April 2005

SAMPLINGS

A Breath of Fresh . . . Hydrogen

Queen's Laundry, a scalding pool in Yellowstone National Park
Photo © John R. Spear

A sulfurous odor permeates the air around the hot springs in Yellowstone National Park. Hordes of microorganisms live in the springs, at temperatures that can exceed 158 degrees Fahrenheit, too hot for photosynthesis. So how do the microorganisms get the energy they need? Until recently, the usual explanation was that they break down sulfur compounds.

Wrong, according to John R. Spear, a molecular biologist, and a team of biologists and astrophysicists at the University of Colorado at Boulder. They discovered that most members of Yellowstone's high-temperature microbial communities are bacteria that draw energy from H2, molecular hydrogen.

At the scalding temperatures that occur in the hot springs, dissolved oxygen is scarce. And in the absence of ample oxygen, hydrogen is easier to metabolize than are other sources of energy, such as sulfur. Other oxygen-poor watery habitats (lake sediments, rice paddies, sewage sludge) harbor many microorganisms that depend on hydrogen. Indeed, the human gut is home to several hydrogen metabolizers—the unwelcome Salmonella among them. Given the abundance of hydrogen in the universe and the wealth of hydrogen-loving microorganisms here on Earth, perhaps there are some living elsewhere, too. (Proceedings of the National Academy of Sciences 102:2555–60, 2005)

—Stéphan Reebs

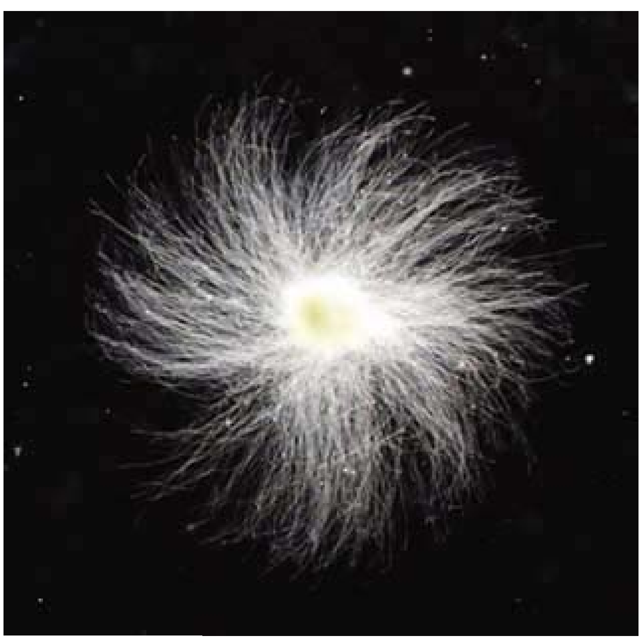
Picky Eaters

Vegetarians must balance their diet, because few plants can supply all the essential nutrients. The herbivores of the animal world do a balancing act as well, seeming to know instinctively what to eat, and in what proportions. Carnivores, however, should be unconcerned about balancing their diet, because most parts of an animal's body provide a fairly complete set of nutrients. Yet a new study shows that some invertebrate carnivores choose their prey carefully, day by day.

David Mayntz, a zoologist at the University of Oxford, and several colleagues studied three species of carnivore—the mobile ground beetle (which can select what's worth chasing), the "sit and wait" wolf spider (which can choose where to wait in ambush, but must content itself with the traffic of the hour), and the web-building desert spider (which has no control over what arrives at its web of the week). All the animals received nutritionally unbalanced meals for one or two days. Some beetles got a powder rich in lipids; the rest got a powder rich in proteins. Some spiders got fat (lipid-rich) live fruit flies; the rest got lean (protein-rich) ones. Then the beetles were given a choice of both types of prey, the wolf spiders were given only one prey type but could choose how much to eat, and the desert spiders were given half an hour to deal with one prey type as they saw fit.

The beetles and the wolf spiders ate more of the type they'd been deprived of. The desert spiders did something even more interesting: they compensated for their last meal's imbalance by adjusting the amount of nitrogen (protein) and carbon (lipids) they extracted from the flies they ate for lunch. (*Science* 307:111–13, 2005)

—S. R.



When sent to space, moss grows in spirals.

Photo © Volker D. Kern

Which Way Is Up?

