Current Research Activities

The Weizmann Institute of Science

מכון ויצמן למדע

2006

About the Weizmann Institute of Science

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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

Zvi Livneh, 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, and evolution of enzymes.
2. Proteins involved in controlling DNA stability, repair and expression of genetic information.
3. Structure and function of ion channels, pumps and other proteins that transport solutes across the cell membrane.
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.
6. Biomolecular computers, including engineering of computers made of DNA and proteins, and their application to the analysis and synthesis of information present in biomolecules.

A variety of methodologies are being utilized, with an emphasis on biochemistry, biophysics, molecular genetics, and computation methods. 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. Structure determination and comparative genomics of cellulosome components.
4. Nanosome technology − Selective engineering of chimaeric cellulosome constructs for nanotechnology.
5. Avidin−biotin system − Mutated avidins and streptavidins

E. Bibi

Structure/function studies of the *E. coli* multidrug transporter, MdfA.
E. Bibi, Oded Lewinson; Nadajda Sigal; Dvora Cohen−Karni

1. The multidrug recognition pocket of MdfA (genetic and biochemical studies)
2. 2D and 3D crystallization of MdfA
3. Mechanism of MdfA−mediated multidrug transport
4. Physiological activities of MdfA

The signal recognition particle (SRP) system in *Escherichia coli* and its role in membrane protein biogenesis:
E. Bibi, Elena Bochkareva; Asa Eitan; Liat Levy; Ido Yosef

1. FtsY, the essential prokaryotic SRP−receptor: its role in biogenesis of membrane proteins.
2. Structure−function studies on the functional NG domain of FtsY.
3. Membrane targeting and association of ribosomes in E. coli.
4. Identification of cellular factors involved in targeting insertion and assembly of membrane proteins.

R. Dikstein

Transcription regulation: the mechanisms of action of the basal transcription factor TFIID and NF−kappaB

1. Functional analysis of tissue specific TFIID subunit (TAF).
2. Molecular mechanism of TAF (TFIID subunit) activity.
3. The role of specific TAFs (TFIID subunits) in cell fate determination (i.e., cell cycle progression, cell survival and cell death).
4. The mechanism of rapid transcriptional induction of NF−kappaB target genes.

M. Eisenbach

Thermotaxis of mammalian sperm cells: molecular mechanism

Chemotaxis of mammalian sperm cells

1. Kinematics of sperm chemotaxis
2. Molecular mechanism of sperm chemotaxis

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 intracellular protein traffic

1. Isolation and characterization of novel proteins regulating targeting and fusion between transport vesicles and their target membranes.
2. Involvement of small GTP binding proteins of the Rab−family in vesicular transport.
3. Regulation of autophagocytosis in yeast and mammalian cells.

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. Signaling and trafficking of neurotrophin−receptor complexes.

A. Futerman

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

The regulation of ceramide synthesis by LASS gene family members

Sphingolipid signaling during neuronal development.

H. Garty

Regulation of epithelial ion transport:

1. Structure−function relationships of epithelial Na+ channels.
2. Kinases mediating hormonal regulation of epithelial ion−transport.
3. FXYD proteins as tissue specific regulators of the Na+/K+ ATPase.

S. Karlish

Molecular structure and function of Na/K−ATPase.

Regulation of Na/K−ATPase by FXYD proteins.

Molecular mechanisms involved in generation of essential hypertension.

Z. Livneh

Role of DNA Repair in the Risk of Cancer

Molecular and Cellular Analysis of novel DNA polymerases specialized in lesion bypass and mutagenesis.

Mechanisms and biomedical applications of DNA repair.

D. Mirelman

Molecular pathogenesis of the human intestinal parasite *Entamoeba histolytica*.

1. Molecular biology and genome organization in the lower eukaryot *Entamoeba histolytica*.
2. Selective inhibition of expression of virulence genes by Antisense RNA.
3. Mechanism of action of Allicin from Garlic and its potential applications for therapy.
4. Transcriptional gene silencing mechanisms

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

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

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), growth−stimulatory, 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.

Department of Molecular Genetics

Adi Kimchi, Head

Research in this department focuses on the utilization of molecular genetics for the study of diverse biological processes, including the study of viruses, control of cell growth and death, cytokines and receptors, human genetic disorders, gene expression, intracellular trafficking and development. Genetic approaches are being used in model organisms and mamalian cell cultures for studying developmental processes and basic cellullar events such as apoptosis. The molecular basis of human genetic diseases is being explored and various mice model systems were generated for this purpose. Another focus of the department is on genomics and computational biology. Utilization of quantitative approaches is undertaken for the analysis of the wealth of information provided by the completed genome sequences and the accumulating gene expression data from DNA arrays.

N. Barkai

Developing new computation tools for analyzing large−scale gene expression data ("DNA chips").

Quantitative study and modeling of morphogen gradients in Drosophila.

A. Elson

Regulation of physiological processes by protein dephosphorylation.

1. The role of PTPe in mammary tumorigenesis/breast cancer.
2. The role of PTPe in myelination of axons in the nervous system.
3. The role of PTPe in regulating bone mass.
4. Identification of substrates and interactors of PTPe.
5. Characterization of alternative isoforms of PTPe.
6. Obtaining molecular−level insight into the details and consequences of protein dephosphorylation by PTPe.

