tics such as feathers and fused collarbones.

But in 1985, British astrophysicist Fred Hoyle and other critics based at University College in Cardiff, Wales, claimed that a limestone paste was probably used to create the image of feathers around a genuine reptilian skeleton. Photographs of the fossil, said Hoyle, reveal a fine-grained substance under the feathers and distinctive blobs that could be remnants of a forger's cement. He and his colleagues also contended that elevated and depressed regions on one slab are not perfectly mirrored on the other.

The British Museum scientists used microscopes to examine the surface of the fossil and cross sections of the imprints. They found no evidence of an added cement layer or artificial feather impressions. The blobs cited by critics, maintain the investigators, are natural irregularities created when the limestone was split to reveal the ancient bird. These and other irregularities, they add, often become slightly exaggerated after years of cleaning and examination.

Critics also have noted areas where the same feather appears to make two slightly displaced impressions, but the British Museum scientists say these "double strikes" are the likely result of two overlapping layers of feathers.

The most conclusive evidence that *Archaeopteryx* is genuine, however, is provided by hairline cracks running in various directions across the feathers and other parts of the impression. The cracks show up under ultraviolet photography, and those on the main slab correspond perfectly with those on the opposite face. It would be impossible, contend the researchers, to forge exactly matching crack patterns. *— B. Bower*

Sneaking in a therapeutic enzyme

The body's normal functions can work at cross purposes to a person's survival. Such is the case when the enzyme adenosine deaminase (ADA) is injected into babies born without the gene that produces it. The vital enzyme is quickly broken down, either by a knee-jerk immune system reaction to the foreign protein or by normal metabolic processes. Without ADA, the infants' immune systems eventually and fatally shut down.

So far, all attempts to directly replace the enzyme ultimately have failed, bone marrow transplantation of cells that make ADA is frequently not possible or successful, and gene therapy has yet to be used in humans.

Last month, researchers tried a new approach on an ADA-deficient infant using ADA studded with innocuous molecules that shield it from short-term destruction without disturbing the enzyme's active site. The treatment, claims Enzon, Inc., the South Plainfield, N.J., company that manufactures the altered enzyme, is simpler and safer than gene therapy.

Rebecca Buckley of Duke University in Durham, N.C., who is directing the human trial, says it is much too early to determine whether the treatment is effective. The patient had already received two bone marrow transplants, both of which failed.

ADA deficiency is one cause of severe combined immunodeficiency disease (SCID), sometimes known as the "bubble boy" disease, named for the Texas boy who lived most of his life in a sterile bubble. He died at age 12 after a bone marrow transplant (SN: 3/3/84, p. 133).

Bone marrow transplantation to graft in new cells that produce the enzyme is the only proven treatment for the rare condition. But a matched donor is needed, and the therapy fails about as often as it succeeds.

Research in gene therapy — transferring ADA-producing genes into the patient's own marrow cells — is currently under investigation at Memorial Sloan-Kettering Cancer Center, the National Institutes of Health and Princeton University (SN: 8/24/85, p. 117). Researchers at the three institutions have used a virus to transfer the normal human gene for ADA into monkey marrow cells, transplanted the cells back into the monkeys, and detected a low but significant level of human ADA production, Richard O'Reilly of Sloan-Kettering in New York City told SCIENCE NEWS. In addition to getting government approval, many details have to be worked out before the procedure can be used therapeutically, he says.

In the new enzyme-replacement technique, polyethylene glycol (PEG) is hooked onto the ADA. The PEG "studs" effectively block out the large immune cells while the small molecules on which the enzyme acts can slip through to the active site, explains Abraham Abuchowski of Enzon.

Normally, the enzyme conducts its business within blood cells — adenosine from the blood plasma enters the cells and is broken down by intracellular ADA. With the protected PEG-ADA, the interaction is in the plasma. "It's totally unnecessary to get the enzyme into the cell," Abuchowski says.

