One of the fundamental, unique traits of the human race is the immense curiosity inherent in our drive to explore, discover and invent. It is this trait that explains the success of humans in adapting to life in extreme conditions, combatting disease, increasing our lifespan and rapidly accumulating knowledge, all the while altering our societies and changing our environment. The Weizmann Institute was established to expand the limits of science for the benefit of humanity, its foundation arising from an understanding of the fundamental impact of science as the fountainhead from which the river of progress and wellbeing flows. Curiosity-driven research is the essential link – the shared core values of the Weizmann Institute and those of ERC. This is, indeed, research that aims for the blue sky, reaching beyond visible or tangible targets. By searching for the unknown, such research leads to unforeseen discoveries on the nature of the universe, the formation and destruction of stars, the secrets of life and the causes of human disease. Since its inception, 10 years ago, the ERC program has made a truly significant impact on research in Europe, in general, and on the Weizmann Institute in particular. Today it is hard to imagine science without the ERC. With its generous funding, the ERC has enabled 96 Weizmann scientists at all stages of their careers to take considerable risks and embark on extensive journeys that, for all of the perils, have more than once resulted in substantial rewards that would not have been attainable otherwise.

History demonstrates that the pursuit of fundamental knowledge can often lead to material gains in the form of translatable ideas, discoveries and inventions that are exploited for direct human benefit. The supplementary support introduced through the ERC Proof of Concept program provides a novel model – one that we hope other funding agencies will adopt – in which the translation of discoveries is promoted, but not at the expense of the core science.

On behalf of the Weizmann Institute, we congratulate the ERC for the first 10 years of outstanding support of the quest for knowledge.

Prof. Michal Neeman
Vice President
Weizmann Institute of Science
The outer surfaces of leaves and petals are covered in a protective polymer – cutin – that is the plant’s main interface with the air. Prof. Aharoni and his colleagues discovered that when an enzyme called Defective in Cuticular Ridges (DCR) is silenced, spaghetti-like structures on the petals’ surface – cuticular ridges (seen in the left-hand images) – did not appear (right-hand images). Images were obtained by scanning electron microscopy.

The warping of the accretion disk by the stars changes the average orientation of the disk in a random way (blue point, its trajectory the light blue line). This affects the spin axis of the massive black hole in the center by the frame-dragging effect of Einstein’s theory of general relativity. As a result, the spin axis of the black hole tries to “catch up” with the orientation of the disk (red point, trajectory traced by the magenta line). Prof. Alexander and his colleagues showed this cosmic game of “tag” may explain why strong radio jets emitted by massive black holes into the empty space between galaxies along their spin axes are sometimes observed to have kinks and bends.

The Arabidopsis DCR encoding a soluble b-HAD acyltransferase is required for cutin polyester formation and seed hydration properties. Plant Physiology

THE ARABIDOPSIS DCR ENCODING A SOLUBLE b-HAD ACYLTRANSFERASE IS REQUIRED FOR CUTIN POLYESTER FORMATION AND SEED HYDRATION PROPERTIES. Plant Physiology

THE TORQUING OF CIRCUMNUCLEAR ACCRETION DISKS BY STARS AND THE EVOLUTION OF MASSIVE BLACK HOLES IN GALACTIC NUCLEI. Astrophysical Journal

MetKnock | Precise and non-GMO engineering of nutritional factors for breeding high quality crops

FDP-MBH | Fundamental dynamical processes near massive black holes in galactic nuclei

Prof. Asaph Aharoni
PROF. ASAPH ACHARONI

Prof. Tal Alexander
PROF. TAL ALEXANDER
In the course of evolution, different traits undergo optimization that ultimately determines the chances of survival. A single trait, such as beak shape, head width or body mass, may be best suited to performing one task, but not another. Prof. Alon and his colleagues looked at the trade-off that natural selection imposes between multiple traits, each of which is best suited to a particular task. These trade-offs, represented here by the light-blue shaded triangles, were found to obey the Pareto front concept, which describes the most efficient allocation of resources in economics and engineering.
The sperm, originally clumped in bundles, are split apart from the head to the tail by the passage of the individualization complex (bright yellow). The motion of this molecular machine is made possible by caspases, the executioner enzymes of the cell death program, which help to break down the cytoskeleton holding the sperm cells together. Prof. Arama and his colleagues have discovered the mechanism that keeps the caspases in check. It includes the A-S-beta protein (green) on the surface of energy-producing organelles, the mitochondria, in the adult fruit fly. The A-S-beta activates ubiquitin complexes which, in turn, activate the caspases. Only those caspases that have come into physical contact with the ubiquitin complexes become activated. This mechanism ensures that the caspases are not activated all at once, which would kill the sperm or cause unwanted damage.

