Science & Technology Series

Environmental and Global Research of Aquatic Systems

What Lies Beneath

Tradition of Excellence

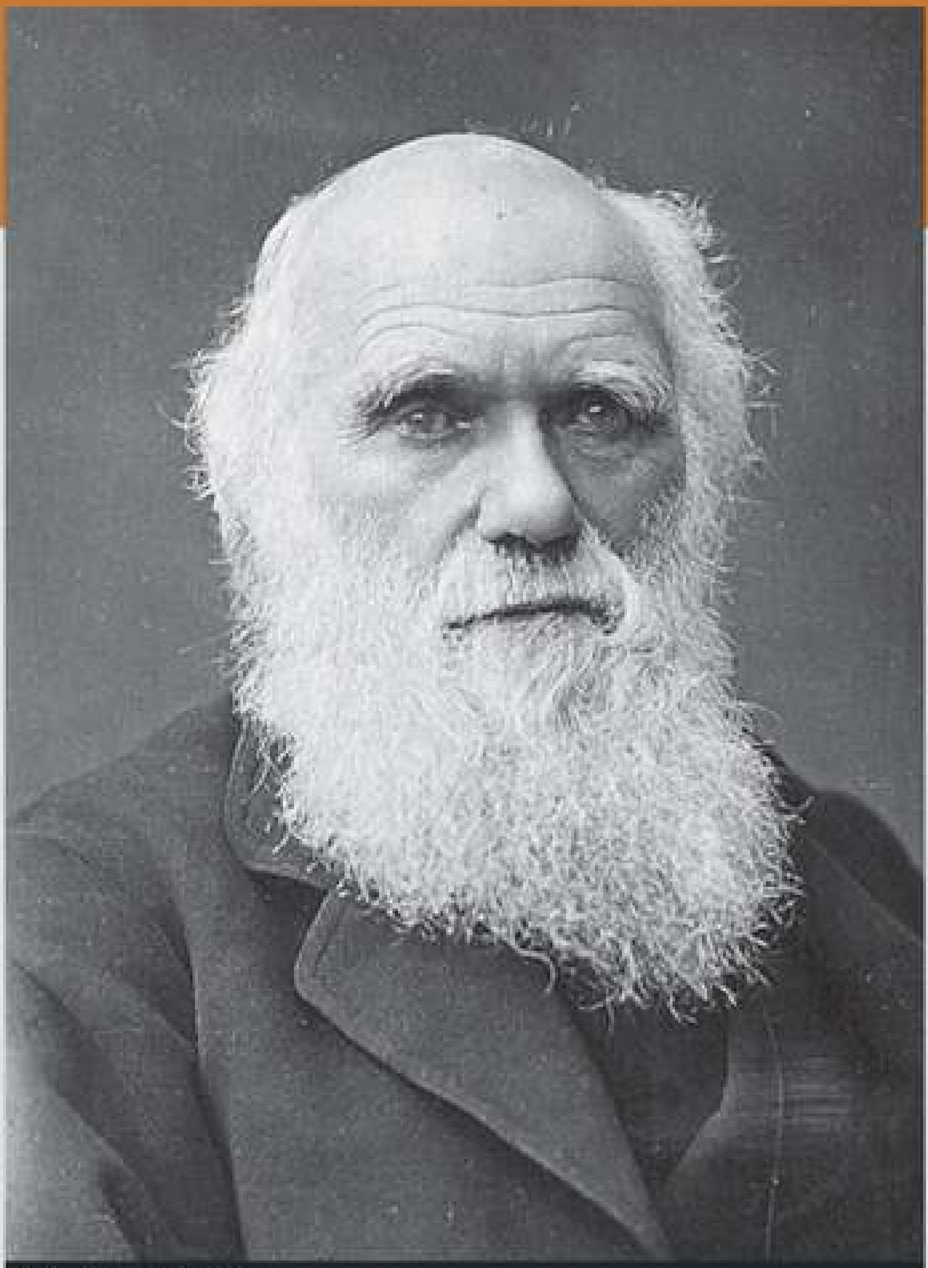
Bar-Ilan University

Using cutting edge techniques taken from the world of chemistry, physics and the biological sciences, BIU experts are revealing important information that will help mankind preserve and protect marine environments.

Pictured from left to right:
Dr. Yishai Weinstein
Prof. Steve Brenner
Dr. Oren Levy
Dr. Rakefet Schwarz

Global
What Lies

Beneath



Charles Darwin

When the young naturalist Charles Darwin took to the sea aboard the HMS Beagle in 1826, he began an intellectual journey that would eventually serve as the foundation for ecology – a modern scientific discipline that embraces both the organization of life at various levels of complexity, and organisms' relationship with the physical world.

