and the focus of these studies are many and diverse, including the characterization of soluble growth factors and their receptors, the nature of complex signal transduction pathways, the action of specific regulators of cytokine action, rearrangement of genes associated with oncogenic processes, and the properties of tumor suppressor and apoptosis promoting genes. Since such processes involve networks of interacting factors, we are also interested in mathematical modeling and computerized analysis of biological gene circuits.

In addition, there is broad interest in the molecular mechanisms of cell adhesion and their involvement in the regulation of cell fate. These studies include characterization of the basic rules underlying adhesive interactions, the binding of surface-associated adhesion molecules with the cytoskeleton, and the nature of growth- and differentiation-promoting signals triggered by adhesive interactions. Of special interest are proteins such as -catenin, which play a crucial role in reinforcing cell-cell adhesions as well as triggering gene expression.

U. Alon

Systems level analysis of gene regulation networks, with E. coli as a model system.

Combining theoretical, bioinformatic and experimental methods to discover design principles of genetic networks.

A. Ben-Ze'ev

The interplay between the role of -catenin in cell adhesion and signaling during colon cancer development.

The role of novel -catenin target genes in tumor development and metastasis

The molecular basis and signaling roles of nerve cell adhesion receptors in colon cancer metastasis

Epithelial-mesenchymal transition (EMT), Wnt target genes and colon cancer cell invasion and metastasis

A. Bershadsky

Integrin-mediated cell-matrix adhesions as mechanosensors: molecular requirements for the force-induced focal adhesion growth.

Cell-cell contact-dependent regulation of the actin cytoskeleton and microtubule system: Role of p120 catenin and other components of cadherin adhesion complex.

Role of myosin-driven contractility in the retrograde surface flow and cell motility.

Cooperation between neuregulin, ErbB-family receptors, and cell surface heparan sulfate proteoglycans in the regulation of cell motility and morphogenesis.

E. Canaani

Comparison of the properties of the leukemogenic ALL-1 fusion proteins with those of normal ALL-1.

Transcription profiles of primary tumors with ALL-1 rearrangements.

Functions of the human ASH1 protein.

Studies of the ALR gene.

B. Geiger

Molecular diversity of adhesion complexes

The roles of mechanical force in adhesion development

Role of phosphorylation in regulating cell adhesion and migration

Signaling from the ECM

Cell adhesion and migration in cancer

Quantitatibve automated microscopy and high throughput screens

Z. Kam

Cellular Biophysics

1. Quantitative analysis of structural features and dynamic changes in cells using microscope imaging
2. High throughput high-definition microscopy application in systems cell biology
3. Adaptive optics methods applied to thick sample imaging
4. Cell level informatics

S. Lev

Molecular Aspects of Neuronal Survival Differentiation and Degeneration.

1. Signal transduction mediated by the calcium regulated tyrosine kinase, PYK2 in neuronal cells.
2. Molecular mechanism of retinal degeneration and blindness.
3. Cellular function of a novel family of human genes related to the Drosophila retinal degeneration B (rdgB) in the central nervous system.

G. Levkowitz

Developmental neurobiology

hypothalamus

M. Oren

Molecular biology of p53.

Regulation of proteins by covalent modifications

Role of microRNAs in cancer

Relationship of p53 to programmed cell death.

Gain of function of mutant p53 in cancer
M. Oren, Prof. Varda Rotter

Role of p53 in tumor-host interactions
M. Oren, Dr. Jair Bar, Sheba Medical Center

Regulation of the Mdm2 oncoprotein.
M. Oren, Prof. Yossi Shilo, Tel Aviv University

Chromatin modifications in regulation of gene expression and in cancer
M. Oren, Prof. Yossi Shiloh, Tel Aviv University, Prof. Robert Roeder, Rockefeller University

E. Peles

Cellular junctions of myelinated nerves.

Role of Caspr family members in neuronal development.

Generation of specialized domains along myelinated axons.

Function of Caspr proteins in generating cell-cell contact in *C. elegans*.

Molecular mechanisms of neuron-glia interactions.

V. Rotter

Molecular mechanisms controlling the expression of p53 in normal cells and its deregulation in cancer cells

1. Involvement of p53 in cell differentiation and apoptosis: *in vivo* and in vitro models.
2. Cellular proteins that specifically complex with the p53 protein.

3. Cellular proteins that are induced upstream or downstream to the p53 protein following genotoxic stress.

O. Schuldiner

Molecular mechanisms of neuronal remodeling during development: Developmental axon pruning in Drosophila

1. The role of cell-cell interaction in regulating developmental axon pruning
2. The role of intracellular signaling in regulating developmental axon pruning
3. The role of trafficking in regulating developmental axon pruning

Molecular mechanisms of neuronal remodeling during development: Signals that control axon re-growth

E. Segal

Quantitative models for transcription and chromatin regulation

Modeling the role of microRNAs and non-coding RNAs in gene regulation

Y. Zick

Receptor trafficking: Regulation of endocytosis and recycling of the insulin receptor.

Mammalian lectins as regulators of cell adhesion, cell growth, and apoptosis.

The insulin receptor as a model system for transmembrane signaling: Mode of interaction of the insulin receptor with its downstream effector molecules.

The molecular basis of Insulin Resistance: a Phosphorylation based Uncoupling of Insulin Signalling

Mode of action of galectin-8, a mammalian lectin

Role of Galectin-8 in bone remodeling

D. Zipori

Regulation of normal cell differentiation and tumor cell growth by the mesenchymal hemopoietic microenvironment

1. Mesenchymal stem cells: patterns of gene expression and biological functions.
2. Characterization of the cytokine antagonist, Activin A; signal transduction and biological functions.
3. Stem cell growth and the organ stroma.
4. Functions of the T cell receptor in mesenchymal cells

Department of Neurobiology

Yadin Dudai, Head

Research in Neuroscience in the Department of Neurobiology encompasses a wide variety of subjects, in areas including cellular and molecular biology, neuroanatomy, functional magnetic resonance imaging (fMRI), physiology, pharmacology, psychophysics, and computational sciences.

Basically, the research of the various groups of the Department covers, among others, the following topics:

- Analysis of the molecular and cellular basis of neuronal and synaptic function.
- Imaging of neuronal activity underlying higher brain functions.
- Tracing and characterization of neuronal communication profiles.
- Characterization of the CNS response to trauma and lesion; developing molecular and cellular therapeutic agents.
- Determination of the underlying processes and mechanisms of vision, perception, learning, and memory in behaving rodents and primates.
- Computer modeling of brain function.

At the Neurobiology Department, the structure, function, development, and plasticity of the nervous system are studied at various levels of analysis, using different types of cell and experimental animal models. The groups studying neuronal function at the molecular and cellular levels use *in vitro* systems ranging from non-neuronal and neuronal cell lines to primary neuronal and glial cells of cerebellar, hippocampal and cortical origin. In many cases, the cells studied are transfected with genes of interest. These cell systems allow the study of the roles of various components of the nervous system, including cell surface membrane components, specific enzymes, neurotransmitters, neuromodulators, growth factors, neuroreceptors, lipid components, ionic channels and cytoskeletal constituents. Algorithms for the synaptic plasticity between neurons, and the role of dendritic ion channels in synaptic input and information processing, are also being studied. Injury models of nerve lesion and oxidative stress paradigms are applied to examine the principles of CNS regeneration, rescue from ischemia and stroke, and apoptotic cell death and senescence.

The groups studying the CNS at the system level are striving to understand the complex neuronal mechanisms underlying learning, memory, and sensory processing (vision, taste, smell), and to determine the relationship between brain and mind. Using track tracing methods, the rules governing the interconnections in the visual cortex are being unraveled. Behavioral studies focus on principles of learning and consolidation, cortical information processing, learning disabilities, and addiction. Functional brain imaging of the human visual cortex is being studied by various techniques, including fMRI. Psychophysical approaches are being used to define processes involved in image segmentation, learning and memory skill acquisition, motor control, and language. Nearly 20 groups of researchers carry out both independent studies and collaborative research with colleagues from within the Department

and outside it.

E. Ahissar

Active sensing: Mechanisms of closed loop perception.

Biomimetic technology for active vibrissal touch

Object localization

Sensory substitution - from vision to touch

S. Barash

Neuroscience of looking and seeing

Y. Dudai

The role of saliency-and novelty-detectors in the acquisition and retention of memory in brain.

Mechanisms of memory consolidation, reconsolidation and extinction in the mammalian brain.

Theories of learning and memory.

A. Grinvald

The functional architecture underlying visual perception.
A. Grinvald, D. Omer, L. Rom,

Cortical correlates of attention in behaving monkeys.
A. Grinvald, D. Omer, L. Rom

The space-time dynamics of cortical activity as revealed by population activity (EEG, LFP and real-time optical imaging) coupled with single-unit and intracellular recordings.
A. Grinvald, D. Omer, L. Rom M. Tsodyks

The Interactions between evoked and on-going activity and their potential functional role in cortical processing.
A. Grinvald, D. Omer, M. Tsodyks

The dynamics of cortical representations in the visual cortex.
A. Grinvald, S. Naaman

T. Kimchi

Neuronal Basis of Sexually Dimorphic Behaviors

1. Sexually dimorphic pheromone signals perception, processing and biology function
2. Characterizing novel pheromone-mediated responses in wild-caught mouse colonies
3. Identifying the genetic basis of sex-typical social and reproductive behaviors
4. Mapping brain circuits controlling innate social and reproductive behaviors

I. Lampl

Synaptic plasticity inducted by sensory stimulation in the cortex

Construction of receptive field properties in the somatosensory cortex

1. studying functional connectivity in the barrel cortex
2. Mechanisms of adaptation in the cortex

Noise and synchrony in the mammalian cortex

1. Dynamic properties and mechanisms of ongoing activity in the cortex
2. Patterns in neuronal activity in the cortex

R. Malach

Mapping object-related areas in the human brain.

1. Gestalt effects in the human brain.
2. Dynamics of object-selective activation.
3. Principles of organization of object areas in the human brain.

R. Paz

Neurobiology of learning and memory

Neuronal circuits and interactions between the amygdala and the prefrontal cortex

Generalization and specificity of learning

Extinction of memory

Motivational and emotional modulation of memory

Computational approaches to coding mechanisms in the brain

Psychiatric disorders from pathologies in the amygdala-preftonal pathway (e.g. autism, anxiety-disorders, post-traumatic-stress-disorder (PTSD), epilepsy)

D. Sagi

Human vision, with an emphasis on processes involved in image segmentation, learning, and memory.

