Current Research Activities

The Weizmann Institute of Science

2015

About the Weizmann Institute of Science

Table of Contents

About the Weizmann Institute of Science

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

Faculty of Biochemistry

Dean

Department of Biological Chemistry

Eitan Reuveny, Head

The scientific activities in the department of biological chemistry span several areas in the Life Sciences. The common thread is the study of the biochemistry of life and disease. Emphasis is given to the examination of proteins, whether soluble or membrane-bound, and their key biological functions and we seek a molecular understanding of their evolution, cellular interactions, structures and functions. A variety of biochemical, biophysical, structural, molecular-biological, and state of the art imaging methodologies are employed in our department. Overlapping interests and inter-group cooperations signify the spirit of our research. The department has more than 20 research groups whose activities are centered around the following foci of interest:

1. Protein science and macromolecular machines. Several groups investigate the basic principles governing protein-protein interactions; composition, assembly, and architecture of multi-enzyme and other large complexes; catalytic mechanisms and the evolution of proteins and enzymes. A major aim is to understand how the findings relate to intricate biological processes.

2. DNA and regulation of gene expression. Various aspects of nucleic acids research are addressed in our department including: DNA repair and mutagenesis in mammals; basal and activated transcription; specific gene expression in the pancreas; phylogenetic analysis of accumulated somatic mutations.

3. Structure, function, and biogenesis of membrane proteins. We investigate important integral membrane proteins on the biochemical, biophysical, structural, and physiological levels. This includes Na+ and K+ channels, Na+/K+ ATPase and its FXYD protein regulators, multidrug transporters, intra-membrane proteases, and peptides that integrate into membranes in various systems.

4. Membranes, lipids, and organelle structure, function, and biogenesis. Studies in our department include the biosynthetic pathway of membrane proteins; intracellular protein traffic, especially during the process of autophagy; lysosome biogenesis and lipid homeostasis; Calcium homeostasis; and, assembly and function of membrane proteins involved in the immune response, infectious diseases, and viral envelopes.

5. Signaling within and between cells. Several researchers in the department are interested in problems related to signal transduction. Cell guidance and navigation; axon guidance; cell death and tissue damage; long distance intracellular signaling; regulation of expression of virulence factors; regulation of the circadian rhythm; epigenetic gene silencing; epigenetics and developmental regulation.

6. Molecular basis of disease. Many research programs in our department involve human disorders, diseases, and syndromes. This includes inflammation, infections and antibiotic resistance, organophosphate detoxification, obesity and diabetes, cancer, and lysosomal storage diseases. Many of these disorders are investigated at the molecular level.

A variety of methodologies are being utilized, with an emphasis on biochemistry, biophysics, molecular genetics, advanced light microscopy, computation methods, and structural tools (such as crystallography, atomic force microscope, mass spectrometry). Additional information can be obtained in the department&#39s Home Page.

E. Bayer

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

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

E. Bibi

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

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

Membrane protein biogenesis in E. coli
E. Bibi, E.S. Bochkareva, A. Kinori, D. Ben-Halevy, I. Noach

1. FtsY, the essential prokaryotic SRP-receptor: biogenesis and function
2. Membrane targeting and association of ribosomes in E. coli.
3. Membrane targeting and association of mRNAs encoding membrane proteins

R. Dikstein

Transcriptional control of coding and non-coding genes

1. Mechanism of rapid transcriptional induction of NF-kappaB target genes
2. The mammalian core promoter diversity
3. Links between mammalian transcription and translation through common regulatory elements
4. Transcriptional control of microRNA genes
5. The role of TFIID subunits in embryonic stem cell pluripotency and self renewal

Translation initiation

1. Unique translation initiation of mRNAs containing TISU element
2. Biological significance of TISU-mediated translation initiation
3. Links between mammalian transcription and translation through TISU

M. Eisenbach

Sperm guidance in humans

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

Chemotaxis of bacteria

1. Molecular mechanisms and function of acetylation of the response regulator
2. Molecular mechanism of function of the switch of the bacterial flagellar motor

Z. Elazar

Molecular mechanisms of autophagy

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

Mechanism of intracellular protein trafficking

1. Regulation of intra-Golgi protein transport

M. Fainzilber

Molecular mechanisms underlying spatial signaling within neurons and other large cells

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

S. Fleishman

Computational design of protein function

1. Computational design and experimental characterization via in vitro evolution of high affinity interactions
2. The role of multispecificity in small signaling networks
3. Specificity and multispecificity in membrane-protein interactions
4. Design of membrane-protein interactions

A. Futerman

The molecular mechanisms of sphingolipid storage diseases (Gaucher disease).

The regulation of ceramide synthesis

S. Karlish

Crystalization and function of Na/K-ATPase.

Regulation of Na/K-ATPase by FXYD proteins.

Molecular mechanisms involved in generation of essential hypertension.

Development of isoform-selective drugs

Z. Livneh

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

1. Principles of operation of mammalian error-prone DNA repair.
2. Screening for novel genes involved in mammalian DNA damage tolerance.
3. Genome-wide analysis of mammalian error-prone DNA repair.
4. Analysis of DNA damage tolerance in mammalian chromosomes.

DNA repair biomarkers for risk assessment and early detection of cancer.

Mechanisms and regulation of DNA repair in stem cells.

DNA damage tolerance via homologous recombination repair in mammals.

D. Mirelman

Molecular pathogenesis of the human intestinal parasite *Entamoeba histolytica*.
D. Mirelman, Rivka Bracha

1. Molecular biology and genome organization in the lower eukaryot *Entamoeba histolytica*.
2. Selective inhibition of expression of virulence genes by Antisense RNA.

3. Transcriptional epigenetic gene silencing mechanisms
4. Pathogenesis of Amoebiasis
5. Development of vaccine against *Entamoeba histolytica*.

Mode of action and therapeutical potential of Allicin from Garlic
D. Mirelman, Aharon Rabinkov, Elena Appel

1. Uses of derivatives of Allicin against hypertension and obesity
2. Antifungal delivery system which produces in situ toxic allicin molecules
3. A delivery system for the in-vivo killing of cancer cells by Allicin

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.

M. Sharon

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

1. Developing novel methodological approaches for structural mass spectrometry
2. Structure-function relationship of the signalosome complex
3. Investigation of the 20S ubiquitin-independent degradation pathway

Y. Shechter

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

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

D. Tawfik

Evolution and mechanism of enzymes

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

M. Walker

Selective gene expression in pancreatic beta cells:

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

diagnosis and therapy of diabetes.

D. Wallach

Regulation of cell death and tissue damage:

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

M. Wilchek

Study and application of molecular biorecognition

1. Avidin-biotin system: Studies of the strong binding using chemical, physical and biological methods; new applications of the system.
2. Affinity chromatography: Studies to improve purification of protein by developing new carriers, new activation methods and new principles.
3. Affinity therapy: Development of methods to couple drugs and toxins to biological carriers, such as antibodies, and their delivery to target cells.

A. Yaron

Mechanisms of axonal degeneration

Signaling mechanisms of axonal guidance cues

Department of Molecular Genetics

Naama Barkai, Head

The molecular basis of genetics and related biological processes are under investigation in our Department. The investigators approach these processes from the most reduced and reconstructed systems up to more systemic and computational analysis. Different organisms are employed including virus, yeast, Drosophila, mouse and human. These animal models and cell culture systems are used to study the mechanisms of;
a. Basic processes in gene expression, such as transcription, translation and protein degradation.

b. Cellular responses to various stimuli, such as cytokines, growth factors and exposure to DNA-damage.
c. Regulation of cell growth, senescence, differentiation and death.
d. Development; Mechanistic view of zygote to embryo transition and development of various organs, such as brain, muscles, bones and pancreas.
e. Genetic and acquired diseases such as cancer and virus infection. Embryonic stem cell biology, early development and advance human disease modeling.
f. Study of pluripotent stem cell biology and epigenetic reprogramming.
g. Computational and system biology. The function/evolution of genes and their diversification.

E. Arama

Genetic regulation of apoptosis and its molecular mechanisms.

Roles of caspases in ?conventional? apoptosis and during cellular remodeling.

N. Barkai

Robustness and scaling of morphogen gradients .

