



**Department of
Chemistry @ BGU**



Dr. Barak Akabayov

Biochemistry, Chemical Biology

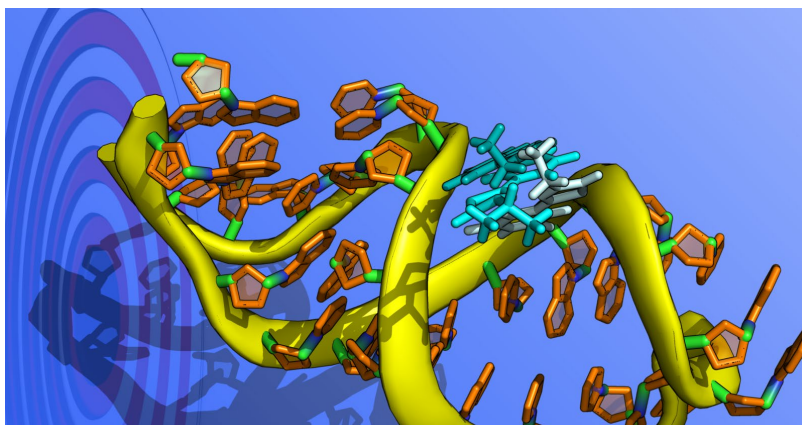
Our overarching goal is to understand DNA replication and protein translation at the molecular level. Our research lab utilizes innovative biophysical tools and approaches to assess the structural nature and the biomolecular interactions in protein-protein and protein-nucleic acid complexes. In turn, we learn how these interactions determine and impact the biological catalysis of these domains of life. Our interdisciplinary approach, spanning and integrating chemistry and biology, employs a wide range of techniques. The imminent need to develop new antibacterial drugs will lead us to discover inhibitors targeted against components in central molecular biology domains in a bacterial cell.

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SELECTED PUBLICATIONS

1. M. Singh, S. Ilic, B. Tam, Y. Ben-Ishay, D. Sherf, D. Pappo, B. Akabayov. Dual acting small-Molecule inhibitors targeting Mycobacterial DNA replication. , (2020). Chemistry – A European Journal, 26 (47), 10849-10860.
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3. Afek, S. Ilic, J. Horton, D. Lukatsky, R. Gordan, B. Akabayov. DNA sequence context controls the binding and processivity of the T7 DNA primase. (2018). iScience, 2, 141-147.



Prof. Eyal Arbely

Synthetic Biology, Biochemistry, Chemical Biology

GET IN TOUCH

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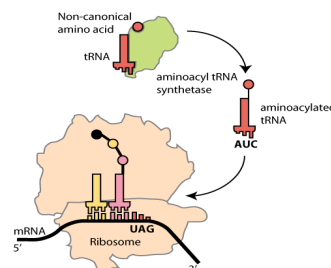
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Expanding the chemical repertoire of living organisms

Synthetic Biology is a new and rapidly evolving interdisciplinary research field that aims to design and create new (synthetic) life forms with enhanced functionalities that do not exist in natural organisms. For example, genetic code engineering (also known as genetic code expansion technology) now enables the site-specific incorporation of non-proteinogenic (*i.e.*, non-natural) amino acids into ribosomally synthesized proteins. The incorporated non-natural amino acid may carry a chemical group that is not part of the engineered organism's chemical repertoire, thereby enable the expression of proteins with unique chemical and physical properties. Our group develops and utilizes genetic code expansion technology, with the aim of unraveling the role of lysine post-translational modifications in the regulation of enzymatic activity. Specifically, we conduct an interdisciplinary research at the interface of chemistry, biology, and engineering, to understand how metabolic processes are regulated by lysine acetylation, and how these regulatory mechanisms are modified in cancerous cells.

In addition, we devise and implement new technologies for site-specific chemical modification of proteins in living organisms. To this end, we explore new methodologies for expression of proteins with non-natural chemical groups and chemically synthesize new reagents for chemical reactions in living cells.



SELECTED PUBLICATIONS

1. Cohen, S. and Arbely, E. Single-plasmid-based system for efficient non-canonical amino acid mutagenesis in cultured mammalian cells. 2016, *ChemBioChem*, 17(11), 1008–1011.
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5. Kramarski, L., and Arbely, E. Translational read-through promotes aggregation and shapes stop codon identity. 2020, *Nucleic Acids Research*. 48(7), 3747–3760



Prof. Gonen Ashkenasy

Laboratory of Systems Chemistry

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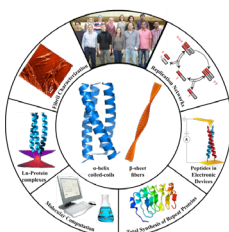
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The Systems Chemistry of Peptide Networks

The main research effort in our lab is devoted to the design and synthesis of multi-component chemical systems, termed as Molecular Networks, and for analysis of their dynamic self-organization. This study within the new field of Systems Chemistry is inspired by the complexity in structure and function observed within natural cells. We use peptides and proteins as the active components in these studies, and thus the observed structure-function relationships are further interpreted for understanding fundamental processes, such as protein folding as well as protein interactions with small molecules and bio-macromolecules. Our findings can be used for understanding the organizational principles of biological systems, to shine light on plausible scenarios in early molecular evolution and the Origins of Life, and to develop devices of nanotechnology and biotechnology importance.