M. Schwartz

The cross-talk between the immune and nervous systems autoimmunity as a mechanism of tissue repair: Molecular, cellular, physiological and behavioral aspects.

Immunological aspects of neuronal loss in neurodegenerative and mental disorders (Alzheimer s, ALS, Huntingdon, Glaucoma).

Spinal cord injury and repair

Development of vaccination for neurodegenerative disorders.

Neurogenesis (stem cells) and inflammation in the CNS.

M. Segal

Intracellular calcium and structural/functional plasticity in cultured neurons.
M. Segal, Dr. Eduard Korkotian, Professor Michael Frotscher, Prof. Thomas Deller

Hippocampal structure and function during stress.
M. Segal, Dr. Nicola Maggio, Dr. Gayane Grigoryan

Electrical activity in small hippocampal networks
M. Segal, Dror Cohen

Activity maintains survival of neurons in culture
M. Segal, Eldi Schonfeld-Dado

N. Sobel

Olfaction

Functional Imaging

V. Teichberg

Penetration of prion protein into brain via the blood brain barrier
V. Teichberg, Itzik Cooper

Peripheral mechanisms for brain neuroprotection
V. Teichberg, Yael Klin, Alexander Zlotnik and Yoram Shapira

Enzymatic scavenging of blood glutamate in the treatment of neurodegenerative diseases
V. Teichberg, Keti-Cohen-Kashi-Melina, Itzik Cooper, Alexander Zlotnik, Yoram Shapira, Angela Ruban, Yael Klin, Moti Boyko

1. Treatment of acute brain neurodegenerative conditions by activation of a blood glutamate scavenging system
2. Glutamate transport in an in vitro model of the blood brain barrier
3. Treatment of malignant gliomas with blood glutamate scavengers
4. Treatment of amyotrophic lateral sclerosis with blood glutamate scavengers
5. Treatment of nerve gas exposure with blood glutamate scavengers
6. GABA transport in an in vitro model of the blood brain barrier.
7. Treatment of melanoma with blood glutamate scavengers

M. Tsodyks

Modeling of cortical neuronal populations: From microcircuits to large scale networks.

Information transmission through dynamic synapses.
M. Tsodyks, H. Markram

Population activity in visual cortex.
M. Tsodyks, A. Grinvald, D. Sagi

N. Ulanovsky

* Neurobiology of learning and memory: a sytems neuroscience approach

* Mammalian hippocampus - hippocampal place cells

* Neuronal circuits and hippocampal neural activity in freely-behaving echolocating bats

* Towards neurophysiological recordings in freely flying bats, using radio-telemetry

* From the bat's biological sonar system to spatial cognition

* The neural basis of behavior

Z. Vogel

The cannabinoid ligands, their endogenous ligands and signal transduction.
Z. Vogel, Raphael Mechoulam

Regulation of microglial activation by cannabinoids: Possible role in neurodegenrative and neuroinflammatory diseases

Molecular mechanisms of opiate addiction, tolerance and withdrawal.

A. Zangen

Depression and Addiction in the Brain Reward System

1. Evaluation of neurochemical and electrophysiological alterations in the brain reward

system of animal models for addiction and depression.

2. Behavioral and neurochemical effects of brain stimulation in reward-related brain sites: Deep Transcranial Magnetic Stimulation in humans and localized electrical stimulation in animal models.

Faculty of Chemistry

Department of Chemical Physics

Shimon Vega, Head

Research in the Department covers a broad spectrum of topics, including many subjects of current interest in chemistry and physics. Areas of research include theoretical studies of turbulence, the physics of fractals, properties of glass, chaos (classical and quantum mechanical), tunneling and dissipative phenomena, kinetics, and dynamics in surface condensed phases and ultrafast processes. Other areas include experimental and theoretical diffusion studies of the interaction of coherent light with matter, nonlinear optics, laser-induced processes in van der Waals molecules, coherent control of chemical reactions, cooling of molecules and theoretical quantum optics in dispersive media and in microcavities. A different area of active research is the study of the structure and properties of large molecular systems, and the interaction of electrons and molecules with organized thin films. Molecules on semiconductor surfaces are studied by combination of lasers and STM. A strong magnetic resonance group is active within the department, working on fields such as solid state NMR, MASS NMR of semiconductors, liquid crystals and proteins, porous materials, as well as pulsed EPR and electron-nuclear double resonance on metalloenzymes and porous solids. The department encourages interdisciplinary approaches to science, and there is much collaboration among members of the department and scientists and students from other faculties such as physics and the life sciences.

I. Averbukh

Atomic and molecular wave packets, ultra-fast optical phenomena.

Laser control of molecular orientation.

Manipulation of atoms and molecules by laser fields, laser cooling, atom lithography.

E. Bouchbinder

Nonequilibrium and statistical physics

Continuum solid mechanics and materials physics

1. Dynamic fracture
2. Statistical physics of cracks
3. Nonequilibrium thermodynamics of driven glassy systems
4. Amorphous and dislocation-mediated plasticity theories

B. Dayan

Experimental Quantum Optics

1. Cavity QED with single atoms coupled to chip-based micro-resonators
2. Nonclassical photon-photon interactions

L. Frydman

Development of new methods in nuclear magnetic resonance and magnetic resonance imaging analysis.

Application of novel magnetic resonance methods to the study of new materials, bioinorganic metal-binding processes, liquid crystalline phases.

D. Goldfarb

Study of mesoporous and microporous materials by pulsed EPR/ENDOR.

Studies of the structure of paramagnetic active sites in metalloenzymes and model compounds by pulsed ESR and pulse ENDOR.

High field EPR/ENDOR spectroscopy.

N. Gov

Theoretical studies and modelling of the physics that determines the shapes and dynamics of cells.

Theoretical problems in biological physics; active processes in cells involving molecular motors.

The physics of large scale pattern formation of cells in cellular cultures, in morphogenesis and wound-healing.

Research of collective quantum effects in Super-fluid, solid and super-solid Helium. Including magnetic phase transitions in solid and liquid helium.

G. Haran

Protein folding studied on the level of the individual molecule.
G. Haran, Devarajan Thirumalai (University of Maryland), Lynne Regan (Yale University), Stefano Gianni (University of Rome)

Single-molecule fluorescence spectroscopy of the mechanism of action of molecular chaperones
G. Haran, Amnon Horovitz

Plasmonics: probing the interaction of metal nanoparticles with light

Single-molecule studies of protein conformational dynamics, diffusion and association
G. Haran, Gideon Schreiber

Single-particle tracking for studying peptide-membrane interactions
G. Haran, Yechiel Shai, Daniella Goldfarb

G. Kurizki

Quantum optics of cold atoms .

Superluminal effects in optics.

Quantum and nonlinear optics in photonic band gap structures.

Control of quantum states and decoherence.

R. Naaman

Molecular controlled semiconductor electronic devices.

Electronic and magnetic properties of organized organic thin films
R. Naaman, Zeev Vager, Dep. of Particle Physics

Molecular electronics
R. Naaman, David Cahen, Mordechai Sheves

Electron transmission through organized organic thin films.

Penetration of electrons through chiral molecular monolayers
R. Naaman, Zeev Vager, Dep. of Particle Physics

Coherent control of electron transmission through organized organic layers
R. Naaman, Yaron Zilberberg, Dep. of Complex Matter Physics

Interaction of electrons with DNA and membranes

E. Pollak

Quantum Molecular Dynamics and Structure

1. Real time quantum Monte Carlo methods
2. Molecular spectroscopy
3. Molecular reaction dynamics
4. Electron transfer processes
5. Molecular dynamics on surfaces

Y. Prior

Alignment and orientation of atoms and molecules in strong laser fields.
Y. Prior, Ilya Averbukh

Strong field nonlinear optics.

Molecular Dynamics with ultrashort shaped femtosecond pulses.

femtosecond laser material processing

I. Procaccia

Turbulence.

Fractals and scaling in nonequilibrium physics.

Failure in Amorphuos Media: fracture, shear bands and necking.

Mechanical properties of amorphus solids with theory of plasticity

The glass transition and slow relaxation phenomena

D. Tannor

Control of chemical reactions with tailored femtosecond pulses.

Laser cooling of molecules.

Quantum theory of dissipation and chemical reactions in solution.

Semiclassical theory of reactive scattering.

S. Vega

solid state NMR of bioorganic materials

Proton NMR Spectroscopy of Solids

Molecular mobility of solutions in mesoporous materials

Department of Environmental Sciences and Energy Research

Dan Yakir, Head

This Department, established in 1990, is dedicated to understanding the complex inter-relationships among the major Earth Systems, and between the human need for energy

and the consequent impact on the Earth's environment. This requires knowledge of all the interdependent components that together constitute the &#34environment&#34, as well as a commitment to protect this environment by improving the manner in which energy is utilized by humans.

The Department's research activities have several general areas of activities. One focuses on water and includes physical oceanography and hydrology. A second is in the use of stable isotopes for reconstructions of paleoclimatic and of biosphere-atmosphere interactions, and a third is in the area of atmospheric chemistry and clouds physics. Research in solar energy is conducted in a dedicated facility, the Solar Tower, on campus. The Department is distinguished by the interactions among scientists from quite different backgrounds and expertise, which is critical to achieve a comprehensive understanding of the global environment. We also promotes international collaboration based on short- and long-term visits for research and training by scientists who complement existing activities in the department. The interdisciplinary nature of the Department is well reflected in the academic training of the research students. Their backgrounds vary enormously from physics and mathematics through geology to biology. We encourage the participation of students who are interested in not only investigating in depth a specific subject, but who are also interested in a broader, more integrative approach to science.

B. Berkowitz

Fluid flow and chemical transport in groundwater systems.

Percolation, scaling and statistical physics models of structural and dynamic processes in geological formations.

Experimental and theoretical analysis of reactive transport and precipitation/dissolution patterns in porous media.

Development of chemical methods for remediation of water polluted by organic compounds and heavy metals.

