assumed that it is then reduced in the cells [3–5]. The present communication suggests the presence of one pathway for this reduction in the microsomal system that does not seem to have been reported previously. The more exact nature and magnitude of this process in various tissues need to be studied further.

The carcinogenicity of Cr(VI) compounds – particularly less water-soluble ones – has been documented [6]. Cr(VI) has also been reported to be mutagenic in bacterial systems [7, 8]. The biological effect of Cr(VI) thus certainly depends on where it is reduced – whether in extracellular spaces or in the cytoplasm or the nucleus of various organ cells. The importance of Cr(VI) metabolism does not diminish by the fact that Cr(III) compounds, at sufficiently high concentrations, have been found to be mutagenic in the *Salmonella* system (unpublished data).

This work has been supported by ERDA grant E(04-3)-34-PA156 and carried out in the laboratory of Dr. B.N. Ames, University of California, Berkeley, whom I would like to thank for his support and advice.

Received November 23, 1977

1. Löfroth, G., Ames, B.N.: Abstract Aa-1, Eighth Annual Meeting, Environmental Mutagen Society, Colorado Springs 1977
2. Ames, B.N., et al.: Mutat. Res. *31*, 347 (1975)
3. Mertz, W.: Physiol. Rev. *49*, 163 (1969)
4. Committee on Biological Effects of Atmospheric Pollutants: Chromium. Washington, D.C.: Nat. Acad. Sci. 1974
5. Sanderson, C.J.: Transplantation *21*, 526 (1976)
6. IARC Monograph on the Evalution of Carcinogenic Risk of Chemicals to Man, Vol. 2, p. 100. Lyon: Int. Agency for Research on Cancer 1973
7. Venitt, S., Levy, L.S.: Nature *250*, 493 (1974)
8. Petrilli, F.L., DeFlora, S.: Appl. Environ. Microbiol. *33*, 805 (1977)

Direct Phosphorus Transfer from Leaf Litter to Roots

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Tropical ecologists have long suspected that one of the nutrient-conserving mechanisms in the undisturbed rain forest of the Amazon basin is a direct recycling that involves the movement of nutrients from fallen litter to the conspicuous root mat covering the soil surface in many regions [1]. Such a nutrient-cycling pathway would reduce losses due to leaching which can be severe under high rainfall conditions. Went and Stark [2] have hypothesized that mycorrhizal fungi are one of the pathways of transfer between litter and roots, but to our knowledge no evidence is yet available. Recently Jordan and Stark (Acta Cient. Venez., in press) have shown that over 99% of the phosphorus applied on the surface of the root mat of an Amazonian rain forest, is retained and translocated before reaching the mineral soil. In the present study we report evidence of one of the possible mechanisms responsible for mineral cycling in Amazonia.

The experiments were performed near San Carlos de Rio Negro, between upper Rio Negro and Casiquiare, a system draining towards the Amazon river, where an interdisciplinary project on forest ecology is presently carried out under the auspices of MAB Program 1 [3]. There we have observed that recently fallen leaves become attached to root tips of the dense root mat covering the mineral soil. Twenty twigs of the dominant tree species, *Micrandra spruceana* (Baill.) R. Schult. and *Eperua leucantha* Bth., were clipped and immediately inserted into vials, each containing 0.5 mCi of ^{32}P as HCl-free H_3PO_4 in 0.5 ml solution. The radioactive solution entered the leaves via the transpirational stream within 60 min. Clipped leaves were then oven-dried, rewetted with troughfall water collected in the experimental site and placed in situ in growth chambers having a lateral hole through which an intact root tip from the living root mat was inserted. These growth chambers were covered with a lid in order to isolate the experimental preparation from rain and other roots and litter. Eight weeks later the leaves and the root length that had grown attached to them were harvested by clipping the root close to the point where it joined the leaf. The samples were refrigerated and flown to the laboratory in Caracas where they were fixed and stained by standard techniques for light and electron microscopy [4]. Several sections were covered with an autoradiographic emulsion and exposed for one month. Subsamples were digested and counted by scintillation techniques, to verify that the leaves had received the radioactive label.