Current research includes the following topics:

- Self-organization of replication networks
- Peptide fibrils self-assembly and self-replication
- Chemical networks out of equilibrium
- Nucleic-acid-peptide interaction networks
- Protein-based functional elements in molecular electronics

SELECTED PUBLICATIONS

1. G. Ashkenasy, T. M. Hermans, S. Otto, A. F. Taylor "Systems Chemistry" *Chem. Soc. Rev.* 2017, 46, 2543-2554.
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3. J. Nanda, B. Rubinov, D. Ivnitski, R. Mukherjee, E. Shtelman, Y. Motro, Y. Miller, N. Wagner, R.C. Luria, G. Ashkenasy "Emergence of native peptide sequences in prebiotic replication networks" *Nat. Commun.* 2017, 8, 434.
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Prof. Maya Bar Sadan

Nanoparticles, Growth Mechanism and functionality, Catalysts and advanced materials

CHEMISTRY AT THE ATOMIC SCALE

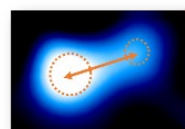
Nanostructures are born and grown to make functional structures, where specific atomic-scale features make active sites and dictate activity. Imagine that we could make every structure that we wish, just by adding atoms in a similar way to playing Tetris... We know fundamental processes and principles in chemistry that allow us to control the growth and design nanoparticles of various shapes and properties. To do that, we mainly use advanced characterization tools to understand the structure, and we test the functionality of the structures. We are interested in developing catalysts that will enable to perform clean and efficient reactions, where we produce alternative fuels using water or CO₂ and N₂ from the atmosphere.

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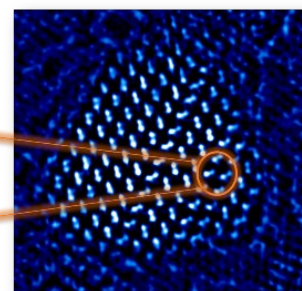
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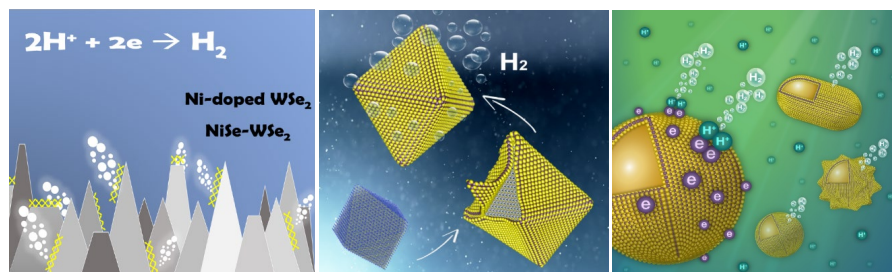
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1.4 Å – the scale of the chemical bond



CdSe@Cds



SELECTED PUBLICATIONS

1. Kadam, S. R.; Enyashin, A. N.; Houben, L.; Bar-Ziv, R.; Bar-Sadan, M., Ni-WSe₂ nanostructures as efficient catalysts for electrochemical hydrogen evolution reaction (HER) in acidic and alkaline media. *J. Mater. Chem. A* 2020, 8 (3), 1403-1416.
2. Ghosh, S.; Kadam, S. R.; Houben, L.; Bar-Ziv, R.; Bar-Sadan, M., Nickel phosphide catalysts for hydrogen generation through water reduction, ammonia-borane and borohydride hydrolysis. *Appl. Mater. Today* 2020, 20, 100693.
3. Aronovitch, E.; Houben, L.; Bar-Sadan, M., Seeded Rods with Ag and Pd Bimetallic Tips—Spontaneous Rearrangements of the Nanoalloys on the Atomic Scale. *Chem. Mater.* 2019, 31 (18), 7231-7237.
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Dr. Joshua H. Baraban

Physical chemistry, Spectroscopy

Research in the Baraban group focuses on understanding reactive species. We pursue this goal by exploring high temperature chemistry and developing spectroscopic tools to interrogate kinetics and dynamics. Novel homebuilt sources of hot molecules, creative optical systems, and other innovative experimental strategies are key to these efforts, as is close coordination with high accuracy quantum chemistry.

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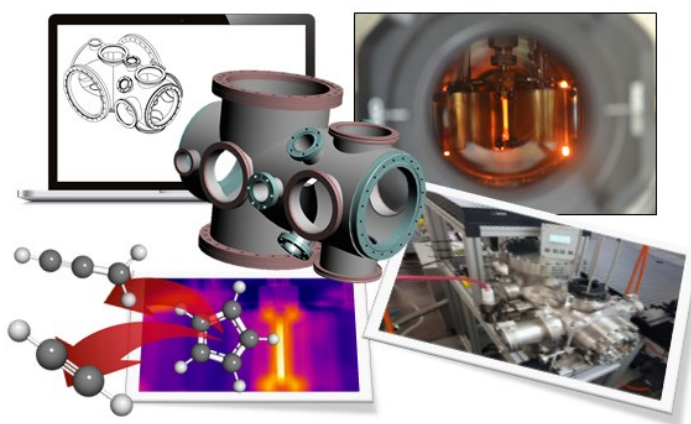
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SELECTED PUBLICATIONS

1. J. H. Baraban, P. B. Changala, G. C. Mellau, J. F. Stanton, A. J. Merer, and R. W. Field. Spectroscopic characterization of isomerization transition states. *Science*, 350(6266):1338–1342, 2015
2. J. H. Baraban, D. E. David, G. B. Ellison, and J. W. Daily. An Optically Accessible Pyrolysis Microreactor. *Review of Scientific Instruments*, 87(1):014101, 2016
3. J. H. Baraban, M.-A. Martin-Drumel, P. B. Changala, S. Eibenberger, M. Nava, D. Patterson, J. F. Stanton, G. B. Ellison, and M. C. McCarthy. The molecular structure of gauche-1,3-butadiene: Experimental establishment of non-planarity. *Angewandte Chemie International Edition*, 57:1821–1825, 2018
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Prof. Leah Gheber