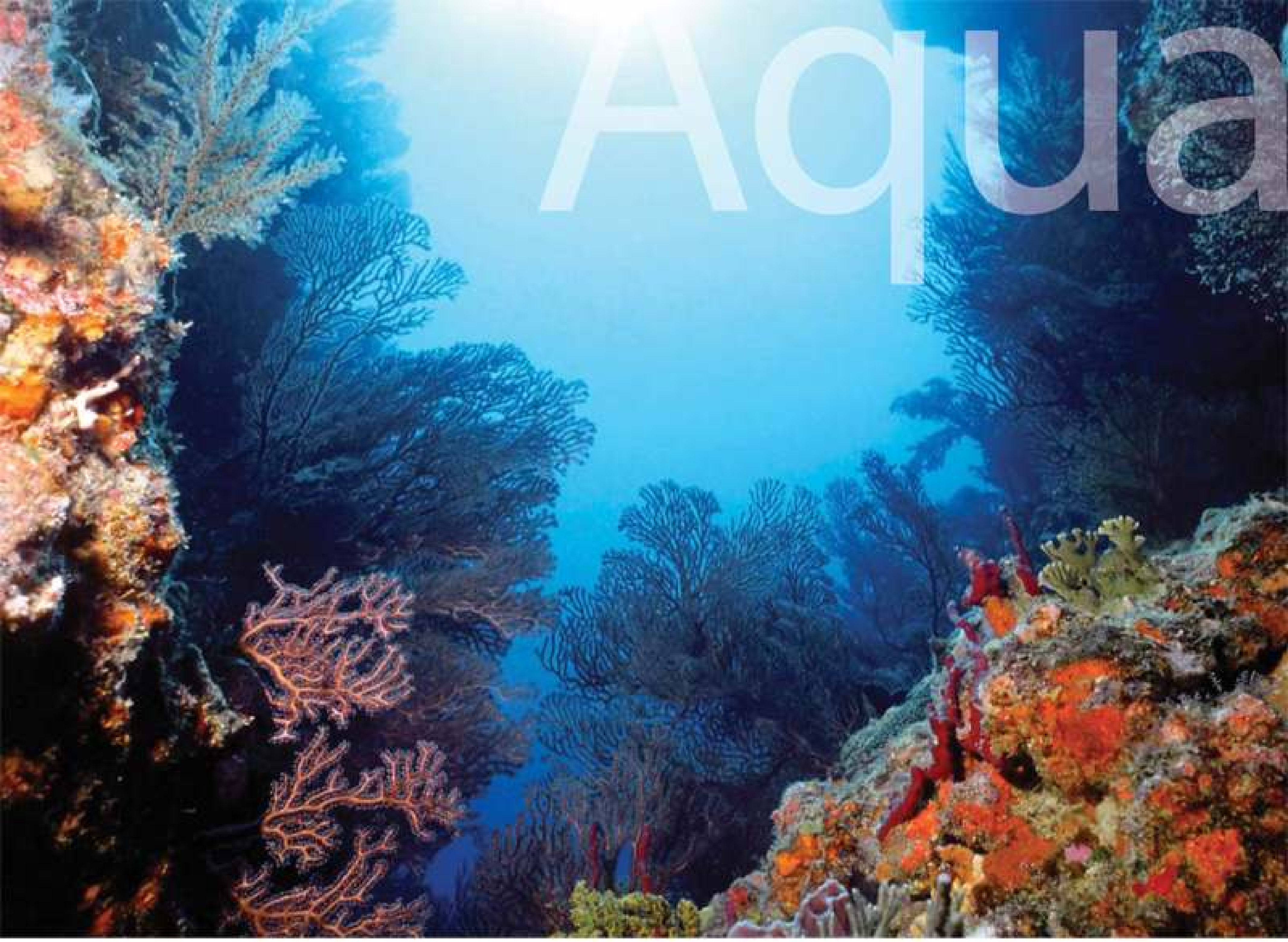
Today, researchers at Bar-Ilan University are participating in the rebirth of maritime natural history, by spearheading integrated advances in the study of marine environments. They work at all levels, from genetic studies, to the physiological characterization of organisms, to the examination of habitats, to the system-wide analysis of biodiversity, air and water circulation, and ecosystem function. Employing cutting-edge techniques taken from the world of chemistry, physics and the biological sciences, BIU experts are revealing important information that will help mankind preserve and protect the marine environments that make up over 70 percent of the Earth's surface, while enhancing the future availability of water-based resources for the benefit of all.

