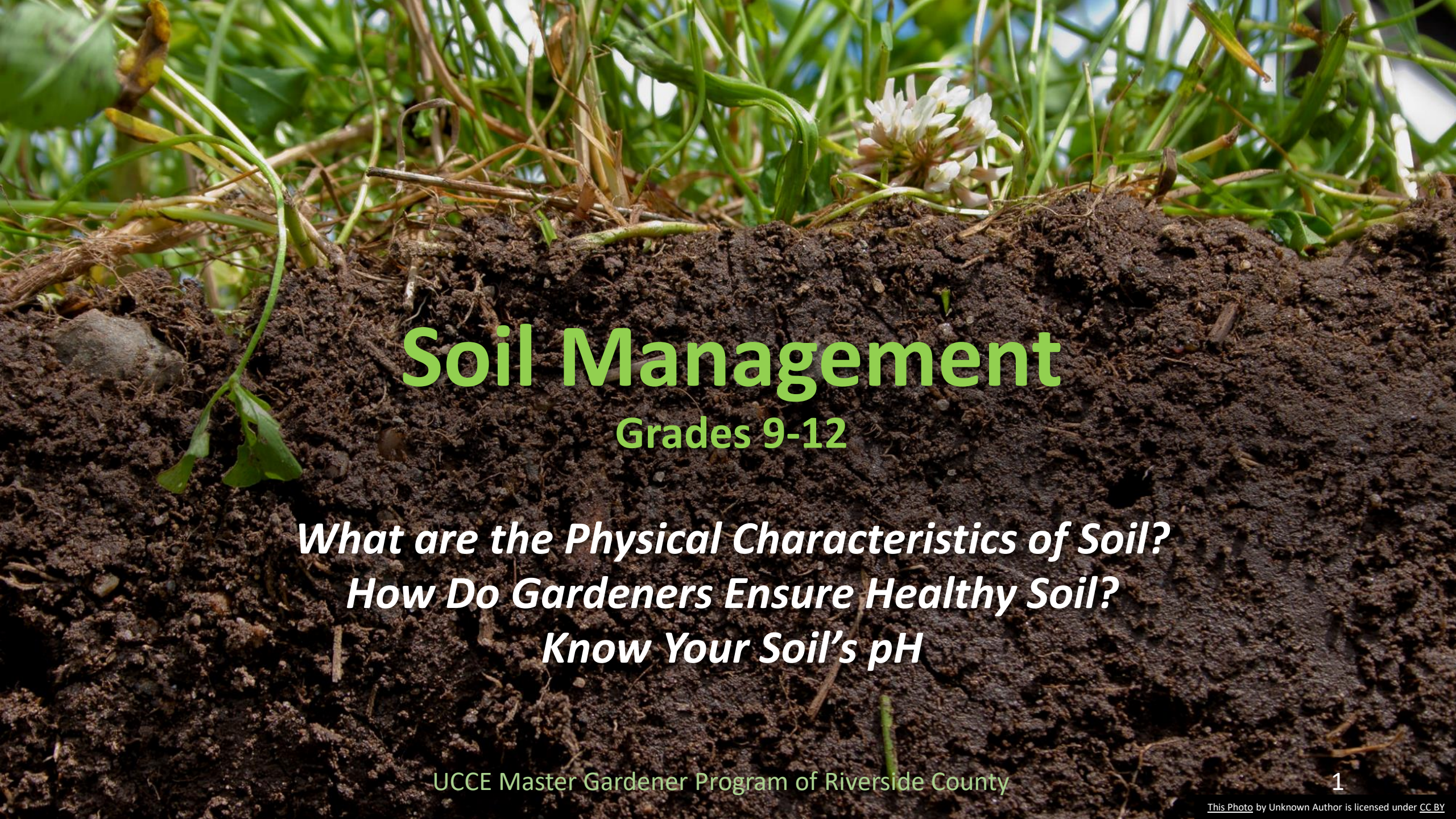

Soil Management

Grades 9-12

What are the Physical Characteristics of Soil?
How Do Gardeners Ensure Healthy Soil?
Know Your Soil's pH

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Master Gardeners

The University of California Cooperative Extension (UCCE) Master Gardener Program (MGP) is an educational program designed to teach and effectively extend information to address home gardening and non-commercial horticulture needs in California.

UCCE is the outreach arm of UC's division of Agriculture and Natural Resources (ANR). Master Gardener volunteers (MG volunteers) promote the application of basic environmentally appropriate horticultural practices through UCCE-organized educational programs that transfer research-based knowledge and information.

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program

Why Is This Important?

We may walk all over it, take it for granted and treat it like *dirt.* However it is SOIL, and our lives depend on it!

- Soil is the upper layer of the earth that may be plowed and in which plants grow. Depending on location, soil can be a few inches to more than 100 feet deep.
- Soil is a complex, dynamic natural material in which physical, chemical and biological reactions are constantly occurring.

Learning Goal:

Students will learn basic concepts of soil health and pH.

(Note: All underlined vocabulary in PPT are hyperlinked to definitions.)


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Healthy soil is a *living* system that includes:

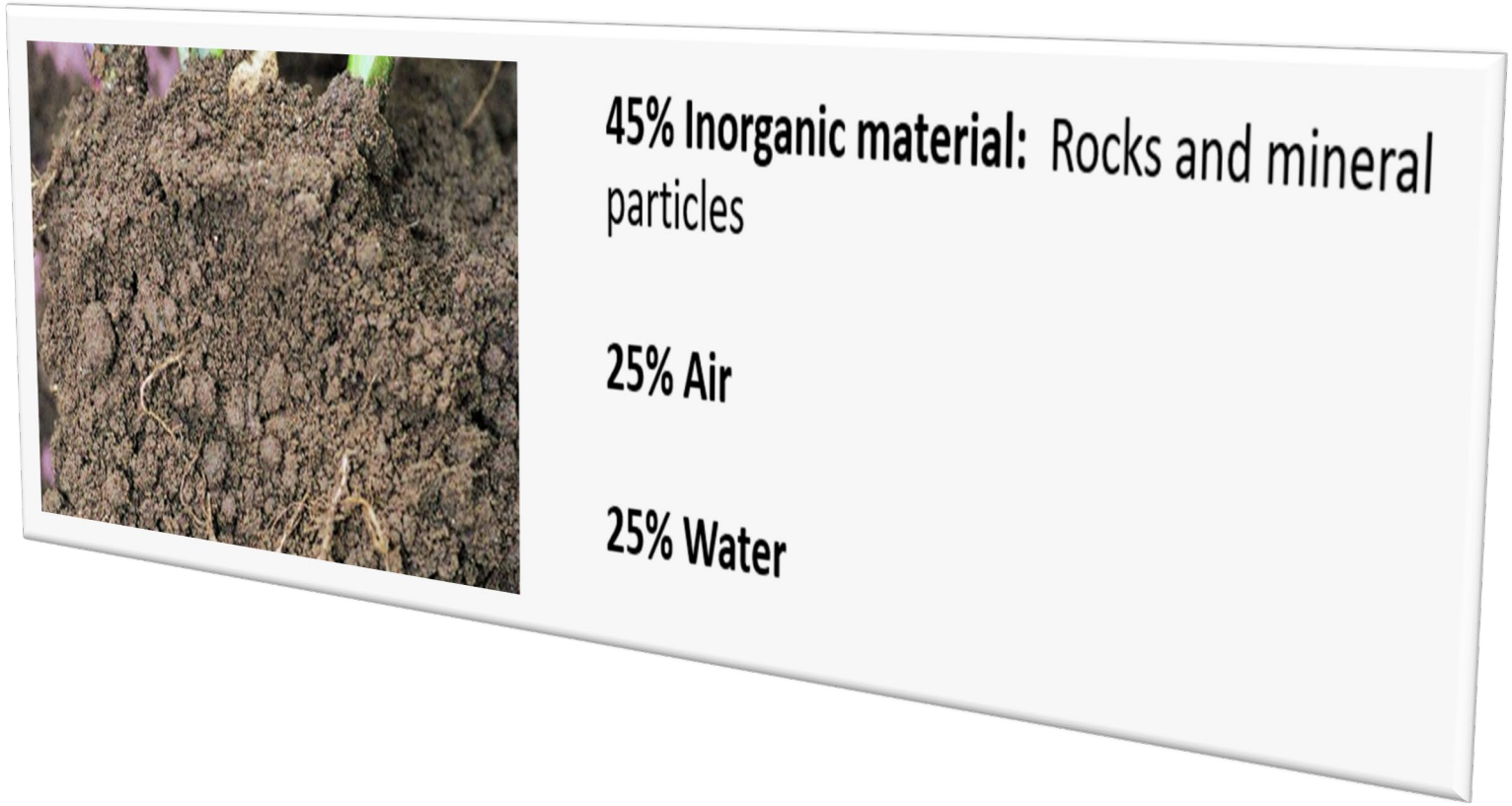
45% Inorganic material: Rocks and mineral particles