Biophysical chemistry, molecular nano-motors, cytoskeleton, mitosis

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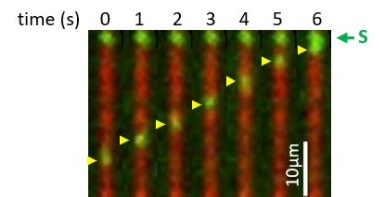
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Mitosis is a process by which duplicated genomic information is transferred from mother to daughter cells. This essential process is accomplished by the spindle, a highly dynamic, microtubule-based structure, which in each mitotic cycle, undergoes a well-programmed set of morphological changes. Compromised spindle integrity is one of the key factors for chromosome mis-segregation, which in turn may lead to genetic disease, cell death and cancer. Recent evidence indicates that molecular nano-motors from the Kinesin superfamily, which bind and move along microtubules, play central roles in mediating spindle dynamics. Our research focuses on the Kinesin-5 mitotic motor proteins, whose function is essential for chromosome segregation during mitosis. Our objective is to explore the mechanisms by which Kinesin-5 motors perform their multiple mitotic functions by combining biophysical, biochemical, cell biology and genetics approaches such as single-molecule fluorescence motility assays and live-cell microscopy. Until recently, Kinesin-5 motors were believed to perform their essential mitotic functions as plus-end directed motors. However, we have shown that the *Saccharomyces cerevisiae* Kinesin-5 homologs Cin8 and Kip1 are bi-directional motors. In our current and future research, we aim to examine the structural and regulatory mechanisms that control the switchable directionality of Kinesin-5 motors *in vivo* and *in vitro*.

Time-lapse sequence of a single kinesin-5 molecule (green, arrowhead) moving on a polarity-marked microtubule (red). S – green seed indicating the minus end of the microtubule, from bottom to top. Bar – 10 μm ; time (s) is indicated on top.



SELECTED PUBLICATIONS

1. O. Shapira and L. Gheber (2016) Motile properties of the bi-directional kinesin-5 Cin8 are affected by phosphorylation in its motor domain. *Scientific Reports* 6:25597
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3. A. Goldstein, N. Siegler, D. Goldman, H. Judah, E. Valk, M. Kõivomägi, M. Loog, and L. Gheber (2017) Three Cdk1 sites in the kinesin-5 Cin8 catalytic domain coordinate motor localization and activity during anaphase. *Cellular and Molecular Life Sciences* 74(18):3395-3412
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<https://www.biorxiv.org/content/10.1101/2020.01.24.918714v1>



Prof. Yonatan Dubi

Theoretical nano-science

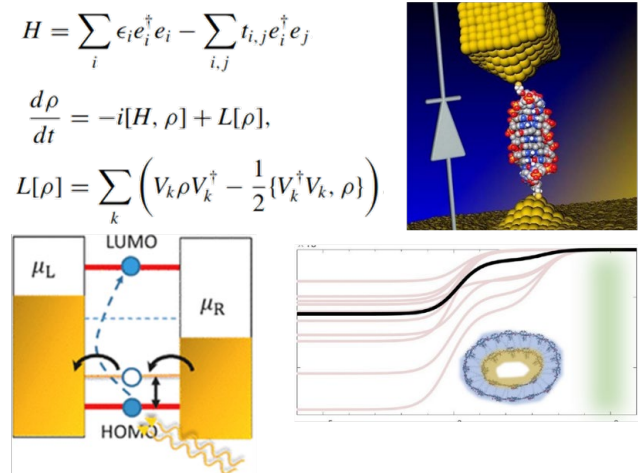
Research in the Dubi group is devoted to the theoretical study of charge and energy transport in nano-scale systems such as single-molecule junctions, self-assembled monolayers, nanoparticles, DNA-based structures, exciton networks and more. Such processes are relevant to a wide variety of physical and chemical phenomena, ranging from nanoscale photo-catalysis, through molecular magnetism to quantum biology. The group develops both models and theoretical tools needed to address the problems, including a wide variety of numerical and analytical methods.

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SELECTED PUBLICATIONS

1. E. Zerah-Harush & Y. Dubi, Do photosynthetic systems use quantum coherence to enhance their efficiency? Probably not. *Science advances*, in press.
2. Y. Sivan, J. Baraban, I. W. Un & Y. Dubi, Thermal effects - an alternative mechanism for plasmonic-assisted photo-catalysis, *Chem. Sci.*, 2020, 11, 5017-5027
3. Y. Dubi & Y. Sivan, "Hot" electrons in metallic nanostructures - no -thermal carriers or heating? *Nature Light: Science & Applications* 8, Article number: 89 (2019)
4. Elinor Zerah-Harush and Yonatan Dubi, Universal Origin for Environment-Assisted Quantum Transport in Exciton Transfer Networks, *J. Phys. Chem. Lett.* 2018, 9, 7, 1689-169.
5. J. Zhou, K. Wang, B. Xu & Yonatan Dubi, Photoconductance from Exciton Binding in Molecular Junctions, *J. Am. Chem. Soc.*, 140 (1), pp 70-73 (2018).
6. C. Guo, K. Wang, E. Zerah-Harush, J. Hamill, B. Wang, Y. Dubi and B. Xu, Molecular rectifier composed of DNA with high rectification ratio enabled by intercalation, *Nature Chemistry* 8, 484-490 (2016)



Prof. Idan Hod

Hybrid Materials for Sustainable Energy

In a world that is running out of natural resources, there is a growing need to design and develop sustainable and green energy resources. In that respect, photo-electrocatalytically driven reactions to produce alternative fuels (such as water splitting or CO₂ reduction) hold the potential to provide a route for future carbon neutral energy economy. Nevertheless, the slow kinetics of those catalytic reactions demands the development of efficient catalysts in order to drive it at lower overpotentials.

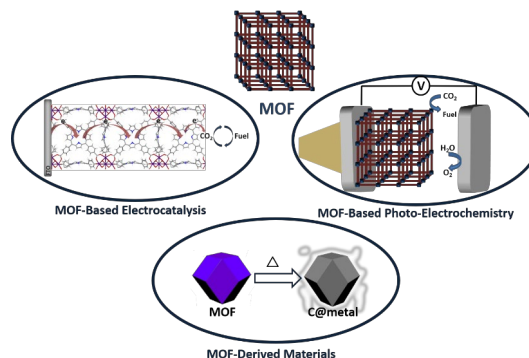
Our group utilizes Metal-Organic Frameworks (MOFs) as a platform for heterogenizing molecular electrocatalysts. Their unique properties (porosity and flexible chemical functionality) enable us to use MOFs for integrating all the different functional elements needed for efficient catalysts: 1) immobilization of molecular catalysts, 2) electron transport elements, 3) mass transport channels, and 4) modulation of catalyst secondary environment. Thus, in essence, MOFs could possess all of the functional ingredients of a catalytic enzyme.

