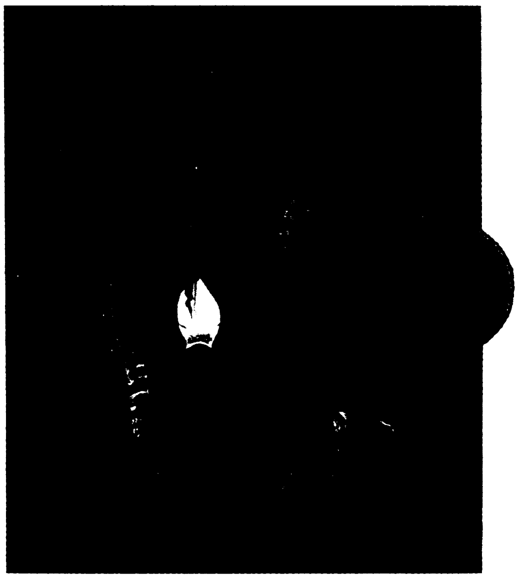
Record-breaking muscle reveals its secret

Someday athletes may carry toadfish and rattlesnake charms for good luck. Both animals have some of the fastest muscles of any vertebrate.

The male toadfish (*Opsanus tau*) produces its mating call by contracting the muscles surrounding its gas-filled swim bladder 200 times per second. Swim bladders normally help fish maintain buoyancy, but the toadfish uses the organ primarily to whistle at passing females. Male and female western diamondback rattlesnakes (*Crotalus atrox*) also deserve a medal for muscle speed, as they can rattle their tails 90 times per second.

What makes these potential Olympians so fast? The contraction speed requires more than just a lot of energy, according to new findings. Although these sonic muscles work much like muscles of other animals, including humans, they perform a couple of key steps with impressive speed, say Lawrence C. Rome of the University of Pennsylvania in Philadelphia and the Marine Biological Laboratories in Woods Hole, Mass., and his colleagues.

Understanding these super achieving muscles provides clues to how different parts of all muscles work, even though the study doesn't have any immediate applications for humans, asserts Michael L. Fine of Virginia Commonwealth University in Richmond.


Robert Golder

An oil painting of a toadfish with its swim bladder muscles highlighted (center) and a rattlesnake shaking its rattler.

Most muscle cells contain a salt solution, called the myoplasm, and a storage compartment for calcium, called the sarcoplasmic reticulum. To make the muscle contract and relax, calcium goes from the sarcoplasmic reticulum to the myoplasm and back. To begin a contraction, a molecular bridge must form between two types of muscle filaments. Calcium entering the myoplasm enables those bridges to form, and its departure causes the filaments to separate, Rome explains.

The sonic muscles of toadfish and rattlesnakes pump calcium out of the myoplasm 50 times faster than the locomotor muscles do, Rome's group reports in the July 23 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (PNAS).

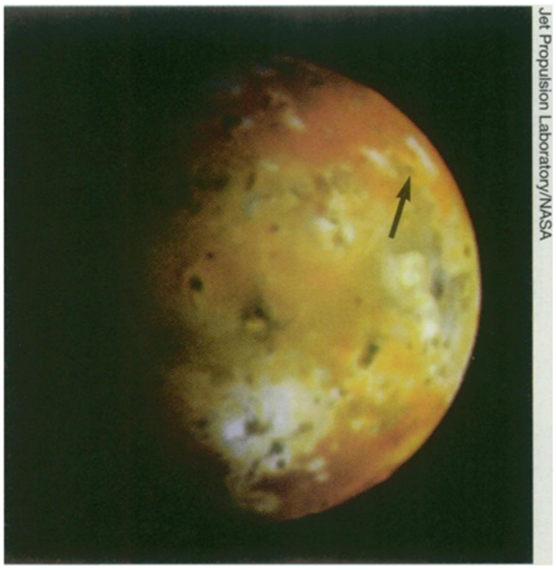
In addition, filaments in their sonic muscles release each other and get ready for the next contraction much more quickly than those in the locomotor muscles, Rome and his colleagues find. In fact, recent, unpublished work by the team suggests that sonic muscle filaments release 100 times faster. Also, sonic muscles have fewer bridges connected at any one time than locomotor muscles do, the new study indicates.

In their experiments, the researchers dissect small bundles of muscle fibers in a salt solution. To measure how fast the calcium moves, they inject a calcium-sensitive dye into the muscle cells. In the PNAS study, they measured bridge attachment and detachment rates by monitoring the maximum speed at which the muscles can shorten during contraction. Rome and his team have recently developed a more direct technique, which they've used in the unpublished studies, he says. — *T. Adler*

Galileo spacecraft glimpses changes on Io

En route to its first rendezvous with Jupiter's moon Ganymede, the Galileo spacecraft late last month took a quick look at the mottled face of another large Jovian moon, volcanically active Io. The relatively low-resolution images, one of which NASA released last week, can't distinguish mountains from valleys, but they do show that the color and brightness of the surface have changed significantly since the Voyager spacecraft viewed it 17 years earlier.

Several of these alterations stem from the numerous sulfur-spewing volcanoes that continually erupt, notes Michael J.S. Belton, head of the Galileo imaging team at Kitt Peak National Observatory near Tucson. Particularly striking is a fresh sulfur dioxide frost surrounding the volcano Masubi in Io's southern hemisphere. "The sulfur dioxide gas that drives the volcano makes a big plume, condenses, then paints the surface white," he says.


Jet Propulsion Laboratory/NASA

True-color image of Jupiter's moon Io. White patches are sulfur dioxide frost; arrow marks possible caldera from a recent eruption. Volcano Masubi appears at lower center.

However, says John R. Spencer of Lowell Observatory in Flagstaff, Ariz., some hot spots on Io, seen in the infrared from Earth, have not noticeably modified the moon's surface. He speculates that these hot spots represent long-term eruptions that do not throw out enough high-temperature material at any one time to alter the surface.

Combining data from the Hubble Space Telescope with Galileo's considerably sharper images, Spencer and Alfred S. McEwen of the U.S. Geological Survey in Flagstaff have found evidence of small amounts of rare forms of sulfur. The reddish hue of Io's poles and the color of some recent volcanic deposits hint at the presence of short-lived forms of sulfur—molecules composed of three or four sulfur atoms—even though these molecules don't typically last as long as common sulfur, composed of eight atoms.

High temperatures within volcanoes may trigger chemical reactions that produce the short-chain forms of sulfur, McEwen suggests. Continual volcanic activity would maintain the supply of these ephemeral molecules. At the poles, high-intensity radiation may decompose elemental sulfur into the short-chain forms, which can persist at the cooler temperatures there.

As intriguing as the new images are, they don't reveal detail smaller than 23 kilometers across. Galileo missed its best opportunity to view Io last Dec. 7, when the craft entered orbit around Jupiter and passed near enough to Io to discern structures 10 meters in diameter. Because of a problem with the craft's tape recorder, NASA decided not to take high-resolution images at that time.

Belton is hoping that after Galileo completes its primary mission 17 months from now, the space agency will give the go-ahead for one last hurrah. Galileo would require an additional 18 months to make a final close approach to Io, but "it's just mind-boggling what you can get," he notes. — *R. Cowen*