25% Air

25% Water

5% Organic matter: Living organisms including roots, worms, microbes, and decomposing/decomposed organisms

Healthy Soil
Part 1



Digging Deeper: What are the Physical Characteristics of Soil?

Physical Characteristics of Soil

Understanding Inorganic Material

The rocks and mineral particles in your soil determines its:

- Air and Water Content
- Texture/Structure
- Tilth

What You Need to Know
Tilth

Tilth is the physical condition of soil in relation to its ability to support plant growth.

- Soil with good **tilth** has large pore spaces for air infiltration and water movement. Roots only grow where the soil **tilth** allows for adequate levels of soil oxygen.
- Soil with good **tilth** also holds a reasonable supply of water and nutrients and contains organic matter.

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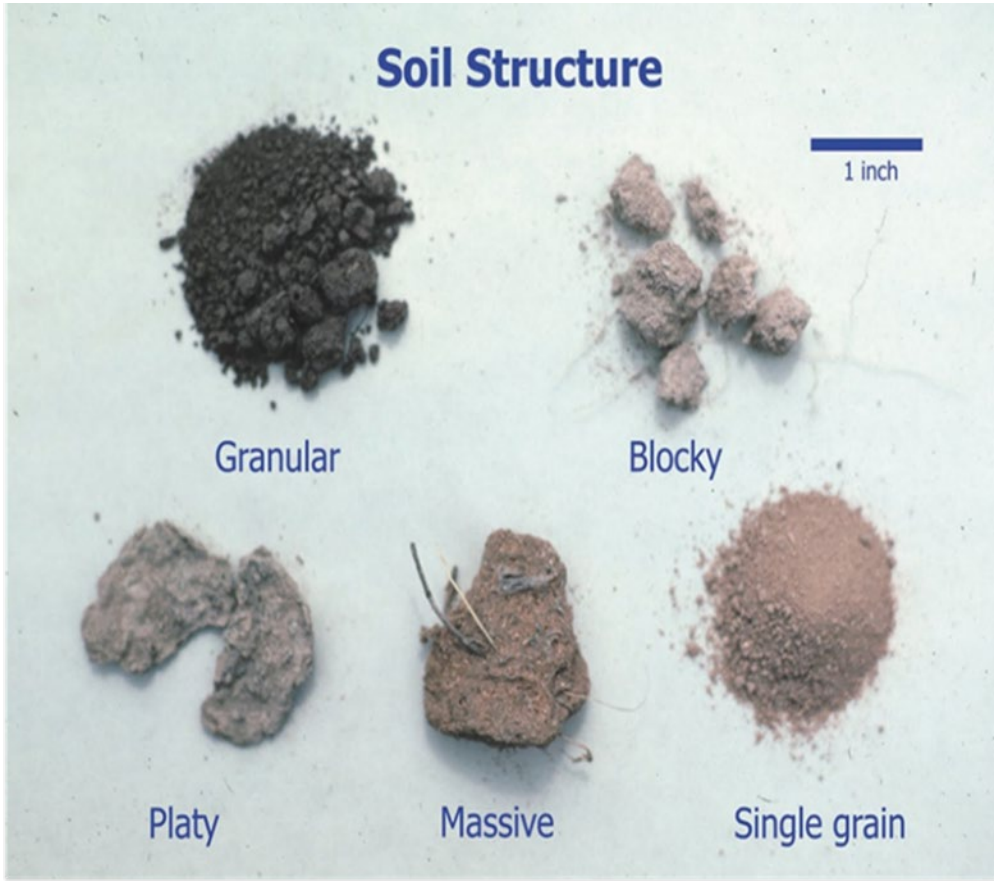
Physical Characteristics of Soil

Understanding Soil Structure

- Except for sand grains, soil particles usually do not exist as single particles; instead, combining into groups of particles known as aggregates.
- Soil structure is the way these aggregates are arranged into various sized crumbs and clods.



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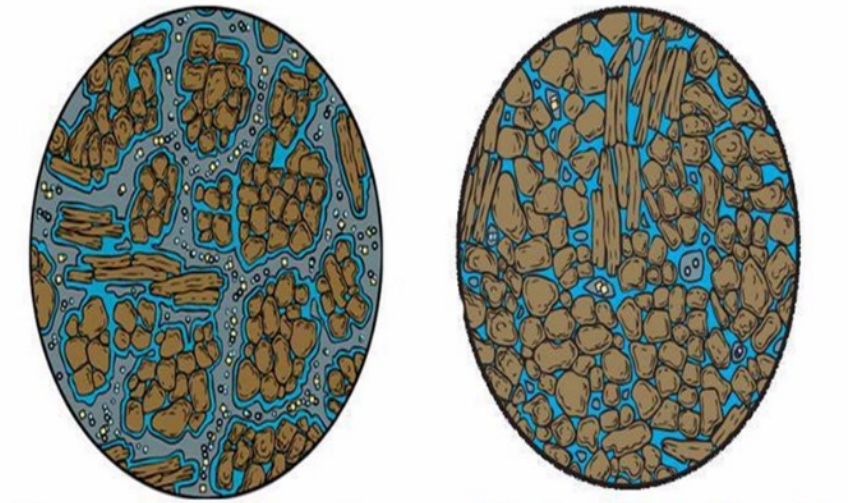
Physical Characteristics of Soil

Good Structure Versus Poor Structure

- **Good structure:** holds water (micropore space) and has air space (macropore space).
- **Poor structure:** lacks adequate macropore space.

This means good soil structure will have water infiltration, drainage, and overall good tilth.



