AMERICAN COMMITTEE FOR THE WEIZMANN INSTITUTE OF SCIENCE
SCIENCE FOR THE BENEFIT OF HUMANITY

Issue No. 42

WEIZMANN*views*

BETTER ENERGY FOR A BRIGHTER FUTURE

Prof. David Cahen

Population growth and rising standards of living worldwide are driving a rapid increase in demand for energy. In fact, says Prof. David Cahen of the Weizmann Institute of Science's Department of Materials and Interfaces, "the prediction is that 25 years from now we'll need double the amount of energy we currently need." However, he adds, "dearth of funding had, by 2006, created a situation of several decades of few new ideas in basic research that would help address this energy issue."

Despite these many years of awareness that the way we live is altering Earth's climate, the vast majority of our energy still comes from the burning of fossil fuels; this releases pollutants into the atmosphere, including the greenhouse gases that contribute to climate change. In fact, before 2015 was even over, NOAA and NASA reported that it was the hottest year on record globally – as was the previous year.

Fortunately, scientists are working hard to move us into a clean-fuel future. "We are doing the basic research now so that 20 or 30 years hence, engineers will be able to make major technological advances," says Prof. Cahen.

Israel's semi-arid and desert climates necessitate heightened awareness of water and energy conservation, and plentiful sunlight makes it an excellent lab for solar and related alternative sustainable energy research; accordingly, the Weizmann Institute has long been involved in the search for safe, renewable fuel sources that can protect – or at least not further damage – the environment. To encourage its scientists to pursue research on affordable clean energy sources, the Institute took a creative approach: establishing a program that would issue grants internally, with particular focus on supporting blue-sky research that likely would not otherwise be funded.

The Weizmann Institute launched this program, the Alternative Sustainable Energy Research Initiative, or AERI, in 2006. Prof. Cahen, the AERI's scientific director, notes that it is one of the largest internal-granting programs at the Weizmann Institute, providing funds to projects that tend to be multidisciplinary, at an early stage, and that would be difficult to sufficiently fund through outside sources. Another important reason for providing in-house funds is ensuring continuity of research. If scientists have to stop work while awaiting the results of a grant application, the break could be fatal to the project.

The AERI is currently supporting important new research on biofuels, solar energy, and artificial photosynthesis – a chemical process that mimics photosynthesis by converting sunlight into usable fuel. "Collaboration" is a guiding philosophy on campus; likewise, the alternative energy investigations bring together scientists from a range of disciplines to take creative approaches: for example, computer scientists, theoretical chemists, and physicists are collaborating to develop computational ways of predicting the electronic structure of photovoltaic materials.

One of the projects that Prof. Cahen feels is quite promising involves utilizing saltwater algae to produce lipids, which then become raw material for biofuel. Dr. Assaf Vardi of the Department of Plant and Environmental Sciences discovered viruses that can exploit algae, using them as "hosts" and modifying their lipid production. Dr. Vardi's team is now working to identify the virus and algae genes that are involved in the regulation of lipid biosynthesis in the host algae.

"It might be possible to infect algae with a virus that will force it to make the kind of

lipids that are a good material for biofuel production," says Prof. Cahen. "I think it's a brilliant idea from one of our young scientists."

The AERI is also funding research on methods of concentrating sunlight, including a number of projects that aim to redesign solar cells – devices that convert sunlight into electricity – to maximize their use of incoming light. For example, Prof. Nir Davidson and Dr. Dan Oron, both of the Department of Physics of Complex Systems, are working with Prof. Yehiam Prior, Dean of the Faculty of Chemistry, to "manage" photons so that, when they reach the solar cells, they can make more efficient use of available sunlight. On the macro scale, the team is experimenting with the geometry of lenses, diffraction screens, and reflectors to concentrate the incoming light, while on the nanoscale, they are developing nanostructures and ways of manipulating light in order to significantly enhance the sunlight absorption rate.

Prof. Cahen's own work focuses on improving the efficiency and reducing the cost of solar cells. He is particularly interested in creating highly efficient, multi-layer solar cells by taking, for example, the dominant type of inexpensive solar cells, which are mainly manufactured in China, and then "painting" a second solar cell on top of it. For years, the types of materials that seemed best suited for producing the "paint" gave poor results. Then, however, four years ago, a family of compounds called halide perovskites started to show interesting results, and Prof. Cahen, with longtime colleague Prof. Gary Hodes, immediately realized that these could be used instead. "We have been dreaming about finding such a substance for years, and now it seems possible," Prof. Cahen says; although, he warns, at present the dream materials still contain lead – a toxic metal – thus presenting a challenge for materials researchers.

Perovskites were first used in a solar cell in 2009 by Japanese researchers, and spread rapidly through the research world. Within a very short time, other scientists were creating experimental perovskite solar cells that rivaled standard solar cells – such as silicon-based ones – in efficiency, while producing higher voltage. Prof. Cahen and colleagues Profs. Hodes, Leeor Kronik, Boris Rybtchinsky, and Igor Lubomirsky and Dr. Sidney Cohen – all at Weizmann – now focus on elucidating the mechanisms by which perovskites convert sunlight into electricity with high-voltage efficiency in order to uncover ways to improve such solar cells.

Prof. Cahen grew up in the Netherlands and received his PhD in materials research and physical chemistry from Northwestern University in Illinois. A postdoctoral fellowship first brought him to the Weizmann Institute in 1973 – and he's been there ever since.

"The Weizmann Institute is a unique place to work," he says. "And the most important reason is that we have internal funds to support our researchers so that they can pursue an unusual idea with some continuity." The AERI funding can serve as a bridge, enabling the scientist to get through the early, more experimental stages until the project is advanced enough that outside funding agencies will pitch in. "We say: go ahead and try out your strange idea, and hopefully you'll soon be able to stand on your own two feet and get additional grants." Perhaps supporting blue-sky research will result in literal blue skies, for all future generations of life on earth.

"We are doing the basic research now so that 20 or 30 years hence, engineers will be able to make major technological advances."

Prof. David Cahen's research is supported by the Mary and Tom Beck Canadian Center for Alternative Energy Research, which he heads; the Nancy and Stephen Grand Center for Sensors and Security; the Ben B. and Joyce E. Eisenberg Foundation Endowment Fund; the Leona M. and Harry B. Helmsley Charitable Trust; the Carolito Stiftung; the Wolfson Family Charitable Trust; and Martin Kushner Schnur, Mexico. Prof. Cahen is the incumbent of the Rowland and Sylvia Schaefer Professorial Chair in Energy Research.