FACT: CORN PLANTS NEED SOIL — AND SO DO PEOPLE

LESSON 1:	There's a lot in This Spoonful	(Language, Music, Dance, Art)*
LESSON 2:	Corn Eats Lunch	(Science)*
LESSON 3:	Topsoil Dessert	(Science)*
LESSON 4:	Farmers Till With Care	(Social Studies, Current Events)*

*All Lesson plans are adaptable for ALL ages!

ANN LEARNS TO PLOW

Prologue:
There's something humbling about tilling the earth. It's a time to bury the old crop and prepare for the new. Throughout history, cultivation of the land has revolved around this turning over of the soil; plows have been used since agriculture began.

But the machines and tools, and the management systems that go hand in hand with them, have continuously improved. Today there are new tools and improved systems that were unimaginable only 30 years ago. Farmers today can raise corn with less tillage than either their parents or their grandparents. Less tillage leaves a protective layer of residue, which protects the soil from wind and water erosion. Today, Ann would use a different method. But it was 1969.

It was the first time they'd let Ann drive a tractor by herself. It was the 1650 Oliver, the biggest tractor on the farm; olive green, wide front wheels, plenty of horsepower.

Her brother, five years younger, had driven a tractor many times, and that wasn't fair. But her mom and dad couldn't stop her any longer. She had her driver's permit and knew how to drive a car. A tractor couldn't be much different.

They had dropped her off this morning at the field called "The 120" because it was 120 acres. Now, here she was, plowing by herself.

A day or two before, they'd finished harvesting the corn, so the ground was covered with dried corn stalks and leaves. She couldn't see the ground through that residue. But it didn't matter. All she had to do was keep the right wheel in the furrow made by the plow on the pass before. It was like following a ribbon cut into the field. Simple.

Behind the plow, the freshly turned soil was dark and shiny. The Native Americans had named it "blue earth." She wondered why they hadn't called it black earth; that's how it looked to her.

Hundreds of gulls trailed after her. They swooped down to eat fresh worms uncovered by the plow, then flew back into the air. She was a parade queen, riding a tractor. Behind her came a plow, a flock of birds, a ribbon of blue soil.

The sun was bright. The air was crispy cool. She loved the wind ruffling her hair, the tractor engine roaring, the

cornstalks mixing with new soil. She felt powerful.

She plowed down the field to the end, lifted the plow by pushing the hydraulic lever the way her dad had taught her, turned around, put it back into the ground, plowed back the other direction. Back and forth. Up and down the field.

It was repetitive, peaceful work. Down the field one way. Back the other. North. Then south. Back and forth all afternoon, watching the soil turn, the gulls swoop. Following the furrow.

She had lots of time to think as she plowed. To think and to daydream. Her dad used his time on the tractor to invent new pieces of machinery. Ann liked to let her mind wander too.

She remembered the science fair project about soil that she'd done in the sixth grade. She'd written a letter to every county in her state and asked someone to send a bag of soil from his or her county. More than 20 people had answered, and she'd put those samples into clear baby food bottles, with a string taped from each lid to a map of the state. The soil type was different in every part of the state. It was dark black, brown lumpy, tan sandy or soft powdery, depending where it came from. She had never realized there were so many colors and textures.

Before that project, her mom used to call it dirt.

Ann thought of what she'd learned in junior high science: in every handful of soil are millions of tiny plants and animals, so small only a microscope could make them visible. All those creatures were hiding in there, living and working, decaying old corn stalks, feeding new corn plants. The bugs and worms that were big enough to see made tunnels for air and water to move through. Soil was a busy place.

By the middle of the afternoon she was hungry. She wondered how corn ate. She knew there were minerals in the soil, like those in her food and vitamin pills. Once she'd seen a root under a microscope, so she knew it was covered with tiny hairs that helped get those minerals and water into the plant.

She'd also heard her dad talk about feeding phosphorus and potassium to the corn. "P and K," he called it, and she'd seen the fertilizer trucks spreading it; small white pebbles sprinkled over the ground. She'd also seen him pulling a white tank through the fields that he said had nitrogen gas in it. He said the plants used nitrogen to grow tall.

Thinking of corn plants eating their supper made her laugh. She wondered if baby corn was fussy about its food. Or if teenage corn liked junk food. She was in the middle of a daydream about a plate heaped high with soil, little root hairs reaching for it, when all of a sudden there was a clunk.

The tractor tipped forward.

It felt like she was tipping down, down, far down to her left. Her heart stopped. She grabbed the steering wheel and squeezed so hard her hands hurt. She pushed the clutch in with one foot, the brake with the other, and closed her eyes.

She was shaking and dizzy, but not dead, yet. The tractor quit tipping. She opened her eyes.

The plow was still there. So were the birds, and the sunshine. The left front wheel was in a hole, but she could still see the top of it, so maybe it wasn't too deep. She climbed down.

The hole was four feet across. The wheel was in it, one foot deep, resting on solid ground. But two feet to the west she couldn't even see the bottom. She gasped. Only two feet from disaster.

It was a washout! She'd seen one before. It had been caused by a tile breaking, deep in the ground. Years before, her dad had hired a crew to put cement drain tiles into all his fields. Those tiles helped drain water down through the soil; otherwise rushing water could carry soil off the fields. They also helped drain excess water after heavy rains; otherwise the corn could drown. Roots needed oxygen to live, just like people.

But now, here was Ann stuck in a hole caused by a broken one. She had two choices—to walk home and get her dad, or try to back out.

No, there wasn't a choice. There was no way she'd risk her brother seeing her walk home.

She carefully climbed back into the tractor, put it in reverse, lifted the plow, said a prayer, and backed out. Then slowly, very slowly, she drove around the washout, leaving a big circle of unplowed ground.

She would tell her dad about it later.

LESSON 1: THERE'S A LOT IN THIS SPOONFUL!

SUBJECT: Language Arts, Music, Dance, Art

OBJECTIVE: Students will learn about the plant and animal life in a teaspoonful of soil, most of which is invisible to our naked eyes.

EVALUATION: Students will be able to express knowledge of, and appreciation for, the plant and animal life in the soil.

