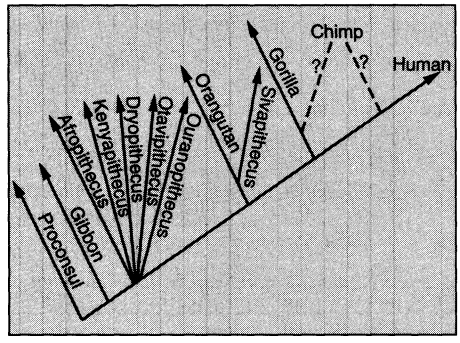
these middle-Miocene species based on their common morphological features—but most participants at the workshop thought it was too early to pick the most promising candidate. And what's more, they wanted additional time to examine the fossils. "Putting cladograms up like this forces us to make decisions we can't make," complained Washington University Medical School paleoanthropologist Glenn C. Conroy.

Part of the problem that leads to Conroy's complaint is that there is another major gap in the fossil record in Africa just after the middle-Miocene apes lived: from 14 million to 4 million years ago. And that's just the time when one of these hominoids was diverging from the ancestors of African apes (including chimps and gorillas) to give rise to the group that includes humans and other extinct species of *Homo* and *Australopithecus*. Anthropologists covet fossils from this second major break in the fossil record—the so-called hominid gap—because they could provide the missing link between the hominoids and *Australopithecus afarensis*, which probably



SOURCE: P. ANDREWS, E. DELSON A. HENRY

Early days? Some researchers believe it's too soon for cladograms of hominoid descent, such as this one put forth at the workshop.

was ancestral to humans and extinct species.

They may be missing from the fossil record in Africa, but late Miocene fossils are turning up in other parts of the world—such as northern Greece. That's where French paleontologist Louis de Bonis found a 10-million-year-old fossil face last year, one that he has named *Ouranopithecus macedoniensis*. At first, anthropologists thought that this species had traits that made it ancestral to orangutans. But now, an analysis of its small canines, thick tooth enamel, and other features prompts de Bonis to say it "would be possible" to consider it the sister group of hominids or their early forerunner. If he proves right, "it could be either the closest thing we know to a common ancestor to all living apes, including people, or it's already on the line leading to chimp, gorilla, and human," says Delson.

By the time the anthropologists were packing up their bones at the end of the day and planning to swap casts, it was clear they were reeling with the sense of the many ways it is possible to be a Miocene ape. While some professed to having a clearer understanding of the Miocene and a new glimpse of the late Oligocene, others said they had a new respect for the complexity of the period—and how difficult it would be to sort out the different species. Just one look at the fossils on the table made that apparent. As Johns Hopkins University anthropologist Pat Shipman says, "Boy, there are a million ways to be apes!"

–Ann Gibbons

CELL BIOLOGY

How Cells Get Their Actin Together

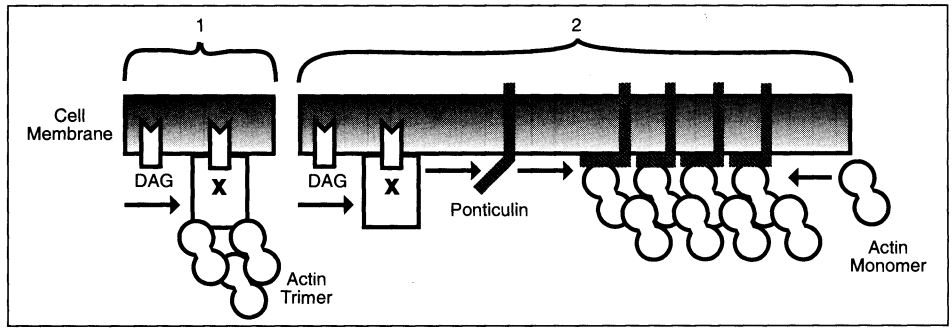
Cells are constantly on the move—white blood cells crawl at a snail's pace of millimeters per days; sperms cells can be virtual speed demons, whipping through their reproductive journey in under a day. But what makes these cells go? The closer scientists get to answering this "simple" question, the more they discover how exceedingly complex that answer will be—not to mention how important such an understanding would be to apparently mundane mysteries like how amoebas crawl and incredibly important ones like how cancer spreads and how healing cells rush to wounds.

