Subcellular Localization of Inorganic Ions in Plant Cells

Van Iren and Van der Spiegel (*1*) reported that they obtained the "first direct evidence for significant amounts of ions in the endoplasmic reticulum" of plant cells. They used an in vivo precipitation technique in which barley roots were exposed to Tl^+, and then treated with I^-, leading to precipitation of TlI in the tissue. The intracellular distribution of the precipitates was examined electron microscopically. As Van Iren and Van der Spiegel stated, Tl^+ may be used as a "physiological isotope" for K^+. The administration of I^- as an analog of the nutrient ion Cl^- is questionable, however, as these two halide ions appear to be absorbed by different mechanisms (*2*).

We have independently studied the intracellular localization of Cl^- in barley roots by using an in vitro precipitation technique originally proposed by Komnick (*3*). Roots of intact barley seedlings were allowed to absorb Cl^-, after which root specimens were fixed for electron microscopy in the presence of Ag^+ to precipitate Cl^- as AgCl. The precipitates were found to be located particularly in the endoplasmic reticulum and in plasmodesmata of cells of the cortex and of the stele in these roots (*4, 5*). We were able to detect the precipitates in the endoplasmic reticulum of xylem parenchyma cells after an absorption period of only 20 minutes from 5 m*M* Cl^- (*5*). This emphasizes the efficiency of the symplasmic pathway for ion transport to the xylem of roots in which the apoplasmic pathway is blocked by the Casparian strip of the endodermis (*6*). Using the Ag^+ precipitation technique, Van Steveninck *et al.* (*7*) also succeeded in localizing Cl^- in the endoplasmic reticulum of cells of the alga *Nitella translucens*.

The Ag^+ precipitation technique has been criticized, because Cl^- ions may diffuse in the specimen during the preparation or may even be lost from it (*1*). We have tested for loss of ^{36}Cl from barley roots during specimen preparation and found that less than 4 percent was lost during the whole preparation procedure (*8*). Furthermore, the electron-dense precipitates observed with the electron microscope were shown by electron microprobe analysis to be composed of Ag and Cl (*8*). Localization of Cl^- by the Ag^+ precipitation technique has the additional advantage that the AgCl precipitates are stable under the electron beam (*4, 5, 7, 8*), whereas TlI evaporates, leading to holes at the sites of its original location (*1*). Nonetheless, possible localization artifacts arising from diffusion during the use of the Ag^+ precipitation technique must be considered critically (*9*). We have concluded that during the preparation procedure, ions may migrate within a membrane-bound cell compartment (*4, 5, 9*). Thus, localization at the level of the endoplasmic reticulum would not be affected qualitatively by a possible migration of ions in the course of the specimen preparation.

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ticle through the emission of either a positive muon or a positron, and a neutrino. Because of the detector they used, however, the researchers observing dimuons do not have direct evidence of the presence of a strange particle. Altogether, more than 80 dimuon events have been found.

Although the discovery of a new particle in itself is sufficient to generate excitement among physicists, in this case the interest is heightened by the possibility that the particle may possess the property of charm (*Science*, 8 August 1975, p. 443). Like strangeness, charm does not correspond to any physically observable property. Instead, strangeness and charm are arbitrary designations for quantum numbers whose existence is implied by the results of certain experiments.

Theorists' favorite explanation for the existence of the *J*/psi particle invokes certain hypothetical entities called charmed quarks. Quarks have been conjectured as the fundamental constituent particles that make up the hadrons (which feel the strong force) (*Science*, 17 May 1974, p. 782). Among the many varieties of quark theories extant in physics today, a model with four such particles, one of which possesses the property of charm, is the most widely discussed.

The *J*/psi particle, it has been proposed, comprises a charmed quark and its antiquark. Thus, this meson, as a whole, does not exhibit charm. Although a number of experiments at the Stanford Linear Accelerator Center (SLAC) and at the DESY Laboratory in West Germany involving apparent excited states of the *J*/psi particle are seen by scientists as being consistent with this model, the failure of experimentalists to observe charmed hadrons (containing only one charmed quark) when some of these excited states decay has been a major stumbling block to acceptance of the charm model. Hence the interest in the neutrino experiments: although there is as yet no direct connection between the proposed new particles and either the specific charm model that was first proposed in the 1960's or the *J*/psi particles, the mere existence of a new quantum number suggests charm in the general sense of there being a fourth quark. In fact, it is not inconceivable that there are even more quarks with other properties.

Because the Wisconsin-California-CERN-Hawaii experiment explicitly identified all the final state particles, it seems to some to be a little more clear-cut in its interpretation than the other experiments. Theorist Benjamin Lee of Fermilab, for example, thinks that this experiment constitutes the strongest evidence yet for charm, and SLAC's Sidney Drell says that the events seem to admit of a natural interpretation in terms of states of charm. But all observers emphasize that it is still premature to make the connection. Lee cautions that he would like to see more events so that all the consequences of the charm model can be verified. More cautious still is Sheldon Glashow, an originator of the charm concept, who maintains it is still absolutely crucial that charmed particles be seen in the electron-positron storage ring experiments when *J*/psi particles in sufficiently highly excited states are produced. The states that may exist near 4.1 and 4.4 Gev, for example, would be energetic enough to decay into two 2-Gev particles.

With the electron-positron storage ring experiments and the neutrino beam experiments both suggesting charm, in the words of one physicist, "Things are really coming to a boil, not just in one spot, but all over the pot."—ARTHUR L. ROBINSON