UT Extension
W 292-A

Environmental Science

Life Beneath Your Feet

In this activity, students will explore the variety of organisms that live in soils.

Subject Area:
Environmental Science

Skill Level:

Beginner to Intermediate

Learner Outcomes:

⇒ Understand the types of microbes and small invertebrates that live in soils.

⇒ Isolate small invertebrates and nematodes from soil using a Berlese funnel.

⇒ Observe, describe and identify the organisms isolated.

Tennessee Science Curriculum Standard GLEs:

S1. Embedded Inquiry
0607.Inq.1-5, 0707.Inq.1-5, 0807.Inq.1-5

S2. Interdependence
0607.2.1-2

S5. Biodiversity and Change
0807.5.1-3

Success Indicator:
Students will understand the role of decomposers and be able to identify a couple of types of organisms.

Science Skills:
Develop hypothesis, experimental design, observe, collect data, interpret.

Life Skills:
Observing, Reasoning

Tags:
soil microfauna, arthropods, habitat, decomposer

Money Saving Tip:
The last few pages of the student handout have a colorful "field guide" to common soil organisms. To save on printing costs, just print one or two copies for the class (you could laminate and pass around or project on a screen).

Note on timing: The isolation of microfauna from soils using a Berlese funnel takes one to three days. Students can participate in the collection of soils and funnel setup, then observe the results three days (or more) later. If collecting insects in ethanol or isopropanol, they will be preserved and can be observed a week (or more) later. You could also set this up yourself, let it sit for a few days, then bring the preserved organisms to your 4-H'ers.

Introduce the activity by explaining key concepts:

⇒ Different parts of the soil provide different **habitats** for organisms. Some favorite places include the **rhizosphere** (around roots), in **leaf litter**, in **humus**, on **aggregates** (clumps) and in **pore spaces**. Have the students examine the diagram on page two and fill in some of these favorite habitats (ANSWERS: leaf litter, pore spaces, around roots).

⇒ Most organisms in the soil are **decomposers**. They are nature's recyclers. They are responsible for cleaning up the old plant material. They use it for food, turning it back into nutrients and food in the soil that plants can use. They also are an important part of the soil food web. (Some examples of common soil organisms are found in the student handout, along with a diagram of the soil food web.)

⇒ There are A LOT of these organisms in soil! In a single square meter of soil, we can find millions and millions of these little organisms. (See the pyramid diagram in the student handout.)

⇒ In this exercise we will be using a **Berlese funnel** to funnel small invertebrates living in the soil into a collection container for observation. Explain that most soil organisms don't like to dry out, so as the lamp dries the soil, organisms will burrow deeper and deeper until they fall out of the bottom into the collection container.

Collect 2-3 cups of several types of soil or litter. Some examples include:

⇒ Litter, topsoil or moss from a forest — you will find LOTS of organisms here.

⇒ Soil from an agricultural field or garden.

⇒ Soil from a compost pile.

⇒ Soil from the subsurface (e.g., from a construction site) — you should find much fewer organisms here.

Ask your students to predict answers to the following:

⇒ What sort of organisms do you think we'll find in our different soil samples?

⇒ Out of which soil will we isolate the most microfauna?

Investigate:

Set up the Berlese funnels (instructions on next page). Three (or more) days later, use microscopes, magnifying glasses, etc., to observe your samples. You also can include freshly collected soil or smaller samples. Have the students draw and answer questions about three organisms they find — see if they can identify them. Direct students to a field guide or the online dichotomous key at http://www.insectidentification/insect-key.asp.

Make Observations:

⇒ Did you notice different types of organisms in the different soils?

⇒ Were your predictions correct?

⇒ What types of organisms did you find?

Discuss and Apply:

⇒ Why did the organisms fall out of the bottom of the funnel?

⇒ Which soil sample had lots of springtails (or mites, or worms, or nematodes)?

⇒ Why do we need these decomposers in our soil?

