molecular geneticist Kiyotaka Okada of Osaka University in Japan.

Clark's team at Ann Arbor was looking for proteins that associate with the *CLV1* receptor and may trigger its effects in the cell. Research associate Amy Trotochaud searched for intracellular proteins that bind to CLV1 and found two CLV1-containing protein complexes, the larger of which apparently forms when CLV1 is turned on by ligand binding. Its levels closely mirror CLV1 activity. Trotochaud identified two other proteins in the complex besides CLV1. One, an enzyme called KAPP, was already known to bind to CLV1. It apparently inactivates the receptor by removing key phosphate groups. Clark suggests this could serve to raise the threshold for triggering the pathway or alternatively could turn off CLV1 once the pathway has been tripped.

The other protein, identified with help from Zhenbiao Yang's group at Ohio State University in Columbus, is a good candidate for transmitting the *CLV3* signal to other proteins within the plant cell. It resembles signaling proteins found in animal cells, called Rho proteins, which are involved in regulating a variety of cell activities. There's a twist, however. In animals, kinase receptors don't interact with Rho proteins, but instead transmit their signals through a related protein called Ras. Plants don't have Ras, Clark says, and the Rho-like proteins may take its place.

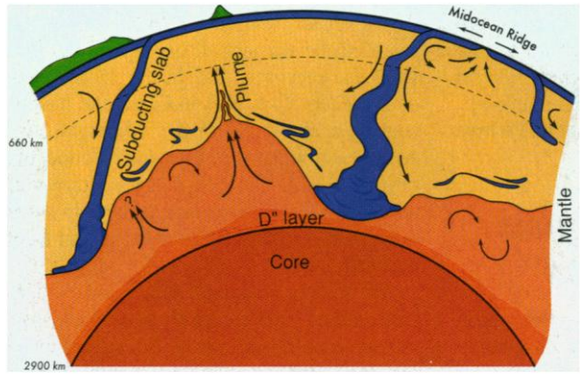
With this as their beginning, researchers now hope to trace out the entire pathway controlling the size of the apical meristem. "We are moving out in both directions from the receptor," Clark says. "What is nice about the *CLAVATA* story," adds Walker, "is we are getting enough pieces together that it is going to be a lot easier to go further. You are going to be able to make good hypotheses about a lot of the other [plant] receptor kinases and their signaling pathways." **–MARCIA BARINAGA**

GEODYNAMICS

A Lava Lamp Model for The Deep Earth

Lava lamps, those glowing, roiling conversation pieces, went out with the '70s. And now they're back, not only with the '70s revival but in the thinking of geophysicists who ponder the mantle, the vast layer of viscous rock between Earth's molten iron core and the outer shell of tectonic plates. For decades researchers have debated whether the mantle is more like a giant layer cake, neatly divided at a depth of 660 kilometers into two layers that never mix, or a boiling pot of water, churning from top to bottom over the eons. Neither picture quite fits. Seismic images of sinking ocean plates piercing the 660-kilometer "barrier" have upset the layer cake model (*Science*, 31 January 1997, p. 613), yet geochemical data pose problems for the one-pot model by suggesting that some of Earth's ingredients are sequestered in an isolated part of the mantle.

Now in this issue of *Science* (beginning on p. 1881), seismologists and modelers offer a new model that incorporates elements of each of the old ones and might best be described with a third metaphor—that of a lava lamp on low. Just as a lava lamp's heat causes its two layers to shrink and swell in complex patterns without mixing, so in this model Earth's radiogenic heat—abetted by plunging tectonic plates—causes the bottom mantle layer to vary markedly in thickness, bulging upward in some places and squeezing close to the mantle floor in others. Yet just as the colored fluid in a lava lamp's lower layer never mixes upward, a very deep rock layer, from 1700 kilometers or so down to the base of the mantle at 2900 kilometers, remains intact (see diagram).



Mantle ups and downs. A new model of Earth's interior shows two layers moving in complex patterns but never mixing.

"This might be an answer to our dilemma," says geochemist Albrecht Hofmann of the Max Planck Institute for Chemistry in Mainz, Germany. Others are more cautious. "Certainly, something strange is going on down there" in the deep mantle, says mineral physicist Craig Bina of Northwestern University, but he isn't sure it's best described by this scenario. Still, "it's a good model to take potshots at."