BACKGROUND FOR TEACHERS:

The soil is the home of innumerable kinds of plant and animal life that range in size from those too small to be seen without a powerful microscope, to large ones such as earthworms.

The microscopic life includes bacteria, protozoa, some fungi and algae. There can be 1 to 4 **billion** one-celled bacteria per gram of soil, or 8,000 to 1 **million** fungi. Soil algae may run as high as 100,000 per gram under favorable conditions.

Animal life in the soil includes nematodes, and larger animals such as rodents, earthworms, ants, snails, spiders, mites and various other worms and insects.

Earthworms are an important group of the larger animals. The earthworms in an acre of soil pass several tons of soil through their bodies each year, and in so doing, make certain nutrients available to plants. Burrows left by earthworms let water and air move more freely through the soil. The number of earthworms may range from a few hundred to more than a million per acre.

STUDENT ACTIVITIES:

1. Ask students to read the story Ann Learns to Plow, paying close attention to the paragraph where she talks about gulls finding worms in the soil, and also the one where she says, "In every handful of soil are millions of tiny plants and animals, so small only a microscope could make them visible…Soil is a busy place!"

2. Then introduce a small box to the students, saying, "This box contains soil, one of the most important things on earth." Use a teaspoon to remove a scoop of soil from the box. Show them pictures of the microscopic (and other) life in the soil, Example 1, and read one of the following:

   "…Take just the top inch of soil, the world squirming right under my palms. In the top inch of forest soil, biologists found 'an average of 1,356 living creatures present in each square foot, including 865 mites,

265 springtails, 22 millipedes, 19 adult beetles, and various numbers of 12 other forms…' Had an estimate also been made of the microscopic population, it might have ranged up to two billion bacteria and many millions of fungi, protozoa and algae—in a mere teaspoonful of soil."

Annie Dillard, Pilgrim at Tinker Creek (New York; Bantam Books, Inc. 1974)

BLACK ENERGY
Life is seething in this soil
which has been millions of years
in the making.
It has been forever
in the making.

A mingling of untold billions of bodies
of plants and animals:
grasses of this prairie
buffalo and antelope grazing down
into roots and back again
into the sun.
Birds and insects, their wings still hum
in this soil.

And this swarm drinks
sunlight and rain,
and rises again
into corn and bean
and flesh and bone.

The quick bodies of animals and men
risen from this black energy.

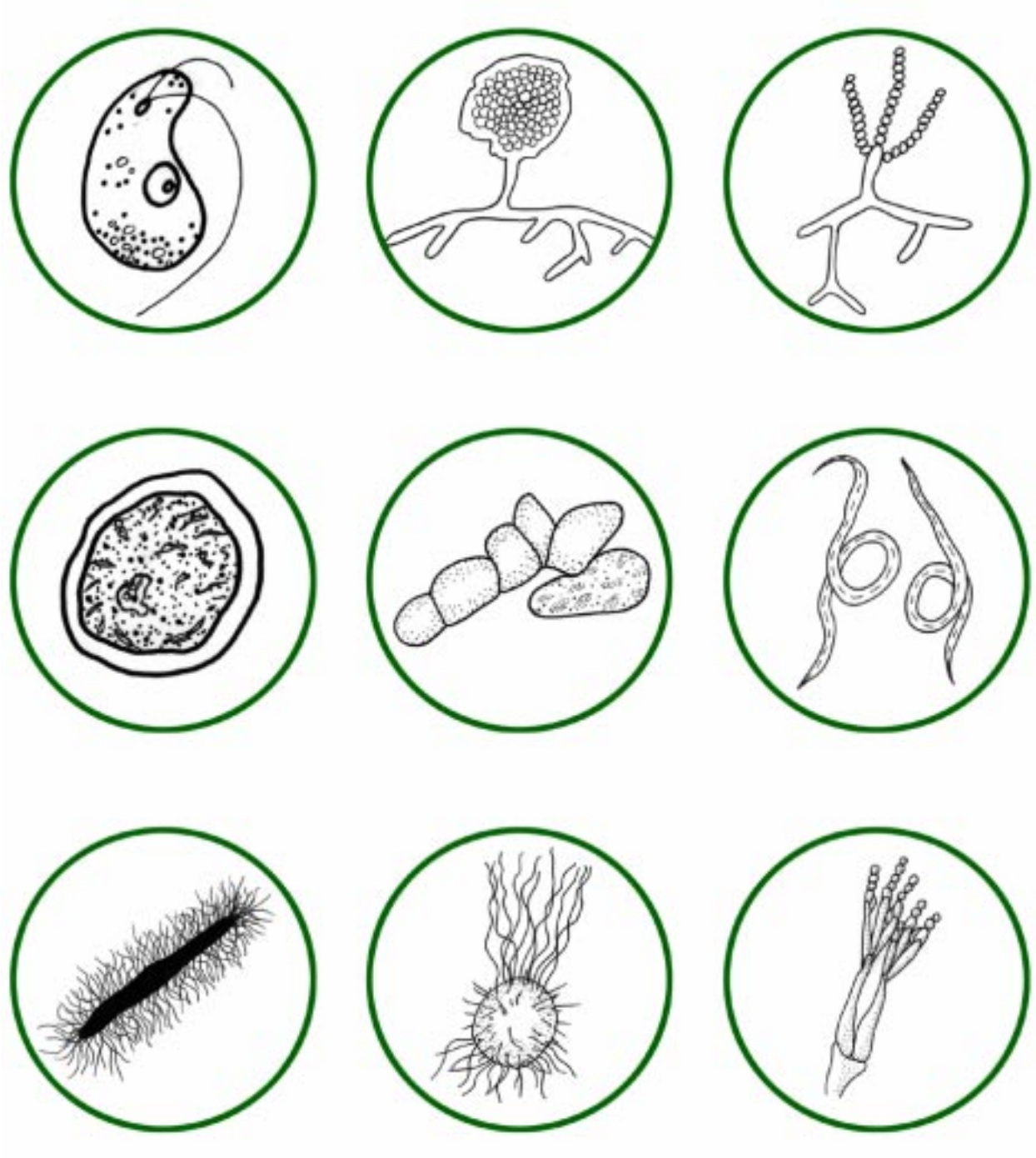
Joe Paddock, Land Stewardship Project materials, Stillwater, MN 55082

