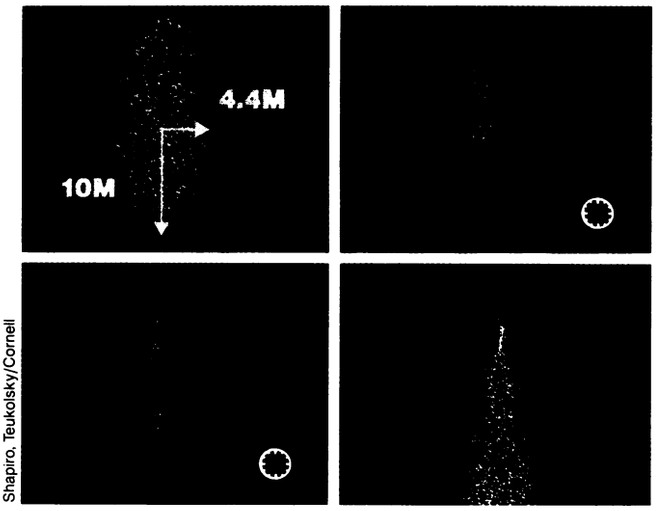
SCIENCE NEWS of the week

Throwing Light on Cosmic Censorship

Einstein's general theory of relativity provides a framework for understanding how gravity drives the collapse of massive stars or generates the tidal forces that tear apart colliding galaxies. But the equations are so difficult to solve that theorists are just beginning to explore the complex sorts of behavior encompassed by general relativity.

Using a supercomputer to solve Einstein's equations, Stuart L. Shapiro and Saul A. Teukolsky of Cornell University in Ithaca, N.Y., have now uncovered evidence that the gravitational collapse of certain three-dimensional distributions of matter leads to the formation of a "naked" singularity—an exposed point in space where physical quantities such as density and gravitational force become infinite. When such infinities occur, theorists can no longer solve the equations to predict the future course of gravitational collapse, and the theory of relativity breaks down.



Shapiro, Teukolsky/Cornell

In the gravitational collapse of a sufficiently large, elongated sphere (top left), the object thins faster than it squishes down, and takes on a spindle shape (top right). Before this configuration finishes collapsing, "naked" singularities appear at the spindle's ends (bottom), stopping the computation.

"This could be one of the most important results we have found with our supercomputer calculations to date," Shapiro says. "If it holds up, it could in fact be very significant for relativity theory." He and Teukolsky report their findings in the Feb. 25 PHYSICAL REVIEW LETTERS.

Singularities associated with gravitational collapse appear frequently in the solutions of Einstein's equations, even though nature doesn't countenance such bizarre features. What saves relativity theory is that these singularities normally sit at the centers of black holes—collapsed regions where the gravitational force is so strong that not even light can escape.

Because nothing that happens within a black hole could ever influence anything outside, the presence of a singularity there doesn't matter. Relativity theory would still work everywhere outside the black hole. For this reason, theorists believed they could safely ignore any such well-hidden nuisances that surfaced in their solutions to Einstein's equations.

In 1969, mathematical physicist Roger Penrose of Oxford University in England enshrined this idea in his "cosmic censorship" hypothesis, stating that singularities would always be found inside black holes. There are no naked singularities, he claimed.

To test this notion, Shapiro and Teukolsky computed the gravitational collapse of assorted three-dimensional balls of particles. They discovered that compact balls collapsed to become singularities enveloped in black holes. However, sufficiently large, nonspherical distributions collapsed to singularities without the formation of censoring black holes, leaving the singularities naked to the rest of the universe (see illustrations).

This violation of cosmic censorship represents a potential disaster for general relativity, Shapiro says. It exemplifies a situation in which relativity theory clearly fails to model the physical world, in which no such singularities appear.

Physicists now face either the formidable task of salvaging cosmic censorship or the dismaying prospect of modifying a landmark theory. "If cosmic censorship really goes out the window — and one would need more work to really nail that down—then one would need to revise the mathematical equations for relativistic gravity," Shapiro says.

Shapiro and Teukolsky are studying the effects of the object's spin and are seeking to determine whether treating matter as a fluid rather than as a distribution of particles would change their results.

