

# GRADE 4 GARDENING & ANIMALS

First edition

8 units

32 lessons

A video for every lesson

FIRST EDITION

## COURSE GUIDE

In Grade 4 the student moves from simply noticing the living world to understanding how it works. You will learn why a gardener plans around frost dates, how a cover crop feeds next year's soil, how a root cellar keeps carrots crisp until spring, and how a field of wheat becomes a loaf of bread. You will trace a backyard food web from clover to fox, read the layers of soil like pages in a book, test your soil's pH, and meet the bacteria and fungi that quietly keep the garden alive.

The year also brings you close to animals: choosing and budgeting for a pet, comparing small mammals, caring for reptiles and amphibians, and visiting the vet. You will study how a cow's four-part stomach turns grass into milk, why pigs are clever, how ducks and turkeys are raised, and how a honeybee colony lives through all four seasons. In spring you will build a seed-starting station, harden off and transplant seedlings, plant a patio container garden and learn how farmers plant whole fields. The year ends with plant doctoring: telling a nutrient problem from a pest or a disease.

The method is simple and old: **observe, learn, tend and grow**. Each lesson begins with careful looking, teaches the real science plainly, studies one great picture, and then puts the student to work with soil, seeds or animals. The student is treated as a steward of God's creation, called "to dress it and to keep it" (Genesis 2:15). *Fabricando fit faber*: by making, one becomes a maker, and by tending, one becomes a gardener.

Most videos come from university extension services, established gardening and homestead educators (such as The Ripe Tomato Farms, Epic Gardening, GrowVeg and Mlgardener), reputable kids' science channels (SciShow Kids, Homeschool Pop), nature programs, veterinarians and beekeeping educators. Every video was watched through in preview frames for content. A few gardening channels mention their own seed shop or a product near the end; you may

stop the video when the teaching ends. Watch with your child the first time, and use the pause button freely.

**Start with Lesson 1.1 →**

## WHO IT IS FOR

Students about 9 to 10 years old (Grade 4) who read independently and can follow multi-step written directions with some help. No yard, livestock or pet is required: every project has a windowsill, balcony, library or farm-visit option, and pet projects work for families without a pet.

## HOW TO USE THIS COURSE

1. **Weekly rhythm.** The course has 32 lessons, one per week, each in two sessions of about 45 minutes. Session 1: warm-up, core ideas, video and picture study. Session 2: the hands-on project and the nature journal. Some projects (sprouting, composting, growth logs) keep going for a week or two in the background; a few minutes a day is enough.
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, plant science and 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 own average first and last frost dates in Lesson 1.1 and **shift units to match them**. A family in a warm zone may plant in Unit 7 a month earlier than a family in the North.
3. **Picture study.** Each lesson has one public-domain painting or natural-history illustration. Look at it quietly for two minutes, then put it away and tell back everything you remember. Then look again with the “Look for” list and talk through the questions. The pictures are chosen to teach the lesson’s science as well as to delight.
4. **The nature journal.** Keep one bound sketchbook for the whole year. Date every page and note the weather. Draw from life, label what you see, record measurements and keep logs. By spring it will be a true record of your own seasons.
5. **Unit review and portfolio.** Each unit ends with a 50-point unit review (oral or written) and a portfolio project that gathers the unit’s skills into one real thing: a

frost-date calendar, a soil report, a pet care plan, a container garden. Keep photos and journal pages in a portfolio folder.

6. **Safety and supervision.** Read each lesson's safety note before you begin. An adult works alongside the student for tools, soil amendments, compost and manure, any animal visit, and all beekeeping. Wash hands after soil, animals and reptiles. Never touch or feed wild animals, and never handle pesticides.
7. **Fairs, 4-H and contests.** The course prepares students for real youth programs: 4-H, Junior Master Gardener, county and state fair youth classes, the conservation-district poster contest and the Federal Junior Duck Stamp contest. Along the way students keep 4-H-style records (dates, care, costs and results), judge classes of seedlings and poultry and give reasons, prepare a vegetable or potted-plant exhibit, practice poultry and rabbit showmanship, and give an illustrated talk. Rules differ by place, so check your county extension office or fair book.
8. **No yard? No problem.** Every planting lesson works in pots on a sunny windowsill or balcony. Farm-animal lessons can be done by visiting a farm, a 4-H fair, a farmers' market or a library. If something you need is out of season, read ahead, watch the video, and come back to the hands-on part when the time is right.

## SCOPE AND SEQUENCE

### UNIT 1 • WEEKS 1–4

#### Harvest and the Seasons

Growing zones and frost dates, the fall garden and cover crops, storing the harvest in a root cellar, and following wheat from field to flour.

- 1.1 Growing Zones and Frost Dates
- 1.2 The Fall Garden and Cover Crops
- 1.3 Root Cellars and Storing the Harvest
- 1.4 From Wheat to Flour

### UNIT 2 • WEEKS 5–8

#### Wildlife in the Backyard Food Web

The backyard food web, predators such as coyotes, foxes, hawks and owls, night visitors and rabies safety, and fair ways to keep deer, rabbits and squirrels out of the garden.

- 2.1 The Backyard Food Web
- 2.2 Predators: Coyotes, Foxes, Hawks and Owls
- 2.3 Night Visitors and Rabies Safety
- 2.4 Keeping Deer, Rabbits and Squirrels Out of the Garden

## **UNIT 3 • WEEKS 9–12**

### **Soil: Layers, pH and Living Things**

Soil horizons, pH and a home soil test, the bacteria and fungi of living soil including mycorrhizae, and earthworms as the garden's engineers.

- 3.1 Soil Horizons: Reading the Layers
- 3.2 pH and a Home Soil Test
- 3.3 Bacteria and Fungi in Living Soil
- 3.4 Earthworms: Engineers of the Soil

## **UNIT 5 • WEEKS 17–20**

### **Plant Science**

Plant cells and photosynthesis, flowers and pollination, how seeds travel, and how plants respond to light and gravity.

- 5.1 Plant Cells and Photosynthesis
- 5.2 Flowers and Pollination
- 5.3 How Seeds Travel
- 5.4 How Plants Respond to Light and Gravity

## **UNIT 4 • WEEKS 13–16**

### **Pets: Choosing Well and Caring Faithfully**

Choosing and budgeting for a pet, comparing small mammals, caring for reptiles and amphibians, and visiting the vet to keep a pet healthy.

- 4.1 Choosing and Budgeting for a Pet
- 4.2 Small Mammals Compared
- 4.3 Reptiles and Amphibians
- 4.4 Visiting the Vet and Keeping a Pet Healthy

## **UNIT 6 • WEEKS 21–24**

### **Farm Animals and Bees**

Cattle and the four-part stomach, pigs, ducks and turkeys, and the honeybee colony through the year.

- 6.1 Cattle and the Four-Part Stomach
- 6.2 Pigs on the Farm
- 6.3 Ducks, Turkeys and Showing Small Animals
- 6.4 The Honeybee Colony Through the Year

## UNIT 7 • WEEKS 25–28

### Planting: From Seed Tray to Field

Building a seed-starting setup, hardening off and transplanting, a patio container garden, and planting a field with rows, tillage and seed drills.

- 7.1 A Seed-Starting Setup: Light, Warmth and Air
- 7.2 Hardening Off and Transplanting
- 7.3 A Patio Container Garden and a Fair Exhibit
- 7.4 Planting a Field: Rows, Tillage and Seed Drills

## UNIT 8 • WEEKS 29–32

### Plant Health: Bacteria, Fungi, Pests and Problems

Helpful and harmful bacteria, fungal diseases such as rust, mildew and damping off, the life cycles of squash bugs and Japanese beetles, and diagnosing a sick plant.

- 8.1 Bacteria: Garden Helpers and Plant Diseases
- 8.2 Fungi: Rust, Mildew and Damping Off
- 8.3 Pest Life Cycles: Squash Bugs and Japanese Beetles
- 8.4 Plant Doctor: Nutrient, Pest or Disease?

## WEEKLY PACING CALENDAR

| WEEK | PLAN                                                                                                                                                                                                                                                                                                                                                                               |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <ul style="list-style-type: none"><li>• Session 1: Lesson 1.1 Growing Zones and Frost Dates: warm-up, video, teaching and picture study</li><li>• Session 2: Lesson 1.1 hands-on project and nature journal</li></ul> <p><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></p> |
| 2    | <ul style="list-style-type: none"><li>• Session 1: Lesson 1.2 The Fall Garden and Cover Crops: warm-up, video, teaching and picture study</li><li>• Session 2: Lesson 1.2 hands-on project and nature journal</li></ul>                                                                                                                                                            |
| 3    | <ul style="list-style-type: none"><li>• Session 1: Lesson 1.3 Root Cellars and Storing the Harvest: warm-up, video, teaching and picture study</li><li>• Session 2: Lesson 1.3 hands-on project and nature journal</li></ul>                                                                                                                                                       |
| 4    | <ul style="list-style-type: none"><li>• Session 1: Lesson 1.4 From Wheat to Flour: warm-up, video, teaching and picture study</li><li>• Session 2: Lesson 1.4 hands-on project and nature journal</li><li>• Session 3: Unit 1 review and portfolio project</li></ul>                                                                                                               |
|      |                                                                                                                                                                                                                                                                                                                                                                                    |

| WEEK | PLAN                                                                                                                                                                                                                                                                                                       |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5    | <ul style="list-style-type: none"> <li>• Session 1: Lesson 2.1 The Backyard Food Web: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 2.1 hands-on project and nature journal</li> </ul>                                                                                           |
| 6    | <ul style="list-style-type: none"> <li>• Session 1: Lesson 2.2 Predators: Coyotes, Foxes, Hawks and Owls: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 2.2 hands-on project and nature journal</li> </ul>                                                                       |
| 7    | <ul style="list-style-type: none"> <li>• Session 1: Lesson 2.3 Night Visitors and Rabies Safety: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 2.3 hands-on project and nature journal</li> </ul>                                                                                |
| 8    | <ul style="list-style-type: none"> <li>• Session 1: Lesson 2.4 Keeping Deer, Rabbits and Squirrels Out of the Garden: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 2.4 hands-on project and nature journal</li> <li>• Session 3: Unit 2 review and portfolio project</li> </ul> |
| 9    | <ul style="list-style-type: none"> <li>• Session 1: Lesson 3.1 Soil Horizons: Reading the Layers: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 3.1 hands-on project and nature journal</li> </ul>                                                                               |
| 10   | <ul style="list-style-type: none"> <li>• Session 1: Lesson 3.2 pH and a Home Soil Test: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 3.2 hands-on project and nature journal</li> </ul>                                                                                         |
| 11   | <ul style="list-style-type: none"> <li>• Session 1: Lesson 3.3 Bacteria and Fungi in Living Soil: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 3.3 hands-on project and nature journal</li> </ul>                                                                               |
| 12   | <ul style="list-style-type: none"> <li>• Session 1: Lesson 3.4 Earthworms: Engineers of the Soil: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 3.4 hands-on project and nature journal</li> <li>• Session 3: Unit 3 review and portfolio project</li> </ul>                     |
| 13   | <ul style="list-style-type: none"> <li>• Session 1: Lesson 4.1 Choosing and Budgeting for a Pet: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 4.1 hands-on project and nature journal</li> </ul>                                                                                |
|      |                                                                                                                                                                                                                                                                                                            |

| WEEK      | PLAN                                                                                                                                                                                                                                                                                            |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>14</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 4.2 Small Mammals Compared: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 4.2 hands-on project and nature journal</li> </ul>                                                                               |
| <b>15</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 4.3 Reptiles and Amphibians: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 4.3 hands-on project and nature journal</li> </ul>                                                                              |
| <b>16</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 4.4 Visiting the Vet and Keeping a Pet Healthy: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 4.4 hands-on project and nature journal</li> <li>• Session 3: Unit 4 review and portfolio project</li> </ul> |
| <b>17</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 5.1 Plant Cells and Photosynthesis: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 5.1 hands-on project and nature journal</li> </ul>                                                                       |
| <b>18</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 5.2 Flowers and Pollination: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 5.2 hands-on project and nature journal</li> </ul>                                                                              |
| <b>19</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 5.3 How Seeds Travel: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 5.3 hands-on project and nature journal</li> </ul>                                                                                     |
| <b>20</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 5.4 How Plants Respond to Light and Gravity: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 5.4 hands-on project and nature journal</li> <li>• Session 3: Unit 5 review and portfolio project</li> </ul>    |
| <b>21</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 6.1 Cattle and the Four-Part Stomach: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 6.1 hands-on project and nature journal</li> </ul>                                                                     |
| <b>22</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 6.2 Pigs on the Farm: warm-up, video, teaching and picture study</li> <li>• Session 2: Lesson 6.2 hands-on project and nature journal</li> </ul>                                                                                     |
| <b>23</b> | <ul style="list-style-type: none"> <li>• Session 1: Lesson 6.3 Ducks, Turkeys and Showing Small Animals: warm-up, video, teaching and picture study</li> </ul>                                                                                                                                  |

| WEEK | PLAN                                                                                                                                                                                                                                                                                           |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|      | <ul style="list-style-type: none"> <li>Session 2: Lesson 6.3 hands-on project and nature journal</li> </ul>                                                                                                                                                                                    |
| 24   | <ul style="list-style-type: none"> <li>Session 1: Lesson 6.4 The Honeybee Colony Through the Year: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 6.4 hands-on project and nature journal</li> <li>Session 3: Unit 6 review and portfolio project</li> </ul>            |
| 25   | <ul style="list-style-type: none"> <li>Session 1: Lesson 7.1 A Seed-Starting Setup: Light, Warmth and Air: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 7.1 hands-on project and nature journal</li> </ul>                                                            |
| 26   | <ul style="list-style-type: none"> <li>Session 1: Lesson 7.2 Hardening Off and Transplanting: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 7.2 hands-on project and nature journal</li> </ul>                                                                         |
| 27   | <ul style="list-style-type: none"> <li>Session 1: Lesson 7.3 A Patio Container Garden and a Fair Exhibit: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 7.3 hands-on project and nature journal</li> </ul>                                                             |
| 28   | <ul style="list-style-type: none"> <li>Session 1: Lesson 7.4 Planting a Field: Rows, Tillage and Seed Drills: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 7.4 hands-on project and nature journal</li> <li>Session 3: Unit 7 review and portfolio project</li> </ul> |
| 29   | <ul style="list-style-type: none"> <li>Session 1: Lesson 8.1 Bacteria: Garden Helpers and Plant Diseases: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 8.1 hands-on project and nature journal</li> </ul>                                                             |
| 30   | <ul style="list-style-type: none"> <li>Session 1: Lesson 8.2 Fungi: Rust, Mildew and Damping Off: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 8.2 hands-on project and nature journal</li> </ul>                                                                     |
| 31   | <ul style="list-style-type: none"> <li>Session 1: Lesson 8.3 Pest Life Cycles: Squash Bugs and Japanese Beetles: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 8.3 hands-on project and nature journal</li> </ul>                                                      |
| 32   | <ul style="list-style-type: none"> <li>Session 1: Lesson 8.4 Plant Doctor: Nutrient, Pest or Disease?: warm-up, video, teaching and picture study</li> <li>Session 2: Lesson 8.4 hands-on project and nature journal</li> </ul>                                                                |

## MATERIALS

### **Nature journal (sketchbook or bound notebook)**

Used every week for drawings, logs, measurements and weather notes.

### **Colored pencils, a pencil, a ruler and a magnifying glass**

For close observation and labeled diagrams.

### **Outdoor thermometer (and a soil thermometer if you have one)**

For frost watch, soil temperature and seed starting.

### **Simple soil test kit (pH, and N-P-K if possible)**

Garden-center capsule kits work well. Unit 3; used again in Units 7 and 8.

### **Potting mix, seed-starting mix, and pots, cups or trays with drainage holes**

For seed starting, transplanting and the container garden.

### **Seeds: radish, lettuce, beans or peas, marigolds, a cover-crop mix (oats, crimson clover or winter rye), sunflowers and a few herbs**

Inexpensive packets. A small bag of wheat berries is used in Lesson 1.4.

### **Clear jars, zip bags, paper towels and a spray bottle**

For soil-settling jars, germination tests and mold watching.

### **Trowel, watering can and garden gloves**

Tool use is always with an adult nearby.

### **A shop light or LED grow light with a timer (optional)**

For the seed-starting station in Unit 7. A bright south window can substitute.

### **Large container (5 gallons or more) or a small raised bed**

For the patio container garden. A balcony or doorstep is fine.

### **Store-bought worm bin or a plastic tote (optional)**

For the earthworm lesson; a jar observation works too.

### **Access to a farm, 4-H fair, pet store, shelter or vet clinic (optional)**

For visits in Units 4 and 6. Library books and videos can substitute.

## GRADING

Grade 4 uses simple weights so that faithful work, careful observation and real understanding all count. Projects and journals are graded on effort, care and accuracy, not on whether a seed happened to sprout.

| 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 needs review and another try.

- A failed crop is not a failed grade. If seeds rot or a plant gets sick, grade the student on what was observed, recorded and learned, and let them try again.
- Unit reviews may be given orally. Accept answers in the student's own words when they show understanding.
- Grade the nature journal on regular, dated entries, careful drawings from life, labels and honest records, not on artistic talent.
- Use each portfolio rubric to talk through strengths and one thing to improve before assigning a score.

## A NOTE TO PARENTS

This course is meant to get your child's hands dirty and eyes open. You do not need to be a gardener or own animals. You only need to be willing to learn alongside your child, to let them try things that might not work, and to keep a few pots on a sunny windowsill. Many lessons are best done outdoors, so go out in every season and let the weather be part of the lesson.

We teach the natural world as God's creation, wonderfully made and given to us to tend. The course is plain and honest about how farm animals are raised for eggs, milk, wool and meat, but it never shows or describes the killing of animals, and it

treats predators and prey with restraint. Animal life cycles are described simply and modestly. Please preview videos if you wish; each one has been checked, and parent notes point out anything worth knowing. Above all, enjoy the slow, patient work of growing things together. “While the earth remaineth, seedtime and harvest ... shall not cease.”

## UNIT 1

# HARVEST AND THE SEASONS

Every gardener and farmer lives by the calendar God set in motion: “seedtime and harvest, and cold and heat.” In this unit you will learn to read that calendar for your own place. You will find your growing zone and your frost dates, the two most important days in a gardener’s year, and use them to plan a fall garden.

Then you will learn what wise gardeners do as summer ends. They sow cover crops to protect and feed the soil over winter, and they store the harvest so it lasts until spring. Finally you will follow the most important crop in history, wheat, from a golden field to a sack of flour, and grind some yourself.

### PREREQUISITES

- Can read a simple map and a calendar
- Can read a thermometer in degrees Fahrenheit
- Knows that plants need light, water, warmth and nutrients
- Has a nature journal and colored pencils

### MASTERY CHECKLIST

- ☐ I can explain what a hardiness zone is and find my own zone.
- ☐ I can find my average last spring frost and first fall frost dates and count the days between them.
- ☐ I can name cool-season crops that grow in fall and explain what a cover crop does for soil.
- ☐ I can explain how temperature, moisture and darkness keep stored vegetables fresh.
- ☐ I can name the three parts of a wheat kernel and tell how wheat becomes flour.

### LESSONS IN THIS UNIT

#### 1.1 Growing Zones and Frost Dates

2 sessions of 45 minutes

#### 1.2 The Fall Garden and Cover Crops

2 sessions of 45 minutes

#### 1.3 Root Cellars and Storing the Harvest

2 sessions of 45 minutes

#### 1.4 From Wheat to Flour

2 sessions of 45 minutes

# UNIT 1 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. 5 pts

What does a USDA hardiness zone tell a gardener?

2. 5 pts

What are your two frost dates, and what is your growing season?

3. 5 pts

Name two crops a light frost would kill and two that would survive it.

4. 5 pts

Give three ways a cover crop helps the soil over winter.

5. 5 pts

Why are clover and vetch especially good cover crops?

6. 5 pts

Why does cold storage keep a carrot fresh longer?

7. 5 pts

Which needs dry storage: carrots or onions? Which needs damp storage?

8. 5 pts

Why should you keep apples away from potatoes in storage?

9. 5 pts

Name the three parts of a wheat kernel. Which part is white flour made from?

10. 5 pts

In Bruegel's *The Harvesters*, what jobs are the workers doing by hand that a combine does today?

## ANSWER KEY

1. Which perennial plants can survive the winter there, based on the area's average coldest winter temperature.
2. My average last spring frost date and first fall frost date (student's own dates); the growing season is the number of frost-free days between them.
3. Killed: tomatoes, peppers, beans, squash, basil (any two). Survive: kale, spinach, lettuce, carrots, cabbage, peas (any two).
4. Any three: holds soil against erosion, adds organic matter when it rots, legumes add nitrogen, roots loosen soil, crowds out weeds, keeps nutrients from washing away.
5. They are legumes; bacteria in their root nodules take nitrogen from the air and leave it in the soil.
6. Cold slows the carrot's respiration, so it uses up its stored sugar and water more slowly.
7. Onions need cool, dry storage; carrots need cold, damp storage.
8. Apples give off ethylene gas, which makes potatoes sprout and spoil sooner.
9. Bran, germ and endosperm; white flour is mostly endosperm.
10. Cutting the wheat (reaping), and gathering it for threshing and cleaning; a combine cuts, threshes and winnows all at once.

## PORTFOLIO PIECE: MY GARDEN YEAR CALENDAR

Make a large, neat poster or two-page journal spread of your garden year. Show your hardiness zone, your frost dates and growing season, the weeks for sowing cool-season crops and a cover crop, when tender crops can go out, and a storage plan listing five crops and where you would keep each one in winter. Decorate it with small drawings from life of your own seedlings or stored vegetables.

| LOOK FOR              | WHAT IT MEANS                                                                                                         |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>Accurate dates</b> | Zone, both frost dates and the length of the growing season are correct for your town.                                |
| <b>Planting plan</b>  | Shows at least three cool-season and three warm-season crops placed in sensible weeks, plus a cover-crop sowing date. |
| <b>Storage plan</b>   | Five crops are each matched to the right storage conditions (cold and damp, cool and dry, or warm and dry).           |
| <b>Observation</b>    | Includes at least two careful drawings from life with labels.                                                         |
| <b>Craftsmanship</b>  | The calendar is neat, easy to read, titled, signed and dated.                                                         |

# 1.1 GROWING ZONES AND FROST DATES

## OBJECTIVES

- Explain what a USDA hardiness zone measures and find your own zone.
- Find your average last spring frost and first fall frost dates and count your growing season.
- Tell the difference between a light frost and a hard freeze, and name crops that can survive each.

**Warm-up.** Step outside or look out a window. In your journal, write the date, the time and three things you notice about the weather: the temperature (read a thermometer if you have one), the sky and the wind. Then answer: Do you think it could frost tonight? Why or why not?

## WATCH

### Frost Dates Explained - Garden Quickie Episode 20

The Ripe Tomato Farms · 3:48

<https://www.youtube.com/watch?v=EW01jeZGIQE>

## WHEN TO WATCH

After the core ideas. Listen for the two frost dates and what each one tells a gardener.

## BACKUP VIDEO

### How to PERFECTLY Time Your Fall Garden Planting

Epic Gardening · 10:59

<https://www.youtube.com/watch?v=ElmqmOOB-3Y>

On the second day, to see how a gardener counts backward from the first fall frost to plan a fall garden.

## KEY TERMS

### **hardiness zone**

An area on the USDA map grouped by its average coldest winter temperature. Each zone is 10 degrees Fahrenheit warmer than the one below it.

### **frost**

Ice crystals that form on plants and the ground when the air near the ground drops to 32 °F or colder.

**last spring frost date**

The average date of the last frost in spring for your area. After it, tender plants are usually safe outdoors.

**first fall frost date**

The average date of the first frost in fall. It marks the end of the season for tender plants.

**growing season**

The number of frost-free days between the last spring frost and the first fall frost.

**hard freeze**

A night when the temperature falls to about 28 °F or below for several hours, cold enough to kill most garden plants.

**CORE IDEAS**

Every place has its own weather pattern, and a wise gardener learns it. The United States Department of Agriculture (USDA) made a map that divides the country into **hardiness zones**. Your zone is based on the coldest temperature your area usually reaches each winter. Zone 3 in northern Minnesota can fall to -40 °F. Zone 9 in Florida rarely drops below 20 °F. Each zone is 10 degrees warmer than the one below it, and each is split into “a” and “b” halves.

Your zone tells you which **perennials**, plants that live for many years such as fruit trees, roses and asparagus, can survive your winters. A plant tag that says “Zones 4–8” means the plant should live through winter in those zones. But the zone does not tell you *when* to plant tomatoes or beans. For that you need your frost dates.

Your **last spring frost date** is the average day of the last frost in spring. Your **first fall frost date** is the average day of the first frost in autumn. These are averages, so a frost can still come a week or two later in spring or earlier in fall. The days between them are your **growing season**. A garden in Ohio might have about 180 frost-free days; a garden high in the mountains might have fewer than 100. You can find your dates from your state’s extension service or a frost-date chart for your town.

Not all cold is the same. A **light frost** (29 to 32 °F) kills tender plants such as tomatoes, peppers, squash, beans and basil, but hardy crops like kale, spinach, cabbage, carrots and lettuce shrug it off. In fact, a light frost makes kale and carrots taste sweeter, because the plants turn some starch into sugar, which works like antifreeze. A **hard freeze** (about 28 °F or colder) ends the season for most crops.

Gardeners use frost dates to plan. To time a fall crop, count backward from your first fall frost date: take the days to maturity on the seed packet and add about two weeks,

because plants grow more slowly as days get short and cool. Frost settles first in low spots and on clear, still nights, so watch the sky as well as the calendar. God promised that “cold and heat, and summer and winter” would not cease, and the faithful gardener plans by that rhythm.

## PICTURE STUDY



*The Magpie*, Claude Monet, 1868–1869 · Oil on canvas · Musée d'Orsay, Paris

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

Claude Monet painted this winter morning in the French countryside after a heavy snowfall. He worked outdoors in the cold so he could study how sunlight falls on snow. It shows the season when the garden rests.

### Look closely

- Find the magpie. Where is it sitting, and what color is it?
- Look at the shadows on the snow. Are they gray, or blue and violet?
- Notice which side of the fence the sun is shining on. From which direction is the light coming?
- Find the trees and hedges. Do they have any leaves? What does that tell you about the season?

### Talk about it

1. Would a tomato plant survive in this place right now? What about a garlic bulb buried under the snow?
2. A blanket of snow can actually protect plants and soil from the coldest air. Why do you think that is?
3. If this were your garden, about how many weeks might it be until the last spring frost?

## HANDS-ON PROJECT

### My Frost-Date Calendar and Frost Watch

You will find your zone and frost dates, make a calendar of your growing season, and keep a one-week frost watch with a thermometer.

#### You will need

- Nature journal
- A computer or library book with a USDA hardiness zone map and a frost-date chart (or your state extension service website)
- A wall calendar or a sheet of paper ruled into 12 months
- Colored pencils
- An outdoor thermometer

#### Steps

1. With a parent, look up your USDA **hardiness zone** using your zip code. Write it at the top of a fresh journal page.
2. Look up your average **last spring frost date** and **first fall frost date**. Write both down.
3. Count the days between them. This is your **growing season**. (Hint: count the days left in the first month, add the full months, then add the days in the last month.)
4. On your 12-month calendar, color the frost-free months green, the frosty months blue, and the two or three weeks around each frost date yellow for “watch out.”
5. Add three tender crops (such as tomatoes, beans and basil) in the green part only, and three hardy crops (such as kale, peas and spinach) that can start in the yellow weeks.
6. Hang the thermometer outdoors in the shade, about 4 or 5 feet off the ground, away from the house wall.
7. For seven days, read it each morning before breakfast and again after school. Record both temperatures and the sky (clear, cloudy, windy or still).

8. At the end of the week, circle the coldest morning. Was the sky clear or cloudy the night before?

#### **Tips**

- Keep your frost-date calendar in the front of your journal. You will use it all year, especially in Unit 7.
- If your thermometer reads 36 °F or lower on a clear, still evening, frost is possible by dawn. Gardeners cover tender plants with an old sheet on such nights.

#### **Check your work**

- ☐ I know my hardiness zone and both of my frost dates.
- ☐ I can count the days in my growing season.
- ☐ I kept a week of temperature records and noticed what kind of nights are coldest.

#### **NATURE JOURNAL**

1. Draw a small map of your state and shade your hardiness zone. Label your town.
2. Make a line graph of your seven morning temperatures. Draw a dashed line across at 32 °F.
3. On a frosty morning, look at frost on a leaf, a car window or a blade of grass with a magnifying glass. Draw the ice crystals you see.

**From history.** Thomas Jefferson kept a *Garden Book* for nearly sixty years at Monticello. He recorded when he planted each crop, when the first peas came to table, and when frost came. Careful records like his helped later gardeners learn the seasons of Virginia.

#### **COMMON MISTAKES**

- Thinking the frost date is a promise. It is an average; a frost can still come after it, so watch the weather forecast too.
- Using the hardiness zone to decide when to plant vegetables. Zones are for winter survival of perennials; frost dates are for planting times.
- Hanging the thermometer in direct sun or against a warm wall, which makes the readings too high.

**Make it a game • Frost Date Forecaster.** Draw a twelve-month strip on paper and mark your last spring frost and first fall frost with two buttons. Parent names a crop; you slide a button-chip to the month it can safely go outside. Then count your growing season aloud, month by month. Beat your own count for correct crops in two minutes.

**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 their order. Frost dates work because God’s world is faithful and dependable.

## 1.2 THE FALL GARDEN AND COVER CROPS

### OBJECTIVES

- Name cool-season crops that grow well in fall and explain why they can handle cold.
- Explain four ways a cover crop helps the soil over winter.
- Sow a cover crop and a fall crop in a bed or a large pot.

**Warm-up.** Look at a bare patch of soil (in a yard, a park, a planter or a field you pass) after a rain. In your journal, describe what you see. Is the soil crusted, washed into little channels, or splashed onto nearby things? Now look at a patch covered with grass or plants. How is it different?

### WATCH

#### Cover Cropping: The LAZIEST Way to Improve Your Soil

Epic Gardening · 7:17

<https://www.youtube.com/watch?v=tgYJDI6hpw0>

#### WHEN TO WATCH

After the core ideas and before the project. Watch how the seed is scattered and lightly covered.

**Note:** The gardener names the seed company he bought from; you can use any cover-crop seed.

### BACKUP VIDEO

#### Which Cover Crop Is BEST For Your Garden & Why

Mlgardener · 11:49

<https://www.youtube.com/watch?v=FPx4L1oKkM8>

On the second day, to compare grains and legumes as cover crops.

### KEY TERMS

#### **cool-season crop**

A vegetable that grows best in cool weather and can stand light frost, such as lettuce, spinach, kale, radishes, peas and carrots.

#### **cover crop**

A crop grown to protect and improve the soil rather than to eat, such as winter rye, oats or clover.

**green manure**

A cover crop that is cut down and left on or mixed into the soil so it rots and feeds the soil.

**erosion**

The wearing away of soil by rain, running water or wind.

**legume**

A plant in the pea and bean family. Legumes such as clover and vetch work with soil bacteria to add nitrogen to the soil.

**CORE IDEAS**

Many gardeners stop in September, but late summer is the start of a second season. **Cool-season crops** such as lettuce, spinach, kale, radishes, turnips, carrots and peas grow happily in the short, cool days of fall. Garlic cloves are planted in fall to sprout roots before winter and grow on in spring. Fall crops have fewer insect pests, and many taste sweeter after a light frost.

In fall, bare soil is in danger. Rain beats on it and carries the finest, richest soil away in muddy streams. This is **erosion**. Winter wind can blow dry soil away. Nutrients wash down past the reach of roots. Bare soil also invites weeds to move in first in spring. God made soil to be covered, as it always is in a pasture or a forest.

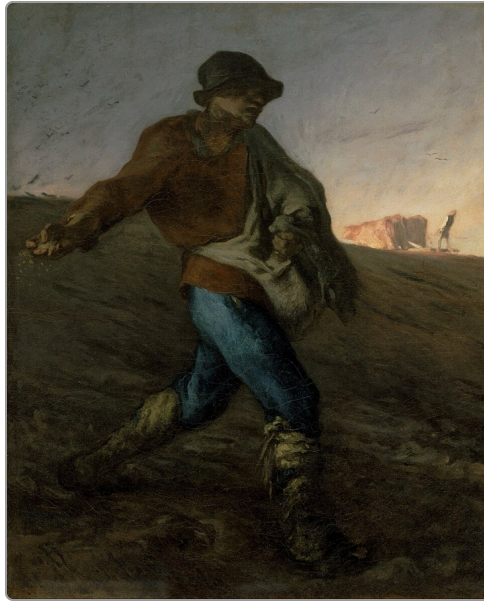
A **cover crop** is a crop planted to protect and feed the soil. Grains like **winter rye** and **oats** grow thick roots that hold soil in place and loosen hard ground. **Legumes** like crimson clover and hairy vetch carry tiny bacteria in bumps on their roots that take nitrogen from the air and leave it in the soil for next year's crops. Many gardeners sow a mix of a grain and a legume.

Timing matters. Sow most cover crops about four to six weeks before your first fall frost so they can grow roots before the cold. Winter rye is the toughest and can be sown later. Oats usually die in a cold winter and lie flat like a mulch, which makes spring easy. Rye and clover live through winter and start growing again in spring.

In spring, about two or three weeks before planting, the gardener cuts the cover crop down and leaves it on the surface or turns it lightly into the soil. As it rots, it becomes **green manure**, feeding earthworms, fungi and bacteria and adding organic

matter. A cover crop is a gift to next year's garden, a way of giving back to the soil that fed you.

#### PICTURE STUDY



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

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

Jean-François Millet grew up on a farm in Normandy, France, and painted the hard, faithful work of farm families. Here a sower scatters grain on a field in autumn, the same season you will sow your cover crop.

#### Look closely

- Watch the sower's right arm. Can you see the seed flying from his hand?
- Find the seed bag. How is it tied to his body so both hands are not needed to hold it?
- Look for the birds near the top of the field. Why might birds follow a sower?
- Find the second farmer and his oxen on the hilltop. What job might they be doing?

#### Talk about it

1. This farmer sows by hand. How do you think he gets the seed spread evenly?
2. Why must seed be covered with a little soil after it is scattered?
3. Jesus told a parable about a sower whose seed fell on different kinds of ground. What kind of ground would this sower want?

**Safety first.** Wear gloves when clearing old plants, and keep rakes and forks pointed down when not in use. Wash hands after working in soil.

## HANDS-ON PROJECT

### Sow a Fall Bed with a Cover Crop

You will plant a small fall crop and sow a cover crop beside it, then watch both grow as the weather cools.

#### You will need

- A garden bed, a 3-by-3-foot patch, or two large pots (at least 10 inches wide) of potting mix
- Cover-crop seed: oats, winter rye or crimson clover (a small bag or a handful)
- A packet of radish or lettuce seed
- A garden rake or hand fork
- Watering can
- Ruler and plant labels
- Gloves

#### Steps

1. Check your frost-date calendar. Count the weeks until your first fall frost and write the number in your journal.
2. Pull weeds and old plants from your patch or pot. Loosen the top 2 inches of soil with a rake or hand fork.
3. Divide the space in half with a stick or string. One half is for food, the other for the cover crop.
4. In the food half, sow radish or lettuce seed in a short row about  $\frac{1}{4}$  inch deep, following the seed packet. Label it.
5. In the cover-crop half, scatter the seed evenly by hand, the way Millet's sower does, about one seed every inch or so.
6. Rake or pat the soil lightly so the seeds are just covered, about  $\frac{1}{2}$  inch deep for oats and rye,  $\frac{1}{4}$  inch for clover.
7. Water gently until the soil is damp but not puddled. Keep it moist until the seeds sprout.

8. Each week, measure the tallest cover-crop plant and the radish leaves. Record the height, the morning temperature and what you did, and note the cost of your seed, the way a 4-H project book does.

#### **Tips**

- If you only have pots, sow oats in one pot and radishes in another, and set them side by side on a porch or balcony.
- Birds love cover-crop seed. A light layer of straw or an old window screen over the bed for a week helps.

#### **Check your work**

- ☐ I can name three cool-season crops.
- ☐ I can explain how a cover crop protects soil from erosion and feeds it.
- ☐ I sowed a cover crop and am recording its growth.

#### **NATURE JOURNAL**

1. Draw one oat or rye seedling and one radish seedling side by side, life-size, with their first leaves. How are the leaves different?
2. After a rain, compare your cover-crop patch with a bare patch of soil. Draw and describe both.
3. Keep a weekly growth table: date, temperature, height of cover crop, height of radish.

**From history.** George Washington Carver, a Christian and a scientist at Tuskegee Institute in Alabama, saw that years of growing only cotton had worn out the soil of the South. He taught farmers to rotate their fields with peanuts, cowpeas and sweet potatoes, legumes and other crops that rebuilt the soil. He traveled with a wagon called a “movable school” to show farmers how.

#### **COMMON MISTAKES**

- Sowing a cover crop too late, so it never grows enough roots before winter.
- Burying cover-crop seed too deep. Most small seeds need only a light covering.
- Forgetting to water. Fall can be dry, and seeds still need moisture to sprout.

**Make it a game • Cold-Hardy Crop Sprint.** Set a timer for sixty seconds and name every cool-season crop you can that handles fall cold, such as kale or spinach. Parent keeps tally with beans. Next round, tell four ways a cover crop helps winter soil, one bean each. Try to beat your high score of cold-lovers and cover-crop jobs.

## 1.3 ROOT CELLARS AND STORING THE HARVEST

### OBJECTIVES

- Explain how cold, moisture, darkness and air keep stored vegetables fresh.
- Sort common crops into groups that need cold-and-damp, cool-and-dry, or warm-and-dry storage.
- Set up a storage experiment and record what happens over two weeks.

**Warm-up.** Open your refrigerator's crisper drawer and your pantry with a parent. List three foods kept in each place. Why do you think people keep carrots in the refrigerator but onions and potatoes in a cupboard?

### WATCH

#### The Best Way to Store Root Vegetables

GrowVeg • 8:07

<https://www.youtube.com/watch?v=k7rk-ViwAtE>

### WHEN TO WATCH

After the core ideas. Pause when the carrots are packed in damp material and explain why it keeps them crisp.

### BACKUP VIDEO

#### Storing Potatoes After Harvest Garden Quickie Episode 91

The Ripe Tomato Farms • 3:05

[https://www.youtube.com/watch?v=j\\_AtKRLj4c4](https://www.youtube.com/watch?v=j_AtKRLj4c4)

Before the project, to see how potatoes are cured and stored.

### KEY TERMS

#### **root cellar**

An underground or partly buried room that stays cool, dark and damp all winter, used to store vegetables and fruit.

#### **humidity**

The amount of moisture in the air. Root vegetables keep best when the air is damp.

**curing**

Letting a crop rest for a time after harvest so its skin toughens and small wounds heal before storage.

**respiration**

The slow “breathing” of living vegetables after harvest. They use up stored sugars and give off heat and moisture.

**ethylene**

A gas given off by ripening fruit such as apples. It makes nearby produce ripen, sprout or spoil faster.

**CORE IDEAS**

A carrot pulled from the garden is still alive. Its cells keep **respiring**, slowly using up the sugar stored inside. Warmth speeds this up, so a warm carrot goes limp and bitter in days. Cold slows it down. That is the first secret of storage: keep most crops cool, just above freezing.

Before refrigerators, families dug a **root cellar**, a room under the house or built into a hillside. A few feet down, the earth stays cool and steady all winter, about 32 to 40 °F, and the air stays damp. Root vegetables like carrots, beets, turnips and parsnips, and cabbages too, keep for months in this cold, moist air. They are often packed in boxes of damp sand, sawdust or leaves so they do not dry out.

Not every crop wants the same thing. **Potatoes** want cool (about 40 °F), dark and humid, but not colder, or their starch turns to sugar and they taste sweet. Light turns potato skins green, and the green parts should not be eaten. **Onions and garlic** want cool and *dry* air, or they sprout and rot. **Winter squash and pumpkins** want warmer, dry air, about 50 to 55 °F, like a spare room or closet.