System Biology: from functional genomics to network analysis

A. Elson

Protein phosphatases and cell signaling

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

J. Gerst

Intracellular protein and mRNA transport in cell growth and disease

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

Y. Groner

Positive and negative transcriptional regulation by Runx3

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

Biological function of the RUNX transcription factors

Molecular genetics of Down syndrome.

Dynamic combinatorial interactions of RUNX1 and cooperating partners during megakaryocytic differentiation
Y. Groner, Amos Tanay Department of Computer Science & Applied Mathematics

E. Hornstein

miRNA role in human disease

1. miRNA role in motor neurons and amyotrophic lateral sclerosis
2. miRNA role in pancreas and diabetes
3. miRNA stem cells

C. Kahana

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

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

Identification and characterization of regulatory and structural components of the polyamine transport system.

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

Identification and characterization of functional domains of mammalian ornithine decarboxylase.

Characterization of ornithine decarboxylase degradation.

A. Kimchi

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

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

D. Lancet

Genomic and evolutionary analyses of molecular recognition systems.

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

S. Pietrokovski

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

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

Y. Pilpel

Systems biology of genetics regulatory networks

O. Reiner

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

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

Functional Analysis of Genes Involved in Lissencephaly.

M. Revel

Applications of IL-6 Chimera and Interferon-beta in neurology, hematopoiesis, and oncology.
M. Revel, J. Chebath

Interleukin-6 Chimera, a superactivator of the gp130 receptor system: role in nerve myelination, neuroprotection and in the development of neuro-glial cells from embryonic tissues and stem cells.
M. Revel, J. Chebath

Transdifferentiation of neural crest cell derived melanoma into myelinating Schwann cell. Genes controlling cell growth, differentiation, melanogenesis and synthesis of myelin proteins.
M. Revel, J. Chebath

M. Rubinstein

Regulation and role of endoplasmic reticulum stress in cell survival and cell death
M. Rubinstein, Efrat Dvash, Rina Vasserman, Ofir Meir, Chiara Riganti (University of Turin, Italy).

1. Role of glutathione transferases in cell survival and cell death under ER stress
2. Role of ABCA1 in cholesterol-triggered endoplasmic reticulum stress
3. Role of C/EBP beta in drug resistance of tumor cells

The mode of action of the soluble LDL receptor as an antiviral protein
M. Rubinstein, Danit Finkelshtein-Beker, Ariel Werman, Daniela Novick

Cytokine receptors and binding proteins
M. Rubinstein, D. Novick

Role of FABP4 and PPARgamma in ER stress - imlications in the metabolic syndrome
M. Rubinstein, Tali Garin, Rinat OZ, A. Rudich (Ben Gurion University), G. Hotamisligil (Harward University).

M. Schuldiner

Understanding the Molecular Mechanisms Driving Endoplasmic Reticulum Inheritance

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

Y. Shaul

proteasomal degradation of intrinsically disordered proteins (IUP or IDP). the concept of degradation by default

proteasome composition, dynamics, function and regulation and various conditions.

proteasomes as a target in cancer therapy

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

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

Transcription regulation of the hepatitis B virus. To understand how overlapping promoters are autonomously functional.

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

B. Shilo

Development of the *Drosophila* tracheal system.

Signaling by the Drosophila EGF receptor pathway during development.

R. Sorek

Computational discovery of novel natural antibiotics

Microbial genomics and RNAomics with Illumina sequencing

CRISPR, an antiviral microbial defense system

T. Volk

The molecular basis for muscle-tendon interactions during embryonic development

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

The formation of the Blood Brain Barrier in Drosophila

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

E. Zelzer

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

Studying the role of mechanical load on embryonic bone development

Faculty of Biology

Dean

Department of Biological Regulation

Rony Seger, 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 (iv) mechanisms of angiogenesis and oncogenesis and (v) role of proteases and protein degradation in cellular regulation. The results of these investigations advance our basic understanding of phenomena related to reproduction as well as tumor and vascular biology. In addition, it enables us to develop useful applications that intend to improve patient management.

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

H. Degani

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

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

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

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

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

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

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

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

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

N. Dekel

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

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

Mechanisms involved in successful implantation.

Molecular characterization of the ovulatory cascade

L. Gilboa

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

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

A. Gross

Establishing the role of MTCH2/MIMP in mitochondrial metabolism and apoptosis

Establishing the role of the ATM-BID pathway in regulating the quiescence of haematopoietic stem cells

M. Neeman

Cardiac MRI
M. Neeman, Katrien Vandoorne, Moriel Vandesburger

Vascular remodeling during pregnancy and development
M. Neeman, Tal Raz, Katrien Vandoorne, Reut Avni,

Angiogenesis in ovarian cancer
M. Neeman, Gila Meir, Sefi Addadi, Hagit Dafni, Roni Oren, Michal Weiler

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

Regulation of lymphangiogenesis.
M. Neeman, Batya Cohen, Gila Meir, Sefi Addadi

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

Development of a reporter gene for MRI
M. Neeman, Batya Cohen, Moriel Vandsburger, Marina Radoul

1. Ferritin expression in tumor cells
2. Ferritin expression in fibroblasts

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

Y. Salomon

Anti-cancer treatments :

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

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

Vascular biology and vascular destruction.

R. Seger

MAPK and PKB signaling in proliferation and oncogenic transformation

1. The nuclear translocation of MAPKs - characterization and molecular mechanisms.
2. Inter-relationship between the PKB, JNK and ERK cascades.
3. Mechanisms of GPCR signaling to MAPKs and PKB.
4. Alternative splicing in determining signaling specificity of ERKs.
5. Role of calcium in MAPK-protein interactions

Alterantive nuclear translocation mechanisms of signaling proteins

1. Characterization of nuclear translocation of MAPKs and other signaling proteins.
2. Molecular mechanisms of the nuclear translocation of MAPKs.
3. Inhibition of nuclear shuttling as anti-oncogenic therapy

PEDF phosphorylation: role in angiogenesis and cancer.

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

A. Tsafriri

Molecular regulation of ovulatory changes in mammals.
A. Tsafriri, Helena Ashkenazi, Shmulik Motola, Xiumei Cao, Malka Popliker, Seymour Pomerantz, Marco Conti, Stanford

1. The roles of gonadotropins and EGF-like factors in triggering ovulation.
2. The resumption of meiosis and its regulation.
3. Ovulation as a tissue remodeling process.

The development and demise of ovarian follicles *in vivo* and *in vitro*: the role of apoptosis.
A. Tsafriri, Atan Gross, KerenYacobi

E. Tzahor

Head muscle patterning and differentiation

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

Cardiac and skeletal muscle progenitors during vertebrate embryogenesis

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

I. Ulitsky

Roles of long noncoding RNAs in gene regulation

1. Functions of long noncoding RNAs in establishing cell identify
2. Sequence determinants in long noncoding RNAs
3. Evolution of intergenic regions in vertebrates
4. Subcellular localization determinants in long RNAs

Y. Yarden

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

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

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

Roles for microRNAs and other non-coding RNAs in signal transduction and tumor progression

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

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

Department of Immunology

Yair Reisner, Head

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

J. Abramson

Deciphering the molecular and cellular mechanisms that control the establishment of central immune tolerance.

Understanding how breakdown of this process results in autoimmunity.

R. Alon

Chemokine activation of leukocyte integrins at endothelial contacts under shear stress.

Endothelial stores of chemokines and their function in leukocyte extravasation.

The role of talin1 and Kindlin-3 in integrin activation and lymphocyte adhesiveness to inflamed vessels under shear stress.

Role of lymph node chemokines in lymphocyte scanning of dendritic cells.

Effector lymphocyte trafficking to sites of inflammation.

The functions of endothelial and myeloid ICAM-1 in adaptive and innate immunity.

Mice models for chronic obstructive pulmonary diseases (COPD) .

I. Amit

Genomics and Systems Biology of the Immune System.

Decoding the mammalian transcriptional Regulatory Code in health and disease.

R. Arnon

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

Pathological mechanism in the CNS of various multiple sclerosis animal models.

Neuroprotection, neurogenesis and remyelination ? consequences of Glatiramer Acetate treatment in EAE.

