Sperm stem cells beat ice, species barrier

In the space of a heartbeat, a male mammal creates thousands of sperm. These mature germ cells originate from an inexhaustible source of sperm stem cells, or spermatogonia, that replicate continuously in the testes.

Sperm have been routinely frozen and thawed for decades, but now researchers can cryopreserve mouse sperm stem cells. Thawed and transplanted into the testes of mice, these spermatogonia generate apparently normal sperm.

Cryopreserving sperm stem cells could help investigators store the genetic material of endangered species or animals that might be useful in research or agriculture.

"Any valuable animal and all its possibilities can be stored indefinitely for future use," says Ralph L. Brinster of the University of Pennsylvania's School of Veterinary Medicine in Philadelphia. He and his colleagues report their work in the June NATURE MEDICINE.

During spermatogenesis, explains Brinster, a stem cell's two sets of chromosomes are scrambled and winnowed to the sperm's single set of genes, preparing it to combine with the maternal set of chromosomes in the egg.

"When you freeze a sperm, you freeze an end product that will never divide again or rearrange its genes. When you freeze a sperm stem cell, you freeze an individual and make it immortal," says Brinster.

Researchers already have some means of cryopreserving animals, but those options have their limitations. "Freezing embryos is a complex and often costly process, and for many species, including mice, survival of frozen sperm is very poor. As these studies show, freezing spermatogonia is much simpler and more effective," observes Robin Lovell-Badge of the National Institute for Medical Research in London in an accompanying commentary.

Since spermatogonia of all species appear similar, the freezing of human sperm stem cells is probably feasible, Brinster says. He and Lovell-Badge suggest that this could benefit men about to undergo cancer chemotherapy that will render them infertile. Physicians might be able to transplant a patient's thawed spermatogonia back into his testes to restore his fertility.

In 1994, Brinster's group reported isolating spermatogonia from a mouse and transplanting the cells into the testes of another mouse (SN: 11/26/94, p. 356). The transplanted stem cells produced normal sperm in recipient mice and enabled previously infertile mice to father offspring. The scientists have not yet attempted to prove that sperm from thawed spermatogonia can fertilize eggs.

They have, however, performed another new trick with sperm stem cells: cross-species transplantation. Brinster's team has taken spermatogonia from rats and transplanted them into mice whose own sperm-generating ability had been chemically destroyed. These mice appear to yield ordinary rat sperm, the researchers report in the May 30 NATURE.

Although the evolutionary histories of rats and mice diverged 11 million years ago, the spermatogenic process has changed so little that mice testes can support the germ cells of rats and produce fully normal sperm, says Brinster. "That comes as a big surprise."

The mouse-made rat sperm can presumably fertilize rat eggs and generate healthy progeny, but the investigators have not yet performed that test.

The cross-species transplant stemmed from curiosity about what factors govern the creation of sperm. Mouse sperm take 35 days to form, notes Brinster, while rat sperm need 52 days. To discover whether the Sertoli cells in mice, which nourish developing sperm cells in the testes, influence maturation speed, Brinster plans to observe how long it takes rat spermatogonia to form sperm in a mouse.

Brinster suggests that it may be possible to transplant human sperm stem cells into a suitable host animal. He argues that such an unusual endeavor would help investigators understand human spermatogenesis and provide leads to new contraceptives and the causes of infertility. —*J. Travis*

Craft offers new views of Earth's auroras

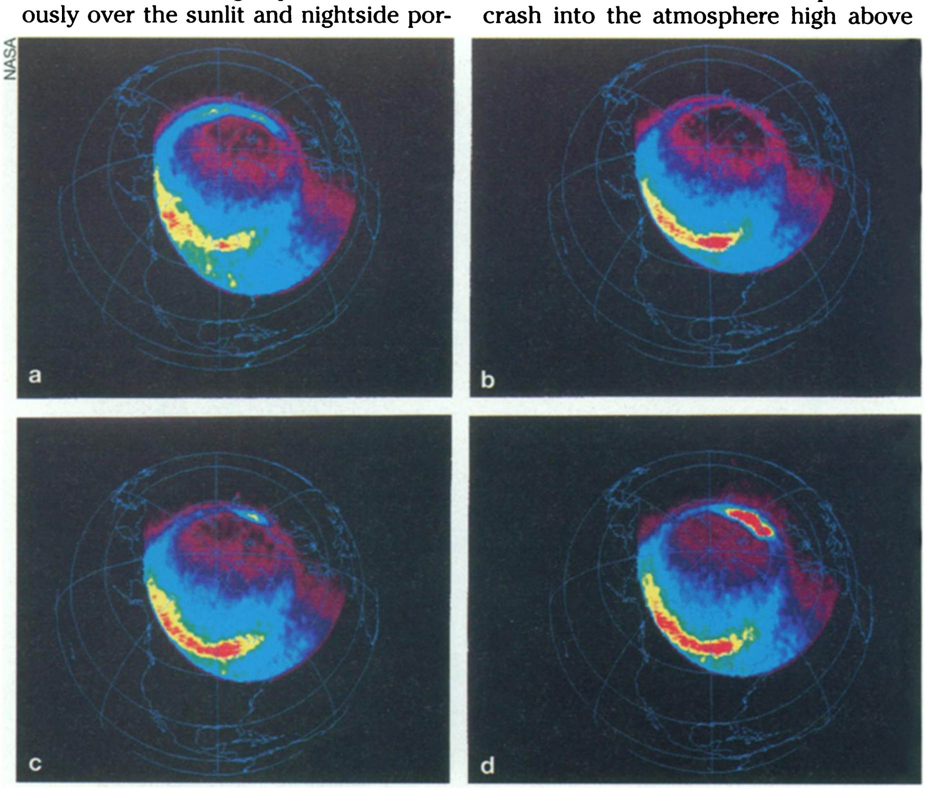
Like a shimmering curtain of light, bands of yellow-green and red dance across the sky, creating an otherworldly glow. More than just a riveting vision, Earth's auroras—the northern and southern lights—illustrate how energy from the sun travels to our planet.