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SELECTED PUBLICATIONS

1. He, W.; Liberman, I.; Rozenberg, I.; Ifraemov, R.; Hod, I.; "Electrochemically Driven Cation Exchange Enables the Rational Design of Active CO₂ Reduction Electrocatalysts", *Angewandte Chemie*, 2020, 132, 2 – 10.
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5. He, W.; Ifraemov, R.; Raslin, A.; Hod, I.; "Room-Temperature Electrochemical Conversion of Metal-Organic Frameworks into Porous Amorphous Metal Sulfides with Tailored Composition and Hydrogen Evolution Activity", *Advanced Functional Materials*, 2018, 28, 1870121.



Prof. Raz Jelinek

Nanotechnology, Biophysical Chemistry, Two-dimensional nanostructures, Biomimetic cellular membranes

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The research carried out in the laboratory of Dr. R. Jelinek aims at exploiting biomimetic chemistry approaches for both understanding important biological processes, as well as developing novel nanostructures. The inspiration and focus of the Jelinek laboratory has been the cellular membrane. In particular, Prof. Jelinek has introduced unique chromatic lipid/polymer molecular assemblies, including small vesicles, giant vesicles, Langmuir monolayers, and polymer-labelled cells, which both mimic cellular membranes as well as provide convenient biosensing platforms. These systems have been shown to exhibit wide-ranging scientific and biotechnological applications based upon the interconnection between the biomimetic surface [the lipid assembly] and the colorimetric/fluorescent reporter [the polymer domains]. Recently, The Jelinek laboratory has discovered new "lithography-less" approaches for construction of two-dimension nanostructures, utilizing biomimetic lipid templates at the air/water interface.

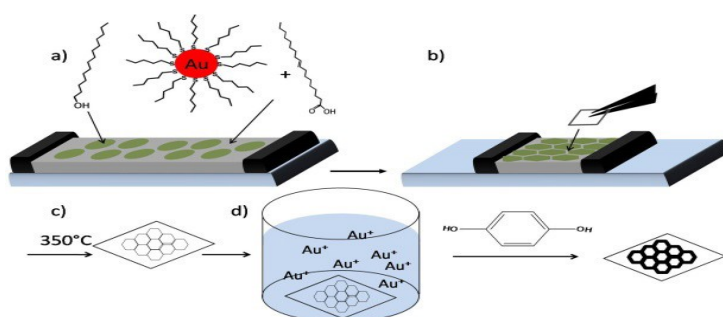


Figure: Self-assembled Au nanoparticle electrodes at the air/water interface

SELECTED PUBLICATIONS

1. "Solar-Mediated Oil-Spill Cleanup by a Carbon Dot-Polyurethane Sponge", Seema Singh, Raz Jelinek, *Carbon*, 2020, 160, 196-203.
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3. "Polydiacetylene-peryleneimide supercapacitor", Amrita De Adhikari, Ahud Morag, Joonsik Seo, Jong-Man Kim, Raz Jelinek, *ChemSusChem*, 2020, 13, 3230 – 3236.
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5. "Porous graphene oxide-metal ion composite for selective sensing of organophosphate gases", Nitzan Shauloff, Nagappa Teradal, Raz Jelinek, *ACS Sensors*, 2020, 5, 1573-1581.



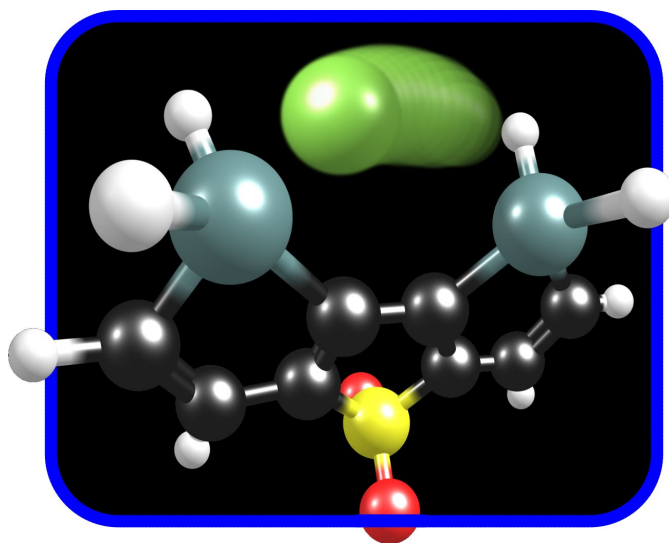
Prof. Sebastian Kozuch

Computational Chemistry

Chemistry from a Computational Perspective

Computational chemistry is an increasingly powerful tool to understand chemical reactions. In our group we use quantum chemistry tools to understand and predict molecular effects mainly on three areas:

1. Homogeneous catalysis through mechanistic and kinetic modeling.
2. The nature of hole interactions and other novel types of chemical bonds.
3. Quantum mechanical tunneling reactions.



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SELECTED PUBLICATIONS

1. Switch Chemistry at Cryogenic Conditions: Quantum Tunnelling under Electric Fields" Kirshenboim; Frenklah; Kozuch; DOI: 10.1039/D0SC06295B
2. "Isotope-Controlled Selectivity by Quantum Tunneling: Hydrogen Migration versus Ring Expansion in Cyclopropylmethylcarbenes" Nandi; Gerbig; Schreiner; Borden; Kozuch; *J. Am. Chem. Soc.* 2017, 139, 9097
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8. "How to Conceptualize Catalytic Cycles? The Energetic Span Model" Kozuch; Shaik; *Acc. Chem. Res.* 2011, 44, 101-110.



