מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

Science Tips

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Bacteria Beat the Heat

How do some microorganisms manage to exist and even thrive in surroundings ranging from Antarctica to boiling hot springs? A team of scientists from the Weizmann Institute's Plant Sciences Department, led by Prof. Avigdor Scherz, has found that a switch in just two amino acids (the building blocks of protein) can make a difference between functioning best at moderate temperatures and being adapted to living in extreme heat. The results of their research, which recently appeared in *Nature*, might have implications for future attempts to adjust crops to differing climate conditions or improve enzyme efficiency in industrial processes.

The team compared two different kinds of bacteria – one found in moderate environments and the other, an intense heat lover. Both were photosynthetic (that is, using the sun's energy to create sugars for food). The focus of the research was a reaction that takes place in enzymes in the photosynthetic "reaction center" of the bacterial cell. While gradually raising the surrounding temperature, the scientists timed this reaction to see how reaction rates changed as things heated up.

A general rule for enzyme reactions states that as the heat rises, so does the reaction rate. Contrary to this rule, and the scientist's expectations, both reaction rates peaked at a certain point, and remained steady thereafter. For each enzyme, the peak occurred in the bacteria's "comfort zone." Further comparisons of the nearly identical enzymes turned up differences in just two of the hundreds of amino acids making up the enzyme sequence. When the scientists replaced these two amino acids in the enzyme adapted to the moderate temperatures with those of the heat-loving enzyme, they observed an increase of about 10 degrees in the average temperature at which the reaction rate peaked. Scherz: "This study shows that enzyme efficiency is tuned to the average temperature of the bacterial habitat, rather than the immediate conditions. This may protect the cells from harmful swings in enzyme activity. We can envision using this knowledge, for instance, to facilitate enzymatic reactions in different applications, enhance crop production in areas subject to extreme temperature changes or create new resources for biofuel production that will not only provide more biomass per acre, but absorb more of the greenhouse gas, carbon dioxide, as well." ❙

Prof. Avigdor Scherz's research is supported by the Charles W. and Tillie K. Lubin Center for Plant Biotechnology; the Sylvia and Martin Snow Charitable Foundation; H. Thomas Beck, Toronto, Canada; the Canadian Society for the Weizmann Institute of Science; Samuel T. Cramer, Beverly Hills, CA; Mr. and Mrs. Abraham Kahn, Mexico; and Mrs. Sharon Zuckerman, Toronto, Canada. Prof. Scherz is the incumbent of the Yadelle and Robert N. Sklare Professorial Chair in Biochemistry.

Time in Space

Stars may lead fascinating lives but sometimes, it's in death that they really shine. Some stars finish up as black holes but, a moment before the end, they explode, sending material in all directions and shining with a light that can be seen throughout the universe. This end only comes to the heavies of the neighborhood, those that weigh 30 times as much as our sun or more. When it happens, their dazzling light can be seen at much greater distances than previously. Thus, early observers of the heavens saw bright points of light appear in the sky where none had existed the night before, and they dubbed them "supernova" or "new stars."

Until now, scientists had only been able to spot supernova several days after stars in the process of exploding had begun to brighten. But the scientists who investigate this phenomenon needed to be able to observe what happens to these stars in real time. That's precisely what NASA scientists have managed to do, for the first time, and their achievement has confirmed theoretical research carried out by Prof. Eli Waxman of the Weizmann Institute.

Aided by NASA's advanced research satellite, Swift, the scientists succeeded in detecting the supernova just 160 seconds after the event began. Seeing the supernova so early allowed the scientists to observe, in addition to the material being thrown out in all directions, jets of gamma rays and X rays shooting out from the vicinity of the explosion. This confirmed the theory that supernovas are the source of gamma ray bursts that have been measured in the past. They also found that the star was composed mainly of oxygen and carbon, signs that the star was, indeed, very heavy. For the first time, scientists were able to identify shock waves that give rise to the gamma and x-ray radiation emanating from the center of the star and moving toward the surface. These findings have bolstered the theoretical model of such supernova explosions proposed by Waxman several years ago. ❙

Prof. Eli Waxman's research is supported by the Rosa and Emilio Segre Fund.