3. Then ask students to complete one or more of the following:

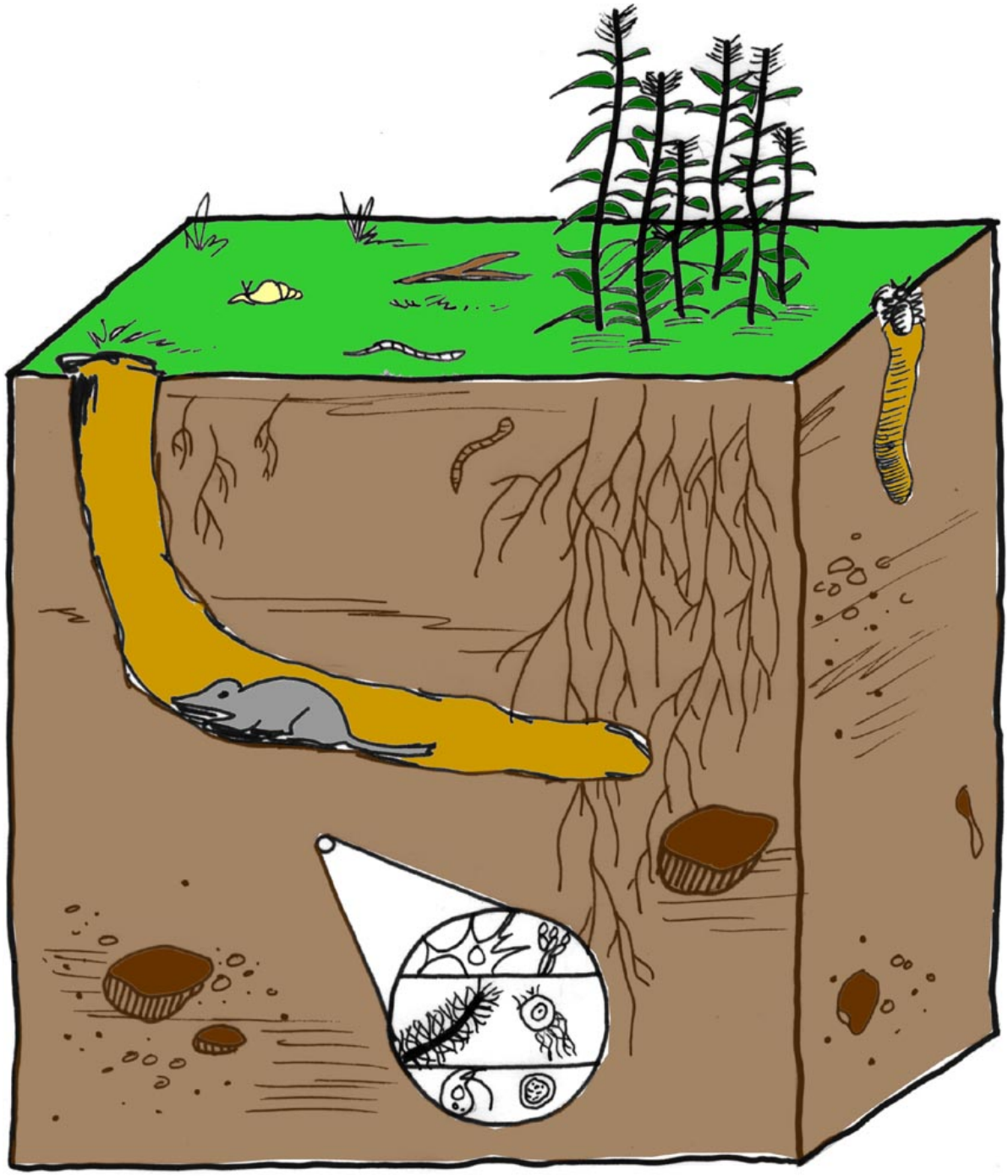
- Write a story in which they ARE one of the life forms living in the soil, and ask them to describe what they smell, feel and taste. Ask them to describe what sounds they hear, and how they spend their days.
- Create a dance of the "squirming" of life under the soil.
- Draw or paint a picture of a teaspoonful of soil, and all the plant and animal life it holds.

- Write a poem about the hundreds, thousands, millions of years it takes to create soil from rock, plants and animals. Then imagine what the future brings.
- Write and perform a play, in which the characters are the different life forms in the soil—plant and animal.
- Build a model of a soil "community," including all the life forms that make the soil their home, complete with their "houses, roads, and gathering places." Use Example 2.

Microscopic Life in the Soil



A Soil Ecosystem



LESSON 2: CORN EATS LUNCH

SUBJECT: Science

OBJECTIVE: Students will be able to label a diagram of a corn root and describe the process of nutrient exchange (eating lunch) in a corn plant.

EVAULATION: Students can to identify the parts of a corn root and describe in simple terms how it eats lunch.

BACKGROUND FOR TEACHERS:

Corn obtains nutrients and moisture from the soil through its roots.

The hard, tough root cap, located on the tip, protects the growing root. In the area immediately behind the root cap, cells are rapidly dividing to form new cells. This is called the region of elongation. The combination of cell division and elongation creates great pressures that push the root through the soil.

Roots get energy to grow from sugars that are made during photosynthesis (see Unit 1, Lesson 1) which occurs in the leaves. As the roots grow, they use oxygen from the surrounding pore spaces (see Unit 2, Lesson 3) to breathe. The carbon dioxide given off in respiration reacts with soil water to form weak carbonic acid.

Roots absorb nutrients and water primarily through tiny projections called root hairs. This is called the region of absorption. Soil water places the root hairs in chemical contact with nutrients that are on the surface of clay and organic matter particles. The weak carbonic acid clinging to the root hairs provides hydrogen ions to the soil water. The hydrogen ions are then exchanged with chemical nutrients held on the surfaces of soil particles. These nutrients are then absorbed by root hairs.

Soil water is distributed through the corn plant by osmosis, a method of diffusion by which a solvent (water) and solute (nutrients) pass through membranes of living cells. This is how the water, nutrients and chemicals slowly progress from the root to the tip of the plant.