At one point in the process of cell division, before it splits in two, the cell has double the amount of genes. Since replication is not synchronous, this doubling could lead to an imbalance in the expression of early vs. late expressing genes, with possibly deleterious consequences. Prof. Barkai and her colleagues discovered that in budding yeast a chemical tag deposited on replicated DNA helps prevent their activation. The graph shows this process over time: In yeast lacking the tag, messenger RNA peaks along with DNA synthesis.
During the past decade, topological classification has revolutionized our conception of the properties of materials. Topological materials host exotic electronic states on their surfaces. Dr. Beidenkopf and his colleagues have studied the surface of the topological Weyl semimetal tantalum arsenide using scanning tunneling microscopy. Among various trivial surface states, the scientists visualized and characterized the unique properties of the topological Fermi-arc states. The researchers achieved this visualization through the interference patterns of quasiparticles (purple and white) that scattered electrons embed.
Resilient encoding proofs are highly useful for cloud computing. Prof. Dinur and her colleagues described the encoding of proofs (PCPs) that are very resilient. These proofs are probabilistically checkable by looking at a constant number of locations; for example, when performing a complex bank transaction on a cell phone, the server may check its integrity relatively quickly using a PCP. A key idea is to break a proof to pieces in a redundant way and then use a recursive encoding on each piece, as shown in the figure.

Imaging of very small objects as nanocrystals, viruses or single molecules is a challenge in many research fields. Obtaining very high resolution images in optical imaging is limited by the wavelength of light, while x-ray imaging presents challenges in the reconstruction of the structure from the scattering of the rays. Prof. Dudovich, working with Profs. Dan Oron and Boaz Nadler attained a breakthrough that enables one to reconstruct an object’s shape from a single photo.
After dieting, the weight of many people rebounds. Worse, still, they usually gain more weight with each dieting cycle. Dr. Elinav and Prof. Eran Segal, together with colleagues, discovered that the gut microbiome plays an unexpectedly important role in exacerbated post-dieting weight gain, and that this common phenomenon may in the future be prevented or treated by altering the microbiome. In the figure, the curves (from black to green) show the increased obesity of mice with each repeated dieting-weight regain cycle.

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Dr. Erez and her colleagues discovered that an enzyme called Ass1, which plays a role in the body's urea cycle, is downregulated in the intestines in villi when they proliferate. In the study, they found that this downregulation may also be used by cancer cells to proliferate. In the image, Ass1 appears in green dots in the intestine of a genetically engineered mouse.

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How does a cell know how large it is and how much more it needs to grow? Prof. Fainzilber and his colleagues found a mechanism that helps large cell types “measure” their length and size with molecular motors that travel up and down microtubule structures. Their experiments showed that the mechanism requires a nuclear import factor that colocalizes with the motor (colocalization shown by the red dot).

This snapshot from a dynamic model captures the three subunits of a protein called laminin (blue, gray and purple) as they wrap around one another to form the spine of the protein. Laminin is a fibrous protein that helps give structure to the extracellular matrix surrounding and supporting our cells. To create the dynamic model, Prof. Fass, Gad Armony and their colleagues introduced chemical cross-links (magenta and green) that revealed which parts of the structure are close to one another.
Dr. Ofer Firstenberg is developing experiments in which photons – particles of light that do not normally interact – are coupled to atoms and thus interact strongly. The illustration depicts new phenomena that may arise from these experiments, for example, the crystallization of light. As well, it may lead to such applications as all-optical logic-gates for quantum networks.

Proteins found on the outer surfaces of bacteria, viruses and parasites can serve as vaccines for preventing or blocking infection. But these proteins are often unstable, and their production is sometimes extremely costly. Using an algorithm they developed, Dr. Fleishman and his colleagues modified a protein from the surface of the malaria parasite. On its 3D structure, the modified spots are marked by orange spheres. The altered protein is resistant to heat and can be produced simply and cheaply.
An exploding star detected in a nearby galaxy just three hours into the process provided Prof. Gal-Yam and his colleagues working with the Palomar Transient Factory a unique opportunity for studying how supernovae form. The Keck Telescope in Hawaii provided the optical spectra of the material thrown into space, which told the story of a star that was already unstable at least a year prior to the big explosion, and this yielded new clues to the steps leading up to the formation of core-collapse supernovae.

"Super signals" in metabolic MRI. Prof. Frydman and his colleagues rely on a method known as dissolution Dynamic Nuclear Polarization (dDNP), in which a cryogenic pellet containing a chemical of interest is hyperpolarized and then injected at room temperature into a body to monitor cancer and other physiological processes. Ultrafast spectroscopic imaging methods, known by the acronym SPEN, developed in his group, then provide the high resolution 3D MR images of the metabolic products in the sub-second timescales needed to characterize the processes. In the image, the method is used on a mouse liver and kidneys. Ultrafast MRI in combination with dDNP could become a minimally invasive way to monitor cancer treatments and other metabolic changes in the body.

