It took months of hard work to do this. "It only looked easy after it was finished," says Ketterle. First, he and his colleagues created two condensates by beaming a laser up through the middle of their magnetic trap. The laser light repelled the atoms and split the condensate into two distinct halves. For this test, there was no need to pulse the condensates out of the trap; instead, the group just turned off the trap and let them free fall. As the condensates fell, they expanded into the surrounding vacuum until they overlapped and interfered, demonstrating the atomic version of the bright and dark fringes in an interference pattern.

"The density of the overlapping region is modulated," says Ketterle. "Every 15 microns, we have matter, no matter, matter, no matter. Now, we just shine some light onto the pattern and see this shadow with black-and-white stripes." Says Burnett, "It's not just a little crappy demonstration but a big, juicy interference pattern."

Having proved the condensate is coherent, Ketterle and his colleagues can use the output coupler to extract the condensate in pulses, which makes the setup effectively the first primitive atom laser and raises the question of where they go next. So far, they have been able to get eight pulses out of a condensate before they have to reload, which takes 20 to 30 seconds. One of their first goals is to figure out a way to restock the condensate as they go along to create the atomic version of a continuous wave laser. "Remember, these things are a few weeks old," Ketterle says, "and we need a major improvement in output power, a major reduction in complexity, and also improvement in shaping the pulses."

At that point, any field that relies on beams of atoms might benefit from the brighter and better controlled beams of an atom laser. Atomic clocks, which are based on the vibrations of atoms drifting through a cavity, are one candidate. Another is nanolithography, the technique by which circuit designers lay out minuscule features. It now depends on a mask or stencil to control where atoms or light land on a surface, but an atom laser—which could be focused and directed like a light laser—might provide a way of writing the patterns directly, says University of Texas physicist Dan Heinzen.

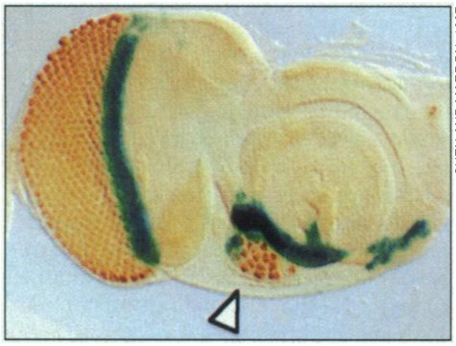
The technology does seem to come with a handicap: Unlike light, an atomic laser beam can't propagate freely through the atmosphere. But Burnett says it's too early to focus on limits. After all, at the birth of the light laser, "people talking about applications really didn't imagine them being in every supermarket check-out counter."

–**Gary Taubes**

DEVELOPMENTAL BIOLOGY

A "Master Control" Gene for Fly Eyes Shares Its Power

In a startling experiment reported 2 years ago, Swiss biologists caused surplus eyes to sprout on fruit flies' wings, legs, and antennae—all by manipulating a single gene called *eyeless* (*ey*). Grotesque as this spectacle was, researchers hailed it at the time: Besides shedding light on eye development, it also supported the seductive idea of "master control genes" that can single-handedly order up complex organs by turning on other genes. But now it seems that *ey* has a partner—perhaps even two—and the all-powerful master controller may be merely a member of a committee instead.



SHEN AND MARDON, 1997

Eyes up. Expressing the *dac* gene in the wrong place in flies causes eyes to sprout (arrow) where antennae normally grow.

New work reported in the January issue of the journal *Development* shows that a fly gene called *dachshund* (*dac*) can, like *ey*, give rise to ersatz eyes when turned on in out-of-the-way places such as a developing leg or antenna. And the researchers also discovered that *ey* can't build these so-called ectopic eyes in flies missing *dac*—an indication that the two genes normally work together. "It's really an oversimplification to say that any one gene is the master-control gene for eye development," concludes developmental geneticist Graeme Mardon of Baylor College of Medicine in Houston, who authored the study with technician Weiping Shen.

The Baylor team's result "is a very interesting discovery," agrees Nancy Bonini, a *Drosophila* geneticist at the University of Pennsylvania. "If *dac* had been found before *ey*, you might say that *dac* is 'the' master regulatory gene in eye development. So, maybe we should think differently about these terms." But Walter Gehring, the Swiss geneticist who led the original dramatic *ey* study—and whose lab recently discovered yet another eye-forming fly gene, christened *twin-of-eyeless* (*toy*)—says *eyeless* is still the master switch. "I don't think this [label] has to be revised," he says.

