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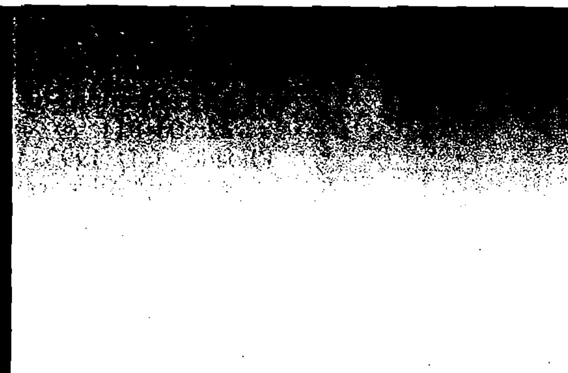
Organisms and Ecology of the Soil[1]



Under the silent, relentless chemical jaws of the fungi, the debris of the forest floor quickly disappears. . . .

—*A. Forsyth and K. Miyata*, Tropical Nature

ORGANISMS IN SOILS.

Fauna:

macrofauna (such as moles, prairie dogs, earthworms, and millipedes)
larger than 2 mm in width

mesofauna (such as tiny springtails and mites)
0.2 and 2 mm

microfauna (such as nematodes and single-celled protozoans).
less than 0.2 mm

Flora: include the roots of higher plants, as well as microscopic algae and diatoms.

Other microorganisms (too small to be seen without the aid of a microscope) include fungi, bacteria, and actinomycetes, which tend to predominate in terms of numbers, mass, and metabolic capacity.

A typical, healthy soil: might contain

- ***several species*** of **vertebrate animals** (mice, gophers, snakes, etc.),
- ***half dozen species*** of **earthworms**,
- ***20 to 30 species*** of **mites**,
- ***50 to 100 species*** of **insects** (collembola, beetles, ants, etc.),
- ***dozens of species*** of **nematodes**,
- ***hundreds of species*** of **fungi**, and
- ***thousands of species*** of **bacteria and actinomycetes**.