Prof. N. Gabriel Lemcoff

Organometallic Chemistry, Polymers, Organic Chemistry

Synthesis, Characterization, Properties and Development of Novel Catalysts and Polymers

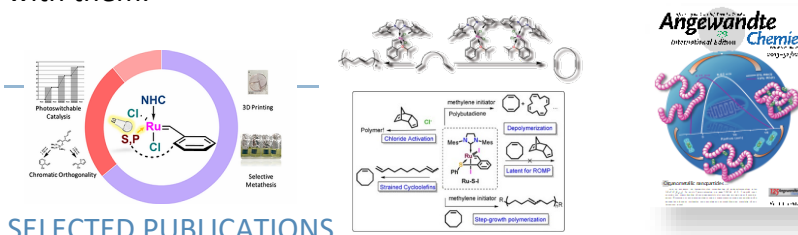
The advancement of polymer science embraces the invention of molecular constructs that provide functional applications. As a result, the development of novel methodologies for the production of polymers and complex macromolecular architectures and the design of new catalysts stand out as appealing goals enthusiastically pursued by the chemical community. Our group's research is mainly devoted to the synthesis, characterization, development and analysis of new catalysts and novel macromolecular compounds. We are especially very interested in the development of latent ruthenium olefin metathesis catalysts. Our achievements in the area were the synthesis of the first thermoswitchable, as well as photoswitchable olefin metathesis systems. Another recent area of research in our group is the development of "organometallic nanoparticles". These macromolecular constructs are prepared by catching metals with pi-electron rich polymers; inducing single-chain collapse that leads to well-defined hybrid nanoparticles. Our growing expertise in the area of light induced catalysis has led us to develop methodologies to produce 3D-printed structures of extremely robust polymers. In the group we have today the expertise to fully characterize both the special catalysts we develop and the novel materials that we produce with them.

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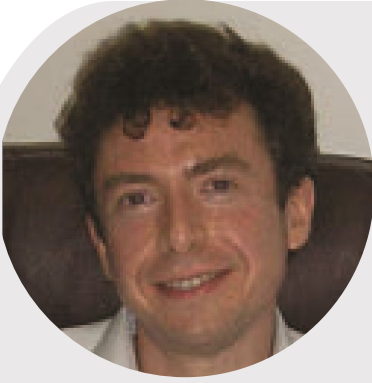
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Prof. David Lukatsky

Theoretical Biophysical Chemistry, Biophysics
Design principles of protein-protein recognition,
promiscuity and plasticity versus specificity

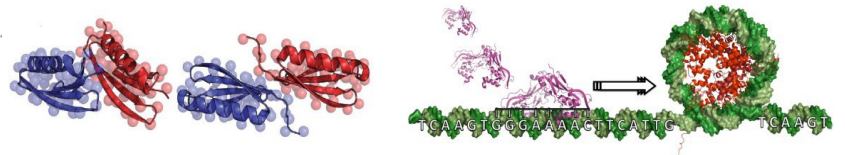
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The main focus of the research activity of the Dr. Lukatsky's laboratory is the problem of specificity and design principles of protein-protein and protein-DNA interactions, and principles of biomolecular recognition in general. The main finding of the last academic year was the discovery of the genetic code for nonspecific protein-DNA interactions. In particular, we predicted that genomic DNA of eukaryotic organisms encodes its intrinsic propensity for nonspecific binding to transcription factors (TFs), and other DNA-binding proteins. Using extensive bioinformatics analysis, we verified that the predicted effect is operational in the yeast *S. cerevisiae* genome. We showed that nonspecific protein-DNA binding significantly influences TF-DNA binding preferences and nucleosome occupancy in yeast. We are currently analyzing the consequences of the predicted effect in the worm and fly genomes.



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Prof. Michael M. Meijler

Synthetic Bioorganic Chemistry, Chemical Biology, Quorum Sensing

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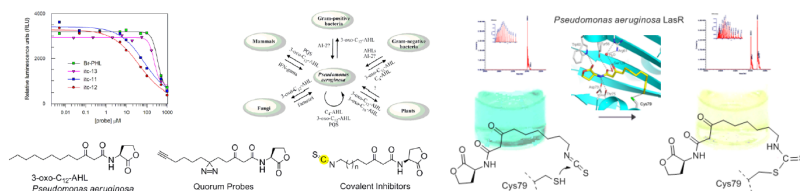
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Bacterial Intra- and Interspecies Communication

Quorum Sensing: An important focus of our research is the study of bacterial intra- and interspecies signaling molecules. Cell-to-cell communication is used by single-cell organisms to coordinate their behavior and function in such a way that they can adapt to changing environments and possibly compete with multicellular organisms. Chemical communication amongst bacteria has been termed “quorum sensing” (QS). Examples of QS-controlled behaviors are biofilm formation, virulence factor expression, antibiotic production and bioluminescence. These processes are beneficial to a bacterial population only when they are carried out in a coordinated fashion. Quorum sensing systems exist in both gram-positive and -negative bacteria and a variety of oligopeptides and *N*-acylhomoserine lactones have been identified as QS molecules. We aim to clarify the role of various QS molecules in bacterial signaling through synthesis and evaluation of QS molecules and potential antagonists and we have developed methodologies to study a wide variety of newly discovered and undiscovered QS molecules.



Bacterial-Eukaryotic Interkingdom Signaling: Recent reports have shown that several QS molecules can also have a direct effect on eukaryotes. My group currently examines the hypothesis that diverse eukaryotic species have developed mechanisms to react to the presence of specific bacterial QS molecules in a receptor mediated fashion, with focused experiments that are designed to provide greater insight into the primary molecular mechanism of QS molecule induced effects on mammals, fungi and nematodes.

SELECTED PUBLICATIONS

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5. R. Gregor, S. David, M. M. Meijler: Chemical strategies to unravel bacterial-eukaryotic signaling Chem. Soc. Rev., 47(5), 1761-1772, 2018



Dr. Anat Milo

Physical Organic Chemistry, Catalyst design, Selectivity, Stereochemistry

From energy conversion, through the production of polymers and materials, to the synthesis of natural products, pharmaceuticals, and fine-chemicals – catalysts have been key to advancing our modern lifestyle. However, most industrial catalytic processes rely on toxic, expensive metals that have to be rigorously removed from the products. Organocatalysis offers a greener alternative, but often requires high catalyst loading, suffers from reproducibility issues, and is tailored for a limited range of substrates. To overcome these limitations and unlock organocatalysts' full potential, it is necessary to uncover the structural origin of their reactivity and selectivity, thereby providing a knowledge-driven approach to their design and optimization.

