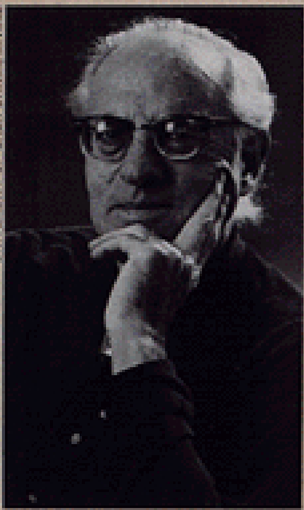
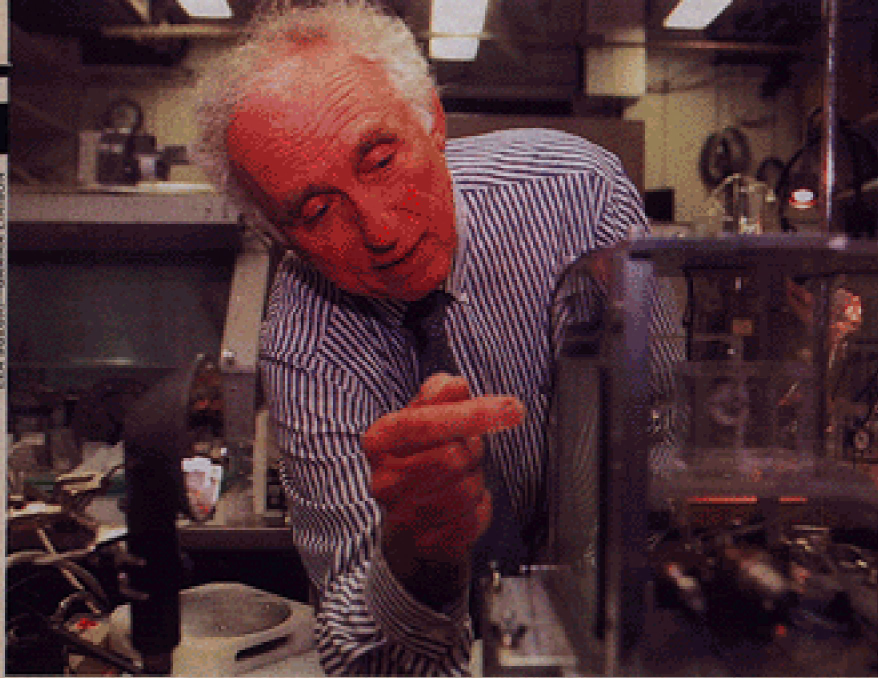
PHYSICS

UNIVERSITY OF CALIFORNIA, IRVINE



REINES

LEA SUZUKI—GAMMA LIAISON



PERL

STEVEN SENNE—AP

MOLINA

MAX PLANCK INST.—AP

CRUTZEN

■ NOBELS

Of Ozone and Fruit Flies

A German, a Dutchman and seven Americans win the science prizes

To perplexed laymen, the celebrated Nobel Prizes often seem to point down obscure pathways of science, focusing on narrow, highly specialized research that few nonscientists can understand or appreciate. Not this year. The $1 million 1995 prizes in physics, chemistry, economics, and medicine or physiology, announced in Stockholm last week, went to scientists who have wrestled with questions at once basic and easily grasped: What is the universe made of? How does DNA create complex life-forms? What made the hole in the ozone layer? And how do people decide how they spend and invest their money?

PARTICLE SLEUTHS When Wolfgang Pauli first proposed the existence of the neutrino in 1930, he labeled his hypothetical particle "a frightful thing." The neutrino would neatly explain a tiny energy imbalance in certain nuclear reactions, but it would also be so ethereal that the average neutrino could zip through a trillion-mile-thick chunk of lead without hitting a single atom. Since the particles would presumably sail undetected through any measuring device, Pauli lamented, his clever idea could never be proved correct.

"Never" turned out to be in around 25 years. It was in the mid-1950s that Frederick Reines and the late Clyde Cowan, then at Los Alamos, set out to find Pauli's impossible particle—the research that earned Reines, now at the University of California at Irvine, half of this year's prize. (Cowan was ineligible because Nobels are not awarded posthumously.)

Rather than try to detect one neutrino at a time, Reines and Cowan used a nuclear reactor that spewed out trillions of neutrinos every second. With so many particles, they reasoned, observed over a long enough period of time (it ended up being years), they should be able to measure at least a few neutrino impacts in their detector, a tank of chemical-tinged water.

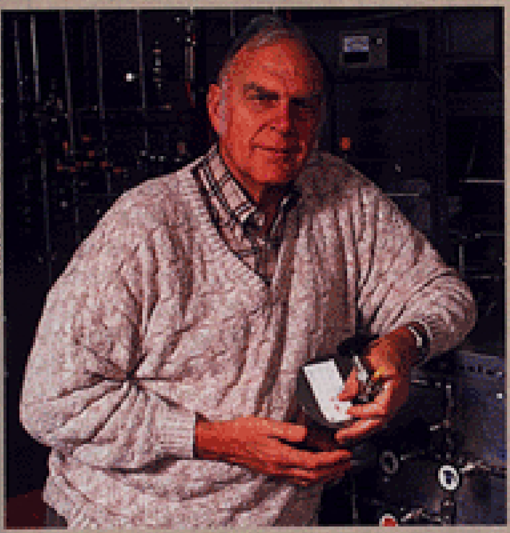
The discovery of what the Nobel citation called one of "nature's most remarkable subatomic particles" tied up an important theoretical loose end and spawned a new field of neutrino physics. But by the early 1970s, it was also clear that the neutrino was only one element in an elegant organizational scheme, now known as the Standard Model, by which nature groups the subatomic particles.

