CURSO
QUÍMICA MEDIOAMBIENTAL

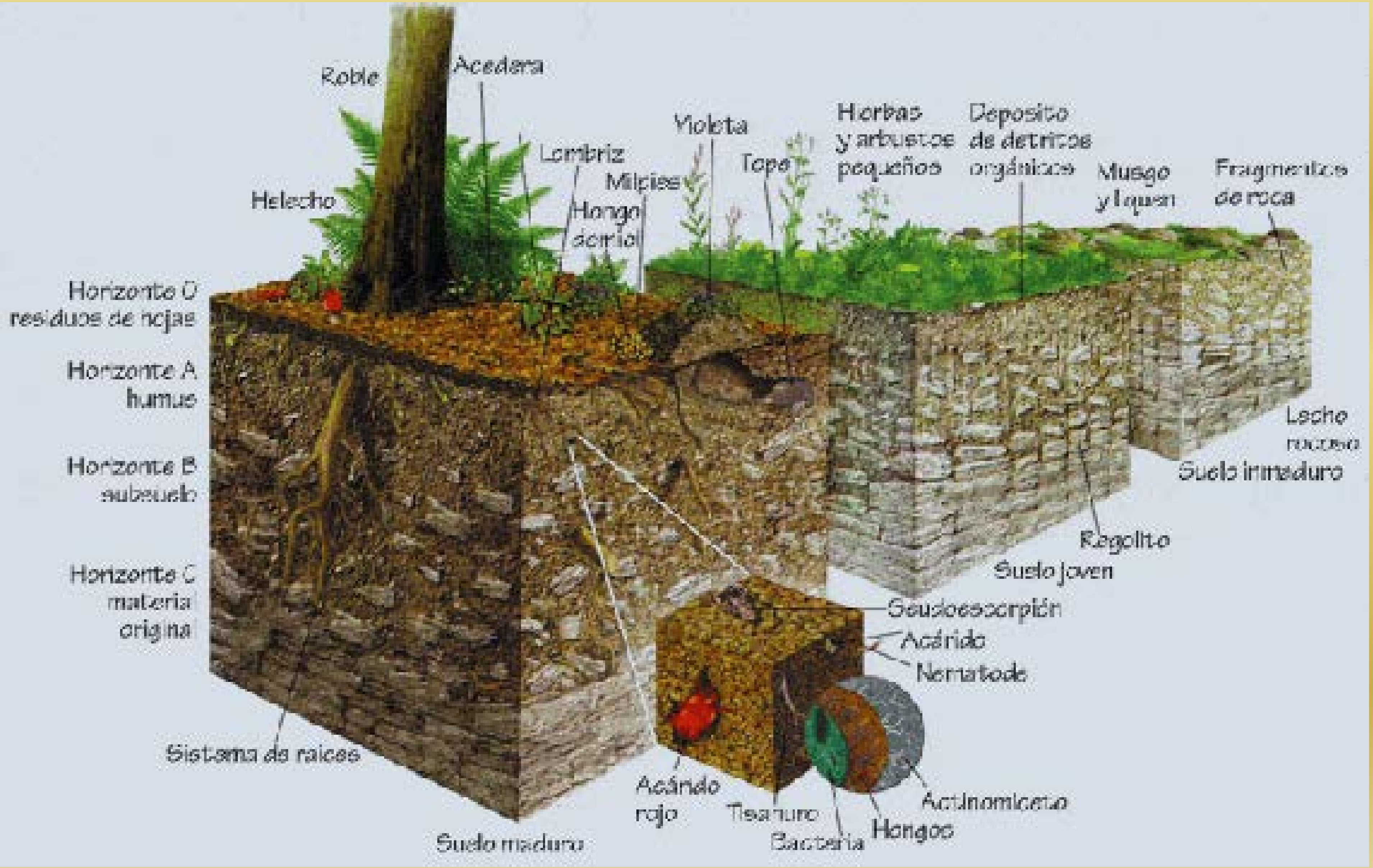
«Importancia de la materia orgánica sobre la actividad biológica y el secuestro de carbono en suelos»