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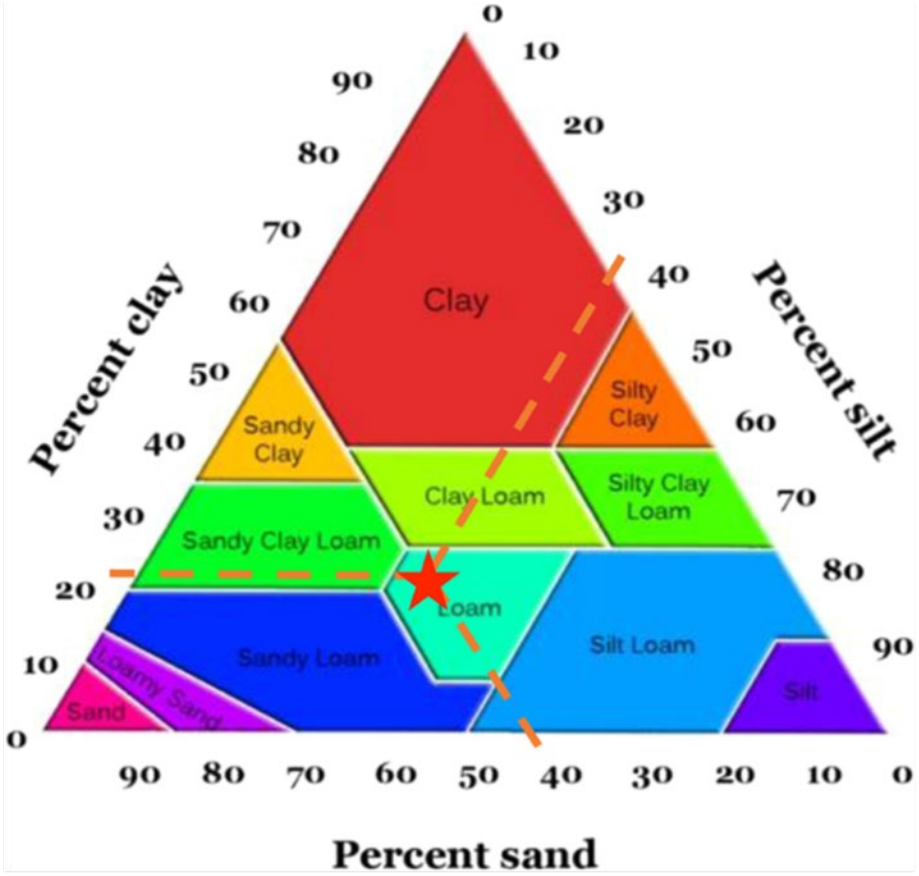
Physical Characteristics of Soil

Understanding Soil Texture

Soil texture refers to the percentage of the mineral components of sand, silt, and clay in a body of the soil.

- This percentage of sand, silt and clay is based on the soil triangle.
- An ideal soil contains equivalent amounts of sand, silt and clay.
- This ideal soil is called **loam**.



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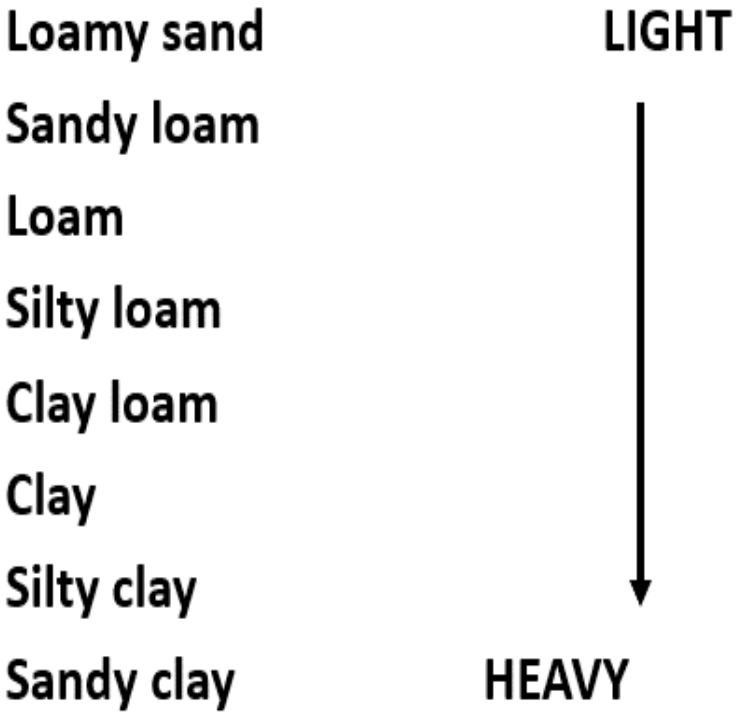
Understanding Soil Texture
Light versus Heavy

- Sandy, coarse-textured soil is often called a light soil.
- Clay or fine-textured soil is referred to as a heavy soil.
- The terms *light and heavy soil* reflect the relative ease of working the soil types.

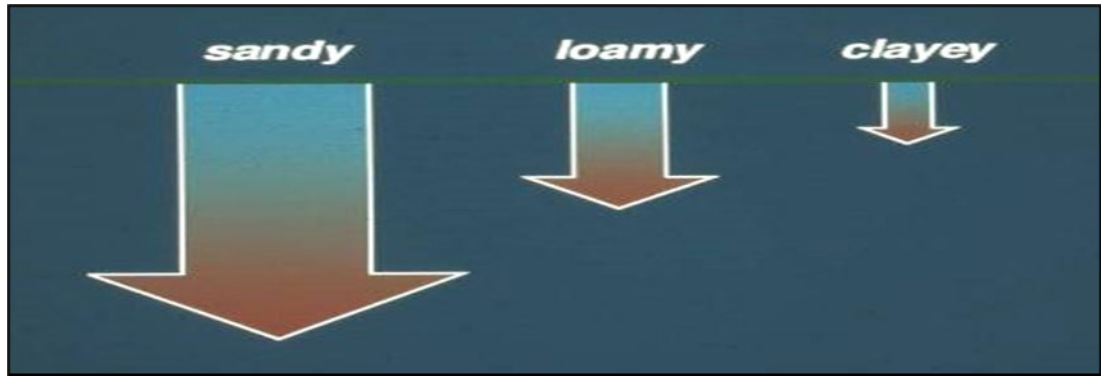


Understanding Soil Texture
Water Content

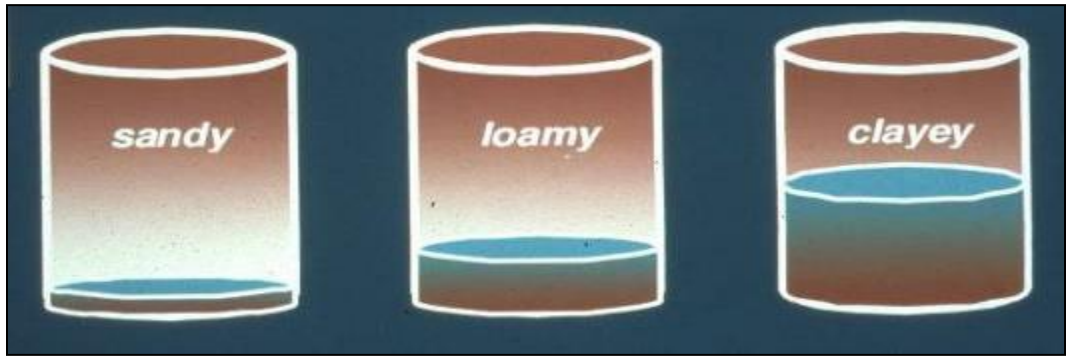
Soil texture affects how well nutrients and water are retained in the soil.

- Clay soil holds onto much more water than sandy soils, but drainage through clay soils is slow.
- Loam is the ideal soil in terms of water permeability and holding capacity.

Permeability



Water Holding Capacity



Understanding Soil Texture
Administer the Texture Test

Squeeze a handful of damp soil.

- Sand will fall apart as soon as you open your hand.
- Loam will hold its shape, and when you give it a light poke, it crumbles.
- Clay will hold its shape, and, when poked, sits stubbornly in your hand or can be extruded from your hand in a strip.

Check For Understanding

Why is soil tilth important?

What will good soil structure have?

Why is loam the ideal soil texture?

