nantly chrysotile fiber and sheet silicates (Fig. 1), whereas the Nouméan ores appeared to be mixtures of clay (montmorillonite), other sheet silicates including the serpentine phases, and especially large amounts of chrysotile fiber (Fig. 2). The sheet silicates consisted of aggregates, often intergrown and contiguous with chrysotile fibrils. Selected-area electron diffraction (SAED) patterns obtained on single clay grains displayed Debye-Scherrer rings, which clearly indicated the aggregate nature of these particles on the submicron-sized scale. Chrysotile in the ore specimens consisted of fibers and fibrils with shapes ranging from equant (clumps) to the more characteristic asbestiform fibers. The SAED patterns obtained on chrysotile tended to range from single, well-defined reflections to Debye-Scherrer rings. The most common pattern consisted of both forms (Fig. 1C). Chemical analyses of chrysotile fibers from "garnierite" indicate a marked increase in the integrated peak count ratio of silicon to magnesium from 1.73 ± 0.05 measured on non-nickeliferous chrysotile specimens from Globe, Arizona, to 5.41 ± 0.05 obtained on most Nouméan chrysotile fibers, to 7.84 ± 0.05 obtained on some low-magnesium chrysotile fibers. The increasing peak count ratio reflected magnesium depletion and was accompanied by a corresponding increase in the nickel x-ray emission.

The New Caledonian "garnierite" specimen and the three ores obtained from Nouméa were heavily contaminated with chrysotile asbestos. The occurrence of lung cancer, and possibly other tumors, among workers at this smelter might be due to exposure to this mineral. Various hypotheses are possible: (i) that the nickel is the essential factor, with the asbestos fibers serving as a vehicle to localize and maintain the metal in the tissue; (ii) that the asbestos fibers are of primary importance, with the carcinogenic potential of the nickel of less consequence; or (iii) that the metal and the fiber interact, both adding to the risk, another example of multiple factor interaction in carcinogenesis (*16*). It will be interesting to test these possibilities in appropriate animal models and to reevaluate epidemiological data in relation to exposures in various smelters. Also, mineralogical analysis of lung tissues from miners in these locations will provide needed information.

Examination of geological data from a number of "garnierite"-bearing nickel deposits around the world and of one in the United States (Riddle, Oregon), and preliminary analyses of other "garnierite" specimens, suggest that asbestos contamination by either chrysotile or amphibole fibers may be common. Asbestos contamination of chromite ores should also be studied in relation to lung cancers in chromate workers (*17*). Other ores, for example, platinum and related metals, are derived from or are associated with serpentinized host rocks. Here too a mineral-biological interface may be present.

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2. See extensive bibliographies in F. W. Sunderman, Jr., chairman, *Medical and Biological Effects on Environmental Pollutants: Nickel* (National Research Council, Washington, D.C., 1975) and in (*1*).
3. One of the striking features remaining unexplained is the lack of increased cancer risk in human populations employed in secondary industries which use these materials [F. W. Sunderman, Jr., *Fed. Proc.* **37**, 40 (1978)]. In the Soviet Union, lung and gastric cancers occur in excess of the anticipated numbers. The Soviet nickel deposit is located in the Ural Mountains, in the same geological area as the chrysotile operations. Both the chrysotile and nickel ores occur in serpentinized ultramafic bodies [see A. M. Bateman, *Economic Mineral Deposits* (Wiley, New York, 1959)].
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10. Based on charge and ionic size, nickel readily substitutes for magnesium and iron in silicate mineral structures. It is dispersed in the silicate minerals of the upper mantle. The New Caledonian nickel deposit, of Tertiary age, occurs in serpentinized peridotite, the host rock probably derived from mantle sources. Although the nickel concentration is only about some 2000 parts per million in the parent ultramafic rocks, the process of laterization, under tropical conditions, has produced an in situ concentration of iron and nickel oxide-hydroxide complexes. These pockets are numerous and grade as a continuum into the encapsulating serpentinized peridotite. Residues of weathered serpentinite occur throughout the laterite, with admixtures on the microscopic scale being common. The nickel concentration in the laterite may approach several percent. The serpentine in this deposit has not been studied in detail. The nickel ore is called "garnierite," which was considered a mineral species with the chemical formula $(MgNi)_3Si_2O_5(OH)_4$. A number of other hydrous nickel-magnesium oxides and silicates occur throughout this deposit [J. Avias, in *19th International Geological Congress* (Comptes Rendus, Algiers, 1954), vol. 12, p. 271]. The serpentine on New Caledonia is known to contain both chrysotile and traces of asbestiform tremolite [see the mineralogical description of the deposit in J. W. Montoya and G. S. Baur, *Am. Mineral.* **48**, 1227 (1963)]. This geological picture fits well the three modes of origin for nickel deposits: primary sulfides, nickeliferous silicates, and laterites-serpentines [see G. C. Ware, *U.S. Bur. Mines Bull.* **630**, 607 (1965)].
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12. The history of "garnierite" on New Caledonia is detailed in Montoya and Baur (*10*), with mineral descriptions from A. La Croix (1942), E. de Chetelat (1947), and S. Caillere and M. S. Henin (1960) cited.
13. The mineral "garnierite" was originally described as a nickel—magnesium silicate. Later it was observed to consist of many admixed mineral phases, so that it has become a generic term, like asbestos [see W. T. Pecora, S. W. Hobbs, K. J. Murata, *Econ. Geol.* **44**, 13 (1949); G. T. Faust, *Am. Mineral.* **51**, 279 (1966); H. Hayashi and T. Nishiyama, *J. Jpn. Assoc. Min. Pet. Econ. Geol.* **71**, 17 (1976)].
14. Past characterization of "garnierite" and nickeloan phases was based primarily on analytical measurements carried out on bulk materials. Therefore, mineral phases within mixtures escaped identification. Observed in "garnierite" deposits are the following: nickeloan talc, willemseite; nickeloan "serpentine," nepouite; nickeloan chlorite, schushardite, and nimite; nickeloan montmorillonite, pimelite; and nickeloan quartz, chrysoprase. Many other terms are in the mineralogical literature but have been discredited because the deposits have been found to be mixtures of nickel silicates; for example, "garnierite," noumeite, and nepouite, all found in New Caledonia, are observed to consist of mixtures of pimelite and serpentine phases [see references in (*8*), S. A. DeWaal, *Am. Mineral.* **55**, 31 (1970); *ibid.*, p. 18].
15. American Museum of Natural History specimen 31584, "garnierite," Nouméa, New Caledonia.
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Pit Connections and Translocation in Red Algae