Many crops need **curing** first. Potatoes rest in a dark, cool, humid spot for about two weeks so their skins toughen. Onions and garlic dry in the shade with good air flow until their necks are papery. Winter squash cures in the warm sun or a warm room for a week or two. Only perfect, unbruised vegetables should go into storage, because one rotting potato can spoil the box.

Finally, keep apples away from potatoes and carrots. Ripening apples give off **ethylene** gas, which makes potatoes sprout and carrots bitter. Check stored food every week and remove anything soft. A full cellar in January is the reward of

a diligent summer, as Proverbs says of the ant, which “provideth her meat in the summer.”

## PICTURE STUDY



*The Potato Eaters*, Vincent van Gogh, 1885 · Oil on canvas · Van Gogh Museum, Amsterdam

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

Vincent van Gogh lived among farm families in the Netherlands and wanted to show their honest life. This family is eating potatoes they grew and stored themselves, by lamplight after a day of work.

### Look closely

- Find the plate of potatoes. Can you see steam rising from them?
- Look at the hands of the family. What do they tell you about their daily work?
- Find the lamp. Where does the light fall brightest, and where is it dark?
- Look for things in the room that show it is a simple farm cottage.

### Talk about it

1. The painting shows winter evening light. Where do you think this family kept their potatoes until now?
2. Potatoes were a main food for many farm families for months. Why is good storage so important for them?
3. Van Gogh wrote that he wanted to show that these people had worked the soil with the very hands they now put in the dish. What do you think he meant?

**Safety first.** Do not eat potatoes that have turned green or are sprouting heavily; cut away green parts or throw them out. Ask an adult before storing food in a garage or basement.

## HANDS-ON PROJECT

### The Great Carrot Storage Test

You will test three ways of storing carrots and find out which keeps them crisp longest. You will also set up a proper storage spot for potatoes or onions.

#### You will need

- 9 fresh carrots with tops cut off (garden or store-bought)
- A small box or tub of slightly damp sand, peat-free potting mix or sawdust
- A plastic bag and a bowl
- A refrigerator
- A cool, dark place for potatoes or onions (a closet floor, basement or garage that stays above freezing)
- A paper bag or basket
- Journal and ruler

#### Steps

1. Number your carrots 1 to 9 and weigh or measure each one. Record their size and how firm they feel (snap test on a spare carrot: it should snap crisply).
2. **Method A:** Put 3 carrots in an open bowl on the kitchen counter.
3. **Method B:** Put 3 carrots in a bowl in the refrigerator with no covering.
4. **Method C:** Bury 3 carrots so they do not touch each other in the tub of damp sand or sawdust, and put the tub in the refrigerator or a cold garage that stays above freezing.
5. Write a prediction: which method will keep carrots crisp the longest, and why?
6. Every three days for two weeks, check one carrot from each method. Bend it gently. Is it crisp, bendy or soft? Record what you find.
7. Put a few potatoes or onions in a paper bag or basket in your cool, dark spot. Keep them away from apples.
8. At the end of two weeks, write a short report: which method won, and how it matches what you learned about cold and moisture.

### Tips

- The sand should feel like a wrung-out sponge, not wet. Too wet and carrots rot; too dry and they shrivel.
- Real root cellars keep carrots this way all winter, so your winner can stay in the sand and be eaten later.
- Many county fairs have a youth vegetable class for potatoes, onions or carrots. A plate of matched, well-cured potatoes, brushed clean but never washed, is exactly what the judges look for. Check your county extension office or fair book.

### Check your work

- ☐ I can explain why cold and damp keep carrots crisp.
- ☐ I can name a crop that needs dry storage and one that needs damp storage.
- ☐ I tested three methods and recorded my results honestly.

### NATURE JOURNAL

1. Draw a cutaway diagram of a root cellar dug into a hillside. Label the door, shelves, vent, bins of sand, and the thermometer.
2. Make a three-column chart titled “Cold and Damp,” “Cool and Dry” and “Warm and Dry.” Sort ten crops into it.
3. Draw your three test carrots on the last day, side by side. Show any wrinkles or soft spots.

**From history.** Early American farm families depended on root cellars to eat through the winter. Many dug them into the side of a hill with a stone front wall and a sod roof. Some farms also had a springhouse, a small building over a cold spring, where milk and butter stayed cool in the running water.

### COMMON MISTAKES

- Storing apples next to potatoes, which makes the potatoes sprout.
- Washing root crops before storage. Brush off dirt instead; wet vegetables rot faster.
- Storing bruised or cut vegetables. Eat those first and store only the best.

**Make it a game • Cellar Sorting Shuffle.** Write twelve crops on scraps of paper. Make three floor zones with towels: cold-and-damp, cool-and-dry, warm-and-dry. Parent calls the clock and you place each scrap, saying why: humidity, curing, or ethylene. Parent secretly moves one scrap to the wrong zone. Catch it and explain what would go wrong in storage.

## 1.4 FROM WHEAT TO FLOUR

### OBJECTIVES

- Describe the life of a wheat plant from fall sowing to summer harvest.
- Name the three parts of a wheat kernel and what each becomes.
- Grind wheat into flour by hand and compare whole-wheat and sifted flour.

**Warm-up.** Look at the ingredients list on three foods in your kitchen, such as bread, crackers and pasta. Circle or list each one that contains wheat or flour. How many of your family's foods start in a wheat field?

### WATCH

#### Baked Bread: how flour is made

Eat Happy Project • 2:49

<https://www.youtube.com/watch?v=y8vLjPctrCU>

#### WHEN TO WATCH

After the core ideas. Watch for the combine harvester and the three parts of the grain.

**Note:** This short video was made in England, where wheat harvest comes in August.

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### BACKUP VIDEO

#### The Journey of Wheat - from Field to Table

Kansas Wheat • 4:58

<https://www.youtube.com/watch?v=3ihTep7zMNI>

On the second day, to see American wheat fields, the six classes of wheat, and a modern flour mill.

### KEY TERMS

#### **kernel**

A single seed of wheat or another grain, also called a wheat berry.

#### **bran**

The tough brown outer layer of the kernel, full of fiber.

**germ**

The tiny part of the kernel that would grow into a new plant. It is rich in oil and vitamins.

**endosperm**

The large starchy center of the kernel, food for the young plant. White flour is ground endosperm.

**threshing**

Knocking or rubbing the kernels loose from the heads of grain.

**winnowing**

Using moving air to blow away the light chaff and leave the heavier grain.

**CORE IDEAS**

Wheat is a grass. In much of the United States, farmers plant **winter wheat** in early fall. The seedlings grow a few inches, rest under winter snow, then shoot up in spring. By early summer the plants stand waist-high with heads full of kernels, and the green field turns gold. In colder northern states farmers plant **spring wheat** in spring and harvest it in late summer.

Each **kernel** is a seed with three parts. The **bran** is the brown outer coat. The **germ** is the tiny embryo that would sprout into a new plant. The **endosperm** is the starchy food packed around it, made by the parent plant from sunlight. Whole-wheat flour is all three ground together. White flour is mostly the endosperm, with the bran and germ sifted away.

For thousands of years, wheat was harvested by hand. Reapers cut the stalks with a sickle or scythe and tied them into bundles called sheaves. Then came **threshing**: beating the heads with a jointed stick called a flail to knock the kernels loose. Then **winnowing**: tossing the grain in the wind so the light chaff blew away and the heavy kernels fell back. Today a **combine** does all three jobs at once as it drives across the field: it cuts, threshes and cleans.

At the mill, the grain is cleaned and then ground between rollers (or, in the old days, between two great millstones turned by water or wind). The flour is sifted through fine screens. A family once took its own grain to the village mill and paid the miller with a share of the flour.

Bread is one of the oldest and most important foods in the world. Jesus called Himself “the bread of life,” and taught us to pray, “Give us this day our daily bread.” When you eat a sandwich, you are eating the work of a farmer, a miller and a baker, and the gift of God who sends the rain.

## 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 the months of the farm year for a wealthy merchant in Antwerp. This is the wheat harvest in late summer, about 450 years ago. It shows every step of harvest by hand.

### Look closely

- Find the workers cutting wheat with long curved scythes. How tall is the wheat compared with them?
- Find the sheaves, the tied bundles of wheat standing in the field. How are they stacked?
- Look for the workers resting under the tree. What are they eating and drinking from?
- Find a person carrying sheaves along the path and a wagon loaded with grain in the distance.

### Talk about it

1. How can you tell this wheat is ripe and ready to harvest?
2. What jobs in this picture does a modern combine do all at once?
3. Why do you think harvest was a time when the whole village worked together?

**Safety first.** An adult operates the coffee grinder or grain mill and the stove. Anyone with a wheat allergy should not handle flour; use oats or corn for the activity instead.

## HANDS-ON PROJECT

### Grind Your Own Flour

You will thresh, winnow and grind wheat by hand, then sift it to see the bran and the white endosperm. You will also sprout a few kernels to see that each one is alive.

#### You will need

- ½ cup of wheat berries (hard red or white, from a grocery or health-food store)
- A few heads of dried wheat or grass seed heads if you can find them (optional)
- A clean pillowcase or paper bag and a rolling pin (for threshing)
- A shallow bowl or tray and a small fan or your breath (for winnowing)
- A clean coffee grinder, hand grain mill, or a mortar and pestle
- A fine mesh strainer
- Two small dishes, a magnifying glass, a clear cup and a damp paper towel

#### Steps

1. If you have wheat heads, put them in a pillowcase and roll or gently beat them to **thresh** out the kernels.
2. Pour your grain into a tray outdoors and blow gently across it, or use a fan on low. Watch the light chaff fly and the kernels stay. That is **winnowing**.
3. Look at one kernel with a magnifying glass. Find the crease and the tiny germ at one end. Draw it.
4. Put 10 kernels on a damp paper towel in a clear cup. Check each day for three days and record when they sprout.
5. With an adult, grind 2 tablespoons of wheat berries in the coffee grinder or hand mill until fine, or pound them in a mortar for several minutes.
6. Pour your flour through the fine strainer into a dish. The white powder that falls through is mostly **endosperm**. The flakes left in the strainer are **bran** (with some germ).

7. Compare your sifted flour, your bran and some store-bought white flour side by side. Rub each between your fingers and record the color and feel.
8. If you like, mix your whole flour with a little water and salt and, with an adult, cook small flat cakes in a dry pan.

#### **Tips**

- Grinding by hand is slow work. Count how long it takes to make 2 tablespoons, and imagine making enough for a family's bread every day.
- Try to keep the kernels you sprout. In a pot on a sunny windowsill they will grow into little wheat grass plants.

#### **Check your work**

- ☐ I can name the bran, germ and endosperm.
- ☐ I can explain threshing and winnowing.
- ☐ I ground my own flour and can tell the difference between whole-wheat and white flour.

#### **NATURE JOURNAL**

1. Draw a large labeled diagram of a wheat kernel cut in half: bran, germ, endosperm.
2. Draw the path of wheat as a comic strip of six boxes: sowing, growing, harvesting, threshing, milling, baking.
3. Draw your sprouted wheat kernels on day 3. Which grew first, the root or the shoot?

**From history.** In 1831 a young Virginia farmer named Cyrus McCormick showed a horse-drawn reaper that could cut wheat as fast as several men with scythes. Later machines also threshed the grain, and today's combine harvesters grew from these inventions. They let fewer farmers grow far more food.

#### **COMMON MISTAKES**

- Thinking white flour is a different plant from whole-wheat flour. Both come from the same kernels; white flour has the bran and germ removed.
- Calling the wheat stalk the grain. The grain is the kernel in the head; the stalk becomes straw.
- Grinding too much at once in a small grinder, which overheats it.

**Make it a game • Kernel Quiz Show.** Draw a big wheat kernel and label bran, germ and endosperm from memory, then cover it. Parent plays a game-show host and asks what each part becomes, how wheat grows from fall sowing to summer, and the difference between threshing and winnowing. Each right answer earns a bean. Reach ten beans to win the loaf.

**Scripture.** “He causeth the grass to grow for the cattle, and herb for the service of man: that he may bring forth food out of the earth;” (Psalms 104:14, KJV)

Wheat is a grass that God made to feed people. Every loaf of bread is food He brings “out of the earth” through the work of farmers.

## UNIT 1

# HARVEST AND THE SEASONS

Every gardener and farmer lives by the calendar God set in motion: “seedtime and harvest, and cold and heat.” In this unit you will learn to read that calendar for your own place. You will find your growing zone and your frost dates, the two most important days in a gardener’s year, and use them to plan a fall garden.

Then you will learn what wise gardeners do as summer ends. They sow cover crops to protect and feed the soil over winter, and they store the harvest so it lasts until spring. Finally you will follow the most important crop in history, wheat, from a golden field to a sack of flour, and grind some yourself.

### PREREQUISITES

- Can read a simple map and a calendar
- Can read a thermometer in degrees Fahrenheit
- Knows that plants need light, water, warmth and nutrients
- Has a nature journal and colored pencils

### MASTERY CHECKLIST

- ☐ I can explain what a hardiness zone is and find my own zone.
- ☐ I can find my average last spring frost and first fall frost dates and count the days between them.
- ☐ I can name cool-season crops that grow in fall and explain what a cover crop does for soil.
- ☐ I can explain how temperature, moisture and darkness keep stored vegetables fresh.
- ☐ I can name the three parts of a wheat kernel and tell how wheat becomes flour.

### LESSONS IN THIS UNIT

#### 1.1 Growing Zones and Frost Dates

2 sessions of 45 minutes

#### 1.2 The Fall Garden and Cover Crops

2 sessions of 45 minutes

#### 1.3 Root Cellars and Storing the Harvest

2 sessions of 45 minutes

#### 1.4 From Wheat to Flour

2 sessions of 45 minutes

# UNIT 1 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. 5 pts

What does a USDA hardiness zone tell a gardener?

2. 5 pts

What are your two frost dates, and what is your growing season?

3. 5 pts

Name two crops a light frost would kill and two that would survive it.

4. 5 pts

Give three ways a cover crop helps the soil over winter.

5. 5 pts

Why are clover and vetch especially good cover crops?

6. 5 pts

Why does cold storage keep a carrot fresh longer?

7. 5 pts

Which needs dry storage: carrots or onions? Which needs damp storage?

8. 5 pts

Why should you keep apples away from potatoes in storage?

9. 5 pts

Name the three parts of a wheat kernel. Which part is white flour made from?

10. 5 pts

In Bruegel's *The Harvesters*, what jobs are the workers doing by hand that a combine does today?

## ANSWER KEY

1. Which perennial plants can survive the winter there, based on the area's average coldest winter temperature.
2. My average last spring frost date and first fall frost date (student's own dates); the growing season is the number of frost-free days between them.
3. Killed: tomatoes, peppers, beans, squash, basil (any two). Survive: kale, spinach, lettuce, carrots, cabbage, peas (any two).
4. Any three: holds soil against erosion, adds organic matter when it rots, legumes add nitrogen, roots loosen soil, crowds out weeds, keeps nutrients from washing away.
5. They are legumes; bacteria in their root nodules take nitrogen from the air and leave it in the soil.
6. Cold slows the carrot's respiration, so it uses up its stored sugar and water more slowly.
7. Onions need cool, dry storage; carrots need cold, damp storage.
8. Apples give off ethylene gas, which makes potatoes sprout and spoil sooner.
9. Bran, germ and endosperm; white flour is mostly endosperm.
10. Cutting the wheat (reaping), and gathering it for threshing and cleaning; a combine cuts, threshes and winnows all at once.

## PORTFOLIO PIECE: MY GARDEN YEAR CALENDAR

Make a large, neat poster or two-page journal spread of your garden year. Show your hardiness zone, your frost dates and growing season, the weeks for sowing cool-season crops and a cover crop, when tender crops can go out, and a storage plan listing five crops and where you would keep each one in winter. Decorate it with small drawings from life of your own seedlings or stored vegetables.

| LOOK FOR              | WHAT IT MEANS                                                                                                         |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| <b>Accurate dates</b> | Zone, both frost dates and the length of the growing season are correct for your town.                                |
| <b>Planting plan</b>  | Shows at least three cool-season and three warm-season crops placed in sensible weeks, plus a cover-crop sowing date. |
| <b>Storage plan</b>   | Five crops are each matched to the right storage conditions (cold and damp, cool and dry, or warm and dry).           |
| <b>Observation</b>    | Includes at least two careful drawings from life with labels.                                                         |
| <b>Craftsmanship</b>  | The calendar is neat, easy to read, titled, signed and dated.                                                         |

## UNIT 2

# WILDLIFE IN THE BACKYARD FOOD WEB

Your yard, park or neighborhood is full of wild neighbors, even if you rarely see them. In this unit you will learn how they fit together in a **food web**: plants that capture sunlight, the animals that eat plants, the predators that eat them, and the decomposers that return everything to the soil.

You will meet the hunters of the neighborhood, coyotes, foxes, hawks and owls, and the night visitors, raccoons, skunks, opossums and bats. You will learn the most important safety rule of wildlife study: watch from a distance and never touch. Finally you will learn fair, humane ways to keep deer, rabbits and squirrels from eating your garden.

### PREREQUISITES

- Knows that animals need food, water and shelter
- Can sort animals into plant-eaters and meat-eaters
- Has finished Unit 1 or knows the season and frost dates for home

### MASTERY CHECKLIST

- ☐ I can draw a backyard food web with producers, consumers and decomposers.
- ☐ I can describe how coyotes, foxes, hawks and owls are built for hunting.
- ☐ I can name animals that can carry rabies and explain what to do if I see a wild animal acting strangely.
- ☐ I can tell deer, rabbit and squirrel damage apart and choose a fair way to protect plants from each.
- ☐ I watch wild animals from a safe distance and never feed or touch them.

### LESSONS IN THIS UNIT

#### 2.1 The Backyard Food Web

2 sessions of 45 minutes

#### 2.2 Predators: Coyotes, Foxes, Hawks and Owls

2 sessions of 45 minutes

#### 2.3 Night Visitors and Rabies Safety

2 sessions of 45 minutes

## UNIT 2 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. 5 pts

What is a producer? Give two examples from your yard.

2. 5 pts

Write a food chain with four links that ends with a hawk or an owl.

3. 5 pts

What do decomposers do, and why are they important?

4. 5 pts

Why are there many more mice than hawks in a grassy field?

5. 5 pts

Name two features that help an owl hunt at night.

6. 5 pts

Give two ways to protect a flock of hens from predators.

7. 5 pts

Which four kinds of wild animals most often carry rabies in the United States?

8. 5 pts

You see a raccoon wandering in the middle of the day, stumbling and acting tame. What should you do?

9. 5 pts

How can you tell rabbit damage from deer damage?

10. 5 pts

Why must a deer fence be about 8 feet tall, while a rabbit fence can be about 2 feet?

**ANSWER KEY**

1. A living thing that makes its own food from sunlight, such as grass, clover, trees or garden plants.
2. Example: grass seeds → mouse → snake → hawk, or clover → rabbit → fox... any sensible chain beginning with a plant.
3. They break down dead plants, animals and wastes into nutrients that return to the soil and feed plants again.
4. Only a small part of the energy passes up each step of the food chain, so there is less energy to support animals higher up.
5. Any two: facial disc that gathers sound, ears at different heights, soft fringed feathers for silent flight, large forward-facing eyes, sharp talons.
6. Lock them in a predator-proof coop at night, cover the run with wire, use hardware cloth, close the door at dusk, keep watch (any two).
7. Raccoons, skunks, bats and foxes.
8. Stay far away, do not touch or feed it, go inside and tell an adult, who can call animal control.
9. Rabbits snip stems cleanly at an angle close to the ground; deer tear plants leaving ragged edges, often higher up.
10. Deer can jump about 8 feet high; rabbits cannot jump high but can dig, so a rabbit fence is short but buried or bent outward at the bottom.

## PORTFOLIO PIECE: A WILDLIFE FIELD GUIDE TO MY NEIGHBORHOOD

Make a small field guide (a booklet or a section of your journal) of at least eight wild animals that live near your home. For each, include a careful drawing, its tracks or signs, what it eats, its place in the food web, and a safety or garden note. Finish with a full-page food web connecting all of them and a “Look, Don’t Touch” safety page.

| LOOK FOR                      | WHAT IT MEANS                                                                                                        |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------|
| <b>Observation</b>            | At least four entries include signs, tracks or sightings you found yourself, with dates.                             |
| <b>Accuracy</b>               | Foods, habits, tracks and rabies notes are correct for each animal.                                                  |
| <b>Food web</b>               | The final web connects every animal with arrows pointing from food to eater, and includes producers and decomposers. |
| <b>Safety and stewardship</b> | Includes clear safety rules and at least two humane ways to protect gardens or flocks.                               |
| <b>Craftsmanship</b>          | Drawings are careful and labeled; the guide is neat, titled and signed.                                              |

## 2.1 THE BACKYARD FOOD WEB

### OBJECTIVES

- Define producer, consumer and decomposer and give backyard examples of each.
- Explain how energy from the sun passes along a food chain.
- Build a food web from your own backyard observations.

**Warm-up.** Write the heading “Who eats whom?” Then list everything you ate yesterday. Next to each food, write whether it came from a plant or an animal. For each animal food, write what that animal ate. Does every line end with a plant?

### WATCH

#### The Food Chain for Kids | Producers, Consumers, and Decomposers

Homeschool Pop • 10:48

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

### WHEN TO WATCH

After the warm-up and before the core ideas. Pause at each new word and write it in your journal.

### KEY TERMS

#### **producer**

A living thing that makes its own food from sunlight. Green plants are producers.

#### **herbivore**

An animal that eats only plants, such as a rabbit, deer or grasshopper.

#### **decomposer**

A living thing such as a fungus, bacterium or earthworm that breaks down dead plants and animals and returns nutrients to the soil.

#### **consumer**

An animal that gets energy by eating plants or other animals.

#### **predator**

An animal that hunts and eats other animals. The animal it eats is its prey.

#### **food web**

All the food chains in one place, linked together because most animals eat, and are eaten by, more than one kind of living thing.

## CORE IDEAS

Every living thing needs energy, and nearly all of it on earth starts with the sun. Green plants are **producers**: their leaves catch sunlight and use it to make sugar from air and water. Grass, clover, oak trees, garden lettuce and dandelions are all producers. God told Adam that He had given “every green herb for meat” to the beasts and birds (Genesis 1:30).

Animals cannot make their own food, so they are **consumers**. A rabbit eating clover is a **herbivore**, or plant-eater. A red fox eating the rabbit is a **carnivore**, or meat-eater, and a **predator**. Many backyard animals are **omnivores** that eat both plants and animals: raccoons, opossums, skunks, robins and even foxes, which love berries in summer.

A **food chain** shows one path of energy: clover → rabbit → fox. But real animals eat many things. A hawk eats mice, voles, squirrels and snakes. A mouse eats seeds, berries and insects. When you draw all the chains at once, they cross and connect into a **food web**. If one strand weakens, others are affected. If owls and hawks disappeared from a farm, mice would multiply and eat much more grain.

Only a small part of the energy in each step passes on to the next, because animals use most of it to move, keep warm and grow. That is why a grassy field has thousands of grasshoppers, a good number of mice, but only a few hawks. There are always far more plants than plant-eaters, and far more plant-eaters than predators.

At the end of every chain wait the **decomposers**: fungi, bacteria, earthworms, pill bugs and beetles. They break down fallen leaves, dead plants and animal droppings into nutrients that feed the soil, and the soil feeds the plants again. Nothing is wasted in God’s design. A gardener who makes compost is joining in the decomposers’ work.

## PICTURE STUDY



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

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

More than five hundred years ago, the German artist Albrecht Dürer lay down close to the ground and painted a single clump of field plants. Most people would walk past it. He saw a whole little world. This is where every food web begins: with plants.

### Look closely

- Find the dandelions. Can you see their flowers, buds and long jagged leaves?
- Find the wide, flat leaves of plantain near the bottom and the feathery leaves of yarrow.
- Look at the dark, damp soil at the bottom. What living things might be hiding in it?
- Count how many different kinds of plants you can tell apart.

### Talk about it

1. Which animals in your neighborhood might eat the plants in this picture?
2. What would eat those animals? Make a food chain that starts with one of these plants.
3. Why do you think Dürer called this the *Great Piece of Turf* when it is really so small?

**Safety first.** Turn over rocks and boards only with an adult, lifting the far side toward you so anything underneath can escape away from your hands. Look but do not touch spiders, wasps or animal droppings, and wash your hands afterward.

## HANDS-ON PROJECT

### My Backyard Food Web

You will become a field scientist, gather evidence of who lives near your home, and connect them into a food web on a large sheet of paper.

#### You will need

- Nature journal and pencil
- A sit spot outdoors (yard, park, school field or a window with a view)
- Magnifying glass
- A large sheet of poster paper or two taped journal pages
- Colored pencils or markers
- A field guide or library book on backyard animals (optional)

#### Steps

1. Choose a **sit spot**. Sit quietly for 15 minutes. List every plant, animal and sign of an animal you see or hear: birds, insects, chewed leaves, holes, tracks, droppings, webs.
2. Gently turn over a rock, board or patch of leaf litter with an adult. List the small creatures underneath, then put everything back as you found it.
3. At home, sort your list into three groups: producers, consumers and decomposers.
4. On the poster, draw or write the producers along the bottom: grass, trees, clover, garden plants.
5. Above them, add the herbivores you found (or know live nearby): rabbits, squirrels, caterpillars, mice, deer.
6. Above those, add predators and omnivores: robins, snakes, foxes, raccoons, hawks, owls.
7. Draw arrows from each food to the animal that eats it. The arrow shows which way the energy goes.
8. Along the side, draw the decomposers with arrows from everything to them, and from them back to the soil and plants.

### Tips

- Use a different color for each level so your web is easy to read.
- Try the “what if” test: cover one animal with your finger. Which arrows break? Which animals would have more food, and which less?

### Check your work

- ☐ I can name producers, consumers and decomposers from my own yard.
- ☐ My arrows point from the food to the eater.
- ☐ My food web includes at least 12 living things and 15 arrows.

### NATURE JOURNAL

1. Draw your sit spot as a small map. Mark where you saw each living thing.
2. Draw one small creature from under a rock or leaf (a beetle, pill bug or worm) as large as your page, with labels.
3. Write three food chains of four links each, using only living things you saw yourself.
4. Watch a pond, river or wetland for ducks and geese. Draw a mallard drake, a mallard hen and a Canada goose, labeling field marks such as the drake’s green head and white neck ring, the hen’s blue wing patch, and the goose’s black neck and white chin strap. Add the wetland plants around them and the food chain they belong to.

**From history.** Since 1934 the Federal Duck Stamp has raised money to buy and protect wetlands for ducks, geese and many other creatures. Students can enter the Federal Junior Duck Stamp art contest, which asks for an accurate painting of a North American duck, goose or swan in its wetland habitat; check the U.S. Fish and Wildlife Service for current rules.

### COMMON MISTAKES

- Drawing the arrows backward. The arrow means “is eaten by” and points toward the eater.
- Forgetting the decomposers, which are some of the most important members of the web.
- Thinking a food chain is the whole story. Most animals eat many kinds of food.

**Make it a game • Food Web String Tangle.** Write backyard plants and animals on index cards: grass, grasshopper, sparrow, hawk, fungus. Lay them out and connect them with yarn to build a food web. Name each card as a producer, consumer or decomposer. Parent pulls one card away. Explain aloud who loses food, and trace the sun's energy along the string.

**Scripture.** “He giveth to the beast his food, and to the young ravens which cry.” (Psalms 147:9, KJV)

Every strand of the food web is part of God’s provision. He feeds the wild creatures, and He cares for us too.

## 2.2 PREDATORS: COYOTES, FOXES, HAWKS AND OWLS

### OBJECTIVES

- Describe how coyotes, red foxes, red-tailed hawks and owls are built for hunting.
- Explain how predators help keep the numbers of mice, voles and rabbits in balance.
- Name ways farmers and families protect chickens and small pets from predators.

**Warm-up.** Close your eyes and sit very still for one minute. Have someone drop a coin or crumple a piece of paper somewhere in the room. Point to where you think the sound came from, then open your eyes. Try it again with your hands cupped behind your ears. Was it easier?

### WATCH

#### Experiment! How Does An Owl Fly So Silently? | Super Powered Owls | BBC

BBC Earth • 4:13

[https://www.youtube.com/watch?v=d\\_FEaFgJyfA](https://www.youtube.com/watch?v=d_FEaFgJyfA)

### WHEN TO WATCH

After the core ideas. Watch which bird makes no sound on the microphones, and why.

**Note:** A real experiment comparing an owl, a pigeon and a hawk flying past sensitive microphones. No hunting is shown.

### BACKUP VIDEO

#### Red-tailed Hawk: Bird in the Spotlight

Cornell Lab of Ornithology • 2:19

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

On the second day, before you go out to look for hawks on poles and treetops.

## KEY TERMS

### **raptor**

A bird of prey, such as a hawk, eagle, falcon or owl, that hunts with sharp talons and a hooked beak.

### **talons**

The long, sharp, curved claws of a bird of prey.

### **nocturnal**

Active mainly at night. Most owls are nocturnal.

### **facial disc**

The round, dish-shaped face of an owl, made of stiff feathers that gather sound toward its ears.

### **pounce**

To leap up and land on prey from above. Foxes pounce on mice hidden in grass or snow.

## CORE IDEAS

Predators are wonderfully made for their work. The **coyote** is a wild member of the dog family, about the size of a medium dog, with a bushy tail it carries low. Coyotes live in every state except Hawaii, in farm country and even in cities. They eat mice, voles, rabbits, insects, fruit and carrion. Coyotes are most active at dawn, dusk and night, and their yips and howls carry far.

The **red fox** is smaller and lighter, with a white-tipped tail and black “stockings.” Its ears can hear a mouse squeak or scratch under grass or even under snow. The fox stands still, tilts its head, then leaps high and **pounces** nose-first to pin the mouse with its front paws.

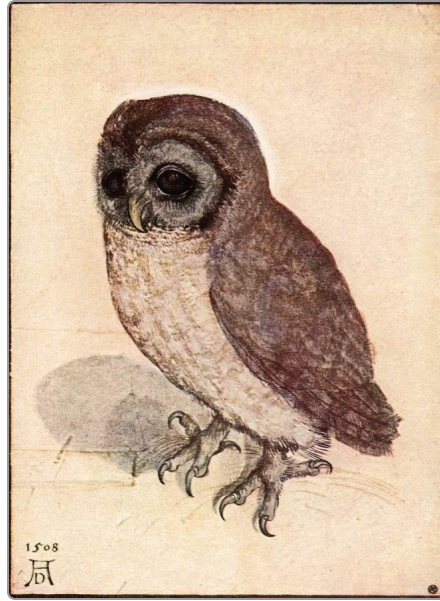
The **red-tailed hawk** is the most common large hawk in North America. Watch for it perched on a pole or tree beside a highway, or soaring in wide circles. Its eyes see far more sharply than ours, so it can spot a vole moving in the grass from high above. It drops down and grabs prey with its **talons**. Hawks hunt by day.

Owls take the night shift. A **great horned owl** or **barn owl** hunts mostly by sound. Its round **facial disc** works like a satellite dish, funneling sound to its ears, which in many owls are set at slightly different heights so it can tell exactly where a sound

comes from. Its flight feathers have soft, comb-like edges and a velvety surface that hush the air, so the owl flies almost silently.

Predators keep the food web in balance. One barn owl family may eat thousands of mice and voles in a year, which protects farmers' grain. But a hungry coyote, fox, raccoon or hawk will also take an unguarded chicken, duck or small pet. Wise keepers lock hens in a predator-proof coop every night, cover runs with wire, keep cats indoors and walk small dogs on a leash at dawn and dusk. We respect predators by keeping our distance and guarding what is in our care.

## PICTURE STUDY



*The Little Owl*, Albrecht Dürer, 1508 · Watercolor and gouache on paper · Albertina, Vienna

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

Dürer painted this little owl from life, feather by feather. Little owls are common in Europe and hunt beetles, worms and mice at dusk. Look closely at how an owl is built for hunting by sound and sight.

### Look closely

- Look at the owl's eyes. Where are they placed on its head, at the sides or in the front?
- Find the ring of feathers around each eye that forms the owl's face. This is part of its facial disc.
- Look at the beak. What shape is it, and why might that shape help a predator?
- Study the feather pattern. How would these colors help the owl hide by day?

### Talk about it

1. Why do you think an owl's eyes face forward like ours instead of to the sides like a rabbit's?
2. If you were a mouse, what would make this bird hard to escape?
3. How did Dürer show that the feathers are soft? What might soft feathers have to do with silent flight?

**Safety first.** Never approach a coyote or fox. If one comes close, stand tall, make noise and back away slowly toward an adult or a building. Do not run.

## HANDS-ON PROJECT

### Owl Ears and Hawk Eyes

You will test how an owl's face helps it hear, practice spotting "prey" from far away like a hawk, and make predator field cards for your journal.

#### You will need

- Two paper plates or two large plastic cups with the bottoms cut out
- Tape
- A blindfold or scarf
- A ticking timer, a phone playing a quiet sound, or a squeaky toy
- Ten small brown pom-poms, beans or acorns
- Binoculars (optional)
- Index cards and colored pencils

#### Steps

1. **Owl ears:** Sit blindfolded in the middle of a room. A helper sets the quiet sound somewhere in the room. Point to it. Record whether you were right, close or far off.
2. Now cup a paper plate behind each ear (curved side toward your head, like an owl's facial disc). Repeat the test five times. Record your results.
3. Next, place one plate a little higher than the other, as some owls' ears are, and try again. Compare all three sets of results.
4. **Hawk eyes:** Outside, have a helper scatter the ten brown "voles" in the grass while you look away.
5. Stand far back. Find as many as you can in one minute. Then walk halfway and look again. Record how many you found from each distance.
6. Make four **predator cards** (coyote, red fox, red-tailed hawk, great horned owl). On each, draw the animal and write: size, when it hunts, what it eats, its special tool (ears, eyes, talons, speed), and how to protect hens and pets from it.

#### Tips

- Look for red-tailed hawks on telephone poles and fence posts when you ride in the car.
- Listen at dusk on a still evening for owls hooting. A great horned owl's call sounds like "Hoo, h'hoo, hoo, hoo."

#### Check your work

- ☐ I can explain how an owl's face helps it find sounds.
- ☐ I can describe how a fox, a hawk and an owl each catch mice.
- ☐ I can name two ways to protect a chicken flock from predators.

#### NATURE JOURNAL

1. Draw a red-tailed hawk perched, and another soaring, from a photo or a real bird. Label the red tail, hooked beak and talons.
2. Draw an owl's face as a dish with arrows showing sound traveling to its ears.
3. Keep a two-week log of any hawks, owls, foxes or coyotes you see or hear: date, time, place and what the animal was doing.

**From history.** Farmers in Europe used to build "owl holes" into the gable walls of their barns so barn owls could nest inside. The owls paid their rent by catching the mice and rats that ate stored grain.

#### COMMON MISTAKES

- Thinking owls see in total darkness. They see well in dim light, but they rely on their hearing in the darkest places.
- Thinking predators are bad. They are part of God's design and keep mice and rabbits from overrunning fields.
- Leaving hens out after dark. Most losses to predators happen at night or at dawn.

**Make it a game • Silent Hunter Charades.** Act out a hunter without speaking while your parent guesses: a coyote's patient stalk, a fox's pounce, a hawk's dive, an owl turning its head. Then swap. For each guess, the actor must name one body feature that fits the hunt, like talons or facial disc, and one prey animal kept in balance.

## 2.3 NIGHT VISITORS AND RABIES SAFETY

### OBJECTIVES

- Identify raccoons, skunks, opossums and bats and describe what each eats and how it lives.
- Explain what rabies is, which animals most often carry it, and the warning signs of a sick animal.
- Know exactly what to do if you find a wild animal acting strangely or are bitten or scratched.

**Warm-up.** Think about the things that might disappear from a yard or porch overnight: pet food, birdseed, sweet corn, garbage, a ripe tomato. For each one, write which night animal you think might take it, and what clue it might leave behind.

### WATCH

#### Mythbusting Opossum Facts | Backyard Nature

Nature on PBS · 3:16

<https://www.youtube.com/watch?v=fLYofE1WFMs>

### WHEN TO WATCH

After the core ideas about opossums. Write down one myth and the true fact.

### BACKUP VIDEO

#### How Do Bats See with Sound? | Echolocation | Amazing Animal Senses | SciShow Kids

SciShow Kids · 4:11

<https://www.youtube.com/watch?v=fSIFU8OTwrg>

With the core ideas about bats, to learn how echolocation works.

### KEY TERMS

#### **marsupial**

A mammal whose young are born very tiny and grow in a pouch on the mother's belly. The opossum is North America's only marsupial.

#### **echolocation**

Finding objects by sending out high sounds and listening for the echoes. Bats use it to catch insects in the dark.

**rabies**

A serious disease caused by a virus that attacks the brain. It spreads through the bite or saliva of an infected mammal and is deadly without quick treatment.

**carrier**

An animal that often has and spreads a disease. Raccoons, skunks, bats and foxes are the main rabies carriers in the United States.

**nocturnal**

Active mainly at night and resting by day.

**CORE IDEAS**

When you go to bed, the night shift wakes up. The **raccoon** wears a black mask and a ringed tail. Its front paws are so sensitive and nimble that it can open latches, lids and even some doors. Raccoons eat almost anything: crayfish, frogs, insects, eggs, fruit, garbage, pet food and ripe sweet corn the night before you planned to pick it.

The **striped skunk** is a gentle, slow animal with a powerful defense. When frightened, it first stamps its feet, hisses and raises its tail as a warning. If that fails, it turns and sprays a stinging, smelly oil that can reach about ten feet. Skunks eat beetles, grubs and mice, and they leave small, cone-shaped holes in lawns where they dig for grubs.

The **Virginia opossum** is North America's only **marsupial**. Its tiny young grow in the mother's pouch, then ride on her back. It has a long, bare tail that can grip, and 50 teeth, more than any other North American land mammal. When badly frightened, an opossum may "play possum," falling over stiff and still until danger passes. Opossums eat insects, snails, fruit, carrion and garden scraps.

**Bats** are the only mammals that truly fly. Most bats in the United States eat night-flying insects such as moths, beetles and mosquitoes, catching them by **echolocation**: they send out high squeaks and listen for echoes. A colony of bats can eat an enormous number of insects in one summer night, so farmers and gardeners are glad to have them.

These animals are good neighbors at a distance, but some can carry **rabies**, a deadly disease of the brain spread by bites or saliva. The main carriers in the United States are raccoons, skunks, bats and foxes. A sick animal may wander in daylight, stagger,

seem tame or unafraid, drool, or act fierce for no reason. **Never touch, feed or pick up any wild animal, even a baby or one that seems hurt, and never touch a bat.** Tell an adult, who can call animal control or the health department. If you are ever bitten or scratched, wash the wound with soap and water for several minutes and tell an adult right away; a doctor can give shots that prevent the disease. Keep your pets' rabies shots up to date.

## PICTURE STUDY



*Virginian Opossum*, John James Audubon, 1845–1848 · Hand-colored lithograph, Plate LXVI of *The Viviparous Quadrupeds of North America* · *The Viviparous Quadrupeds of North America*, by John James Audubon and John Bachman

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

John James Audubon, famous for his birds, also set out with his sons and his friend John Bachman to paint the mammals of North America. This plate shows the opossum, a night visitor found in much of the United States, eating ripe persimmons.

### Look closely

- Find the opossums' long, bare tails. How is one opossum using its tail on the branch?
- Look at the faces. What color are they, and how are the ears and nose shaped?
- Look at the feet. Can you see the hind foot's thumb, which helps an opossum grip branches?
- Find the orange persimmons. What does this tell you about what opossums eat?

### Talk about it

1. What clues in the picture tell you the opossum is a good climber?
2. If you saw an opossum in your yard at night, what should you do?

3. Audubon studied real animals to make his paintings accurate. Why is accuracy important in a natural-history picture?

**Safety first.** Never touch, feed or approach a raccoon, skunk, opossum, fox or bat, even a baby or one that seems tame or hurt. A wild animal out in daylight acting oddly may be sick, so go inside and tell an adult. Do not touch animal droppings; raccoon droppings can carry harmful worms. Wash hands after the tracking project.