The growth of a corn plant is affected by the fertility of the soil. Most plants need about 10-12 chemical elements. Three major elements include nitrogen, phosphorus and potassium. Secondary elements include calcium, magnesium, and sulfur. Trace, or minor, elements include zinc, iron, boron, manganese, copper, and aluminum.

Nitrogen stimulates the growth of leaves and stems, and produces the rich green color which is characteristic of a healthy plant. The plant's use of potassium, phosphorus and other nutrients is also stimulated by the presence of nitrogen.

Phosphorus is present in all living tissue. It is particularly concentrated in the younger parts of the plant and in the flowers and the seed. Phosphorus is necessary for such life processes as photosynthesis, the synthesis and breakdown of carbohydrates, and the transfer of energy within the plant.

Potassium is necessary for basic plant physiological functions and also assists different plants in a number of specialized ways. It enhances the size, flavor and color of some fruits and vegetables. It increases the resistance of some plants to particular diseases. It improves the rigidity of stalks and stems.

Nitrogen, phosphorus and potassium are so commonly used in commercial fertilizers that their percentage is always noted on the fertilizer bag in the same order. For example, a 10-20-10 fertilizer is one that contains 10 percent nitrogen (N), 20 percent phosphorus (P), and 10 percent potassium (K).

Since very few soils contain the right balance of all the elements needed for any one plant, some kind of fertilizer is usually needed. A soil may be high in nitrogen and potassium but low in phosphorus. Since crop yields are limited by the element most deficient, the elements that are deficient should be added.

STUDENT ACTIVITIES:

1. Ask students to read the story Ann Learns to Plow, and ask them to imagine, as she does, how corn eats…"Once she'd seen a root under a microscope…She'd heard her dad talk about feeding phosphorus and potassium to the corn…Thinking of corn plants eating supper made her laugh…"

2. Explain "nutrient exchange" with this simple analogy: The root hairs use hydrogen from their root surface like money to "buy" a nutrient from the soil. The soil takes the hydrogen, and the roots keep the nutrient.

   Ask students to role-play the process. One student can be a "root" holding a hydrogen ion, another student is the "soil particle" (see Lesson 3 to learn more about soil particles) holding a phosphorus or potassium nutrient. The "root" gives the hydrogen to the "soil" and in exchange, the "soil" hands over the nutrient, which the "root" then "eats" (absorbs).

3. To demonstrate the ability of plants to absorb the nutrients ("eat"), and move them to the leaves, ear and other important parts of the plant where they're used to manufacture food (See Unit 1, Lesson 1), use the following activity:

   - Cut a celery stalk at the end where the stalks meet.
   - Stand the stalk in a jar of water and add red ink or food color to the water.
   - At the next class period, remove the stalk and cut it into cross sections at various places. Have the students observe the red areas. Explain that the water has been rising in the plant, carrying nutrients with it.

4. To better understand roots, and their importance to the plants, ask students to complete the following worksheets. Younger students can match the names of the parts of the corn root to the picture; older students can fill in blanks in the worksheet. (Worksheet 1 for younger students, Worksheets 2 & 3 for older students.)

5. To allow students to see root hairs, germinate a package of radish seeds between two moist cloths. They germinate and grow very quickly! Or use a microscope to examine roots of corn, grass, or any other available plants.