Data from earthquake waves probing the deep mantle provided the impetus for the new model. In their paper on page 1885, seismologists Rob van der Hilst and Hrafnkell Kárason of the Massachusetts Institute of Technology (MIT) note that above a depth of 1700 kilometers or so, the changing velocities of seismic waves—which depend on both the temperature and the composition of the rock—clearly show how cold slabs of ocean plate sink through the 660-kilometer barrier and into the middle mantle. But below 1700 kilometers, this pattern breaks up, and seismic velocities vary widely from point to point in no recognizable pattern. This suggests to van der Hilst and Kárason that the lowermost mantle represents a separate regime.

On page 1888, seismologists Satoshi Kaneshima of the Tokyo Institute of Technology and George Helffrich of the University of Bristol in the United Kingdom offer another hint of a deep boundary. They present seismic evidence of a thin, chemically distinct slice of rock between 1400 and 1600 kilometers down that could be a very old crustal slab come to rest on the top of the lowermost mantle layer.

If the lowermost mantle really is sealed off, it should have a different composition from shallower regions, and that's what other seismic observations reported in the last few years imply, van der Hilst and Kárason say. For example, small regions tens of kilometers across in the lowermost mantle scatter seismic waves, an effect that could only be due to compositional variations, because temperature would not vary on such a small scale. And two huge "megaplumes" rising from the base of the mantle slow seismic waves more than temperature alone could, again suggesting a different composition, perhaps richer in iron, deep in the mantle.

To see whether the lowermost mantle could stay isolated and chemically distinct over the eons, modeler Louise Kellogg of the University of California, Davis, geophysicist Bradford Hager of MIT, and van der Hilst constructed a computer model of a mantle (reported on p. 1881) with a bottom layer 4% denser than the overlying rock. They turned on the radiogenic heat of the lowermost mantle, sent slabs descending from the top, and found that the bottom layer swelled upward in places and thinned beneath slabs. Yet the layer survived as a distinct entity for billions of model years.

Of course, the point of a lava lamp is its mesmerizing variety of flows, and other researchers have their own versions of this in the mantle. Geophysicist Richard O'Connell of Harvard University has suggested that separate blobs of chemically distinct, more viscous rock might bob about in the lowermost mantle (*Science*, 23 February 1996, p. 1053). Between these blobs, cold slabs might slip all the way to the bottom of the mantle, and hot plumes might rise. "It might be hard to distinguish between a layer and blobs," he says.

But other researchers are far from convinced that the lowermost mantle is a distinct layer—or even a collection of blobs—that has resisted mixing. Seismologist Thorne Lay of

CREDIT: KELLOGG *ET AL.*

the University of California, Santa Cruz, notes that the seismic images from below 1700 kilometers may be muddy simply because seismic data are poor at those depths. And there are seismic signs, he says, that the deepest mantle could be more dynamic than allowed by the layers in the lava lamp model. He also notes that the proposed structure will be "very difficult to detect seismically."

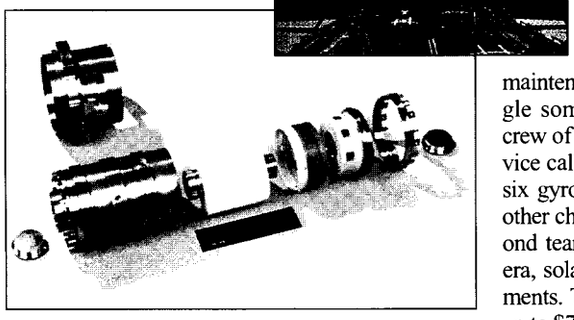
Van der Hilst agrees that testing the model will be a challenge, but "it's certainly more promising than any of the end-member models presented so far." If the model does pan out, lava lamps are one '70s craze that may have a lasting effect. **–RICHARD A. KERR**

ASTRONOMY

NASA Plans Earlier Hubble Rescue

WASHINGTON, D.C.—For months, NASA has been weighing the possibility of losing its most productive science instrument, the Hubble Space Telescope, against the certainty of disrupting a carefully choreographed launch schedule involving its most important engineering mission, the international space station. Hubble won. NASA announced last week that it will mount a special space shuttle mission in October to replace failing gyroscopes that threaten to cripple the telescope's ability to do science.