H. Gildor

Paleoclimate
H. Gildor, Yossi Ashkenazy, Eli Tziperman, Dick Peltier

1. Glacial cycles
2. The Red Sea during the Last Glacial Maximum
3. The role of dust in the climate system

Submesoscale processes in the ocean
H. Gildor, Erick Fredj, Stephen Monismith, Amatzia Genin, Riyad Manasrah

1. Mixing and dispersion
2. Deep water formation
3. Density currents

Interaction between the biota and climate

1. Ocean biota and light penetration into the ocean
2. The lightning-biota-climate feedback
3. The role of ocean biota in the carbon cycle

J. Karni

Development of directly irradiated solar receivers.

Carbon dioxide dissociation using concentrated solar energy

Energy transport in particles seeded flows at high temperature.

Development of alternative fuels and their production methods using solar energy

1. Carbon dioxide dissociation using concentrated solar energy

I. Koren

Anthropogenic Effects on Clouds and Precipitation and the Derived Climate Forcing
I. Koren, NASA-GSFC, UMBC

The twilight zone - convective clouds and their interaction with the free atmosphere
I. Koren, NOAA-ESRL Boulder CO.

Cloud microphysics and dynamics

Cloud classification and cloud textures and morphology

Y. Rudich

Nano-sized particles and their environmental effects

1. Engeeniring of multicomponent submicron sized particles
2. Studying the chemical processes of submicron particles
3. Activation of particles to cloud droplets
4. Electron microscopy of micron sized particles

The chemistry of organic aerosols: reactivity with atmospheric radicals and oxidants.

1. Flowtube experiments
2. Aerosol flow experiments
3. Reactions of ozone and OH with particles, identification of surface and bulk products

Optical properties of absorbing aerosols

1. Cavity ring down aerosol spectrmetry
2. Asborbing aerosols

Chemical identification of organic compounds in atmospheric aerosols.

1. Absorption of organic compounds onto mineral dust particles
2. Identification of water-soluble material in biomass burning aerosols from Brazil
3. Use of analytical techniques such as GCMS and ion chromatography

A. Shemesh

Stable isotops and paleoceanography of the Southern Ocean.

Biogenic opal and its use in marine and continental paleo-climate reconstructions.

Oxygen and carbon isotopes in corals.

D. Yakir

Environmental and climatic influence on the exchange of trace gases and energy between plants, soil and the atmosphere.

Developing the use of stable isotopes (in particular, 13C, 18O, 15N, 2H) as tracers of biogeochemical cycles on land.

Climatic influence on the natural abundance of carbon, oxygen and hydrogen isotopes in CO2, O2, H2O and organic matter.

Department of Materials and Interfaces

David Cahen, Head

Activities in the Department of Materials and Interfaces span range of topics from materials to energy research, nanoscience, and biomolecular systems. A UNIFYING THEME is the STUDY OF MATERIAL FUNCTIONALITY AND ITS RELATION TO FUNDAMENTAL PROPERTIES AT MULTIPLE SCALES. These properties may be mechanical, structural, electronic, and chemical. Some examples are: How do shapes and sizes of nm-sized particles affect their spectral properties? How can we tune the properties of solar cells by manipulating their surfaces? How does friction in knee and hip joints depend on the polyelectrolytes that lubricate them? How can we design self-assembling, even self-replicating chemical or biomolecular systems? THE RESEARCH IS BASED ON AN INTERDISCIPLINARY APPROACH, and indeed the scientists bring complementary experience in chemistry, physics, and biophysics, including theory and experiment.

Among the materials under active study we can note:

- nano-particles and nanotubes of carbon and inorganic materials
- composite materials down to the nanoscale, with unique mechanical properties
- nano-crystalline ceramics with unique combinations of electrical and mechanical properties;
- crystalline and non-crystalline pyroelectric and piezoelectric materials
- self-assembling supra-molecular architectures

- opto-electronic, pyroelectric, superconducting solids with extended bonding
- functionalized semiconductors and metals
- ultrathin ceramic or molecular organic films
- polymers and polyelectrolytes, complex fluids
- biomolecular materials: DNA, cytoskeleton
- biological tissues, cells, and matrix elasticity
- *materials and processes for alternative, sustainable energy*: electrochemical sequestration and recycling of atmospheric CO_2; photovoltaic (solar cell) materials and device structures

Experimental and theoretical approaches include:

- optical and X-ray photoelectron spectroscopies, Kelvin probe
- first-principles calculations, density functional theory
- inorganic synthesis, template synthesis, electrochemistry
- solid state impedance spectroscopy;
- surface force apparatus, atomic force microscopy, optical tweezers
- mechanical testing, elasticity & indentation
- crystal templating, chiral crystals, racemic separations
- X-ray diffraction & scattering
- advanced micro- & nanofabrication, including new (non-traditional) processes
- microfluidic devices
- advanced optical, electron, and X-ray microscopies
- *in vitro* reconstitution of functional biosystems, biomimetics
- theory of membranes and gels, charge interactions & elasticity
- application of theory to understanding biological cell & tissue properties.

Many facilities that we use are part of the Chemical Research Support Unit. They include the Electron Microscopy Unit, Surface Science (Scanning Probe Microscopies and Photoelectron Spectroscopy) unit, X-ray diffraction unit, combined clean rooms / micro-fabrication / biological specimen manipulation (&#34nano-bio&#34) laboratories. Further facilities in the department or Chemical Support Services include systems for low temperature electrical transport and for optical and magnetic characterization of materials. In addition to new insights in how materials properties can be understood from their atomic, molecular, macro-/supra-molecular and over-all composition and structure, *our inter- and multi-disciplinary strategy to the study of the functionality of materials and its relation to fundamental properties of matter at multiple scales*, permits exploring new materials and combinations. It has also led to a number of practical applications.

R. Bar-Ziv

Artificial biochemical circuits

1. Cell-free gene expression on a chip
2. Cell-free expression of protein nano-structures
3. Autonomous interrogation of the state of a living cell

The physics of microfluidic crystals

D. Cahen

Chemistry of Optoelectronic Materials and Devices - Molecule-controlled (opto)(bio)electronics

1. Molecules as Electronic Conductors: Understanding the fundamentals, *with L. Kronik, C. Sukenik (Bar Ilan), A.Kahn (Princeton), J. Gooding (UNSW), H, Zuilhof (Wageningen)*
2. Bio-opto-electronics: Electronic transport through proteins *with M. Sheves, I. Pecht*

Solar Energy: New materials concepts, basic understanding, micro-/nano-scopic studies of photovoltaics

1. Molecular electronics for solar cells.
2. How do nano- and poly-crystalline solar cells work? *with G. Hodes, S. Cohen, K. Gartsman*
3. Optimizing the use of solar photons, *with I. Lubomirsky, A. Zaban (Bar Ilan U)*

M. Elbaum

Cellular Biophysics and Molecular Transport Machines

1. Single-molecule manipulations using optical tweezers.
2. Dynamics of DNA uptake into the cell nucleus.
3. Structure and function of the nuclear pore complex (with Z. Reich): application of atomic force microscopy and advanced optical spectroscopies.
4. Anomalous diffusion in polymer networks and living cells (with R. Granek).
5. Organization of forces driving cell movements (with A. Bershadsky): optical force measurements and particle tracking studies; influence of cell biochemistry on biophysical forces.
6. Novel surface-patterning lithographies.

G. Hodes

Semiconductor Films: preparation and properties

1. Electrochemical and chemical bath deposition of semiconductor films.
2. Nanocrystalline solar cells; semiconductor-sensitized nanoporous cells (with D. Cahen)
3. Charge transfer in nanocrystalline films

E. Joselevich

Nanoscale Materials Chemistry and Biophysics;

Molecular Wires: From Self-Organization to Functional Nanosystems

1. Organization of molecular wires and one-dimensional nanostructures
2. Integration of molecular wires and one-dimensional nanostructures into functional nanosystems
3. Characterization of molecular wires and one-dimensional nanostructures by

mechanical and electrical measurements

J. Klein

Polymers, Complex Fluids, and Interfaces - Experimental studies of the behavior of confined simple and polymeric fluids.

1. Confinement induced phase transitions
2. Nanotribology

Surface-forces-measurement techniques at angstrom surface separations; polymers as molecular lubricants

1. ATRP growth of polymers from surfaces
2. Polyelectrolyte brushes

Molecular origins of biological lubrication Hydration lubrication: a new paradigm

1. Properties of thin liquid films including aqueous electrolytes and polyelectrolytes.
2. Hydrophobic interactions
3. Slip at surfaces
4. Boundary lubrication under water
5. Tissue engineering and regenerative medicine: the role of lubrication

L. Kronik

Quantum Theory of Materials

1. Unique properties of organic/inorganic interfaces
2. Theory of novel magnetic materials
3. Orbital-dependent functionals in density functional theory
4. Real-space computational methodologies

I. Lubomirsky

Dielectric materials

1. Properties of Ultra-Thin Self-Supported Crystalline Oxide Films.
2. Infrared focal plane array based on freestanding pyroelectric films.
3. Oxygen ion transport in thin freestanding films.
4. High temperature, electrochemical CO_2 reduction

I. Rubinstein

Nanomaterials, Supramolecular chemistry, Sensors, Surface Chemistry, Electrochemistry

1. Self-assembled supramolecular nanostructures on surfaces (with A. Vaskevich, H. Leader)
2. Nanoparticle organization on surfaces using coordination layer-by-layer assembly (with A. Vaskevich, H. Leader)
3. Plasmonic systems based on metal nano-island films prepared by evaporation/annealing (with A. Vaskevich)
4. Application of metal nanoisland films in chemical and biological sensing using localized surface plasmon resonance spectroscopy (with A. Vaskevich)
5. Chemical and electrochemical template synthesis in nanoporous membranes (with A. Vaskevich)

S. Safran

Soft Matter and Biomaterials

1. Statistical physics of soft matter and biological physics (theory)
2. Single cell physics and cell activity: cell shape, orientation, mechanics & polarization.
3. Cooperative physics of cell activity: cell-surface interactions (adhesion), cell-cell elastic interactions.
4. Inhomogeneous membranes, physics of inclusions in membranes: connection to lipid rafts.
5. Membrane self-assembly of surfactants, lipids, and amphiphilic polymers.
6. Electrostatic and fluctuation induced interactions in charged colloidal and membrane systems.
7. Coupling of shape and shear elasticity in membranes and in biological cells.