"Numerical work is probably the only way you're going to be able to determine whether or not these naked singularities form, but you have to be extremely careful," says David W. Hobill of the University of Illinois at Urbana-Champaign. "We have a long way to go before we really understand what's happening."

— I. Peterson

Sizing up the risks of heart-saving drugs

A gold-standard therapy for heart attacks works as well as newer—and more expensive — clot-busters, according to interim results of a large international trial. More important, this comparison of a trio of clot-dissolvers shows that the standard treatment poses a dramatically lower risk of stroke.

"Streptokinase is safer and just as effective—that's really the bottom line of the trial," says Peter Sleight, a cardiologist at Oxford University in England. He leads the scientists in Europe, North America and New Zealand who are conducting this ongoing trial.

At the American College of Cardiology's annual scientific sessions in Atlanta this week, Sleight's team presented data on the 42,000 heart-attack victims they are tracking. Each patient randomly received streptokinase, tissue plasminogen activator (tPA) or anisoylated plasminogen-streptokinase activator complex (APSAC) at the time of the heart attack. By dissolving blood clots in the coronary arteries, all three drugs restore blood flow to the oxygen-starved heart tissue.

People who received streptokinase infusions during the first hours of a heart attack proved as likely to survive the risky next few months as those who got infusions of tPA or APSAC.

Patients treated with streptokinase gained an unexpected benefit, however: They suffered significantly fewer hemorrhagic strokes compared to patients treated with the other two drugs. Hemorrhagic strokes, which occur when a brain blood vessel ruptures, can cause death or permanent brain damage. Ninety-four patients in the tPA group suffered such a stroke, most within 24 hours of treatment. That's about 25 percent more than in the APSAC-treated group (75) and almost 2½ times as many as in the streptokinase-treated group (39).

"It appears streptokinase has the optimal benefit-to-risk ratio," says U.S. study leader Charles H. Hennekens at the Har-

vard Medical School in Boston.

Although some scientists had speculated tPA would prove a superior heart-attack treatment because it dissolves clots faster than streptokinase (SN: 12/12/87, p.376), this trial showed no survival edge for people getting tPA or APSAC. Indeed, the relatively new clot-busters may prove a disadvantage if they are more likely to dissolve beneficial clots in other parts of the bloodstream, such as clots repairing a breach in a brain blood vessel, Hennekens warns.

The new findings also add weight to previously voiced concerns about the high price tag of newer clot-busting agents (SN: 4/8/89, p.214). A course of tPA treatment costs about $2,200, and the typical tab for APSAC is roughly $1,700, Hennekens notes. Streptokinase, a drug that has been in use for a variety of purposes for 30 years, costs only about $200.

The cost and safety advantages may encourage more physicians – especially U.S. clinicians who now favor tPA – to use streptokinase when treating heart attacks, the researchers say. However, Hennekens cautions, physicians should look to tPA for patients previously treated with streptokinase or APSAC.

Because they are derived from bacteria, streptokinase and APSAC are more likely to trigger an allergic reaction than tPA, which is a genetically engineered human protein, Hennekens says.

– K.A. Fackelmann

Retinoic acid flunks as a master molecule

Two reports published this week question a dominant tenet of developmental biology – that a relative of vitamin A serves as a master control chemical that prompts the formation of such disparate anatomical structures as fingers, legs and toes.

By implanting microscopic beads coated with retinoic acid into the limb buds of unhatched chicks, two independent groups of researchers – one from the University of California, Irvine, and another from three Japanese universities – have shown that retinoic acid, a metabolite of vitamin A, does not directly dictate the pattern of limb formation in developing embryos.

The studies already have stirred two deeply divided camps of developmental biologists: those who believe that a single master chemical, or morphogen, calls the shots during development, and those who believe that a subtle interplay between the embryonic cells themselves determines whether they will become part of a finger or a thumb.

"I don't think the morphogen view works," says Susan V. Bryant, head of the Irvine laboratory. Bryant believes that as-yet-unidentified molecules on the surfaces of embryonic cells enable the cells to recognize one another and grow into the precise patterns that lead to limbs and digits.

In their experiment, reported in the March 7 NATURE, Bryant's group put a retinoic acid-soaked bead under the surface of the front edge of a chick-limb bud. They removed the bead, and an hour and a half later cut a tiny wedge of tissue from next to the implant site. When the tissue wedge was grafted onto an untreated limb bud, it made the chick grow an extra set of digits.