A. Ben-Nun

Neuroimmunology, pathogenic autoimmunity, myelin/neuronal repair, and treatment of autoimmune diseases in central nervous system (CNS):

1. T-cell pathogenesis and regulation in autoimmune diseases of the CNS.
2. Effects of functional epistasis between HLA class-II alleles on genetic predisposition to multiple sclerosis (MS) in ?humanized? HLA-Tg mice and MS patients.
3. Defining major pathogenic MS-related myelin/neuronal epitopes in HLA-transgenic (Tg) mice.
4. Antigen-based immune-specific approaches to therapy (and mechanisms) of MS and other T-cell mediated autoimmune diseases.
5. Myelin/neuronal repair by adult neural stem cells in mice with chronic MS-like disease.

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.

I. Cohen

Autoimmune T cells and tissue maintenance in the nervous system
I. Cohen, M. Schwartz

Autoimmunity to hsp60 and the development of subunit vaccines against infectious diseases.

Regulation of immune inflammation by small carbohydrate molecules
I. Cohen, O. Lider

Autoimmunity to p53 and the development of systemic lupus erythematosus
I. Cohen, V. Rotter

Autoimmune diabetes: Pathogenesis and immune therapy.

L. Eisenbach

T cell receptor evolution for immunotherapy

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

tumor escape and tolerance

cryoimmunotherapy

the role of small interferon induced genes in tumorigenicity and apoptosis

Cancer Stem Cells and immunotherapy

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

Z. Eshhar

Redirecting effector T cells for adoptive cell treatment of cancer.

Redirecting regulatory T cells for adoptive cell therapy of autoimmune inflammation.

Study of colorectal induced tumors in colitis.

Development of universal vaccine for the control of allergic responses.

N. Friedman

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

Studies of CD4 T cell differentiation combining experimental single cell approaches and mathematical modeling.

Live cell imaging of T cell activation and differentiation using microfluidics devices.

Mapping T cell receptor repertoire using high-throughput sequencing (TCR-seq): developing methodologies and bioinformatic tools.

Applications of TCR-seq: Autoimmunity, Neuroimmunology, Vaccination.
N. Friedman, R. Arnon, M. Schwartz, B. Chain - UCL

S. Fuchs

The basis of D2 dopamine receptor diversity: Cloning, signal transduction, development, and correlation with disease.

The nicotinic acetylcholine receptor: Structure, function, and regulation of gene expression.

Myasthenia gravis: Regulatory mechanisms, epitopes, and immunodulation.

S. Jung

The role CX3C chemokine axis in intercellular communication.

Dendritic cell, Macrophage and Monocyte Contributions to the Maintenance of Intestinal Homeostasis and the Development of Inflammatory Bowel Disease (IBD).

Molecular Cues guiding Mononuclear Phagocyte Differentiation focusing on the role of microRNAs.

Microglia Functions in Functional Brain Maintenance and Neurological Disorders.

T. Lapidot

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

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

E. Mozes

Systemic lupus erythematosus (SLE): Mechanisms for the induction and development and approaches for disease immunomodulation.

T cell and cytokine dysregulation in autoimmune diseases.

T cell epitopes of the human acetylcholine receptor and their analogs in myasthenia gravis.

Autoimmunity in aging: The SLE experimental model.

I. Pecht

Antigen recognition and trans-membrane signaling by immuno-receptors.

Electron transfer mechanisms in proteins.

Y. Reisner

Role and mechanism of tolerance induction by activated CD8 T cells: A novel cell therapy for chimerism induction, stem cell transplant engraftment and enhanced Graft versus Lymphoma

/ Leukemia effect.

Developing a protocol for the production of human central memory CD8 T cells, to induce tolerance in allogeneic stem cell transplantation.

Investigating the use of activated CD8 T cells as novel cell therapy for the treatment of autoimmune diseases.

Immature dendritic cells: investigating a novel granule mediated killing mechanism and the therapeutic potential for the prevention of Graft versus Host Disease.

Hematopoietic size control: A novel role for coagulation cascade factors in regulating the interplay between dynamic bone structure and long term survival and mobilization of hematopoietic stem cells.

Crossing allogeneic and xenogeneic barriers by growing organs in-vivo from embryonic tissues : potential curative approaches for diabetes, hemophilia and lung diseases.

M. Sela

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

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

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

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

Synergy of antibodies towards decreasing pancreatic cancer.
M. Sela, R. Maron, B. Schechter, Y. Yarden

Towards vaccination: Generation of peptide mimotopes specific for anti ErbB-2 monoclonal antibodies.
M. Sela, E. Witsch, Y. Yarden

An aptamer strategy to target oncogenic signaling in ErbB2 carrying human tumors.
M. Sela, G. Mahlknecht , Y. Yarden G. Mahlknecht

I. Shachar

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

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

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

G. Shakhar

Dendritic cell behavior:

1. The dynamics of antigen sampling, chemokinesis, lymphatic migration
2. Antigen presentation by dendritic cells as revealed by intravital imaging

Department of Molecular Cell Biology

Elior Peles, 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 and experimental methods to discover design principles of biological circuits

Systems Immunology
U. Alon, Nir Friedman

Evolution

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

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

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

Epithelial-mesenchymal transition (EMT), cancer stem cells (CSCs) and Wnt target genes in colon cancer metastasis

A. Bershadsky

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

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

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

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

E. Canaani

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

normal ALL-1.

Transcription profiles of primary tumors with ALL-1 rearrangements.

Functions of the human ASH1 protein.

Studies of the ALR gene.

B. Geiger

Molecular diversity of adhesion complexes

The roles of mechanical force in adhesion development

Role of phosphorylation in regulating cell adhesion and migration

Signaling from the ECM

Cell adhesion and migration in cancer

Quantitatibve automated microscopy and high throughput screens

S. Itzkovitz

Design Principles of mammalian tissues

Combining mathematical models and sensitive single-molecule measurements to study how single cells interact in tissues to jointly bring about physiological goals

Z. Kam

Cellular Biophysics
Z. Kam, Benjamin Geiger, John Sedat, David Agard (UCSF)

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

V. Krizhanovsky

The role of cellular senescence in human disease

Mechanisms of interaction of senescent cells with their microenvironment

Cellular senescence in cancer development and treatment

S. Lev

Breast cancer progression and metastasis.

1. Signal transduction therapy for triple negative breast cancer (TNBC).
2. PYK2 and FAK as potential therapeutic targets for breast cancer metastasis.
3. Chemotherapy resistance and recurrence of breast cancer.

G. Levkowitz

Developmental neurobiology

hypothalamus

Molecular neurophysiology

Genetics

Neuroendocrinology

M. Oren

Molecular biology of p53.

Regulation of proteins by covalent modifications.

Role of microRNAs in cancer.

Relationship of p53 to programmed cell death.

Gain of function of mutant p53 in cancer.
M. Oren, Prof. Varda Rotter, Weizmann Institute; Prof. Vassilis Gorgoulis, Athens University Medical School

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

Histone ubiquitylation in regulation of gene expression and in cancer.
M. Oren, Prof. Yossi Shiloh, Tel Aviv University, Prof. Robert Roeder, Rockefeller University; Prof. Steven Johnsen, Goettingen University; Dr. Itay Ben-Porath, HUJI

E. Peles

Cellular junctions of myelinated nerves.

Role of Caspr family members in neuronal development.

Generation of specialized domains along myelinated axons.

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

Molecular mechanisms of neuron-glia interactions.

V. Rotter

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

1. Involvement of p53 in cell differentiation and apoptosis: *in vivo* and in vitro models.
2. Cellular proteins that specifically complex with the p53 protein.
3. Cellular proteins that are induced upstream or downstream to the p53 protein following genotoxic stress.

O. Schuldiner

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

1. The role of cell-cell interaction in regulating developmental axon pruning
2. The role of intracellular signaling in regulating developmental axon pruning
3. The role of trafficking in regulating developmental axon pruning
4. Glia and their effect on neuronal growth and remodeling

A genetic dissection of developmental axon regeneration

Y. Zick

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

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

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

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

Mode of action of galectin-8, a mammalian lectin

Role of Galectin-8 in bone remodeling

Department of Neurobiology

Rafi Malach, Head

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

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

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

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

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

and outside it.

E. Ahissar

Active sensing: Mechanisms of closed loop perception.

Biomimetic technology for active vibrissal touch

Object localization

Sensory substitution - from vision to touch

S. Barash

Neuroscience of looking and seeing

Y. Dudai

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

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

Theories of learning and memory.

