GEOL 408/508

ORGANISMS AND ECOLOGY OF THE SOIL

Chapter 11

Brady and Weil, Rev. 14th Ed.

DIVERSITY OF ORGANISMS IN THE SOIL

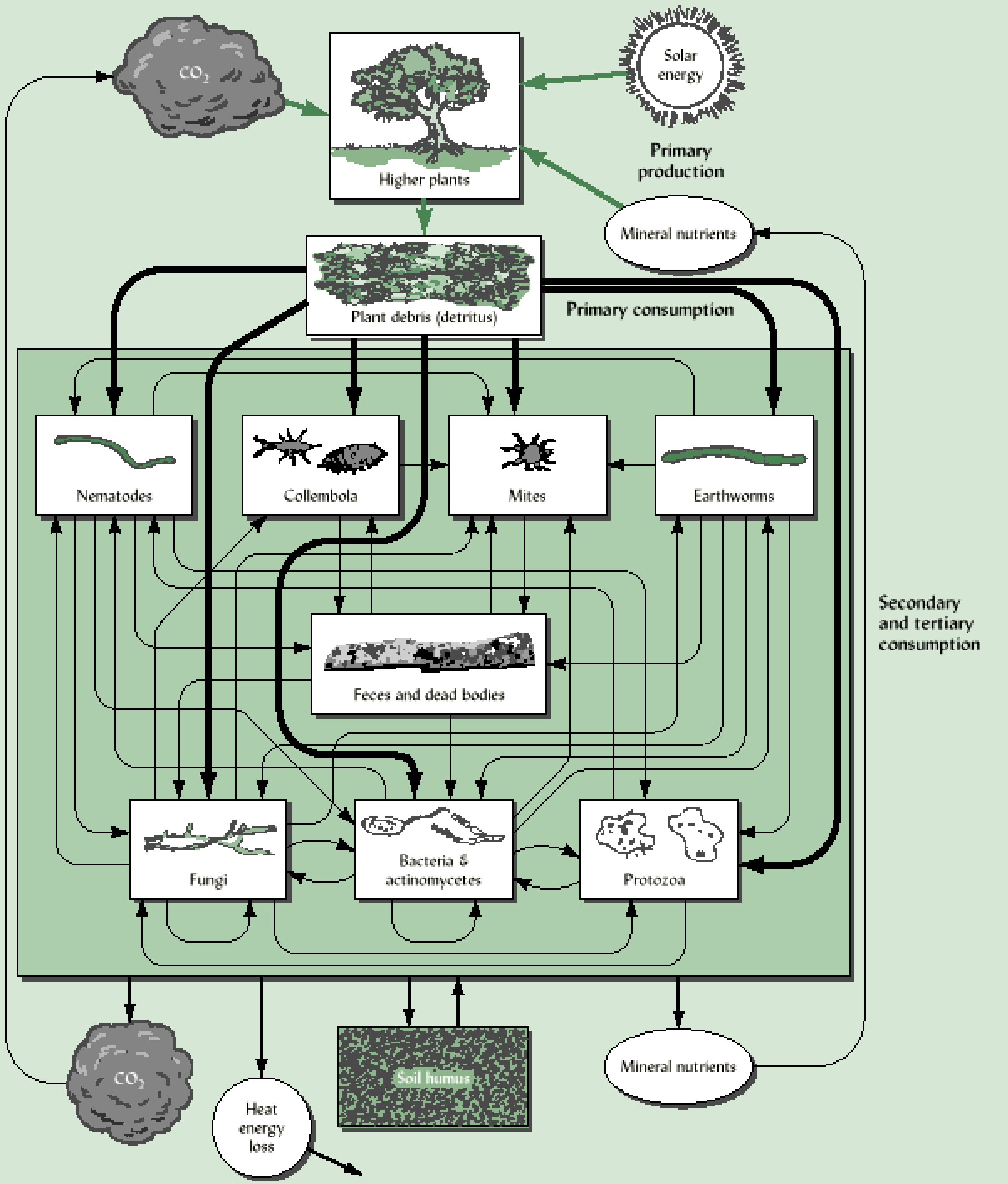
Sizes of organisms:

Animals = fauna; Plants = flora

- **Macro (>2 mm in width):**
  - **- fauna: gophers, mice, moles, termites, earthworms**
  - **- flora: plant feeder roots, mosses**
- **Meso (0.1-2 mm):**
  - **- fauna: mites, springtails**
  - **- flora:??**
- **Micro (<0.1 mm)**
  - **- fauna: nematodes, rotifers, protozoa**
  - **- flora: root hairs, algae, fungi, actinomycetes, bacteria**

SIMPLIFIED FOOD WEB

Greatly simplified diagram of the food web involved in the breakdown of higher-plant tissue. (FIG 11.1 – modified))



DIVERSITY OF ORGANISMS IN THE SOIL

Types of diversity:

- **Great degree of diversity possible due to the wide range of habitats and nearly limitless variety of foods present in soil**
- **High species diversity indicates that organisms are fairly evenly distributed among a large number of species**
- **High degree of functional diversity generally accompanies high species diversity**
- **Functional diversity = capacity to utilize a wide variety of substrates & carry out a wide array of processes**

DIVERSITY OF ORGANISMS IN THE SOIL

Ecosystem dynamics:

- **Functional redundancy - the presence of several organisms to carry out each task - leads to both ecosystem stability and resilience**
  WHY??

- **However, for many processes there are keystone species - have primary responsibility for a given function**

Genetic resources:

- **Soil organisms make an enormous contribution to global biodiversity**

- **Major bank for DNA, much of which may make even greater contributions to human welfare**

ORGANISMS IN ACTION - 1

Primary producers:

- The food base of the entire food web
- Vascular plants are most important primary producers
- Also are mosses, algae, lichens, photosynthesizing bacteria

Primary consumers:

- utilize energy stored in plant residues

- **Herbivores:**
  - parasitic nematodes, insect larvae, ants, termites, mice, voles
  - most are considered as pests since they attack living plants

ORGANISMS IN ACTION - 2

Primary consumers:

- **Detritivores:**
  - consume debris of dead tissue
  - vast majority of soil organisms are detritivores
  - nematodes, mites, rotifers, protozoa

- **Saprophytic microorganisms:**
  - [saprophytic - feeding on dead tissues]
  - most actual decomposition carried out by bacteria & fungi
  - break down a great variety of substances, from simple to complex woody tissues

ORGANISMS IN ACTION - 3

Secondary consumers:

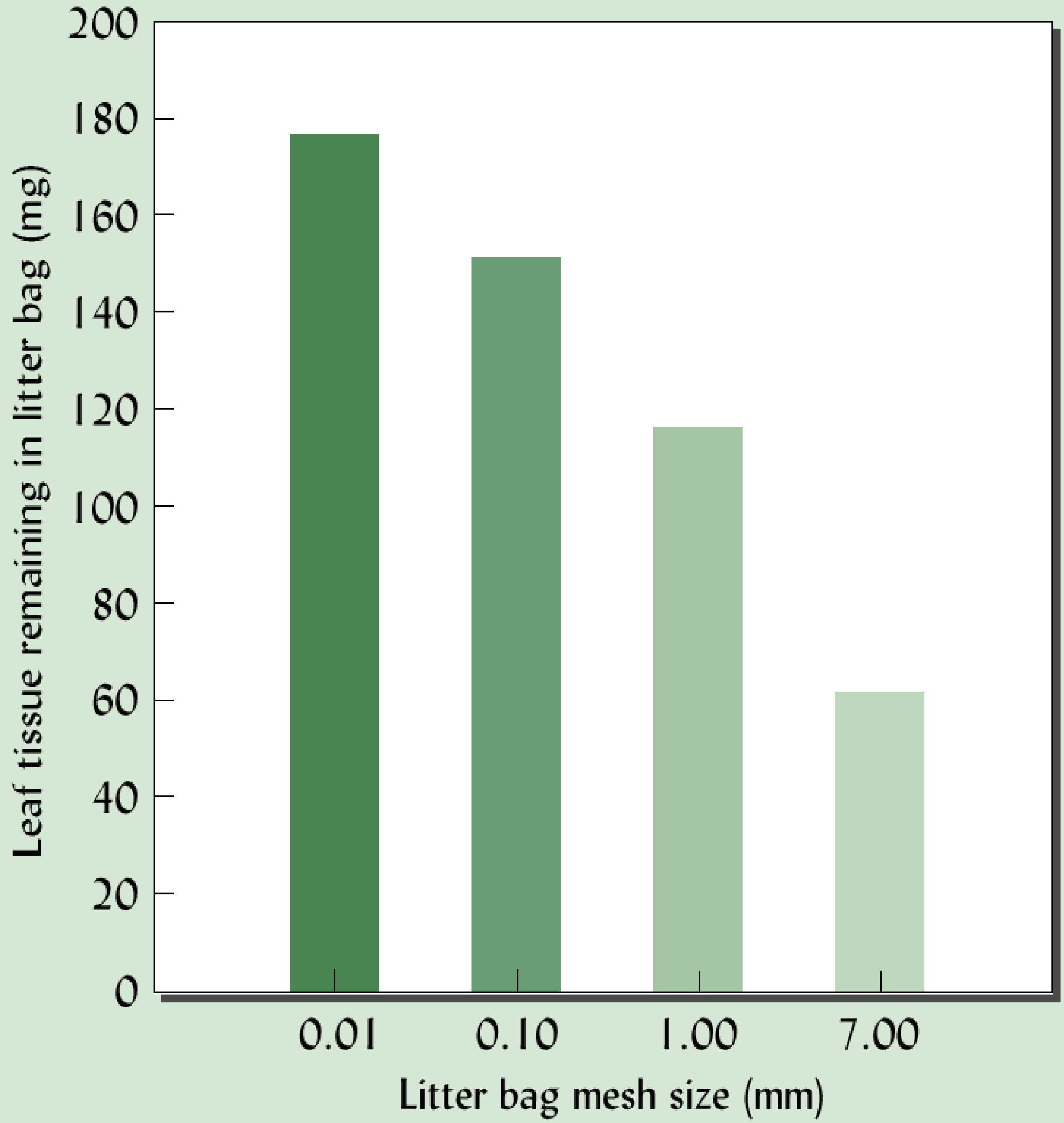
- **Predators & microbial feeders:**
  - feed on bodies/cells of primary consumers
  - microflora - bacteria, fungi & actinomycetes
  - carnivores - centipedes, mites spiders, snails
  - microphytic feeders - mites, termites, nematodes, protozoa
  - much of consumed biomass is microflora

- **Stimulation of decomposition:**
  - macrofauna & mesofauna reduce size & relocate plant residues
  - this action enhances decomposition by microbes
  - these fauna also spread microorganisms
  - greatly different effect by diff. sized organisms

A predatory mite dining on its prey, a microscopic roundworm

Influence of various sized organisms on decomposition

Influence of various sizes of soil organisms on the decomposition of corn leaf tissue buried in soil.