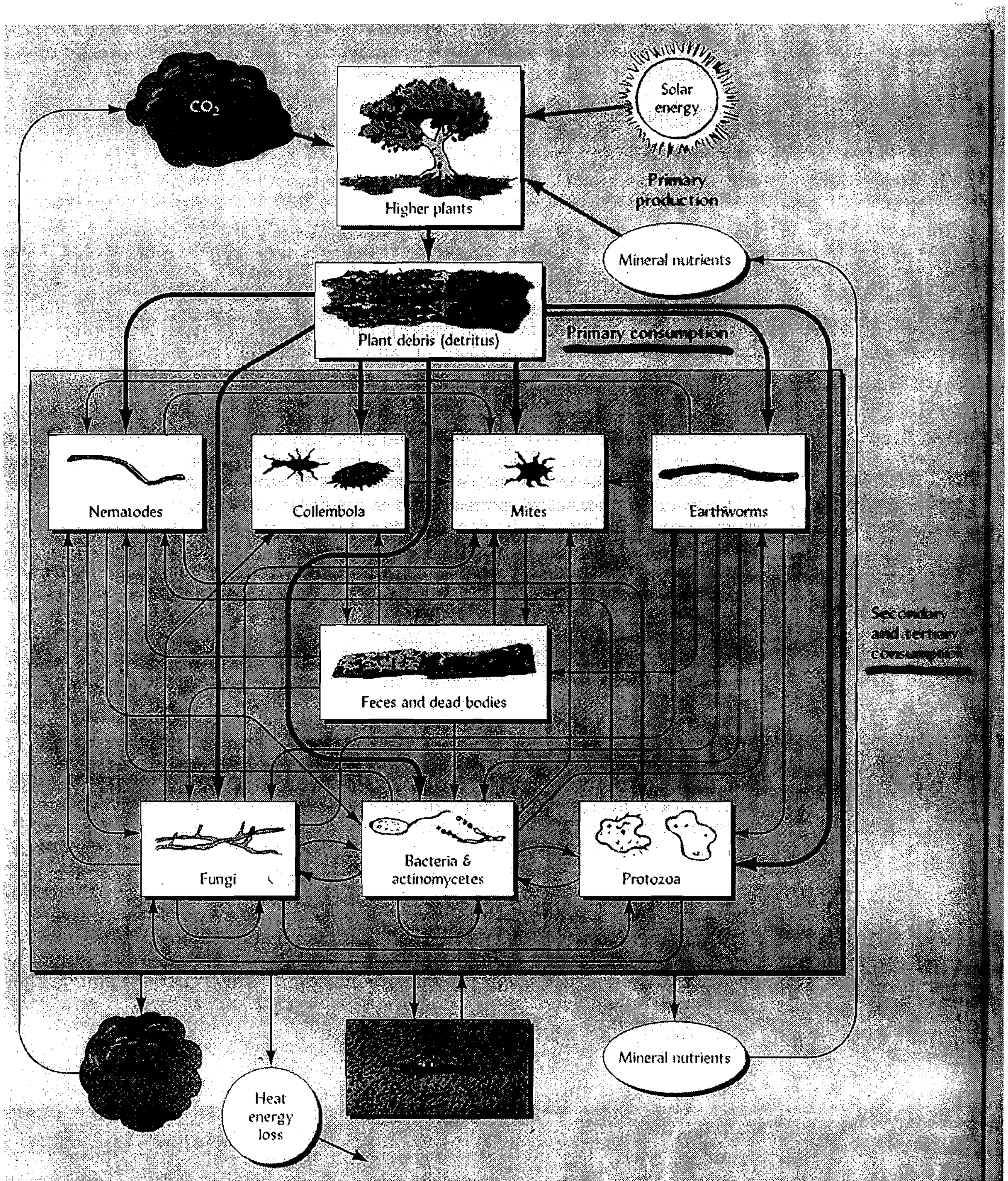


FIGURE 11.2 Greatly simplified diagram of the food web involved in the breakdown of higher-plant tissue. The boxes represent broad groups of organisms and pools of organic material, while the arrows represent transfers of carbon, energy, and nutrients between these pools. Because they capture carbon dioxide and energy, the higher plants are known as *primary producers*. Heavy arrows from the plant debris (detritus) to various organism groups represent *primary consumption*. The