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The degenerate Whittaker models in the work of Dr. Gourevitch and his colleagues are closely related to Fourier coefficients of automorphic forms used in analytic number theory and string theory. These in turn are generalizations of the classical Fourier series. Since their introduction two centuries ago, Fourier series have had a tremendous number of applications in mathematics and physics. The formula depicted above describes a connection between the degenerate Whittaker models and another important notion in representation theory of real reductive groups: wave-front set of representation.

\[
\Psi_0(\pi) \subset WF(\pi) \cap \Psi \subset F_G \cdot \Psi_0(\pi) = \Psi_0(\sigma).
\]
Microbes that live where oxygen is in short supply, for example, under the ocean floor, "breathe" sulfur, and these play an important role in the planet's carbon cycle. In this figure, Dr. Halevy and his colleagues developed models to predict the concentrations of various chemicals within the cells of such microbes and relate the growth conditions of these microbes to their preference for the light isotope of sulfur.

How do embryonic stem cells know how and when to stop being stem cells and start differentiating? Dr. Hanna and his colleagues have identified a molecule they named Mettl3 that works on the messenger RNA, silencing strands that promote the embryonic stem cell state. Mouse embryos lacking Mettl3 did not completely shut down their "stemness," and were only partially able to differentiate.

Dr. Itay Halevy
AEROBiC | Assessing the effects of rising O2 on biogeochemical cycles: Integrated laboratory experiments and numerical simulations

INTRACELLULAR METABOLITE LEVELS SHAPE SULFUR ISOTOPE FRACTIONATION DURING MICROBIAL SULFATE RESPIRATION. *PNAS*

Dr. Jacob Hanna
CELLNAIVETY | Deciphering the Molecular Foundations and Functional Competence of Alternative Human Naive Pluripotent Stem Cells

m6A mRNA METHYLATION FACILITATES RESOLUTION OF NAIVE PLURIPOTENCY TOWARD DIFFERENTIATION. *Science*
The image shows the interdependencies of the behavioral scenarios in a program for the game of tic-tac-toe. Dependent scenarios are linked by edges. Scenario-based programming, a new method developed by Prof. Harel and his colleagues, is based on parallel execution of scenarios that represent behaviors of the system during the execution of the interface. It is used for building such complex systems as industrial robots and medical instruments. The image is from a paper about an adaptive version of the method, in which the system is able to “choose wisely.”

When one measures the trajectory of a quantum particle, the particle behaves as a classical particle. This process is called dephasing via “which-path” detection. For the particle to regain its lost quantum behavior, the information gained in the “which-path” detection must be “erased.” The image, obtained by Prof. Heiblum and his colleagues, shows the results of applying quantum erasing in a mesoscopic electronic device. The white vertical line crosses the interference pattern (bright and dark regions) of a recovered quantum behavior, while the nearby dotted white line crosses a region of a dephased (classical) system.

Prof. David Harel
LIBPRP O | Commercialization and public dissemination of LIBPR research result

ADAPTIVE BEHAVIORAL PROGRAMMING
23rd IEEE International Conference on Tools with Artificial Intelligence

Prof. Moty Heiblum
NEUTRAL | Neutral quasi-particles in mesoscopic physics

AN ELECTRONIC QUANTUM ERASER
Science
when viewed under the electron microscope reveal that the activity of a unique RNA gene, microRNA-142, is required to maintain their familiar “biconcave” shape. Prof. Hornstein and his colleagues found that when microRNA-142 was lacking (bottom), the red blood cells were misshapen and dysfunctional. An emerging conclusion from the work in Hornstein’s group is that miRNAs are essential to maintain normal cellular function and physiology.

Red blood cells viewed under the electron microscope reveal that the activity of a unique RNA gene, microRNA-142, is required to maintain their familiar “biconcave” shape. Prof. Hornstein and his colleagues found that when microRNA-142 was lacking (bottom), the red blood cells were misshapen and dysfunctional. An emerging conclusion from the work in Hornstein’s group is that miRNAs are essential to maintain normal cellular function and physiology.

miRNAs confer robustness to adult beta-cell identity

Prof. Shahal Ilani

See-1D-Qmatter | Unraveling fragile 1D quantum states of matter with ultra-sensitive imaging

Prof. Eran Hornstein

miRNAbetaIdentity | microRNAs confer robustness to adult beta-cell identity

REALIZATION OF PRISTINE AND LOCALLY TUNABLE ONE-DIMENSIONAL ELECTRON SYSTEMS IN CARBON NANOTUBES

Nature Nanotechnology

The smallest nanoelectronics, which will be measured in single electrons, will require extreme precision. Prof. Ilani and his colleagues have developed a method of producing ultra-pure carbon nanotubes in which they can control the movements of individual electrons. The image tracks the passage of electrons through a nanotube which is moved and in which the current is altered, revealing the possibility of complete control over the process.