A. Grinvald

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

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

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

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

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

T. Kimchi

Neuronal Basis of Sexually Dimorphic Behaviors

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

Y. Koch

Regulation of GnRH expression in the mammary gland.

Development of cytotoxic analogs of gonadotropin-releasing hormone (GnRH).

Expression and functions of GnRH-II in the brain and in T lymphocytes.

I. Lampl

Synaptic plasticity inducted by sensory stimulation in the cortex

Construction of receptive field properties in the somatosensory cortex

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

Noise and synchrony in the mammalian cortex

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

R. Malach

Mapping object-related areas in the human brain.

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

R. Paz

Neurobiology of learning and memory

Neuronal circuits and interactions between the amygdala and the prefrontal cortex

Generalization and specificity of learning

Extinction of memory

Motivational and emotional modulation of memory

Computational approaches to coding mechanisms in the brain

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

M. Rivlin

Direction selective circuits in the retina and their adaptive properties.

Dynamic computations in retinal ganglion cells.

Mechanisms of retinal adaptation.

Information flow along the visual pathway and interpretation of retinal adaptation by higher order visual structures.

D. Sagi

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

E. Schneidman

Computational Neuroscience

1. Neural Coding
2. Information and noise in neural populations
3. Decoding neural activity
4. Network organization and design
5. Natural Scenes

Animal swarming and collective behavior

Decision making and learning

Biological networks

M. Schwartz

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

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

Spinal cord injury and repair

Development of vaccination for neurodegenerative disorders.

Neurogenesis (stem cells) and inflammation in the CNS.

M. Segal

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

Hippocampal structure and function during stress
M. Segal, Dr. Gayane Grigoryan, Prof. Gal Richter-Levin

Electrical activity in small hippocampal networks
M. Segal, Dominik Freche

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

I. Silman

Localization and anchorage to the plasma membrane of acetylcholinestera.

Regulation of folding and assembly of acetylcholinesterase.

Three-dimensional structure of acetylcholinesterase and
acetylcholinesterase-anticholinesterase complexes.

N. Sobel

Olfaction

Functional Imaging

M. Tsodyks

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

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

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

N. Ulanovsky

* Neurobiology of learning and memory: a systems neuroscience approach

* Mammalian hippocampus (hippocampal place cells) and entorhinal cortex (grid cells)

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

* Neurophysiological recordings of individual neurons in freely flying bats, using radio-telemetry -- in hippocampus and entorhinal cortex

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

* The neural basis of behavior

* Neural codes for 2-D and 3-D space in the mammalian brain

Z. Vogel

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

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

Molecular mechanisms of opiate addiction, tolerance and withdrawal.

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.

O. Yizhar

* Development of novel optogenetic methods for light-based control of neural activity in vitro and in vivo

* Synaptic organization and function in cortical networks

* Functional analysis of neural circuit changes associated with psychiatric disease

Faculty of Chemistry

Dean

Department of Chemical Physics

Eli Pollak, Head

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

I. Averbukh

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

Laser control of molecular orientation.

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

E. Bouchbinder

Statistical physics of nonequilibrium phenomena

Continuum solid mechanics and materials physics

1. Dynamic fracture and friction
2. Nonequilibrium thermodynamics of driven glassy systems
3. Amorphous and dislocation-mediated plasticity theories
4. The mechanics of biomaterials

B. Dayan

Experimental Quantum Optics

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

L. Frydman

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

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

D. Goldfarb

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

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

High field EPR/ENDOR spectroscopy.

N. Gov

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

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

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

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

G. Haran

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

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

Plasmonics: probing the interaction of metal nanoparticles with light

Single-molecule studies of membrane protein diffusion and association
G. Haran, Yechiel Shai

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

Interaction of electrons with bio-molecules

Electron transmission through organized organic thin films.

E. Pollak

Quantum Molecular Dynamics and Structure
E. Pollak, R. Ianconescu, S. Daon, R. Conte, A. Azuri

1. Real time quantum Monte Carlo methods
2. Molecular spectroscopy
3. Molecular reaction dynamics
4. Quantum diffraction and surface scattering
5. Molecular dynamics on surfaces
6. Atomic and Molecular Structure

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 in classical and in quantum fluids
I. Procaccia, Victor L'vov, Anna Pomyalov, Laurent Boue'

Fractals and scaling in nonequilibrium physics.

Failure in Amorphuos Media: fracture, shear bands and necking.
I. Procaccia, Ratul Dasgupta, Ashvin Joy, Eran Bouchbinder

Mechanical properties of amorphus solids with theory of plasticity
I. Procaccia, Valery Ilyin, Ratul Dasgupta, Limei Xu, Smarajit Karmakar

The glass transition and slow relaxation phenomena
I. Procaccia, Jacques Zylberg, Yossi Cohen

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

Dynamic Nuclear Polarization
S. Vega, Akiva Feintuch

Proton NMR Spectroscopy of Solids

Surface mobility of molecules in mesoporous materials

Department of Earth and Planetary Sciences

Brian Berkowitz, 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&#39s environment. This requires knowledge of the interdependent components that together constitute the &#34environment&#34, as well as a commitment to protect this environment by improving the manner in which water, land and energy are utilized by humans.

The Department&#39s research activities have several general areas of activities. One focuses on water and includes hydrology, geochemistry, land-plant-atmosphere interactions and oceanography. A second activity is in the use of stable isotopes for reconstructions of paleoclimatic and of biosphere-atmosphere dynamics, and a third is in the area of atmospheric chemistry and dynamics, and cloud physics. A fourth area of research is in planetary sciences. Research in solar energy is conducted in a dedicated facility, the Solar Tower, on campus. The Department is distinguished by the interactions among scientists from different backgrounds and expertise, which is critical to achieve a comprehensive understanding of the global environment. We also promote international collaboration based on short- and long-term visits for research and training by scientists who complement existing activities in the Department. The interdisciplinary nature of the Department is well reflected in the academic training of the research students. Their backgrounds vary enormously from physics and mathematics through geology to biology. We encourage the participation of students who are interested in not only investigating in depth a specific subject, but who are also interested in a broader, more integrative approach to science.

B. Berkowitz

Fluid flow and chemical transport in groundwater systems.

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

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

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

I. Halevy

The co-evolution of planetary climate and geochemistry on multiple timescales

1. The geological and geochemical history of Earth, planets and satellites
2. Global biogeochemical cycles and their interaction with the climate system
3. Drivers and consequences of episodes of global climatic and geochemical change

J. Karni

Development of directly irradiated solar receivers.

Carbon dioxide dissociation using concentrated solar energy

Energy transport in particles seeded flows at high temperature.

Development of alternative fuels and their production methods using solar energy

1. Carbon dioxide dissociation using concentrated solar energy

Y. Kaspi

Geophysical fluid dynamics

Atmospheric dynamics on Earth and other planets

1. Storm track dynamics
2. Geostrophic turbulence
3. Superrotation
4. Climate dynamics

Planetary interiors

1. Gravitational signature of internal dynamics on giant planets
2. Jets on giant planets
3. Internal tides
4. The Juno mission to Jupiter

I. Koren

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

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

Cloud microphysics and dynamics

Cloud classification and cloud textures and morphology

Y. Rudich

Nano-sized particles and their environmental effects

1. Optical properties of aerosols
2. Studying the chemical processes of submicron particles
3. Health effects of environmental nanoparticles
4. Electron microscopy of micron sized particles

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

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

Optical properties of absorbing aerosols

1. Cavity ring down aerosol spectrmetry
2. Asborbing aerosols

Chemical identification of organic compounds in atmospheric aerosols.

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

A. Shemesh

Stable isotops and paleoceanography of the Southern Ocean.

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

Oxygen and carbon isotopes in corals.