Since its launch in 1990, the $2 billion telescope has delivered a steady stream of spectacular images of the universe. But it has had to overcome its share of problems, including a now-corrected flaw in an expensive mirror that initially rendered its images nearly useless to scientists. The Hubble's current predicament involves its six gyroscopes—small, rapidly spinning wheels enclosed in liquid-filled containers that act like compasses. The navigational aids make it possible for the telescope to lock onto targets and maintain a rock-steady focus on small patches of space for long periods. In 1995 and 1998, for instance, the Hubble stared at two patches of sky for 10 consecutive days each, revealing thousands of previously unseen galaxies believed to be at the edges of the universe.



Hubble trouble. Corrosion may have disabled three of six gyroscopes (*above*) that stabilize the telescope (*inset*).

CREDIT: NASA

Concerns about the Hubble's gyroscopes surfaced last October, after two of the devices—which were installed in 1993 and checked in 1997—failed within 18 months. The losses, which a NASA official termed "disquieting," left the Hubble with four working gyroscopes. Three are needed to keep the spacecraft from entering a self-protective safe mode, in which its scientific instruments are shut down. When a third gyroscope showed signs of breaking down in late January, NASA activated an emergency response plan. "When Hubble reached the point of being one failure away from doing science, our flight rules said we must look at a mission to correct the situation," explains John Campbell, Hubble project director at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

NASA officials faced several obstacles, however. After a series of delays, the next Hubble maintenance mission was scheduled for June 2000, and some key instruments would not be ready for an earlier launch. Moreover, three of the agency's four shuttles have been reconfigured to carry construction payloads for the space station, and their launch schedules were booked. That left Columbia as the favored vehicle for Hubble repairs. But NASA had a long-scheduled overhaul of Columbia planned for this fall—just when engineers feared the telescope might be forced out of action.

To forestall that disaster, NASA officials decided to jury-rig the shuttle Atlantis, stretch out the planned Hubble maintenance over two missions, and juggle some space station launches. One crew of astronauts will make a 9-day service call to Hubble this fall to replace all six gyros and a computer and do a few other chores. Next year or in 2001, a second team will install an improved camera, solar panel, and new science instruments. The two visits could cost NASA up to $75 million extra over the next couple of years, officials say.

Although putting off the installation of new instruments may delay some science, researchers support the plan. Indeed, "splitting the mission may make things easier, since the servicing mission was getting very crowded," says astrophysicist Rodger Johnson of the University of Arizona, Tucson, lead scientist for the Hubble's Near-Infrared Camera and Multiobject Spectrometer. The instrument, which has been out of action since January due to a lack of nitrogen coolant, will now have to wait at least 6 months longer for a new supply. But, says Johnson, "it gives us more time to analyze the data we've already got."

The October mission will also give NASA an early opportunity to do autopsies on the dead gyros and get its first look at the performance of a new design. Engineers believe the existing gyroscopes—which cost $3 million each and are built by Allied Signal Corp. of Teterborough, New Jersey—fail when their copper electrical cables become corroded. The corrosion occurs, they believe, because compressed air was used to pack the thick fluid surrounding the spinning wheels into the devices. Oxygen from the air mixes with bromine in the fluid, catalyzing the corrosive reaction.

To defuse that threat, the company is now using compressed nitrogen to pack the gyroscopes. But building the devices is "like crafting a fine watch: It can take years," says Campbell. As a result, just three of the new units may be ready to be installed on the October flight; the other replacements will probably be of the older type. But Campbell is confident that the arrangement can keep Hubble pointing in the right direction until its planned demise in 2010. **–DAVID MALAKOFF**

EUROPEAN UNION

Cresson Resigns in Wake of Fraud Report

The European Union's (EU's) embattled research commissioner, Edith Cresson, submitted her resignation this week along with the other 19 EU commissioners in the wake of a scathing report by a European Parliament investigative panel that alleged cronyism and mismanagement in the EU's executive body. The panel singled out Cresson for the harshest criticism. As *Science* went to press, it was not yet clear whether some commissioners—all of whom are political appointees—would be renamed to their positions by their respective governments, to serve out terms that had been scheduled to expire at the end of this year. However, two sources in Brussels said it was "highly unlikely" that the French government would restore Cresson to her post, and officials are beginning to speculate about her successor.

The commission's mass resignation—roughly equivalent to the entire U.S. federal Cabinet stepping down at the same time—comes just a month after the EU's science directorate, known as DGXII, formally launched its new 4-year, $17.6 billion research program, Framework 5. DGXII officials say it is still unclear exactly what impact, if any, the resignation of the unpopular Cresson will have on the nascent program.