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Credits: Jennifer DeBruyn and Andrea Ludwig

Materials:

⇒ Large funnel. You also can use heavyweight paper rolled in a cone or the top of a 2 L pop bottle.

⇒ Heat source (e.g., lamp with 20- to 40-watt bulb)

⇒ Tape

⇒ Mesh screen (larger than window screen)

⇒ Jar for collecting invertebrates

⇒ 70% alcohol for preserving invertebrates (ethanol or isopropanol, aka "rubbing alcohol")

⇒ Dissecting microscope or magnifying glass

⇒ Forceps, needles, etc., for manipulating the invertebrates

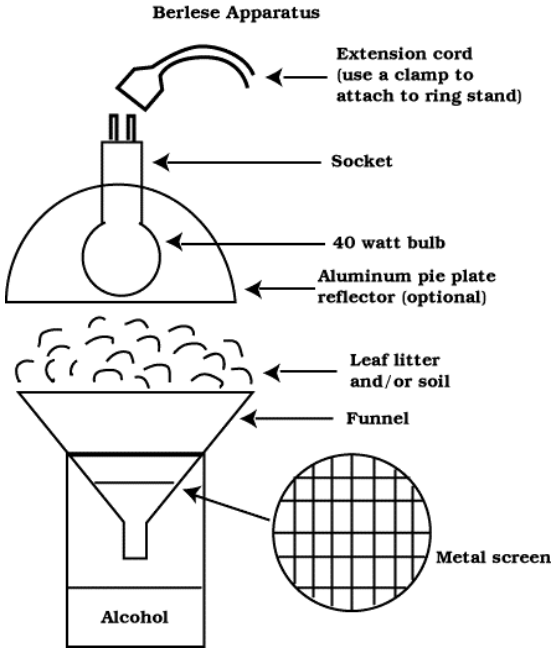
⇒ Petri or other shallow dish

⇒ Insect guidebook (optional)

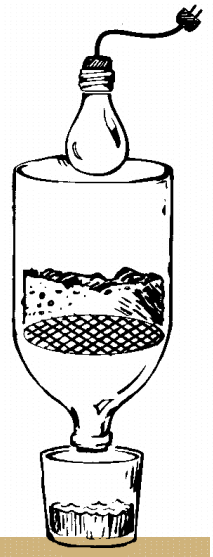
VIDEO: Watch a video description of Berlese funnel construction using a 2 L pop bottle here: http://www.youtube.com/watch?v=J5rGo3uBFIU

Watch SOIL SCIENCE INVESTIGATORS at work in *Matters of Life and Death* http://forces.si.edu/soils/video/mold.html

Berlese Funnel



1. If you don't have a funnel, use scissors and tape to cut a manila folder into a half-circle and fold this into a cone-shaped funnel using tape to hold it together. You also can use a 2 L pop bottle, cut in half. Use the top half inverted as your funnel (see bottom diagram).
2. Fill the collection container with a small amount of water or 70% alcohol (ethanol or isopropanol).
3. Place the funnel inside the collection container and a piece of mesh screen inside the funnel at the bottom.
4. Collect approximately 1-2 cups of soil and/or leaf litter. Try to find two different samples to compare (e.g., forest floor, meadow, farmer's field, roadside ditch, compost pile).
5. Place the soil and leaf litter loosely into the funnel, being careful not to let it fall through to the alcohol.
6. Place the light on top so that it will illuminate but not touch the funnel. It should be about 10-15 cm from the funnel. Turn the light on.
7. Allow the litter/soil to dry slowly under the light (at least three days, longer if wet). Then remove the funnel carefully.



Day of Observation:

1. Pour the contents of the jar into a petri dish for observation.
2. Use magnifying glasses and dissecting microscopes to observe. Use forceps to move organisms around. What sorts of organisms do you see?

Additional Resources:

⇒ Collection of soil biology movies — T. Loynachan, Iowa State University. http://www.agron.iastate.edu/~loynachan/mov.

⇒ Soil Biology (Microfauna) — Terry Tollefson. http://www.youtube.com/watch?v=VuHznslr8aI.