## HANDS-ON PROJECT

### Night Visitor Detective and Safety Card

You will look for signs of night visitors around your home, make a track-and-sign chart, and make a wildlife safety card to keep by the door.

#### You will need

- Nature journal
- A shallow tray or patch of smooth soil or sand, about 2 feet square
- A little water to dampen it
- Flashlight
- Index card, colored pencils and clear tape
- A library book or printout of animal tracks (optional)

#### Steps

1. With a parent, choose a spot near a garden, woodpile or fence line. Smooth the soil or sand in your tray and dampen it so tracks will show.
2. Do not put out any food. You want to learn where animals already travel, not invite them closer to your home.
3. Early the next morning, check the tray. Draw any tracks life-size and measure them.
4. Compare with a track guide: a raccoon print looks like a tiny human hand; an opossum's hind foot has a thumb that sticks out sideways; a skunk shows five toes with long claws in front; a cat shows four round toes and no claws.
5. Wash your hands after touching the tray. Search the yard for other signs: tipped trash, dug cone-shaped holes, scratched bark, droppings (look, do not touch).
6. Make a chart in your journal: animal, tracks, signs, what it eats, rabies risk.
7. On the index card, write the rule "Look, Don't Touch," the warning signs of a sick animal, and the three steps if bitten: wash, tell, see a doctor. Tape it by your door.

#### Tips

- On a summer evening, watch the sky near a streetlight or pond at dusk for bats darting after insects.
- Many families set up an inexpensive trail camera. If you have one, point it at your track tray.

#### **Check your work**

- ☐ I can tell raccoon, opossum and skunk tracks apart.
- ☐ I can name four animals that can carry rabies.
- ☐ I know the warning signs of a sick animal and what to do if bitten.

#### **NATURE JOURNAL**

1. Draw raccoon, opossum and skunk tracks life-size side by side and label the toes.
2. Draw a bat with its wings spread. Label the long finger bones that hold up the wing skin.
3. Write a short paragraph: “If I find a bat in the house, I will ...”

**From history.** In 1885 the French scientist Louis Pasteur first used his new rabies treatment to save a nine-year-old boy named Joseph Meister, who had been bitten by a sick dog. Treatments that grew from his work still protect people today.

#### **COMMON MISTAKES**

- Thinking a baby wild animal alone needs rescuing. Its mother is usually nearby; leave it and tell an adult.
- Thinking only “foaming” animals have rabies. A sick animal may simply seem tame, wobbly or confused.
- Leaving pet food or open trash outside, which invites night visitors close to the house.

**Make it a game • Night Visitor Riddles.** Write four riddle cards from memory, one each for raccoon, skunk, opossum and bat, using food, habits and clues. Read them aloud as a mysterious night announcer while your parent guesses. Then answer one safety question: what is rabies, which animals carry it most often, and what are the warning signs of a sick animal?

## 2.4 KEEPING DEER, RABBITS AND SQUIRRELS OUT OF THE GARDEN

### OBJECTIVES

- Tell deer, rabbit and squirrel damage apart by the clues they leave.
- Compare fences, barriers, netting and repellents and choose the right one for each animal.
- Build a simple wire cage or barrier to protect young plants.

**Warm-up.** Look at two leaves: one torn by hand and one cut cleanly with scissors. Draw the edges. Then guess: which kind of edge would a deer leave, which has no top front teeth, and which would a rabbit leave, which has sharp front teeth?

### WATCH

#### How to Keep Out: Deer, Rabbits, Squirrels & Birds from Garden with Fencing, Netting & Repellents!

AlboPepper - Drought Proof Urban Gardening · 8:24

[https://www.youtube.com/watch?v=\\_e1raG56cOs](https://www.youtube.com/watch?v=_e1raG56cOs)

### WHEN TO WATCH

After the core ideas and before the project. List each kind of barrier he uses and which animal it stops.

### BACKUP VIDEO

#### Try These 3 EASY Ways Keep Squirrels Out of Your Garden

Mlgardener · 12:01

<https://www.youtube.com/watch?v=hbgD5TOZohg>

On the second day, if squirrels are your main problem.

### KEY TERMS

#### **browse**

To feed on leaves, twigs and buds of plants. Deer are browsers.

#### **barrier**

Anything that keeps an animal from reaching a plant, such as a fence, cage, netting or row cover.

**hardware cloth**

Strong wire mesh with small square holes, used to keep out digging and gnawing animals.

**repellent**

A spray or substance with a smell or taste that animals dislike, used to keep them away from plants.

**deer-resistant plant**

A plant deer usually avoid because of its smell, taste or texture, such as many herbs, daffodils and marigolds.

**CORE IDEAS**

A garden full of tender lettuce, beans and strawberries looks like a salad bar to hungry wild animals. Before you can protect your plants, you must be a detective. **Deer** have no top front teeth, so they tear plants, leaving ragged edges, usually 1 to 6 feet off the ground, plus heart-shaped hoof prints. **Rabbits** have sharp front teeth that snip stems clean at an angle, close to the ground, and leave small round droppings. **Squirrels** dig holes, unearth bulbs and seeds, and take a bite or two out of tomatoes and leave them.

The surest protection is a **barrier**. Deer can jump about 8 feet high, so a deer fence must be tall, about 7 or 8 feet. Some gardeners use two shorter fences a few feet apart, because deer do not like to jump into a narrow space they cannot see clearly. Rabbits are stopped by a fence of chicken wire about 2 feet tall, with the bottom bent outward or buried a few inches so they cannot dig under.

Squirrels climb and dig, so fences do not stop them. Gardeners cover seedbeds and bulbs with **hardware cloth** or wire, build cages over tomato and berry plants, and drape bird netting over fruit. A simple wire cage over each young plant protects it from rabbits, squirrels and birds until it is big and tough.

**Repellents** are sprays with smells or tastes that animals dislike, such as egg, garlic or hot pepper. They work for a while, but rain washes them off and animals get used to them, so they must be renewed and changed. An adult should always handle sprays. You can also plant things animals usually avoid, such as onions, garlic, many herbs, marigolds and daffodils, around more tender crops.

A good steward protects the garden in a fair and humane way. We do not try to harm animals; we simply make the garden hard to reach. Keep in mind that a garden open

to every visitor feeds the deer, but a fenced garden feeds the family. The Bible speaks of “the little foxes, that spoil the vines”; small animals can do great damage, and a wise gardener watches and guards.

## PICTURE STUDY



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

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

This is one of the most famous animal paintings in the world. Dürer probably kept the hare in his studio while he painted it. Hares and rabbits are close cousins, and both love a vegetable garden.

### Look closely

- Find the reflection of a window in the hare's eye. What does it tell you about where Dürer painted?
- Look at the long ears. Why would big ears help an animal that many predators hunt?
- Find the long whiskers and the strong hind feet.
- Look at the direction of the fur. How did Dürer show that it is soft and thick?

### Talk about it

1. Where are the hare's eyes placed on its head? How does that help it watch for danger?
2. What signs would a rabbit leave in your garden that a deer would not?
3. How tall and how deep would a fence need to be to keep this animal out of your lettuce?

**Safety first.** An adult cuts the wire. Wear gloves and safety glasses when bending wire, because cut ends are sharp. An adult handles any repellent sprays.

## HANDS-ON PROJECT

### Damage Detective and a Seedling Cage

You will look for evidence of animal feeding near your home, then build a wire cage to protect young plants from rabbits, squirrels and birds.

#### You will need

- Nature journal and ruler
- A piece of chicken wire or hardware cloth about 2 feet by 3 feet (or a wire hanging basket or berry basket for a pot)
- Work gloves and safety glasses
- Wire cutters or tin snips (adult use)
- Four short stakes or garden pins
- Young plants or seedlings in a bed or pot

#### Steps

1. Walk around your yard, a park edge or a community garden. Look for chewed plants, droppings, tracks and dug holes.
2. For each sign, measure how high off the ground it is and look at the edge of the bite: ragged or clean-cut?
3. Record each clue in a chart and decide: deer, rabbit, squirrel or something else.
4. Plan your cage on paper. It should be wide enough to cover your seedlings with a few inches to spare, and tall enough for them to grow for a few weeks.
5. With an adult cutting the wire, bend the chicken wire or hardware cloth into a box or arch shape with gloves on. Fold sharp edges inward.
6. Set it over the seedlings and pin it down firmly so animals cannot push under it. For a pot, an upside-down wire basket works well.
7. Leave one unprotected plant nearby as a “control.” Check both every morning for a week and record any damage.

#### Tips

- Make the cage easy to lift so you can water and weed.

- If you see no animal damage, your cage still protects seedlings from birds pulling up sprouts.

#### Check your work

- ☐ I can tell deer, rabbit and squirrel damage apart.
- ☐ I can explain why a deer fence must be much taller than a rabbit fence.
- ☐ I built a barrier and tested it against an unprotected plant.

#### NATURE JOURNAL

1. Draw a chewed leaf from deer and one from a rabbit (or from your scissors-and-hand test) side by side, and label the edges.
2. Draw a heart-shaped deer track and a rabbit's track pattern of two long hind prints and two small front prints.
3. Draw a plan of your garden or pots with the barriers you would use for each crop.

#### COMMON MISTAKES

- Building a short fence for deer. Deer jump right over a 4-foot fence.
- Forgetting that rabbits dig. Bend or bury the bottom of the fence.
- Using one repellent forever. Animals get used to it; change it and reapply after rain.

**Make it a game • Garden Raider Clue Cards.** Draw three clue cards: ragged torn stems, clean angled cuts, and dug holes. Parent shuffles them and holds one up; you name the culprit, deer, rabbit or squirrel, and pick the best fix from fence, hardware cloth, netting or repellent. Win a point for each right match. Then invent a fourth clue and quiz your parent.

**Scripture.** “Take us the foxes, the little foxes, that spoil the vines: for our vines have tender grapes.” (Song of Solomon 2:15, KJV)

Vineyard keepers in Bible times guarded their tender vines from small animals. Protecting the garden is part of faithful stewardship.

## UNIT 2

# WILDLIFE IN THE BACKYARD FOOD WEB

Your yard, park or neighborhood is full of wild neighbors, even if you rarely see them. In this unit you will learn how they fit together in a **food web**: plants that capture sunlight, the animals that eat plants, the predators that eat them, and the decomposers that return everything to the soil.

You will meet the hunters of the neighborhood, coyotes, foxes, hawks and owls, and the night visitors, raccoons, skunks, opossums and bats. You will learn the most important safety rule of wildlife study: watch from a distance and never touch. Finally you will learn fair, humane ways to keep deer, rabbits and squirrels from eating your garden.

### PREREQUISITES

- Knows that animals need food, water and shelter
- Can sort animals into plant-eaters and meat-eaters
- Has finished Unit 1 or knows the season and frost dates for home

### MASTERY CHECKLIST

- ☐ I can draw a backyard food web with producers, consumers and decomposers.
- ☐ I can describe how coyotes, foxes, hawks and owls are built for hunting.
- ☐ I can name animals that can carry rabies and explain what to do if I see a wild animal acting strangely.
- ☐ I can tell deer, rabbit and squirrel damage apart and choose a fair way to protect plants from each.
- ☐ I watch wild animals from a safe distance and never feed or touch them.

### LESSONS IN THIS UNIT

#### 2.1 The Backyard Food Web

2 sessions of 45 minutes

#### 2.2 Predators: Coyotes, Foxes, Hawks and Owls

2 sessions of 45 minutes

#### 2.3 Night Visitors and Rabies Safety

2 sessions of 45 minutes

## UNIT 2 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. 5 pts

What is a producer? Give two examples from your yard.

2. 5 pts

Write a food chain with four links that ends with a hawk or an owl.

3. 5 pts

What do decomposers do, and why are they important?

4. 5 pts

Why are there many more mice than hawks in a grassy field?

5. 5 pts

Name two features that help an owl hunt at night.

6. 5 pts

Give two ways to protect a flock of hens from predators.

7. 5 pts

Which four kinds of wild animals most often carry rabies in the United States?

8. 5 pts

You see a raccoon wandering in the middle of the day, stumbling and acting tame. What should you do?

9. 5 pts

How can you tell rabbit damage from deer damage?

10. 5 pts

Why must a deer fence be about 8 feet tall, while a rabbit fence can be about 2 feet?

**ANSWER KEY**

1. A living thing that makes its own food from sunlight, such as grass, clover, trees or garden plants.
2. Example: grass seeds → mouse → snake → hawk, or clover → rabbit → fox... any sensible chain beginning with a plant.
3. They break down dead plants, animals and wastes into nutrients that return to the soil and feed plants again.
4. Only a small part of the energy passes up each step of the food chain, so there is less energy to support animals higher up.
5. Any two: facial disc that gathers sound, ears at different heights, soft fringed feathers for silent flight, large forward-facing eyes, sharp talons.
6. Lock them in a predator-proof coop at night, cover the run with wire, use hardware cloth, close the door at dusk, keep watch (any two).
7. Raccoons, skunks, bats and foxes.
8. Stay far away, do not touch or feed it, go inside and tell an adult, who can call animal control.
9. Rabbits snip stems cleanly at an angle close to the ground; deer tear plants leaving ragged edges, often higher up.
10. Deer can jump about 8 feet high; rabbits cannot jump high but can dig, so a rabbit fence is short but buried or bent outward at the bottom.

## PORTFOLIO PIECE: A WILDLIFE FIELD GUIDE TO MY NEIGHBORHOOD

Make a small field guide (a booklet or a section of your journal) of at least eight wild animals that live near your home. For each, include a careful drawing, its tracks or signs, what it eats, its place in the food web, and a safety or garden note. Finish with a full-page food web connecting all of them and a “Look, Don’t Touch” safety page.

| LOOK FOR                      | WHAT IT MEANS                                                                                                        |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------|
| <b>Observation</b>            | At least four entries include signs, tracks or sightings you found yourself, with dates.                             |
| <b>Accuracy</b>               | Foods, habits, tracks and rabies notes are correct for each animal.                                                  |
| <b>Food web</b>               | The final web connects every animal with arrows pointing from food to eater, and includes producers and decomposers. |
| <b>Safety and stewardship</b> | Includes clear safety rules and at least two humane ways to protect gardens or flocks.                               |
| <b>Craftsmanship</b>          | Drawings are careful and labeled; the guide is neat, titled and signed.                                              |

## UNIT 3

# SOIL: LAYERS, PH AND LIVING THINGS

Soil is not just dirt. It is a living, layered, carefully balanced home for plants and for more living things than you can count. In this unit you will dig down and read the layers of the soil, called horizons, the way a detective reads clues. You will test whether your soil is acid or alkaline and learn why that matters to plants.

Then you will meet the invisible workers of the soil, bacteria and fungi, including the amazing fungi that join with plant roots to help them drink and feed. Finally you will watch earthworms, the engineers of the garden, at work in a glass jar. By the end you will be able to write a real soil report for your own yard or garden pot.

### PREREQUISITES

- Knows that soil is made of rock bits, water, air and organic matter
- Can use a ruler to measure in inches and centimeters
- Knows what a decomposer is (Lesson 2.1)

### MASTERY CHECKLIST

- ☐ I can name and describe the O, A, B and C horizons of a soil profile.
- ☐ I can explain the pH scale and test my soil's pH.
- ☐ I can explain how bacteria and fungi help plants, including mycorrhizae and nitrogen fixers.
- ☐ I can describe how earthworms improve soil.
- ☐ I wear gloves and wash my hands after working with soil.

### LESSONS IN THIS UNIT

#### 3.1 Soil Horizons: Reading the Layers

2 sessions of 45 minutes

#### 3.2 pH and a Home Soil Test

2 sessions of 45 minutes

#### 3.3 Bacteria and Fungi in Living Soil

2 sessions of 45 minutes

#### 3.4 Earthworms: Engineers of the Soil

2 sessions of 45 minutes

## UNIT 3 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

Name the soil horizons from top to bottom.

2. (5 pts)

Why is topsoil usually darker than subsoil?

3. (5 pts)

Why must gardeners protect topsoil?

4. (5 pts)

What does a pH of 7 mean? What about a pH of 5?

5. (5 pts)

What pH range do most vegetables like? Name a plant that likes very acid soil.

6. (5 pts)

What might a gardener add to raise the pH of very acid soil?

7. (5 pts)

What are mycorrhizae, and how do the fungus and plant help each other?

8. (5 pts)

What lives inside the nodules on a pea or clover root, and what do they do?

9. (5 pts)

Give three ways earthworms improve the soil.

10. (5 pts)

Why do earthworms need moist soil?

#### ANSWER KEY

1. O (organic layer), A (topsoil), B (subsoil), C (parent material), R (bedrock). Some soils also have an E horizon between A and B.
2. It contains much more humus, the dark organic matter from decayed plants and animals.
3. It forms very slowly but can wash or blow away quickly, and it is where most roots and soil life are.
4. 7 is neutral; 5 is acid.
5. About 6.0 to 7.0; blueberries (or azaleas).
6. Lime (ground limestone) or wood ashes, after a soil test.
7. Partnerships between fungi and roots; the fungus brings water and nutrients like phosphorus, and the plant gives the fungus sugar.
8. Nitrogen-fixing bacteria; they turn nitrogen from the air into a form the plant can use.
9. Any three: burrows let in air and water, castings add nutrients, they mix organic matter into the soil, their slime builds crumb structure, roots follow their burrows.
10. They breathe through their skin, which must stay moist.

## PORTFOLIO PIECE: A SOIL REPORT FOR MY GARDEN

Write and illustrate a two- or three-page soil report for one garden bed, yard spot or large pot. Include your soil profile drawing with horizon depths, your pH test results, the results of your cotton strip test, a worm count from one trowel of soil, and three recommendations for improving the soil (such as adding compost, mulch, a cover crop or lime), each with a reason.

| LOOK FOR                 | WHAT IT MEANS                                                                     |
|--------------------------|-----------------------------------------------------------------------------------|
| <b>Soil profile</b>      | Shows at least two horizons with correct labels, depths, colors and textures.     |
| <b>Test results</b>      | Includes a pH number, a cotton strip result and a worm count, each with the date. |
| <b>Science explained</b> | Explains in your own words what the results mean for plants and soil life.        |
| <b>Recommendations</b>   | Gives three sensible ways to improve the soil, each tied to a test result.        |
| <b>Craftsmanship</b>     | The report is neat, illustrated, titled, signed and dated.                        |

## 3.1 SOIL HORIZONS: READING THE LAYERS

### OBJECTIVES

- Name the main soil horizons (O, A, B, C and bedrock) and describe each one.
- Explain why topsoil is the most valuable layer for gardeners and farmers.
- Dig or core a small soil profile and record its layers by color, texture and depth.

**Warm-up.** Look at a slice of layered food such as a sandwich, a piece of lasagna or a layer cake, or a picture of one. Draw it and label each layer from top to bottom. Which layer would you call the richest? Soil has layers too.

### WATCH

#### Soil Horizons

KStateAgronomy · 5:03

<https://www.youtube.com/watch?v=b1VcCc0co78>

### WHEN TO WATCH

After the core ideas. A Kansas State University soil scientist stands in a real soil pit. Pause at each horizon and point to it.

**Note:** From Kansas State University's agronomy department; aimed at older students, so pause often and explain.

### KEY TERMS

#### **soil profile**

A side view of the soil from the surface down to the rock beneath, showing all its layers.

#### **topsoil**

The A horizon: the dark upper layer, rich in humus and living things, where most plant roots grow.

#### **horizon**

One layer of soil, different from the layers above and below in color, texture or what it contains.

#### **subsoil**

The B horizon under the topsoil, usually lighter or redder, with more clay and minerals and less organic matter.

**parent material**

The weathered rock or deposits (the C horizon) that the soil above slowly formed from.

**humus**

Dark, crumbly organic matter left after leaves, roots and other once-living things have decayed.

**CORE IDEAS**

If you could slice down through the ground like a cake, you would see a **soil profile**: layers called **horizons**, each with its own color and feel. Soil scientists name them with letters, from the top down. Learning the letters lets you read the story of any soil you dig.

At the very top is the **O horizon** (O for organic): fallen leaves, twigs and grass, some fresh and some half-rotted. Below it is the **A horizon**, or **topsoil**. It is dark brown or black because it is full of **humus**. It crumbles easily, holds water and air, and is packed with roots, worms, insects, fungi and bacteria. Most of a garden's life happens here, often in the top 6 to 12 inches.

Under the topsoil lies the **B horizon**, or **subsoil**. It is usually lighter, yellow, red or gray, and often stickier, because clay and minerals washed down from above collect here. Fewer roots reach it, though deep roots such as those of trees, alfalfa and dandelions do. Below that is the **C horizon**: broken, weathered rock, the **parent material** the soil formed from. At the bottom is solid **bedrock**, called R. (Forest soils often have a pale **E horizon** between A and B.)

Topsoil forms very slowly as rock weathers and plants grow and decay year after year. It can take hundreds of years to build an inch, but a single heavy rain on bare ground can wash an inch away. That is why farmers and gardeners guard their topsoil with cover crops, mulch and compost, and why the soil of a good farm is a treasure handed down from parents to children.

Different places have different profiles. A prairie soil may have topsoil two feet deep and nearly black. A sandy soil near a beach may have only a thin, pale topsoil. A clay soil may turn hard and sticky just under the surface. When you know your profile, you know why water puddles or drains, and what your soil needs.

## PICTURE STUDY



*The Ploughed Field (The Furrows)*, Vincent van Gogh, 1888 · Oil on canvas · Van Gogh Museum, Amsterdam

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

Van Gogh painted this freshly ploughed field near Arles, in the south of France, in the autumn. Ploughing turns the topsoil over and opens it to air before sowing. Look at how much of the picture is simply soil.

### Look closely

- Find the furrows, the long ridges and grooves left by the plough. Which way do they run?
- Look at the colors of the soil. How many different colors did Van Gogh use for brown earth?
- Notice how thick the paint is. How does it make the soil look lumpy and heavy?
- Find the horizon line where the field meets the sky. How high on the canvas is it?

### Talk about it

1. Which soil horizon has the plough turned over in this field?
2. Why might the soil look darker in some furrows and lighter in others?

3. If heavy rain fell on this bare field before anything was planted, what could happen to the topsoil?

**Safety first.** Call or ask an adult to check for underground lines before digging; in the U.S. adults can call 811. Wear gloves, keep feet clear of the shovel, and wash hands when finished.

## HANDS-ON PROJECT

### My Soil Profile Board

You will dig a small hole or take a soil core, study each layer, and make a soil profile board with real samples to keep.

#### You will need

- A shovel or a long trowel (or a bulb planter or a 2-inch PVC pipe for coring)
- A strip of stiff cardboard about 4 inches wide and 24 inches long
- Clear packing tape or white glue
- Ruler or tape measure
- Magnifying glass
- Spray bottle of water
- Gloves
- Journal and colored pencils

#### Steps

1. With a parent, choose a spot where digging is allowed and there are no buried pipes or cables. A garden bed edge or a bare patch works well.
2. Dig a hole about 18 to 24 inches deep with one smooth, straight side, or push a coring tool down several times to pull up a column of soil.
3. Lay your cardboard strip beside the hole. Mark inches down its edge, with 0 at the top for the soil surface.
4. Look at the smooth side of the hole. Find where the color changes. Measure the depth of each change and record it.
5. For each layer, note the color, whether it feels gritty, smooth or sticky when moistened, whether roots, worms or stones are present, and how it smells.
6. Take a small pinch from each layer and stick it onto the cardboard at the right depth with glue or a strip of clear tape.
7. Label each layer O, A, B or C on your board and write its depth.

8. Fill the hole back in, putting the subsoil in first and the topsoil on top, so you leave the profile as you found it.

#### **Tips**

- If you cannot dig, look at the side of a road cut, a stream bank, or a construction site from a safe distance, or fill a clear jar with a soil core from a pot.
- Spray a little water on the side of the hole. Moist soil shows its colors much more clearly.

#### **Check your work**

- ☐ I found and measured at least two different horizons.
- ☐ I described each layer's color and texture.
- ☐ I can explain why the topsoil is darker than the subsoil.

#### **NATURE JOURNAL**

1. Draw your soil profile in color, full page, with depths and labels.
2. Look at a pinch of topsoil and a pinch of subsoil under a magnifying glass. Draw what you see in each.
3. Draw a tree with its roots spreading through the A and B horizons. Show which roots go deepest.
4. Make a conservation poster about protecting topsoil, with a short slogan, a large drawing of a soil profile and one way farmers or gardeners keep soil from washing away. Posters like this are entered each year in the conservation poster contest run by local conservation districts and the National Association of Conservation Districts; check your local district for the theme and rules.

**From history.** In the 1800s, a Russian scientist named Vasily Dokuchaev studied the rich black soils of the Russian plains. He showed that soils form in layers shaped by rock, weather, plants and time. Soil scientists still use the idea of horizons he helped begin.

#### **COMMON MISTAKES**

- Thinking all soil looks the same deep down. Every place has its own profile.
- Mixing the layers when refilling the hole. Put subsoil back first and topsoil on top.
- Calling the leaf layer “dirt.” The O horizon is organic matter on its way to becoming humus.

**Make it a game • Layer Cake Soil Stack.** Build a soil profile out of pretend layers: stack pieces of paper or snack items on the table in order from top to bottom, labeling O, A, B, C and bedrock. Close your eyes while your parent swaps two layers. Open them and fix the stack, then explain why topsoil is the treasure for gardeners.

## 3.2 PH AND A HOME SOIL TEST

### OBJECTIVES

- Explain the pH scale and the words acid, neutral and alkaline.
- Explain why soil pH matters for plants and name crops that like acid or neutral soil.
- Test soil pH with a kit and with a homemade red cabbage indicator.

**Warm-up.** Taste a tiny drop of lemon juice, and smell a little vinegar. Then feel a pinch of baking soda between wet fingers. In your journal describe each one: sour, sharp, slippery or chalky. Lemon and vinegar are acids; baking soda is a base. Which do you think garden soil is like?

### WATCH

#### How to Test and Measure Your Soil pH at Home

Epic Gardening • 8:48

<https://www.youtube.com/watch?v=PPzsBKnxj3g>

### WHEN TO WATCH

After the core ideas and before using your own test kit. Watch how he mixes soil and water and reads the color chart.

### BACKUP VIDEO

#### DIY Soil pH Test - Garden Quickie Episode 114

The Ripe Tomato Farms • 3:47

<https://www.youtube.com/watch?v=OvWB86nglds>

On the second day, for a quick fizz test with vinegar and baking soda.

### KEY TERMS

#### **pH**

A number from 0 to 14 that tells how acid or alkaline something is. 7 is neutral.

#### **acid**

Having a pH below 7. Lemon juice and vinegar are acids. Acid soils are often called sour.

**alkaline**

Having a pH above 7. Baking soda and lime are alkaline (also called basic). Alkaline soils are often called sweet.

**neutral**

Neither acid nor alkaline; a pH of 7, like pure water.

**indicator**

A substance that changes color to show whether something is acid or alkaline.

**lime**

Ground limestone that gardeners add to raise the pH of acid soil.

**CORE IDEAS**

The **pH scale** runs from 0 to 14. In the middle, 7 is **neutral**, like pure water. Below 7 is **acid**: vinegar is about 3, lemon juice about 2. Above 7 is **alkaline**, or basic: baking soda in water is about 8 or 9. Each step on the scale is ten times stronger than the one before, so soil at pH 5 is ten times more acid than soil at pH 6.

Most garden soils fall between about 5 and 8. Most vegetables, including tomatoes, beans, lettuce and squash, grow best in slightly acid soil, about **6.0 to 7.0**. A few plants love strongly acid soil: **blueberries** want about 4.5 to 5.5, and so do azaleas. Some plants, like lilacs and asparagus, do fine in slightly alkaline soil.

Why does pH matter? Plant food in the soil, such as nitrogen, phosphorus, potassium and iron, dissolves in soil water before roots can take it in. When the pH is too high or too low, some nutrients get locked up and roots cannot use them, even if they are there. A plant in the wrong pH may turn yellow and grow poorly no matter how much you feed it. The pH also affects which soil bacteria and fungi can thrive.

Gardeners change pH slowly and only after testing. To raise the pH of acid soil, they add **lime** (ground limestone) or wood ashes. To lower the pH for blueberries, they add garden sulfur or acid organic matter such as pine needles or peat. These work over months, not days. Adding compost every year helps keep soil near the middle of the range. Always follow the label and a test result, with an adult.

Some plants show you the pH by themselves. **Bigleaf hydrangeas** bloom blue in acid soil and pink in alkaline soil, because acid soil lets them take up a metal called aluminum that turns the flowers blue. You can make your own color-changing **indicator** from red cabbage. God has hidden chemistry lessons in the kitchen and the flower bed alike.

## PICTURE STUDY



*Hydrangea (Hortensia)*, Pierre-Joseph Redouté, about 1827–1833 · Stipple engraving, hand-colored, from *Choix des plus belles fleurs · Choix des plus belles fleurs*, Paris

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

Pierre-Joseph Redouté was called “the Raphael of flowers.” He painted the gardens of France with such accuracy that botanists still admire his work. Hydrangeas are famous for changing color with the pH of the soil.

### Look closely

- Look at the color of the flower head. Is it all one color, or do you see pink and blue mixed?
- Count the petals on one small flower in the cluster.
- Look at the leaves. Find the toothed edges and the veins.
- Notice how the flowers form one big rounded ball. How many small flowers might be in it?

### Talk about it

1. If this hydrangea were moved to very acid soil, what color would its new flowers likely be?
2. If the flowers here are pinkish, what might that tell you about the soil it grew in?

3. Why would a gardener test the soil before trying to change a hydrangea's color?

**Safety first.** An adult handles hot water and the blender. Do not taste soil or test liquids. Wear gloves for soil, keep test chemicals away from eyes and mouth, and wash hands afterward. Lime and sulfur are handled only by adults, following the label.

## HANDS-ON PROJECT

### Cabbage Juice and Soil pH Lab

You will make a natural color-changing indicator from red cabbage, test kitchen liquids, and then test soil from two or three places with the indicator and a soil test kit.

#### You will need

- ¼ head of red cabbage
- Hot (not boiling) water and a blender or a pot (adult help)
- A strainer and a jar
- 6 clear cups or small jars
- Vinegar, baking soda, lemon juice and water
- A simple soil pH test kit (capsule or strip type)
- Distilled water if available
- Soil samples from 2 or 3 places (garden, lawn, under a pine tree, a potted plant)
- Spoons, labels and journal

#### Steps

1. With an adult, chop the cabbage and soak it in hot water for 15 minutes (or blend it with hot water). Strain the purple juice into a jar. This is your **indicator**.
2. Pour a little indicator into four cups. Add a spoon of vinegar to one, lemon juice to another, baking soda to the third, and plain water to the fourth. Record the colors: acids turn pink or red, neutral stays purple, bases turn blue-green.
3. Collect soil samples from 2 or 3 places, digging down 4 inches and removing stones and roots. Let them dry a little on paper. Label each.
4. For each soil, mix one spoon of soil with a few spoons of distilled water in a cup. Stir, let it settle for 10 minutes, then pour off the clear water into a new cup.

5. Add a little cabbage indicator to each soil water. Compare the color with your kitchen cups and estimate: acid, neutral or alkaline?
6. Now use your soil test kit on the same samples, following its directions exactly. Match the color to the chart and record the pH number.
7. Make a table: place, cabbage color, kit pH, and which crops would grow well there.

#### **Tips**

- Soil water is often only slightly acid or alkaline, so the cabbage color change may be small. Hold the cup against white paper to see it clearly.
- Soil under pine trees or in rainy places is often more acid. Soil near a concrete walk or foundation is often more alkaline.

#### **Check your work**

- ☐ I can explain what pH 5, 7 and 9 mean.
- ☐ I tested at least two soils and recorded their pH.
- ☐ I can name one plant that likes acid soil and say how gardeners raise the pH of acid soil.

#### **NATURE JOURNAL**

1. Draw a pH scale from 0 to 14 as a long rainbow strip. Mark lemon, vinegar, water, baking soda and your soil samples on it.
2. Paint or color six squares with the colors your cabbage indicator made, and label each.
3. Draw a blue hydrangea flower and a pink one, and write under each what the soil is like.

#### **COMMON MISTAKES**

- Using tap water for the test. Tap water often has its own pH; distilled water is best.
- Testing only one spot. Soil can change a lot from one part of the yard to another.
- Adding lime or sulfur without a test, which can make the problem worse.

**Make it a game • The pH Line-Up.** Make a pH line across the floor with paper numbers from 0 to 14. Parent calls out lemon juice, water, baking soda or garden lime; you stand at the right spot and say acid, neutral or alkaline. Then name a crop that likes acid soil and one that likes neutral. Race for ten correct stands in a row.

## 3.3 BACTERIA AND FUNGI IN LIVING SOIL

### OBJECTIVES

- Describe how soil bacteria and fungi break down organic matter and recycle nutrients.
- Explain what mycorrhizae are and how fungi and plant roots help each other.
- Explain how nitrogen-fixing bacteria in legume roots feed the soil.

**Warm-up.** Smell a handful of moist garden soil or potting mix with compost in it. Then smell a handful of dry sand, if you have some. Describe each smell. That sweet, earthy smell of good soil comes from living things too small to see.

### WATCH

#### Soil Is Alive! | SciShow Kids

SciShow Kids · 6:45

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

### WHEN TO WATCH

After the warm-up and before the core ideas. Make a list of every living thing the video names.

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### BACKUP VIDEO

#### Mycorrhiza: what connects fungus and plant

Bayerisches Umweltministerium · 2:30

<https://www.youtube.com/watch?v=iboE8UZBgkM>

After the core idea about mycorrhizae, to see an animation of fungal threads trading with tree roots.

### KEY TERMS

#### **microbe**

A living thing too small to see without a microscope, such as a bacterium.

#### **bacteria**

Tiny one-celled living things. Soil bacteria break down dead matter and change nutrients into forms plants can use.

**hyphae**

The thin, thread-like strands that make up the body of a fungus.

**mycorrhizae**

Partnerships between fungi and plant roots. The fungus brings the plant water and nutrients, and the plant gives the fungus sugar.

**nitrogen fixation**

Changing nitrogen gas from the air into a form plants can use. Bacteria in the root nodules of legumes do this.

**nodule**

A small bump on the roots of beans, peas and clover where nitrogen-fixing bacteria live.

**CORE IDEAS**

A single spoonful of healthy garden soil can hold millions upon millions of **bacteria**, plus long threads of fungi, tiny worms and other creatures. Most are far too small to see. They are not enemies; most are hard-working helpers. Without them, fallen leaves would pile up forever and plants would run out of food.

Soil **bacteria** are decomposers. They eat dead leaves, roots and manure and release the nitrogen, phosphorus and other nutrients locked inside, so plant roots can use them again. One group of soil microbes makes the earthy smell you notice after rain or when you turn over a garden bed. A sweet-smelling soil is usually a healthy, living one.

Some bacteria do something even more remarkable. Air is mostly nitrogen, which plants need to make leaves, but plants cannot use nitrogen gas. Special bacteria called **rhizobia** live in **nodules**, small pink-centered bumps on the roots of legumes such as peas, beans, clover and alfalfa. They capture nitrogen from the air in the soil and turn it into plant food, and the plant feeds them sugar in return. This is called **nitrogen fixation**, and it is why farmers plant clover and beans to enrich their fields.

**Fungi** grow as networks of thin white threads called **hyphae**. You can sometimes see them in leaf litter or under wood chips. Many fungi break down tough materials like wood and straw that bacteria cannot. Others form **mycorrhizae**, partnerships with plant roots. The fungal threads wrap around or enter the roots and spread far out into the soil, much finer and longer than roots. They gather water and phosphorus and pass them to the plant. In return, the plant shares sugar it made in its leaves. Most garden plants and trees have these fungal partners.

We can care for these soil helpers. They need food (compost, mulch, plant roots and cover crops), air, moisture, and as little disturbance as possible, because heavy digging tears the fungal threads. Chemicals that kill pests can harm them too. A gardener who feeds the soil and covers it is caring for an unseen world that God made to keep the garden growing.

## PICTURE STUDY



*Mushrooms, Plate 221 of Coloured Figures of English Fungi, James Sowerby, about 1799 · Hand-colored engraving · Coloured Figures of English Fungi or Mushrooms, London*

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

James Sowerby was an English naturalist and illustrator who drew hundreds of British mushrooms from real specimens. A mushroom is only the fruit of a fungus. Most of the fungus lives hidden in the soil or wood as a web of fine threads.

### Look closely

- Find the mushroom lying on its side. What do you see under its cap?
- Look at the base of the stems. What are the mushrooms growing out of?
- Compare the young, small mushrooms with the larger, open ones. How does the cap change as it grows?
- Look for tiny bits of moss and soil. Why would the artist include them?

### Talk about it

1. If the mushroom is just the fruit, where is the rest of the fungus?
2. What job might this fungus be doing in the soil or in rotting wood?
3. Why must you never eat a wild mushroom you find, even one that looks like a picture?

**Safety first.** Wear gloves when digging, and wash hands well afterward. Do not touch or eat any wild mushroom. An adult cuts open the nodule if a knife is used.

## The Cotton Strip Test and Root Nodule Hunt

You will measure how busy the soil microbes are in two places by burying strips of cotton, and you will dig up a legume to look for nitrogen-fixing nodules.

### You will need

- Two strips of 100% cotton cloth (an old white cotton T-shirt or cotton underwear works), each about 2 by 8 inches
- Two craft sticks or labels
- A trowel and gloves
- Two places to test: a garden bed or compost-rich soil, and a hard, bare or sandy spot (or two pots: potting mix with compost, and plain sand)
- A clover, bean or pea plant (or a patch of white clover in a lawn)
- A bucket of water, a magnifying glass and journal

### Steps

1. Write a prediction: which soil has more microbes at work, and why?
2. In each place, dig a narrow slit about 6 inches deep. Slide in one cotton strip so most of it is underground and a little sticks out. Press the soil back and mark it with a label.
3. Keep both spots about equally damp for three weeks. Note the date and the weather.
4. Meanwhile, with permission, dig up one clover, bean or pea plant with a big ball of soil around the roots.
5. Swish the roots gently in a bucket of water until the soil falls away.
6. Look for small round bumps on the roots. These are **nodules**. With an adult, cut one open with a fingernail or knife. A pink or red center means the bacteria are busy fixing nitrogen.
7. After three weeks, gently pull up both cotton strips. Rinse them and lay them side by side.

8. Compare: which strip has more holes, thin places or stains? Microbes eat cotton just as they eat dead plants, so more damage means a livelier soil. Record your results.

#### **Tips**

- Try a third strip in a pot of potting mix you keep on a windowsill, or in a lawn, for a bigger comparison.
- Look under a log or in wood-chip mulch for white fungal threads. Draw them, then put the log back.

#### **Check your work**

- ☐ I can explain what bacteria and fungi do in the soil.
- ☐ I found or looked for root nodules and can explain what lives in them.
- ☐ I compared two soils and recorded which had more microbe activity.

#### **NATURE JOURNAL**

1. Draw a legume root with nodules, life-size or larger, and label the nodules.
2. Draw a mushroom above ground with its web of hyphae spreading below ground and touching a plant's roots.
3. Glue a small piece of each cotton strip into your journal (in a zip bag if damp), with the dates and places.

**From history.** In the 1880s, German scientists Hermann Hellriegel and Hermann Wilfarth discovered that peas grew well in poor soil only when their roots had nodules. They showed that the nodules held tiny living things that took nitrogen from the air. This explained why farmers since ancient times had found that beans and clover made a field richer.

#### **COMMON MISTAKES**

- Thinking all bacteria and fungi are harmful. Most soil microbes are helpers.
- Using cotton blend cloth. Polyester does not rot, so use 100% cotton.
- Thinking the mushroom is the whole fungus. It is only the fruit; the fungus lives as threads underground.

**Make it a game • Microbe Helpers Act-Out.** Act out the soil's unseen workers. Be bacteria munching a dead leaf, then hyphae stretching thread-like arms to meet a plant root as mycorrhizae, trading minerals for sugar. Your parent guesses each role and asks what nitrogen fixation does and what a root nodule is. Switch roles and let your parent try one scene.

## 3.4 EARTHWORMS: ENGINEERS OF THE SOIL

### OBJECTIVES

- Describe the body of an earthworm and how it moves, eats and breathes.
- Explain four ways earthworms improve soil for plants.
- Build a wormery and observe how worms mix soil layers and pull in leaves.

