

GRADE 3 GARDENING & ANIMALS

First edition

8 units

32 lessons

A video for every lesson

FIRST EDITION

COURSE GUIDE

This course is a whole school year of learning by doing. Third graders plant seeds and measure them, dig into soil and find out what lives there, care for (or plan the care of) real pets and farm animals, follow tracks across a muddy yard, and learn how a honeybee colony turns flower nectar into honey. Each lesson pairs clear teaching with a short video, a great picture to study, a hands-on project and a page in the nature journal.

The year moves with the seasons. In the fall we study why seasons happen, what is ripe, how to save seeds, and how wild animals get ready for winter. In early winter we turn to soil, compost and pets. In late winter we start seeds indoors and learn how leaves, stems and roots work. In spring we visit the farm and the beehive, plant containers and garden beds, and finish by learning to protect the garden from pests and diseases in kind and simple ways.

Underneath it all is a simple idea: God made a good and orderly world and gave us the work of tending it (Genesis 2:15). A child who learns to watch closely, water faithfully, handle animals gently and give thanks for the harvest is learning more than science. As our motto says, *Fabricando fit faber*: by making, one becomes a maker. By tending, one becomes a gardener.

Most videos come from university extension services and state wildlife agencies, museums and science centers, SciShow Kids and Mystery Science, Cornell Lab of Ornithology, and experienced gardening, homestead, pet and beekeeping teachers. Every video was checked frame by frame for content. Some growers mention their own seed shop, book or sponsor at the start or end; simply skip those parts. A parent should preview any video before the child watches, and watch alongside a younger or sensitive child.

WHO IT IS FOR

Third graders, about ages 8–9, who can read simple instructions, measure with a ruler and write a few sentences. No yard and no animals are required: every project has a windowsill, balcony-pot, farm-visit or library-book option, and pet lessons work for families who do not own a pet.

HOW TO USE THIS COURSE

1. **The weekly rhythm.** There are 32 lessons, one a week. Each lesson takes two sessions of about 45 minutes. Session 1 is the warm-up, the core ideas, the video and the picture study. Session 2 is the hands-on project and the nature journal. Many projects (seed tests, compost, plant logs) keep going for a few minutes a day after Session 2.
2. **The calendar.** The units follow a school year that starts in late summer: harvest and wildlife in the fall, soil and pets in early winter, seeds indoors in late winter, farm animals and bees in early spring, planting in spring, and plant health as the garden grows. Look up your average last spring frost date and first fall frost date, and shift Units 5, 7 and 8 earlier or later so planting happens at the right time where you live.
3. **Picture study.** Each lesson has one great picture: a painting, a drawing or an old natural-history plate. Let your child look quietly for two minutes, then put the picture away and ask them to tell you everything they saw. Then look again together, using the “Look for” items and the questions. Over the year your child will come to know Dürer, Millet, Van Gogh, Audubon and others as old friends.
4. **The nature journal.** Keep one bound sketchbook or notebook for the whole year. Every journal page gets a date, the weather, and a title. Drawings should be made from real things whenever possible, with labels and measurements. Neatness matters less than honest looking.
5. **Unit review and portfolio project.** The last week of each unit adds a third short session for the unit review (ten short questions worth 50 points; let your child answer aloud or in writing) and the portfolio project, a larger piece of work that shows what the unit taught.

6. **Safety and adult supervision.** Read the safety box in each lesson before you start. Wash hands with soap after handling soil, compost, animals or reptiles. Never touch or feed wild animals. Check for ticks after time in tall grass or woods. Sharp tools, big animals and bees always need an adult. Children do not handle fertilizers, sprays or pesticides.
7. **Fairs, 4-H and contests.** This course builds the habits that youth programs ask for: dated records with costs and measurements (like a 4-H project record book), judging classes where students rank four items and give reasons, fair exhibits (a potted plant, a plate of vegetables, an insect collection), and posters. Homeschoolers can join 4-H through the county extension office, and many county fairs have youth and open classes. Check your county extension office or fair book for ages, classes and rules.
8. **No yard? No animals?** Use pots on a sunny windowsill or balcony, visit a farm, a 4-H fair, a pet store, a shelter or a nature center, and use library books. The goal is real observation of real things, at whatever scale you can manage.

SCOPE AND SEQUENCE

UNIT 1 • WEEKS 1-4

Harvest and the Seasons

Why the tilted earth has seasons, how day length tells plants what to do, how to know when food is ripe, and how to save seeds and sort plants into families.

- 1.1 Earth's Tilt and the Seasons
- 1.2 Day Length and Plants
- 1.3 When Is It Ripe?
- 1.4 Seed Saving and Plant Families

UNIT 2 • WEEKS 5-8

Wildlife

Reading tracks and signs; white-tailed deer, their antlers and the ticks they carry; how squirrels and chipmunks store food; and how birds build nests and migrate.

- 2.1 Tracks and Signs
- 2.2 Deer: Antlers, Browsing and Ticks
- 2.3 Squirrels and Chipmunks
- 2.4 Birds' Nests and Migration

UNIT 3 • WEEKS 9–12

Soil

Sand, silt and clay in a soil jar; the worms, bacteria and fungi that make soil alive; compost from browns and greens; and how water drains through and washes away soil.

- 3.1 The Soil Jar Test and Texture
- 3.2 Living Soil: Worms, Bacteria and Fungi
- 3.3 Compost Science: Browns and Greens
- 3.4 Drainage and Erosion

UNIT 5 • WEEKS 17–20

Seeds and What Plants Need

A fair germination experiment, how leaves make food from light, how water moves from roots to leaves, and the three big plant nutrients N, P and K.

- 5.1 A Germination Experiment with One Variable
- 5.2 Leaves and Photosynthesis
- 5.3 Roots, Stems and Transpiration
- 5.4 N-P-K and Deficiency Signs

UNIT 4 • WEEKS 13–16

Pets

Caring for pets well: a clean aquarium, the heat and light reptiles need, rabbits and their hay, and training a dog with patience.

- 4.1 An Aquarium and Keeping Water Clean
- 4.2 Leopard Geckos and Bearded Dragons
- 4.3 Rabbits: Hay, Housing and Handling
- 4.4 Dog Training and Responsibility

UNIT 6 • WEEKS 21–24

Farm Animals and Bees

A backyard flock of hens, dairy goats and milk, sheep and the path from wool to yarn, and life inside a honeybee hive.

- 6.1 Keeping a Backyard Flock
- 6.2 Dairy Goats
- 6.3 Sheep: From Wool to Yarn
- 6.4 Inside the Beehive

UNIT 7 • WEEKS 25–28

Planting: Pots, Beds and Fields

Choosing containers and potting mix, repotting a root-bound plant, mapping sun and shade to plan a garden, and planting corn, beans and squash together.

- 7.1 Containers and Potting Mix
- 7.2 Repotting a Root-Bound Plant
- 7.3 Planning a Garden with a Sun Map
- 7.4 Planting a Field Crop: Corn, Beans and Squash

UNIT 8 • WEEKS 29–32

Plant Health

Common insect pests, the helpful insects that eat them, fungal diseases like powdery mildew and blight, and simple, gentle ways to keep a garden healthy.

- 8.1 Insect Pests: Aphids, Hornworms and Cabbage Worms
- 8.2 Beneficial Insects
- 8.3 Fungal Diseases: Powdery Mildew and Blight
- 8.4 Simple Pest Management: Hand-Picking, Barriers and Healthy Soil

WEEKLY PACING CALENDAR

WEEK	PLAN
1	• Session 1: Lesson 1.1 Earth's Tilt and the Seasons: warm-up, video, teaching and picture study • Session 2: Lesson 1.1 hands-on project and nature journal <i>Two sessions a week is the usual rhythm. Younger children can split a long session in two; older students can do both sessions in one sitting.</i>
2	• Session 1: Lesson 1.2 Day Length and Plants: warm-up, video, teaching and picture study • Session 2: Lesson 1.2 hands-on project and nature journal
3	• Session 1: Lesson 1.3 When Is It Ripe?: warm-up, video, teaching and picture study • Session 2: Lesson 1.3 hands-on project and nature journal
4	• Session 1: Lesson 1.4 Seed Saving and Plant Families: warm-up, video, teaching and picture study • Session 2: Lesson 1.4 hands-on project and nature journal • Session 3: Unit 1 review and portfolio project
5	• Session 1: Lesson 2.1 Tracks and Signs: warm-up, video, teaching and picture study • Session 2: Lesson 2.1 hands-on project and nature journal

WEEK	PLAN
6	• Session 1: Lesson 2.2 Deer: Antlers, Browsing and Ticks: warm-up, video, teaching and picture study • Session 2: Lesson 2.2 hands-on project and nature journal
7	• Session 1: Lesson 2.3 Squirrels and Chipmunks: warm-up, video, teaching and picture study • Session 2: Lesson 2.3 hands-on project and nature journal
8	• Session 1: Lesson 2.4 Birds' Nests and Migration: warm-up, video, teaching and picture study • Session 2: Lesson 2.4 hands-on project and nature journal • Session 3: Unit 2 review and portfolio project
9	• Session 1: Lesson 3.1 The Soil Jar Test and Texture: warm-up, video, teaching and picture study • Session 2: Lesson 3.1 hands-on project and nature journal
10	• Session 1: Lesson 3.2 Living Soil: Worms, Bacteria and Fungi: warm-up, video, teaching and picture study • Session 2: Lesson 3.2 hands-on project and nature journal
11	• Session 1: Lesson 3.3 Compost Science: Browns and Greens: warm-up, video, teaching and picture study • Session 2: Lesson 3.3 hands-on project and nature journal
12	• Session 1: Lesson 3.4 Drainage and Erosion: warm-up, video, teaching and picture study • Session 2: Lesson 3.4 hands-on project and nature journal • Session 3: Unit 3 review and portfolio project
13	• Session 1: Lesson 4.1 An Aquarium and Keeping Water Clean: warm-up, video, teaching and picture study • Session 2: Lesson 4.1 hands-on project and nature journal
14	• Session 1: Lesson 4.2 Leopard Geckos and Bearded Dragons: warm-up, video, teaching and picture study • Session 2: Lesson 4.2 hands-on project and nature journal

WEEK	PLAN
15	• Session 1: Lesson 4.3 Rabbits: Hay, Housing and Handling: warm-up, video, teaching and picture study • Session 2: Lesson 4.3 hands-on project and nature journal
16	• Session 1: Lesson 4.4 Dog Training and Responsibility: warm-up, video, teaching and picture study • Session 2: Lesson 4.4 hands-on project and nature journal • Session 3: Unit 4 review and portfolio project
17	• Session 1: Lesson 5.1 A Germination Experiment with One Variable: warm-up, video, teaching and picture study • Session 2: Lesson 5.1 hands-on project and nature journal
18	• Session 1: Lesson 5.2 Leaves and Photosynthesis: warm-up, video, teaching and picture study • Session 2: Lesson 5.2 hands-on project and nature journal
19	• Session 1: Lesson 5.3 Roots, Stems and Transpiration: warm-up, video, teaching and picture study • Session 2: Lesson 5.3 hands-on project and nature journal
20	• Session 1: Lesson 5.4 N-P-K and Deficiency Signs: warm-up, video, teaching and picture study • Session 2: Lesson 5.4 hands-on project and nature journal • Session 3: Unit 5 review and portfolio project
21	• Session 1: Lesson 6.1 Keeping a Backyard Flock: warm-up, video, teaching and picture study • Session 2: Lesson 6.1 hands-on project and nature journal
22	• Session 1: Lesson 6.2 Dairy Goats: warm-up, video, teaching and picture study • Session 2: Lesson 6.2 hands-on project and nature journal
23	• Session 1: Lesson 6.3 Sheep: From Wool to Yarn: warm-up, video, teaching and picture study • Session 2: Lesson 6.3 hands-on project and nature journal
24	• Session 1: Lesson 6.4 Inside the Beehive: warm-up, video, teaching and picture study

WEEK	PLAN
	- Session 2: Lesson 6.4 hands-on project and nature journal - Session 3: Unit 6 review and portfolio project
25	- Session 1: Lesson 7.1 Containers and Potting Mix: warm-up, video, teaching and picture study - Session 2: Lesson 7.1 hands-on project and nature journal
26	- Session 1: Lesson 7.2 Repotting a Root-Bound Plant: warm-up, video, teaching and picture study - Session 2: Lesson 7.2 hands-on project and nature journal
27	- Session 1: Lesson 7.3 Planning a Garden with a Sun Map: warm-up, video, teaching and picture study - Session 2: Lesson 7.3 hands-on project and nature journal
28	- Session 1: Lesson 7.4 Planting a Field Crop: Corn, Beans and Squash: warm-up, video, teaching and picture study - Session 2: Lesson 7.4 hands-on project and nature journal - Session 3: Unit 7 review and portfolio project
29	- Session 1: Lesson 8.1 Insect Pests: Aphids, Hornworms and Cabbage Worms: warm-up, video, teaching and picture study - Session 2: Lesson 8.1 hands-on project and nature journal
30	- Session 1: Lesson 8.2 Beneficial Insects: warm-up, video, teaching and picture study - Session 2: Lesson 8.2 hands-on project and nature journal
31	- Session 1: Lesson 8.3 Fungal Diseases: Powdery Mildew and Blight: warm-up, video, teaching and picture study - Session 2: Lesson 8.3 hands-on project and nature journal
32	- Session 1: Lesson 8.4 Simple Pest Management: Hand-Picking, Barriers and Healthy Soil: warm-up, video, teaching and picture study - Session 2: Lesson 8.4 hands-on project and nature journal - Session 3: Unit 8 review and portfolio project <i>Last week. Hold a family harvest fair: set out the best project from each unit (journal pages, plants, photos of animal care) and let the student show guests one of them.</i>

MATERIALS

Nature journal (sketchbook or bound notebook)

One for the whole year: drawings, measurements, logs and weather notes.

Colored pencils, a pencil and an eraser

For journal drawings and labels.

Magnifying glass (hand lens)

For seeds, soil, insects, tracks and leaves.

Ruler, measuring tape and an outdoor thermometer

Measuring plants, tracks and temperatures.

Seeds: beans, peas, radishes, lettuce, sunflowers, marigolds, corn and squash

Cheap packets from a garden center; dry beans from the grocery store also sprout.

Potting mix, small pots or cups with drainage holes, and saucers

For seed starting, the repotting lesson and container gardens.

Clear jars with lids, zip bags and paper towels

Soil jar test, germination tests and seed saving.

Spray bottle and a small watering can

Gentle watering for seedlings.

Trowel and garden gloves

Digging, compost and planting, with an adult nearby.

Paper envelopes and labels

Seed saving and plant labels.

A compost bin, tote or pile (optional)

Unit 3. A large plastic tote with holes works well.

A garden bed or two large pots (optional)

Unit 7. A 12–18 inch pot can hold a small three-sisters planting.

A pet or a pet-sitting opportunity (optional)

Unit 4 works without a pet: plan a habitat and budget, or visit a shelter or pet store.

A farm, 4-H fair or apiary visit (optional)

Unit 6. Call ahead; many farms welcome families in spring.

GRADING

Third graders receive letter grades built mostly from real work: projects, the nature journal and portfolio pieces. The unit reviews check understanding but are a small part of the grade.

PART	%
Hands-on projects	40
Nature journal	20
Unit reviews	15
Portfolio projects	25

Scale: A 90–100, B 80–89, C 70–79, D 60–69. Below 60, repeat the work with help.

- Grade projects with the “check” statements at the end of each project: did the child do each one honestly?
- Grade the journal for effort, dates, labels, measurements and drawing from life, not for artistic skill.
- Living things sometimes die or fail to sprout. Grade the care, the observation and the record, not the result.
- Keep the portfolio pieces and the best journal pages in a folder or take photos for an end-of-year family harvest fair.

A NOTE TO PARENTS

You do not need to be a gardener or an animal expert to teach this course. You only need to be willing to look closely alongside your child, ask “What do you notice?” and let real things do the teaching. A bean that rots, a compost pile that smells, a seed that never sprouts: these are lessons too. Help your child ask why, and try again.

Some lessons involve living animals. Please model gentleness and responsibility, and keep adult supervision firm around big animals, bees, wild animals and anything that bites or scratches. Farm animals are raised for eggs, milk, wool, work and meat;

the course says so plainly and kindly and never shows anything upsetting. Our aim is a child who is grateful for God's creatures and faithful in caring for them.

UNIT 1

HARVEST AND THE SEASONS

Every fall the garden changes. The days grow shorter, the tomatoes slow down, the squash vines turn yellow, and the apples finally taste sweet. In this unit you will find out **why**. You will learn how the tilt of the earth gives us seasons, how plants “know” what time of year it is by the length of the day, how to tell when food is truly ripe, and how to save seeds so next year’s garden can begin from this year’s harvest.

Our pictures this unit come from painters who loved the harvest: Claude Monet’s wheat stacks, Jules Breton’s farm girl at sunrise, Pieter Bruegel’s harvesters, and Vincent van Gogh’s sunflowers. God promised Noah that “seedtime and harvest” would not cease. In this unit you will watch that promise at work.

PREREQUISITES

- Knows the four seasons and the twelve months in order
- Can measure with a ruler and read a simple thermometer
- Has a nature journal and colored pencils ready

MASTERY CHECKLIST

- ☐ I can explain that the tilt of the earth, not its distance from the sun, causes the seasons.
- ☐ I can tell how day length changes through the year and what it does to plants.
- ☐ I can check at least five fruits or vegetables for ripeness.
- ☐ I can save, dry, label and store seeds from beans or another easy crop.
- ☐ I can sort common vegetables into plant families.

LESSONS IN THIS UNIT

1.1 Earth’s Tilt and the Seasons

2 sessions of 45 minutes

1.2 Day Length and Plants

2 sessions of 45 minutes

1.3 When Is It Ripe?

2 sessions of 45 minutes

1.4 Seed Saving and Plant Families

2 sessions of 45 minutes

UNIT 1 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

What causes the seasons?

2. (5 pts)

Why does slanted winter sunlight warm the ground less than summer sunlight?

3. (5 pts)

Is the earth closer to the sun in summer? Explain.

4. (5 pts)

What does a plant sense to know that winter is coming?

5. (5 pts)

What is bolting, and when does spinach do it?

6. (5 pts)

Give two signs that a watermelon is ripe.

7. (5 pts)

How can you tell sweet corn is ready?

8. (5 pts)

Why are beans, peas and tomatoes good crops for a beginner to save seed from?

9. (5 pts)

Name the plant family for each: pumpkin, pepper, radish.

10. (5 pts)

How should saved seeds be stored?

ANSWER KEY

1. Earth's axis is tilted. As Earth travels around the sun, our half is tipped toward the sun in summer and away from it in winter.
2. Slanted light spreads the same sunlight over a bigger area, so each spot gets less warmth. The days are also shorter.
3. No. The earth is actually slightly closer to the sun in early January. Distance does not cause the seasons.
4. It senses the length of the night (day length). Longer nights tell it fall has come.
5. Bolting is when a leafy plant sends up a flower stalk. Spinach bolts when days get long in late spring and early summer.
6. The tendril nearest the melon is dry and brown, and the ground spot has turned creamy yellow. It also sounds deep and hollow when thumped.
7. The silks are brown and dry, and a kernel pressed with a fingernail squirts milky juice.
8. Their flowers usually pollinate themselves, so the seeds grow true to the parent plant.
9. Pumpkin: squash family. Pepper: tomato family. Radish: cabbage family.
10. Completely dry, in labeled paper envelopes, in a cool, dry, dark place.

PORTFOLIO PIECE: MY HARVEST SEASON RECORD

Put together a record of this fall's harvest season. Include your day-length graph and noon-shadow log, your ripeness field guide, and your labeled seed envelope set. Finish with a one-page "harvest letter" telling what you learned about God's rhythm of seedtime and harvest and what you plan to plant with your seeds next spring.

LOOK FOR	WHAT IT MEANS
Seasons and day length	Day-length chart and shadow log are kept accurately, with dates, for at least six weeks.
Ripeness field guide	Pages for at least five crops, each with a careful drawing and three correct ripeness signs.
Seed saving	At least two kinds of seeds are dry, clean, and stored in envelopes labeled with plant, variety, date and place.
Harvest letter	Explains the cause of the seasons and plans next year's planting in clear sentences.

1.1 EARTH'S TILT AND THE SEASONS

OBJECTIVES

- Explain that Earth's axis is tilted and stays pointed the same way as Earth travels around the sun.
- Show with a model why direct sunlight makes summer and slanted sunlight makes winter.
- Record the sun's height by measuring a shadow at noon.

Warm-up. Stand outside (or by a sunny window) at the same time you did your morning chores. Where is the sun? Point to it without looking straight at it. Then look at your own shadow. Is it longer or shorter than you are? Make a guess: will your shadow be longer or shorter at noon in December?

WATCH

Why Do We Have Different Seasons? | California Academy of Sciences

California Academy of Sciences · 3:17

https://www.youtube.com/watch?v=WgHmqv_-UbQ

WHEN TO WATCH

After the core ideas. Watch the yellow sunlight lines: where do they hit the earth straight on in June, and where in December?

BACKUP VIDEO

Why Are There Seasons?

SciShow Kids · 2:20

<https://www.youtube.com/watch?v=UQjT5uKp2hg>

A second, simpler explanation if the first video was hard to follow.

KEY TERMS

axis

An imaginary line through the earth from the North Pole to the South Pole. The earth spins around it once a day.

tilt

The lean of Earth's axis, about $23\frac{1}{2}$ degrees. It always points the same way in space.

orbit

The path Earth travels around the sun.
One trip takes a year.

direct sunlight

Sunlight that strikes the ground nearly straight on. It packs a lot of warmth into a small spot.

Northern Hemisphere

The half of the earth north of the equator, where the United States is.

CORE IDEAS

The earth spins like a top, once every day. But it does not spin straight up and down. Its **axis** leans over about 23½ degrees, and it always leans the same way, toward the North Star, all year long.

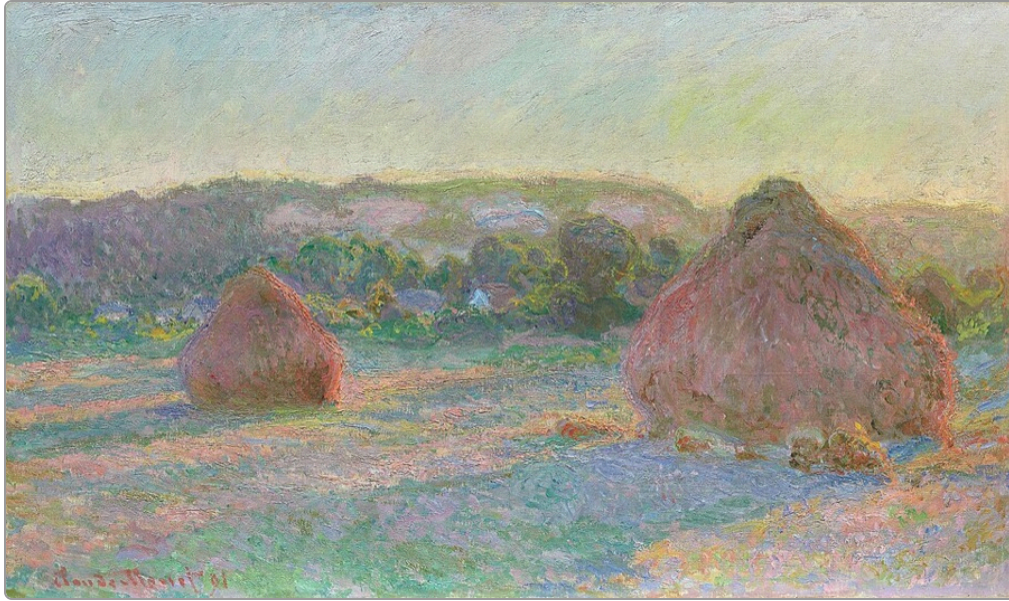
As the earth travels around the sun in its yearly **orbit**, that lean makes a big difference. In June, the Northern Hemisphere is tipped *toward* the sun. The sun climbs high in the sky, its light hits us almost straight on, and the days are long. That is summer. In December, our half is tipped *away* from the sun. The sun stays low, its light comes in at a slant, and the days are short. That is winter.

Why does slanted light feel colder? Shine a flashlight straight down at a table: you get a small, bright circle. Now tilt the flashlight: the same light spreads out into a big, dim oval. Slanted winter sunlight spreads its warmth thin, like a little butter on a lot of toast.

Many people think summer comes because the earth is closer to the sun. It isn't! The earth is actually a little *closer* to the sun in early January. It is the tilt that makes the seasons. That is also why, when it is summer in Ohio, it is winter in Australia, on the other half of the world.

Spring and fall come in between, when neither half is tipped toward the sun. In late March and late September, day and night are almost the same length everywhere. God set this steady rhythm in place, and farmers have planned their planting around it for thousands of years.

PICTURE STUDY



Stacks of Wheat (End of Summer), Claude Monet, 1890–1891 · Oil on canvas · Art Institute of Chicago

Image: [Wikimedia Commons](#), public domain

Claude Monet painted the same wheat stacks near his home in France over and over: in summer, in fall, in snow, at sunrise and at sunset. He wanted to show how the light changes through the day and through the year. This one shows the end of summer, right after harvest.

Look closely

- Find the two wheat stacks. What were they made from, and when were they made?
- Look at the shadows beside the stacks. Which way is the light coming from?
- Find the colors Monet used in the field. Are they the bright greens of early summer or something else?
- Look at the sky. Does it look like a hot noon sky or a softer evening sky?

Talk about it

1. Monet painted these same stacks in winter snow. How do you think the shadows would look then, when the sun stays low?
2. Why did farmers stack the wheat instead of leaving it lying in the field?
3. How can you tell this is the end of summer and not the beginning?

HANDS-ON PROJECT

A Flashlight Seasons Model and a Noon Shadow Log

You will build a simple model of the earth going around the sun to see the tilt at work. Then you will start a shadow log that you will keep, once a month, for the whole school year.

You will need

- An orange or a foam ball and a pencil or skewer (an adult pushes it through)
- A marker
- A flashlight or a lamp with the shade off
- A yardstick or ruler and a straight stick about 1 foot tall
- Your nature journal

Steps

1. Ask an adult to push the pencil through the orange from top to bottom. This is Earth's axis. Draw a line around the middle for the equator, and put a dot about halfway up for where you live.
2. Darken the room. Set the flashlight on a table pointing sideways. This is the sun.
3. Tilt your orange so the top of the pencil leans a little to one side. Walk it in a big circle around the "sun," but keep the pencil leaning toward the same wall the whole time. Do not let it turn!
4. Stop on the side where your dot leans toward the light. Notice that the light hits your dot straight on. This is June: summer.
5. Walk to the opposite side. Now your dot leans away and the light hits at a slant. This is December: winter.
6. Shine the flashlight straight down on paper, then tilted. Trace both light spots and label them "summer sun" and "winter sun."
7. Outside, push the stick straight into the ground in a sunny spot (or stand a pencil in clay on a sunny windowsill). At about 1 p.m. (noon sun time during daylight saving), measure the stick's shadow.

8. Start a table in your journal with the date, the shadow length and the weather. Measure again on the same day each month.

Tips

- The hardest part of the model is keeping the tilt pointed the same way. Pick one wall and keep the pencil leaning toward it.
- Mark the spot where your shadow stick stands so you can use the same spot every month.

Check your work

- ☐ I can show with my model where Earth is in June and in December.
- ☐ I can explain why slanted light warms the ground less.
- ☐ I measured and recorded a noon shadow.

NATURE JOURNAL

1. Draw your orange-and-flashlight model at two places: summer and winter. Use arrows for the sunlight and label the axis, the equator and your town.
2. Make a weather page for this week: each day, write the high temperature and draw the sky.
3. Look out the same window at sunrise or sunset on two days a week apart. Sketch where the sun is against a tree or rooftop. Did it move?

From history. Long before anyone knew the earth went around the sun, farmers watched where the sun rose along the hills to know when to plant. In 1543 Nicolaus Copernicus, a Polish astronomer and church official, published his book explaining that the earth travels around the sun, which made the seasons much easier to understand.

COMMON MISTAKES

- Thinking summer comes because Earth is closer to the sun. The tilt causes the seasons.
- Letting the pencil “axis” turn while walking around the lamp. The tilt always points the same way.
- Measuring the shadow at different times of day. Use the same time every month.

Make it a game • Tilt Tour Showdown. Use a flashlight and a ball with a pencil stuck through as the axis. Walk the ball around the light, keeping the pencil pointed at the same corner. Stop at four spots and predict which season it is, then explain whether the light is direct or slanted. Score one point per correct explanation.

Scripture. “While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease.” (Genesis 8:22, KJV)

God promised Noah that the seasons would keep coming. The tilted, orbiting earth is how He keeps that promise every year.

1.2 DAY LENGTH AND PLANTS

OBJECTIVES

- Describe how the number of daylight hours changes through the year.
- Explain that plants sense day length and use it to know when to grow, flower, store food or drop leaves.
- Track sunrise, sunset and day length for several weeks.

Warm-up. Think back to summer vacation. Was it still light outside at bedtime? Is it light at bedtime now? With your teacher, look up today’s sunrise and sunset times on a weather app or in the newspaper and figure out how many hours of daylight we have today.

WATCH

How plants tell time - Dasha Savage

TED-Ed · 4:19

<https://www.youtube.com/watch?v=3jIW5wW2WC0>

WHEN TO WATCH

After the core ideas. Pause after the part about the leaf measuring the length of the night and say it back in your own words.

Note: This animated lesson uses a few big words (like “photoreceptor”). The parent may pause and explain: it is a part of the leaf that senses light.

KEY TERMS

day length

The number of hours between sunrise and sunset.

solstice

The longest day of the year (about June 21) or the shortest day (about December 21).

equinox

A day in March or September when day and night are about equal everywhere.

short-day plant

A plant that flowers when nights grow long, such as chrysanthemums and poinsettias.

long-day plant

A plant that flowers when days grow long, such as spinach, lettuce and radishes.

CORE IDEAS

In the middle of the United States, the longest day in June has about 15 hours of daylight. The shortest day in December has only about 9 hours and 20 minutes. Between those two, the day grows or shrinks by a minute or two every single day.

Plants cannot read a calendar, but they can “read” the night. Special parts of their leaves sense light and darkness. As nights grow longer in the fall, a plant gets the message: winter is coming. Trees slow down, pull food back into their twigs and roots, and drop their leaves. Perennials like rhubarb and asparagus store food underground for next spring.

Day length also tells many plants when to **flower**. Chrysanthemums and poinsettias are **short-day plants**: they bloom when nights are long, in fall and winter. Spinach, lettuce and radishes are **long-day plants**: when June days get long, they stop making tender leaves and shoot up a flower stalk. Gardeners call that “bolting.” That is why we plant spinach in early spring and again in fall.

Short days also mean less light for making food. When days are shorter than about 10 hours, most vegetables barely grow at all, even if it is not freezing yet. Gardeners plant fall crops in late summer so they are nearly full-size before the days get that short.

God built a clock into every plant. Because the sun’s schedule never fails, plants can trust it more than the weather. A warm week in November may fool you, but it will not fool a maple tree.

PICTURE STUDY



The Song of the Lark, Jules Breton, 1884 · Oil on canvas · Art Institute of Chicago

Image: [Wikimedia Commons](#), public domain

Jules Breton grew up in a farming village in France and spent his life painting farm workers. Here a young woman on her way to work in the fields stops to listen to a skylark singing as the sun comes up.

Look closely

- Find the sun. Is it rising or setting? How can you tell?
- Look at the tool in her hand. It is a sickle, used for cutting grain or grass.
- Find the haystacks or grain stacks far away on the left. What season might this be?
- Look at the light on her face and arms. Where is it coming from?

Talk about it

1. Farm workers often started at sunrise. Why would they work earlier in summer than in winter?
2. The lark sings at dawn. How do you think birds and plants know when morning comes?
3. What do you think she is feeling as she listens?

HANDS-ON PROJECT

A Day-Length Chart and a Light Experiment

You will start a chart of sunrise, sunset and day length that you will keep up through the fall. You will also see for yourself how much plants depend on light by growing two pots of seedlings with different amounts of light.

You will need

- Sunrise and sunset times from a weather app, almanac or newspaper
- Graph paper
- Two small pots or cups with drainage holes, potting mix and radish or lettuce seeds
- A sunny windowsill and a dim corner of a room

Steps

1. Make a table in your journal with four columns: date, sunrise, sunset, hours of daylight.
2. Find today's day length. Count the hours and minutes from sunrise to sunset (an adult can help with the subtraction).
3. Fill in the table once a week through December. On graph paper, put the weeks along the bottom and the hours of daylight up the side, and mark a dot each week.
4. Plant 5 radish or lettuce seeds about $\frac{1}{4}$ inch deep in each of two pots. Water both the same.
5. Put one pot on the sunny windowsill and the other in a dim corner away from the window. Label them.
6. Every other day, give both pots the same amount of water and measure the tallest seedling in each.
7. After two weeks, compare the color, height and stems of the two pots. Write what you see.

Tips

- Seedlings in dim light grow tall, pale and floppy as they stretch toward light. That is called being "leggy."

- Keep everything the same for the two pots except the light, so the test is fair.

Check your work

- ☐ I can find the day length from sunrise and sunset times.
- ☐ I can explain how plants use the length of the night to know the season.
- ☐ I compared seedlings grown in bright and dim light and recorded the difference.

NATURE JOURNAL

1. Draw a tree near your home now. Draw the same tree again in four weeks. What changed?
2. Draw your two radish pots side by side after two weeks, with measurements.
3. Write two sentences: "The shortest day of the year is about _____. The longest day is about _____."

COMMON MISTAKES

- Forgetting that day length changes slowly, a minute or two a day. You need several weeks to see the pattern.
- Thinking cold alone makes trees drop leaves. Shorter days start the change; cold helps finish it.
- Giving the dim-corner pot more water. Keep the water the same so only the light is different.

Make it a game · Day Length Graph Guess. Without looking, sketch a line graph of daylight hours through a year and mark the solstices and equinoxes. Then check against a chart or almanac. Score a point for each marker placed within a month. Explain how a short-day plant and a long-day plant would react. Try to beat your own sketch.

1.3 WHEN IS IT RIPE?

OBJECTIVES

- Use color, feel, smell, sound and size to judge when fruits and vegetables are ready.
- Describe the signs of ripeness for at least five common crops.
- Harvest gently and safely, with clean hands and the right tool.

Warm-up. Your teacher sets out two or three pieces of the same fruit, some ripe and some not quite (bananas or pears work well). Without tasting, use your eyes, nose and fingers to put them in order from least ripe to most ripe. Explain your clues.

WATCH

How to Tell When Your Fruits and Vegetables are Ready to Harvest

GrowVeg • 5:29

<https://www.youtube.com/watch?v=8gCt675555o>

WHEN TO WATCH

After the core ideas. Make a list as you watch: write the name of each crop and one ripeness sign for it.

Note: The opening mentions the channel's book; you can skip the first few seconds.

KEY TERMS

ripe

Fully grown and ready to eat or to save seed from, with the best flavor.

mature

Finished growing. Some crops, like green beans, are best picked before they are fully mature.

harvest

Gathering a crop when it is ready; also the crop itself.

rind

The tough outer skin of a squash or melon.