Hikers' lore has it that (in the Northern Hemisphere) moss grows on the north, shady side of trees, and so can help you find your way through the woods. Not true: it often grows on the south side, or the leeward side, or evenly all around the trunk. One thing is certain, though: on Earth, even in total darkness, moss grows upward, opposite gravity's pull.

But how would the plant grow in the absence of gravity and light? Curious to find out, plant biologists Volker D. Kern of NASA and Fred D. Sack of Ohio State University in Columbus, along with several colleagues, arranged to have some colonies of moss launched aboard two space shuttle missions. The investigators expected the moss to grow in random directions. Surprisingly, its "tip cells"—the cells that, on Earth, elongate against gravity and grow toward the light—grew outward, initially forming a starburst pattern and then a clockwise spiral as most of the moss filaments curved to the right.

Why would moss respond in such a nonrandom way to conditions never encountered on Earth? Perhaps spiral growth is an ancient default program in mosses, later overridden but never disabled. In any case, the orderliness of the plants' growth in space remains a mystery. (*Planta* DOI:10.1007/s00425-004-1467-3, 2005)

—S. R.

Kindred Strokes for Different Folks

Greek or Latin, Hebrew or Mongolian, Tagalog or Tamil, most of the writing systems devised throughout human history are at heart surprisingly similar—and the similarities are probably not coincidental, say two neurobiologists, Mark A. Changizi and Shinsuke Shimojo of Caltech.

Writing is orderly mark making. In nonpictographic writing systems (such as the alphabet you're reading right now), lines, loops, and other strokes are combined to form individual characters—letters and numbers. Characters that are hard to write and (probably more important) hard to read are unlikely to catch on. In contrast, characters made of just a few simple strokes stand a far better chance of surviving.

Changizi and Shimojo studied more than a hundred writing systems, and what emerged was a consistent economy of expression. Each character, on average, is made up of three strokes, no matter how many characters occur in the writing system. Such economy might be explained by earlier findings that people can store roughly three objects at a time in visual short-term memory. Even more astounding is the redundancy of the average character: even if half of its constituent strokes are removed, it remains potentially recognizable. (*Proceedings of the Royal Society of London B* 272:267–75, 2005)

—T. J. Kelleher

Crow Bar

Crow tool use: Betty retrieves a bucket containing meat, using a wire she has just bent.

Corbeau, a hand-reared offspring of Betty, holds a bit of pandanus leaf that he can use as a tool.

For additional images and film clips, see "Tool use in corvids," Behavioural Ecology Research Group, Oxford University.

New Caledonian crows *(Corvus moneduloides)* are famous for poking twigs under bark or into crevices to dislodge grubs. Only one other species of bird, the woodpecker finch, uses an object for probing—a cactus spine. But are these cases of nature or of nurture? Does such resourcefulness come naturally to the "average joe" crow (or woodpecker finch)? Or did some unsung Einstein among the birds invent a practice subsequently picked up by every other bird that cared to watch and learn?

Ben Kenward and his colleagues at the University of Oxford have a persuasive answer. In separate aviaries littered with twigs and pocked with holes and crevices, the ornithologists hand-raised two New Caledonian crow chicks, each in isolation. The young birds spontaneously began to use the twigs to reach into the holes and crevices, and, at the tender ages of sixty-three and seventy-nine days, respectively, they got hold of their first tasty morsels. (Two other chicks, raised together and tutored in the art of twig probing by the investigators, first retrieved food from crevices on days sixty-eight and seventy-two.) On day ninety-nine, one of the isolated birds even shaped its own tool by tearing up a proffered leaf and probing for food with the remaining rib.

If two random New Caledonian crows can, by themselves, acquire expertise in twig usage—and if having companions and regular tutelage doesn't speed up the learning process—it seems safe to assume that most members of the species are naturals with an organic version of the bar that bears their name. The scientists conclude that the crow's brain is well wired for both tool use and toolmaking. (*Nature* 433:121, 2005)

—S. R.

Slick Sisters

Until recently, zoologists thought the membership list of the order Artiodactyla was limited to hoofed mammals with an even number of toes: camels, cows, deer, giraffes, goats, hippopotamuses, pigs, sheep. But mounting evidence suggests dolphins, porpoises, and whales—the water-dwelling mammals known as cetaceans—should be added to the list.

