CURRENT RESEARCH ACTIVITIES

2019

Weizmann Institute of Science
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The Weizmann Institute of Science is one of the world's leading multidisciplinary basic research institutions in the natural and exact sciences. The Institute's five faculties Biology, Biochemistry, Chemistry, Physics, Mathematics and Computer Science are home to scientists and students who embark daily on fascinating journeys into the unknown, seeking to improve our understanding of nature and our place within it. The Institute has been the venue of pioneering research in neuroscience, nanotechnology and alternative energy, the search for new ways of fighting disease and hunger and creating novel materials and developing new strategies for protecting the environment. Mathematicians and computer scientists working together with biologists are uncovering unseen patterns in everything from our DNA to the ways our cells age to personal nutrition. From participating in the discovery of the Higgs boson at CERN to joining in scientific missions to the planets in our solar system, Weizmann Institute researchers are helping lead international science. The campus comprises of 1.1sq km (280 acres) and includes over 240 buildings, research facilities, administration and housing; 2,500 faculty and staff; 1,400 students and postdocs Research volume annually is of more than $100m total worth of grants for Weizmann Institute research projects.
The Department of Biological Regulation is comprised of approximately 170 people organized in 13 research groups. We are located in the Candiotty and Britannia buildings, which are equipped with all the cutting-edge facilities required for running excellent research endeavors. Our research is concentrated on the regulation of processes responsible for the concerted action of cells, tissues, and organs. A diversity of methodologies and experimental approaches are being used in order to tackle these pivotal issues in biology. These include biochemical, molecular and physiological methods, organ and tissue cultures, and whole animal studies utilizing mice and fish. In addition, some researchers of the Department are using methodologies and concepts of systems biology, host-pathogen interactions and a variety of imaging methods, including magnetic resonance imaging (MRI). Since de-regulation of biological control circuits often underlays human diseases (e.g., malignant transformation, stroke, infertility, and defective tissue regeneration after injury), we make many efforts to implement the results of our studies in research projects leading to the development of new tools for early diagnosis, along with novel compounds suitable for pharmacological interventions.

The main projects that are currently performed in the department are:

- Host-pathogen interactions - Dr. Roi Avraham
- Cell metabolism in health and disease - Dr. Ayelet Erez
- Cell death and metabolism - Prof. Atan Gross
- Protein degradation by the ubiquitin/proteasome system - Prof. Ami Navon
- Vascularization during pregnancy and cancer development - Prof. Michal Neeman
- ECM remodeling: from biophysical principles to drug design - Prof. Irit Sagi
- Intracellular signaling cascades in health and disease - Prof. Rony Seger
- Epigenetics in stem cells and cancer: developing and applying single-molecule imaging technologies to study the epigenetic code - Dr. Efrat Shema
- Genome and epigenome regulation - Prof. Amos Tanay
- Cellular functions of long noncoding RNAs - Dr. Igor Ulitsky
- The development of the vascular system - Dr. Karina Yaniv
- Growth factors and their receptors in cancer - Prof. Yossi Yarden

Investigating functional, metabolic and architectural features of normal and malignant tissues with magnetic resonance techniques - Prof. Hadassa Degani
- The control of reproduction - Prof. Nava Dekel
- Investigating ovarian follicle physiology, regulation and demise in mammals with emphasis on the ovulatory response, including the control of oocyte maturation, transformation of the follicle into corpus luteum and culminating with the release of the
fertilizable ovum - Prof. Alex Tsafiriri

In December 2018, we expect that Prof. Philipp Selenko and his team will complete their relocation to Rehovot â€“ Dr. Selenko is interested in cellular structural biology of human amyloid proteins.

Department of Immunology

*Department Head: Prof. Steffen Jung*

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.

Department of Molecular Cell Biology

*Department Head: Prof. Eldad Tzahor*

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 $\beta$-catenin, which play a crucial role in reinforcing cell-cell adhesions as well as triggering gene expression.

Department of Neurobiology

Department Head: Prof. Alon Chen

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.
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:

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.

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.

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.

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.

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.

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's Home Page.

Department of Molecular Genetics

*Department Head: Prof. Naama Barkai*

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.

Department of Plant and Environmental Sciences

*Department Head: Prof. Yuval Eshed*

Plants offer the world its only renewable resource of foods, alternative energy and biotherapeutic compounds. Plants have highly sophisticated short and long-term adaptive mechanisms to the environment as a result of the simple fact that they cannot alter their location during environmental change. Basic understanding of how plants react to the environment and why they grow the way they do are central to devising a rational approach to address three important global challenges, namely to secure more and healthier food, to develop novel plant-based products associated with biotherapeutics and to produce alternative energy resources in the form of biofuels. Research activities in the Department of Plant Sciences are associated with all of the above-mentioned global challenges and range from studies on the function and regulation of isolated genes to their interactive behavior in the context of the whole plant. We have developed extensive in-house genomic, bioinformatics and transgenic infrastructure that enables us to isolate novel genes by gene trapping, knockout or map-based cloning. Cloned genes are manipulated and studied by transgenic analysis to establish their potential in the whole
plant. Our research as listed below integrates methodologies of molecular biology, protein modeling, genomics, metabolomics, bioinformatics, system biology, genetics, biochemistry and physiology.