Haematologica

ERYTHROCYTE SURVIVAL IS CONTROLLED BY MICRORNA-142

Prof. Eran Hornstein

Prof. Shahal Ilani
Imaging of individual mRNAs (red dots) in intact liver tissue reveals a clear gradient in the expression of the Pck1 gene, a key gene involved in glucose processing. In research performed by Dr. Itzkovitz and his colleagues, these genes are highly expressed within the periportal zone (PP) of the liver lobules. Green shows cell membranes; blue, DAPI stained nuclei. (Scale bar – 30um).

Scanning electron microscope images of nanowires made of gallium nitride (GaN) that grow horizontally on quartz, created by Prof. Joselevich and his colleagues. The crystal structure of quartz directs the nanowire growth, and etching enables the nanowire structures to be transferred to another substrate with their orderly structure intact.

Dr. Shalev Itzkovitz
LIVHET | Single cell heterogeneity in the mammalian liver

Prof. Ernesto Joselevich
GuidedNW | Guided Nanowires: From growth mechanism to self-integrating nanosystems
Prof. Jung and his colleagues investigate the contributions of certain immune cells – monocytes and tissue-resident mononuclear phagocytes – to the maintenance of health and the handling of such challenges as inflammation and infection. In this specific experiment they explored the regulation of microglia – macrophages in the brain that are mostly quiescent, but which play a role in inflammation. Using genetically-engineered mice, they investigated the function of regulatory microRNAs at different stages, finding that these limit the inflammatory response, and that their performance may drop over time. The figure reveals gene expression in these mice when exposed to a toxin (blue low expression, red high).

Life is networks of proteins interacting with each other. Prof. Kimchi and her colleagues developed a platform in which proteins that go together give off “sparks” of luminescence. The figures show sets of protein interactions whose outcome can spell life or death for the cell.

Prof. Steffen Jung
MONOTOMACRO | Studying in vivo differentiation of monocytes into intestinal macrophages and their impact on gut homeostasis

Prof. Adi Kimchi
DEATHSWITCHING | Identifying genes and pathways that drive molecular switches and back-up mechanisms between apoptosis and autophagy
In the images, a nanoparticle aggregate “explodes,” releasing molecules trapped inside. Such aggregates, assembled from unique nanoparticles by Prof. Klajn and his colleagues upon exposure to light, become “nanoflasks” in which chemical reactions take place at unexpectedly rapid rates. Such nanoflasks could improve both the rate and the selectivity of chemical reactions.
Biological lubrication, for example, of our knees and hips, must last for years under continuous stress and slippage. Its secret may be adding a bit of water: Prof. Klein and his colleagues reveal how systems in which double layers of liposomes (shown in blue) slide past one another easily, due to highly hydrated head groups. Such liposomes are believed to reduce friction in living joints; understanding how the body reduces friction may lead to better treatments for osteoarthritis.

Satellite images from NASA show aerosol optical depth (AOD), a measure of liquid or solid particles suspended in the atmosphere, over several months in 2007. The rectangles mark pristine areas in which the levels of aerosols emitted into the atmosphere are lowest. Prof. Koren and his colleagues investigated the physical processes at work in the formation of “aerosol-limited clouds” in these regions, offering an explanation to observations showing invigorated clouds in polluted environments.
Research by Dr. Krizhanovsky and his colleagues reveals the interaction of a senescent cell (green) with other cells. Cytoskeletal elements are stained in red in both cell types. Senescent cells – cells that have not died but don’t proliferate – play roles in both tumor suppression and aging. Here, senescent cells “reach out” to other cells by forming tiny tubes that connect the cell membranes.

Dr. Valery Krizhanovsky
Eliminate Senescent

The role of elimination of senescent cells in cancer development

Prof. Leeor Kronik
PPOLAH

Predicting properties of large heterogeneous systems with optimally tuned range separated hybrid functionals

Prof. Kronik and his colleagues developed new methods for accurate prediction of the electronic structure of molecules and materials from first principles. The approach – which they call optimal tuning – has been developed within the framework of the well-known density functional theory. In the image, different electron orbitals of the copper phthalocyanine molecule (depicted right) are plotted according to their predicted energy levels, given as a function of numerical parameters.
Optical instruments, for example, light microscopes, are limited by the wavelength of light. An instrument called an absolute optical instrument, illustrated here in a study by Prof. Leonhardt and his colleagues, might inject the waves at one source and have them perfectly focused at the correct image position, granting, in theory, unlimited resolution.
Prof. Lipman and Noam Aigerman developed a method for mapping surfaces in three dimensions onto a two dimensional plane while preserving the geometric properties of the surface and respecting the symmetry of the plane. The image depicts tiling of the plane with a flat version of a three dimensional scan of the face of Michelangelo’s David.

One of the characteristic signs of Alzheimer’s disease is the formation of amyloid-beta plaques in the brain. Dr. Margulies and his colleagues developed a synthetic molecule that acts as a tiny sensor that can track the formation of such plaques with fluorescent signals.