CORE IDEAS

Picking at the right moment is a skill. Pick too early and food is hard, sour or bland. Pick too late and it is tough, seedy, mushy or eaten by bugs. Good gardeners use all their senses: **look, touch, smell, listen** and, when the grown-ups say so, **taste**.

Tomatoes are ripe when they are fully colored and give a little when you squeeze gently. **Sweet corn** is ready when the silks are brown and dry and a kernel pressed with a fingernail squirts milky juice. **Green beans** should be picked young, before the seeds make bumps in the pod. **Zucchini** are best at 6 to 8 inches long; they can grow into giant clubs in just a few days.

Winter squash and pumpkins are ripe when the rind is so hard you cannot dent it with a fingernail and the stem has turned dry and corky. **Watermelons** are ready when the curly tendril closest to the melon dries brown and the spot where it rests on the ground turns from white to creamy yellow. **Apples** are ready when they come off with a gentle lift and twist and their seeds have turned brown.

Root crops hide underground, so we look for other signs. **Carrots** push their orange “shoulders” up out of the soil. **Potatoes** are ready a couple of weeks after their tops turn yellow and die back.

Harvest gently. Cut squash and peppers with clippers (an adult’s job, or with an adult beside you) instead of yanking, so you don’t break the plant. Harvest in the cool of the morning when you can, and wash your hands before and after. Picking often keeps many plants, like beans and zucchini, making more.

PICTURE STUDY



The Harvesters, Pieter Bruegel the Elder, 1565 · Oil on wood · The Metropolitan Museum of Art, New York

Image: [Wikimedia Commons](#), public domain

Pieter Bruegel painted a set of pictures showing the farm year, month by month. This one shows the wheat harvest in late summer in the Low Countries (today's Belgium and the Netherlands). It is one of the most famous pictures of farm work ever painted.

Look closely

- Find the workers cutting wheat with long scythes. Find the ones tying it into bundles called sheaves.
- Look at the color of the wheat. How can you tell it is ripe?
- Find the people eating lunch under the tree. What foods can you see?
- Look far into the distance. Can you find a cart, a church and other fields?

Talk about it

1. Why do you think everyone worked so hard at harvest time instead of waiting a few weeks?
2. What would happen to ripe wheat if it stood in the field through many rainstorms?
3. Which person in the picture would you most like to be? Why?

Safety first. Only an adult uses knives and clippers, or a child uses them with an adult right beside. Never eat anything from a garden or a wild plant unless a grown-up says it is safe. Wash produce and your hands after harvesting.

HANDS-ON PROJECT

A Ripeness Detective Field Guide

You will become a ripeness detective. You will test real fruits and vegetables from your garden, a farm stand or the grocery store and make a field guide that you can use at harvest time for years.

You will need

- At least five kinds of produce, some ripe and some not, such as tomatoes, apples, pears, bananas, corn, squash, melons or beans
- A cutting board and a knife (adult use only)
- Your nature journal and colored pencils

Steps

1. Set out your produce. For each kind, find one that you think is ripe and one that is not, if you can.
2. Look closely at the color of each one. Draw both and color them carefully.
3. Touch each gently. Is it hard, firm or soft? Write the word.
4. Smell each near the stem end. Ripe melons, pears and tomatoes often smell sweet there.
5. Listen: thump a melon or squash with a knuckle. A ripe watermelon sounds deep and hollow.
6. Ask an adult to cut one ripe and one unripe piece open. Compare the seeds and the inside color.
7. If your teacher says it is safe, taste a small piece of each. Write one word for each taste.
8. Make one field-guide page for each crop: the name, a drawing, and three ripeness signs.

Tips

- If you have a garden, visit it every other day at harvest time. Many crops go from “almost” to “too late” quickly.
- Farm stands and orchards are good places to ask a farmer, “How do you know when it’s ripe?”

- Many county fairs have a youth vegetable class. Judges want a plate of 3 to 5 matched vegetables of one variety: all the same size, shape and ripeness, true to type, clean (wiped, not scrubbed), with no blemishes, and correctly labeled. Choose your best matched set from your ripeness test and practice. Check your fair book for the rules.

Check your work

- ☐ I can give three ripeness signs for at least five crops.
- ☐ My field guide has a drawing and notes for each crop.
- ☐ I know which tools I may use only with an adult.

NATURE JOURNAL

1. Draw one tomato or apple every two days as it ripens on the plant or on the counter. Color each drawing exactly.
2. Cut-open drawing: with an adult, cut a ripe and an unripe fruit in half. Draw and label the seeds and flesh of each.
3. Weather watch: write this week's high and low temperatures. Do warm days or cool nights help fruit ripen?
4. Practice judging: lay out four tomatoes (or apples) and rank them 1 to 4 for ripeness and quality. Write one reason for each placing.

COMMON MISTAKES

- Waiting too long to pick zucchini and green beans. They are best young.
- Pulling fruit off the vine and breaking the stem. Use a gentle twist or have an adult cut it.
- Judging only by size. Color, feel and smell matter more.

Make it a game • Ripeness Detective Duel. Your grown-up names a crop. You have thirty seconds to give its ripeness signs using color, feel, smell, sound or size, such as the thump of a melon. Get a point for every sign. Score five crops in a row, with rind clues for melons, and see if you can reach fifteen points.

Scripture. “a time to plant, and a time to pluck up that which is planted;” (Ecclesiastes 3:2, KJV)

There is a right time to plant and a right time to harvest. A wise gardener watches and waits for it.

1.4 SEED SAVING AND PLANT FAMILIES

OBJECTIVES

- Explain why gardeners save seeds and which crops are easiest to save.
- Tell the difference between open-pollinated (heirloom) and hybrid seeds.
- Sort common crops into five plant families.
- Dry, label and store seeds correctly.

Warm-up. Look at a bean pod, a pea pod, a tomato cut in half and a sunflower head (or pictures of them). Where are the seeds in each? Count the seeds in one bean pod. How many new plants could come from that one pod?

WATCH

How to Save Seeds: Seed Saving Techniques EXPLAINED

Epic Gardening · 12:45

<https://www.youtube.com/watch?v=iMErBLSyxBk>

WHEN TO WATCH

After the core ideas. Watch the first half on plant families, heirlooms and hybrids in Session 1, and the dry and wet seed-saving parts before your project in Session 2.

BACKUP VIDEO

Saving Seeds from Beans, Peppers, Onions...and More!

GrowVeg · 5:12

<https://www.youtube.com/watch?v=dPwMf3uA8Q8>

A shorter how-to; good to watch right before you save your bean seeds.

KEY TERMS

seed saving

Collecting, drying and storing seeds from your own plants to plant next year.

open-pollinated

A variety whose seeds grow into plants just like the parent. Old open-pollinated varieties are called heirlooms.

hybrid

A plant made by crossing two different parent varieties. Its seeds usually do not grow true to the parent.

plant family

A group of plants that are related and share features, such as flower shape and seed type.

CORE IDEAS

Every garden plant you have ever eaten came from someone, long ago, saving the seeds of a good plant. When you save seeds from your healthiest, tastiest plants, you are joining a chain of gardeners that goes back thousands of years.

The easiest seeds to save come from plants that pollinate themselves: **beans, peas, tomatoes and lettuce**. Their flowers usually fertilize themselves before insects can bring in pollen from a different variety, so the seeds grow true. Squash, pumpkins and corn are harder, because bees and wind carry pollen between varieties and the seeds may grow into surprise plants.

Look at your seed packet. If it says **F1 hybrid**, the plant came from crossing two different parents. Its seeds will usually grow into plants that are different from the one you liked. If it says **heirloom** or **open-pollinated**, the seeds should grow true. Save seeds from these.

Plants come in **families**, like people. Knowing the families helps you save seeds, plan your garden and spot pests. The **bean family** (beans, peas) has seeds in pods. The **tomato family** (tomatoes, peppers, potatoes, eggplant) has five-pointed flowers. The **squash family** (squash, pumpkins, cucumbers, melons) has big yellow flowers and climbing tendrils. The **cabbage family** (cabbage, broccoli, kale, radishes) has four-petaled flowers. The **daisy family** (sunflowers, lettuce, marigolds) has many tiny flowers packed into one flower head.

Seeds must be **dry** before you store them, or they will mold. Let bean and pea pods dry on the plant until they rattle. Spread seeds on a plate for a week, then store them in a labeled paper envelope in a cool, dry, dark place. Most vegetable seeds stay good for two to five years.

PICTURE STUDY



Sunflowers, Vincent van Gogh, 1888 · Oil on canvas · National Gallery, London

Image: [Wikimedia Commons](#), public domain

Vincent van Gogh painted a whole series of sunflowers in a vase. He loved them at every stage: fresh, fading and gone to seed. Look closely and you will see the life cycle of a sunflower in one painting.

Look closely

- Find a fresh sunflower with all its petals. Then find one whose petals have dropped.
- Look at the big centers. Each little bump there becomes one seed.
- Find a flower head that is turned away from you. What does the back look like?
- Count how many flowers are in the vase.

Talk about it

1. Which flowers would you choose if you wanted to save sunflower seeds? Why?
2. Sunflowers are in the daisy family. What makes a sunflower look like a giant daisy?
3. Why do you think Van Gogh painted the old, drooping flowers too, not only the pretty ones?

HANDS-ON PROJECT

A Seed-Saving Envelope Set

You will save seeds from at least two kinds of plants, dry them, and store them in envelopes you make and label yourself. You will also make a plant-family chart for your journal.

You will need

- Dry bean or pea pods from the garden (or dry beans from the grocery store for practice)
- A ripe heirloom tomato, a pepper, or a dry sunflower or marigold head
- Paper plates, a fine strainer, and a small jar
- Small paper envelopes (or envelopes folded from paper) and a pen
- A glass jar with a lid for storage

Steps

1. **Dry seeds:** Shell your dry bean or pea pods. Pick out only plump, whole seeds; toss any that are moldy, cracked or eaten.
2. Rub a dry marigold or sunflower head over a plate to loosen the seeds. Pick out the bits of petal.
3. **Wet seeds:** Have an adult cut the tomato in half. Squeeze the seeds and their jelly into a small jar with a little water. Let it sit 2–3 days, stirring daily, until a film forms. Pour off the film and floating seeds, rinse the good seeds that sank in a strainer, and spread them on a plate.
4. Spread all your seeds out to dry for at least one week, out of the sun, in a spot where pets won't knock them over.
5. Make envelopes. On each one write the plant, the variety, the date and where it grew. Draw a small picture of the plant.
6. Fill the envelopes, seal them, and put them in a glass jar with a lid. Store the jar in a cool, dark closet.
7. In your journal, make a five-column chart: bean family, tomato family, squash family, cabbage family, daisy family. List at least three plants under each.

Tips

- A dry bean seed is hard enough that your fingernail barely dents it. If it is soft, dry it longer.
- Choose seeds from your best plants: the strongest, healthiest, tastiest ones.

Check your work

- ☐ I saved, dried and labeled seeds from at least two plants.
- ☐ I can explain why seeds from an F1 hybrid may not grow true.
- ☐ I can name the five plant families and three members of each.

NATURE JOURNAL

1. Draw one seed from each family at its real size and then again four times bigger using a magnifying glass.
2. Draw a bean pod opened up, showing every seed inside. Count and label them.
3. Find a plant in a yard or park that has gone to seed. Draw it and write how the seeds might travel.

From history. In 1866 Gregor Mendel, a monk in a monastery garden in what is now the Czech Republic, published his careful experiments with pea plants. By saving seeds and counting tall and short, green and yellow peas, he discovered the rules for how traits pass from parent plants to their offspring.

COMMON MISTAKES

- Storing seeds before they are completely dry, so they mold.
- Saving seeds from a hybrid and expecting the same plant next year.
- Forgetting to label envelopes. Every seed looks the same by spring!

Make it a game • Heirloom or Hybrid Challenge. Your grown-up calls out a seed fact and you shout open-pollinated, hybrid, or both. Then name the easiest crops to save seeds from, like beans and peas. Next, race to sort ten pretend seed packets into plant families. Explain why saved seeds from a hybrid might not match the parent plant.

UNIT 1

HARVEST AND THE SEASONS

Every fall the garden changes. The days grow shorter, the tomatoes slow down, the squash vines turn yellow, and the apples finally taste sweet. In this unit you will find out **why**. You will learn how the tilt of the earth gives us seasons, how plants “know” what time of year it is by the length of the day, how to tell when food is truly ripe, and how to save seeds so next year’s garden can begin from this year’s harvest.

Our pictures this unit come from painters who loved the harvest: Claude Monet’s wheat stacks, Jules Breton’s farm girl at sunrise, Pieter Bruegel’s harvesters, and Vincent van Gogh’s sunflowers. God promised Noah that “seedtime and harvest” would not cease. In this unit you will watch that promise at work.

PREREQUISITES

- Knows the four seasons and the twelve months in order
- Can measure with a ruler and read a simple thermometer
- Has a nature journal and colored pencils ready

MASTERY CHECKLIST

- ☐ I can explain that the tilt of the earth, not its distance from the sun, causes the seasons.
- ☐ I can tell how day length changes through the year and what it does to plants.
- ☐ I can check at least five fruits or vegetables for ripeness.
- ☐ I can save, dry, label and store seeds from beans or another easy crop.
- ☐ I can sort common vegetables into plant families.

LESSONS IN THIS UNIT

1.1 Earth’s Tilt and the Seasons

2 sessions of 45 minutes

1.2 Day Length and Plants

2 sessions of 45 minutes

1.3 When Is It Ripe?

2 sessions of 45 minutes

1.4 Seed Saving and Plant Families

2 sessions of 45 minutes

UNIT 1 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. 5 pts

What causes the seasons?

2. 5 pts

Why does slanted winter sunlight warm the ground less than summer sunlight?

3. 5 pts

Is the earth closer to the sun in summer? Explain.

4. 5 pts

What does a plant sense to know that winter is coming?

5. 5 pts

What is bolting, and when does spinach do it?

6. 5 pts

Give two signs that a watermelon is ripe.

7. 5 pts

How can you tell sweet corn is ready?

8. 5 pts

Why are beans, peas and tomatoes good crops for a beginner to save seed from?

9. 5 pts

Name the plant family for each: pumpkin, pepper, radish.

10. 5 pts

How should saved seeds be stored?

ANSWER KEY

1. Earth's axis is tilted. As Earth travels around the sun, our half is tipped toward the sun in summer and away from it in winter.
2. Slanted light spreads the same sunlight over a bigger area, so each spot gets less warmth. The days are also shorter.
3. No. The earth is actually slightly closer to the sun in early January. Distance does not cause the seasons.
4. It senses the length of the night (day length). Longer nights tell it fall has come.
5. Bolting is when a leafy plant sends up a flower stalk. Spinach bolts when days get long in late spring and early summer.
6. The tendril nearest the melon is dry and brown, and the ground spot has turned creamy yellow. It also sounds deep and hollow when thumped.
7. The silks are brown and dry, and a kernel pressed with a fingernail squirts milky juice.
8. Their flowers usually pollinate themselves, so the seeds grow true to the parent plant.
9. Pumpkin: squash family. Pepper: tomato family. Radish: cabbage family.
10. Completely dry, in labeled paper envelopes, in a cool, dry, dark place.

PORTFOLIO PIECE: MY HARVEST SEASON RECORD

Put together a record of this fall’s harvest season. Include your day-length graph and noon-shadow log, your ripeness field guide, and your labeled seed envelope set. Finish with a one-page “harvest letter” telling what you learned about God’s rhythm of seedtime and harvest and what you plan to plant with your seeds next spring.

LOOK FOR	WHAT IT MEANS
Seasons and day length	Day-length chart and shadow log are kept accurately, with dates, for at least six weeks.
Ripeness field guide	Pages for at least five crops, each with a careful drawing and three correct ripeness signs.
Seed saving	At least two kinds of seeds are dry, clean, and stored in envelopes labeled with plant, variety, date and place.
Harvest letter	Explains the cause of the seasons and plans next year’s planting in clear sentences.

UNIT 2

WILDLIFE

You share your neighborhood with more wild animals than you think. Most of them are shy, and many come out at dawn, dusk or night, so we usually know them by what they leave behind: footprints in mud, chewed acorn shells, nibbled bushes and empty nests. In this unit you will learn to read those signs like a detective.

You will study four kinds of neighbors closely: tracks of many animals, white-tailed deer (and the ticks they carry), squirrels and chipmunks getting ready for winter, and birds building nests and flying south. Albrecht Dürer and John James Audubon, two of the finest animal artists who ever lived, will help you look. The most important rule all unit: **look, don't touch**. Wild animals stay wild, and we keep a safe and respectful distance.

PREREQUISITES

- Can use a ruler and draw simple shapes carefully
- Knows the difference between a wild animal and a pet or farm animal
- Has permission and an adult to go on short walks outdoors

MASTERY CHECKLIST

- ☐ I can tell dog, cat, deer, rabbit, squirrel, raccoon and bird tracks apart.
- ☐ I can explain how antlers grow and fall off each year, and how antlers differ from horns.
- ☐ I can do a tick check and know what to do if I find a tick.
- ☐ I can explain how squirrels and chipmunks store food for winter.
- ☐ I can describe three kinds of bird nests and give two reasons birds migrate.

LESSONS IN THIS UNIT

2.1 Tracks and Signs

2 sessions of 45 minutes

2.2 Deer: Antlers, Browsing and Ticks

2 sessions of 45 minutes

2.3 Squirrels and Chipmunks

2 sessions of 45 minutes

2.4 Birds' Nests and Migration

2 sessions of 45 minutes

UNIT 2 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

A track has four toes, claw marks and an oval shape. What kind of animal probably made it?

2. (5 pts)

In a rabbit's track group, why are the big prints in front?

3. (5 pts)

Name two animal signs other than tracks.

4. (5 pts)

How are antlers different from horns?

5. (5 pts)

What is velvet, and what does it do?

6. (5 pts)

How can you tell a twig nibbled by a deer from one chewed by a rabbit?

7. (5 pts)

Name three places to check for ticks, and say who should remove an attached tick.

8. (5 pts)

What is the difference between scatter-hoarding and larder-hoarding?

9. (5 pts)

Describe a cavity nest and a hanging nest, and name a bird for each.

10. (5 pts)

Give two reasons many birds migrate south in the fall.

ANSWER KEY

1. A dog, fox or coyote (a canine).
2. When a rabbit hops, its big back feet swing forward and land ahead of its small front feet.
3. Any two: chewed nuts or cones, droppings, burrows, nests, rubs on trees, nibbled plants, fur or feathers.
4. Antlers are bone that grow and fall off every year, mostly on males. Horns stay on the animal for life and are never shed.
5. Velvet is soft skin full of blood vessels that covers growing antlers and feeds them.
6. Deer have no top front teeth, so they leave a torn, ragged tip. Rabbits leave a clean, slanted cut close to the ground.
7. Any three: behind the ears, hairline, armpits, waist, behind the knees, between toes. An adult removes it with fine tweezers.
8. Scatter-hoarders hide food one piece at a time in many places (gray squirrels). Larder-hoarders store lots of food in one place (chipmunks, red squirrels).
9. A cavity nest is inside a hole (woodpecker, chickadee, bluebird). A hanging nest is a woven pouch hanging from a branch (Baltimore oriole).
10. Insects and nectar become scarce and the ground freezes, so food is hard to find. Shorter days signal it is time to go; warmer places have food.

PORTFOLIO PIECE: MY WILDLIFE SIGN JOURNAL

Make a wildlife sign journal for your neighborhood. Include at least eight signs you found yourself this unit: tracks (drawn life-size and measured), chewed food, browsed twigs, nests, rubs or burrows. For each, give the date, place, a careful drawing, and the animal you think left it with your reasons. Add your track chart, tick-check card and bird log.

LOOK FOR	WHAT IT MEANS
Observations	At least eight real signs, each with date, place and a careful drawing.
Identification	Each sign has a reasonable animal guess with clues (toes, claws, shape, height, location).
Safety	Includes the tick-check card and shows the look-don't-touch rule was followed.
Ongoing records	Bird log and squirrel tallies are kept faithfully with dates.

2.1 TRACKS AND SIGNS

OBJECTIVES

- Identify common tracks by counting toes, looking for claws and noticing shape.
- Read a track pattern to tell whether an animal walked, hopped or bounded.
- Find and record at least three animal signs besides tracks.

Warm-up. Press your bare foot (or your shoe) into a pan of damp sand or flour, then walk across it, then hop across it. Look at the prints. How can you tell walking from hopping? What clues would tell someone how big you are?

WATCH

Animal Track Detective! | Science for Kids

SciShow Kids · 4:52

<https://www.youtube.com/watch?v=Xz02S-CizAU>

WHEN TO WATCH

After the core ideas. Try to solve each mystery track before Jessi gives the answer.

BACKUP VIDEO

Identifying Animal Tracks

Jessamine County Public Library · 13:12

<https://www.youtube.com/watch?v=Oov9ZF9UwtY>

A longer lesson from a master naturalist who presses real track models into sand. Good before your tracking walk.

KEY TERMS

track

A single footprint left by an animal.

trail

A line of tracks that shows where an animal went and how it moved.

sign

Any clue an animal leaves behind: tracks, chewed food, droppings, fur, feathers, burrows or nests.

hoof

The hard covering on the toes of deer, cows, goats and horses.

gait

The way an animal moves: walking, trotting, hopping or bounding.

CORE IDEAS

Start with three questions: **How many toes? Are there claw marks? What shape is the whole print?** Dogs, foxes and coyotes leave four toes with claw marks in an oval print. Cats leave four round toes with no claw marks, because they pull their claws in. Raccoons leave five long, skinny toes that look like a tiny child's hand. Deer leave two pointed halves, like a split heart.

Rabbits and squirrels **hop**. Their big back feet swing forward and land *in front of* their small front feet, so a group of four prints looks like a "Y" or a triangle. A squirrel's group often ends at a tree; a rabbit's heads for a brushy hiding place.

Birds that walk, like crows and robins, leave prints one in front of another. Birds that hop, like sparrows, leave prints side by side. Most bird tracks have three toes pointing forward and one pointing back.

Tracks are only one kind of **sign**. Look for acorn shells chewed open, pine cones stripped like corn cobs (a squirrel's work), small holes in the lawn, bark rubbed off a sapling, fur caught on a fence, or a pile of feathers. Droppings are signs too, but look, don't touch: they can carry germs.

The best tracking spots are muddy stream banks, a sandbox, the edge of a puddle, or fresh snow. Go out early in the morning, before tracks are trampled or melted. Move slowly and quietly. You may not see the animal, but you will learn its story.

PICTURE STUDY



Young Hare, Albrecht Dürer, 1502 · Watercolor and gouache on paper · Albertina, Vienna

Image: [Wikimedia Commons](#), public domain

Albrecht Dürer painted this hare more than five hundred years ago, and it is still one of the most famous animal pictures in the world. He looked so carefully that you can almost count the hairs. Hares and rabbits leave some of the easiest tracks to find in snow.

Look closely

- Find the hare's big back feet tucked under its body and its smaller front paws in front.
- Look at the long ears. Which way are they pointing? What might the hare be listening for?
- Find the whiskers. How do whiskers help an animal moving at night?
- Look for a tiny window reflected in the hare's eye. What does that tell you about where Dürer painted it?

Talk about it

1. When this hare hops, which feet land in front: the big back feet or the small front ones?
2. Why do you think a hare's eyes are on the sides of its head instead of the front?

3. How long do you think Dürer spent painting this? Why would he take so much care?

Safety first. Never touch animal droppings, bones or fur with bare hands. Stay on paths, and go tracking only with an adult. Wash hands after outdoor exploring.

HANDS-ON PROJECT

A Track Trap and a Tracking Walk

You will make a “track trap,” a smooth patch of damp sand or mud where animals will leave their prints overnight. Then you will go on a tracking walk and record every sign you find.

You will need

- A shallow pan or box lid at least 2 feet across, or a patch of bare ground
- Fine sand or garden soil and a spray bottle of water
- A ruler and a magnifying glass
- A few sunflower seeds or an apple slice for bait (optional)
- Your nature journal

Steps

1. Fill the pan with damp sand or smooth a patch of soil with a board until it is flat and slightly wet, like the edge of a puddle.
2. Put the trap near the edge of the yard, a hedge or a garden bed. Set a few seeds or an apple slice in the middle if you like.
3. In the morning, check the trap before anyone walks near it. Look from low to the side so shadows show the prints.
4. For each track, count the toes, look for claws, and measure its length and width with your ruler.
5. Draw the best track life-size in your journal. Write your guess about which animal made it and why.
6. Smooth the trap and try again for two more nights.
7. Take a 20-minute tracking walk with an adult in a park or along a field edge. Write down every sign: tracks, chewed nuts, nests, holes, nibbled plants or feathers.
8. At home, match your tracks to a field guide or the track chart you make in your journal.

Tips

- If nothing visits, move the trap closer to bushes, where animals feel safe.
- In winter, fresh snow is the best track trap of all.

Check your work

- ☐ I can tell canine, feline, deer, raccoon, rabbit and bird tracks apart.
- ☐ I measured and drew at least one real track.
- ☐ I recorded at least three different animal signs.

NATURE JOURNAL

1. Make a track chart: draw dog, cat, deer, raccoon, rabbit, squirrel and bird tracks, with the number of toes and claws for each.
2. Draw a hopping pattern (rabbit or squirrel) and a walking pattern (dog or cat). Add arrows to show which way the animal was going.
3. Draw one other sign you found, such as a chewed pine cone or acorn, and write who you think left it.

From history. Long before cameras, Native American hunters and early American frontiersmen like Daniel Boone could read the ground like a book, telling which animal passed, how fast it moved and how long ago. Today wildlife biologists still count tracks in snow to learn how many animals live in a forest.

COMMON MISTAKES

- Thinking the big prints in a rabbit group are the front feet. The big back feet land in front.
- Mixing up dog and cat tracks. Look for claw marks: dogs show them, cats usually don't.
- Walking right across the tracks before studying them.

Make it a game • Track Reader Challenge. Press a damp hand, a fist and fingertips into flour on a tray to make tracks. Your grown-up makes a pattern. Say whether it shows walking, hopping or bounding, and count the toes. Switch and make a mystery pattern. Name the animal that might leave it, with points for toes, claws and gait.

2.2 DEER: ANTLERS, BROWSING AND TICKS

OBJECTIVES

- Describe how a white-tailed buck grows, uses and sheds its antlers each year, and how antlers differ from horns.
- Recognize deer browsing on plants and name ways gardeners protect plants from deer.
- Explain how ticks are carried by deer and do a careful tick check.

Warm-up. Look at your teacher's hair and fingernails. Hair and nails keep growing, and we trim them. Now imagine a bone that grows out of your head every summer and falls off every winter! Guess: which animal does that?

WATCH

White-tailed Deer (Supports Virginia SOL Objective 2.4)

Virginia Department of Wildlife Resources · 3:35

<https://www.youtube.com/watch?v=wUmjreuVvKA>

WHEN TO WATCH

After the first two core ideas. Watch for a buck with antlers, does with spotted fawns, and deer browsing on leaves.

BACKUP VIDEO

From Nubs To Growing Antlers: An Incredible Process

MSU Deer Lab TV · 1:49

<https://www.youtube.com/watch?v=nyRgxQal7Dw>

A short clip from a university deer research lab. A scientist explains how new antlers start growing right after the old ones fall off.

KEY TERMS

antler

A branched bone that grows from a male deer's head each year and falls off in winter.

horn

A permanent pointed growth on a cow, goat or sheep, made of a bone core covered by a hard sheath. It is never shed.

velvet

Soft, fuzzy skin full of blood vessels that covers and feeds growing antlers.

browse

To eat twigs, buds and leaves of bushes and trees; also the plants that deer eat.

tick

A tiny eight-legged animal that clings to grass and bites to drink blood. Some ticks can carry diseases.

CORE IDEAS

White-tailed deer are the most common large wild animal in much of the United States. They are built for quick escape: long, springy legs, big ears that swivel like radar, eyes on the sides of the head to watch for danger, and a white tail they flip up like a flag to warn other deer as they bound away.

Only bucks (males) grow **antlers**. In spring, new antlers begin to grow from two bumps on the buck's head. All summer they are covered in fuzzy **velvet** that carries blood to feed the growing bone. Antlers are among the fastest-growing bone in the world. In late summer the velvet dries and the buck rubs it off on small trees, leaving scraped "rubs." The antlers fall off in late winter, and mice and squirrels gnaw the shed antlers for minerals. Next spring, new ones grow.

Horns are different. Cows, goats and sheep keep their horns their whole lives. Horns grow a little each year and are never shed.

Deer eat many plants: acorns, grasses, twigs, buds, and garden favorites like hostas, tulips, beans and young fruit trees. Deer have no top front teeth, so when they **browse** they tear plants, leaving ragged, torn tips. Rabbits leave a clean, slanted cut. Gardeners protect plants with tall fences (deer can jump about 8 feet), netting, or cages around young trees.

Deer also carry **ticks**. Blacklegged ticks, often called deer ticks, wait on tall grass and brush and grab onto deer, pets and people who brush past. Some can carry Lyme disease. Young deer ticks are as small as a poppy seed. Protect yourself: wear long pants tucked into socks in tall grass, stay in the middle of trails, and do a tick check after every outdoor adventure.

In late spring, a doe hides her spotted fawn in the grass and leaves it alone for hours while she feeds nearby. The fawn is not lost! If you find one, leave it where it is, back away, and let its mother come back.

PICTURE STUDY



Common or Virginian Deer, John James Audubon and John Woodhouse Audubon, 1845–1848 · Hand-colored lithograph, from *The Viviparous Quadrupeds of North America* · *The Viviparous Quadrupeds of North America*

Image: [Wikimedia Commons](#), public domain

After painting America's birds, John James Audubon and his sons set out to paint all of its four-footed animals. This plate shows a white-tailed buck and doe beside a woodland stream, painted from careful study of real deer.

Look closely

- Find the buck's antlers. Count the points on one side.
- Find the doe. Does she have antlers?
- Look at the deer's legs and hooves. How are they built for running and leaping?
- Find the large ears. Which deer is listening for danger while the other drinks?

Talk about it

1. What season do you think this is? (Hint: are the buck's antlers grown?)
2. Why might one deer stand guard while the other drinks?
3. What plants near the stream might a deer browse?

Safety first. Never approach or try to touch a deer or a fawn. After walks in grass or woods, do a tick check with an adult. If you find a tick attached, do not pull it yourself: an adult removes it with fine tweezers, grabbing close to the skin and pulling straight out, then washes the spot.

HANDS-ON PROJECT

A Deer Detective Report and a Tick-Check Card

You will look for signs of deer near your home or in a park, figure out whether deer are eating garden plants, and make a tick-check card your family can hang by the back door.

You will need

- Your nature journal and a ruler
- An index card, markers, and tape or a magnet
- Pictures of deer-browsed and rabbit-chewed twigs (from a library book or the video)
- Long pants and socks for your walk

Steps

1. Dress for ticks: long pants tucked into socks and closed shoes.
2. With an adult, walk along a woods edge, a park or a field. Look for heart-shaped tracks, droppings in piles of small pellets, trails pressed into grass, rubs on young trees, and nibbled shrubs.
3. Find a nibbled twig. Look closely with a magnifying glass. Is the tip torn and ragged (deer) or cut cleanly at a slant (rabbit)? Measure how high above the ground it is.
4. Record each sign in your journal with a drawing, its height above ground and where you found it.
5. Make a list of plants in your yard or neighborhood that deer seem to like, and plants they leave alone.
6. Make a tick-check card. Draw a simple person and mark the places ticks like to hide: behind the ears, the hairline, the armpits, the waist, behind the knees and between the toes.
7. Write the steps on the back: check, shower, put clothes in a hot dryer, tell an adult if you find one.
8. Back home, do a tick check with your adult using your new card.

Tips

- Deer browse up to about 5 or 6 feet high. Rabbits can only reach as high as they can stretch, about 2 feet (higher on snow).
- Late fall and early winter is a great time to find buck rubs on saplings.

Check your work

- ☐ I can explain how antlers grow and fall off each year, and how they differ from horns.
- ☐ I can tell deer browsing from rabbit chewing.
- ☐ I made a tick-check card and know where ticks hide.

NATURE JOURNAL

1. Draw an antler calendar: four small drawings of a buck's head in spring, summer, fall and late winter.
2. Draw a deer track life-size (about 2–3 inches long) and label the two halves of the hoof.
3. Draw a tick next to a poppy seed and a sesame seed using a magnifying glass or a picture. How small is a young tick?

COMMON MISTAKES

- Calling antlers “horns.” Antlers are shed every year; horns are not.
- Thinking a fawn alone is abandoned. Its mother is nearby. Leave it be.
- Skipping the tick check because you were only out a short time. Ticks can grab on in minutes.

Make it a game • Antler or Horn? Your grown-up reads facts about deer and cattle: shed each year, grows in velvet, stays for life, covered in keratin. Shout antler or horn. Then list ways to protect plants from deer, like fences, scent or tall barriers. Finish by naming three steps for a tick check after a walk outdoors.

Scripture. “As the hart panteth after the water brooks, so panteth my soul after thee, O God.” (Psalm 42:1, KJV)

A hart is a male deer. Just as the deer in Audubon's picture needs water, our hearts need God.

2.3 SQUIRRELS AND CHIPMUNKS

OBJECTIVES

- Compare gray squirrels, red squirrels and eastern chipmunks.
- Explain scatter-hoarding and larder-hoarding, two ways animals store food for winter.
- Observe and record a squirrel or chipmunk's behavior for timed periods.

Warm-up. Your teacher hides ten pieces of cereal around the room while you wait outside. Come back and find as many as you can in one minute. How did you remember or find them? A squirrel does this with hundreds of nuts every fall!

WATCH

How Do Squirrels Find the Food they Hide? | How Animals Prepare for Winter | SciShow Kids

SciShow Kids · 3:36

<https://www.youtube.com/watch?v=6ckDOcVvz-k>

WHEN TO WATCH

After the core ideas. Listen for the two ways squirrels find their buried food.

BACKUP VIDEO

Creature Feature: Eastern Chipmunk

Culture & Heritage Museums · 7:46

<https://www.youtube.com/watch?v=l7GoAKGHsPU>

A museum naturalist explains how chipmunks live, dig burrows and store food. Good before your observation project.

KEY TERMS

rodent

A mammal with front teeth that never stop growing, such as squirrels, chipmunks, mice and beavers.

scatter-hoarding

Hiding food one piece at a time in many different places.

larder-hoarding

Storing lots of food together in one place, like a pantry.

cheek pouch

A stretchy pocket inside a chipmunk's cheek for carrying food.

drey

A squirrel's round nest of leaves and twigs, high in a tree.

CORE IDEAS

Squirrels and chipmunks are **rodents**. Their four front teeth never stop growing, so gnawing on hard nuts keeps the teeth worn down to just the right length. God designed them to be the perfect nut-crackers.

Gray squirrels are **scatter-hoarders**. In fall they bury acorns and nuts one at a time in hundreds, even thousands, of little holes. In winter they find many of them again using memory and their keen sense of smell, even under snow. The acorns they forget sprout in spring. Squirrels plant whole forests of oak trees without meaning to!