⇒ *Soil Biology Primer.* USDA. http://soils.usda.gov/sqi/concepts/soil_biology/biology.html.

⇒ *Soil Education*. USDA Natural Resources Conservation Service. http://soils.usda.gov/education.

⇒ S. Jeffery et al. (eds.). 2010. European atlas of soil biodiversity. European Commission, Publications Office of the European Union, Luxembourg. Available for free download here: http://eusoils.jrc.ec.europa.eu/library/maps/Biodiversity_Atlas/Documents/Biodiversity_Altas.pdf.

⇒ *Soil Biological Communities.* National Science & Technology Center, Bureau of Land Management. http://www.blm.gov/nstc/soil/index.html.

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Life Beneath Your Feet

Soil isn't just dirt. It's a complex environment that is home to all kinds of microorganisms. Did you know there are millions and millions of organisms that make soil their home?

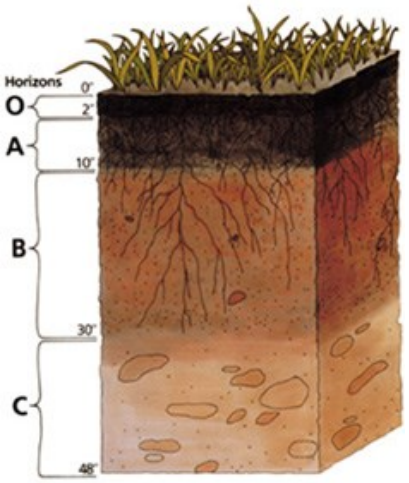
Check it out!
Watch SOIL SCIENCE INVESTIGATORS at work in *Matters of Life and Death*
http://forces.si.edu/soils/video/mold.html

Words to Explore:

- ⇒ Leaf litter
- ⇒ Decomposer
- ⇒ Rhizosphere
- ⇒ Humus
- ⇒ Aggregate
- ⇒ Pore
- ⇒ Microfauna
- ⇒ Water bear
- ⇒ Rotifer
- ⇒ Springtail
- ⇒ Soil mite
- ⇒ Nematode
- ⇒ Earthworm

WHERE DO SOIL ORGANISMS LIVE?

The organisms of the food web are not uniformly distributed through the soil. Each species and group exists where they can find appropriate space, nutrients and moisture. They occur wherever organic matter occurs – mostly in the top few inches of soil (O horizon), although microbes have been found as deep as 10 miles (16 km) in oil wells.



Most soils have three major horizons — the surface horizon (A), the subsoil (B) and the substratum (C). Some soils have an organic horizon (O).

FAVORITE HABITATS FOR SOIL MICROBES

Around roots. This is called the rhizosphere. Organisms use the sloughed-off plant cells and the proteins and sugars released by roots.

In litter. Fungi are common decomposers of plant litter because litter has large amounts of complex, hard-to-decompose carbon. Bacteria are abundant in the green litter of younger plants, which is higher in nitrogen and simpler carbon compounds. Bacteria and fungi are able to access a larger surface area of plant residue after shredder organisms, such as earthworms, leaf-eating insects, millipedes and other arthropods, break up the litter into smaller chunks.

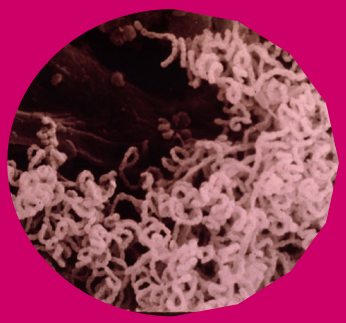
On humus. Humus is the "leftovers" after bacteria, fungi, arthropods and worms have had their fill of plant litter. Fungi are common here because they can make some of the enzymes needed to degrade the hard-to-digest compounds in humus.

On the surface of soil aggregates. Many aggregates ("clumps") are actually the fecal pellets of earthworms and other invertebrates. Biological activity, in particular that of aerobic bacteria and fungi, is greater near the surfaces of soil aggregates where they can get lots of oxygen.