Light-microscopy observations revealed that the attachment of root tips to leaf surfaces consisted of numerous septate fungal hyphae bridges originating in the rhizoplan. A complete hyphae connection between the living root tissue and a decomposing leaf is shown in Figure 1, as

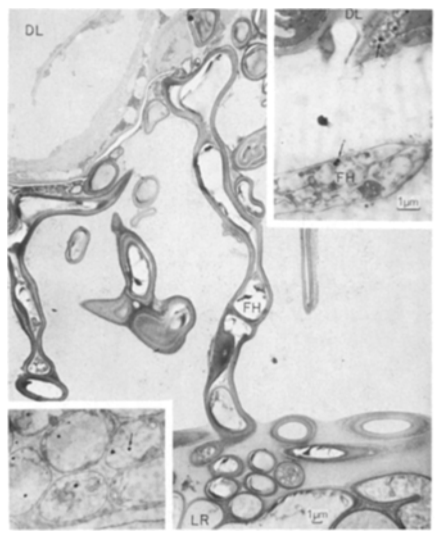

Fig. 1. Electron micrograph of mycorrhizal hyphae bridge (*FH*), between living root (*LR*) and decomposing leaf (*DL*). Inserts are electron-microscope autoradiographs from corresponding parts. Silver grains (*arrows*) indicate transfer of ^{32}P from decomposing leaf to living root through fungal hyphae

observed under the electron microscope. Radioactivity was detected by autoradiography in the leaf, as well as in the hyphae and root tissues (Fig. 1). No silver grains were observed in control experiments not labelled with ^{32}P.
These results furnish evidence that ^{32}P was transferred from the radioactive leaf to the living root through the fungal hyphae. Among other nutrient-conserving mechanisms of the tropical rain forests as discussed by Herrera et al. (Interciencia, in press), the direct cycling mechanism here reported can be considered of importance in oligotrophic environments.
The rapid loss of fertility occurring when Amazonian and other rain forests are cut and burned for agriculture, is well documented [5]. When the available nutrients are removed either by leaching or harvest, a greatly empoverished ecosystem is left. Its recovery is determined by the possibility of re-establishing the nutrient-conserving mechanisms such as the direct cycling of nutrients from fallen litter to roots. This effect is more pronounced in oligotrophic ecosystems which seem to be abundant in Amazonia [6, 7].

This study is part of the Amazonian Ecosystem Project of Instituto Venezolano de Investigaciones Científicas. Funding agencies are the Venezuelan Consejo Nacional de Investigaciones Científicas y Tecnológicas, the Organization of American States and the U.S. National Science Foundation. We are grateful to Dr. F. Rawlins for help with the autoradiography, to Dr. Hans Klinge for his critical reading of the manuscript and to Mr. P. Medina for his photographic work.

Received January 16, 1978

1. Went, F.W., Stark, N.: Proc. Nat. Acad. Sci. USA *60*, 497 (1968)
2. Went, F.W., Stark, N.: BioSci. *18*, 1035 (1968)
3. Medina, E., et al.: Natur. Resour. Res. *13*, 4 (1977)
4. Gunning, B.E.S.: J. Cell Biol. *24*, 79 (1965)
5. Nye, P.H., Greenland, D.J.: Techn. Comm. No. 51, Comm. Bur. Soils, Harpenden, Bucks, England (1960)
6. Sioli, H.: Amazoniana *1*, 267 (1968)
7. Fittkau, E.-J.: Münst. Forsch. Geol. Paläontol. *20/21*, 35 (1971)

