Macrofauna Family

Macrofauna family
Beetle larva

Beetle larva
Woodlouse
Earthworm
Ant
Millipede
Termite

© Parc national de la Vanoise - Balais Christian

A beetle larva, also called a white grub, lives in the soil and may attack roots.

Actual size 4 cm

Macrofauna family
Woodlouse

Beetle larva
Woodlouse
Earthworm
Ant
Millipede
Termite

© JRC - S. Taiti

A woodlouse, also called a sowbug, lives in litter in the dark and feeds on dead leaves on the ground.

Actual size 1.5 cm

Macrofauna family
Earthworm

Beetle larva
Woodlouse
Earthworm
Ant
Millipede
Termite

© JRC - P. Schmidt

An earthworm contributes to soil fertility and improves the soil structure by digesting several tonnes of soil a year.

Actual size 5-30 cm

Macrofauna family
Ant

Beetle larva
Woodlouse
Earthworm
Ant
Millipede
Termite

© JRC - A. Mori & D. Grasso

An ant is omnivorous. It feeds on everything, including small insects, plant debris, etc.

Actual size 0.8-2 cm

Macrofauna family
Millipede

Beetle larva
Woodlouse
Earthworm
Ant
Millipede
Termite

© E. Blanchart

A millipede is detritivorous. It feeds on, and cuts into pieces, plant debris that has fallen on the ground.

Actual size 8 cm

Macrofauna family
Termite

Beetle larva
Woodlouse
Earthworm
Ant
Millipede
Termite

© JRC - E. Chiappini

A termite feeds on wood, grass, fungi or humus. It lives in termite mounds.

Actual size 0.5-1 cm

The Hidden Life of soils

back of the cards

PROGRAMME SOL

GESSOL
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Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
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INVESTISSEMENTS D'AVENIR

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Megafauna Family

Megafauna family
Wild rabbit

Wild rabbit
Eurasian beaver
Badger
Mole
Marmot
Toad

A wild rabbit stays in its burrow during the day. It comes out at dusk and night to feed on plants (leaves, stems, etc.).

Actual size 40 cm

Megafauna family
Eurasian beaver

Wild rabbit
Eurasian beaver
Badger
Mole
Marmot
Toad

An Eurasian beaver digs burrows and feeds mainly on tree barks, leaves and fruits.

Actual size 1 m

Megafauna family
Badger

Wild rabbit
Eurasian beaver
Badger
Mole
Marmot
Toad

A badger is omnivorous. It feeds on everything (insects, rodents, fungi, earthworms, etc.).

Actual size 70 cm

Megafauna family
Mole

Wild rabbit
Eurasian beaver
Badger
Mole
Marmot
Toad

A mole lives alone in tunnels that it digs, where it finds its preferred food – earthworms!

Actual size 15 cm

Megafauna family
Marmot

Wild rabbit
Eurasian beaver
Badger
Mole
Marmot
Toad

A marmot hibernates underground for 6 months. It likes eating plants in the summer, consuming everything from the stems to the flowers.

Actual size 50 cm

Megafauna family
Toad

Wild rabbit
Eurasian beaver
Badger
Mole
Marmot
Toad

A toad feeds on insects. It is particularly active at night and hides during the day in holes that it digs in the ground.