Until well into the 1980s, anatomical studies suggested that hippos may have evolved from pigs. DNA studies from the past decade, however, indicate that hippos are closer relatives of cetaceans than of pigs, which don't chew their cud, or of ruminants (cows, deer, goats, sheep, and so forth), which do. So Jean-Renaud Boisserie, a paleontologist at the University of California, Berkeley, and two French colleagues looked afresh at the fossil evidence—and also at a new trove of whale fossils unearthed in Pakistan—to see whether it supports the DNA link. The investigators compared eighty distinct skeletal and dental features of hippos with those of numerous other artiodactyls. The fossils, they conclude, confirm the DNA.

According to Boisserie and his colleagues, almost 60 million years ago a four-legged artiodactyl gave rise to two main offshoots: the early, quasi-aquatic cetaceans (later to become fully aquatic and lose their hind limbs) and a widespread, diverse group of piglike beasts that probably spent much of their time in water. Of the latter, only the hippopotamuses—which appeared some 15 million years ago—are still with us, and still fond of prolonged immersion in lakes and rivers. (*Proceedings of the National Academy of Sciences* 102:1537–41, 2005)

—S. R.

Landscape of Plenitude

No one is certain why the watershed of the Amazon River is home to such a profusion of flora and fauna. What scientists do know is that many of its millions of species appeared sometime in the past 5 million years. Investigators have speculated that the region's geologic record might hold clues to the explosion of species, but few geologists have been able to examine the rocks. Now Dilce de Fátima Rossetti, a geologist at Brazil's National Institute for Space Research in São Paulo, and her colleagues have done just that in a 1,250-mile-long swath along both sides of the Amazon-Solimões River in northwestern Brazil.

About 20 million years ago, Rossetti's stretch of the Amazon lay at the bottom of a huge lake. From time to time, the lake was flooded by a rising sea. Between 3 million and 1 million years ago, the climate became more arid. Now the lake turned into a system of turbulent, northeast-flowing rivers studded with islands. The rivers flooded periodically, creating fan-shaped deltas of large lakes and floodplains—much like the mouth of the modern Mississippi. The area became choked with sediment, until rumbling tectonic faults dropped the land surface. Any streams that escaped flooding were shifted to a west-to-east flow. Those streams were the precursors of the modern

Amazon River. Finally, as the climate became wetter, the area was again flooded.

According to Rossetti and her colleagues, the dynamism of the landscape probably put pressure on plants and animals to adapt to changing conditions. Flooding may have pushed aquatic species into new habitats. The rivers-and-islands system may have trapped small groups of land creatures. Amazonia's organisms were forced to evolve rapidly, taking on the myriad forms seen today, when tens of thousands of species coexist per acre of land in some areas. (*Quaternary Research* 63:78–89, 2005)

—Dave Forest

Returning Reeds?

A *mudhif* is a typical floating house made of reeds by the marsh dwellers of southern Iraq. Once inhabited by abundant fish, birds, and people, most of the marshes' original 6,000 square miles were desiccated by 2000—the result of thirty-two dams built upstream since the 1960s and a massive drainage program in the 1990s. During the past two years, however, local residents have reflooded about 20 percent of the devastated areas by shutting down water pumps, opening sluice gates, and breaching embankments. Reflooding does not guarantee restoration, though. Ecologists think some of the marshland could be successfully restored, but stress that accumulated concentrations of salt and toxic wastes must first be flushed from the surface so that they do not redissolve and thus pollute the newly introduced water. (*Science* 307:1307–11, 2005)

Talented Newcomer

You might assume that the genes essential to the survival of an organism's genome would have evolved early in the history of the species. But it ain't necessarily so.

Here's how an alternate scenario might work. Imagine taking a job at a well-established corporation. At first your role is minor, but soon you come up with some highly beneficial innovations. Your work makes the corporation so successful that your co-workers must adjust to your innovations. Although you're a relative newcomer, you have become powerful—indispensable, in fact.

So it goes for certain genes, according to Benjamin Loppin, a geneticist at Claude Bernard University in Lyon, France, and an international team of molecular biologists. The gene K81, for instance, is vital in some fruit fly species. Without it, sperm cannot fertilize eggs. Yet it appeared "only" between 1 million and 2 million years ago, as a misplaced copy of another gene. The original gene still functions throughout the fly's body, but the now-modified copy functions only in the testes (though its exact job has not yet been determined).

How did the flies get by before the duplicate gene appeared? Other genes were probably doing the same job, just not as well, and they were made redundant by the newcomer's innovation. (*Current Biology* 15:87–93, 2005)

—S. R.