in many ways similar to the learning observed in more traditional studies and takes the position that universal laws of learning can be modified to incorporate various biological predispositions.

A few scientists, such as M. E. Bitterman of the University of Hawaii, do not think that the phenomenon has been adequately demonstrated, so that, as of this date, it poses no challenge to traditional learning principles. Richard Krane, now at Acadia University, and Alan Wagner of Yale University criticize in particular the hypothesis that animals may be biologically predisposed to associate two

Latest New Particle Caps the Evidence for Charm

New particle discoveries are occurring faster and faster. In mid-August researchers at the Fermi National Accelerator Laboratory in Batavia, Illinois, announced that they had found 50 examples of a new particle that is substantially different from but related to another particle discovered 2 months earlier at the Stanford Linear Accelerator Center, Palo Alto, California. The latest finding comes close to clinching the idea that the new particles discovered in the last 2 years are composed, in one way or another, of charmed quarks. The theory of charm has done so well at predicting the properties of these new particles that there is little doubt that there is a whole family of charmed particles.

The scientific trail leading to the Fermilab particle began in November 1974, when two different laboratories unexpectedly found a peculiar new particle that was named the J or psi and is now explained as a meson having hidden charm. Mesons are a class of strongly interacting particles that may be created or destroyed in nuclear reactions, and charm is a quantum property postulated 10 years ago by James Bjorken and Sheldon Glashow for both mesons and baryons, the other class of strongly interacting particles. The charm theory is closely linked to the theory that mesons and baryons are made up of hypothetical subunits called quarks—one of which can be a charmed quark.

In mesons of the J/psi type, charm is said to be hidden because the particle is composed of a charmed quark and its antiparticle. At least five different particles related to the J/psi have now been found at Stanford and the Deutsches Elektronen Synchrotron laboratory (DESY) in Hamburg, Germany.

In early summer, a meson with undisguised charm was found at Stanford (*Science*, 18 June, p. 1219). It is composed of a charmed quark and the antiparticle of a normal quark, so no cancellation of the charm quantum number occurs. Two more charmed mesons were subsequently discovered at Stanford, so the number of charmed mesons now stands at three.

The particle discovered at Fermilab apparently extends charm into the baryons, so now an example of charm has been found in each of the major classes of elementary particles. Baryons are composed of three quarks, one of which is charmed in the latest experiments. As with the mesons, many more charmed baryons are presumably waiting to be discovered.

The Fermilab particle has a mass of 2.26 giga-electron volts (Gev) and a relatively long life for such a heavy particle (estimated 10^{-13} second). It is presumably the lightest charmed baryon, and coincides remarkably well with the properties predicted by Sheldon Glashow, Alvaro De Rújula, and Howard Georgi of Harvard University. These authors predicted in the 16 August issue of *Physical Review Letters* that the particle should have a mass of 2.25 ± 0.05 Gev.

The new charmed baryon was discovered by researchers from Columbia University, the University of Hawaii, the University of Illinois, and Fermilab. Naming of the new particle—so far untitled—is the prerogative of the research group, which was led by Wonyong Lee of Columbia. The group also has some evidence for a second charmed baryon with a mass of about 2.5 Gev.

The new particles were produced when high-energy x-rays interacted with a beryllium target and produced a shower of particles that were collected in a wide-angle magnetic detector. The initiating x-rays were produced at energies of 100 to 200 Gev from the primary proton beam of the Fermilab accelerator. Out of about 15 million events collected over a 3-month period, 50 had the decay properties expected for a charmed baryon. In these events the unseen baryon decayed into four particles: a lambda particle and three pi mesons. The decay sequence is not a unique signature of charm, but it is "very consistent with everything charm theory predicts," according to Lee. It is also the decay mode specifically mentioned by Glashow and his colleagues, who predicted that "lambda-pi spectroscopy can reveal a whole family of singly charmed" baryons.

None of the decay products are charmed, and it is believed that charm vanished because the decay was a weak interaction. In effect, charm was transmuted into strangeness, another quantum number whose introduction dates back 25 years. The lambda is the lightest strange baryon.

The only puzzle in the Fermilab experiment is that two charmed baryons should have been produced in the experiment, but only one has been positively identified. The detected particle has a negative charge (actually the antiparticle of the charmed baryon was detected), and the analogous particle with positive charge should have also been produced. The higher background for positive particles could be obscuring the second particle, however. The 2.5-Gev particle detected in a few instances has a doubly negative charge.

The same sort of evidence for a charmed baryon was reported in April 1975 by Nicholas Samios and co-workers at the Brookhaven National Laboratory, but the datum (a bubble chamber measurement of lambda–three pi decay) was not judged conclusive because only one event was found.

Now that the charm theory has successfully predicted the mass of the lightest charmed meson and the lightest charmed baryon, it appears to be making the transition from the avant-garde to the established. Many more charmed particles are now expected. A few more mesons—including those that are both strange and charmed—should be found, and many more baryons are predicted. According to Lee, there should be about twice as many charmed baryons as strange baryons. Physicists will eagerly search for these, but when they find them the discoveries will probably not be called surprises.—W.D.M.