huge family of receptors, each of which seems to respond to different bitter-tasting compounds. The researchers have also discovered how those various signals are apparently combined to send just one bitter message to the brain. "This is clearly a major breakthrough for taste research," says Gary Beauchamp, director of the Monell Chemical Senses Center in Philadelphia. "It all fits together in a very nice story. My only regret is that I didn't make the discovery."

For years researchers have struggled to identify receptors for the five different tastes—sweet, bitter, sour, salty, and umami (MSG)—that the taste cells in our taste buds detect. The stumbling block has been a lack of starting material; there is no way to grow taste-bud cells in the lab. So with the exception of a recent discovery of a possible receptor for umami, receptors for the different tastes in vertebrates have not been identified.

Taking a new tack, Ryba and Zuker (whose team this week also reports the discovery of a receptor for touch sensation; see previous story), decided to let genetics lead the way. Taste researchers have long known that some people can taste a bitter compound known as PROP, while others can't. Last year, Danielle Reed at the University of Pennsylvania and Linda Bartoshuk at Yale narrowed down the chromosomal location of the gene responsible for that difference. Zuker grad student Ken Mueller suspected that this gene might encode a bitter taste receptor and set out to find it.

Mueller had one clue to guide him. Bitter receptors are known to interact with so-called G proteins, which are involved in intracellular signaling in taste and other responses. So Mueller looked in the vicinity of the PROP-tasting mutation for genes that might encode receptors with the ability to interact with G proteins. He found one, and together with Elliot Adler, a postdoc in Ryba's lab, discovered that it is part of a family of at least 50 genes that cluster at several locations along the human chromosomes. The large number of genes was encouraging, says Zuker, because the team had suspected that many bitter receptors would be required to recognize all the different chemicals that taste bitter. What's more, in mice as in humans, the genes turned out to reside in chromosomal areas known to be involved in bitter perception.

Next, Mark Hoon, a postdoc in Ryba's lab, isolated the mouse counterparts of the human genes and investigated which taste cells in mice express them. He discovered that taste cells that respond to bitter flavors generally express not just one or two of the receptor genes, but most of them. As a result, each individual cell should be able to detect a wide variety of bitter-tasting compounds. This may explain why the brain can't distinguish among bitter chemicals, because no matter which receptor type is activated, the cell will send the same signal to the brain. As a result, the brain receives "a single channel of information" with the simple message that this food is to be avoided, says Robert Margolskee, a taste researcher at the Mount Sinai School of Medicine in New York City. In addition, Hoon found that the receptors are made in the same taste cells as gustducin, a G protein necessary for the perception of bitter tastes. To Margolskee, whose lab discovered gustducin, that essential association nearly cinched the case.

But definitive proof that the family of genes does in fact encode the bitter receptors came when Jayaram Chandrashekar, a postdoc in Zuker's lab, showed directly that the receptors are activated by bitter-tasting compounds. He did this by separately putting each of 11 receptor genes into cultured cells that were engineered so that triggering the receptor would activate a dye. Chandrashekar then exposed the cells one at a time to several bitter compounds. He found that three receptors responded, each to different compounds. What's more, in a different test, the team showed that the activated receptors bind to gustducin, the first step in sending their bitter signal to the brain. The team was able to go even further to show that a mutation in the receptor molecule that recognizes the bitter chemical cycloheximide makes mice less able to taste that compound.

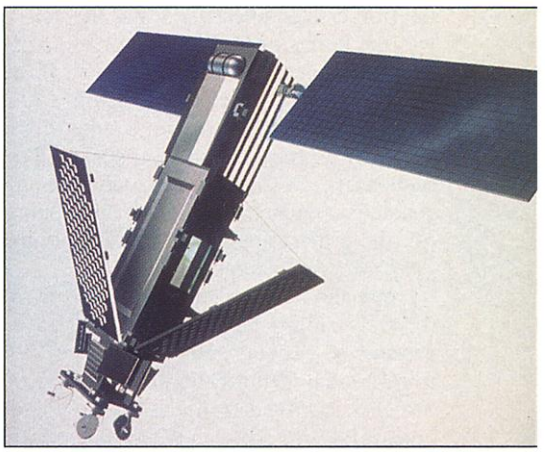
These results led Margolskee to conclude that the molecules are "unqualified taste receptors, as opposed to 'candidate' receptors." Those bona fide bitter receptors represent "an extremely powerful tool," says Catherine Dulac, who studies the chemical senses at Harvard University. They will enable researchers not only to learn more about how the brain encodes taste, but also to develop antidotes for bitter flavors in medicines and foods. And for kids who hate brussels sprouts or taking their medicine, that would be a sweet outcome indeed. **–MARCIA BARINAGA**

COMMUNICATIONS SATELLITES

Iridium's Loss Is Astronomers' Gain

A spectacular business flop is evoking sweet sorrow among radio astronomers. The once high-flying Iridium mobile phone company last week pulled the plug on its $5 billion satellite fleet and will eventually send the 68 orbiting craft into fiery death dives in Earth's atmosphere. That means an end to electronic smog that clouded sensitive telescopes. "I'm not going to say Iridium deserved it, but they certainly were not good neighbors," says Willem Baan, director of Holland's Westerbork Observatory. The experience has also steeled astronomers' resolve to protect important frequencies.

Iridium's globe-girdling constellation was supposed to be the next big thing in communications when it went live in late 1998 (*Science*, 2 October 1998, p. 34). But radio astronomers weren't thrilled, because the satellites produced static that interfered with the faint cosmic signals they study. In particular, Iridium threatened a 1612-megahertz signal produced by hydroxyl masers, blasts of laser-like radio waves that provide important insights into stellar evolution. After 6 years of tense negotiations, the company agreed to provide some unobstructed listening hours each day to radio telescopes in Europe, the United States, and India, and to fix the problem in newer satellites. That deal is now moot, however, as technical glitches and Iridium's high prices—the phones cost $3000 and calls up to $7 a minute—forced the company to shut down on 17 March.



Going down. Iridium's bankruptcy dooms 68 satellites that have irritated researchers.

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The Iridium episode has prompted astronomers "to become much more vigilant" about the interference threat from the growing communications industry, says Baan. In the United States, for instance, a recent government proposal to loosen standards on satellite radio emissions drew angry replies from 50 concerned astronomers, an unprecedented response. And researchers are organizing to protect key bandwidths at an international spectrum-allocation conference to be held in Istanbul in May.

Meanwhile, Iridium's demise will also lighten the load on some optical astronomers. Solar panels on the satellites produce flashes that amateur sky watchers occasionally mistake for new celestial bodies, says Daniel Green of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. "At least we won't be getting these weekly reports from people saying they've discovered another naked-eye supernova," he says. **–DAVID MALAKOFF**