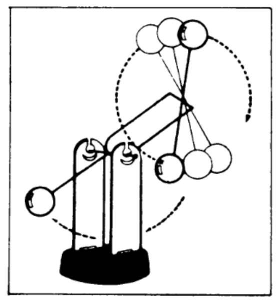
Another PEG-coated enzyme is currently under evaluation in the United States and Europe for its activity against several types of leukemia. PEG-enzymes may also prove useful for some of the thousands of genetic diseases, Abuchowski says. *— J. Silberner*

Toying with a touch of chaos

Gyrating like a stiff but daring gymnast, the Space Ball moves in mysterious ways. This simple toy's erratic oscillations recently attracted the attention of engineer Alan Wolf, who started to explore its movements for signs of chaos — motions that can be described by simple equations and yet are quite unpredictable (SN: 7/30/83, p. 76).

Most chaotic systems that people investigate are expensive to set up and rather complicated to study, says Wolf, who works at the Cooper Union School of Engineering in New York City. "This is a [low-priced] toy that generates high-quality chaos data," he says. "I can easily collect experimental data from it." Wolf presented his findings this week in Washington, D.C., at a meeting of the American Physical Society.

"A very hot issue is the attempt, in looking at experimental systems, to reconcile them with theory," says Wolf. "The theory is farther along than the experimental work." Simple models like the Space Ball and several other similar systems provide a useful way of testing competing theories and of learning how to define the amount of chaos present (SN: 5/26/84, p. 328).



The Space Ball is an electrically driven toy that can exhibit the erratic oscillations characteristic of chaos.

The Space Ball, which is made in Taiwan, runs on a 9-volt battery hidden in the toy's base. This activates an electromagnet that, in turn, "kicks" another electromagnet in the lower ball. "Basically, it's a very efficient electric motor," says Wolf.

For his experiments, Wolf removed the battery and added a power supply that can feed in anything from 0 to 40 volts. Wolf alters the Space Ball's motion by changing the voltage or the toy's starting position. "Sometimes, I get nothing," he says. "Sometimes, I can get it to come to rest. At other times, I can get it doing simple periodic motion [like a pendulum] or more complicated periodic motions. And I can get chaos.

"It'll do things like practically stop for a period of time, and you think it's ready to quit," Wolf says. "Then it starts spinning rapidly, then it slows down, then it spins rapidly but at a different rate. You can watch it for a week and there may be no two periods of five minutes during which it does anything roughly similar."

Wolf has come up with two equations, based on Newton's laws of motion, that describe the toy's behavior. Solving the equations on a computer gives numbers that match the Space Ball's observed motions. "In a sense," says Wolf, "that's a proof that it's chaotic as opposed to being poorly built."

His aim, however, is to quantify the amount of chaos present, not just in the toy but also in any system that may be suspected of exhibiting chaotic behavior. He has developed a computer program, running on a microcomputer, that calculates a quantity called the Lyapunov exponent.

This number provides an estimate of how long the behavior of a system is predictable. For a nonchaotic system, that exponent would be infinite because its future behavior is completely predictable. In chaotic systems, a tiny difference in starting conditions leads to widely divergent and, as a result, unpredictable behavior. The Lyapunov exponent puts a number on how fast this divergence occurs.

"Engineers and scientists have discovered a whole new regime of dynamics," says Francis C. Moon of Cornell University in Ithaca, N.Y., "and we're trying to categorize these different regimes. We want to know when these things occur and what the characteristics of this chaos are. Simple models help us test the criteria."

Another simple but useful model, also presented at this week's meeting, is the work of graduate student Nicholas B. Tufillaro of Bryn Mawr (Pa.) College. His mechanical device consists of a small, vibrating table (constructed from a loudspeaker) and a ball that is constrained to bounce vertically on the table's surface.

As in the case of the Space Ball, a simple set of equations describes the physical system. At the same time, says Tufillaro, "the bouncing-ball system exhibits the whole zoo of nonlinear phenomena shown by far more complex and less comprehensible systems."

In the bouncing-ball apparatus, changing the table's frequency or amplitude alters the ball's motion. At certain frequencies, the ball's motion becomes extremely erratic. Thus, this model allows researchers to study how a physical system shifts into chaos. Moreover, because the ball makes a click every time it hits the table, listeners can actually hear the sound of chaos.

The bouncing-ball system also has educational value, says Tufillaro. Some people still attribute what is often labeled as chaos to factors like background "noise" instead of believing that it results from the nature of the motion itself. Showing these skeptics a simple system that actually works as predicted mathematically can be very convincing. *— I. Peterson*

Quake potential off the San Andreas

The earthquake that laid waste to San Francisco in 1906 brought the San Andreas fault into the seismologic limelight. Now a new study suggests that scientists should also be keeping a watchful eye on the San Gregorio-Hosgri fault system to the west of the San Andreas. According to researchers who presented their findings at the recent Charleston, S.C., meeting of the Seismological Society of America, sections of the San Gregorio-Hosgri fault may be capable of generating earthquakes of magnitude 7 or greater.