(FIGURE 11.4)

ORGANISMS IN ACTION - 4

Tertiary consumers:

- **Predators:**
  - ants consume centipedes, spiders, mites
  - birds eat beetles, worms
  - moles prey on grubs, worms
- **Microbial feeders:**
  - microflora involved at every level of process
  - are present in digestive track of most animals
  - decompose residues in animal feces & bodies
  - are considered ultimate decomposers
- **Diversification within broad groups:**
  - fungi, nematodes, mites: primary, secondary & tertiary consumers
  - some nematodes attack fungi & vice versa

ORGANISMS IN ACTION - 5

Ecosystem engineers:

- **Burrowing animals:**
  - dig channels that greatly alter air & H_2O movement
  - move significant amounts of subsoil to surface
  - channels & burrows also enhance root growth
  - ants, termites, gophers, moles, earthworms

- **Dung beetles:**
  - form round balls from animal feces, deposit eggs inside and bury in soil
  - disburses and incorporates OM into soil
  - can significantly increase vegetative production

ORGANISM ABUNDANCE, BIOMASS & METABOLIC ACTIVITY - 1

- **Tremendous variability across different soil types and conditions:**
  - **desert vs semi-arid vs forest**
  - **native vs cultivated**
  - **acid vs alkaline soils**
- **Generally greater diversity of fauna under forests**
- **Generally greater total faunal biomass under grasslands**
- **Total soil biomass related to amount of soil OM**
- **Soil OM:detritus:microbial biomass: faunal biomass = 1000:100:10:1**

ORGANISM ABUNDANCE, BIOMASS & METABOLIC ACTIVITY - 2

Comparative organism activity:

- Importance is generally measured by:
  - numbers of individuals in the soil
  - biomass per unit volume or area
  - metabolic activity (often measured as CO_2 evolved)
- Microorganisms have greatest numbers & biomass
- Microflora may account for ~80% of total soil metabolism
- Macro- & mesofauna gen. have more localized impacts; also pre-treat OM for microorganisms

Source of energy & carbon :

- Autotrophs: obtain C from CO_2 or carbonates
  - E from solar or chemical sources
- Heterotrophs: obtain E & C from oxid'n of OM

EARTHWORMS - 1

- Earthworms are probably the most important macroanimals in the soil.
- Epigeic earthworms:
  - relatively small, live in litter layer or organic-rich layer very near the surrface
- Endogeic earthworms:
  - live in upper 10-30 cm of soil and make shallow, mostly horizontal burrows
  - commonly expel casts onto surface
  - several commonly known as “red worm”
- Anecic earthworms:
  - relatively large in size, make mainly vertical burrows, up to several meters
  - pull organic debris down into burrow

EARTHWORMS - 2

EARTHWORMS - 3

Corn plant leaf being pulled into burrow by night crawler

EARTHWORMS - 4

Influence on soil productivity:

- **Burrows:**
  - earthworms may ingest 2-30 times their body weight of soil per day
  - create an extensive system of burrows
  - in 1 m^2, the burrows may range from 5-100 m, contributing from 0.1 to >9 L of biopores
- **Casts:**
  - in gut, OM is shredded & mixed with mineral soil
  - soil is expelled from guts as globular aggregates
  - aggregates high in polysaccharides & stable
  - nutrient content different than soil

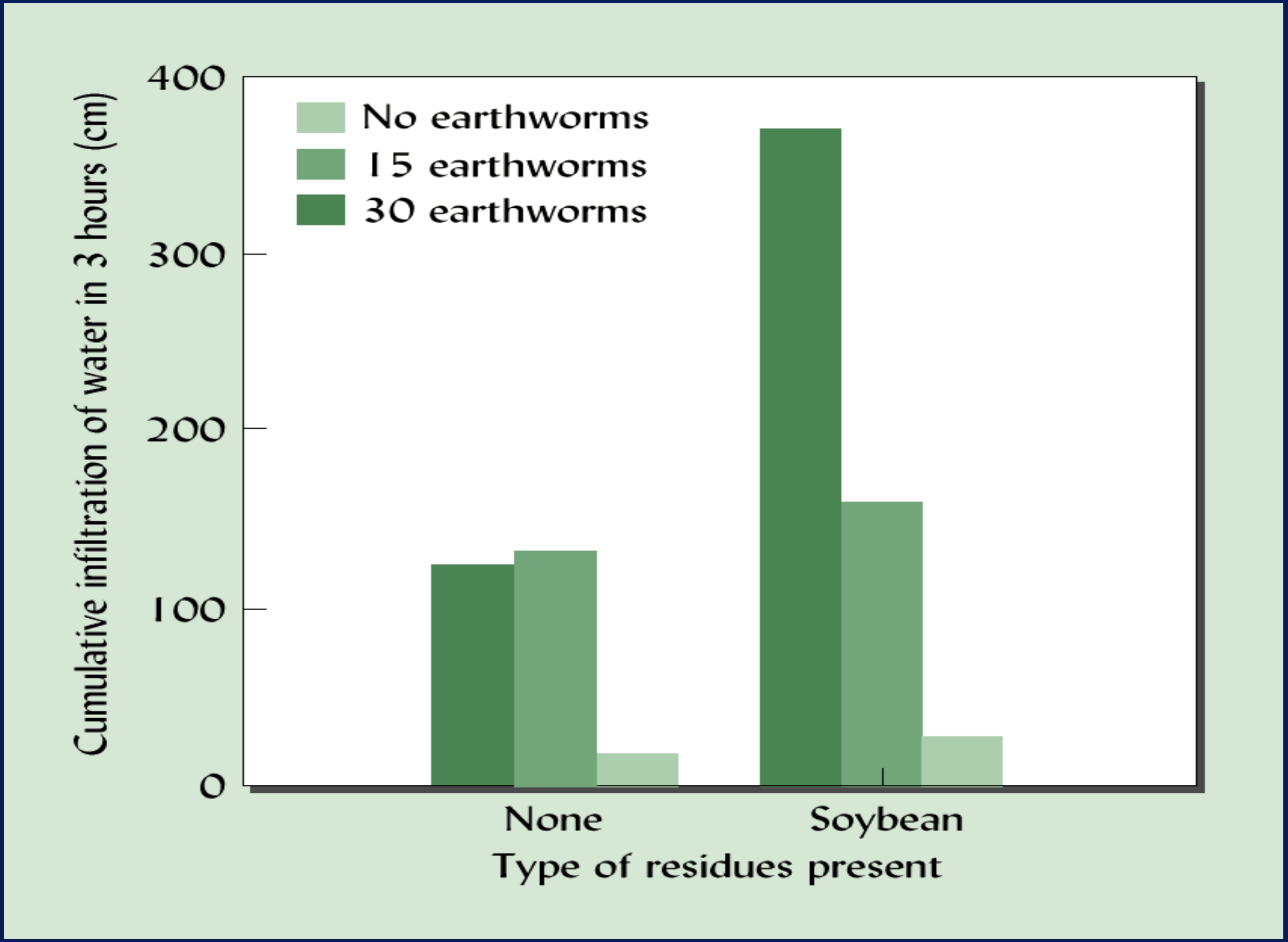
EARTHWORMS - 5

Influence on soil productivity:

- **Nutrients:**
  - CEC, Exch Ca, K, sol P increased in casts
  - OM, bacteria content increased in casts
  - earthworm tissue contains high nutrient levels
  - physical incorporation of surface residues reduces loss of nutrients; especially important in untilled soils

- **Beneficial physical effects:**
  - burrows increase aeration & drainage
  - burrows may increase infiltration
  - in turf grass, mixing activity may reduce compaction & nearly eliminate thatch layer
  - casts may comprise large amount of aggregates

EFFECT OF EARTHWORMS IN SOIL



Earthworms may dramatically increase the infiltration of water into a soil, especially where they can feed on plant residues left on the soil surface.

EARTHWORMS - 6

Influence on chemical leaching:

- vertical burrows may carry chemical contaminants toward ground water
- OM enriched material lining burrow has 2-5 times greater sorbing capacity than soil - may sorb much of material in percolating water

Factors affecting earthworm activity:

- they prefer moist, well-aerated environment
- grow best where there is abundant OM (they feed on bacteria & fungi)
- thrive at pH = 5.5-8.5 with abundant Ca
- optimum temp of about 10°C
- predators are: moles, mice, mites., millipedes
- certain insecticides are lethal
- tillage is detrimental

ANTS AND TERMITES - 1

Ants:

- nearly 9000 soil-dwelling species
- include detritivores, herbivores & predators
- nest-building can improve soil aeration, increase infiltration & modify soil pH
- roles in soil not well studied

Termites:

• **Diversity & distribution:**

- about 2000 species
- major contributors to breakdown of OM in soils
- most prevalent in humid & semiarid tropics & subtropics
- activity on a scale comparable to earthworms

ANTS AND TERMITES - 2

Termites:

- **Mound-building activities:**
  - common in Africa, Latin America, Australia & Asia
  - colony may occupy area of 30 m^2
  - most consume rotting woody materials & plant residues - large amounts
  - move extensive amounts of subsoil to surface
  - as much as 2.4 million kg/ha of soil material may be incorporated into termite mounds
  - (15 cm soil layer in 1 ha weighs ~2 million kg)
  - mounds occupied for 10-20 years after which they can be broken down to use for crops
  - not generally worthwhile to destroy occupied mound

ANTS AND TERMITES - 3

Termites:

- **Effect of termites on soil productivity:**
  - generally do not have beneficial effect
  - digestive processes much more efficient - little returned to soil
  - plant residue mixing is very localized and in mounds which cannot be used for cultivation
  - most crop residues simply removed from soil
- **Plant growth on termite mound material:**
  - mound material often has lower OM content than surrounding soil (composed of subsoil)
  - in some cases, subsoil may be richer in nutrients
  - may provide better drained areas in wetter soils
  - macrochannels greatly increase water infiltration

SOIL MICROANIMALS - 1

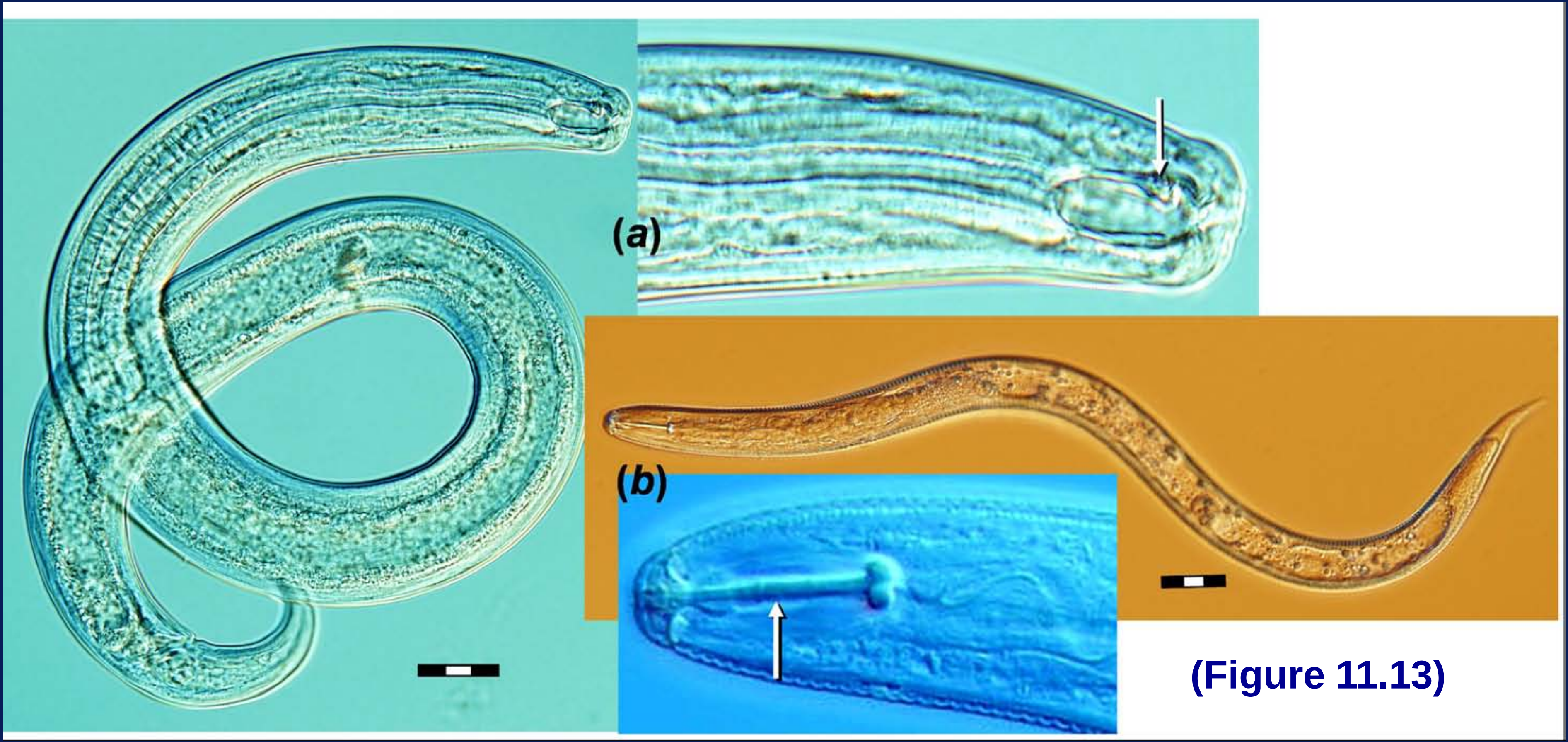
Nematodes:

- commonly called threadworms or eelworms
- unsegmented roundworms, 4-100 μm diameter
- especially abundant in moist, sandy soils
- when soil dries, can coil into cryptobiotic state for long periods of time

• **Predation:**

- very diverse group
- most are predatory on other nematodes, fungi, bacteria, algae, protozoa & insect larvae
- some are used as biological control agents for crop pests (corn rootworm)
- nematode grazing on bacteria often stimulates cycling & release of plant-avail nitrogen

Soil nematodes, a predator (a) and a plant root parasite (b)

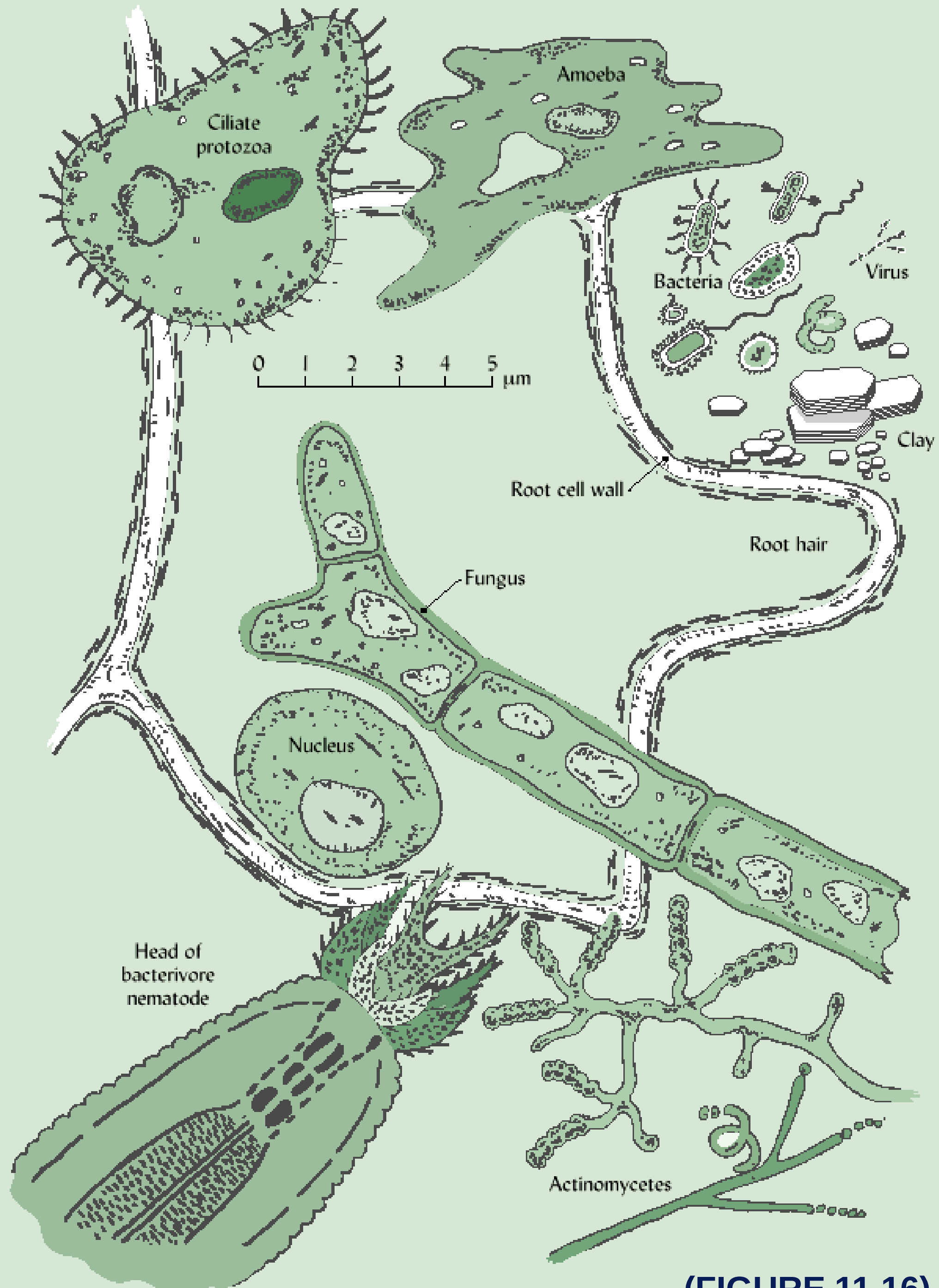


(Figure 11.13)

Note hard teeth in predator (a) and retractable spearlike mouth part in (b). Scale bars marked in 10 µm units.

SOIL MICROORGANISMS

A depiction of representative groups of soil microorganisms, showing their relative sizes.



(FIGURE 11.16)

SOIL MICROANIMALS - 2

Nematodes:

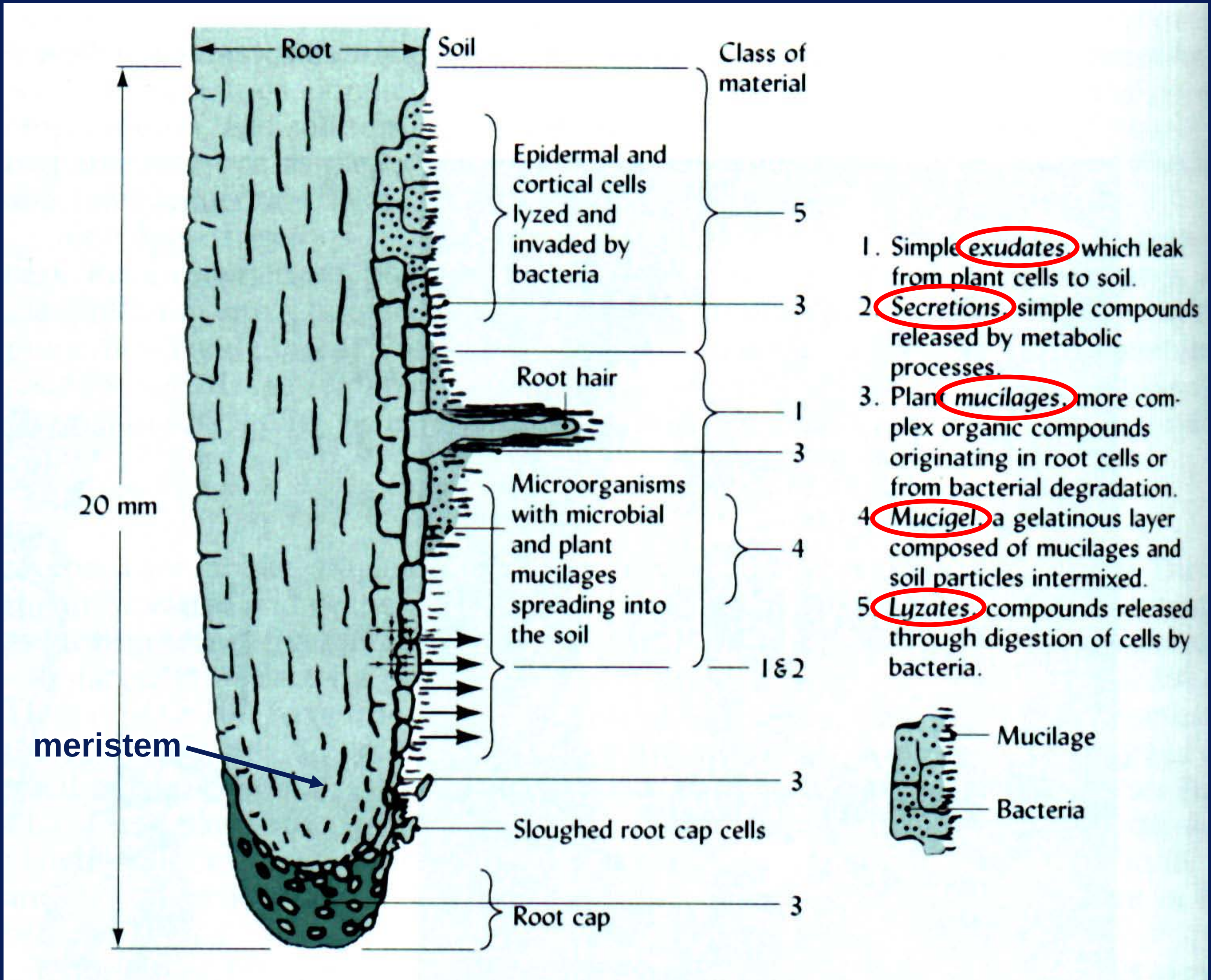
- **Plant parasites:**
  - some nematodes attack plant roots, sometimes allowing infection by secondary pathogens
  - cyst-forming nematodes are major pests of soybeans
  - root-knot forming nematodes damage fruit trees
- **Nematode control:**
  - very difficult - long (5-year) plant rotations with non-host crops; use of resistant varieties and nematicides
  - more resistant varieties now available
  - interplant or rotate with plants like marigolds or canola, which produce root exudates with nematicidal properties

SOIL MICROANIMALS - 3

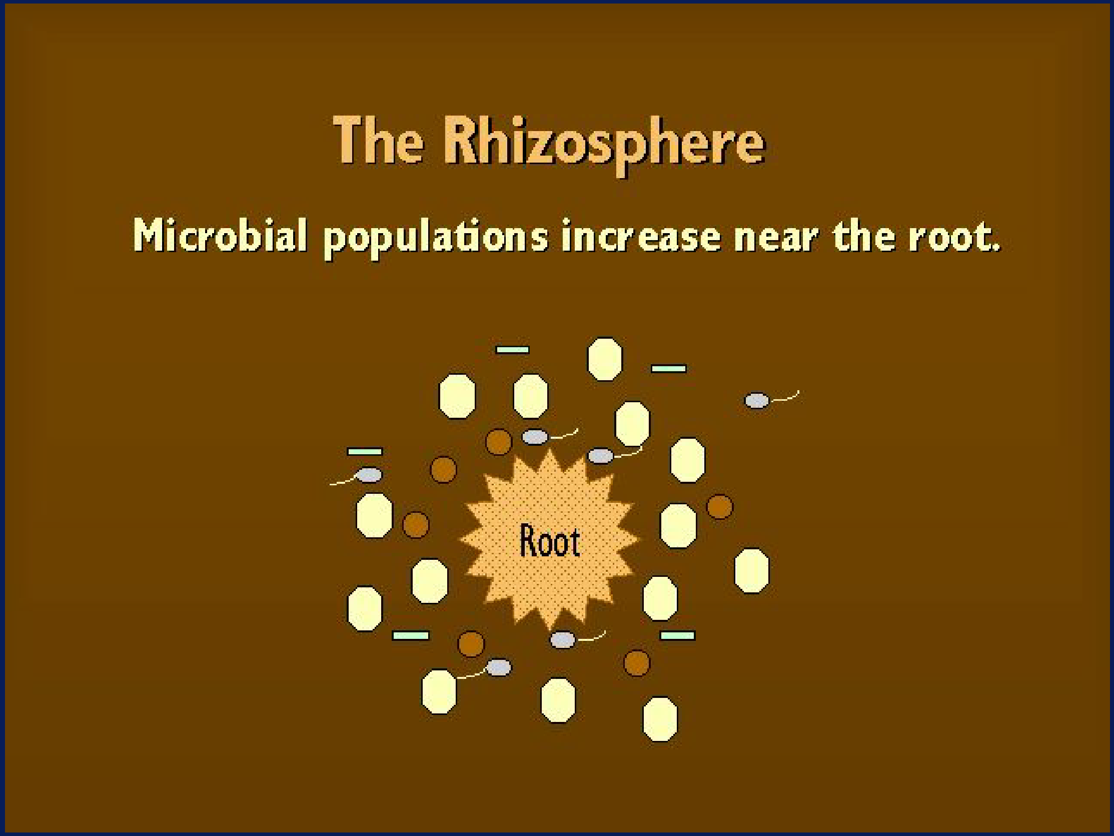
Protozoa:

- most varied & numerous of soil microfauna
- mobile, single-celled creatures that capture & engulf their food
- include amoebas, ciliates & flagellates
- considerable number of human & animal diseases are caused by protozoa, but mostly waterborne instead of soilborne
- most soil-inhabiting protozoa prey on bacteria
- thrive in moist, well-drained soils and are most numerous in surface horizons
- especially active in the rhizosphere

ROOTS OF HIGHER PLANTS



ROOTS OF HIGHER PLANTS



Root Exudates:

- Polysaccharides
- Amino acids
- Sugars
- Organic acids

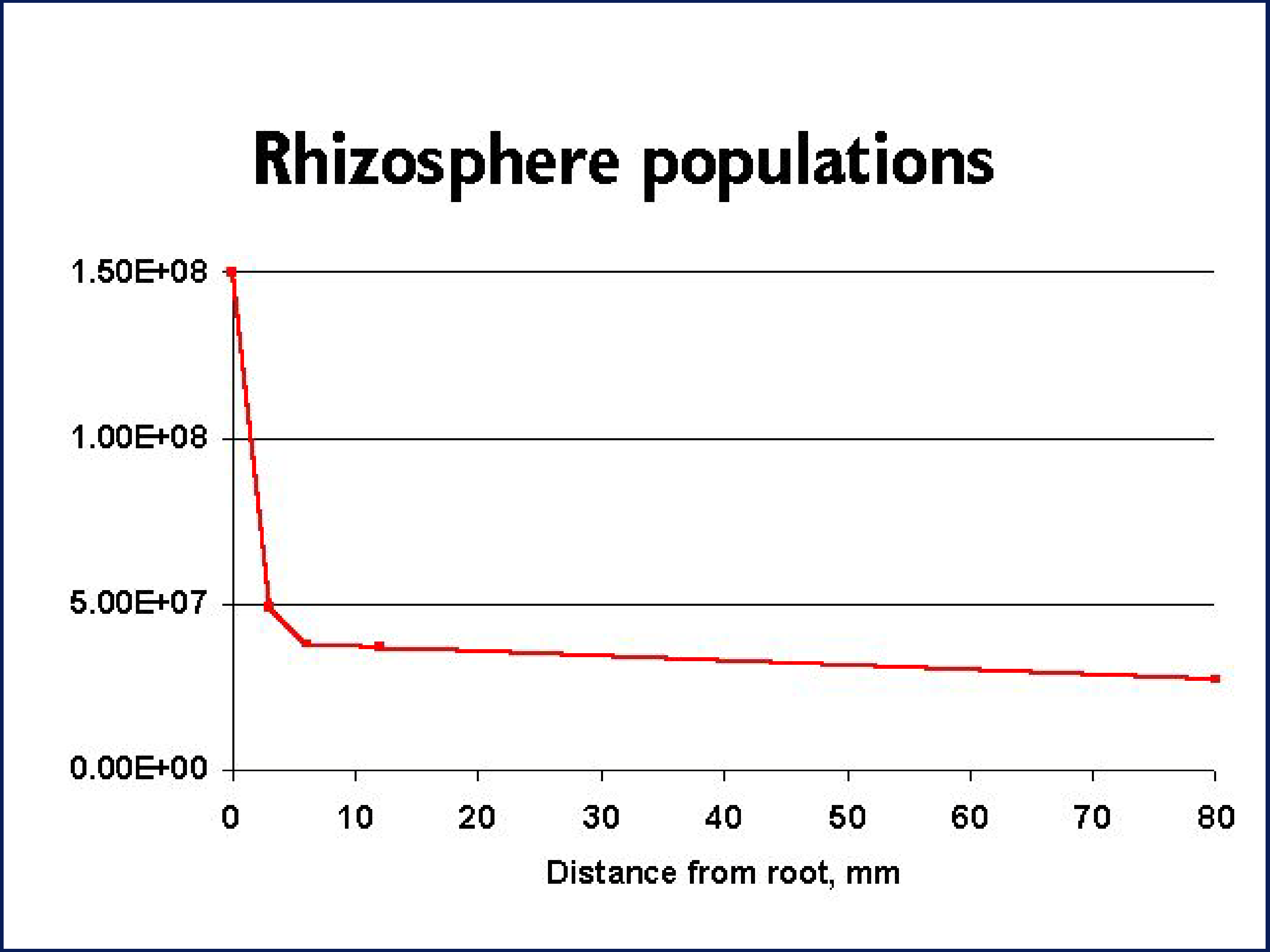
Gen. Lower pH

Rhizosphere important to plant health:

- disturbed during transplanting
- reason for extra care after transplanting

The rhizosphere around living roots

ROOTS OF HIGHER PLANTS



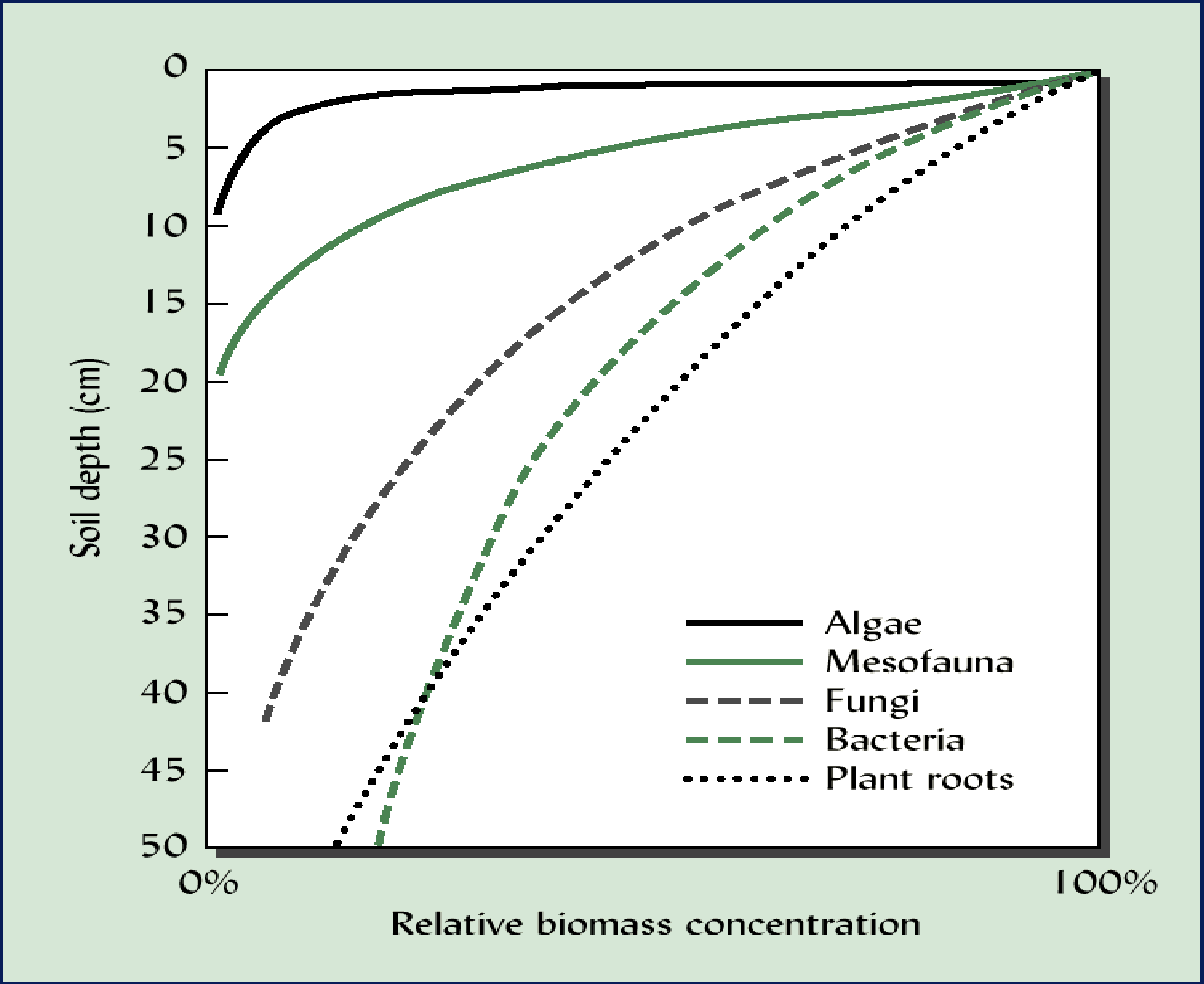
ROOTS OF HIGHER PLANTS

Rhizodeposition:

- Some root exudates exert growth-regulating influences on other plants & microorganisms (**allelopathy**); trees known for this are holly, black walnut
- High-molecular weight mucilages secreted near apical zone mixes with clay particles & bacteria to form **mucigel:**
  - improves root-soil contact
  - lubricates root movement through soils
  - may protect root from certain toxic chemicals
  - ideal environ for growth of microorganisms
- Accounts for 2-30% of total dry-matter production in young plants

VERTICAL DISTRIBUTION OF SELECTED OF SOIL ORGANISMS

RELATIVE VERTICAL DISTRIBUTION OF VARIOUS GROUPS OF SOIL ORGANISMS IN A REPRESENTATIVE GRASSLAND SOIL.