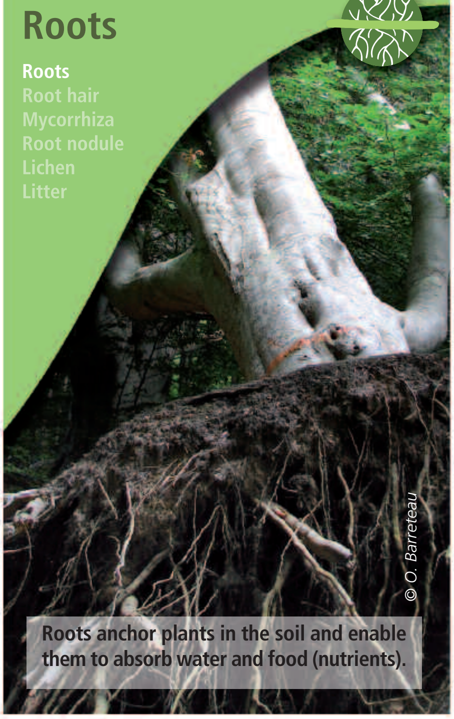
Actual size 5-10 cm

The Hidden Life of soils

Plant Family

Plant family
Roots

Roots
Root hair
Mycorrhiza
Root nodule
Lichen
Litter

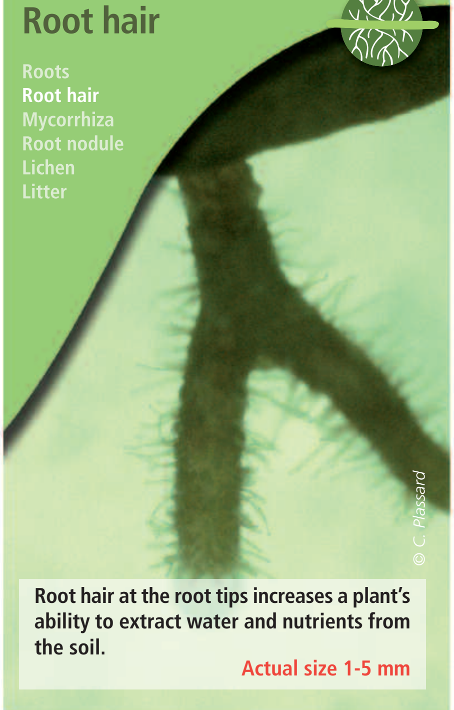


© O. Barreteau

Roots anchor plants in the soil and enable them to absorb water and food (nutrients).

Plant family
Root hair

Roots
Root hair
Mycorrhiza
Root nodule
Lichen
Litter



© C. Plassard

Root hair at the root tips increases a plant's ability to extract water and nutrients from the soil.

Actual size 1-5 mm

Plant family
Mycorrhiza

Roots
Root hair
Mycorrhiza
Root nodule
Lichen
Litter

© C. Plassard

Mycorrhiza is a symbiotic interaction between a fungus (white on the image) and a root. It enables fungi and plants to join forces for feeding.

Plant family
Root nodule

Roots
Root hair
Mycorrhiza
Root nodule
Lichen
Litter

© JRC - K. Ritz

Root nodules host bacteria that have established a symbiotic interaction with a root. It enables plants to take up essential nitrogen directly from the air.

Actual size 1-5 mm

Plant family
Lichen

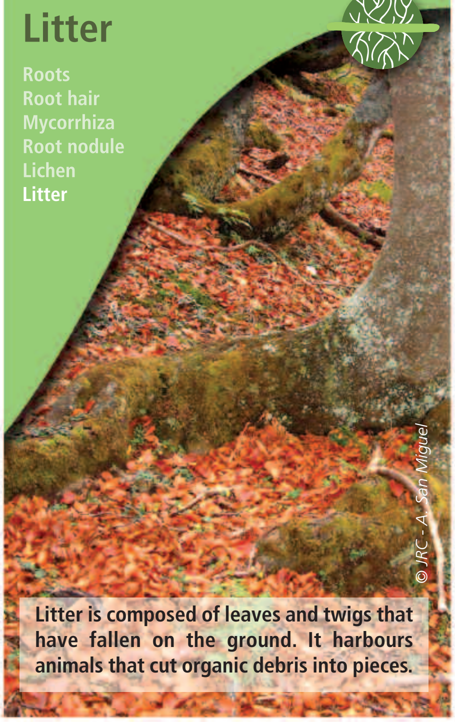
Roots
Root hair
Mycorrhiza
Root nodule
Lichen
Litter

© JRC - B. Haynold

Lichens are the result of a symbiotic relationship between an alga and a fungus. They are able to attach directly onto rocks and may initiate soil formation.

Plant family
Litter

Roots
Root hair
Mycorrhiza
Root nodule
Lichen
Litter



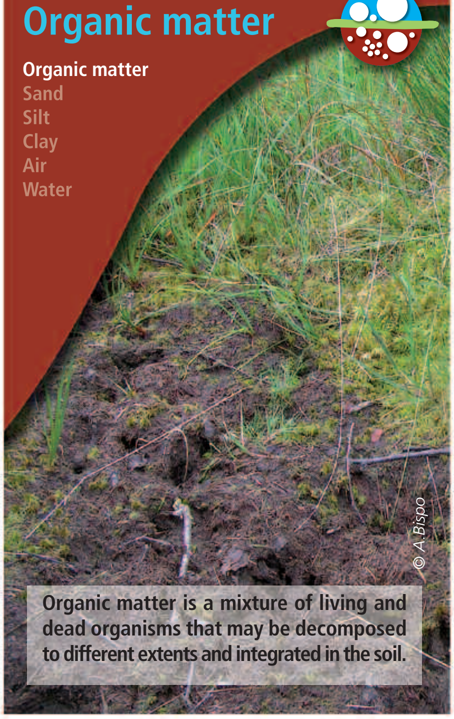
© JRC - A. San Miguel

Litter is composed of leaves and twigs that have fallen on the ground. It harbours animals that cut organic debris into pieces.