J. Gerst

The Molecular Basis for Polarized Cell Growth: Vesicle and mRNA Transport

1. SNAREs (vesicle fusion proteins) and SNARE regulators in exocytosis and endocytosis.
2. Phosphorylation in the control of SNARE assembly and membrane fusion.
3. Molecular requirements for the biogenesis of secretory vesicles
4. mRNA transport and the control of polarized cell growth in yeast

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.

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

Deciphering molecular networks underlying apoptosis and other basic biological processes.

1. Structure/function studies of DAP genes − a set of pro−apoptotic proteins isolated by a functional approach to gene cloning.
2. Implication of DAP genes in cancer development and in the control of cellular events such as protein translation initiation, and cytoskeletal organization.
3. Function−based gene "hunting" and the development of novel strategies to identify the basic principles of complex molecular networks.

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

Genome−wide analysis of genetics regulatory networks

Specificity−determining factors in receptor−ligand interactions

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

Y. Shaul

Study of proteasomal p53 and p73 degradation by a mechanism that does not involve ubiquitination.
Y. Shaul, C. Kahana

The mechanisms of cell response to double−strand DNA break. In particular understanding the roles of p73 and c−Abl.

RFX1 is a unique transcription activator. It teaches us how a single protein acts as both activator and repressor of transcription.

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 the X protein of HBV modifies cell behavior.

Development of new antiviral strategies that involves gene therapy technologies.

Generation of semi “synthetic viruses”. The aim is to develope the safest macromolecule delivery vehicle.

B. Shilo

Development of the *Drosophila* tracheal system.

Signaling by the Drosophila EGF receptor pathway during development.

T. Volk

The molecular basis for muscle−tendon interactions during embryonic development

1. The mechanism by which the RNA−binding protein Held out wing regulate tissue differentiation in Drosophila.
2. The mechansim of muscle attraction by tendon cells.
3. Structure−function analysis of Kakapo/Shortstop, a cross−linker between the actin and the microtubule networks in tendon cells.
4. Maturation of Drosophila perineural cells

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

Gad Galili, Head

Plants offer the world its only renewable resource of foods, building material and energy. 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 secure more food, and food of better quality. Research activities in the Department 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, bioinformatic 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, bioinformatics, 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.

Plant metabolism and growth. Research is centered around elucidating the pathways for production regulation of essential amino acids and secondary metabolites as well as understanding what controls cycles of differentiation and dedifferentiation in plant cells. Plant genome organization. Molecular tools have been developed to examine the fluidity of the plant genome as described by transposon elements and the concerted evolution of gene families.

A. Aharoni

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

1. Genetic regulation of secondary metabolism (e.g. flavors and pigments) in fruit
2. Metabolic pathways of fruit surface and their regulation
3. The role of RCC1−domain containing proteins in linking UV−B stress signaling cascades to the induction of secondary metabolism in plants
4. Functional analysis of a tandem array of six Cytochrome P450 genes associated with stress induced metabolism in Arabidopsis

I. Chet

biological control of plant diseases
I. Chet, Dr Ada Viterbo and Dr Michal Shoresh

induced resistance in plants
I. Chet, Viterbo and Shoresh

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.

M. Edelman

Modeling ligand−protein interactions.

Consensus structures for ATP binding sites.

Computer tools for analyzing molecular structures.

Tentoxin: structural mechanism of action.

Genetic engineering of aquatic plants.

National Center for Bioinformatic−Genetic Infrastructure.

R. Fluhr

Role of reactive oxygen species in pathogen defense and signal transduction.
R. Fluhr, Cher Ashtamker and Moshe Sagi

Application of microarray technology to problems in plant growth and environmental response.
R. Fluhr, O. Davydov

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, Ofra Hadrian and Yehudit Zohar

Dynamics of alternative splicing during stress and development
R. Fluhr, Hadas Ner−Gaon

G. Galili

Regulatory metabolic and physiological networks in plant development and response to stress
G. Galili, Zevulun Elazar, Aviah Zilberstein, Rachel Amir, Yoram Kapulnik, Rainer Hoefgen, Alisaider Fernie, Christoph Benning

1. Regulation of expression and functional role of lysine catabolism
2. Metabolic engineering of high−lysine plants
3. Genetic, genomic and bioinformatics approaches to elucidate metabolic networks in plants
4. Cellular and physiological roles of water channel aquaporins in 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

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

Hormonal regulation of angiogenesis and perfusion of breast cancer; Molecular and MRI studies including clinical testing of a new method for breast cancer diagnosis.

Glucose and choline metabolism in breast cancer; The regulation and role of the corresponding transporters and transport kinetics measured by MRS.

Renal function through sodium grandients; Non−invasive, high resolution sodium MRI.

N. Dekel

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

Cell−to−cell communication: regulation of expression,posttranslational modification, degradation and function of the gap junction protein, Cx43.

Endothelin1−mediated regulation of vascularization: role in implantation.

Molecular characterization of the ovulatory cascade

A. Gross

Ovarian follicle atresia as a model of apoptosis: The role of caspase proteases in this process.
A. Gross, Prof Alex Tsafriri

DNA damage and apoptosis: The role of BID in cell life and death decisions.

Mitochondria in apoptosis: Mechanisms of action of the pro−apoptotic BID molecule.