Hyobanche sanguinea L. (Scrophulariaceae), ein Blattparasit

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Parasitisch lebende Blütenpflanzen zeichnen sich dadurch aus, daß sie mit Hilfe von Kontaktorganen, den Haustorien, Zugang zu organischen oder anorganischen Substanzen ihrer Wirtspflanze erlangen. Außer Voll- und Halbparasiten unterscheidet man bei diesen Ernährungsspezialisten je nach Herkunft ihrer Kontaktorgane zudem Sproß- und Wurzelparasiten [1].
Die parasitisch sich ernährenden Scrophulariaceen (Rachenblütler) sind fast ausnahmslos Wurzelparasiten; ihre Kontaktorgane entstehen also an den Wurzeln. Im Gegensatz dazu weist *Hyobanche sanguinea* L., ein südafrikanischer Vertreter dieser Familie [2], eine bisher unbekannte Art der Haustorienbildung auf, nämlich an den Blättern. Da dieses Phänomen bei allen am natürlichen Standort untersuchten Pflanzen dieser Art beobachtet wurde, müssen wir *Hyobanche sanguinea* als Blattparasiten einstufen.
Wächst eine Wurzel auf das unterirdische, mit schuppenförmigen Blättern ausgestattete Rhizom des Vollparasiten zu, so entsteht an dessen nächstgelegenem Schuppenblatt ein kleiner Höcker (Fig. 1a, Pfeil), der das erste Stadium eines Blatthaustoriums darstellt. Hat das Schuppenblatt Kontakt mit der Wirtswurzel erlangt (Fig. 1a), reagiert die Wirtswurzel im Kontaktbereich mit einer starken Anschwellung. Im weiteren Verlaufe der Entwicklung schwillt auch das Schuppenblatt an (Fig. 1b). Obwohl die Wirtswurzel von der Spitze bis zum Kontaktbereich hin abstirbt, weist sie im Kontaktbereich selbst weiteres Dickenwachstum auf. Als Reaktion auf den Blattbefall bilden sich in diesem Wirtswurzel-Bereich auch vermehrt Seitenwurzeln. An den älteren Kontaktorganen von *Hyobanche* ist kaum noch zu erkennen, daß sie aus Schuppenblättern hervorgegangen sind (Fig. 1c), denn auch die benachbarten Blätter suchen den Kontakt mit der Wirtswurzel und zeigen nach der Kontaktaufnahme entsprechende Ver-

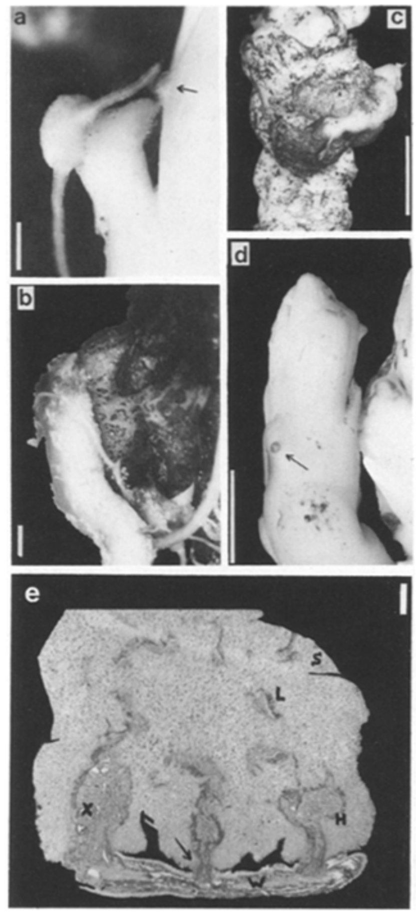

Fig. 1. a) Jüngere Wurzel (*Hermannia*) an einem Schuppenblatt von *Hyobanche sanguinea*, die im Kontaktbereich stark geschwollen ist. Pfeil: kleines Blatthaustorium, das den Kontakt mit der Spitze der Wirtswurzel noch nicht erlangt hat. b) Großes Haustorium attakkiert eine kräftige Wirtswurzel. c) Wirtswurzel am Rhizom, die von mehreren Schuppenblättern angezapft wird. d) Jüngeres Rhizom, an dessen Schuppenblättern kleine dunkle Höcker (Pfeil) die ersten Entwicklungsstadien von Blatthaustorien darstellen. e) Querschnitt durch das Rhizom (1c). Die der Wirtswurzel (*W*) anliegenden Schuppenblätter sind zu Blatthaustorien (*H*) umgewandelt. Ein Xylem-System (*X*) liegt zentral im Haustorium zwischen dem intrusiven Organ (Pfeil) und den Leitbündeln (*L*) des Sprosses. *S* normales Schuppenblatt des Rhizoms. Die Maßstäbe entsprechen 1 mm (1a, b, e) bzw. 1 cm (1c, d)