UN MUNDO
BAJO TUS PIES

Javier López Robles
Área de Edafología y Química Agrícola

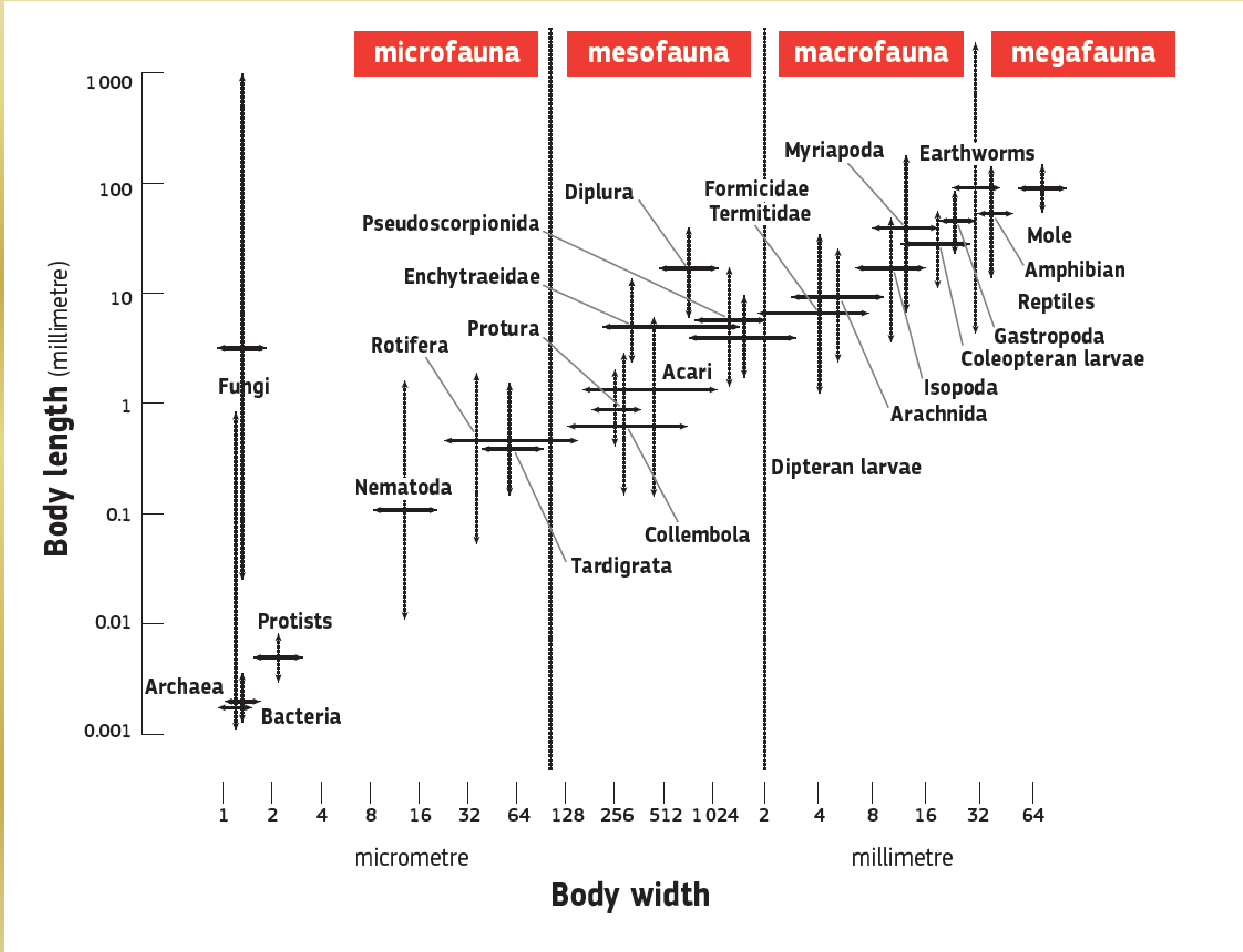
16 de Enero de 2018

HABITANTES DEL SUELO



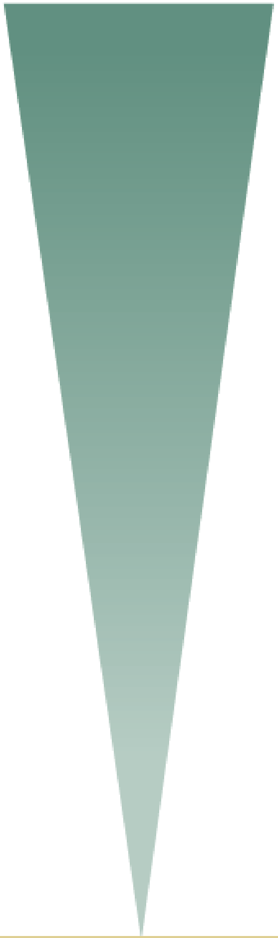
Linnaeus	1735	2 kingdoms	Animalia	Vegetabilia						
Haeckel	1866	3 kingdoms	Animalia	Plantae		Protista				
Chatton	1925	2 empires	Eukaryota						Prokaryota	
Copeland	1938	4 kingdoms	Animalia	Plantae		Protista			Monera	
Whittaker	1969	5 kingdoms	Animalia	Fungi	Plantae	Protista			Monera	
Woese *et al.*	1977	6 kingdoms	Animalia	Fungi	Plantae	Protista			Archaebacteria	Eubacteria
Woese *et al.*	1990	3 domains	Eucarya						Archaea	Bacteria
Cavalier-Smith	1993	8 kingdoms	Animalia	Fungi	Plantae	Chromista	Protozoa	Archezoa	Archaebacteria	Eubacteria
Cavalier-Smith	1998	6 kingdoms	Animalia	Fungi	Plantae	Chromista	Protozoa		Bacteria	
Ruggiero *et al.*	2015	7 kingdoms	Animalia	Fungi	Plantae	Chromista	Protozoa		Archaea	Bacteria

Since ancient times, scientists have been trying to classify living organisms. By the end of the 20^{th} century, the English biologist Thomas Cavalier-Smith, after intense study of protists, created a new model with six kingdoms. During the 21^{st} century, a phylogenetic approach, based on DNA comparisons (see box below), to classify organisms has gained strength. However, the real evolutionary relationship among eukaryotes, in particular protists (see page 31), is still debated and future changes in the classification might be needed. (JRC)

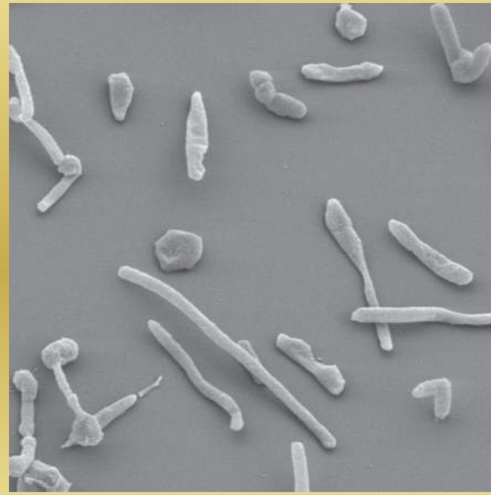


microfauna
mesofauna
macrofauna
megafauna
Body length (millimetre)
1 000
100
10
1
0.1
0.01
0.001
Fungi
Archaea
Bacteria
Protists
Rotifera
Nematoda
Protura
Enchytraeidae
Pseudoscorpionida
Diplura
Formicidae
Termitidae
Myriapoda
Earthworms
Mole
Amphibian
Reptiles
Gastropoda
Coleopteran larvae
Isopoda
Arachnida
Dipteran larvae
Acari
Collembola
Tardigrata
1
2
4
8
16
32
64
128
256
512
1 024
2
4
8
16
32
64
micrometre
millimetre
Body width

Known and estimated number of species of soil organisms and vascular plants organised according to size. Values of estimated diversity comply with the published literature, and are supported by expert judgement. Asterisks indicate numbers of species that live in the soil (updated from Barrios, Ecological Economics, 2007).

Organism size	Group	Known species	Estimated species	% described
	Vascular plants	350700	400000	88 %
	Macrofauna			
	Earthworms	7000*	30000*	23 %
	Ants	14000	25000 - 30000	60 - 50 %
	Termites	2700	3100	87 %
	Mesofauna			
	Mites	40000*	100000	55 %
	Collembolans	8500*	50000	17 %
	Microfauna ad microorganisms			
	Nematodes	20000 - 25000*	1000000 - 10000000*	0.2 - 2.5 %
	Protists	21000*	7000000 - 70000000*	0.03 - 0.3 %
	Fungi	97000	1500000 - 5100000	1.9 - 6.5 %
	Bacteria	15000	>1000000	< 1.5 %

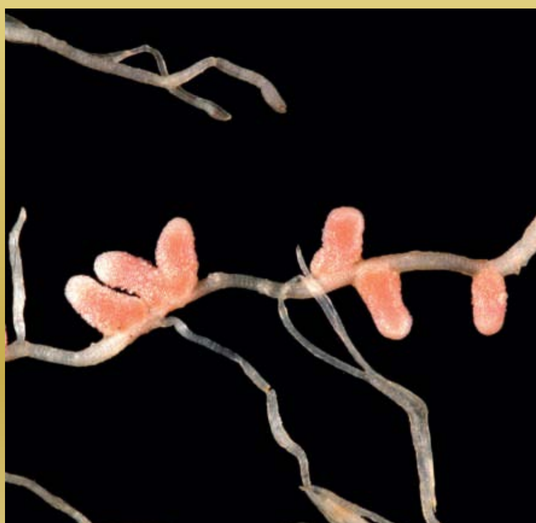
Prokaryota – Archaea



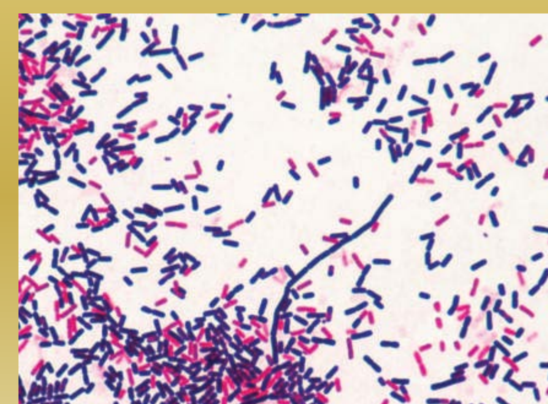
The versatile archaea

- The discovery of archaea altered our understanding of evolution, but recent research suggests that eukaryotes evolved from archaea. So humans may actually be derived from archaea.
- Archaea live in the widest range of environmental conditions of any organisms, from pH 0 to pH 12, 0˚C to 120˚C, and up to 35 % salinity.
- Hyperthermophilic archaea survive at temperatures greater than 90°C by having a thin membrane, made up of double-headed lipids, that insulates the cell interior from the heat. In acid or salty environments, this sort of membrane acts as a barrier to water molecules and other ions.
- The halophilic archaeon, now called *Haloquadratum walsbyi*, was for a long time known as 'Walsby's square bacterium' as it is box shaped and forms large fragile flat sheets in the environment.
- Archaea do not have a nucleus.

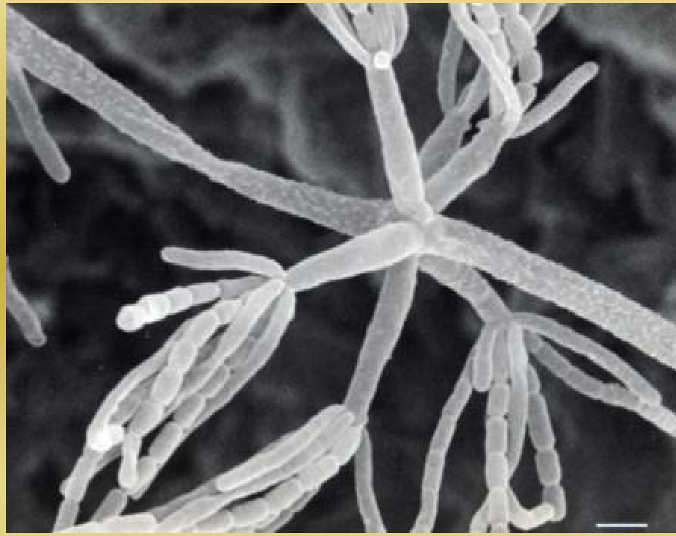
Prokaryota – Bacteria



Medicago italica formed by *Sinorhizobium meliloti*.