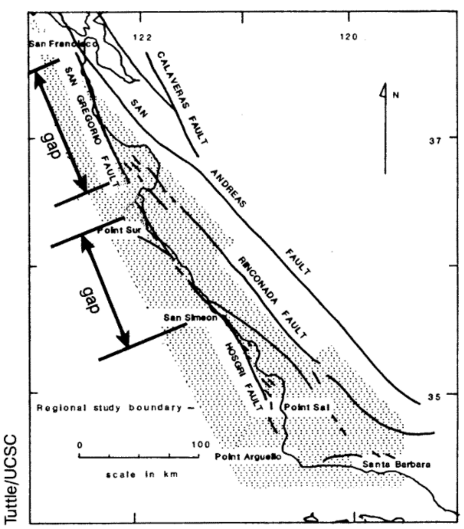
The complete San Gregorio-Hosgri fault zone was first identified and became the focus of controversy several years ago during the planning of the Diablo Canyon (near San Luis Obispo) nuclear power plant, which was originally designed without the knowledge that the Hosgri fault lay a couple of miles offshore. More recently, the fault has attracted the interest of scientists trying to piece together plate motions. Researchers have found that the North American and Pacific plates are slipping past one another at a rate that is much faster than the movement of the San Andreas fault (SN: 12/21 & 28/85, p. 388). Many have considered the San Gregorio-Hosgri fault a likely candidate for taking up some of that excess slip.

Now, looking at the seismic history of the fault, Martitia P. Tuttle at Lamont-Doherty Geological Observatory in Palisades, N.Y., and Karen C. McNally at the University of California at Santa Cruz identify two segments that they suspect are seismic "gaps" — regions of a fault that may be ripe for an earthquake. According to Tuttle, the regions of the fault lying between San Francisco and Santa Cruz and between Monterey and Ragged Point have not experienced magnitude 6 or greater earthquakes since 1880 and possibly since 1800. Based on the length and width of these segments, she estimates that they could rupture with magnitude 7.4 and 7.3 quakes respectively (assuming the fault does not slip "aseismically," or smoothly). In supporting calculations, based on geologic and seismic data for the entire fault, she estimates that a maximum 7.2 quake could occur anywhere along the fault, although it would be most likely to happen at one of the two gaps.

Suggesting yet another possible scenario, Tuttle says the pattern of seismic activity over the last 15 years in the Monterey Bay area is similar to that which preceded magnitude 6 earthquakes in more active spots — possibly indicating that a magnitude 6 earthquake could shake the southern gap in the next 10 years.

One reason relatively little attention has been paid to the San Gregorio-Hosgri fault is that most of it lies offshore, making it extremely difficult to study. And the fault zone, which extends to 1.5 kilometers in width, is made up of many individual strands that, at the surface at least, are not connected. So while there may be movement along the fault at depth, it's not easy to measure or predict.

"I have no doubt that the San Gregorio-Hosgri fault zone is active and capable of future earthquakes," says Kenneth R. Lajoie of the U.S. Geological Survey (USGS) in Menlo Park, Calif. During the last 10 years, he says, he and a co-worker have found ample geologic evidence that the fault has slipped within the last 8,000 years. But the problem, he says, is that the geologic data are not good enough to be used in calculating a quantitative value of slip rate, which is an important ingredient in earthquake and plate motion analysis. And even if scientists could confidently document past movement along one strand, they could not assume that other strands moved at all or moved in the same way.



Tuttle/UCSC

Two "gaps" in the San Gregorio-Hosgri fault zone concern seismologists.

Measurements of ongoing fault movement have also been very limited, because there is no land west of the fault, except in a few spots at the northern end, on which to place geodetic instruments. According to William H. Prescott, also with USGS in Menlo Park, "There's no geodetic evidence that there's much slip occurring along that fault."

In spite of these difficulties, Tuttle and McNally believe the seismic data are compelling enough to call for greater seismic coverage and more intense scientific scrutiny of the fault. *— S. Weisburd*