Wetherbee (*1*) described pit plugs between carposporophyte cells of the red alga *Polysiphonia novae-angliae* and suggested that the pit plugs are structurally specialized for nutrient translocation. His hypothesis is based on interpretations of plug ultrastructure; no direct evidence of translocation was presented. The structural features Wetherbee described involve plug shape, plug core density, and most importantly, the presence or absence of a plug cap membrane (membrane between plug core and cytoplasm of adjacent cells).

Reports earlier than Wetherbee's described plugs lacking distinguishable cap membranes (*2*), as well as plugs with a cap membrane visible on only one face of the plug (*2*, *3*), but usually a membrane is visible on each face (*2*, *4*, *5*) or a membrane is present within a multilamellar plug cap (*5*, *6*). Determining the number and position of plug cap membranes is often exceedingly difficult because of the electron opacity of the plug caps; contradictory interpretations of the same species are not uncommon (*7*). In contradiction to his abstract Wetherbee concedes, "Although a membrane does not appear associated with these layers, the electron opacity of the cap might obscure such a structure." Procedures such as freeze-etching, membrane extraction, and induced plasmolysis (*6*) could have been used to resolve the crucial question of whether a cap membrane is appressed to or included within the plug caps in *Polysiphonia* carposporophytes.

Wetherbee reported acropetal flaring of carposporophyte pit plugs and speculated that flaring increases plug surface area to expedite translocation. However, increased surface area is advantageous only if a semipermeable plug cap membrane is present; if cap membranes are lacking as Wetherbee claims, the narrowest part of the plug would limit the flow rate. Even if one accepts the premise that increased surface area is important for translocation, one would expect both faces of the plug to be flared equally; this is not what Wetherbee found.

Translocation has not been demonstrated for carposporophytes of *Polysiphonia* or of any other red alga. However, translocation has been demonstrated in other phases of the life histories of several parasitic red algae (*8*). Ultrastructural investigations of parasites known to perform translocation have revealed plug cap membranes (*3*, *8*).

Until the plugs of *Polysiphonia* carposporophytes are reexamined by techniques that can reveal membranes appressed to or included within the electron-opaque plug caps and until translocation is demonstrated to occur in carposporophytes, speculation concerning "transfer connections" should be held in abeyance.

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There are two major points in Pueschel's criticism. The first relates to the transport capabilities of transfer connections, and the second relates to the presence or absence of cap membranes.

The evidence for translocation is circumstantial and is based on the assumption that there is a need. The meristematic cells at the carposporophyte surface are highly active, yet lack mature chloroplasts to provide for their own nutrition. Furthermore, other cells of the carposporophyte appear modified to provide this assistance (*1*); and transfer connections consistently appear only between cells where transport would be expected, and are structurally modified in a manner that would appear advantageous for transport.

The most significant ultrastructural feature characterizing transfer connections in *Polysiphonia* is that they are intracellular and that their size increases in positions where maximum transport would be expected. Pueschel queries whether cap membranes are actually absent, stating that additional techniques should have been employed to establish this point. Although researchers have suggested the presence of more than one set of cap membranes, the published micrographs are of insufficient magnification or quality (or both) to warrant such conclusions. The transfer connections in *Polysiphonia* clearly lack cap membranes in the normal position, and there is no evidence to suggest that position changes, or that more than one set of cap membranes ever exists. Pueschel's own work on *Palmaria* demonstrates this fact (*2*). Typical electron micrographs of this organism give the impression that several cap membranes are present, although only one was found.

Although Pueschel states that cap membranes have been observed in parasite cells known to perform translocation, I disagree with this interpretation. To my knowledge, Goff has not published an electron micrograph of a parasite-parasite pit connection of *Harveyella*, although Peyriere (*3*) has and her micrograph strongly suggests that cap membranes are absent. Cap membranes do appear in some micrographs of host-parasite pit connections of *Harveyella* but are absent in others. More work is required on these organisms, but it is reasonable to expect most parasite-parasite pit connections in colorless red algae to lack cap membranes.

Translocation of nutritive materials undoubtedly occurs in a number of red algae. The remaining question is whether the major avenue is the cell wall or the pit connections. It would appear more logical to suggest that cells take advantage of their established connections, rather than pump materials indiscriminately across the cell wall. The fact that pit connections look like plugs does not preclude the possibility that materials pass through. In consideration of the evidence, circumstantial as it may be, I have no hesitation in speculating on the presence of "transfer connections" in the red algae.

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