**Warm-up.** After a rain or a watering, look on a sidewalk, lawn or garden for earthworms or their castings (little piles of crumbly soil). Count what you find in one minute. If none are out, gently dig one trowel of moist garden soil and count the worms in it.

### WATCH

#### How to Attract More Earthworms To Your Garden (& Why They Matter)

Epic Gardening · 9:52

<https://www.youtube.com/watch?v=gGSe1OeyAkk>

#### WHEN TO WATCH

After the core ideas. Listen for the three kinds of worms and the conditions worms need.

**Note:** He shows a worm bag he sells; any worm bin works.

### BACKUP VIDEO

Worms Are Wonderful | Amazing Animals | Backyard Science | SciShow Kids

SciShow Kids · 4:34

[https://www.youtube.com/watch?v=l-zc\\_1vjLnI](https://www.youtube.com/watch?v=l-zc_1vjLnI)

Before the wormery project, as a simple review of worm bodies.

### KEY TERMS

#### castings

Earthworm droppings: rich, crumbly bits of soil full of nutrients and helpful microbes.

#### burrow

A tunnel an animal digs. Earthworm burrows let air and water into the soil.

**setae**

Tiny bristles on each segment of an earthworm that grip the soil as it moves.

**segments**

The ring-shaped sections that make up an earthworm's body.

**nightcrawler**

A large earthworm that digs deep vertical burrows and pulls leaves down into them at night.

**red wiggler**

A small reddish worm that lives in leaf litter and compost. It is the best worm for a worm bin.

**CORE IDEAS**

An earthworm has no eyes, no ears, no legs and no lungs, yet it is one of the most useful animals on earth. Its body is made of many ring-like **segments**. It moves by squeezing muscles to make itself long and thin, then short and fat, while tiny bristles called **setae** grip the soil. It breathes through its moist skin, which is why worms need damp soil and why they come up when the ground floods.

Worms eat their way through the soil, swallowing bits of dead leaves, roots and soil itself. Inside, a muscular gizzard grinds the food with tiny grains of sand. What comes out the other end are **castings**, dark crumbs much richer in plant nutrients than the soil that went in, and full of helpful bacteria. A garden with many worms is fed by them every day.

Worms are the soil's **engineers**. Their **burrows** make channels for air and rainwater to reach roots. Roots follow the burrows down. Worms mix the layers, carrying organic matter from the surface down into the topsoil and bringing deeper soil up. Their slime glues tiny soil bits into crumbs, which gives soil a good, loose structure.

There are different kinds of worms for different jobs. Big **nightcrawlers** dig deep, straight-down burrows and come up on damp nights to pull leaves into them. Smaller garden worms tunnel sideways in the topsoil. **Red wigglers** live in rotting leaves and manure; they cannot live deep in soil, but they are champions in a compost or worm bin. Each worm has a thick band near the front, called the clitellum, which forms small cocoons that hold eggs; baby worms hatch from them.

You can make your garden a good home for worms: keep the soil covered with mulch, add compost and leaves, keep it moist but not soggy, and avoid deep digging

and harsh chemicals. God gave Adam the work “to dress it and to keep it,” and the humble earthworm has been working alongside every faithful gardener ever since.

#### 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

Millet painted this farmer resting for a moment while clearing hard, stony ground with a hoe. It shows how much work it is to turn rough land into a garden. Soil without humus and worms is hard to dig.

#### Look closely

- Look at the ground around the man. Is it soft, dark garden soil or rough, stony land?
- Find the weeds and thistles. What would the farmer have to do with them?
- Look at the hoe. How heavy do you think it is?
- Look into the distance. Can you see any smoother, worked fields?

#### Talk about it

1. How could adding compost, mulch and earthworms change this field over many years?
2. Why is it harder to dig hard, worm-free soil than loose, crumbly soil?
3. What does the farmer's face and posture tell you about this work?

**Safety first.** Wear gloves or wash hands well after handling worms and soil. An adult cuts the plastic bottle. Be gentle with the worms and return them to the soil when finished.

## HANDS-ON PROJECT

### Build a Wormery

You will build a clear-sided worm home with layers of sand and soil, add a few earthworms, and watch for two weeks as they tunnel, mix the layers and pull leaves underground. Then you will return them to the garden.

#### You will need

- A large clear jar or a 2-liter bottle with the top cut off (adult cuts)
- Garden soil and light-colored sand
- A handful of dead leaves, grass clippings and a few vegetable peels
- 4 to 6 earthworms from the garden (or bought as bait)
- Spray bottle of water
- Dark paper or cloth and tape
- Ruler and journal

#### Steps

1. Put a 1-inch layer of soil in the bottom of the jar, then a 1-inch layer of sand. Repeat until the jar is about two-thirds full. Spray each layer lightly so it is damp, not wet.
2. Scatter leaves, grass and a few peels on top.
3. Gently dig up 4 to 6 earthworms with wet hands, or collect them after a rain. Place them on the surface and watch how they burrow.
4. Wrap the jar in dark paper, because worms avoid light. Keep it in a cool place out of the sun.
5. Every two days, unwrap the jar and observe for a few minutes. Draw the layers and any tunnels you see. Spray if the top looks dry.
6. Record how the sand and soil layers change, and whether leaves are disappearing or being pulled down.
7. After two weeks, gently tip everything out into a shady garden bed so the worms can go home.

#### Tips

- Handle worms gently with wet hands and keep them out of the sun; dry skin keeps them from breathing.
- Make a light test: shine a flashlight on one end of a tray with a worm on damp paper towels. Which way does it go?

**Check your work**

- ☐ I can describe how a worm moves and breathes.
- ☐ I saw and recorded worms mixing the soil layers.
- ☐ I can name four ways worms help the soil.

**NATURE JOURNAL**

1. Draw an earthworm large, with labels: segments, clitellum, front end, back end, setae.
2. Draw your wormery on day 1 and day 14 side by side to show how the layers changed.
3. Draw a cross-section of a garden showing worm burrows, roots following them, and leaves pulled into a burrow.

**COMMON MISTAKES**

- Letting the wormery dry out or sit in sun. Worms need cool, damp, dark conditions.
- Using too many worms in a small jar.
- Forgetting to return the worms. They are helpers to be borrowed, not kept.

**Make it a game • Worm Wiggle Teach-Back.** Be the earthworm professor. Teach your parent how a worm moves with setae and segments, eats and breathes through its skin, then list four ways worms help soil, including castings and burrows. Your parent sneaks in one false fact, such as worms having lungs. Ring a bell, or clap, when you catch the wrong fact.

**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)

Gardening is work God gave us from the beginning. Caring for soil and its creatures is part of dressing and keeping His creation.

## UNIT 3

# SOIL: LAYERS, PH AND LIVING THINGS

Soil is not just dirt. It is a living, layered, carefully balanced home for plants and for more living things than you can count. In this unit you will dig down and read the layers of the soil, called horizons, the way a detective reads clues. You will test whether your soil is acid or alkaline and learn why that matters to plants.

Then you will meet the invisible workers of the soil, bacteria and fungi, including the amazing fungi that join with plant roots to help them drink and feed. Finally you will watch earthworms, the engineers of the garden, at work in a glass jar. By the end you will be able to write a real soil report for your own yard or garden pot.

### PREREQUISITES

- Knows that soil is made of rock bits, water, air and organic matter
- Can use a ruler to measure in inches and centimeters
- Knows what a decomposer is (Lesson 2.1)

### MASTERY CHECKLIST

- ☐ I can name and describe the O, A, B and C horizons of a soil profile.
- ☐ I can explain the pH scale and test my soil's pH.
- ☐ I can explain how bacteria and fungi help plants, including mycorrhizae and nitrogen fixers.
- ☐ I can describe how earthworms improve soil.
- ☐ I wear gloves and wash my hands after working with soil.

### LESSONS IN THIS UNIT

#### 3.1 Soil Horizons: Reading the Layers

2 sessions of 45 minutes

#### 3.2 pH and a Home Soil Test

2 sessions of 45 minutes

#### 3.3 Bacteria and Fungi in Living Soil

2 sessions of 45 minutes

#### 3.4 Earthworms: Engineers of the Soil

2 sessions of 45 minutes

## UNIT 3 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

Name the soil horizons from top to bottom.

2. (5 pts)

Why is topsoil usually darker than subsoil?

3. (5 pts)

Why must gardeners protect topsoil?

4. (5 pts)

What does a pH of 7 mean? What about a pH of 5?

5. (5 pts)

What pH range do most vegetables like? Name a plant that likes very acid soil.

6. (5 pts)

What might a gardener add to raise the pH of very acid soil?

7. (5 pts)

What are mycorrhizae, and how do the fungus and plant help each other?

8. (5 pts)

What lives inside the nodules on a pea or clover root, and what do they do?

9. (5 pts)

Give three ways earthworms improve the soil.

10. (5 pts)

Why do earthworms need moist soil?

#### ANSWER KEY

1. O (organic layer), A (topsoil), B (subsoil), C (parent material), R (bedrock). Some soils also have an E horizon between A and B.
2. It contains much more humus, the dark organic matter from decayed plants and animals.
3. It forms very slowly but can wash or blow away quickly, and it is where most roots and soil life are.
4. 7 is neutral; 5 is acid.
5. About 6.0 to 7.0; blueberries (or azaleas).
6. Lime (ground limestone) or wood ashes, after a soil test.
7. Partnerships between fungi and roots; the fungus brings water and nutrients like phosphorus, and the plant gives the fungus sugar.
8. Nitrogen-fixing bacteria; they turn nitrogen from the air into a form the plant can use.
9. Any three: burrows let in air and water, castings add nutrients, they mix organic matter into the soil, their slime builds crumb structure, roots follow their burrows.
10. They breathe through their skin, which must stay moist.

## PORTFOLIO PIECE: A SOIL REPORT FOR MY GARDEN

Write and illustrate a two- or three-page soil report for one garden bed, yard spot or large pot. Include your soil profile drawing with horizon depths, your pH test results, the results of your cotton strip test, a worm count from one trowel of soil, and three recommendations for improving the soil (such as adding compost, mulch, a cover crop or lime), each with a reason.

| LOOK FOR                 | WHAT IT MEANS                                                                     |
|--------------------------|-----------------------------------------------------------------------------------|
| <b>Soil profile</b>      | Shows at least two horizons with correct labels, depths, colors and textures.     |
| <b>Test results</b>      | Includes a pH number, a cotton strip result and a worm count, each with the date. |
| <b>Science explained</b> | Explains in your own words what the results mean for plants and soil life.        |
| <b>Recommendations</b>   | Gives three sensible ways to improve the soil, each tied to a test result.        |
| <b>Craftsmanship</b>     | The report is neat, illustrated, titled, signed and dated.                        |

## UNIT 4

# PETS: CHOOSING WELL AND CARING FAITHFULLY

A pet is a living creature placed in your care, not a toy. In this unit you will learn to think like a wise pet keeper before an animal ever comes home: what it needs, how long it lives, how much time and money it takes, and whether it fits your family. You will compare hamsters, guinea pigs, rabbits and gerbils, and learn the special needs of reptiles and amphibians.

Finally you will learn how a veterinarian keeps pets healthy and how to spot the early signs that an animal is sick. You do not need to own a pet for any of these lessons. You can plan, budget, visit a pet store, shelter or vet clinic, or help care for a friend's or neighbor's animal.

### PREREQUISITES

- Can add and multiply money amounts
- Knows the basic needs of animals: food, water, shelter and care
- Has permission and an adult partner for any visit to a store, shelter or clinic

### MASTERY CHECKLIST

- ☐ I can list the questions a family should ask before getting a pet.
- ☐ I can make a first-year and monthly budget for a pet.
- ☐ I can compare the needs of hamsters, guinea pigs and rabbits.
- ☐ I can explain why reptiles need heat and light and why everyone must wash hands after handling them.
- ☐ I can describe a vet checkup and name signs that a pet may be sick.

### LESSONS IN THIS UNIT

#### 4.1 Choosing and Budgeting for a Pet

2 sessions of 45 minutes

#### 4.2 Small Mammals Compared

2 sessions of 45 minutes

#### 4.3 Reptiles and Amphibians

2 sessions of 45 minutes

#### 4.4 Visiting the Vet and Keeping a Pet Healthy

2 sessions of 45 minutes

## UNIT 4 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

Name four questions a family should ask before getting a pet.

2. (5 pts)

What is the difference between a one-time cost and an ongoing cost? Give an example of each.

3. (5 pts)

Why do rabbits, hamsters and guinea pigs need to chew hay or chews every day?

4. (5 pts)

Which should live alone, a Syrian hamster or a guinea pig? Why?

5. (5 pts)

What vitamin must guinea pigs get from food every day?

6. (5 pts)

Name two ways reptiles and amphibians are different.

7. (5 pts)

Why does a reptile's enclosure need a warm side and a cool side?

8. (5 pts)

What should you always do after touching a reptile or its tank, and why?

9. (5 pts)

Name four things a vet checks during a wellness exam.

10. (5 pts)

Name four signs that a pet might be sick.

## ANSWER KEY

1. Any four: Who will care for it daily? Do we have room? Can we afford food, supplies and vet care? Allergies? How long does it live? Does it fit our schedule and other pets?
2. A one-time cost is paid once (cage, adoption fee); an ongoing cost repeats (food, bedding, checkups).
3. Their front teeth grow all their lives and must be worn down.
4. A Syrian hamster; it is solitary and fights others. Guinea pigs are social and should live in pairs.
5. Vitamin C.
6. Any two: reptiles have dry scaly skin, amphibians moist smooth skin; reptiles lay shelled eggs on land, amphibians jelly eggs in water; amphibians go through metamorphosis (tadpole to frog).
7. Reptiles are ectotherms and control their body temperature by moving between warm and cool places.
8. Wash hands with soap, because reptiles can carry salmonella germs that make people sick.
9. Any four: weight, eyes, ears, teeth and gums, heart and lungs, belly, skin and coat, joints, temperature.
10. Any four: not eating or drinking, hiding, weakness or sleepiness, vomiting or diarrhea, hard breathing, limping, runny eyes or nose, lumps or wounds.

## PORTFOLIO PIECE: A COMPLETE PET CARE PLAN

Choose one pet and make a complete care plan your family could really use. Include a fact card (lifespan, size, diet, day or night), a scale drawing of its home, a first-year and monthly budget with real prices, a daily and weekly chore chart with names, a weekly health-check chart, and the name and phone number of a local vet who treats that animal.

| LOOK FOR              | WHAT IT MEANS                                                                                           |
|-----------------------|---------------------------------------------------------------------------------------------------------|
| <b>Accurate needs</b> | Diet, housing size, temperature or social needs are correct for the chosen animal.                      |
| <b>Budget</b>         | Includes one-time and ongoing costs with real prices and correct totals.                                |
| <b>Daily care</b>     | The chore chart covers food, water, cleaning, exercise and health checks, with a person named for each. |
| <b>Health plan</b>    | Includes a health-check chart, signs of illness, and a vet's contact information.                       |
| <b>Craftsmanship</b>  | Neat, organized, illustrated, titled, signed and dated.                                                 |

## 4.1 CHOOSING AND BUDGETING FOR A PET

### OBJECTIVES

- List the questions a family should answer before choosing a pet.
- Compare pets by lifespan, space, time, and cost.
- Make a first-year budget and a daily chore plan for one pet.

**Warm-up.** Make two columns: “Things I would love about having a pet” and “Things that would be hard.” Write at least four in each. Then circle the hard thing you think people forget most often.

### WATCH

#### What’s the Real Cost of Owning A Pet?

Two Cents • 5:38

<https://www.youtube.com/watch?v=ma3Mt5BPITE>

### WHEN TO WATCH

After the core ideas and before making your budget. Write down the kinds of costs they mention.

**Note:** A PBS personal-finance show for grown-ups. It opens with a short sponsor message and uses dog costs as its example; watch together and pause to explain.

### KEY TERMS

#### **lifespan**

How many years an animal usually lives. A pet is a commitment for its whole lifespan.

#### **ongoing cost**

Money spent again and again, such as food, bedding, litter and checkups.

#### **one-time cost**

Money spent once at the start, such as the adoption fee, cage or tank, and first supplies.

#### **budget**

A plan for how much money will be needed and spent.

## **steward**

Someone trusted to take care of what belongs to another. We care for animals as stewards of God's creatures.

### **CORE IDEAS**

Choosing a pet is a big decision, because you are promising to care for a living creature every day for its whole life. A wise family asks questions first. **Time:** Who will feed, clean and play with it every day, even on busy days and vacations? **Space:** Is there room for a big cage, a tank, or a yard? **Money:** Can we pay for food, supplies and the vet? **Fit:** Does anyone have allergies? Are there small children or other pets? Do we want an animal that is active by day or by night?

Think about **lifespan**. A hamster lives about 2 to 3 years, a guinea pig about 5 to 7, a rabbit about 8 to 12, a dog about 10 to 15, and a cat often 15 years or more. A leopard gecko can live 15 to 20 years, and some parrots outlive their owners. A pet you get at age 10 might still need you when you go off to college.

Every pet has **one-time costs** and **ongoing costs**. One-time costs include the adoption fee or purchase price, a cage, tank or crate, bowls, lights and heaters, and a first vet visit. Ongoing costs come every week or month: food, hay, bedding, litter, toys to replace, and yearly checkups and shots. The animal itself is often the cheapest part. Emergencies cost the most, so wise families set some money aside.

Good places to find a pet include animal shelters and rescues, reputable breeders who care for their animals, and well-kept pet stores. Visit first. Healthy animals have bright eyes, clean noses and bottoms, smooth coats, and are alert. Ask how the animal has been cared for and what it eats.

If the answer right now is “not yet,” that is a wise answer too. You can practice by helping with a neighbor's pet, volunteering with an adult at a shelter, or keeping a small, easy creature such as a few fish first. “A righteous man regardeth the life of his beast.” Caring well begins with choosing well.

## PICTURE STUDY



*Sympathy*, Briton Rivière, 1877 · Oil on canvas · Tate Britain, London

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

Briton Rivière was an English painter famous for his pictures of animals, especially dogs. In this painting a little girl has been sent to sit on the stairs, and her dog has come to keep her company. It shows the bond between a child and a well-loved pet.

### Look closely

- Look at the dog's face. What do you think it is feeling?
- Look at the girl's face and hands. How does she feel?
- Notice how close the dog sits to her. What does that tell you about them?
- Look at the dog's coat and body. Does it look healthy and well cared for? How can you tell?

### Talk about it

1. What does this dog need from its family every day to stay healthy and happy?
2. Why do you think the painter called this picture *Sympathy*?
3. What kind of person would make a good owner for a loyal dog like this?

**Safety first.** Visit pet stores, shelters and other people's animals only with an adult. Ask before touching any animal, and wash hands afterward.

## HANDS-ON PROJECT

### My Pet Plan and Budget

You will choose one pet you might like someday, research its needs, price everything it needs, and make a first-year budget and a daily chore chart.

#### You will need

- Journal or a sheet of graph paper
- A pet-care book from the library or a care sheet from a veterinarian or extension website
- A visit to a pet store or its website with a parent (to find prices)
- Calculator
- Colored pencils

#### Steps

1. Choose one pet: a rabbit, guinea pig, hamster, cat, dog, leopard gecko, parakeet or fish tank.
2. Research its lifespan, adult size, diet, housing size, and whether it is active by day or night. Write a short fact card.
3. List every **one-time** item it needs (cage or tank, bowls, hides, heater or light, carrier, first vet visit, adoption fee). Find a real price for each and add them up.
4. List every **ongoing** cost (food, hay, bedding, litter, treats, chews, yearly checkup and shots). Figure the cost per month.
5. Multiply the monthly cost by 12 and add the one-time costs. This is the **first-year cost**. Then multiply the monthly cost by 12 again for each year of its lifespan to find the lifetime care cost.
6. Make a daily and weekly chore chart: feeding, fresh water, cleaning, exercise, play and health checks. Put a name beside each chore.
7. Write a short paragraph: Is this pet a good fit for our family right now? Why or why not?

#### Tips

- Add a little extra to your budget, about one month's costs, for surprises like a vet visit.
- Ask a family who owns your chosen pet what they wish they had known before getting it.
- 4-H pet, rabbit and small-animal projects keep a record book with a budget like this one, plus a log of feed, care and costs. Check your county extension office to learn how homeschoolers can join.

#### Check your work

- ☐ I know my chosen pet's lifespan and daily needs.
- ☐ I made a first-year budget with real prices.
- ☐ My chore chart shows who will care for the pet every day.

#### NATURE JOURNAL

1. Draw your chosen pet from life (at a store, shelter or friend's house) or from a careful photo, with labels for its features.
2. Make a pie chart or bar graph showing where the money goes in your pet's first year.
3. Draw the ideal home for your pet with measurements.

**From history.** People have kept animals as companions and helpers since the earliest times. In the Bible, the prophet Nathan told the king a story about a poor man's little lamb that "grew up together with him, and with his children," ate from his plate and slept in his arms like a daughter. Even then, people understood how dear a cared-for animal could be.

#### COMMON MISTAKES

- Choosing a pet only because it is cute or popular without learning its needs.
- Forgetting ongoing costs and vet bills when planning.
- Thinking a small pet means little work. Small animals need daily care and clean cages too.

**Make it a game • Pet Plan Price Duel.** Parent names a pet and you shout its likely lifespan, space, daily time, one-time cost and ongoing cost from memory. Score a bean per category within a fair guess. Then play the budget round: pick the pet you would care for as a steward and defend your choice in thirty seconds. Switch and let your parent argue a pet.

**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 care for it well.  
Choosing a pet wisely is the first step of that care.

## 4.2 SMALL MAMMALS COMPARED

### OBJECTIVES

- Compare hamsters, gerbils, guinea pigs and rabbits by diet, social needs, activity and lifespan.
- Explain why rodents and rabbits need hay or chews for their teeth and why guinea pigs need vitamin C.
- Practice safe, gentle handling of a small mammal.

**Warm-up.** Look closely at your own front teeth in a mirror, and then at a picture of a rabbit's or hamster's front teeth. Draw both. How are they different in shape and color?

### WATCH

#### The Best Pets For Kids

Happy Tails • 11:42

<https://www.youtube.com/watch?v=yvJRQCV7zJI>

### WHEN TO WATCH

After the core ideas. Pause after each animal and fill in that row of your comparison chart.

**Note:** The presenter holds each animal as she talks about its pros and cons. She also covers rats, ferrets, hedgehogs, bearded dragons, dogs and cats.

### KEY TERMS

#### **rodent**

A mammal with front teeth that never stop growing, such as a hamster, gerbil, guinea pig, rat or mouse.

#### **hay**

Dried grass, such as timothy hay. It is the main food of rabbits and guinea pigs and wears down their teeth.

#### **incisors**

The sharp front teeth used for gnawing. In rodents and rabbits they grow all their lives.

#### **social animal**

An animal that is happiest living with others of its kind, such as guinea pigs, gerbils and rabbits.

**solitary**

Living alone. Syrian hamsters are solitary and fight if kept together.

**crepuscular**

Most active at dawn and dusk. Rabbits and many hamsters are crepuscular or nocturnal.

**CORE IDEAS**

Small mammals can be wonderful first pets, but each kind has its own needs. All of them share one thing: their front teeth, or **incisors**, never stop growing. Hamsters, gerbils and guinea pigs are **rodents**. Rabbits are not rodents, but their teeth grow all their lives too. They must chew hay, wood chews and rough food every day, or their teeth grow too long and they cannot eat.

**Hamsters** live about 2 to 3 years. Syrian hamsters are **solitary**: they must live alone, or they fight. They sleep in the day and run at night, sometimes for miles on a wheel. They need a large cage with deep bedding to burrow in, a solid wheel big enough that their backs do not bend, and a mix of pellets, seeds and a little fresh vegetable. **Gerbils** are desert diggers that live happily in pairs or small groups and are active in short bursts day and night.

**Guinea pigs** live about 5 to 7 years and are **social**, so they should be kept in pairs. They squeak and “wheek” to greet you. They eat mostly hay, plus guinea pig pellets and fresh vegetables. Like people, guinea pigs cannot make their own **vitamin C**, so they need it every day from foods like bell peppers and leafy greens, or they get sick.

**Rabbits** live about 8 to 12 years. Their diet should be mostly unlimited **hay**, with fresh leafy greens and a small amount of pellets; carrots and fruit are only treats. Rabbits need room to hop and stretch, time outside the cage every day, and something to chew. They can learn to use a litter box. Their backs are fragile: never lift a rabbit by its ears or scruff, and always support its hindquarters.

Handle all small mammals gently and close to the floor. Sit down, scoop the animal up with two hands under its chest and bottom, and hold it against your body. Never squeeze, chase or drop it. Small animals are prey animals that God made to be watchful and quick, so a calm voice and slow hands help them learn to trust you. Wash your hands before and after.

## PICTURE STUDY



*Selling Guinea Pigs*, George Morland, about 1789 · Oil on canvas · Royal Collection, United Kingdom

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

George Morland was an English painter of farm and country life. Here a traveling seller has brought guinea pigs to a family's door, more than two hundred years ago. Guinea pigs have been kept as pets in Europe since the 1500s.

### Look closely

- Find the guinea pigs on the ground. How many can you see?
- Look at the children's faces and hands. Which child seems most excited?
- Find the basket the seller uses to carry his guinea pigs.
- Notice how the mother watches. What might she be thinking about?

### Talk about it

1. What questions should this family ask before buying a guinea pig?
2. How many guinea pigs should they buy, and why?
3. What would the guinea pig need every day in its new home?

**Safety first.** Small mammals can bite or scratch if scared. Hold them low over a soft surface with two hands, never squeeze, and let an adult help. Wash hands before and after handling.

## **Small Mammal Comparison and Care Visit**

You will build a comparison chart of four small mammals, visit a real one if you can, and design a proper home on paper for the one that would suit your family best.

### **You will need**

- Journal or large paper
- Ruler and colored pencils
- Library books or care sheets from a vet or animal shelter
- A visit to a pet store, shelter, friend's home or 4-H show with a parent (optional but best)
- A tape measure

### **Steps**

1. Make a chart with four columns: hamster, gerbil, guinea pig, rabbit. Make rows for lifespan, size, diet, alone or in pairs, day or night, cage size, special needs, and handling tips.
2. Fill in the chart from the core ideas, the video and a library book.
3. If you can, visit a small mammal with an adult. Ask the keeper how to hold it, and practice sitting on the floor and scooping it up gently with two hands.
4. Watch the animal for 10 minutes without touching it. Record what it does: eating, grooming, digging, hiding, exploring.
5. Pick the animal that would fit your family best. On graph paper, draw its home to scale, with a hiding place, hay rack or food bowl, water bottle, bedding, chew toys and exercise space.
6. Write a one-week menu for it, including hay and fresh foods, and note any foods that are unsafe (such as chocolate, onions, or sugary treats).

### **Tips**

- Use a tape measure in a pet store to see how big a good cage really is. Many cages sold for small animals are too small.

- A shelter or rescue is a good place to meet guinea pigs and rabbits and ask questions.

#### **Check your work**

- ☐ I can tell which of these animals should live alone and which in pairs.
- ☐ I can explain why hay and chewing are important.
- ☐ I designed a home that meets my chosen animal's needs.

#### **NATURE JOURNAL**

1. Draw a guinea pig, rabbit or hamster from life, showing its whiskers, ears and feet.
2. Draw the teeth of a rabbit and a hamster, and write why they must chew every day.
3. Keep a 10-minute behavior log while watching a small animal: each minute, write what it was doing.

#### **COMMON MISTAKES**

- Keeping two Syrian hamsters together. They fight; they must live alone.
- Feeding rabbits mostly carrots and pellets. Rabbits need mostly hay.
- Keeping a guinea pig alone, or forgetting its daily vitamin C.

**Make it a game • Small Mammal Match-Up.** Make eight memory cards: four small mammals, hamster, gerbil, guinea pig and rabbit, and four care facts, such as hay for teeth, vitamin C, social animal, crepuscular. Lay them face down. Flip two at a time and keep only true matches, explaining each aloud. Fewest flips wins; try to beat your own record.

## 4.3 REPTILES AND AMPHIBIANS

### OBJECTIVES

- Tell reptiles from amphibians by their skin, eggs and life cycle.
- Explain why reptiles need a warm side and a cool side, and why some need UVB light.
- Know the hygiene rules for handling reptiles and amphibians.

**Warm-up.** Hold a mug of warm water in one hand and a cold spoon in the other for one minute. How does each hand feel? Now imagine you were an animal whose whole body took on the temperature of whatever it touched. Write how that would change your day.

### WATCH

#### Complete Leopard Gecko Care Guide!

TikisGeckos · 6:06

[https://www.youtube.com/watch?v=hU681Z\\_KXvM](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 what geckos eat.

**Note:** From a gecko keeper's channel; it shows live insects as food and briefly mentions his own shop.

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### BACKUP VIDEO

#### Fire-Bellied Toad, The Best Pet Frog?

Clint's Reptiles · 11:26

<https://www.youtube.com/watch?v=fKDtEh0zkQQ>

On the second day, to learn how an amphibian's needs differ from a gecko's.

## KEY TERMS

### **reptile**

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

### **ectotherm**

An animal that gets its body heat from its surroundings. Reptiles and amphibians are ectotherms.

### **UVB light**

A special lamp that gives off ultraviolet light like the sun. Many reptiles need it to use calcium and keep their bones strong.

### **amphibian**

A cold-blooded animal with moist skin that usually starts life in water, such as a frog, toad or salamander.

### **basking spot**

The warmest place in a reptile's enclosure, where it lies to warm up.

### **salmonella**

Germs that many reptiles and amphibians carry. They can make people sick, so we wash hands after handling.

## CORE IDEAS

Reptiles and amphibians are both **ectotherms**, which people sometimes call cold-blooded. They cannot make their own body heat the way mammals and birds do. Instead they move between warm and cool places to set their temperature. A lizard basks on a warm rock in the morning and hides in shade at noon.

**Reptiles**, such as lizards, snakes and turtles, have dry, scaly skin and breathe with lungs. Most lay eggs with tough or leathery shells on land, and the babies hatch looking like small adults. **Amphibians**, such as frogs, toads and salamanders, have smooth, moist skin that soaks up water and even some air. Most lay jelly-coated eggs in water. A frog begins as a tadpole with gills and changes into a frog with lungs. This change is called **metamorphosis**.

Because of this, a pet reptile's home must have a **temperature gradient**: a warm side and a cool side. A **leopard gecko** needs a warm spot of about 88 to 92 °F on the floor of one end, with the cool end in the low to mid 70s, plus hides on both sides and a moist hide for shedding. It eats live insects such as crickets and mealworms dusted with calcium powder. A **bearded dragon** needs a hot basking spot of about 95 to 110 °F, a cooler side around 75 to 85 °F, a large enclosure, and a **UVB light** for about 12 hours a day, because without it its bones grow weak. Use thermometers, not guesses.

Amphibians need cooler, damp homes with clean, dechlorinated water. Their skin is so thin that soap, lotion or salt on your hands can harm them, so most amphibians are pets to watch, not hold. Some, like the fire-bellied toad, have skin that can sting your eyes if you touch your face.

Many reptiles and amphibians carry **salmonella** germs that do not make them sick but can make people very sick. Always wash your hands with soap after touching the animal, its tank or its water, never hold a reptile near your face, keep reptiles and their supplies out of the kitchen, and keep them away from small children. Never release a pet reptile or amphibian outdoors; it may die or harm wild animals. These creatures are wonderfully made for warm deserts and damp forests, and a good keeper copies their home as closely as possible.

## PICTURE STUDY



*Tree Frogs, Plate IX of The Natural History of Frogs, August Johann Rösel von Rosenhof, 1758 · Hand-colored engraving · Historia naturalis ranarum nostratium, Nuremberg*

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

August Johann Rösel von Rosenhof was a German painter and naturalist who spent years raising and studying frogs and toads at home. In this plate he drew the little European tree frog from several sides, and one he kept in a glass jar so he could watch it closely.

### Look closely

- Find the frog inside the glass jar. How is it holding on to the smooth glass?
- Look at the toe pads on the frogs' feet. How might they help a tree frog climb?
- Compare the frog seen from above with the one seen from below. How are the colors different?
- Find the frog resting on the oak leaf. Does its skin look dry and scaly or smooth and moist?

### Talk about it

1. How can you tell from this picture that frogs are amphibians and not reptiles?
2. Rösel kept a frog in a jar to study it. What would a frog in a jar need to stay healthy?

3. What would a frog's home need that a leopard gecko's home would not?

**Safety first.** Always wash your hands with soap after touching a reptile, amphibian, its tank or its water; salmonella can make people very sick. Keep reptiles away from the kitchen and small children. Hot lamps are used only with an adult and kept away from paper and cloth.

## Design a Reptile Habitat and Gradient Test

You will measure a real temperature gradient with a lamp, then design a proper home for a leopard gecko or bearded dragon, and make a hand-washing sign.

### You will need

- A desk lamp with an incandescent or halogen bulb (or a sunny windowsill)
- Two or three thermometers
- A shoebox or plastic tub
- Ruler
- Graph paper and colored pencils
- A care sheet for a leopard gecko or bearded dragon from a veterinarian or a reputable reptile source

### Steps

1. Set the shoebox on a table. With an adult, point the lamp down into one end, about 8 inches above the bottom.
2. Place one thermometer under the lamp, one in the middle, and one at the far end. Wait 20 minutes.
3. Record all three temperatures. This is a **temperature gradient**, like the one a reptile needs.
4. Move the lamp higher or lower and test again. How could a keeper adjust the hot spot?
5. Choose a leopard gecko or a bearded dragon. Using its care sheet, draw its enclosure to scale on graph paper: the size, warm side and cool side with temperatures, hides, water dish, light or UVB lamp, and safe floor covering.
6. Write the daily and weekly care: feeding schedule, misting or moist hide, cleaning, checking temperatures.
7. Make a bright sign to post beside a reptile tank: “Wash your hands with soap after touching the animal, its tank or its water.”

### Tips

- If you can visit a reptile at a pet store, nature center or zoo, look for the basking lamp and the thermometers in its enclosure.
- Never use a heat lamp near paper or cloth without an adult watching. Turn it off when finished.

#### Check your work

- ☐ I can name two differences between reptiles and amphibians.
- ☐ I measured a warm-to-cool gradient and know why reptiles need one.
- ☐ I know the hand-washing rules for reptiles and amphibians.

#### NATURE JOURNAL

1. Draw a lizard and a frog side by side. Label the skin, feet, eyes and how each breathes.
2. Draw the life cycle of a frog in a circle: eggs, tadpole, tadpole with legs, froglet, adult frog.
3. Record your gradient temperatures on a drawing of your shoebox.

#### COMMON MISTAKES

- Guessing temperatures instead of using a thermometer.
- Forgetting UVB light for a bearded dragon, which leads to weak, bent bones.
- Handling amphibians often or with lotion on your hands.

**Make it a game • Warm Side, Cool Side.** Mark a rope or masking line on the floor as a reptile tank: one end hot basking spot, the other cool. Be a lizard and move to regulate your body temperature as your parent calls out 'too hot' or 'too cold.' Then sort reptile and amphibian clues: dry scales, jelly eggs, tadpole stage, and why some need UVB.

## 4.4 VISITING THE VET AND KEEPING A PET HEALTHY

### OBJECTIVES

- Describe what happens during a veterinary wellness exam.
- Name signs that a pet may be sick and needs a vet.
- Do a gentle nose-to-tail health check on a pet or a model.

**Warm-up.** Think about your own last checkup at the doctor. List everything the doctor checked: height, weight, eyes, ears, heart. Which of these do you think a veterinarian checks on a dog or cat?

### WATCH

#### In the Exam Room: Preventive Care Visits

American Veterinary Medical Association • 4:43

[https://www.youtube.com/watch?v=MnuhJ\\_it4UY](https://www.youtube.com/watch?v=MnuhJ_it4UY)

### WHEN TO WATCH

After the core ideas. List each part of the body the veterinarian checks, in order.

### KEY TERMS

#### **veterinarian**

A doctor trained to care for animals.  
Some vets treat pets; others treat farm animals, horses or exotic animals.

#### **parasite**

A living thing that lives on or in another animal and feeds from it, such as fleas, ticks and worms.

#### **stethoscope**

A tool a doctor uses to listen to the heart and lungs.

#### **wellness exam**

A regular checkup when an animal is healthy, to catch problems early.

#### **heartworm**

A dangerous worm spread to dogs and cats by mosquito bites. Monthly medicine prevents it.

## CORE IDEAS

A **veterinarian** is a doctor for animals. Most pets should see a vet for a **wellness exam** once a year, and young, old or sick animals more often. Animals cannot tell us when something hurts, and many hide signs of illness, so regular checkups catch problems early, when they are easier and cheaper to treat.

At a wellness exam, the vet weighs the animal and checks it from nose to tail. She looks into the eyes and ears, checks the teeth and gums, listens to the heart and lungs with a **stethoscope**, gently feels the belly for lumps or pain, looks at the skin and coat, checks the joints, and may take the temperature. She asks the owner about eating, drinking, bathroom habits and behavior. The pet may get its yearly shots, which protect it from diseases such as rabies.

Vets also help prevent **parasites**. Fleas and ticks bite and can spread disease. Worms can live in the gut. **Heartworm**, spread by mosquitoes, can damage a dog's heart, so many dogs take a monthly preventive. Clean bedding, regular grooming and checking for ticks after walks all help.

You are the first line of defense, because you see your pet every day. Call the vet if an animal stops eating or drinking, hides more than usual, seems weak or very sleepy, vomits or has diarrhea more than once, breathes hard or makes noisy breaths, limps, has runny eyes or nose, or has a lump or wound. Small animals like hamsters and guinea pigs can become very sick in just a day or two, so act quickly.

Rabbits, guinea pigs, birds and reptiles often need an **exotic animal vet** who knows their special needs. Find one before you need one. Keeping a pet healthy is part of the daily faithfulness that God asks of stewards: fresh water, good food, a clean home, gentle handling and help when they are sick.

## PICTURE STUDY



*Dignity and Impudence*, Sir Edwin Landseer, 1839 · Oil on canvas · Tate Britain, London

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

Sir Edwin Landseer was the most famous animal painter in Victorian England. Queen Victoria loved his pictures of her dogs. Here a big, solemn bloodhound and a small, cheeky terrier share a kennel.

### Look closely

- Compare the two dogs' sizes, faces and ears.
- Look at their eyes and noses. Do they look clear and healthy?
- Look at their coats. How did Landseer show the shine of healthy fur?
- Find the kennel. What does it tell you about how these dogs were housed?

### Talk about it

1. If you were a vet examining these dogs, what would you check first?
2. What signs in the picture suggest these dogs are well cared for?
3. Would these two very different dogs need different amounts of food and exercise? Why?

**Safety first.** Only examine an animal with its owner or an adult present, and stop if it growls, hisses, bites or struggles. Never put your face close to an unfamiliar animal's face. Wash hands afterward.

## **Nose-to-Tail Health Check**

You will learn to do a gentle weekly health check, the same way a vet does, and make a pet health record and a simple first-aid kit list.

### **You will need**

- A calm pet (your own, a friend's or a neighbor's, with an adult present) or a stuffed animal for practice
- A kitchen scale or bathroom scale (for weighing)
- A small flashlight
- Health check chart in your journal
- Pencil and colored pencils

### **Steps**

1. Make a chart with rows: weight, eyes, ears, nose, teeth and gums, coat and skin, belly, feet and nails, bottom, eating and drinking, energy, and columns for each week.
2. With an adult, choose a calm time. Let the animal sniff your hand first, and speak softly.
3. Weigh the animal. (For a small pet, weigh it in a container; for a larger one, weigh yourself holding it and subtract your own weight.)
4. Look at the eyes (bright and clear?), ears (clean, no bad smell?), nose (no crust or drip?), and with the adult's help, teeth and gums (pink and clean?).
5. Run your hands gently over the body, feeling for lumps, scabs or sore spots. Part the fur to look for fleas or ticks. Check the feet and nails.
6. Record what you found. Write "normal" or describe anything unusual.
7. Make a pet health record page: the pet's name, birthday, vet's name and phone number, shot dates, and weight history.
8. Make a list for a simple pet first-aid kit, and if you can, visit or call a vet clinic with an adult and ask one question about pet health.

