gether," explains Smith. This type of interaction, he says, enables researchers to artificially slow down chemical interactions that normally are too fleeting to measure.

Carl Kocher of Oregon State University in Corvallis thinks materials science could also benefit from Rydberg atoms. When he shoots them through the openings of a fine gold grid, they shed their outer electrons in patterns that change detectably when he covers the metal with patches of another substance just a single atom or molecule thick. He conjectures that a Rydberg-based analytical device might yield insights into the atom-by-atom growth of thin films, a booming area of materials science.

The supersensitivity of Rydberg atoms recently proved its value in another area. Building on earlier work by researchers at the Max Planck Institute for Quantum Optics in Munich, Serge Haroche's group at l'École Normale Supérieure in Paris reported recently that it had used Rydberg atoms to make direct measurements of the "graininess" of light (*Science*, 5 April, p. 34). The experiment measured subtle energy oscillations induced in Rydberg electrons by the electric field generated by individual photons trapped inside a small cavity. In ordinary atoms, any effect would be undetectable. But because the distance between a Rydberg atom's positively charged core and outermost electron is so large, the atom has an enormous electric dipole moment, which amplified the effect of the trapped field.

Technology, quantum mechanics, and the physics of electromagnetic fields aren't the only places on which the shadow of these swollen atoms is falling. First detected in space, Rydberg atoms showed up there again in 1995 when astronomers, pointing their radio telescopes at a very hot star in the constellation Cygnus, observed the first natural laser in the gases surrounding the sta (*Science*, 8 September 1995, p. 1336). The laser's wavelengths could only have come from hydrogen atoms in Rydberg states.

Such surprises have kept more than a few researchers hooked on Rydberg atoms for decades. "I have always been interested in these atoms, because they have exaggerated properties and you can use them to do things you otherwise only could dream about," remarks Thomas F. Gallagher, a University of Virginia AMO physicist. When he started studying Rydberg atoms in the mid-1970s, he says, "nobody had any conception of how many things would happen."

–Ivan Amato

Ivan Amato's book on materials science, Stuff, *will be published early next year by Basic Books.*

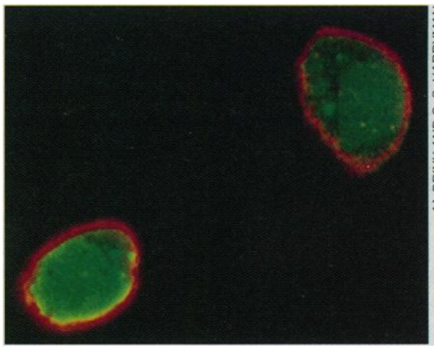
DEVELOPMENTAL BIOLOGY

Receptor for Vital Protein Finally Found

Biologists, like wiretappers eavesdropping on clandestine molecular conversations, have been trying to trace protein signals as they travel from one cell to another and then to the recipient's genes, the masters of the cell's fate. But the connections in some of these communications circuits have been hard to pin down because the proteins that carry the signals are elusive. That has been the case with the "Wnt" proteins, which help trigger the growth of the cerebellum in mice and—in some cases—cancerous cell proliferation. Researchers just haven't been able to identify the receptor molecules on the cell surface that pick up a Wnt signal and relay it to the interior.

Now, however, researchers have traced a call. They have identified the receptor for one Wnt family member, the fruit fly protein Wingless. A team led by Jeremy Nathans, a molecular biologist at Johns Hopkins University, and Roel Nusse, a developmental geneticist at Stanford University, reports in the 18 July issue of *Nature* that when they inserted the gene for a novel fruit fly protein into cells from *Drosophila* embryos that were normally deaf to Wingless's signals, the cells, in essence, pricked up their ears: They initiated a chain of processes involved in cell adhesion—an event usually triggered by Wingless. That is strong evidence that the new protein, called Drosophila frizzled 2 (Dfz2), is Wingless's long-sought partner.

"It opens up a whole new set of experiments," says Harvard University developmental geneticist Andrew McMahon. With the receptor, researchers can get a clear look at the molecules that carry Wingless's signal to the nucleus and determine the exact genes that receive this signal. And that work could have broad implications, for researchers have found dozens of Wnt molecules in mice, frogs, nematodes, and humans, and the proteins have proven to be crucial regulators of development. Fruit fly embryos with defective Wingless protein, for example, have body patterning problems, failing to develop proper body segment boundaries, eyes, and—as the name implies—wings. But because the Wnt proteins are difficult to obtain in purified form for use in biochemical experiments, they had remained "orphan" growth factors, ligand molecules with no known receptors.



M. BRINK AND C. S. HARRYMAN

Wingless connection. Wingless protein (red) binds to the surface of fruit fly embryo cells engineered to make its receptor.

Nathans's laboratory had the opposite problem: a family of receptors without ligands. Nathans and co-workers Purnima Bhanot, Deborah Andrew, Jen-Chih Hsieh, Yanshu Wang, and Jennifer Macke had discovered that a receptorlike *Drosophila* protein called frizzled has a host of counterparts in birds, fish, and mammals. Biologist Paul Adler at the University of Virginia had shown in the 1980s that flies lacking frizzled suffer curious patterning defects, including wing hairs that swirl in erratic directions. "All of that got us thinking," Nathans says. Because both the Wnt and frizzled families were large, and because another protein called disheveled seemed to be a mediator of both Wingless and frizzled signals, "the Wnts seemed like a good bet" as frizzled ligands.

That bet paid off when Nathans sent his frizzled molecules to Nusse. When exposed to Wingless, some *Drosophila* cells begin accumulating a protein called Armadillo, which helps cells stick together. But cells called Schneider cells, cultured from early fly embryos and thought to resemble mammalian immune cells called macrophages, lack this ability. Guessing that the Schneider cells are missing some component of the mechanism that activates Armadillo accumulation—including, perhaps, the receptor for Wingless—Nusse and colleagues Marcel Brink and Cindy Samos Harryman inserted the gene encoding one of Nathans's new frizzled proteins, Dfz2, into the cells, then incubated them in the presence of Wingless. The cells promptly bound Wingless on their surfaces and began building up Armadillo. "That was an enormous surprise," Nusse says. "We didn't expect that simply transfecting the gene would allow the cells to respond."

With one receptor identified, Nusse, Nathans, and others are busy searching for Dfz2 homologs in mice and other animals. They are also designing biochemical and genetic experiments to discover what substances interact with Dfz2 inside the cell. "We know that the Wnts play roles in regulating cell fate," says McMahon. "Having the receptor gives us a way of probing how they work."

–Wade Roush