Dr. David Margulies

GlycoTracker | Tracking glycosylations with targeted, molecule-sized “noses”
Newly formed proteins tend to undergo further modifications before they perform their assigned tasks. Post-translational modification (PTM) profiling monitors these changes in thousands of proteins within their biological context to reveal global patterns of regulation and fundamental cellular processes. PTM profiling was used here by Dr. Merbl and her colleagues to understand how ubiquitin and ubiquitin-like molecules create an abnormal protein modification pattern in cancer.

With the three primary colors red, green and blue, one can create an entire palette. When fluorescent proteins in combinations of these colors are inserted into bacterial colonies, the resulting patchwork can report on the success of systems containing synthetic pathways, offering quick insight into the imbalances they provoke and point to means of fine-tuning their expression. The E. coli colonies in the image produced by Prof. Milo and his colleagues have irregular shapes where they abut other colonies; colonies in which the expression of the fluorescent proteins was weak appear black.
Storing and using hydrogen safely and efficiently has been a major stumbling block to its use as a green fuel, particularly for transportation purposes. Prof. Milstein and his colleagues used a catalyst they designed to develop a new system for carrying hydrogen. The system is based on an organic liquid – ethanolamine – which can store and release hydrogen chemically, and can be readily regenerated. Pictured is the ruthenium complex involved in the catalytic process.

Illustration of the chiral induced spin selectivity (CISS) effect. Chiral molecules that have screw-like symmetries – that is, they spiral around in a right-or left-handed direction – can be used to select electrons with a particular spin. Such “spin filters” as those developed by Prof. Naaman and his colleagues could prove useful in the field of spintronics, in which data is stored and computation is performed by the electrons’ spin instead of their charge.
Collisions between molecules – which govern chemical reaction rates – are not impacts between two round “balls,” and in classical physics their relative orientation affects these rates. But at very low temperatures, where quantum effects take over, this picture breaks down and the rotational state of the molecule dictates its “shape.” In the figure, Prof. Narevicius and his colleagues show that rotationally excited hydrogen molecules react differently than those in the ground state, essentially “switching” between shapes.

Preclinical research often involves imaging the internal organs of small animals, sometimes on different days or with different methods. Prof. Neeman and her colleagues developed a method for the automated extraction of anatomical features by segmenting the images according to the intensity of the signals. This enabled the researchers to merge data from such systems as MRI and CT, and images from different days, producing multimodal imaging.
To visually reconstruct a hidden object, Prof. Oron and his colleagues turned to interference – between measurements of the way light scatters off an object. In the figure, the images encoded in the interference pattern between two partial measurements, with the object partially illuminated, facilitates the reconstruction of the image (in this case, the letters WIS, not shown).

How long does it take for a lengthy, complex molecule known as messenger RNA (mRNA) to be copied from the DNA in the genome? The researchers, Profs. Oren and Amit, and their colleagues developed a method for measuring the rate of mRNA production in live cells on a global scale. The method entails stopping the process – transcription elongation – adding a label, and then allowing elongation to continue. Harvesting RNA at different time points and checking the progression of labeled strands yields an overall rate for numerous genes.
A quantum logical gate, one of the basic building blocks for a quantum computer, was created by Prof. Ozeri and his colleagues with the help of a diode laser on two trapped atomic ions. The gate is intended for reversing one qubit (the quantum analogue of the classical bit) in accordance with the condition of another qubit. This operation requires the two qubits to interact, or "sense" one another. The result of the gate is the creation of an entangled state. The three images, based on experimental data, provide a graphical representation for the probability, expressed by color (red: high probability; blue: low probability) of finding the qubits: from left to right – in the 00 state, the 01 and 10 states, and the 11 state, as a function of gate parameters.

Universal Gate-Set for Trapped-Ion Qubits Using a Narrow Linewidth Diode Laser

To understand how emotions are involved in learning and memory, Prof. Paz and his colleagues investigate the connectivity between brain regions, in this case the amygdala and the anterior-cingulate-cortex (ACC). In this study they investigated different types of negative reinforcement: partial, that is, a surprise, unwelcome stimulus; and full, when the outcome is predictable. The partial reinforcement was linked to higher connectivity and less ability to forget the lesson – a factor that could play a role in post-traumatic stress disorder (PTSD).