Red squirrels are smaller and noisier. They **larder-hoard**, piling pine cones in one big heap called a midden and chattering at anyone who comes near. **Chipmunks** are larder-hoarders too. They stuff seeds into their stretchy **cheek pouches**, carry them underground, and store them in a room in their burrow.

In winter, squirrels stay active. They sleep in a leafy nest called a **drey** or in a hollow tree and come out on milder days to dig up food. Chipmunks spend most of the winter underground, sleeping deeply and waking every so often to eat from their pantry.

Squirrels and chipmunks can be garden pests: they dig up bulbs, nibble tomatoes and raid bird feeders. Gardeners cover bulbs with wire mesh and put baffles on feeder poles. Never feed squirrels by hand or try to pet them; they bite hard.

PICTURE STUDY



Two Squirrels, Albrecht Dürer, 1512 · Watercolor and gouache on vellum · Private collection

Image: [Wikimedia Commons](#), public domain

Dürer painted these two red squirrels with the same patience he gave to his hare. One faces away from us; the other is busy eating a hazelnut. Look at the bits of shell on the ground.

Look closely

- Find the nut in the squirrel's front paws. How does it hold it?
- Find the broken nutshells. How did the squirrel open them?
- Look at the tails. What might a squirrel use its bushy tail for?
- Find the ear tufts on the squirrel on the left.

Talk about it

1. Is this squirrel scatter-hoarding, larder-hoarding, or just eating? How can you tell?
2. If you found shells like these under a tree, what would they tell you?
3. How are these red squirrels different from the gray squirrels you may see in your yard?

HANDS-ON PROJECT

A Squirrel Watch

You will be a field scientist. You will watch a squirrel or chipmunk for timed periods, write down exactly what it does, and look for evidence of food storage.

You will need

- A window with a view of trees, or a park bench
- A timer or watch with a second hand
- Binoculars (optional)
- Your nature journal
- An unshelled peanut, a hazelnut and an acorn to examine

Steps

1. Make a tally chart with these behaviors: eating, digging, burying, carrying food, climbing, chasing, resting, chattering.
2. Find a squirrel or chipmunk. Start your timer and watch for 5 minutes without stopping. Make a tally mark each time it changes what it is doing.
3. Write down any food you see it carry and where it takes the food.
4. Repeat your 5-minute watch on two more days, at different times (morning and afternoon).
5. Add up your tallies. Which behavior did you see most?
6. Look at the ground under an oak, walnut or pine tree. Collect and draw any chewed shells or stripped cones you find.
7. Write a short field report: what animal you watched, when, what it did most, and whether you saw evidence of food storage.

Tips

- Sit very still. Animals get used to you after a few minutes.
- Fall, when acorns drop, is the busiest burying season.

Check your work

- ☐ I watched for three 5-minute periods and kept a tally.
- ☐ I can explain scatter-hoarding and larder-hoarding.

- ☐ I wrote a field report from my own observations.

NATURE JOURNAL

1. Draw a squirrel and a chipmunk side by side and label the differences: size, stripes, tail and where each lives.
2. Draw a chewed acorn or pine cone from three sides.
3. Draw a cutaway of a chipmunk burrow: tunnel, sleeping room and food pantry.

COMMON MISTAKES

- Moving or talking during an observation. The animal will run away.
- Thinking squirrels hibernate. They stay active all winter; chipmunks sleep much of it.
- Feeding squirrels by hand. Wild animals can bite and should stay wild.

Make it a game • Hoarder Showdown. Be a scatter-hoarder: hide twenty buttons in different spots around the room and write down where. Your grown-up is the thief. Then be a larder-hoarder and pile all twenty in one spot. Which strategy kept more buttons safe? Explain, and compare gray squirrels, red squirrels and chipmunks by size and habits.

2.4 BIRDS' NESTS AND MIGRATION

OBJECTIVES

- Describe four kinds of nests: cup, cavity, hanging and ground nests.
- Explain why many birds migrate and how shortening days help tell them when to go.
- Build a model nest using a bird's methods and materials.

Warm-up. Look out a window for three minutes and list every bird you see or hear.

Are there birds you saw all summer that you haven't seen lately? Where do you think they went?

WATCH

Nurturing Nests | Birds | The Good and the Beautiful

The Good and the Beautiful Homeschool Science • 6:38

<https://www.youtube.com/watch?v=H8vY7fD7rYU>

WHEN TO WATCH

After the first three core ideas. Name the kind of each nest you see: cup, cavity, hanging or ground.

BACKUP VIDEO

Meet 12 Birds You Can Only See On Spring and Autumn Migration

Cornell Lab of Ornithology • 7:10

<https://www.youtube.com/watch?v=CRwXFortpul>

After the migration core ideas. Watch the moving maps show birds traveling north and south.

KEY TERMS

migration

A long trip animals make each year between a summer home and a winter home.

cup nest

A bowl-shaped nest of twigs, grass and sometimes mud, like a robin's.

cavity nest

A nest inside a hole in a tree, post or birdhouse.

incubate

To keep eggs warm, usually by sitting on them, until they hatch.

flyway

A main route that many birds follow when they migrate.

CORE IDEAS

A nest is a cradle. Birds build nests to hold their eggs, keep them warm while they **incubate**, and protect the chicks from weather and predators. Each kind of bird builds its own kind of nest, and it builds it right the very first time, without lessons.

Cup nests are the most common. A robin weaves grass and twigs and plasters the inside with mud, then lines it with soft grass. **Cavity nests** are inside holes: woodpeckers chisel their own, while chickadees and bluebirds use old woodpecker holes or birdhouses. **Hanging nests**, like the Baltimore oriole's, are woven pouches that swing from the tip of a branch where predators can't reach. **Ground nests**, like a killdeer's, are just a scrape among pebbles, and the speckled eggs blend right in.

Many birds **migrate**. In fall, insects disappear and the ground freezes, so birds that eat insects and nectar fly south, some as far as Central and South America. In spring they return north to nest, where long summer days give them more hours to find food for their chicks. Shortening fall days help tell their bodies it is time to go, the same signal you learned about in plants.

Most songbirds migrate at night. They find their way using the sun, the stars, the earth's magnetism and landmarks like rivers and coastlines. The tiny ruby-throated hummingbird, weighing about as much as a penny, can fly across the Gulf of Mexico without stopping. Birds that stay all winter, like cardinals, chickadees and blue jays, switch to seeds and berries.

Enjoy nests with your eyes only. Never touch a nest that is in use. Even empty nests of wild birds are protected by law in the United States, so we draw and photograph them and leave them where they are. You can help birds by planting berry bushes and putting up a nest box or a clean feeder.

PICTURE STUDY



Baltimore Oriole, John James Audubon, 1827 · Hand-colored engraving, Plate 12 of *The Birds of America* · *The Birds of America*

Image: [Wikimedia Commons](#), public domain

John James Audubon traveled across America in the early 1800s to paint every bird he could find, life-size. In this plate the male orioles flash their orange and black while the female sits at her hanging nest among the leaves and flowers of a tulip tree.

Look closely

- Find the nest. How is it attached to the branch?
- What materials do you think the nest is woven from?
- Find the female. How are her colors different from the males'?
- Find the tulip-tree flowers and leaves. Can you see why it is called a tulip tree?

Talk about it

1. Why is a hanging nest at the tip of a branch a safe place for eggs?
2. Why might the female be duller in color than the males?
3. Baltimore orioles spend the winter in Central America. What do you think they eat there?

HANDS-ON PROJECT

Build a Bird's Nest and Start a Migration Log

You will try to build a nest using only materials a bird could gather and your hands for a “beak.” Then you will start a bird log to notice which birds leave in fall and which stay.

You will need

- Natural materials: dry grass, small twigs, pine needles, moss, leaves
- A little mud (soil and water) in a cup
- A small bowl to shape around (optional)
- Three small stones or jelly beans for “eggs”
- Your nature journal

Steps

1. Gather a pile of dry grass, thin twigs, pine needles and moss from your yard or a park.
2. Decide which bird you will be: a robin (cup nest with mud) or an oriole (woven pouch).
3. Robin nest: weave twigs and grass in a ring, press a thin layer of mud on the inside to hold it together, and line it with soft grass. Let it dry overnight.
4. Oriole nest: braid and weave long grasses into a little bag and hang it from a branch or a coat hanger.
5. Test your nest: put in three “eggs” and gently tip it. Do the eggs stay in?
6. Write about how long it took and how hard it was. Remember, a bird does this with only its beak!
7. Start a bird log: once a week, watch for 10 minutes and list each kind of bird. Keep it going until spring to see which birds leave and which return.

Tips

- Use only fallen or dead materials, and leave living plants alone.
- A field guide or the Merlin Bird ID app from Cornell can help you name birds.

Check your work

- ☐ I can describe cup, cavity, hanging and ground nests.
- ☐ I built a nest that holds three eggs.
- ☐ I can explain why birds migrate and how they find their way.

NATURE JOURNAL

1. Draw the four kinds of nests and label each with a bird that builds it.
2. Watch a flock of geese or other birds flying over. Draw the shape of the flock and note the direction and date.
3. Find a nest from a distance (bare winter trees make them easy to see). Draw it where it sits, without touching it.

COMMON MISTAKES

- Touching or taking nests. Look, draw and leave them be.
- Thinking all birds migrate. Many stay all year and change what they eat.
- Building a model nest with living leaves and branches torn off plants.

Make it a game • Nest Builder Auction. You have sticks, yarn, leaves, paper and mud. Describe the four nest types: cup, cavity, hanging and ground. For each, say which bird builds it and why that design works. Score a point for each right fact. Then explain why shorter days tell birds to migrate. Two minutes per round.

Scripture. “Yea, the stork in the heaven knoweth her appointed times; and the turtle and the crane and the swallow observe the time of their coming;” (Jeremiah 8:7, KJV)

The “turtle” here is the turtledove. God made migrating birds to know their appointed times without a calendar.

UNIT 2

WILDLIFE

You share your neighborhood with more wild animals than you think. Most of them are shy, and many come out at dawn, dusk or night, so we usually know them by what they leave behind: footprints in mud, chewed acorn shells, nibbled bushes and empty nests. In this unit you will learn to read those signs like a detective.

You will study four kinds of neighbors closely: tracks of many animals, white-tailed deer (and the ticks they carry), squirrels and chipmunks getting ready for winter, and birds building nests and flying south. Albrecht Dürer and John James Audubon, two of the finest animal artists who ever lived, will help you look. The most important rule all unit: **look, don't touch**. Wild animals stay wild, and we keep a safe and respectful distance.

PREREQUISITES

- Can use a ruler and draw simple shapes carefully
- Knows the difference between a wild animal and a pet or farm animal
- Has permission and an adult to go on short walks outdoors

MASTERY CHECKLIST

- ☐ I can tell dog, cat, deer, rabbit, squirrel, raccoon and bird tracks apart.
- ☐ I can explain how antlers grow and fall off each year, and how antlers differ from horns.
- ☐ I can do a tick check and know what to do if I find a tick.
- ☐ I can explain how squirrels and chipmunks store food for winter.
- ☐ I can describe three kinds of bird nests and give two reasons birds migrate.

LESSONS IN THIS UNIT

2.1 Tracks and Signs

2 sessions of 45 minutes

2.2 Deer: Antlers, Browsing and Ticks

2 sessions of 45 minutes

2.3 Squirrels and Chipmunks

2 sessions of 45 minutes

2.4 Birds' Nests and Migration

2 sessions of 45 minutes

UNIT 2 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

A track has four toes, claw marks and an oval shape. What kind of animal probably made it?

2. (5 pts)

In a rabbit's track group, why are the big prints in front?

3. (5 pts)

Name two animal signs other than tracks.

4. (5 pts)

How are antlers different from horns?

5. (5 pts)

What is velvet, and what does it do?

6. (5 pts)

How can you tell a twig nibbled by a deer from one chewed by a rabbit?

7. (5 pts)

Name three places to check for ticks, and say who should remove an attached tick.

8. (5 pts)

What is the difference between scatter-hoarding and larder-hoarding?

9. (5 pts)

Describe a cavity nest and a hanging nest, and name a bird for each.

10. (5 pts)

Give two reasons many birds migrate south in the fall.

ANSWER KEY

1. A dog, fox or coyote (a canine).
2. When a rabbit hops, its big back feet swing forward and land ahead of its small front feet.
3. Any two: chewed nuts or cones, droppings, burrows, nests, rubs on trees, nibbled plants, fur or feathers.
4. Antlers are bone that grow and fall off every year, mostly on males. Horns stay on the animal for life and are never shed.
5. Velvet is soft skin full of blood vessels that covers growing antlers and feeds them.
6. Deer have no top front teeth, so they leave a torn, ragged tip. Rabbits leave a clean, slanted cut close to the ground.
7. Any three: behind the ears, hairline, armpits, waist, behind the knees, between toes. An adult removes it with fine tweezers.
8. Scatter-hoarders hide food one piece at a time in many places (gray squirrels). Larder-hoarders store lots of food in one place (chipmunks, red squirrels).
9. A cavity nest is inside a hole (woodpecker, chickadee, bluebird). A hanging nest is a woven pouch hanging from a branch (Baltimore oriole).
10. Insects and nectar become scarce and the ground freezes, so food is hard to find. Shorter days signal it is time to go; warmer places have food.

PORTFOLIO PIECE: MY WILDLIFE SIGN JOURNAL

Make a wildlife sign journal for your neighborhood. Include at least eight signs you found yourself this unit: tracks (drawn life-size and measured), chewed food, browsed twigs, nests, rubs or burrows. For each, give the date, place, a careful drawing, and the animal you think left it with your reasons. Add your track chart, tick-check card and bird log.

LOOK FOR	WHAT IT MEANS
Observations	At least eight real signs, each with date, place and a careful drawing.
Identification	Each sign has a reasonable animal guess with clues (toes, claws, shape, height, location).
Safety	Includes the tick-check card and shows the look-don't-touch rule was followed.
Ongoing records	Bird log and squirrel tallies are kept faithfully with dates.

UNIT 3

SOIL

Soil is not just dirt. It is a mix of broken-down rock, rotted leaves and roots, water, air, and more living creatures than you can imagine. Every carrot, apple and loaf of bread you have ever eaten came out of soil. Good gardeners say, “Feed the soil, and the soil will feed the plants.”

In this unit you will separate soil into its parts in a jar, meet the worms, bacteria and fungi that keep it alive, build a compost pile from “browns” and “greens,” and test how water drains through soil and how it can wash soil away. Our pictures show soil being worked by hand: Millet’s tired farmer with his hoe, Dürer’s clump of turf, Pissarro’s village gardens and Constable’s riverbank.

PREREQUISITES

- Can measure with a ruler in inches and read a thermometer
- Has learned about plant families and seeds (Unit 1)
- Has garden gloves and a trowel, or permission to use a parent’s

MASTERY CHECKLIST

- ☐ I can tell sand, silt and clay apart by feel and in a soil jar.
- ☐ I can name living things in soil and explain how they help plants.
- ☐ I can build a compost pile with the right mix of browns and greens.
- ☐ I can test how fast water drains through soil.
- ☐ I can explain how plant roots and mulch keep soil from washing away.

LESSONS IN THIS UNIT

3.1 The Soil Jar Test and Texture

2 sessions of 45 minutes

3.2 Living Soil: Worms, Bacteria and Fungi

2 sessions of 45 minutes

3.3 Compost Science: Browns and Greens

2 sessions of 45 minutes

3.4 Drainage and Erosion

2 sessions of 45 minutes

UNIT 3 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

List sand, silt and clay from biggest particles to smallest, and say how each feels.

2. (5 pts)

In a soil jar test, which layer settles first and which settles last?

3. (5 pts)

What is loam, and why do gardeners like it?

4. (5 pts)

What does a decomposer do? Name two.

5. (5 pts)

Give two ways earthworms help a garden.

6. (5 pts)

How do some bacteria help bean and pea plants?

7. (5 pts)

Sort these into browns and greens: dry leaves, grass clippings, cardboard, apple core.

8. (5 pts)

A compost pile is slimy and smells bad. What went wrong and how do you fix it?

9. (5 pts)

Why do plant roots need soil that drains?

10. (5 pts)

Name two ways to stop soil erosion in a garden.

ANSWER KEY

1. Sand (gritty), silt (smooth like flour), clay (sticky when wet).
2. Sand settles first, in about a minute. Clay settles last, after a day or more.
3. A balanced mix of sand, silt and clay with organic matter. It drains well but still holds water and nutrients.
4. It breaks down dead plants and animals and returns nutrients to the soil.
Examples: earthworms, bacteria, fungi, millipedes, roly-polies.
5. Their tunnels let in air and water, and their castings are rich fertilizer. They also mix the soil.
6. They live in nodules on the roots and turn nitrogen from the air into plant food.
7. Browns: dry leaves, cardboard. Greens: grass clippings, apple core.
8. Too many greens and not enough air. Add browns and turn the pile.
9. Roots need air as well as water. In waterlogged soil there is no air, and roots rot.
10. Cover soil with mulch, keep plants growing, plant grass on slopes, plow across slopes instead of up and down.

PORTFOLIO PIECE: A WORKING COMPOST PILE AND SOIL REPORT

Keep your compost pile (or compost bottle) going for the rest of the unit and beyond, and present a soil report for your home. Include your soil jar drawing and soil type, your drainage test result, your soil-safari creature count, and your compost temperature graph. Finish by writing three things you will do to make your soil better for next spring's garden.

LOOK FOR	WHAT IT MEANS
Compost care	Pile or bottle is built with about three parts browns to one part greens, kept damp, turned, and logged for at least three weeks.
Soil tests	Jar test layers are measured and soil type named; drainage test is recorded in inches per hour.
Soil life	Creature count is complete and decomposers are correctly explained.
Plan	Three sensible soil improvements are explained using what the tests showed.

3.1 THE SOIL JAR TEST AND TEXTURE

OBJECTIVES

- Name the three sizes of mineral particles in soil: sand, silt and clay.
- Identify soil texture by feel using a squeeze test and a ribbon test.
- Separate a soil sample into layers with a jar test and estimate its makeup.

Warm-up. Your teacher gives you three small piles: play sand, flour and a lump of wet modeling clay (or real clay soil). Rub each between your fingers with your eyes closed. Describe how each one feels using one word. Gritty? Silky? Sticky?

WATCH

Why Different Soils Feel Different

[SciShow Kids](#) · 6:51

<https://www.youtube.com/watch?v=qJ9fJU1X9mA>

WHEN TO WATCH

After the core ideas, before the feel test. Feel your three warm-up piles again as each soil is explained.

BACKUP VIDEO

Understanding Soil Types and Soil Texture (test your own soil)

[Garden Fundamentals](#) · 9:01

<https://www.youtube.com/watch?v=AUhOBxVFcFk>

Watch in Session 2, right before you set up your own jar. Pause after each step.

KEY TERMS

sand

The biggest soil particles. Sand feels gritty, and water runs through it fast.

silt

Medium-sized particles, too small to see one by one. Silt feels smooth and silky, like flour.

clay

The tiniest particles. Clay feels sticky when wet, holds water and nutrients, and gets hard when dry.

loam

A soil with a good balance of sand, silt and clay, plus organic matter. Most garden plants love it.

texture

How much sand, silt and clay a soil has, which you can feel with your fingers.

CORE IDEAS

Soil is made of tiny bits of broken-down rock, plus rotting plant matter, water and air. The rock bits come in three sizes. If a grain of **clay** were the size of a pinhead, a grain of **silt** would be a marble, and a grain of **sand** could be as big as a basketball.

Each size behaves differently. **Sand** has big spaces between its grains, so water and air rush through and it dries out fast. **Clay** has tiny spaces, so it holds water and plant food tightly but can get soggy, sticky and short of air. **Silt** is in between. The best garden soil, called **loam**, is a mix of all three with plenty of rotted plant matter.

You can find your soil's **texture** with your fingers. Wet a spoonful of soil and squeeze it into a ball. If it falls apart and feels gritty, it is sandy. If it holds together, squeeze it out between your thumb and finger into a flat ribbon. A ribbon that breaks off under an inch long means loam or silty soil; a long, shiny ribbon of two inches or more means lots of clay.

A **jar test** sorts soil by size. Shake soil with water in a jar and let it settle. The heavy sand sinks first, in about a minute. Silt settles over the next few hours. The tiny clay can float for a day or more before it settles on top. Bits of rotted leaves and roots float on the very top.

You cannot change your soil's texture much, but you can make any soil better by adding compost. Compost helps sandy soil hold water and helps clay soil drain and breathe.

PICTURE STUDY



Man with a Hoe, Jean-François Millet, 1860–1862 · Oil on canvas · J. Paul Getty Museum, Los Angeles

Image: [Wikimedia Commons](#), public domain

Jean-François Millet grew up on a farm in Normandy, France, and he knew how hard it was to work the land by hand. Here a laborer stops to catch his breath after breaking up hard, stony ground with a heavy hoe.

Look closely

- Look at the soil near his feet. Is it soft and crumbly or hard, lumpy and full of stones?
- Find the thistles and weeds in the front of the picture.
- Look far behind him. Can you see smoke rising, where other workers are burning weeds?
- Look at the man's body and face. How does he feel?

Talk about it

1. Do you think this soil is sandy, clay, or loam? What clues do you see?
2. What could a farmer add to hard, lumpy soil to make it easier to work over the years?
3. Why do you think Millet wanted people to see how hard farm work is?

HANDS-ON PROJECT

Soil Detective: Feel Test and Jar Test

You will collect soil from two or three places, test each one by feel, and set up jar tests to see the layers. In a few days you will measure the layers and figure out what kind of soil you have.

You will need

- Soil from two or three places (garden, yard, under a tree, a field), about 1 cup each
- A clear straight-sided quart jar with a lid for each sample
- Water and 1 teaspoon of dishwasher detergent or dish soap per jar
- A ruler, a marker and masking tape
- A spray bottle and a paper plate

Steps

1. With an adult, dig about 4 inches down in each spot and collect a cup of soil. Pick out rocks, roots and worms (put the worms back!).
2. **Feel test:** Put a spoonful on a plate. Spray it until it is damp like putty. Squeeze it into a ball, then press it into a ribbon between your thumb and finger. Measure the ribbon. Write “sandy,” “loam” or “clay” for each sample.
3. **Jar test:** Fill each jar one-third full of soil. Add water until the jar is three-quarters full, then add a teaspoon of detergent (it helps the clay separate).
4. Close the lid tightly and shake hard for 3 minutes.
5. Set the jar down and start a timer. After 1 minute, put a piece of tape on the side and mark the top of the layer that settled: that is sand.
6. After 4 hours, mark the next layer: that is silt.
7. After 2 days, when the water is clearer, mark the top layer: that is clay.
8. Measure each layer in inches. Divide each by the total to estimate the share of sand, silt and clay. Draw and color your jar in your journal.

Tips

- Don't bump the jar while it settles.

- If the water stays cloudy for days, your soil has a lot of very fine clay.

Check your work

- ☐ I can describe how sand, silt and clay feel.
- ☐ I made a ribbon and measured it.
- ☐ I measured the layers in my jar and named my soil type.

NATURE JOURNAL

1. Draw your soil jar life-size with the layers colored and labeled, and the date and time of each mark.
2. Look at a pinch of dry soil under a magnifying glass. Draw what you see: grains, bits of leaf, roots, tiny creatures.
3. Draw the sand–silt–clay size comparison: a pinhead, a marble and a basketball.

COMMON MISTAKES

- Measuring the clay layer too soon. Clay can take two days or more to settle.
- Using a jar with curved sides, which makes layers hard to measure.
- Thinking you need to replace your soil. Adding compost improves any texture.

Make it a game • Squeeze and Ribbon Score. Squeeze damp soil into a ball and press a ribbon between thumb and finger. Predict the texture before measuring the ribbon length with a ruler. Score a point for each correct guess of sand, silt, clay or loam. Beat your own score on the second sample, using the soil words correctly each time.

3.2 LIVING SOIL: WORMS, BACTERIA AND FUNGI

OBJECTIVES

- Name the living things in soil, from earthworms down to bacteria.
- Explain how decomposers turn dead leaves into food for plants.
- Describe how earthworms, helpful bacteria and fungi help plants grow.

Warm-up. Lift a log, a flat stone or a board in the yard (with an adult) and look underneath for one minute. Count every living thing you see. Gently put the stone back exactly where it was.

WATCH

Soil Is Alive! | SciShow Kids

SciShow Kids · 6:45

<https://www.youtube.com/watch?v=Q-J2FErZHuA>

WHEN TO WATCH

After the core ideas. List every soil creature you hear about.

KEY TERMS

decomposer

A living thing that breaks down dead plants and animals into simpler things, returning nutrients to the soil.

fungi

Living things like mushrooms and molds. In soil they grow as long, thin threads that break down dead material.

humus

Dark, spongy, well-rotted plant matter in soil. It holds water and plant food.

bacteria

Living things made of one tiny cell, far too small to see without a microscope. Billions live in a handful of soil.

castings

Earthworm droppings; a rich, crumbly natural fertilizer.

CORE IDEAS

Healthy soil is alive. A single teaspoon of good garden soil holds more tiny living things than there are people on the whole earth. Most are **bacteria** and **fungi**, too

small to see. Bigger ones you can see include earthworms, beetles, mites, springtails, roly-polies, millipedes and centipedes.

Many of these creatures are **decomposers**. When a leaf falls, millipedes and roly-polies chew it into pieces. Then bacteria and fungi break those pieces down further, until the leaf becomes dark, spongy **humus** and the nutrients that were in it are free for new plants to use. Nothing is wasted in God's design.

Earthworms are soil's plowmen. They have no eyes, but they sense light and vibration. They swallow soil and bits of dead leaves and leave behind rich **castings**. Their tunnels let air and water reach roots. Charles Darwin counted worm castings for years and found worms can bring up a thin new layer of soil every year.

Some bacteria and fungi help plants directly. Special bacteria live in little bumps called nodules on the roots of beans and peas and turn nitrogen from the air into plant food. Many fungi wrap their thin threads around plant roots and reach out far into the soil, bringing back water and minerals in trade for a little sugar from the plant. They work like an extra set of roots.

Soil life needs food (dead leaves, compost, roots), water, air and shelter. Bare, packed, dry soil has little life. Soil covered with mulch, full of roots and fed with compost is crowded with helpers.

PICTURE STUDY



Great Piece of Turf, Albrecht Dürer, 1503 · Watercolor and gouache on paper · Albertina, Vienna

Image: [Wikimedia Commons](#), public domain

Dürer dug up a clump of ordinary field grass and painted it as carefully as if it were a king. Nobody had painted weeds and grass this way before. Look at the bottom of the picture, where the plants meet the soil.

Look closely

- Find the dark, damp soil at the bottom. What color is it?
- Find the dandelion leaves and the seed head of a dandelion.
- Count how many different kinds of plants you can find.
- Look at where the roots go into the ground. What might be living down there that Dürer could not paint?

Talk about it

1. What happens to these grass blades and leaves when they die in the fall?
2. Why do you think the soil under a grassy field is darker than sand?
3. If you dug up a clump of your own lawn, what living things might you find?

Safety first. Wear gloves or wash hands well with soap after digging and handling soil. Handle earthworms gently with damp hands, keep them out of the sun, and put them back where you found them.

HANDS-ON PROJECT

A Soil Safari and a Worm Observation Jar

You will search a square foot of soil for living things and count them. Then you will make a worm observation jar for one week to watch worms mix and tunnel, and return them to the garden afterward.

You will need

- A trowel, garden gloves and a white tray or old sheet
- A magnifying glass and a ruler
- A large clear jar or 2-liter bottle with the top cut off (adult cuts)
- Sand, dark garden soil, and dry leaves
- 4–6 earthworms from the garden (or bait-shop red wigglers)
- Dark paper and tape

Steps

1. Mark off a square foot of garden soil or lawn edge. With an adult, dig out the top 4 inches and spread it on the white tray.
2. Search slowly with your magnifying glass. Tally every creature: worms, beetles, roly-polies, centipedes, millipedes, ants, larvae, spiders. Look for white fungus threads on old leaves too.
3. Return the soil and creatures to their spot.
4. For the worm jar, put thin layers of sand and dark soil in the jar, about 1 inch each, until it is three-quarters full. Spray each layer lightly until damp.
5. Put dry leaves and a few vegetable peelings on top. Gently add the worms.
6. Wrap the jar in dark paper (worms like the dark) and keep it in a cool place.
7. Each day for a week, unwrap it for a minute and draw what you see. Are the layers mixing? Can you see tunnels? Keep the soil damp, not soggy.
8. After one week, return the worms to the garden.

Tips

- Worms come up after a rain. That is a good time to find them.
- Never let worms dry out; their skin must stay moist for them to breathe.

Check your work

- ☐ I counted and named the creatures in a square foot of soil.
- ☐ I can explain what decomposers do.
- ☐ I watched worms mix soil layers and returned them safely.

NATURE JOURNAL

1. Draw an earthworm from life with a magnifying glass. Label the segments, the band (clitellum) and which end is the head.
2. Draw the worm jar on Day 1 and Day 7. What changed?
3. Find a rotting leaf or log. Draw it and any fungus threads, mushrooms or creatures on it.

From history. In 1881 the English naturalist Charles Darwin published a whole book about earthworms. After years of measuring, he showed that worms slowly bury stones and old ruins by bringing up castings, and he wrote that few creatures have played so important a part in the history of the world.

COMMON MISTAKES

- Thinking all bacteria and fungi are bad. Most soil microbes are helpers.
- Leaving worms in a sunny window or letting the jar dry out.
- Forgetting to return creatures to the place you found them.

Make it a game • Soil Food Web Chain. Stand in a line. Each player is one soil creature or microbe: earthworm, fungus, bacteria, roly-poly. Pass a paper leaf from one to the next and say what that creature does to it. The last one hands over humus and castings to a pretend plant. Time the chain and beat your record.

3.3 COMPOST SCIENCE: BROWNS AND GREENS

OBJECTIVES

- Sort compost materials into browns (carbon) and greens (nitrogen).
- Explain the four things a compost pile needs: browns, greens, water and air.
- Build a compost pile or bin and record its temperature.

Warm-up. Your teacher sets out a pile of items: dry leaves, banana peel, newspaper, grass clippings, coffee grounds, straw, an apple core, cardboard, a plastic fork. Sort them into three piles: “brown and dry,” “green and wet,” and “does not belong in compost.”

WATCH

How does composting work?

[Mystery Science](#) · 7:49

<https://www.youtube.com/watch?v=aH2FI5FJsv0>

WHEN TO WATCH

After the warm-up and the first core idea. Pause when the video asks a question and make a guess before going on.

BACKUP VIDEO

The Carbon To Nitrogen Ratio Explained - Garden Quickie Episode 105

[The Ripe Tomato Farms](#) · 3:01

<https://www.youtube.com/watch?v=k0mJ79DhxWE>

Before you build your pile. A gardener explains why we need more browns than greens.

KEY TERMS

compost

Dark, crumbly material made when decomposers break down plant scraps; a rich food for soil.

browns

Dry, carbon-rich materials such as dead leaves, straw, shredded paper and cardboard.

greens

Fresh, moist, nitrogen-rich materials such as grass clippings, fruit and vegetable scraps and coffee grounds.

aerate

To let air in, for example by turning a compost pile with a fork.

CORE IDEAS

A compost pile is a feast for decomposers. Bacteria, fungi, worms and bugs eat the scraps and turn them into dark, sweet-smelling **compost**. To keep them working, they need four things: **browns, greens, water and air**.

Browns are dry and full of carbon, which is like bread for the microbes: dead leaves, straw, shredded newspaper, cardboard and sawdust. **Greens** are fresh and full of nitrogen, which is like meat for the microbes: grass clippings, fruit and vegetable scraps, coffee grounds and garden weeds before they go to seed. A good rule is about **three buckets of browns for every one bucket of greens**.

Too many greens and the pile gets slimy and smells bad, because there is not enough air and the extra nitrogen escapes as smelly gas. Too many browns and the pile just sits there for a year. The pile should be as damp as a wrung-out sponge. Turning it with a garden fork every week or two **aerates** it and speeds things up.

A big, well-mixed pile heats up! As billions of microbes eat and multiply, the middle can reach 130 to 160 °F, hot enough to steam on a cold morning. The heat kills many weed seeds and plant diseases. When the pile cools down and looks dark and crumbly, with no food scraps left, the compost is ready, usually in two months to a year.

Keep meat, bones, dairy, oily foods, pet waste and diseased plants **out** of a home compost pile. They smell, attract rats and raccoons, or spread germs. Plastic, metal and glass never break down, so they don't belong either.

PICTURE STUDY



Kitchen Gardens at L'Hermitage, Pontoise, Camille Pissarro, 1874 · Oil on canvas · Scottish National Gallery, Edinburgh

Image: [Wikimedia Commons](#), public domain

Camille Pissarro lived in the village of Pontoise, near Paris, and loved painting its kitchen gardens, where families grew their own vegetables. In these gardens nothing went to waste: scraps, straw and manure were piled and rotted down to feed the soil.

Look closely

- Find the rows of green vegetables in the front. What kind of vegetables might grow in winter?
- Look at the trees. Are their leaves on or off? What season is it?
- Find the people working and walking. Can you see anyone carrying something?
- Look for walls and fences between the gardens.

Talk about it

1. Where do you think these gardeners put their old leaves and vegetable scraps?
2. How do you think these gardens stayed rich enough to grow food year after year without a store to buy fertilizer?

3. Would you like to live in this village? Why?

Safety first. Wear gloves when handling compost, and wash hands with soap afterward. An adult uses the garden fork. Never add meat, pet waste or diseased plants.

HANDS-ON PROJECT

Build a Compost Pile (or a Compost Bottle)

You will build a real compost pile or bin and keep a temperature log. If you have no yard, you will build a small compost bottle and watch it change on a windowsill or balcony.

You will need

- A spot about 3 feet square, a store-bought bin, or a large plastic tote with holes drilled in it by an adult
- Browns: dry leaves, straw or shredded paper
- Greens: grass clippings, fruit and vegetable scraps, coffee grounds
- A shovel of garden soil or finished compost
- A watering can, garden gloves and a garden fork (adult use)
- A compost or long-stem thermometer (optional)
- No-yard option: a clear 2-liter bottle with the top cut off (adult cuts) and small holes poked in the sides

Steps

1. Collect browns and greens for a week. Keep kitchen scraps in a lidded container.
2. Start with a 4-inch layer of coarse browns, like twigs or straw, on the bottom so air can get in.
3. Add a layer of greens about 2 inches thick, then a layer of browns about 6 inches thick. Sprinkle in a shovel of soil to bring in decomposers.
4. Water each layer until it feels like a wrung-out sponge.
5. Repeat the layers until the pile is about 3 feet tall, ending with browns on top to keep away flies.
6. Every day for two weeks, push the thermometer into the middle and record the temperature. Also record the outside temperature.
7. After a week, have an adult turn the pile with a fork. Notice the smell, the heat and any steam.

8. Bottle version: layer soil, browns and chopped greens in the bottle, water lightly, cover with plastic wrap with holes in it, and draw it once a week.

