SOHO craft helps solve a solar mystery

For more than 50 years, a simple property of the sun's outer atmosphere, the corona, has mystified astronomers. Though it lies thousands of kilometers above the surface of the sun, the corona is much hotter, with an average temperature hundreds of times as great.

It would require only a tiny fraction of the sun's energy to fire up the corona to several million kelvins, but ordinary heat can't flow from a cooler region to a hotter one (SN: 8/31/96, p. 136). Scientists have suggested instead that a sudden release of energy stored in the sun's magnetic field could do the trick, but they lacked compelling evidence. New findings from a spacecraft that stares continuously at the sun may go a long way to providing that proof.

Observations with the Solar and Heliospheric Observatory (SOHO) reveal that the visible surface of the sun is carpeted with tens of thousands of magnetic field bundles that loop upward into the corona. Each bundle is composed of pairs of oppositely directed field lines that about every 40 hours, merge and annihilate each other releasing vast amounts of energy. New bundles then emerge to replenish the magnetic carpet.

SOHO has also found that in a region of the solar atmosphere just below the corona—some 1,600 km above the sun's surface—the brightest features lie directly above the highest concentration of magnetic bundles at the surface.

"This is direct evidence for the upward transfer of energy from the sun's surface toward the corona," says Alan M. Title of the Stanford-Lockheed Institute for Space Research in Palo Alto, Calif. "There is more than enough energy coming up from the loops of the magnetic carpet to heat the corona."

Title's colleague, Mandy Hagenaar of the University of Utrecht in the Netherlands, reported the findings this week at a NASA briefing in Washington, D.C.

Theorist Edward Spiegel of Columbia University notes that the findings "don't solve the problem" of coronal heating completely. The craft can only detect the bundles at the sun's surface, whereas the energy still must travel thousands of kilometers to reach the corona. Spiegel suggests that the energy released by the magnetic field lines gets absorbed by electrons, which transport it upward.

Spiegel is excited that the magnetic bundles appear to be concentrated at the sun's midlatitudes, just where new sunspots occur at the start of each 11-year solar activity cycle. The peak of the next cycle is predicted to occur in about a year. The midlatitudes, enhanced magnetic field density in the could be an early warning sign of that event, Spiegel speculates. —*R. Cowen*

Stanford-Lockheed/NASA

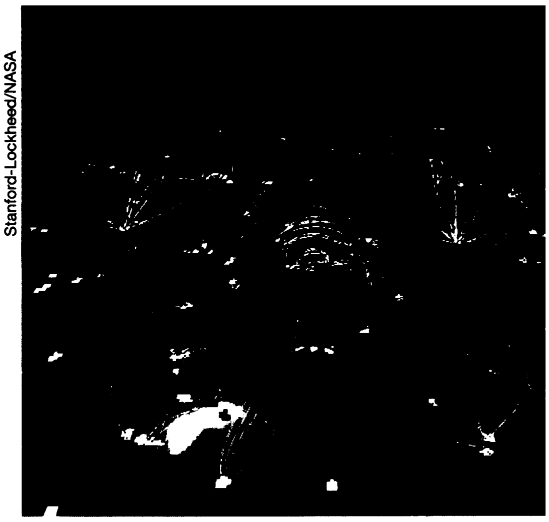


Image depicts the carpet of magnetic field concentrations on the sun's surface, with black and white spots indicating opposite polarities. Magnetic field lines extend upward toward the corona. In the corona, shown here below the carpet, white represents dense regions, and dark green indicates less dense regions.

Mighty mouths: How whales keep the heat

Anyone who has eaten ice cream on a cold winter day can relate to the way gray whales feed. Swimming in near-freezing arctic waters, the behe-mouths slurp up sediments by the tubful to strain out enough tiny crustaceans to sustain their 35-ton forms.

"These animals have big mouths, they're feeding in cold waters—they could be losing a tremendous amount of heat," says John E. Heyning, curator of mammals at the Natural History Museum in Los Angeles.

Yet even with mouths agape, the marine mammals manage to stay about as warm as a person eating ice cream. The whale's secret lies in its massive tongue. A clever arrangement of veins and arteries keeps the animal's heat from being squandered through the uninsulated tongue—fully 5 percent of the body's surface area.

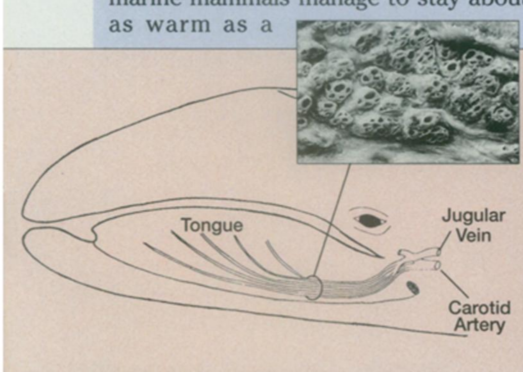
Heyning found the array of vessels by happenstance, while dissecting a whale's tongue for a study of its muscles. He and James G. Mead of the National Museum of Natural History in Washington, D.C., report the anatomical discovery in the Nov. 7 SCIENCE.

The vessels follow a well-known design in engineering—and in other animal parts (SN: 5/14/94, p. 312). In human limbs, blood vessels lie side by side, modestly conserving heat as the blood flowing out warms the blood coming in. Marine mammals excel in the use of these countercurrent heat exchangers, especially in their flukes and fins.

"Classically," says Heyning, the structure is "a central artery with a sheath of veins around it so it looks like a little rosette." In the gray whale, a large bundle of 50 such structures carries warm blood into the muscular, 5-foot-long tongue. By the time the blood reaches the surface of the tongue, the heat has been dumped into the cooled, incoming blood of the adjacent veins. Says Heyning, "Blood coming back into the body core can be just about the same temperature as blood leaving the body core."

It's "a wonderful bit of anatomy," says Ann Pabst of the University of North Carolina at Wilmington, who studies the biomechanics of marine mammals. Equally impressive, she says, is the researchers' report of a whale's tongue in action. Using a thermal sensor on a captive gray whale calf as it fed, they found little difference between water and tongue temperature.

Despite people's ancient interest in the animals—gray whales were cleaned out of the Atlantic Ocean by the 1700s—their size makes them difficult to study and good specimens are rare. The result, says Pabst, is that "a lot of very interesting functional aspects of their anatomy are being described today." —*C. Mlot*



Adapted from Heyning and Mead/SCIENCE

Chill out: A thick bundle of heat-exchanging veins and arteries (inset) courses through the gray whale's couch-sized tongue.

Heyning

Say ahhh: A rare calf found orphaned off Southern California provided what may be the first measures of gray whale mouth temperature.