Learning and Anxiety in Amygdala-based Neural Circuits
The discovery of the Higgs particle in the Large Hadron Collider (LHC) confirms the accepted theory about the origin of the mechanism by which the mediators of the weak interaction acquire their masses. Nonetheless, the origin of the masses of the matter particles, the building blocks of nature, called fermions, and presence of the large hierarchy between the three generations of quarks remain unanswered. Prof. Perez and his colleagues have now proposed a method to use the LHC to probe the Higgs coupling to the light quarks that is expected to be behind the origin of their masses, which had been thought to be nearly impossible in the LHC "noisy" environment.
Soil, sand, rocks or glasses – all are disordered systems liable to be under pressure. Computing the forces acting between all the particles from knowledge of their positions alone was considered an insoluble problem. The mechanical constraints are that the sums of forces acting on each particle must vanish, but the number of individual forces is larger than the number of these constraints. Prof. Procaccia and his colleagues solved this theoretical problem. The figure shows an experimental system that can demonstrate the solution: The system is composed of plastic disks that, under applied pressure, rotate polarized light in a manner that is related to the amount of force applied to the disks. Such systems enable the researchers to test their theory against experimental evidence.
Metastatic cells degrade their surroundings to break free. Cell lines derived from a melanoma patient, stained for actin (left), and fluorescently labeled for extracellular matrix, reveal massive degradation of the matrix in the middle panel (black holes) and cell nuclei in the right. The study conducted by Profs. Samuels and Geiger, and their colleagues revealed that the invadopodia – cancer cell protrusions needed to degrade the surrounding matrix – are regulated by one of the main melanoma driver genes, RAC1.

Take a circle, divide it into two equal halves, and randomly choose a point, X, on the circle. Now start rotating X by a fixed angle, alpha. Every time the rotated point falls in one half of the circle take a step to the left, and every time it falls in the other half of the circle take a step to the right. You have now taken a “random walk.” The figure, from research by Prof. Sarig and his colleagues, depicts two possible representations of an infinite translation of surfaces.
The joint activity patterns of neuronal electrical signals are "words" in the language of the brain. Prof. Schneidman and his colleagues investigated the "semantic" organization of these activity patterns in the vertebrate retina as they were shown either artificial (left) or natural (right) movies. The top matrices plot the similarity in meaning between neural words of a group of cells responding to the same stimuli, revealing "synonyms." Small charts: active neurons emitting electrical pulses (black) corresponding to the columns in the matrix above. Bottom: An intuitive matrix of the overlap of neural words based on their syntactic similarity does not reveal synonyms, demonstrating that the language of our brain has a semantic design that resembles natural language much more than we might have expected.
During development, neurons grow long processes that are often pruned back and later regrow to form the functional neuronal circuit. Investigating this process in fruit flies, which undergo several stages of growth, degeneration and regeneration from larvae to adult, Prof. Schuldiner and his colleagues discovered that a gas, nitric oxide (NO), acts as a switch between the two processes. In the fruit fly brain region pictured, axons (green) exposed to low NO grow well (right) while those exposed to high NO levels (left) do not. Schuldiner notes that this activity shares some similarities with nerve repair following injury.

Prof. Oren Schuldiner

AxonGrowth | Systematic analysis of the molecular mechanisms underlying axon growth during development and following injury

Prof. Michal Schwartz

Immune/memory aging | Can immune system rejuvenation enable restoration of age-related memory loss?
Prof. Eran Segal and his colleagues mutated different regions of messenger RNA (mRNA) molecules in order to discover molecular elements that attract the ribosome, the protein-making “factory.” Each row represents a different mRNA molecule; each column represents a mutated region. Highlighted in blue are the regions that were found to affect protein manufacture. Using this approach, the scientists identified two types of mRNA sequences that attract ribosomes.
Advanced mass spectrometry enabled Prof. Sharon and her colleagues to discover a new subunit for one of the cell’s machines – the signalosome complex. This complex regulates ubiquitination – the “tagging” process by which proteins are sorted for recycling. CSNAP, as the group named it, adds to the other eight known subunits of this important complex, and their findings show that this subunit, which had evaded detection for decades, probably because of its small size, is crucial for the signalosome function.
Visualizing individual olfactory fingerprints, from research by Prof. Sobel and his colleagues. The fingerprints are based on matrices of perceived odorant similarity and provide characterization of an individual’s perception. The study found that each person has a unique perception and that this reflects their genetic makeup. Here, subject one, shown in the middle and 30 days later at right, maintained a highly similar olfactory fingerprint, while subject two, left, had a very different fingerprint. The study suggests that a test based on 35 different odorants could be used to “fingerprint” everyone on Earth. (image: Ofer Perl)

Prof. Noam Sobel
SocioSmell | Social chemosignaling as a factor in human behavior in both health and disease

Often viruses seem to “choose” between two states: the direct, quick attack and a more dormant state. Prof. Sorek and his colleagues, working with viruses called phages that attack bacteria, discovered a means of communication used by the viruses to inform these decisions. A peptide they name *arbitrium* is deposited into the environment for other viruses to find, letting each generation know how the infection process is proceeding and what their best strategy entails.