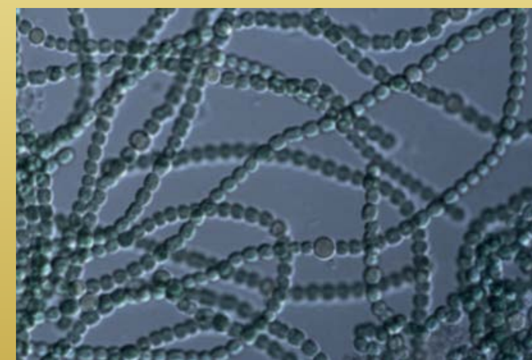
Actinobacteria



Why does the air smell of soil after rain?

- The earthy smell after it rains is linked to Actinobacteria.
- In particular, the molecule responsible for the aroma is known as geosmin.
- Geosmin is produced by the Gram-positive bacterium *Streptomyces*, a genus of Actinobacteria, and released when these microorganisms die.
- The human nose is extremely sensitive to geosmin and is able to detect it at very low concentrations.
- Geosmin is also responsible for the earthy taste of beetroots.

Cyanobacteria



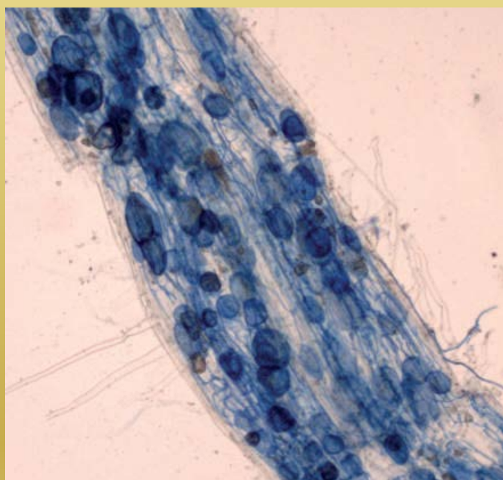
Protists

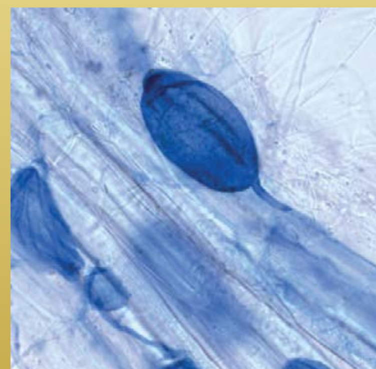
Fungi – Macrofungi

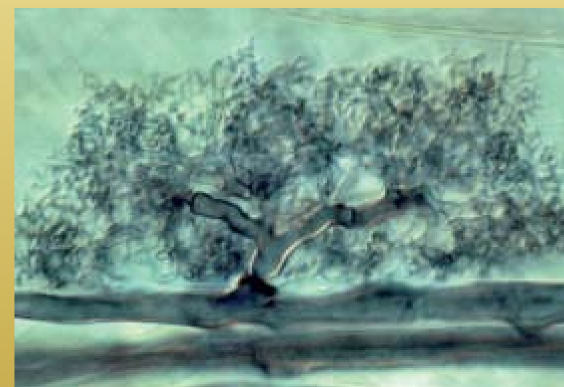
Hygrocybe sp

Mycena chlorophos

Fungi – Mycorrhizal fungi







(**a**) show the colonisation by arbuscular mycorrhizal fungi (AMF). The AMF develop unique structures within root cells: (**b**) vesicles with storage function, and (**c**) arbuscules, the typical brush-like structure which gives the name to this group of fungi. (SLS, MBR)