M. Liscovitch

Role of caveolin−1 in regulating growth and survival of human cancer cells

Role of phospholipase D and phosphatidic acid in cell signaling and membrane transport

Engineering ligand−modulated recombinant proteins

M. Neeman

Positive and negative regulators of pre−ovulatory angiogenesis in the normal rat ovary, ovarian preservation by ectopic implantation.
M. Neeman, Tomer Israely, Alex Tsafriri

Angiogenesis during embryonic implantation
M. Neeman, Vicki Plaks, Nava Dekel

MRI of angiogenesis
M. Neeman, Liora Shiftan, Galit Mazooz, Dorit Granot, Gila Meir

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 MR contrast material for mapping activity of tissue transglutaminase
4. Development of a contrast material for MR mapping hyaluronidase activity

In vivo MRI analysis of lymphatic drain and lymphangiogenesis.
M. Neeman, Hagit Dafni, Keren Ziv, Batya Cohen, Zaver Bhujwalla

1. The role of VEGF−A in interstitial convection and lymphatic drain
2. MRI analysis of lymphatic drain and lymph node metastasis
3. Development of avidin chase for non invasive mapping of lymphatic drain
4. The role of VEGF family members in tumor lymphangiogenesis

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

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

Signal transduction via G protein−coupled receptors.
R. Seger, Z. Naor

Identification, characterization and cloning of two novel MAP kinase isoforms.

The nuclear translocation of ERK and MEK − characterization and molecular mechanisms.

Y. Yarden

Targeted therapy of cancer tailored to intecept grwoth factor receptor signaling

Signal transduction networks in development and disease.

The role growth factor in human cancer

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.

R. Arnon

Studies on antigenicity and vaccine development.

Immunochemical aspects of schistosomiasis.

Synthetic peptides and synthetic vaccines.
R. Arnon, M. Sela

Experimental allergic encephalomyelitis and its suppression by basic copolymers of amino acids: Relevance to multiple sclerosis.
R. Arnon, M. Sela

The possible use of antibodies for local drug delivery of the anti−cancer agent, cis−platinum.
R. Arnon, M. Wilchek

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.

MNC classI and classII TAA peptides in anti−tumor immunotherapy.

Antigen presentation and induction of anti−tumor immunity.

Z. Eshhar

Adoptive Cellular Immunotherapy of Cancer

Genetic Programming of the Recognition of T−Cells

Genetic Signature of Prostate Cancer Metastases and Resistance to Irradiation
Z. Eshhar, Prof. Eytan Domany

Modulation of Allergic Responses
Z. Eshhar, Dr Gideon Gross

S. Jung

The Role of the CX3CR1 chemokine receptor in the homing of Pulmonary Memory T cells

Dendritic Cell In Vivo Functions Defined By Conditional Cell Ablation

Origin of Peripheral Myeloid Cells in Homeostasis and Pathogen Challenge

T. Lapidot

Mechanism of human stem cell migration and development, both normal and leukemic and the factors that regulate these processes in vivo.

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 during inflammation, injury and bleeding as part of organ repair.
3. Steady state homeostatic release and function of blood circulating stem cells.
4. In vivo migration and dissemination of leukemic human AML stem cells, the role of the proteolytic enzyme elastase and the chemokine SDF−1.
5. T lymphocyte and stem cells / blood vessel wall interactions during transendothelial migration, assayed by electron and confocal microscopy.

6. CXCR4/SDF−1 signaling in normal and leukemic hematopoiesis.
7. Lentiviral vectors for stem cell gene transfer. GFP and CXCR4 overexpression
8. The essential roles of the adhesion molecule CD44 in normal and malignant stem cell motility, assayed by migration and confocal microscopy.

CD45 signalling in stem cell development

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

Mechanism of action of peptides inhibiting experimental myasthenia gravis
M. Sela, E. Mozes

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

Its use in prevention of transplant rejection
M. Sela, R. Arnon, R. Aharoni

Monoclonal antibodies to ErbB1 and ErbB2 and their respective B cell epitopes, and their roles in potential anti−tumor strategy
M. Sela, Y. Yarden

I. Shachar

Determine the mechanisms regulating immature B cell differentiation in the spleen.

Follow the mechanisms controlling homing of immature B cells to the spleen.

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. Amsterdam

Plasticity of gene expression during differenatiation in the gonads.

Crosstalk amond signals that control apoptosis.

Carcinogenesis in endocrine glands.

A. Ben−Ze'ev

The interplay between ″−catenin signaling and p53−responsive pathways in the development of colon cancer.

The dual role of ″−catenin and plakoglobin in adhesion and transactivation: novel target genes activated by ″−catenin and their role in oncogenesis.

The molecular basis of the role of cell−cell adhesion in malignant transformation: the ″−catenin/APC case.

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.

Z. Kam

Cellular Biophysics
Z. Kam, B. Geiger, J.W. Sedat (UCSF)

1. Computerized light microscopy: development of methods and application to cell biology.
2. Quantitative analysis of structural features and dynamic changes in cells using microscope imaging.
3. High throughput cell−based microscope probing of complex mechanisms and pathway networks.
4. Adaptive optics methods applied to thick sample imaging.

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.

M. Oren

Molecular biology of p63.

Regulation of proteins by phosphorylation, ubiquitylation, neddylation and acetylation.

Structure−function analysis of p53.

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

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.

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

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: Principles of sensory processing and acquisition by sensory−motor loops.