D. Yakir

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

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

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

Department of Materials and Interfaces

Leeor Kronik, Head

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

Among the materials under active study we can note:
? nano-particles and nanotubes of carbon and inorganic materials
? composite materials down to the nanoscale, with unique mechanical properties
? crystalline and non-crystalline pyroelectric and piezoelectric materials

? self-assembling supra-molecular architectures, also for nanoscale lithography
? functionalized electronic materials, also for sensing and energy conversion
? ultrathin ceramic or molecular organic films
? polymers and polyelectrolytes, complex fluids
? biomolecular materials: DNA, cytoskeleton
? biological tissues, cells, and matrix elasticity
? materials and processes for alternative, sustainable energy conversion and storage.
? opto-electronic, pyroelectric, superconducting solids with extended bonding
? nano-crystalline ceramics with unique mechanical & electrical property combinations;

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

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

R. Bar-Ziv

Artificial biochemical circuits

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

The physics of microfluidic crystals

D. Cahen

Bio molecular and molecular (opto)electronics
D. Cahen, M. SHEVES, I.PECHT, L. Kronik,A.Vilan, R.Naaman, C.Sukenik (Bar Ilan), A.Kahn (Princeton), N.Koch (Humboldt), M.Tornow, J.Gooding (UNSW), H.Zuilhof (Wageningen)

1. Understanding charge transport across organic molecules; with A. Vilan
2. Understanding charge transport across proteins
3. Proteins as dopable electronic materials
4. Hybrid Organic/Inorganic, Molecular/Non-Molecular materials; fundamentals and impications for devices, e.g. solar cells

Solar Energy: New materials and concepts, and understanding of Photovoltaics
D. Cahen, G. Hodes,D. Oron, S. Cohen, K. Gartsman, A. Kahn (Princeton)

1. Molecular electronics for solar cells. The importance of molecules for inversion cells.
2. Assessing possibilities and limitations of solar to electrical and chemical energy conversion
3. Photovoltaic effect at Inorganic/Organic Hybrid Interfaces
4. Extremely Thin Absorber Solar Cells

M. Elbaum

Cellular Biophysics and Molecular Transport Machines

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

G. Hodes

Semiconductor-sensitized nanoporous solar cells and semiconductor film deposition
G. Hodes, D. Cahen (WIS)

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

E. Joselevich

Nanoscale Materials Chemistry and Biophysics;

Molecular Wires: From Self-Organization to Functional Nanosystems

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

J. Klein

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

1. Nanotribology
2. Surface forces between heterogeneous surfaces
3. Confinement induced phase transitions

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

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

Molecular origins of biological lubrication Hydration lubrication: a new paradigm

1. Properties of thin liquid films including aqueous electrolytes and polyelectrolytes.
2. Hydrophobic interactions
3. Slip at surfaces
4. Boundary lubrication under water
5. Tissue engineering and regenerative medicine: the role of lubrication
6. Hydrogels
7. Macro-tribological studies of soft matter

L. Kronik

Quantum Theory of Materials

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

M. Lahav

Solid State Chemistry in 2- and 3-dimensions

1. Organization of molecules at surfaces and interfaces; effects of environment on crystal growth
2. Chirality, Chemistry and the origin of life

L. Leiserowitz

Crystallography and Chemistry in 2- and 3-dimensions

1. Grazing incidence x-ray diffraction
2. Malaria

I. Lubomirsky

Dielectric materials

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

I. Rubinstein

Functional Nanomaterials

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

S. Safran

Soft Matter and Biomaterials

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

J. Sagiv

Supramolecular Architecture at Interfaces (with R. Maoz)

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

R. Tenne

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

D. Wagner

Mechanics of Composite Materials and Carbon Nanotubes

1. Micro- and nano-mechanics of tubes (C, WS_2)
2. Electrospun polymer nanofibers
3. LBL clay-films, and their composites
4. Mechanics of biological composites (bone, dentin, cell adhesion)

Department of Organic Chemistry

Ronny Neumann, Head

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

M. Bachi

Organic synthesis through free radical reactions.

Synthesis of Yingzhaosu A and related antimalarial drug candidates.

Stereocontrol through Sulfur-Mediated Temporary Intramolecularization of Reactions.

Y. Burstein

Thermophilic enzymes

1. Isolation, characterization and cloning of enzymes from extremophilic microorganisms.
2. Structure, function and thermal stability relationship studies of extremophilic enzymes.
3. Crystalization and determination of the three-dimensional structures of extremophilic enzymes.

M. Fridkin

Chemical-Biological and Clinical studies on novel drugs, primarily of peptidic nature,related to therapy of infectious ,inflamatory and neoplastic diseases.
M. Fridkin, Y. Koch I. Gozes (TAU) I. Offek (TAU) R. Catane (TEL-HASHOMER)

1. Anticancer, Antibacterial Antiinflammatory

Novel synthetic and analytical methdologies are being developed.

1. Solid-phase synthesis
2. Classical solution chemistry
3. Combinatorial technologies

Studies include: drug design, pro-drugs, long-acting drugs and drug delivery.
M. Fridkin, Y. Shechter

Novel iron chelatores as potential drugs for neurodegenarative diseases
M. Fridkin, M. Youdim (Technio9n)

1. small-molecules
2. amino acids and peptides

G. Martin

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

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

D. Milstein

Organometallic chemistry and catalysis

1. Bond activation by electron-rich transition metal complexes.
2. Rational design of homogeneous catalysis and synthetic methodology based on transition metal complexes.
3. Impact of molecular order on catalysis and reactivity.
4. Generation and stabilization of elusive (potentially biologically active) molecules

R. Neumann

Catalysis and oxidation - Green chemistry

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

B. Rybtchinski

Organic self-assembly: nanoreactors and nanocapsules

Solar fuels: photoinduced water splitting for hydrogen production

Artificial photosynthesis: light-harvesting materials for solar energy conversion

A. Shanzer

Supramolecular chemistry

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

M. Sheves

Molecular mechanism for the function of retinal proteins

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

M. van der Boom

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

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

Mono- and multilayer based memory and sensor elements

Halogen bonded thin film assemblies

Department of Structural Biology

Abraham Minsky, Head

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

L. Addadi

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

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

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

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

J. Anglister

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

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

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

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

R. Diskin

Viral glycoproteins - HIV and others

BBSome structure and function

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; Maya Schuldiner;

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

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

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

K. Levy

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

assembly

The biophysics and evolution of post-translational modifications

A. Minsky

Cellular organization of biomacromolecules

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

Infection cycles of giant viruses
A. Minsky, Michael Rossmann

1. DNA translocations within host cells
2. Formation and structure of viral factories

Repair of double-strand DNA breaks

1. DNA diffusion
2. Repair in highly-resistant organisms (e.g. Deinococcus Radiodurans)

Z. Shakked

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

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

Structural and biochemical studies of proteins involved in transcriptional regulation.

1. The tumor-suppressor protein p53 and its interaction with DNA and the basal transcription machinery
2. The leukemia-related RUNX1(AML1) transcription regulator

J. Sussman

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

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

J. Sussman, Israel Silman

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

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

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

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

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

S. Weiner

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

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

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

A. Yonath

Protein biosynthesis

Ribosomal mechanisms

Antibiotics targeting ribosomes

Faculty of Mathematics and Computer Science

Dean

Department of Computer Science and Applied Mathematics

Uriel Feige, Head

The principal interests of the department lie in the areas of computer science and applied mathematics. Research areas include (but are not limited to) algorithms, their design and analysis; biological applications, bioinformatics, system biology, biological modeling; computational complexity, probabilistic proof systems, hardness of approximation, circuit complexity, combinatorial games; computer vision, image processing; cryptography; differential equations; distributed and parallel computing; dynamical systems; fluid dynamics; logic of programs, specification methodologies; machine learning and mathematical statistics; numerical analysis; randomness and its relation to computation; robotics and motion control; visual perception and brain modeling.

The departmental computer facilities include multiple PCs, multiple unix servers, two Linux clusters with multiple nodes, and large data storage systems. In addition, the vision laboratories, robotics laboratories and computational biology laboratories have a combination of experimental equipment and large-scale computing clusters.

R. Basri

Computer vision, image processing

1. Object recognition and categorization under unknown lighting and pose
2. 3D shape reconstruction
3. Perceptual grouping and segmentation

A. Brandt

Multi-level computational methods, scientific computation.

I. Dinur

Probabilistically Checkable Proofs

Hardness of Approximation

U. Feige

Coping with NP-hard combinatorial optimization problems, algorithms, computational complexity, random walks, algorithmic game theory.

T. Flash

Robotics, motor control and learning, movement disorders, computational neuroscience, virtual reality.

O. Goldreich

Property Testing; 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, visualization.