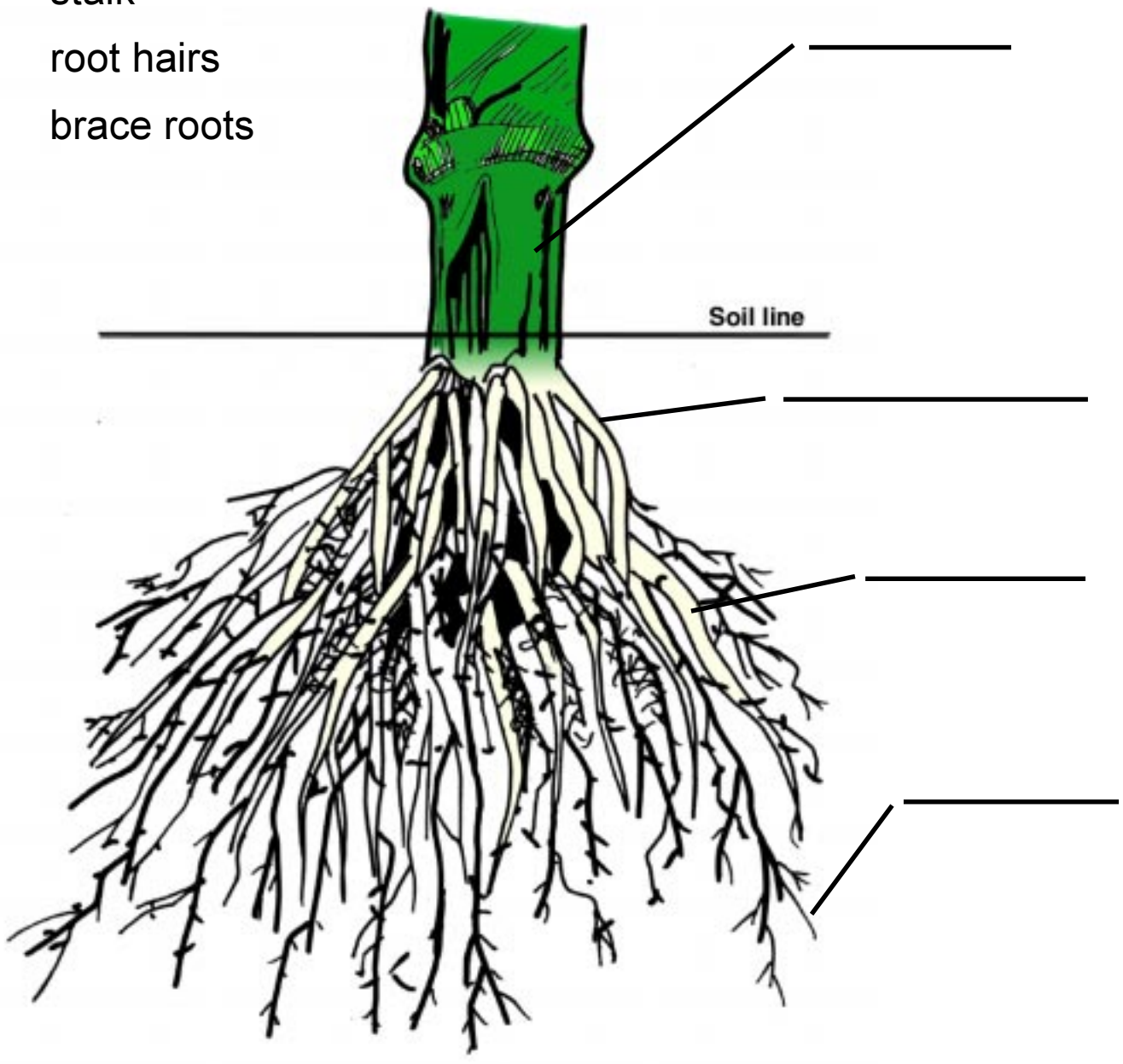
Match the parts to the name

nodal roots

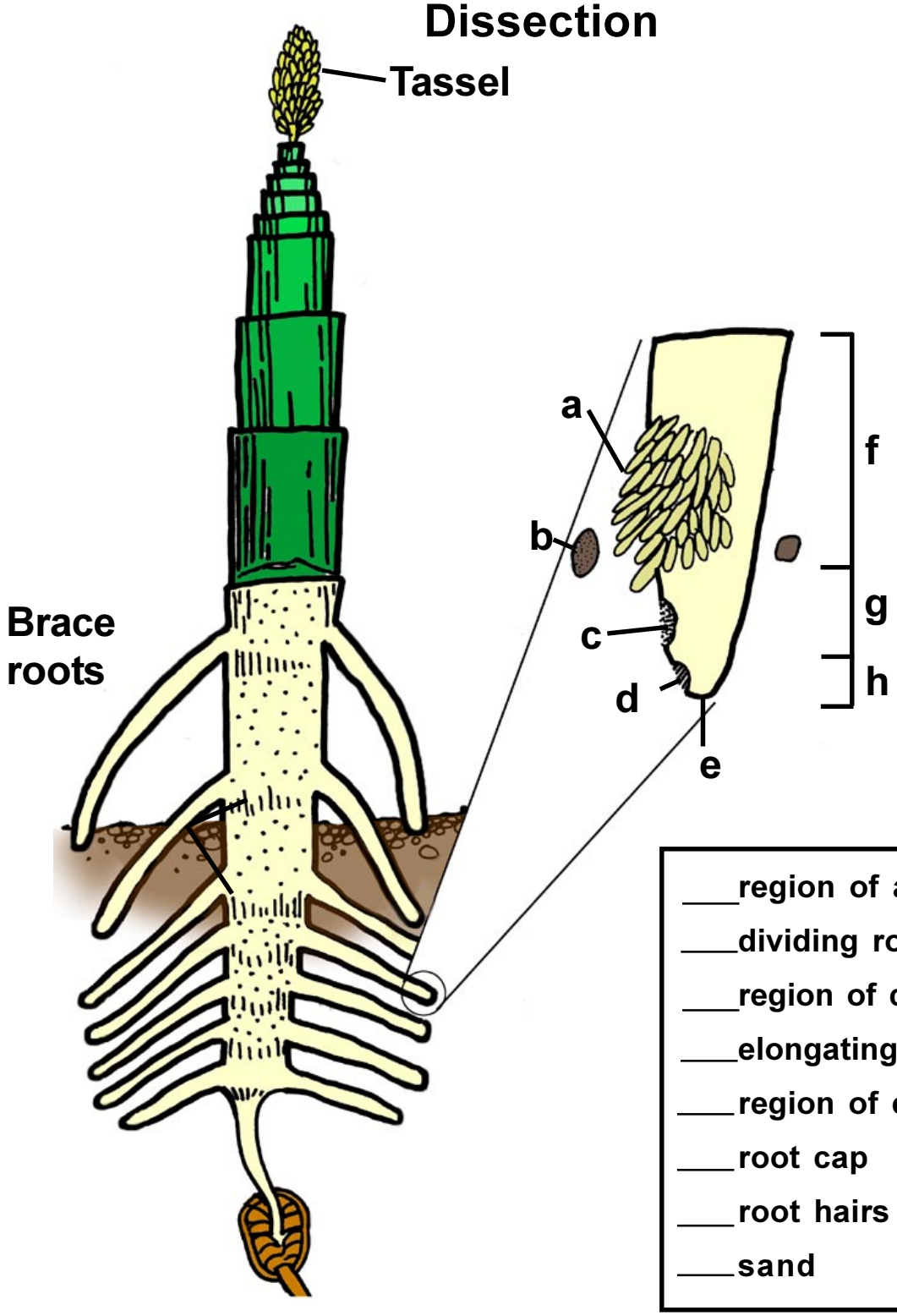
stalk

root hairs

brace roots



Dissection



___region of absorption
___dividing root cells
___region of cell division
___elongating root cells
___region of elongation
___root cap
___root hairs
___sand

LESSON 3: TOPSOIL DESSERT

SUBJECT: Science

OBJECTIVE: Students will create two models, one they can EAT that demonstrates a complete soil profile, and the other that demonstrates the structure of particles and pore spaces in the topsoil. They will also see the effect of water in the soil.

EVALUATION: Students can visualize and describe a soil profile and the different sized particles of which soil is composed. They will also be able to describe the problems of too much, or too little, water.