SOIL ALGAE

- Groups:
  - are eukaryotes (nuclei inside cell membrane)
  - (1) green, (2) yellow-green, (3) diatoms
  - group formerly called blue-green algae are prokaryotes & are considered with bacteria
- Are photoautotrophs - photosynthesize
- Most grow best under moist to wet conditions; some are found in hot or cold deserts
- Mostly found at or near the soil surface
- Algae plus fungi form lichens, important primary colonizers of rock & other low OM environs
- Commonly are components of microbial crusts in deserts

SOIL FUNGI - 1

- Extremely diverse group of microorganisms
- Tens of thousands of species identified; as many as 2500 at a single location
- May dominate the biomass & metabolic activity in many soils
- Heterotrophs - depend upon living or dead OM for C & energy
- Are aerobic organisms, many can tolerate very low O_2
- Groups: yeasts, molds & mushrooms
- Molds & mushrooms are filamentous fungi
  - hyphae: individual fungal filaments
  - mycelia: strands of filaments

SOIL FUNGI - 2

Molds:

- **Distinctly filamentous, microscopic or submicroscopic**
- **Play an extremely important role in soil OM breakdown**
- **Grow vigorously in acid, neutral and alkaline soils; may dominate the microflora in acid surface soils**
- **Are especially important decomposers in acid forest soils**
- **Four common gerera are: *Penicillium*, *Mucor*, *Fusarium* & *Aspergillis***
- **Complexity of OM seems to determine the particular molds which are prevalent**
- **More or less normal range: 100,000 - 1 million per gram**

SOIL FUNGI - 3

Mushroom fungi:

- **Grow in grass and forested areas with ample moisture & OM**
- **The above ground fruiting body for most mushrooms is only a small part of the total organism**
- **An extensive network of hyphae permeates the underlying soil or organic residue**
- **Largest living organism known is thought to be a fungus growing in the soil in the Pacific northwest**

SOIL FUNGI - 4

Activities of fungi:

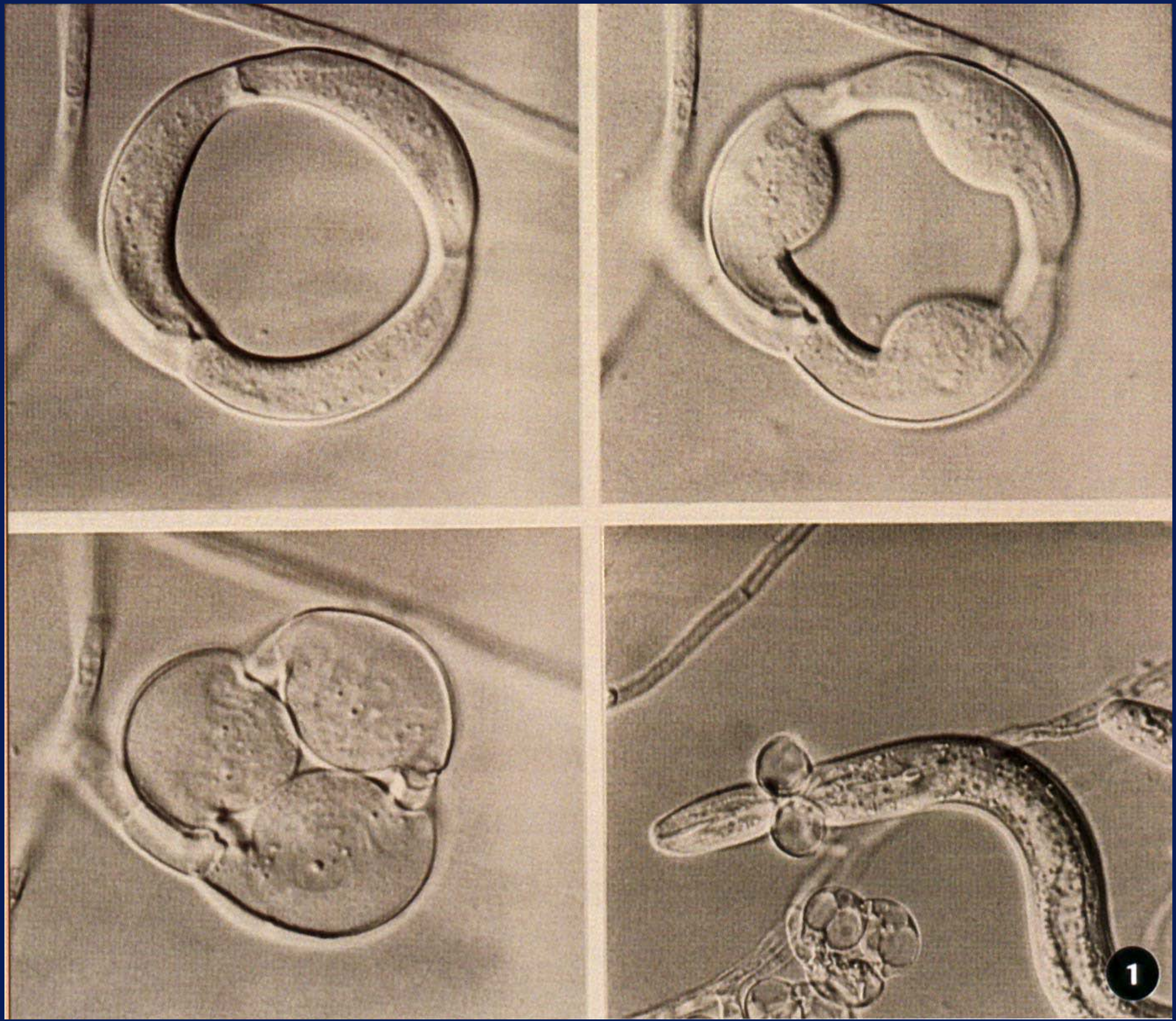
- **Most versatile & persistent of any group of decomposers**
- **Decompose cellulose, starch, gums, lignin**
- **More efficient in assimilation of OM into their tissues (50%) than bacteria (20%)**
- **Continue to decompose resistant residues after bacteria & actinomycetes have ceased to function**
- **Very important to soil fertility via nutrient cycling & to soil tilth due to stabilizing effect on soil aggregates**
- **May produce mycotoxins, highly toxic to plants or animals - aflatoxin produced by *A. flavus* on peanuts**
- **May be predatory on other microorganisms**

Fungal mycelia growing from the soil into leaves and woody debris on the forest floor

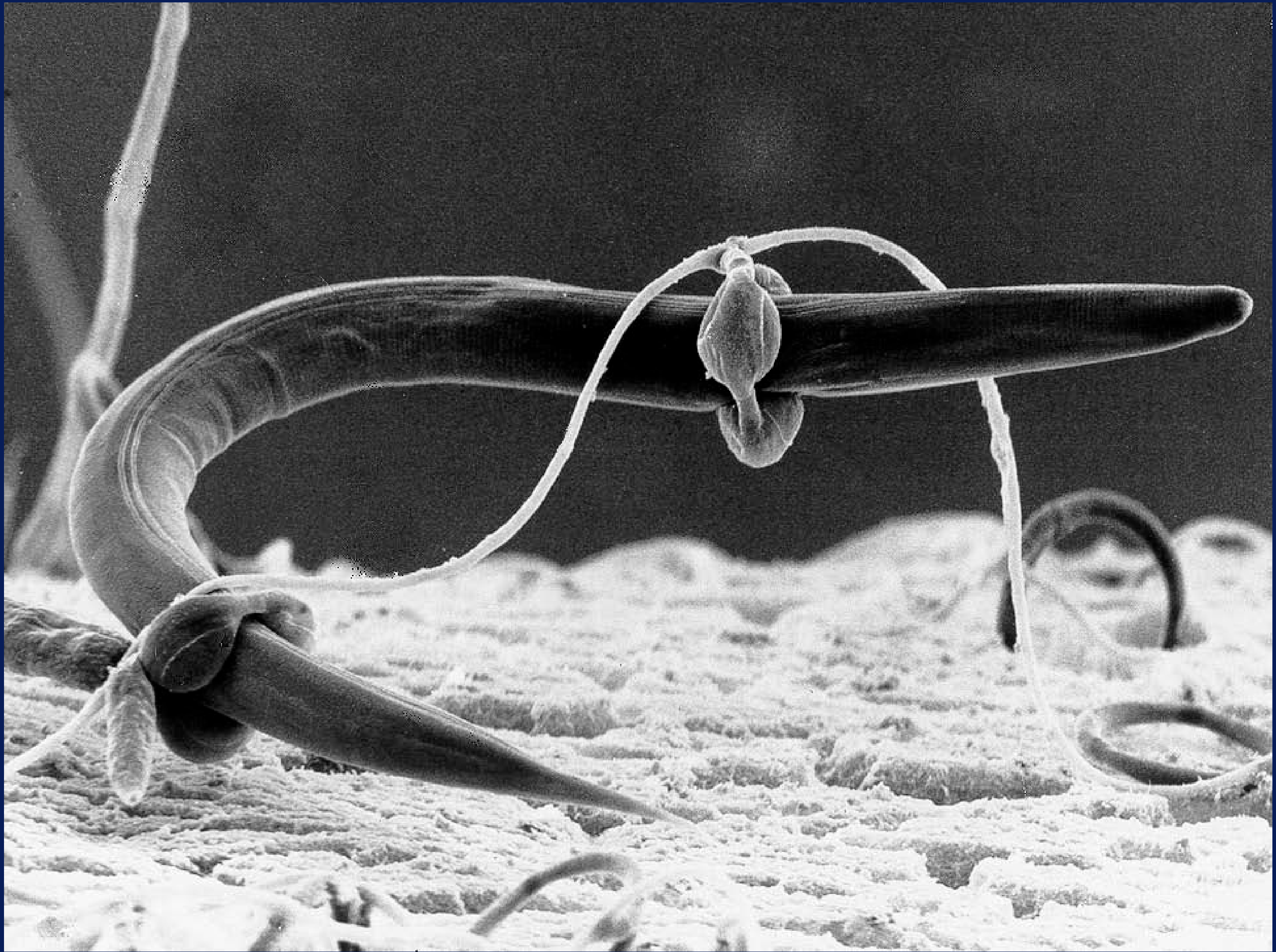
SOIL FUNGI - 5
WOOD-INVADING FUNGI

SOIL FUNGI - 6

Loops of Arthrobotrys anchonia, showing the constricting mechanism and an entrapped nematode



FUNGI WITH TWO LOOPS FIRMLY ATTACHED TO A NEMATODE

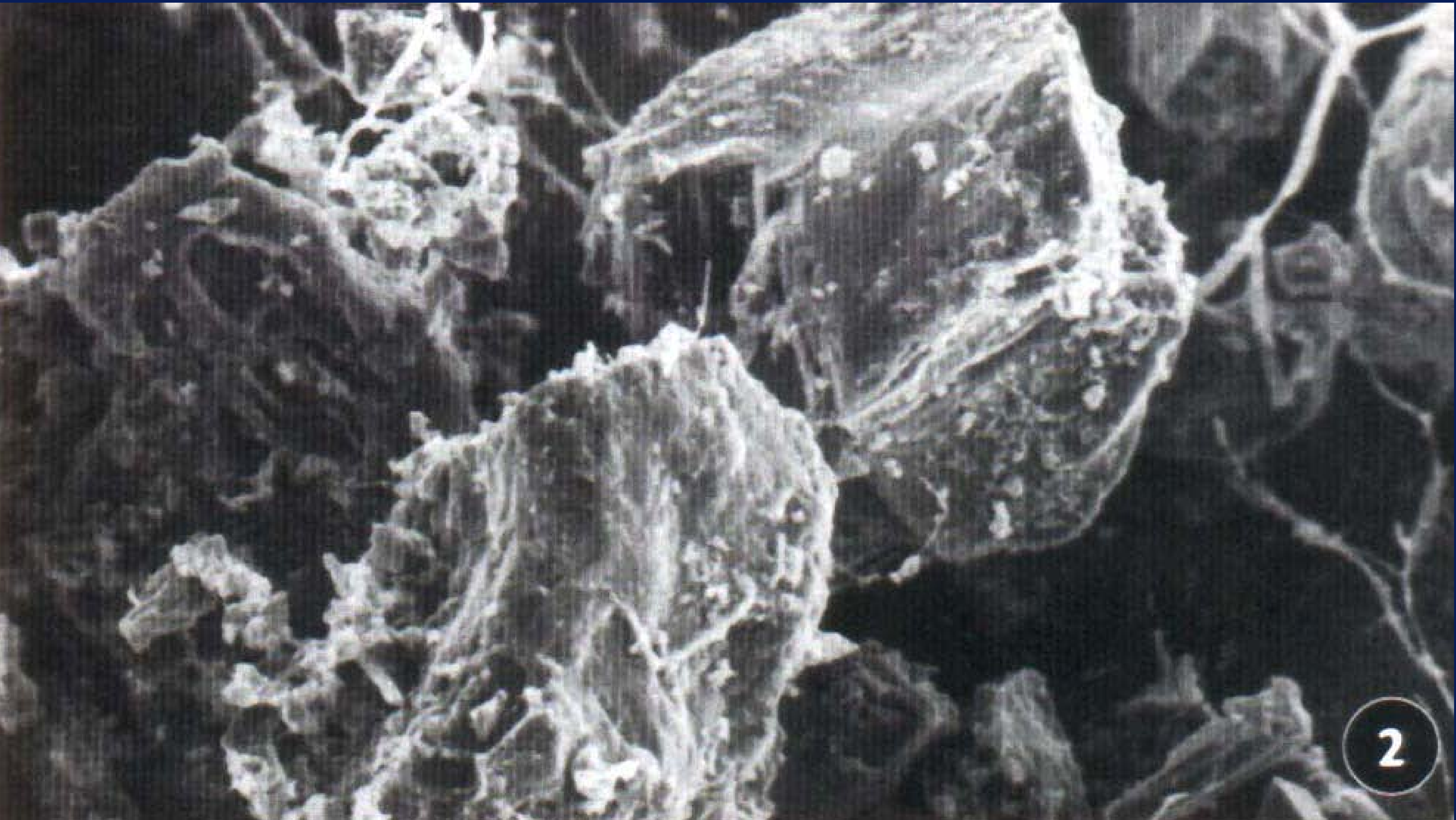


SOIL FUNGI - 7

Fungal mycelia growing around small aggregates of clay and humus. Note aggregates suspended within the pore space.