Tips

- Chop scraps into small pieces. Smaller pieces break down faster.
- If the pile smells bad, add browns and turn it. If it is dry and cold, add greens and water.

Check your work

- ☐ I can sort materials into browns, greens and things that don't belong.
- ☐ I built a compost pile or bottle with about three parts browns to one part greens.
- ☐ I kept a temperature or change log for two weeks.

NATURE JOURNAL

1. Draw a cutaway diagram of your compost pile with each layer labeled.
2. Make a line graph of your pile's temperature for two weeks.
3. Draw one banana peel or apple core on Day 1, Day 7 and Day 14 in the compost bottle.

COMMON MISTAKES

- Adding mostly kitchen scraps and no browns, so the pile gets slimy and smelly.
- Letting the pile dry out completely. Decomposers need water.
- Putting meat, dairy or oily foods in the pile.

Make it a game • Compost Recipe Balance. Make two stacks of index cards: browns and greens. Your grown-up names a scrap and you decide which stack, then say whether it is carbon or nitrogen. Build a perfect pile with browns, greens, water and air. Add one wrong item and your grown-up guesses what is missing. Score a point for each.

Scripture. “And he answering said unto him, Lord, let it alone this year also, till I shall dig about it, and dung it:” (Luke 13:8, KJV)

In Jesus' parable, the patient gardener wants to feed the soil around a struggling fig tree before giving up on it. Feeding the soil is an old and wise practice.

3.4 DRAINAGE AND EROSION

OBJECTIVES

- Measure how fast water drains through soil with a drainage (percolation) test.
- Explain why most plants need well-drained soil.
- Show how water erodes bare soil and how plants and mulch protect it.

Warm-up. Pour half a cup of water onto a pile of sand and half a cup onto a pile of clay soil (or a dry sponge and a plate). Watch for 30 seconds. Where did the water go in each case?

WATCH

Erosion and Soil

[funsciencedemos](https://www.youtube.com/watch?v=im4HVXMG168) • 7:36

<https://www.youtube.com/watch?v=im4HVXMG168>

WHEN TO WATCH

After the core ideas. Before each pour, guess which tray will lose the most soil.

BACKUP VIDEO

Simple DIY Soil Drainage Test (Do This Before Planting a Fruit Tree!)

[The Fruit Grove](https://www.youtube.com/watch?v=bd6Q8AJjOVk) • 4:10

<https://www.youtube.com/watch?v=bd6Q8AJjOVk>

Watch in Session 2, right before your drainage test. Notice how he fills the hole twice.

KEY TERMS

drainage

How quickly water soaks down through soil and leaves room for air.

waterlogged

So full of water that there is no air left for roots.

erosion

Soil being carried away by water or wind.

mulch

A covering, such as straw, wood chips or leaves, spread on top of soil to protect it.

runoff

Rainwater that flows over the ground instead of soaking in.

CORE IDEAS

Roots need water, but they also need **air**. Between soil grains are tiny spaces called pores. After a rain, water fills the pores, then drains down, and air moves back in. If water never drains away, the soil is **waterlogged**, roots cannot breathe, and they rot.

Sandy soil drains fast, sometimes too fast, so plants get thirsty. Clay soil drains slowly and can stay soggy for days. Gardeners test drainage before planting: they dig a hole about a foot deep, fill it with water, let it drain, fill it again, and measure how far the water drops in one hour. About 1 to 3 inches an hour is good for most plants. Less than half an inch an hour means poor drainage.

Poor drainage can be fixed by adding compost, planting in raised beds, or choosing plants that like wet feet. Pots must always have **drainage holes**, or water collects at the bottom and the roots drown.

Water can also carry soil away. When rain falls on bare soil, each drop splashes loose grains. As water runs downhill as **runoff**, it carries soil with it, cutting little gullies. This is **erosion**. Good topsoil takes many years to build, but a hard storm can wash it away in an afternoon.

Plants are soil's best protection. Leaves break the force of the raindrops, and roots hold soil together like a net. A layer of **mulch** does the same job in a garden. Farmers plant grass along streams, plow across a hill instead of up and down, and keep fields covered with plants in winter to stop erosion.

PICTURE STUDY



The Hay Wain, John Constable, 1821 · Oil on canvas · National Gallery, London

Image: [Wikimedia Commons](#), public domain

John Constable painted the English countryside where he grew up, beside the River Stour. A farm wagon, called a wain, crosses the shallow river on its way to the hayfields. Constable loved painting clouds, water and the green banks of the river.

Look closely

- Find the riverbank on the left near the cottage. What is growing along it?
- Look at the water. Is it muddy or fairly clear?
- Find the big clouds. What might happen to bare soil if those clouds bring a hard rain?
- Find the hayfields in the distance. Is the ground covered with plants or bare?

Talk about it

1. How do the plants and tree roots on the riverbank keep the bank from washing away?
2. Why might a farmer leave a strip of grass and trees along a river instead of plowing right to the edge?

3. Why might the wagon be standing in the river? (Some people think it was to give the horses a drink or to soak the wooden wheels so they would not shrink and loosen.)

Safety first. An adult helps dig the drainage hole and fills it back in afterward so no one trips. Wash hands after handling soil.

HANDS-ON PROJECT

A Drainage Test and an Erosion Model

You will measure how fast water drains through the soil in your yard (or in pots of different soils), then build a small model hillside to compare erosion from bare soil, mulched soil and soil with plants.

You will need

- A trowel or shovel, a ruler and a timer
- Water in a bucket or watering can
- Three shallow containers the same size (foil pans, shoe-box lids lined with plastic, or cut-open milk jugs)
- Garden soil, a handful of straw or leaves for mulch, and a piece of sod or a pan of sprouted grass or wheat seed
- Three clear cups and a watering can with a sprinkle head

Steps

1. **Drainage test:** With an adult, dig a hole about 12 inches deep and 6 inches wide. Fill it with water and let it drain completely (this soaks the soil).
2. Fill it again. Stand a ruler in the hole, note the water level, and start a timer.
3. After one hour, measure the new water level. Record how many inches drained. Is your drainage good, slow or very fast?
4. **No-yard option:** fill three pots with sand, potting mix and clay soil. Pour 1 cup of water into each over a cup and time how long until it stops dripping.
5. **Erosion model:** Fill three containers with soil and tilt each one on a book so it slopes. Leave one bare, cover one with mulch, and use sod or sprouted grass for the third.
6. Put a clear cup under the low end of each to catch runoff (cut a notch so water can pour out).
7. Sprinkle the same amount of water, 2 cups, on the top of each slope, like rain.
8. Compare the cups. Which runoff is muddiest? Let them settle and measure the soil in each cup.

Tips

- Pour the “rain” from the same height for each tray so the test is fair.
- Start sprouting wheat or grass seed in a tray a week ahead, or use a piece of lawn sod.

Check your work

- ☐ I measured how many inches of water drained in one hour.
- ☐ I compared runoff from bare, mulched and planted soil.
- ☐ I can explain why roots and mulch stop erosion.

NATURE JOURNAL

1. Draw your three erosion trays and three runoff cups after the test, coloring the muddy water carefully.
2. After the next rain, walk your yard or street. Draw any place where soil washed away or water puddled.
3. Draw a pot with a drainage hole and one without. Show where the water goes in each.
4. Make a conservation poster for your county’s soil and water conservation district contest (many districts run the national NACD poster contest; the 2026 theme is “Soil. Where It All Begins”). Show how plants and mulch protect soil. Check your district for the rules and deadline.

From history. In the 1930s, after years of drought, wind blew the bare, plowed topsoil of the Great Plains into huge dust storms. This was the Dust Bowl. Afterward, farmers learned to plant rows of trees as windbreaks, plow along the curves of hills and keep fields covered, and these practices still protect American farms today.

COMMON MISTAKES

- Measuring the drainage test on the first filling. The soil must be soaked first.
- Using pots or cups with no drainage holes for plants.
- Leaving garden soil bare all winter, where rain and wind can carry it off.

Make it a game • Percolation Bet. Make your guess before you pour. Which soil drains faster, sandy or clay? Use a cup with holes and a timer. Pour in a measured amount of water and record the seconds. Score a point if you were within ten seconds. Then explain erosion and runoff and how mulch slows them down.

UNIT 3

SOIL

Soil is not just dirt. It is a mix of broken-down rock, rotted leaves and roots, water, air, and more living creatures than you can imagine. Every carrot, apple and loaf of bread you have ever eaten came out of soil. Good gardeners say, “Feed the soil, and the soil will feed the plants.”

In this unit you will separate soil into its parts in a jar, meet the worms, bacteria and fungi that keep it alive, build a compost pile from “browns” and “greens,” and test how water drains through soil and how it can wash soil away. Our pictures show soil being worked by hand: Millet’s tired farmer with his hoe, Dürer’s clump of turf, Pissarro’s village gardens and Constable’s riverbank.

PREREQUISITES

- Can measure with a ruler in inches and read a thermometer
- Has learned about plant families and seeds (Unit 1)
- Has garden gloves and a trowel, or permission to use a parent’s

MASTERY CHECKLIST

- ☐ I can tell sand, silt and clay apart by feel and in a soil jar.
- ☐ I can name living things in soil and explain how they help plants.
- ☐ I can build a compost pile with the right mix of browns and greens.
- ☐ I can test how fast water drains through soil.
- ☐ I can explain how plant roots and mulch keep soil from washing away.

LESSONS IN THIS UNIT

3.1 The Soil Jar Test and Texture

2 sessions of 45 minutes

3.2 Living Soil: Worms, Bacteria and Fungi

2 sessions of 45 minutes

3.3 Compost Science: Browns and Greens

2 sessions of 45 minutes

3.4 Drainage and Erosion

2 sessions of 45 minutes

UNIT 3 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

List sand, silt and clay from biggest particles to smallest, and say how each feels.

2. (5 pts)

In a soil jar test, which layer settles first and which settles last?

3. (5 pts)

What is loam, and why do gardeners like it?

4. (5 pts)

What does a decomposer do? Name two.

5. (5 pts)

Give two ways earthworms help a garden.

6. (5 pts)

How do some bacteria help bean and pea plants?

7. (5 pts)

Sort these into browns and greens: dry leaves, grass clippings, cardboard, apple core.

8. (5 pts)

A compost pile is slimy and smells bad. What went wrong and how do you fix it?

9. (5 pts)

Why do plant roots need soil that drains?

10. (5 pts)

Name two ways to stop soil erosion in a garden.

ANSWER KEY

1. Sand (gritty), silt (smooth like flour), clay (sticky when wet).
2. Sand settles first, in about a minute. Clay settles last, after a day or more.
3. A balanced mix of sand, silt and clay with organic matter. It drains well but still holds water and nutrients.
4. It breaks down dead plants and animals and returns nutrients to the soil.
Examples: earthworms, bacteria, fungi, millipedes, roly-polies.
5. Their tunnels let in air and water, and their castings are rich fertilizer. They also mix the soil.
6. They live in nodules on the roots and turn nitrogen from the air into plant food.
7. Browns: dry leaves, cardboard. Greens: grass clippings, apple core.
8. Too many greens and not enough air. Add browns and turn the pile.
9. Roots need air as well as water. In waterlogged soil there is no air, and roots rot.
10. Cover soil with mulch, keep plants growing, plant grass on slopes, plow across slopes instead of up and down.

PORTFOLIO PIECE: A WORKING COMPOST PILE AND SOIL REPORT

Keep your compost pile (or compost bottle) going for the rest of the unit and beyond, and present a soil report for your home. Include your soil jar drawing and soil type, your drainage test result, your soil-safari creature count, and your compost temperature graph. Finish by writing three things you will do to make your soil better for next spring's garden.

LOOK FOR	WHAT IT MEANS
Compost care	Pile or bottle is built with about three parts browns to one part greens, kept damp, turned, and logged for at least three weeks.
Soil tests	Jar test layers are measured and soil type named; drainage test is recorded in inches per hour.
Soil life	Creature count is complete and decomposers are correctly explained.
Plan	Three sensible soil improvements are explained using what the tests showed.

UNIT 4

PETS

A pet is a gift and a responsibility. It depends on you every single day for food, clean water, a safe home, gentle handling and care when it is sick. In this unit you will learn what four very different pets truly need: fish in an aquarium, reptiles like leopard geckos and bearded dragons, rabbits, and dogs.

You do not need to own a pet to do this unit. You can plan a habitat and a budget, help care for a neighbor's or relative's pet, or visit a pet store, animal shelter or nature center. Our pictures include a goldfish bowl, a page of lizards from an old natural-history book, a girl feeding her rabbits, and Sir Edwin Landseer's famous rescue dog. As Proverbs says, "A righteous man regardeth the life of his beast."

PREREQUISITES

- Can measure in inches and add simple money amounts
- Understands that animals feel hunger, fear and pain
- Knows to wash hands with soap for 20 seconds

MASTERY CHECKLIST

- ☐ I can explain how an aquarium filter, helpful bacteria and water changes keep fish water clean.
- ☐ I can describe the heat, light, food and hand-washing a leopard gecko or bearded dragon needs.
- ☐ I can tell what a rabbit should eat each day and how to hold one safely.
- ☐ I can teach a dog to sit using rewards, and I know how to greet a dog safely.
- ☐ I can make a daily and weekly care schedule and a simple budget for a pet.

LESSONS IN THIS UNIT

4.1 An Aquarium and Keeping Water Clean

2 sessions of 45 minutes

4.2 Leopard Geckos and Bearded Dragons

2 sessions of 45 minutes

4.3 Rabbits: Hay, Housing and Handling

2 sessions of 45 minutes

UNIT 4 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. **5 pts**
What turns fish waste into ammonia, and what turns ammonia into something less harmful?
2. **5 pts**
Describe a weekly water change in three steps.
3. **5 pts**
Why should goldfish not live in a small bowl?
4. **5 pts**
Why does a reptile home need a warm side and a cool side?
5. **5 pts**
What does UVB light do for a bearded dragon?
6. **5 pts**
What must you always do after handling a reptile, and why?
7. **5 pts**
What should be most of a pet rabbit's diet, and why?
8. **5 pts**
Describe the safe way to hold a rabbit.
9. **5 pts**
What is positive reinforcement? Give an example.
10. **5 pts**
Name three things to do when meeting a dog you don't know.

ANSWER KEY

1. Fish waste and leftover food break down into ammonia. Helpful bacteria in the filter and gravel change it into less harmful nitrate.
2. Siphon out about one-quarter of the water while vacuuming the gravel, rinse the filter in old tank water, and refill with conditioned water of the same temperature.
3. Goldfish grow large and make a lot of waste. A bowl has no filter and too little water, so ammonia builds up.
4. Reptiles are cold-blooded and move between warm and cool spots to control their body temperature.
5. It lets the dragon make vitamin D so it can use calcium and grow strong bones.
6. Wash hands with soap and warm water, because reptiles often carry Salmonella germs that can make people sick.
7. Grass hay, because it wears down the rabbit's always-growing teeth and keeps its gut healthy.
8. One hand under the chest, the other under the bottom supporting the hind legs, held close to your body, low to the ground. Never by the ears.
9. Rewarding a behavior right away so it happens more often, like giving a treat and saying "yes!" the instant a dog sits.
10. Ask the owner first, let the dog sniff your closed hand, pet its shoulder gently; never bother it while eating or sleeping.

PORTFOLIO PIECE: A PET CARE PLAN AND BUDGET

Choose one pet from this unit (fish, leopard gecko, bearded dragon, rabbit or dog) and create a complete care plan as if your family were about to bring it home. Include a labeled habitat drawing, a food list, a daily and weekly chore chart, a first-year budget (setup plus monthly costs plus a veterinarian), and a safety page. Present it to your family, and if you already care for a pet, add a two-week care log.

LOOK FOR	WHAT IT MEANS
Habitat	Drawing shows correct space, temperature or water needs, shelter and equipment for the chosen pet.
Food and chores	Diet is accurate for the animal; chore chart lists daily and weekly tasks and who does them.
Budget	Setup and monthly costs are listed and added correctly, including money for a veterinarian.
Safety and kindness	Includes hand-washing, gentle handling and safe behavior around the animal.

4.1 AN AQUARIUM AND KEEPING WATER CLEAN

OBJECTIVES

- List the parts of a healthy aquarium: tank, filter, heater (for tropical fish), conditioned water and plants.
- Explain simply how fish waste becomes ammonia and how helpful bacteria and water changes keep water safe.
- Do or plan a partial water change step by step.

Warm-up. Look at two glasses of water: one clear tap water and one with a pinch of soil and a drop of food coloring stirred in. Which would you rather live in? Now think: a fish lives in its water, breathes it and makes waste in it all day long. Where does the waste go?

WATCH

How To Clean A Fish Tank | Chewtorials

Chewy · 3:13

<https://www.youtube.com/watch?v=k0BrA9Z5l80>

WHEN TO WATCH

In Session 2, right before the water-change project. Pause after each step and repeat it aloud.

BACKUP VIDEO

Fishkeeping Tips - How To Perform A Water Change On An Aquarium

Maidenhead Aquatics · 3:06

<https://www.youtube.com/watch?v=ftOzqeJXdJc>

A second short how-to from a fish shop expert. Notice how he adds water conditioner to the new water.

KEY TERMS

aquarium

A glass or plastic tank where fish and water plants are kept.

filter

A machine that pulls water through sponges or pads to catch dirt and give helpful bacteria a place to live.

ammonia

A poison made from fish waste and rotting food. Even a little can make fish sick.

water conditioner

Drops added to tap water to remove chlorine, which harms fish.

water change

Taking out part of the old tank water and replacing it with clean, conditioned water.

CORE IDEAS

Fish breathe the oxygen dissolved in water through their gills, and they make all their waste in that same water. In a pond or river the waste is washed away and cleaned up by nature. In a tank, **you** are the one who keeps the water clean.

Fish waste and leftover food turn into **ammonia**, a poison. Thankfully, God made helpful bacteria that eat ammonia and change it into something much less harmful called nitrate. These bacteria live on the gravel and especially in the **filter**. A new tank needs about four to six weeks for these bacteria to grow before many fish are added. Pet stores call this “cycling” the tank.

Nitrate still builds up slowly, so once a week you do a **water change**: siphon out about one-quarter of the water while vacuuming the gravel, then refill with tap water treated with **water conditioner** and close to the same temperature. Never wash the filter sponge under the tap; rinse it in the bucket of old tank water so the good bacteria survive.

Overfeeding is the most common mistake. Feed only what your fish finish in one or two minutes, once or twice a day. Leftover food rots and makes ammonia.

Goldfish grow much bigger than most people think, often 6 to 10 inches or more, and they make a lot of waste. They need a large tank with a filter, not a little bowl. A good rule is to start small and simple: a 10- or 20-gallon tank with a few hardy fish, a filter, and live plants that help clean the water.

PICTURE STUDY



The Goldfish Bowl, William Daniels, 1800s · Oil on canvas · Ashmolean Museum, Oxford

Image: [Wikimedia Commons](#), public domain

In the 1800s, goldfish in round glass bowls were a popular pet and a favorite subject for painters. William Daniels, an English painter from Liverpool, shows a quiet young person with two goldfish. Today we know a great deal more about what fish need.

Look closely

- Count the goldfish in the bowl.
- Look for a filter, a heater, a plant or gravel in the bowl. What do you find?
- Look at how much room the fish have to swim.
- Find the flowerpot next to the bowl. What is growing in it?

Talk about it

1. What would happen to the water in this bowl after a few days with no filter?
2. How could you make a better home for these two goldfish?
3. What do you think the person in the painting is thinking about?

Safety first. Unplug the heater and filter before reaching into a tank or doing a water change. Wash hands with soap before and after touching aquarium water. Never use soap or cleaners on anything that goes in the tank.

HANDS-ON PROJECT

A Water Change (or an Aquarium Plan)

If you have a fish tank, you will do a real partial water change with an adult. If you don't, you will design an aquarium on paper with a supply list and a weekly care schedule, and visit a pet store or aquarium to observe a well-kept tank.

You will need

- A fish tank and a gravel siphon (vacuum), or paper and a pet store visit
- A clean bucket used only for the aquarium
- Water conditioner and a thermometer
- A towel for spills
- Your nature journal

Steps

1. Wash your hands. Unplug the heater and filter (an adult checks).
2. Use the siphon to vacuum the gravel, letting about one-quarter of the water flow into the bucket. Watch the dirt get sucked up.
3. Dip the filter sponge in the bucket of old tank water and squeeze it gently a few times. Put it back.
4. Fill the clean bucket with tap water close to the tank's temperature. Check with the thermometer.
5. Add water conditioner, following the label with an adult.
6. Pour the new water in slowly so you don't blast the fish or plants. Plug the equipment back in.
7. Watch the fish for five minutes and record their behavior.
8. No-tank option: draw a tank plan with its size, filter, plants and three suitable fish. Write a daily and weekly care schedule and price the supplies at a pet store or online with an adult.

Tips

- Pour old tank water on houseplants or the garden; it is full of plant food.

- Pick a regular day for water changes, like every Saturday, so you never forget.

Check your work

- ☐ I can explain why fish need a filter and water changes.
- ☐ I did a water change or wrote a complete aquarium plan.
- ☐ I know how much to feed and why overfeeding is harmful.

NATURE JOURNAL

1. Draw one fish from life (at home, a pet store or a public aquarium). Label the fins, gills, eye, mouth and scales.
2. Draw a diagram of how a filter works with arrows showing the water path.
3. Keep a one-week fish log: feeding times, how the fish acted, and the water temperature.

COMMON MISTAKES

- Overfeeding. Feed only what is eaten in one or two minutes.
- Putting goldfish in a small bowl with no filter.
- Washing the filter under the faucet, which kills the helpful bacteria.

Make it a game • Ammonia Chain Game. Stand in a circle. Pass a paper fish waste card around, adding one step each: waste becomes ammonia, bacteria change it, the filter helps, water changes remove extra. Explain why water conditioner matters. Then list every part of a healthy tank in thirty seconds. Beat your own record.

4.2 LEOPARD GECKOS AND BEARDED DRAGONS

OBJECTIVES

- Explain why reptiles need a warm side and a cool side in their home.
- Compare the needs of leopard geckos and bearded dragons: heat, light, food and space.
- Practice and teach safe hand-washing after handling reptiles.

Warm-up. Feel a rock or a sidewalk that has been in the sun and one in the shade. Which is warmer? If you were a lizard and could not make your own body heat, where would you sit on a cool morning? Where would you go on a hot afternoon?

WATCH

Complete Leopard Gecko Care Guide!

TikisGeckos · 6:06

https://www.youtube.com/watch?v=hU681Z_KXvM

WHEN TO WATCH

After the core ideas. Write down the tank size, the hot-spot temperature and the foods he shows.

Note: This keeper breeds and sells geckos and mentions his shop. The care advice is sound; skip the ads.

BACKUP VIDEO

A Beginner Guide To Bearded Dragon Lights and Heat

Cold Blood Creations · 15:20

<https://www.youtube.com/watch?v=ttmhdEtj0Sk>

For bearded dragons: a reptile keeper shows basking bulbs, UVB tubes and thermometers. Watch the first half in Session 2 while you design your habitat.

KEY TERMS

reptile

A cold-blooded animal with dry, scaly skin, such as a lizard, snake or turtle.

cold-blooded (ectotherm)

An animal that gets its body heat from its surroundings instead of making its own.

basking spot

A warm place under a heat lamp where a reptile warms up.

UVB light

A special lamp that gives off a kind of sunlight reptiles need to make vitamin D and build strong bones.

Salmonella

A germ that many reptiles carry without being sick. It can make people very sick, so we wash our hands.

CORE IDEAS

Reptiles are **cold-blooded**. Their bodies do not make their own heat, so they move between warm and cool spots to keep the right temperature. A reptile home needs a **warm side** with a heat source and a **cool side** without one, so the animal can choose. A thermometer on each side is a must.

Leopard geckos come from rocky, dry grasslands in South Asia. They are most active at dusk and night. They need a tank at least the size of a 20-gallon long (bigger is better), a warm spot about 88 to 92 °F on the floor of the warm side, a cool side in the 70s, and three hiding places, including a damp hide to help them shed. They eat live insects such as crickets and mealworms dusted with calcium powder. Many keepers now add a low UVB light too. Never grab a gecko by the tail; it can drop off to escape a predator.

Bearded dragons come from the hot, sunny deserts of Australia and are active in the day. An adult needs a very large home, about 4 feet long, a basking spot around 100 to 110 °F for adults, a cooler end around 75 to 85 °F, and a strong **UVB light** 12 to 14 hours a day. Without UVB they cannot use calcium and get weak, bent bones. Young dragons eat mostly insects; adults eat mostly leafy greens and vegetables with some insects.

Reptiles can live a long time: leopard geckos often 15 to 20 years, bearded dragons 10 to 15. Before getting one, a family must plan for the cost of lamps, bulbs that need replacing, live insects every week and a reptile veterinarian.

Almost all reptiles carry **Salmonella** germs on their skin and in their droppings, even when they look perfectly healthy. Always wash your hands with soap and warm water right after touching a reptile or anything in its tank. Never hold a reptile up

to your face or let it near food or the kitchen sink. Children under 5 should not handle reptiles.

PICTURE STUDY



*Lizards and Chameleons, Plate 83, Albertus Seba, 1734 · Hand-colored engraving, from *Thesaurus* (Locupletissimi rerum naturalium thesauri) · *Locupletissimi rerum naturalium thesauri*, Amsterdam*

Image: [Wikimedia Commons](#), public domain

Albertus Seba was a Dutch pharmacist who collected thousands of animals, shells and plants from sailors returning from faraway lands. He hired artists to engrave them for a giant four-volume book. This page shows desert lizards and chameleons, all of them reptiles.

Look closely

- Find the two flat, spiny lizards at the top. How might spines help a desert lizard?
- Find the chameleons. Look at their feet and curled tails. How are they built for climbing?
- Look at the scales on each animal. Are they all the same?
- Find the snake. Is a snake a reptile too?

Talk about it

1. A bearded dragon also has spiny scales. Which lizard on this page looks most like one?
2. Where do you think these lizards warmed themselves in the wild?
3. Why do you think people long ago wanted pictures of animals from far away?

Safety first. Wash hands with soap and warm water right after touching any reptile, its food or its tank. Keep reptiles away from the kitchen and never hold them up to your face. Heat lamps get very hot; only an adult adjusts them.

HANDS-ON PROJECT

Design a Reptile Habitat with a Heat Map

You will design a safe home for a leopard gecko or a bearded dragon. You will draw it with a warm side and a cool side, make a supply list with prices, and write a care schedule. If you can, visit a pet store or nature center to see a reptile habitat and measure its temperatures.

You will need

- Graph paper, a ruler and colored pencils (red, orange, yellow, blue)
- A pet supply catalog or website (with an adult) for prices
- Two thermometers (optional) and a desk lamp to test a warm spot
- Your nature journal

Steps

1. Choose your reptile: leopard gecko or bearded dragon. Write its home country, its active time (day or night) and its adult size.
2. On graph paper, draw the enclosure to scale (1 square = 3 inches). A 20-gallon long tank is 30 by 12 inches; a dragon home is about 48 by 24 inches.
3. Mark the heat lamp or heat mat at one end. Color a heat map: red for the hottest spot, orange and yellow as it cools, blue for the cool end.
4. Draw and label the hides, water dish, food dish, basking rock, UVB light and thermometers.
5. Write a supply list with prices. Add the monthly costs too: insects, greens, calcium powder and replacement bulbs.
6. Write a daily and weekly care schedule.
7. Optional test: set two thermometers on a table, one 6 inches under a desk lamp and one 2 feet away. After 20 minutes, record both. This is how a warm side and cool side work.
8. Make a hand-washing sign to hang near the habitat.

Tips

- If you visit a store, ask an employee to show you the thermometers and UVB bulb in a display tank.

- Look up the needs on a reptile care sheet from a veterinarian or a zoo with an adult.

Check your work

- ☐ My habitat has a warm side, a cool side and thermometers on both.
- ☐ I can explain why a bearded dragon needs UVB light.
- ☐ I know when and how to wash my hands after handling a reptile.

NATURE JOURNAL

1. Draw a lizard from life (pet store, nature center, or a wild fence lizard from a distance). Label its scales, eyes, toes and tail.
2. Make a Venn diagram comparing leopard geckos and bearded dragons.
3. Record the temperature of a sunny spot and a shady spot outdoors at noon. How many degrees apart are they?

COMMON MISTAKES

- Using only one thermometer. You need to know both the warm and the cool side.
- Forgetting to replace UVB bulbs. They stop giving off UVB long before they burn out, usually within about a year.
- Skipping hand-washing because the reptile “looks clean.”

Make it a game • Warm Side, Cool Side Map. Draw a tank as a rectangle and color a heat map with a warm basking side and a cool side. Your grown-up asks about a leopard gecko and a bearded dragon in turn, and you answer heat, light, food and space. Add UVB and Salmonella handwashing. Compare both reptiles in a table.

4.3 RABBITS: HAY, HOUSING AND HANDLING

OBJECTIVES

- Explain why hay must be most of a rabbit's diet.
- Describe a safe, roomy rabbit home and daily and weekly chores.
- Pick up and hold a rabbit (or a stuffed animal for practice) correctly, always supporting the hind legs.

Warm-up. Run your tongue over your front teeth. They stopped growing long ago. A rabbit's teeth grow about half an inch every month for its whole life! Guess: what does a rabbit need to chew all day to keep its teeth the right length?

WATCH

Daily Rabbit Care

Training Through Life · 4:17

https://www.youtube.com/watch?v=JSx_309wLBs

WHEN TO WATCH

After the core ideas. Make a checklist of every daily chore you see.

BACKUP VIDEO

How to Pick Up Rabbits

AnimalCareTV · 5:23

<https://www.youtube.com/watch?v=KD9jQtzLBbc>

Watch before practicing the handling steps in the project.

KEY TERMS

hay

Dried grass, such as timothy or orchard grass. It should be about four-fifths of a pet rabbit's food.

pellets

Small pressed pieces of rabbit food. Adults need only a small amount.

prey animal

An animal that other animals hunt. Prey animals are easily frightened and like to stay low and hidden.

litter box

A box of paper or wood bedding and hay that a rabbit can learn to use as a bathroom.

CORE IDEAS

A rabbit's teeth never stop growing, and its stomach and gut are made to handle huge amounts of grass. That is why **hay** is the most important food. A pet rabbit should have unlimited fresh grass hay, like timothy or orchard grass, every day, about four-fifths of all it eats. Chewing hay wears down the teeth and keeps the gut moving.

Add a few handfuls of fresh leafy greens each day (romaine lettuce, cilantro, parsley, carrot tops), a small scoop of plain **pellets**, and always clean, fresh water. Carrots and fruit are sweet treats, only a bite or two. Bunnies in cartoons eat carrots all day, but real rabbits that do get sick.

Rabbits need room to hop, stretch up tall, and run. A small cage is not enough. A good home is a large pen or a rabbit-proofed room with a hiding box, a **litter box** with hay, food and water dishes, and chew toys. Rabbits chew everything, so electric cords must be covered. Clean the litter box every day or two and the whole area weekly.

Rabbits are **prey animals**. In the wild, being picked up means being caught by a hawk, so many rabbits are frightened when lifted. Their backbones are delicate: if a rabbit kicks hard while held wrong, it can hurt its back. Never pick up a rabbit by its ears or the scruff of its neck. Sit on the floor and let it come to you. If you must lift it, put one hand under its chest and the other under its bottom, support the hind legs, and hold it close against your body.

Rabbits often live 8 to 12 years. They are social and gentle, and many learn their names and come running for greens. A happy rabbit may leap and twist in the air, a jump called a “binky.”

PICTURE STUDY



Feeding the Rabbits, Émile Munier, 1888 · Oil on canvas · Private collection

Image: [Wikimedia Commons](#), public domain

Émile Munier was a French painter who loved to paint children caring for animals. Here a farm girl has brought food for her family's rabbits. Look carefully at what the rabbits are eating.

Look closely

- Count the rabbits. What colors are they?
- Find what the rabbits are eating. Is it the food a rabbit should eat most?
- Look at what the girl is carrying.
- Look at the rabbits' ears and bodies. Do they look relaxed or frightened?

Talk about it

1. What would you add to this rabbits' meal to keep them healthy?
2. How can you tell the girl is being careful and gentle?
3. Where do you think these rabbits sleep at night?

Safety first. Always sit on the floor or hold a rabbit low over a soft surface. Never lift by the ears or scruff. Rabbits can scratch and bite when scared; let an adult help, and wash hands after handling.

HANDS-ON PROJECT

A Rabbit Care Plan and Handling Practice

You will make a full care plan for a rabbit: a home layout, a food list, a chore chart and a budget. Then you will practice safe handling, first with a stuffed animal and then, if possible, with a real rabbit belonging to a friend, a 4-H member or a shelter.

You will need

- Graph paper and colored pencils
- A handful of timothy hay, some pellets and a few greens to look at (from a pet store), optional
- A stuffed animal about rabbit-size
- Access to a calm real rabbit with its owner (optional)
- Your nature journal

Steps

1. Examine the hay, pellets and greens with a magnifying glass. Draw each and write how much a rabbit eats per day.
2. Draw a floor plan for a rabbit pen at least 4 feet by 4 feet, with a hiding box, litter box, hay rack, water and toys.
3. Make a chore chart: daily (hay, water, greens, check eating and droppings, spot-clean litter) and weekly (full clean, brush, check nails and teeth).
4. Make a monthly budget with an adult: hay, pellets, greens, litter, and money saved for a veterinarian.
5. Practice handling on the stuffed animal: kneel, slide one hand under the chest, scoop the other under the bottom and back feet, and hold it close against your chest.
6. If you visit a real rabbit, sit on the floor first and offer a leaf of greens. Let the rabbit come to you. Stroke its forehead and back gently.
7. Write a short report: what surprised you most about rabbit care?

Tips

- Rabbits are most active in the early morning and evening.

- A rabbit that flops on its side or grinds its teeth softly is relaxed and content.

Check your work

- ☐ I can explain why hay is most of a rabbit's diet.
- ☐ My care plan includes a pen, food, chores and a budget.
- ☐ I can show the safe way to hold a rabbit.

NATURE JOURNAL

1. Draw a rabbit from life or from the painting. Label its long ears, eyes, whiskers, strong back legs and fluffy tail.
2. Draw a rabbit's front teeth and write why they need hay.
3. Make a page of rabbit body language: ears up, ears flat, thumping, flopping, binky. Draw each with what it means.

COMMON MISTAKES

- Feeding mostly pellets or carrots and not enough hay.
- Lifting a rabbit by the ears or without supporting the back legs.
- Keeping a rabbit in a small cage all day with no room to run.

Make it a game • Rabbit Diet Pie Chart. Draw a circle and divide it into the parts of a healthy rabbit diet. Hay should take up most of the circle. Your grown-up quizzes you on why hay matters and what chores come daily and weekly. Then rehearse handling with a stuffed animal: support the back legs and hold it close.

4.4 DOG TRAINING AND RESPONSIBILITY

OBJECTIVES

- Explain positive reinforcement: rewarding the behavior you want, right away.
- Teach a dog (or practice with a family member) the “sit” cue in short sessions.
- List a dog’s daily needs and the safe way to meet an unfamiliar dog.