M. Irani

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

R. Krauthgamer

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

Embeddings of finite metric spaces, high dimensional geometry

A. Levin

Computer vision, Computer graphics, Image processing

Y. Lipman

Geometric modeling, geometry processing, shape analysis, computer graphics, Discrete differential geometry

D. Michelson

Numerical analysis, differential equations, dynamical systems.

B. Nadler

Mathematical Statistics, Statistical Machine Learning, Statistical Signal and Image Processing, Applied Mathematics

M. Naor

Cryptography and Complexity

Distributed Computing

Concrete Complexity

D. Peleg

graph algorithms, spanners, approximation algorithms
D. Peleg, Cyril Gavoille, Liam Roditty

distributed computing, fault tolerance, multi-robot systems, multi-agent systems
D. Peleg, Gopal Pandurangan, Pierre Fraigniaud, Andrzej Pelc, Roger Wattenhofer

communication networks, wireless communication
D. Peleg, Zvi Lotker, Chen Avin

R. Raz

Complexity Theory: In particular: Boolean circuit complexity, arithmetic circuit complexity, communication complexity, probabilistically checkable proofs, quantum computation and communication, randomness and derandomization.

V. Rom-Kedar

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

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

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

Chaotic mixing of fluid flows

V. Rom-Kedar, R. Aharon, H. Gildor

E. Segal

Models for transcription and chromatin regulation

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

A. Shamir

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

O. Shamir

Machine Learning, statistical learning, online learning, learning theory, optimization, big data

E. Shapiro

Biomolecular computing and its medical applications

High-throughput Computer-Aided Design, Manufacturing and Application

Human and mouse cell lineage trees
E. Shapiro, E. Shapiro, Prof. Nava Dekel, Prof. Karl Skorecki, Dr Liran Shlush

E. Titi

Nonlinear Partial Differential Equations and Dynamical Systems

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

Fluid Dynamics and geophysical flows

1. Navier-Stokes, Euler and related geophysical models
2. Turbulence theory
3. Polymeric flows and non-Newtonian complex fluid

S. Ullman

Vision, image understanding, brain theory, artificial intelligence.

Department of Mathematics

Sergei Yakovenko, Head

The principal research interests of the department lie in the broadly understood areas of analysis, probability, algebra, and geometry.

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

Research in **Probability** theory covers random walks and graphs, motion in random media, percolation, random matrices, Gaussian fields and other probabilistic models in mathematical physics.

Areas of **Geometric** research include the structure of finite and infinite dimensional spaces, analytic, real algebraic and semi-algebraic geometry, typology of foliations and complex vector fields.

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

For the research done at our sister department, the Department of Scomputer Science and Applied Mathematics, see here.

A. Aizenbud

Representation theory of real and p-adic groups: Harmonic analysis on Spherical varieties, Gelfand pairs, asymptotic representation theory

Algebraic geometry: Algebraic groups, Singularity theory Geometric invariant theory

Functional analysis: Distributions and generalized functions, Microlocal analysis, Topological vector spaces.

Z. Artstein

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

Decisions under uncertainty.

Ordinary differential equations, singular perturbations, averaging, nonautonomous systems.

I. Benjamini

Probability and geometry.

V. Berkovich

Non-Archimedean analytic geometry.

Algebraic geometry.

Number theory.

H. Dym

Inverse problems.

Operator theory.

Classical analysis.

E. Friedgut

Combinatorics and discrete Fourier analysis.

T. Gelander

Geometric group theory.

Discrete and dense subgroups af Lie Groups.

Algebraic groups and number theory.

Arythmetic groups and locally symmetric spaces.

S. Gelbart

Complex and p-adic Automorphic forms and L-functions.

M. Gorelik

Representation theory and Lie superalgebras

D. Gourevitch

Representation theory of reductive groups over local fields: Representations of real reductive groups, Representations of p-adic reductive groups, Relative representation theory, Gelfand pairs

Invariant distributions

A. Joseph

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

Y. Kannai

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

Partial differential equations.

V. Katsnelson

System representation theory of matrix functions.

Analytic theory of differential equations.

Harmonic analysis.

Operator theory

Classical analysis

G. Kozma

Probability

Harmonic Analysis

E. Lapid

Authomorphic forms, representation theory, trace formula

D. Novikov

Hilbert 16th problem

Ordinary differential equations

A. Regev

Non-commutative ring theory, Algebras satisfying polynomial identities

Combinatorics: Symmetric functions, Permutation statistics

O. Sarig

Ergodic theory and dynamical systems

G. Schechtman

Convex geometry

Functional analysis and geometry of Banach spaces

Probability

S. Yakovenko

Analytic theory of ordinary differential equations.

Singularity theory. Singular foliations, limit cycles, holonomy.

Y. Yomdin

Analytic Theory of Differential Equations, Generalized Moments, Compositions

Zeroez distribution in Families of Analytic Functions

Semialgebraic Complexity of functions, Signals Acquisition via non-linear model approximation

High Order Data Representation, Nonlinear Model Approximation. Taylor Models, High-Order Numerical methods

Model-based image analysis, representation, compression. Model-based search, capturing, and animation

O. Zeitouni

Motion in random media

Random matrices

Faculty of Physics

Dean

Department of Condensed Matter Physics

Eli Zeldov, Head

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

The Braun Center for sub micron research is an integral part of the department. It is a modern and well equipped center, with growth (three MBE&#39s) and characterization systems, which allows to conduct experiments on sub micron semiconductor structures under high magnetic filed, normal and high temperature superconductors, and nanowires made of carbon nanotubes and semiconductor nanowires.

I. Bar-Joseph

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

Near field spectroscopy of semiconductor heterostructures.

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

H. Beidenkopf

Topological phases of matter:

1. Topological insulators
2. Weak topological insulators
3. Topological superconductors
4. Crystalline topological Insulators
5. Helical nanowires
6. Scanning tunneling microscopy

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

Edge reconstruction and edge channels in the fractional quantum Hall effect and Topological Insulators.

Exotic excitations in the fractional quantum Hall effect and Topological Insulators.

Weak measurement, weak values and foundations of quantum mechanics.

Interferometry and dephasing with electronic and anyonic systems.

Low-dimensional interacting systems out of equilibrium.

M. Heiblum

Fractional charges and their fractional statistics
M. Heiblum, students/postdocs, D. Mahalu, V. Umansky

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

Interference and dephasing of electrons
M. Heiblum, students/postdocs, D. Mahalu, V. Umansky

1. Phase measurements via a double path interferometer
2. controlled dephasing
3. Interferometers functioning in a high magnetic field, Mach-Zehnder Interferometer

Neutral mode transport
M. Heiblum, students/postdocs, D. Mahalu, V. Umansky

1. downsteam and upstream neutral modes
2. hole conjugate states
3. even denomenator states

nanowires
M. Heiblum, andrey kritinin, anindya das, hadas shtrikman

1. InAs wires
2. ballistic transport
3. incorporation with superconductors

S. Ilani

Carbon nanoelectronics

Transport in ultra-clean carbon nanotubes

Nano-mechanics of carbon systems

Spin manipulation in carbon systems

Charge imaging on nanometer scales using scanning nanotube single electron transistors.

Two dimensional electron systems at the interface between oxides (LaAlO/SrTiO).

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

Atom-atom interactions in cold gasses and BEC

Resonant scattaring off photonic slabs

Non classical light.

Interaction of Squeezed Light with Atoms and Semiconductor Nanostructures

Full vector path integrals for light propagation in dielectrics.

Y. Oreg

Our research concentrates on a few generic examples where the electron-electron interaction plays an important role. In particular, we study systems where interaction and collective phenomena cannot be comprehended by the current paradigm theory of condensed matter metals (the Fermi-liquid theory). Among them are:

1. Majorana fermions in superconducting wires and topological superconductors
2. Quantum dots and the Kondo effect and the multi channel Kondo effect
3. Disorder superconductors and normal metal super-conducting junctions

4. Glassy systems

Luttinger liquids in one-dimensional systems such as:

1. carbon nano tube
2. edges of a quantum hall systems
3. edges of two dimensional topological insulator

D. Shahar

Experiments on materials at ultra low-temperatures.

Scanning tunneling experiments at ultra-low temperatures

Physics of electron's spin

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

Fractional and integer quantum Hall effect and related phenomena.