Now, the recently launched POLAR satellite has taken the most detailed images of auroras ever made from space. In addition to visible-light pictures, the images include the first ultraviolet portrait of an aurora glimpsed simultaneously over the sunlit and nightside portions of the atmosphere and the first X-ray image of an entire aurora.

Researchers unveiled these pictures last week at a meeting of the American Geophysical Union in Baltimore.

The images shed light on the interaction between Earth's magnetic field and the solar wind, the breeze of charged particles emanating from the sun's outer atmosphere. As the wind approaches Earth, the planet's magnetic field steers the charged particles toward the North and South Poles. When the particles crash into the atmosphere high above

NASA



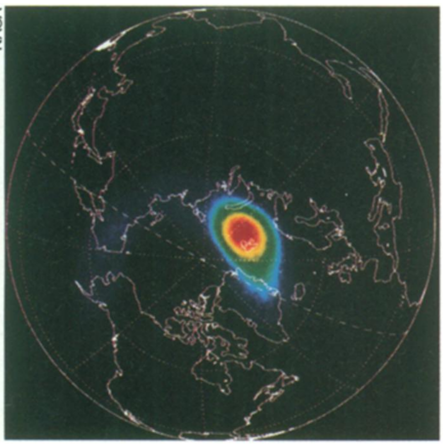
POLAR ultraviolet images, taken during a 47-minute period on April 9, show that sunlit and nightside portions of an aurora vary from each other: a) sunlit portion of an aurora over Canada and its more quiescent nightside counterpart over Siberia; b) brightening of the sunlit portion over the Hudson Bay; c) first brightening of the nightside aurora; and d) increased nightside brightening.

the poles, they collide with local atoms, generating the eerie auroral glow.

In visible light, auroras reveal themselves only over the nightside part of Earth. On the dayside, the glare of sunlight overwhelms their faint glow. POLAR, however, can view the dayside and nightside of an aurora simultaneously in both the ultraviolet and X rays.

The ultraviolet images demonstrate that the dayside and nightside of an aurora can vary from one another in both intensity and shape. "Each has a mind of its own," says George E. Parks, principal investigator of POLAR's ultraviolet imaging study at the University of Washington in Seattle. The differences, he notes, may reflect the fact that the magnetic field on the nightside has a cometlike tail that extends deep into space.

NASA



Global X-ray image of Earth's northern aurora, taken by POLAR on March 20. The dashed line marks the boundary between day and night. The picture shows a hot spot above the atmosphere near midnight and a band of weaker X-ray emissions extending through the night and morning hours. Blue depicts the weakest intensity, red the highest.

The X-ray images selectively track the motion of high-speed electrons in the solar wind, notes David Chenette of the Lockheed Martin Advanced Technology Center in Palo Alto, Calif., principal investigator of POLAR's ionospheric X-ray imaging experiment. "The X rays provide us with a very solid measure of the power that is [dumped] into the upper atmosphere from these electrons."

By examining Earth's auroras, POLAR tracks disturbances in the solar wind. The craft is part of a fleet of satellites, including the solar observatory SOHO (SN: 5/4/96, p. 277), that collectively studies the interaction between the sun and Earth. The goal of this fleet, explains Mario Acuna of NASA's Goddard Space Flight Center in Greenbelt, Md., "is to be able to predict when and where disturbances [originating from the sun] might occur in [Earth's] magnetosphere and ionosphere and how severe they might be." *— R. Cowen*

Finding some quiet time for reproduction

Algae that spend their days soaking in cool waters off an uninhabited Swedish island offer animals and other plants an important lesson in reproduction. Don't bother trying during turbulent times—wait for your environment to settle down.