Prof. Rotem Sorek
DrugSense | Ribo-regulators that sense trace antibiotics

**SocioSmell**
Social chemosignaling as a factor in human behavior in both health and disease

**DrugSense**
Ribo-regulators that sense trace antibiotics

*Note:* This is a natural reading of the content, respecting the original language and structure without hallucinations.
Illustration of coupled quantum wires in a magnetic field. This theoretical study conducted by Prof. Stern and his colleagues investigates the way in which the interactions of electrons with one another and with the magnetic field lead to so-called quasiparticles – particles which are made of electrons, yet carry a fraction of an electron’s charge. Such fractional charges may, among other things, be used to compute and store information in the future.
Fullerene-like nanoparticles and nanotubes made of inorganic compounds already have numerous applications – today mainly as solid lubricants. But future applications include medical technologies, reinforcement in polymer composites and as part of future “smart” materials. Doping – adding minute amounts of foreign elements – is used in today’s semiconductors to control their properties, and thus it will play a role in creating new nanomaterials; for example, the particle captured here by Prof. Tenne and his colleagues in the high resolution transmission electron microscope. This MoS2 fullerene-like nanoparticle is doped with rhenium atoms, giving it unique physical/chemical properties and superior lubrication capabilities.

A section of the heart of a day-old-mouse shows the receptor ERBB2 (red), cardiac tropo-nin (green), and cell nuclei (blue). Prof. Tzahor and his colleagues found that ERBB2 is involved in cardiomyocyte (the contracting cells in the heart) growth and renewal. Its levels diminish soon after birth. Reintroducing this protein after injury to the heart in mice promoted heart regeneration.

Prof. Eldad Tzahor

ERBB2 TRIGGERS MAMMALIAN HEART REGENERATION BY PROMOTING CARDIOMYOCYTE DEDIFFERENTIATION AND PROLIFERATION Nature Cell Biology

Prof. Reshef Tenne

MEDIF-2 Medical applications of IF nanoparticles

CONTROLLED DOPING OF MS2 (M=W, Mo) NANOTUBES AND FULLERENE-LIKE NANOPARTICLES Nanomaterials
How do bats – mammals that fly in all directions – navigate that space? By mapping the three-dimensional flight paths of bats (pictured) and tracking the neurons in their brains as they navigated toward a goal, Prof. Ulanovsky and his colleagues found that the “place cells” in the hippocampus brain regions of bats represent all three axes in space equally, with the same sharp resolution.

Dr. Igor Ulitsky and his colleagues discovered a long-noncoding RNA called NORAD that works in the cytoplasm of the cell, as revealed in the dots in this image (the nuclei are stained purple). NORAD increases the expression of other RNAs, especially those that regulate genes for cell division; when NORAD is deleted, the result is an accumulation of cells with an incorrect number of chromosomes.

Dr. Nachum Ulanovsky

NATURAL_BAT_NAV Neural basis of natural navigation: Representation of goals, 3-D spaces and 1-km distances in the bat hippocampal formation – the role of experience

REPRESENTATION OF THREE-DIMENSIONAL SPACE IN THE HIPPOCAMPUS OF FLYING BATS Science

A CONSERVED ABUNDANT CYTOPLASMIC LONG NONCODING RNA MODULATES REPRESSION BY PUMILO PROTEINS IN HUMAN CELLS Nature Communications
How do we recognize objects from blurred or partial images? Answering this question has fundamental implications for understanding the visual system and for constructing machine vision applications. Prof. Ullman and his colleagues discovered that there are "atomic" units of recognition that are basically the same for all of us. A minute change to an atomic image turns it from recognizable to puzzling. This is demonstrated in the figure, bottom left, in which the image of the eagle (see top, red frame) is at the lower limit of recognizability. The center image shows the detailed internal interpretation of the participants; and the colored frames in the right-hand image represent additional "atomic" images that can be lifted from the original.

Prof. Assaf Vardi, Dr. Shilo Rosenwasser and their colleagues show that far from being passive drifters in the ocean, phytoplankton sense their environmental conditions and respond accordingly. In this figure, they reveal a metabolic map of diatom cells, identifying specific enzymes that are sensitive to oxygen radicals, including the nitrogen pathways. Elucidation of the function and regulation of these key metabolic pathways can help reveal the molecular, ecological secrets underlying large scale algal blooms in the ocean.

Mapping the diatom redox-sensitive proteome provides insight into response to nitrogen stress in the marine environment
Drs. Yotam Asscher and Elisabetta Boaretto, and Prof. Weiner and colleagues performed radiocarbon dating at the Tell el-Safi/Gath archaeological site, occupied by the Philistines in the Iron Age. They found that the Philistines had appeared at this site earlier than previously thought – in the late 13th century BC. In the image, a cross-section revealing some of the sediment layers that were dated. The inset shows a high magnification view of the sediments.
A hallmark of aggressive cancer is the hijacking of growth factors. Prof. Yarden and his colleagues asked whether these growth factors, like many substances in the body, are tied to our biological clocks. Indeed, they found that growth factors are mainly active at night; the hormone cortisol suppresses their activity in the daytime. The three figures show how a growth factor, EGF, enhances cell migration, and cortisol (DEX) inhibits that migration. The conclusion: Anticancer drugs that repress growth factor activities might be more effective at night.
Many antibiotics attack the ribosomes of bacteria, preventing them from manufacturing proteins. The image, from research by Prof. Yonath and her colleagues, shows a part of the backbone (in gray) of the large ribosomal subunit of the bacterium *S. aureus*, a common pathogen that is, in some cases, resistant to multiple antibiotics. The colors highlight ribosomal RNA regions that exhibit fold variability compared with other, non-pathogenic bacteria, and the green crescent delineates a location that could be exploited with designed antibiotics.