For a privileged few cells, the answer to their mobility is easy of course. They have specialized parts like flagella or cilia to speed them about—sperm cells are an obvious example. The vast majority of mobile cells, however, simply crawl, thrusting out extensions called pseudopods, or "false feet," but no one knows precisely how. In recent years, cell biologists have determined that a protein called actin plays a crucial role in this cell movement. They've even figured out that the protein works by forming a skeleton of filaments inside each cell. But understanding how these actin assemblies form, much less what they can then do, has proved a Herculean task. By studying the cells of an organism more common to the forest floor than the lab bench, cell biologists Aneesa Shariff and Elizabeth Luna of the Worcester Foundation for Experimental Biology report, in this week's issue (p. 245), that they may have found important clues to the construction of these vital filaments.

Like other researchers seeking to understand the actin puzzle, Shariff and Luna have been trying to sort out the babble of chemical signals inside a cell that cause the individual protein molecules, called actin monomers, to arrange themselves into long filaments, a process known as polymerization. Scientists understand the physical processes by which actin comes together, but don't ask them how the cell directs the process. Says Sally Zigmond, a cell biologist at the University of Pennsylvania: "It's been extremely difficult to figure out anything about actin polymerization in cells."

That's ironic considering the abundance of actin in eukaryotic cells: Sometimes over 15% of a cell's total protein is made up of actin. But, at any given time, more than half of the actin inside a cell is not linked together in the polymerized form. Instead, it remains isolated as a monomer or forms small chains of monomers, in both cases "capped" by other proteins that bind to it. And as Thomas Pollard, a cell biologist at Johns Hopkins Medical School, explains: "To get from an actin monomer to an actin filament with hundreds of subunits is a complex, highly regulated process in the cell." Still, researchers are determined to map out that process, because the very act of assembling and disassembling these actin filaments may be how cells move. And that's where Shariff and Luna come in.

In their report, the two researchers suggest that a lipid molecule called diacylglycerol holds a key to polymerization. In a number of in vitro experiments with the cellular slime mold *Dictyostelium discoideum*, a slug-like or-



SOURCE: E. LUNA ILLUSTRATION: A. HENRY

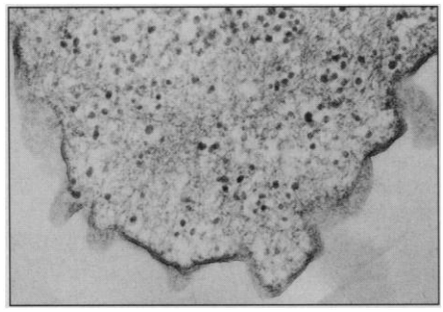
Forming filaments. Two possible mechanisms for the diacylglycerol (DAG)-mediated regulation of actin assemble in *Dictyostelium* membranes. (1) Activation of an unknown peripheral protein (X) that directs the formation of trimeric actin nuclei. (2) Activation of X increases activity of ponticulin, a membrane protein that promotes actin nucleation.

ganism found in forests, they discovered that diacylglycerol, in conjunction with a still-unknown protein, stimulates individual actin monomers to nucleate—come together at a site near the plasma membranes of the cell. This figures to set the stage for polymerization, since three monomers must link up in an actin trimer before the long filaments can grow.

Until recently, another molecule, in some respects the parent of diacylglycerol, captured most of the attention in the actin community, but Shariff and Luna's work may change that. This molecule, a phospholipid called PIP_2 (for phosphatidy-linositol-4,5-bisphosphate), gives birth to diacylglycerol when it is split into two pieces by cellular enzymes. PIP_2 drew the spotlight when a number of proteins that bind to actin, such as gelsolin and profilin, were found to bind also to PIP_2, raising the possibility that the lipid was at the heart of all the signals that controlled assembly and disassembly of actin filaments within the cell. While interactions between PIP_2 and actin are certainly observed, questions about their importance and timing in regards to cell movement have grown, especially as some inconsistencies have arisen in further research. "We simply do not have enough information about the biochemistry or events in live cells," says Pollard. "No one has enough data to prove any one theory correct."

The unknown protein. For now, Pollard may be right, but Shariff and Luna think the case for diacylglycerol's importance will be bolstered once they nail down a mysterious protein their work revealed. Their experiments clearly indicated that diacylglycerol did not directly provide nucleation sites but needed to interact with a mystery protein, which they contend is also bound in the plasma membrane. Indeed, they hazarded a guess—that the enzyme protein kinase C, known to be a popular target of diacylglycerol's action, was the quarry. But a number of tests the duo did seemed to rule out that possibility. So now all they are able to say is that the mystery protein may contain a diacylglycerol-binding site similar to that of protein kinase C and may work by regulating the activity of ponticulin, an actin-binding membrane protein implicated in nucleation. And then there's another possibility, says Luna: that this mystery protein directly promotes nucleation. To test the two alternatives, the two scientists plan to examine the effect of diacylglycerol on membranes that do not contain ponticulin.