J. Sagiv

Supramolecular Architecture at Interfaces (with R. Maoz)

1. Supramolecular Surface Chemistry: Bottom-up Nanofabrication using Planned Self-Assembling Mono- and Multilayer Systems (with R. Maoz)
2. Constructive Lithography: Contact Electrochemical Surface Patterning on Lateral Length Scales from Nanometer to Centimeter (with R. Maoz)

R. Tenne

Inorganic nanotubes and inorganic fullerene like materials: new materials with cage structure. From basic science to applications.

D. Wagner

Mechanics of Composite Materials and Carbon Nanotubes

1. Micro- and nano-mechanics of tubes (C, WS_2)
2. Electrospun polymer nanofibers

3. LBL clay-films, and their composites
4. Mechanics of biological composites (bone, dentin, cell adhesion)

Department of Organic Chemistry

Ronny Neumann, Head

The areas of research in the Department of Organic Chemistry include synthetic and mechanistic organic and organometallic chemistry, novel reactions for organic synthesis, bond activation by metal complexes, polymeric reagents and catalysis. Bioorganic chemistry includes the studies of plant antiviral agents, the molecular mechanism of action of rhodopsin, artificial ion carriers and molecular sensors. Biological chemistry includes studies on structure,function, and mode of action of biologically active peptides and proteins; thermophilic enzymes; enzymes involved in DNA repair, DNA and RNA processing; studies of ordered, compact states of nucleic acids; and biomedical applications of EPR and NMR. Computational chemistry deals with the prediction of molecular properties by first principles (ab initio) and semiempirical quantum mechanical calculations.

M. Bendikov

Polyselenophenes: A Novel Type of Conducting Polymers

Study of Structure-Property-Reactivity Relations in Novel Organic Electronic Materials

Polysiloles and Silicon Containing Oligothiophenes

Applications of Computational Quantum Chemistry

G. Martin

Computational Quantum Chemistry
G. Martin, D. Milstein, M. van der Boom, R. Neumann, M. A. Iron, L. Kronik

1. High-accuracy ab initio thermochemistry: method development and applications.
2. Development of novel, more universal, density functionals
3. Application of density functional methods to organometallic systems, with special reference to homogenous catalysis.
4. Ab initio prediction of rotation-vibration spectra beyond the harmonic approximation.

D. Milstein

Organometallic chemistry and catalysis

1. Bond activation by electron-rich transition metal complexes.
2. Rational design of homogeneous catalysis and synthetic methodology based on transition metal complexes.

3. Impact of molecular order on catalysis and reactivity.
4. Generation and stabilization of elusive (potentially biologically active) molecules

A. Minsky

Cellular organization of biomacromolecules

1. High-resolution structural studies of ordered cellular biomacromolecules and chemical properties of ordered DNA phases and DNA-protein complexes.
2. Packaging and ordered phases of DNA in living systems (viruses, bacteria, sperm cells).
3. Effects of stress (starvation, drugs, cold-shock) on DNA and protein organization within cells.

R. Neumann

Catalysis and oxidation - Green chemistry

1. Catalytic oxidation, activation of molecular oxygen, hydrogen peroxide, nitrous oxide and ozone - Green chemical transformations.
2. Polyoxometalates as novel catalysts for oxidation reduction and acid catalyzed reactions.
3. New organo-polyoxometalate materials.

B. Rybtchinski

Organic self-assembly: nanoreactors and nanocapsules

Solar fuels: photoinduced water splitting for hydrogen production

Artificial photosynthesis: light-harvesting materials for solar energy conversion

A. Shanzer

Supramolecular chemistry

1. Biomimetic ion binders, diagnostic tools in imaging technologies (fluorescent probes) and potential therapeutic agents. Synthesis, using classical and combinatorial chemistry methods and evaluation.
2. Synthesis and properties of molecular based devices; molecular sensors, switches and logical gates for application in nanotechnology.
3. Surface bound functional assemblies.

M. Sheves

Molecular mechanism for the function of retinal proteins

1. Spectroscopic properties of retinal proteins.
2. Molecular mechanism for visual pigments photochemistry.
3. Protein-chromophore interactions in bacteriorhodopsin.

M. Van Der Boom

Design, synthesis, and characterization of chromophores and metal complexes for the generation of new molecule-based photonic materials

Understanding and control over molecular orientation, interactions and properties in functional thin films

Mono- and multilayer based memory and sensor elements

Halogen bonded thin film assemblies

Department of Structural Biology

Zippora Shakked, Head

Structural biology is an increasingly important and exciting area. Much of the research in this area at the Weizmann Institute is carried out in the Faculty of Chemistry. Current research projects involve utilization of the main methodologies available for biological structural studies, such as X-ray crystallography, NMR, electron and atomic force microscopies, molecular biology and various other spectroscopic techniques. Modern and sophisticated instrumentational facilities are available, most of which are state-of-the-art. Studies are being performed to determine molecular structures and structure-function relationships in biological macromolecules, such as proteins, DNA and their complexes. Efforts are also directed towards the design of potential drugs. Whole intracellular assemblies and organelles, such as the ribosomes, which contain tens of macromolecules, are being investigated. The powerful techniques of site-directed mutagenesis and thermodynamics are being used together with theoretical analyses to characterize the interactions that stabilize proteins and determine their activity. Antigen-antibody complexes and other protein-protein interactions such as that of interferon with its receptor are being studied by multi-dimensional NMR methods. Biomineralization, i.e. controlled mineral deposition by organisms to form skeletal tissues, is being investigated from the molecular interactions between proteins and crystals to the ultrastructure and properties of the tissue.

L. Addadi

Antibodies that recognize crystal surfaces and 2-dimensional organized patterns.

1. antibody recognition of chiral crystal surfaces
2. structure of cholesterol/ceramide monolayer mixtures. Molecular organization of lipid rafts
3. Pathological crystallizations. Gout
4. antibody recognition of amiloid structures

Mechanisms of crystal nucleation and modulation of crystal growth and properties in biomineralization (bone, mollusk shells, echinoderms).
L. Addadi, S. Weiner

Mechanism of cell adhesion using crystal substrates.
L. Addadi, B. Geiger

J. Anglister

The structure of the V3 loop of the HIV-1 envelope protein gp120 and its interactions with chemokines receptors
J. Anglister, F. Naider

The structure of the membrane proximal extra-cellular region of HIV-1 gp41 and its role in viral fusion
J. Anglister, F. Naider

NMR structure of alpha Interferon complex with its receptor
J. Anglister, J. Piehler

The interactions of scorpion toxins with sodium channels and the structures of the channels extra-cellular loops
J. Anglister, M. Gurevitz, D. Gordon

D. Fass

Structures of retrovirus envelope proteins and mechanisms of retrovirus entry into cells.

Structure and function of proteins that modulate intracellular membrane dynamics.

Origins of disulfide bonds for oxidative protein folding.

A. Horovitz

Chaperonin-mediated protein folding.
A. Horovitz, Gilad Haran

Linear free energy relationships (LFER) analysis of allosteric transitions in proteins.

Allostery in the structure and function of GroEL and CCT chaperonins.
A. Horovitz, Keith Willison (Cancer Research Institute, London)

Analysis of correlated mutations in proteins
A. Horovitz, Ron Unger (Bar Ilan University)

K. Levy

The mechanisms of protein-DNA recognition: understanding the driving forces for fast

assembly

The biophysics and evolution of post-translational modifications

I. Rousso

The assembly and budding of virions.

1. The kinetics and localization of viral budding.
2. The surface localization and mobility of the envelope glycoprotein.
3. The mechanical properties of the virus particle.

Hearing micromechanics - the mechanical properties of the tectorial membrane

M. Safro

On the Role of Electrostatic Interactions in Formation of Aminoacyl-tRNA Synthetase - tRNA Encounter Complexes

Human, Cytoplasmic and Mitochondrial Phenylalanyl-tRNA Synthetase: Cloning, Expression, 3-D-structure, Complexes with Functional Ligands
M. Safro, Dr. N. Moor

Fidelity of the Genetic Code Translation: Editing Activity of Phenylalanyl-tRNA synthetase

Amino Acids Biogenesis, Evolution of the Genetic Code and Aminoacyl-tRNA Synthetases

I. Sagi

Structural -Dynamic studies of Metalloenzymes and Protein-Nucleic Acid Interactions.

Our research covers a wide range of areas with the common themes of dynamic structure-function investigations. The principle areas of investigation are mechanism of action of metalloenzymes and protein-nucleic acid interactions. Our objective is to study

Z. Shakked

Crystal structure and solution studies of DNA oligomers.
Z. Shakked, Donald Crothers (Yale University)

1. DNA regulatory elements
2. DNA bending by adenine-thymine tracts

Structural and biochemical studies of proteins involved in transcriptional regulation.

1. The tumor-suppressor protein p53 and its interaction with DNA and the basal

transcription machinery
2. The leukemia-related RUNX1(AML1) transcription regulator

J. Sussman

X-ray structural analysis and molecular biology studies on proteins from the nervous system, including acetylcholinesterase (AChE), human, torpedo, drosophila, and krait; butyrylcholinesterase; neural cell adhesion proteins with sequence similarity to ACh
J. Sussman, Israel Silman

Structure based drug design studies on AChE and beta-secretase, including studies of complexes with transition state analogs; potential drugs for the treatment of Alzheimer's disease; and snake neurotoxins.
J. Sussman, Israel Silman

Application of ultra rapid X-ray diffraction methods to study the enzymatic mechanism of AChE in real time.
J. Sussman, Israel Silman

Visualization of 3D Protein Structures via new web based tool Proteopedia
J. Sussman, Jaime Prilusky & Israel Silman

3D Structure Fucntions studies of Paraoxonase
J. Sussman, Dan Tawfik & Israel Silman

3D Structure Funciton Studies or proteins related to Autism
J. Sussman, Israel Silman

3D Structure Funciton of proteins related to Gaucher Disease
J. Sussman, Tony Futerman & Israel Silman

S. Weiner

Archaeological science: revealing the microscopic archaeological record
S. Weiner, E. Boaretto, I Finkelstein, A. Maier, R. Shahack-Gross

Structure - mechanical function relations in mineralized tissues (bones and teeth) using Optical Metrology.
S. Weiner, Ron Shahar

Biomineralization: mechanisms of mineral formation and growth in biology.
S. Weiner, L. Addadi, Irit Sagi, Leeor Kronick

A. Yonath

Protein biosynthesis

Ribosomal mechanisms

Faculty of Mathematics and Computer Science

Department of Computer Science and Applied Mathematics

Uriel Feige, Head

The principal interests of the department lie in the areas of computer science and applied mathematics. Research in computer science includes the study of computational complexity, the development and analysis of algorithms, cryptography, proof theory, parallel and distributed computing, logic of programs, specification methodologies, the formal study of hybrid systems, combinatorial games, biological applications, brain modeling, visual perception and recognition, robotics and motion control. Research in applied mathematics includes dynamical systems, combinatorics, numerical analysis, the use of mathematical techniques to elucidate phenomena of interest in the natural sciences, such as biology and geophysics, and on the development of new numerical tools for solving differential equations, computing integrals, providing efficient approximations to complex continuous models, and solving other mathematical problems.