In spaces between soil aggregates. Those arthropods and nematodes that cannot burrow through soil move in the pores between soil aggregates. Organisms that are sensitive to drying out, such as protozoa and many nematodes, live in water-filled pores.

Did you know?

The reason soil smells "earthy" is because of bacteria called ACTINOMYCETES. These helpful bacteria produce a number of antibiotics that we use.



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Where do soil organisms live?

Label the diagram with favorite habitats for soil organisms. (HINT — Read the first page of this handout!)

ACTIVITY: Who lives in my soil?

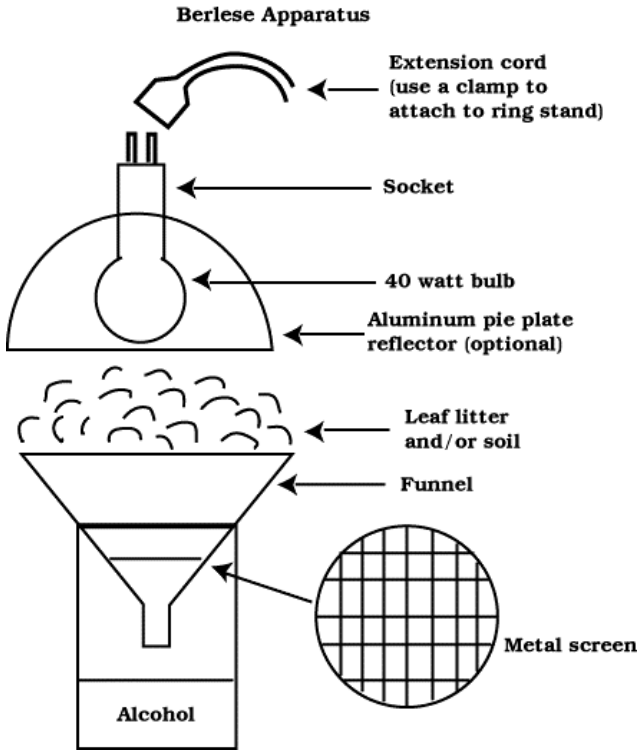
You will be using a Berlese funnel to collect organisms in soils.

Materials:

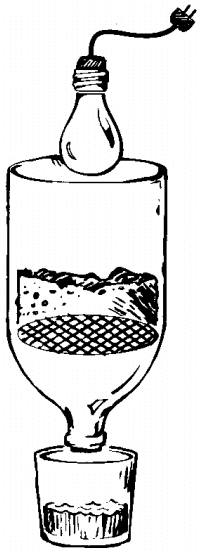
- ⇒ Large funnel. You can also use heavyweight paper rolled in a cone or the top of a 2 L pop bottle.
- ⇒ Heat source (e.g., lamp with a 40-watt bulb)
- ⇒ Tape
- ⇒ Strainer or mesh screen
- ⇒ Ring stand and clamp to hold funnel or a wire coat hanger that can be shaped
- ⇒ Jar for collecting invertebrates
- ⇒ Alcohol for preserving invertebrates (e.g., 70% isopropanol)
- ⇒ Dissecting microscope or magnifying glass
- ⇒ Forceps, needles, etc., for manipulating the invertebrates
- ⇒ Petri or other shallow dish
- ⇒ Insect guidebook (optional)

Preparation: Berlese Funnel Setup

1. If you don't have a funnel, use scissors and tape to cut a manila folder into a half-circle and fold this into a cone-shaped funnel using tape to hold it together.
2. Place the funnel inside the ring stand and the strainer inside the funnel at the bottom.
3. Place a jar half full of water or ethanol or isopropanol under your funnel setup.
4. Place the light on top of the ring stand so that it will illuminate but not touch the funnel.