Luna sees her paper as a wake-up call that should draw interest to diacylglycerol. Most of the actin world has been thinking of actin regulation in terms of PIP_2, or possibly other compounds such as inositol triphosphate or calcium, she says. "This will shake things up." Many of the scientists in the field, including Luna, hesitate to polarize the issue into a PIP_2-diacylglycerol contest. They point out that still undiscovered mechanisms may be important. Indeed, two or three new actin-binding proteins are discovered each year.



Actin at work. A thick network of actin filaments and other proteins allows cells to move about.

More important, says Pollard, the work on diacylglycerol "is not necessarily in conflict with PIP_2 theories." For instance, while diacylglycerol may control actin nucleation, PIP_2 could regulate how filaments assemble and disassemble.

All this uncertainty in the theories about actin polymerization is a source of real frustration to researchers. If the myriad of cellular signals involved can be cleared up, the mysteries of how amoebas crawl and cancers spread may finally reveal their secrets. Now, Luna says, "the race is on to find this [new] protein." Perhaps when Shariff and Luna find their mystery protein that works with diacylglycerol, it will be an effective weed killer for misguided theories.

–John Travis

NUCLEAR PHYSICS

Cluster Fusion: Close, But No Cigar

Another fusion dream is hanging by a thread. In September 1989, a research trio at Brookhaven National Laboratory (BNL) reported what looked to them like a promising new route to nuclear fusion. When clusters of hundreds of heavy-water molecules are accelerated into targets loaded with deuterium (heavy hydrogen), the researchers argued, the energy of the collision was somehow getting concentrated into a few of the deuterium atoms, spurring them to fuse. The output wasn't dramatic—this was no cold fusion—but the Brookhaven team did claim that minuscule amounts of energy had been produced from what they dubbed cluster-impact fusion. So, while fusion power from their discovery might be but a remote prospect, it was at least a prospect, the researchers suggested. And while skeptics quickly emerged, a number of physicists bought the argument and set up their own experiments.

No surprise, then, that for 2 years the trio worked diligently to strengthen their position and deflect the skeptics' contentions that experimental or interpretational errors were lurking behind the exciting claim (*Science*, 25 October 1991, p. 515). But the skeptics were on to something, the BNL team of Robert Beuhler, Lewis Friedman, and Gerhart Friedlander now concedes.

In an erratum in the 30 March *Physical Review Letters*, the researchers write that artifacts in the accelerated cluster beams "are primarily responsible for events that have been ascribed to cluster-impact fusion." The sobering results, they say, come from experiments done "during the last several months" with collaborator Y.K. Bae, who joined the BNL team last year, in which small artifact ions in the beam were deflected from the target by a magnetic field. The beam lost as much as half of its mass as it passed through the field, and the fusion rate dropped at least a hundredfold. Apparently, the fusion events that had tantalized the group were triggered by small, still unidentified ions slamming into the target, not some exotic energy-concentration mechanism involving the clusters.

Richard Petrasso, a plasma physicist at the Massachusetts Institute of Technology, isn't surprised; he and his colleagues had predicted as much. On the page just before the BNL team's erratum, Petrasso and his colleagues published a "comment" in which they argue that small, highly accelerated artifacts in the beam could have yielded the observed fusion rates. But Petrasso is "staggered" by something that's not mentioned in the BNL erratum: his own team's comment.

Petrasso had showed a draft of it to the BNL team as early as last November, and he even spoke with Friedman on the phone about the comment in early February. Friedman defends the omission, in part by saying that his team had the magnetic deflection experiments on the agenda for a year, well before Petrasso's team worked up its objections. Petrasso isn't impressed.

Meanwhile, the debate over cluster-impact fusion isn't quite over: Fusion research has a knack for showing different sides to different people. For skeptics like Petrasso, cluster-impact fusion is just another busted fusion claim. For fellow physicist Robert Vandenbosch of the University of Washington, there's still hope that it is a real phenomenon—though his own cluster-impact fusion experiments will now move to a back burner. And for Friedman the new evidence is a setback, but not the end of the road: "We were not as cautious as we could have been," he told *Science*, then added that "it's premature to say there's nothing left."

–Ivan Amato