Fetus tells mother: It's time for labor

A specific region in the fetal brain may serve as the biosensor that triggers the events leading to birth, according to two new studies of sheep.

This "dramatic" finding represents the first solid proof that the fetal brain initiates labor, at least in an animal model, says physiologist Gloria E. Hoffman of the University of Pittsburgh School of Medicine. "Down the line, it may offer some insight into how to develop strategies to prevent premature labor," she adds. Premature babies face a higher risk of death and serious health problems because they are born with underdeveloped organs.

Twenty years ago, New Zealand researchers showed that destroying the adrenal and pituitary glands in fetal sheep could delay labor. While this hinted that a fetal factor provided the main impetus for labor, other scientists have argued for a maternal "master switch."

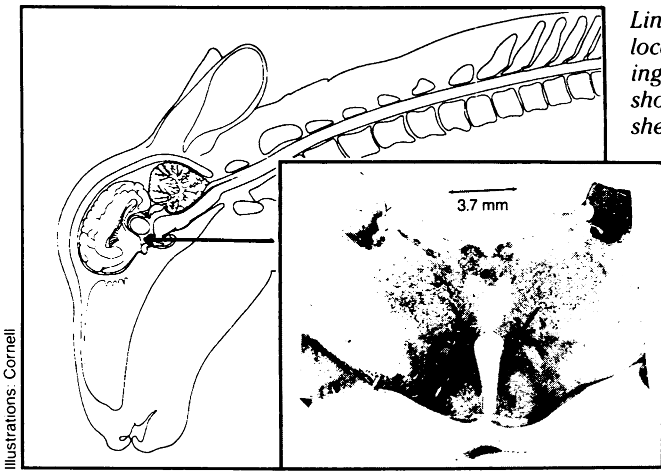
Peter W. Nathanielsz and Thomas J. McDonald of Cornell University have now extended that early work, showing that the adrenal and pituitary glands of fetal sheep respond to signals from a pea-sized region of the fetal brain, called the paraventricular nucleus.

The Cornell study, combined with similar evidence reported by Peter D. Gluckman and his colleagues at the University of Auckland, New Zealand, suggests that the paraventricular nucleus starts labor in sheep, says Nathanielsz. Both groups describe their findings in the Sept. 15 AMERICAN JOURNAL OF OBSTETRICS AND GYNECOLOGY.

Gluckman's team produced a three-dimensional map of the fetal sheep brain, which enabled the Cornell group to locate the paraventricular nucleus of nine fetuses in the third trimester of gestation. With the nine pregnant ewes under anesthesia, the researchers used an electrode-tipped needle to deliver a blast of radio waves that destroyed the paraventricular nucleus in five of the fetuses. The other four fetuses received a "sham operation" that left the brain intact.

All sheep recovered from the operation, and the pregnancies continued. Five days after surgery, the researchers began collecting daily blood samples from the carotid arteries of the fetuses.

Scientists know that two hormones — cortisol and adrenocorticotropic hormone (ACTH) — reach their peak levels in the fetal bloodstream just before birth. The four control fetuses followed this pattern, showing a steep rise in the hormones about a week before delivery. In the five experimental fetuses, however, blood levels of ACTH and cortisol remained constant throughout the experiment.



Illustrations: Cornell

Line drawing shows location of labor-triggering brain region. Photo shows section of fetal sheep brain with paraventricular nucleus (dark areas) indicated by arrows.

On average, the control ewes gave birth on schedule, at about 146 days of gestation. But the experimental group showed no signs of labor even at 157 days, when the researchers delivered these fetuses by cesarean section.

Nathanielsz suggests that the fetal brain may act as a tiny monitor, tracking its own development. When the fetus is ready for birth, the paraventricular nucleus signals the fetal pituitary gland to step up ACTH secretion. The pituitary, in turn, tells the fetal adrenal gland to secrete more cortisol. The increases in fetal hormones spark changes in maternal hormones, which lead to uterine contractions, Nathanielsz says.

Whether the sheep findings extend to humans remains unclear. The Cornell scientists now hope to determine whether the paraventricular nucleus plays a similar role in monkeys, whose reproductive systems resemble those of humans, Nathanielsz says.