SOIL FUNGI - 8

Fungal threads around clay aggregates



SOIL FUNGI - 9

Yeasts:

Importance:

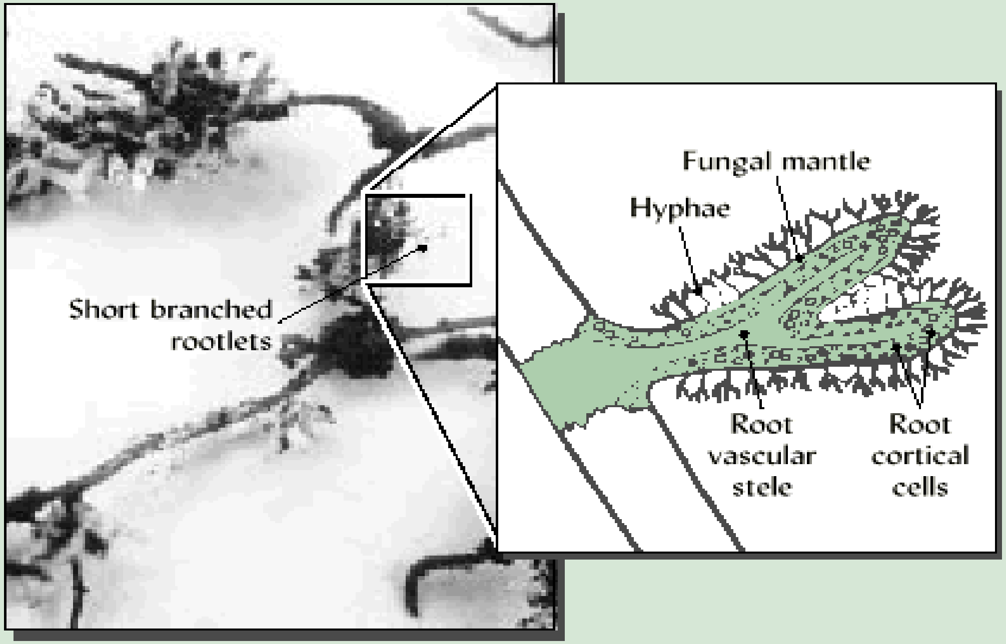
SOIL FUNGI - 10

Mycorrhizae:

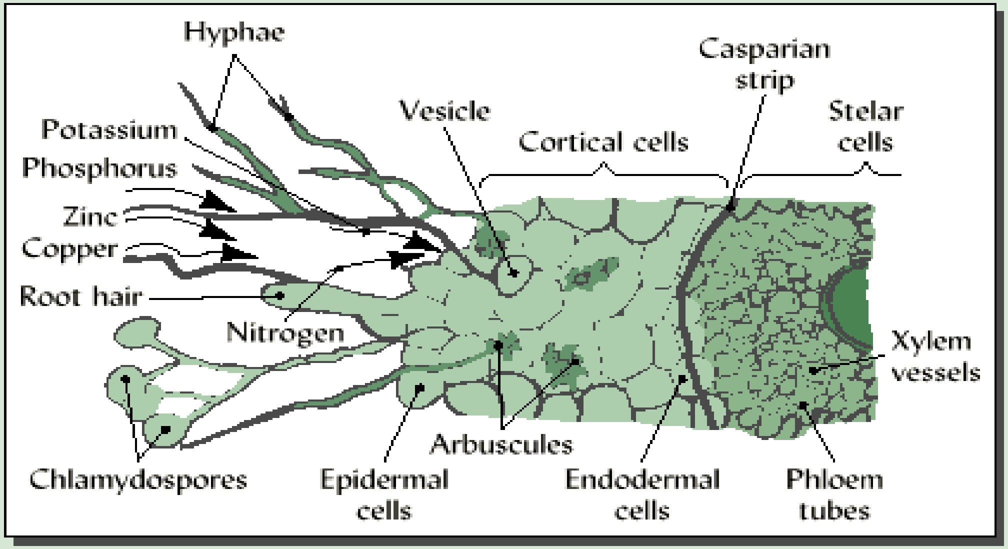
- Symbiotic relationship between certain fungi & roots of higher plants
- Fungal threads serve as extended root system
- Important for adaptation to acid mineral soils with low P & high Al
- Important where root system:
  - is impaired by Al toxicity
  - has no enhanced organic acids
- Ectomycorrhiza on tree species decreases Al toxicity

MYCORRHIZA ASSOCIATION WITH PLANT ROOTS

Diagram of ectomycorrhiza and arbuscular mycorrhiza (AM) association with plant roots. **(FIGURE 11.24)**



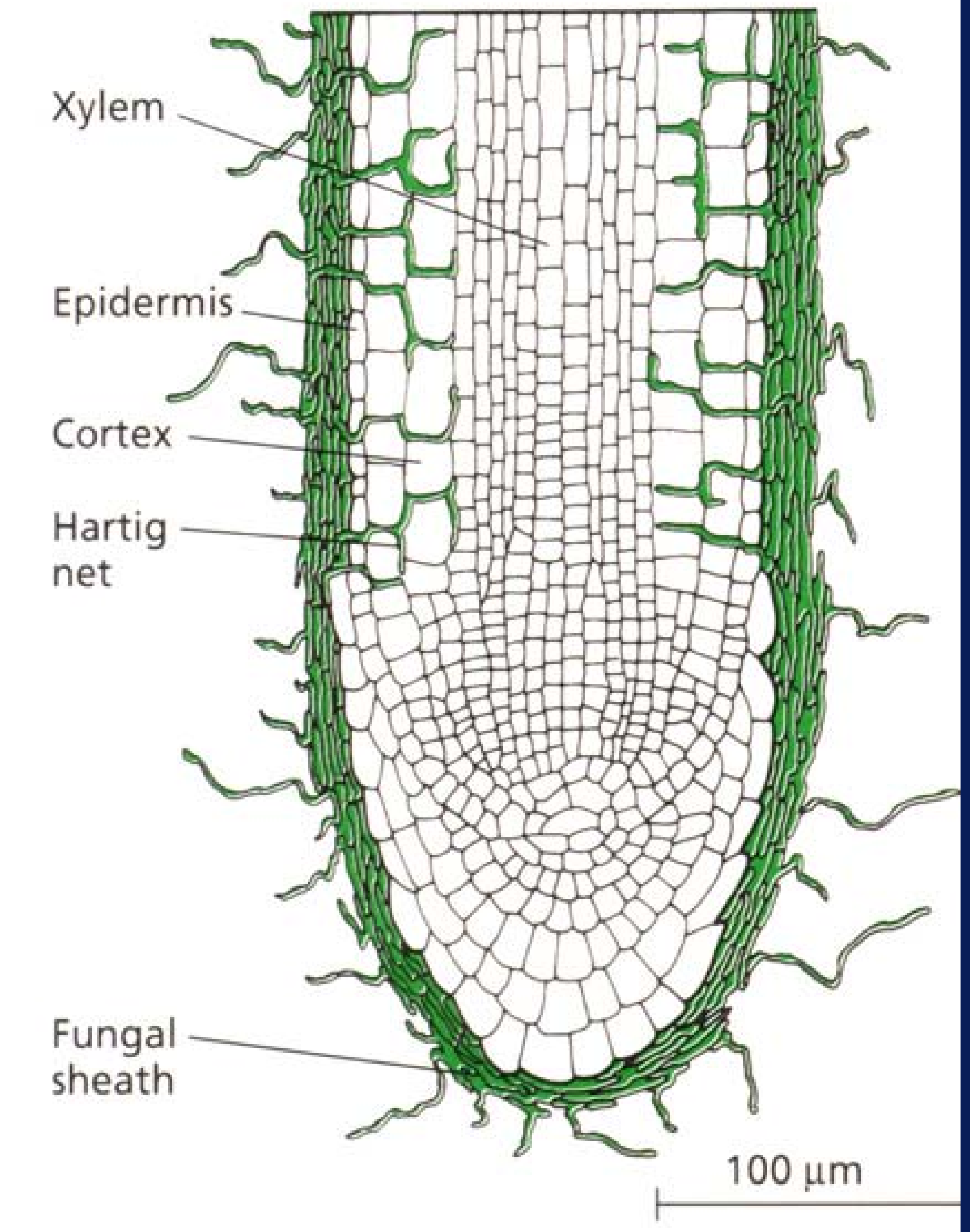
(*a*)



(*b*)

