of chloroplast DNA than about that of mitochondrial DNA. This is surprising in view of the primary role of chloroplasts in maintaining all living organisms. The view was expressed that this situation stems from the failure of too many departments of botany and biochemistry to promote interest in the biochemistry of plants; consequently far fewer biochemists study chloroplast development than study mitochondrial development. Several groups are currently preparing restriction fragments of chloroplast DNA, so some progress in mapping the chloroplast genome can be expected. One structural gene firmly established as located in this genome is that for the large subunit of Fraction I protein (ribulose-*bis* phosphate carboxylase). R. J. Ellis (University of Warwick) reported that this subunit was made *in vitro* by the free ribosomes of the chloroplast but not by the membrane-bound ribosomes. Isolated spinach chloroplasts will use light energy to incorporate ^{3}H-uridine into a discrete RNA species of molecular weight 2.7×10^6; M. R. Hartley (University of Warwick) and H. J. Bonert (University of Dusseldorf) reported hybridisation data which showed that this RNA species contains cistrons for both 16S and 23S chloroplast ribosomal RNA.

It is clear that most of the proteins of both mitochondria and chloroplasts are made on cytoplasmic ribosomes, and are then imported across the bounding membranes into the developing organelle. G. Schatz (University of Basle) suggested that the mechanism of specific protein uptake into these organelles is a major problem in cell biology, but no new data were presented at the meeting that shed any light on the process.

More and more promising

from David J. Miller

> The International Particle Physics Conference was held in Palermo on July 23–28, 1975.

At last year's International Particle Physics conference in London, some theorists placed bets that "charm" would be discovered before this year's conference in Palermo. Charm is a suggested new quantum number, like the well-established "strangeness" number carried by hyperons and K-mesons. It had been incorporated into a very plausible scheme to explain the weak interactions, including the recently established neutral current effects, but no one had seen a "charmed" particle. Now the Palermo conference has passed, but it is still not clear who has won the bets.

Remarkable things have been discovered during the year, the psi (or J) and psi′ particles in particular. In the last few weeks a collaboration working at the DORIS electron–positron colliding-beam machine near Hamburg has reported a new intermediate state between the psi and the psi′. They claim that when their e^+e^- collision energy was 3.7 GeV (that is, when they were making psi′) they saw a number of events whose final state particles consisted of two fixed energy gamma rays and a psi. The psi was recognised when it delayed to a muon- or electron-pair with a mass of 3.1 GeV. The production of the two gamma rays is interpreted as a two-stage de-excitation cascade (psi′→new particle + gamma ray, followed by new particle→psi + gamma ray). Such cascades are encountered frequently in atomic or nuclear spectroscopy. Rumours from the SPEAR storage rings at Stanford, California suggest that similar intermediate levels have been observed there.

Charm lovers know exactly what they want these new objects to be. They say that the intermediate particle(s) are the p-wave states of "charmonium", that is, states with one unit of angular excitation. The psi is supposed to be an s-wave ground state, and the psi′ is the first radial excitation. The states have been called charmonium by analogy with "positronium", a short lived atom-like structure formed from an electron and a positron. Charmonium should be made in a similar way from a charmed quark and a charmed antiquark. The only doubts one can have about this argument are that no one has yet proved that charm exists, and we haven't seen any quarks.

But progress has been made on both of these problems. The Stanford–Berkeley collaboration at SPEAR has now had time to collect e^+e^- annihilation data up to about twice the energy at which the psi′ is produced. They have seen one other bump, wider than the psi and psi′, centred at about 4.15 GeV, but they have also made a high-statistics run at a fixed rate collision energy of 4.8 GeV. This energy was chosen just because there seemed to be no specially interesting energy-dependent behaviour there. In the final states of this sample they have found evidence for another new phenomenon, the correlated production of muons and electrons. Combinations of a positive muon with a negative electron or of a negative muon with a positive electron have both been recognised, but there are no signs of combinations with the same charge for both the muon and the electron. The measured momenta of the electrons and muons show that they do not carry 4.8 GeV of energy between them, so neutral particles must have escaped undetected.

Charm lovers are, once more, ready with an explanation. A pair of charmed mesons (real charmed particles, not charmonium) has been produced, they say. They must carry opposite charges, and they decay just like pions or K-mesons to muons or electrons, with neutrinos and perhaps neutral pions to take away the unseen energy. It is interesting that a very similar decay process for charmed particles could explain the neutrino-induced events with pairs of muons in the final state, reported at last year's conference by the Harvard–Pennsylvania–Wisconsin–Fermilab group, and confirmed this summer by the Caltech group, also working at Fermilab near Chicago. It is beginning to look as if the charm lovers may be right, but none of the evidence is really firm yet and physicists like to be sure before they pay out on a bet.

As for the problem of seeing quarks, theoretical physicists now tell us that we should not even try. Quarks exist, they say, but they can never be seen. They explain many of the properties of all strongly-interacting particles. They carry most of the mass, as well as the charge, strangeness and charm quantum numbers, but they can never be shaken free from the groupings of three quarks, or quark and antiquark, out of which particles are built. A group at the Massachusetts Institute of Technology has invented a model in which the quarks are permanently confined in "bags" about 10^{-15} m across. Other groups, including one at Cornell University, have models in which the quarks are tied on strings. Until recently these models were regarded as purely phenomenological; just rigged up to fit the data. But at Palermo, and afterwards at the Erice summer-school, near Palermo, it has become clear that fundamental field theories of elementary particles might provide very natural and attractive schemes in which quark-confinement could be achieved. This would be very exciting, since it could lead to a unified theory in which the strong, weak and electromagnetic interactions could be explained at the same time. At the moment some of the leaders in this effort, such as Coleman from Harvard or 't Hooft from Utrecht, are still proving beautiful theorems about two-dimensional space–time. K. Wilson of Cornell works in four dimensions, but his space and time form a quantised lattice. It may take a few years to get to the four-dimensional space–time continuum that physics actually happens in, but many theorists are very optimistic; although nobody is placing any bets.