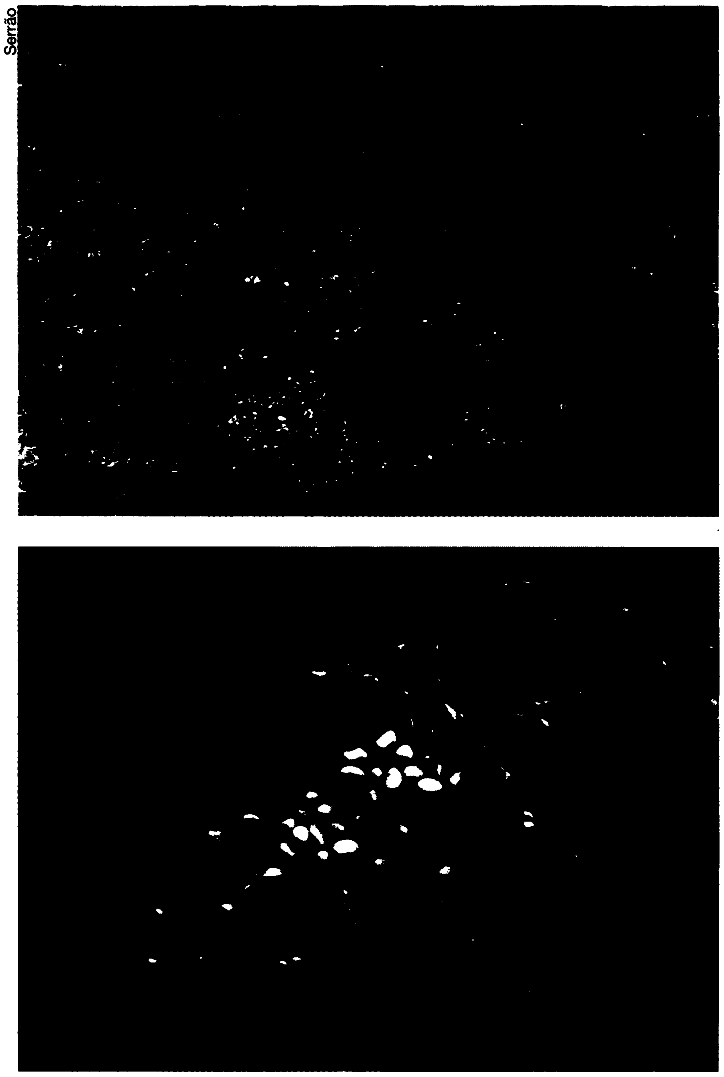
Many marine organisms like the alga *Fucus vesiculosus* reproduce by releasing sperm and eggs into the water. These gametes must fuse to grow into a new individual. However, researchers have suspected that this approach to fertilization has a low success rate. In experiments where scientists have released various plant or animal gametes into the ocean, egg and sperm have often failed to meet.

One common type of algae, and probably other forms of marine life, is savvy about reproduction. It determines when the surrounding water becomes calm and only then releases large amounts of eggs and sperm, report Ester A. Serrão of the University of Maine in Orono and her colleagues in the May 28 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

"This paper shows there is at least one elegant mechanism out there," asserts Mark Denny of Stanford University. Some marine organisms, such as sea urchins, just spew out lots of gametes to increase the odds of fertilization.

Serrão and her colleagues collected eggs, sperm, and zygotes from two beds of *F. vesiculosus* off Askö, Sweden, during the 2-month reproductive season. They noticed that the algae released eggs and sperm only in calm water—slower than about 0.2 meter per second—and only in late afternoon. The proportion of gametes to zygotes indicated almost 100 percent fertilization.

Serrão



The alga F. vesiculosus *in the ocean off Sweden. At the end of their branchlike structures, shown close-up, are the receptacles that store gametes (bottom).*

The scientists then put the algae's receptacles, which store either sperm or eggs, in tubes anchored in the ocean. Like intact plants, the receptacles released gametes only in calm water. The researchers found signs of a sperm's nucleus in almost every egg released.

The investigators then measured the response of *F. vesiculosus* and two other algae in the same family to agitation in laboratory water. They put the algae's receptacles in flasks and shook them for various amounts of time up to a week, Serrão explains. The receptacles released their gametes only during the early evening of the day after the shaking stopped. The longer the period of shaking, the more eggs and sperm were released.

These algae appear to be responding to at least one characteristic of calm water—a low concentration of dissolved inorganic carbon, the team learned recently. In quiet water, algal photosynthesis depletes the carbon from the thin layer of static water surrounding the receptacles, and little new carbon mixes in.

When the researchers removed all dissolved carbon from water in the lab, the algae released their gametes, even when the water was turbulent. When the team added carbon, the plants released no gametes, even under calm conditions.

— T. Adler