Harnessing light energy and energy transduction in the plant cell: Research is carried out on the basic biophysical phenomenon of photon absorption by chlorophyll through transduction of this energy to ATP and the regulation of energy flux by the plant redox state.

Adaptive response in the plant to the biotic and abiotic environment: Molecular mechanisms that drive the cellular response are investigated under environmental perturbation. Research is directed in understanding the elements that play a role in the recognition of pathogens and the subsequent mounting of plant defense responses as well as in the response of plants to abiotic stresses, such as salt stress.

Plant metabolism and growth: Research is centered around elucidating regulatory metabolic networks for production of essential primary and secondary metabolites as well as understanding gene expression and hormonal networks that control plant metabolism, growth, reproduction and productivity.

Plant genome organization: Molecular tools have been developed to examine the fluidity of the plant genome, as described by transposon element, and the evolution of polyploid plants.
The Chemical and Biological Physics Department provides an interdisciplinary home to a broad range of topics spanning Physics, Chemistry, and Biology. The Department is composed of over 20 tenured and tenure-track physicists and chemists, evenly split between theorists and experimentalists, and working on the following broad areas:

**Fundamental quantum frontiers are explored with advanced theoretical tools,** including topics in the quantum control of atomic and molecular dynamics (Ilya Averbukh, Eli Pollak, David Tannor); light-matter interactions (Ilya Averbukh, Gershon Kurizki, David Tannor); fundamental issues in quantum information, control and thermodynamics (Gershon Kurizki, David Tannor); ab-initio quantum chemistry and surface scattering (Eli Pollak); and real time quantum dynamics methods (Eli Pollak, David Tannor).

**The department has a strong program at the interface between classical physics, chemistry and biology.** Eran Bouchbinder studies the plasticity of disordered systems, glassy phenomena, dynamic fracture, frictional interfaces and biophysics. Itamar Procaccia studies turbulence, as well as the physics of fractals, glass formation and mechanical properties of amorphous systems. Theoretical biological physics is the main thrust of research of Nir Gov, who models with predictive power emerging phenomena ranging from cellular shapes to the collective behavior of insects. Samuel Safran employs statistical thermodynamics to study the structure, phase behavior and dynamics of soft matter in biology.

**The chemistry/biology interface is also studied and evaluated experimentally** by Roy Bar-Ziv, who develops and explores living-like systems in cell-free environments, and by Michael Elbaum, who employs advanced microscopic tools to elucidate the complex behavior of cells and biomolecules.

**Experimental atomic and molecular spectroscopies are also mainstays of the Department.** Quantum optics is the focus of Barak Dayan’s experiments on atom mediated photon-photon interactions. Light matter interaction, nonlinear laser spectroscopy and plasmonics are the focus of the experimental research of Yehiam Prior. Edvardas Narevicius is a leader in using magnetic field control and the slowing down of molecular beams to study quantum effects in sympathetically cooled systems. Oren Tal has developed unique methods for the study of single molecule conductors, including electronic, spintronic and thermal conductivity effects. Molecular electronics and spin-chemistry are also main themes of research for Ron Naaman, who investigates these using organic-inorganic interfaces via self-assembled monolayers. Single molecule
spectroscopy and its application to a broad range of topics, from protein dynamics to nanoplasmonics, are at the center of the experimental program of Gilad Haran. Baran Eren exploits new forms of microscopy and spectroscopy, to understand the chemistry and electronic behavior of solid surfaces under relevant conditions with unprecedented accuracy.

A centerpiece of the combined experimental/theoretical program in the Department rests on Magnetic Resonance research. Amit Finkler bridges this topic with optics, in a program relying on optically-detected magnetic resonance as an emerging form of quantum sensing. Lucio Frydman and his group focus on developing and utilizing new concepts and techniques in NMR and MRI, with applications ranging from Physics to Biology and Medicine. Assaf Tal's group focuses on developing new spectroscopy and imaging tools for understanding the brain's physiology in-vivo. Shimon Vega and Daniella Goldfarb are developing and utilizing dynamic nuclear polarization methods for NMR and EPR research, with the Vega group also deeply involved in solid state NMR, and the Goldfarb research also focused on multiple-resonance high-field EPR techniques applied to biophysics and materials science. Although emeritus, Zeev Luz still partakes of these efforts with his research on liquid crystal NMR.