Proof of the human fetus' role in labor would be tricky to obtain, he notes. However, if primate studies confirm the sheep findings, scientists could begin developing drugs to block the fetal signal in women who show signs of premature labor, he says. Obstetricians currently rely on drugs that quiet the uterine muscle — a strategy that often fails.

— K.A. Fackelmann

New Hubble trouble: Spectrograph awry

Add another malfunction to the spate of problems plaguing the Hubble Space Telescope. A faulty power supply has forced NASA to halt indefinitely all research conducted with a key spectrograph aboard the Earth-orbiting craft.

The ailing spectrograph, which uses diffraction gratings to separate ultraviolet light into its component wavelengths, has significantly higher spectral resolution than Hubble's only other spectrograph. Unless engineers can replace or compensate for its defective power supply, astronomers will have to forgo several types of Hubble observations that require resolution of minute differences between spectral lines, says Blair D. Savage of the University of Wisconsin-Madison, who helped design the spectrograph. These would include studies of the chemical composition and abundance of interstellar matter, he notes.

Scientists got their first inkling of Hubble's latest trouble on July 24, when the Goddard High-Resolution Spectrograph failed to relay some of its ultraviolet data. But the problem abated within minutes, and researchers didn't become alarmed until it recurred during observations on Aug. 5.

In the past month, researchers from NASA's Goddard Space Flight Center in Greenbelt, Md., and the Ball Corp. in Broomfield, Colo. — which built the Goddard-designed spectrograph 10 years ago — have identified what they consider the likely cause of the communications failure. The suspect: a defective solder joint on a low-voltage power supply that provides the electricity for one of the two adjacent electronic sections of the spectrograph. Each section powers roughly half of the instrument.

The balky voltage source can't supply enough power to operate the photon detector and other components on the section known as side 1, says Goddard's Jean Lane, experiment manager for the spectrograph.

Side 2, powered by a separate voltage source, still functions normally, she says. But for scientists eager to continue observations, there's a catch. In order to transmit information from the spectrograph to the ground or to an onboard computer or tape recorder, a device called a formatter must first package the raw data. And the formatter now connected to side 2 gets its voltage from the defective power supply. As a result, Lane says, side 2 transmits data only intermittently.

Hubble officials have concluded that continued use of the crippled spectrograph would waste precious observing time. Two weeks ago, they temporarily suspended all science operations with the spectrograph, says Peter Stockman, deputy director of the Baltimore-based Space Telescope Science Institute, which coordinates Hubble observations.

Preston Burch, NASA's deputy project manager for Hubble operations and ground systems, says engineers will begin tests next month to gather more information on the equipment failure. They hope to determine whether changes in such factors as the spectrograph's temperature can boost the power supply's performance enough to allow more frequent and predictable data transmission by side 2. The tests could take up to a month to complete, Burch says.

If testing does not suggest a way to improve the power supply, NASA still has two key options for salvaging the spectrograph, says Goddard astrophysicist Sara R. Heap, a member of the spectrograph research team. Using software relayed from the ground to the telescope, researchers could attempt to connect side 2 to a second onboard formatter, which does not use the defective voltage source. The formatter change could take two to three months. Although side 1 would remain inactive, a successful switchover should fully revive operations with side 2, Heap says.

But the undertaking poses some formidable risks, she adds. Hubble's four other science instruments – which now function normally – would also have to switch to the second formatter, requiring ground-based technicians to temporarily turn off their power, place the instruments in an inactive "safe mode" for several days, and then power them back up. Power surges inherent in this process might damage equipment, notes Burch. Moreover, says Heap, the second formatter has not been tested in space. Some scientists worry that if this formatter does not operate properly, the engineers may have difficulty switching the instruments back to the original device.

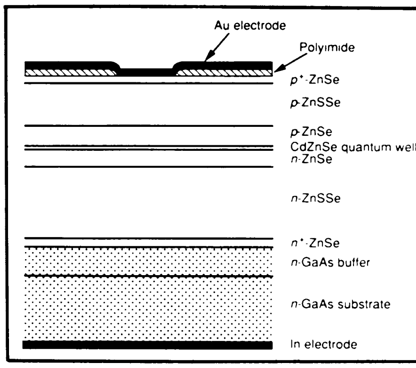
"It's like a chess game," says Burch. "You don't want to make a move you don't know how to deal with, or you might get checkmated." The formatter change remains a possible option, he says, but if it caused a working instrument to fail, "we'd really look like a bunch of fools."