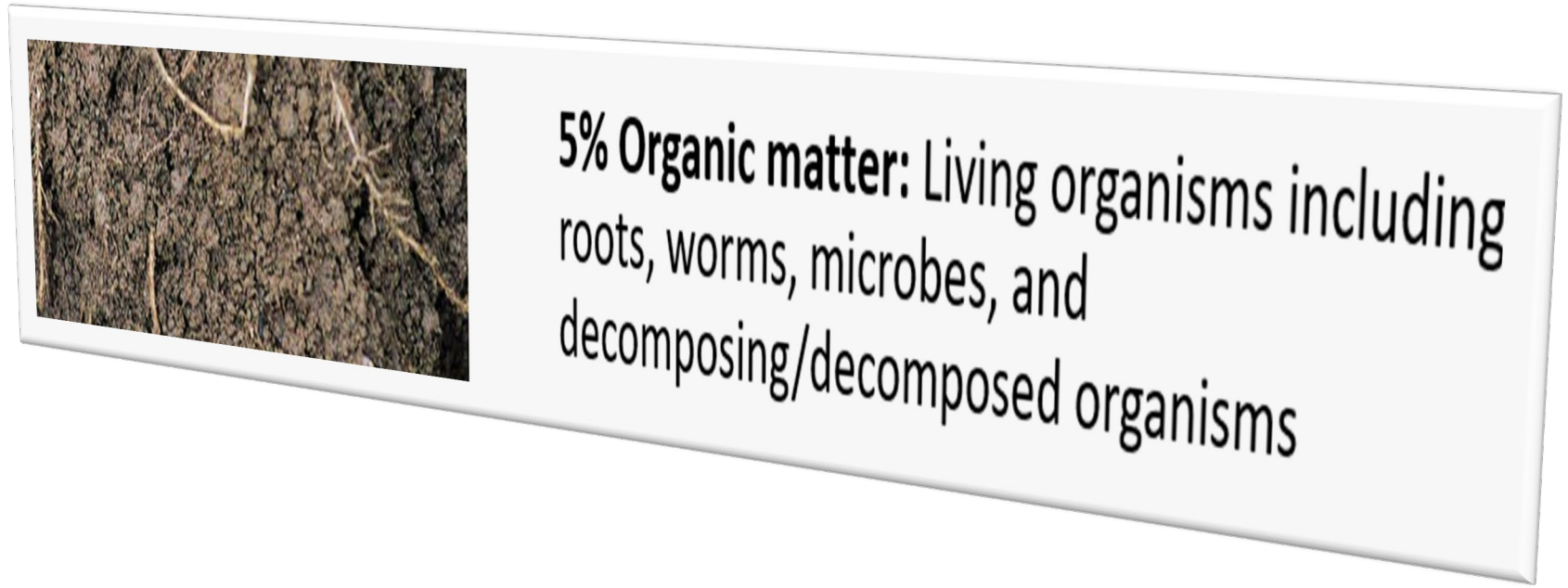
How can you determine soil texture in your garden?

Apply Your Understanding

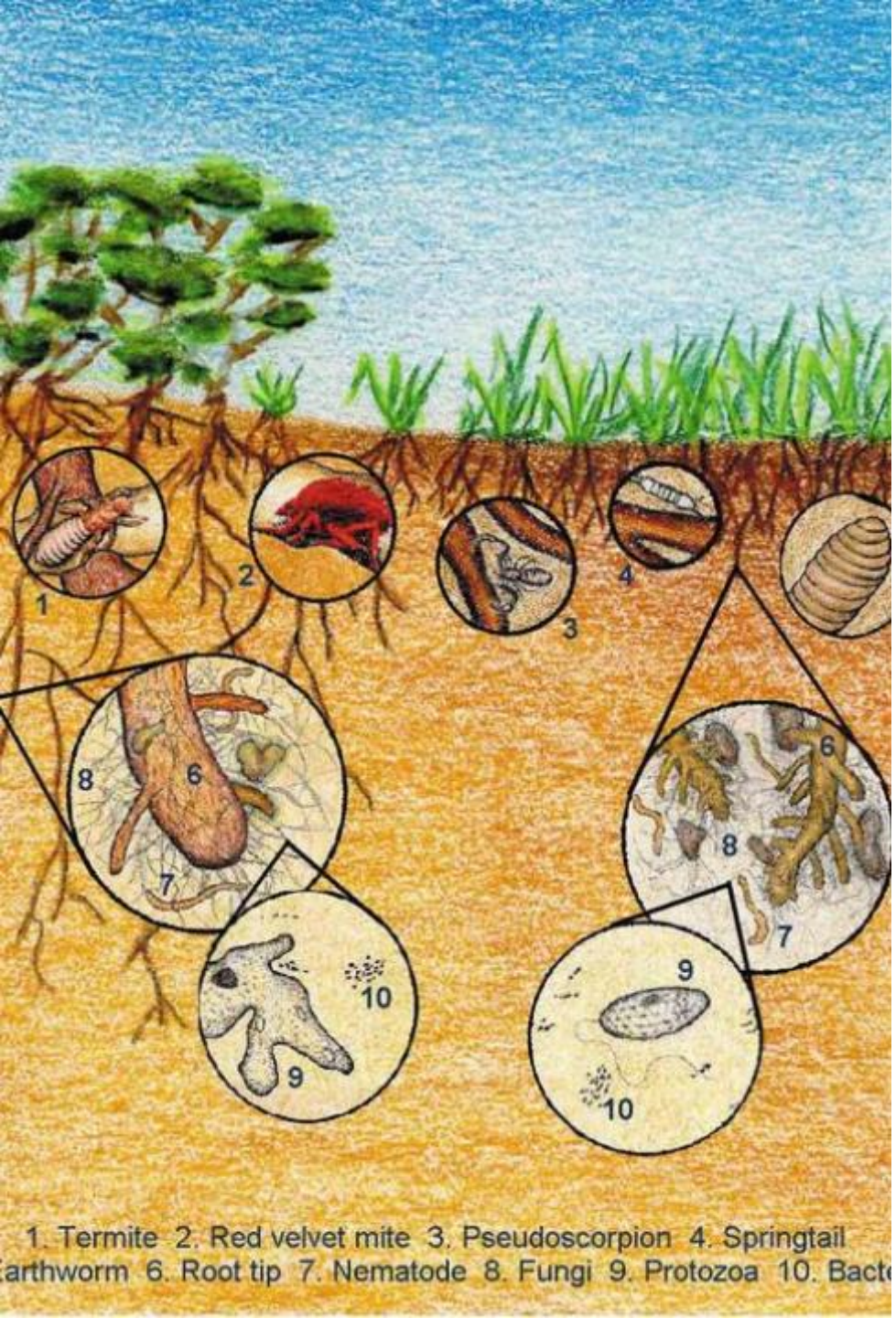
What is the soil texture in your garden?

- Administer the soil texture test.

Healthy Soil
Part 2



Digging Deeper: How Do Gardeners Ensure Healthy Soil?



Teaming With Life

The 5% of organic matter in soil contains billions of microbes, including bacteria and fungi, which are dependent on each other.

These are the Foundation of a Symbiotic (Interdependent) Ecosystem

- **Bacteria** are very important in the soil. Some are decomposers, others provide nutrients and others interact with nitrogen in the soil. *There may be as many as 5 billion in a teaspoon of soil.*
- **Protozoa** recycle nutrients by feeding on bacteria. *There are up to 5 million per teaspoon of soil.*
- **Fungi** bind soil together, decompose organic material, and may have symbiotic relationships with plants. *There may be as much as 20,000 km of fungi networks in a cubic meter of soil.*
- **Nematodes** Recycle nutrients by feeding on fungi, bacteria, plant roots, amoeba, and other nematodes. There are many different species, some attack crops, others are beneficial. *There may be many as 5,000 per teaspoon of soil.*

What is a Symbiotic Ecosystem?

The soil food web demonstrates how organisms are interdependent

Soil Food Web

- Depending on the health of the soil, the soil food web will contain and support many different plants, animals, arthropods, earthworms and microbes. These feed on organic matter from a variety of sources.

- Soil organisms are affected by what happens to the soil ***and also*** affect the soil.