1. Encoding, decoding and representations of vibrissal touch in the rat: Electrophysiology, neuropharmacology, behavior, theory.
2. Modifications of vibrissal processing by learning: Neuronal plasticity, role of acetylcholine, theory.
3. Encoding, sensory−motor control, and learning in humans: Touch and vision.
4. Rodent whisking behavior and mechanics

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.

I. Ginzburg

Control of expression of tau protein in normal and diseased brains (Alzheimer's).

Neuronal polarity: Control of expression of microtubule genes.

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

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.

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.

Cholinergic neuromodulation in the brain.

Behavior and electrophysiology in transgenic mice.

V. Teichberg

Protein−protein interactions of glutamate receptors at the synaptic membrane.
V. Teichberg, J. Ratnam

Interactions of glutamate receptors and anti−Glutamate receptor antibodies in epilepsy.
V. Teichberg, Y. Ganor, K. Cohen−Kashi

Enzymatic scavenging of blood glutamate in the treatment of neurodegenerative diseases
V. Teichberg, I. Maoz, I. Levite, Z. Haitov, Y. Wang

1. In vitro evolution of a glutamate scavenging system for the treatment of stroke, head trauma and amyotrophic lateral sclerosis.
2. Glutamate transport in an in vitro model of the blood brain barrier
3. Treatment of malignant gliomas with 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

Z. Vogel

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

Regulation of signaling and changes in gene expression by chronic cannabinoid or opiate exposure.
Z. Vogel, Avraham Zangen

Molecular mechanisms of opiate addiction, tolerance and withdrawal.

E. Yavin

Signal transduction and protein kinase C isozymes in brain of normal and growth−retarded fetuses.

Free radicals and lipid modulators in the developing and aging brain.

Novel genes during oxidative stress in utero and role of docosahexaenoic acid.

A. Zangen

Depression, Addiction and the Brain reward system

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.

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 properties and dynamics of biological membranes of cells.

Modelling the dyanmics of cell metabolism, motion and reaction to physics and chemical stimuli.

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

Analysis of dyanmis processes in BEC.

G. Haran

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

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

Single−molecule Raman spectroscopy as a probe of surface dynamics

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

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.

Complex growth problems.

M. Shapiro

Quantum theory of elementary exchange reactions, quantum chaos and intramolecular dynamics.

Quantum information and computing.

Control of chemical reactions using coherent light, experiments on coherent control with nonlinear optics.

Theory of photodissociation and photo recombination processes, theory of laser catalysis, strong field effects.

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

^{17}O solid state NMR in bioorganic materials

Proton Spectroscopy in Solid State NMR.

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 ecosystems that together constitute the 34, as well as a commitment to improving the manner in which energy is utilized by humans.

The Department's research activities have several areas of focus. One is in the field of physical oceanography and hydrology. A second is in the use of stable isotopes for paleoclimatic reconstructions and biosphere−atmosphere interactions, and a third is in the field of atmospheric chemistry. Research in solar energy is conducted in a dedicated facility, the Solar Tower, on campus. The Department is distinguished by the fact that many collaborations exist among faculty members from quite different backgrounds. Such collaborations are viewed as essential in the fields of environmental and energy sciences. The interdisciplinary nature of the Department is well reflected in the academic training of the research students. Their backgrounds vary enormously from physics to biology and geology. 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.

E. Aharonov

Granular media, applications to landslides and Earthquakes.

1. Granular dynamic simualtions (with Dr. Dave Sparks)
2. Liquifaction experiments (with Dr Amotz Agnon, Sofia Schnitke)
3. Theoretical modeling of landslide acceleration due to pore heating

Fluid flow in deformable and reactive porous media.

Experimental Pressure Solution
E. Aharonov, Dr Chris Scholz, Zvi Karz

Modeling of anticracks
E. Aharonov, Dr Regina Katsman, Dr. Harvey Scher

1. modeling compaction bands fromation in rocsk
2. modeling pressure solution

Tectonics
E. Aharonov, Dr Yossi Mart

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

Climate dynamics

1. Interaction between ocean biota and climate
2. Paleoclimate

Oceanography of the Red Sea and the Gulf of Eilat

J. Karni

Development of directly irradiated solar receivers.

Spectral, angular and temperature dependence of radiation properties of high temperature materials.

Energy transport in particles seeded flows at high temperature.

Development of alternative fuels and their production methods using solar energy

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

Aerosol−Cloud interactions
Y. Rudich, Prof. Rosenfeld − Hebrew University, Prof. Levin − Tel Aviv University

1. Desert dust and its effects of precipitation
2. The effect of salt−dust on precipitating clouds
3. Effect of the Kuwait oil fires (1991) on clouds

Chemical identification of organic compounds in atmospheric aerosols.