A. Stern

Fractionalized topological phases - how to construct them, how to measure them, and how to use them for topological quantum computation

Non-abelian electronic states - quantum Hall states, topological superconductors and Majorana fermions.

Quantum interference phenomena in the fractional Quantum Hall effect. Electronic transport in strong magnetic fields.

Low density two dimensional electronic systems.

One dimensional electronic systems - electronic transport in the presence of interactions.

E. Zeldov

Scanning nanoSQUID magnetic microscopy

Scanning thermal microscopy

High-temperature superconductors

Vortex matter phase transitions and vortex dynamics

Nano-structured superconductors

Magnetic phenomena in topological insulators

Magnetism at oxide interfaces

Magnetic nanoparticles and nanomagnetism

Department of Particle Physics and Astrophysics

Tal Alexander, Head

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

O. Aharony

Dualities between field theories in various dimensions
O. Aharony, G. Gur-Ari, S. Minwalla, P. Narayan, S. Razamat, N. Seiberg, T. Sharma, B. Willett, R. Yacoby

Strongly coupled field theories in anti-de Sitter space
O. Aharony, M. Berkooz, S. Rey, D. Tong, S. Yankielowicz

Effective actions on strings (in particular confining strings)
O. Aharony, Z. Komargodski, A. Schwimmer, J. Sonnenschein, S. Yankielowicz

Weakly coupled versions of the AdS/CFT correspondence and possible derivations
O. Aharony, S. Minwalla, G. Gur-Ari, R. Yacoby

T. Alexander

Massive black holes

Dynamic of galactic nuclei

Gravitational wave sources

Circum-nuclear accretion disks

The growth of black holes in the early universe

Stellar phenomena in the center of the Milky Way

M. Berkooz

Theoretical high energy physics

1. String theory, Field theory, Gravity
2. Particle Phenomenology
3. Conformal field theory applications in condensed matter systems
4. Quantum information and black holes

A. Breskin

Basic phenomena in Radiation Detection Physics
A. Breskin, L. Arazi

1. ionization and excitation in gases and noble liquids
2. charge transport and multiplication in gas and noble liquids
3. photoemission from solids
4. Light multiplication in noble liquids ? Liquid Hole Multipliers (LHM)

Novel radiation detection concepts
A. Breskin, S. Bressler, L. Arazi

1. Gaseous electron multipliers: GEM, THGEM, WELL
2. Charged-particle detectors for particle, astroparticle and nuclear physics
3. Detectors for digital calorimetry (for future colliders)
4. Gaseous photomultipliers (GPM) for UV and visible light
5. Detector concepts for neutron imaging
6. Dark Matter Detectors
7. Detection of hidden explosives and nuclear materials

Early detection and diagnosis of prostate cancer
A. Breskin, S. Shilstein, D. Vartsky

R. Budnik

Dark Matter detection:

1. The XENON Dark Matter project: Data analysis, physics interpretations, development and construction of the future detector XENON1T

Detector physics:

1. Novel effects in LXe detectors
2. Future concepts and technologies for rare event detection

Other:

1. Future concepts for Cosmic Ray precision detection

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
5. multi-jet final states

Study of substructure in high transverse momentum jets with the ATLAS detector at CERN
E. Duchovni, G. Perez, S. Sinervo

1. Jets at CDF
2. Jet's mass
3. Angularity and planar flow

Study of strange resoinance production with the ATLAS detector at CERN

1. K0S
2. Phi

Y. Frishman

Confinement and screening.
Y. Frishman, Jacob Sonnenschein

Non-abelian gauge theories.
Y. Frishman, Marek Karliner, Jacob Sonnenschein

From current to constituent quarks.
Y. Frishman, Marek Karliner

A. Gal-Yam

Cosmic explosions

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

Wide-field variability surveys
A. Gal-Yam, S. Kulkarni, E. Ofek, (Caltech), M. Sullivan (UK), P. Mazzali (Germany/Italy), J-P Kneib (France)

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

D. Gepner

Rational conformal field theory and solvable lattice models.

E. Gross

Higgs Physics with the ATLAS detector at the LHC
E. Gross, Students: Ohad Silbert and Ofer Vitells,Liron Barak

1. Search for Charged Higgs Boson
2. Search for Supersymmetric Higgs decaying into Taus
3. Higgs physics in general

Jets faking electrons with the ATLAS detector
E. Gross, Student: Ohad Silbert

S. Gurvitz

Multi-dimensional tunnelling.
S. Gurvitz, Xin-Qi Li, D. Sokolovski

1. Two-potential approach to tunneling problems
2. Cluster decay
3. Modified tunneling Hamiltonian
4. Tunneling of the Bose-Einstein Condensate

Final state interaction in inclusive reactions.
S. Gurvitz, A. Aharony, O. Entin-Wohlman, Xin-Qi Li, Wei-Min Zhang

1. Number and energy resolved master equations for quantum transport
2. Relaxation and dephasing in persistent current
3. Zeno effect and quantum description of classical apparatus

Quantum transport in mesoscopic systems and the measurement problem.
S. Gurvitz, M. Traini

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

H. Harari

Neutrino Physics (Particle Physics, cosmology, astrophysics implications)

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

M. Hass

Light rare-isotope beams for nuclear astrophysics, neutrino physics and fundamental interactions
M. Hass, Dr. Guy Ron, Hebrew Univresity, Dr. Dan Berkovits, Dr. Israel Mardor: Soreq Nuclear Research Centre. Dr. Oded Heber (WI)

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

U. Karshon

Heavy quark production at the HERA e-p collider.

Gluon density in the proton and partonic structure of the photon.

Tests of QCD dynamics in high energy e-p collisions.

B. Katz

Open questions in theoretical astrophysics including:

1. How do stars explode to produce supernovae? (I think there is an actual chance to finally answer this soon due to accumulating data and new ideas!)
2. The three body problem (surprisingly connected to supernovae)
3. Where do Cosmic Rays come from and how are they accelerated?

M. Kirson

The shell model and interacting boson model for nuclei.

Theory and systematics of nuclear structure.

Z. Komargodski

Particle Physics and Quantum Field Theory

Y. Maron

Investigation of matter and plasma subjected to high-energy-density deposition with implications to fusion and space physics:

1. Laser-matter interaction

2. Warm dense matter formed by intense laser solid-state interaction (solid-state with temperatures of hundreds of thousands degrees).
3. Radiation transport and ion temperature in imploding plasmas.
4. Plasmas under pulsed magnetic fields.
5. Particle acceleration by laser-plasma interaction.
6. Instabilities and turbulent phenomena.

Development of novel spectroscopic diagnostic methods for matter under extreme conditions:

1. Calculation and analysis of spectral line-shapes and intensities.
2. Design and building of fast optical spectroscopic systems (from the visible to the x-rays).

Close collaboration with major plasma laboratories in the US and Germany

G. Mikenberg

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

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

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

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

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

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

M. Milgrom

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

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

Black holes at the centers of galaxies

A. Milov

Analysis of the Heavy Ion data from the ATLAS experiment at the LHC

Global event characterization

Heavy boson production and boson-jet correlations

Collective dynamics.

Detector upgrades for ATLAS and PHENIX

Y. Nir

Higgs physics

Flavor physics

CP violation

Top physics

Particle cosmology (dark matter, leptogenesis, baryogenesis)

Neutrino physics

E. Ofek

Transients and cosmic explosions: supernova, shock breakout and interaction of supernova ejecta with circum-stellar matter

Probing the edge of the solar system using stellar occultations: Building instruments with high temporal resolution to search for small objects in the Kuiper belt and the Oort cloud

Gravitational lensing and microlensing

Direct search for exoplanets using high contrast imaging techniques

G. Perez

What gives masses to the particles? We believe that it is related to electroweak symmetry breaking which raises the hierarchy problem, the huge gap between the weak and Planck scales. The LHC experiments will address these questions very soon. Recent cosmological-observation raised additional puzzles: What is the source of dark matter and energy? We explore experimental and theoretical methods to improve our knowledge regarding these issues.