- They affect the soil by using plant and animal materials to create soil humus, recycle carbon, nitrogen and other nutrients, and support plant growth.

Organisms Help Maintain Soil Structure

Most soil organisms are found in the topsoil, from 0 -10 cm, where the maximum amount of carbon, a main food supply, is found.

- Soil organisms *decompose organic matter*, slowly producing humus, highly resistant to further breakdown.
- Soil organisms *produce glues and filaments that bind tiny mineral particles* and humus together into soil crumbs.
- In addition to these organisms, worms and other burrowing creatures *continuously open pathways for roots, air and water*.

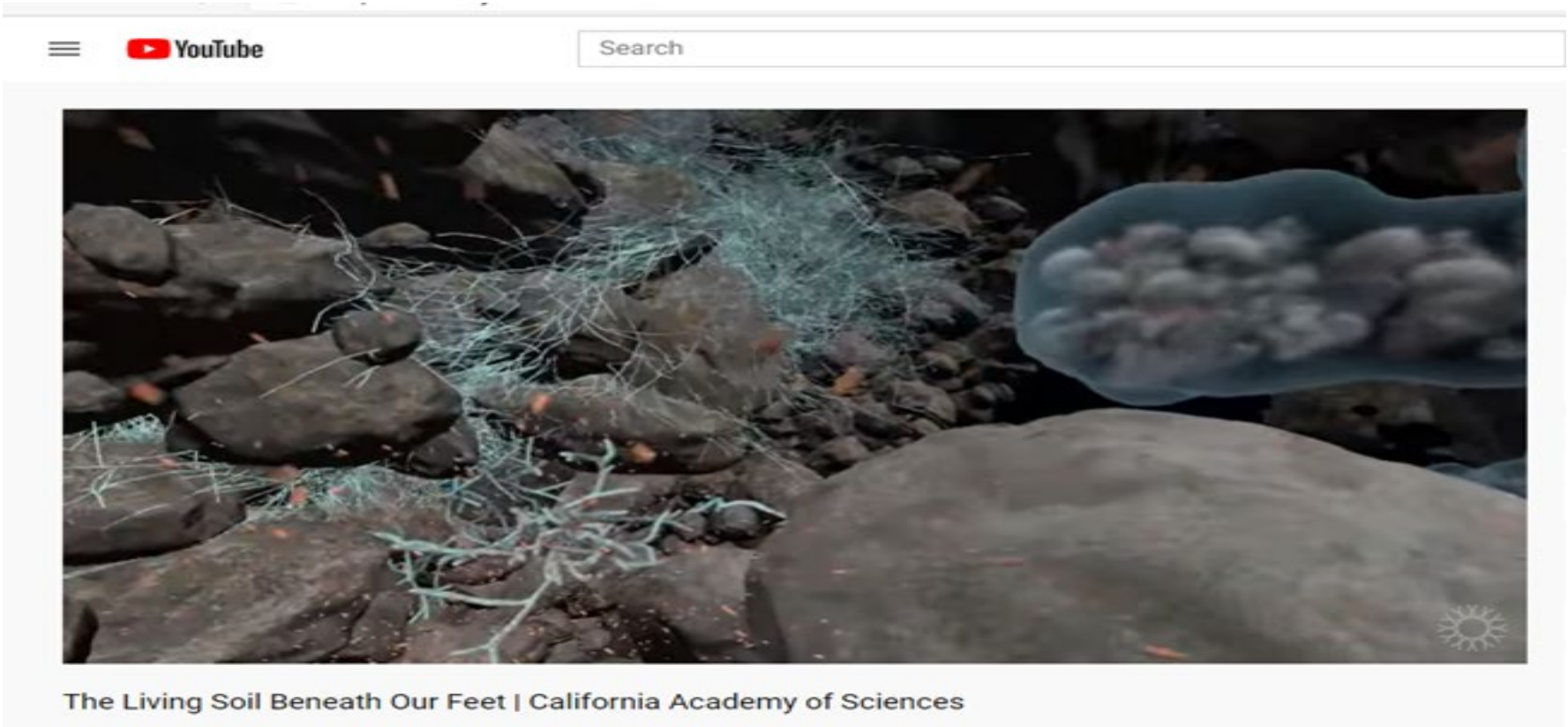
A Closer Look at Burrowing Creatures

- **Spiders, molluscs, beetles, and ants** burrow and tunnel, loosening and turning over soil which mobilizes nutrients. Their excretions help to bind the soil. They break down organic matter and move it into the soil.

- **Larger species such as mice, rabbits, moles and gophers** turn over soil and loosen it for other organisms.

- **Earthworms** decompose smaller organisms when eating soil and their excretions bind the soil. Earthworms are considered an indicator species for soil health.

Video: The Living Soil Beneath Our Feet

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Keep These Organisms Alive!

- Keep these organisms alive and healthy, and **they** will maintain your garden's soil structure and keep the nutrient cycle (soil food web) going.

- To do this, follow gardening practices that allow the beneficial soil organisms to flourish.

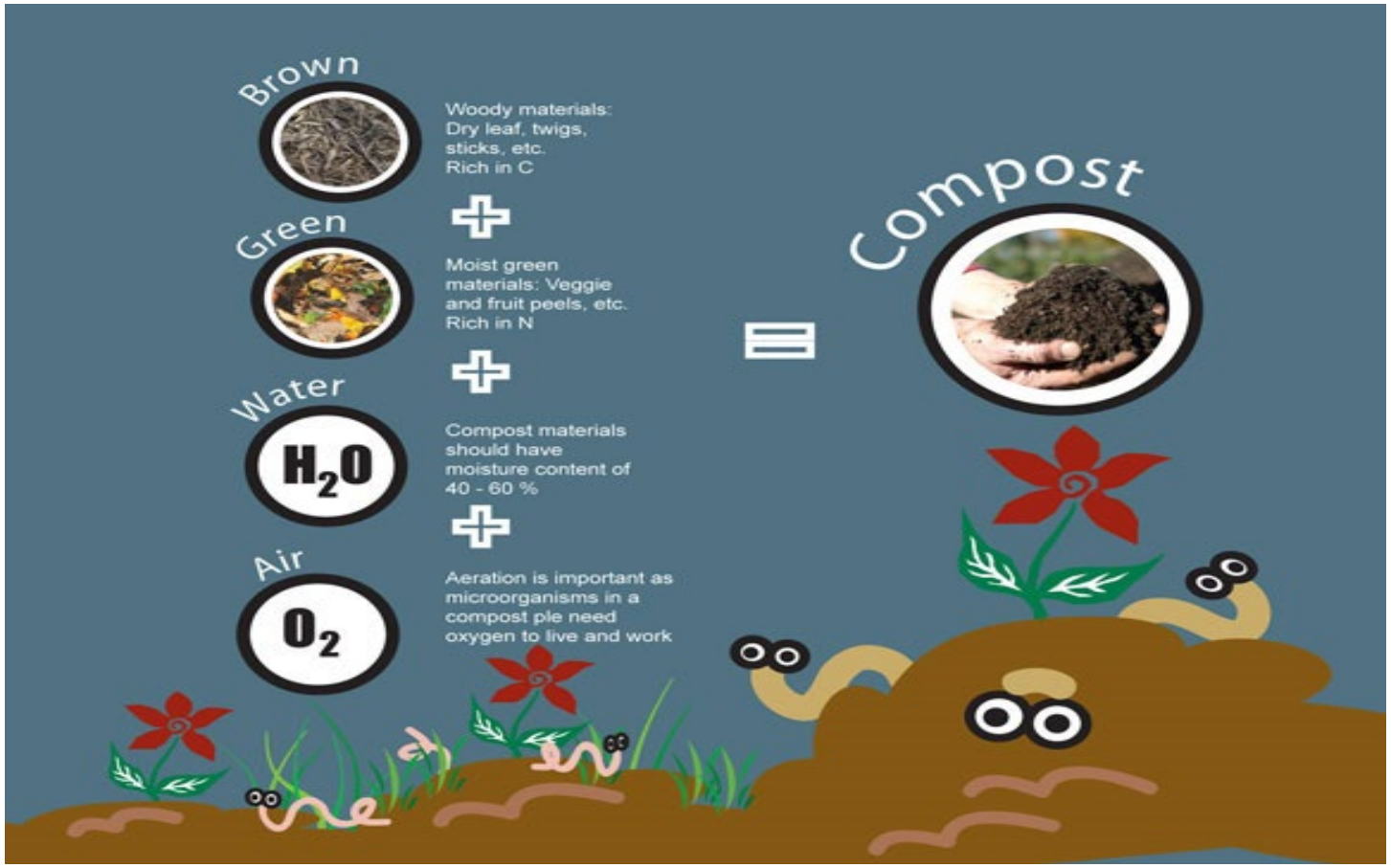
What are the Best Gardening Practices for Maintaining Good Soil Structure?