1. Absorption of organic compounds to 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

Reshef Tenne, Head

The scientific research of the department focuses on the understanding and design of functional materials with unique physical and chemical properties. This includes a broad range of materials, such as solids with extended bonding displaying cooperative properties (superconductors and semiconductors); nanomaterials, like carbon nanotubes, and inorganic nanotubes; ultra thin ferroelectric films; solids and liquids with mainly molecular bonding, such as complex fluids and molecular crystals; ultra−thin organic, inorganic and biological films and assemblies; size−quantized nanoparticles and fulleroids; molecularly functionalized semiconductors; metals and polymers, including polymer brushes and polymers for cloud seeding; and nanocomposites displaying unique mechanical properties. Biopolymer mechanics and molecular transport phenomena in the cell; imitation of biological transport strategies. Planned self−assembly of novel nanostructures on scanning−probe−patterned organic monolayer templates. Three new research groups have been established over the last few years: Dr. Ernesto Joselvich−carbon nanotubes and scanning probe microscopy; Dr. Roy Bar−Ziv−studies the mechanisms of biological transcription on silicon chip using microfabriction and microfluidics. Dr. Leeor Kronik− uses density functional theory to study clusters; magnetic nanoparticles; nanocrystalline material; inorganic−organic interfaces and optical phenomena in semiconductors. The group of Dr. Igor Lubomirsy studies nanocrystalline electrocermaic films, and quasi amorphous films of ceramic materials, in particular.
Several groups in the department are developing novel theoretical and experimental methodologies for probing liquid−liquid, solid−liquid, solid−solid, solid−gas and liquid−gas interfaces. These include force measurements techniques at Ångstrom surface separation; nanomechanical testing of carbon and inorganic nanotubes; electrochemistry; grazing angle X−ray diffraction and X−ray reflectivity using bright and collimated light from synchrotron sources; optical tweezers; scanning probe microscopy and spectroscopy, grazing angle infrared spectroscopy; and unique applications of X−ray photoelectron spectroscopy. Two new research facilities, which are used extensively by the department scientists, have been completed this year, i.e the high resolution electron microscopy laboratory, and the combined clean rooms/microfabrication/biological specimen manipulation laboratory.

D. Cahen

POLY− &NANO−CRYSTALLINE SOLAR CELLS, THEIR CHEMISTRY &PHYSICS
D. Cahen, in cooperation with G. Hodes, S. Cohen, K. Gartsman; A. Zaban (Bar Ilan U)

1. Molecular electronics for poly− and nano−crystalline solar cells.
2. Nanocrystalline solar cells: how do they work?
3. Self−assembling solar cells (with Univ. Uppsala)

4. Scanning probe &Electron beam microscopies for nanoscale solar cell characterization
5. How can polycrystalline solar cells outperform than their single crystal analogues?

MOLECULE−CONTROLLED ELECTRONICS, OPTOELECTRONICS &BIO−OPTOELECTRONICS
D. Cahen, Cooperations with M. Sheves, M.vanderBoom, A Shanzer, R.Arad−Yellin,; C.Sukenik(Bar Ilan), F.Diederich(ETHZ), A.Kahn,J.Schwartz(Princeton),G.Meyer(John Hopkins)

1. Understanding and controlling electrical contacts to molecules
2. Molecular electronic sensors, Fundamentals (why?) and practice (how?)
3. Unique molecular electronic device effects: Negative Differential Resistance and more
4. Towards bio−optoelectronics:Science and practice of Bacteriorhodopsin− based devices

PHOTO−ASSISTED WATER PURIFICATION: Use of mesoporous, nanoparticulate membrane electrodes.
D. Cahen, in cooperation with A. Zaban (Bar Ilan U), A. Abed Rabbo &H. Hallak (Bethlehem U)

ELECTRON TRANSPORT ACROSS MOLECULES AND MOLECULAR LAYERS
D. Cahen, in cooperation with L. Kronik, A. Nitzan (Tel Aviv Univ.), R. Naaman

1. Fundamental mechanisms for electronic charge transport through molecules
2. How can information be transferred across insulating molecular layers?

M. Elbaum

Single−molecule manipulations using optical tweezers.

Dynamics of DNA uptake into the cell nucleus.

Structure and function of the nuclear pore complex (with Z. Reich): application of atomic force microscopy and advanced optical spectroscopies.

Anomalous diffusion in polymer networks and living cells (with R. Granek).

Organization of forces driving cell movements (with A. Bershadsky): optical force measurements and particle tracking studies; influence of cell biochemistry on biophysical forces.

Novel surface−patterning lithographies.

G. Hodes

Electrochemical and chemical bath deposition of nanocrystalline semiconductor quantum dot

(QD) films.

Surface modification of semiconductor nanocrystals.

Charge transfer in QDs.

Thin film photovoltaic cells.
G. Hodes, Prof. David Cahen

J. Klein

Experimental studies of surface structure and interactions, and of the behavior of confined simple and polymeric fluids.

Surface−forces−measurement techniques at angstrom surface separations; polymers as molecular lubricants; properties of thin liquid films including aqueous electrolytes and polyelectrolytes.

Nuclear reaction analysis investigations of polymer interfaces. Interfacial structure and phase equilibrium between incompatible polymers; studies of transport and self−diffusion in bulk polymers.

Wetting and stability of thin films; use of polymer surfactants to modify surface and interfacial behaviour.

L. Kronik

Spintronic materials: electronic and magnetic properties

Organic semiconductors: structural and electronic properties
L. Kronik, E. Umbach, C. Heske (U. Wurzburg, Germany)

Quantum dots: optical properties

Site−specific photoelectron spectroscopy: predicting &explaining experiment
L. Kronik, J. C. Woicik (NIST, USA)

Nano−clusters: non−equilibrium effects

molecular electronics
L. Kronik, D. Cahen (WIS), A. Nitzan (Tel Aviv Univ.)

I. Lubomirsky

Properties of Ultra−Thin Self−Supported Crystalline Oxide Films.

Infrared focal plane array based on freestanding pyroelectric films.

Oxygen ion transport in thin freestanding films.