arrows within the large box represent *secondary and tertiary consumption*. Although all the groups shown play important roles in the process, the microorganisms represented by the lower three boxes account for 80 to 90% of the total metabolic activity. As a result of this metabolism, soil humus is synthesized, and carbon dioxide, heat energy, and mineral nutrients are released into the soil environment.

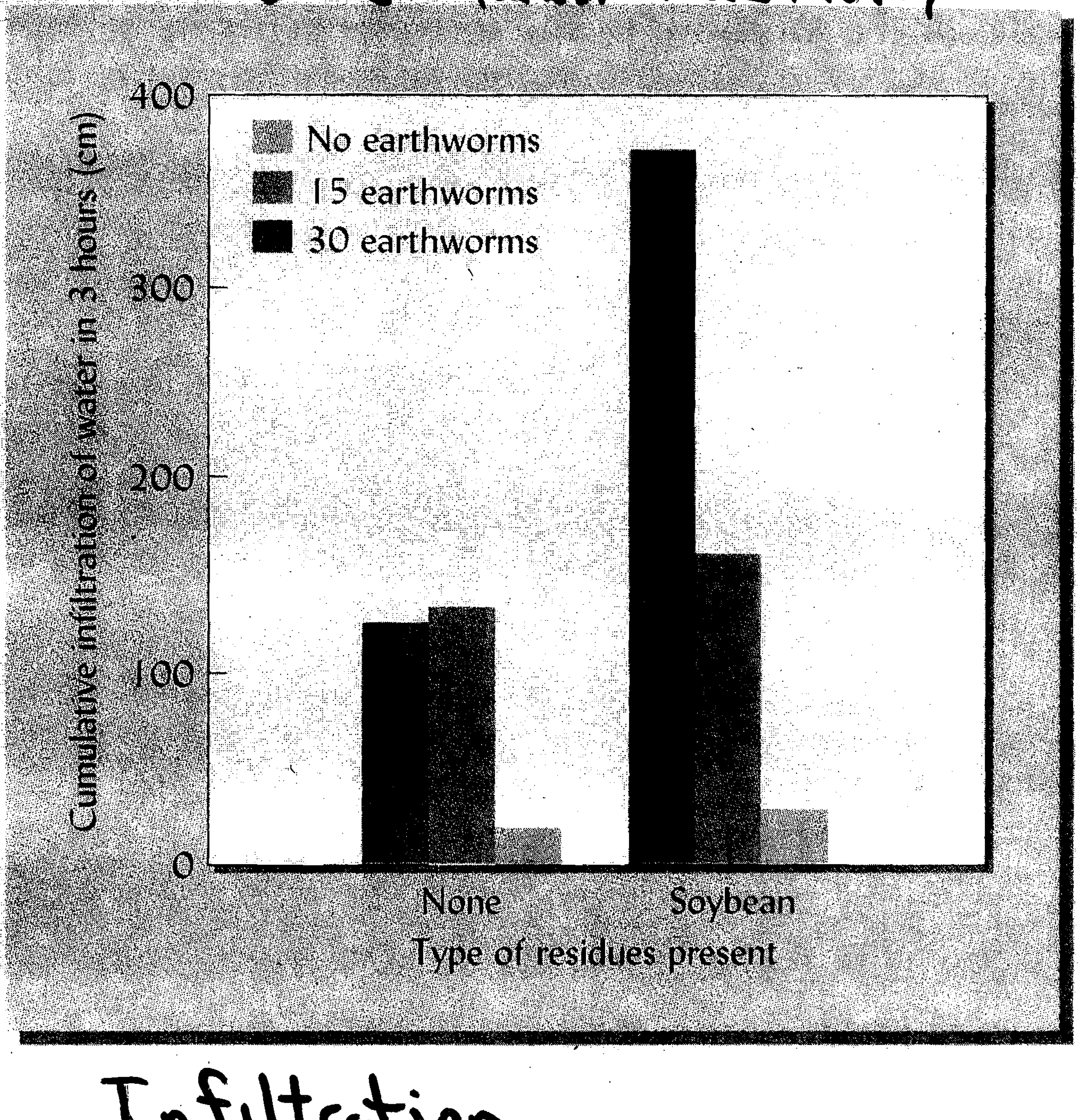
TABLE 11.4 Comparative Characteristics of Earthworm Casts and Soils