Soil Family

Soil family
Organic matter

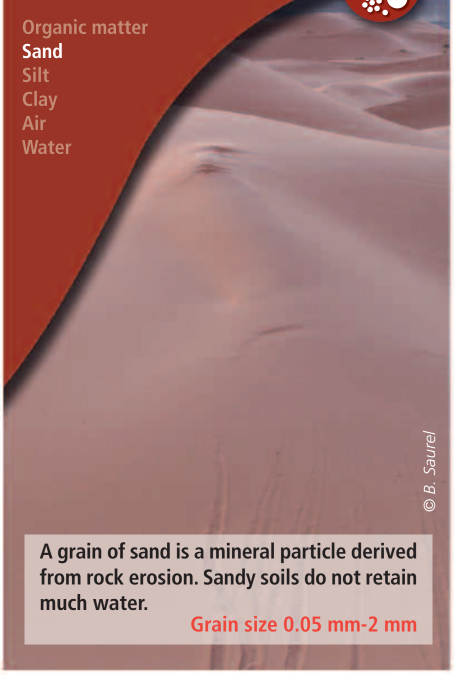
Organic matter
Sand
Silt
Clay
Air
Water



Organic matter is a mixture of living and dead organisms that may be decomposed to different extents and integrated in the soil.

Soil family
Sand

Organic matter
Sand
Silt
Clay
Air
Water

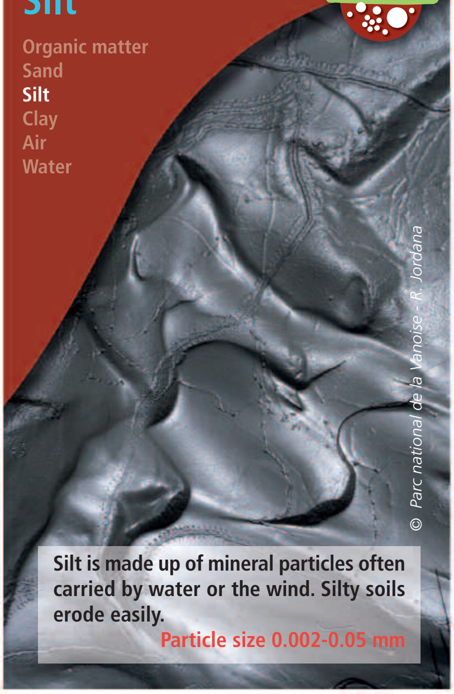


A grain of sand is a mineral particle derived from rock erosion. Sandy soils do not retain much water.

Grain size 0.05 mm-2 mm

Soil family
Silt

Organic matter
Sand
Silt
Clay
Air
Water

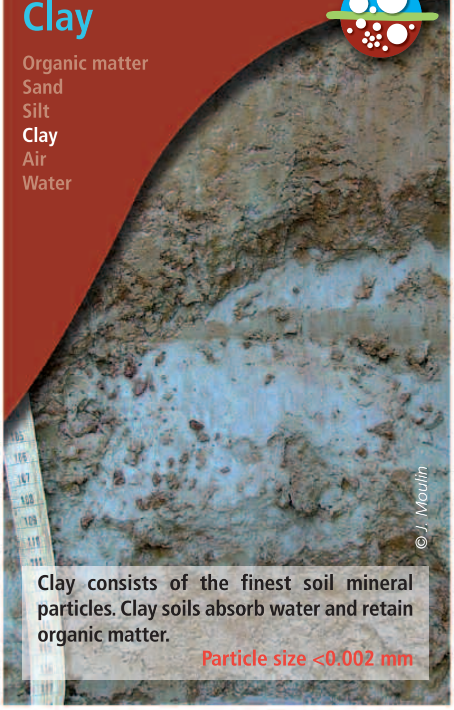


Silt is made up of mineral particles often carried by water or the wind. Silty soils erode easily.

Particle size 0.002-0.05 mm

Soil family
Clay

Organic matter
Sand
Silt
Clay
Air
Water



Clay consists of the finest soil mineral particles. Clay soils absorb water and retain organic matter.