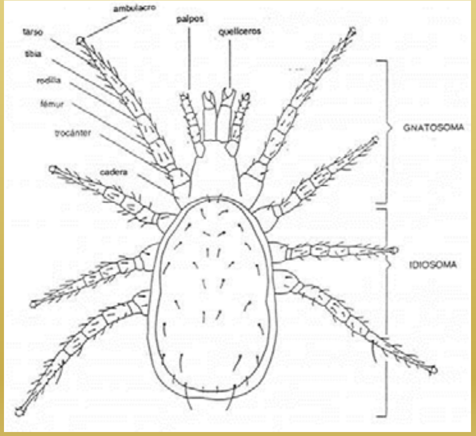
Microfauna – Tardigrada

Microfauna – Rotifera

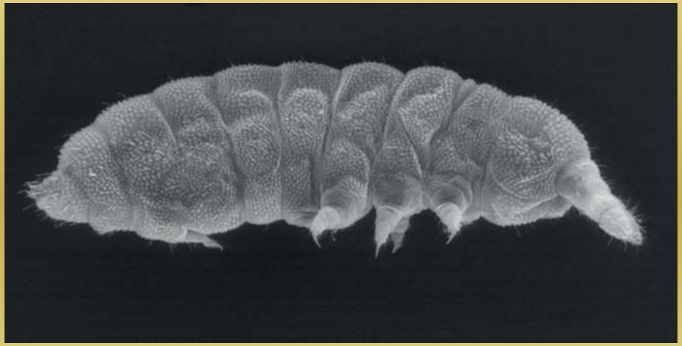
Microfauna – Nematoda

Mesofauna – Enchytraeidae

Mesofauna – Acari



Mesofauna – Collembola



Mesofauna – Protura

Mesofauna – Diplura

Mesofauna – Pseudoscorpionida

Macrofauna – Formicidae

Macrofauna – Termites

Macrofauna – Isopoda

Macrofauna – Myriapoda

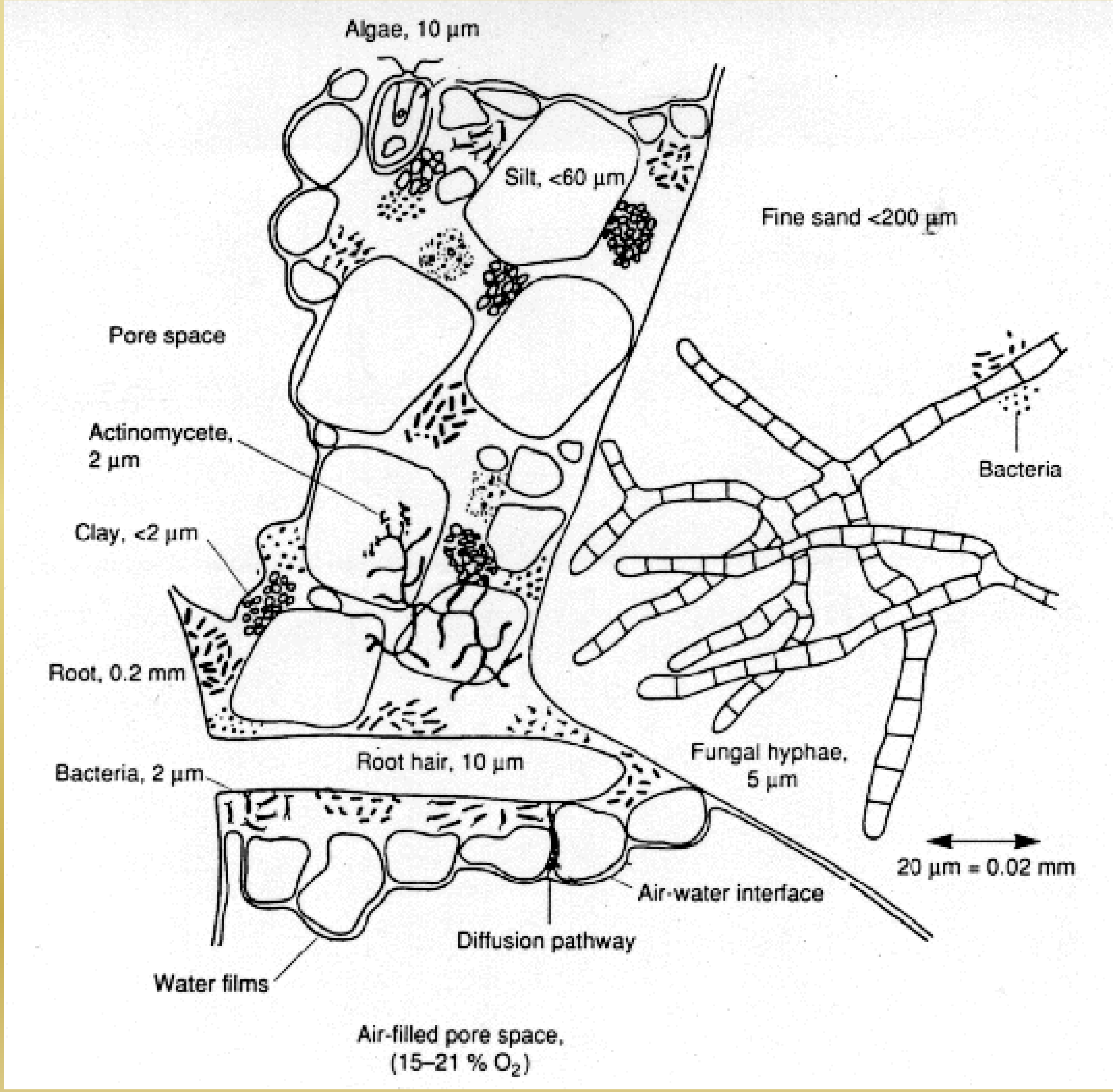
Macrofauna – Coleoptera

Macrofauna – Earthworms

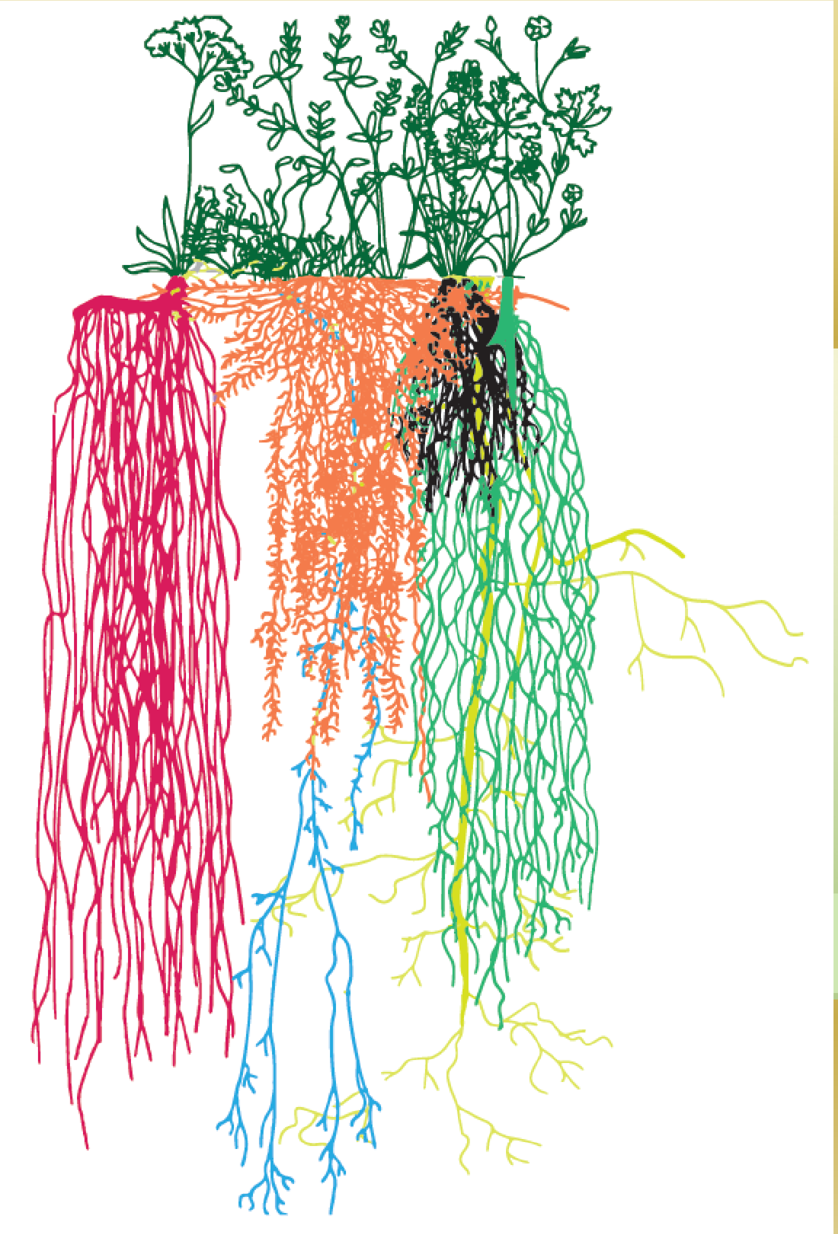
Macrofauna – Soil insect larvae

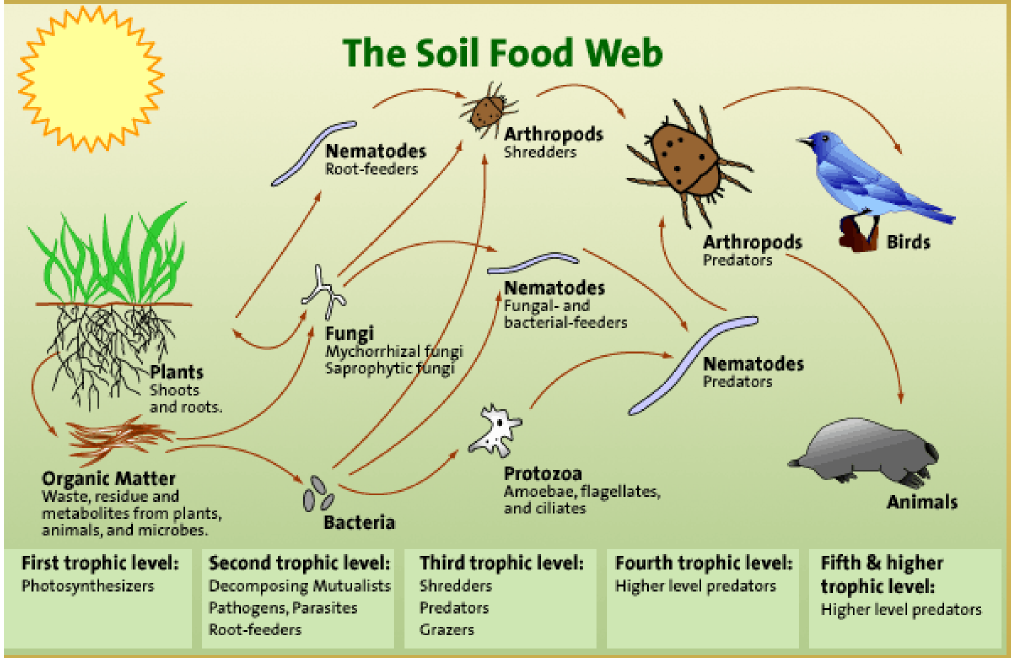
Macrofauna – Ground- and litter-dwelling macrofauna

Megafauna – Mammalia, Reptilia and Amphibia



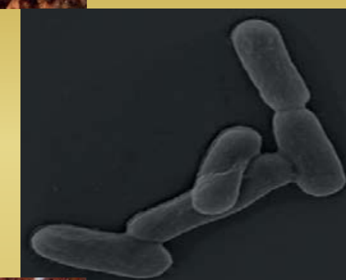
Algae, 10 µm
Silt, <60 µm
Fine sand <200 µm
Pore space
Actinomycete,
2 µm
Bacteria
Clay, <2 µm
Root, 0.2 mm
Root hair, 10 µm
Fungal hyphae,
5 µm
Bacteria, 2 µm
20 µm = 0.02 mm
Air-water interface
Diffusion pathway
Water films
Air-filled pore space,
(15–21 % O2)