Warm-up. Play “hot and cold.” One person hides an object, and the other finds it while the hider says only “yes!” each time the finder moves the right way. How fast did you learn which way to go? Dogs learn the same way: by a happy “yes!” and a reward.

WATCH

How to Teach your Puppy to Sit and Stay

Zak George · 7:22

<https://www.youtube.com/watch?v=DPNz6reMVXY>

WHEN TO WATCH

After the core ideas, before the training project. Watch how quickly he gives the treat after the puppy sits.

BACKUP VIDEO

How To Teach A Dog To Sit | Chewtorials

Chewy · 2:07

<https://www.youtube.com/watch?v=-wLejBHUMsQ>

A short step-by-step to watch right before your training session.

KEY TERMS

positive reinforcement

Giving a reward right after a behavior so the animal does it more often.

cue

The word or hand signal that tells a dog what to do, such as “sit.”

lure

A treat held in front of a dog’s nose to guide it into a position.

consistency

Everyone in the family using the same words and rules every time.

CORE IDEAS

Dogs have lived and worked with people for thousands of years: herding sheep, guarding farms, pulling sleds, finding lost people and keeping us company. But no dog is born knowing our words. We have to teach them, patiently and kindly.

Dogs learn by what happens right after they do something. If sitting brings a tasty treat and a happy “Yes! Good dog!” the dog will sit more often. This is **positive reinforcement**. The reward must come within a second or two, or the dog won’t connect it with the behavior.

To teach “sit,” hold a small treat at the dog’s nose as a **lure**, then slowly move it up and back over its head. As the nose goes up, the bottom goes down. The instant the bottom touches the floor, say “yes!” and give the treat. After several tries, say the **cue** “sit” just before you move your hand. Keep sessions short, about five minutes, and end while the dog is still having fun.

Once your dog knows “sit,” teach the other basic obedience cues the same patient way, one at a time: **down** (lie down), **stay** (wait in place until released), **come** (run to you when called), and **heel** (walk calmly at your left side on a loose leash). These five are the first skills taught in 4-H dog projects.

Yelling and hitting teach a dog to be afraid, not to obey. **Consistency** matters more than anything: everyone in the family uses the same words, and the dog is never rewarded for jumping up or begging at the table.

A dog needs food and fresh water every day, walks and play, a warm bed, grooming, picking up after it, a collar with a tag, and yearly visits to the veterinarian. Dogs often live 10 to 15 years, so a dog is a promise for a long time.

Meet strange dogs safely: always ask the owner first, let the dog sniff your closed hand, and pet its shoulder, not the top of its head. Never bother a dog that is eating, sleeping or chewing a toy. If an unfamiliar dog runs toward you, stand still like a tree with your arms at your sides and don’t look into its eyes.

PICTURE STUDY



A Distinguished Member of the Humane Society, Sir Edwin Landseer, 1838 · Oil on canvas · Tate Britain, London

Image: [Wikimedia Commons](#), public domain

Sir Edwin Landseer was the most famous animal painter in Victorian England. This dog, a Newfoundland named Paul Pry, lived by the water. Newfoundlands are strong swimmers and were famous for pulling people out of the water. The title jokes that the dog was an honored member of a lifesaving society.

Look closely

- Look at the dog's thick coat and big webbed paws. How do they help a water rescue dog?
- Find the iron ring in the stone dock. What might boats tie to it?
- Look at the dog's eyes and posture. Is it relaxed or alert?
- Find the seagulls in the sky.

Talk about it

1. What jobs have dogs done for people? Name as many as you can.
2. How do you think a rescue dog like this was trained?
3. What does this dog need from its owner every day?

Safety first. Train only a dog you know well, with its owner present. Never put your face close to a dog's face. Ask before petting any dog, and wash hands after handling dogs and their toys.

HANDS-ON PROJECT

Teach a Sit and Write a Dog Care Contract

You will teach a dog to sit (or improve its sit) using treats and praise, keeping a training log for a week. If you don't have a dog, you can work with a relative's or neighbor's dog with the owner's help, or practice the timing by "training" a family member with a clicker game. Then you will write a dog care contract.

You will need

- A dog you know well and its owner, or a family member for the practice game
- Tiny soft dog treats (pea-sized) in a pouch or pocket
- A quiet room with few distractions
- Paper for a training log and a care contract

Steps

1. Choose a quiet room. Have about 20 tiny treats ready.
2. Stand in front of the dog. Hold a treat at its nose and slowly move it up and back over its head.
3. The moment its bottom touches the floor, say "yes!" and give the treat. Praise warmly.
4. Repeat 5 to 10 times, then stop and play. Train like this twice a day.
5. After a day or two, say "sit" once, then move your hand. Reward every sit.
6. Each session, record in your log how many tries and how many sits.
7. No-dog option: play the training game with a family member. Without words, say "yes!" and give a raisin when they move toward a secret goal (like touching a lamp). Feel how timing helps learning.
8. Write a dog care contract: list the daily, weekly and yearly jobs, and who in the family will do each one. Sign it.

Tips

- If the dog jumps up for the treat, your hand is too high. Keep it just above its nose.

- End every session on a success, even an easy one.
- After sit, add down, stay, come and heel, one new cue a week. Many 4-H clubs have dog projects where children train and show their own dogs; check your county extension office.

Check your work

- ☐ I can explain positive reinforcement.
- ☐ I kept a one-week training log (or completed the timing game).
- ☐ I can show how to meet a strange dog safely.

NATURE JOURNAL

1. Draw a dog from life in three quick poses: sitting, standing and lying down.
2. Draw a dog body-language page: happy and relaxed, playful, scared, and “leave me alone.”
3. Make a graph of your training log: sessions along the bottom, successful sits up the side.

COMMON MISTAKES

- Waiting too long to give the treat, so the dog doesn’t know what earned it.
- Repeating “sit, sit, sit.” Say it once, then help with the lure.
- Training for too long, until the dog is bored or tired.

Make it a game • Sit Cue Practice Round. Use a stuffed dog or a family member and teach a cue in three short rounds. Give the cue, lure, then reward right away. Your grown-up scores consistency out of ten. Explain positive reinforcement before you start. Write one line of your care contract and read it aloud.

Scripture. “A righteous man regardeth the life of his beast:” (Proverbs 12:10, KJV)

To “regard” an animal’s life is to pay attention to its needs and treat it kindly. Patient training and faithful care are ways we obey this proverb.

UNIT 4

PETS

A pet is a gift and a responsibility. It depends on you every single day for food, clean water, a safe home, gentle handling and care when it is sick. In this unit you will learn what four very different pets truly need: fish in an aquarium, reptiles like leopard geckos and bearded dragons, rabbits, and dogs.

You do not need to own a pet to do this unit. You can plan a habitat and a budget, help care for a neighbor's or relative's pet, or visit a pet store, animal shelter or nature center. Our pictures include a goldfish bowl, a page of lizards from an old natural-history book, a girl feeding her rabbits, and Sir Edwin Landseer's famous rescue dog. As Proverbs says, "A righteous man regardeth the life of his beast."

PREREQUISITES

- Can measure in inches and add simple money amounts
- Understands that animals feel hunger, fear and pain
- Knows to wash hands with soap for 20 seconds

MASTERY CHECKLIST

- ☐ I can explain how an aquarium filter, helpful bacteria and water changes keep fish water clean.
- ☐ I can describe the heat, light, food and hand-washing a leopard gecko or bearded dragon needs.
- ☐ I can tell what a rabbit should eat each day and how to hold one safely.
- ☐ I can teach a dog to sit using rewards, and I know how to greet a dog safely.
- ☐ I can make a daily and weekly care schedule and a simple budget for a pet.

LESSONS IN THIS UNIT

4.1 An Aquarium and Keeping Water Clean

2 sessions of 45 minutes

4.2 Leopard Geckos and Bearded Dragons

2 sessions of 45 minutes

4.3 Rabbits: Hay, Housing and Handling

2 sessions of 45 minutes

UNIT 4 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. **5 pts**
What turns fish waste into ammonia, and what turns ammonia into something less harmful?
2. **5 pts**
Describe a weekly water change in three steps.
3. **5 pts**
Why should goldfish not live in a small bowl?
4. **5 pts**
Why does a reptile home need a warm side and a cool side?
5. **5 pts**
What does UVB light do for a bearded dragon?
6. **5 pts**
What must you always do after handling a reptile, and why?
7. **5 pts**
What should be most of a pet rabbit's diet, and why?
8. **5 pts**
Describe the safe way to hold a rabbit.
9. **5 pts**
What is positive reinforcement? Give an example.
10. **5 pts**
Name three things to do when meeting a dog you don't know.

ANSWER KEY

1. Fish waste and leftover food break down into ammonia. Helpful bacteria in the filter and gravel change it into less harmful nitrate.
2. Siphon out about one-quarter of the water while vacuuming the gravel, rinse the filter in old tank water, and refill with conditioned water of the same temperature.
3. Goldfish grow large and make a lot of waste. A bowl has no filter and too little water, so ammonia builds up.
4. Reptiles are cold-blooded and move between warm and cool spots to control their body temperature.
5. It lets the dragon make vitamin D so it can use calcium and grow strong bones.
6. Wash hands with soap and warm water, because reptiles often carry Salmonella germs that can make people sick.
7. Grass hay, because it wears down the rabbit's always-growing teeth and keeps its gut healthy.
8. One hand under the chest, the other under the bottom supporting the hind legs, held close to your body, low to the ground. Never by the ears.
9. Rewarding a behavior right away so it happens more often, like giving a treat and saying "yes!" the instant a dog sits.
10. Ask the owner first, let the dog sniff your closed hand, pet its shoulder gently; never bother it while eating or sleeping.

PORTFOLIO PIECE: A PET CARE PLAN AND BUDGET

Choose one pet from this unit (fish, leopard gecko, bearded dragon, rabbit or dog) and create a complete care plan as if your family were about to bring it home.

Include a labeled habitat drawing, a food list, a daily and weekly chore chart, a first-year budget (setup plus monthly costs plus a veterinarian), and a safety page. Present it to your family, and if you already care for a pet, add a two-week care log.

LOOK FOR	WHAT IT MEANS
Habitat	Drawing shows correct space, temperature or water needs, shelter and equipment for the chosen pet.
Food and chores	Diet is accurate for the animal; chore chart lists daily and weekly tasks and who does them.
Budget	Setup and monthly costs are listed and added correctly, including money for a veterinarian.
Safety and kindness	Includes hand-washing, gentle handling and safe behavior around the animal.

UNIT 5

SEEDS AND WHAT PLANTS NEED

Late winter is seed-starting time. Before the ground outside is ready, gardeners fill trays and pots on sunny windowsills and wake up seeds. In this unit you will become a plant scientist. You will run a fair germination experiment, find out how leaves make food from sunlight, watch water climb up a stem and disappear into the air, and learn the three big plant nutrients printed on every bag of plant food: N, P and K.

Each lesson asks you to test an idea with real plants and to keep careful records, just as real scientists and 4-H members do. Our pictures come from Millet's sower, Dürer's columbine, and two paintings by Van Gogh: his irises and his green spring wheat.

PREREQUISITES

- Can measure in inches and centimeters and keep a dated table
- Knows the parts of a plant: roots, stem, leaves, flowers, seeds
- Has learned about soil and compost (Unit 3)

MASTERY CHECKLIST

- ☐ I can design a fair test that changes only one thing.
- ☐ I can figure out a germination rate out of 10 seeds.
- ☐ I can explain how a leaf uses light, water and air to make food and give off oxygen.
- ☐ I can explain how water travels from the roots up the stem and out of the leaves.
- ☐ I can tell what N, P and K do for a plant and spot signs that a plant is hungry for one of them.

LESSONS IN THIS UNIT

5.1 A Germination Experiment with One Variable

2 sessions of 45 minutes

5.2 Leaves and Photosynthesis

2 sessions of 45 minutes

5.3 Roots, Stems and Transpiration

2 sessions of 45 minutes

5.4 N-P-K and Deficiency Signs

2 sessions of 45 minutes

UNIT 5 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. 5 pts

Name the three parts of a bean seed and tell what the cotyledons do.

2. 5 pts

What three things do most seeds need to germinate?

3. 5 pts

You want to test whether light helps beans sprout. What do you change, and name two things you keep the same.

4. 5 pts

7 out of 10 seeds sprouted. What is the germination rate?

5. 5 pts

Give the recipe for photosynthesis.

6. 5 pts

What does chlorophyll do?

7. 5 pts

What is transpiration, and how does it help move water up a plant?

8. 5 pts

Why should you water deeply in the morning instead of in the hot afternoon?

9. 5 pts

What do the numbers 10-5-5 on a bag mean?

10. 5 pts

A tomato plant's lowest, oldest leaves are turning pale yellow and it grows slowly. Which nutrient might be missing?

ANSWER KEY

1. Seed coat, embryo and cotyledons. The cotyledons store food for the baby plant.
2. Water, air (oxygen) and the right temperature.
3. Change only the light. Keep the same kind and number of seeds, the same water, temperature and paper towels.
4. 7 out of 10, or 70 percent.
5. Water + carbon dioxide + light energy make sugar and oxygen.
6. It is the green substance that captures sunlight energy for photosynthesis.
7. Water leaving leaves as vapor through the stomata. As it leaves, it pulls more water up through the xylem from the roots.
8. Plants transpire most in the heat, so morning watering gives them water before they need it, and less water evaporates.
9. 10 parts nitrogen, 5 parts phosphorus and 5 parts potassium out of 100, always in N-P-K order.
10. Nitrogen (after checking that water, light and cold are not the problem).

PORTFOLIO PIECE: MY PLANT SCIENCE NOTEBOOK

Put together your plant science notebook for the unit, written like a real 4-H project record. Include your bean temperature experiment (question, guess, data table, graph and conclusion), your foil-patch leaf drawings, your celery and leaf-bag results, and your three-week Hungry Bean growth record. Add a cover page and a short letter explaining the most surprising thing you learned about how plants live.

LOOK FOR	WHAT IT MEANS
Fair testing	Each experiment states a question, a guess, the one variable changed and what was kept the same.
Records	Data tables are dated, complete and neatly kept, with measurements in inches or centimeters.
Graphs and drawings	Graphs have titles and labels; drawings are made from real plants and labeled.
Understanding	Conclusions correctly explain germination, photosynthesis, transpiration and N-P-K.

5.1 A GERMINATION EXPERIMENT WITH ONE VARIABLE

OBJECTIVES

- Name the parts of a seed: seed coat, embryo and cotyledons.
- Explain what seeds need to germinate: water, air and the right temperature.
- Design and run a fair test that changes only one variable, and figure the germination rate.

Warm-up. Soak a few large dry beans in water overnight. Today, gently peel one and split it in half with your fingernail. Use a magnifying glass. Can you find the tiny baby plant tucked inside? Draw what you see.

WATCH

Grow Your Own Plants! - #sciencegoals

SciShow Kids · 5:31

<https://www.youtube.com/watch?v=Lly75dEbXE8>

WHEN TO WATCH

After the core ideas. Notice what Jessi keeps the same for every seed and what she changes.

BACKUP VIDEO

Fair Tests

ESB Science Blast · 5:28

<https://www.youtube.com/watch?v=yYMPbKbK1yo>

Before you plan your own experiment, if you want more practice with the idea of a fair test.

KEY TERMS

germination

When a seed wakes up and the baby plant begins to grow out of it.

embryo

The tiny baby plant inside a seed.

cotyledon

A seed leaf that stores food for the baby plant. Beans have two.

variable

Anything in an experiment that can change, such as temperature, water or light.

fair test

An experiment where you change only one variable and keep everything else the same.

CORE IDEAS

A seed is a baby plant in a lunchbox. Inside its tough **seed coat** is the **embryo**, a tiny root and shoot, and one or two **cotyledons** packed with stored food. A dry seed is alive but resting. It can wait months or even years for the right moment.

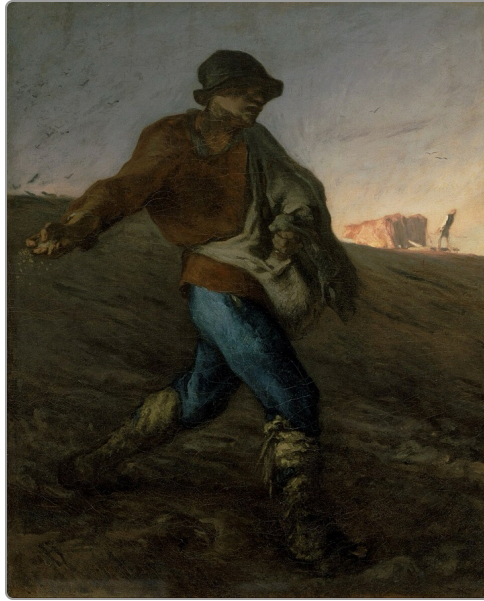
To **germinate**, most seeds need three things: **water**, **air** and the **right temperature**. Water soaks in and the seed swells and splits its coat. Air gives the busy cells oxygen. Warmth tells the seed it is safe to grow. Most garden seeds do not need light to sprout, because they start underground; a few tiny seeds, like lettuce, sprout better with a little light.

First the root pokes out and turns downward. Then the shoot hooks upward, pulls the cotyledons out of the soil, and the first true leaves open. Beans sprout in about a week at room temperature; radishes in three to five days. Cold soil slows everything down, which is why we wait to plant beans outside until the soil is warm.

Scientists test ideas with a **fair test**. If you want to know whether temperature matters, you change *only* the temperature. Everything else stays the same: the same kind of seed, the same number, the same paper towel, the same amount of water. If you change two things at once, you can't tell which one made the difference.

We count results as a **germination rate**. If 8 out of 10 seeds sprout, the germination rate is 8 out of 10, or 80 percent. Seed companies test this too and print it on the packet.

PICTURE STUDY



The Sower, Jean-François Millet, 1850 · Oil on canvas · Museum of Fine Arts, Boston

Image: [Wikimedia Commons](#), public domain

Jean-François Millet painted a farmer sowing grain by hand, scattering seed in wide swings as he walks. Long ago, all grain was planted this way. The painting became so famous that it was printed on seed packets and stamps.

Look closely

- Find the seed bag on the sower's shoulder. Which hand is throwing the seed?
- Look at the birds above the field on the left. What might they be doing?
- Find the oxen plowing far away on the hilltop.
- Look at his long stride. How does it show that he is moving fast?

Talk about it

1. Why do you think some of the scattered seed would never sprout?
2. What does a seed need once it lands in the soil?
3. Jesus told a parable about a sower like this one. What happened to the seeds in that story?

HANDS-ON PROJECT

The Great Bean Temperature Test

You will run a fair test to find out whether temperature changes how fast and how many bean seeds germinate. You will keep everything the same except where the bags are kept.

You will need

- 30 bean seeds of the same kind (or radish seeds)
- 3 zip bags and 3 paper towels the same size
- A measuring spoon and water
- A thermometer
- A marker and your nature journal

Steps

1. Write your question: “Does temperature change how many bean seeds germinate in 7 days?” Then write your guess (your hypothesis).
2. Fold each paper towel the same way. Wet each with exactly 3 tablespoons of water.
3. Lay 10 seeds on each towel, spaced apart. Slide each into a bag and seal it, leaving a little air inside.
4. Label the bags: COLD, ROOM and WARM. Put COLD in the refrigerator, ROOM on a shelf, and WARM on top of the refrigerator or near (not on) a heater vent.
5. Measure and record the temperature in each place.
6. Every day at the same time, count how many seeds have a root poking out. Record the numbers in a table.
7. On Day 7, figure the germination rate for each bag (sprouted out of 10).
8. Make a bar graph. Write your conclusion: was your guess right? What would you test next?

Tips

- Don't open the bags more than you need to. Count through the plastic.

- Plant your best sprouts in pots of soil afterward to keep growing.

Check your work

- ☐ I changed only one variable and kept the others the same.
- ☐ I recorded my counts every day in a table.
- ☐ I figured the germination rate for each bag and made a graph.

NATURE JOURNAL

1. Draw the inside of a soaked bean, life-size and then 4 times bigger. Label the seed coat, cotyledons and embryo.
2. Draw one sprouting bean every day for a week to show the root and shoot growing.
3. Copy your data table and bar graph neatly, with a title and labels.

COMMON MISTAKES

- Changing two things at once, like temperature and amount of water.
- Letting the paper towels dry out.
- Counting a swollen seed as sprouted before the root actually comes out.

Make it a game • Fair Test Referee. Your grown-up describes a plan: two bean cups, one warm and one cold, but one has more water too. Be the referee. Call out the unfair part and fix it so only one variable changes. Name the seed coat, embryo and cotyledons. Referee three plans and earn a whistle for every catch.

Scripture. “And he said, So is the kingdom of God, as if a man should cast seed into the ground; And should sleep, and rise night and day, and the seed should spring and grow up, he knoweth not how. For the earth bringeth forth fruit of herself; first the blade, then the ear, after that the full corn in the ear.” (Mark 4:26-28, KJV)

We can plant, water and watch, but the growing itself is God’s work. Your sprouting beans show “first the blade.”

5.2 LEAVES AND PHOTOSYNTHESIS

OBJECTIVES

- Explain that plants make their own food in their leaves using light, water and carbon dioxide.
- Name chlorophyll and stomata and tell what each does.
- Show with an experiment that a leaf needs light to stay green and healthy.

Warm-up. Collect five different leaves. Lay them in a row and compare them: size, shape, edge, veins, and color on top and underneath. Which leaf would catch the most sunlight? Why is almost every leaf flat and thin?

WATCH

Photosynthesis for Kids - Introduction to Photosynthesis for Children: FreeSchool

Free School · 4:50

<https://www.youtube.com/watch?v=XCzFE0SB2N4>

WHEN TO WATCH

After the first two core ideas. Afterward, say the photosynthesis “recipe” from memory.

BACKUP VIDEO

Photosynthesis for Kids | Learn how plants MAKE their own food

Learn Bright · 5:32

<https://www.youtube.com/watch?v=lln136eMl4g>

A second explanation with clear diagrams, good for review in Session 2.

KEY TERMS

photosynthesis

The way plants use light energy to turn water and carbon dioxide into sugar (food) and oxygen.

chlorophyll

The green substance in leaves that captures sunlight.

carbon dioxide

A gas in the air that we breathe out and plants take in.

stomata

Tiny openings, mostly on the underside of leaves, that let air in and water vapor out.

oxygen

A gas in the air that people and animals need to breathe; plants give it off.

CORE IDEAS

Animals have to find their food, but plants make their own. A leaf is a little food factory. Its “recipe” is called **photosynthesis**: water from the roots + **carbon dioxide** from the air + energy from sunlight = sugar for the plant + **oxygen** that goes out into the air.

The green color in leaves comes from **chlorophyll**. Chlorophyll is like a solar panel: it catches light energy to run the factory. That is why leaves are flat and thin and turn to face the light; they are spreading out their solar panels.

On the underside of most leaves are thousands of tiny doors called **stomata**, too small to see without a microscope. They open to let carbon dioxide in and oxygen out. Each stoma has two guard cells that close it when the plant is short of water.

The sugar a leaf makes travels to every part of the plant. Some is used right away for energy and growth, and some is stored: in a potato, a carrot root, a bean seed or an apple. When you eat these foods, you are eating sunlight energy that a plant stored.

In fall, as days shorten, trees stop making chlorophyll. The green fades and the yellow and orange colors that were hidden underneath show through. The oxygen we breathe and nearly all the food we eat depend on green leaves catching sunlight. God designed the whole living world to rest on this quiet work.

PICTURE STUDY



Columbine, Albrecht Dürer, 1526 · Watercolor and gouache on vellum · Albertina, Vienna

Image: [Wikimedia Commons](#), public domain

Dürer painted this wild columbine near the end of his life. He showed every leaf from a slightly different angle, some facing us flat and some turned sideways. Look at how the leaves are arranged to catch the light.

Look closely

- Find the leaves. How many parts (lobes) does each one have?
- Find a leaf that faces you flat and one that is turned sideways.
- Look at the stems. Are the leaves crowded together or spread out?
- Find the flowers. Which way are they hanging?

Talk about it

1. Why might a plant spread its leaves out instead of stacking them on top of each other?
2. Where is this plant making its food?
3. What part of the plant would you need to look at with a microscope to see stomata?

HANDS-ON PROJECT

The Foil Patch Experiment and a Leaf Print Collection

You will block light from part of a living leaf for a week to see what happens when a leaf can't make food. You will also make a collection of leaf rubbings and compare leaf shapes.

You will need

- A healthy potted plant with large leaves (a bean seedling, geranium or houseplant)
- Aluminum foil and paper clips or tape
- Scissors
- Paper and unwrapped crayons for leaf rubbings
- A magnifying glass

Steps

1. Choose two leaves on your plant. Cut two small squares of foil about 1 inch across.
2. Fold each square over part of a leaf, top and bottom, and clip it gently. Leave the rest of the leaf uncovered.
3. Put the plant in a sunny window and water it normally.
4. Predict what the covered part will look like in one week. Write your guess.
5. After 7 days, remove the foil. Compare the covered patch with the rest of the leaf. Draw and color both.
6. Leaf rubbings: collect 6 different leaves. Put each under paper, vein side up, and rub with the side of a crayon.
7. Label each rubbing with the plant name, the leaf shape and the vein pattern.
8. Look at the underside of a leaf with your magnifying glass. Describe what you see.

Tips

- Don't press the foil so tightly that it tears the leaf.
- Thin, soft leaves like bean leaves show the change fastest.

Check your work

- ☐ I can say the recipe for photosynthesis.
- ☐ I covered part of a leaf and recorded what changed.
- ☐ I can explain what chlorophyll and stomata do.

NATURE JOURNAL

1. Draw a leaf as a food factory: label sunlight coming in, water arriving from the stem, carbon dioxide going in through stomata, and oxygen going out.
2. Draw your foil-patch leaf before and after.
3. Find a leaf that is changing color. Draw and color it, and write which colors were hiding under the green.

From history. In the 1770s the English scientist Joseph Priestley found that a mint plant could “restore” air in a sealed jar so that a candle would burn again. A few years later the Dutch doctor Jan Ingenhousz showed that plants do this only in sunlight, which was a key step toward understanding photosynthesis.

COMMON MISTAKES

- Thinking plants get their food from the soil. They make food in their leaves; soil gives water and minerals.
- Thinking plants don’t need oxygen. They make it, but they also use some.
- Covering a whole leaf so tightly that it is crushed instead of shaded.

Make it a game • Photosynthesis Recipe Race. Write the ingredients and products on cards: light, water, carbon dioxide, sugar and oxygen. Shuffle them and sort into inputs and outputs under a timer. Then tell your grown-up what chlorophyll and stomata do. Make a leaf print with a crayon and label the veins to finish.

5.3 ROOTS, STEMS AND TRANSPIRATION

OBJECTIVES

- Describe how root hairs take in water and how stems carry it upward.
- Explain transpiration: water leaving leaves as vapor and pulling more water up.
- Show water movement with a celery dye test and a leaf-bag test.

Warm-up. Put a paper towel strip with one end in a cup of colored water. Watch for three minutes. What happens? Plants move water upward too, but in a different and much more amazing way.

WATCH

The Color-Changing Celery Experiment!

[SciShow Kids](#) · 4:13

<https://www.youtube.com/watch?v=Klug9Foou3s>

WHEN TO WATCH

In Session 1, right before you set up your own celery so it can soak overnight.

BACKUP VIDEO

LEAF TRANSPIRATION Experiment (what is transpiration?)

[Kids Fun Science \(Kids Fun Science\)](#) · 3:57

<https://www.youtube.com/watch?v=YeOw-wJR9fc>

Before the leaf-bag test in Session 2.

KEY TERMS

root hairs

Tiny hair-like growths on roots that soak up water and minerals.

xylem

Tiny tubes in roots, stems and leaves that carry water upward.

transpiration

Water leaving a plant's leaves as invisible water vapor.

wilting

Drooping when a plant loses water faster than it can take it in.

CORE IDEAS

Roots hold a plant in place and drink for it. Near the tip of every root grow thousands of tiny **root hairs**, so small and many that a single plant's root hairs could stretch for

miles if laid end to end. They soak up water and dissolved minerals from the soil.

Inside the root and stem are bundles of tiny tubes called **xylem**, like drinking straws running from the roots to every leaf. In celery, you can see them as the strings in the stalk. Other tubes carry sugar from the leaves down to the roots.

How does water get all the way to the top of a tall tree with no pump? The leaves do the pulling. Water evaporates out of the stomata as invisible vapor; this is **transpiration**. As each tiny bit of water leaves, it pulls on the water behind it, all the way down the xylem to the roots, like sipping on a very long straw.

Plants lose a lot of water this way. A large oak tree can give off about 40,000 gallons of water in a year. On a hot, windy day, a plant transpires faster. If the roots can't keep up, the plant **wilts**. That is why we water deeply, mulch to keep soil moist, and water in the morning instead of the hot afternoon.

Transpiration also cools the plant, just as sweating cools you. And all that water vapor rises, forms clouds and falls again as rain. The forests and fields help water the earth that waters them.

PICTURE STUDY



Irises, Vincent van Gogh, 1889 · Oil on canvas · J. Paul Getty Museum, Los Angeles

Image: [Wikimedia Commons](#), public domain

Van Gogh painted these irises in the garden of a hospital where he was staying in southern France. He painted them from life, looking closely at their long, swordlike leaves and twisting flowers.

Look closely

- Find the long green leaves. Are they standing up stiff or flopping over?
- Find the one white iris among the blue ones.
- Look at the orange-red soil at the bottom. Does it look wet or dry?
- Find a flower stem. How tall is it compared with the leaves?

Talk about it

1. How do these stiff, upright leaves show the plants have enough water?
2. What would these irises look like on a hot afternoon if the soil were very dry?
3. Irises grow from thick underground stems called rhizomes. How might they help the plant in dry weather?

Safety first. Food coloring stains clothes and hands; wear old clothes. Only an adult cuts the celery stalk with a knife.

HANDS-ON PROJECT

Celery Dye Test and Leaf-Bag Test

You will see water climbing a stem by putting celery in colored water, and you will catch the water that leaves give off by tying a clear bag around a leafy branch.

You will need

- 2–3 celery stalks with leaves (or white carnations)
- Clear glasses, water and dark food coloring (blue or red)
- A clear plastic sandwich bag and a twist tie
- A leafy outdoor plant or a large houseplant in the sun
- A ruler, a magnifying glass and a timer

Steps

1. Have an adult trim the bottom of each celery stalk with a fresh cut.
2. Fill a glass halfway with water and add 20 drops of food coloring. Put the celery in.
3. Set up a second glass with plain water as a control.
4. Check after 1 hour, 4 hours and the next morning. Record where the color has reached and measure how far it climbed.
5. Ask an adult to cut a slice across the stalk. Look at the colored dots with your magnifying glass. These are the xylem tubes.
6. Leaf-bag test: on a sunny morning, slip a clear bag over a leafy branch and twist it closed around the stem. Do not pull leaves off.
7. After 2 hours and again after 6 hours, look at the bag. Draw what you see inside.
8. Remove the bag carefully at the end of the day and measure or describe the water you collected.

Tips

- Leaves on the celery speed up the color climb because they transpire.
- Try one bag in the sun and one in the shade to compare.

Check your work

- ☐ I measured how far the colored water climbed and found the xylem tubes.
- ☐ I collected water from transpiration in a bag.
- ☐ I can explain how leaves pull water up from the roots.

NATURE JOURNAL

1. Draw a plant from roots to leaves with blue arrows showing the path of water and label root hairs, xylem, stomata and transpiration.
2. Draw the celery slice under the magnifying glass, showing the colored dots.
3. Draw your leaf bag at 2 hours and 6 hours.

COMMON MISTAKES

- Thinking water is pushed up from the roots. It is mostly pulled up by transpiration.
- Watering a little every day instead of deeply when the soil is dry.
- Pulling leaves off when putting on the bag.

Make it a game • Transpiration Pull Duel. Hold one end of a string and your grown-up holds the other. Pretend the string is water in the stem. As water leaves the leaves, pull gently, and tell the steps: root hairs take in water, xylem carries it up, transpiration pulls more. Switch roles. Then explain what wilting means.

Scripture. “And he shall be like a tree planted by the rivers of water, that bringeth forth his fruit in his season; his leaf also shall not wither;” (Psalm 1:3, KJV)

A tree by a river never runs short of water, so its leaves stay green. The psalm says the person who loves God’s word is like that tree.

5.4 N-P-K AND DEFICIENCY SIGNS

OBJECTIVES

- Name the three main plant nutrients, nitrogen, phosphorus and potassium, and what each does.
- Read the three numbers on a fertilizer or compost label.
- Recognize common signs that a plant is short of a nutrient, and run a simple growing test.

Warm-up. Look at two bean or houseplant leaves, one deep green and one pale or yellow (or pictures of them). What could cause the difference? Make a list of every idea you can think of: water, light, food, bugs, cold.

WATCH

NPK Fertilizer Numbers - what they really mean

Garden Fundamentals · 7:48

<https://www.youtube.com/watch?v=BGVU75oRKyo>

WHEN TO WATCH

After the core ideas. Watch the first half, which explains what the three numbers stand for; the second half is for parents who want more detail.

BACKUP VIDEO

Understanding Fertilizer Labels

Rutgers New Jersey Agricultural Experiment Station · 3:04

<https://www.youtube.com/watch?v=m692lYUkjms>

A short explanation from a university extension expert. Good before you read a real label.

KEY TERMS

nutrient

A substance a living thing needs to grow and stay healthy.

nitrogen (N)

The nutrient for green leaves and stems.

phosphorus (P)

The nutrient for strong roots, flowers, fruits and seeds.

potassium (K)

The nutrient for overall health, strong stems and resisting disease.

deficiency

Not having enough of a needed nutrient.

CORE IDEAS

Plants make their own sugar from sunlight, but to build leaves, roots and fruit they also need minerals from the soil. The three they need most are **nitrogen** (N), **phosphorus** (P) and **potassium** (K). An easy way to remember them: “**up, down and all around.**” N for leaves up top, P for roots down below, K for health all around.

Every bag of fertilizer and many bags of compost and potting mix show three numbers, like 5-10-5 or 10-10-10. They are always in the same order: N-P-K. A 10-10-10 bag has 10 parts out of 100 nitrogen, 10 phosphorus and 10 potassium. Compost has small numbers but feeds the soil slowly and helps soil life.

Plants show us when they are hungry. **Nitrogen deficiency:** the oldest, lowest leaves turn pale yellow first, and the plant grows slowly and looks thin. **Phosphorus deficiency:** plants stay small and the leaves may turn dark green with a purplish color, especially in cold soil. **Potassium deficiency:** the edges of older leaves turn yellow, then brown and crispy, as if scorched.

But be a careful detective! Yellow leaves can also come from too much water, too little light, cold weather or pests. Check those first. A soil test from your county extension office tells you exactly what your soil needs, so you add only what is missing. Too much fertilizer can burn roots and wash into streams.

Gardeners can feed soil naturally: compost, aged manure, and beans and peas, whose root bacteria add nitrogen. Children never handle fertilizers; an adult reads the label and measures exactly.