Silence of the Amoebae

Weizmann Institute scientists render a disease-causing pathogen harmless

Freedom of expression is great, but silence is golden – at least when it comes to amoebae – intestine-dwelling parasites that cause life-threatening dysentery in many parts of the world. Three years ago, scientists at the Weizmann Institute accidentally discovered a way to silence the expression of a key amoebic gene, one which codes for a toxic protein that kills human intestinal cells infected with this devastating illness. Now the scientists have developed a way to successfully silence the expression of two additional virulence genes in the same amoebae.

Rivka Bracha and colleagues in the lab of Prof. David Mirelman in the Biological Chemistry Department had shown that expression of the gene coding for the toxic protein could be prevented by inserting a plasmid (a small loop of DNA) containing a copy of a specific part of that gene into the amoeba cell nucleus. Introducing the plasmid led to the modification of DNA "packing" proteins, causing the DNA-protein packages to become more tightly coiled – something like a tangled telephone cord – and causing an irreversible silencing of gene expression. In a recent paper published in *PLoS Pathogens*, the Weizmann scientists report the silencing of two additional virulence genes in the same amoebae using a similar plasmid-induced principle.

The scientists now plan to test the ability of these silenced amoebae to serve as a live vaccine

The disabled amoebae, though rendered harmless, still display the same repertoire of surface antigens (markers recognized by the immune system) as the disease-causing strain. The scientists now plan to test the ability of these silenced amoebae to serve as a live vaccine by evoking an intestinal immune response. If successful, it may put an end to amoebic diseases that claim the lives of thousands yearly and afflicts millions more.

Prof. David Mirelman's research is supported by the M.D. Moross Institute for Cancer Research; Mrs. Erica A. Drake, Scarsdale, NY; Mr. and Mrs. Henry Meyer, Wakefield, RI; and the late Claire Reich, Forest Hills, NY. Prof. Mirelman is the incumbent of the Besen-Brender Chair of Microbiology and Parasitology.

A Better Water Test

Water is essential for life. Nevertheless, even small amounts of water in the wrong places – fuels, lubricants, or organic solvents – can cause motors to sputter, metal parts to rust, or chemical reactions to go awry. That's why one of the most common lab tests performed in industry is one that looks for traces of water in other substances, even though the test itself is complicated and time-consuming.

A new method for detection and measurement of small amounts of water, developed in the lab of Dr. Milko van der Boom in the Weizmann Institute's Organic Chemistry Department, might allow such tests to be performed accurately and quickly. Van der Boom and postdoctoral fellow Dr. Tarkeshwar Gupta created a versatile film on glass that's only 1.7 nanometers thick, which can measure the number of water molecules in a substance even when it contains only a few parts per million.

"The problem," says van der Boom, "is that water is hard to detect and to quantify." His method is a departure from previous sensing techniques. In general, such sensor systems are based on relatively weak, but selective "host-guest" interactions. In the Weizmann Institute team's sensor, metal complexes embedded in the film steal electrons from the water molecules. When the number of electrons in the metal complexes changes, so does their color, and this change can be read optically. Devices based on optical readout do not need to be wired directly to larger-scale electronics – an issue that's still a tremendous challenge for much of molecular-based electronics.

Testing for water in fuel or solvents might become as simple as checking chlorine levels in a swimming pool

The test can be done in as little as five minutes, and the molecular film can be returned to its original state by washing with a simple chemical. The film also remains stable, even at high temperatures and with repeated use. And, it can be deposited in an inexpensive, one-molecule-thick layer on glass, silicon, optical fiber or plastic. The ease and low cost of fabrication may also make such films ideal for one-time use. Testing for water in fuel or solvents might become as simple as checking chlorine levels in a swimming pool.

Optical detection and quantification by electron transfer could potentially work for numerous substances other than water. The scientists are now exploring the possibility of adapting the method to testing for trace amounts of materials or substances such as specific metal ions or gasses.

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