nonaddictive analgesic," says Brownstein. "If you had the entire family of receptors, and if you could learn which ones of those are really involved in mediating pain sensation...you could imagine trying to target [those] with a set of drugs very specific for them."

The cloning of the receptor also holds promise for progress on drug dependence. "Most biological systems adapt to the constant presence of a drug," says Evans, and after such adaptation, withdrawal is a painful process. Indeed, some theories suggest that drug addiction is merely the avoidance of withdrawal. Researchers have been trying for years to discover the changes in cells that account for adaptation to opiates—but with only limited success. The receptor clone will be an important aid in that search, enabling researchers to probe the receptor for chemical changes that may alter its behavior. Understanding those changes, Evans adds, may lead to better means of helping addicts cope with withdrawal.

Clinical payoffs like that will have to wait a while. Still, this week's findings in cannabinoid and opiate research have left researchers in both fields feeling not only optimistic about the future, but also in a state that can only be described as being, well, high.

–Marcia Barinaga

PHYSICAL SCIENCE

Survival of the Fittest in 1992's Physics and Astronomy Bestiary

Out on the frontiers of physics and astronomy some strange beasts pop in and out of sight. At first nobody knows which are real and which are just the mirages of researchers thirsty for discoveries. A sighting or two, or even a footprint, can be enough to get these objects or phenomena into the journals and conference presentations, but even then they remain in the shadows until some decisive experiment either dispels the cloud of doubt or makes them real.

Sometimes a claim is so outlandish that only a few other researchers will take the time to check it out for themselves. Other times scientists leap to the task: The sighting is vivid, or strongly predicted by theory. Even so, there's no guarantee that the beast—a supermassive neutrino or a missing quark—will make it into the physics bestiary; even after several confirmations by independent teams, these eagerly sought creatures can fade off into the mists again.

In 1992, a handful of not-quite-real creatures got a closer look. Some vanished, others solidified into real science, and a few remain in limbo, still embraced by their discoverers and ignored by everyone else.

A quantized stairway to heaven?

If University of Arizona astronomer William Tifft is right and galactic red shifts follow a "quantized" distribution, every textbook in physics and astronomy may end up in the trash. But astronomers have seen such revolutionary findings come and go, so they didn't react with much surprise when, earlier this year, a research group in Scotland backed up Tifft's claim and garnered some print in *The New York Times* and *Scientific American*.

Tifft first detected this periodic spacing of red shifts from galaxies back in the 1970s. The red shift of light from an object indicates its velocity away from Earth, the recession stretching the wavelengths toward the longer, red end of the spectrum. Unless something weird is going on, a big enough sample of galaxies should give a random distribution of red shifts. But Tifft noticed a bunching around values corresponding to multiples of 72 kilometers a second. If true, it implies that galaxies are arranged in some sort of evenly spaced, stairstep fashion.

This year a second sighting came from Bruce Guthrie and William Napier, both recently retired from the Royal Observatory in Edinburgh. They examined red shifts from 89 galaxies and found they bunched up in around 30 cycles of 37 kilometers a second—close enough to half the length of Tifft's cycles to appear to substantiate his claim. Guthrie says he and Napier didn't expect to see any pattern when they started analyzing a catalogue of galaxy red shifts compiled by various radio telescopes. "It was quite a surprise when we found it difficult to reject Tifft's hypothesis," says Guthrie. "It's a very strong effect," he adds; the probability that such a pattern would crop up by chance, he says, is around one in 10,000.

Prominent astronomers scoff at the suggestion. "It's just noisy data," says Joseph Silk of the University of California, Berkeley. The sample is too small, he says, to determine if a pattern like this is real. James Gunn of Princeton agrees. "The measurements aren't terribly good," says Gunn of the work. "If you look at a large enough body of data you will find strange things. There is a strong propensity to find what you want to find."

Guthrie agrees about that danger and calls for better data. But Gunn, Silk, and most other astronomers aren't planning to go looking for it. "We have [a lot of] crank science in our field," says Gunn. "It's easy to pooh-pooh this because there's so much of this kind of thing going on." Sure, he says, he could investigate, "but there are only 24 hours in the day." He says his strongest skepticism stems from the radical nature of the claim. "If Tifft is right, physics is wrong," he says. And if he were a betting man, he says, he'd go with physics.