### **Tips**

- Repeat your health check every week for a month. Changes over time, like slow weight loss, are important clues.
- If the animal becomes upset, stop and try again another day. Never force an exam.

#### **Check your work**

- ☐ I can describe what a vet checks during a wellness exam.
- ☐ I can name five signs that a pet should see a vet.
- ☐ I did a gentle health check and recorded my findings.

#### **NATURE JOURNAL**

1. Draw a dog or cat and label the nine places you check in a nose-to-tail exam.
2. Draw a tick and a flea, greatly enlarged, from a picture, and write how to check a pet for them.
3. Make a line graph of a pet's weight over four weeks.

**From history.** The first school for training veterinarians was founded in Lyon, France, in 1761 by Claude Bourgelat, an expert on horses. At first vets cared mostly for horses and farm animals, because a family's living depended on them. Today vets care for everything from goldfish to elephants.

#### **COMMON MISTAKES**

- Waiting too long when a small pet stops eating. Small animals can become very sick quickly.
- Thinking a healthy pet does not need a checkup.
- Giving a pet human medicine. Many are poisonous to animals; only give what a vet prescribes.

**Make it a game • Pretend Vet Visit.** Use a stuffed animal as the patient. You are the veterinarian and your parent is the worried owner. Go nose to tail with a pretend wellness exam: eyes, ears, teeth, coat, belly, stethoscope. Your parent describes a sick sign, like not eating, and you must say what to check or when to call a vet. Swap roles.

## UNIT 4

# PETS: CHOOSING WELL AND CARING FAITHFULLY

A pet is a living creature placed in your care, not a toy. In this unit you will learn to think like a wise pet keeper before an animal ever comes home: what it needs, how long it lives, how much time and money it takes, and whether it fits your family. You will compare hamsters, guinea pigs, rabbits and gerbils, and learn the special needs of reptiles and amphibians.

Finally you will learn how a veterinarian keeps pets healthy and how to spot the early signs that an animal is sick. You do not need to own a pet for any of these lessons. You can plan, budget, visit a pet store, shelter or vet clinic, or help care for a friend's or neighbor's animal.

### PREREQUISITES

- Can add and multiply money amounts
- Knows the basic needs of animals: food, water, shelter and care
- Has permission and an adult partner for any visit to a store, shelter or clinic

### MASTERY CHECKLIST

- ☐ I can list the questions a family should ask before getting a pet.
- ☐ I can make a first-year and monthly budget for a pet.
- ☐ I can compare the needs of hamsters, guinea pigs and rabbits.
- ☐ I can explain why reptiles need heat and light and why everyone must wash hands after handling them.
- ☐ I can describe a vet checkup and name signs that a pet may be sick.

### LESSONS IN THIS UNIT

#### 4.1 Choosing and Budgeting for a Pet

2 sessions of 45 minutes

#### 4.2 Small Mammals Compared

2 sessions of 45 minutes

#### 4.3 Reptiles and Amphibians

2 sessions of 45 minutes

#### 4.4 Visiting the Vet and Keeping a Pet Healthy

2 sessions of 45 minutes

## UNIT 4 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

Name four questions a family should ask before getting a pet.

2. (5 pts)

What is the difference between a one-time cost and an ongoing cost? Give an example of each.

3. (5 pts)

Why do rabbits, hamsters and guinea pigs need to chew hay or chews every day?

4. (5 pts)

Which should live alone, a Syrian hamster or a guinea pig? Why?

5. (5 pts)

What vitamin must guinea pigs get from food every day?

6. (5 pts)

Name two ways reptiles and amphibians are different.

7. (5 pts)

Why does a reptile's enclosure need a warm side and a cool side?

8. (5 pts)

What should you always do after touching a reptile or its tank, and why?

9. (5 pts)

Name four things a vet checks during a wellness exam.

10. (5 pts)

Name four signs that a pet might be sick.

## ANSWER KEY

1. Any four: Who will care for it daily? Do we have room? Can we afford food, supplies and vet care? Allergies? How long does it live? Does it fit our schedule and other pets?
2. A one-time cost is paid once (cage, adoption fee); an ongoing cost repeats (food, bedding, checkups).
3. Their front teeth grow all their lives and must be worn down.
4. A Syrian hamster; it is solitary and fights others. Guinea pigs are social and should live in pairs.
5. Vitamin C.
6. Any two: reptiles have dry scaly skin, amphibians moist smooth skin; reptiles lay shelled eggs on land, amphibians jelly eggs in water; amphibians go through metamorphosis (tadpole to frog).
7. Reptiles are ectotherms and control their body temperature by moving between warm and cool places.
8. Wash hands with soap, because reptiles can carry salmonella germs that make people sick.
9. Any four: weight, eyes, ears, teeth and gums, heart and lungs, belly, skin and coat, joints, temperature.
10. Any four: not eating or drinking, hiding, weakness or sleepiness, vomiting or diarrhea, hard breathing, limping, runny eyes or nose, lumps or wounds.

## PORTFOLIO PIECE: A COMPLETE PET CARE PLAN

Choose one pet and make a complete care plan your family could really use. Include a fact card (lifespan, size, diet, day or night), a scale drawing of its home, a first-year and monthly budget with real prices, a daily and weekly chore chart with names, a weekly health-check chart, and the name and phone number of a local vet who treats that animal.

| LOOK FOR              | WHAT IT MEANS                                                                                           |
|-----------------------|---------------------------------------------------------------------------------------------------------|
| <b>Accurate needs</b> | Diet, housing size, temperature or social needs are correct for the chosen animal.                      |
| <b>Budget</b>         | Includes one-time and ongoing costs with real prices and correct totals.                                |
| <b>Daily care</b>     | The chore chart covers food, water, cleaning, exercise and health checks, with a person named for each. |
| <b>Health plan</b>    | Includes a health-check chart, signs of illness, and a vet's contact information.                       |
| <b>Craftsmanship</b>  | Neat, organized, illustrated, titled, signed and dated.                                                 |

## UNIT 5

# PLANT SCIENCE

Late winter is the perfect time to look closely at how plants work, just before the seed-starting season. In this unit you will look inside a leaf at the tiny cells that capture sunlight and make food from air and water. You will take apart a flower to find out how pollen becomes seeds and fruit.

Then you will learn the clever ways God designed seeds to travel, by wind, water, animals and even explosions, and discover how plants sense light and gravity and grow toward what they need. Every experiment in this unit can be done on a kitchen table or a windowsill.

### PREREQUISITES

- Can name the main parts of a plant: roots, stem, leaves, flowers, fruit and seeds
- Knows that plants need light, water, air, warmth and nutrients
- Can use a magnifying glass and record observations in a table

### MASTERY CHECKLIST

- ☐ I can name the main parts of a plant cell and explain what chloroplasts do.
- ☐ I can state what goes into photosynthesis and what comes out.
- ☐ I can name the parts of a flower and explain how pollination leads to seeds and fruit.
- ☐ I can describe four ways seeds travel, with an example of each.
- ☐ I can explain how stems and roots respond to light and gravity.

### LESSONS IN THIS UNIT

#### 5.1 Plant Cells and Photosynthesis

2 sessions of 45 minutes

#### 5.2 Flowers and Pollination

2 sessions of 45 minutes

#### 5.3 How Seeds Travel

2 sessions of 45 minutes

#### 5.4 How Plants Respond to Light and Gravity

2 sessions of 45 minutes

## UNIT 5 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. **5 pts**

Name three parts that plant cells have but animal cells do not.

2. **5 pts**

What goes into photosynthesis and what comes out?

3. **5 pts**

Why did the leaf disks float in light but not in the dark?

4. **5 pts**

Name the male and female parts of a flower and what each makes.

5. **5 pts**

What is pollination, and what happens after it?

6. **5 pts**

Name a wind-pollinated crop and explain how its flowers differ from bee flowers.

7. **5 pts**

Give one example each of a seed that travels by wind, by animals, and by bursting.

8. **5 pts**

Why is it good for a plant to spread its seeds away from itself?

9. **5 pts**

What is phototropism? How does auxin cause it?

10. **5 pts**

If you lay a sprouting bean on its side, what will its root and shoot do?

#### ANSWER KEY

1. Cell wall, chloroplasts, and a large central vacuole.
2. In: carbon dioxide, water and light energy. Out: sugar and oxygen.
3. In light they made oxygen by photosynthesis, which filled the disks and made them float; in the dark no photosynthesis happened.
4. Stamen (anther and filament) makes pollen; pistil (stigma, style, ovary) holds the ovules that become seeds.
5. Moving pollen from an anther to a stigma; afterward the ovules become seeds and the ovary becomes the fruit.
6. Corn, wheat or another grass; its flowers are small and plain with no scent or nectar, and make lots of light pollen.
7. Wind: dandelion or maple. Animals: burdock burrs, berries or acorns. Bursting: pea or bean pods or jewelweed.
8. So young plants do not crowd and compete with the parent for light, water and nutrients, and can reach new places.
9. Growing toward light; auxin collects on the shady side and makes those cells grow longer, so the stem bends toward the light.
10. The root turns and grows downward (toward gravity) and the shoot turns and grows upward.

## PORTFOLIO PIECE: MY PLANT SCIENCE NOTEBOOK

Gather your four experiments into a neat plant science notebook or display board. For each one, include the question you asked, your prediction, what you did, your data (tables or graphs), a labeled drawing, and a one-paragraph conclusion. Finish with a full-page labeled diagram of a whole plant showing where photosynthesis, pollination, seed making and tropisms happen.

| LOOK FOR                 | WHAT IT MEANS                                                                                        |
|--------------------------|------------------------------------------------------------------------------------------------------|
| <b>Scientific method</b> | Each experiment has a question, a prediction, steps and a conclusion.                                |
| <b>Data</b>              | Results are recorded honestly in tables or graphs with units and dates.                              |
| <b>Accurate science</b>  | Conclusions use the correct terms (photosynthesis, pollination, dispersal, tropism) and explain why. |
| <b>Diagrams</b>          | Drawings are from life, carefully labeled and large enough to read.                                  |
| <b>Craftsmanship</b>     | The notebook is neat, organized, titled, signed and dated.                                           |

## 5.1 PLANT CELLS AND PHOTOSYNTHESIS

### OBJECTIVES

- Name the parts of a plant cell, including the cell wall, vacuole and chloroplasts.
- Explain photosynthesis: what goes in, what comes out, and where it happens.
- Show that leaves make oxygen in light with a floating leaf-disk experiment.

**Warm-up.** Hold a leaf up to a bright window and look through it with a magnifying glass. Draw what you see: the veins, the edges, any tiny dots or patterns. Then turn it over. Is the underside the same color and texture as the top?

### 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 warm-up and before the core ideas. Listen for the three things a plant needs to make food.

### BACKUP VIDEO

#### What are Cells? | Science For Kids

National Science Foundation News · 3:18

<https://www.youtube.com/watch?v=ex0x-w00Uy4>

With the core idea about cells.

### KEY TERMS

#### **cell**

The smallest living unit. All plants and animals are made of cells.

#### **cell wall**

The stiff outer layer of a plant cell, made of cellulose, that gives plants their shape.

#### **chloroplast**

A tiny green part inside a plant cell where photosynthesis happens.

#### **chlorophyll**

The green substance in chloroplasts that captures energy from light.

**photosynthesis**

The process by which plants use light energy to make sugar from carbon dioxide and water, giving off oxygen.

**stomata**

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

**CORE IDEAS**

Every living thing is made of **cells**, tiny building blocks too small to see without a microscope. A single leaf has millions of them. A plant cell has a thin skin called the cell membrane, a jelly-like inside called cytoplasm, and a nucleus that directs the cell's work. Plant cells also have three special parts animal cells do not: a stiff **cell wall**, a large **vacuole** filled with water that keeps the cell firm, and green **chloroplasts**.

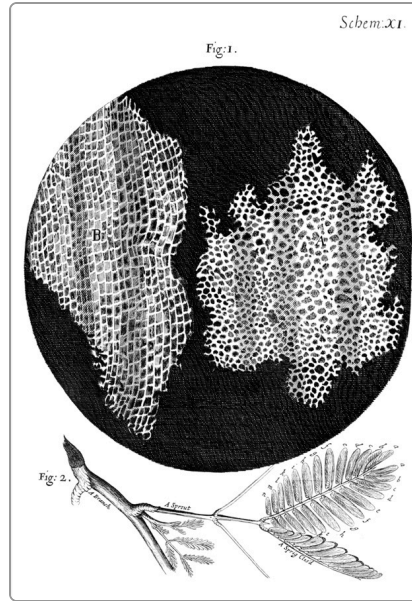
When a plant wilts, its vacuoles have lost water and the cells go soft, like a balloon losing air. When you water it, the vacuoles fill, press against the walls, and the plant stands up again. That is why a limp stalk of celery crisps up when you stand it in cold water.

The chloroplasts are where the plant makes its food. They are full of **chlorophyll**, the green substance that catches energy from light. In **photosynthesis**, the plant takes in **carbon dioxide** from the air through tiny pores called **stomata**, and **water** from the soil through its roots. Using the energy of light, it joins them to make **sugar**. The leftover is **oxygen**, which the plant releases into the air. You can remember it this way: carbon dioxide + water + light → sugar + oxygen.

The sugar is the plant's food and building material. It flows through the plant in tubes called phloem and is used to grow roots, stems, leaves, flowers and fruit, or stored as starch in potatoes, carrots, seeds and grain. Water travels up from the roots in other tubes called xylem. Plants also "burn" some of their sugar for energy, day and night, just as you do.

Nearly every bite of food you eat, and much of the oxygen you breathe, comes from photosynthesis. A tomato, a slice of bread, a glass of milk from a cow that ate grass: all of it began as sunlight caught by a leaf. "O LORD, how manifold are thy works! in wisdom hast thou made them all."

## PICTURE STUDY



*Cork Cells, from Micrographia, Robert Hooke, 1665 · Engraving · Micrographia, London*

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

In 1665 the English scientist Robert Hooke looked at a thin slice of cork through a microscope he had built. He saw rows of tiny boxes and called them “cells,” because they reminded him of the small rooms monks lived in. This drawing is the first picture of plant cells ever published.

### Look closely

- Find the rows of little boxes. How are they arranged?
- Compare the two slices. One was cut across and one lengthwise. How do the cells look different?
- Look at the walls between the boxes. Are they thick or thin?
- Find the sprig of the cork oak tree in the drawing.

### Talk about it

1. Hooke saw only the empty walls of dead cork cells. What parts of a living plant cell were missing?
2. Why do you think a microscope changed how scientists understood living things?
3. Which part of a plant cell gives cork its stiffness?

**Safety first.** Use a syringe without a needle. An adult helps with the lamp, which can get hot. Do not drink the baking-soda water.

## HANDS-ON PROJECT

### Floating Leaf Disks: Watching Photosynthesis

You will cut tiny disks from a spinach leaf, make them sink in water, and watch them rise as they make oxygen in light. You will also cover part of a living leaf to see what happens without light.

#### You will need

- A few fresh spinach leaves
- A plastic drinking straw or a hole punch
- A clean plastic syringe (10 mL or larger, no needle), from a pharmacy
- Two clear cups
- Water,  $\frac{1}{4}$  teaspoon baking soda, and 1 drop of dish soap
- A bright lamp or sunny window
- A timer
- A houseplant or garden plant and a small piece of aluminum foil with a paper clip

#### Steps

1. Mix 1 cup of water,  $\frac{1}{4}$  teaspoon of baking soda (it adds carbon dioxide) and 1 drop of dish soap. Pour half into each clear cup.
2. Punch 10 small disks from a spinach leaf, avoiding the big veins.
3. Remove the plunger from the syringe, drop the disks in, and put the plunger back. Draw up a little of the baking-soda water.
4. Point the syringe tip up, push out the air, then cover the tip with your finger and pull back the plunger to make a vacuum. Hold for 10 seconds, then release. Repeat until the disks sink.
5. Pour the sunken disks into one cup. Put it under the bright lamp or in sun. Put the second cup, with 10 more sunken disks, in a dark cupboard.
6. Every minute, count how many disks are floating in the light cup. Record the counts for 20 minutes. Then check the dark cup.
7. Explain: oxygen made by photosynthesis collects in the disks and makes them float.

8. On a living plant, fold foil over half of one leaf and clip it. After one week, remove the foil and compare the covered and uncovered parts.

#### **Tips**

- If disks will not sink, add a tiny bit more soap and try the vacuum step a few more times.
- Try a third cup at a different distance from the lamp to see whether brighter light makes the disks rise faster.

#### **Check your work**

- ☐ I can name the inputs and outputs of photosynthesis.
- ☐ My leaf disks floated in light and stayed down in the dark, and I can explain why.
- ☐ I can name three parts found in plant cells but not in animal cells.

#### **NATURE JOURNAL**

1. Draw a large plant cell and label the cell wall, cell membrane, nucleus, vacuole, cytoplasm and chloroplasts.
2. Make a line graph of how many disks floated each minute.
3. Draw the foil-covered leaf after one week, showing the difference in color.

**From history.** Robert Hooke's book *Micrographia*, published in 1665, showed people a hidden world: the eye of a fly, the point of a needle, a flea and the cells of cork. Hooke was a skilled builder of instruments and helped rebuild London after the Great Fire of 1666.

#### **COMMON MISTAKES**

- Thinking plants get their food from the soil. Plants make their food from air and water using light; soil gives water and minerals.
- Forgetting that plants also use oxygen and sugar for energy, just as animals do.
- Thinking only leaves are green. Green stems and unripe fruit can photosynthesize too.

**Make it a game • Plant Cell Blueprint.** Draw a plant cell from memory in one minute with a cell wall, vacuole and chloroplasts, then color the chloroplasts green. Cover it and tell your parent the photosynthesis recipe: what goes in, what comes out, and where it happens. Your parent checks a card of answers. Beat your own labeling time next round.

## 5.2 FLOWERS AND POLLINATION

### OBJECTIVES

- Name the parts of a flower and tell what each does.
- Explain pollination and how it leads to seeds and fruit.
- Dissect a flower and observe pollinators at work.

**Warm-up.** Look at a bouquet, a garden flower or a picture of a lily. In your journal, list every part you can see without touching it. Then write a guess: which part do you think makes the seeds?

### WATCH

#### Look Inside a Flower! | Science Project for Kids

SciShow Kids · 4:14

<https://www.youtube.com/watch?v=R9sn7HZM7uY>

### WHEN TO WATCH

Before the hands-on project. Pause when each flower part is named and point to it on your own flower.

### KEY TERMS

#### **petal**

The often colorful part of a flower that attracts pollinators.

#### **pistil**

The seed-making part in the center of a flower: the sticky stigma, the style and the ovary.

#### **pollination**

The moving of pollen from an anther to a stigma, by insects, birds, wind or a gardener's hand.

#### **stamen**

The pollen-making part of a flower, made of a thin filament topped by an anther.

#### **pollen**

Fine powder made in the anthers. It must reach a stigma for seeds to form.

#### **ovary**

The swollen base of the pistil that holds the ovules. After pollination the ovules become seeds and the ovary becomes the fruit.

## CORE IDEAS

A flower is a plant's seed factory. On the outside are green **sepals** that protected the bud. Next come the **petals**, colored, scented or patterned to invite visitors. Inside the petals is a ring of **stamens**. Each stamen has a thin stalk, the filament, holding up an **anther** that makes dusty **pollen**.

In the very center is the **pistil**. Its sticky tip is the **stigma**, which catches pollen. A tube called the style leads down to the **ovary**, which holds tiny ovules. When pollen lands on a stigma, it grows a tiny tube down to an ovule and joins with it. Then the ovule grows into a **seed**, and the ovary swells into a **fruit** to hold and protect the seeds. Every apple, bean pod, tomato and cucumber was once the ovary of a flower.

**Pollination** means getting pollen from an anther to a stigma. Many flowers depend on animals. Bees are the champion pollinators: hairy bodies collect pollen as they visit flower after flower for nectar. Butterflies, moths, flies, beetles and hummingbirds help too. Flowers that attract them are colorful, sweet-smelling and full of nectar, and some have lines on their petals that guide the visitor to the center.

Other plants are pollinated by **wind**. Corn, wheat, oats and grasses have small, plain flowers with no scent, and they make huge amounts of light pollen. On a corn plant, the tassel at the top sheds pollen, which drifts down onto the silks of the ears below. Each silk leads to one kernel, so an ear with missing kernels had some silks that were never pollinated.

Gardeners can help. Squash and cucumbers have separate male and female flowers; the female has a tiny fruit behind its petals. If bees are few, a gardener can carry pollen from a male flower to a female flower with a small brush. Planting flowers among the vegetables invites more pollinators. Jesus said that "even Solomon in all his glory was not arrayed like one of these," and the beauty of flowers has a purpose: to bring visitors who help them make seeds.

## PICTURE STUDY



*Vase of Flowers*, Jan van Huysum, 1722 · Oil on panel · J. Paul Getty Museum, Los Angeles

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

Jan van Huysum was a Dutch painter who studied real flowers so carefully that botanists admired his work. He often waited months for different flowers to bloom so he could paint each one from life. Look closely at the flower parts he painted.

### Look closely

- Find a flower where you can see the stamens in the center. What color are the anthers?
- Find a tulip and a rose. How are their petals arranged differently?
- Look for insects. Where are they, and what might they be doing?
- Find a flower bud that has not opened yet, and one that is fading.

### Talk about it

1. These flowers bloom at different times of year in a real garden. How do you think the painter managed to paint them all together?
2. Which flowers in this painting would most attract bees? Why?
3. If a bee visited the roses and then the poppies, would it help either one make seeds? Why or why not?

**Safety first.** An adult handles the craft knife. Lily pollen is poisonous to cats; keep lilies away from pets. Wash hands after handling flowers. Anyone with pollen allergies may wear gloves or choose a flower with little pollen. Watch bees calmly from a distance and never swat at them.

## HANDS-ON PROJECT

### Flower Dissection and Pollinator Watch

You will take apart a real flower, mount each part on a card with labels, and spend time watching pollinators visit flowers.

#### You will need

- A large, simple flower such as a lily, alstroemeria, tulip, daffodil or apple blossom (a grocery bouquet works)
- A craft knife or small scissors (adult help)
- Magnifying glass
- An index card or journal page and clear tape
- Tweezers
- A cotton swab or small paintbrush
- A timer

#### Steps

1. Draw the whole flower before you begin, from the side.
2. Gently pull off the green sepals and tape them to your card. Label them.
3. Remove the petals one by one. Count them and tape one or two to the card.
4. Find the stamens. Touch an anther with a cotton swab and look at the pollen under the magnifying glass. Tape one stamen down and label the filament and anther.
5. Find the pistil in the center. Touch the stigma. Is it sticky? Tape it down and label the stigma, style and ovary.
6. With an adult, slice the ovary across with the knife. Look for the tiny ovules inside with your magnifying glass. Draw what you see.
7. **Pollinator watch:** On a warm day, sit by flowering plants for 10 minutes (or watch flowers at a garden center or park). Record each visitor: bee, butterfly, fly, beetle, bird. Note what color flowers they visit most.

#### Tips

- Lilies have huge anthers and pollen that stains clothing, so work over newspaper.
- If it is too early for outdoor pollinators, watch a pollination video or look for the earliest blooms on crocuses, dandelions or a flowering tree.

#### Check your work

- ☐ I labeled the sepal, petal, stamen (anther and filament) and pistil (stigma, style and ovary).
- ☐ I can explain how pollination leads to seeds and fruit.
- ☐ I can name three pollinators and one wind-pollinated crop.

#### NATURE JOURNAL

1. Draw a large cutaway diagram of a flower and label all its parts.
2. Draw pollen grains as you see them under a magnifying glass, and note their color.
3. Make a tally chart of your pollinator watch and a bar graph of the results.

**From history.** Gregor Mendel, a monk and teacher in what is now the Czech Republic, studied pea plants in his monastery garden in the 1850s and 1860s. He carefully moved pollen from one pea flower to another with a small brush and kept records of thousands of plants. His work showed how traits such as flower color and seed shape pass from parent plants to their offspring.

#### COMMON MISTAKES

- Thinking the petals make the seeds. The ovary, inside the pistil, holds the seeds.
- Calling bees the only pollinators. Many insects, birds, wind and people pollinate flowers.
- Forgetting that fruits like cucumbers, peppers and tomatoes are the swollen ovaries of flowers.

**Make it a game • Flower Parts Fix-Up.** Draw a flower from memory and label petal, stamen, pistil and ovary. Your parent erases one label and you must restore it and tell the part's job. Then tell the story of pollination as a short drama: a bee visits, pollen travels, the ovary swells into fruit. Add actions and a dramatic announcer's voice.

## 5.3 HOW SEEDS TRAVEL

### OBJECTIVES

- Describe four ways seeds are dispersed: wind, animals, water and bursting pods.
- Explain why plants benefit from spreading their seeds away from the parent.
- Collect, sort and test real seeds, and grow seeds collected on a sock.

**Warm-up.** Blow on a dandelion seed head if you can find one, or drop a maple “helicopter” or a feather from as high as you can reach. Watch how it falls. Then drop a dry bean from the same height. Which falls faster, and why?

### WATCH

#### How Do Plant Seeds Travel? | Spring is Here! | SciShow Kids

SciShow Kids · 5:46

<https://www.youtube.com/watch?v=WqgVks9NViQ>

### WHEN TO WATCH

After the warm-up and before the core ideas. Write each way of traveling as a heading in your journal.

### BACKUP VIDEO

#### How do seeds get around?! (in MACRO!) | Maddie Moate

Maddie Moate · 7:15

<https://www.youtube.com/watch?v=nJAbo-F6tO4>

On the second day, to see seeds up close in macro filming before you sort your collection.

### KEY TERMS

#### **seed dispersal**

The ways seeds are carried away from the parent plant.

#### **samara**

A winged seed, like a maple “helicopter,” that spins as it falls and drifts on the wind.

#### **pappus**

The fluffy parachute on dandelion and thistle seeds that catches the wind.

#### **burr**

A seed case covered with hooks that catch on fur and clothing.

## **germinate**

To begin to grow; a seed germinates when it sends out its first root and shoot.

### **CORE IDEAS**

A plant cannot walk, but its seeds can travel. Why should they? If every seed fell straight down, the young plants would crowd under the parent, fighting for light, water and nutrients in its shade. Seeds that travel can find open ground and new places to grow. God fitted each kind of plant with its own clever way to send its seeds on a journey.

**Wind.** Dandelion and milkweed seeds have a fluffy parachute called a **pappus** that lets them float for miles. Maple, ash and elm seeds have wings; a maple's winged **samara** spins like a helicopter blade, slowing its fall so the wind can carry it away from the tree. Tiny, dusty seeds like those of orchids blow about like powder.

**Animals.** Burdock and cocklebur seeds are wrapped in **burrs** with tiny hooks that grab fur, feathers and socks. Juicy berries, cherries and tomatoes invite birds and animals to eat them; the seeds pass through the animal unharmed and are dropped far away. Squirrels and blue jays bury acorns and nuts to eat in winter, but forget some, which sprout into new trees.

**Water.** Coconuts float across oceans to land on new beaches. Many streamside plants have seeds with air pockets or waxy coats that float. **Bursting.** Some plants shoot their seeds out. When a pea or bean pod dries, its two halves twist and snap open, flinging the seeds. Jewelweed, also called touch-me-not, has ripe pods that burst at the slightest touch.

Gardeners use what they know about seed travel. They pull weeds like dandelions before they go to seed, cover seeded beds so birds do not carry seeds off, and save seed from their best plants. Each seed carries a tiny plant and its packed lunch inside a protective coat, waiting for warmth and water to germinate. "The earth brought forth grass, and herb yielding seed after his kind."

## PICTURE STUDY



*Dandelion (Taraxacum officinale)*, Franz Eugen Köhler (publisher), Walther Müller (illustrator), 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 1887. Botanical artists drew every part of a plant, including enlarged details, so that readers could identify it. The dandelion is one of the best seed travelers in the world.

### Look closely

- Find the round white seed head. How many seeds do you think it holds?
- Find the enlarged single seed. Trace the stalk up to the parachute.
- Look at the long root. Why is a dandelion so hard to pull out?
- Find a yellow flower and a closed bud. Which comes first?

### Talk about it

1. How does the parachute help the seed travel?
2. Why might a gardener want to pull dandelions before the seed heads form?
3. What other plants that you know travel by wind?

**Safety first.** Do not eat any wild seeds or berries you collect. Wash hands after sorting seeds. An adult operates the fan or hair dryer.

## HANDS-ON PROJECT

### Seed Travelers: Collect, Sort, Test and Grow

You will gather seeds, sort them by how they travel, test which wind seeds fly farthest, and see what grows from the seeds that hitch a ride on a sock.

#### You will need

- An old fuzzy sock large enough to pull over your shoe
- A tray or shallow container of potting mix
- Small zip bags or an egg carton for collecting
- Magnifying glass
- A fan or a hair dryer on cool (adult help)
- A tape measure
- Paper, scissors and paper clips for a paper helicopter

#### Steps

1. Pull the old sock over your shoe and walk slowly through a weedy field, field edge or untidy yard for 10 minutes.
2. Look at what stuck to your sock with a magnifying glass. Draw the hooks or bristles on two seeds.
3. Lay the sock flat on a tray of damp potting mix, cover it lightly with mix, and keep it moist on a windowsill. Count and draw what sprouts over three weeks.
4. Collect other seeds you can find (maple helicopters, dandelion fluff, acorns, burrs, pine cones, bean pods, fruit seeds from the kitchen). Sort them into wind, animal, water and bursting groups.
5. Make a paper helicopter: cut a strip of paper, fold two wings at the top, add a paper clip at the bottom for weight.
6. Drop your helicopter, a real maple seed (if you have one) and a bean from the same height in front of a fan on low. Measure how far each lands from the drop spot. Repeat three times and average.
7. Change one thing on your paper helicopter (longer wings or a heavier clip) and test again. Record what happened.

### Tips

- Fall and early spring both work for the sock walk. In late winter, try the dried weeds at the edge of a parking lot or field.
- Some seeds need a cold winter before they will sprout, so not every seed on your sock will grow right away.

### Check your work

- ☐ I sorted seeds into four ways of traveling.
- ☐ I tested how wing size or weight changes how far a seed flies.
- ☐ I can explain why spreading seeds helps young plants.

### NATURE JOURNAL

1. Draw four seeds, one for each way of traveling, and label the part that helps it travel.
2. Draw what sprouted from your sock after three weeks.
3. Make a table of your helicopter drop test with distances and averages.

**From history.** In 1941 a Swiss engineer named George de Mestral came home from a walk with his dog and found both covered with burdock burrs. Under a microscope he saw the tiny hooks that caught on loops of fur and cloth. He copied the design to invent the hook-and-loop fastener we know as Velcro.

### COMMON MISTAKES

- Thinking all seeds are carried by wind. Animals and water carry many seeds.
- Dropping the test seeds from different heights, which makes the test unfair.
- Throwing away the sock before giving the seeds time to sprout.

**Make it a game • Seed Travel Charades.** Take turns acting like a seed traveling: float like a samara, parachute like a dandelion pappus, cling like a burr, pop like a bursting pod, bob like a water traveler. Your parent guesses the method. Then explain in one sentence why seeds that land away from the parent plant do better. First to six right guesses wins.

**Scripture.** “And the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after his kind: and God saw that it was good.” (Genesis 1:12, KJV)

From the beginning, God made plants to carry seed for the next generation. Each seed’s design for travel is part of that good plan.

## 5.4 HOW PLANTS RESPOND TO LIGHT AND GRAVITY

### OBJECTIVES

- Define phototropism and gravitropism and give examples of each.
- Explain how a plant bends toward light.
- Grow a bean through a shoebox maze and turn a seedling on its side to observe responses.

**Warm-up.** Look at houseplants near a window. Do their leaves and stems lean in a certain direction? Draw one plant and draw an arrow showing which way it leans. Where is the window?

### WATCH

#### Plant Tropisms - For Kids

Mr. Queso's Classroom · 3:34

<https://www.youtube.com/watch?v=nP9msHiGkBU>

### WHEN TO WATCH

After the core ideas. Write down each tropism and an example.

### BACKUP VIDEO

#### Changing the direction of the light during plant growth - Time lapse #greentimelapse #gtl #timelapse

Green Timelapse · 2:09

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

Before setting up your maze, to see seedlings turn as the light moves.

### KEY TERMS

#### **tropism**

A plant's growth toward or away from something, such as light, gravity or touch.

#### **gravitropism**

Growing in response to gravity. Roots grow down and stems grow up.

#### **phototropism**

Growing toward light. Stems and leaves bend toward a window or the sun.

#### **thigmotropism**

Growing in response to touch, like a pea tendril curling around a string.

## **auxin**

A plant hormone that makes cells grow longer. It collects on the shady side of a stem, making it bend toward light.

### **CORE IDEAS**

Plants cannot walk to a sunny spot, but they can grow toward one. A plant's growth in response to something in its surroundings is called a **tropism**. God designed plants to sense light, gravity, water and touch, and to grow in the direction that helps them survive.

**Phototropism** means growing toward light. Put a houseplant by a window and in a week its stems will lean toward the glass. How does it work? The growing tip of a stem makes a hormone called **auxin**. When light comes from one side, auxin moves to the shady side. There it makes the cells grow longer, so the shady side stretches more than the sunny side, and the stem bends toward the light. Gardeners turn their potted plants every few days to keep them straight.

**Gravitropism** means responding to gravity. Roots grow *down*, toward gravity, where water and anchorage are. Shoots grow *up*, away from gravity, toward the light. Plant a seed upside down and the root will still turn and grow down, and the shoot will turn and grow up. Special cells in root tips contain tiny heavy grains that settle to the low side, telling the plant which way is down.

**Thigmotropism** means responding to touch. When a pea tendril touches a string or a twig, the cells on the far side grow faster, so the tendril curls around its support. Pole beans and morning glories twine around poles the same way. Roots also grow toward moist soil, which helps them find water.

Young sunflowers show another kind of movement. Their buds face east in the morning, follow the sun across the sky during the day, and turn back east at night. When the flowers open, most heads stay facing east, where the morning sun warms them and draws more bees. Every one of these responses helps a plant get the light, water and support it needs to grow and bear fruit.

## PICTURE STUDY



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

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

Van Gogh painted sunflowers again and again in the summer of 1888 to decorate a room for a friend. He painted them at every stage, from fresh blooms to heads heavy with seeds. Sunflowers are famous for following the sun when they are young.

### Look closely

- Find a sunflower in full bloom, one that is drooping, and one that has lost its petals.
- Look at the centers. Can you see the many tiny florets or seeds packed in spirals?
- Notice which way each flower head faces. Do they all face the same way?
- Look at the stems. Are they straight or bent?

### Talk about it

1. These flowers were cut and put in a vase. Can they still turn toward the sun? Why or why not?
2. In a field, which direction would most mature sunflowers face?
3. Why do you think the heads bend down as they get older and fill with seeds?

**Safety first.** An adult helps cut the cardboard. Raw dry beans are not for eating; wash hands after handling seeds.

## The Bean Maze and the Sideways Seedling

You will build a maze in a shoebox and watch a bean plant find its way to the light. At the same time you will turn sprouting seeds on their side to watch roots and shoots respond to gravity.

### You will need

- A shoebox with a lid
- Extra cardboard, scissors and tape
- A small pot or cup of potting mix
- 2 or 3 dry bean seeds (pole or bush beans), soaked overnight
- A clear jar or a zip bag and paper towels
- A sunny windowsill
- Ruler and journal

### Steps

1. Plant two soaked bean seeds about 1 inch deep in the small pot. Water it and wait until a shoot appears (about 5 to 7 days).
2. Meanwhile, cut a hole about 2 inches wide in one short end of the shoebox. Stand the box on its end with the hole at the top.
3. Tape two cardboard shelves inside the box, each covering about two-thirds of the width, on opposite sides, to make a zigzag path.
4. Set the sprouted bean pot in the bottom of the box. Close the lid and tape any light leaks. Place the box with the hole facing a sunny window.
5. Open the lid briefly every two days to water and to draw the stem's path. Watch it grow around the shelves and out the hole.
6. **Sideways seedling:** Line a jar with a damp paper towel and slip three soaked beans between the towel and the glass. When the roots are about 1 inch long, turn the jar on its side.
7. Draw the roots every day for four days. Which way do they turn?
8. Write a conclusion: what did the bean do in the maze, and what did the roots do in the sideways jar?

### Tips

- Paint the inside of the box black or use a dark box so light only comes from the hole.
- For a simpler test, set a potted seedling on a windowsill and do not turn it for a week.

### Check your work

- ☐ My bean grew through the maze toward the light, and I can explain why.
- ☐ I saw roots turn downward after the jar was turned, and I can name that response.
- ☐ I can explain how auxin makes a stem bend.

### NATURE JOURNAL

1. Draw the path of your bean through the maze on days 2, 6 and 10.
2. Draw your sideways-jar roots each day for four days, side by side.
3. Draw a stem bending toward light with arrows showing where auxin collects.

**From history.** In 1926 a young Dutch botanist named Frits Went cut the tips off oat seedlings and set them on tiny blocks of gelatin. When he put the blocks on one side of other cut seedlings, those seedlings bent away from that side, even in the dark. He had found the growth substance that came to be called auxin.

### COMMON MISTAKES

- Letting light leak into the maze, which confuses the result.
- Forgetting to water the maze plant because it is hidden in the box.
- Thinking the plant “wants” to see. Plants have no eyes; their cells sense light and respond.

**Make it a game • Bendy Plant Statue Game.** Play a statue game where you are a seedling. Lean toward a bright window for phototropism, stretch your roots down for gravitropism, and curl around a chair leg for thigmotropism. Parent calls the stimulus and you freeze in the right pose. Explain in a sentence how auxin makes the stem bend. Swap roles.

## UNIT 5

# PLANT SCIENCE

Late winter is the perfect time to look closely at how plants work, just before the seed-starting season. In this unit you will look inside a leaf at the tiny cells that capture sunlight and make food from air and water. You will take apart a flower to find out how pollen becomes seeds and fruit.

Then you will learn the clever ways God designed seeds to travel, by wind, water, animals and even explosions, and discover how plants sense light and gravity and grow toward what they need. Every experiment in this unit can be done on a kitchen table or a windowsill.

### PREREQUISITES

- Can name the main parts of a plant: roots, stem, leaves, flowers, fruit and seeds
- Knows that plants need light, water, air, warmth and nutrients
- Can use a magnifying glass and record observations in a table

### MASTERY CHECKLIST

- ☐ I can name the main parts of a plant cell and explain what chloroplasts do.
- ☐ I can state what goes into photosynthesis and what comes out.
- ☐ I can name the parts of a flower and explain how pollination leads to seeds and fruit.
- ☐ I can describe four ways seeds travel, with an example of each.
- ☐ I can explain how stems and roots respond to light and gravity.

### LESSONS IN THIS UNIT

#### 5.1 Plant Cells and Photosynthesis

2 sessions of 45 minutes

#### 5.2 Flowers and Pollination

2 sessions of 45 minutes

#### 5.3 How Seeds Travel

2 sessions of 45 minutes

#### 5.4 How Plants Respond to Light and Gravity

2 sessions of 45 minutes

## UNIT 5 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

Name three parts that plant cells have but animal cells do not.

2. (5 pts)

What goes into photosynthesis and what comes out?

3. (5 pts)

Why did the leaf disks float in light but not in the dark?

4. (5 pts)

Name the male and female parts of a flower and what each makes.

5. (5 pts)

What is pollination, and what happens after it?

6. (5 pts)

Name a wind-pollinated crop and explain how its flowers differ from bee flowers.

7. (5 pts)

Give one example each of a seed that travels by wind, by animals, and by bursting.

8. (5 pts)

Why is it good for a plant to spread its seeds away from itself?

9. (5 pts)

What is phototropism? How does auxin cause it?

10. (5 pts)

If you lay a sprouting bean on its side, what will its root and shoot do?