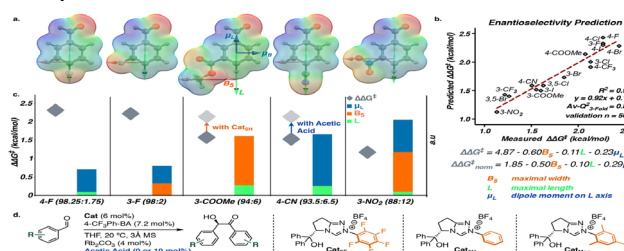
My research group synergistically integrates experimental, computational, and statistical methods to design and construct modular catalyst libraries and provide a powerful strategy for discovering and optimizing selective catalytic reactions. To this end, we experimentally introduce transient directing groups by forming orthogonal bonds. These directing groups serve to control and tune the secondary-sphere interactions between the organocatalyst and substrates or intermediates in the rate- and product-determining transition state(s). Modifying a catalyst structure *in situ* is challenging due to the required orthogonality between the binding mode and catalytic activity. Nonetheless, this approach is appealing as it can uncover general molecular design principles for the facile introduction of highly modular selectivity- and reactivity-controlling handles to a variety of catalytic systems.

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Prof. Yifat Miller

Computational Biophysical Chemistry, Computational Physical Chemistry

Our research activity mainly focuses in self-assembly of amyloids – proteins that are related to type 2 diabetes, Alzheimer's disease, and Parkinson's disease. Our computational laboratory conducts fundamental and applied research at the interface of computational structural biology, biomaterial, and bio-nanotechnology, with the goal to better understanding of biophysicochemical interactions in the self-assembly of peptides for practical applications in biomaterials and medicine.

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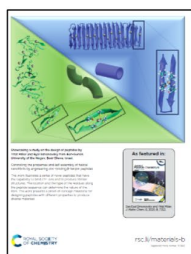
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Our main research interests:

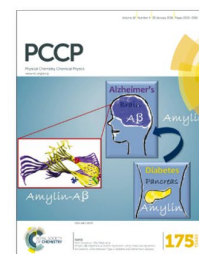
1. Molecular mechanisms of amyloid plaques formations in Alzheimer's disease, Parkinson's disease and type 2 diabetes.
2. Link between type 2 diabetes and neurodegenerative diseases.
3. Effect of metals on type 2 diabetes and neurodegenerative diseases.
4. Investigating inhibitors for amyloid plaques: Prevention and treatment for neurodegenerative diseases.
5. *In silico* design of novel self-assembling peptides for nanotechnology applications.



Controlling the properties and self-assembly of helical nanofibrils by engineering zinc-binding β -hairpin peptides
Simonovsky et al. *J. Mater. Chem. B* 2020



Mechanistic perspective and functional activity of insulin in Amylin aggregation
Baram et al. *Chem. Sci.* 2018



Link between type 2 diabetes and Alzheimer's disease
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Prof. Taleb Mokari

Nanochemistry, Nanomaterials, Photovoltaics, Renewable Energy

Synthesis, characterization and application of nanostructures

The primary focus of our research activity is development of novel nanostructures for optical, electrical, biological and energy application. Our Laboratory studies the science of optimally preparing and characterizing metal, semiconductor, magnetic, insulating inorganic nanostructures, and multi-component nanostructures with various interfaces, including nanocrystals, nanotubes and nanowires with controlled size, shape, and composition. The synthesis of 1-dimensional nanostructures is conducted by gas- and solution-phase, where we develop our own approaches to achieve new nanomaterials and a better control of the synthesis parameters. The research encompasses the design and synthesis of precursors, the study of microscopic elementary processes in nanostructure nucleation and growth, and the use of nanostructures in functional, multi-component devices.

The applications our group focuses on are catalysis and solar energy conversion USING nanomaterial composite systems. As catalysts, nanomaterials could improve product selectivity, thereby reducing chemical waste and produce cleaner fuels. As energy conversion materials, they could lower the final cost per kWh to the end user. From precursor design to impact on the environment, we examine the possible contributions nanomaterials could have on our world.

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SELECTED PUBLICATIONS

1. Habas, S. E.; Yang, P.; Mokari, T. "Selective Growth of Metal and Binary Metal Tips on CdS Nanorods" *J. Am. Chem. Soc.*, 2008, 130, 3294.
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Prof. Eyal Nir

Biophysical Chemistry, Experimental Chemical Physics

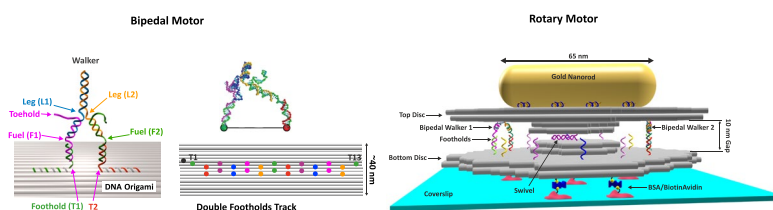
Our group specializes in developing DNA based molecular machines. We have utilized DNA nanotechnology, novel microfluidics technology, and single-molecule light microscopy to progressively improve the performance of externally controlled DNA bipedal linear and rotary motors. Our motors are driven forward by hybridization and dehybridization of the walker legs with DNA 'fuel' and 'antifuel' command strands provided by a computer-controlled microfluidics device on an asymmetric DNA track imbedded in a DNA origami platform. Our decade long efforts led to ~4 orders of magnitude improvement in motor performance, defined as the product of motor yields and speed. Our research includes developing single-molecule microscopy methods, such as FRET and imaging defocused scattered light, and novel usage of microfluidics device that enables computer controlled of the molecular machines. These externally controlled molecular motors are steps towards autonomous molecular motors and machines.