Average of six Nigerian soils.

Characteristic	*Earthworm casts*	*Soils*
Silt and clay, %	38.8	22.2
Bulk density, Mg/m^3	1.11	1.28
Structural stability[a]	849	65
Cation exchange capacity, cmol/kg	13.8	3.5
Exchangeable Ca^{2+}, cmol/kg	8.9	2.0
Exchangeable K^+, cmol/kg	0.6	0.2
Soluble P, ppm	17.8	6.1
Total N, %	0.33	0.12

[a] Numbers of raindrops required to destroy structural aggregates.
From de Vleeschauwer and Lal (1981).

Effect of Plant residue on earthworm activity



Infiltration

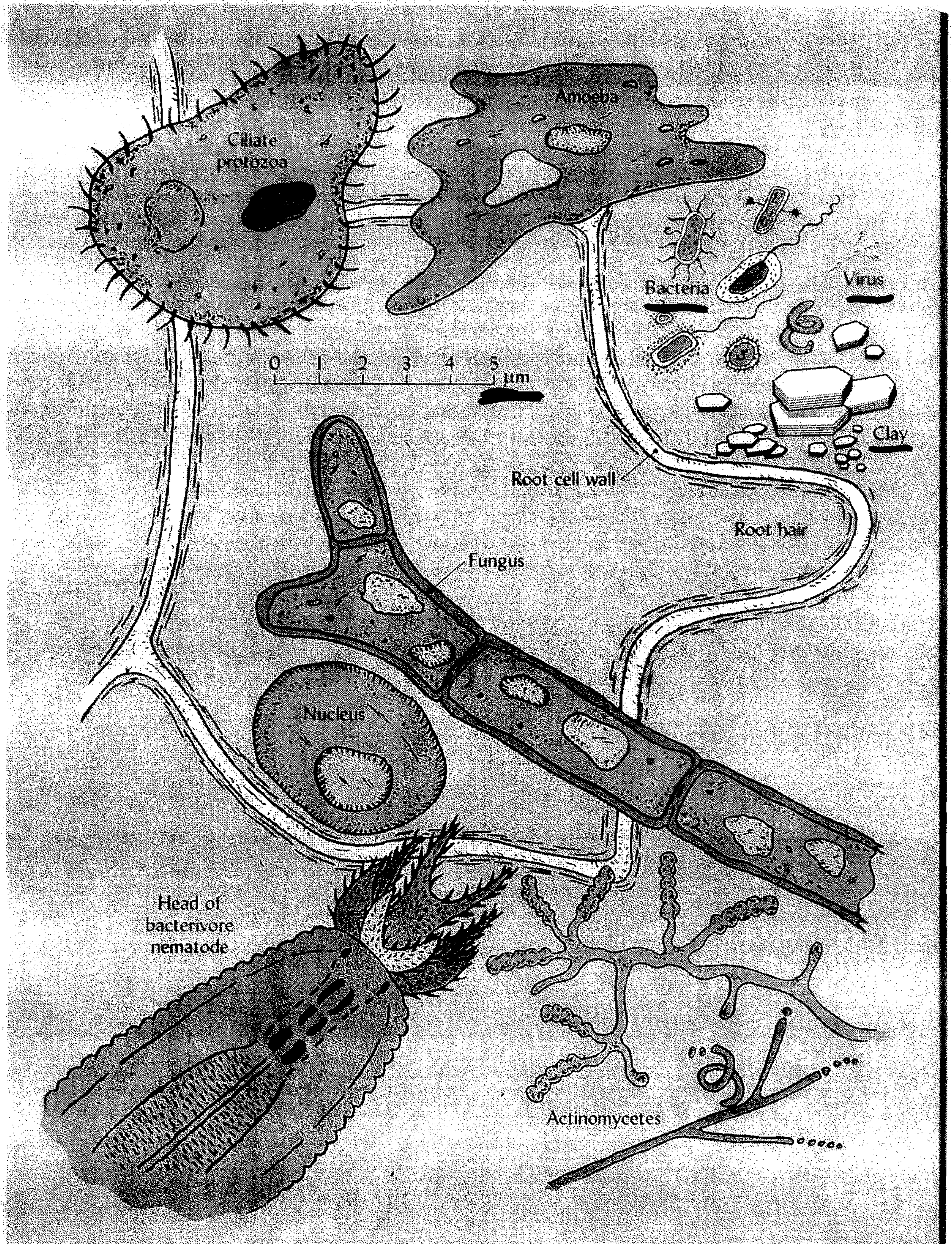
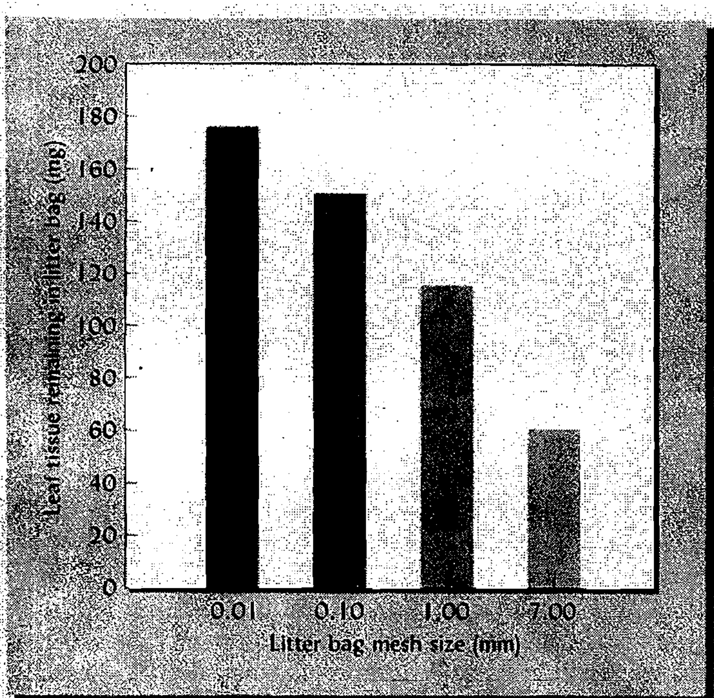


FIGURE 11.10 A depiction of representative groups of soil microorganisms, showing their relative sizes (Drawing courtesy of R. Weil)

Corn Leaf decomposition in mesh bags buried in Soil



Mass remaining versus Mesh size

Size of Mesh

FIGURE 11.3 Influence of various sizes of soil organisms on the decomposition of corn leaf tissue buried in soil. Small bags made of nylon material with four different-size openings (mesh size) were filled with 558 mg (dry weight) of corn leaf tissue and buried in the soil for 10 weeks. The amount of corn leaf tissue remaining in the bags was considerably greater (less decomposition had taken place) where the meso- and macrofauna were excluded by the smaller mesh sizes. [Data from Weil and Kroontje (1979)]