#### ANSWER KEY

1. Cell wall, chloroplasts, and a large central vacuole.
2. In: carbon dioxide, water and light energy. Out: sugar and oxygen.
3. In light they made oxygen by photosynthesis, which filled the disks and made them float; in the dark no photosynthesis happened.
4. Stamen (anther and filament) makes pollen; pistil (stigma, style, ovary) holds the ovules that become seeds.
5. Moving pollen from an anther to a stigma; afterward the ovules become seeds and the ovary becomes the fruit.
6. Corn, wheat or another grass; its flowers are small and plain with no scent or nectar, and make lots of light pollen.
7. Wind: dandelion or maple. Animals: burdock burrs, berries or acorns. Bursting: pea or bean pods or jewelweed.
8. So young plants do not crowd and compete with the parent for light, water and nutrients, and can reach new places.
9. Growing toward light; auxin collects on the shady side and makes those cells grow longer, so the stem bends toward the light.
10. The root turns and grows downward (toward gravity) and the shoot turns and grows upward.

## PORTFOLIO PIECE: MY PLANT SCIENCE NOTEBOOK

Gather your four experiments into a neat plant science notebook or display board. For each one, include the question you asked, your prediction, what you did, your data (tables or graphs), a labeled drawing, and a one-paragraph conclusion. Finish with a full-page labeled diagram of a whole plant showing where photosynthesis, pollination, seed making and tropisms happen.

| LOOK FOR                 | WHAT IT MEANS                                                                                        |
|--------------------------|------------------------------------------------------------------------------------------------------|
| <b>Scientific method</b> | Each experiment has a question, a prediction, steps and a conclusion.                                |
| <b>Data</b>              | Results are recorded honestly in tables or graphs with units and dates.                              |
| <b>Accurate science</b>  | Conclusions use the correct terms (photosynthesis, pollination, dispersal, tropism) and explain why. |
| <b>Diagrams</b>          | Drawings are from life, carefully labeled and large enough to read.                                  |
| <b>Craftsmanship</b>     | The notebook is neat, organized, titled, signed and dated.                                           |

## UNIT 6

# FARM ANIMALS AND BEES

Farm animals turn grass, grain and garden scraps into milk, eggs, wool, leather and meat, and they need faithful daily care to do it. In this unit you will learn how a cow's amazing four-part stomach turns grass into milk, why pigs are among the smartest animals on the farm, and how ducks and turkeys are raised.

You will finish with the honeybee colony, following it through all four seasons of the year, from the winter cluster to the spring swarm to the fall honey harvest. You do not need to own any animals. A farm visit, a county fair or 4-H show, a nature center with an observation hive, or a good library book will serve you well.

### PREREQUISITES

- Knows the difference between herbivores and omnivores (Lesson 2.1)
- Knows the basic needs of animals: food, water, shelter and care
- Knows what pollination is (Lesson 5.2)

### MASTERY CHECKLIST

- ☐ I can name the four compartments of a cow's stomach and tell what each does.
- ☐ I can describe how pigs are cared for and why they wallow in mud.
- ☐ I can compare how ducks and turkeys are raised and what they give us.
- ☐ I can describe what a honeybee colony does in each season.
- ☐ I follow the safety rules for being around large animals and bees.

### LESSONS IN THIS UNIT

#### 6.1 Cattle and the Four-Part Stomach

2 sessions of 45 minutes

#### 6.2 Pigs on the Farm

2 sessions of 45 minutes

#### 6.3 Ducks, Turkeys and Showing Small Animals

2 sessions of 45 minutes

#### 6.4 The Honeybee Colony Through the Year

2 sessions of 45 minutes

## UNIT 6 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

What is a ruminant? Name two.

2. (5 pts)

Name the four compartments of a cow's stomach in order.

3. (5 pts)

Why can a cow live on grass when people cannot?

4. (5 pts)

Name one dairy breed and one beef breed of cattle.

5. (5 pts)

Why do pigs wallow in mud?

6. (5 pts)

Name three chores a 4-H member does every day for a market pig.

7. (5 pts)

How does a duck keep its feathers waterproof?

8. (5 pts)

How is a heritage turkey different from a Broad Breasted White?

9. (5 pts)

What do honeybees do in winter?

10. (5 pts)

What is a swarm, and when does it usually happen?

#### ANSWER KEY

1. A hoofed animal with a four-part stomach that chews its cud, such as a cow, sheep, goat or deer.
2. Rumen, reticulum, omasum, abomasum.
3. Microbes in her rumen break down the tough plant fiber, and she chews her cud to grind it finer.
4. Dairy: Holstein or Jersey. Beef: Angus or Hereford.
5. They cannot sweat much, so mud cools them and protects their skin from sunburn and insects.
6. Any three: feed, give fresh water, clean the pen, add bedding, check health, practice walking.
7. It spreads oil from its preen gland over its feathers.
8. Heritage turkeys grow more slowly, forage, can fly and roost, and raise their own young; Broad Breasted Whites are a fast-growing commercial meat breed.
9. They form a tight cluster around the queen, shiver to make heat, and eat stored honey.
10. The old queen leaving with about half the workers to start a new colony; usually in spring when the hive is crowded.

**PORTFOLIO PIECE: A FARM CHORE CALENDAR**

Make a one-year chore calendar for a small family farm with two dairy goats or a cow, two pigs, five ducks and one beehive (you may substitute animals you have studied). Show the daily chores, the seasonal jobs (such as spring piglets or calves, summer honey supers, fall honey harvest and winter water checks), and a list of what each animal gives the family. Include at least one drawing from life made on a farm or fair visit, or from careful observation of a picture.

| LOOK FOR         | WHAT IT MEANS                                                                        |
|------------------|--------------------------------------------------------------------------------------|
| Daily care       | Daily chores for each animal include food, water, shelter and health checks.         |
| Seasons          | Seasonal jobs are placed correctly, including the beekeeper’s year.                  |
| Accurate science | Feeding and housing match each animal’s needs (ruminant, omnivore, waterfowl, bees). |
| Products         | Lists what each animal gives, such as milk, eggs, meat, honey, wax or leather.       |
| Craftsmanship    | The calendar is neat, organized, illustrated, titled, signed and dated.              |

## 6.1 CATTLE AND THE FOUR-PART STOMACH

### OBJECTIVES

- Explain what a ruminant is and why cattle chew their cud.
- Name the four compartments of a cow's stomach and describe what happens in each.
- Tell the difference between dairy and beef cattle and name a breed of each.

**Warm-up.** Chew a cracker 30 times before swallowing, counting each chew. Then think: what if your food were tough grass instead? How many times would you need to chew it? Write your guess.

### WATCH

#### Mobile Dairy Classroom: Learn About Cattle Eating Habits and Cow Digestion, Grades 4-6

Dairy Council of California · 3:04

<https://www.youtube.com/watch?v=meMHJ4Pt8kl>

### WHEN TO WATCH

After the core ideas. Name each stomach compartment as it is shown.

### BACKUP VIDEO

#### Ruminant Nutrition: A Symbiotic Relationship

Penn State Extension · 5:12

<https://www.youtube.com/watch?v=GedC1WjJEnM>

On the second day, to learn more about the microbes in the rumen.

### KEY TERMS

#### **ruminant**

A hooved animal with a four-part stomach that chews its cud, such as a cow, sheep, goat or deer.

#### **cud**

A ball of partly digested food that a ruminant brings back up from its stomach to chew again.

**rumen**

The first and largest stomach compartment, where billions of microbes break down grass.

**abomasum**

The fourth compartment, the “true stomach,” which digests food with acid much like a human stomach.

**dairy cattle**

Cattle raised for milk, such as Holsteins and Jerseys.

**beef cattle**

Cattle raised for meat, such as Angus and Herefords.

**CORE IDEAS**

Grass is tough. People cannot digest it at all, but a cow can live on grass and hay and turn it into milk and meat. The secret is her stomach, which has four compartments. Cattle, sheep, goats and deer are **ruminants**, animals designed with this special system. “He causeth the grass to grow for the cattle,” says Psalm 104, and God fitted the cow to eat it.

A cow first swallows her grass after only a little chewing. It goes into the **rumen**, a huge fermenting vat that in a grown cow can hold many gallons of food. Inside live billions of bacteria and other microbes that break down the tough plant fiber. The cow and the microbes help each other: she gives them food and a warm home, and they turn grass into nutrients she can use.

Next to the rumen is the **reticulum**, lined with a honeycomb pattern. Together they form food into soft balls called **cud**. When the cow rests, she burps up a cud and chews it slowly, sometimes for hours a day. This is called “chewing the cud” or ruminating. A cow lying in a pasture, calmly chewing, is hard at work. After rechewing, the food passes to the **omasum**, whose many leaf-like folds squeeze out water, and finally to the **abomasum**, the “true stomach,” which digests it with acid like ours.

Farmers raise two main kinds of cattle. **Dairy cattle**, like black-and-white Holsteins and brown Jerseys, are milked usually twice a day. A cow begins giving milk after she has her calf, often in spring. **Beef cattle**, like black Angus and red-and-white Herefords, are raised for meat and for leather. Steers and heifers graze on pasture and may be finished on grain before they go to market. Cattle need a lot of fresh water every day, along with grass or hay, minerals and shelter from harsh weather.

Cattle are large, strong animals. Even gentle cows can step on feet or push without meaning to. Always have an adult with you, move calmly and speak softly, never stand directly behind a cow, and do not get between a mother and her calf. A good herdsman knows each animal and notices if one stops eating or chewing her cud, a sign that she may be sick.

## PICTURE STUDY



*Ploughing in the Nivernais*, Rosa Bonheur, 1849 · Oil on canvas · Musée d'Orsay, Paris

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

Rosa Bonheur was a French painter who studied animals more carefully than almost anyone of her time. She visited farms and markets to draw cattle from life. Here teams of oxen, cattle trained to work, plough a field in central France in autumn.

### Look closely

- Count the oxen. How are they joined together to pull?
- Find the yoke across the oxens' necks or horns.
- Look at the muscles, hooves and hides. How did the painter show their strength and weight?
- Find the farmer guiding the team. Where is he walking?

### Talk about it

1. Oxen are ruminants. When would these oxen chew their cud?
2. Why might a farmer long ago have used oxen instead of horses for heavy ploughing?
3. What would these oxen need each day to stay strong for their work?

**Safety first.** Visit cattle only with an adult and with the farmer's permission. Stay outside fences unless invited, never stand behind a cow, and do not enter a pen with a bull or a mother and calf. Wash hands after any farm visit.

## HANDS-ON PROJECT

### Model the Four-Part Stomach (and Watch Cows Chew)

You will build a model of a cow's four stomach compartments and follow a mouthful of "grass" through it. If you can, you will also watch real cattle and count their chews.

#### You will need

- Four zip bags of different sizes (one gallon, two quart, one sandwich), or four plastic containers
- Labels and a marker
- A handful of torn lettuce or grass clippings
- A little water and a spoon of vinegar (for "acid")
- Poster board, tape and colored pencils
- A visit to a dairy or beef farm, a fair, or a pasture you can safely watch from the road with an adult (optional)
- A watch or timer

#### Steps

1. Label the bags: rumen (largest), reticulum, omasum, abomasum (smallest is fine).
2. Tape them on the poster in order, with a mouth and esophagus drawn above, and arrows showing the path, including the arrow back up to the mouth for chewing cud.
3. Put the torn lettuce in the rumen bag with a little water. Squeeze and squish it. This is the rumen's mixing and fermenting.
4. Move a small handful into the reticulum bag and press it into a ball. That is the cud. Take it out, "chew" it by mashing it with a spoon, and put it back.
5. Move it to the omasum bag and squeeze out the extra water.
6. Move it to the abomasum bag and add a spoon of vinegar to stand for stomach acid.
7. Label each bag on the poster with one sentence about its job.

8. If you can visit cattle, watch a cow lying down and chewing. Count her chews for one cud, then watch for the next cud coming up. Record your counts.

#### **Tips**

- Throw the model contents away when finished and wash your hands.
- Ask a farmer how much water a cow drinks in a day. The answer may surprise you.

#### **Check your work**

- ☐ I can name the four compartments in order.
- ☐ I can explain why cows chew their cud.
- ☐ I can name one dairy breed and one beef breed.

### **NATURE JOURNAL**

1. Draw a cow from the side and lightly sketch the four stomach compartments inside her, with labels.
2. Draw a Holstein, a Jersey, an Angus and a Hereford, and label each as dairy or beef.
3. Record your cud-chewing counts in a table: cow number, chews per cud, seconds between cuds.

**From history.** For thousands of years, oxen were the main farm power in much of the world. American pioneers often chose oxen to pull covered wagons west, because oxen were strong, steady and could live on prairie grass along the trail.

### **COMMON MISTAKES**

- Saying a cow has four stomachs. She has one stomach with four compartments.
- Thinking cows digest grass by themselves. The microbes in the rumen do much of the work.
- Standing behind a large animal, where it cannot see you and may kick or step back.

**Make it a game • Four Stomachs Relay.** Set out four bowls or cups in a row as the rumen and its neighbors. Carry a bean 'grass' from bowl to bowl, naming each compartment and what happens there, then bring it back up for chewing the cud. Parent times you. Add a second round where you explain beef versus dairy cattle. Beat your fastest time.

**Scripture.** “Be thou diligent to know the state of thy flocks, and look well to thy herds.” (Proverbs 27:23, KJV)

A good herdsman watches his cattle closely every day: how they eat, chew and move. Knowing your animals well is part of caring for them faithfully.

## 6.2 PIGS ON THE FARM

### OBJECTIVES

- Describe how pigs eat, why they root, and why they wallow in mud.
- Explain how a 4-H member raises and cares for a market pig.
- Name products we get from pigs and several pig breeds.

**Warm-up.** Look at the shape of your own nose and then at a picture of a pig's snout. Draw both. How is a pig's snout built for digging? Write two guesses about what pigs look for in the ground.

### WATCH

#### 4-H Market Swine

Iowa PBS • 3:12

<https://www.youtube.com/watch?v=3McdO9uRvsQ>

#### WHEN TO WATCH

After the core ideas. Notice the daily chores the 4-H member does for her pig.

**Note:** A market pig is raised for pork; the video mentions the sale at the fair but shows nothing beyond it.

### BACKUP VIDEO

#### 4-H Swine Showmanship

NDSU Extension 4-H • 7:15

<https://www.youtube.com/watch?v=plknAqfh0dg>

On the second day, to see how young people guide and show pigs with a cane or whip and a board.

### KEY TERMS

#### **swine**

Another word for pigs and hogs.

#### **sow**

An adult female pig that has had piglets. A young female is a gilt.

**boar**

An adult male pig kept for raising piglets. A young male raised for market is a barrow.

**rooting**

Digging in the ground with the snout to find roots, grubs and other food.

**wallow**

To roll and lie in mud or water to cool off and protect the skin.

**omnivore**

An animal that eats both plants and animals. Pigs are omnivores.

**CORE IDEAS**

Pigs are among the most intelligent animals on the farm. They learn their names, open latches, and quickly learn routines like feeding time. Unlike cows, pigs have a simple, single stomach like ours, and they are **omnivores**. On a farm they eat a balanced feed made mostly of corn and soybean meal, and many also enjoy pasture, garden scraps (with a farmer's care) and acorns.

A pig's **snout** is a strong, flat disc of tough skin with a keen sense of smell. Pigs use it for **rooting**, digging in soil for roots, grubs and worms. A few pigs can turn over a whole pasture, so some farmers use pigs to clear and loosen ground for a garden, then move them on.

Pigs have few sweat glands, so they cannot cool themselves by sweating. Instead they **wallow** in mud or water. The wet mud cools them as it dries and protects their skin from sunburn and insects. Pigs are actually clean animals when given space: they choose one corner of their pen as a bathroom and keep their sleeping area clean.

A mother pig, or **sow**, usually has a litter of about eight to twelve piglets at a time. Piglets grow fast. Many young people in 4-H and FFA raise a market pig from a small piglet in spring to a full-grown hog by the county fair in late summer. Every day they feed and water it, clean its pen, check its health and practice walking it with a cane or board so it is calm in the show ring. Pigs are raised for pork, ham and bacon, and they also give us leather and lard. Raising one teaches responsibility, patience and record keeping.

Some common breeds are the Yorkshire (white, with upright ears), the Duroc (red), the Hampshire (black with a white belt) and the Berkshire (black with white points). Grown pigs can weigh more than you and your parents together, and they can bite.

Work around pigs only with an adult, keep a board between you and a large pig, and wash your hands afterward.

#### PICTURE STUDY



*Pigs*, George Morland, about 1790s · Oil on canvas · Birmingham Museums Trust, England  
Image: [Wikimedia Commons](#), public domain

George Morland loved painting farmyards and the animals in them, especially pigs. This painting shows pigs in an English farmyard more than two hundred years ago, before modern barns.

#### Look closely

- Count the pigs. What is each one doing?
- Look at their snouts and ears. Are the ears upright or floppy?
- Find the straw or bedding. Why would pigs need it?
- Look at the shelter. How does it protect the pigs?

#### Talk about it

1. What clues tell you whether these pigs are cool or warm?
2. How is this farmyard different from the clean pen a 4-H member keeps?
3. What chores would the farmer need to do for these pigs every day?

**Safety first.** Pigs are strong and can bite or knock you over. Be around grown pigs only with an adult, keep a board between you and the pig, and do not reach into a pen with a sow and piglets. Wash hands after visiting any farm animal.

## HANDS-ON PROJECT

### A Market Pig Care Plan

You will plan the care of a 4-H market pig from spring to fair, with a pen design, feeding chart, chore schedule and record sheet. If you can, you will visit pigs at a farm or fair.

#### You will need

- Graph paper and colored pencils
- A calculator
- A 4-H swine project book or care sheet from your county extension office (free online)
- A visit to a farm, county fair or 4-H show (optional)
- Journal

#### Steps

1. Draw a pen to scale on graph paper with a dry sleeping area, a feeder, a waterer, shade, a place to cool off (mister or wallow), and a bathroom corner. Label each part.
2. Make a daily chore chart: morning and evening feeding, fresh water, cleaning the pen, adding bedding, health check, and walking practice.
3. A pig often grows from about 50 pounds in spring to about 250 to 280 pounds by fair time. Use your calculator: if the pig gains about 2 pounds a day, how many days will it take to gain 200 pounds?
4. Make a weekly record sheet, like the one in a 4-H project book, with columns for date, estimated weight, feed used, health notes and cost. Below it, make a simple **expense and income table**: list expenses (piglet, feed, bedding, vet, show supplies) and possible income (the sale at the fair), then subtract to find the profit or loss.
5. List what a pig needs from the vet and how you would know if it was sick (not eating, lying alone, coughing, limping).
6. If you can visit pigs, watch one for 10 minutes and record its behavior: eating, rooting, lying, drinking, playing. Ask the owner one question about

pig care.

#### Tips

- Your county extension office runs 4-H. Many have “cloverbud” and visitor programs where you can meet pigs and their young keepers.
- Pigs sunburn easily, especially light-colored breeds. Shade is not optional.

#### Check your work

- ☐ I can explain why pigs wallow and root.
- ☐ My pen design includes shade, water, feed, bedding and a way to keep cool.
- ☐ My chore chart shows care twice a day, every day.
- ☐ I kept a 4-H-style record with an expense and income table.

#### NATURE JOURNAL

1. Draw a pig from the side and label its snout, ears, curly tail, hooves and back.
2. Draw the four breeds named in the lesson, showing their colors and markings.
3. Make a line graph of a market pig's expected weight from spring to fair.

**From history.** In 1539 the Spanish explorer Hernando de Soto landed in Florida with a small herd of pigs to feed his men. Pigs were easy to drive overland and could find much of their own food in the woods. Settlers after him brought pigs to nearly every colony, and pork became a staple food of early America.

#### COMMON MISTAKES

- Thinking pigs are dirty by nature. Given room, they keep their beds clean.
- Forgetting shade and a way to cool off. Pigs suffer badly in heat.
- Treating a grown pig like a small pet. It is a large animal that needs care and respect.

**Make it a game • Pig Facts Two Truths.** Tell your parent three statements about pigs: two true and one tall tale. Use rooting, wallowing, eating habits and market pig care. Your parent guesses the tall tale and explains why. Then swap. Play three rounds. Whoever catches more tall tales wins. Try one claim about why a pig wallows in mud, and make it clever.

## 6.3 DUCKS, TURKEYS AND SHOWING SMALL ANIMALS

### OBJECTIVES

- Describe how ducks are built for water and what they need in a backyard.
- Describe how turkeys are raised and how heritage and commercial turkeys differ.
- Identify common poultry and rabbit breeds and practice small-animal showmanship and judging.

**Warm-up.** Put a drop of water on a piece of waxed paper and another on a paper towel. What happens to each drop? Now rub a little cooking oil on a feather or a scrap of paper and drop water on it. Write what you notice. How might this help a duck?

### WATCH

#### Raising Ducks for Beginners | What you Need to Know

Two Toe Farm • 4:55

<https://www.youtube.com/watch?v=ieMqxbSC1Bw>

### WHEN TO WATCH

After the core ideas about ducks. List the things ducks need.

### KEY TERMS

#### **poultry**

Birds raised for eggs or meat, such as chickens, ducks, turkeys and geese.

#### **poult**

A baby turkey.

#### **preen gland**

A gland near a bird's tail that makes oil. Ducks spread this oil over their feathers to waterproof them.

#### **heritage breed**

An older, traditional breed that can live outdoors, forage and raise its own young, such as the Bourbon Red turkey.

**snood**

The fleshy flap that hangs over a turkey's beak. It grows long and red when a tom is excited.

**biosecurity**

Habits that keep germs from spreading between flocks or herds, such as washing hands, cleaning boots, and keeping new or show animals apart for a while.

**CORE IDEAS**

**Ducks** are made for water. Their webbed feet are paddles, their bills strain food from mud and water, and their feathers are waterproof. A duck reaches back to the **preen gland** near its tail, collects oil on its bill, and spreads it over every feather. Underneath is a thick layer of soft down that keeps it warm even in icy water.

Ducks are hardy, cheerful birds that do well in rain and cold. They need a secure shelter at night, because foxes, raccoons and owls hunt them, and they need water deep enough to dip their whole heads in so they can clean their eyes and nostrils. A pond is a joy but not required; a tub that is emptied and refilled often works. Ducks forage for slugs, snails, insects and weeds, so they help gardeners, though they will also nibble lettuce. Some breeds, like the Khaki Campbell and Indian Runner, lay many large eggs; others, like the white Pekin, are raised mostly for meat.

**Turkeys** are the largest common poultry. A male is a tom; he puffs his feathers, fans his tail, and gobbles. His bare head and the fleshy **snood** and wattle turn bright red when he is excited. Females, called hens, are smaller and quieter. Baby turkeys, called **poults**, are delicate at first and need warmth, clean water and high-protein feed.

Most turkeys sold in stores are the Broad Breasted White, a fast-growing commercial breed raised for meat. **Heritage breeds**, such as the Bourbon Red, Narragansett and Bronze, grow more slowly, forage on pasture, roost in trees and can raise their own poults. Many small farms raise heritage turkeys for the holiday table. Turkeys are curious and friendly, but big toms can be pushy. Farmers often keep turkeys apart from chickens, because chickens can carry a disease that harms turkeys.

Ducks and turkeys, like chickens, are given to us for food: eggs, meat and even feathers for pillows and quilts. Raising them well means good food, clean water, dry bedding, shelter from predators, and daily attention. When we gather at

Thanksgiving, we can remember the farmer's work and give thanks to God for the harvest of field and flock.

Young people show small animals at county fairs and 4-H shows. They learn to tell breeds apart: chickens such as the Rhode Island Red, Plymouth Rock, Leghorn, Orpington and Silkie, and rabbits such as the New Zealand, Californian, Holland Lop, Mini Rex and Dutch. In **showmanship**, the judge looks at how well the exhibitor knows and handles the animal. A rabbit exhibitor carries the rabbit securely, poses it squarely on the table, then turns it over gently to check its teeth, ears, eyes, toenails and coat, and answers the judge's questions. Good exhibitors also practice **biosecurity**: they wash hands and clean boots between barns, and they keep animals coming home from a show apart from the rest of the flock or herd for a while, so no sickness spreads.

## PICTURE STUDY



*Wild Turkey Hen and Young*, John James Audubon, about 1825 (published 1827) · Hand-colored engraving, Plate 6 of *The Birds of America* · *The Birds of America*

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

John James Audubon set out to paint every bird in America, life-size. This plate shows a wild turkey hen leading her poults through the grass. Wild turkeys are the ancestors of the turkeys raised on farms.

### Look closely

- Find the hen's bare head. What color is it?
- Count the poults. How do their feathers help them hide in grass?
- Look at the hen's feathers. How many colors can you find in them?
- Look at the hen's legs and feet. How are they built for walking and scratching?

### Talk about it

1. How is this wild turkey different from a white farm turkey?
2. Why do you think poults stay close to their mother?
3. What would heritage turkey poults on a farm need to stay safe and warm?

**Safety first.** Wear gloves when handling found feathers and wash hands afterward, because wild birds can carry germs. Watch wild ducks from a distance and do not feed them bread. Wash hands after visiting poultry, which can carry salmonella. Handle a bird only with its owner's permission, hold it gently without squeezing, and keep it away from your face. Rabbits can scratch hard with their hind feet; always support the hindquarters and wear long sleeves.

## **Poultry Comparison, Showmanship and a Judging Class**

You will test how oil makes feathers waterproof, compare chickens, ducks and turkeys, practice how a young exhibitor shows a bird at the fair, and judge a class of four birds the way 4-H judges do.

### **You will need**

- Two feathers (craft feathers or found feathers, handled with gloves and washed)
- Cooking oil and a cotton swab
- A spray bottle of water and a paper towel
- A drop of dish soap
- Journal, ruler and graph paper
- A visit to a farm, fair or park pond with an adult (optional)
- A calm hen or duck with its owner (at a farm, fair or friend's home), or a stuffed bird or rolled towel for practice
- Pictures of four hens of the same breed (from a breed book, poultry catalog or fair website)
- A breed book or pictures of chicken and rabbit breeds, and index cards

### **Steps**

1. Spray one plain feather with water. Watch how the water soaks in or beads up. Then rub a thin coat of oil onto the second feather with a cotton swab, like a duck preening, spray it, and compare.
2. Now add a drop of dish soap to the oiled feather and spray again. What happens? (This is why ducks caught in oil spills are in danger, and why we never put soap in a duck's water.)
3. Make a chart comparing chickens, ducks and turkeys: size, eggs per week, eggs' size, foods, shelter, water needs, noise, and what each gives us. Plan a small duck setup on graph paper for three ducks: a predator-proof house, a fenced run, a water tub, a feeder and a place to dump dirty water.

4. If you can, watch ducks on a pond or at a farm for 10 minutes. Record how often they preen, dabble, dive and swim.
5. **Breed ID:** Make ten picture cards from a breed book or a fair or breed-club website: five chicken breeds (Rhode Island Red, Plymouth Rock, Leghorn, Orpington, Silkie) and five rabbit breeds (New Zealand, Californian, Holland Lop, Mini Rex, Dutch). Write one field mark on the back of each. Quiz a family member, then let them quiz you.
6. **Showmanship:** Practice holding a bird the way a 4-H exhibitor does: the bird's head toward your elbow, its body resting on your forearm, your fingers holding its legs gently between them, your other hand on its back. Practice with a stuffed bird first.
7. Practice the show routine slowly: carry the bird to the table, set it down facing the judge, then turn it gently to show the head (comb, eyes, beak), the wings spread one at a time, the feathers, the vent area and the feet and legs. Keep calm, smile and talk to the judge about your bird.
8. **Rabbit showmanship (optional):** With a calm rabbit and its owner, or a stuffed toy, practice the routine: carry it with one hand under the chest and one supporting the hindquarters, pose it squarely on the table facing left, then gently turn it over to check the teeth, ears, eyes, toenails and coat, and turn it back and pose it again.
9. **Judging class:** Lay out pictures of four hens of the same breed. Look for a bright eye, a red comb, smooth clean feathers, straight toes and a body shape that is true to the breed. Rank them 1 to 4.
10. Write your **reasons:** one or two sentences for each placing, such as "I placed hen 2 over hen 4 because she has brighter eyes and cleaner, tighter feathers."

#### **Tips**

- Ducks splash water everywhere. Put their water tub on gravel or where the overflow can water a garden bed.
- Watch a park duck preening through binoculars. You can see it reach back to the base of its tail for oil.
- Many county fairs have youth poultry showmanship classes, and some allow birds borrowed from a family farm. Check your county extension office or fair book.

- Biosecurity tip: after visiting another farm or a fair barn, wash your hands and change or scrub your shoes before going near your own birds or rabbits.

#### Check your work

- ☐ I can explain how a duck keeps its feathers waterproof.
- ☐ I can name one egg breed and one meat breed of duck, and one heritage turkey breed.
- ☐ My chart compares chickens, ducks and turkeys correctly.
- ☐ I can show a bird safely and rank a class of four with reasons.

#### NATURE JOURNAL

1. Draw a duck's webbed foot and a turkey's foot side by side. Why are they different?
2. Draw a turkey tom's head and label the snood, wattle and beak.
3. Draw your two feathers after the water test and describe each.
4. Write your judging card: the four placings in order and your reasons for each.

**From history.** In a 1784 letter to his daughter, Benjamin Franklin wrote that the turkey was “a much more respectable Bird” than the bald eagle and “a true original Native of America.” Wild turkeys became scarce by the early 1900s, but careful protection has brought them back to every mainland state.

#### COMMON MISTAKES

- Thinking ducks must have a pond. A tub deep enough to dip their heads works well.
- Keeping turkeys with chickens without asking an experienced keeper, because chickens can pass a disease to turkeys.
- Feeding bread to ducks, which fills them up without the nourishment they need.

**Make it a game • Poultry Show Ring.** Hold a pretend show ring at home. You play a judge and your parent plays a handler with a toy duck or turkey. Ask five questions about water-ready duck features, preen gland, poults and heritage versus commercial turkeys. Then switch and show your animal with careful handling, naming parts like the snood. Award a paper ribbon.

## 6.4 THE HONEYBEE COLONY THROUGH THE YEAR

### OBJECTIVES

- Name the three kinds of honeybees in a colony and the jobs of each.
- Describe what the colony does in winter, spring, summer and fall.
- Explain what a beekeeper does in each season.

**Warm-up.** Think about what your family does to get ready for winter: storing food, wearing coats, staying close together near the heat. Write three things. Then guess: how might a colony of bees get ready for winter?

### WATCH

#### Honey Bee Colony Life Cycle | Beekeeping Academy | Ep. 67

[UFhoneybeelab](#) · 14:07

<https://www.youtube.com/watch?v=tFs0ybiM6rA>

### WHEN TO WATCH

After the core ideas. Watch in two parts: stop halfway and tell back what you have learned.

**Note:** From the University of Florida Honey Bee Research and Extension Laboratory. Florida's seasons are milder than most of the country, so winter there is shorter.

### BACKUP VIDEO

#### What Do Honeybees Do in Winter?

[Scientific American](#) · 2:39

<https://www.youtube.com/watch?v=aPj0W2eT9PM>

With the core idea about the winter cluster.

### KEY TERMS

#### **colony**

A whole family of honeybees living together: one queen, thousands of workers, and in warm months some drones.

#### **queen**

The one bee in the colony that lays eggs, as many as a thousand or more a day in spring and summer.

**worker bee**

A female bee that does all the work: cleaning, nursing young, building comb, guarding and gathering nectar and pollen.

**drone**

A male bee. Drones do not sting or gather food; they live in the warm months and are pushed out of the hive in fall.

**winter cluster**

A tight ball of bees around the queen that keeps the colony warm through winter.

**swarm**

A large group of bees that leaves the hive with the old queen to start a new colony, usually in spring.

**CORE IDEAS**

A honeybee colony works like one great creature. There is one **queen**, who lays all the eggs. There are tens of thousands of **workers**, all females, who change jobs as they grow older: first cleaning cells, then feeding young, making wax and building comb, guarding the door, and finally flying out to gather nectar, pollen and water. In summer, a worker lives only about six weeks. In warm months there are also a few hundred **drones**, the males, who do not sting or work.

**Winter.** Bees do not sleep through winter. When it gets cold, they form a **winter cluster**, a tight ball with the queen in the middle. They shiver their flight muscles to make heat, keeping the center of the cluster warm while snow falls outside. Bees on the cold outside slowly trade places with those inside. They eat the honey they stored in summer, so a strong colony may need a large store of honey to survive a northern winter. Winter bees live for months instead of weeks.

**Spring.** As days lengthen, the queen lays more and more eggs. The first pollen comes from maples, willows and dandelions, and the colony grows quickly. When the hive is crowded, the workers raise new queens, and the old queen leaves with about half the bees in a **swarm**, a buzzing cloud that settles on a branch while scouts look for a new home. Swarming is how colonies multiply. Beekeepers give their bees more room to help prevent it.

**Summer.** This is the great nectar flow. Clover, basswood and many other flowers bloom, and foragers bring nectar home by the drop. House bees fan it with their wings to dry it into honey and seal it in wax cells. The beekeeper adds boxes called honey supers on top for the extra honey. **Fall.** Goldenrod and asters give the last

nectar. Workers push the drones out, the queen slows her laying, and the colony shrinks and packs the hive with honey. The beekeeper harvests only the extra honey, always leaving enough for winter.

Honeybees pollinate many of our fruits, nuts and vegetables, and they give us honey and beeswax. “Sweeter also than honey and the honeycomb,” says the psalmist of God’s word. Beekeeping is done by trained adults in protective veils, suits and gloves, with a smoker to calm the bees. If you are near a hive, stay calm, move slowly, and keep away from the entrance. Anyone allergic to stings must be especially careful.

## PICTURE STUDY



*The Beekeepers and the Birdnester*, Pieter Bruegel the Elder, about 1568 · Pen and brown ink on paper ·  
Kupferstichkabinett, Berlin

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

Pieter Bruegel drew this scene of beekeepers in Flanders about 450 years ago. In his time, bees lived in straw baskets called skeps. The beekeepers covered their faces with woven masks, much like the veils beekeepers wear today.

### Look closely

- Find the straw skeps. How many can you count?
- Look at the beekeepers' masks. What are they made of?
- Find a beekeeper carrying a skep. How is he holding it?
- Find the boy in the tree. What is he doing?

### Talk about it

1. Why do you think the beekeepers cover their faces?
2. What season do you think this is? What might the beekeepers be doing with the skeps?
3. How are these old skeps different from the wooden hives beekeepers use today?

**Safety first.** Watch bees from a calm distance and never disturb a hive or swarm. Only adult beekeepers in protective gear open hives. If you are allergic to stings, tell your parent before any bee activity and keep away from hives. If stung, tell an adult and scrape the stinger out quickly with a fingernail.

## HANDS-ON PROJECT

### The Bee Year Wheel and a Bee Watch

You will make a circular calendar of the honeybee year, plan a garden with flowers for bees in every season, and watch real bees at work.

#### You will need

- A paper plate or a circle of poster board
- A ruler, compass or bowl to trace
- Colored pencils
- A brad fastener and a cardboard arrow (optional)
- A library book or extension guide on flowers for bees
- A timer and journal
- Flowering plants in a yard, park or garden center

#### Steps

1. Divide your circle into four equal parts and label them winter, spring, summer and fall. Color each section.
2. In each section, draw and write what the bees do: the winter cluster, spring buildup and swarming, summer nectar flow, and fall drone removal and honey storage.
3. Around the outside, write what the beekeeper does in each season: checking honey stores, adding space, adding honey supers, harvesting and preparing for winter.
4. Add an arrow with a brad in the center so you can point to the current season.
5. Make a list of flowers that bloom for bees in each season where you live (for example, crocus and dandelion in early spring, clover in summer, goldenrod and aster in fall).
6. On a warm, sunny day, watch bees on flowers for 10 minutes from a calm distance. Count how many visits you see, which flowers they like best, and whether you see full pollen baskets on their back legs.

7. If you can, visit a nature center with an observation hive or a local beekeeper with an adult.

#### **Tips**

- Bees are calm on flowers. Stand still and watch; do not swat or wave your arms.
- Look for the yellow, orange or even gray lumps on a bee's back legs. These are pollen baskets.

#### **Check your work**

- ☐ I can name the three kinds of bees and the jobs of workers.
- ☐ My bee year wheel shows what the colony and the beekeeper do in each season.
- ☐ I watched bees at work and recorded what I saw.

#### **NATURE JOURNAL**

1. Draw a queen, a worker and a drone side by side, and label how they differ in size and shape.
2. Draw the winter cluster inside a hive with arrows showing bees moving from outside to inside.
3. Record your bee watch in a tally chart by flower color or kind.

**From history.** In 1851 a Pennsylvania pastor named Lorenzo Langstroth discovered that bees leave a space of about three-eighths of an inch open between combs. He designed a wooden hive with removable frames spaced just right, so beekeepers could inspect the colony without harming it. Nearly all modern hives are based on his design.

#### **COMMON MISTAKES**

- Thinking bees hibernate in winter. They stay awake in a warm cluster and eat stored honey.
- Thinking the queen rules the hive. She lays eggs; the workers make most decisions together.
- Taking all the honey. Bees need much of it to survive winter.

**Make it a game • Bee Year Wheel Spin.** Draw a circle divided into four seasons and spin a paper arrow or pencil. Wherever it lands, tell what the honeybee colony is doing: winter cluster, spring growth, summer abundance or fall preparation. Then name the queen, workers and drones and each one's job. Parent keeps score. Reach five correct spins without a hint.

**Scripture.** “More to be desired are they than gold, yea, than much fine gold: sweeter also than honey and the honeycomb.” (Psalms 19:10, KJV)

The psalmist wrote that God’s words are sweeter than honey. The bees’ year of work produces a sweetness that reminds us of the goodness of God’s word.

## UNIT 6

# FARM ANIMALS AND BEES

Farm animals turn grass, grain and garden scraps into milk, eggs, wool, leather and meat, and they need faithful daily care to do it. In this unit you will learn how a cow's amazing four-part stomach turns grass into milk, why pigs are among the smartest animals on the farm, and how ducks and turkeys are raised.

You will finish with the honeybee colony, following it through all four seasons of the year, from the winter cluster to the spring swarm to the fall honey harvest. You do not need to own any animals. A farm visit, a county fair or 4-H show, a nature center with an observation hive, or a good library book will serve you well.

### PREREQUISITES

- Knows the difference between herbivores and omnivores (Lesson 2.1)
- Knows the basic needs of animals: food, water, shelter and care
- Knows what pollination is (Lesson 5.2)

### MASTERY CHECKLIST

- ☐ I can name the four compartments of a cow's stomach and tell what each does.
- ☐ I can describe how pigs are cared for and why they wallow in mud.
- ☐ I can compare how ducks and turkeys are raised and what they give us.
- ☐ I can describe what a honeybee colony does in each season.
- ☐ I follow the safety rules for being around large animals and bees.

### LESSONS IN THIS UNIT

#### 6.1 Cattle and the Four-Part Stomach

2 sessions of 45 minutes

#### 6.2 Pigs on the Farm

2 sessions of 45 minutes

#### 6.3 Ducks, Turkeys and Showing Small Animals

2 sessions of 45 minutes

#### 6.4 The Honeybee Colony Through the Year

2 sessions of 45 minutes

## UNIT 6 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. (5 pts)

What is a ruminant? Name two.

2. (5 pts)

Name the four compartments of a cow's stomach in order.

3. (5 pts)

Why can a cow live on grass when people cannot?

4. (5 pts)

Name one dairy breed and one beef breed of cattle.

5. (5 pts)

Why do pigs wallow in mud?

6. (5 pts)

Name three chores a 4-H member does every day for a market pig.

7. (5 pts)

How does a duck keep its feathers waterproof?

8. (5 pts)

How is a heritage turkey different from a Broad Breasted White?

9. (5 pts)

What do honeybees do in winter?

10. (5 pts)

What is a swarm, and when does it usually happen?

#### ANSWER KEY

1. A hoofed animal with a four-part stomach that chews its cud, such as a cow, sheep, goat or deer.
2. Rumen, reticulum, omasum, abomasum.
3. Microbes in her rumen break down the tough plant fiber, and she chews her cud to grind it finer.
4. Dairy: Holstein or Jersey. Beef: Angus or Hereford.
5. They cannot sweat much, so mud cools them and protects their skin from sunburn and insects.
6. Any three: feed, give fresh water, clean the pen, add bedding, check health, practice walking.
7. It spreads oil from its preen gland over its feathers.
8. Heritage turkeys grow more slowly, forage, can fly and roost, and raise their own young; Broad Breasted Whites are a fast-growing commercial meat breed.
9. They form a tight cluster around the queen, shiver to make heat, and eat stored honey.
10. The old queen leaving with about half the workers to start a new colony; usually in spring when the hive is crowded.