Particle size <0.002 mm

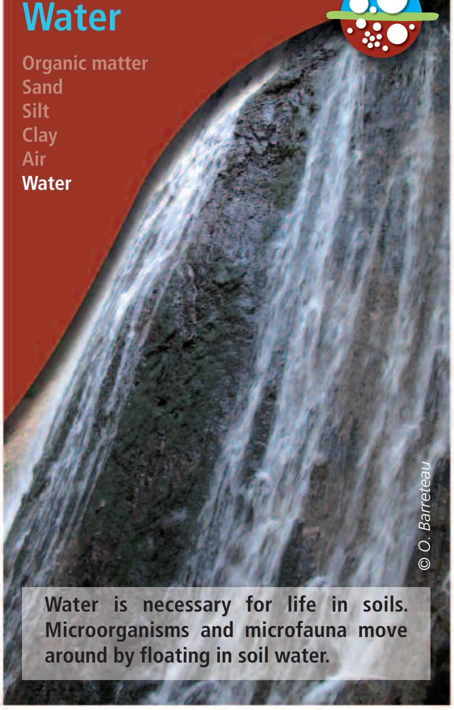
Soil family
Air

Organic matter
Sand
Silt
Clay
Air
Water

Air provides the oxygen necessary for soil organisms, which in turn release carbon dioxide (CO_2).

Soil family
Water

Organic matter
Sand
Silt
Clay
Air
Water

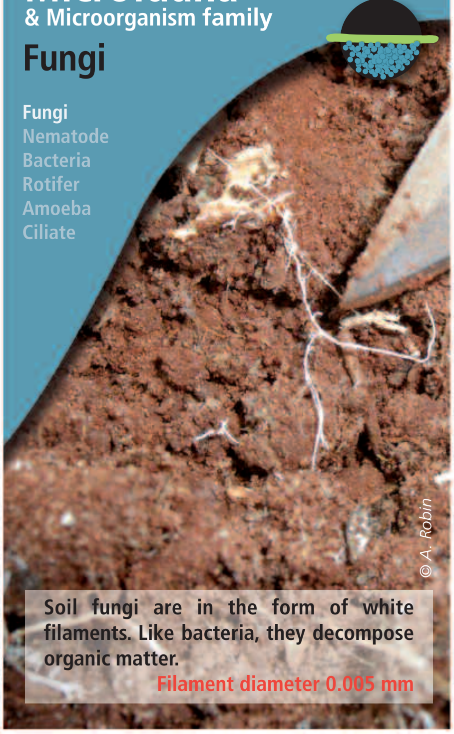


Water is necessary for life in soils. Microorganisms and microfauna move around by floating in soil water.

MicroFauna Family

Microfauna
& Microorganism family
Fungi

Fungi
Nematode
Bacteria
Rotifer
Amoeba
Ciliate



Soil fungi are in the form of white filaments. Like bacteria, they decompose organic matter.
Filament diameter 0.005 mm

Microfauna
& Microorganism family
Nematode

Fungi
Nematode
Bacteria
Rotifer
Amoeba
Ciliate

A nematode may be a plant parasite or a predator of bacteria, fungi or other nematodes.
Actual size 0.2 mm

Microfauna
& Microorganism family
Bacteria

Fungi
Nematode
Bacteria
Rotifer
Amoeba
Ciliate

Bacteria are widespread in soils. They transform organic matter into nutrients that feed plants.
Actual size 0.003 mm

Microfauna
& Microorganism family
Rotifer

Fungi
Nematode
Bacteria
Rotifer
Amoeba
Ciliate

A rotifer lives in soil water and feeds on bacteria and protozoans.
Actual size 0.3 mm

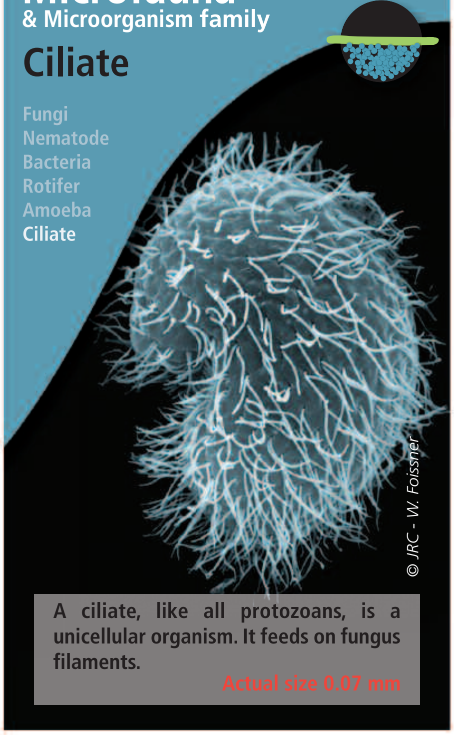
Microfauna
& Microorganism family
Amoeba