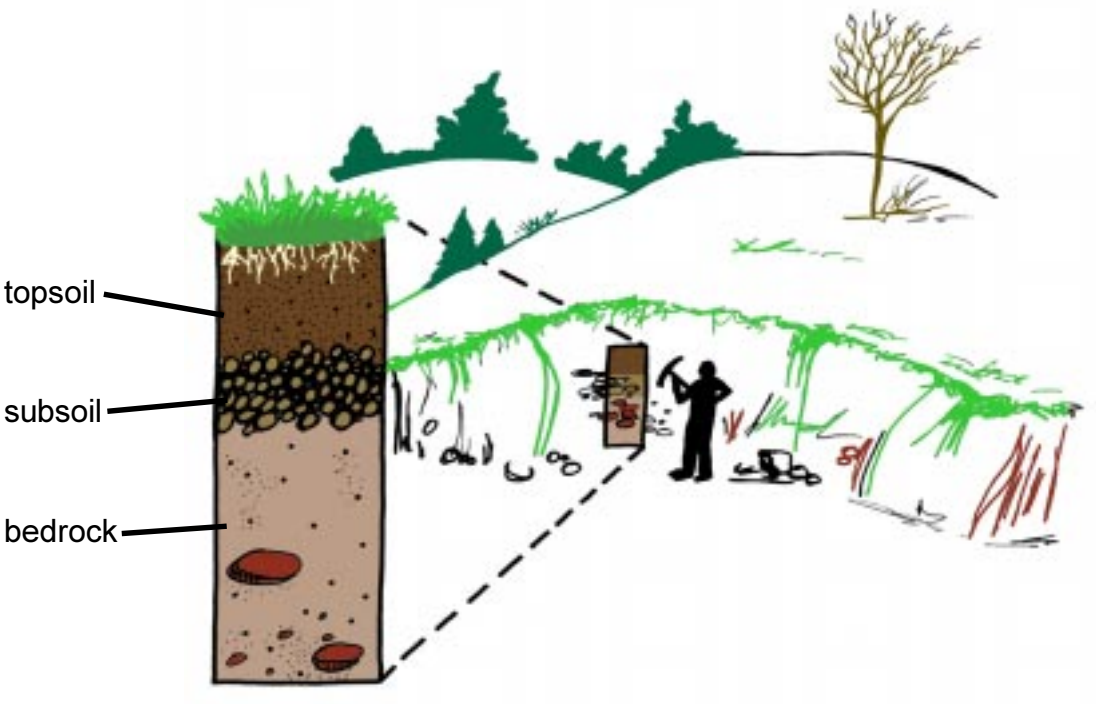
BACKGROUND FOR TEACHERS:

The soil profile has three main layers.

The BEDROCK LAYER is the bottom layer, and is also called the "parent material." It is the rock from which the soil was made hundreds, thousands or millions of years ago. It might be dozens of feet below the surface of the soil, or very near the surface, depending on the geology of the region. (The chocolate chips in the dessert are the "rocks" in this layer.)

The SUBSOIL LAYER is the layer above the bedrock. If the topsoil is eroded, the subsoil may be at, or very near, the surface of the soil. If the topsoil is rich and deep, the subsoil may be several feet below the surface.

The TOPSOIL is where roots of corn and other plants live. This area is filled with millions of plants and animals



(see Unit 2, Lesson 1), and is the area where nutrients feed the plants (see Unit 2, Lesson 2). Wind or water erosion can wash away this valuable layer; that's why farmers work hard to protect it (see Unit 2, Lesson 4).

It takes nature over 500 years to replace one inch of topsoil!

The topsoil is composed of three kinds of particles: sand, silt and clay. The worksheet picture shows the relative sizes.

Clay particles are smaller than 0.002 millimeters in diameter. It would take more than 12,500 clay particles side by side to form a line one inch long. This line would be so thin that it would take more than 250 lines side by side to form a line as wide as a pencil mark.

Silt particles are from 0.002 to 0.05 millimeters in diameter. Sand ranges from 0.05 to 2.0 millimeters. Particles larger than 2.0 millimeters are called gravel or stones.

Most soils contain a mixture of sand, silt and clay in different proportions.

The amount of open space, called "pores" between the particles affects how fast water moves through a soil, and how much water it will hold. Too much clay, in proportion to silt and sand, causes a soil to absorb water very slowly. These soils stay wet longer, and are sticky when wet. They often need to be drained by tile or ditches.

Sandy soils cannot hold as much water, so plants cannot live long in them without frequent rains or irrigation.

The pore spaces between soil particles are also very important because they hold the oxygen that plants need to live (See Unit 2, Lesson 2). If the soil has no pore space because of the kind of soil, or because the soil was compacted by machinery, or if that space is filled with water, plants will not do well. They might even die.

STUDENT ACTIVITIES:

1. Ask students to read Ann Learns to Plow, paying close attention as she describes the characteristics of the topsoil in her field— its color, and how it looks shiny and moist when it's turned. Note also the paragraph in which "she remembered the science fair project she'd done in the sixth grade…" where she describes the many different kinds of soil in her state. Discuss the color and other characteristics of the topsoil in **your** part of the country.

2. Help students each make a Topsoil Dessert. (recipe courtesy of Illinois Ag in the Classroom; Illinois Farm Bureau):

- Gather the following ingredients:
  See-through plastic cups (1 per person)
  1 large package chocolate sandwich-type cookies (Oreo™ is an example)
  3/4 pound gummy worms (See Unit 9 for another story about gummy worms)
  12 oz. miniature chocolate chips
  green-colored coconut
  4 Tablespoons butter or margarine
  8 oz. cream cheese
  1 cup powdered sugar
  3 1/2 cups milk
  2-3 oz. pkg. Vanilla instant pudding
  12 oz. whipped topping (Cool Whip™ is an example)
- Crush and set aside cookies.
- Cream together butter, cream cheese and powdered sugar.
- Mix together milk, pudding and whipped topping.
- Mix together the creamed mixture and the pudding mixture.
- Set the plastic cups out. Fill with layers as described.
- Bottom layer: Begin with a layer of crushed cookies. Mix chocolate chips with half of the blended pudding mixture and smooth it over the cookies.
- Middle layer: Add more crushed cookies, then a blended pudding layer and the gummy worms. Save one worm for the top.
- Top layer: Finish with a layer of crushed cookies. Sprinkle with green coconut "grass" and poke a gummy worm through the top to peek out of the soil.

3. Explain that the dessert is a model of a soil profile (see Example 1), and ask students to explain what they've learned about each layer. (See the teacher's background for more information.)