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SELECTED PUBLICATIONS

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Dr. Benjamin A. Palmer

Organic biomineralization and bio-inspired optical materials

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Many animals use crystals of small organic molecules to manipulate light. For example, crystals of the nucleotide base guanine are used to produce the silvery reflectance of fish, the tunable iridescent colors of chameleons and crustaceans and image-forming mirrors in animal eyes (Fig. 1). These organisms exert exquisite control over the shape and size of the constituent crystals, utilizing crystallization strategies far beyond the capabilities of solid-state chemistry.

The Palmer lab sits at the interface between solid-state chemistry, photonics and cell biology. Our aim is to uncover the crystallization 'tricks' which organisms use to produce biological optical materials, revealing new synthetic methods for the design of organic materials. We have three main research directions: (i) the discovery and characterization of new organic bio-crystals in animals, (ii) mechanisms of biologically controlled crystallization and (iii) bio-inspired crystallization of novel organic optical materials. We utilize a raft of physical characterization techniques to explore these problems including cryo-electron microscopy (Fig. 1), optical microscopy, X-ray and electron diffraction.

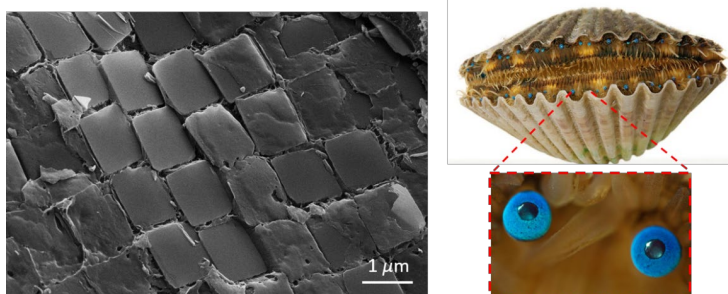


Figure 1. Cryo-SEM micrograph of the image-forming mirror in the eyes of scallops, formed from square guanine crystals (left). The scallop *Pecten maximus* with hundreds of iridescent eyes lining the mantle tissue.

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Prof. Doron Pappo

Synthetic Organic Chemistry

Organisms Synthetic Methodologies

The research in the Pappo group focuses on the design and development of novel redox C–H functionalization catalytic systems based on earth abundant metals. Our main aim is to offer a strategy to synthesize a vast array of complex arene-based materials that exist in many pharmaceuticals and natural products and used in catalysis in a direct manner, starting from simple and available starting materials.

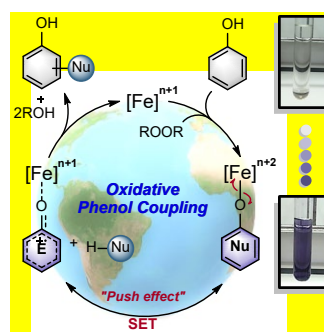
Number of iron, cobalt, manganese and copper catalysts that bring together two arene, arenol or aniline units in a single step were developed. By adopting a mechanistic oriented approach, the chemoselectivity, regioselectivity and stereoselectivity in these sustainable transformations were controlled. Therefore, by selecting one catalytic system over another, a given pair of substrates can lead to different coupling products and hence to unlimited possibilities.

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SELECTED PUBLICATIONS

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Prof. Ehud Pines

Physical chemistry, experimental chemical physics, biophysical chemistry

Water chemistry is the essence of Life on Earth and acid-base chemistry is one of the most fundamental chemical processes in nature. Combining the two has made one of the most important and enduring questions in chemistry and biology continuously puzzling experts and laymen alike. Prof. Pines has made remarkable progress in this continuously demanding and highly competitive research field with a bottom-up strategy and with an attitude of a long-distance runner: he has studied the fundamentals of proton solvation and proton transfer from a mechanistic point of view using novel experimental techniques, each time incrementally increasing our knowledge of these very complex and convoluted processes. In 2003 Prof. Pines teamed up with Dr. Erik Nibbering from the Max-Born Institute in Berlin and conducted several ground-breaking experiments in acid-base chemistry. The study heavily relied on research done in Pines Labs for the past 15 years and utilized the much-improved experimental setup at MBI for measuring vibrational spectroscopy with ultra-short laser pulses. The early stage of the study was published in the prestigious Science magazine and was chosen by the Chemical and Engineering News journal in its end-of-the-year issue as one of the 3 most important papers in physical chemistry appearing in 2003. Improving on this early observation a second publication in Science in 2005 revealed for the first time the spectroscopic signature of the solvated proton in the IR region with extremely high time-resolution. Using novel experimental techniques, hydrogen ions could be “captured in the act” in the form of H_3O^+ while being transmitted from acid to base by water molecules in a sequential fashion. This important finding may well become relevant for technological applications, e.g., in fuel cells. Prof. Pines has advanced on these ground-breaking experimental observations and published a generalized model for acid-base reaction in aqueous solutions. The model extends the classic kinetic model for acid-base reactions in solution which successfully served the chemistry community for the past 60 years. He also investigates proton solvation by water, hydrogen bonding interactions and the mechanism by which water transfer the proton, the so called Grotthuss mechanism.

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SELECTED PUBLICATIONS

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Prof. Menny Shalom

Materials Science, Supramolecular Chemistry,
Photoelectrochemistry

One of the promising technologies for future alternative energy sources is the direct conversion of sunlight into chemical or electrical energy by using photocatalysis or photoelectrochemical cells (PEC), respectively. The greatest challenge in these fields is to develop new types of advanced materials with the desired electrical and optical properties that will replace the conventional raw materials that are currently used. Although in the last years a significant progress has been made, it is still an essential task to find efficient and low-cost materials as photoactive materials and co-catalysts. More importantly, it is necessary to gain a basic understanding of the physical properties and the fundamental operation mechanisms in this field.