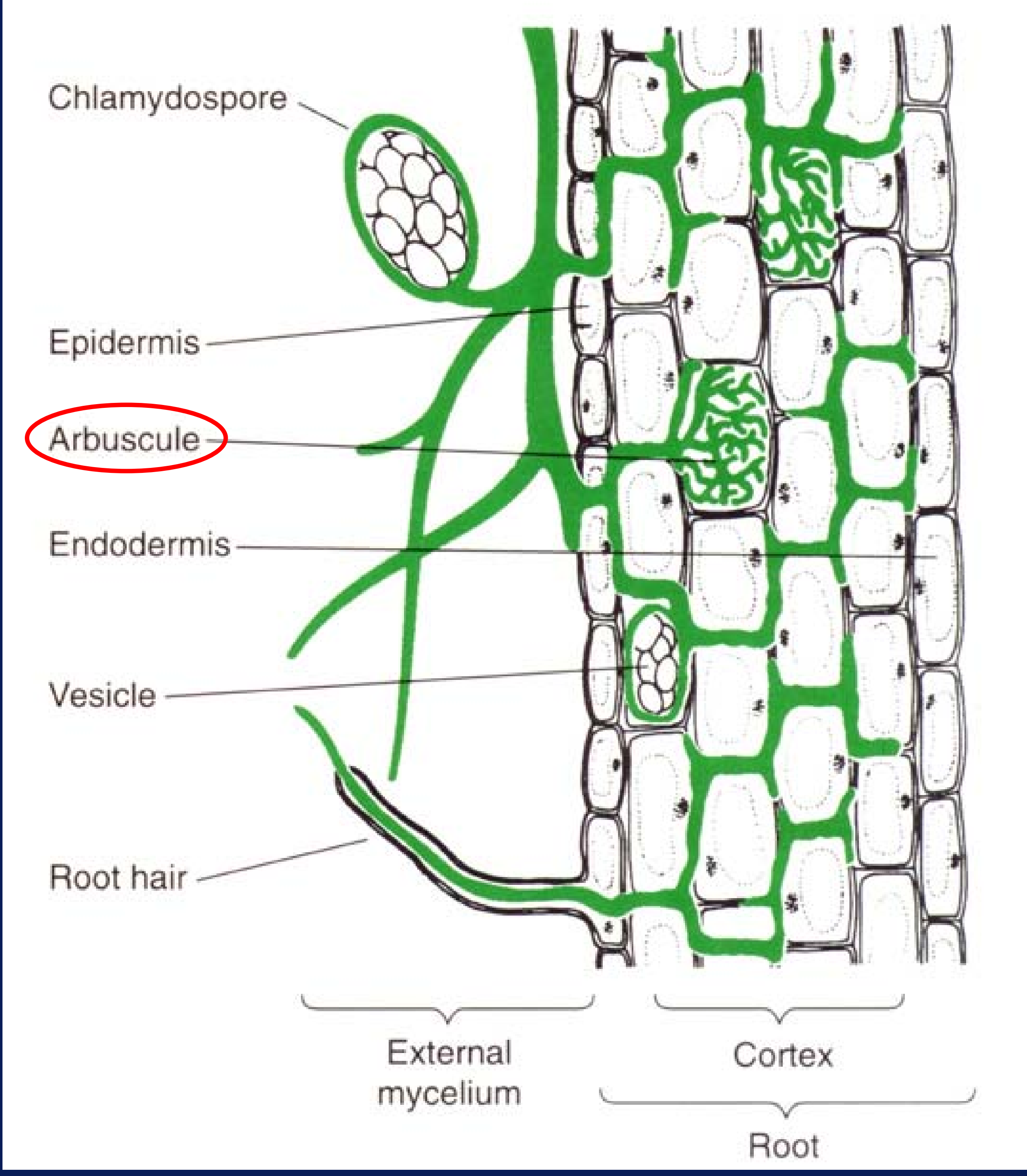
ECTOTROPHIC MYCORRHIZAL FUNGI

Around and between the cells



ENDOTROPHIC MYCORRHIZAL FUNGI

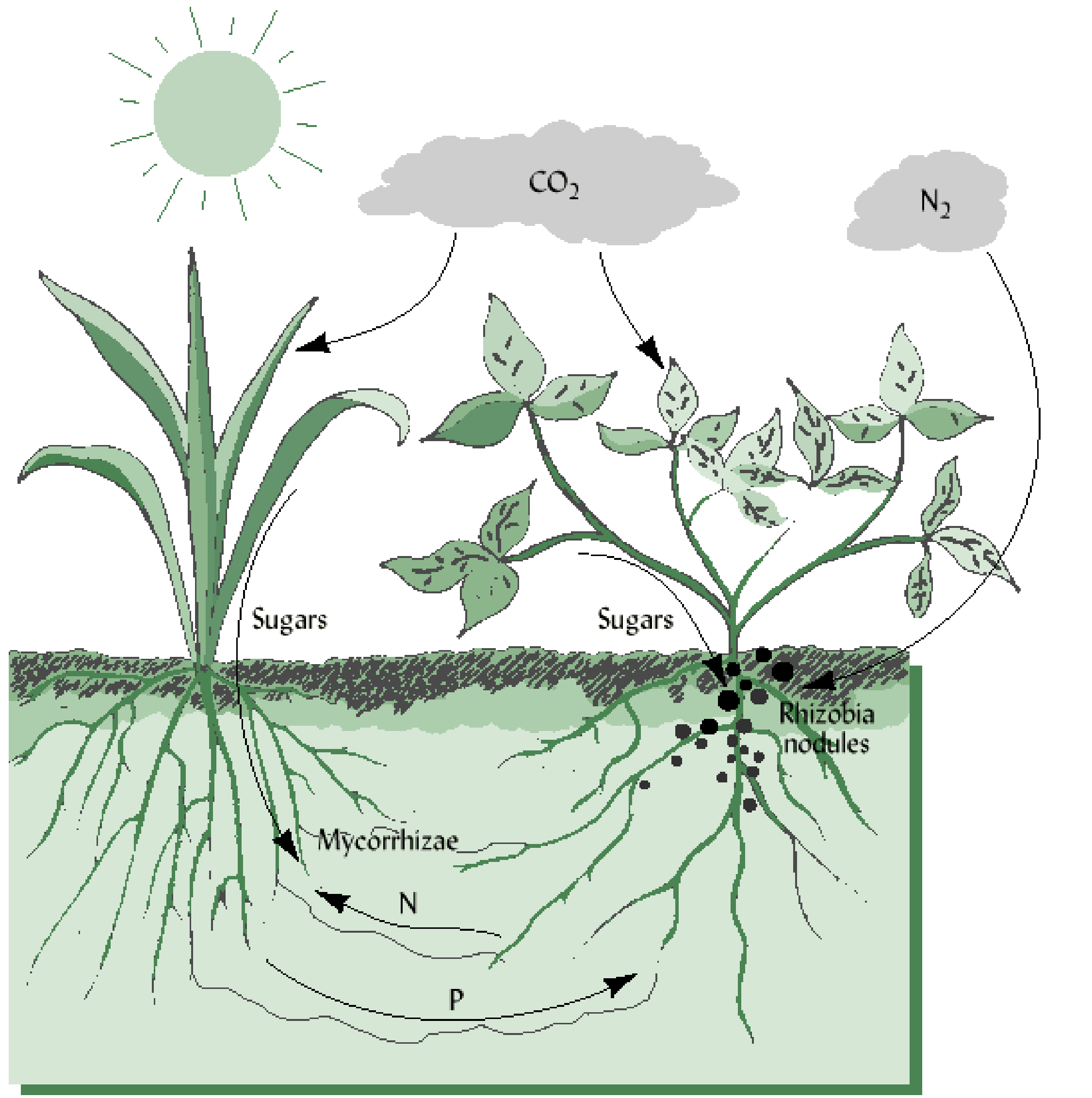
In between and inside the cells



MUTUALLY BENEFICIAL RELATIONSHIPS IN SOILS

Mycorrhizal fungi, rhizobia bacteria, legumes, and nonlegume plants can all interact in a four-way, mutually beneficial relationship.

(FIGURE 11.26)



SOIL BACTERIA - 1

Characteristics:

- Very small (0.5-5 μm), single celled & prokaryotic (no distinct nucleus)
- Smallest ones are near the size of an average clay particle
- Shapes: round (coccus) , rodlike (bacillus) & spiral (spirillum)
- Probably the most diverse group of soil organisms; one gram of soil typically contains 20,000 different species
- Found in extreme environments - pH = 2-10; cold, hot; anaerobic conditions; desiccated salt flats

SOIL BACTERIA - 2

Bacterial populations in soils:

- **Highly variable; from a few billion to > 1 trillion per gram**
- **Biomass of 400- to 5000-kg/ha live weight is common in upper 15 cm of fertile soil**
- **Can form very resistant resting stages (our lab exper)**
- **Extremely rapid reproductive potential - respond quickly when food source is added**

SOIL BACTERIA - 3

Source of energy:

- **Autotrophic:**
  - Energy from:
    - \- photoautotrophics
    - \- chemoautotrophs (N, S, Fe)
  - C from:
    - \- CO_2 or dissolved carbonates
- **Heterotrophic:**
  - \- Most soil bacteria are heterotrophic
  - \- Obtain energy and C from OM
  - \- Along with fungi & actinomycetes, account for the general breakdown of OM in soils

SOIL BACTERIA - 4

Importance of bacteria:

- Participate vigorously in virtually all organic transformations that characterize healthy soil system
- Can degrade crude oil, pesticides & other organic toxins
- Responsible for the oxidation or reduction of selected chemical elements in soils
- Can fix atmospheric N to form organic N compounds
- Transform N-compounds in the soil system
- Cyanobacteria:
  - Previously classified as blue-green algae
  - Photosynthetic; also fix N; significant in wet soils

SOIL ACTINOMYCETES

- Have some characteristics similar to bacteria; others similar to fungi
- Are filamentous, but mycelial threads are much smaller than those of fungi
- Are unicellular like bacteria & similar in size; are prokaryotic; often break up into spores
- Generally are aerobic heterotrophs; many produce antibiotics that are toxic to other microorganisms
- Produce: actinomycin, neomycin & streptomycin
- More drought tolerant than bacteria or fungi
- More numerous than all other organisms except bacteria

CONDITIONS AFFECTING THE GROWTH OF SOIL MICROORGANISMS

Organic matter requirements:

- Heterotrophs, majority of soil organisms, use plant detritus & soil OM as energy sources
- Some microorganisms are stimulated by specific compounds (amino acids, “growth factors”)
- Bacteria - utilize simple compounds; more active beneath surface
- Fungi & actinomycetes - can utilize cellulose & other resistant compounds; fungi esp active on surface

CONDITIONS AFFECTING THE GROWTH OF SOIL MICROORGANISMS - 2

Oxygen requirements:

- most microorganisms are aerobic & use O_2
- some bacteria are anaerobic & use NO_3^-, SO_4^{-2}, etc
- facultative bacteria use either aerobic or anaerobic forms of respiration

Moisture & temperature:

- optimum moisture for higher plants (-10 to -70 kPa) is usually best for most aerobic microbes
- microbial activity is gen greatest at T = 20-40 °C
- biological zero for most organisms is 5 °C

Exchangeable Ca & pH:

- most bacteria grow best at high Ca & pH ~7
- at low pH, fungi become dominant

BENEFICIAL EFFECTS OF SOIL ORGANISMS - 1

Organic matter decomposition:

- perhaps the most important function - release of nutrients & soil structure effects

Breakdown of toxic compounds:

- those produced by soil organisms or applied
- xenobiotic compounds - foreign to biological systems; are often most resistant to breakdown
- bacteria & fungi most important

Inorganic transformations:

- affects N, P, S - Organic/inorganic; Fe, Mn - redox

Nitrogen fixation:

- accomplished by actinomycetes, cyanobacteria & rhizobia bacteria

BENEFICIAL EFFECTS OF SOIL ORGANISMS - 2

Rhizobacteria:

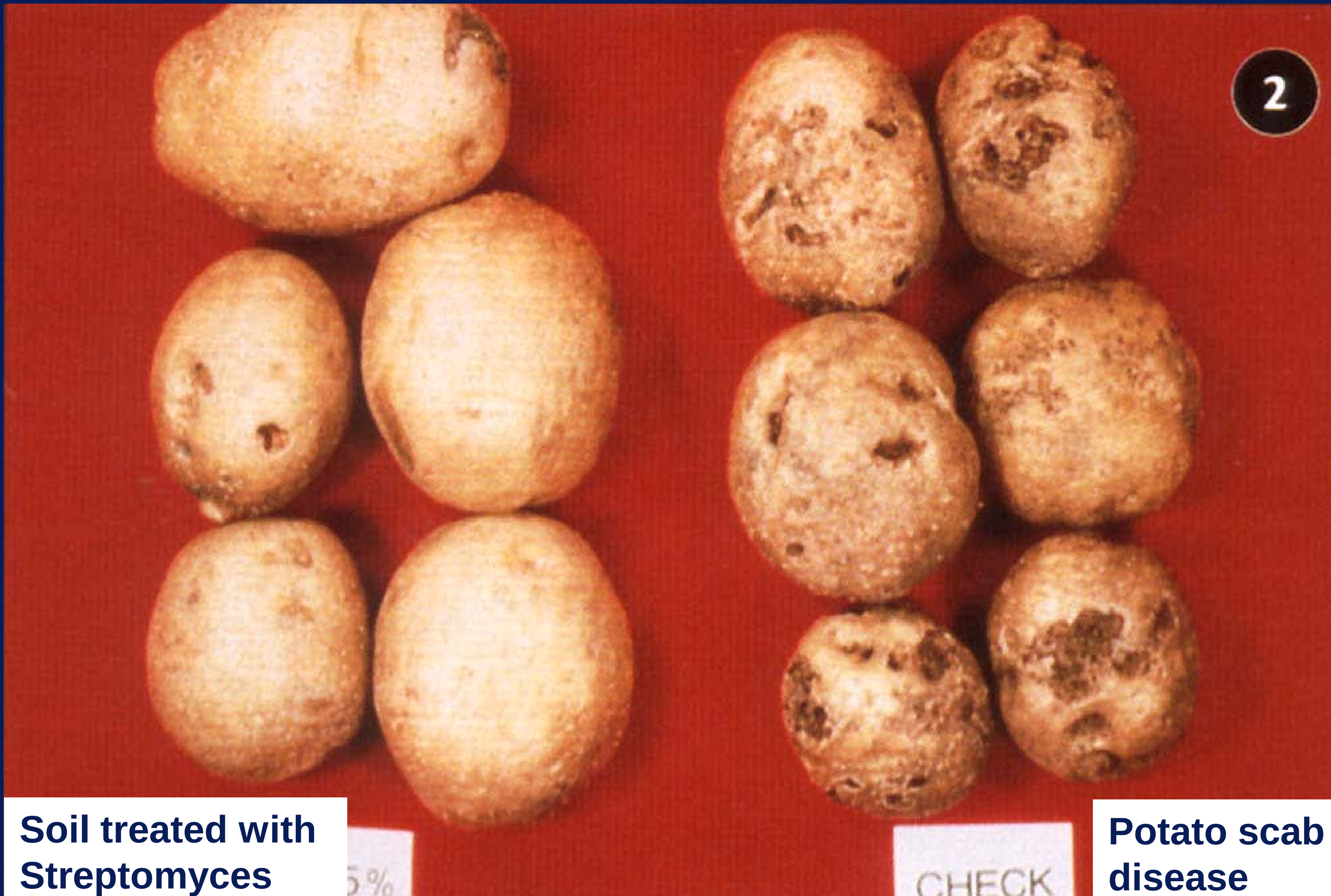
- especially adapted to living within the rhizosphere
- plant growth-promoting rhizobacteria - beneficial to higher plants - compounds synthesized
- may help ward off plant diseases
- deleterious rhizobacteria - inhibit root growth via secretion of chemical compounds
- may possibly be able to use deleterious bacteria effects to control weeds

SOIL ORGANISMS & DAMAGE TO HIGHER PLANTS

Plant pests and parasites:

- **Soil fauna:**
  - rodents, snails, slugs, ants cause plant damage
  - nematodes & insect larvae cause greatest damage
  - many of these problems can be lessened by use of proper crop rotation & OM addition
- **Microflora & plant disease:**
  - fungi cause most of common plant diseases
  - wilts, damping-off, root rots, potato blight (photo)
  - diseases are easily transported
  - once infestation occurs, eradication is difficult

SOIL ORGANISMS & DAMAGE TO HIGHER PLANTS - 2



Soil treated with Streptomyces

Potato scab disease

SOIL ORGANISMS & DAMAGE TO HIGHER PLANTS - 3

Plant disease control by soil management:

Prevention is best defense against soil borne diseases

- strict quarantine systems
- eliminate host crop from infected field
- crop rotation with non-host crops

- **Soil pH:**
  - soil pH <5.2 controls actinomycetes-caused potato scab & spring dead spot (fungal) in turf grass
  - soil pH ≈ 7 controls clubfoot disease in cabbage

- **Air & temperature:**
  - *damping-off*: seed rots & seedling diseases caused by wet, cold soils - use soil ridges
  - use steam or chemical sterilization for greenhouse

SOIL ORGANISMS & DAMAGE TO HIGHER PLANTS - 4

Plant disease control by soil management:

- **Disease-suppressive soils:**
  - apparently certain soils host bacteria & fungi that are antagonistic toward pathogenic organisms
  - in some cases, build-up of pathogens is ultimately overcome by build-up of antagonist organisms
  - sometimes residue from one crop may provide control of pathogens of subsequent crop
  - certain composts seem to contain large numbers of antagonist organisms

SOIL ORGANISMS & DAMAGE TO HIGHER PLANTS - 5

Plant disease control by soil management:

- **Rhizosphere camouflage:**
  - rhizosphere contains microbe types that are more similar to those in the bulk soil than rhizosphere of susceptible plants
  - may help this process by adding large quantities of fresh OM
- **Induced systemic resistance:**
  - beneficial rhizobacteria produce a signaling chemical that is absorbed into the root, transmitted up the shoot and induces leaf cells to produce chemical defenses - prior to arrival of pathogen

SOIL ORGANISMS & DAMAGE TO HIGHER PLANTS - 6

Competition between plants and soil microorganisms:

- **Competition for nutrients:**
  - rapidly growing microorganisms can absorb nutrients more quickly than plant root
  - most important for N & Fe; also for P, K, Ca
  - situation with N is discussed in Section 12.3
- **Reduction of O_2 supply:**
  - soil microflora may deplete O_2 under conditions of poor drainage
  - some O_2 is needed for root respiration
  - forms of N, S, Fe, Mn will be reduced & availability will change

ECOLOGICAL RELATIONSHIPS AMONG SOIL ORGANISMS

Mutualistic associations:

- mycorrhizae & N-fixing nodules
- lichens
- algal-fungal associations on rocks & soils

Microbiotic crusts:

- algae or cyanobacteria and fungi, mosses, bacteria &/or liverworts
- crusts provide protection against wind & water erosion
- improve arid-region ecosystem productivity by:
  - helping conserve & recycle nutrients
  - increase N-supplies (cyanobacteria)
  - increase infiltration & reduce evaporation
  - contribute to net OM production

Fragil Ecosystem!

ECOLOGICAL RELATIONSHIPS AMONG SOIL ORGANISMS - 2

Competitive interactions:

- **Competition for food:**
  - population of soil microbes gen. limited by food
  - when fresh OM is added, intense competition between bacteria, fungi & actinomycetes
  - bacteria will dominate if simple compounds are present
  - as simple compounds are depleted, fungi & actinomycetes become more competitive
- **Antibiotics & other competitive mechanisms:**
  - some bacteria, fungi & actinomycetes produce antibiotics to inhibit competition
  - some produce substances to bind Fe so that other organisms cannot obtain Fe for growth

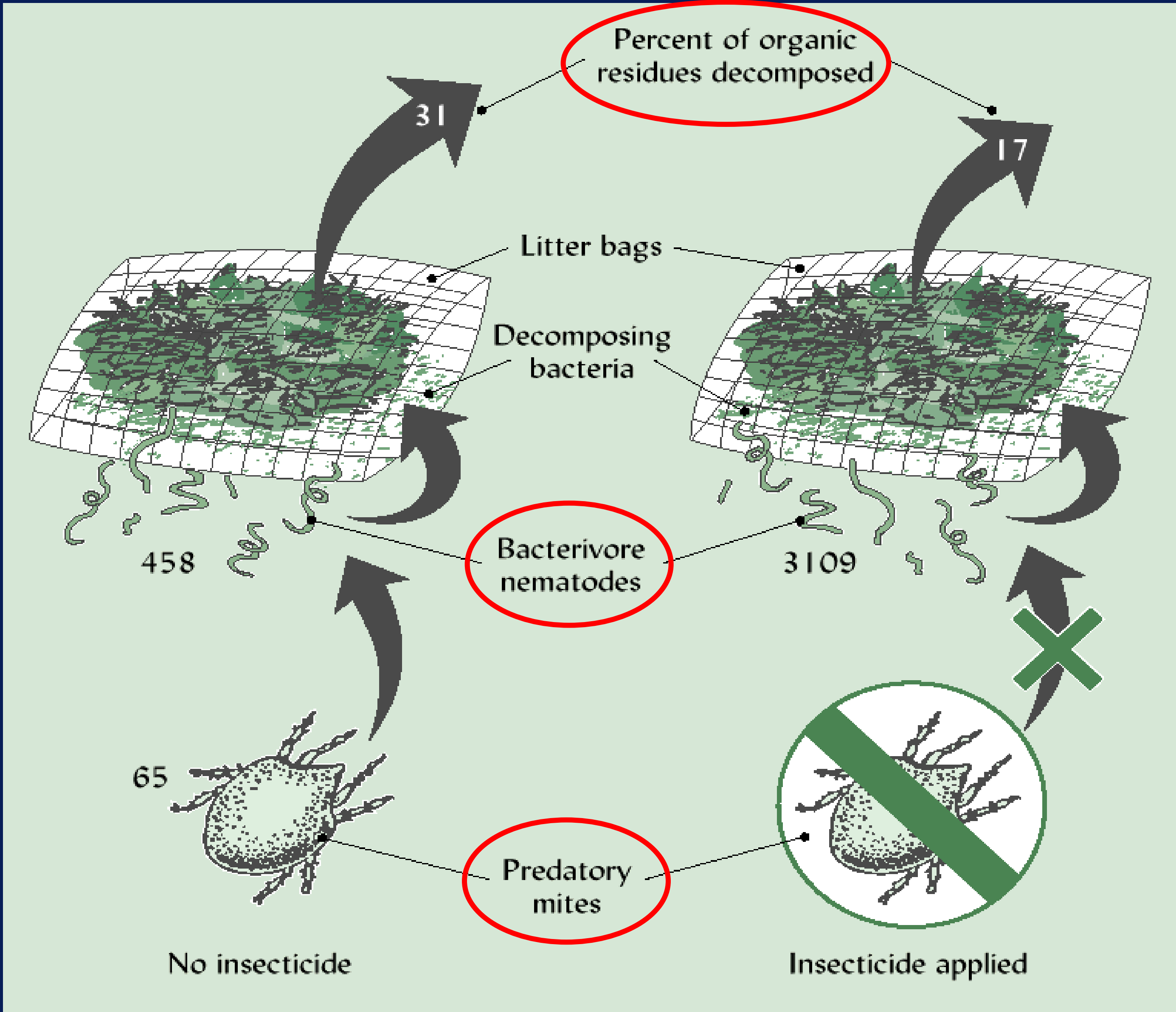
ECOLOGICAL RELATIONSHIPS AMONG SOIL ORGANISMS - 3

Effects of management practices on soil organisms:

- clearing of forest or grassland will drastically change soil environmant
- monocultures or some crop rotations will reduce organism diversity
- monoculture may increase population of a few species
- addition of lime & fertilizers to infertile soil increases microbial & faunal activity
- tillage drastically disturbs soil ecosystem
- pesticides have highly variable results; may reduce overall numbers or may give advantage to a few microorganisms (next slide)

INDIRECT EFFECTS OF INSECTICIDE TREATMENT

The indirect effects of insecticide treatment on the decomposition of creosote bush litter in desert ecosystems. (FIGURE 11.37)



GENETICALLY ENGINEERED MICROORGANISMS

Recombinant organisms: those that have new genetic combinations - not seen in nature

Potential benefits:

- degradation of organic contaminants, especially toxic xenobiotics
- transferred genes from *Bacillus thuringiensis* (Bt) to bacteria that inhabits rhizosphere of corn roots and prevents corn rootworm infestation
- production of drugs using soil microbes

Environmental & safety concerns:

- effects may be more widespread than intended
- genes/DNA may be transferred to other organisms
- may transfer to pathogens via viruses
- use of antibiotic-resistant genes as markers risky