

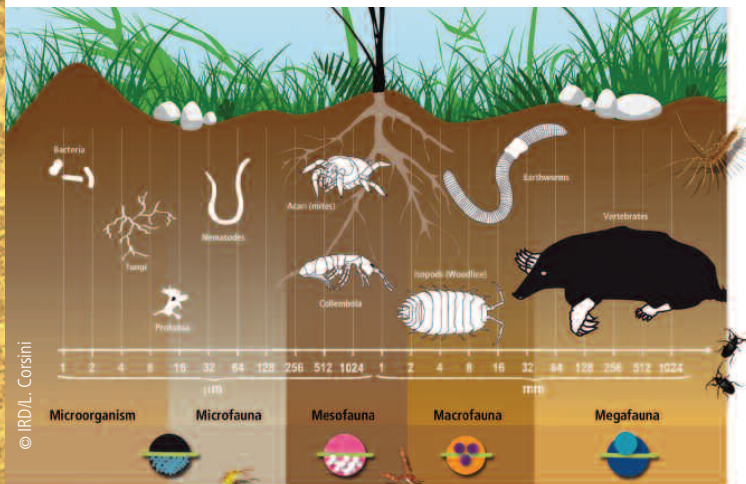
The Hidden Life of soils

PROGRAMME



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.



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

7 Happy Families The Hidden Life of Soils

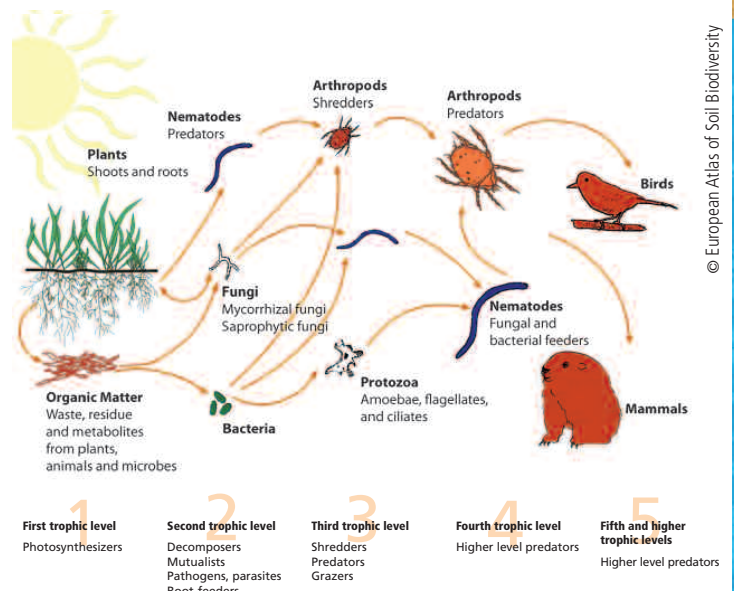
1- Microfauna and Microorganism family

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.

The soil trophic network



- 1 First trophic level: Photosynthesizers
- 2 Second trophic level: Decomposers, Mutualists, Pathogens, parasites, Root-feeders
- 3 Third trophic level: Shredders, Predators, Grazers
- 4 Fourth trophic level: Higher level predators
- 5 Fifth and higher trophic levels: Higher level predators

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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