The departmental computer facilities include a multiple-CPU server, SGI, Sun and DEC workstations, and NCD X-terminals. The vision and robotics laboratories contain state-of-the-art equipment, including an Adept four-axis SCARA manipulator, an Eshed Robotec Scorbot ER IVV manipulator, Optotrak system for three-dimensional motion tracking, and a variety of input and output devices.

R. Basri

Computer vision, image processing, object recognition under unknown lighting and pose, categorization, perceptual grouping and segmentation.

I. Dinur

Probabilistically Checkable Proofs

Hardness of Approximation

U. Feige

NP-hard combinatorial optimization problems, computational complexity, algorithms, cryptography, random walks, combinatorial optimization.

T. Flash

Robotics, motor control and learning, movement disorders, computational neuroscience,

virtual reality.

O. Goldreich

Probabilistic proof systems, Pseudorandomness, Foundations of Cryptography, Property Testing, and Complexity theory.

S. Goldwasser

Probabilistic proofs, cryptography, computational number theory, complexity theory.

D. Harel

Visual formalisms, software engineering, biological modeling, visualization, odor communication and synthesis

M. Irani

Computer Vision, Video information analysis and applications, Image Processing.

R. Krauthgamer

Design and analysis of algorithms, including massive data sets, data analysis, and combinatorial optimization

Embeddings of finite metric spaces, high dimensional geometry

A. Levin

Computer vision, Computer graphics, Image processing

D. Michelson

Numerical analysis, differential equations, dynamical systems.

E. Mossel

Algorithms, Bioinformatics and Combinatorial Statistics
E. Mossel, M. Braverman, C. Daskalakis, A. Sly, M. Steel, S. Roch

Influence of Functions, Computational Complexity and Social Choice
E. Mossel, P. Austrin, G. Kalai, R. O'Donnell, K. Oleszkiewicz, O. Schramm

Discrete Probability
E. Mossel, Y. Peres, S. Roch, A. Sly

B. Nadler

Mathematical Statistics, Machine Learning, Statistical Signal Processing, Stochastic Processes.

M. Naor

Cryptography and Complexity

Distributed Computing

Concrete Complexity

D. Peleg

Graph algorithms, approximation algorithms, distributed computing, fault tolerance, communication networks

R. Raz

Complexity Theory: In particular; Boolean circuit complexity, arithmetic circuit complexity, communication complexity, propositional proof theory, probabilistic checkable proofs, quantum computation and communication, randomness and derandomization.

O. Reingold

Foundations of Computer Science

1. Computational Complexity
2. Foundations of Cryptography
3. Randomness, Derandomization and Explicit Combinatorial Constructions

V. Rom-Kedar

Hamiltonian systems - theory and applications
V. Rom-Kedar, M. Radnovic, A. Rapoport, E. Shlizerman, D. Turaev

1. Near-integrable systems
2. The Boltzmann ergodic hypothesis and soft billiards.
3. Chaotic scattering.
4. Resonant surface waves.
5. Perturbed nonlinear Schrodinger equation.

Mathematical models of the hematopoietic system and their medical implications
V. Rom-Kedar, R. Malka, E. Shochat.

Chaotic mixing of fluid flows
V. Rom-Kedar, R. Aharon, H. Gildor

E. Segal

Quantitative models for transcription and chromatin regulation

Modeling the role of microRNAs and non-coding RNAs in gene regulation

A. Shamir

Cryptography, cryptanalysis, electronic money, smartcard security, internet security, complexity theory, the design and analysis of algorithms.

E. Shapiro

Biomolecular computing and its medical applications

E. Titi

Nonlinear Partial Differential Equations and Dynamical Systems

1. Infinite-dimensional dynamical systems
2. Numerical analysis of dissipative PDEs
3. Reduced dynamical systems
4. Limit behavior of fast and slow dynamics

Fluid Dynamics

1. Navier-Stokes and related equations
2. Turbulence theory
3. Geophysical models of oceanic and atmospheric dynamics
4. Polymeric flows and non-Newtonian complex fluid

S. Ullman

Vision, image understanding, brain theory, artificial intelligence.

Department of Mathematics

Sergei Yakovenko, Head

The principal research interests of the department lie in the broadly understood areas of analysis, algebra, and geometry, very often on the cross-roads between these areas, and closely related to the research at the department of computer science and applied mathematics.

Topics covered in **analysis** include operator and matrix theory, spectral theory, linear and nonlinear ordinary and partial differential equations, functional and harmonic analysis, ergodic theory and dynamical systems, control theory in its various manifestations, optimization, game theory, approximation and complexity of functions, numerical analysis, singularity theory and robotics.

Probability theory is prominently featured at the interface between analysis and **geometry**. Special emphasis is put on the study of random walks on graphs and groups, motion in random media, percolation theory, and random matrices. Other areas of geometric research include the structure of finite and infinite dimensional spaces, analytic, real algebraic and semialgebraic geometry and topology of foliations.

The **algebraic** direction includes some aspects of algebraic geometry, representation theory, quantum groups, crystals, number theory, automorphic forms, ring theory, statistics of Young diagrams, algebraic combinatorics and enveloping algebras, invariants and crystals.

Although the approach taken is primarily that of theoretical mathematics, some of the research leans towards possible applications.

Z. Artstein

Control and optimal control, singularly perturbed systems, variational analysis.

Decisions under uncertainty.

Ordinary differential equations, singular perturbations, nonautonomous systems.

I. Benjamini

Probability and geometry.
I. Benjamini, A. Dvoretzky, G. Schechtman, O. Schramm

V. Berkovich

Algebraic geometry.
V. Berkovich, S. Yakovenko

Number theory.
V. Berkovich, S. Gelbart

Non-Archimedean analytic geometry.

S. Gelbart

Automorphic forms and L-functions.
S. Gelbart, F. Shahidi, E. Lapid, S. Miller

Group representations.

M. Gorelik

Representation theory and Lie superalgebras
M. Gorelik, V. Serganova, V. Kac

A. Joseph

Lie algebras and enveloping algebras, quantum groups. Invariant theory.

Y. Kannai

Mathematical economics, statistical analysis of occurrence of asthma in children.

Partial differential equations.
Y. Kannai, M. Solomyak

V. Katsnelson

System representation theory of matrix functions.
V. Katsnelson, Dym, H.

Analytic theory of differential equations.
V. Katsnelson, Volok, D.

Harmonic analysis.
V. Katsnelson, Gurarii, V.

Operator theory

Classical analysis

G. Kozma

Probability
G. Kozma, Itai Benjamini, Gideon Amir, Omer Angel, Marek Biskup, Asaf Nachmias.

Harmonic Analysis
G. Kozma, Alexander Olevskii, Jean Bourgain

D. Novikov

Hilbert 16th problem

Ordinary differential equations

A. Regev

Non-commutative ring theory

Combinatorics
A. Regev, Yuval Roichman

1. Symmetric functions
2. Permutation statistics

G. Schechtman

Convex geometry

Functional analysis and geometry of Banach spaces

Probability

S. Yakovenko

Limit cycles of vector fields, analytic theory of ordinary differential equations.
S. Yakovenko, G. Binyamini, D. Novikov

Singularity theory.
S. Yakovenko, G. Binyamini

Y. Yomdin

Analytic Theory of Differential Equations, Generalized Moments, Compositions
Y. Yomdin, M. Briskin, N. Roytvarf, F. Pakovich,

Zeroez distribution in Families of Analytic Functions
Y. Yomdin, M. Briskin, N. Roytvarf

Semialgebraic Complexity of functions, Signals Acquisition via non-linear model approximation
Y. Yomdin, G. Comte, N. Roytvarf

High Order Data Representation, Nonlinear Model Approximation. Taylor Models, High-Order Numerical methods
Y. Yomdin, N. Roytvarf

Model-based image analysis, representation, compression. Model-based search, capturing, and animation
Y. Yomdin, G. Dinkin, M. Briskin

O. Zeitouni

Motion in random media

Random matrices

Applications in nonlinear filtering, Communication and Information theory

Faculty of Physics

Department of Condensed Matter Physics

Moty Heiblum, Head

The scientific activity of the department is mainly concentrated around the experimental and theoretical research in quantum solid state physics. It includes experimental research of mesoscopic physics, quantum Hall physics, high temperature superconductors, two and one dimensional superconductors, metal-insulator transition, carbon nanotubes, semiconductor nanowires,and study of material growth. The theoretical efforts concentrate on similar subjects with added work on disordered materials, cold atoms, and quantum optics.

The Braun Center for sub micron research is an integral part of the department. It is a modern and well equipped center, with growth (three MBE's) and characterization systems, which allows to conduct experiments on sub micron semiconductor structures under high magnetic filed, normal and high temperature superconductors, and nanowires made of carbon nanotubes and semiconductor nanowires.

I. Bar-Joseph

Optical spectroscopy of the two-dimensional electron gas in zero and strong magnetic fields.

Near field spectroscopy of semiconductor heterostructures.

Electron-hole complexes in quantum wells: Dynamics and steady state properties.

A. Finkelstein

Effects of the electron-electron interaction in low dimensional and disordered systems.

Metal-insulator transition in 2D conductors.

Magnetic fluctuations in high - Tc superconductors.

Y. Gefen

Quantum dots: Interplay between Electron-Electron Interaction & Spin and Quantum Interference Effects.

The Fractional Quantum Hall Effect : Quasi-Particle Tunneling.

weak measurement and weak value in nanoscopic systems

Geometric (Berry) Phases in the Presence of Dissipation and Quantum Computing Qubits.