PICTURE STUDY



Green Wheat Fields, Auvers, Vincent van Gogh, 1890 · Oil on canvas · National Gallery of Art, Washington, D.C.

Image: [Wikimedia Commons](#), public domain

Van Gogh painted this field of young spring wheat in the village of Auvers in France, just weeks before he died. The wheat is thick, deep green and blowing in the wind: a field full of healthy growth.

Look closely

- Look at the color of the wheat. Is it pale yellow-green or rich, deep green?
- Find places where the color changes from one part of the field to another.
- Look at the brushstrokes. How do they show the wind moving the wheat?
- Find the clouds. How are they painted differently from the field?

Talk about it

1. Which nutrient helps young wheat grow such thick, green leaves?
2. If one corner of this field were pale yellow, what might a farmer check?
3. What will this field look like in two months, at harvest?

Safety first. Children do not handle fertilizers. An adult reads the label, wears gloves and measures. Wash hands after handling compost or potting mix.

HANDS-ON PROJECT

The Hungry Bean Test

You will grow bean seedlings in three different growing mixes to see how plant food in the soil changes growth. You will measure and record every few days for three weeks, like a 4-H project record.

You will need

- 3 pots or cups the same size with drainage holes
- Plain washed play sand
- Finished compost or bagged compost
- Potting mix
- 9 bean seeds (or pre-sprouted beans from Lesson 5.1)
- A ruler, labels, and a sunny window

Steps

1. Label the pots: SAND, SAND + COMPOST (half and half), and POTTING MIX.
2. Fill each pot to the same level. Plant 3 beans in each, 1 inch deep.
3. Put all three pots in the same sunny window and give each the same amount of water.
4. Every 3 days, measure the tallest plant in each pot, count the leaves, and note the color: deep green, light green or yellow.
5. Record everything in a table with the date, what you did (watered, turned pots), and your measurements.
6. After 3 weeks, compare. Draw one plant from each pot side by side.
7. Look for signs from the core ideas: are the lower leaves of any plant turning yellow first?
8. Write a conclusion: which mix grew the healthiest beans, and why do you think so?

Tips

- Sand has almost no nutrients, so the beans live on the food stored in their cotyledons at first and then begin to struggle.

- Turn the pots a little each day so the plants don't lean.

Check your work

- ☐ I can say what N, P and K each do.
- ☐ I can read the three numbers on a label.
- ☐ I kept a growth record for three weeks and wrote a conclusion.

NATURE JOURNAL

1. Draw three leaves: one showing nitrogen deficiency, one phosphorus, one potassium. Label each.
2. Copy the N-P-K numbers from a real bag of potting mix, compost or plant food (with an adult) and explain them.
3. Make a line graph of your bean heights from all three pots in three colors.

COMMON MISTAKES

- Thinking more fertilizer is always better. Too much can burn roots.
- Blaming every yellow leaf on hunger. Check water, light and cold first.
- Forgetting the N-P-K order on the label.

Make it a game • N-P-K Label Reader. Write three fertilizer labels like 10-5-5 or 5-10-10 on cards. Your grown-up asks which number is nitrogen, phosphorus and potassium, and what each does. Predict deficiency signs for a plant with pale leaves or purple stems. Score a point for each right match. Beat your best total on a second pass.

UNIT 5

SEEDS AND WHAT PLANTS NEED

Late winter is seed-starting time. Before the ground outside is ready, gardeners fill trays and pots on sunny windowsills and wake up seeds. In this unit you will become a plant scientist. You will run a fair germination experiment, find out how leaves make food from sunlight, watch water climb up a stem and disappear into the air, and learn the three big plant nutrients printed on every bag of plant food: N, P and K.

Each lesson asks you to test an idea with real plants and to keep careful records, just as real scientists and 4-H members do. Our pictures come from Millet's sower, Dürer's columbine, and two paintings by Van Gogh: his irises and his green spring wheat.

PREREQUISITES

- Can measure in inches and centimeters and keep a dated table
- Knows the parts of a plant: roots, stem, leaves, flowers, seeds
- Has learned about soil and compost (Unit 3)

MASTERY CHECKLIST

- ☐ I can design a fair test that changes only one thing.
- ☐ I can figure out a germination rate out of 10 seeds.
- ☐ I can explain how a leaf uses light, water and air to make food and give off oxygen.
- ☐ I can explain how water travels from the roots up the stem and out of the leaves.
- ☐ I can tell what N, P and K do for a plant and spot signs that a plant is hungry for one of them.

LESSONS IN THIS UNIT

5.1 A Germination Experiment with One Variable

2 sessions of 45 minutes

5.2 Leaves and Photosynthesis

2 sessions of 45 minutes

5.3 Roots, Stems and Transpiration

2 sessions of 45 minutes

5.4 N-P-K and Deficiency Signs

2 sessions of 45 minutes

UNIT 5 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. 5 pts

Name the three parts of a bean seed and tell what the cotyledons do.

2. 5 pts

What three things do most seeds need to germinate?

3. 5 pts

You want to test whether light helps beans sprout. What do you change, and name two things you keep the same.

4. 5 pts

7 out of 10 seeds sprouted. What is the germination rate?

5. 5 pts

Give the recipe for photosynthesis.

6. 5 pts

What does chlorophyll do?

7. 5 pts

What is transpiration, and how does it help move water up a plant?

8. 5 pts

Why should you water deeply in the morning instead of in the hot afternoon?

9. 5 pts

What do the numbers 10-5-5 on a bag mean?

10. 5 pts

A tomato plant's lowest, oldest leaves are turning pale yellow and it grows slowly. Which nutrient might be missing?

ANSWER KEY

1. Seed coat, embryo and cotyledons. The cotyledons store food for the baby plant.
2. Water, air (oxygen) and the right temperature.
3. Change only the light. Keep the same kind and number of seeds, the same water, temperature and paper towels.
4. 7 out of 10, or 70 percent.
5. Water + carbon dioxide + light energy make sugar and oxygen.
6. It is the green substance that captures sunlight energy for photosynthesis.
7. Water leaving leaves as vapor through the stomata. As it leaves, it pulls more water up through the xylem from the roots.
8. Plants transpire most in the heat, so morning watering gives them water before they need it, and less water evaporates.
9. 10 parts nitrogen, 5 parts phosphorus and 5 parts potassium out of 100, always in N-P-K order.
10. Nitrogen (after checking that water, light and cold are not the problem).

PORTFOLIO PIECE: MY PLANT SCIENCE NOTEBOOK

Put together your plant science notebook for the unit, written like a real 4-H project record. Include your bean temperature experiment (question, guess, data table, graph and conclusion), your foil-patch leaf drawings, your celery and leaf-bag results, and your three-week Hungry Bean growth record. Add a cover page and a short letter explaining the most surprising thing you learned about how plants live.

LOOK FOR	WHAT IT MEANS
Fair testing	Each experiment states a question, a guess, the one variable changed and what was kept the same.
Records	Data tables are dated, complete and neatly kept, with measurements in inches or centimeters.
Graphs and drawings	Graphs have titles and labels; drawings are made from real plants and labeled.
Understanding	Conclusions correctly explain germination, photosynthesis, transpiration and N-P-K.

UNIT 6

FARM ANIMALS AND BEES

Early spring is a busy time on a farm. Hens start laying more eggs as the days grow longer, dairy goats have their kids, sheep are sheared, and honeybees build up their colonies for the first flowers. In this unit you will learn how a family keeps a small flock of hens, how dairy goats give milk, how wool travels from a sheep's back to a ball of yarn, and how thousands of bees work together inside a hive.

You do not need to own any animals. Visit a farm, a 4-H fair, a farmers' market or a beekeeper; read library books; and make careful plans and models. You will also try your first **judging class**, the way young people do at 4-H and county fairs: ranking four animals from best to last and giving reasons. Our pictures come from the Dutch poultry painter Melchior d'Hondecoeter, Adriaen van de Velde, Jean-François Millet and Pieter Bruegel.

PREREQUISITES

- Understands day length and the seasons (Unit 1)
- Has learned gentle handling and hand-washing with pets (Unit 4)
- Can keep a dated record table in the nature journal

MASTERY CHECKLIST

- ☐ I can list the daily and weekly chores for a backyard flock and keep an egg record.
- ☐ I can rank four hens and give reasons, like a 4-H judge.
- ☐ I can explain how a dairy goat is milked and how milk is kept clean and cold.
- ☐ I can describe the steps from shearing a sheep to spinning yarn.
- ☐ I can name the three kinds of honeybees and the jobs worker bees do.

LESSONS IN THIS UNIT

6.1 Keeping a Backyard Flock

2 sessions of 45 minutes

6.2 Dairy Goats

2 sessions of 45 minutes

6.3 Sheep: From Wool to Yarn

2 sessions of 45 minutes

UNIT 6 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

Why do hens lay more eggs in spring and summer?

2. (5 pts)

Name four things a chicken coop needs.

3. (5 pts)

Name three signs of a healthy hen that a judge looks for.

4. (5 pts)

In a judging class, what are “reasons”?

5. (5 pts)

How often is a dairy goat milked, and what happens to the milk right after?

6. (5 pts)

Why should you never keep just one goat?

7. (5 pts)

Put in order: spinning, shearing, carding, washing.

8. (5 pts)

Why do farm sheep need shearing every year?

9. (5 pts)

Name the three kinds of honeybees and one fact about each.

10. (5 pts)

How do bees turn nectar into honey?

ANSWER KEY

1. Days are longer. Hens lay best with about 14 to 16 hours of light.
2. Any four: enough floor space, roosts, nest boxes, a fenced run, predator-proof hardware cloth, a door locked at night, feed and water.
3. Bright eyes, a bright red comb, clean shiny feathers, smooth legs, alert and active.
4. Sentences that explain why you placed one animal over another, comparing them, such as “I placed B over A because B has a redder comb.”
5. Twice a day, about 12 hours apart. The milk is strained and chilled quickly (and often pasteurized).
6. Goats are herd animals and are lonely and unhappy alone.
7. Shearing, washing, carding, spinning.
8. Their wool keeps growing, and without shearing they would become hot, heavy, dirty and sick.
9. Queen: lays all the eggs. Workers: females that do all the work. Drones: males with no stinger that don't gather food.
10. They add enzymes, spread it in cells, and fan their wings to evaporate most of the water, then cap the cells with wax.

PORTFOLIO PIECE: A FARM ANIMAL CARE NOTEBOOK WITH A JUDGING CARD

Choose one farm animal from this unit (hens, dairy goats, sheep or honeybees) and make a care notebook like a 4-H project record book. Include a labeled drawing, a housing plan, a daily and weekly chore chart, a two-week record (eggs, milk, observations or bee counts), and a page on what the animal gives us. Add your hen judging card with your placing and three reasons.

LOOK FOR	WHAT IT MEANS
Care plan	Housing, food, water and chores are correct and complete for the chosen animal.
Records	A dated two-week record is kept faithfully, like a 4-H record book.
Judging	Four hens are placed 1-4 with three clear comparing reasons.
Presentation	Drawings are labeled and the notebook is neat, complete and shows careful observation.

6.1 KEEPING A BACKYARD FLOCK

OBJECTIVES

- Describe what hens need: a safe coop, feed, water, nest boxes and roosts.
- Explain why hens lay more eggs in spring and summer.
- Plan daily and weekly flock chores and keep an egg record.
- Judge a class of four hens and give reasons.

Warm-up. Look closely at a raw egg in a bowl (and a hard-boiled one cut in half). Find the shell, the white, the yolk and the little air pocket at the wide end. What do you think a hen needs to eat to make a strong shell every day?

WATCH

BACKYARD CHICKENS FOR BEGINNERS! | Caring For Egg Laying Hens The EASY Way!

Whitepepper Farms Homestead · 9:48

<https://www.youtube.com/watch?v=6DtfXDKSITk>

WHEN TO WATCH

After the core ideas. List each piece of equipment you see in the coop.

Note: The host shows a feed product he likes; families can use any complete layer feed.

KEY TERMS

hen

An adult female chicken. Hens lay eggs whether or not there is a rooster.

coop

The shelter where chickens sleep, lay eggs and stay safe at night.

roost

A bar or pole where chickens perch to sleep.

layer feed

Chicken feed made for laying hens, with extra calcium for eggshells.

comb

The red, fleshy crest on top of a chicken's head. A bright red comb is a sign of a healthy, laying hen.

CORE IDEAS

Chickens are among the easiest farm animals for a family to keep, and many towns allow a few hens. A good laying hen can give about five eggs a week in spring and summer. Hens do not need a rooster to lay eggs; a rooster is only needed for eggs that will hatch into chicks. Some chicken breeds are raised mainly for eggs, some for meat, and some for both.

Hens lay the most eggs when days are long, about 14 to 16 hours of light. In fall and winter, as days get short, most hens slow down or stop laying and grow new feathers. You learned in Unit 1 that plants read day length; chickens do too.

A flock needs a **coop** with about 4 square feet of floor per hen, **roosts** to sleep on, one nest box for every four or five hens, and a fenced run outside. Raccoons, foxes, hawks and dogs all want to eat chickens, so the coop is closed with strong hardware cloth (not thin chicken wire) and the door is locked every night at dusk.

Hens eat **layer feed** and drink a lot of clean water. A dish of crushed oyster shell gives extra calcium for shells. They also love garden weeds, bugs and kitchen scraps as treats. Daily chores: fresh water and feed, collect eggs (once or twice a day), and close the door at night. Weekly: add fresh bedding and clean the coop.

Healthy hens are alert and busy, with bright eyes, a red **comb**, clean shiny feathers and smooth legs. A hen that sits fluffed up in a corner, with dull eyes and a pale comb, may be sick. At 4-H and county fairs, judges look for these same things when they rank poultry. Chickens can carry Salmonella germs, so always wash your hands after handling them or their eggs, and never hold them up to your face.

PICTURE STUDY



A Cock, Hens and Chicks, Melchior d'Hondecoeter, about 1668 · Oil on canvas · National Gallery, London

Image: [Wikimedia Commons](#), public domain

Melchior d'Hondecoeter was a Dutch painter who painted almost nothing but birds, especially farmyard poultry. Rich families hung his pictures in their country houses. Look how carefully he painted each feather.

Look closely

- Find the rooster. How is he different from the hens: comb, tail, size and color?
- Find the white hen with a crest of fluffy feathers on her head.
- Count the chicks. What are they doing?
- Look at the hens' eyes, combs and feathers. Which hen looks healthiest to you?

Talk about it

1. If you were judging these hens at a fair, which would you place first? Why?
2. What does a mother hen do to protect her chicks?
3. What clues tell you these birds live on a farm and not in the wild?

Safety first. Wash hands with soap after touching chickens, eggs, feeders or the coop. Hold hens gently with both hands, wings held against the body. An adult should be present when a child handles a rooster.

HANDS-ON PROJECT

A Flock Chore Plan, an Egg Record and a Judging Class

You will plan the coop and chores for a small flock of four hens, start an egg record, and judge your first class of four hens, ranking them 1 to 4 and giving reasons the way 4-H members do.

You will need

- Graph paper and colored pencils
- Four pictures of hens of the same breed (from a poultry book, a feed-store catalog or the internet with an adult), labeled A, B, C and D
- A carton of eggs (for the egg record practice, or real eggs from a flock)
- Your nature journal

Steps

1. Draw a coop and run for four hens on graph paper. Show 16 square feet of floor, a roost, one nest box and a door that locks.
2. Make a chore chart: morning, evening and weekly jobs, with a name beside each.
3. Start an egg record table: date, number of eggs, feed added, water refilled, and notes. Keep it for two weeks if you have hens, or with a neighbor's flock, a farm or practice numbers from a carton.
4. Judging class: lay out your four hen pictures. Look at each one for 2 minutes. Check eyes, comb, feathers, legs, body shape and how alert she looks.
5. Rank the hens 1st, 2nd, 3rd and 4th. Write your placing as letters, like B-A-D-C.
6. Write reasons: one sentence for why your 1st beat your 2nd, one for 2nd over 3rd, and one for 3rd over 4th. Start each with "I placed B over A because..."
7. Compare your placing with a parent or sibling who judged the same four. Talk about your reasons.
8. If you can, visit a farm, feed store in spring, or a county fair poultry barn and watch real hens.

Tips

- Good reasons compare: “B has a brighter red comb and cleaner feathers than A.”
- Many county fairs have youth poultry shows; check your county extension office or fair book to learn how to enter.
- Biosecurity: wash hands and change or clean your shoes before and after visiting another flock, and don’t share feeders, crates or tools between farms. This keeps bird diseases from spreading, and fairs require it too.

Check your work

- ☐ My coop plan gives enough space, roosts, nest boxes and predator protection.
- ☐ I kept a dated egg and chore record.
- ☐ I ranked four hens and wrote three comparing reasons.

NATURE JOURNAL

1. Draw a hen from life or from the painting. Label the comb, wattle, beak, eye, ear lobe, wing, tail, shank and toes.
2. Draw an egg cut in half with its parts labeled.
3. Make a graph of eggs per day from your two-week record.

COMMON MISTAKES

- Using thin chicken wire, which raccoons can tear through.
- Forgetting to close the coop at dusk.
- Judging by color alone instead of health and body shape.

Make it a game • Flock Chore Speed Round. Set a timer for sixty seconds. Name everything a hen needs: safe coop, feed, water, nest boxes, roosts. Your grown-up counts. Then explain why hens lay more in spring and summer. Switch: your grown-up tries to catch your mistake in a chore plan with one wrong item hidden in it.

6.2 DAIRY GOATS

OBJECTIVES

- Name common dairy goat breeds and how to tell them apart.
- Explain what goats eat and what they need for shelter and company.
- Describe how a goat is milked and how milk is kept clean and cold.

Warm-up. Taste a little goat milk, goat cheese or goat-milk yogurt if you can find some at the store, and compare it with cow's milk. How are they alike and different? (Skip this if anyone has a milk allergy.)

WATCH

How To Milk A Goat!

Blue Cactus Dairy Goats · 7:58

<https://www.youtube.com/watch?v=1upYWlbtgZs>

WHEN TO WATCH

After the core ideas. Watch the order: clean the udder, check the first squirts, milk, then dip the teats.

BACKUP VIDEO

How to Milk a Goat - Taught by an 8 year old kid!

Weed 'em & Reap · 2:07

<https://www.youtube.com/watch?v=evsU098mhm8>

A short demonstration by a farm girl about your age.

KEY TERMS

doe

A female goat. A male is a buck, and a baby is a kid.

milk stand

A raised platform with a head gate where a goat stands calmly while being milked.

udder

The bag under a doe's belly where milk is made, with two teats.

browser

An animal that likes to eat leaves, twigs and shrubs more than grass, as goats and deer do.

pasteurize

To heat milk to a set temperature to kill harmful germs.

CORE IDEAS

Goats have given milk to families for thousands of years; the Bible speaks of “goats’ milk enough for thy food.” A dairy goat is small enough for a child to help care for but gives enough milk for a family. Common breeds include **Nubians** with long floppy ears, **LaManchas** with tiny ears, **Alpines**, white **Saanens**, and small **Nigerian Dwarfs**.

A doe makes milk after she gives birth to her kids in spring. She is usually milked twice a day, about 12 hours apart, every day, for many months. A full-size dairy goat may give around a gallon a day at her best; a Nigerian Dwarf gives about one to two quarts. Milking is a faithful daily chore, morning and evening, in rain or snow.

To milk, the goat stands on a **milk stand** eating her grain. The milker washes and dries the **udder**, squirts the first bit of milk into a separate cup to check it, then milks by closing off the top of the teat with thumb and finger and squeezing down with the other fingers, one hand at a time. Milk is strained right away, chilled quickly, and often **pasteurized** to keep it safe.

Goats are **browsers**. They love leaves, brush, vines and weeds, plus good hay, a little grain, loose minerals and plenty of water. Like cows, they chew their cud. They are curious and clever and climb everything, so they need strong fences. Goats are herd animals and are unhappy alone; always keep at least two.

Goat milk becomes cheese, yogurt, butter, ice cream and even soap. Goats also give meat, and some breeds give fiber. Their hooves grow all the time and must be trimmed every month or two.

PICTURE STUDY



A Woman Milking a Goat outside a Barn, Adriaen van de Velde, 1660s · Oil on panel · Royal Collection, United Kingdom

Image: [Wikimedia Commons](#), public domain

Adriaen van de Velde was a Dutch painter who loved peaceful farm scenes. Here a farm wife milks a goat outside the barn on a sunny day, while her family and other animals look on.

Look closely

- Find the woman milking. Is she milking from the side or the back of the goat?
- Find the bucket or pail. Where is it?
- Find the other farm animals in the picture. What might each one give this family?
- Look at the thatched barn. What is the roof made of?

Talk about it

1. How is her way of milking like the milking in the video? How is it different?
2. Why do you think goats were a good animal for a small farm family long ago?
3. What would this family do with the milk?

Safety first. Visit goats only with the farmer's permission and an adult. Goats can butt and jump, so stay calm and don't turn your back on a buck. Wash hands after touching animals. Drink only pasteurized milk unless your parents decide otherwise.

HANDS-ON PROJECT

A Goat Visit or a Milking Model, and a Dairy Record Page

If you can, visit a goat farm, 4-H member or petting farm and watch milking. If not, make a simple milking model to practice the hand motion. Then plan a dairy goat's daily care and keep a practice milk record.

You will need

- A latex-free glove or a small balloon, a pin (adult use), water and a bowl (for the model)
- Graph paper and colored pencils
- Your nature journal

Steps

1. Visit option: ask the farmer to show you the milk stand, the goats' shelter, the hay and minerals. Watch a milking from start to finish. Write down each step.
2. Model option: fill a glove with water and tie it closed. Have an adult poke one tiny hole in the tip of two fingers. Hang it over a bowl.
3. Practice the milking motion: pinch the top of a finger closed with your thumb and pointer finger, then squeeze downward with your other fingers. Watch the stream. Try both hands, one after the other.
4. Draw a goat barn plan: shelter, hay rack, mineral feeder, water, milk stand and a fenced browse area.
5. Make a daily care chart with times for morning and evening milking.
6. Make a milk record page like a 4-H dairy record: date, morning amount, evening amount, total, feed given, notes. Fill in a week of practice numbers or real numbers from a farm.
7. Add up the week's total milk. How many gallons is that?

Tips

- Remember: 4 quarts make a gallon, and 2 pints make a quart.
- Many 4-H clubs have dairy goat projects. Ask your county extension office about visiting one.

Check your work

- ☐ I can name three dairy goat breeds.
- ☐ I can describe the milking steps in order.
- ☐ I made a care chart and a dated milk record.

NATURE JOURNAL

1. Draw a dairy goat and label the ears, horns or polled head, beard, udder, teats, hooves and tail.
2. Draw the faces of a Nubian and a LaMancha side by side to show the ear difference.
3. Write a short “day in the life” of a goat-keeping child, from morning milking to evening milking.

COMMON MISTAKES

- Keeping only one goat. Goats need a goat friend.
- Pulling down on the teat instead of closing the top and squeezing.
- Leaving milk warm. It must be strained and chilled quickly.

Make it a game • Goat Breed Mystery. Your grown-up reads clues about a dairy goat breed, like upright ears or floppy ears. Name it. Then share what goats eat, their shelter, and why they need company. Act out a milking sequence on a pretend milk stand and tell why pasteurize matters. Score a point per correct fact.

Scripture. “The lambs are for thy clothing, and the goats are the price of the field. And thou shalt have goats’ milk enough for thy food, for the food of thy household,” (Proverbs 27:26-27, KJV)

Long ago a family’s sheep gave them clothing and their goats gave them milk. This unit studies both gifts.

6.3 SHEEP: FROM WOOL TO YARN

OBJECTIVES

- Explain why sheep are sheared once a year and that shearing does not hurt them.
- List the steps from fleece to yarn: shearing, skirting, washing, carding, spinning.
- Card and spin a short piece of yarn by hand.

Warm-up. Feel a wool sweater, a cotton T-shirt and a fleece jacket (made from plastic). Rub each against your cheek. Which is warmest? Which is scratchiest? Which one came from an animal?

WATCH

Wool: From Sheep to Yarn | MD F&H

Maryland Farm & Harvest • 5:18

<https://www.youtube.com/watch?v=bjPWTeFCAjo>

WHEN TO WATCH

After the core ideas. Number each step of the wool's journey on paper as you watch.

BACKUP VIDEO

Wonderful Wool!

SciShow Kids • 4:33

<https://www.youtube.com/watch?v=x0HeCL6nano>

A simpler explanation of why wool keeps sheep (and us) warm.

KEY TERMS

fleece

The whole wool coat sheared from one sheep, usually in one piece.

lanolin

The natural grease in wool that keeps rain off the sheep. It is used in lotions and lip balm.

shearing

Clipping the wool off a sheep, like a haircut.

carding

Brushing wool fibers so they all lie the same way, ready to spin.

spinning

Twisting fibers together into a long, strong thread called yarn.

CORE IDEAS

Wild sheep shed their coats, but most farm sheep have been bred for so many generations to grow wool that it keeps growing year after year. If they were never sheared, they would become hot, heavy, dirty and sick. So every spring, before hot weather, sheep are **sheared**. A skilled shearer can clip a sheep in a few minutes, and it doesn't hurt, just as a haircut doesn't hurt.

The wool comes off in one piece, called a **fleece**, usually weighing about 5 to 10 pounds. Next it is **skirted**: the dirty edges and bits of straw are picked off. Then it is **washed** in hot, soapy water to remove dirt and the sticky **lanolin**.

Clean wool is a tangle. **Carding** brushes the fibers with paddles full of tiny wire teeth until they lie smooth and fluffy. Then comes **spinning**: pulling out a thin bit of fiber and twisting it. The twist locks the tiny scales on the fibers together into strong **yarn**. Two strands are often twisted together (plied) to make it stronger. The yarn can be dyed, then knitted or woven into sweaters, socks, blankets and coats.

Wool is a wonderful fiber. It is warm even when damp, it resists catching fire, and it can soak up a lot of moisture without feeling wet. Sheep also give us meat, called lamb or mutton, and some give milk for cheese.

Shepherds care for their flocks every day: fresh water, good pasture or hay, trimmed hooves, and protection from coyotes and dogs. The Bible often compares God's care for His people to a good shepherd's care for his sheep.

PICTURE STUDY



Woman Spinning, Jean-François Millet, about 1855–1860 · Oil on canvas

Image: [Wikimedia Commons](#), public domain

In Millet's day, farm women spun the family's wool into yarn at home during the long winter evenings. Here a woman sits at her spinning wheel, quietly turning a fluffy mass of wool into thread.

Look closely

- Find the big wheel. What do you think turns it?
- Find the wool she is spinning. Where is the yarn going?
- Find the basket on the floor. What is in it?
- Look at her hands. What is each hand doing?

Talk about it

1. How many steps happened to this wool before it reached her spinning wheel?
2. How long do you think it would take to spin enough yarn for one sweater?
3. Why do you think spinning was done in winter?

Safety first. Raw wool can carry dirt and germs; wear gloves to wash it and wash hands afterward. An adult handles hot water. Hand carders have sharp little teeth; brush gently and keep fingers clear.

HANDS-ON PROJECT

Wash, Card and Spin a Little Wool

You will follow wool on its journey. You will wash a small handful of raw wool (or use clean wool roving from a craft store), card it, and spin your own short piece of yarn on a homemade drop spindle.

You will need

- A handful of raw wool from a farm or fair, or clean wool roving from a craft store
- Dish soap, a dishpan, hot tap water (adult) and gloves
- Two stiff pet brushes or a pair of hand carders
- A homemade drop spindle: a 12-inch wooden dowel or pencil pushed through an old CD with a lump of clay to hold it, and a small cup hook screwed into the top (adult helps)
- A piece of ready-made yarn about 18 inches long, for a leader

Steps

1. If using raw wool, have an adult fill a dishpan with hot water and soap. Gently push the wool under and let it soak 20 minutes. Do not stir hard or it will felt.
2. Lift it out, rinse it in warm water, squeeze gently, and dry it on a towel overnight.
3. Carding: put a little wool on one brush. Brush across it lightly with the other brush, over and over, until the fibers are smooth and fluffy. Roll it into a loose tube.
4. Tie the leader yarn to the spindle under the CD, wrap it up the shaft, and hook it through the cup hook.
5. Overlap the end of the leader with the end of your carded wool.
6. Spin the spindle clockwise like a top and let it hang. Pinch the wool just above the twist, and slowly pull out a thin bit of wool with your other hand. Let the twist run up into it.

7. When the spindle slows or touches the floor, wind your new yarn onto the shaft and start again.
8. Spin at least a yard of yarn. Tape a piece into your journal next to a sample of raw wool and carded wool.

Tips

- Lumpy yarn is normal at first! Every spinner's first yarn is lumpy.
- Many county fairs have a sheep barn and a wool or fiber arts building. Watch the spinners there.

Check your work

- ☐ I can list the steps from sheep to yarn in order.
- ☐ I washed or carded wool and spun at least a yard of yarn.
- ☐ I can explain why sheep must be sheared.

NATURE JOURNAL

1. Make a wool-journey comic strip with six boxes: sheep, shearing, washing, carding, spinning, sweater.
2. Draw a sheep before and after shearing.
3. Look at a wool fiber and a cotton fiber with a magnifying glass. Draw and describe them.

From history. In colonial America, nearly every family spun its own wool and flax. Before the War for Independence, colonists held spinning bees to make their own cloth instead of buying it from England. George Washington's Mount Vernon kept hundreds of sheep for wool.

COMMON MISTAKES

- Stirring wet wool hard in hot water, which makes it shrink and felt into a mat.
- Thinking shearing hurts the sheep.
- Pulling out too much wool at once while spinning, so the yarn breaks.

Make it a game • Fleece to Yarn Order. Write five steps on cards: shear, skirt, wash, card, spin. Shuffle and put them in order within thirty seconds. Then explain why shearing does not hurt sheep and what lanolin does. Pull apart a cotton ball and practice carding with your fingers while retelling every step.

6.4 INSIDE THE BEEHIVE

OBJECTIVES

- Describe the three kinds of honeybees: queen, workers and drones.
- List the jobs a worker bee does as she grows older.
- Explain how bees turn nectar into honey and store it in wax comb.

Warm-up. Look at a piece of honeycomb (or a picture of one) and some hexagon shapes cut from paper. Try fitting circles together on a page, then hexagons. Which shape leaves no gaps? Why might bees build with hexagons?

WATCH

Inside the Bee Hive what honey bees do. See eggs, larvae, Queen Laying Eggs, pollen, Condensation

Frederick Dunn • 7:34

<https://www.youtube.com/watch?v=-Blqi5qcGLE>

WHEN TO WATCH

After the core ideas. Pause each time he points to eggs, larvae, pollen or honey and name it aloud.

KEY TERMS

colony

A whole family of honeybees living together: one queen, thousands of workers and some drones.

queen

The one bee in a colony that lays eggs, up to about 1,500 or more a day in summer.

worker bee

A female bee that does all the work of the hive: cleaning, nursing, building, guarding and foraging.

drone

A male bee. Drones have no stinger and do not gather food.

nectar

A sweet liquid made by flowers. Bees turn it into honey.

CORE IDEAS

A honeybee **colony** is like one big family that works as a team. In summer it may have 30,000 to 60,000 bees, but only one **queen**. She is longer than the others and spends her days laying eggs, one in each wax cell. Thousands of **workers**, all female, do every other job. A few hundred **drones**, the males, have big eyes and no stinger; in fall the workers push them out of the hive.

A worker bee changes jobs as she grows up. In her first days she cleans cells. Next she is a **nurse**, feeding the young larvae. Then she makes wax from glands on her belly and **builds** comb, takes nectar from returning bees, and fans her wings to cool the hive. Later she **guards** the entrance. In her last weeks she becomes a **forager**, flying out to gather nectar, pollen and water. In summer a worker lives only about six weeks; she literally wears her wings out working.

Bees build their comb in perfect six-sided cells called hexagons. Hexagons fit together with no gaps and use the least wax to hold the most honey. Some cells hold eggs and growing young, called brood; some hold yellow and orange pollen; and some hold honey.

To make honey, foragers sip **nectar** and carry it home in a honey stomach. Inside, house bees pass it from bee to bee, adding enzymes, and spread it in cells. Then they fan their wings until most of the water evaporates and the nectar thickens into honey. They seal each full cell with a wax cap. A colony needs about 60 or more pounds of stored honey to survive a northern winter. Beekeepers take only the extra.

A forager who finds good flowers comes home and does a “waggle dance” on the comb. The direction and length of her dance tell her sisters which way and how far to fly. God gave these tiny creatures wonderful order.

PICTURE STUDY



The Beekeepers, Pieter Bruegel the Elder, about 1568 · Pen and ink · Kupferstichkabinett, Berlin

Image: [Wikimedia Commons](#), public domain

Pieter Bruegel drew this scene of beekeepers almost 450 years ago. In his day, bees lived in dome-shaped hives woven from straw, called skeps. The beekeepers wear thick clothing and woven masks to protect themselves from stings.

Look closely

- Find the straw hives, called skeps. How many can you count?
- Look at the beekeepers' faces. What are they wearing to protect themselves?
- Find the beekeeper carrying a skep. Where might he be taking it?
- Find the boy up in the tree. What do you think he is doing?

Talk about it

1. Why do you think the beekeepers cover their faces?
2. How is a straw skep different from the wooden box hives beekeepers use today?
3. Why might beekeepers move hives from one place to another?

Safety first. Never open or go near a hive without an adult beekeeper, and always wear a veil and protective gear. Anyone allergic to bee stings must stay away from hives and carry the medicine their doctor prescribed. If a bee lands on you, stay calm and still; swatting makes bees defensive.

HANDS-ON PROJECT

A Hexagon Comb Model and a Hive Visit

You will build a model of honeycomb from paper hexagons, filling cells with eggs, larvae, pollen and capped honey. If possible, you will visit a beekeeper or an observation hive at a nature center, museum or fair.

You will need

- A hexagon template about 1½ inches across, cardstock and scissors
- Yellow, orange, white and brown crayons or paper
- Glue and a large sheet of paper
- A jar of local honey and a magnifying glass
- Your nature journal

Steps

1. Cut out 30 or more paper hexagons and glue them edge to edge on the big sheet to make a comb.
2. In the middle, draw tiny white eggs standing in some cells and curled white larvae in others. This is the brood nest.
3. Around the brood, color cells orange and yellow for pollen.
4. Along the top edge, color cells golden for honey, and cover some with a white wax cap.
5. Label the queen, a nurse bee, a builder bee and a forager on your model.
6. Taste a drop of local honey. Look at it with a magnifying glass. Write what flowers it might have come from.
7. If you can, visit a beekeeper (with protective gear provided) or an observation hive. Find the queen, eggs, pollen and capped honey.
8. Write a short report: the jobs a worker bee does in her life, in order.

Tips

- Many state beekeepers' associations and 4-H programs have junior beekeeping classes; check your county extension office.

- Honey from different flowers has different colors and flavors. Try two kinds side by side.

Check your work

- ☐ I can name the queen, workers and drones and what each does.
- ☐ My comb model shows eggs, larvae, pollen and capped honey.
- ☐ I can explain how nectar becomes honey.