Fungi
Nematode
Bacteria
Rotifer
Amoeba
Ciliate

An amoeba is a protozoan that feeds mainly on bacteria and organic matter in the soil.
Actual size 0.01-0.1 mm

Microfauna
& Microorganism family
Ciliate

Fungi
Nematode
Bacteria
Rotifer
Amoeba
Ciliate



A ciliate, like all protozoans, is a unicellular organism. It feeds on fungus filaments.
Actual size 0.07 mm

The Hidden Life of soils

GSOL

MesoFauna Family

Mesofauna family
Tardigrade

Tardigrade
Enchytraeid
Proturan
Collembola
Mite
Dipluran

© JRC - Eye of science

A tardigrade, also called a water bear, hunts rotifers, nematodes and protozoans.
Actual size 0.5 mm

Mesofauna family
Enchytraeid

Tardigrade
Enchytraeid
Proturan
Collembola
Mite
Dipluran

© JRC - H.C. Fründ

An enchytraeid (left on the photo) is related to the earthworm (right on the photo). It feeds on dead leaves.
Actual diameter 0.2 mm diameter

Mesofauna family
Proturan

Tardigrade
Enchytraeid
Proturan
Collembola
Mite
Dipluran

© JRC - D. Walter

A proturan has 6 legs, but no wings, eyes or antennae. It feeds on microorganisms.
Actual size 1 mm

Mesofauna family
Collembola

Tardigrade
Enchytraeid
Proturan
Collembola
Mite
Dipluran

© JRC - C. Menta

A collembola lives mainly in litter. It feeds on fungi and bacteria.
Actual size 0.5 mm

Mesofauna family
Mite

Tardigrade
Enchytraeid
Proturan
Collembola
Mite
Dipluran

© JRC - D. Walter

Mites are related to spiders. They generally feed on plant debris, but are also sometimes predators.
Actual size 0.5 mm

Mesofauna family
Dipluran

Tardigrade
Enchytraeid
Proturan
Collembola
Mite
Dipluran

© JRC - D. Walter

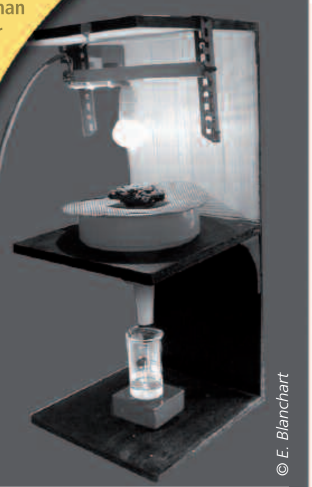
A dipluran is a predator. It hunts mites and collembolae using its mandibles.
Actual size 2 mm

The Hidden Life of soils

Scientific Family

Scientific family
Berlese funnel

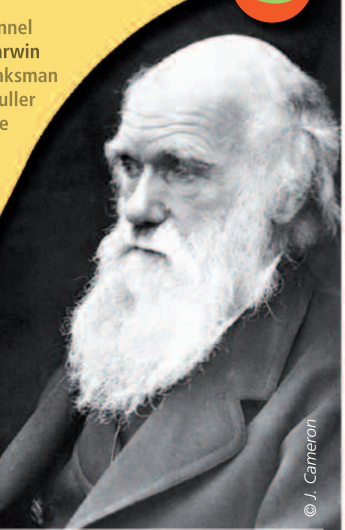
Berlese funnel
Charles Darwin
Selman Waksman
Peter E. Muller
Microscope
Auger


© E. Blanchart

A Berlese funnel is used to extract soil mesofauna to be able to observe and study these small organisms (less than 2 mm).

Scientific family
Charles DARWIN

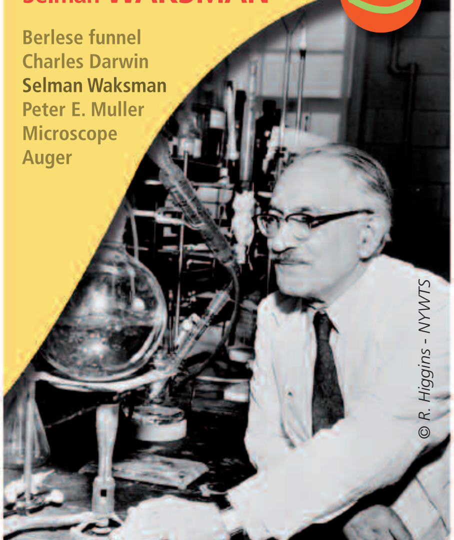
Berlese funnel
Charles Darwin
Selman Waksman
Peter E. Muller
Microscope
Auger


© J. Cameron

Charles DARWIN (1809-1882) was the first scientist to highlight the importance of earthworms in enhancing the fertility and structure of soils.