1. A. Jenkins and G. Perez, 'Looking for Life in the Multiverse, 'Scientific American (01/2010).
2. K. Agashe, K. Blum, S.J. Lee and G. Perez, 'Astrophysical Implications of a Visible Dark Matter Sector from a Custodially Warped-GUT,' arXiv:0912.3070 [hep-ph].
3. A. Fitzpatrick, G. Perez and L. Randall, 'Flavor from Minimal Flavor Violation & a Viable Randall-Sundrum Model,' Phys. Rev. Lett., 100, 171604 (2008) [arXiv:0710.1869 [hep-ph]].
4. K. Agashe, A. Belyaev, T. Krupovnickas, G. Perez and J. Virzi, 'LHC signals from

warped extra dimensions,' Phys. Rev. D 77, 015003 (2008) [arXiv:hep-ph/0612015].

I. Tserruya

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

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

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

V. Usov

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

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

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

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

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

E. Waxman

Theoretical astrophysics

HIgh energy astrophysics (gamma-ray bursts, relativistic plasmas...)

High energy neutrinos and cosmic-rays

D. Zajfman

Molecular astrophysics.
D. Zajfman, O. Heber

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

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

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

Department of Physics of Complex Systems

Nir Davidson, Head

The Department of Physics of Complex Systems has research programs in fundamental and applied physics. Research in optics and atomic physics includes nonlinear optics, ultra fast optics and high harmonic generation, quantum optics, slow light, descrete optics, nano optics and nonlinear microscopy, laser cooling and trapping of atoms and ions, studied of Bose Einstein condensation, precision spectroscopy and quantum information processing. Theoretical and experimental research in condensed matter is concentrated on equilibrium and non-equilibrium statistical physics, clustering of data, bioinformatics and systems biology, electrokinetics of ions and charged particles in low dielectric liquids, colloids, soft materials and complex fluids. Experimental and theoretical hydrodynamics concentrates on turbulence, spatio-temporal chaos, turbulent Rayleigh-Benard convection, liquids at interfaces, droplet impact, sedimentation and dynamics of single micro-objects, such as polymers, vesicles, capsules and hydrodynamics of their solutions. Turbulence theory is developed in general and in applications to cloud physics. Classical and quantum chaos, statistics of nodal lines in quantum systems and turbulence are studied theoretically. Mathematical and computational methods for archaeological research are developed. Theoretical physical biology deals with modeling living information systems, their molecular components and the way they evolve. Experimental bio-physics deals with bio-molecules, neural cultures, neurophysics, physics of the brain, physics of bio-systems and decision making in ant colonies.

N. Davidson

Quantum memories with trapped atomic ensembles.

Bose Einstein Condensation in ultra-cold atomic gas.

Quantum degenerated strongly interacting Fermi gas.

Atomic interferometers.

Phase locking and synchronization of coupled lasers.

Electromagnetic-induced transparency and slow light.

E. Domany

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

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

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

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

N. Dudovich

Strong field light matter interactions

Attosecond Physics

G. Falkovich

Theory of fluid turbulence. Fundamental aspects and applications.

Particles in random flows.

Nonlinear waves and wave turbulence.

O. Feinerman

Collective behavior of ants.

Information sharing in cooperative groups.

Collective decision making.

O. Firstenberg

Quantum optics with interacting photons: photonic quantum gates and fluids of light.

Coherent optical processes in hot and cold atoms.

Atomic sensors.

A. Friesem

Diffractive Optical Elements and Planar Optics.

Photonic Devices.

Novel Laser Configurations.

U. Leonhardt

Geometry and light

Invisibility cloaking and perfect imaging

Analogues of the event horizon

Forces of the quantum vacuum

E. Moses

Physics of the Brain

Computation in Living Neuronal Networks

Neuronal Chips.

EEG and Brain Activity.

D. Mukamel

RNA and DNA denaturation.

Collective phenomena in systems far from thermal equilibrium.

Coarsening processes and slow dynamics.

Systems with long range interactions

D. Oron

ultrafast dynamics of semiconductor quantum dots

sub-diffraction limited imaging

Optical nonlinearity in plasmonic nanostructures

Quantum dot enabled photovoltaics

R. Ozeri

Ultra-cold ions and atoms

Quantum Computing

Quantum metrology and precision measurements

Ultra-cold collisions and interactions

A. Schwimmer

String theory.

Conformal field theory.

Dynamics of gauge theory.

Y. Silberberg

Nonlinear Optics and Quantum Optics.

Ultrafast optics and quantum coherent control.

Nonlinear microscopy.

U. Smilansky

Mathematical methods for Archaeological research.

Semi-classical quantization.

Chaotic scattering.

Quantum chaos.

J. Stavans

Genetic Networks and Systems Biology

1. Regulation of gene expression by small RNAs
2. Developmental decision making

3. Noise and adaptation

Single-Molecule Biological Physics.

1. RNA interference
2. Homologous recombination

Statistical Mechanics

V. Steinberg

Physical hydrodynamics, hydrodynamics of complex fluids, dynamics of single flexible micro-objects (molecules, membranes, etc) in complex fluid flows

1. Hydrodynamics of polymer solutions, Elastic turbulence and Turbulent mixing by polymers.
2. Hydrodynamics and rheology of complex fluids (vesicle, capsule, worm-like micelle, etc suspensions)
3. Dynamics and conformation of single polymer molecule, vesicle, micro-capsule, etc in complex fluid flows.
4. Measurement of velocity and vorticity fields by sound scattering in a turbulent flow.
5. Convective turbulence in a fluid near the gas-liquid critical point.
6. Microfluidics: mixing, cell separation, random flows.
7. Development of non-invasive local sensors for measurements of stress field in fluid flow

Educational Activities

Dean

Department of Science Teaching

Bat Sheva Eylon, Head

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

A. Arcavi

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

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

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

M. Armoni

Fundamental ideas in computer science: Identifying the core ideas of the discipline, examining their teaching and learning processes

1. Reductive thinking: Reduction as a tool for problem solving
2. Nondeterminism: a tool for abstraction
3. Reversing

4. Abstraction

Teaching the foundations of computer science to young students

1. Theoretical foundations of computer science
2. Basic concepts in algorithm and program design

M. Ben-Ari

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

Teaching concurrent programming with model checking

R. Even

The interactions among math curriculum, teachers, and classrooms

1. Teaching the Same Probability Syllabus in Classes of Different Levels
2. Using The Same Algebra Textbook in Different Classes
3. Junior-high school math curriculum and implementation

The professional education and development of mathematics teachers

1. Subject-matter Knowledge for Teaching Mathematics
2. Knowledge about Students for Teaching Mathematics
3. Educating Educators to Work with Practicing Secondary School Mathematics Teachers (MANOR)
4. ICMI Study on the Professional Education & Development of Teachers of Mathematics

Mathematics education research and practice issues

B. Eylon

High school curriculum development

1. Translation and adaptation of selected units from the course "Visual Quantum Mechanics" developed by the Physics Education Research Group in Kansas State University.
2. Preparing texts and materials for elective units for physics majors (lasers, chaos). Using computerized networks (internet and intranet) for distance learning of these courses.
3. Development of modules for student activities in Mechanics, Electricity and Magnetism and Optics.
4. Development of modules for inquiry learning in the context of "mini-projects".
5. Development of a new course on Light and Waves for 10th and 12th grades.
6. Development of physics programs for the Arab population.

7. Elaboration of the national physics syllabus and the matriculation examinations.
8. Preparation of materials for e-learning in mechanics and electricity that can be used in various models that integrate in-class and distance learning of physics.

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

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

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

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

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

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

Preparation of learning materials for 7-9 grade

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

Computerized Materials

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

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

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

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

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

D. Fortus

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

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

Waldorf-Oriented Science Education

1. Anthroposophy
2. Learning Readiness
3. Habits of Mind

Enhancing Motivation to Learn Science

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

A. Hofstein

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

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

Research and evaluation
A. Hofstein, R. Mamlok

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

N. Orion

The outdoor as a learning environment

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

A. Yarden

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

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

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

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

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

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

Characterizing children?s spontaneous interests in science and technology

1. Identifying children's interests in science using questions sent to national and international Ask-A-Scientist sites.
2. Identifying Israeli teachers? interests in science using questions sent to an Ask-A-Scientist site.

The effect of disciplinary identity on interdisciplinary learning

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

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

biology and biotechnology students' comprehension of molecular biology.

E. Yerushalmi

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

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

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

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

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

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