M. Heiblum

Fractional charges and their fractional statistics
M. Heiblum, Yunchul Chung, Oern Zarchin, D. Mahalu, V. Umansky

1. Charge and statistics of quasiparticles
2. Bunching of quasiparticles
3. Dilute quasiparticles and their behavior
4. High frequency shot noise measurements

Interference and dephasing of electrons
M. Heiblum, M. Avinun, I. Neder, D. Rohrlich, D. Mahalu, H. Shtrikman

1. Phase measurements via a double path interferometer
2. Controlled dephasing via 'which path?' detector
3. Interferometers functioning in a high magnetic field, Mach-Zehnder Interferometer

S. Levit

Atom-atom interactions in cold gasses and BEC

Resonant scattaring off photonic slabs

Non classical light.

Interaction of Squeezed Light with Atoms and Semiconductor Nanostructures

Full vector path integrals for light propagation in dielectrics.

Y. Oreg

The transmission phase shift through a quantum dot that is coupled to leads and forms a many body state (known as the Kondo resonance) is calculated. This work is related to experimental studies at the Braun Center for Submicron Research at the Weizmann I

A generalization of Hund’s rules to disordered dots.

Several aspects of disorder superconductors and normal metal - superconducting junctions are studied, including the interplay between bosons and fermions in this system.

Luttinger liquids in one-dimensional systems.

Bi-layer systems.

D. Shahar

Experiments on materials at ultra low-temperatures.

Scanning tunneling experiments at ultra-low temperatures

Physics of electron's spin

Quantum phase transitions: General transport studies and mesoscopics of the metal-insulator, superconductor-insulator and other transitions.

Fractional and integer quantum Hall effect and related phenomena.

A. Stern

Quantum Hall effect and composite fermion theory. Electronic transport in strong magnetic fields.

Non-abelian quantum Hall states and topological quantum computation.

Double layer electronic systems.

Low density two dimensional electronic systems.

One dimensional electronic systems.

E. Zeldov

High-temperature superconductors

Magneto-optical imaging

Vortex matter phase transitions

Nano-structured superconductors

Vortex dynamics

MgB_2 and $NbSe_2$ superconductors

Scanning nano-SQUID microscopy

Department of Particle Physics

Eli Waxman, Head

The Department of Particle Physics is engaged in both experimental and theoretical research, in various directions. These include elementary particle physics, relativistic heavy ion physics, field theory, string theory, molecular physics, nuclear physics, plasma physics, and radiation detection physics.

O. Aharony

Three dimensional gauge theories and their gravitational duals
O. Aharony, J. Maldacena, O. Bergman, D. Jafferis, A. Hashimoto, S. Hirano, P. Ouyang

Supersymmetric gauge theories and supersymmetry breaking
O. Aharony, E. Silverstein, S. Kachru, N. Seiberg

String theory description of large N QCD
O. Aharony, Z. Komargodski, E. Karzbrun

AdS/CFT correspondence and its generalizations
O. Aharony, J. Sonnenschein, S. Yankielowicz, A. Buchel, M. Berkooz, Y. Antebi

The Hagedorn and deconfinement phase transitions
O. Aharony, S. Minwalla, M. Van Raamsdonk, J. Marsano, K. Papadodimas, S. Hartnoll, A. Buchel, R. Yacobi, M. Mussel

T. Alexander

Stars very near massive black holes.

The Galactic Center.

Gravitational Lensing.

Active Galactic Nuclei.

A. Breskin

Basic phenomena, related to radiation detection, including charge transport and multiplication in gases, photoemission and secondary electron emission.
A. Breskin, R. Chechik

Novel particle and photon detection techniques for particle physics, x-ray diffraction. Bio-medicine, surface analysis.
A. Breskin, R. Chechik

Digital mammography, early detection of cancer, radiation damage to DNA.
A. Breskin, R. Chechik

E. Duchovni

Search for Supersymmetry with the ATLAS detector at CERN

1. Inclusive Search

2. Study of Gauge Mediated symmetry breaking
3. Study of R-Parity violating models
4. Study of Anomaly Mediated Symmetry breaking

Search for Fermiofobc Higgs with the OPAL detector at CERN

A. Gal-Yam

Cosmic explosions

1. Core-collapse supernova explosions: their origins, nature, physics and population statistics
2. Thermonuclear supernova explosions (SNe Ia): their nature and rates
3. Gamma-Ray Bursts: their origin and relation to supernovae
4. New types of cosmic explosions

Wide-field variability surveys
A. Gal-Yam, S. Kulkarni, E. Ofek, (Caltech)

1. The Palomar Transient Factory (PTF) - the next generation wide-field variability survey
2. Transients from the supernova Factory (SNF) - a pilot project for the PTF
3. Wide-field radio variability surveys

D. Gepner

Rational conformal field theory and solvable lattice models.

E. Gross

Higgs Physics with the ATLAS detector at the LHC
E. Gross, Students: Ohad Silbert and Ofer Vitells, Post Doc: Amit Klier

1. Search for Charged Higgs Boson
2. Search for Supersymmetric Higgs decaying into Muons
3. Search for Higgs via its decay to Tau Leptons

Muon Identification with the ATLAS detector at the LHC
E. Gross, Student: Ohad Silbert

S. Gurvitz

Multi-dimensional tunnelling.
S. Gurvitz, W. Nazarewicz, K. Kato

1. Two-potential approach to tunneling problems
2. Cluster decay
3. Complex scaling and the semi-classical approximation

4. Modified tunneling Hamiltonian

Final state interaction in inclusive reactions.
S. Gurvitz, M. Traini

1. Bjorken scaling and confinement
2. Higher twist corrections to nucleon structure functions

Quantum transport in mesoscopic systems and the measurement problem.
S. Gurvitz, G. Berman, D. Mozyrsky

1. Quantum rate equations for coherent transport
2. Relaxation and dephasing in a qubit measurement
3. Single-spin measurement and decoherence
4. Zeno effect and quantum description of classical apparatus

H. Harari

Neutrino Physics (Particle Physics, cosmology, astrophysics implications)

Patterns of quarks and leptons (masses, mixing, substructure)

M. Hass

Low-Energy nuclear resctions in astrophysics. Solar fusion reactions (neutrino oscillations) and nucleo-synthesis
M. Hass, Dr. Dan Berkovits, Soreq Nuclear Research Centre.

1. Low-energy fusion reactions, relevant to the solar neutrino issue. Exeriments at the Van de Graaff accelerator of the Weizmann Institute
2. Explosive nucleo-synthesis scenraios and the nuclear reactions playing a role in these astrophysical sites; x-ray bursts, supernoave, rp-process reactions
3. Development of techniques and tools for light radioactive beam production for nuclear astrophysics and neutrino physics. Connection to the SPIRAL-II facility at GANIL (France) and the SARAF accelerator at NRC Soreq

Y. Maron

Dynamics of plasmas, high-energy-density, plasmas, plasmas under pulsed magnetic fields, implications to fusion, transmission of high-current pulses, and space physics (in collaboration with the Technion, Holon Institute of Technology (Israel); Cornell University, NYU, Naval Research Laboratory, Sandia National Laboratories (USA); University of Jena, University of Rostock, GSI (Germany)).
Y. Maron, V. Bernshtam, R. Doron, V. Fisher, E. Kroupp, E. Stambulchik , A. Starobinets, L. Weingarten

1. Z-pinches and plasma switches.
2. Magnetic field penetration into and acceleration of plasmas, relation to space physics.

3. Imploding plasma.
4. Kinetics and transport in non-equilibrium plasmas.
5. Energy conversion in transient plasmas.
6. Turbulent electric fields.

Development of novel spectroscopic diagnostic methods for determining the properties of the plasma and the electric and magnetic fields (in collaboration with University of Maryland, NIST (USA), Lebedev Physical Institute (Russia)).
Y. Maron, V. Bernshtam, R. Doron, V. Fisher, E. Kroupp, E. Stambulchik , A. Starobinets, L. Weingarten

1. Spectral line profiles (broadening, shifts, forbidden components, and polarization).
2. Spectral line intensities.
3. Spectroscopy of highly stripped, heavy ions.
4. Visible-UV, VUV, to X ray regions.

Colision-Radiative-modeling: arbitrary electron-energy distribution, multi-component plasma; atomic calculations of cross sections and probabilities (in collaboration with NIST (USA), Lebedev Physical Institute (Russia)).
Y. Maron, V. Bernshtam, V. Fisher, E. Stambulchik , A. Starobinets, L. Weingarten

Plasma correlation effects and their influence on spectral line shapes.
Y. Maron, E. Stambulchik, D.V. Fisher

Electron states in dense plasmas, effects of statistical weights, kinetic modeling.
Y. Maron, D.V. Fisher. V. Fisher

Stark and Zeeman effects, field ionization (in collaboration with University of Maryland, NIST (USA), University of Rostock (Germany)).
Y. Maron, E. Stambulchik, V. Bernshtam, V. Fisher, A. Starobinets

Measurements of magnetic fields in dense turbulent plasmas.
Y. Maron, E. Stambulchik, R. Doron, S. Tessarin, B. Rubinstein, D. Mikitchuk

G. Mikenberg

Search for the standard-model and SUSY Higgs-bosons at LEP.
G. Mikenberg, E. Duchovni, E. Gross, L. Levinson, D. Lellouch

Detector development and study of physics for LHC.
G. Mikenberg, E. Duchovni, E. Gross, L. Levinson, D. Lellouch

Search for Supersymmetry at LEP.
G. Mikenberg, E. Duchovni, E. Gross, L. Levinson, D. Lellouch

Search for Higgs bosons and SUSY particles at LHC.
G. Mikenberg, E. Duchovni, E. Gross, L. Levinson, D. Lellouch

Trigger and data acquisition for LHC experiments.
G. Mikenberg, E. Duchovni, E. Gross, L. Levinson, D. Lellouch

Reconfigurable computing.
G. Mikenberg, E. Duchovni, E. Gross, L. Levinson, D. Lellouch

M. Milgrom

High energy astrophysics: x-ray sources, gamma-ray sources.

Departure from Newtonian dynamics as an explanation of the dark-matter problem in galactic systems.