This theorem describes the extreme values of a random field, which is the characteristic polynomial of a random matrix. The theorem demonstrates, in one particular case, a phenomenon that is the focus of Prof. Zeitouni and his colleagues’ research, namely, finding that the behavior of the extrema of random fields which are logarithmically correlated is universal, and does not depend on details of the field or whether it is Gaussian.

**Prof. Ada Yonath**
**Prof. Ofer Zeitouni**

**NOVRIB** | **LogCorrelatedFields**
---|---
Novel insights into multi-drug resistance to antibiotics and the primordial ribosome | Extremes in logarithmically correlated fields

**A BRIGHT FUTURE FOR ANTIBiotics?**
Annual Review of Biochemistry, 2017

**THE MAXIMUM OF THE CUE FIELD**
International Mathematics Research Notices
Superconducting Quantum Interference Devices (SQUIDs) are used as sensors capable of demonstrating record sensitivities to small magnetic signals. Prof. Zeldov and his colleagues have developed a SQUID that simultaneously measures two magnetic field components. It can serve for mapping current flow on a nanometer scale or for measuring isolated magnetic nano-objects. The figure shows that experimental interference patterns (left) of the electric current flowing through the sensor, used to calibrate the device, match the theoretical predictions of these patterns (right).

Common wisdom says that broken bones must be realigned to heal properly, but research by Prof. Zelzer and his colleagues suggests that young bones have a realignment mechanism that works something like a car jack. When the fractured ends of mouse leg bones were back to back, mechanical forces were generated that moved the bones into place, even when there was a large displacement.
Our experience of familiar environments is not static but changes over time. Dr. Ziv and his colleagues discovered “timestamps” – specific patterns of neuronal activity that add a point in time to even the most routine experience. These patterns, shown in the brains of mice over a period of weeks, gradually changed over time so that, regardless of the spatial context, timestamps of events that occurred close together were highly similar, whereas timestamps of events that occurred farther apart were distinct. The findings suggest a mechanism by which the brain creates a mental timeline of experienced events, associating or disassociating them in memory by their temporal distances from one another.
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<td>New York University</td>
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<td>New York University</td>
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<td>New York University</td>
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<td>Weizmann-University of Manchester Collaborative Projects Program</td>
<td>New York University</td>
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<tr>
<td>The Pearl Welinsky Merlo Foundation Scientific Progress Research Fund</td>
<td>New York University</td>
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<td>Jacques and Charlotte Wolf Research Fund</td>
<td>New York University</td>
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<td>The Wolfson Family Charitable Trust</td>
<td>New York University</td>
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<td>The Yad Abraham Research Center for Cancer Diagnostics and Therapy</td>
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<td>The Yeda-Sela (YeS) Center for Basic Research</td>
<td>New York University</td>
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<td>Dora Yoachimowicz Endowed Fund for Research</td>
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<td>Sharon Zuckerman Laboratory for Research in Systems Biology</td>
<td>New York University</td>
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<td>Dr. Celia and Dr. Lutz Zwillenberg-Fridman</td>
<td>New York University</td>
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سكنנות שאינה יודעת שובע היא אחת מתכונותיו הבולטות והייחודיות של האדם, והיא אשר עומדת בבסיס הדחף שלנו לחקור,גלות ולהמציא. תכונה זו היא שורש הצלחתו של המין האנושי בברחבות תחומי אופיו הקצרים, בקירתו זרה מעולות, ובחרבות חולות המוניות. מבט.middle

בשימור תדיניסים של הסביבה שאנו חיים בה.

מתוכן ההכרה בשפעטרת העומדות על המתחק המדעי, כמיעון שממנו נובע נהר הקידמה והרווחה, התוכן במכתבים תלמודים, מתקרר במענית ברוח הسكنנות מקושר בין ערכי הליבה המשותפים לחברה המזרחית, שmostat בERC-לונדון בראשות הטכנולוגית רוברט-האנסי, בברית המועצות, אליו נועדו לשלוח הוראה ליווי. בברית, לא נ우רח לא-יודר מבצל המתחק, למדעי בלתי להב, פיזיקאי ער רגנץ, ערא על מדעי היהוד, עד מחקרי התחומים בלתי-פיזיואטריים, שספוגו בין הגון, על הדיונים של כוכבים לחוד, על יזמותו של גמלון ממלוכ.