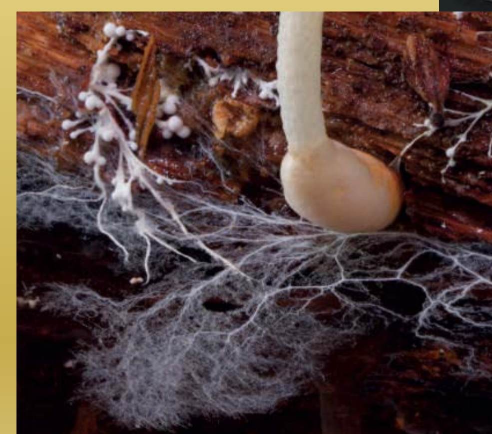


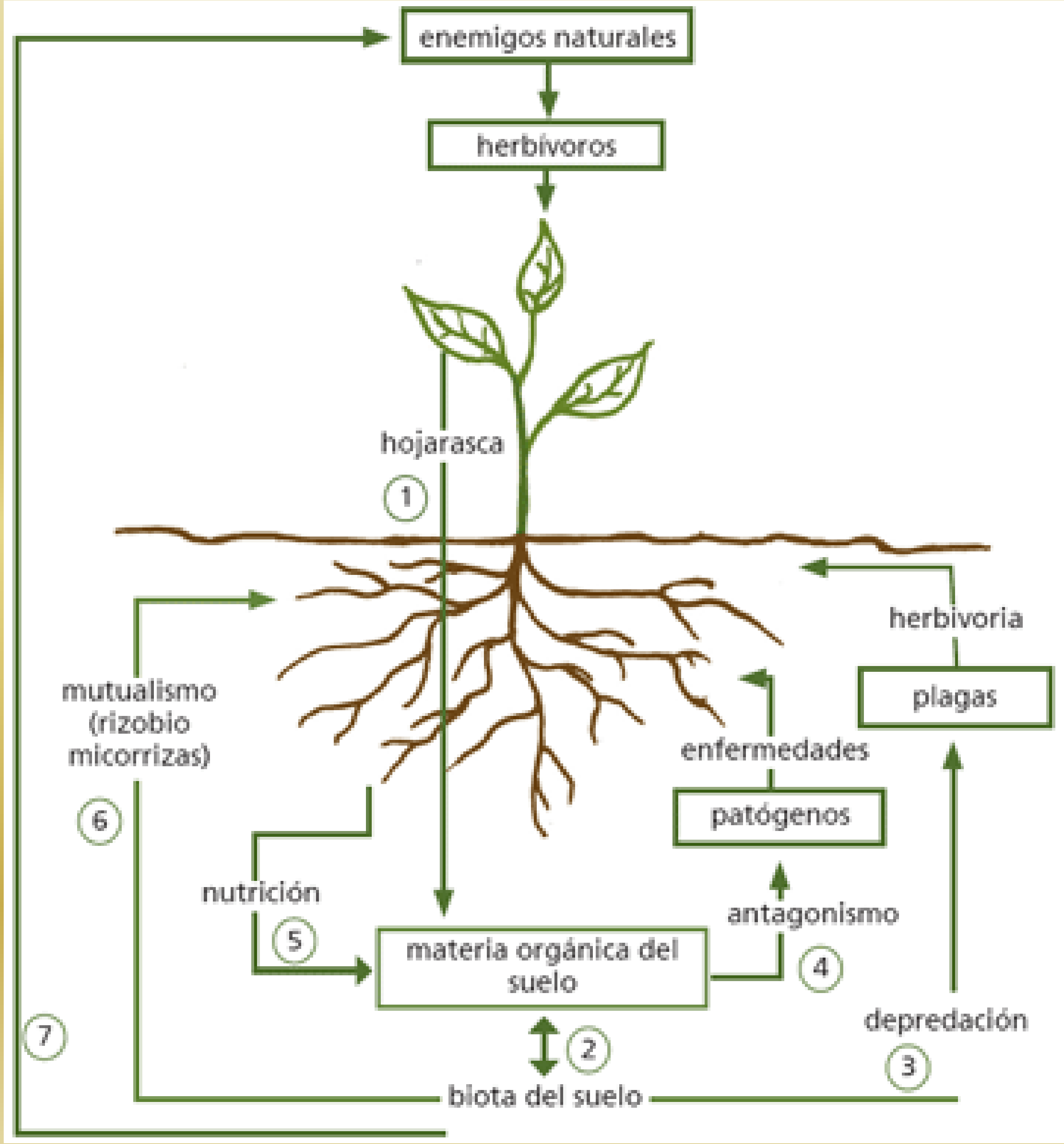


The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Nematodes
Fungal- and
bacterial-feeders
Fungi
Mychorrhizal fungi
Saprophytic fungi
Plants
Shoots
and roots.
Nematodes
Predators
Organic Matter
Waste, residue and
metabolites from plants,
animals, and microbes.
Bacteria
Protozoa
Amoebae, flagellates,
and ciliates
Animals
First trophic level:
Photosynthesizers
Second trophic level:
Decomposing Mutualists
Pathogens, Parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth & higher
trophic level:
Higher level predators

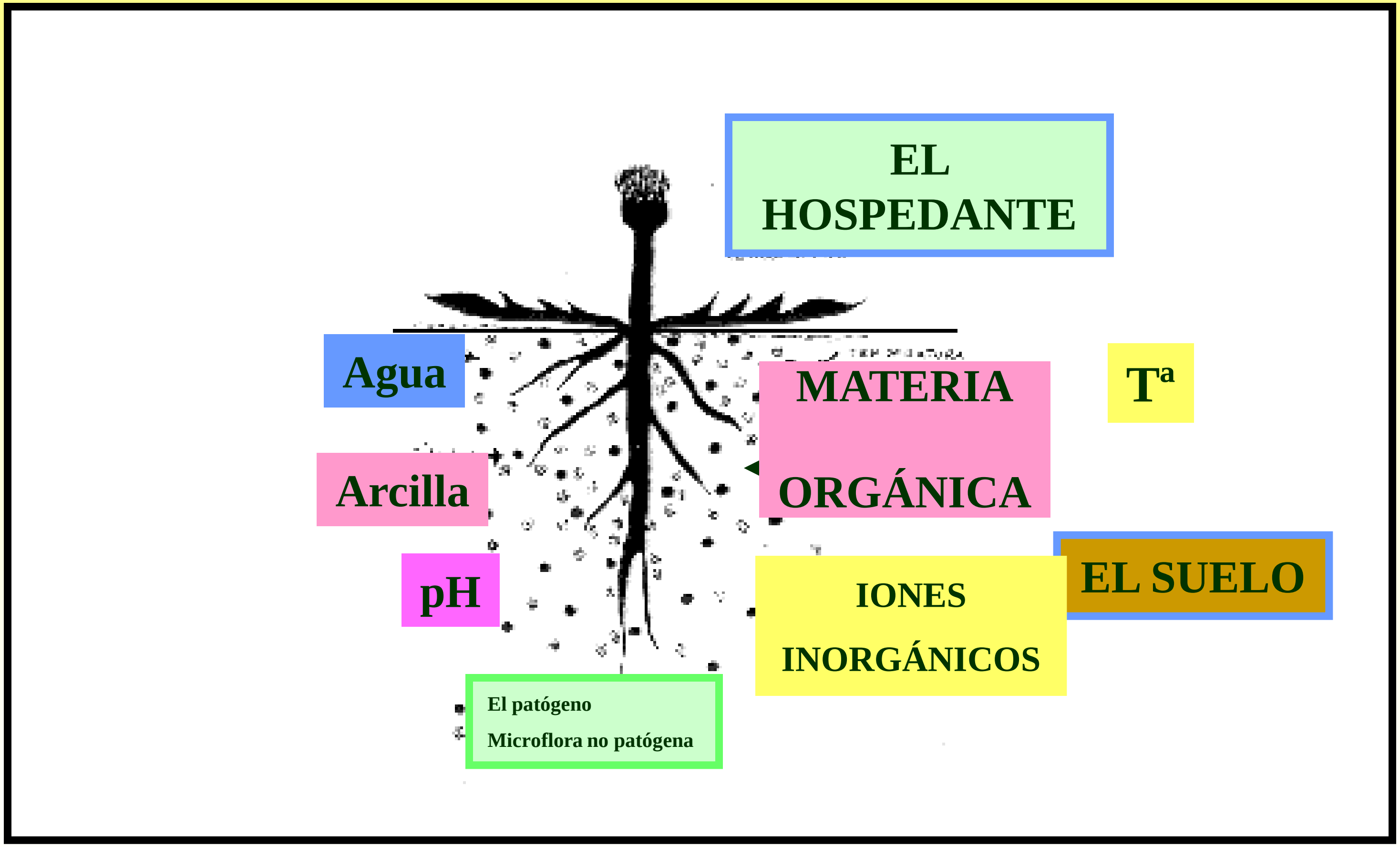

platelmintos
hormigas
aleócaro
ciempiés
seudoescorpiones
ascárides y protozoos
garrapatas
escarabajos
moscas
larvas de mosca
escarabajos
ácaros del suelo
ascárides
bacterias
isópodos
anélidos
tisanuros y colémbolos
hongos
detritos orgánicos
caracoles
milpiés
actinomicetos
garrapatas
babosas