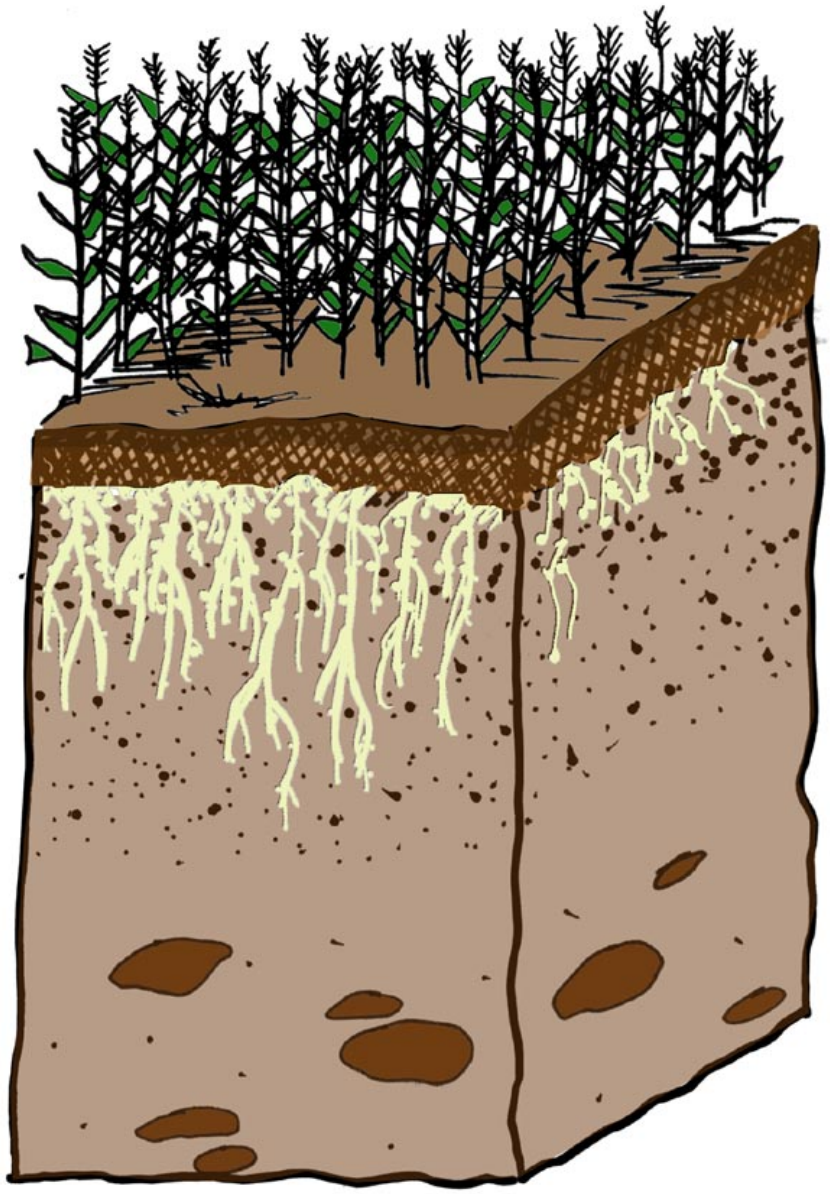
4. Show students the diagram of soil particles, highlighting the size differences, then ask them to complete the worksheet.(Worksheet 1)

5. To illustrate these particle sizes, fill a fruit jar about two-thirds full of marbles or small pebbles (representing sand particles), then add sand (representing silt or clay particles). Tap the jar on the table a few times as you add the sand.

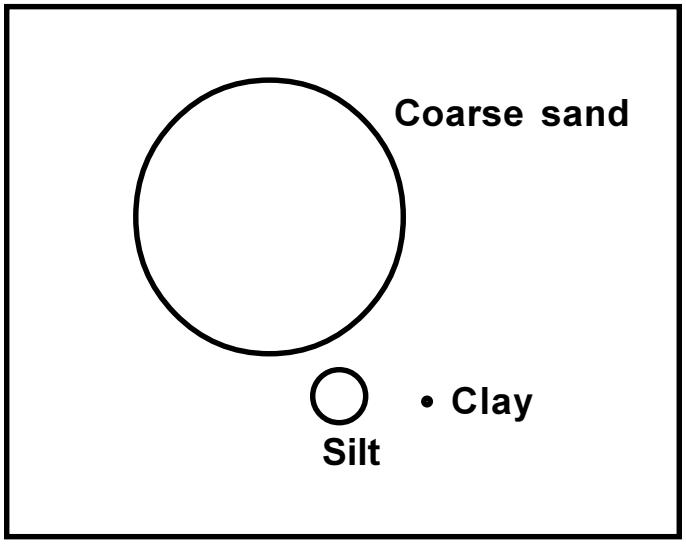
6. To demonstrate water movement in the soil, reread the story, emphasizing the paragraph where Ann explains drainage of the land, "Those tiles helped drain water down through the soil; otherwise rushing water could carry soil off the fields. They also helped drain excess water after heavy rains; otherwise the corn could drown. Roots needed oxygen to live, just like people." (See Unit 2, Lesson 2 for more information on roots and their oxygen requirements.) When the sand completely covers the marbles, and ask students if there is any more space. Proceed to add water, pouring from a measuring cup so you know the amount added.

   - Ask students what would happen to roots in the dry soil (before you add the water), and what would happen to the plant and animal life if the soil were totally dry. This is important to discuss, especially if you live in an area where irrigation is used in crop production.
   - Ask them to predict how much water can be added.
   - Ask them what would happen to roots when the soil is completely saturated with water. Ask them what would happen to the plant and animal life (See Unit 2, Lesson 1 to learn about the plant and animal life) in the soil with no oxygen.