- Avoid excessive soil disturbance such as rototilling.
- Don’t work in or walk on wet, soggy soil. This compacts it.
- Avoid under or overwatering your soil.
- **Most importantly,** use compost and mulch to supply/recycle soil microbes and nutrients to nurture the soil organisms.

Compost is a Recipe for Feeding Billions!

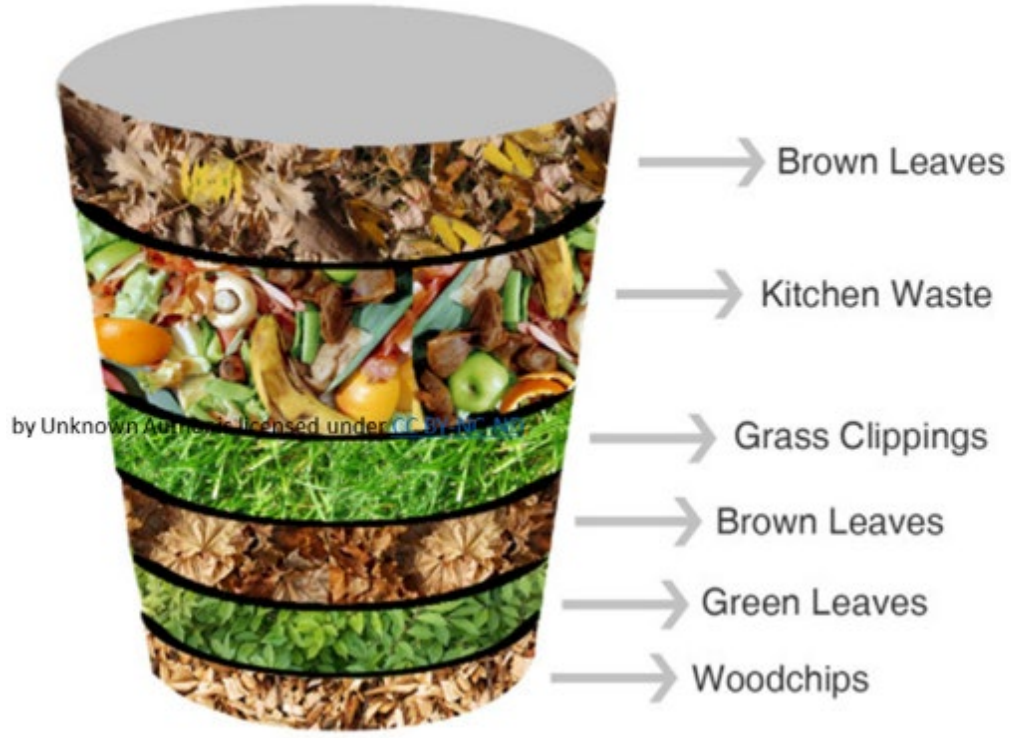
Ingredients

- Equal parts brown and green organic matter
- Water
- Air



Steps: Organic Materials

- Chop greens and browns into small pieces about I ½ inches in size. This will improve decomposition.
- Layer greens between browns.
- Kitchen waste such as vegetable and fruit scraps, coffee grounds (including the filters), and crushed eggshells can be included, but should be covered with browns.
- Do not use seed-bearing weeds.



Steps: Size and Moisture

- Arrange into a pile. Keep adding browns and greens to a pile size of about 3 feet by 3 feet by 3 feet.
- Add water just to the level of wrung-out sponge.

Steps: Turn Frequently

- Turn often to maintain uniform decomposition and help support aeration.
- Do not let your compost pile overheat (above 160 degrees)! Turning the compost pile often will keep this from happening.
- Add water as needed to maintain the wrung-out sponge moisture level.

Steps: Apply to Garden

- As the organic matter decomposes, it will reduce in volume and change in color to dark brown.
- Add into the top few inches of soil or potting mix .
- Enjoy a beautiful and healthy garden!

Check For Understanding

What is the foundation of a symbiotic ecosystem?

How do soil organisms affect the soil?

What are the best gardening practices for maintaining good soil structure?

Which of these practices are *most* important for nurturing soil organisms?

Apply Your Understanding

Start a compost pile for your school garden. Begin by researching different compost bin options: What type of compost bin to use

If you already have a compost pile, below is further information to guide your composting efforts:

How to turn a compost pile

What does NOT go in a compost pile

Trouble shooting your compost pile

What is Hot Method? What is Cold Method?

How long does it take to make compost?

Why are these bugs in my compost pile?