I. Rubinstein

Self−assembled supramolecular systems on surfaces.
I. Rubinstein, A. Vaskevich

Nanostructures based on surface−modified nanoparticles.
I. Rubinstein, A. Vaskevich

Coordination self−assembly of nanostructures comprising organic / inorganic building blocks.
I. Rubinstein, A. Shanzer, A. Vaskevich

Chemical and biological sensing using transmission surface plasmon resonance (T−SPR) spectroscopy.
I. Rubinstein, A. Vaskevich

Nanomaterials prepared by template synthesis in nanoporous membranes.
I. Rubinstein, A. Vaskevich

S. Safran

Statistical physics of soft matter:

1. Membrane self−assembly of surfactants, lipids, and amphiphilic polymers.
2. Coupling of shape and shear elasticity in membranes and in biological cells.
3. Adhesion of cells to surfaces; elastic interactions of cells
4. Membranes: tension induced fusion, inclusions (such as proteins) in membranes.
5. Electrostatic and fluctuation induced interactions in charged colloidal and membrane systems.
6. Microemulsions: structure, phase behavior, dynamics.

J. Sagiv

Studies on novel types of artificial organic−inorganic hybrid superlattice structures with intercalated metal or semiconductor nanoparticles, including collaborative work on characterization by synchrotron X−ray scattering, scanning probe microscopies and
J. Sagiv, R. Maoz

Self−replicating multilayers.
J. Sagiv, R. Maoz

Planned surface self−assembly of nanoscopic organic−inorganic architectures using a scanning probe initiated process of non−destructive nanoelectrochemical patterning of stable self−assembled monolayers.
J. Sagiv, R. Maoz, S. Cohen

R. Tenne

Inorganic nanotubes and inorganic fullerene−like materials: new materials with cage structure.

D. Wagner

Interface micromechanics in composite materials, including characterization by micro−Raman spectroscopy.

Mechanics of single− and multi−wall carbon nanotubes, nanofibers and their composites.

Mechanics of biological composites.
D. Wagner, S. Weiner, L. Addadi

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

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

Polysiloles and Silicon Containing Oligothiophenes

Carbon Nanotube Based Materials for Nanotechnology using Side Wall Covalent Functionalization

Applications of Computational Quantum Chemistry

G. Martin

Computational Chemistry
G. Martin, D. Milstein, M. van der Boom, I. Sagi

1. High−accuracy ab initio thermochemistry: method development and applications.

2. Methodology of density functional theory
3. Application of density functional methods to organometallic systems, with special reference to 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.

J. Sperling

Chemical and biological aspects of protein−nucleic acid interactions

1. Nuclear ribonucleoprotein complexes and their role in the post−transcriptional regulation of gene expression: Biochemical characterization and structural studies using high−resolution electron microscopy.
2. Mechanisms and protein factors involved in pre−mRNA processing.
3. Development of strategies for tagging nucleic acids with gold clusters for their use in Structural Biology, Biotechnology and Micro−electronics.

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 ohf HIV−1 enevelope protein gp120
J. Anglister, S. Zolla−Pazner

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

NMR structure of the alpha subunit of the acetylcholine receptor
J. Anglister, ZZ. Wang

The structure of the transmembrane glycoprotein of HIV−1 gp41.
J. Anglister, Y. Shai

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

LFER analysis of allosteric transitions in proteins.

Allostery in the structure and function of GroEL and CCT chaperonins.

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

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.

3D structural studies of halotolerant proteins from unicellular alga Dunaliella.

Application of ultra rapid X−ray diffraction methods to study the enzymatic mechanism of AChE in real time.

3−D structure analysis and prediction of protein structures; and design and construction of a large object oriented relational data base for 3D structures of biological macromolecules found in the protein data bank.

S. Weiner

Archaeological science: minerals and molecules in the sediments of the archaeological record.

Structure − mechanical function relations in mineralized tissues (bone and teeth).
S. Weiner, H.D. Wagner

Biomineralization: mechanisms of mineral formation and growth in biology.
S. Weiner, L. Sddadi

A. Yonath

Protein biosynthesis

Ribosomal mechanisms

Antibiotics targeting ribosomes

Faculty of Mathematics and Computer Science

Department of Computer Science and Applied Mathematics

Tamar Flash, 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.

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

Complexity theory

S. Goldwasser

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

D. Harel

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

M. Irani

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

D. Michelson

Numerical analysis, differential equations, dynamical systems.

M. Naor

Cryptography and Complexity

Distributed Computing

Concrete Complexity

D. Peleg

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

A. Pnueli

Temporal logic, specification, verification (deductive and algorithmic), development and synthesis of reactive, real−time and hybrid systems, verification of hardware designs, and optimizing compilers, translation validation.

R. Raz

Boolean circuit complexity, arithmetic circuit complexity, communication complexity, propositional proof theory, probabilistic checkable proofs, quantum computation and

communication, derandomization.

V. Rom−Kedar

Transport and mixing in fluid flows.

Structure of highly chaotic systems (smooth billiard potentials).

Structure of near−integrable Hamiltonian systems.