5. Collect approximately 1-2 cups of soil and leaf litter. Try to find two different samples to compare (e.g., forest floor, meadow, farmer's field, roadside ditch).
6. Place the soil and leaf litter into the strainer, being careful not to let it fall through to the alcohol.
7. Turn the light on and make sure it is not touching the funnel. It should be about 10-15 cm from the funnel.
8. Allow the litter/soil to dry slowly under the light (one to three days). Then remove the funnel carefully.



You can also do this with a 2 L soda bottle!

ACTIVITY: Who lives in my soil?

Check it out!

Explore soil microfauna with Terry Tollefson at http://www.youtube.com/watch?

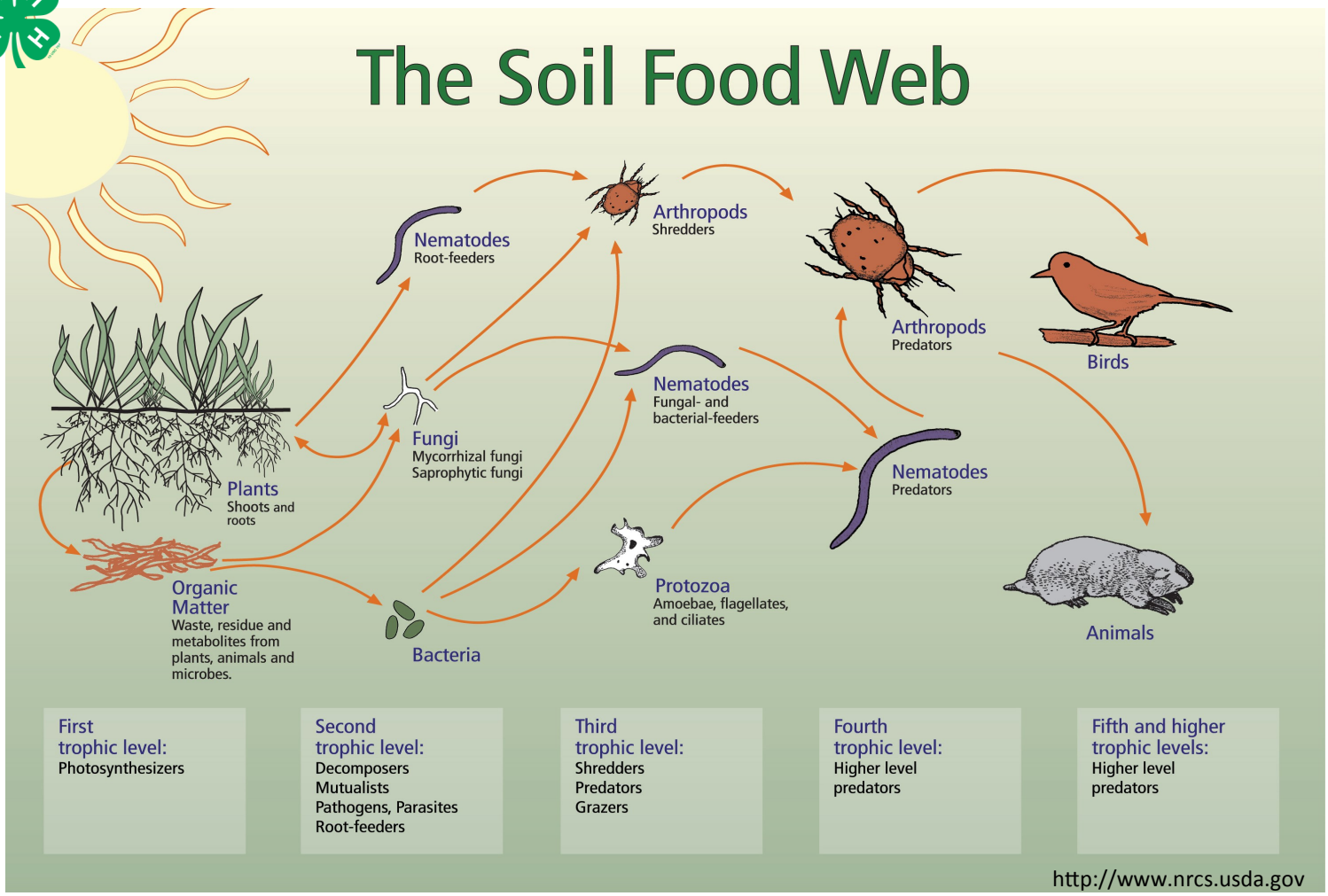
Day of Observation:

1. Pour the contents of the jar into a petri dish for observation.
2. Use magnifying glasses and dissecting microscopes to observe. Use forceps to move organisms around. What sorts of living things do you see?
3. Use the pictures in this handout to identify some of the organisms in your soils.

Draw a picture of and make observations about three of them. Try to identify them! Use pictures, a field guide or the online key at **http://www.insectidentification.org/insect-key.asp**.

	Organism #1	Organism #2	Organism #3
What type of soil sample did I come from?			
Sketch a picture.			
What color am I?			
How many legs do I have?			
How do you think I move?			
WHAT AM I???			

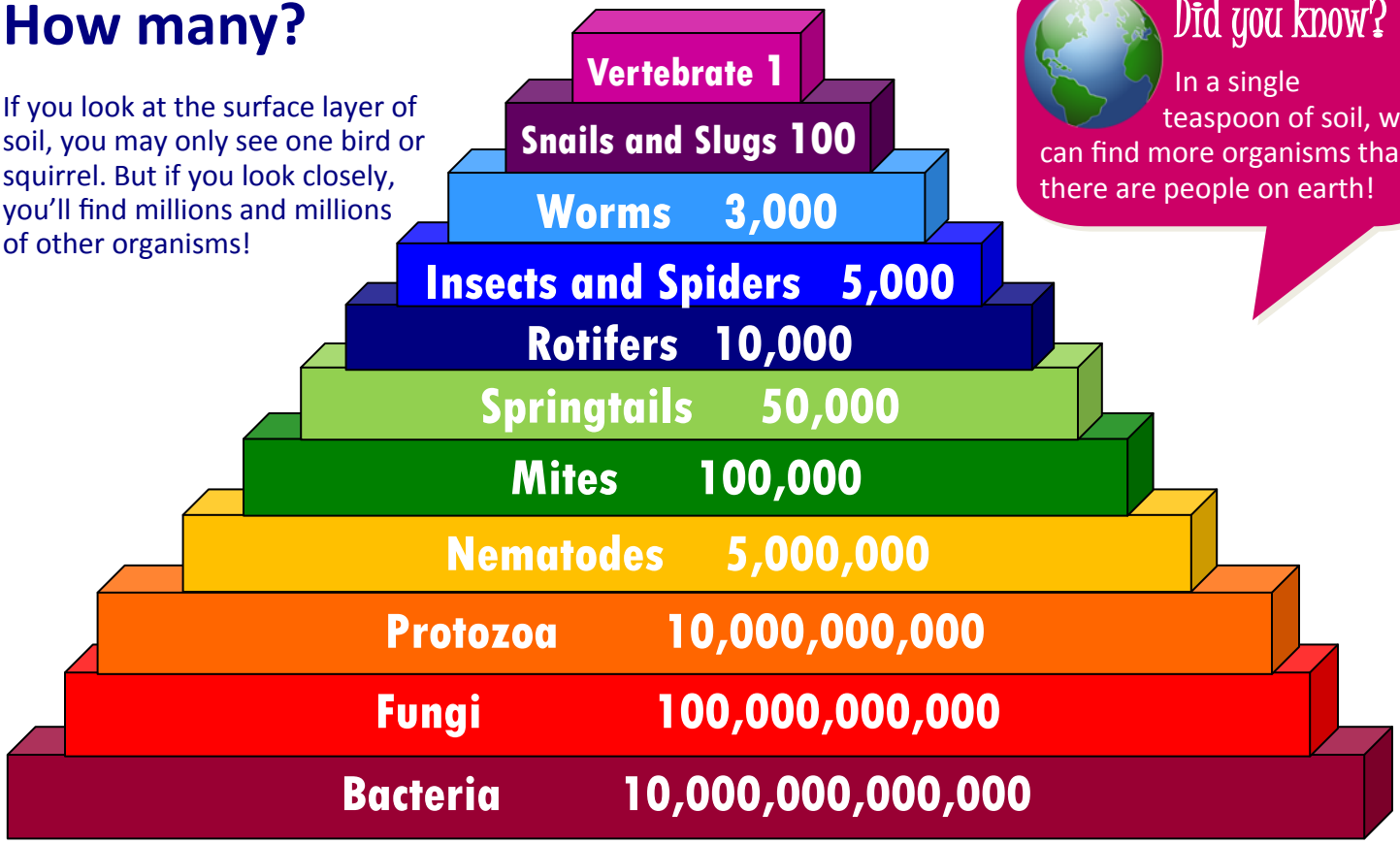
The Soil Food Web



http://www.nrcs.usda.gov

How many?

If you look at the surface layer of soil, you may only see one bird or squirrel. But if you look closely, you'll find millions and millions of other organisms!



Did you know?

In a single teaspoon of soil, we can find more organisms than there are people on earth!

WATER BEARS

Official Name: Tardigrades

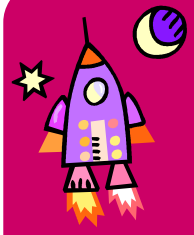
Size: 0.3-0.5 mm

Movement: Crawl around on eight stubby legs.

Habitat: Almost everywhere on earth, but particularly lichens and mosses, sediments, beaches, soil.