Maritime Molecular Processes

Jet-lagged travelers are well acquainted with circadian rhythms – the physical, mental and behavioral changes that follow a roughly 24-hour cycle, based primarily on light and darkness in the environment. But circadian rhythms don't just affect humans. Changes in light exposure also affect the biological "clock" of animals, plants and even microbes. Dr. Oren Levy – an expert on the reef-building corals of the Mediterranean and the Red Sea – studies corals' symbiotic relationship to the photosynthetic algae that "feed" the host coral with the sun's energy. Employing a unique mix of molecular and cell biology techniques, as well as stable isotope mass-spectrometry, Levy's research aims to reveal the basis of circadian response to light in symbiotic corals. In addition, he is examining how environmental stressors – such as pollution and climate change phenomena – can lead to the degradation of coral reefs.

➔ BIU scientists are exploring the molecular processes at work within water-dwelling organisms.

Another BIU scientist exploring the molecular processes at work within water-dwelling organisms is Dr. Rakefet Schwarz. Schwarz focuses on cyanobacteria, micro-organisms that play a prominent role in "carbon fixation" – the conversion of atmospheric CO_2 into non-polluting, organic materials. Examining adaptations that allow these organisms to survive – even when nutrients are scarce – Schwarz's work provides insight into the molecular mechanisms underlying the acclimation process. In another project, Schwarz has revealed conditions that lead to massive accumulation of raw materials for fuel production inside cyanobacterial cells – a discovery related to bio-fuel research she is pursuing in cooperation with BIU Prof. Aharon Gedanken. Finally, Schwarz is examining a phenomenon called "biofouling" in which bacterial build up causes corrosion of submersed objects.
By characterizing a compound that inhibits biofilm formation, Schwarz is closing in on a possible strategy for preventing biofouling damage.



Molecular research being pursued by both Levy and Schwarz benefits from collaboration with bioinformatics expert Dr. Erez Levanon. Levanon is applying genomic technologies and computational tools – many developed "in house" – to the study of fundamental molecular interactions that determine each organism's unique genetic profile. Specifically, he examines how – when body cells replicate and pass down their genetic content – certain well-preserved families of proteins sometimes "edit" DNA and RNA. While until recently such events were considered rare, it is now known that there are a wide range of subtle changes that have a significant impact on an organism's development, morphology and function. Using a combination of computational approaches and next-generation sequencing techniques, Levanon has developed new methods for modeling and detecting RNA and DNA editing in mammals. Working together with BIU researchers specializing in the molecular biology of marine organisms, Levanon's techniques will make it possible, for the first time, to screen for the full range of editing activity within a particular organism – something that will provide systems-level insight about fundamental marine biology puzzles.

When developing his theory of Natural Selection, Charles Darwin used his own powers of observation to intensively study one particular organism: the barnacle. Today, BIU Prof. (Emeritus) Yair Achituv uses modern tools of molecular biology to study barnacles' evolutionary development. Focusing on barnacles living in intertidal areas of the Mediterranean and the Gulf of Eilat, Achituv uses molecular tools to understand dynamic patterns of zonation – the positioning of an organism either above or below the water – in two common intertidal Mediterranean barnacle species. He has also used molecular dating to link patterns of speciation to geological changes that occurred millions of years ago in the Mediterranean and the Black Sea. In his recent work, Achituv identified two novel gene regions that indicate rapid differentiation of species, providing new perspective on the dispersal patterns of marine organisms. In another project, Achituv examined genetic differences between coral-inhabiting barnacles, proving that several types – usually lumped together – are actually representatives of five distinct species.

What Lies Beneath

Weather Above, Weather Below

There is a fiery public debate raging about the causes of climate change. But Bar-Ilan's Prof. Steve Brenner is taking a cool accounting of the situation – by modeling how climate change may affect the internal "weather" in the murky depths of the Mediterranean Sea. His studies are creating a clearer picture of how short- and long-term circulation patterns affect bodies of water, as well as how these circulation patterns may be affected by human activity and wider global forces. Brenner is a partner in the development of an operational ocean forecasting system for the Mediterranean. This system routinely produces daily forecasts for the temperature, sea surface height, and currents for lead times of up to 10 days – something that provides an important model for analyzing and anticipating ecosystem-level behavior, as well as the dispersion of pollutants. Brenner's model has also been applied to assessing the response of the Mediterranean to past climate change, and predicting its response to climate change that may occur in the future.

BIU physicists and geochemists are revealing new insights about the relationship between maritime systems and climate change.