Scientific family
Selman WAKSMAN

Berlese funnel
Charles Darwin
Selman Waksman
Peter E. Muller
Microscope
Auger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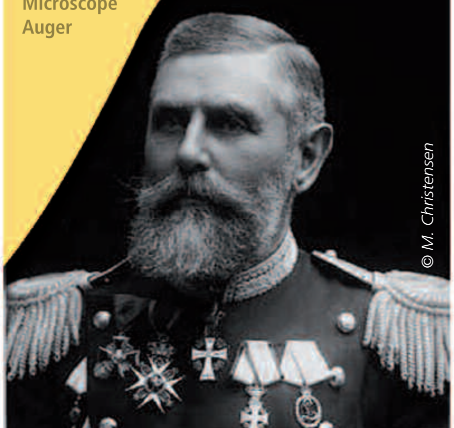
Selman WAKSMAN (1888-1973) studied soil microorganisms. It led him to discover antibiotics that are now widely used to treat diseases.

Scientific family
Peter E. MULLER

Berlese funnel
Charles Darwin
Selman Waksman
Peter E. Muller
Microscope
Auger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Peter E. MULLER (1840-1926) demonstrated that soil organisms participate in soil formation.

Scientific family
Microscope

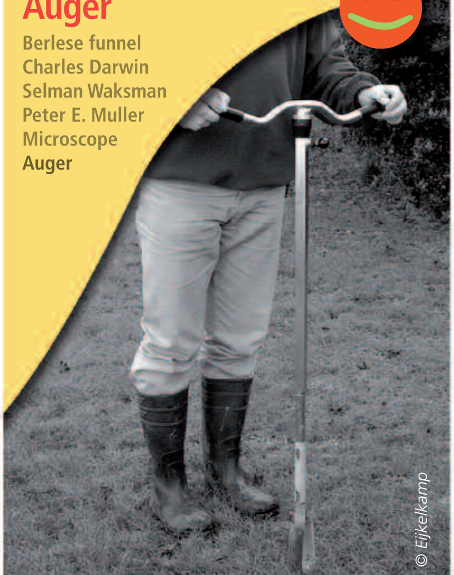
Berlese funnel
Charles Darwin
Selman Waksman
Peter E. Muller
Microscope
Auger


© T. Chevallier

A microscope magnifies minute organisms (0.001-1 mm) to facilitate their observation.

Scientific family
Auger

Berlese funnel
Charles Darwin
Selman Waksman
Peter E. Muller
Microscope
Auger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An auger is used to collect soil samples at different depths. Just turn it and push down on the handle.

7 Happy Families

PLAYING RULES

The object of the game is to collect as many sets of families as possible.

One player shuffles and deals 7 cards to each player. The remaining cards are placed faced down to form the stock. The player to the dealer's left plays first by asking any player for a specific card from a family that he/she is collecting, but the player must already have at least one other card from that family. The aim is to collect the complete family. For example, the asking player can say, "In the Macrofauna family, do you have the earth-worm?" The 6 members of the family are listed at the top of each card. The asked player must hand over the card if he/she has it. If the asking player obtains the requested card then he/she can play again, but if not the top card of the stock must be drawn. If the requested card is drawn, then the player says "good draw" and plays again, otherwise the next player takes the turn. Once a player collects a complete family, it is set on the table and the player plays again. The player who has the most complete family sets at the end wins.