The 17-kilovolt mistake

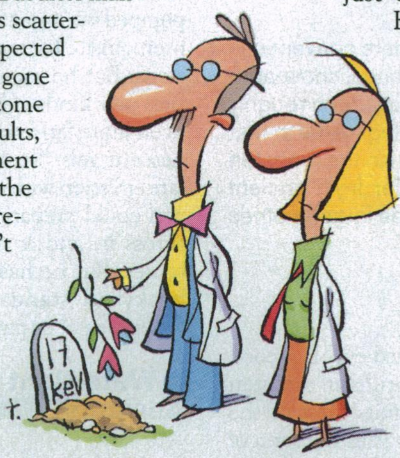
A year ago, particle physicists were flocking to any talk that promised news about a possible new particle known as the 17-kilovolt neutrino. With 1000 times more mass than anyone had reported before for the neutrino, the new particle threatened a major shakeup in particle physics and cosmology. But now the monster neutrino is dead, and physicists are sorting out why it once seemed so alive.

For more than a year, after all, it was the biggest controversy in particle physics. Four different groups, using different experimental setups, had sighted the same thing—what appeared to be a particle with a mass-energy of 17,000 electron volts (17 keV). In the last 6 months, though, the particle's credibility plummeted as other teams failed to duplicate the results. The fatal blow came last October, when one of its strongest backers, Andrew Hime of Los Alamos National Laboratory, identified a mistake in his original experiment that had led him to see a nonexistent neutrino.

Hime's original evidence came from the radioactive decay of sulfur-35; when he measured the energy of the decay products, he found they were missing a consistent 17,000 electron volts of energy, as if some unknown particle was carrying it away. That wasn't the first glimpse of a massive neutrino; John Simpson of the University of Guelph, in Canada, had spotted the same gap in energy spectra in 1985. But Hime's result brought quick confirmations by other workers, and by early 1991 the 17-kilovolt neutrino was all the rage.

ILLUSTRATIONS BY TERRY E. SMITH

Last October, though, Hime announced to his colleagues that he'd found another explanation for the missing energy: The particles were scattering off an aluminum baffle in his apparatus. "If you talked to me a year ago I'd say I'm absolutely convinced this has to be a neutrino," he says. But after making the corrections for this scattering effect, he says, the suspected neutrino "seems to have gone away." Simpson, too, has come to doubt his original results, even though his experiment didn't involve a baffle like the one that explains Hime's result. "The scattering doesn't explain our results. It seems that different factors conspired to make both experiments look like a 17-kilovolt neutrino," he says.

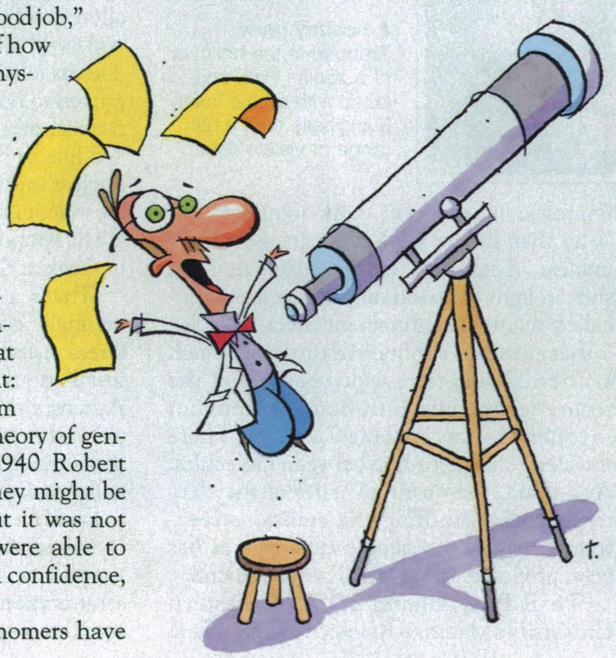


But how could all the other experiments have come up with signs of a new particle, in every case with the same mass? "The fact they all came out at 17 keV is still giving me nightmares," says Hime. It's a combination of bad luck and the pitfalls of selective perception, says University of California, Berkeley, physicist Stuart Freedman, who did some of the most decisive negative experiments. Before this controversy, it was believed that neutrinos had nearly zero mass, so the value you would expect to see from such an experiment was zero. Then, after the first results suggesting the possibility of a 17,000-electron-volt neutrino, he says, there were two acceptable results—zero and 17,000.