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Extend Your Understanding

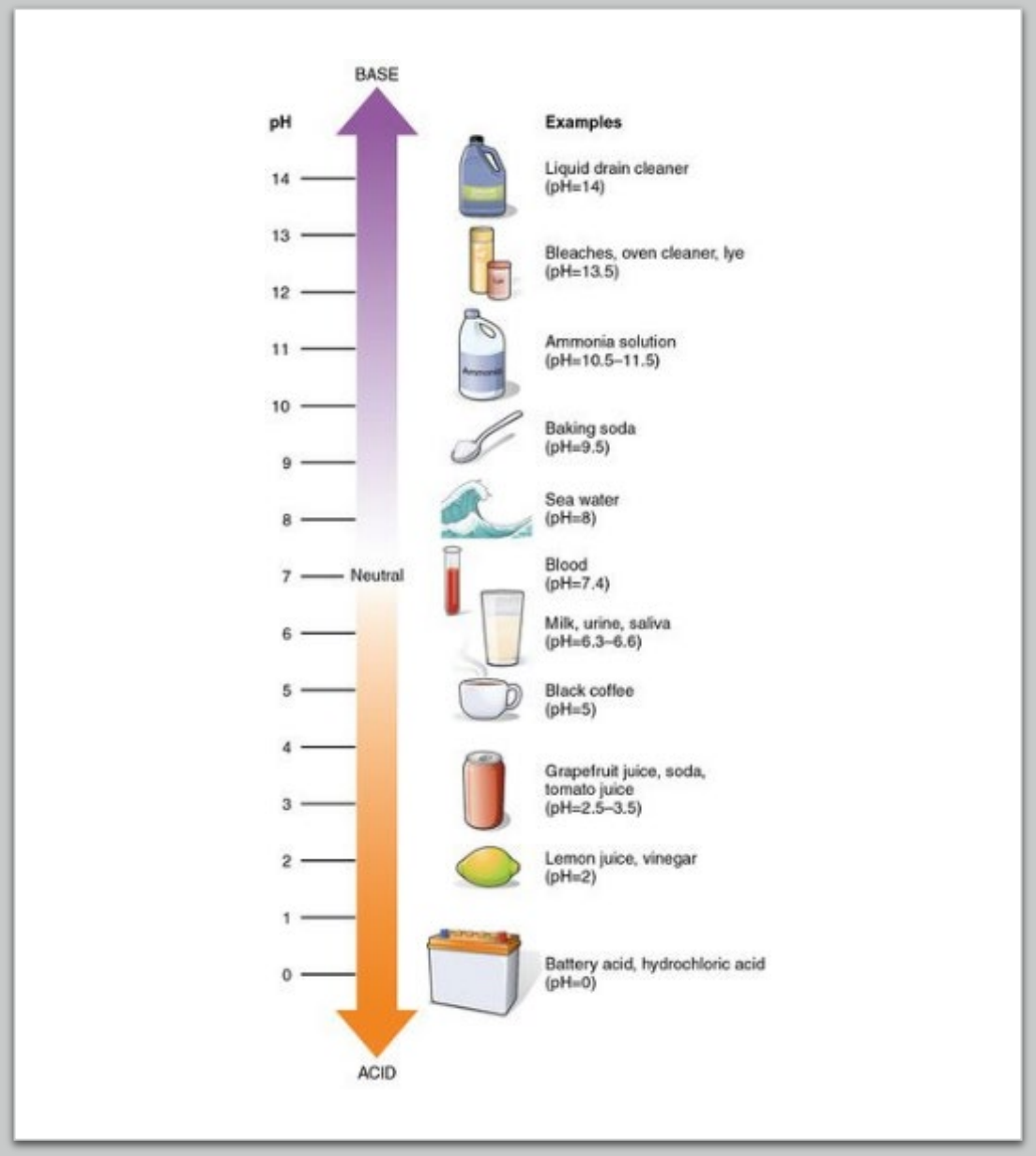
Watch the video Healthy Soil

Then grab a shovel and head out to the garden to evaluate the health of your soil by completing the soil quality card.

Soil Quality Card

Healthy Soil
Part 3

Digging Deeper: Know Your Soil's pH Level



What is pH?

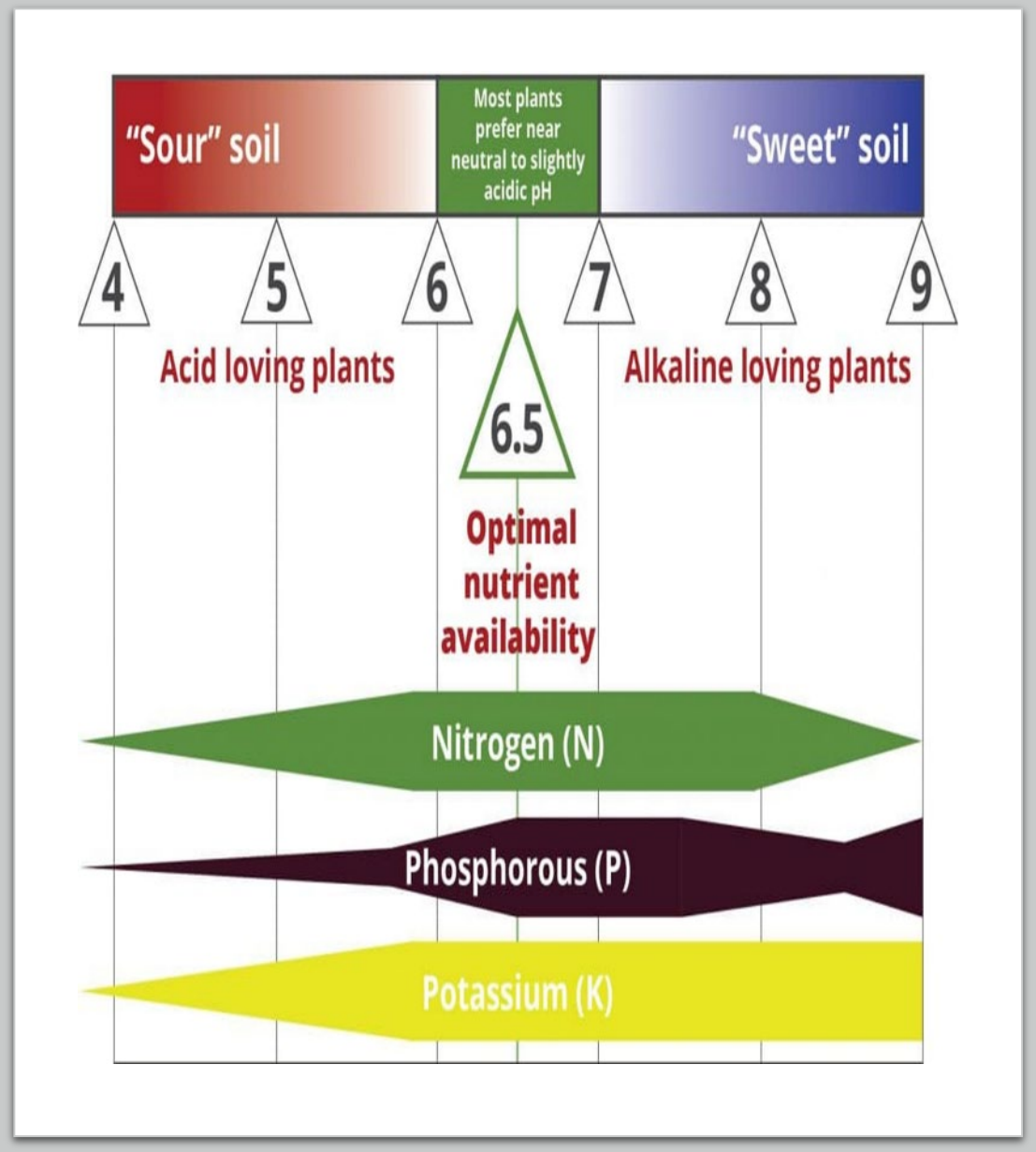
pH is a notation used to express where a substance falls on a scale of 0-14.

- Some substances, like lemon juice, are acids. **Acids** have a *sour* taste.
- Other substances, like aspirin, are alkaline which are also called bases. **Alkalines** have a *bitter* taste.
- Substances that are neither acidic or alkaline are said to be **neutral**.

What is SOIL pH?

Soil pH is the measure of the acidity (sourness) or alkalinity (sweetness) of a soil.

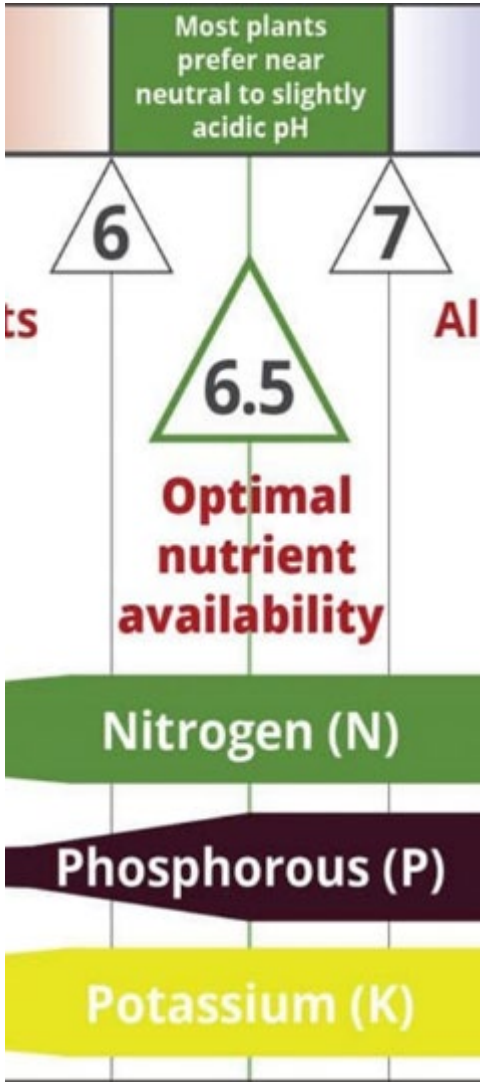
- Soil pH is important because it affects the health of plants. Before a nutrient can be used by plants, it must be dissolved in soil water.
- Most plant nutrients dissolve when the soil is slightly acidic.
- So, many plants do well at a pH range of about 6 to 7.