Diet: Moss, algae, bacteria.

Claim to fame: Capable of **cryptobiosis** (reversible state of suspended animation): They can "die" then come back to life! Using this adaptation, they can survive extreme conditions, including temperature (as low as -450 F and as high as 304 F), dehydration to 1% of their moisture, high doses of radiation, and even the vacuum of outer space!



Learn more about Tarigrades and their adventures in outer space here: http://www.youtube.com/watch?v=6H0E77TdYnY

WHEEL ANIMALS

Official Name: Rotifers

Size: 0.2-0.5 mm

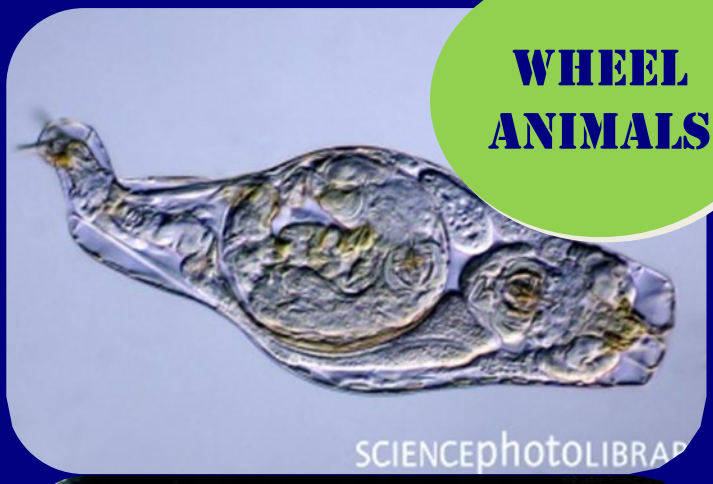
Habitat: Common in freshwater and moist soil or leaf litter.

See a rotifer in action here: http://www.youtube.com/watch?v=PALgTXQOqQo

Feeding: Rotifers have a complete digestive tract. They feed using a ring of cilia around their mouth that moves rapidly — they look just like a wheel. They feed on organic matter and unicellular algae.

Movement: Their body is telescopic, and they move by expanding and contracting. They have a "foot" and "toe" opposite the mouth, which they use to anchor themselves while feeding.

Claim to fame: One of the first organisms discovered by pioneer microscopist Antony van Leeuwenhoek.



