## Plasmodesmata between Hyphal Cells of Geotrichum candidum

Abstract. *Electron-microscopic studies of three isolates of* Geotrichum candidum *from plants and one isolate from man showed the fine structure to be similar to other closely related, yeastlike fungi. Structures were observed that appeared similar to plasmodesmata present in higher plants.*

*Geotrichum candidum* (Link) ex Persoon emend Carmichael (*1*) is a facultative parasite capable of causing decay of certain fruits and vegetables and geotrichosis in man (*2–5*). Carmichael (*1*) classified *Geotrichum* sp. as imperfect, yeastlike fungi. The fine structure of several yeasts and yeastlike fungi, but not that of *Geotrichum* sp., has been reported (*3*). An electron microscope study was made of the fine structure of somatic mycelia of isolates of *G. candidum* from three citrus fruits and from one human. The plant isolates used were designated LA-2 (*5*), ATCC-7019 (*6*), and C-125 (*6*) and the human isolate CH (*5*).

The mycelia were grown on broth containing 20 g of dextrose, 133 ml of canned tomato juice, and the broth from 200 g of autoclaved, peeled Irish potatoes in 1 liter of distilled water. The medium was decanted into 250-ml Erlenmeyer flasks and autoclaved. The flasks were seeded from stock cultures of the test fungus maintained on potato-dextrose agar. Cultures were incubated at room temperature (22° to 32°C). Mycelial mats were harvested after 24 to 36 hours; killed and fixed for two hours in 1.0 percent nonbuffered potassium permanganate solution; dehydrated in an alcohol series; embedded in Maraglas for sectioning; and stained in 1.0 percent lead hydroxide.

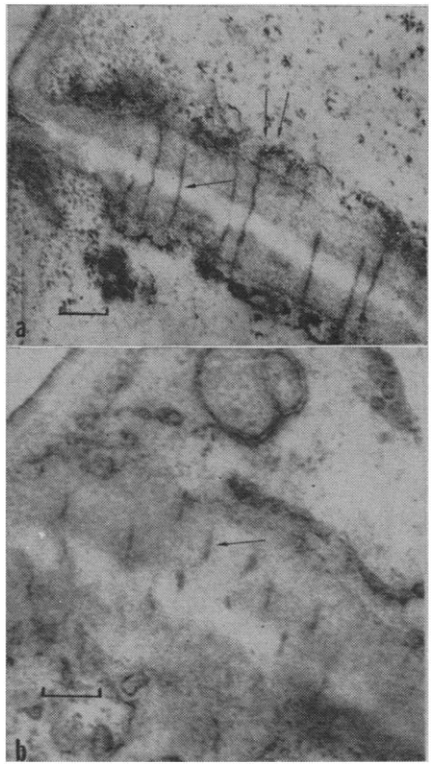

Figure 1. Electronmicrographs showing plasmodesmata (single arrow), in continuity with plasma membrane (double arrows), in between two fungal cells of plant isolate ATCC-7019 of *Geotrichum candidum* in longitudinal section (a) and oblique section (b) (1.0 cm = 0.1$\mu$).

The ultrastructure of *G. candidum* is very similar to that reported (*3, 4, 7*) for closely related, yeastlike fungi, including species of *Histoplasma, Candida, Saccharomyces,* and *Blastomyces.* Distinct structures identical to the plasmodesmata found frequently in higher plants (*8*) were observed in the septa of the three plant isolates (Fig. 1), but not in the septa of human isolate CH. The failure to find these structures in isolate CH was attributed to difficulties in sectioning and staining caused by the presence of a thick, pellicle-like covering around the cells and by the thick cell walls of this isolate (220 to 290 $\mu$ compared to 60 to 120 $\mu$ for cell walls of plant isolates). The pellicle-like covering was not present in the plant isolates.

The plasmodesmata were observed to be connected with the plasma membranes (Fig. 1) in each of the adjoining cells. The fact that the plasma membrane retained its continuity with the plasmodesmata in sections in which the plasma membrane had pulled away from the septum, gave further evidence of this relationship.

If these structures, observed for the first time in this fungus, are comparable to plasmodesmata found in higher plants, then these structures would also function as protoplasmic bridges between hyphal cells in fungi. The presence of plasmodesmata is significant because entire septa are restricted to Phycomycetes and Hemiascomycetes, higher orders of fungi having protoplasmic connections through their septa (*9*).

BEN T. KIRK
JAMES B. SINCLAIR
*Department of Botany and Plant Pathology, Louisiana State University,* and *Agricultural Experiment Station, Baton Rouge, 70803*

**References and Notes**

1. J. W. Carmichael, *Mycologia* **49**, 820 (1947).
2. S. H. Webster, *Dis. Chest* **35**, 273 (1959).
3. B. T. Kirk, thesis, Louisiana State University (1966).
4. ——— and J. B. Sinclair, in preparation. Plant Isolates: LA-2 isolated from Louisiana oranges in 1963; ATCC-7019, American Type Culture Collection isolate, originally received from Argentina as *G. candidum* var. citri-aurantii; and C-125 isolated from California lemon. The last two isolates were obtained from E. E. Butler, University of California, Davis. The human isolate CH was obtained from D. J. Guidry, Louisiana University Medical School, New Orleans.
5. Z. M. El-Tobshy and J. B. Sinclair, *Phytopathology* **55**, 1210 (1965).
6. E. E. Butler, *ibid.*, p. 665.
7. A. Takagi and A. Nagata, *Jap. J. Microbiol.* **6**, 95 (1962).
8. B. R. Voeller, in *The Cell,* J. Brachet and A. E. Mirsky, Eds. (Academic Press, New York, 1964), p. 257.
9. E. A. Bessey, *Morphology and Taxonomy of Fungi* (Blakiston, Philadelphia, 1950), p. 4.
10. This study was aided by PHS grant EF-00564 and the Louisiana State University Foundation.

25 July 1966

## Auditory Sensitivity of the Monkey

Abstract. *Auditory thresholds for pure tones were determined in monkeys (three* Macaca irus *and one* Macaca nemestrina*) by the psychophysical method of constant stimuli after the animals had been trained by operant conditioning procedures. Their audible frequency range was found to extend from below 60 hertz to 40 or 45 kilohertz.*

The extent of the audible frequency range for sub-human primates has not yet been determined. Recent evidence (*1, 2*) indicates that the monkey is sensitive to higher frequencies than man, but the upper limit has not been established except for the marmoset (*2*).

In our experiment we attempted to find the upper limit of the audible frequency range for the macaque. To avoid the difficulties inherent in maintaining uniform free-field stimulation, we used a closed system with earphones mounted directly on the monkey's head (*3*). To measure sound pressure at the ear we inserted a probe tube (6 cm long, 1 mm in diameter) through the cushion of the earphone in such a way that the end of the tube was located directly in front of the phone at the entrance of the external canal.

The probe tube was connected to a condenser microphone (model 4134, Brüel and Kjaer) and cathode follower (model 2615, Brüel and Kjaer). The output of the cathode follower was