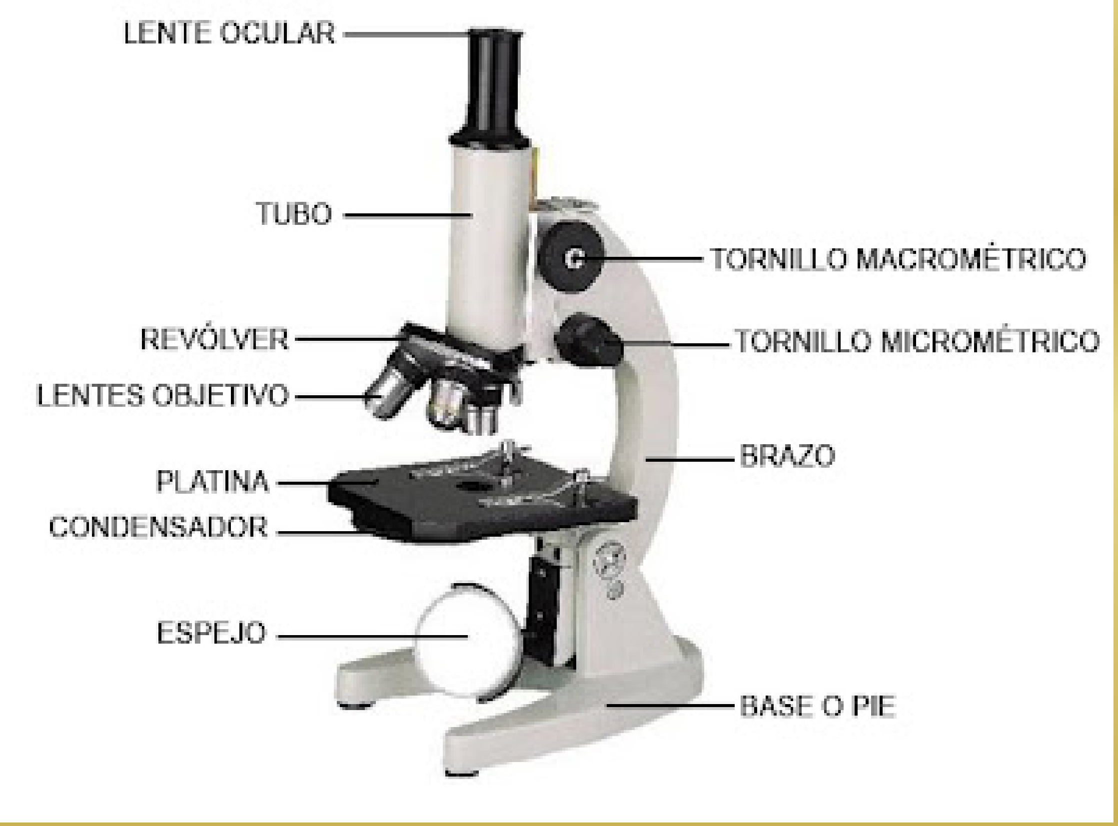



enemigos naturales
herbívoros
hojarasca
1
mutualismo
(rizobio
micorrizas)
6
herbivoria
plagas
enfermedades
patógenos
nutrición
5
antagonismo
materia orgánica del
suelo
4
7
2
depredación
3
biota del suelo

ESQUEMA DEL PATOSISTEMA (según MANGENOT y DIEM 1979)



Methods to study soil biodiversity



Embudo Berlese

Recogida para estudio de la macro y microfauna del suelo

Nematodos de vida libre - Embudo Baermann

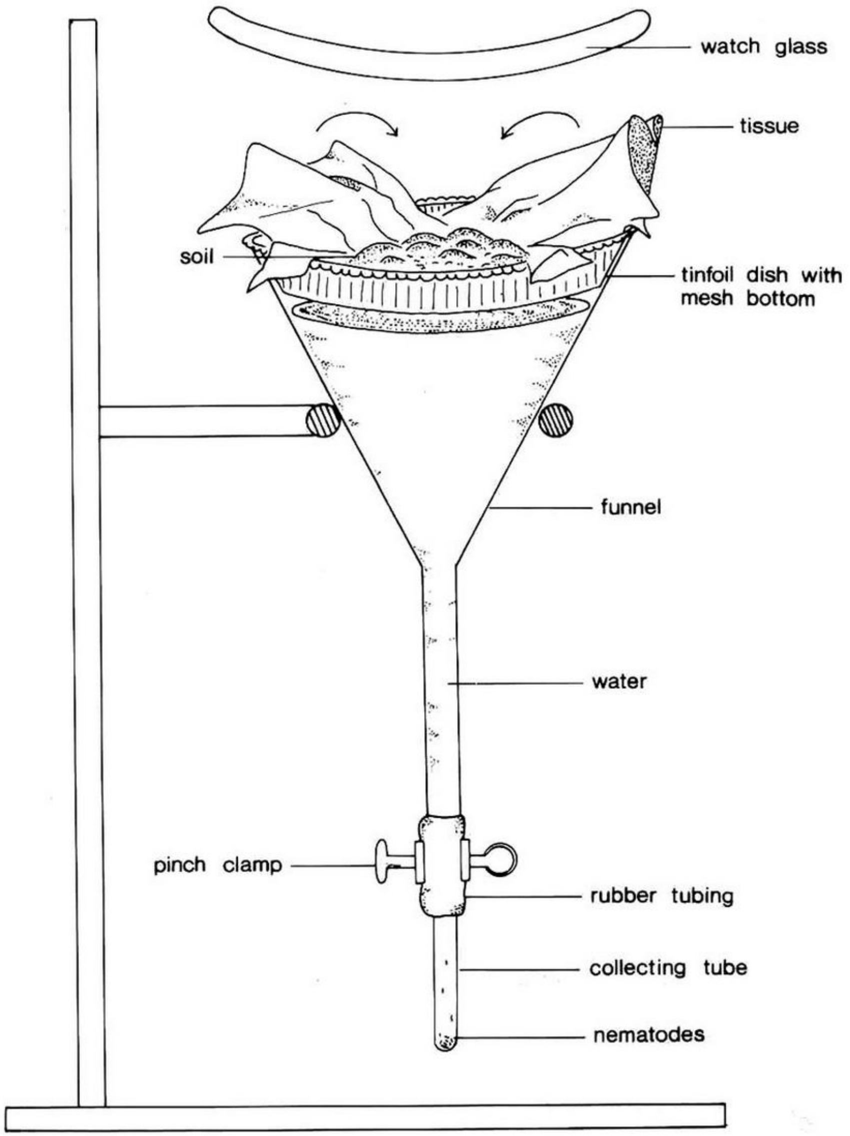
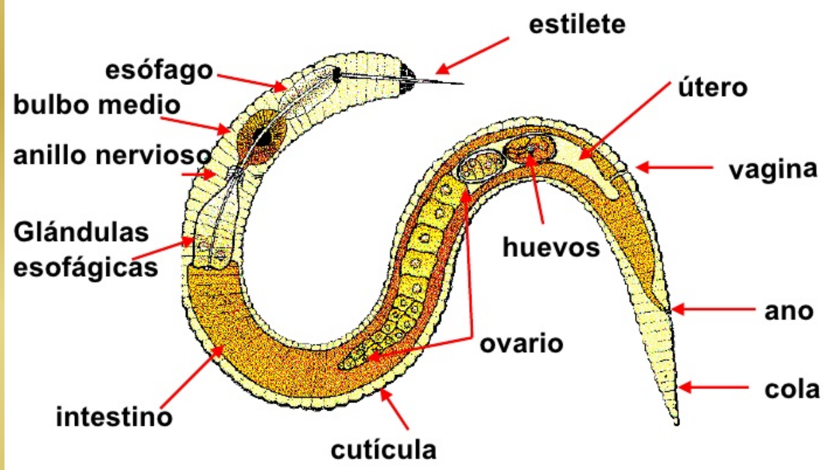


Fig. 57. Baermann funnel apparatus for nematode extraction from soil. Water in funnel should reach just above the bottom of the mesh.