SOIL MITES

Official name: Oribatid mites (Arthropods, Arachnids)

Relatives: Ticks, spiders

Number of legs: Eight

Diet: Leaf litter, fungi, algae, springtails, worms

Feeding: "Shredders" — Decomposers of dead organic material. They use chewing mouthparts to cut leaves and scrape away rinds.

Habitat: Soil mites can't burrow, so they use tunnels made by other animals.

Claim to fame: Mites are the "first responders" of decomposers: they chew leaf litter into smaller pieces, making it more available to worms and bacteria and fungi.

The 200 species of mites in this microscope view were extracted from one square foot of the top two inches of forest litter and soil.

SPRINGTAILS

Official name: Collembola (Arthropods, Hexapods)

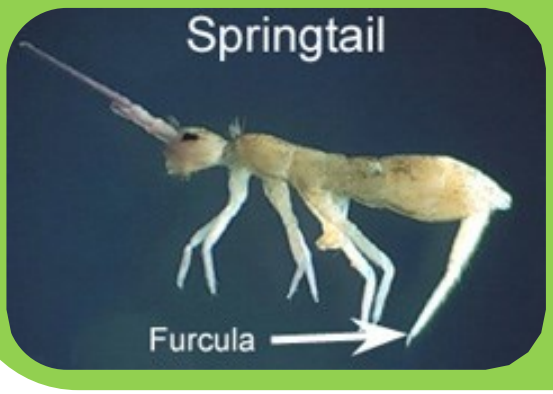
Size: 1-5 mm

Number of legs: Six

Diet: Leaf litter, decaying plant matter, fungi and bacteria

Habitat: Any place that is damp. Springtails hate to dry out!

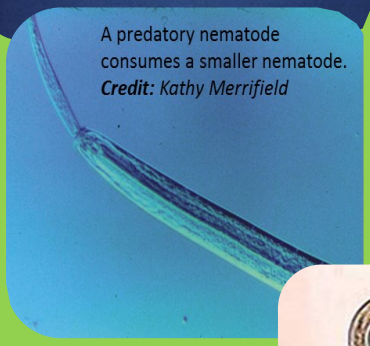
Claim to fame: Springtails get their name because they have a forked tail-like organ called a furcula below their abdomen that helps them "spring" away from predators.



Did you know? A springtail can jump up to 20 times its body length in a single leap!

NEMATODES

Also known as: Roundworms



A predatory nematode consumes a smaller nematode. ***Credit:*** *Kathy Merrifield*

Mouth parts of a bacteria-feeding nematode

Size: Nematodes have a wide range of sizes and lifestyles. They range in size from 0.05-1 mm.

Habitat: Just about everywhere!

Feeding:

⇒ Bacterial feeders.
⇒ Fungal feeders.
⇒ Root (plant pathogens).
⇒ Predatory (eat other nematodes and protozoa).
⇒ Omnivores.

A fungal-feeding nematode with a distinct stylet for piercing hyphae.

Claim to fame: Some are parasites, and others feed on the parasites. Some cause plant diseases, and some help prevent plant diseases!

EARTHWORMS

Size: 1 inch to 2 yards

Diversity: >7,000 species identified

Feeding: Decomposers of dead organic material.

Habitats: Most temperate soils, some tropical soils.

⇒ **Epigeic species:** Live in surface plant litter and are adapted to variable moisture conditions.
⇒ **Endogeic species:** Live in the upper soil layers and feed on soil and organic matter; do not make permanent burrows.
⇒ **Anecic species** (e.g., "night crawlers"): Inhabit permanent burrows that can extend several meters.

Claim to fame: Earthworms play a key role in soil's structure — they mix organic matter into soil and excrete pellets (casts) that help with soil aggregation.

Juvenile and adult earthworms *Pontoscolex corethrurus*
Photo credit: Turetsky,

Check it out!
There are many types of earthworms
http://youtu.be/gS8zyGlkN2c

Earthworm borrow filled with organic material Photo credit: *Edwards, OSU*

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