**PORTFOLIO PIECE: A FARM CHORE CALENDAR**

Make a one-year chore calendar for a small family farm with two dairy goats or a cow, two pigs, five ducks and one beehive (you may substitute animals you have studied). Show the daily chores, the seasonal jobs (such as spring piglets or calves, summer honey supers, fall honey harvest and winter water checks), and a list of what each animal gives the family. Include at least one drawing from life made on a farm or fair visit, or from careful observation of a picture.

| LOOK FOR         | WHAT IT MEANS                                                                        |
|------------------|--------------------------------------------------------------------------------------|
| Daily care       | Daily chores for each animal include food, water, shelter and health checks.         |
| Seasons          | Seasonal jobs are placed correctly, including the beekeeper’s year.                  |
| Accurate science | Feeding and housing match each animal’s needs (ruminant, omnivore, waterfowl, bees). |
| Products         | Lists what each animal gives, such as milk, eggs, meat, honey, wax or leather.       |
| Craftsmanship    | The calendar is neat, organized, illustrated, titled, signed and dated.              |

## UNIT 7

# PLANTING: FROM SEED TRAY TO FIELD

Spring is planting time. In this unit you will build a real seed-starting station with light, warmth and air, raise strong seedlings, harden them off and move them outdoors without shock. You will plant a patio container garden that can grow food on a balcony or doorstep, and learn how to prepare an exhibit for a county fair.

Then you will step out to the farmer's field and learn how whole fields are prepared, planted in rows and sown with seed drills and planters, and why those inventions changed farming. Remember to time this unit by your own frost dates from Lesson 1.1.

### PREREQUISITES

- Knows your average last spring frost date (Lesson 1.1)
- Knows what seeds need to germinate: water, air and warmth
- Understands phototropism (Lesson 5.4) and soil pH (Lesson 3.2)

### MASTERY CHECKLIST

- ☐ I can set up a seed-starting station with the right light, warmth, water and air.
- ☐ I can judge a class of four seedlings and give reasons for my placings.
- ☐ I can harden off seedlings and transplant them with little shock.
- ☐ I can plant and care for a vegetable container garden and prepare a fair exhibit.
- ☐ I can explain how farmers till, plant rows and use seed drills and planters.

### LESSONS IN THIS UNIT

|                                                            |                          |
|------------------------------------------------------------|--------------------------|
| <b>7.1 A Seed-Starting Setup: Light, Warmth and Air</b>    | 2 sessions of 45 minutes |
| <b>7.2 Hardening Off and Transplanting</b>                 | 2 sessions of 45 minutes |
| <b>7.3 A Patio Container Garden and a Fair Exhibit</b>     | 2 sessions of 45 minutes |
| <b>7.4 Planting a Field: Rows, Tillage and Seed Drills</b> | 2 sessions of 45 minutes |

## UNIT 7 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. **5 pts**

Why do seedlings grown on a windowsill often become leggy, and how can you prevent it?

2. **5 pts**

Name four things a seed-starting station needs.

3. **5 pts**

In a judging class of four tomato seedlings, what makes a top-placing seedling?

4. **5 pts**

What is hardening off, and how long does it usually take?

5. **5 pts**

Why should you hold a seedling by a leaf or root ball, not the stem?

6. **5 pts**

Why should tomatoes be planted deeper than most transplants?

7. **5 pts**

Why should you use potting mix, not garden soil, in containers?

8. **5 pts**

Name four things fair judges look for in a vegetable plate exhibit.

9. **5 pts**

What does a seed drill do?

10. **5 pts**

What is no-till farming, and why do farmers use it?

#### ANSWER KEY

1. A window gives too little light, so they stretch; use a grow light a few inches above them for about 14 to 16 hours a day.
2. Any four: clean seed-starting mix, containers with drainage, warmth, strong light, water (bottom watering), air flow, labels.
3. Short and stocky, dark green, thick stem, close leaf spacing, true leaves, healthy roots, no damage.
4. Slowly getting indoor seedlings used to sun, wind and outdoor temperatures; about 7 to 10 days.
5. A crushed stem kills the plant, but a damaged leaf can be replaced.
6. They grow new roots along the buried stem, making a stronger root system.
7. Garden soil packs down in pots and drains poorly; potting mix stays light and drains well.
8. Any four: uniform size, shape, color and ripeness; true to type; no blemishes or damage; clean but not polished; correct number and labeling.
9. Cuts furrows, drops seed at an even depth and spacing, and covers it.
10. Planting into the last crop's stubble without plowing; it protects soil from erosion and keeps soil life and structure.

## PORTFOLIO PIECE: FROM SEED TO EXHIBIT: A PLANTING RECORD

Keep a complete record, like a 4-H project book, of one crop from seed to harvest. Include the seed-starting date, your setup, a growth graph, your hardening-off chart, transplant date and spacing, a care log, a list of costs, a photo or drawing each week, and finally a practice exhibit (a plate or potted plant) with its label card and your own judge's notes. Finish with a short paragraph: what you learned and what you would do differently next year.

| LOOK FOR                     | WHAT IT MEANS                                                                               |
|------------------------------|---------------------------------------------------------------------------------------------|
| <b>Complete record</b>       | Dates, care, measurements and costs are recorded from seed to harvest.                      |
| <b>Good growing practice</b> | Shows correct light, hardening off, transplant depth and spacing, and watering.             |
| <b>Exhibit</b>               | The practice exhibit is uniform, clean, labeled and judged against the five fair standards. |
| <b>Reflection</b>            | Explains honestly what worked, what did not, and what to change.                            |
| <b>Craftsmanship</b>         | The record is neat, organized, illustrated, titled, signed and dated.                       |

## 7.1 A SEED-STARTING SETUP: LIGHT, WARMTH AND AIR

### OBJECTIVES

- Set up a seed-starting station with containers, mix, light, warmth and air flow.
- Use your last frost date to decide when to start each crop indoors.
- Judge a class of four seedlings and give reasons.

**Warm-up.** Look at a picture of a tall, pale, floppy seedling and a short, sturdy, dark green one (or two real seedlings if you have them). Write three differences you see. Which one would you want to plant in your garden, and what do you think made the other one grow that way?

### WATCH

#### What Distance Should My Grow Lights be Above My Seeds Starts? & How Long Do I Leave the Lights On?

Gary Pilarchik (The Rusted Garden) • 3:54

<https://www.youtube.com/watch?v=7lmihHVhNJJs>

### WHEN TO WATCH

After the core ideas and before you hang your light.

### BACKUP VIDEO

#### 7 Tips on How & When to Use a Heat Mat on Garden Seed Starts: A Seed Starting Series

Gary Pilarchik (The Rusted Garden) • 4:27

<https://www.youtube.com/watch?v=vhWYONB4ANY>

On the second day, if you are starting peppers or tomatoes that like warm soil.

### KEY TERMS

#### **seed-starting mix**

A fine, light, clean growing mix made for seeds, usually peat or coir with perlite or vermiculite. It holds moisture but drains well.

#### **leggy**

Describes a seedling that has grown tall, thin and weak because it did not get enough light.

**cotyledons**

The first leaves, or seed leaves, that come out of the seed. They look different from the plant's later leaves.

**true leaves**

The leaves that grow after the seed leaves and have the plant's real leaf shape.

**heat mat**

A waterproof warming pad placed under seed trays to warm the soil for faster germination.

**thinning**

Removing extra seedlings so only the strongest one grows in each cell or spot.

**CORE IDEAS**

Starting seeds indoors gives your garden a head start. Tomatoes, peppers, eggplant, broccoli and many flowers need weeks of growing before it is warm enough to plant outside. Count backward from your last frost date: tomatoes are usually started about 6 to 8 weeks before it, peppers about 8 to 10 weeks, and broccoli and cabbage about 4 to 6 weeks. Fast growers like beans, squash, cucumbers and radishes are usually sown straight into the garden.

Seeds need a clean, light **seed-starting mix**, not garden soil, which packs down and can carry disease. Any container works if it has **drainage holes**: cell trays, yogurt cups or egg cartons. Moisten the mix before filling, sow seeds at about two to three times as deep as the seed is wide, and cover the tray with a clear dome or plastic wrap until sprouts appear.

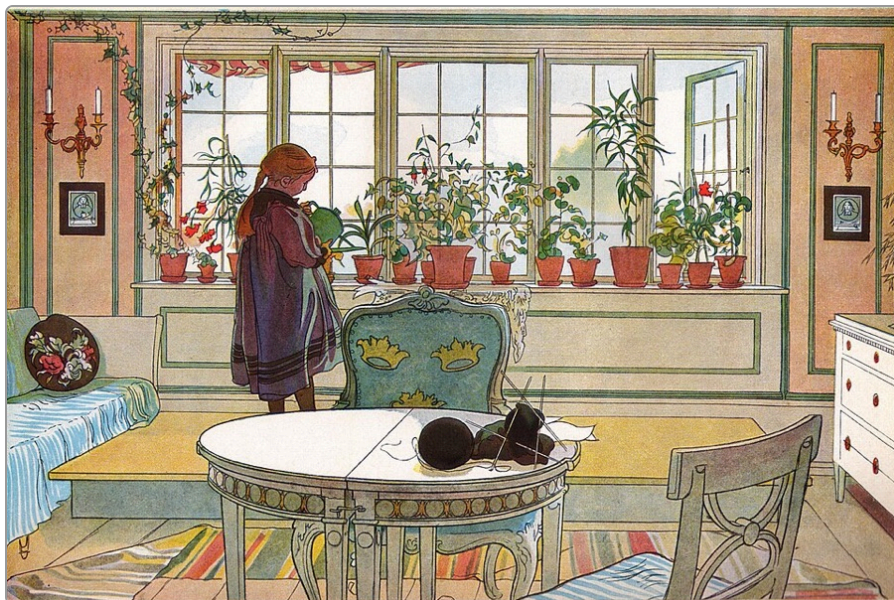
Most vegetable seeds sprout best when the mix is warm, about 70 to 80 °F. Peppers and tomatoes are slow in cold rooms, so many growers use a **heat mat** under the tray. As soon as most seeds sprout, take off the dome and the heat mat. Seedlings grow strongest in cooler air, around 60 to 70 °F.

Light is where most indoor gardens fail. Even a sunny window is much dimmer than outdoors, so seedlings stretch toward it and grow **leggy**. A simple LED shop light or grow light hung just a few inches above the seedlings, on a timer for about 14 to 16 hours a day, grows short, sturdy, dark green plants. Raise the light as the plants grow. A small fan blowing gently for a few hours a day makes stems stronger and helps prevent disease.

Water from the bottom by setting trays in a pan of water for a few minutes, so the mix stays evenly damp but never soggy. When seedlings have their first **true leaves**,

**thin** to one per cell by snipping extras at the soil line. A healthy transplant is short and stocky with dark green leaves, a thick stem, close leaf spacing and white roots that hold the mix together. This is exactly what judges look for at a plant sale or a youth garden show.

#### PICTURE STUDY



*Flowers on the Windowsill*, Carl Larsson, 1894 · Watercolor · Nationalmuseum, Stockholm (from the series *A Home*)

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

Carl Larsson painted his own family's home in the Swedish countryside. In the long, dark Swedish winters, the windowsill was the family's little garden. Look at how the plants are arranged to catch the light.

#### Look closely

- Count the pots on the windowsill. Are they all the same kind of plant?
- Notice which way the plants and leaves are leaning.
- Find the girl. What is she doing to care for the plants?
- Look at the light coming through the window. How bright is the room?

#### Talk about it

1. Would seedlings on this windowsill grow straight up or lean? Why?
2. What could this family do to give their plants more light in winter?
3. What do pots on a windowsill need underneath them, and why?

**Safety first.** An adult hangs the light and checks all cords. Keep water and electrical plugs apart, and use a power strip off the floor. Wash hands after handling mix and seeds; some seeds are coated with treatments.

## HANDS-ON PROJECT

### Build a Seed-Starting Station and Judge a Seedling Class

You will build a small seed-starting station, sow two or three crops timed to your frost date, and keep a 4-H-style record of costs and growth. After three weeks you will judge your seedlings like a fair judge.

#### You will need

- Seed-starting mix
- A cell tray or 12 small cups with holes poked in the bottoms, and a tray to catch water
- Seeds: tomato or pepper, lettuce, and marigold or basil
- Labels and a pencil
- An LED shop light or grow light with chains or a stand, and a plug-in timer (or your sunniest window)
- A clear lid or plastic wrap
- A small fan (optional)
- Ruler, thermometer and journal

#### Steps

1. Use your frost-date calendar to decide which seeds to start this week. Write the date and the planned transplant date for each crop.
2. Moisten the mix until it feels like a wrung-out sponge. Fill the cells and press lightly.
3. Sow 2 seeds per cell at the depth on the packet. Label every cell or row with the crop and date.
4. Cover with the clear lid and set the tray in a warm place (about 70 to 80 °F). Check daily.
5. When the first sprouts appear, remove the lid and set the tray under the light, 2 to 4 inches below the bulbs. Set the timer for 15 hours on.
6. Bottom-water when the mix feels dry on top. Run the fan on low for an hour or two a day if you have one.
7. When true leaves appear, thin to the strongest seedling per cell.

8. Keep a record table: date, what you did, water used, height of the tallest seedling of each crop, and the cost of every supply. Total your costs.
9. **Judging class:** After three weeks, pick four seedlings of one crop. Rank them 1 to 4 for stockiness, color, leaf spacing, true leaves and freedom from damage. Write one sentence of reasons for each placing.

#### **Tips**

- Ask a family member to grow one seedling on a windowsill without the lamp. Compare it with yours in the judging class.
- Many 4-H clubs and Junior Master Gardener groups judge transplants at spring plant sales. Check your county extension office.
- Service idea: grow a few extra seedlings to give to a neighbor, a church or school garden, or a plant sale that raises money for a food pantry.

#### **Check your work**

- ☐ My seedlings are short, sturdy and green, not pale and leggy.
- ☐ I kept a record of dates, care, growth and costs.
- ☐ I ranked four seedlings and gave clear reasons.

#### **NATURE JOURNAL**

1. Draw a seedling with its cotyledons and first true leaves, and label both.
2. Draw your setup with the light height, the timer setting and the temperature labeled.
3. Make a line graph of seedling height over three weeks for each crop.

**From history.** Before electric lights, gardeners started early seedlings in cold frames and hotbeds: wooden boxes with glass lids, warmed from below by a thick layer of fresh manure that heated up as it rotted. Market gardeners near Paris in the 1800s grew lettuce and melons all winter this way.

#### **COMMON MISTAKES**

- Keeping the light too high or too few hours, which grows leggy seedlings.
- Leaving the dome and heat mat on after sprouting, which invites mold and damping off.
- Overwatering. Let the top of the mix dry slightly between waterings.

**Make it a game • Station Setup Race.** Gather pretend supplies on a table: a tray, a lamp, a cup, a fan sketch. Without peeking at notes, build a seed-starting station while narrating light, warmth and air. Then count back from your last frost date to find when to start tomatoes indoors. Parent picks a crop, you give the date. Race the clock.

## 7.2 HARDENING OFF AND TRANSPLANTING

### OBJECTIVES

- Harden off seedlings over 7 to 10 days and explain why it is needed.
- Transplant seedlings into a bed or pot with as little shock as possible.
- Give a 3 to 5 minute illustrated talk on how to transplant a seedling.

**Warm-up.** Imagine you spent all winter indoors and then went outside for a whole hot, windy day without a hat or sunscreen. Write what would happen to you. Then write what you think would happen to indoor seedlings put straight outside.

### WATCH

#### 3 Tips For Hardening Off Your Seedlings In 2025 - Garden Quickie Episode 245

The Ripe Tomato Farms · 4:00

<https://www.youtube.com/watch?v=MI-N0rmOFUM>

### WHEN TO WATCH

After the core ideas about hardening off.

### BACKUP VIDEO

#### How to Transplant Seedlings Into the Garden - 10 MISTAKES to Avoid

Next Level Gardening · 10:15

[https://www.youtube.com/watch?v=GL\\_yLRDL24I](https://www.youtube.com/watch?v=GL_yLRDL24I)

Before you transplant, and again while you plan your illustrated talk.

### KEY TERMS

#### **hardening off**

Slowly getting indoor seedlings used to sun, wind and cooler or hotter outdoor air over about a week or two.

#### **transplant**

To move a plant from one place to another, such as from a cell tray into the garden.

**transplant shock**

Wilting, yellowing or slowed growth after a plant is moved, caused by root damage or sudden change.

**root ball**

The roots and the soil they hold together when a plant is lifted from its pot.

**illustrated talk**

A short talk where you show and explain how to do something step by step with real materials, as 4-H members do (sometimes called a demo).

**CORE IDEAS**

Indoor seedlings have lived a soft life: gentle light, still air and steady temperatures. Outdoor sun can scorch their tender leaves in an hour, and wind can snap them. **Hardening off** toughens them slowly. Their leaves grow thicker waxy coats, their stems grow stronger, and they learn to handle the real world.

Begin about 7 to 10 days before transplanting. On day one, set the seedlings outside in shade, out of wind, for an hour or two. Each day, give them a little more time and a little more sun. By the end of the week they should stay out all day in full sun and, if nights are mild, overnight. Bring them in if frost or a hard wind is coming. Warm-season crops like tomatoes, peppers and basil also need nights above about 50 °F before they go out to stay.

Choose a cloudy day or late afternoon to **transplant**, so the plants can settle in overnight before facing full sun. Water the seedlings an hour before. Dig a hole a little bigger than the **root ball** and fill it with water. Squeeze the cell or tip the pot to slide the plant out, holding it by a leaf or the root ball, never by the stem, because a seedling can grow a new leaf but not a new stem.

Set most plants at the same depth they grew in the pot. Tomatoes are special: bury them deeper, up to their first leaves, and they will grow roots all along the buried stem. Firm the soil gently around the roots, water well, and add mulch. Space plants as the seed packet says, so they have room when they are full-grown. A little wilting the first day is normal **transplant shock**; keep them watered and they will perk up.

Many 4-H members give a **illustrated talk**: a short talk where they show a skill with real materials, explain each step and why it matters, and answer questions. Teaching someone else is one of the best ways to learn a skill well, and it builds courage to speak clearly in front of others.

#### PICTURE STUDY



*The Gardeners*, Gustave Caillebotte, 1875–1877 · Oil on canvas · Private collection

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

Gustave Caillebotte was a French painter who loved gardening and grew orchids and vegetables at his country home. Here two gardeners water rows of young transplants in the evening light of a kitchen garden.

#### Look closely

- Follow the long rows of plants. How evenly are they spaced?
- Find the watering cans. How do the gardeners carry them?
- Look for the glass bell jars, called cloches, that protect tender plants.
- Notice the long shadows. What time of day is it?

#### Talk about it

1. Why might these gardeners water newly set-out plants in the evening?
2. How do the glass cloches help young plants after transplanting?
3. Why are the plants set in straight, evenly spaced rows?

**Safety first.** Use the trowel with care and keep it pointed down when walking. Wear gloves for compost and mulch, and wash hands after gardening.

## Harden Off, Transplant and Give an Illustrated Talk

You will harden off your seedlings from Lesson 7.1 (or bought transplants), plant them in a bed or large pot, and then teach your family how to transplant in a short illustrated talk.

### You will need

- Your seedlings or a six-pack of transplants
- A shady spot outdoors and a tray to carry them
- A garden bed or a large pot of potting mix
- Trowel, watering can and mulch (straw or shredded leaves)
- Ruler or measuring stick
- A poster board or three large cards for your talk
- Journal

### Steps

1. Make a 7-day hardening-off chart. Each day, record how many hours the seedlings spent outside, in shade or sun, and the temperature and wind.
2. Follow the schedule, giving a little more time and sun each day. Note any wilting or pale, scorched leaves.
3. On transplant day, water the seedlings an hour ahead. Choose a cloudy day or late afternoon.
4. Dig each hole, fill it with water, and let it soak in. Measure the spacing from the seed packet.
5. Slide each plant out by the root ball. Plant at the right depth (deeper for tomatoes), firm gently, water and mulch.
6. Check the plants each morning for five days and record how they look.
7. **Illustrated talk:** Make three cards or a small poster: what you are going to show, the steps, and why each step matters. Practice once or twice.
8. Give a 3 to 5 minute talk to your family. Introduce yourself, show each step with a real plant and pot, explain why, sum up, and ask, “Are there any questions?”

### Tips

- Stand where everyone can see your hands, speak slowly and look at your audience. Use the real tools, not just pictures.
- 4-H clubs hold illustrated-talk days where young members give talks like this; check your county extension office for the rules in your area.

### Check your work

- ☐ I hardened off my seedlings over at least 7 days and kept a chart.
- ☐ My transplants were set at the right depth and spacing and are growing.
- ☐ I gave a clear illustrated talk that showed each step and why.

### NATURE JOURNAL

1. Draw a tomato transplant set deep in its hole, showing where the new roots will grow along the buried stem.
2. Draw your bed or pot with each plant labeled and the spacing measured.
3. Write the outline of your illustrated talk: introduction, steps, summary.

### COMMON MISTAKES

- Skipping hardening off and losing seedlings to sun scorch or wind on the first day.
- Holding seedlings by the stem, which can crush them.
- Planting warm-season crops before nights stay above about 50 °F.

**Make it a game • Gentle Transplant Test.** Practice hardening off using a stuffed toy as a seedling. Each 'day' of 7 to 10, you move it a little farther outdoors and name what it's getting used to: sun, wind, cooler nights. Then show how to lift a root ball without squeezing the stem. Parent drops a surprise problem to fix. Explain transplant shock.

## 7.3 A PATIO CONTAINER GARDEN AND A FAIR EXHIBIT

### OBJECTIVES

- Choose containers, mix and crops for a productive container garden.
- Plant and care for a container garden with correct watering and feeding.
- Prepare a vegetable plate or potted plant exhibit the way fair judges expect.

**Warm-up.** Walk around your home and find every place that gets at least six hours of direct sun in a day: a porch, a balcony, a sunny step, a driveway edge. Make a list and draw a small map with the sunny spots marked.

### WATCH

#### **CONTAINER GARDENING for BEGINNERS: 10 Simple Steps**

Growing In The Garden • 8:15

<https://www.youtube.com/watch?v=y1eXnlzXdBE>

#### **WHEN TO WATCH**

After the core ideas and before you plant. Write down any step you had not thought of.

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### BACKUP VIDEO

#### **Top 7 Container Veggies For Beginners - Garden Quickie Episode 142**

The Ripe Tomato Farms • 4:12

<https://www.youtube.com/watch?v=ZW6HUQRhnsq>

When choosing which crops to grow.

### KEY TERMS

#### **container garden**

A garden grown in pots, tubs, buckets, grow bags or boxes instead of in the ground.

#### **potting mix**

A light, fluffy growing mix for containers. It drains well and does not pack down like garden soil.

**drainage hole**

A hole in the bottom of a pot that lets extra water escape so roots do not drown.

**exhibit**

Something you bring to a fair or show to be judged, such as a plate of vegetables or a potted plant.

**true to type**

Looking the way that variety should look in size, shape and color.

**uniform**

All alike. In a vegetable plate, every piece should match in size, shape, color and ripeness.

**CORE IDEAS**

You do not need a yard to grow food. A **container garden** on a sunny porch or balcony can give you herbs, salad greens, tomatoes and peppers all summer. The keys are a big enough container, good mix, plenty of sun and faithful watering.

Bigger containers are easier, because they hold more water and roots. A tomato or a pepper needs at least a 5-gallon pot, and 10 gallons is better. Lettuce, spinach and radishes grow well in a window box or a 2-gallon pot. Herbs like basil, parsley and chives fit in small pots. Every container needs **drainage holes**. Fill it with **potting mix**, never plain garden soil, which packs down and drowns roots in a pot. Fruiting crops need 6 to 8 hours of direct sun; leafy greens can manage with a little less.

Containers dry out much faster than garden beds, and on hot summer days a big tomato may need water every day. Use the finger test: push your finger in up to the second knuckle, and water when it feels dry there, until water runs out the bottom. Potting mix holds few nutrients, so feed with a slow-release organic fertilizer at planting and a gentle liquid feed every couple of weeks, following the label with an adult. Mulch the top to keep moisture in.

Many county fairs have youth vegetable, herb and potted-plant classes. Judges look for an **exhibit** that is **uniform** (every piece alike in size, shape, color and ripeness), **true to type** (looks like its variety should), free of blemishes, bruises and insect damage, clean but not scrubbed or polished, and trimmed and **labeled correctly** as the fair book asks. A plate of three to five matched vegetables usually beats one giant odd one.

A potted plant exhibit should be healthy, full and well shaped, with no yellow or dead leaves, no pests, a clean pot and a neat surface. The exhibitor's faithful care

over many weeks shows on the show table. Read the fair book early, because each class has its own rules for how many to bring and how to trim and label them.

## PICTURE STUDY



*The Artist's Garden at Vétheuil*, Claude Monet, 1880 · Oil on canvas · National Gallery of Art, Washington, D.C.

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

Claude Monet painted his family's rented garden in the village of Vétheuil, France. Monet loved gardening as much as painting. Look for the big blue-and-white flowerpots lining the steps, a container garden more than a century old.

### Look closely

- Find the large blue-and-white pots. How many can you count, and what is growing in them?
- Look at the tall sunflowers on each side of the path. How tall are they compared with the child?
- Find where the sunlight falls brightest. Where would the pots get the most sun?
- Look at the steps. Why is a set of steps a good place for containers?

### Talk about it

1. What would these pots need every day in the heat of summer?
2. Why are big pots easier to care for than small ones?
3. If you were entering one of these potted plants at a fair, what would you check before you brought it?

**Safety first.** An adult drills drainage holes and handles fertilizer, following the label; wear gloves and wash hands after. Full containers are heavy, so lift with an adult and bend your knees.

## HANDS-ON PROJECT

### Plant a Container Garden and Prepare a Fair Exhibit

You will plant at least two containers of vegetables or herbs, keep a care record, and later prepare a practice fair exhibit from your harvest or from the farmers' market.

#### You will need

- Two or more containers with drainage holes (a 5-gallon bucket with holes drilled, a grow bag, a window box or large pots)
- Potting mix and slow-release organic vegetable fertilizer
- Transplants or seeds: a tomato or pepper, lettuce or radishes, and an herb
- A stake or small cage for the tomato or pepper
- Watering can, mulch and labels
- Journal
- Later: a paper plate, a ruler, a soft brush or dry cloth and an index card for the exhibit label

#### Steps

1. Place your containers in the sunniest spot from your warm-up map. Set them on bricks or pot feet if they sit on a hard surface, so water can drain.
2. Fill with moist potting mix and mix in fertilizer as the label says, with an adult.
3. Plant one tomato or pepper per 5-gallon pot (with its stake), lettuce or radishes in rows in a wide pot, and an herb in a smaller pot. Label each.
4. Water until it runs out the bottom. Add mulch.
5. Keep a care record each day: date, finger-test result, water given, and anything you notice. Measure the tallest plant weekly.
6. **Exhibit practice:** When you have a harvest (or using vegetables from a farmers' market), choose the 3 to 5 that match best in size, shape, color and ripeness. Look for blemishes and set those aside.
7. Brush off dirt gently with a soft brush or dry cloth. Do not wash or polish. Trim stems the same length.

8. Arrange them neatly on a plate and write a label card with your name, the crop and the variety. Ask a family member to judge it, then judge it yourself using the five things judges look for.

#### **Tips**

- Get a copy of your county fair book in spring. It lists the youth vegetable, herb and potted-plant classes and how many of each to bring.
- Grow a few extra plants so you have more to choose from when picking a matched plate.

#### **Check your work**

- ☐ My containers have drainage, potting mix, and sun, and I water by the finger test.
- ☐ I kept a daily care record.
- ☐ I prepared a uniform, clean, labeled exhibit and can name what judges look for.

#### **NATURE JOURNAL**

1. Draw your container garden from life with each plant labeled.
2. Draw your exhibit plate from above and label what makes it uniform.
3. Make a weekly chart of plant height and water used.
4. Design a small flower bed the way Junior Master Gardeners do: on graph paper, plan a 3-by-6-foot bed for your sunniest or shadiest spot, with tall plants at the back, medium in the middle and short at the front, and a color scheme of two or three colors. Label each plant's height, color and sun needs.

#### **COMMON MISTAKES**

- Using a pot with no drainage hole, which drowns roots.
- Using small pots for big plants, which dry out quickly.
- Bringing one huge vegetable to a fair instead of a matched plate as the fair book asks.

**Make it a game • Container Crop Draft.** Take turns drafting a container garden. Parent calls a pot size, such as a five-gallon bucket; you name a crop that fits, mix, drainage hole need and watering plan. Score a bean for each correct detail. Then make a fair exhibit rule check: is it true to type and uniform? Whoever has more beans after eight turns wins.

## 7.4 PLANTING A FIELD: ROWS, TILLAGE AND SEED DRILLS

### OBJECTIVES

- Explain how farmers prepare a seedbed by tillage, and what no-till farming does instead.
- Explain why crops are planted in rows and how a seed drill and a corn planter work.
- Compare broadcasting seed with planting in drilled rows in a small test plot.

**Warm-up.** Scatter a small handful of rice or beans on a table as evenly as you can with one toss. Then lay out the same number in straight rows, one every inch. Which way would be easier to weed between? Which way puts every seed at the same depth?

### WATCH

#### Comparing Broadcast and Drill Planting Methods in Wheat

SFNToday • 5:19

<https://www.youtube.com/watch?v=bwz7hh-JZPg>

#### WHEN TO WATCH

After the core ideas. Listen for why drilled wheat often comes up more evenly than broadcast wheat.

**Note:** A farm news report filmed with agricultural scientists; aimed at farmers, so pause to explain.

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### BACKUP VIDEO

#### Grain Drill: How They Work and How to Buy One

The Back 40 • 17:44

<https://www.youtube.com/watch?v=58Y-7jCH82k>

On the second day, watch the first part to see how a grain drill opens the soil, drops seed and closes the row.

## KEY TERMS

### **tillage**

Working the soil with tools such as plows, disks and harrows to prepare it for planting.

### **no-till**

Planting directly into the stubble of the last crop without plowing, to protect soil from erosion.

### **seed drill**

A machine that cuts small furrows, drops seed at an even depth and spacing, and covers it.

### **seedbed**

Soil that has been loosened and smoothed so seeds can be planted evenly and sprout well.

### **broadcast**

To scatter seed over the surface by hand or machine instead of planting in rows.

### **row crop**

A crop such as corn or soybeans planted in rows wide enough to cultivate between.

## CORE IDEAS

A farmer's field is a garden on a grand scale. Before planting, many farmers prepare a **seedbed** by **tillage**. A plow turns over the top layer, burying old stalks and weeds. A disk cuts the clods into smaller pieces, and a harrow smooths the surface. The goal is loose, fine soil where every seed can touch moist earth.

But tillage leaves soil bare, open to erosion, and it breaks up the earthworm tunnels and fungal threads you learned about in Unit 3. Many farmers now use **no-till** or reduced tillage. They plant right into the stubble of last year's crop or a cover crop, using heavy machines that slice a narrow slot, drop the seed, and close it. The old stalks protect the soil like a blanket.

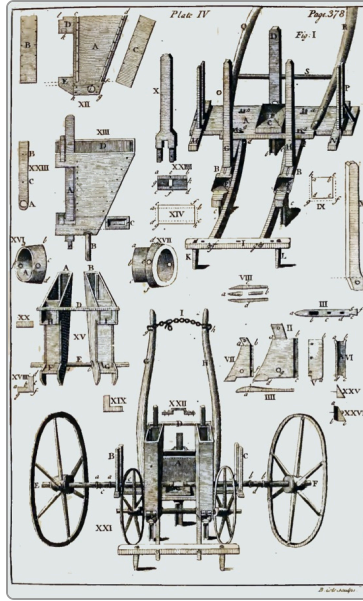
For thousands of years farmers sowed by hand, **broadcasting** seed as Millet's sower did. Much seed landed too deep, too shallow, or in clumps, and birds ate what lay on top. A **seed drill** changed that. It has a row of openers that cut shallow furrows, tubes that drop seed at a steady rate, and wheels or chains that cover each furrow. Every seed is planted at the same depth and spacing, so the crop comes up evenly and uses less seed. Wheat, oats and soybeans are often drilled in narrow rows.

**Row crops** like corn are planted with a **planter** that picks up single seeds and places them one by one, often 30 inches between rows. Rows let a farmer drive between the

plants to cultivate weeds, and they let sunlight and air reach every plant. Today many planters are guided by satellites so the rows are perfectly straight.

On hilly land, wise farmers plant across the slope, following its curves, instead of up and down. This **contour farming** makes every row a little dam that slows rainwater and saves topsoil. From the hand sower to the modern planter, the farmer's goal is the same: to put good seed in good ground, and then wait on God for the increase. "First the blade, then the ear, after that the full corn in the ear."

## PICTURE STUDY



*Jethro Tull's Seed Drill*, Jethro Tull (designer; engraving from his book), 1762 edition (designed about 1701) · Engraving from *The Horse-Hoeing Husbandry* · *The Horse-Hoeing Husbandry*, London

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

Jethro Tull was an English farmer who invented a horse-drawn seed drill around 1701 because his workers would not sow seed the careful way he wanted. This engraving from his book shows how his machine worked, with each part labeled by a letter.

### Look closely

- Find the boxes or hoppers that hold the seed.
- Find the sharp blades, called coulters, that cut the furrows in the soil.
- Find the wheels. How might turning wheels make the seed drop at a steady rate?
- Look for the part at the back that covers the seed with soil.

### Talk about it

1. How is this drill like the modern grain drill in the video? How is it different?
2. Why would planting in rows at an even depth give a better crop than broadcasting?
3. Why do you think the engraver labeled each part with a letter?

**Safety first.** Stay well away from tractors and farm machinery, even when parked. Never climb on equipment without the farmer's permission and an adult. Wash hands after gardening.

## HANDS-ON PROJECT

### Broadcast versus Drilled: A Mini Field Trial

You will plant two small plots of the same seed, one broadcast and one in drilled rows, and compare how evenly they come up and how easy they are to weed. This is a real field trial, like those run by extension scientists.

#### You will need

- A garden bed about 2 by 4 feet, or two large shallow tubs of potting mix
- Two equal amounts of fast seed: radish, oats or wheat berries (count out 100 seeds for each plot)
- A rake, a straight board or yardstick, and a pencil or dowel marked at  $\frac{1}{2}$  inch and 1 inch
- Labels, watering can and journal

#### Steps

1. Rake both plots smooth and level. This is your seedbed.
2. **Broadcast plot:** Scatter 100 seeds over the plot with one or two tosses, as evenly as you can. Rake lightly once to cover.
3. **Drilled plot:** Lay the board across the plot and press the marked dowel along its edge to make a furrow exactly  $\frac{1}{2}$  inch deep. Make four furrows 6 inches apart.
4. Drop 25 seeds evenly in each furrow, about 1 inch apart. Pinch the furrows closed and pat them down.
5. Water both plots gently and equally. Label them.
6. Each day for 10 days, count the seedlings up in each plot. Record the counts.
7. On day 14, time how long it takes to pull weeds from each plot. Note how evenly the plants are spread.
8. Write a report: which method gave more seedlings, more even stands and easier weeding? Was your trial fair? What would you change?

#### Tips

- Visit or drive past farm fields in spring with an adult and look for rows. Can you tell which fields were drilled and which were planted with a corn

planter?

- County fairs and farm shows often display old and new planting equipment. Look for a seed drill and compare it with Tull's.

#### Check your work

- ☐ I can explain what tillage and no-till do.
- ☐ I planted a fair trial with the same number of seeds in each plot.
- ☐ I can explain why a seed drill gives a more even crop than broadcasting.

#### NATURE JOURNAL

1. Draw a simple side view of a seed drill opener: blade, seed tube, seed in the furrow and the closing wheel.
2. Draw your two plots on day 10, showing where each seedling came up.
3. Make a bar graph of seedlings counted in each plot each day.

**From history.** Jethro Tull's seed drill and his book *The Horse-Hoeing Husbandry* (1731) taught farmers to plant in rows and hoe between them with horses. His ideas spread slowly at first, but they helped prepare the way for the great farm machines of the 1800s, like the reaper you learned about in Lesson 1.4.

#### COMMON MISTAKES

- Planting at uneven depths, so some seeds dry out and others never reach the surface.
- Using different amounts of seed or water in the two plots, which makes the trial unfair.
- Thinking straight rows are only for looks. Rows make weeding, watering and harvest easier.

**Make it a game • Seed Drill Charades.** Act out seedbed preparation: tillage, no-till, broadcasting and drilling. Parent guesses which one you are acting. Next, plant dried beans two ways on a baking sheet: scatter them for broadcast, then place them in neat rows like a seed drill. Count how many ended up evenly spaced and explain why rows are easier to tend.

**Scripture.** “For the earth bringeth forth fruit of herself; first the blade, then the ear, after that the full corn in the ear.” (Mark 4:28, KJV)

The farmer plants carefully, but the growth comes from God. Seed drills and planters help us sow well; the increase is still His gift.

## UNIT 7

# PLANTING: FROM SEED TRAY TO FIELD

Spring is planting time. In this unit you will build a real seed-starting station with light, warmth and air, raise strong seedlings, harden them off and move them outdoors without shock. You will plant a patio container garden that can grow food on a balcony or doorstep, and learn how to prepare an exhibit for a county fair.

Then you will step out to the farmer's field and learn how whole fields are prepared, planted in rows and sown with seed drills and planters, and why those inventions changed farming. Remember to time this unit by your own frost dates from Lesson 1.1.

### PREREQUISITES

- Knows your average last spring frost date (Lesson 1.1)
- Knows what seeds need to germinate: water, air and warmth
- Understands phototropism (Lesson 5.4) and soil pH (Lesson 3.2)

### MASTERY CHECKLIST

- ☐ I can set up a seed-starting station with the right light, warmth, water and air.
- ☐ I can judge a class of four seedlings and give reasons for my placings.
- ☐ I can harden off seedlings and transplant them with little shock.
- ☐ I can plant and care for a vegetable container garden and prepare a fair exhibit.
- ☐ I can explain how farmers till, plant rows and use seed drills and planters.

### LESSONS IN THIS UNIT

|     |                                                 |                          |
|-----|-------------------------------------------------|--------------------------|
| 7.1 | A Seed-Starting Setup: Light, Warmth and Air    | 2 sessions of 45 minutes |
| 7.2 | Hardening Off and Transplanting                 | 2 sessions of 45 minutes |
| 7.3 | A Patio Container Garden and a Fair Exhibit     | 2 sessions of 45 minutes |
| 7.4 | Planting a Field: Rows, Tillage and Seed Drills | 2 sessions of 45 minutes |

## UNIT 7 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. **5 pts**

Why do seedlings grown on a windowsill often become leggy, and how can you prevent it?

2. **5 pts**

Name four things a seed-starting station needs.

3. **5 pts**

In a judging class of four tomato seedlings, what makes a top-placing seedling?

4. **5 pts**

What is hardening off, and how long does it usually take?

5. **5 pts**

Why should you hold a seedling by a leaf or root ball, not the stem?

6. **5 pts**

Why should tomatoes be planted deeper than most transplants?

7. **5 pts**

Why should you use potting mix, not garden soil, in containers?

8. **5 pts**

Name four things fair judges look for in a vegetable plate exhibit.

9. **5 pts**

What does a seed drill do?

10. **5 pts**

What is no-till farming, and why do farmers use it?

#### ANSWER KEY

1. A window gives too little light, so they stretch; use a grow light a few inches above them for about 14 to 16 hours a day.
2. Any four: clean seed-starting mix, containers with drainage, warmth, strong light, water (bottom watering), air flow, labels.
3. Short and stocky, dark green, thick stem, close leaf spacing, true leaves, healthy roots, no damage.
4. Slowly getting indoor seedlings used to sun, wind and outdoor temperatures; about 7 to 10 days.
5. A crushed stem kills the plant, but a damaged leaf can be replaced.
6. They grow new roots along the buried stem, making a stronger root system.
7. Garden soil packs down in pots and drains poorly; potting mix stays light and drains well.
8. Any four: uniform size, shape, color and ripeness; true to type; no blemishes or damage; clean but not polished; correct number and labeling.
9. Cuts furrows, drops seed at an even depth and spacing, and covers it.
10. Planting into the last crop's stubble without plowing; it protects soil from erosion and keeps soil life and structure.