The eye-popping powers of *dac* were discovered by accident. The gene got its name several years ago, when Yale University biologist Iain Dawson came across a mutation in the fruit fly *Drosophila melanogaster* that resulted in short, stubby legs—and also affected the arrangement of the 800-some individual eyes (called ommatidia) in each of the flies' compound eyes. Mardon, then a postdoc in the lab of geneticist Gerald Rubin at the University of California, Berkeley, found the gene independently. He went on to clone it and discovered that the protein it encodes resides in the cell nucleus, suggesting that *dac* helps regulate the expression of other genes.

But Mardon couldn't find which genes those might be. Then, in 1995, Gehring and colleagues Georg Halder and Patrick Callaerts at the University of Basel in Switzerland published their study on *ey*. To trick the gene into becoming active where it should be dormant, they used genetically engineered fly larvae that produced a gene-activating protein called GAL4 in many different body parts, such as wings, legs, and antennae. Then, they mated these flies to others in which *ey* was connected to a control switch activated by GAL4. The result was a brood of flies with eyes in unorthodox places (*Science*, 24 March 1995, pp. 1766 and 1788).

Mardon, eager "to see what *dac* might be doing," borrowed the technique, linking not *ey* but *dac* to the GAL4-activated control switch. He and Shen found that 20% of the resulting flies developed clusters of fully formed ommatidia in odd locations. That's a much lower fraction than the Gehring team's 100%—perhaps, Mardon speculates, because making eyes in certain places in the body would require genes that *dac* does not activate, but *ey* does. Intriguingly, the Baylor team also found that ectopic expression of *ey* induces *dac* expression in the same places, and that *dac* can also turn on *ey* in a subset of these cells. And when Gehring's experiment is repeated in flies lacking *dac*, no ectopic eyes form. All this suggests to Mardon that the two genes evolved as partners, reinforcing each other's eye-building signals in a positive feedback loop.

So, which is the true master-control gene for the fly eye? Neither, says Mardon. Both, suggests Ulrike Heberlein, a *Drosophila* geneticist at the University of California, San Francisco. "Maybe we need to talk about a hierarchy of master regulators," she says. But Gehring maintains that between *ey* and *dac*, *ey* is still the master. In his view, the term means that "if you make a gain-of-function mutation or switch the gene on ectopically, you get a complete wing or leg or eye or body segment," he says. *dac* fits this definition, but he thinks it doesn't quite qualify as a master gene, because *ey* always induces *dac*, but *dac* can't always induce *ey*. To him, this suggests that *ey* is higher in the regulatory hierarchy. Or perhaps, suggests University of Southern California geneticist Kevin Moses, it all boils down to semantics: "Any genetic element that can become critical can be seen as a 'master regulator.' "

The "big game" now, says Gehring, is to map out the eye-development pathway in detail, assigning places to *ey*, *dac*, and a handful of other genes known to be involved—including the recently discovered *toy*, a possible "co-master" regulator that seems to help activate *ey*, as Gehring reported at a conference in Tennessee last June. The gene *toy* is even more closely related than *ey* to *pax-6*, a mammalian gene involved in eye development, and may be the ancestral fly-eye gene, with *ey* an accidental duplicate that later took over most of *toy*'s job, Gehring speculates. Whichever gene comes out on top, there will be plenty of depth left to plumb below.

–Wade Roush

ASTRONOMY

Gas Clouds May Be Relics of Creation

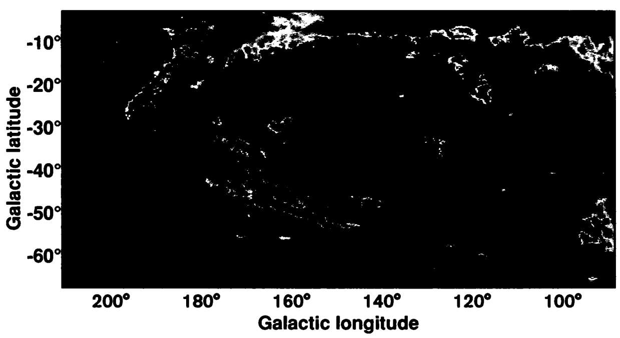
TORONTO—Astronomers who study a mysterious set of gas clouds speeding through the Milky Way can appreciate the plight of the very nearsighted tourist in Africa. A gnat seems to be crawling across her glasses, but when she removes them, the gnat is still there; finally she realizes that a rhino is charging over a ridge. Astronomers haven't had a similar flash of recognition yet. But some have proposed that what they thought were gnats—the spindrift of supernovas exploding in our galaxy—might be something much grander: huge, distant remnants of the galaxy's formation that extend well beyond the Milky Way and could fuel the formation of new stars for billions of years into the future.