Mycorrhizal fungi

Rhizobia Bacteria

Legumes $\leftrightarrow$ non-legumes

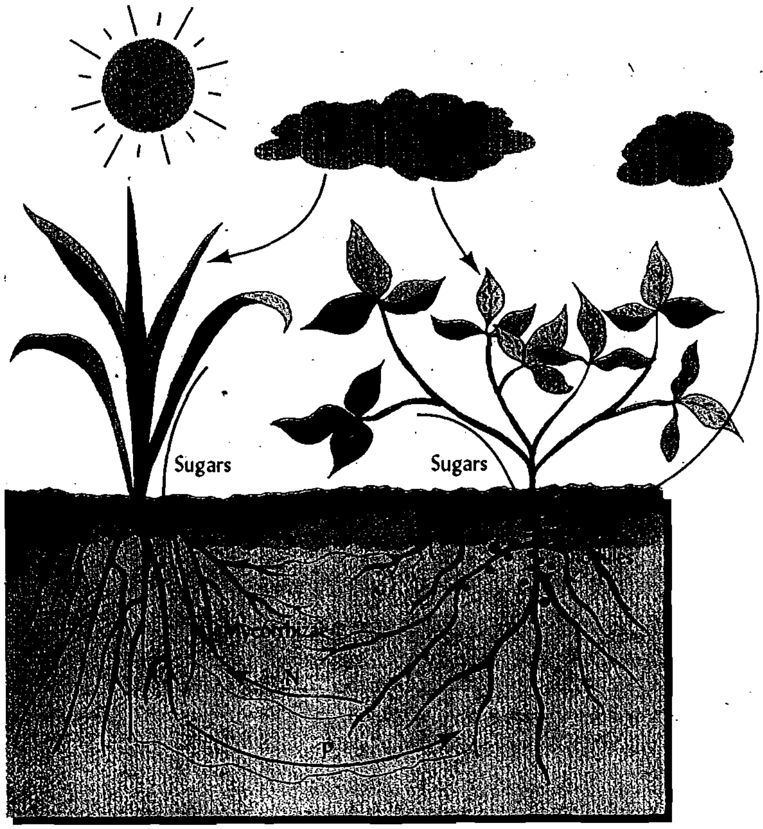


FIGURE 11.21 Mycorrhizal fungi, rhizobia bacteria, legumes, and nonlegume plants can all interact in a four-way, mutually beneficial relationship. Both the fungi and the bacteria obtain their energy from sugars supplied through photosynthesis by the plants. The rhizobia form nodules on the legume roots and enzymatically capture atmospheric nitrogen, providing the legume with nitrogen to make amino acids and proteins. The mycorrhizal fungi infect both types of plants and form hyphal interconnections between them. The mycorrhizae then not only assist in the uptake of phosphorus from the soil, but can also directly transfer nutrients from one plant to the other. Isotope tracer studies have shown that, by this mechanism, nitrogen is transferred from the nitrogen-fixing legume to the nonlegume (e.g., grass) plant, and phosphorus is mostly transferred to the legume from the nonlegume. The nonlegume grass plant has a fibrous root system and an extensive mycorrhizal network, which is relatively more efficient in extracting P from soils than the root system of the legume. Research indicates that some direct transfer of nutrients via mycorrhizal connections occurs in many mixed plant communities, such as in forest understories, grass–legume pastures, and mixed cropping systems.

