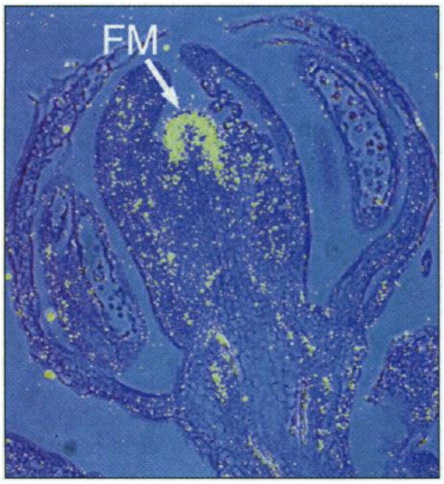
are now quite likely to get more notice. Although the shift out of the Platyhelminthes won't come as a surprise to some, "it will grab the people who teach general biology and shake them up," predicts Smith. Baguñà thinks the group belongs in its own phylum, but Smith notes that a few other so-called platyhelminths may belong with them. And he would like to see more evidence that the acoels, which have a variety of reproductive strategies, are truly simple. "This is a very strange and diverse set of organisms to be finding as a basal group," he says. But he agrees that acoels will have their day in the limelight. Says Jablonski, "Acoels have gone from being an obscure group to one that can provide potentially great insight into the radiation [of multicellular animals]."

—ELIZABETH PENNISI

PLANT BIOLOGY

Key Molecular Signals Identified in Plants

Biologists trying to trace the communication systems that tell plant cells to develop into a leaf or a fruit or a flower, or to fight off deadly pathogens, have found some of the crucial switches and relays but don't know where the wires go. They have identified dozens of proteins called receptor kinases



Partnerless. The bright areas show *CLV1* messenger RNA in a *CLV3* mutant flower meristem (FM)—evidence that CLV1 is present, although it is inactive in the absence of CLV3.

CREDITS: (TOP TO BOTTOM) R. STONE; FLETCHER *ET AL.*

that receive signals from outside the cell, but they've had little luck in finding the signals that trigger specific receptors, or in tracing what happens in the cell once the receptor is activated. Now, two teams report advances toward putting together one such pathway for the plant *Arabidopsis thaliana*.

The pathway in question helps control the growth of the specialized region at the tip of the shoot, called the apical meristem, that gives rise to such plant organs as the leaves and flowers. Geneticists have found three genes in that pathway, which were named *CLAVATA* after the Latin "clavatus," for "club," because mutations in the genes cause the meristem to become enlarged and club-shaped. Two years ago, researchers cloned one of the genes, *CLAVATA1 (CLV1),* and concluded from its sequence that it encodes a receptor kinase. Now, Elliot Meyerowitz of the California Institute of Technology in Pasadena, Rüdiger Simon of the University of Cologne in Germany, and their colleagues report on page 1911 that a protein called CLAVATA3 (CLV3) seems to be the signal, or ligand, that activates the receptor. And in the March issue of *The Plant Cell*, Steven Clark and his colleagues at the University of Michigan, Ann Arbor, announce that they have found two proteins inside the cell that associate with activated CLV1 and presumably help set in motion the intracellular events that keep meristem size in check.

"It is a big advance," says Joanne Chory, who studies plant receptors at the Salk Institute in La Jolla, California. Adds plant biologist John Walker of the University of Missouri, Columbia: "This is giving us direct insight into the mechanism of how [meristem growth control] works." That in turn may pave the way for altering such agriculturally important traits as fruit size and yield. What's more, the new information will also help researchers figure out how similar receptor kinases that control other plant functions work.

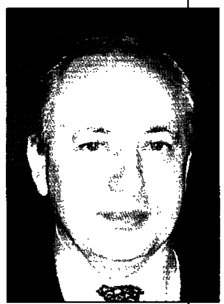
Even though many plant receptors resemble those that respond to extracellular signals in animal cells—a similarity researchers used to identify CLV1 and other plant receptor kinases—the match is not perfect. The disparities mean that plant researchers cannot conclude from the comparison alone what signals trigger the receptors, or which molecules relay their downstream effects.