Investigators who went for the high value have nothing to be ashamed of, says Lawrence Livermore Laboratory physicist Wolfgang Stoeffl, who participated in the neutrino hunt. "Everyone did a good job," he says. "It is a prime example of how tricky it gets at the forefront of physics. You get fooled so easily."

Black holes come out of the shadows

For one of the most compelling concepts in physics, black holes have spent a long time at the edge of reality. There's a venerable case in favor of these concentrations of mass, so great that they warp space and trap light: Albert Einstein recognized them as a consequence of his 1915 theory of general relativity, and around 1940 Robert Oppenheimer first suggested they might be spawned in collapsed stars. But it was not until 1992 that astronomers were able to point up to the sky and say with confidence, "There's a black hole."



True, since the 1970s astronomers have had one good candidate object, Cygnus X-1, a binary system in our galaxy in which a star rotates about an unseen companion. The star's velocity made it appear to be under the grip of an object weighing a few solar masses and dense enough to be a black hole. But that was just one isolated object, says Harvard astronomer Jeffrey McClintock: "It could have been the rarest thing in the world." And if you really wanted to be a stickler, you could argue that the companion star was abnormally light, which would allow a less massive and exotic object—a neutron star instead of a black hole—to account for the measured velocity.

But just this year astronomers found two new binary systems that don't seem vulnerable to those doubts. The first candidate system, V404 Cygni, was found by Philip Charles of the Royal Greenwich Observatory, and the second, Nova Muscae, by Charles Bailyn of Yale and McClintock (*Science*, 26 June). In both cases, the visible star is whirling about its unseen companion so fast that even if the star is a featherweight, the companion has to have the density of a black hole to explain the orbit. "If these are not black holes they are something even more weird," says Bailyn.

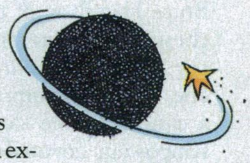
This year also brought sightings of another type of black hole, a million times more massive, found in the centers of galaxies. But the evidence for these monsters is more circumstantial, say astronomers. The case is much stronger for black holes of just a few solar masses right in our own galaxy, says McClintock. "These are where we're certain to have black holes."

Planets come and planets go

For decades astronomers have sought planets outside the solar system, and the search seemed to have culminated last year when astronomers thought they had sighted a planet in a most improbable corner of the universe—around a radio-emitting dead star known as a pulsar. But the quest was far from over. This year opened with a second sighting of pulsar planets, immediately followed by a retraction of the first.

With the demise of the earlier sighting, some people assumed the second one would follow. And yet, says astronomer Dale Frail of National Radio Astronomy Observatory in New Mexico, who worked on the discovery with Aleksander Wolszczan of Cornell University, "It's holding on just fine."

In both cases, the putative planets showed up as slight perturbations in the normally perfect rhythm of radio pulses from the pulsar. Some unseen mass or masses, it seemed, were tugging the pulsar to and fro. The signals made the planets easy to detect, but the pulsars emitting the signals are about the last places you'd expect to find planets. Pulsars are the cinders left over from supernova explosions; finding a planet nearby is like finding lost keys under a blast furnace. And while the first report had just one planet circling a pulsar, Frail and Wolszczan upped the ante to two planets around a different pulsar.



The earlier claim vanished early this year when the wobbles in the pulsar rhythm turned out to be the result of an improper correction for Earth's motion about our sun (*Science*, 24 January, p. 405). But the second planet sighting still stands firm, and it has spawned a cottage industry of theorizing about planets in unlikely places, says Frail, as well as efforts to find others. "We have about a dozen different models," confirms Johns Hopkins astronomer Julian Krolik.

Why has the pulsar planet caught on while other bizarre sightings in astronomy, such as quantized red shifts, have gone begging for attention? "There's a continuum of confidence" about new results, says Krolik. "It depends partly on the track record of the people making the claim, and on how bizarre the result is," he says. At least pulsar planets can be squared with existing physics, he notes, and their signal is clear and easily measured, not buried in mountains of noise. Though Krolik was fooled once before—he spent time speculating about the origin of the original planet—he says he's ready to assume the second result is right.

–Faye Flam