Nematodos

CLASIFICACIÓN DE NEMATODOS SEGÚN SU PAUTA NUTRICIONAL

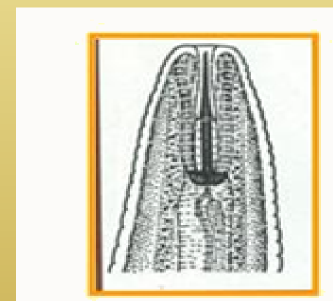
OMNIVOROS
BACTERIOFAGOS que parasitan insectos, y pueden utilizarse en control biológico de plagas
FUNGÍVOROS
PREDADORES

FITOPARÁSITOS parasitan vegetales,

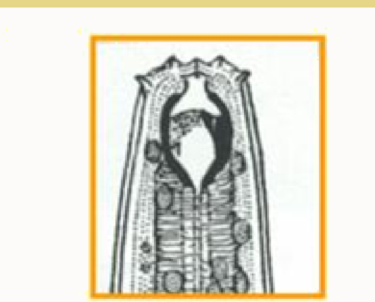
- **ECTOPARÁSITOS**
- **ENDOPARÁSITOS**

OMNIVOROS

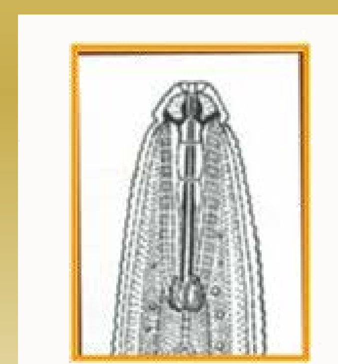
BACTERIOFAGOS



FUNGÍVOROS



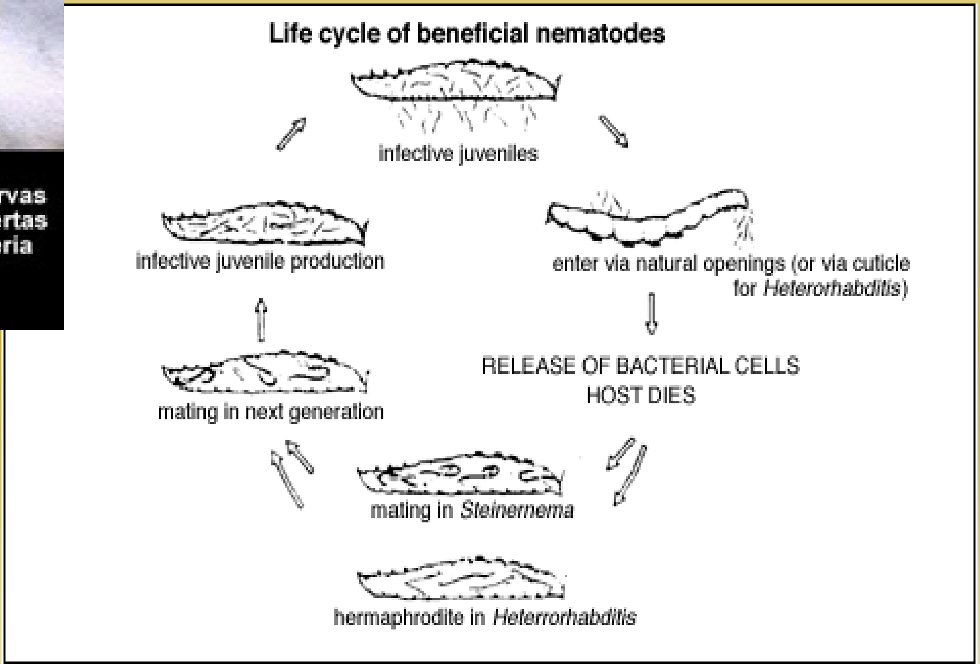
PREDADORES



FITOPARASITOS

Nematodes

Larvas de *Galleria mellonella* muertas por acción de los nematodos. Las larvas de la izquierda han sido muertas por *Steinernema* y las de la derecha muertas por *Heterorhabditis* con el tono rojizo que caracteriza la accion de su bacteria simbionte.
(foto tomada en el laboratorio del Ing. Luis Lizárraga, Cusco-Perú)

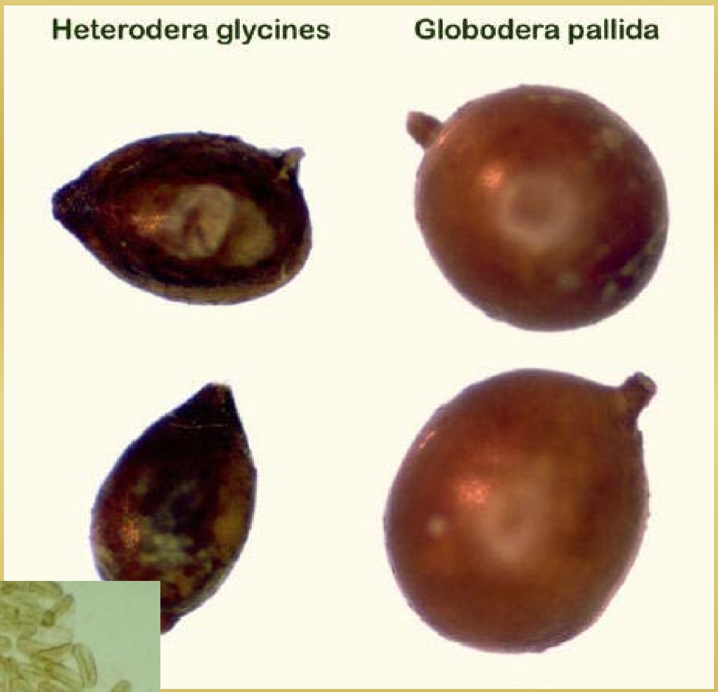


Nematodos

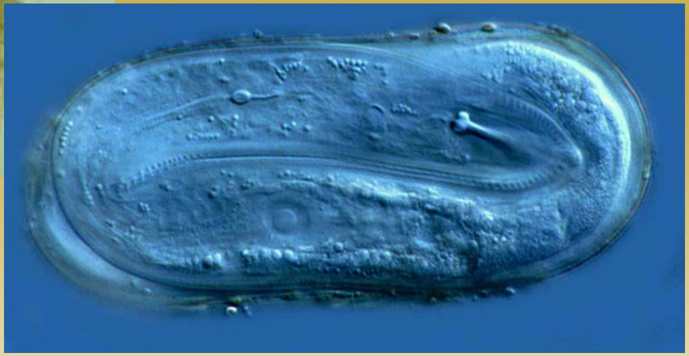
- **La estructura de la comunidad de nematodos juega un papel importante en la mineralización e inmovilización de la MOS. (Neher,2001)**
- **Indicador de calidad de sustrato y de liberación de nutrientes**
- **Bioindicadores**
- **Adición enmiendas orgánicas altera la composición de la comunidad de nematodos.**