Black holes at the centers of galaxies

A. Milov

Identified particle production in Heavy Ion Collisions with the PHENIX experiment at RHIC

Global Obsevrables of the Heavy Ion Collisions with the ATLAS detector at LHC

Y. Nir

Flavor at the LHC
Y. Nir, J. Feng, S. French, Y. Grossman, G. Hiller, Y. Hochberg, C. Lester, Y. Shadmi

Particle cosmology
Y. Nir, K. Blum, J. Feng

Astroparticle physics
Y. Nir, K. Blum, E. Waxman

I. Tserruya

Study of ultra-relativistic heavy-ion collisions using the PHENIX detector at RHIC (Relativistic Heavy Ion Collider) at Brookhaven National Laboratory and the CERES detector at CERN
I. Tserruya, I. Ravinovich

R&D, construction and installation of an HBD (Hadron Blind Detector) for the PHENIX experiment at RHIC.
I. Tserruya, I. Ravinovich

Electron pair production in relativistic heavy ion collisions: search for quark-gluon plasma and chiral symmetry restoration.
I. Tserruya, I. Ravinovich

V. Usov

Physical processes in very strong magnetic fields.
V. Usov, A.E. Shabad

Physical processes in relativistic electron-positron plasma.
V. Usov, G.Z. Machabeli

The theory of nonthermal radiation from compact astronomical objects (pulsars, white dwarfs, gamma-ray bursters etc.).
V. Usov, A.K. Harding, G.Z. Machabeli, D.B. Melrose, A.G. Muslimov, A.E. Shabad

Physical processes at the surface and astrophysical appearance of strange-quark-matter stars.
V. Usov, A.G. Aksenov, K.S. Cheng, T. Harko, M. Milgrom

Hydrodynamics and high-energy physics of colliding stellar winds in binary systems.
V. Usov, N.N. Pilyugin

E. Waxman

Neutrino astrononmy

Relativistic astrophysics (gamma-ray bursts, relativistic plasmas...)

Ultra-high energy cosmic-rays

D. Zajfman

Molecular astrophysics.
D. Zajfman, O. Heber

Cooling of molecular ions and clusters, ion trap dynamics.
D. Zajfman, O. Heber

Molecular physics using storage rings.
D. Zajfman, O. Heber

Femtosecond laser photodynamics
D. Zajfman, Y. Silberberg, O. Heber

Department of Physics of Complex Systems

Gregory Falkovich, Head

The Department of Physics of Complex Systems has research programs in fundamental and applied physics. Research in optics includes nonlinear optics, ultra fast optics and quantum optics, nano optics and nonlinear microscopy, laser cooling and trapping of atoms and ions for studied of Bose Einstein condensation, precision spectroscopy and quantum information processing. In condensed matter, research is concentrated on theory and experiment (in particular equilibrium and non-equilibrium statistical physics, clustering of data, bioinformatics and systems biology, colloids, complex fluids, flame and wet front

propagation, and membranes). Experimental and theoretical hydrodynamics concentrates on turbulence, spatio-temporal chaos, turbulent Rayleigh-Benard convection, and dynamics of single micro-objects, such as polymers, vesicles, capsules and hydrodynamics of their solutions. Classical and quantum chaos, statistics of nodal lines in quantum systems and turbulence are studied theoretically. As an application, mathematical and computational methods for archaeological research are developed. Turbulence theory is developed in general and in applications to cloud physics. Theoretical physical biology deals with modeling living information systems, their molecular components and the way they evolve. Experimental bio-physics deals with bio-molecules, neural cultures, neurophysics, physics of the brain and physics of bio-systems.

N. Davidson

Atomic optics, interferometry and chaos.

Bose Einstein Condensation in Ultra cold atomic gas.

phase locking and synchronization of lasers
N. Davidson, Asher Friesem

electromagnetic-induced transparency and slow light
N. Davidson, Moshe shuker, Ofer Firstenberg, Amiram Ron

E. Domany

Development of tools and algorithms for large scale data analysis. Bioinformatics.

Computational Physics: equilibrium and non-equilibrium statistical mechanics of spin glasses
E. Domany, A. P. Young (UCSC)

Analysis of high-throughput biological data (in particular, gene expression data)
E. Domany, Several research groups at Weizmann, in the USA and in Europe; see below.

1. Controlled experiments on cell lines and mice (with D. Givol, V. Rotter, Y. Groner, L. Sachs; D. Gazit (Hadassa))
2. Development of antigen chips, applications for autoimmune diseases (with I. Cohen)
3. Studies human cancer samples; leukemia (with E. Canaani; G. Rechavi S. Izraeli (Sheba))
4. Colorectal cancer; (with D. Notterman (UMDNJ), F. Barany (Cornell), P. Paty (MSK), A. Levine (Princeton))
5. Prostate cancer; (with Z. Eshhar, A. Orr (TA Sourasky));
6. Glioblastoma; (with M. Hegi, R. Stupp (CHUV))
7. Breast and cervical cancer (with J-P Thiery, F. Radvanyi, X. Sastre, C. Rosty (Inst Curie))

N. Dudovich

Strong field light matter interactions

Attosecond Physics

G. Falkovich

Turbulence theory
G. Falkovich, Vladimir Lebedev, Ithak Fouxon, Stefano Musaccio

Cloud turbulence and rain.
G. Falkovich, Stas Derevyanko, Sergei Turitsyn

Statistical physics
G. Falkovich, Krzysztof Gawedzki, Raphael Chetrite

E. Moses

Physics of the Brain

Computation in Living Neuronal Networks

Neuronal Chips.

EEG and Brain Activity.

D. Mukamel

RNA and DNA denaturation.

Collective phenomena in systems far from thermal equilibrium.

Coarsening processes and slow dynamics.

Systems with long range interactions

D. Oron

ultrafast dynamics of semiconductor quantum dots

sub-diffraction limited imaging

Optical nonlinearity in plasmonic nanostructures

Quantum dot antennas in photovoltaic solar cells

Y. Silberberg

Nonlinear Optics and Quantum Optics.

Ultrafast optics and quantum coherent control.

Nonlinear microscopy.

U. Smilansky

Mathematical methods for Archaeological research.

Semi-classical quantization.

Chaotic scattering.

Quantum chaos.

J. Stavans

Genetic Networks
J. Stavans, Uri Alon

1. The SOS response
2. The Lambda phage decision circuit

Single-Molecule Biological Physics.

1. Proteins of the bacterial chromosome
2. DNA motor proteins

Evolution.

T. Tlusty

Molecular Codes
T. Tlusty, Uri Alon, Guy Sella

1. The Genetic Code
2. Transcription Regulatory Networks
3. Protein-Protein Networks

Mechanisms of Molecular Recognition
T. Tlusty, Joel Stavans

1. Specificity and Conformational Changes
2. Homologous Recombination

Hydrodynamics of Microfluidic Flows
T. Tlusty, Roy Bar-Ziv

2D Neuronal Networks
T. Tlusty, Elisha Moses

Feinberg Graduate School

Department of Science Teaching

Bat Sheva Eylon, Head

The Department is composed of groups working in mathematics, physics, chemistry, computer science, earth and environmental sciences, life sciences, and science and technology for junior-high school. In all these areas there are extensive research and development projects, aimed at (1) studying science and mathematics learning and teaching and their development, (2) producing and implementing improved and up-to-date learning and teaching materials that integrate the use of modern technologies, and (3) providing professional development for teachers, all over Israel. Work is based on an underlying philosophy that considers curriculum development and implementation, teacher professional development, research and evaluation as an interrelated and continuous long-term activity. Research studies focus on cognitive, socio-cultural and affective aspects of learning, teaching and learning to teach science and mathematics, using various research methodologies: quantitative, qualitative and mixed methods.
The department operates two national centers for science teachers (physics, and science and technology in junior high school) specializing in; the development of leadership among science teachers and in continuous professional development for science teachers using effective models. In recent years the department is involved in EU projects aiming at enhancing science education both in the formal as well as in the informal level.

A. Arcavi

Research on cognitive characteristics of non academically oriented math students.
A. Arcavi, Dr. Ronnie Karsenty

Design of curriculum materials as a research based activity
A. Arcavi, Dr. Sue Magidson

Long-term design of a new curriculum for grades 10, 11 and 12 for non-academically oriented students.
A. Arcavi, Dr. Nurit Hadas

M. Ben-Ari

Teaching and learning computer science
M. Ben-Ari, M. Armoni

1. Scratch for teaching programming in middle schools
2. Computer Science Unplugged for introducing computer science to the general public

Concurrent and distributed computation

1. Teaching concurrency with model checking

Visualization and animation for computer science education
M. Ben-Ari, E. Sutinen

History and philosophy in science teaching

R. Even

The interactions among math curriculum, teachers, and classrooms

Teacher knowledge, learning, education and development (MANOR)

1. Education and advancement of providers of professional development for teachers
2. The development of research-, theory- and practice-based resource materials for use in teacher education

Mathematics education research and practice issues

B. Eylon

High school curriculum development

1. Translation and adaptation of selected units from the course "Visual Quantum Mechanics" developed by the Physics Education Research Group in Kansas State University.
2. Preparing texts and materials for elective units for physics majors (lasers, chaos). Using computerized networks (internet and intranet) for distance learning of these courses.
3. Development of modules for student activities in Mechanics, Electricity and Magnetism and Optics.
4. Development of modules for inquiry learning in the context of "mini-projects".
5. Development of a new course on Light and Waves for 10th and 12th grades.
6. Development of physics programs for the Arab population.
7. Elaboration of the national physics syllabus and the matriculation examinations.
8. Preparation of materials for e-learning in mechanics and electricity that can be used in various models that integrate in-class and distance learning of physics.

Research, evaluation and planning
B. Eylon, U. Ganiel

1. Research of problem-solving processes in high school physics.
2. Study of concept learning and misconceptions in high school physics.
3. Study of processes involved in integration of technology in physics learning.
4. Formative and summative evaluation of new courses.
5. Research and development of various strategies for integration of microcomputers in physics learning processes.
6. Investigation of learning processes and teaching methods in teacher training programs.
7. Study of long-term professional development of teachers and leader-teachers.

Application of microcomputers in physics teaching
B. Eylon, U. Ganiel

1. Development of open environments for promoting physics reasoning and inquiry learning.
2. Developing custom made programs for specific learning activities within the physics curriculum.

Teacher development: National center for physics teachers
B. Eylon, E. Bagno, U. Ganiel

1. In-service teacher training courses.
2. In-school projects for promoting the teaching of physics through the use of computers.
3. Long-term didactical courses introducing teachers to current research in physics education and its implications to the learning/teaching process.
4. Long-term frameworks for leader teachers: Three-year courses for basic training and forums for acting teacher-leaders.
5. Resource materials and frameworks for teacher development.
6. An annotated database of selected internet resources relevant to high school physics in Israel (in Hebrew).
7. One-day national conference and workshops for physics teachers in Israel.
8. A prize for outstanding teachers or teams of teachers (together with the physics department and the Amos de-Shalit fund).