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

1. Infinite−dimensional dynamical systems
2. Numerical analysis of dissipative PDEs
3. Control theory for dissipative systems

Fluid Dynamics

1. Navier−Stokes and related equations
2. Turbulence theory
3. Geophysical models of aceanic and atmospheric dynamics

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 two general areas of mathematical analysis and its applications, and of algebra, mainly representation theory, algebraic geometry, and number theory. Topics covered in analysis include structure of finite and

infinite dimensional spaces, operator and matrix theory, function theory on the plane, graphs and Riemann surfaces, spectral theory, several aspects of probability and some applications of statistics, linear and nonlinear ordinary and partial differential equations, harmonic analysis, dynamical systems, control theory in its various manifestations, optimization, game theory, approximation and complexity of functions, numerical analysis, singularity theory, and robotics. The algebraic direction includes some aspects of algebraic geometry, representation theory, quantum groups, number theory, automorphic forms, ring theory, and enveloping algebras. Although the approach taken is primarily that of theoretical mathematics, some of the research leans towards possible applications.

Z. Artstein

Control and optimal control, singular perturbations, hybrid systems, stabilization, relaxation.

Decisions under uncertainty, information structures, games and uncertainty.

Dynamical systems, ordinary differential equations, singular perturbations, invariant measures, nonautonomous systems, relaxation.

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

p−adic analytic geometry.

A. Dvoretzky

Banach spaces.
A. Dvoretzky, G. Schechtman

S. Gelbart

Automorphic forms and L−functions.

Group representations.
S. Gelbart, A. Joseph, A. Regev

M. Gorelik

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

D. Holcman

Modeling biological systems
D. Holcman, Z. Schuss, J. Korenbrot

Analysis on manifolds
D. Holcman, I. Kupka, C. Pugh

A. Joseph

Lie algebras and enveloping algebras, quantum groups.

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

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, Y. Yomdin, D. Novikov

Singularity theory.

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
Y. Yomdin, G. Comte

High Order Data Representation, Nonlinear Approximation, based on Normal Forms of Singularities. Numerical methods

Faculty of Physics

Department of Condensed Matter Physics

Israel Bar−Joseph, Head

The department was formed in October 1993 as a result of the reorganization of the physics faculty. Presently the scientific activity of this young department is mainly concentrated around the experimental and theoretical research in quantum solid state but also includes a growing group of theoretical astrophysicists.

The newly established Braun Center for sub micron research is an integral part of the department. It is a modern and well equipped center which allows to conduct experiments on sub micron semiconductor structures as well as normal and high temperature superconductors.

T. Alexander

Stars very near massive black holes.

The Galactic Center.

Gravitational Lensing.

Active Galactic Nuclei.

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.

Noise and Interactions in Quantum Conductors

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

Y. Imry

Mesoscopic physics: persistent currents, classical and quantum fluctuations, quantum interference effects on transport, decoheherce.
Y. Imry, see below.

Effects of interaction on localization and on single−electron resonances. Many−electron effects and phase−shifts. Dephasing of Quantum interference in mesoscopics. Quantum noise and its detection. Effects of quantum fluctuations on nanosuperconductors.
Y. Imry, Y. Levinson, A. Aharony and E. Entin−Wohlman (TAU and BGU), Y. Ovadyahu and A. schiller (HU), P. Silvestrov (Leiden), M. Schechter and P, Stamp (UBC).

S. Levit

Controlled decoherence of mesoscopic systems. Coupled dephasor−dephasee pairs. Controlled decoherence of various quantum phenomena such as tunneling, Fano resonances, Berry phases, quantum pumps, Anderson localization, etc.

Quantum Chaos (small disordered systems) and Interactions.

Statistics of quasiparticle levels and wave functions in interacting quantum dots. Spin effects. Random matrix theory, supersymmetry and replica methods for the description of such systems.

Non perturbative methods in Quantum Chromodynamics; random colormagnetic fields; matrix models with free random variables.

Quantum Hall effect: Integer and fractional; Chern−Simon' mean field theory; tunneling of anyons; edge states and excitations; composite bosons and fermions.

Non classical light. Squeezed photons in semiconductor microcavities. Anomalous Luminescence. Excitonic effects.

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

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.

Fractional and integer quantum Hall effect and related phenomena.

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

A. Stern

Quantum Hall effect and composite fermion theory. Electronic transport in strong magnetic fields. Non−abelian quantum Hall states.

Low density two dimensional electronic systems.

Double layer electronic systems.

V. Usov

Physical processes in very strong magnetic fields.
V. Usov, D.B. Melrose, and A.E. Shabad

Physical processes in relativistic electron−positron plasma.

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

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

Hydrodynamics and high−energy physics of colliding stellar winds in binary systems.

E. Waxman

Ultra−high energy cosmic−rays
E. Waxman, J. Bahcall

Gamma−ray bursts: Origin and underlying physics
E. Waxman, D. Eichler, A. Levinson, A. Loeb, P. Meszaros, T. Piran

Non−thermal processes in the inter−galactic medium
E. Waxman, A. Loeb, L. Hernquist

High energy neutrino astrononmy
E. Waxman, J. Bahcall, A. Levinson, P. Meszaros

A. Yacoby

Electrostatic imaging of the quantum Hall effect and the 2D metal−insulator transition.

Transport in quantum wires.

Interference and dephasing of composite Fermions.

E. Zeldov

High−temperature superconductors

Magneto−optical imaging

Vortex matter phase transitions

Nano−structured superconductors

Vortex dynamics

MgB_2 and $NbSe_2$ superconductors

Department of Particle Physics

Itzhak Tserruya, 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

Non−gravitational string theories.
O. Aharony, M. Berkooz, E. Silverstein, D. Kutasov, B. Fiol, A. Giveon

Supersymmetric gauge theories.

