EXTREMOMETER

EXTREMOPHILES ARE TYPICALLY ASSIGNED THEIR DRAMATIC TITLE THROUGH THE LENS OF HUMAN COMFORT. MICROBES THAT CAN SURVIVE IN SCALDING OR FRIGID WATERS MAY NOT BE FIGHTING FOR THEIR LIVES, DESPITE INHABITING AN ENVIRONMENT THAT WOULD BE CERTAIN DEATH TO ANY MAMMAL. PERHAPS A BETTER WAY TO ASSESS THE EXTREMENESS OF A SPECIES IS TO CONSIDER ITS ENERGETIC BANK STATEMENT: WHO'S LIVING COMFORTABLY IN THE BLACK, AND WHO'S JUST SCRAPING BY?

SYNECHOCOCCUS

Environment: Hot springs in Yellowstone National Park, water temperatures up to 71 °C (160 °F)

Energy consumption: These cyanobacteria gain energy from light-driven reactions that mobilize electrons from water. Along the outer edges of thermal springs, energy-generating light is abundant.

Extremophile or not?
NOT. Evolving to withstand high temperatures did require some important adaptations (such as disulfide bridges and larger hydrophobic cores of the cyanobacterium's proteins to resist unfolding), but the cyanobacteria of Yellowstone's hot springs are able to photosynthesize in relative peace, with few competitors or predators.

METABOLIC STRATEGY
AVAILABILITY
REQUIREMENTS

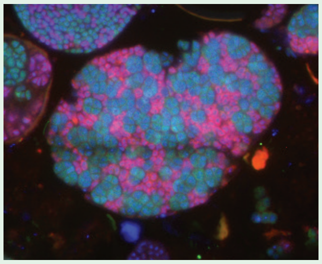
STREPTOMYCES

Environment: Temperate soil

Energy consumption: *Streptomyces* bacteria gain energy by secreting enzymes into the soil to access and degrade organic molecules, such as sugars, amino acids, or aromatic compounds. These energy-rich molecules are abundant, but this strategy of hunting is prone to freeloaders, and the environment is crowded. *Streptomyces* produce a remarkable array of antibiotics to attack their competitors. But antibiotic production is energetically expensive.

Extremophile or not?
EXTREMOPHILE. The backyard may seem like a tame environment, but soil microbes wage war, and only the most resilient survive.

METABOLIC STRATEGY
AVAILABILITY
REQUIREMENTS



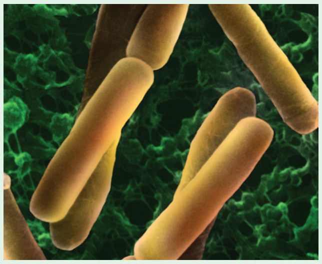
DEEP-SEA ANAEROBIC CONSORTIA

Environment: Deep-sea methane seeps

Energy consumption: Certain archaea and bacteria aggregate together in deep-sea seeps. The archaeal partner oxidizes methane and transfers electrons to the bacteria, which reduce sulfate to sulfide, generating energy. Interestingly, the archaea do not appear to produce enough energy for their own survival; they are reliant on the sulfate-reducing reaction performed by the bacteria.

Extremophiles or not?
EXTREMOPHILES. Extracting and sharing energy among species in methane seeps is an impressive low-energy balancing act.

METABOLIC STRATEGY
AVAILABILITY
REQUIREMENTS



BACILLUS SUBTILIS (SPORULATED)

Environment: Soil

Energy consumption: When the soil bacterium *B. subtilis* finds itself in a period of low energy availability, the microbe initiates a process called sporulation, in which it replicates its genome and stores it in a protective capsule that can withstand extreme heat, radiation, chemical stress, desiccation, and energetically untenable conditions. When the spore senses friendlier surroundings, it can return to a normal life.

Extremophile or not?
NOT. While sporulation is an extreme response to nutrient stress, the bacterium's metabolic hibernation means the organism never has to directly deal with the harsh conditions.

METABOLIC STRATEGY
AVAILABILITY
REQUIREMENTS