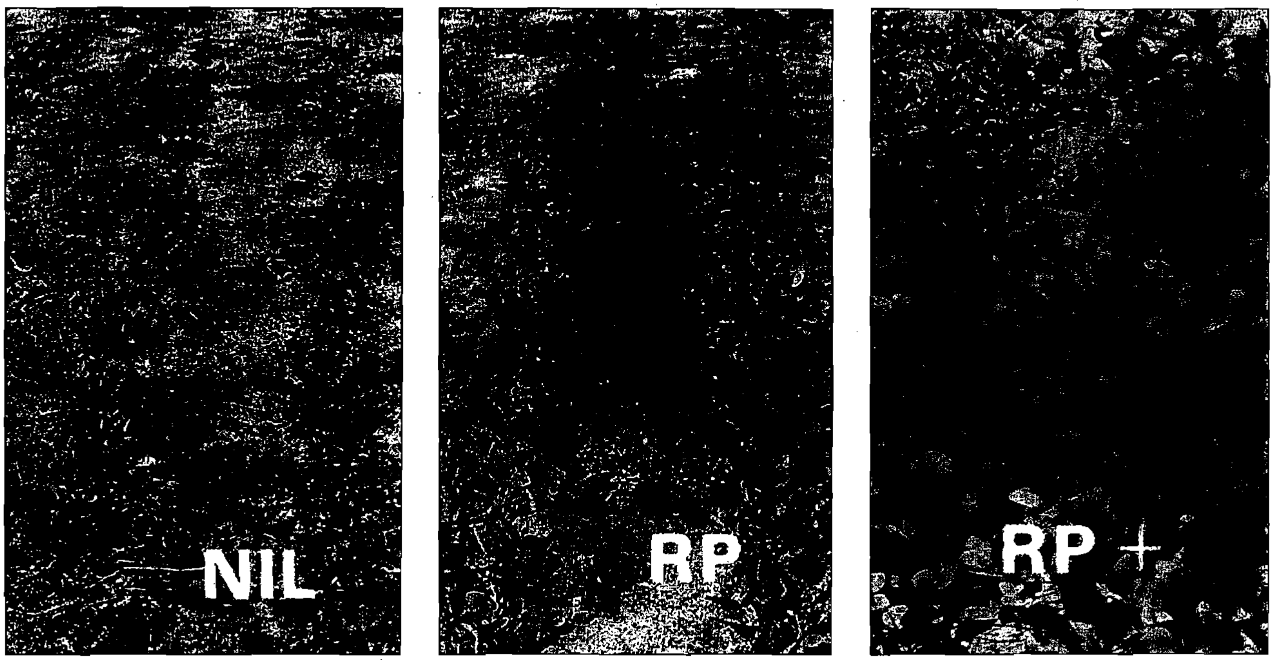
$\longleftarrow$

N

$\longrightarrow$

P

— phosphate phosphate + M



(a) (b) (c)

FIGURE 11.22 The effect of mycorrhizae on availability of phosphorus to a pasture legume, *Pueraria phaseoloides:* (*a*) no treatment, (*b*) rock phosphate, and (*c*) rock phosphate plus mycorrhizae. (Courtesy Dr. Fritz Kramer, CIAT, Cali, Colombia)

Mycorrhizae

Decomposed

31%   17%

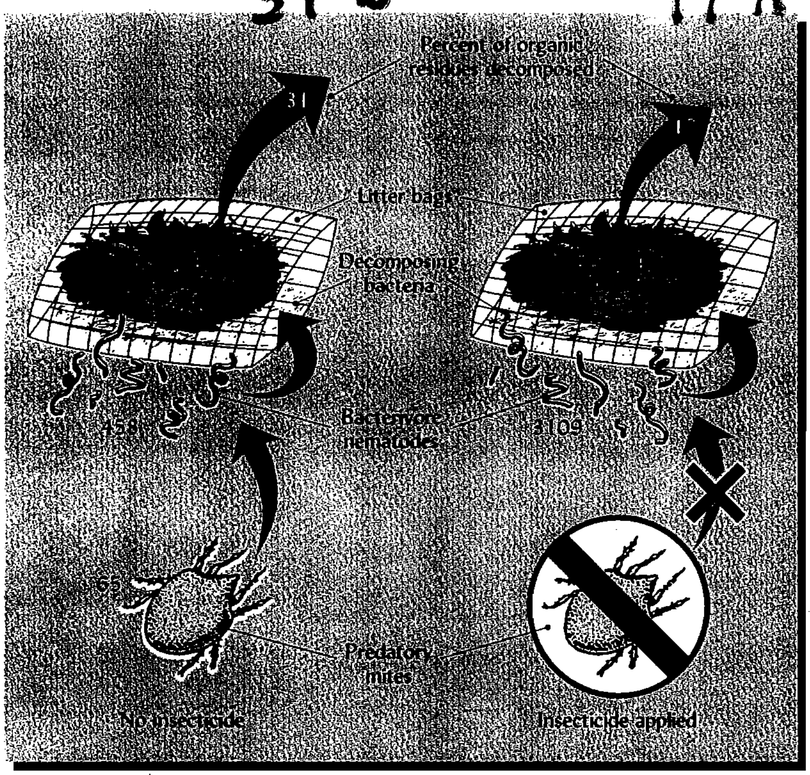


FIGURE 11.28 The indirect effects of insecticide treatment on the decomposition of creosote bush litter in desert ecosystems. Litter bags filled with creosote bush leaves and twigs were buried in desert soils in Arizona, Nevada, and California, either with or without an insecticide (chlordane) treatment. The insecticide killed virtually all the insects and mites. Without predatory mites to hold them in check, bacterivore nematodes multiplied rapidly and devoured a large portion of the bacterial colonies responsible for litter decomposition and nutrient cycling. Thus the insecticide reduced the rate of litter decomposition nearly in half, not by any direct effect on the bacteria, but by the indirect effect of killing the predators of their predators. [Data calculated from Whitford, et al. (1982)]

Mites → nematodes → Bacteria

~~Mites~~ → nematodes   Bacteria

↑ increase   ↓ decrease