All ordinary matter, physicists had learned, was made of four basic particles: electrons, neutrinos and two kinds of quarks. But there was another family of particles, plentiful in the early universe but now found almost exclusively in nuclear accelerators, that seemed to be divided into the same four types: the muon (a sort of heavy electron), the muon neutrino and two more quarks. And in 1976, Stanford University physicist Martin Perl announced he had found a third, even heavier electron, which he dubbed the tau—a discovery that earned him the other half of this year's physics Nobel. Perl's finding suggested that there might be a third family of particles, most of the other members of which were also found in the 1970s. Last spring, with the discovery of the top quark, the third family was finally, satisfyingly complete.

OZONE WHISTLE BLOWERS Rarely does Nobel-prizewinning research galvanize worldwide political action. Yet the findings that have made chemistry laureates of Sherwood Rowland of the University of California at Irvine, Mario Molina of M.I.T. and Paul Crutzen of Germany's Max Planck Institute for Chemistry did just that. Their discovery that man-made chemicals can damage the planet's protective ozone layer was instrumental in triggering the most successful global environmental treaty ever written: the 1987 Montreal Protocol limiting the use of chlorofluorocarbons, or CFCs. Before the treaty, CFCs were widely used in deodorants, spray paints, plastic foam, refrigerators and air conditioners.

Crutzen's work came first, with his demonstration in 1970 that airborne chemicals called nitrogen oxides could damage the ozone gas that floats high in the earth's

CHEMISTRY



ROWLAND

MEDICINE OR PHYSIOLOGY

LEWIS

NÜSSLEIN-VOLHARD

WIESCHAUS

ECONOMICS

LUCAS

stratosphere and screens out ultraviolet light, which can cause sunburn and skin cancer. The real breakthrough, though, came in 1974, when Molina and Rowland determined that CFCs are highly efficient ozone destroyers, gobbling up many times their volume in ozone molecules.

Molina's and Rowland's work didn't thrill industrialists, but it did lead to a ban on CFC-based spray cans in the U.S. in 1978. And after an ozone hole over Antarctica was detected in 1985, industry was goaded into taking swift action. CFCs are now being phased out all over the world for all uses, and production will be banned entirely as of 2006.

LORDS OF THE FLIES To most people, fruit flies are those pesky bugs that swarm around overripe bananas. To biologists, however, they are the key to unlocking some of life's deepest mysteries. They are nearly perfect lab animals: not only do the tiny insects grow quickly, but their genetic structure is strikingly similar to that of humans. So it was only natural for the three researchers who shared this year's Nobel Prize for Medicine or Physiology to use fruit flies to help solve the riddle of how genes control embryonic development—in insects and in humans.

Their experiments led to the discovery of so-called pattern-forming genes that control the body's overall organization and direct the development of body segments and specialized features, like the wings and legs of a fruit fly. Scientists now believe that flawed copies of these genes in humans underlie some miscarriages and perhaps 40% of the birth defects that have no apparent cause.

Edward Lewis, of Pasadena's California Institute of Technology, began studying mutant flies in the late 1930s, breeding more than 100,000 insects over 10 years. After a painstaking series of experiments in which fruit flies were exposed to radiation, Lewis identified the complex of master control genes that organize development of the embryo into discrete segments: head, thorax, abdomen. Some bizarre mutations, he found, result from defective control genes ordering normal segments to appear in abnormal places. For example, flies with an extra set of wings have an extra copy of an entire thoracic body segment.

Three decades later, Eric Wieschaus, of Princeton University, and Christiane Nüsslein-Volhard, of the Max Planck Institute for Developmental Biology in Tübingen, Germany, picked up on Lewis' work but focused instead on searching for the genes that initiate embryo development. Wieschaus and Nüsslein-Volhard bred 40,000 fruit-fly families, each with a single defect. For more than a year, the two peered almost daily into a microscope, scrutinizing dead fly larvae and embryos. They found that most mutations had minor effects on development. But sometimes, says Wieschaus, "extraordinary things would happen. There would be no muscles, or the skin would become composed of nervous cells." By looking at what went wrong, the two scientists determined that of the fly's 20,000 genes, only 139 are absolutely essential for early development.

CHICAGO RULES In the midst of the 1970s recession, U.S. policymakers trying to revive the economy and stimulate job growth turned to one of their favorite tools: intervention. They pumped up federal spending and pushed down interest rates. According to conventional economic theory, inflation should have gone up and unemployment down—a trade-off that seemed worth the risk. What they got, however, was the worst of both worlds: high inflation and high joblessness—a phenomenon known as stagflation.

What happened? The answer—put forward by Robert Lucas, an economist at the University of Chicago—is the deceptively simple theory called "rational expectations," which earned Lucas this year's Nobel Prize for Economic Science.

Rational expectations, according to Lucas, is why government intervention so often fails. People remember the effects of past policies and quickly adjust their behavior in anticipation of what they think new policies are likely to do. In the case of the 1970s recession, Americans knew from experience that any attempt to pump up the economy would spur inflation and erode earnings. As a result, businesses immediately raised prices and workers demanded higher wages. Result: more inflation and continued high unemployment, the opposite of what policymakers had hoped for.

In the 1980s President Reagan made the same mistake. He promised that huge tax cuts would accelerate business activity and eliminate the budget deficit. Instead the economy stumbled, and the deficit rose to its highest level in history. Lucas' recommendation to policymakers: stop trying to fine-tune the economy.

Such intellectual brashness is typical of economists at the University of Chicago, whose emphasis on the theoretical has won them relatively few government appointments but more than their share of Nobel Prizes. The "Chicago boys" have won a total of eight economics Nobels, including five of the past six. "Around here," jokes Lucas, "the Nobel Prize doesn't carry much weight." ■