A second option would involve a fix in space, attaching a working power supply to the spectrograph and leaving the faulty supply intact but disconnected. NASA would piggyback this effort on a Hubble service mission already planned for 1993. The maneuver – similar to the 1984 repairs on the Solar Maximum Mission – would require an extra day on the three-day service mission, says John Campbell of Goddard, the deputy associate director for Hubble flight projects. After all, he notes, astronauts on the service mission will already have their hands full fixing Hubble's blurry optics, failed gyroscopes and loose solar panels.

– R. Cowen

Pushing lasers on a chip into the blue

Semiconductor lasers serve as the most compact, inexpensive sources of light available for use in such products as compact disk players and laser printers. They normally emit red or infrared light, but industrial researchers have now fabricated semiconductor lasers that generate pulsed light at a considerably shorter wavelength.



3M Co

Cross section of blue-green laser diode.

Using a layered crystal composed largely of zinc selenide, Michael A. Haase and his co-workers at 3M Co. in St. Paul, Minn., electrically induced their novel material to emit blue-green light, the shortest wavelength ever generated by a solid-state laser. That success, reported in the Sept. 9 APPLIED PHYSICS LETTERS, marks a significant step toward producing commercial semiconductor lasers that generate blue light. Such lasers would permit the storage of much larger quantities of data and the printing of finer details.

"It's a great achievement," says electrical engineer Jacob B. Khurgin of Johns Hopkins University in Baltimore. "Five or six years ago, lots of people were giving up on the idea of making [blue-green] lasers out of zinc selenide."

A semiconductor diode laser generates light at a junction within the material where negative charge carriers, or electrons, recombine with positive charge carriers known as holes. The energy difference between the electrons and holes determines the wavelength of the emitted light.

Researchers had known for more than three decades that zinc selenide has the right characteristics to generate blue or blue-green light. But until recently, progress was stymied by the immense difficulties of devising a crystal structure that effectively confines electrons to an extremely thin layer and introducing appropriate impurities into zinc selenide to generate a sufficient number of positive charge carriers.

Last year, physicists at the University of Notre Dame in Indiana finally solved the confinement problem by sandwiching a thin layer of zinc selenide mixed with cadmium selenide between layers of zinc selenide. The zinc-cadmium layer acts as a "quantum well" to trap mobile electrons and holes in a small region of the crystal.

"The development of this material was a crucial step," says Notre Dame's Jacek K. Furdyna.

"It seems to be the most promising system for the time being," adds colleague Nitin Samarth. "Everyone's using it."

The problem of introducing holes into zinc selenide was also solved last year when scientists at 3M and the University of Florida in Gainesville developed a way of embedding nitrogen in the material. That technique involves exposing the material, as it forms, to nitrogen gas excited by radio waves.

These two developments allowed the 3M team to fabricate the first layered crystal capable of generating blue-green light when activated electrically. "The fact that they were able to put these two pieces together represents a dramatic breakthrough," says Arto V. Nurmikko of Brown University in Providence, R.I. At a conference last week in Japan, Nurmikko announced that his group, together with researchers at Purdue University in West Lafayette, Ind., had also constructed such a laser and confirmed the 3M result.

The prototype zinc cadmium selenide laser, barely the size of a sand grain, produces pulses of light at a wavelength of 490 nanometers when cooled to the temperature of liquid nitrogen (77 kelvins). At room temperature, the wavelength increases to roughly 500 nanometers.

"We've now built more than 100 lasers," says Charles Walker, who heads 3M's photonics research lab. But commercialization remains several years off, he adds.

One problem centers on the excessive heat generated when the laser operates. Although it takes a relatively high voltage to drive the laser, only a small portion of that energy ends up as light. The rest turns to heat, which limits how long the laser can operate without destroying itself. To produce light as a continuous wave instead of as brief pulses, researchers must find ways of reducing the voltage needed to drive the device.

One sign that continuous-wave operation is feasible appears in a separate paper in the Sept. 9 APPLIED PHYSICS LETTERS, in which the Notre Dame and Brown groups jointly report that an optically driven zinc cadmium selenide laser can generate light continuously at temperatures up to 110 kelvins.

– I. Peterson