## PORTFOLIO PIECE: FROM SEED TO EXHIBIT: A PLANTING RECORD

Keep a complete record, like a 4-H project book, of one crop from seed to harvest. Include the seed-starting date, your setup, a growth graph, your hardening-off chart, transplant date and spacing, a care log, a list of costs, a photo or drawing each week, and finally a practice exhibit (a plate or potted plant) with its label card and your own judge's notes. Finish with a short paragraph: what you learned and what you would do differently next year.

| LOOK FOR                     | WHAT IT MEANS                                                                               |
|------------------------------|---------------------------------------------------------------------------------------------|
| <b>Complete record</b>       | Dates, care, measurements and costs are recorded from seed to harvest.                      |
| <b>Good growing practice</b> | Shows correct light, hardening off, transplant depth and spacing, and watering.             |
| <b>Exhibit</b>               | The practice exhibit is uniform, clean, labeled and judged against the five fair standards. |
| <b>Reflection</b>            | Explains honestly what worked, what did not, and what to change.                            |
| <b>Craftsmanship</b>         | The record is neat, organized, illustrated, titled, signed and dated.                       |

## UNIT 8

# PLANT HEALTH: BACTERIA, FUNGI, PESTS AND PROBLEMS

As your garden grows, so do its troubles. In this unit you will become a plant doctor. You will learn which bacteria help plants and which make them sick, how fungi cause rust, mildew and damping off, and how two common pests, the squash bug and the Japanese beetle, live out their life cycles in and around your garden.

Finally you will put it all together and learn to diagnose a sick plant step by step: is the trouble a missing nutrient, a pest, a disease, or the weather? A good plant doctor looks carefully, asks good questions, and chooses the gentlest fix that works.

### PREREQUISITES

- Knows what bacteria and fungi do in soil (Lesson 3.3)
- Knows N-P-K and that soil pH affects nutrients (Lesson 3.2)
- Has a garden bed, containers or houseplants to observe

### MASTERY CHECKLIST

- ☐ I can name helpful bacteria and two bacterial diseases of garden plants.
- ☐ I can identify powdery mildew, rust and damping off and tell how to prevent each.
- ☐ I can describe the life cycles of the squash bug and the Japanese beetle and when to control each stage.
- ☐ I can diagnose a plant problem by following clear steps and looking for patterns.
- ☐ I choose safe controls such as hand-picking, barriers and good watering, and I never handle pesticides.

### LESSONS IN THIS UNIT

#### 8.1 Bacteria: Garden Helpers and Plant Diseases

2 sessions of 45 minutes

#### 8.2 Fungi: Rust, Mildew and Damping Off

2 sessions of 45 minutes

#### 8.3 Pest Life Cycles: Squash Bugs and Japanese Beetles

2 sessions of 45 minutes

#### 8.4 Plant Doctor: Nutrient, Pest or Disease?

2 sessions of 45 minutes

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## UNIT 8 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. 5 pts

Name two ways bacteria help a garden.

2. 5 pts

How does bacterial wilt get into cucumber plants, and how can you prevent it?

3. 5 pts

Give two ways to keep bacterial leaf spot from spreading.

4. 5 pts

How do fungi spread, and what conditions help them?

5. 5 pts

Describe powdery mildew and rust.

6. 5 pts

What is damping off, and name three ways to prevent it.

7. 5 pts

Name the stages of a Japanese beetle's life. Where do the grubs live?

8. 5 pts

Where do you find squash bug eggs, and how can you remove them?

9. 5 pts

The lower, older leaves of a tomato are turning pale yellow all over. What nutrient might be short?

10. 5 pts

Many different plants in one corner of the yard turned brown on the same morning. Is the cause more likely biotic or abiotic? Give an example.

#### ANSWER KEY

1. Any two: decompose dead matter into plant food, fix nitrogen in legume nodules, crowd out harmful microbes.
2. Cucumber beetles carry the bacteria; prevent with row covers until flowering, hand-picking beetles and resistant varieties.
3. Any two: water at the base, mulch, stay out when leaves are wet, remove spotted leaves, clean seed and tools, rotate crops.
4. By spores on wind, water, tools and hands; moisture, humid air, crowding and poor air flow help them.
5. Powdery mildew: white, floury patches on leaves. Rust: orange, red-brown or yellow powdery bumps, usually under leaves.
6. Seedlings collapse at the soil line from fungi or water molds; prevent with clean mix and containers, bottom watering, not overwatering, removing the dome, air flow and good light (any three).
7. Egg, larva (grub), pupa, adult; grubs live in lawn soil and eat grass roots.
8. In clusters on the undersides of squash and pumpkin leaves; scrape them off or lift them with tape.
9. Nitrogen.
10. Abiotic, such as a frost, a chemical spill or drift, or wind.

## PORTFOLIO PIECE: A PLANT DOCTOR'S FIELD GUIDE AND POSTER

Make a plant doctor's field guide of at least eight garden problems from this unit: two bacterial diseases, three fungal problems, two insect pests and one nutrient shortage. For each, include a drawing from life or a careful copy, the symptoms, the cause, how it spreads, and safe prevention and control. Then make an educational poster on one problem, the kind of poster entered in county fair and conservation-district poster contests, with a clear title, a labeled drawing, three key facts and a prevention tip.

| LOOK FOR                   | WHAT IT MEANS                                                                                            |
|----------------------------|----------------------------------------------------------------------------------------------------------|
| <b>Accuracy</b>            | Symptoms, causes and controls are correct for all eight problems.                                        |
| <b>Observation</b>         | At least three entries come from plants you examined yourself, with dates.                               |
| <b>Safe, wise controls</b> | Prevention and gentle controls come first; pesticides are left to adults and only as a last resort.      |
| <b>Poster</b>              | The poster has a clear title, large labeled drawing, three facts and a tip, readable from across a room. |
| <b>Craftsmanship</b>       | The guide and poster are neat, organized, titled, signed and dated.                                      |

## 8.1 BACTERIA: GARDEN HELPERS AND PLANT DISEASES

### OBJECTIVES

- Name helpful soil bacteria and explain what they do for plants.
- Describe bacterial wilt and bacterial leaf spot and how each spreads.
- Show how splashing water spreads disease and how mulch and careful watering prevent it.

**Warm-up.** Remember the nodules on pea and clover roots from Lesson 3.3. In your journal, write two things soil bacteria do to help plants. Then write a guess: if most bacteria are helpers, how might a few of them make plants sick?

### WATCH

#### Early season management of cucumber beetles and bacterial wilt on pumpkin and squash

The Ohio State University IPM Program • 5:24

[https://www.youtube.com/watch?v=RSzTT\\_gbma4](https://www.youtube.com/watch?v=RSzTT_gbma4)

### WHEN TO WATCH

After the core idea about bacterial wilt. Listen for how the beetle carries the bacteria.

**Note:** From Ohio State University's Integrated Pest Management program. Spray products for farms are mentioned; children never handle these.

### KEY TERMS

#### **pathogen**

A living thing, such as a harmful bacterium, fungus or virus, that causes disease.

#### **bacterial wilt**

A disease of cucumbers, melons and squash in which bacteria clog the water tubes of the stem so the vines suddenly wilt.

**vector**

An animal that carries a disease from one plant to another. Cucumber beetles are the vector of bacterial wilt.

**bacterial leaf spot**

A disease of tomatoes and peppers that causes small, dark, greasy-looking spots on leaves and fruit.

**symptom**

A sign on the plant that something is wrong, such as wilting, spots or yellowing.

**row cover**

A light fabric laid over plants that lets in light and water but keeps insects out.

**CORE IDEAS**

Most bacteria in a garden are friends. Decomposer bacteria turn dead leaves and compost into plant food. **Nitrogen-fixing bacteria** in the nodules of beans, peas and clover take nitrogen from the air and feed it to the plant, which is why gardeners plant legumes before hungry crops like corn. Other bacteria living on and around roots crowd out harmful ones. A garden full of living soil is a healthier garden.

A few bacteria are **pathogens** that cause disease. Bacteria cannot fly or crawl far on their own. They need help to reach a plant: splashing rain, wet hands and tools, infected seeds, or insects. They enter through tiny wounds or natural openings in leaves. Warm, wet weather helps them spread quickly.

**Bacterial wilt** attacks cucumbers, muskmelons and some squash and pumpkins. Striped and spotted **cucumber beetles** carry the bacteria in their bodies and spread them as they chew leaves. Inside the plant, the bacteria multiply and clog the stem's water tubes. The vines wilt during the day, then wilt for good. A test: cut a wilted stem, press the cut ends together and pull them slowly apart. Sticky, stringy threads mean bacterial wilt. There is no cure, so gardeners pull infected plants and protect the next ones by keeping beetles off with **row covers** until the flowers open, hand-picking beetles, and choosing resistant varieties.

**Bacterial leaf spot** attacks tomatoes and peppers. It causes small, dark, greasy-looking spots on leaves, sometimes with a yellow ring, and rough scabby spots on fruit. Leaves may yellow and drop. It spreads in splashing water and on wet hands, so gardeners water at the base of plants, mulch the soil, stay out of the garden when leaves are wet, remove spotted leaves, start with clean seed and healthy transplants, and avoid planting tomatoes and peppers in the same spot every year.

Remember: fungicide sprays do not cure bacterial diseases, and there are few cures for any of them. That is why prevention matters most. Clean tools, good spacing, healthy soil, mulch and crop rotation are a plant doctor's best medicine.

## PICTURE STUDY



Garden Pea (*Pisum sativum*), Otto Wilhelm Thomé, 1885 · Chromolithograph from *Flora von Deutschland, Österreich und der Schweiz* · *Flora von Deutschland, Österreich und der Schweiz*, Germany

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

Otto Wilhelm Thomé was a German botanist and teacher whose book of colored plant plates was used in schools and homes. The pea is a legume, one of the plants that team up with helpful bacteria in their roots.

### Look closely

- Find the tendrils. How does the pea plant use them?
- Find the white flowers and the young pods. Which grows from which?
- Look at the enlarged drawings of the flower parts. Can you find the pistil and stamens?
- Find an open pod. How many peas can you count?

### Talk about it

1. This plate does not show the roots. What would you expect to find on a healthy pea plant's roots?
2. Why would a gardener plant peas or beans before planting corn in the same bed?
3. How could splashing rain spread a disease from one pea plant to its neighbor?

**Safety first.** Wear gloves when removing diseased plants, put them in the trash (not the compost), and wash hands and tools afterward. Children never handle sprays or pesticides.

## HANDS-ON PROJECT

### The Splash Test and a Disease-Prevention Plan

You will see for yourself how splashing water carries “germs” from soil onto leaves, and test how mulch and careful watering stop the splash. Then you will make a prevention plan for your own garden.

#### You will need

- Two potted plants with low leaves (or two clumps of leaves stuck upright in pots of soil)
- Flour, cocoa powder or colored powdered drink mix
- Straw, shredded leaves or a paper-towel layer for mulch
- A watering can with a sprinkler head and a cup for pouring
- White paper and a magnifying glass
- Journal

#### Steps

1. Sprinkle a thin layer of flour or colored powder on the soil surface of both pots. This stands for disease bacteria on the soil.
2. Cover the soil of pot 2 with mulch. Leave pot 1 bare.
3. Set both pots on white paper. Water both from above with the sprinkler head from about 2 feet high.
4. Look at the lower leaves of each plant with a magnifying glass. Count how many spots of powder splashed onto the leaves. Look at the paper around each pot too.
5. Clean up and repeat with fresh powder, but this time pour water gently at the base of each plant from a cup.
6. Record your results in a table: bare or mulched, sprinkled or poured, number of splash spots.
7. Write a disease-prevention plan for your garden with at least five rules (for example: mulch, water at the base, rotate crops, stay out when wet, cover cucumbers with row cover until they bloom).

#### Tips

- If you grow cucumbers or squash, look under the leaves for yellow-and-black striped or spotted beetles. Count them each morning and record the numbers in your journal.
- In the summer, look for nodules on the roots of your bean plants when you pull them at the end of the season.

#### **Check your work**

- ☐ I showed that mulch and base watering reduce splashing onto leaves.
- ☐ I can explain how cucumber beetles spread bacterial wilt.
- ☐ I wrote a prevention plan with at least five rules.

#### **NATURE JOURNAL**

1. Draw a cucumber beetle (striped or spotted) enlarged from a picture or a real one, and label its colors.
2. Draw a tomato leaf with bacterial leaf spot and a healthy leaf side by side.
3. Draw your splash test results: two pots, with splash spots marked on the leaves.

**From history.** In the late 1800s, an American scientist named Erwin Frink Smith at the U.S. Department of Agriculture proved that bacteria could cause plant diseases. Many scientists at the time did not believe it. His careful work on wilts and other diseases helped found the science of plant pathology.

#### **COMMON MISTAKES**

- Thinking all bacteria are harmful. Most garden bacteria are helpers.
- Watering leaves in the evening, which keeps them wet all night and helps disease spread.
- Putting diseased plants in the compost, where the pathogens may survive.

**Make it a game • Germs or Helpers?.** Make two piles of cards: helper bacteria and troublemakers like bacterial wilt and leaf spot. Parent reads clues, such as 'spread by a cucumber beetle vector' or 'fixes nitrogen,' and you slap the correct pile. Then say one prevention step, like row cover or avoiding water splash. Race to twelve correct slaps and call your total aloud.

## 8.2 FUNGI: RUST, MILDEW AND DAMPING OFF

### OBJECTIVES

- Explain how plant-disease fungi spread by spores and what conditions help them.
- Identify powdery mildew, rust and damping off by their symptoms.
- Grow molds safely in sealed bags to watch fungi at work, and list ways to prevent fungal disease.

**Warm-up.** Look closely at a piece of old bread, a fuzzy strawberry, or a moldy orange if you have one (keep it sealed in a bag). Or look at a picture. Describe the colors and textures. What do you think the fuzz is made of?

### WATCH

#### Damping Off In Seedlings - 8 Ways You Can Prevent It

The Ripe Tomato Farms • 8:17

[https://www.youtube.com/watch?v=K7HAyNG\\_FSY](https://www.youtube.com/watch?v=K7HAyNG_FSY)

### WHEN TO WATCH

After the core idea about damping off. Check your seed-starting station from Lesson 7.1 against his list.

### KEY TERMS

#### **spore**

A tiny, dust-like cell that a fungus releases to spread. Spores travel on wind, water, tools and hands.

#### **rust**

A fungal disease that makes orange, red-brown or yellow powdery bumps, usually on the undersides of leaves.

#### **powdery mildew**

A fungal disease that makes white, powdery patches on leaves of squash, cucumbers, peas, zinnias and many other plants.

#### **damping off**

A disease in which soil fungi and water molds attack young seedlings at the soil line, so they suddenly fall over and die.

## **fungicide**

A substance that kills or stops fungi.

Adults may use mild ones; children never handle them.

### **CORE IDEAS**

You learned in Unit 3 that most fungi are helpers: decomposers and root partners. A few fungi are plant **pathogens**. They spread by **spores**, tiny cells as fine as dust, released by the thousands. Spores float on the wind, splash in raindrops, and ride on tools, hands and boots. When a spore lands on a damp leaf, it sprouts thin threads that grow into the leaf and feed on it. Most plant fungi love moisture: wet leaves, humid air, crowded plants and poor air flow.

**Powdery mildew** looks as though someone dusted the leaves with flour. It shows up on squash, cucumbers, pumpkins, peas, zinnias and phlox, often in late summer when days are warm and nights are cool and humid. Infected leaves turn yellow and dry, and the plant weakens. Gardeners prevent it by choosing resistant varieties, spacing plants for air flow, planting in full sun, and removing the worst leaves. Adults sometimes use mild sprays, such as diluted milk, which some studies have found slows it.

**Rust** gets its name from its color. Look for small orange, red-brown or yellow powdery bumps, usually under the leaves, with pale spots on top. Rusts attack beans, hollyhocks, snapdragons, roses and grain crops. In history, wheat stem rust destroyed whole harvests until scientists bred resistant wheat. Rust spores rub off on your finger like orange dust. Pick off infected leaves, water at the base, and clean up fallen leaves in fall.

**Damping off** is the seed starter's enemy. Seedlings that looked fine yesterday lie flat today, their stems pinched and thin at the soil line, as if cut. Fungi and water molds in dirty soil or containers attack the tender stem, especially when the mix stays soggy, the air is still and the room is cool. Prevent it with fresh seed-starting mix and clean containers, bottom watering, letting the surface dry a little, removing the dome once seeds sprout, good air flow from a fan, and enough light. Once a seedling damps off, it cannot be saved, so remove it quickly.

Fungi are part of God's design for breaking down dead things. Our job as gardeners is not to fight every fungus, but to keep our plants strong and to make conditions

hard for the harmful ones: sun, space, air, good soil and dry leaves.

#### PICTURE STUDY



*Blue Mould and Mushrooms, Scheme XII of Micrographia, Robert Hooke, 1665 · Engraving · Micrographia, London*

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

In *Micrographia*, Robert Hooke drew what he saw when he looked at the blue mould growing on leather and other things. No one had ever seen the shape of a mould before. He found that the fuzz was really a tiny forest of stalks with round heads.

#### Look closely

- Find the thin stalks. How many can you count?
- Look at the round heads on top of the stalks. What do you think they hold?
- Notice how the stalks grow close together like a lawn or a forest.
- Compare the size of the stalks with what you see on moldy bread with your eyes alone.

#### Talk about it

1. The round heads release spores. How might those spores reach a new piece of bread or a new leaf?
2. Why does mould grow faster in a damp, warm place?
3. How did Hooke's microscope help people understand diseases of plants?

**Safety first.** Keep the mold bags sealed and throw them away unopened; mold spores can cause breathing problems and allergies. Do not smell or touch mold. Never eat moldy food or wild mushrooms. Wash hands after handling diseased leaves.

## HANDS-ON PROJECT

### A Sealed Mold Garden and a Fungus Hunt

You will grow molds on foods in sealed bags to see how moisture and warmth help fungi grow, then hunt for fungal diseases on real garden plants or houseplants.

#### You will need

- Four zip bags and clear tape
- Four pieces of the same bread (or bread and a piece of fruit)
- A spray bottle of water
- A permanent marker
- A magnifying glass and journal
- Garden plants, houseplants or a park garden to inspect

#### Steps

1. Label four bags: dry and warm, damp and warm, dry and cold, damp and cold.
2. Put one piece of bread in each bag. Spray two of them with water five times. Wipe each piece across a kitchen counter first to pick up spores.
3. Seal each bag and tape it shut. Do not open the bags again.
4. Put the warm bags in a dark cupboard and the cold bags in the refrigerator.
5. Each day for 10 days, look through the bag with a magnifying glass. Record the day mold first appears, its colors, and how much of the bread it covers.
6. At the end, throw the sealed bags away unopened.
7. **Fungus hunt:** Inspect squash, cucumbers, beans, roses, zinnias or houseplants. Look on top of and under leaves for white powder, orange bumps, dark spots or fuzzy gray mold. Draw anything you find.
8. Write a list of five ways to prevent fungal disease in your garden or seed-starting station.

#### Tips

- Rust spores rub off as orange dust on a white tissue. Try it on a suspected rust leaf.
- If your seedlings ever damp off, look at the fallen stem with a magnifying glass. You will see the pinched, dark spot at the soil line.

#### **Check your work**

- ☐ I found which conditions grow mold fastest, and I can explain why.
- ☐ I can tell powdery mildew, rust and damping off apart.
- ☐ I listed five ways to prevent fungal disease.

#### **NATURE JOURNAL**

1. Draw your four bread bags on day 10, side by side, with colors.
2. Draw a squash leaf with powdery mildew and a bean leaf with rust.
3. Draw a seedling that has damped off next to a healthy one and label the pinched stem.

**From history.** In 1845 a water mold destroyed the potato crops of Ireland, and the great famine that followed caused enormous suffering. It led scientists to study plant diseases seriously, and today plant breeders and extension services work to stop such losses before they spread.

#### **COMMON MISTAKES**

- Leaving the clear dome on seedlings after they sprout, which traps moisture and invites damping off.
- Crowding plants so leaves stay damp and air cannot move.
- Opening a mold bag to look closer. Keep it sealed.

**Make it a game • Spore Spotter Showdown.** Draw four plant leaf cards: powdery mildew, rust, damping off and a healthy one. Your parent describes symptoms like white dust, orange pustules or collapsed seedlings, and you name the fungus and one condition that helps it spread. A wrong answer loses a bean. Try to keep all ten beans and explain what a spore is.

## 8.3 PEST LIFE CYCLES: SQUASH BUGS AND JAPANESE BEETLES

### OBJECTIVES

- Compare complete and incomplete metamorphosis using the Japanese beetle and the squash bug.
- Find each pest's eggs, young and adults and describe the damage each does.
- Choose safe controls for the right life stage, and do a grub count.

**Warm-up.** On a sheet of paper, draw four circles in a ring and label them egg, larva, pupa, adult. Then draw three circles labeled egg, nymph, adult. Write one insect you know that fits each cycle (for example, butterfly and grasshopper).

### WATCH

#### Squash Bug Management

Utah State University Extension • 6:12

<https://www.youtube.com/watch?v=68ZwcRr9J78>

### WHEN TO WATCH

After the core ideas. Pause at the life-cycle drawing and name each stage, then watch for the egg clusters under the leaves.

**Note:** From a university extension service. Near the end, spray products are shown for adults; children use only hand-picking, tape and boards.

### KEY TERMS

#### **complete metamorphosis**

A life cycle with four very different stages: egg, larva, pupa and adult. Beetles, butterflies and flies have it.

#### **incomplete metamorphosis**

A life cycle with three stages: egg, nymph and adult. The nymph looks like a small adult without full wings. Squash bugs and grasshoppers have it.

**grub**

The C-shaped white larva of a beetle that lives in soil and eats roots.

**nymph**

A young insect in incomplete metamorphosis that molts several times as it grows into an adult.

**scouting**

Checking plants regularly and carefully for pests, eggs and damage.

**integrated pest management (IPM)**

Controlling pests by combining careful scouting, healthy plants, barriers, hand-picking and helpful insects, using sprays only as a last resort.

**CORE IDEAS**

To control a pest, you must know its life cycle, because each stage lives in a different place, eats different things and can be stopped in different ways. Insects grow by **metamorphosis**, which means “change of form.” There are two kinds.

The **Japanese beetle** has **complete metamorphosis**. In midsummer the shiny green-and-copper adults gather on roses, beans, grapes, raspberries, basil and linden trees, eating the soft tissue between the veins until leaves look like lace. Females lay eggs in lawns and grassy places. The eggs hatch into white, C-shaped **grubs** that eat grass roots. In fall the grubs dig deeper to spend the winter, come up to feed again in spring, then turn into pupae and emerge as adults in early summer.

The **squash bug** has **incomplete metamorphosis**. Flat, gray-brown adults spend the winter hiding in garden trash and wood piles. In early summer they lay clusters of shiny bronze eggs on the undersides of squash and pumpkin leaves, often in the V where veins meet. The eggs hatch into gray-green **nymphs** with dark legs that crowd together and suck sap. They molt several times, growing bigger each time, until they become adults. Their feeding makes yellow speckles, and heavy feeding makes leaves and vines wilt and die.

Gardeners fight each pest at its weakest stage. For squash bugs: **scout** under leaves every few days, scrape off egg clusters or lift them with tape, hand-pick nymphs and adults into soapy water, lay a board on the soil at night and collect the bugs hiding under it in the morning, cover young plants with row covers until they flower, and clean up plant trash in fall. For Japanese beetles: hand-pick the adults in the cool early morning when they are sluggish, holding a cup of soapy water under them so

they drop in. Lawn grubs can be counted, and adults can treat lawns with natural grub controls when counts are high.

This way of working is called **integrated pest management**: watch closely, keep plants healthy, use barriers and hands first, welcome helpful insects and birds, and use sprays only as a last resort and only by adults. It is patient, careful work, the kind of faithful attention a good steward gives.

## PICTURE STUDY



*The Silkworm, Plate 1 of The Wondrous Transformation of Caterpillars*, Maria Sibylla Merian, 1679 · Hand-colored engraving · *Der Raupen wunderbare Verwandlung und sonderbare Blumennahrung*, Nuremberg

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

Maria Sibylla Merian was a German artist and naturalist who raised caterpillars at home and watched them change. In 1679, long before most people understood insect life cycles, she drew each stage on the plant it ate. Her first plate shows the silkworm, a helpful insect, on the mulberry leaf it eats. Pests like the Japanese beetle go through the same four stages.

### Look closely

- Find each stage: eggs, larva (caterpillar), pupa and adult moth.
- Find the mulberry leaf. Where can you see the caterpillar feeding?
- Find the golden cocoons. One is cut open. What is inside?
- Look at the moths. How are they different from the caterpillar?

### Talk about it

1. Is this complete or incomplete metamorphosis? How can you tell?
2. A Japanese beetle grub and a silkworm are both larvae. Where does each one live and feed?
3. Merian watched living insects for weeks. Why does careful watching help a plant doctor?

**Safety first.** Wear gloves when hand-picking; squash bugs give off a bad smell and some people's skin is sensitive. An adult helps cut sod with a spade. Never handle insecticides or grub treatments. Wash hands afterward.

## HANDS-ON PROJECT

### Scout, Count and Draw: A Pest Life Cycle Study

You will set up a scouting route, look for squash bugs and Japanese beetles (or whatever pests your garden has) at every stage, do a lawn grub count, and make a life cycle chart.

#### You will need

- A clipboard or journal
- Magnifying glass
- A small cup of soapy water
- Clear packing tape
- A flat board about 1 foot long
- A trowel or flat spade and a ruler
- Colored pencils
- Gloves

#### Steps

1. Make a scouting chart with columns for date, plant, pest, stage (egg, larva or nymph, pupa, adult), number found, damage seen, and action taken.
2. Twice a week, walk your garden or a community garden with an adult. Turn over leaves of squash, pumpkins, beans and roses. Record everything you find.
3. If you find squash bug eggs, press tape over them to lift them off and stick the tape in your journal. Hand-pick nymphs and adults into soapy water.
4. Lay the board on the soil near squash plants in the evening. Lift it the next morning and count what is hiding underneath.
5. In early summer, check roses, beans or raspberries for Japanese beetles in the early morning. Hold the soapy cup under them and tap them in. Count them.
6. **Grub count:** With an adult, cut three sides of a 1-foot square of lawn about 3 inches deep and fold it back. Count the C-shaped grubs in the soil and roots. Fold the sod back and water it.

7. Make a two-part life cycle chart: the Japanese beetle (complete) and the squash bug (incomplete). Draw each stage and write where it lives and what it eats, and the best way to control that stage.

#### **Tips**

- Extension services say that a handful of grubs per square foot is normal; only high counts need treatment. Check your state extension guide for the number in your area.
- Avoid Japanese beetle bag traps near your garden. The scent can draw more beetles to your plants than the trap catches.

#### **Check your work**

- ☐ I can name the stages of complete and incomplete metamorphosis.
- ☐ I scouted at least four times and recorded what I found.
- ☐ I can choose a safe control for each stage of these two pests.

#### **NATURE JOURNAL**

1. Draw a squash bug egg cluster, a nymph and an adult, enlarged, side by side.
2. Draw a Japanese beetle and a leaf it has eaten into lace.
3. Graph your scouting counts over the weeks of the lesson.

**From history.** Japanese beetles were first found in the United States in 1916 in a plant nursery in New Jersey, probably having arrived as grubs in the soil of imported plants. With no natural enemies here, they spread across much of the eastern and central country. Scientists have since brought in tiny wasps and flies that attack them, and inspectors check plant shipments to stop new pests.

#### **COMMON MISTAKES**

- Only looking at the tops of leaves. Most eggs and nymphs hide underneath.
- Waiting until damage is severe. Early scouting catches pests while they are few.
- Leaving squash vines and garden trash over winter, where squash bugs hide.

**Make it a game • Pest Life Cycle Chain.** Write egg, nymph, adult on three cards for the squash bug, and egg, grub, pupa, adult on four for the Japanese beetle. Shuffle both piles and rebuild each chain as fast as you can, naming the damage at each stage. Then say which is complete and which is incomplete metamorphosis. Beat your own time.

## 8.4 PLANT DOCTOR: NUTRIENT, PEST OR DISEASE?

### OBJECTIVES

- Follow a step-by-step method to diagnose a plant problem.
- Tell common nutrient deficiencies from pest and disease damage by their patterns.
- Write a plant doctor case report with a diagnosis and a treatment plan.

**Warm-up.** Think about what a doctor asks when you feel sick: Where does it hurt? When did it start? What did you eat? Write five questions a plant doctor might ask about a sick tomato plant.

### WATCH

#### Guidelines for Diagnosing Plant Problems

UNH Extension · 6:42

<https://www.youtube.com/watch?v=7HnLVYhvars>

### WHEN TO WATCH

After the warm-up and before the core ideas. Write down each question the extension expert asks.

### KEY TERMS

#### **diagnosis**

Deciding what is causing a problem by studying the symptoms and the evidence.

#### **chlorosis**

Yellowing of leaves because they are not making enough chlorophyll.

#### **deficiency**

A shortage of a nutrient a plant needs, which causes symptoms such as yellow or purple leaves.

#### **abiotic**

Caused by something nonliving, such as weather, too much or too little water, nutrients or chemicals.

**biotic**

Caused by something living, such as insects, animals, fungi or bacteria.

**blossom end rot**

A dark, sunken spot on the bottom of tomatoes and peppers caused by a shortage of calcium in the fruit, usually from uneven watering.

**CORE IDEAS**

When a plant looks sick, it is tempting to grab a spray. A good plant doctor first asks questions and gathers evidence. Step 1: **Know the plant** and what it normally looks like. Step 2: **Look at the pattern** in the whole garden. Step 3: **Look closely** at the plant, top to bottom, including under leaves and at the stem base. Step 4: **Check the roots and soil**: too wet, too dry, pH. Step 5: **Think about the history**: weather, frost, heat, fertilizer, recent work.

The pattern is a powerful clue. If many different kinds of plants in one area all show the same damage at the same time, the cause is probably **abiotic**, something nonliving like frost, drought, flooding, wind or a chemical. If damage is on one kind of plant, appears in scattered spots, and spreads over days and weeks, the cause is probably **biotic**: a pest or a disease.

Nutrient shortages leave tell-tale signs. **Nitrogen** shortage turns the *older, lower* leaves pale yellow all over first, because the plant moves its nitrogen to new growth. **Phosphorus** shortage makes leaves dull and sometimes purplish, with slow growth, especially in cold soil. **Potassium** shortage browns and crisps the edges of older leaves. **Iron** shortage makes the *newest* leaves yellow between green veins, often because the soil pH is too high. **Blossom end rot** on tomatoes comes from a calcium shortage in the fruit, usually caused by uneven watering rather than poor soil.

Pests and diseases leave different evidence. Holes and ragged edges mean chewing insects, slugs or animals; look for droppings, slime trails or the culprits. Fine pale speckles may mean sucking insects or mites. Spots with rings or fuzzy growth suggest fungi. Small, dark, water-soaked spots suggest bacteria. A whole plant wilting while the soil is moist may mean a wilt disease or root damage. Too much water can cause yellowing and wilting just like too little, so always check the soil before watering more.

Once you have a diagnosis, choose the gentlest fix that works: adjust watering, add compost or the right fertilizer after a soil test, remove diseased leaves, hand-pick

pests, add row covers, or improve spacing. If you are not sure, take a sample in a sealed bag to your county extension office or a Master Gardener help desk. In the parable, the gardener asked for one more year to “dig about it, and dung it” before giving up on a fruitless tree. A patient plant doctor does the same.

## 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 in the south of France where he was resting. He painted them from life, studying every twist of leaf and petal. A plant doctor, like an artist, must notice what is different.

### Look closely

- Find the one white iris among all the blue ones.
- Look at the leaves. Are they all straight and green, or are some bent, yellow or brown?
- Look at the soil. What color is it, and does it look wet or dry?
- Find the flowers that are open, the buds, and any that are fading.

### Talk about it

1. If one iris in a whole bed looked yellow and the rest were healthy, would you think the cause was the weather or something living? Why?
2. What questions would you ask before deciding a yellow leaf in this bed needed fertilizer?
3. Why is noticing small differences the first skill of a plant doctor?

**Safety first.** Wear gloves when handling sick plants and soil, and wash hands afterward. Seal disease samples in bags. Fertilizers and soil amendments are measured and applied by an adult following the label.

## Plant Doctor Case Files

You will examine three plants with problems (or one healthy plant and two with problems), follow the five diagnosis steps, and write a case report for each with a treatment plan.

### You will need

- Three plants to examine: garden plants, containers, houseplants, or plants at a community garden (with permission)
- Magnifying glass and ruler
- Soil pH test kit from Unit 3
- Zip bags for samples
- Journal and colored pencils
- A list of the five diagnosis steps

### Steps

1. For each plant, write its name and draw what a healthy one should look like.
2. **Pattern:** Look at neighboring plants. Are other kinds of plants affected too? Is the damage spreading?
3. **Close look:** Examine the plant from top to bottom. Which leaves are affected, old or new? What kind of damage: yellowing, spots, holes, wilting, speckles? Check under leaves and at the stem base. Draw what you see.
4. **Roots and soil:** Push a finger into the soil to check moisture. Test the pH if the problem might be a nutrient. With an adult, gently tip a potted plant out to look at the roots: white and firm is healthy; brown and mushy means rot.
5. **History:** Ask a parent about recent weather, watering and fertilizing.
6. Write a **diagnosis:** nutrient, pest, disease or weather? Give your evidence.
7. Write a **treatment plan** with the gentlest fix first. Carry it out with an adult and check the plant again in one week.
8. If you cannot solve one case, take a sealed sample and your notes to your county extension office or a Master Gardener clinic, and record their answer.

### Tips

- Photograph each plant on day 1 and day 7 so you can compare.
- Many county fairs and Junior Master Gardener programs have plant identification and plant-problem contests. Your case files are good practice; check your county extension office for details.

### Check your work

- ☐ I followed all five diagnosis steps for each plant.
- ☐ Each diagnosis gives evidence for nutrient, pest, disease or weather.
- ☐ My treatment plans start with the gentlest fix and I checked the results.

### NATURE JOURNAL

1. Draw four leaves side by side showing nitrogen, potassium and iron shortage and a healthy leaf.
2. Make a diagnosis flow chart: start with “Are many kinds of plants affected?” and branch to possible causes.
3. Draw each case plant on day 1 and day 7.

### COMMON MISTAKES

- Adding fertilizer or water before checking the soil, which can make the problem worse.
- Blaming a disease for damage that was really frost, heat or overwatering.
- Looking only at the top of the plant and missing pests under leaves or rot at the roots.

**Make it a game • Plant Doctor Clinic.** Be the plant doctor. Parent describes a sick plant with clues: yellow leaves, holes, spots, or a black bottom on a tomato. Follow the steps aloud and choose nutrient, pest or disease, naming terms like chlorosis, biotic, abiotic or blossom end rot. Three correct diagnoses earn a paper doctor's badge. Then swap and diagnose yours.

**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)

Jesus told of a gardener who did not give up on a fruitless fig tree but asked for time to care for it. A good plant doctor is patient, diligent and hopeful.

## UNIT 8

# PLANT HEALTH: BACTERIA, FUNGI, PESTS AND PROBLEMS

As your garden grows, so do its troubles. In this unit you will become a plant doctor. You will learn which bacteria help plants and which make them sick, how fungi cause rust, mildew and damping off, and how two common pests, the squash bug and the Japanese beetle, live out their life cycles in and around your garden.

Finally you will put it all together and learn to diagnose a sick plant step by step: is the trouble a missing nutrient, a pest, a disease, or the weather? A good plant doctor looks carefully, asks good questions, and chooses the gentlest fix that works.

### PREREQUISITES

- Knows what bacteria and fungi do in soil (Lesson 3.3)
- Knows N-P-K and that soil pH affects nutrients (Lesson 3.2)
- Has a garden bed, containers or houseplants to observe

### MASTERY CHECKLIST

- ☐ I can name helpful bacteria and two bacterial diseases of garden plants.
- ☐ I can identify powdery mildew, rust and damping off and tell how to prevent each.
- ☐ I can describe the life cycles of the squash bug and the Japanese beetle and when to control each stage.
- ☐ I can diagnose a plant problem by following clear steps and looking for patterns.
- ☐ I choose safe controls such as hand-picking, barriers and good watering, and I never handle pesticides.

### LESSONS IN THIS UNIT

#### 8.1 Bacteria: Garden Helpers and Plant Diseases

2 sessions of 45 minutes

#### 8.2 Fungi: Rust, Mildew and Damping Off

2 sessions of 45 minutes

#### 8.3 Pest Life Cycles: Squash Bugs and Japanese Beetles

2 sessions of 45 minutes

#### 8.4 Plant Doctor: Nutrient, Pest or Disease?

2 sessions of 45 minutes

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## UNIT 8 REVIEW

Answer each question aloud or in writing. Your parent may read the questions to you.  
Total: 50 points.

1. 5 pts

Name two ways bacteria help a garden.

2. 5 pts

How does bacterial wilt get into cucumber plants, and how can you prevent it?

3. 5 pts

Give two ways to keep bacterial leaf spot from spreading.

4. 5 pts

How do fungi spread, and what conditions help them?

5. 5 pts

Describe powdery mildew and rust.

6. 5 pts

What is damping off, and name three ways to prevent it.

7. 5 pts

Name the stages of a Japanese beetle's life. Where do the grubs live?

8. 5 pts

Where do you find squash bug eggs, and how can you remove them?

9. 5 pts

The lower, older leaves of a tomato are turning pale yellow all over. What nutrient might be short?

10. 5 pts

Many different plants in one corner of the yard turned brown on the same morning. Is the cause more likely biotic or abiotic? Give an example.

#### ANSWER KEY

1. Any two: decompose dead matter into plant food, fix nitrogen in legume nodules, crowd out harmful microbes.
2. Cucumber beetles carry the bacteria; prevent with row covers until flowering, hand-picking beetles and resistant varieties.
3. Any two: water at the base, mulch, stay out when leaves are wet, remove spotted leaves, clean seed and tools, rotate crops.
4. By spores on wind, water, tools and hands; moisture, humid air, crowding and poor air flow help them.
5. Powdery mildew: white, floury patches on leaves. Rust: orange, red-brown or yellow powdery bumps, usually under leaves.
6. Seedlings collapse at the soil line from fungi or water molds; prevent with clean mix and containers, bottom watering, not overwatering, removing the dome, air flow and good light (any three).
7. Egg, larva (grub), pupa, adult; grubs live in lawn soil and eat grass roots.
8. In clusters on the undersides of squash and pumpkin leaves; scrape them off or lift them with tape.
9. Nitrogen.
10. Abiotic, such as a frost, a chemical spill or drift, or wind.

## PORTFOLIO PIECE: A PLANT DOCTOR'S FIELD GUIDE AND POSTER

Make a plant doctor's field guide of at least eight garden problems from this unit: two bacterial diseases, three fungal problems, two insect pests and one nutrient shortage. For each, include a drawing from life or a careful copy, the symptoms, the cause, how it spreads, and safe prevention and control. Then make an educational poster on one problem, the kind of poster entered in county fair and conservation-district poster contests, with a clear title, a labeled drawing, three key facts and a prevention tip.

| LOOK FOR                   | WHAT IT MEANS                                                                                            |
|----------------------------|----------------------------------------------------------------------------------------------------------|
| <b>Accuracy</b>            | Symptoms, causes and controls are correct for all eight problems.                                        |
| <b>Observation</b>         | At least three entries come from plants you examined yourself, with dates.                               |
| <b>Safe, wise controls</b> | Prevention and gentle controls come first; pesticides are left to adults and only as a last resort.      |
| <b>Poster</b>              | The poster has a clear title, large labeled drawing, three facts and a tip, readable from across a room. |
| <b>Craftsmanship</b>       | The guide and poster are neat, organized, titled, signed and dated.                                      |