Nematodos fitoparásitos

Extracción de nematodos formadores de quistes.-Método de Fenwick



Quiste de *Heterodera* mostrando huevos en interior



Nematodos fitopatógenos

Nematodos formadores de agallas

Quistes de nematodos *Globodera spp.*

PLAGAS Y ENFERMEDADES DE CULTIVOS

Escarabajo de la patata *Leptinotarsa decemlineata*

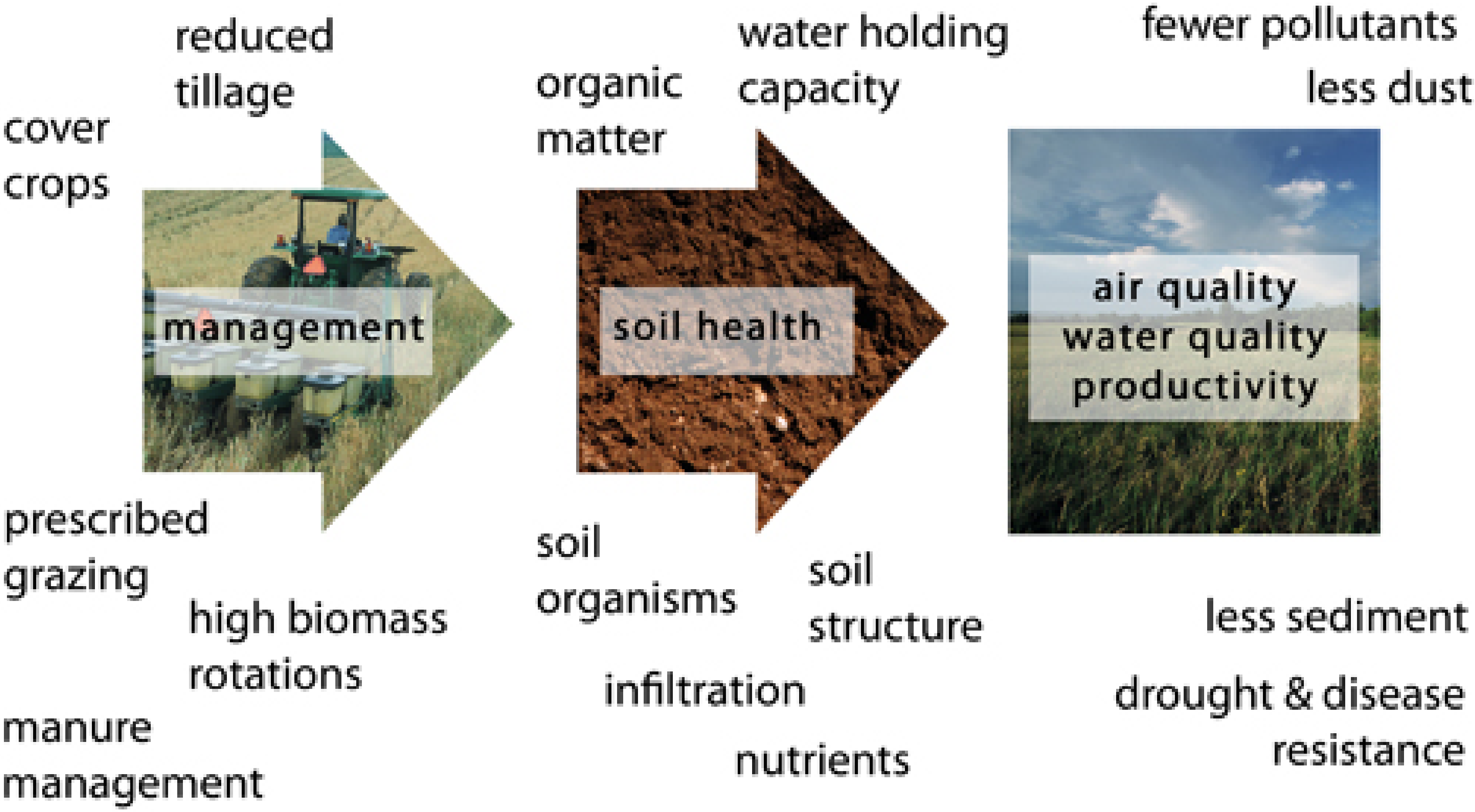
Gorgojo del cereal *Sitophilus granarius*

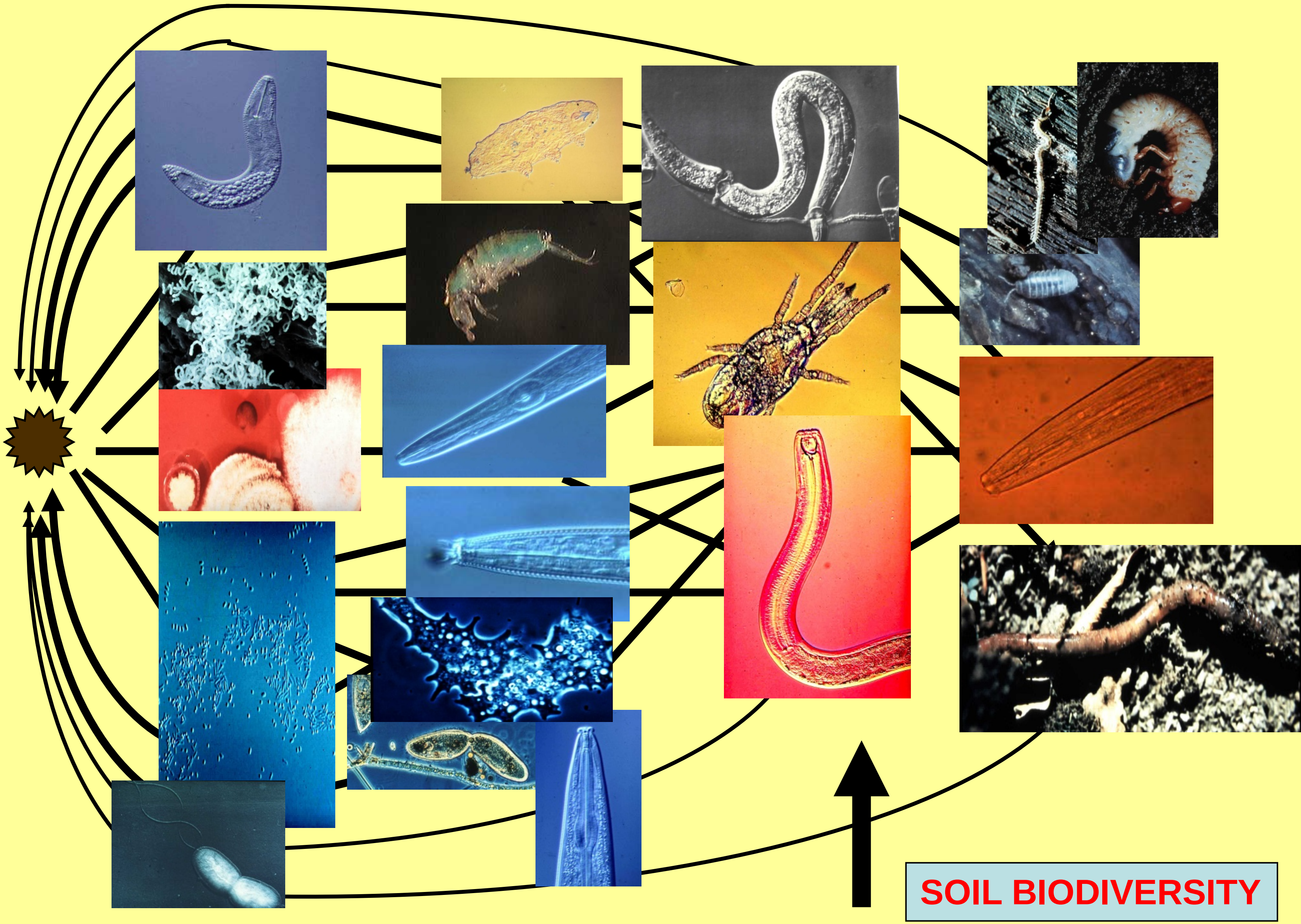
Gorgojo de la lenteja *Bruchus lentis*

Gorgojo de la alubia *Acanthoscelides obtectus*

PLAGAS Y ENFERMEDADES DE CULTIVOS

Managing soil organic matter is the key to air and water quality.




SOIL BIODIVERSITY

SALUD "CALIDAD" DEL SUELO