2-4 | From 8 years | 15 mn

The Hidden Life of soils

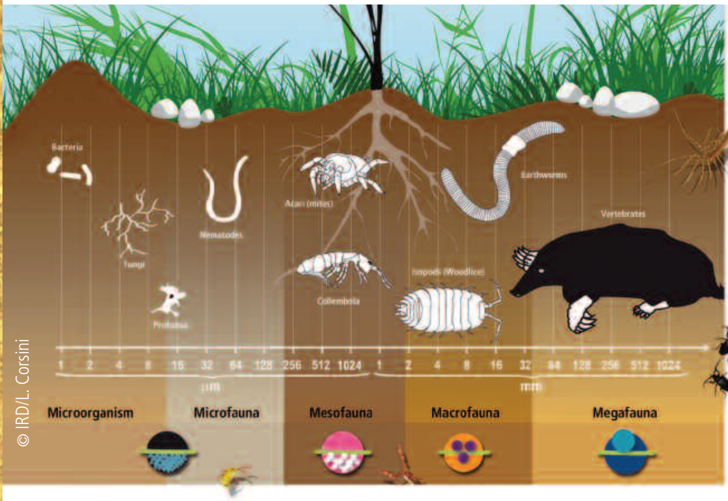
Microfauna Mesofauna Macrofauna Megafauna Soil Plant Scientific

The Hidden Life of soils

PROGRAMME GESSOL Fonctions environnementales & gestion du patrimoine sol

Every day we walk, run and play on the soil, without regard for the world of tiny organisms that it hosts. But just a teaspoon of soil may contain millions of living organisms belonging to thousands of different species. Around 25% of all animal and plant species that have been described in the world inhabit or spend much of their lives in the soil. Our knowledge about these organisms is still limited because they live in a dark opaque environment and most of them are too small to be visible to the naked eye. A large portion of these species have not yet been described and named by specialists – unknown species live in our gardens!

Scientists generally classify soilborne organisms by size. From left to right, smallest are microorganisms (bacteria, fungi, etc.), followed by microfauna (nematodes, etc.), mesofauna (collembola, mites, etc.) and macrofauna (woodlice, earthworms, etc.). Finally, the largest correspond to megafauna, represented by vertebrates such as moles.



7 Happy Families
The Hidden Life of Soils

1- Microfauna and Microorganism family

These are the smallest and most numerous soil organisms. They can only be seen under a microscope. This family includes unicellular organisms, such as bacteria and protozoans (ciliates and amoeba), and multicellular organisms, including fungi, rotifers and nematodes.

2- Mesofauna family

Here again, these organisms are too small (less than 2 mm) to be visible to the naked eye, but they may be viewed under a magnifying glass. Strange invertebrates are found in this family – tardigrades, enchytraeids, mites, and small insects such as collembolans, diplurans and proturans.

3- Macrofauna family

Organisms of this family are visible to the naked eye – some are several centimetres in length, and a few earthworms grow to over a metre! Earthworms and some insect larvae in this invertebrate family may also be seen on the soil surface: woodlice, millipedes, ants and termites.

4- Megafauna family

These organisms are much larger, but not very numerous in soils. You will have to be patient to see them. These burrowing vertebrates include toads, moles, beavers, rabbits and badgers.

5- Soil family

The soil consists of different components: solid particles (sand, silt, clay, organic matter), air and water. Soil diversity depends on the diversity of these particles, the climatic conditions, the soil use (agriculture, forestry, etc.) and the diversity of organisms that inhabit this environment.

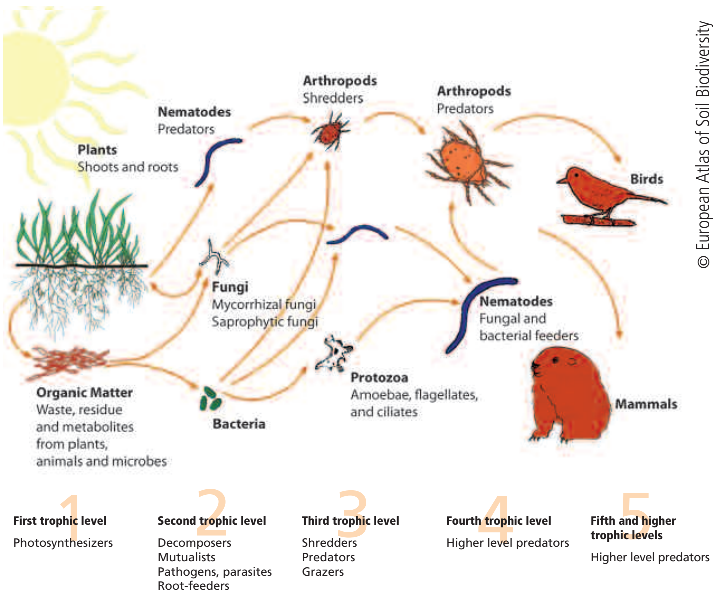
6- Plant family

Plants contribute to soil organic matter with their leaves which fall and form a litter layer on the soil surface. Plants are also anchored in the soils with their roots. Tipped with absorbing root hair, these roots are often associated with fungi (mycorrhizae) or bacteria (nodules). Lichen is also the result of a symbiotic association between an alga and a fungus.