Bryant says the effect could not be due to retinoic acid carried over in the tissue wedge, because the chemical breaks down in less than one hour. She believes instead that retinoic acid turns on a set of cells, termed the zone of polarizing activity, which then go on to choreograph development.

The Japanese team, headed by Sumihare Noji of Okayama University Dental School, reports the results of its grafting studies in the same issue of NATURE. They found that grafts taken from an area of the chick-limb bud known to be important in development do not prompt untreated limb buds to make molecular receptors for retinoic acid. Because studies show that retinoic acid causes the expression of retinoic acid receptors, Noji's team concludes that retinoic acid alone cannot cause limb development.

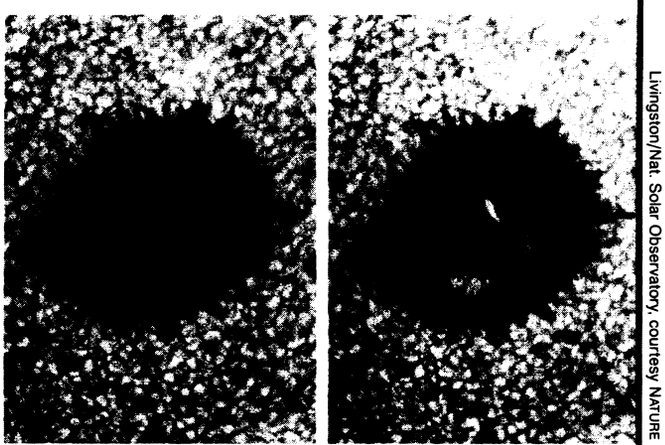
Jeremy Brockes, a developmental biologist from the Ludwig Institute for Cancer Research in London, says in an accompanying commentary that although the new experiments contain some flaws, they do question the role of retinoic acid as a morphogen. But he points out that gradients of retinoic acid have been found across developing limb buds, and researchers have shown that retinoic acid alone can cause newts and salamanders to regenerate amputated limbs. "It's still an open possibility that retinoic acid is responsible" for directing limb development, he says.

The new work "is not very solid," argues Gregor Eichele from Baylor College of Medicine in Houston. Eichele was one of the discoverers of the retinoic acid gradient in developing limbs, and last year he and his wife, Christina Thaller, found a second potential morphogen, 3,4-didehydroretinoic acid (SN: 7/7/90, p.15). "The only way you can find out what retinoic acid is doing is by finding out what genes it turns on," he says.

Thomas Jessell, a developmental biologist at Columbia University in New York City, terms the new studies "interesting." Jessell, who has collaborated with Eichele and Thaller, says the new reports "will make people slightly less complacent about the identity of retinoic acid as a morphogen." But he still doesn't accept Bryant's theory that cell-to-cell interactions govern development. "You have to invoke some magic to get [it] to work," he says.

– C. Ezzell

Images reveal greater sunspot structure



Livingston/Nat. Solar Observatory, courtesy NATURE

Photographs taken with the McMath optical telescope on Kitt Peak near Tucson, Ariz., reveal new details about sunspots, the solar regions where magnetic fields concentrate. The image on the left depicts a conventional view: Filaments of gas – believed to mark the path of magnetic field lines parallel to the solar surface – extend radially from a sunspot's outer edge, or penumbra. They do not appear to extend back into the sunspot's darker central region, or umbra. But when astronomer William Livingston of the National Solar Observatory in Tucson took a longer-exposure photo, he detected filamentary "bridges" spanning the penumbra and umbra – an indication that magnetic field lines cross into the central region. The image on the right, a composite of the long and short exposures, delineates the bridging filaments.

Livingston says his images challenge the accepted view that the umbra has a relatively uniform, granular structure. Instead, it contains filaments separated by dark voids where the magnetic field points perpendicular to the solar surface, he asserts. The new umbral detail also indicates that temperatures may vary significantly over the region, Livingston notes. He credits his findings to the Kitt Peak telescope's high resolution and to excellent viewing conditions. But he adds that other observers may have ignored similar evidence because it did not support the granular theory.