The diverse interests as represented above have created an atmosphere of outstanding scientific creativity. Members of the Department have overlapping interests and collaborations among themselves, with other scientists throughout the Weizmann Institute, and with scientists throughout the world. New training opportunities for students and postdocs are always emerging, at whose conclusion participating scientists will have been exposed to a broad spectrum of challenges and acquired state-of-the-art knowledge. If you are interested in joining this elite group of researchers as a M.Sc., Ph.D or postdoctoral trainee, do not hesitate to contact the expert(s) of your choice.

Department of Earth and Planetary Sciences

Department Head: Prof. Yinon Rudich

The research in this department is dedicated to understanding the complex inter-relationships among the major Earth Systems and on the human impact on the Earth's environment and climate. In addition, research is conducted on planetary atmospheres and planetary geomorphologies.

The Department's 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. The fourth area of research is in planetary sciences. Our research requires knowledge of the
interdependent components that together constitute the "environment", as well as a commitment to protect this environment by improving the manner in which air, water, land, and energy are utilized by humans. The Department is distinguished by the interactions among scientists from different backgrounds and expertise, which is critical for achieving a comprehensive understanding of the global environment and planetary sciences.

The department promotes international collaborations based on short- and long-term visits for research and training by scientists who complement existing expertise in the Department. The interdisciplinary nature of the Department is well reflected in the academic training of the research students. Their backgrounds vary from physics, chemistry, 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 and integrative approach to science.

Department of Materials and Interfaces

Department Head: Prof. Leeor Kronik

Activities in the Department span a wide range of topics from soft, composite and hard materials to energy research, nanoscience, and biological materials. A unifying theme is the study of material functionality and its relation to fundamental properties at multiple scales. These properties may be mechanical, structural, chemical, electronic, magnetic, optical, and more. Some examples are:

How do shapes and sizes of nm-sized particles affect their 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 (bio)chemical systems?

THE RESEARCH IS BASED ON AN INTERDISCIPLINARY APPROACH, and indeed the scientists bring complementary experience in chemistry and physics, including both theory and experiment.

Department of Organic Chemistry

Department Head: Prof. Milko van der Boom

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.

Department of Structural Biology

Department Head: Prof. Deborah Fass

The functions of biological systems emerge from the structures of macromolecules, their conformational dynamics, and their higher order assembly. Determination of biomolecular structures and an understanding of their conformational changes and assembly properties provide great insights into biological mechanisms. Much of the research in structural biology at the Weizmann Institute is carried out in the Faculty of Chemistry, using a diverse set of cutting-edge research tools and methods. Investigators in the Structural Biology Department rely on the primary techniques for experimental structure determination, namely X-ray crystallography, NMR, and electron microscopy, but they also employ a variety of other specialized and emerging spectroscopic methods combined with creative molecular engineering to explore macromolecular structures, energetics, and dynamics. Experimental strategies are complemented by computational and theoretical approaches. Among the specific subjects of research in the department are ribosomes, protein chaperones, viruses, extracellular matrices, and biominerals. Processes being investigated include protein aggregation in cells, conformational dynamics of enzymes, formation of skeletal tissues, cell penetration by viruses, DNA recognition by proteins, and protein folding. Efforts are also directed towards the design of potential drugs. The wide variety of research activities in the department are based on a shared appreciation for the physical and chemical foundations of biological activities.
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.

Department of Mathematics

Department Head: Prof. Omri Sarig

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.
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, topological states of matter, high temperature superconductors, two and one dimensional superconductors, metal-insulator transition, carbon nanotubes, semiconductor nanowires, and study of material growth. The theoretical efforts concentrate on similar subjects with added work on disordered materials, cold atoms, and quantum optics.

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

**Department of Particle Physics and Astrophysics**

*Department Head: Prof. Yosef Nir*

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.

**Department of Physics of Complex Systems**

*Department Head: Prof. Elisha Moses*

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, discrete optics, nano optics and nonlinear microscopy, laser cooling and trapping of atoms and ions, studies of Bose Einstein condensation, precision spectroscopy and quantum information processing. Theoretical and experimental research in soft 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.
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 four national centers for science teachers (physics, chemistry, biology 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. Another avenue promoted by the department for professional development of science teachers is carried out through the Rothschild-Weizmann Program for Excellence in Science Teaching, which provides science teachers unique opportunities to expand and update their knowledge in science and in science education. In addition, the department runs numerous Professional Learning Communities of science teachers all over Israel. Projects in the department are funded by the Israel Science Foundation (ISF), the German Israeli Foundation (GIF), the Trump Foundation and the Israeli Ministry of Education through the Amos de-Shalit Israeli Center for Science Teaching (MALAM). In addition, the department is involved in several EU projects aiming at enhancing science education both in the formal as well as in the informal level.