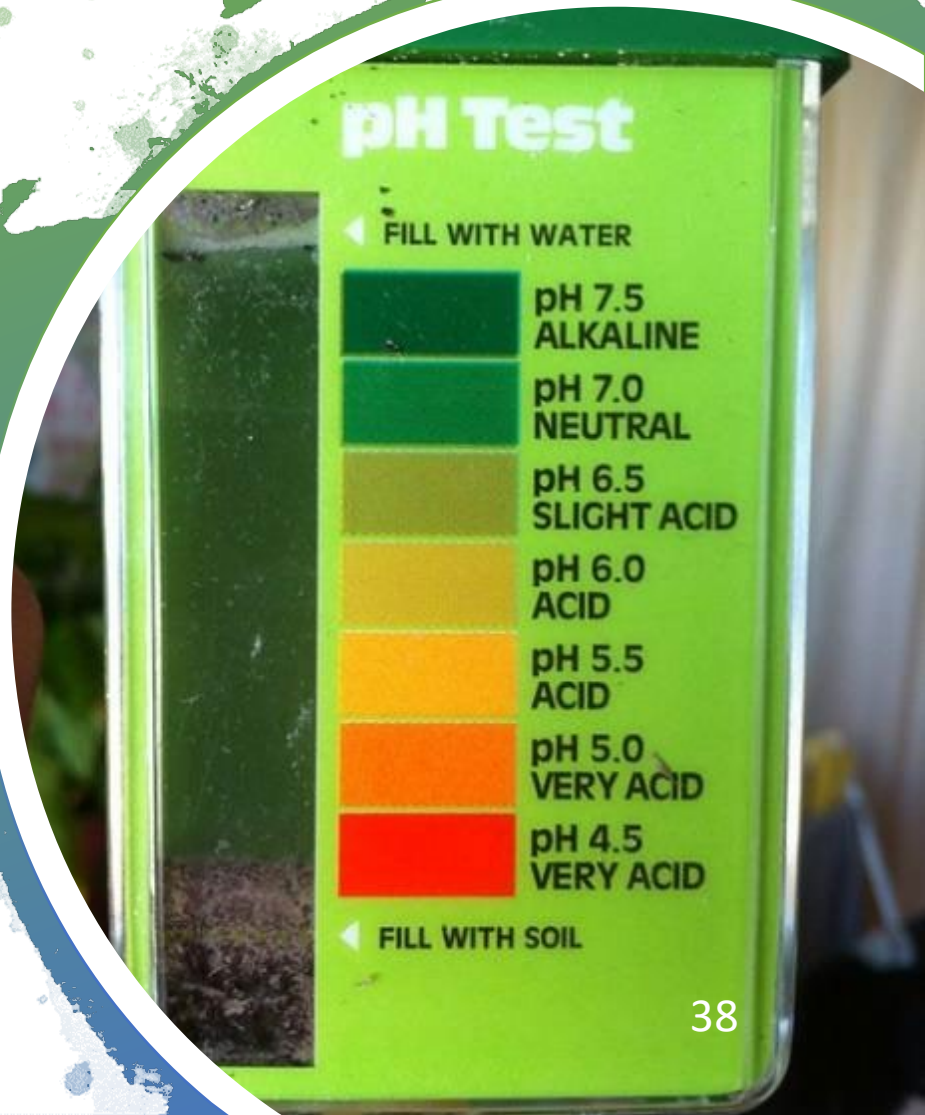


The pH Level of Soil Affects Plants *and* Other Organisms

Bacteria and earthworms do not thrive in highly acidic soils.

- Bacteria that decompose organic matter are hindered in strong acid soils.
- Earthworms thrive at neutral pH. However, they can tolerate a pH from 5.0 to 8.0.
- So, just like Goldilocks finding the most comfortable chair, bacteria, earthworms, and most plants find a pH level from 6 to 7 to be “just right.”





Gardeners have a variety of tools to choose from to determine the pH of soil.

All require that distilled water be used.

Video: Demonstrating pH Testing

Weeds may also serve as soil pH indicators!

- Some weeds, such as sorrels, docks, dandelions, and Queen-Anne's- lace, grow in poor, **acidic soils.**
- Other weeds, such as mustards and thistles, are often found in very **alkaline soils.**

If you have these weeds growing in your garden, change the soil pH, and many of these weeds may leave on their own!

How do you change the pH of the soil?

You can add substances to the soil to make it less or more acidic.

- Add lime or wood ash to acidic soils to make the soil **less** acidic.
- Add sulfur or peat moss to basic soils to make the soil **more** acidic.

Check for Understanding

What is pH?

Why is knowing the pH level of soil important to ensuring its health?

How can gardeners improve the pH of their planting soil?

Extend Your Understanding

Evaluate the pH level of the soil in each of your garden beds.

Use a pH meter or a kit using dyes to measure the pH in each planting bed. Be sure to use distilled water when testing the soil.

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Next Generation Science Standards

LS1.C: Organization for Matter and Energy Flow in Organisms

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

Next Generation Science Standards
Continued

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HSPS1-4),(HS-PS1-5)
- Further clarification, see: https://www.nextgenscience.org/commonly-searched-terms/acids-baseses

Career Technical Education Standards
Ornamental Horticulture Pathway

F2.0 Summarize plant physiology and growth principles.

- F2.1 Understand plant systems, nutrient transportation, structure, and energy storage.
- F2.4 Experiment with the factors that influence plant growth, including water, nutrients, light, soil, air, and climate.
- F5.0 Summarize water and soil (media) management practices.

F5.0 Summarize water and soil (media) management practices.

- F5.1 Explain how basic soil science and water principles affect plant growth.
- F5.3 Prepare and amend soils, implement soil conservation methods, and compare results.

Career Technical Education Standards:
Plant and Soil Science Pathway

- G6.1 Understand soil types, soil texture, structure, and bulk density and explain the U.S. Department of Agriculture (USDA) soil-quality rating procedure.
- G6.2 Analyze soil properties necessary for successful plant production, including pH, electrical conductivity (EC), and essential nutrients.
- G6.3 Explain soil biology and diagram the cycles in nature as related to the soil food chain.
- G7.1 Plan how to effectively manage and conserve soil through conventional, minimum, conservation, and no-tillage irrigation and through drainage and tillage practices.

Resources

- California Master Gardener Handbook, Pettinger, Second Edition 2015
- Healthy Gardens Grow Healthy Soil
- The California Garden Web
- UUCE Master Gardeners of Orange County; Soil Management
- Protecting and Nurturing Soils PowerPoint; Chuck Ingels, Farm & Horticulture Advisor; UC Cooperative Extension, Sacramento County
- Healthy Soils and Carbon Farming: Soil Biology June 20, 2012; Rural Solutions SA
- Roots, Shoots, Buckets and Boots; Sharon Lovejoy, 1999
- Soil Food Webs PowerPoint; Amanda Hodson, PhD; UC Davis
- Soil Science Society of America
- Sustainable Gardening; Contra Costa County UC Master Gardener Program
- Images: Creative Commons; kiddle.com; USDA
- Videos: USDA Soil Series; California Academy of Sciences; Orange County Master Gardeners; Grow Organics

Gardening Questions?

- Email the UCCE Master Gardeners of Riverside County
- Email Helpline
  - anrmgriverside@ucanr.edu
- Riverside Master Gardeners Website

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