Preparation of learning materials for 7-9 grade

1. Introduction to Science and Technology.
2. Vacuum and particles: The particulate model of matter.
3. About Fibers
4. Interactions, Forces and Motion
5. Scientific and Technological Communication.
6. Projects as Tools for Learning.
7. The Materials' Cycle in Earth's Crust.
8. The World of Water.

Computerized Materials

1. Computerized courses and resources for the teaching the topics of "Energy - a Multidisciplinary View", "Nutrition and Health", "Nature as a Model for Imitation - The Bionic Man".
2. Computer simulations for studying units dealing with "Systems".
3. A Computerized environment for analyzing videotapes of motion.
4. Computer programs accompanying the study of Earth-Sciences in grades 7-9.
5. Computer program accompanying the study of the "cell" as a longitudinal strand (with the Center of Educational Technology).
6. "The Golden Way" - A Navigational Tool for Project Based Learning in Science and Technology (with the Association for the Advancement of Science Education in the Upper Galillee).

In-service courses in science and technology for junior-high school teachers
B. Eylon, Z. Scherz, I. Hopfeld, N. Orion, O. Kedem, Y. Ben-Hur

1. Design and implementation of 3-year courses for teachers.
2. Preparation of leading science and technology educators.
3. Conducting regional long term activities in several regional teacher centers.
4. Conducting in-service teacher courses for the Arabic population.
5. A National Teacher Center for Juniour High School Teachers (in collaboration with Tel Aviv University).

Research and Evaluation
B. Eylon, Z. Scherz, N. Orion, S. Rosenfeld, U. Ganiel

1. Research on teacher and teacher-leader development in science and technology.
2. Investigation of various instructional strategies for understanding central concepts in the science and technology syllabus for junior-high school, and development of learning and thinking skills.
3. Investigation of project based learning (PBL) focusing on learning styles and the integrated development of concepts and skills.
4. Investigation of longitudinal development of conceptual frameworks and learning capabilities.
5. Investigation of learning through the course "systematic inventive thinking".

D. Fortus

IQWST - Investigating and Questioning our World through Science and Technology
D. Fortus, J. Krajcik & L. Sutherland - University of Michigan, B. Reiser - Northwestern University

1. Coordinated curriculum materials
2. Scientific Practices
3. Literacy
4. Project-Based Science
5. Large-Scale Evaluation
6. Professional Development

MoDeLS - Modeling Designs for Learning Science
D. Fortus, B. Reiser - Northwestern University, J. Krajcik & E. Davis - University of Michigan, C. Schwarz - Michigan State University

1. Learning Progression
2. Scientific Practices
3. Assessment through construct modeling

Enhancing Motivation to Learn Science

1. Policy Implementation
2. School Culture & Philosophy
3. Teaching Style
4. Curriculum
5. Assessment
6. Parents & Peers Inluence

A. Hofstein

High school chemistry curriculum development and implementation
A. Hofstein, Rachel mamlok-Naaman,

1. The development and implementation of text books and teachers' guide
2. Preparation of resources and units for the teaching of Industrial chemistry in Israel.
3. Development of new instructional techniques to teach chemistry in high schools.
4. Inquiry type experiments and
5. The use of internet for instruction.
6. Development of CAI (computer Assisst Instruction)
7. Development of introductory (basic) modules for a new syllabus in high school chemistry. (
8. Development of modules for non-science oriented students in high schools

Research and evaluation
A. Hofstein, R. Mamlok

1. Formative and summative of curriculum units that are developed by the chemistry group and the science for all students
2. Teachers' and students' perceptions and attitudes towards science and technology.
3. Non science oriented students' conception of key ideas and concept in chemistry
4. The development of modules for non-science oriented students
5. Analysis of learning difficulties and misconception in chemistry in the Israeli Bagrut
6. Development of argumentation skills in inquiry laboratories
7. Misconception regarding bonding and structure of molecules
8. Assessment of students' perception of the chemistry classroom and laboratory learning environment

N. Orion

The outdoor as a learning environment

1. The educational role of the outdoor learning environment.
2. The cognitive contribution of the outdoor learning environment.
3. Development of in service training model for helping teachers to use the outdoor learning environment effectively.
4. Development of curriculum materials for the outdoor learning environment from K-12.

Earth and environmental sciences education: research, development and implemntation from K-12.

1. Research of cognitive aspects of learning earth and environemtal sciences.
2. Development of curriculum materials for all levels from K-12 based on formative evaluation studies.
3. Development of in service teachers training model for a deep changes in teaching focus and style.
4. Development of curriculum materials in earth sciences for all the learning

environments: laboratory, outdoor, computer and classroom.
5. Development of a modules from K-8 based on the Earth systems approach.
6. Development and implementation of learning strategies for classes included high percentage of immegrants.

Y. Shwartz

Chemical Literacy

1. Development of a theoretical definition of chemical literacy
2. Developing an assessment approach and assessment tools for assessing various aspects of chemical literacy
3. Investigating various aspects of chemical literacy among high-school students
4. Design and implementation of workshop for teachers

Development of scientific ideas over time (cognitive coherence)

1. Investigating middle-school students' understanding of the multi-disciplinary facets of energy.
2. Merritt, J., Krajcik, J., Shwartz Y. - Investigating the development of understanding of the particulate nature of matter
3. IQWST - Investigating and Questioning our World through Science and Technology D. Fortus, J. Krajcik & L. Sutherland, B. Reiser. Development of a coordinated science curriculum for middle-school
4. Development of exemplary assessment items for
5. Peled-Levin, R., Nachshon, M., Shwartz, Y. - Developing an instructional approach focusing on coherent understanding of core ideas

Development of Scientific practices

1. D. Fortus, B. Reiser, J. Krajcik B. Davis, C. SchwarzMoDeLS - Modeling Designs for Learning Science: Development of Modeling Practices, Assessment of modeling meta-knowledge and manifestations of meta-knowledge in various contexts, Learning Progression
2. Fortus D., Shwartz, Y. Development of Data Gathering Organization and Analysis (DGOA) practices over time

Curriculum development

1. 1. IQWST - Investigating and Questioning our World through Science and Technology D. Fortus, J. Krajcik & L. Sutherland - University of Michigan, B. Reiser - Northwestern University. Development of 3 chemistry units for middle-school.
2. 2. Levi Nahum, T. Shwartz, Y. Bardov, Z. - Development of a high-school chemistry unit focusing on bonding and the quantitative aspects in chemical reactions

Design, implementation and research of long-term professional development frameworks for high school teachers

1. Shwartz, Y. Bardov, Z., & Mamlok-Naaman, R. Rotchild-Weizmann Project: Teacher's Initiatives

2. Shwartz, Y. Katchevitch, D. & Mamlok-Naaman, R. - Leading chemistry teachers Two-years workshop
3. Peled-Levin, R., Nachshon, M., Shwartz, Y Leading teachers Science for all (MUTAV)
4. Chemical Literacy annual workshop

Investigating Instrcution
Y. Shwartz, Krajcik, J., & Novak, A.

1. Investigating exemplary teaching of inquiry-based curriculum

A. Yarden

Learning using adapted primary literature: development of biological literacy among high-school biology students

1. Development and processing of scientific research papers as learning materials for high school biology students.
2. Development of instructional strategies for teaching and learning using scientific research papers.
3. Investigating the effect of various text genres on the formation of scientific literacy.
4. Characterizing the learning processes of adapted primary literature by high-school biology students.
5. Analysis of the benefits and challenges to teaching and learning using adapted primary literature.

The influence of learning bioinformatics in the high-school biology program on students understanding of basic genetic concepts

1. Development and implementation of learning materials in bioinformatics (http://stwww.weizmann.ac.il/bioinformatics/)
2. Studying the influence of learning modern genetics on students understanding of central genetic concepts.
3. Characterization of deep and surface approaches to learning genetics and bioinformatics.

Understanding of the relationships between cellular processes and function of multicellular organisms at the junior-high school level

1. Development and implementation of learning materials to teach and learn the living cell as a longitudinal axis.
2. Investigating students understanding of the relationships between the micro (cellular and molecular) level and the macro (organism) level when learning the cell topic as a longitudinal axis.
3. Analysis of experienced junior-high-school teachers PCK in light of teaching the living cell as a longitudinal axis.

Characterizing children s spontaneous interests in science and technology

1. Identifying children's interests in science using questions sent to national and international Ask-A-Scientist sites.

2. Identifying Israeli teachers interests in science using questions sent to an Ask-A-Scientist site.

The effect of disciplinary identity on interdisciplinary learning

Identifying means to make molecular biology less abstract for high school biology and biotechnology students

1. Characterizing the conditions and the components of animations, under which they are most effective in promoting comprehension of biotechnological methods.
2. Exploring the use of hands-on molecular biology activities in promoting high-school biology and biotechnology students' comprehension of molecular biology.

E. Yerushalmi

Development implementation and evaluation of a 2-year interdisciplinary program for high school chemistry and physics students on
E. Yerushalmi, A. Hofstein, S. Livne, Y. Roth, R. Blonder, A. Yarden, S. Safran, B. Eylon, B. Geiger

Instructional strategies intended to develop reflective problem solving skills in high school physics students
E. Yerushalmi, C. Singh, E. Cohen, E. Bagno, B. Eylon

1. Study of the effects of self-diagnosis tasks on learning from physics problem solving.
2. Development, implementation and evaluation of web-based test preparation modules aimed at organizing students knowledge and developing awareness of common misconceptions (Mechanics, Electricity and Magnetism).

Development, implementation and research of long-term professional development frameworks for physics high school teachers
E. Yerushalmi, R. Safadi, E. Bagno, A. Rozen

1. Workshops for Arab high school physics teachers intended to develop reflective problem solving skills in their students through alternative assessment activities. Workshop approach: Collaborative inquiry into students' self diagnostic activities.
2. Models for collaborative action research workshops for high school physics teachers.
3. Long-term didactical courses introducing pre-service teachers to current research in physics education and its implications to the learning/teaching process.

University physics faculty perceptions of learning and teaching problem solving.
E. Yerushalmi, C. Henderson, K. Heller, P. Heller, V. Quo, E. Cohen