Dr. Yishai Weinstein studies the chemistry of coastal water and its relationship to climate change, focusing on the interaction between terrestrial fluids – groundwater – and surface water, such as the sea, lakes and coastal rivers. Just as fronts of high and low pressure in the atmosphere trigger storms, fluid "fluxes" – based on groundwater discharge from the sea floor – can strongly influence coastal-water geochemistry and drive ecosystem change. In a recent study of the southeastern Mediterranean, Weinstein quantified levels of dissolved radon and radium isotopes – all produced by the radioactive decay of uranium and other trace elements – that indicate the local level of groundwater discharge. High concentrations of nutrient-rich ground water can stimulate excessive growth of algae, reducing fresh water availability, and negatively impacting fragile ecosystems such as estuaries and coral reefs. Combining field research and computer modeling, Weinstein's group examines how the discharge of terrestrial groundwater is affected by sea level fluctuations, both when water levels are steadily rising – as in the ocean – and when they are dropping precipitously – as in the Dead Sea.

Atmosphere, Light, and Water Ecosystems

The world's oceans are challenged both by global warming and by acidification – an ongoing decline of oceanic pH levels. Rapid changes in the marine environment are affecting the activities of many marine communities, including the reef building corals which – in Indo-Pacific and Caribbean regions – are already demonstrating reduced performance. BIU marine ecologist Dr. Maoz Fine is studying the response of marine ecosystems to climate change. Working from the cellular to the community-wide level, Fine and his group focus on identifying physiological and ecological processes that are affected by ocean-based climate change scenarios. Fine's research is shedding light on fundamental physiological mysteries, while at the same time, providing evidence that helps explain observations from the geological record of coral reef ecosystems.

Another researcher examining how marine organisms respond to ocean acidification is Dr. Ilana Berman-Frank. Berman-Frank's research centers on the biological fixation of nitrogen – a process mediated by a small group of single cell organisms that convert atmospheric nitrogen into the NH_3 (ammonia) required to synthesize life's basic building blocks, including amino acids for proteins. These organisms are ecologically important because they inject new nitrogen into the world's oceans. Not only does this nitrogen injection enhance oceanic productivity – something especially important for organisms living

Interdisciplinary studies are helping BIU scientists understand the forces that affect coral reefs and other fragile ecosystems.

in nitrogen-poor oceans around the world – it also stimulates the removal of CO_2 from the atmosphere by enhancing photosynthesis and primary production. In a series of projects, Berman-Frank is examining how changes in climate and ocean acidification influence nitrogen-fixing marine organisms. She recently elucidated physiological responses of such organisms, and created new models predicting how elevated temperatures and higher CO_2 levels will affect nitrogen fixation and growth, as well as the distribution of nitrogen-fixing organisms in the future.

All life on earth depends on the ability of photosynthetic organisms to harvest the sun's energy and convert it into food. Prof. (Emeritus) Zvy Dubinsky studies microscopic algae that mediate solar energy harvesting in different marine environments. Dubinsky is also looking at light harvesting in large-scale cultures of algae used for the production of biofuel and fine chemicals. Fed on nutrients derived from wastewater, seawater, and CO_2 emitted by power plants, such cultured algal "communities" do not compete for resources needed for agriculture, making them ideal for sun-drenched desert areas where fresh water is scarce and land is plentiful. Employing an interdisciplinary approach that includes remote sensing, photoacoustics and advanced optical techniques, Dubinsky examines photosynthetic efficiency and protein production in algal communities. His basic research is providing important information that may contribute to the optimization of solar energy harvesting by algal biotechnology. In another major area of his research which has been supported by a major grant from the European Union, Dubinsky is clarifying the link between global climate change and decreasing biodiversity among coral reefs and other marine organisms.

From Science to Survival

By addressing fundamental questions about processes that affect ecosystems from intertidal zones to coastlines to deep oceans, Bar-Ilan researchers are charting a steady course toward responsible management of marine habitats and populations. Interdisciplinary initiatives are inspiring innovative new strategies for environmental protection, and are behind an academic "ripple effect" that is bringing Bar-Ilan research to the attention of centers of marine science worldwide.

For more about the research of BIU faculty listed in this brochure go to: www.biu.ac.il and click Research.

BIU's Lilly Shapell
Central Promenade

Produced by the Office of the Vice President for Research and Development and the Division of External Relations

Bar-Ilan University

Science and Technology

Bar-Ilan University stands at the forefront of cutting-edge research. Bar-Ilan researchers are making breakthroughs that improve life around the globe in areas such as drug-development, nanotechnology, medical research, bio-engineering, microscopy, optics, communications, energy, security, and more. As part of a national program to combat Israel's brain drain, BIU has taken the lead by committing to absorb dozens of returning experimental scientists within its world-class research infrastructure, and has added state-of-the-art physical facilities in engineering, brain sciences and nanotechnology to house these innovative initiatives. The Science and Technology Series highlights some of the University's most exciting research endeavors.

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