Soil Profile

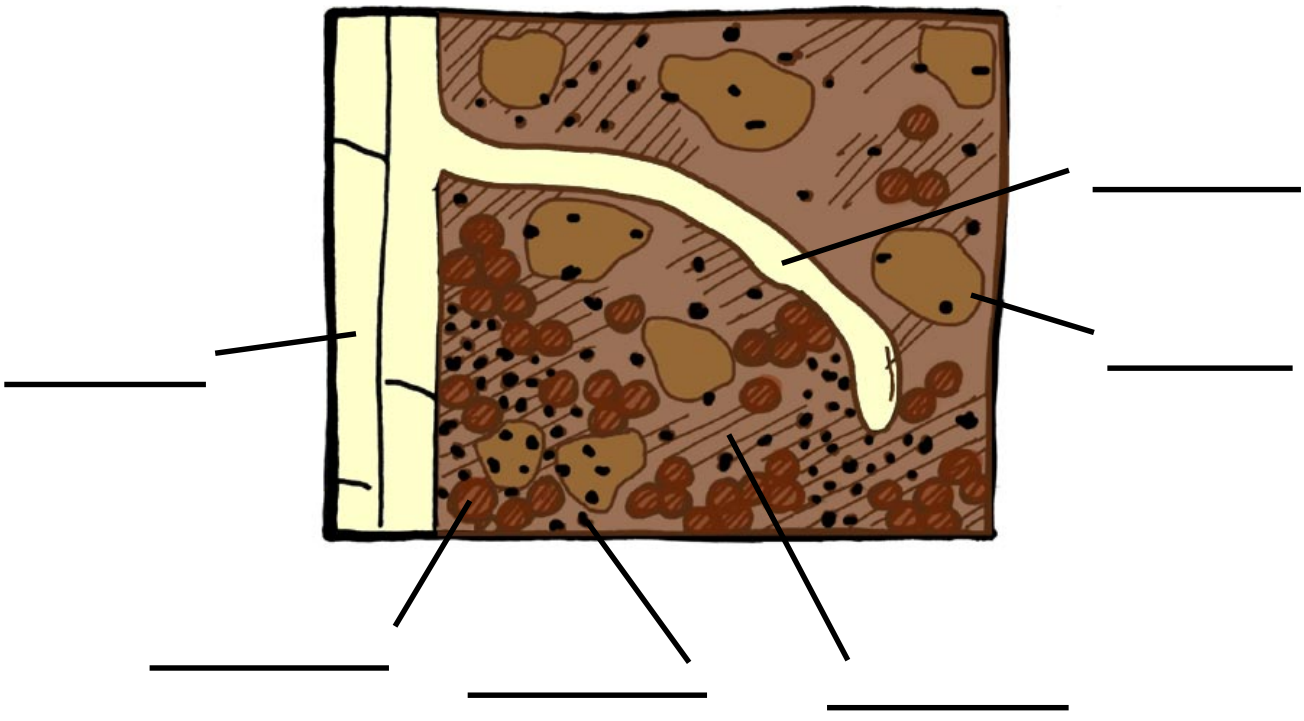


Identify the Soil Particle



Here are the relative sizes of three kinds of soil particles, enlarged more than 500 times.

clay pore spaces root sand silt root hair



LESSON 4: FARMERS TILL WITH CARE

SUBJECT: Social Studies, Current Events

OBJECTIVE: Students will learn that soil can be lost through wind or water erosion, and that plants or plant residue on the surface protect the soil. They will also learn that a majority of farmers are protecting the soil by using conservation tillage methods.

EVALUATION: Students can explain wind and water erosion in simple terms. They understand that new kinds of tillage and new methods of farming have greatly reduced the problem on farmland, but that farmland is not the only place erosion occurs.

BACKGROUND FOR TEACHERS:

In the early 1930s, disaster struck the Great Plains in a period known as the Dust Bowl. In parts of Texas, Oklahoma, New Mexico, Colorado and Kansas, drought and prairie winds blew away billions of tons of topsoil, increasing awareness in this country of the value of the soil, and the necessity for caring for it.

In 1935 the U.S. Congress created the Soil Conservation Service (SCS). The SCS, now known as the National Resource Conservation Service (NRCS), immediately started programs to restore the land. Realizing what erosion could do, Americans began to work to keep good topsoil on the land. Soil-conserving farming techniques, never before taken seriously, gained widespread acceptance.

Conservation tillage is now defined as "leaving more than 30 percent residue on the surface of the soil." It includes no-till, strip-till and mulch-till. Reduced tillage leaves between 15 and 30 percent residue. Intensive or conventional tillage (plowing) leaves less than 15 percent residue on the soil's surface.

Today, many builders, homeowners, farmers and public land managers wisely use soil conservation practices. Good soil conservation practices benefit everyone. When we care for our soil, we make sure that we have productive farmlands, healthy ecosystems, and abundant wildlife for years to come.

STUDENT ACTIVITIES:

1. Ask students to read the story Ann Learns to Plow, then ask, "Can you tell how Ann feels about the land, the soil?"

2. Ask if they have ever seen wind or water erosion. Remember that erosion is not only a problem in rural areas. Some of the highest rates of erosion occur on construction sites (buildings, highways…) where the land has been stripped of its vegetative cover.

3. Use a hair dryer blowing across a pan of bare soil to give a visual impression of wind erosion.

   Use a spray bottle or sprinkling can poured over a pan of bare soil to give a visual impression of water erosion. Elevate the pan slightly. (You'll need a bucket to catch the soil that washes out). Demonstrate that, as the slope is increased (the pan tipped higher) the problem of water erosion increases. Water erosion is not as serious on flat fields.

   If you have time, it's very effective to compare the erosion that occurs on bare soil with soil that is protected by plant material. To do this, sprinkle rye grass seed on the surface of another pan of soil, pat it in, and water until the soil is moist (not saturated). Cover the pan with plastic until the seed begins to germinate, then uncover and put it in the sun. A pan of grass grows well in a school window, and the students will enjoy "mowing" it when it's too long!

   Repeat the wind and water demonstrations when the surface of the soil is covered with growing grass. Now, water running off the pan will not carry soil with it. And wind blowing across it will not carry soil either.

4. Younger students can add plants (corn, grass, trees, flowers) to this picture to show how the soil can be protected by plants and their roots. (Worksheet 1) (See Unit 2, Lesson 2 to learn about corn roots.)

5. Invite someone from your community to speak to the classroom about protecting the soil. Possible visitors are:

   - Employees of the NRCS (National Resource Conservation Service). Ask them to discuss erosion control measures being implemented in both the city and rural areas.
   - Farm equipment dealers (John Deere, Case IH, New Holland, etc.). Ask them to bring pictures or videos of the equipment they sell to farmers that protect the soil.

   (These make great field trips too!)

6. Invite a farmer to your classroom to talk about the tillage methods they use.

Add Plants to Save This Soil!