NATURE JOURNAL

1. Draw a worker bee 10 times bigger than life. Label the head, thorax, abdomen, six legs, four wings, antennae and pollen baskets.
2. Watch bees on flowers for 10 minutes from a safe distance. Count how many flowers one bee visits.
3. Draw the three kinds of bees side by side to show their different sizes and shapes.

From history. In 1851 Lorenzo Langstroth, a minister and teacher in Pennsylvania, discovered “bee space”: bees leave a gap of about three-eighths of an inch between combs. He designed a wooden hive with removable frames spaced exactly that far apart, so beekeepers could lift out combs without breaking them. Most beekeepers still use his design today.

COMMON MISTAKES

- Thinking the queen is the boss who gives orders. She lays eggs; the workers decide most things together.
- Thinking drones are workers. Only female bees work and sting.
- Swatting at bees, which makes them more likely to sting.

Make it a game • Worker Bee Career Ladder. A worker bee changes jobs as she grows older. Act out her career in order without speaking: cleaning cells, feeding young, building comb, guarding the door, foraging for nectar. Your grown-up guesses each job. Then name the queen, workers and drones and what each does. Draw one hexagon.

Scripture. “More to be desired are they than gold, yea, than much fine gold: sweeter also than honey and the honeycomb.” (Psalm 19:10, KJV)

The psalmist says God’s words are sweeter than honey straight from the comb, the sweetest thing he knew.

UNIT 6

FARM ANIMALS AND BEES

Early spring is a busy time on a farm. Hens start laying more eggs as the days grow longer, dairy goats have their kids, sheep are sheared, and honeybees build up their colonies for the first flowers. In this unit you will learn how a family keeps a small flock of hens, how dairy goats give milk, how wool travels from a sheep's back to a ball of yarn, and how thousands of bees work together inside a hive.

You do not need to own any animals. Visit a farm, a 4-H fair, a farmers' market or a beekeeper; read library books; and make careful plans and models. You will also try your first **judging class**, the way young people do at 4-H and county fairs: ranking four animals from best to last and giving reasons. Our pictures come from the Dutch poultry painter Melchior d'Hondecoeter, Adriaen van de Velde, Jean-François Millet and Pieter Bruegel.

PREREQUISITES

- Understands day length and the seasons (Unit 1)
- Has learned gentle handling and hand-washing with pets (Unit 4)
- Can keep a dated record table in the nature journal

MASTERY CHECKLIST

- ☐ I can list the daily and weekly chores for a backyard flock and keep an egg record.
- ☐ I can rank four hens and give reasons, like a 4-H judge.
- ☐ I can explain how a dairy goat is milked and how milk is kept clean and cold.
- ☐ I can describe the steps from shearing a sheep to spinning yarn.
- ☐ I can name the three kinds of honeybees and the jobs worker bees do.

LESSONS IN THIS UNIT

6.1 Keeping a Backyard Flock

2 sessions of 45 minutes

6.2 Dairy Goats

2 sessions of 45 minutes

6.3 Sheep: From Wool to Yarn

2 sessions of 45 minutes

UNIT 6 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. (5 pts)

Why do hens lay more eggs in spring and summer?

2. (5 pts)

Name four things a chicken coop needs.

3. (5 pts)

Name three signs of a healthy hen that a judge looks for.

4. (5 pts)

In a judging class, what are “reasons”?

5. (5 pts)

How often is a dairy goat milked, and what happens to the milk right after?

6. (5 pts)

Why should you never keep just one goat?

7. (5 pts)

Put in order: spinning, shearing, carding, washing.

8. (5 pts)

Why do farm sheep need shearing every year?

9. (5 pts)

Name the three kinds of honeybees and one fact about each.

10. (5 pts)

How do bees turn nectar into honey?

ANSWER KEY

1. Days are longer. Hens lay best with about 14 to 16 hours of light.
2. Any four: enough floor space, roosts, nest boxes, a fenced run, predator-proof hardware cloth, a door locked at night, feed and water.
3. Bright eyes, a bright red comb, clean shiny feathers, smooth legs, alert and active.
4. Sentences that explain why you placed one animal over another, comparing them, such as “I placed B over A because B has a redder comb.”
5. Twice a day, about 12 hours apart. The milk is strained and chilled quickly (and often pasteurized).
6. Goats are herd animals and are lonely and unhappy alone.
7. Shearing, washing, carding, spinning.
8. Their wool keeps growing, and without shearing they would become hot, heavy, dirty and sick.
9. Queen: lays all the eggs. Workers: females that do all the work. Drones: males with no stinger that don't gather food.
10. They add enzymes, spread it in cells, and fan their wings to evaporate most of the water, then cap the cells with wax.

PORTFOLIO PIECE: A FARM ANIMAL CARE NOTEBOOK WITH A JUDGING CARD

Choose one farm animal from this unit (hens, dairy goats, sheep or honeybees) and make a care notebook like a 4-H project record book. Include a labeled drawing, a housing plan, a daily and weekly chore chart, a two-week record (eggs, milk, observations or bee counts), and a page on what the animal gives us. Add your hen judging card with your placing and three reasons.

LOOK FOR	WHAT IT MEANS
Care plan	Housing, food, water and chores are correct and complete for the chosen animal.
Records	A dated two-week record is kept faithfully, like a 4-H record book.
Judging	Four hens are placed 1-4 with three clear comparing reasons.
Presentation	Drawings are labeled and the notebook is neat, complete and shows careful observation.

UNIT 7

PLANTING: POTS, BEDS AND FIELDS

Spring is planting time! In this unit you move from the windowsill to the garden. You will choose the right containers and potting mix, rescue a plant whose roots have outgrown its pot, map the sun and shade in your yard to plan a garden, and plant an old American field-crop team: corn, beans and squash, the “three sisters.”

Wherever you live, you can grow something: a pot of strawberries on a balcony, an herb on a windowsill, a raised bed in a yard, or a corner of a community garden. You will also learn how to prepare a potted plant for a fair exhibit, and you will use your skills to serve a neighbor. Our pictures are by Vincent van Gogh, Gustave Caillebotte, who loved his family’s kitchen garden, and a botanist’s careful drawing of a corn plant.

PREREQUISITES

- Knows what plants need: light, water, air, warmth and nutrients (Unit 5)
- Knows soil texture and drainage (Unit 3)
- Knows your family’s average last spring frost date

MASTERY CHECKLIST

- ☐ I can choose a pot with drainage holes and the right potting mix.
- ☐ I can recognize a root-bound plant and repot it.
- ☐ I can make a sun map and choose crops for sunny and shady spots.
- ☐ I can plant corn, beans and squash together and explain how each helps the others.
- ☐ I can prepare a healthy potted plant for a fair exhibit.

LESSONS IN THIS UNIT

7.1 Containers and Potting Mix

2 sessions of 45 minutes

7.2 Repotting a Root-Bound Plant

2 sessions of 45 minutes

7.3 Planning a Garden with a Sun Map

2 sessions of 45 minutes

7.4 Planting a Field Crop: Corn, Beans and Squash

2 sessions of 45 minutes

UNIT 7 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. 5 pts

Why must every container have drainage holes?

2. 5 pts

Why use potting mix instead of garden soil in pots?

3. 5 pts

Name three things a fair judge looks for in a potted plant exhibit.

4. 5 pts

Give three signs that a plant is root-bound.

5. 5 pts

How much bigger should a new pot be when repotting, and why not much bigger?

6. 5 pts

How many hours of direct sun does “full sun” mean? Name two crops that need it.

7. 5 pts

Why should tall crops go on the north side of a garden?

8. 5 pts

When should warm-season crops like beans and corn be planted?

9. 5 pts

How does each of the three sisters help the others?

10. 5 pts

Why do many farmers plant soybeans the year after corn?

ANSWER KEY

1. So extra water can escape. Without holes, water collects at the bottom and the roots drown and rot.
2. Garden soil packs down hard and drains poorly in a pot. Potting mix stays light and fluffy, holding water and air.
3. A healthy, well-shaped plant with no dead leaves or pests; a clean pot of the right size; a neat, correct label.
4. Roots coming out of the drainage holes, water running straight through, drying out quickly, slow growth, roots circling the root ball.
5. Only 1–2 inches wider. A much bigger pot holds extra wet mix the roots can't use, which can cause rot.
6. At least 6 to 8 hours. Examples: tomatoes, peppers, squash, beans, corn.
7. So they don't shade the shorter plants, since the sun shines from the south in the Northern Hemisphere.
8. After the last spring frost, when the soil is warm.
9. Corn is a pole for beans; beans add nitrogen to the soil; squash shades out weeds, keeps soil moist and discourages raccoons.
10. Soybeans, like other beans, add nitrogen to the soil, which feeds the next corn crop.

PORTFOLIO PIECE: MY GARDEN PLAN AND PLANTING RECORD

Present your garden for the season: your sun map, your scaled garden plan with crops and planting calendar, and a planting record for your container and three-sisters mounds (dates, what you did, costs, measurements and photos or drawings). Bring your best container plant groomed and labeled as a fair exhibit, and add a page about the plant you repotted for someone else.

LOOK FOR	WHAT IT MEANS
Sun map and plan	Sun map is based on real observations; each crop is placed where its sun needs are met; beds and paths are drawn to scale.
Planting record	Dated records of planting, watering, growth and costs are kept for at least four weeks.
Exhibit	The potted plant is healthy, groomed, in a clean pot and neatly labeled.
Service	A plant was repotted or cared for to help someone, with a note about what was done.

7.1 CONTAINERS AND POTTING MIX

OBJECTIVES

- Choose a container of the right size with drainage holes.
- Explain why potting mix, not garden soil, belongs in pots.
- Plant a container and prepare a potted plant the way a fair judge likes to see it.

Warm-up. Fill one cup with garden soil and one with potting mix. Press each down with your thumb, then pour a little water into each. Which one packs hard? Which one drains? Lift both: which is lighter?

WATCH

STOP Putting Gravel At The Bottom Of Your Pots!

Epic Gardening • 4:35

<https://www.youtube.com/watch?v=1aHPIZX-6EA>

WHEN TO WATCH

After the core ideas. Watch the sponge demonstration closely and explain it in your own words.

BACKUP VIDEO

Welcome To The Garden: How to Choose the Right Container

Bonnie Plants • 2:06

<https://www.youtube.com/watch?v=Dxcsw1SKtq8>

A short guide to pot sizes and materials, before you choose your container.

KEY TERMS

container

Any pot, box, tub or bag used to grow a plant above the ground.

drainage hole

A hole in the bottom of a container that lets extra water escape.

potting mix

A light, fluffy growing mix, usually of peat moss or coconut coir, bark, perlite and compost, made for containers.

perlite

Tiny white puffed bits of volcanic rock added to potting mix to make air spaces.

exhibit

Something you show at a fair to be judged, like a potted plant or a plate of vegetables.

CORE IDEAS

A plant in a pot lives in a very small world. Everything it needs, water, air and food, must fit in that pot. So the container and what you fill it with matter a great deal.

Every pot must have **drainage holes**. Without them, water collects at the bottom and roots drown and rot. Putting gravel in the bottom does *not* help; water stays in the mix above the gravel, so the soggy zone just moves closer to the roots. Simply use good mix and a pot with holes.

Fill pots with **potting mix**, not garden soil. Garden soil packs down into a hard brick in a pot and drains poorly. Potting mix is made of light materials like peat moss or coconut coir, bark, compost and white **perlite**, so it stays fluffy, holds water and lets air reach the roots.

Pick the right size. Herbs and lettuce grow in 6- to 8-inch pots; a tomato needs a pot of about 5 gallons or more; a strawberry plant fits in a 6-inch pot or a pocket of a strawberry jar. Clay (terra cotta) pots breathe and dry out fast; plastic pots hold water longer; fabric pots let roots breathe. Small pots dry out quickly in summer and may need water every day.

Water until water runs out of the holes, then wait until the top inch feels dry before watering again. Because water washes nutrients out of pots, container plants need gentle feeding with compost or plant food (measured by an adult) every few weeks.

Many county fairs have a youth class for potted plants. Judges look for a **healthy, well-shaped plant** with no dead or yellow leaves and no pests, a **clean pot** of a size that fits the plant, and a **neat label** with the plant's name and the exhibitor's name. Check your county fair book for the rules, such as how long you must have grown the plant.

PICTURE STUDY



Geranium in a Flowerpot, Vincent van Gogh, 1886 · Oil on canvas

Image: [Wikimedia Commons](#), public domain

Van Gogh painted this geranium in a clay pot while he was living in Paris and practicing bright colors. Geraniums are one of the easiest and most popular container plants, then and now.

Look closely

- Find the clay pot. Is it big or small compared with the plant?
- Look at the leaves. Are they healthy and green, or are some dry?
- Count the flower clusters. What colors are they?
- Look at the shape of the whole plant. Is it bushy and even, or lopsided?

Talk about it

1. If this geranium were entered at a fair, what would a judge like about it? What might she want improved?
2. Do you think this pot has a drainage hole? Why does it matter?
3. Where in your home would a geranium get enough sun?

Safety first. Wear a dust mask or dampen bagged potting mix before scooping, and don't breathe the dust. Wash hands after handling potting mix or compost.

HANDS-ON PROJECT

Plant a Container (Herbs or Strawberries) and Prepare It for Exhibit

You will plant a container of herbs, flowers or strawberries. You will care for it for several weeks, keep a record, and then groom and label it as if you were entering it in a county fair.

You will need

- A pot 8–12 inches across with drainage holes (or a strawberry jar), and a saucer
- Fresh potting mix and a little compost
- Plants: an herb (basil, parsley, chives), marigolds, or 2–3 strawberry plants
- A trowel, a watering can and garden gloves
- A plant label, clean scissors and a damp cloth

Steps

1. Check the pot for drainage holes. Wash it if it was used before.
2. Dampen the potting mix in a tub until it feels like a wrung-out sponge. Mix in a scoop of compost.
3. Fill the pot to about 2 inches below the rim.
4. Gently tip each plant out of its nursery pot. Set it in so the top of its root ball is level with the mix. Strawberry plants: keep the crown, where the leaves join the roots, just at the surface, not buried.
5. Fill around the plants, press gently, and water slowly until water runs out the bottom.
6. Put the pot where it gets at least 6 hours of sun. Start a care record: date, water, feeding, height, flowers or berries, and costs of supplies.
7. After 3–4 weeks, prepare it for “exhibit”: snip off dead leaves and spent flowers, turn the pot so the plant grows evenly, wipe the pot clean, and make a neat label with the plant name, variety and your name.
8. Ask a family member to judge it like a fair judge using the four checks: healthy plant, good shape, clean pot, neat label.

Tips

- Strawberries are a fruit you can grow in a pot. June-bearing kinds give one big crop; everbearing kinds give berries off and on all summer.
- Turn your pot a quarter turn every few days so the plant grows evenly instead of leaning toward the window.

Check your work

- ☐ My container has drainage holes and is filled with potting mix.
- ☐ I kept a care record with dates and costs.
- ☐ I groomed and labeled my plant the way a fair judge likes.

NATURE JOURNAL

1. Draw a cutaway of your pot showing the mix, the roots, the drainage hole and arrows for water draining out.
2. Draw your plant on planting day and again four weeks later, with measurements.
3. Make a page comparing clay, plastic and fabric pots: one good thing and one problem for each.

COMMON MISTAKES

- Using a pot with no drainage hole, or adding gravel at the bottom.
- Filling pots with heavy garden soil.
- Watering a tiny bit every day instead of soaking and then waiting until the top inch is dry.

Make it a game • Pot Picker Challenge. Line up three containers on the table. Your grown-up names a plant and you choose the right pot, explaining size, drainage holes and why potting mix beats garden soil. Name perlite's job. Score one point per correct choice and try to exhibit your best plant with a clean pot, name card and tidy soil.

7.2 REPOTTING A ROOT-BOUND PLANT

OBJECTIVES

- Recognize the signs that a plant is root-bound.
- Repot a plant into a pot one size larger, loosening circling roots.
- Care for a plant after repotting, and serve a neighbor by repotting a plant for them.

Warm-up. Try on a pair of shoes or a coat you wore two or three years ago. How does it fit? What would happen to your feet if you had to wear shoes that small every day? Plants in pots can outgrow their homes too.

WATCH

How to Re-Pot a Root-Bound Plant

[ehowhome](#) • 4:12

<https://www.youtube.com/watch?v=hRKumwd-49Q>

WHEN TO WATCH

In Session 2, right before you repot. Pause after the roots are loosened and look at your own plant's roots.

BACKUP VIDEO

Root bound plants - 2 ways to loosen the roots plus what NEVER to do!

[Backyard Farmer Pat](#) • 7:39

<https://www.youtube.com/watch?v=i811VMaDrls>

A closer look at teasing apart circling roots.

KEY TERMS

root-bound

When roots have filled a pot so completely that they circle around the inside and have no room to grow.

root ball

The roots and soil that hold together when a plant is lifted out of its pot.

repot

To move a plant into a larger pot with fresh mix.

transplant shock

Wilting or slowed growth after a plant is moved, while its roots recover.

CORE IDEAS

Roots keep growing as long as the plant does. In a pot, they hit the wall, turn, and start circling round and round. When the pot is packed with roots and there is almost no soil left, the plant is **root-bound**.

Look for clues: roots poking out of the drainage holes or creeping over the top; water running straight through the pot; the plant drying out a day or two after watering; slow growth or yellowing even with good care; a plant so top-heavy it tips over. To be sure, tip the plant out and look. A root-bound **root ball** is a solid mat of roots.

To **repot**, choose a pot only 1 to 2 inches wider than the old one. A pot that is far too big holds extra wet mix that roots can't reach, and the plant may rot. Gently tease the circling roots loose with your fingers so they will grow outward into the new mix. Very tight roots can be scored with a few shallow cuts by an adult.

Set the plant at the same depth it grew before, fill around it with fresh potting mix, and water well. Keep it out of hot, direct sun for a few days while it gets over **transplant shock**. Spring, when plants are starting to grow, is the best time to repot.

Repotting is also a kind gift. Many older neighbors and church members have houseplants they can no longer lift or repot. Offering your new skill is a simple way to serve.

PICTURE STUDY



The Gardeners, Gustave Caillebotte, 1875–1877 • Oil on canvas • Private collection

Image: [Wikimedia Commons](#), public domain

Gustave Caillebotte's family had a large kitchen garden at their country home at Yerres, near Paris. Here two gardeners water young plants that have just been set out. Notice the glass bell jars, called *cloches*, protecting some tender seedlings.

Look closely

- Find the two gardeners. How many watering cans does each one carry?
- Find the glass *cloches*. What are they for?
- Look at the young plants in rows. Are they newly planted or fully grown?
- Look at the soil. Is it wet or dry where they are watering?

Talk about it

1. Why do newly moved plants need extra watering?
2. Why might a gardener protect some seedlings under glass?
3. Why do you think the gardeners are barefoot?

Safety first. An adult does any root cutting with a knife or scissors. Lift heavy pots with an adult. Wash hands after handling potting mix.

HANDS-ON PROJECT

Rescue a Root-Bound Plant (and Repot One for a Neighbor)

You will repot a crowded houseplant or garden-center plant, then use your new skill to serve someone else by repotting a plant for a neighbor, grandparent or church friend.

You will need

- A root-bound plant (an old houseplant, or a bargain plant from a garden center)
- A new pot 1–2 inches wider, with drainage holes
- Fresh potting mix, a trowel, newspaper to work on, and gloves
- A watering can and a ruler

Steps

1. Spread newspaper. Water the plant an hour before so the root ball slides out more easily.
2. Turn the pot on its side, support the stem between your fingers, and tap or squeeze the pot until the plant slides out.
3. Look at the roots. Draw them and measure the root ball. Are they circling?
4. Gently pull and untangle the outer roots so they point outward. Ask an adult to make a few shallow cuts if they are very tight.
5. Put a little mix in the new pot so the top of the root ball will sit about 1 inch below the rim.
6. Set the plant in, fill around the sides with mix, and press gently.
7. Water slowly until water runs out the bottom. Keep the plant out of hot sun for three days.
8. Record the date and watch for new growth for three weeks.
9. Service: offer to repot a plant for an older neighbor or a church or nursing-home friend. Bring your own mix and pot, and leave a card with care tips.

Tips

- If roots are rotten (brown, mushy and smelly), cut those off and use a pot the same size, not bigger.
- Many 4-H clubs and Junior Master Gardener groups do community service planting projects. Your repotting service is a great start.

Check your work

- ☐ I can list three signs a plant is root-bound.
- ☐ I repotted a plant into a pot one size larger and loosened its roots.
- ☐ I served someone by repotting or caring for their plant.

NATURE JOURNAL

1. Draw the root ball before and after you loosened it.
2. Draw the old pot and new pot side by side with their sizes.
3. Write a thank-you note or a care card for the person whose plant you repotted.

COMMON MISTAKES

- Moving into a pot that is much too big.
- Burying the stem deeper than it grew before (except for tomatoes, which like it).
- Putting a freshly repotted plant in hot sun right away.

Make it a game • Root-Bound Rescue. Tangle a few strands of yarn tightly around a ball of clay or paper. Your grown-up describes signs of a root-bound plant, and you say the diagnosis. Then loosen the circling roots with your fingers, step by step, and place the ball in a larger cup. Explain transplant shock.

7.3 PLANNING A GARDEN WITH A SUN MAP

OBJECTIVES

- Make a sun map of a yard or balcony by recording sun and shade through the day.
- Match crops to full sun, part sun and shade.
- Draw a garden plan to scale with beds, paths and planting dates.

Warm-up. Remember your noon shadow log from Unit 1. Look at it now. Is your spring shadow longer or shorter than in December? What does that tell you about how high the sun is getting?

WATCH

Sun Mapping Your Garden the Easy Way Determine Sun, Shade and Part Shade

Garden Fundamentals • 6:16

https://www.youtube.com/watch?v=AAIhO_olcDg

WHEN TO WATCH

After the core ideas, before you start your own sun map.

BACKUP VIDEO

Planning a Vegetable Garden for Beginners: The 5 Golden Rules

GrowVeg • 5:05

<https://www.youtube.com/watch?v=9R-utqpmwmE>

In Session 2, before you draw your garden plan.

KEY TERMS

full sun

At least 6 to 8 hours of direct sunlight a day.

sun map

A drawing of a garden space that shows where and how long the sun shines during the day.

part sun (part shade)

About 3 to 6 hours of direct sun a day.

frost date

The average date of the last frost in spring or the first frost in fall where you live.

raised bed

A garden bed built up above the ground, often inside a wooden frame.

CORE IDEAS

Before you plant, you need to know where the sun shines. Most vegetables that make fruit, like tomatoes, peppers, squash, beans and corn, need **full sun**: at least 6 to 8 hours of direct sunlight. Leafy crops and herbs like lettuce, spinach, kale, parsley and mint can grow in **part sun**, 3 to 6 hours. Almost no vegetable grows well in deep shade.

A **sun map** shows you. On a sunny day, look at your space every two hours, from about 8 in the morning to 6 in the evening, and mark which parts are in sun and which are shaded. Count the sunny hours for each spot. Remember that trees leafing out in spring and the sun climbing higher in summer will change the map a little.

Plan the beds. Put tall crops like corn, pole beans and sunflowers on the north side so they don't shade shorter plants. Make beds no wider than 4 feet so you can reach the middle without stepping on the soil. Leave paths. Put the garden close to a water faucet; a garden far from water is a garden that goes thirsty.

Plan the timing with your **frost dates**. Cool-season crops like peas, lettuce, spinach and radishes can be planted a few weeks before the last spring frost. Warm-season crops like beans, corn, squash and tomatoes must wait until after the last frost, when the soil is warm.

God placed the first man in a garden “to dress it and to keep it.” Planning carefully before you dig is part of being a good keeper.

PICTURE STUDY



The Kitchen Garden, Yerres, Gustave Caillebotte, 1877 · Oil on canvas · Private collection

Image: [Wikimedia Commons](#), public domain

This is another view of Caillebotte's family kitchen garden at Yerres. Look at the long shadows! He painted the garden when the sun was low, so you can see exactly where the walls and hedges block the light.

Look closely

- Find the long blue shadows. Which way is the sun shining from?
- Find the parts of the garden in bright sun and the parts in shade.
- Follow the path down the middle. How does it help the gardener?
- Find the high wall at the back. What might it protect the garden from?

Talk about it

1. If you were planting tomatoes here, which beds would you choose? Why?
2. Would the shadows look the same at noon? How would they change?
3. Where might you plant lettuce, which can take some shade?

HANDS-ON PROJECT

My Sun Map and Garden Plan

You will map the sun in your yard, balcony or a community garden plot, then draw a garden plan to scale with crops chosen for each spot and a planting calendar.

You will need

- Graph paper, a pencil, a ruler and colored pencils (yellow, orange, gray)
- A measuring tape and a compass (or a phone compass with an adult)
- A timer or clock
- Seed catalogs or seed packets

Steps

1. Measure your garden space and draw its outline on graph paper (1 square = 1 foot). Mark north with an arrow. Add the house, trees, fences and the water faucet.
2. On a sunny day, go out at 8, 10, 12, 2, 4 and 6 o'clock. Each time, shade in gray the parts that are in shadow. Use a fresh copy of the outline each time, or tracing paper.
3. Stack your six maps. Count the sunny hours for each part. Color 6+ hours yellow (full sun), 3–6 hours orange (part sun), and less than 3 gray (shade).
4. Choose crops. Write each crop's sun needs from its seed packet. Place sun-lovers in yellow areas and leafy crops in orange.
5. Draw beds no wider than 4 feet, with paths. Put tall crops on the north side.
6. Use the spacing on the seed packets to fill in each bed.
7. Make a planting calendar: list each crop and the date you will plant it, counting from your last frost date.
8. Optional: add a small fruit spot for strawberries or a blueberry bush in full sun.

Tips

- No yard? Map a balcony, porch or a single sunny windowsill and plan containers.

- Blueberries need acid soil, so they usually grow best in a big pot or a specially prepared bed; ask a local nursery or your county extension office.

Check your work

- ☐ My sun map shows full sun, part sun and shade.
- ☐ My plan places each crop where it will get the sun it needs.
- ☐ My planting calendar is based on my frost date.

NATURE JOURNAL

1. Draw your finished sun map in color with a key.
2. Draw the shadow of a tree or fence at 9 a.m., noon and 3 p.m. on the same day.
3. Write a list of five crops for full sun and five for part sun.

COMMON MISTAKES

- Guessing the sun instead of watching it all day.
- Putting tall corn or sunflowers on the south side, where they shade everything else.
- Planting warm-season crops before the last frost.

Make it a game • Sun Map Prediction. Walk the house or yard at three times of day and draw where the sun and shade fall. Before you check, predict each spot. Then match crops to full sun, part sun and shade. Score a point for every correct match and beat your own score by planning three beds.

Scripture. “And the LORD God took the man, and put him into the garden of Eden to dress it and to keep it.” (Genesis 2:15, KJV)

The first job God gave people was gardening. Planning, planting and tending are part of that good work.

7.4 PLANTING A FIELD CROP: CORN, BEANS AND SQUASH

OBJECTIVES

- Explain how corn, beans and squash help one another when planted together.
- Plant a small three-sisters mound or bed at the right time and spacing.
- Compare a family garden planting with how farmers plant corn and beans in big fields.

Warm-up. Look at a dry corn kernel, a dry bean and a squash seed. Which plant family is each from (remember Unit 1)? Guess which one will sprout first if planted together.

WATCH

Planting Corn, Squash and Beans Using The Three Sisters Method

GrowOrganic Peaceful Valley · 4:13

<https://www.youtube.com/watch?v=kRLANoPbs1o>

WHEN TO WATCH

In Session 2, right before planting. Note the order in which the seeds go in.

BACKUP VIDEO

3 Sisters Garden

UC Master Gardeners of Santa Clara County · 4:00

<https://www.youtube.com/watch?v=HrGgCs7EqOY>

A master gardener shows a three-sisters planting growing in a demonstration garden.

KEY TERMS

companion planting

Growing plants together that help each other.

three sisters

The old Native American practice of planting corn, beans and squash together.

field crop

A crop grown in large fields, such as corn, wheat or soybeans.

pollen

Fine powder from the male flower parts. Wind carries corn pollen from the tassels to the silks.

CORE IDEAS

Long before Europeans came to America, the Haudenosaunee (Iroquois) and many other Native American farmers planted corn, beans and squash together in mounds. They called them the **three sisters**, because the three plants grow best together, each helping the others.

The **corn** grows tall and straight and makes a living pole. The **beans** climb the corn stalks toward the sun, and the helpful bacteria in their root nodules (remember Unit 3) add nitrogen to the soil, which hungry corn needs. The **squash** spreads its big, prickly leaves over the ground, shading out weeds, keeping the soil moist like a living mulch, and discouraging raccoons from walking through.

Plant after your last frost, when the soil is warm, about 60 °F. Make mounds about a foot across and 4 feet apart. Plant 4 to 6 corn seeds in each mound. When the corn is about 4 to 6 inches tall, plant pole beans around each stalk. A week later, plant squash seeds around the edge. Corn is pollinated by wind: **pollen** drifts from the tassels at the top to the silks on each ear. Planting corn in blocks or groups, not one long row, helps every ear fill out.

On today's farms, corn and soybeans (a kind of bean) are the biggest field crops in America. Farmers plant them in huge fields with planting machines that drop seeds at exactly the right depth and spacing. Many farmers grow corn one year and soybeans the next, because the soybeans leave nitrogen in the soil for the next corn crop: the same idea as the three sisters, on a much bigger scale.

Whether you plant one mound or a thousand acres, the same God sends the rain and gives the increase. A farmer's work is to prepare, plant and tend faithfully.

PICTURE STUDY



Zea mays (Corn), Franz Eugen Köhler (publisher), 1887 · Chromolithograph, from *Köhler's Medizinal-Pflanzen* · Köhler's Medizinal-Pflanzen, Germany

Image: [Wikimedia Commons](#), public domain

This plate comes from a German book of useful plants printed in the 1880s. Botanical artists drew every part of a plant, from root to seed, so readers could learn to identify it. Look closely: this one shows the whole life of a corn plant on one page.

Look closely

- Find the tassel at the top. This is where the pollen is made.
- Find the young ear with its silks. Where do the silks go?
- Find the ripe golden ear. How many rows of kernels can you count?
- Find the roots at the bottom of the stalk. Some corn roots grow out of the stalk above the ground. Can you see them?

Talk about it

1. How does the pollen get from the tassel to the silks?
2. Why would bean vines grow well on a stalk like this?
3. Why do you think a scientist would draw the plant in pieces instead of in a field?

HANDS-ON PROJECT

Plant a Three-Sisters Mound

You will plant a small three-sisters garden, either a few mounds in the yard or one big container, and keep a growth record through the summer.

You will need

- Sweet corn seeds, pole bean seeds and winter squash or pumpkin seeds
- A sunny spot about 8 feet by 8 feet, or a large container at least 18 inches across and deep
- Compost, a trowel, a ruler, and garden stakes and labels
- A watering can or hose

Steps

1. After your last frost, when the soil feels warm, rake the spot free of weeds and mix in compost.
2. Make 2–4 flat-topped mounds about 12 inches wide and 4 inches high, about 4 feet apart.
3. Plant 4–6 corn seeds about 1 inch deep in a circle on top of each mound, about 6 inches apart. Water well.
4. When the corn is 4–6 inches tall, plant 4 pole bean seeds around each mound, about 3 inches from the corn.
5. About one week later, plant 2–3 squash seeds at the edge of each mound or between mounds.
6. Water deeply once or twice a week when it doesn't rain. Gently guide the bean vines to the corn if they wander.
7. Every week, measure the tallest corn, count bean vines climbing, and note squash leaves and flowers. Record your work and any costs.
8. Container option: plant 3 corn seeds in the middle, 3 beans around them later, and one bush squash at the edge.

Tips

- Plant blocks of several mounds so corn pollen can blow from plant to plant.

- Choose a pole bean variety and a vining squash for the real three sisters; bush types work in containers.

Check your work

- ☐ I planted corn, beans and squash in the right order and spacing.
- ☐ I can explain how each sister helps the others.
- ☐ I kept a weekly growth record.

NATURE JOURNAL

1. Draw a three-sisters mound from the side with corn, beans and squash, and label how each helps.
2. Draw a corn tassel and a corn ear with silks when they appear.
3. Make a line graph of your corn's height through the summer.

From history. In the spring of 1621, a Patuxet man named Tisquantum, often called Squanto, showed the Pilgrims at Plymouth how to plant corn in hills and bury small fish in each hill to feed the soil. That fall's harvest helped the colony survive, and the Pilgrims gave thanks to God.

COMMON MISTAKES

- Planting beans and squash at the same time as the corn, so they smother the young corn.
- Planting corn in one long single row, which gives poor pollination.
- Planting before the soil is warm.

Make it a game • Three Sisters Teams. Three players stand in a mound: one is corn standing tall, one is beans climbing up the corn, and one is squash spreading low. Each explains how it helps the others. Then switch roles. Name the planting steps in order and the right spacing. Rate each helper from one to three stars.

UNIT 7

PLANTING: POTS, BEDS AND FIELDS

Spring is planting time! In this unit you move from the windowsill to the garden. You will choose the right containers and potting mix, rescue a plant whose roots have outgrown its pot, map the sun and shade in your yard to plan a garden, and plant an old American field-crop team: corn, beans and squash, the “three sisters.”

Wherever you live, you can grow something: a pot of strawberries on a balcony, an herb on a windowsill, a raised bed in a yard, or a corner of a community garden. You will also learn how to prepare a potted plant for a fair exhibit, and you will use your skills to serve a neighbor. Our pictures are by Vincent van Gogh, Gustave Caillebotte, who loved his family’s kitchen garden, and a botanist’s careful drawing of a corn plant.

PREREQUISITES

- Knows what plants need: light, water, air, warmth and nutrients (Unit 5)
- Knows soil texture and drainage (Unit 3)
- Knows your family’s average last spring frost date

MASTERY CHECKLIST

- ☐ I can choose a pot with drainage holes and the right potting mix.
- ☐ I can recognize a root-bound plant and repot it.
- ☐ I can make a sun map and choose crops for sunny and shady spots.
- ☐ I can plant corn, beans and squash together and explain how each helps the others.
- ☐ I can prepare a healthy potted plant for a fair exhibit.

LESSONS IN THIS UNIT

7.1 Containers and Potting Mix

2 sessions of 45 minutes

7.2 Repotting a Root-Bound Plant

2 sessions of 45 minutes

7.3 Planning a Garden with a Sun Map

2 sessions of 45 minutes

7.4 Planting a Field Crop: Corn, Beans and Squash

2 sessions of 45 minutes

UNIT 7 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. 5 pts

Why must every container have drainage holes?

2. 5 pts

Why use potting mix instead of garden soil in pots?

3. 5 pts

Name three things a fair judge looks for in a potted plant exhibit.

4. 5 pts

Give three signs that a plant is root-bound.

5. 5 pts

How much bigger should a new pot be when repotting, and why not much bigger?

6. 5 pts

How many hours of direct sun does “full sun” mean? Name two crops that need it.

7. 5 pts

Why should tall crops go on the north side of a garden?

8. 5 pts

When should warm-season crops like beans and corn be planted?