The proposal, presented during an American Astronomical Society meeting held here from 12 to 16 January, relies on computer simulations of gas left over from the formation of the first galaxies and clusters of galaxies. The simulations show that these leftovers could survive until the present as clouds of gas roiling in the gravity of our Local Group of galaxies. "We start these [models] at about 1 billion years after the big bang and just let them evolve," says Leo Blitz of the University of California, Berkeley. Fast-forwarding to the present, "we get what we see"—assuming the observed high-velocity clouds are lumbering masses in deep intergalactic space.

Few astronomers believe that the evidence is strong enough yet to prove these cosmic claims. But by pointing to the kinds of observations that could finally pin down the nature of the clouds, says Joel Bregman of the University of Michigan, "this breathes new life into the problem."

The mystery dates back to the 1960s, when observations of radio emissions from hydrogen atoms in interstellar space showed that some of them belonged to clouds stampeding in all directions at hundreds of kilometers per second relative to Earth. The most complete catalog to date, compiled by Bart Wakker of the University of Wisconsin, lists about 550 of these rogue clouds. The biggest obstacle to understanding them is astronomers' ignorance of their distance and thus their actual size. "Distance is the most critical, but the most difficult," says Wakker.

Still, Wakker thinks the clouds are closely associated with our galaxy. One possibility is that they are the handiwork of supernovas. By driving gas out of the plane of the galaxy in "fountains" that would tumble back, supernovas could stir up clumps of interstellar gas. "There are supernovas in the [galactic] plane; they do explode, so where does the gas go?" asks Wakker. "The galactic fountain seems reasonable." Wakker has shown that this picture can account for most of the observations, although he and Bregman concede that it has a hard time explaining the very fastest clouds.



All in tatters. Radio-emitting clouds of hydrogen (red and yellow) could be left over from the galaxy's formation.

DAP HARTMANN/HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS

Blitz, along with David Spergel of Princeton University, Dap Hartmann of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, W. Butler Burton of the University of Leiden in the Netherlands, and Peter Teuben of the University of Maryland, College Park, decided to try out a grander picture. They suggest that, rather than lying 10,000 or 15,000 light-years away, the high-velocity clouds are scattered on scales of more than a million light-years, stretching well beyond our galaxy toward its neighbors. And instead of being run-of-the-mill interstellar gas, they are relics of the great filament of primordial gas that coalesced to form the entire Local Group of galaxies. If so, the gravity of the Andromeda galaxy and the Milky Way could be accelerating the clouds to the high velocities that have puzzled observers.

To test this idea, says Blitz, the team used "an extremely simplified model of our local region of the universe." In the model, the newborn Milky Way and Andromeda galaxies first draw apart with the general expansion of the universe, then move closer again because of their mutual attraction. Based on the changing gravitational field created by the two galaxies, the model calculates how nearby gas clouds should move, how much of the gas should get swallowed up by the galaxies, and how much should survive to the present epoch.

Hartmann says the model's predictions of where the clouds should tend to congregate in the sky and how fast they should move just about match his own detailed radio observations. The model predicts, for example, that clouds should be concentrated along a line connecting the Milky Way and Andromeda—the orientation of the original gas filament that formed the Local Group. The clouds do seem to cluster along that line, which impresses David Weinberg, a specialist in cosmic structure formation at Ohio State University. Throughout space, galaxies form patterns "like beads on a string," says Weinberg. "If this is correct, then in addition to seeing the beads, you can still see the string."

These leftovers, if that's what they are, should amount to roughly 100 billion solar masses of material—enough to nourish star formation in the Milky Way for billions of years. That would brighten the galaxy's future, says Blitz, who notes that observers have had a hard time finding enough fresh gas to sustain the present rate of star formation for much longer. Before astronomers draw too many conclusions, though, they want definitive evidence for or against the new cloud theory. So far, one observation has given it a boost by showing that the composition of one high-speed cloud could be extragalactic. But another has raised doubts by showing that a different cloud lies relatively nearby—too close for comfort in the new scenario. The cloud watchers are still waiting for that shock of recognition.

–James Glanz