Simon's and Meyerowitz's teams have moved the field beyond that impasse, at least for CLV1, by cloning the *CLV3* gene. Genetic analysis had already hinted that CLV3 interacts directly with CLV1, and the gene's sequence suggests that *CLV3* encodes a small protein ligand, says Meyerowitz postdoc and lead author on the paper, Jennifer Fletcher.

CLV3 has the hallmarks of a protein that is secreted from cells, and it is made in a different region of the meristem than CLV1. Both of these findings, plus others in the paper, suggest that CLV3 is an extracellular signal that travels to exert its effects on CLV1. The researchers have not yet shown that CLV3 binds to CLV1, and until they do, it remains possible that it helps to synthesize or somehow aids the binding of an as-yet-unknown ligand. Nevertheless, "it is very likely" that CLV3 is the ligand, says plant

ScienceScope

Making Science Pay Russia's applied researchers can look forward to government initiatives to make their work pay for itself. Last week, Science Minister Mikhail Kirpichnikov sketched out plans to support applied research by moving into new commercial ventures, and announced that the German government has promised to lend Russia 100 million marks ($56 million) to buy scientific equipment over the next 2 years.



Kirpichnikov has talked much about weaning Russia's dwindling scientific corps off of state support (*Science*, 11 December 1998, p. 1979). Now nearly a half-year into his tenure as minister, he's taking the first steps toward that goal. His ministry, with the Economics Ministry and the Russian Academy of Sciences, has proposed forming a governmental commission to ram through tax incentives to encourage entrepreneurial research—a goal shared by the Duma, which is drafting legislation to that effect.

Eleventh-Hour Reprieve? Taking the smallpox virus off death row could serve science, says a U.S. government advisory panel. The finding, released this week, could aid scientists seeking to delay the planned destruction this June of the last two research stocks of the dreaded virus.

Since it was eradicated 2 decades ago, the variola virus has been bottled up like a genie at two high-security labs in the United States and Russia. In 1993, the World Health Organization ordered the stocks destroyed to prevent future outbreaks from their accidental—or intentional—release. But some researchers say variola should be spared, particularly because it might be useful in preparing defenses against smallpox weapons. This week, the preservationists won a small victory: Although it didn't give a direct opinion on what should happen to the stocks, an Institute of Medicine panel concluded that live variola could play an "essential role" in developing new drugs and vaccines. But destruction proponents, such as D. A. Henderson of Johns Hopkins University, say the report is unconvincing.

Now it's up to President Bill Clinton—who has said White House policy will be guided by the new report—to decide what will happen to the U.S.'s smallpox cache.

Contributors: Andrei Ol'khovatov, Eliot Marshall

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.

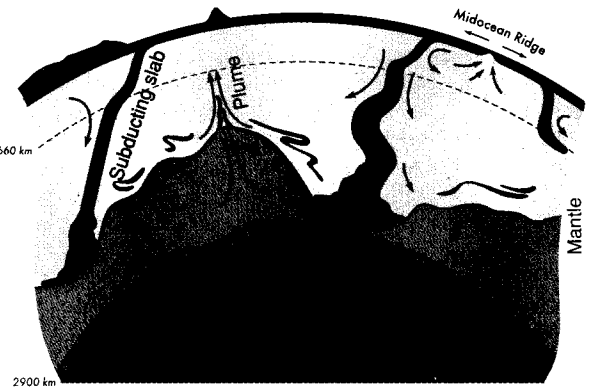
With this as their beginning, researchers now hope to trace out the entire pathway controlling the size of the apical meristem. "We are moving out in both directions from the receptor," Clark says. "What is nice about the *CLAVATA* story," adds Walker, "is we are getting enough pieces together that it 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

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