Non−perturbative effects and formulations of string theories.

Relations between field theories and string theories.

1. AdS/CFT correspondence
2. String theory for large N QCD

The Hagedorn and deconfinement phase transitions
O. Aharony, S. Minwalla, M. Van Raamsdonk, J. Marsano, K. Papadodimas

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

D. Gepner

Rational conformal field theory and solvable lattice models.

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

Nuclear polarization via multifoil techniques: signs of quadrupole moments and magnetic moments of exotic mirror nuclei.

Nuclear electromagnetic moments extreme isospin. Use of Radioactive Beam Facilities.

Accelerator mass spectrometry (AMS) measurements of nuclear reactions relevant to astrophysical processes.

Low−Energy nuclear resctions in astrophysics. Solar fusion reactions (neutrino oscillations) and nucleo−synthesis

M. Kirson

The shell model and interacting boson model for nuclei.

Theory and systematics of nuclear structure.

Y. Maron

Dynamics of plasmas subjected to high energy deposition, shock waves, ionization fronts, kinetics and transport in nonequilibrium plasmas, magnetic field penetration, particle flows, turbulent electric fields, nonthermal electron energy distributions.
Y. Maron, V. Bernshtam, V. Fisher, Y. Ralchenko, A. Starobinets

Z−pinches and plasma switches, spectroscopic diagnostics of plasmas in the visible to x−ray region.
Y. Maron, V. Bernshtam, V. Fisher, Y. Ralchenko, A. Starobinets

Atomic calculations, cross sections and probabilities, field ionization, Stark and Zeeman effects.
Y. Maron, V. Bernshtam, V. Fisher, Y. Ralchenko, A. Starobinets

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

Y. Nir

Neutrino masses
Y. Nir, M.C. Gonzalez−Garcia, Y. Shadmi

Particle cosmology
Y. Nir, M. Berkooz, M. Dine, Y. Grossman, T. Kashti, E. Roulet, T. Volansky

CP violation
Y. Nir, A. Falk, Y. Grossman, Z. Ligeti, G. Raz, H. Quinn

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

RDof 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

D. Zajfman

Molecular astrophysics.
D. Zajfman, O. Heber, Z. Vager

Cooling of molecular ions, ion trap dynamics.
D. Zajfman, O. Heber, Z. Vager

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

Molecular structure using Coulomb explosion imaging and laser−induced photodetachment.
D. Zajfman, O. Heber, Z. Vager

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 holography, image processing, non−linear effects in optical fibers, electro−optics, planar optics and ultrafast optics, atomic lithography, laser cooling and trapping of atoms. In condensed matter, research is concentrated on theory and experiment (in particular equilibrium and non−equilibrium statistical physics, clustering of data, protein folding, colloids, complex fluids, flame and wet front propagation, and membranes). Experimental and theoretical hydrodynamics concentrates on turbulence, spatio−temporal chaos, Rayleigh−Benard convection, and flows that contain polymers and particles. Statistics of nodal lines in quantum systems and turbulence are studied theoretically. Experimental bio−physics deals with bio−molecules, neural cultures, optical measurements of brain activity and physics of bio−systems.

N. Davidson

Atomic optics, interferometry and chaos.

Bose Einstein Condensation in Ultra cold atomic gas.

Laser cooling and trapping of atoms.

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))

G. Falkovich

Entropy production away from equilibrium.

Cloud turbulence and rain.

E. Moses

Molecular Motor Assemblies and Cell Division.

EEG and Brain Activity.

Neuronal Chips.

High Resolution Imaging in Cells.

D. Mukamel

RNA and DNA denaturation.

Collective phenomena in systems far from thermal equilibrium.

Coarsening processes and slow dynamics.

Systems with long range interactions

A. Schwimmer

String theory.

Conformal field theory.

Dynamics of gauge theory.

Y. Silberberg

Nonlinear optics and soitons.

Ultrafast optics and 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.

V. Steinberg

Physical hydrodynamics, pattern dynamics of non−equilibrium systems

1. Hydrodynamics of polymer solutions.
2. Turbulent mixing by polymers.
3. Dynamics and conformation of a single polymer molecule in complex flows.
4. Development of measurement of vorticity distribution in a turbulent flow.
5. Convective turbulence in a fluid near the gas−liquid critical point.
6. Microfluidics: mixing, cell separation,chaotic flows.

Feinberg Graduate School

Department of Science Teaching

Avi Hofstein, 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 three national centers for science teachers (chemistry, 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. .

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

Object−oriented programming in introductory computer science

Concurrent and distributed computation

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

Understanding nondeterminism
M. Ben−Ari, M. Armoni

History and philosophy in science teaching

R. Even

Mathematics education research and practice issues

Teacher 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 teacher knowledge and teaching practice

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".

A. Hofstein

High school chemistry curriculum development and implementation
A. Hofstein, Rachel mamlok−Naaman, Miri Kesner

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 and M. Kesner

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. The educational effectiveness of learning chemistry by using the web.
7. Misconception regarding bonding and structure of molecules
8. Assessment of students' perception of the chemistry classroom and laboratory learning environment

Professional development of science teachers (Bi national project with King's College London)
A. Hofstein, Bat−Sheva Eylon

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.

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