7- Scientific family

Scientists such as C. Darwin, P.E. Muller and S. Waksman, using simple tools such as an auger, Berlese funnel or microscope, have enhanced our knowledge on life in soils. Nowadays, scientists use bioinformatics and advanced technologies to study soil biodiversity via DNA analysis

The soil trophic network



The hidden life of soils

The soil is a dark, opaque, heterogeneous and ever-changing environment. Microorganisms, microfauna, mesofauna and macrofauna cross paths and eat, ignore or associate with one another. Soil organisms feed on **organic matter** or organisms that have fed on organic matter in what is called the **soil trophic network,** which is sometimes simply represented as a **food chain.** Microorganisms, **bacteria and fungi,** are the main organic matter consumers, which are in turn eaten by protozoans (such as **ciliates or amoeba), rotifers, nematodes or collembolans.** The latter are also eaten by their predators, i.e. slightly larger organisms such as **tardigrades, mites, proturans,** etc. Through this activity, plant debris is cut into small pieces, fragmented, transformed and mixed with soil mineral particles by fungi, bacteria, protozoans, **insect larvae, earthworms, millipedes, enchytraeids, diplurans,** etc.

This trophic network, fueled by dead plant debris, is essential for plant growth. All of these organisms ingest organic matter to generate energy, resulting in waste and nutrient production. **These nutrients** are then taken-up by plants through their roots and absorbing **root hair and allows them to grow**. The same nutrients, such as nitrogen (N), phosphorus (P) and potassium (K), are found in bags of fertilizer. Soil organisms thus recycle **organic matter** produced above the soil to make the nutritional mineral matter required for plant growth. Without these organisms, debris from leaves and dead wood would accumulate in very thick layers on the soil surface and plants would merely die out!

Soil organisms do not just eat one another, some of them also facilitate plant nutrition via associations – a phenomenon called **symbiosis.** Such associations between two organisms belonging to different species are generally mutually beneficial. **Lichen** is an association between an alga and a fungus. Algae provide sugar and sometimes nitrogen from the air, while fungi provide protection, water and nutrients. In the soil, some plant roots have developed symbioses with **fungi (mycorrhizae)** or bacteria (nodes or **nodules**). In mycorrhizae, fungal filaments broaden the root expansion area, thus enhancing the uptake of soil nutrients and water. In nodules, bacteria capture atmospheric nitrogen and transmit part of it to the roots. In turn, the plant provides sugar required for bacterial or fungal development. Most plants have mycorrhizae. Symbioses between bacteria and roots occur mainly in legumes (a plant family that includes beans, peas, broad beans and soybeans).

Soil organisms also contribute to soil production and structuring. **Lichen** is able to attach directly on rocks and participates in the gradual soil formation process and the installation of other plants and animals. The activity of these organisms subsequently participates directly in soil structuring. The soil is not a uniform compact layer of material – there are 'voids', i.e. holes and galleries in which **air and water** can circulate, as well as 'solids', i.e. soil clumps or aggregates of different sizes. Most of these holes and aggregates are formed by soil organisms (galleries and droppings of **earthworms, insect larvae, termites, ants**) and may be consolidated by fungal filaments or adhesives produced by bacteria. Root penetration in the soil is highly dependent on the layout of these voids and solids, i.e. the soil structure. This structure also determines the quantity of air and water stored in the soil and available for uptake by plant roots.

The activities of organisms that live in the soil ensure its proper functioning, especially plant growth, as well as the quality of the air and water that passes through this environment. The soil is fragile, like all living environments. Soil biodiversity is directly threatened by soil degradation. A degraded soil, e.g. depleted of organic matter or eroded, can be restored, but this is often difficult and takes a very long time. Urbanisation, erosion and pollution are the main threats to soils. Urbanisation, deforestation, cropping, and other land use changes, can also lead to biodiversity loss because the organisms generally do not have enough time to move or adapt to the new environment. Gaining insight into soils, their functioning and the hosted organisms which shape them helps preserve soils and the services they provide, such as wood and food production.

This card game was initially designed and published in French under the GESSOL research programme, funded by the French Ministry of Ecology. This programme supports many research initiatives regarding soils and their sustainable management (www.gessol.fr).

For a complete and visually stunning depiction of soil biodiversity, the European atlas of soil biodiversity edited by the European Commission is available for order and free download here: http://bookshop.europa.eu/

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