Learning how cells respond to stressful conditions

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A hibernating dormouse. Credit: Zoë Helene Kindermann, CC-BY-SA-4.0

Developing approaches to protect human well-being in a changing climate will depend on a deeper understanding of how mammalian cells and organisms adapt to dramatic shifts in temperature and in the availability of food and water. To help build this knowledge base, Institute researchers are exposing cells from multiple types of mammals to a range of increased and decreased temperatures; then they are observing the mechanisms the cells may use to survive extreme conditions.

For example, Siniša Hrvatin, Institute Member and assistant professor of biology at MIT, is studying animal hibernation. He explains, "To survive cold winters and limited food availability, certain animals enter hibernation, lowering their metabolism and body temperature to conserve energy. However, increased environmental temperatures appear to inhibit animals from entering deep hibernation, which may decrease their survival during winters." Hrvatin's lab is expanding its investigations on how changes in environmental temperature affect animals' ability to fully enter hibernation and hibernation-like states.

Rising temperatures are also predicted to induce sterility in many kinds of insects, fish, and mammals—potentially exacerbating an already-significant global decline in fertility. Institute researchers are leveraging their globally renowned research on germ cells—the precursors of egg and sperm cells—to explore this phenomenon and seek ways to counter it.

"We have started by looking at some organisms that have evolved a certain capacity to adapt to abnormal temperatures in their environments," explains Lehmann lab postdoctoral researcher Arjuna Rajakumar. "The key question we are asking is whether those organisms modified their germline to gain that capacity. We've begun by observing and tracking the underlying molecular mechanisms of germ cell temperature sensing in multiple Drosophila species."

Certain animal and plant species have evolved capacities to survive, and even thrive, despite extreme environmental change. Understanding how these capacities function at the molecular and cellular levels could be the springboard for new biotechnologies that enable other species to adapt to climate change. For example, Institute Member Ankur Jain is studying the role that Late Embryogenesis Associated (LEA) proteins play in the ability to survive severe dehydration—a capacity known as desiccation tolerance—displayed by certain animals, bacteria, and plants.

Jain explains, "At a certain point, plant seeds undergo programmed dehydration, losing about 90% of their water content. While it is not clear how they stay viable afterward, we recognize that the process is associated with massive upregulation of LEA proteins." This family of proteins has also been identified in animals that can withstand severe dehydration, such as tardigrades and desert scorpions; and expression of LEA proteins also imparts desiccation tolerance to certain bacteria.

"Our team is building on work suggesting that the proteins form a gel-like network that retains water," says Jain, who is also assistant professor of biology and the Thomas D. and Virginia W. Cabot Career Development Professor at MIT. "Once we better understand the mechanisms involved in desiccation tolerance, we intend to develop transgenic models with increased tolerance for dehydration."

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