9. 5 pts

How does each of the three sisters help the others?

10. 5 pts

Why do many farmers plant soybeans the year after corn?

ANSWER KEY

1. So extra water can escape. Without holes, water collects at the bottom and the roots drown and rot.
2. Garden soil packs down hard and drains poorly in a pot. Potting mix stays light and fluffy, holding water and air.
3. A healthy, well-shaped plant with no dead leaves or pests; a clean pot of the right size; a neat, correct label.
4. Roots coming out of the drainage holes, water running straight through, drying out quickly, slow growth, roots circling the root ball.
5. Only 1–2 inches wider. A much bigger pot holds extra wet mix the roots can't use, which can cause rot.
6. At least 6 to 8 hours. Examples: tomatoes, peppers, squash, beans, corn.
7. So they don't shade the shorter plants, since the sun shines from the south in the Northern Hemisphere.
8. After the last spring frost, when the soil is warm.
9. Corn is a pole for beans; beans add nitrogen to the soil; squash shades out weeds, keeps soil moist and discourages raccoons.
10. Soybeans, like other beans, add nitrogen to the soil, which feeds the next corn crop.

PORTFOLIO PIECE: MY GARDEN PLAN AND PLANTING RECORD

Present your garden for the season: your sun map, your scaled garden plan with crops and planting calendar, and a planting record for your container and three-sisters mounds (dates, what you did, costs, measurements and photos or drawings). Bring your best container plant groomed and labeled as a fair exhibit, and add a page about the plant you repotted for someone else.

LOOK FOR	WHAT IT MEANS
Sun map and plan	Sun map is based on real observations; each crop is placed where its sun needs are met; beds and paths are drawn to scale.
Planting record	Dated records of planting, watering, growth and costs are kept for at least four weeks.
Exhibit	The potted plant is healthy, groomed, in a clean pot and neatly labeled.
Service	A plant was repotted or cared for to help someone, with a note about what was done.

UNIT 8

PLANT HEALTH

Your garden is growing, and so are the creatures that want to share it. Some insects chew leaves and suck sap; others eat those pests for breakfast. Tiny fungi can cover leaves in white powder or brown spots. In this unit you will become a garden doctor and detective: you will learn to recognize common pests and their helpful enemies, spot fungal diseases early, and keep plants healthy in simple, gentle ways, starting with healthy soil.

You will also start an insect collection with careful labels, a favorite 4-H fair project, and judge a class of plants for health. Our pictures come from great natural-history artists, Maria Sibylla Merian, John Curtis and Robert Hooke, and end with Millet's famous painting of two farm workers pausing to pray in their potato field.

PREREQUISITES

- Has a garden bed, container plants or seedlings to observe (Units 5 and 7)
- Knows the parts of a plant and what plants need
- Can use a magnifying glass and keep dated records

MASTERY CHECKLIST

- ☐ I can identify aphids, tomato hornworms and cabbage worms and the damage they cause.
- ☐ I can name four beneficial insects and how to welcome them.
- ☐ I can recognize powdery mildew and early blight and explain how to prevent them.
- ☐ I can follow the steps of simple pest management: prevent, scout, identify, act gently.
- ☐ I can label an insect collection and judge four plants for health.

LESSONS IN THIS UNIT

8.1 Insect Pests: Aphids, Hornworms and Cabbage Worms	2 sessions of 45 minutes
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8.2 Beneficial Insects	2 sessions of 45 minutes
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8.3 Fungal Diseases: Powdery Mildew and Blight	2 sessions of 45 minutes
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8.4 Simple Pest Management: Hand-Picking, Barriers and Healthy Soil	
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UNIT 8 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. **5 pts**

What do aphids look like and what damage do they do?

2. **5 pts**

How can you find a tomato hornworm, and what should you do if it has white cocoons on its back?

3. **5 pts**

What information belongs on an insect collection label?

4. **5 pts**

Name two beneficial insects and the pest each eats.

5. **5 pts**

How can a gardener welcome beneficial insects?

6. **5 pts**

What does powdery mildew look like, and what plants does it often attack?

7. **5 pts**

How does early blight get onto tomato leaves, and how does mulch help?

8. **5 pts**

Name three ways to prevent fungal diseases.

9. **5 pts**

List the four steps of IPM in order.

10. **5 pts**

Give two barriers or traps and the pest each stops.

ANSWER KEY

1. Tiny, soft, pear-shaped insects on new shoots and under leaves. They suck sap, curling leaves and leaving sticky honeydew.
2. Look for chewed leaves and dark droppings below. If it has white cocoons, leave it, because helpful wasps are taking care of it.
3. The date, the place (town and state), the collector's name, and the insect's name (and the plant it was on).
4. Ladybugs and their larvae eat aphids; lacewing larvae eat aphids; hover-fly larvae eat aphids; parasitic wasps attack hornworms and aphids.
5. Plant flowers with tiny blossoms (dill, alyssum, yarrow, zinnias), give water, and don't spray insect poisons.
6. White or gray powder on leaves. It often attacks squash, pumpkins, cucumbers and zinnias.
7. Its spores live in the soil and splash up onto lower leaves. Mulch stops the soil from splashing.
8. Space plants for air, water the soil in the morning, mulch, remove spotted leaves to the trash, rotate crops, choose resistant varieties.
9. Prevent, scout, identify, and act with the gentlest method first.
10. Row cover stops cabbage butterflies and squash bugs; cardboard collars stop cutworms; a board trap catches slugs; netting stops birds.

PORTFOLIO PIECE: MY INSECT COLLECTION AND GARDEN HEALTH RECORD

Finish your insect collection with at least 10 identified insects, each with a proper label (date, place, collector, name), sorted into pests and helpers. Add your summer scouting chart, your prevention checklist, your barrier results, and your judging card. Display it like a fair exhibit, and present it to your family at the end-of-year harvest fair.

LOOK FOR	WHAT IT MEANS
Collection	At least 10 insects, correctly named and grouped, each with date, place and collector on its label.
Scouting record	Dated scouting charts show pests and diseases found and the gentle actions taken.
Judging	Four plants are placed 1–4 with three clear comparing reasons.
Display	The exhibit is neat, clearly titled and easy for a visitor to understand.

8.1 INSECT PESTS: APHIDS, HORNWORMS AND CABBAGE WORMS

OBJECTIVES

- Identify three common garden pests and the damage each causes.
- Explain the simple life cycle of a caterpillar pest: egg, caterpillar, pupa, adult.
- Scout plants carefully and start a labeled insect collection.

Warm-up. Walk to a garden, a weedy patch or a houseplant with a magnifying glass. Turn over five leaves and look underneath. Count every insect, egg or speck you find. Why might insects hide under leaves?

WATCH

7 Pests You Probably Have In Your Garden (And What To Do)

Epic Gardening • 12:43

<https://www.youtube.com/watch?v=em5t8bScq9s>

WHEN TO WATCH

After the core ideas. Watch the parts on aphids and caterpillars in Session 1; the rest can wait for Lesson 8.4.

Note: The host shows a few organic sprays. In this course, sprays are for adults only.

BACKUP VIDEO

Defeating the Dreaded Tomato Hornworm: Your Battle Plan

CaliKim Garden & Home • 5:35

<https://www.youtube.com/watch?v=wO6mkyRuuK4>

Before you scout tomato plants. Look for the clues she shows: chewed leaves and dark droppings.

KEY TERMS

pest

A creature that damages crops or garden plants.

aphid

A tiny, soft, pear-shaped insect that sucks sap from new leaves and stems.

hornworm

A large green caterpillar with a little horn on its tail end that eats tomato and pepper leaves.

larva

The young stage of an insect that changes completely, such as a caterpillar. More than one are larvae.

honeydew

The sticky, sugary liquid aphids leave on leaves.

CORE IDEAS

A pest is any creature eating plants we want to keep. Most insects in your garden are not pests at all, and many are helpers. A good gardener learns to tell them apart before doing anything.

Aphids are tiny, soft insects, green, black, gray or pink, that cluster on new shoots and under leaves. They poke their beaks into the plant and suck sap, so leaves curl and pucker. They leave sticky **honeydew**, and ants often guard them to collect it. Aphids multiply very fast, but a strong spray of water knocks many off, and ladybugs love to eat them.

The **tomato hornworm** is a fat green caterpillar, as long as your finger, with white stripes and a little horn on its tail. It eats tomato, pepper and potato leaves and even green tomatoes. It is so well camouflaged that you usually find its dark droppings on the leaves below before you find it. In time it becomes a large moth called a hawk moth or sphinx moth. Gardeners pick hornworms off by hand. If one is covered with tiny white cocoons like grains of rice, leave it: a tiny helpful wasp is already taking care of it.

The **imported cabbageworm** is a velvety green caterpillar that chews holes in cabbage, broccoli and kale. Its parent is the little white cabbage butterfly you see fluttering over the garden. Gardeners cover these crops with light fabric called row cover so the butterflies can't lay eggs on them.

Many pests are **larvae**. Butterflies and moths go through four stages: egg, larva (caterpillar), pupa and adult. Knowing the life cycle helps you find pests early, when they are eggs or small larvae, before they do much damage.

PICTURE STUDY



Plant Study with Peppers, Maria Sibylla Merian, about 1700 · Watercolor on vellum

Image: [Wikimedia Commons](#), public domain

Maria Sibylla Merian was a German artist and naturalist who traveled all the way to South America in 1699 to study insects and the plants they ate. She was one of the first people to paint the whole life cycle of an insect together with its food plant, as she did here with a pepper plant.

Look closely

- Find the large caterpillar with a horn on its tail. What is it sitting on?
- Find the moth. How are its wings patterned?
- Find the dark, shiny pupa. Which stage comes before it, and which after?
- Find the peppers. How many colors are they?

Talk about it

1. Why did Merian paint the caterpillar and moth on the plant they eat?
2. This caterpillar is a relative of the tomato hornworm. Which of your garden plants would you check for it?
3. How does the caterpillar's color help it hide?

Safety first. Wear gloves if you like when hand-picking pests; some caterpillars have stinging hairs, so don't touch fuzzy caterpillars you don't know. Wash hands after working in the garden. Children never handle sprays or pesticides.

HANDS-ON PROJECT

Pest Patrol and an Insect Collection

You will scout your plants for pests twice a week, record what you find, and begin an insect collection, a favorite 4-H fair project. A photo collection is the easiest way to start; older collectors may make a pinned collection with an adult.

You will need

- A magnifying glass and a ruler
- A clipboard with a scouting chart: date, plant, insect found, how many, damage
- A camera or phone (with an adult) for a photo collection, or small clear containers
- A notebook, index cards or small labels
- For a pinned collection (optional, with an adult): a foam board, insect pins and a freezer

Steps

1. Choose 5 plants to scout, such as a tomato, a cabbage or kale, a bean, a squash and a flower.
2. Twice a week, check the top and underside of 5 leaves on each plant, plus the new tips. Look for insects, eggs, droppings, holes and curled leaves.
3. Record each find on your chart. Measure caterpillars. Draw or photograph each new insect.
4. Remove any pests you find by hand (hornworms, cabbageworms) or with a spray of water (aphids), and record what you did.
5. Start your collection: for each insect, make a label with the date, the place (town and state), the plant it was on, and the collector's name (you!). Add its name once you identify it.
6. Photo collection: print or arrange your photos in a binder with labels, sorted into groups (beetles, butterflies and moths, true bugs, and so on).

7. Pinned collection (optional, with an adult): collect only common garden insects, never bees. An adult places the insect in a container in the freezer overnight, which is a quick, gentle end. Then pin it through the body onto foam and add its label underneath.
8. Use a field guide or a 4-H entomology book to identify at least 10 insects by the end of the unit.

Tips

- Insect collections are a favorite youth exhibit at county fairs. Judges look for neat labels with date, place and collector, and correct names. Check your fair book for the rules.
- Keep scouting all summer. You may watch a pest's whole life cycle.

Check your work

- ☐ I scouted plants twice a week and kept a dated chart.
- ☐ I can identify aphids, hornworms and cabbageworms.
- ☐ I started an insect collection with proper labels.

NATURE JOURNAL

1. Draw the four stages of a cabbage butterfly or hornworm moth in a circle with arrows.
2. Draw an aphid 20 times bigger than life, using a magnifying glass.
3. Draw a leaf with pest damage: holes, curled edges or chewed edges. Write which pest you think did it.

COMMON MISTAKES

- Thinking every insect is a pest. Most are harmless or helpful.
- Only looking at the tops of leaves.
- Waiting until damage is bad. Scout often and act early.

Make it a game • Pest Profile Cards. Write aphid, hornworm and cabbage worm on three cards. Your grown-up reads a damage clue, like sticky honeydew or stripped leaves. Slap the right pest card. Then tell the life cycle of a caterpillar pest in four steps. Score a point for each right match, with a tie broken by life cycle.

8.2 BENEFICIAL INSECTS

OBJECTIVES

- Name and identify four beneficial insects and the pests they eat.
- Recognize the larvae of ladybugs and lacewings, which look very different from the adults.
- Plant or plan flowers that welcome helpful insects.

Warm-up. Look at a picture of a young ladybug larva (it looks like a tiny, spiky black-and-orange alligator). Would you have guessed it was a ladybug? What might a gardener do by mistake if he didn't know?

WATCH

★ 10 Beneficial Insects You Want in the Garden (Insect Guide)

Project Diaries · 6:54

https://www.youtube.com/watch?v=ai8XRf_wYjA

WHEN TO WATCH

After the core ideas. Make a list of each insect and what it eats.

BACKUP VIDEO

How to promote beneficial insects in your garden. Ladybugs, Parasitic Wasps, and Green Lacewings.

Midwest Gardener · 2:42

<https://www.youtube.com/watch?v=n45QOlwpoTw>

Before you plan your helper-insect flower bed.

KEY TERMS

beneficial insect

An insect that helps the gardener, by eating pests, pollinating flowers or breaking down dead material.

predator

An animal that catches and eats other animals.

parasitic wasp

A tiny wasp, harmless to people, that lays its eggs in or on pest insects.

pollinator

An animal, such as a bee, that carries pollen from flower to flower.

CORE IDEAS

For every garden pest, God has made something that eats it. Gardeners call these helpers **beneficial insects**. If we protect them, they do much of our pest control for free.

Ladybugs (lady beetles) are the most famous. An adult ladybug can eat about 50 aphids a day. Their larvae look nothing like the adults: they are long, spiky and black with orange spots, like tiny alligators, and they eat even more aphids. **Green lacewings** are delicate green insects with clear, lacy wings; their larvae are called “aphid lions” because they gobble aphids.

Hover flies look like small bees but are flies; they hover in the air like tiny helicopters. Their larvae eat aphids, and the adults pollinate flowers. **Parasitic wasps** are smaller than a grain of rice and cannot sting people. They lay eggs inside pests like aphids and hornworms. Ground beetles, spiders and praying mantises are **predators** too, though a mantis eats good bugs as well as bad.

To welcome helpers, plant flowers with many tiny blossoms, which give adult helpers nectar and pollen: dill, fennel, cilantro gone to flower, sweet alyssum, yarrow and zinnias. Give them water in a shallow dish with pebbles. Most important, do not spray insect poisons, which kill helpers along with pests.

Bees and other **pollinators** are beneficial too. Without them, squash, cucumbers, melons and many fruits would never form.

PICTURE STUDY



Ladybird on a Plant (Plate 208), John Curtis, about 1825 · Hand-colored engraving, from *British Entomology* · *British Entomology*, London
Image: [Wikimedia Commons](#), public domain

John Curtis spent sixteen years engraving and coloring the insects of Britain for his book *British Entomology*. Each plate shows an insect at life size and enlarged, on a plant where it lives, with tiny drawings of its parts for scientists.

Look closely

- Find the small ladybird on the stem and the large one below. Which shows its real size?
- Count the spots on the large ladybird.
- Find the tiny drawings at the bottom. What parts of the insect do you think they show?
- Look at the plant's leaves. Do they show any signs of aphids?

Talk about it

1. Why would a ladybird be found on a plant like this?
2. Why do you think scientists drew insect parts so large?
3. What label information would you add if this were in your collection?

Safety first. Watch beneficial insects without squeezing them. Some, like wasps and bees, can sting if grabbed. Children never use insect sprays.

HANDS-ON PROJECT

A Helper Hunt and a Beneficial Insect Garden

You will search your garden and nearby flowers for beneficial insects at every stage, add them to your collection (photos are best for helpers), and plant or plan a small bed of flowers that will feed them.

You will need

- A magnifying glass, a camera or phone (with an adult) and your collection labels
- Seeds or small plants of dill, sweet alyssum, zinnias, cilantro or yarrow
- A pot or a small sunny bed
- A shallow dish and pebbles for a bug bath

Steps

1. Look for aphid colonies. Then look nearby for ladybug adults, larvae and yellow egg clusters, lacewing eggs on thin threads, and hover-fly larvae.
2. Photograph or draw each helper. Label it with date, place and collector, and add it to your insect collection.
3. Find an aphid colony with a ladybug larva on it. Watch for 10 minutes and count how many aphids it eats.
4. Plant a helper bed: sow dill, alyssum and zinnias in a pot or a sunny corner of the garden, or plant small transplants.
5. Set out a shallow dish of water with pebbles so insects can drink without drowning.
6. Once a week, visit your helper bed and count the insects you see visiting the flowers.
7. Make a “Wanted: Garden Helpers” poster showing four beneficial insects at their adult and larva stages.

Tips

- Store-bought ladybugs often fly away. It is better to grow flowers that bring in the ones already living near you.
- Early morning is a good time to find insects resting on plants.

Check your work

- ☐ I can name four beneficial insects and what they eat.
- ☐ I can recognize a ladybug larva.
- ☐ I planted or planned flowers for helpful insects.

NATURE JOURNAL

1. Draw the ladybug life cycle: eggs, larva, pupa and adult.
2. Draw a hover fly next to a honeybee and label how to tell them apart (flies have one pair of wings and short antennae).
3. Draw your helper bed and record the insects that visit.

COMMON MISTAKES

- Squashing ladybug larvae because they look like pests.
- Spraying insect poisons, which kill helpers too.
- Planting only big, showy flowers; many helpers need tiny flowers.

Make it a game • Helper Hunt Sketch Off. Draw a ladybug, a lacewing and their larvae from memory, showing how larvae differ from adults. Your grown-up guesses which pest each one eats. Name four beneficial insects in all. Give a point for each correct drawing and each correct pest. The artist with more helpers wins.

8.3 FUNGAL DISEASES: POWDERY MILDEW AND BLIGHT

OBJECTIVES

- Explain that some fungi cause plant diseases, spreading by tiny spores.
- Identify powdery mildew and early blight on leaves.
- Prevent fungal diseases with good spacing, watering, mulching and cleanup.

Warm-up. Look (without touching or sniffing closely) at a piece of bread or fruit that has been sealed in a bag for a week. What do you see? Mold is a fungus. Where did it come from if nobody put it there?

WATCH

How to Prevent Tomato Diseases or Greatly Reduce Damage: Leaf Spots, Early Blight, & Late Blight

Gary Pilarchik (The Rusted Garden) · 5:50

<https://www.youtube.com/watch?v=nTlhHrIPlas>

WHEN TO WATCH

After the core idea on blight. Listen for the ways to stop spores from splashing up from the soil.

BACKUP VIDEO

Prevent & Treat Powdery Mildew and 4 Home Remedies that Work!!

Next Level Gardening · 6:45

https://www.youtube.com/watch?v=A_xsjZ139g4

Watch the first half for how powdery mildew looks and how to prevent it. Any spraying is done by an adult.

KEY TERMS

fungus

A living thing, such as a mushroom, mold or mildew, that feeds on living or dead material. More than one are fungi.

spore

A tiny speck, like a seed, that a fungus makes to spread itself. Spores float on air or splash in water.

powdery mildew

A fungus that coats leaves with white or gray powder, common on squash, cucumbers and zinnias.

early blight

A fungus that makes brown spots with rings like a target on the lower leaves of tomatoes.

crop rotation

Planting a crop in a different place each year so its diseases in the soil die out.

CORE IDEAS

In Unit 3 you met the helpful fungi that build soil. A few kinds of fungi, though, attack living plants. A **fungus** spreads by **spores**, specks so tiny that millions could fit on a fingernail. Spores ride the wind, splash up from the soil in raindrops, and hitch rides on hands and tools.

Powdery mildew looks as if someone dusted the leaves with flour. It grows on squash, pumpkins, cucumbers, zinnias and many more, especially in late summer when days are warm, nights are damp, and plants are crowded. Badly infected leaves turn yellow and die early.

Early blight attacks tomatoes. Its spores live in the soil and splash onto the lowest leaves. It makes brown spots with rings inside, like a little target, often with a yellow edge. The spots spread upward until the plant loses many leaves. A worse disease, late blight, can kill a whole tomato plant in a week in cool, wet weather.

Prevention is the best medicine. Give plants room so air moves between them. Water the soil, not the leaves, and water in the morning so leaves dry quickly. Spread **mulch** under tomatoes so spores can't splash up. Pick off the first spotted lower leaves and put them in the trash, not the compost. Plant tomatoes in a different spot each year (**crop rotation**), and choose resistant varieties.

Remember that a white powder or brown spot can have other causes too. A good garden detective looks closely, compares with pictures, and asks a master gardener or the county extension office when unsure.

PICTURE STUDY



Blue Mould (Micrographia, Scheme 12), Robert Hooke, 1665 · Engraving, from Micrographia · Micrographia, London

Image: [Wikimedia Commons](#), public domain

In 1665 Robert Hooke, an English scientist, published *Micrographia*, one of the first books of drawings made through a microscope. Here he drew the blue mold that grew on a piece of leather. For the first time, people could see that mold is made of tiny stalks bearing round heads of spores.

Look closely

- Find the thin stalks. What do they hold up at the top?
- Look at the round heads. What might be inside them?
- Compare the top drawing with the bottom one. Which is magnified more?
- Find the letters Hooke put on the drawing to label the parts.

Talk about it

1. How could the spores from these little heads spread to a new place?
2. Why do you think nobody understood mold before the microscope?
3. Powdery mildew is also made of tiny threads and spores. How might wind help it spread in a garden?

Safety first. Don't eat or sniff moldy food. Wear gloves when removing diseased leaves, put them in the trash, and wash hands and tools afterward. Fungicide sprays are for adults only, following the label.

Disease Detective and a Spore Print

You will scout your garden for signs of fungal disease, practice prevention, and make a spore print from a store-bought mushroom to see how many spores a fungus makes.

You will need

- A magnifying glass, gloves and a trash bag
- Mulch (straw or shredded leaves)
- A fresh store-bought mushroom with open gills (portobello or button), a bowl, and white and dark paper
- Your nature journal

Steps

1. Scout squash, cucumber, zinnia and tomato plants. Look for white powder on leaves and brown target spots on lower tomato leaves.
2. Draw any spots you find, life-size, and note the date and the plant.
3. With gloves, pick off a few badly spotted lower leaves and put them in the trash bag. Wash your hands and tools.
4. Spread 2–3 inches of mulch under tomato plants, keeping it an inch away from the stems.
5. Check that plants have room for air. Note any that are crowded.
6. Spore print: have an adult cut the stem off a store-bought mushroom. Set it gills-down on half white, half dark paper and cover with a bowl overnight.
7. In the morning, lift the bowl and mushroom carefully. Look at the pattern with your magnifying glass. Each speck of dust is a spore!
8. Write a garden prevention checklist and hang it near your garden tools.

Tips

- Use only store-bought mushrooms for spore prints. Never pick or eat wild mushrooms.
- Spray a clear art fixative (adult only) over the spore print to keep it.

Check your work

- ☐ I can recognize powdery mildew and early blight.
- ☐ I can list four ways to prevent fungal disease.
- ☐ I made a spore print and can explain what spores do.

NATURE JOURNAL

1. Draw a healthy leaf, a leaf with powdery mildew and a tomato leaf with early blight side by side.
2. Draw your spore print and the mushroom gills it came from.
3. Record the weather for a week: rain, dew and temperature. Did any disease spread?

From history. In the 1840s a plant disease called late blight destroyed most of the potato crop in Ireland, where many families depended on potatoes for food, and many people went hungry or left for America. Scientists studying it later learned how plant diseases spread, and farmers began rotating crops and growing resistant potatoes.

COMMON MISTAKES

- Watering the leaves in the evening, so they stay wet all night.
- Putting diseased leaves in the compost pile.
- Crowding plants so air can't move between them.

Make it a game • Disease Detective Duel. Your grown-up describes a leaf: white powder, or brown spots with rings. Declare powdery mildew or early blight and explain how spores spread. Then give two ways to help prevent it, like crop rotation and water at the soil. Play five rounds. Look at diseased leaves with a magnifier only, then wash your hands.

8.4 SIMPLE PEST MANAGEMENT: HAND-PICKING, BARRIERS AND HEALTHY SOIL

OBJECTIVES

- List the steps of simple pest management: prevent, scout, identify, and act gently first.
- Use hand-picking, water sprays, barriers and traps to protect plants.
- Judge a class of four plants for health and give reasons.

Warm-up. Your teacher shows four leaves or four pictures of plants: one healthy, one chewed, one with spots, one wilted. In two minutes, sort them from healthiest to least healthy. What clues did you use?

WATCH

What is Integrated Pest Management (IPM) and How To Use It In Your Garden

[GrowOrganic Peaceful Valley](https://www.youtube.com/watch?v=ABVvq6i8MF4) · 3:39

<https://www.youtube.com/watch?v=ABVvq6i8MF4>

WHEN TO WATCH

After the first core idea. Write down the steps in order.

BACKUP VIDEO

How to Make Row Covers to Protect Your Plants from Pests

[Utah State University Extension](https://www.youtube.com/watch?v=LS2HWI3VnY4) · 4:00

<https://www.youtube.com/watch?v=LS2HWI3VnY4>

Before you build your barrier in the project.

KEY TERMS

integrated pest management (IPM)

A careful plan for pests: prevent problems, watch closely, and choose the gentlest action that works.

scouting

Checking plants regularly for pests and disease.

barrier

Something that keeps pests away from plants, like row cover, netting or a collar.

row cover

A light, see-through fabric laid over plants that lets in sun and rain but keeps insects out.

judging class

A set of four items that a judge ranks from best to last and explains with reasons.

CORE IDEAS

Gardeners have a wise plan for pests called **integrated pest management**, or IPM. It has four steps: **prevent** problems, **scout** often, **identify** what you find, and **act**, starting with the gentlest method that works.

Prevention starts in the soil. Plants growing in rich, living soil with compost, enough water and full sun are stronger, just as a well-fed child fights off colds better. Rotate crops, choose resistant varieties, and keep weeds down so pests have fewer places to hide.

Gentle actions come first. Hand-pick big pests like hornworms, beetles and cabbageworms and drop them in a jar of soapy water. Knock aphids off with a strong spray of water. Use **barriers**: **row cover** over cabbage and squash, a cardboard collar around young transplants to stop cutworms, and netting over berries to stop birds. Use traps: a board laid on the ground overnight collects slugs underneath, which you can scrape into soapy water in the morning.

Only when gentle methods fail does an adult consider a spray, and even then chooses the mildest one, reads the label, and sprays only the plants that need it. Children never handle pesticides.

A little damage is fine. A few holes in a leaf don't hurt the harvest. The goal is not a garden with no insects but a healthy garden in balance, where helpers and pests both live and the plants still feed the family. At county fairs, judges of vegetables and plants look for exactly this: healthy, clean, true-to-type plants with little damage.

PICTURE STUDY



The Angelus, Jean-François Millet, 1857–1859 · Oil on canvas · Musée d'Orsay, Paris

Image: [Wikimedia Commons](#), public domain

Millet painted a young farm couple digging potatoes. When the church bell rings for evening prayer, the Angelus, they stop work and bow their heads. Millet said the painting came from memories of his grandmother, who always stopped to pray when she heard the bell.

Look closely

- Find the basket of potatoes on the ground between them.
- Find the tools: the pitchfork and the wheelbarrow with sacks.
- Find the church steeple far away on the horizon.
- Look at the sky. What time of day is it?

Talk about it

1. What did this couple need to do all season to bring in a good potato harvest?
2. Why do you think they stop working to pray?
3. How does this picture show both hard work and thankfulness?

Safety first. An adult handles any spray. Wear gloves when hand-picking or handling slug traps, and wash hands afterward. Never touch slugs and then your mouth.

HANDS-ON PROJECT

Protect a Plant and Judge a Class of Four

You will use at least two gentle methods to protect a crop, keep a record of how well they work, and then judge a class of four plants for health, ranking them 1–4 with reasons like a 4-H judge.

You will need

- Row cover fabric or tulle netting, garden hoops or bent wire, and rocks or clips
- Cardboard tubes (toilet paper rolls) for cutworm collars
- A small board for a slug trap and a jar of soapy water with a lid
- Four potted plants of the same kind (such as your Hungry Bean plants from Lesson 5.4), labeled A, B, C and D
- Your scouting chart and nature journal

Steps

1. Choose a crop to protect, such as cabbage, kale, squash or young transplants.
2. Barrier: bend hoops over the bed and drape row cover or tulle over them. Hold down the edges with rocks so insects can't crawl under.
3. Collars: slide a cardboard tube over each young transplant and push it an inch into the soil.
4. Trap: lay a board on damp soil near your plants in the evening. In the morning, with gloves, lift it and drop any slugs into soapy water.
5. Keep scouting twice a week. Record pests found, what you did, and the damage you see, protected plants compared with unprotected ones.
6. Judging class: set the four plants in a row. Look at each for 2 minutes: leaf color, pests or spots, size and shape, and how well it stands up.
7. Place them 1st to 4th and write your placing (for example, C-A-D-B).
8. Write three reasons: "I placed C over A because C has greener leaves and no chewed spots..." Then compare with a family member's placing.

Tips

- Remove row cover from squash when it starts to flower so bees can pollinate it.
- Good judges compare, not just describe: “greener than,” “fewer spots than,” “more even than.”

Check your work

- ☐ I used at least two gentle pest methods and recorded the results.
- ☐ I can list the IPM steps in order.
- ☐ I placed four plants 1–4 and wrote three comparing reasons.

NATURE JOURNAL

1. Draw your barrier, collar and trap with labels.
2. Make a comparison chart: protected plants and unprotected plants, damage each week.
3. Draw your judging class and write your placing and reasons.

COMMON MISTAKES

- Reaching for a spray first instead of hand-picking or a barrier.
- Leaving gaps under row cover where insects can crawl in.
- Expecting a garden with no insects at all.

Make it a game · Judge a Class of Four. Set four plants or pictures in a row. Be the judge. Rank them from best to worst and give reasons for each rank, using prevent, scout, identify and act gently. Your grown-up asks one question per plant. Name a barrier and a trap in your reasons. Switch roles.

Scripture. “And let us not be weary in well doing: for in due season we shall reap, if we faint not.” (Galatians 6:9, KJV)

Scouting, hand-picking and watering week after week can be tiring. Faithful, patient care brings a harvest in due season.

UNIT 8

PLANT HEALTH

Your garden is growing, and so are the creatures that want to share it. Some insects chew leaves and suck sap; others eat those pests for breakfast. Tiny fungi can cover leaves in white powder or brown spots. In this unit you will become a garden doctor and detective: you will learn to recognize common pests and their helpful enemies, spot fungal diseases early, and keep plants healthy in simple, gentle ways, starting with healthy soil.

You will also start an insect collection with careful labels, a favorite 4-H fair project, and judge a class of plants for health. Our pictures come from great natural-history artists, Maria Sibylla Merian, John Curtis and Robert Hooke, and end with Millet's famous painting of two farm workers pausing to pray in their potato field.

PREREQUISITES

- Has a garden bed, container plants or seedlings to observe (Units 5 and 7)
- Knows the parts of a plant and what plants need
- Can use a magnifying glass and keep dated records

MASTERY CHECKLIST

- ☐ I can identify aphids, tomato hornworms and cabbage worms and the damage they cause.
- ☐ I can name four beneficial insects and how to welcome them.
- ☐ I can recognize powdery mildew and early blight and explain how to prevent them.
- ☐ I can follow the steps of simple pest management: prevent, scout, identify, act gently.
- ☐ I can label an insect collection and judge four plants for health.

LESSONS IN THIS UNIT

8.1 Insect Pests: Aphids, Hornworms and Cabbage Worms	2 sessions of 45 minutes
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8.2 Beneficial Insects	2 sessions of 45 minutes
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8.3 Fungal Diseases: Powdery Mildew and Blight	2 sessions of 45 minutes
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8.4 Simple Pest Management: Hand-Picking, Barriers and Healthy Soil	
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UNIT 8 REVIEW

Answer each question in a sentence or two. You may answer out loud while your teacher writes, or write your own answers. 50 points in all.

1. **5 pts**

What do aphids look like and what damage do they do?

2. **5 pts**

How can you find a tomato hornworm, and what should you do if it has white cocoons on its back?

3. **5 pts**

What information belongs on an insect collection label?

4. **5 pts**

Name two beneficial insects and the pest each eats.

5. **5 pts**

How can a gardener welcome beneficial insects?

6. **5 pts**

What does powdery mildew look like, and what plants does it often attack?

7. **5 pts**

How does early blight get onto tomato leaves, and how does mulch help?

8. **5 pts**

Name three ways to prevent fungal diseases.

9. **5 pts**

List the four steps of IPM in order.

10. **5 pts**

Give two barriers or traps and the pest each stops.

ANSWER KEY

1. Tiny, soft, pear-shaped insects on new shoots and under leaves. They suck sap, curling leaves and leaving sticky honeydew.
2. Look for chewed leaves and dark droppings below. If it has white cocoons, leave it, because helpful wasps are taking care of it.
3. The date, the place (town and state), the collector's name, and the insect's name (and the plant it was on).
4. Ladybugs and their larvae eat aphids; lacewing larvae eat aphids; hover-fly larvae eat aphids; parasitic wasps attack hornworms and aphids.
5. Plant flowers with tiny blossoms (dill, alyssum, yarrow, zinnias), give water, and don't spray insect poisons.
6. White or gray powder on leaves. It often attacks squash, pumpkins, cucumbers and zinnias.
7. Its spores live in the soil and splash up onto lower leaves. Mulch stops the soil from splashing.
8. Space plants for air, water the soil in the morning, mulch, remove spotted leaves to the trash, rotate crops, choose resistant varieties.
9. Prevent, scout, identify, and act with the gentlest method first.
10. Row cover stops cabbage butterflies and squash bugs; cardboard collars stop cutworms; a board trap catches slugs; netting stops birds.

PORTFOLIO PIECE: MY INSECT COLLECTION AND GARDEN HEALTH RECORD

Finish your insect collection with at least 10 identified insects, each with a proper label (date, place, collector, name), sorted into pests and helpers. Add your summer scouting chart, your prevention checklist, your barrier results, and your judging card. Display it like a fair exhibit, and present it to your family at the end-of-year harvest fair.

LOOK FOR	WHAT IT MEANS
Collection	At least 10 insects, correctly named and grouped, each with date, place and collector on its label.
Scouting record	Dated scouting charts show pests and diseases found and the gentle actions taken.
Judging	Four plants are placed 1–4 with three clear comparing reasons.
Display	The exhibit is neat, clearly titled and easy for a visitor to understand.