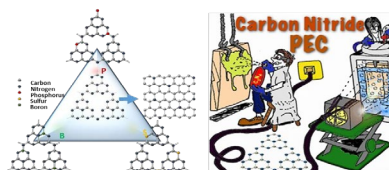
Our group develops new methods to synthesize metal-free materials and earth-abundant metal-containing materials with welldefined structure and properties toward their utilization in energy-related applications such as photo- and electro-catalysis. Our focus is the synthesis of materials appropriate for utilization in solar-to-fuel conversion reactions.

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SELECTED PUBLICATIONS

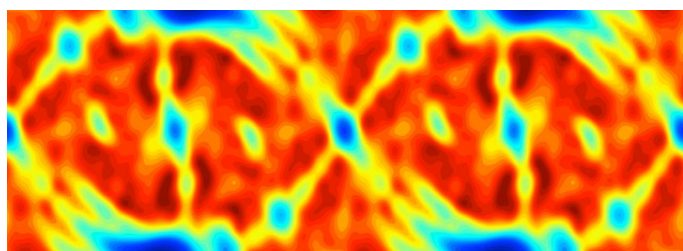
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Prof. Amichay Vardi

Quantum Dynamics and Thermodynamics

We theoretically study the dynamics of many-body quantum systems, focusing on fundamental questions concerning the emergence of irreversible macroscopic thermodynamics from the reversible microscopic quantum dynamics of isolated systems. We aim to construct minimal models for demonstrating quantum ergodization, thermalization and many-body localization and to establish the role of dynamical chaos in mesoscopic thermodynamics and quantum control. Recent research achievements include the study of adiabatic passage through chaos and the discovery of quantum detours around it, the suggestion of probabilistic hysteresis in isolated Bose-Hubbard models, the observation of prethermalization in an array of subsystems exhibiting negative specific heat, and the development of semiclassical methods for characterization of many-body localization. Notable past results include the discovery of anisotropic solitons in Bose-Einstein condensates of dipolar particles, the stabilization of coherent matter-wave states in driven atom interferometers via a Kapitza inverted pendulum effect and a many-body quantum Zeno effect, the optimization of atom interferometry below the standard quantum limit, phase-space tomography via temporal fluctuations, the discovery of interferometric signatures of chaos in bosonic Josephson junctions, the discovery of incoherent matter-wave solitons, and the proposal of Bose-enhanced chemistry.



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SELECTED PUBLICATIONS

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Prof. Ira A. Weinstock

Metal-oxygen clusters, inorganic reaction mechanisms, supramolecular chemistry, nanoscience

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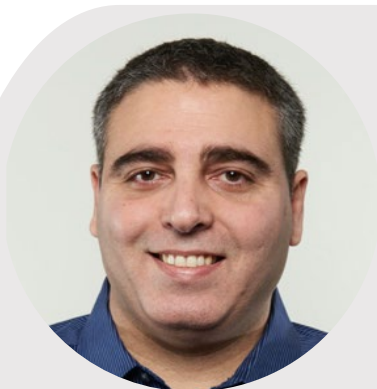
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Metal-oxide cluster science

Numerous intellectually substantive phenomena and societally important issues can be addressed using metal-oxygen cluster anions (polyoxometalates, or POMs), and much of Weinstock's work involves their use as physicochemical probes of molecular processes and as well-defined components of supramolecular and nano-scale assemblies. Many POMs possess extensive and reversible redox chemistries, and as a class, their compositions and structures, which control the physicochemical properties that impart functionality, can be rationally modified at the atomic level. Functional systems are prepared through incorporation of reactive elements, such as additional transition-metal ions, by control over the nanoscale metal-oxide architectures of larger POM frameworks, and by use of POM clusters as components of supramolecular and nanoscale assemblies. In this context, Weinstock's work addresses topics in three areas: 1) inorganic synthesis and reaction mechanisms (including electron transfer), 2) supramolecular chemistry, and 3) nanoscience. Small one-electron reduced heteropolyanions, are used to investigate fundamental steps in the reduction of O₂ in water. The findings suggest that concerted proton-electron transfer (CPET) pathways, with the hydronium ion as the proton donor, may prove a general feature of sufficiently endergonic reductions of O₂ by otherwise "outer-sphere" complexes (or electrode reactions) at sufficiently low pH values in water. In supramolecular chemistry, a porous and water-soluble oxomolybdate macro-ion is used to address fundamental issues pertinent to host/guest and supramolecular chemistry: 1) the size-restricted passage of molecules through subnanometer-scale apertures of open-framework structures, 2) hydrophobically and H-bond driven self-assembly, and 3) catalysis in nanoconfined domains. In nanoscience, metal oxide cluster-anions form monolayers on planar surfaces, stabilize metal nanoparticles in solution, and serve as structural components of hollow, single walled vesicles. Until recently, each of these classes of superstructures was viewed as fundamentally distinct. Moreover, electrostatically stabilized POM ligands shells are being used to design entirely new types of protecting-shell structures that rationally control the assembly and reactions of gold nanoparticles in water.

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Prof. Yossi Weizmann

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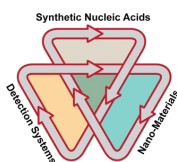
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Research in the Weizmann group is based on a multidisciplinary field interfacing biology, chemistry, nanotechnology, and materials science. This exciting frontier offers unparalleled opportunities for designing groundbreaking advances in medical diagnostics and research platforms. My research is concerned with the application of plasmonic nanoparticles and nucleic acids with the aim of exploring and exploiting nanoscale advantages in the world of material chemistry, to address significant chemical, biochemical, and technological problems. By approaching nanoscience from a multidisciplinary perspective, integrating biomaterials, inorganic materials, and small molecules via noncovalent and covalent interactions, we can develop new hybrid materials with emergent properties.

Specific Research Topics:

- DNA Nanotechnology: Design and applications of novel complex molecular topologies using nucleic acids and their biological consequences.
- Construction and characterization of novel RNA-based self-assemblies for biomedical applications.
- Synthesis, purification, and functionalization of colloidal nanoparticles for studies relating to plasmonics, polymers, and biomedical applications.
- Design and development of light-based programmable nucleic acid amplification methods for real-time bioassays using photothermal nanoparticles.



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