PURDUE EXTENSION

4-H-1041-W

Helper's Guide

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Harvest and Storage

Careers

Solutions

Resources

Acknowledgements

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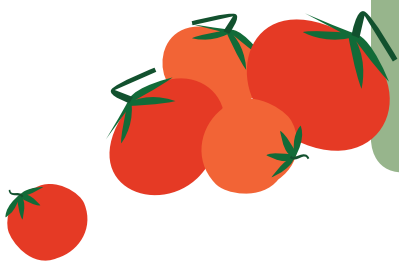


Overview

Congratulations on your decision to serve as an adult or teen helper for the garden project. Your role is critical in providing opportunities for youth to learn and grow in a caring and supportive environment. This guide gives you activities, ideas, and content to help you with this challenging and exciting role.

Many people think you must have a huge plot of land to grow a garden. This isn't true! Youth can implement the garden project in container gardens just as well as on a plot of land.

Gardening is for people of all abilities. This curriculum includes several ideas for gardening with youth who have special needs. In fact, gardening is often used as a therapy and coping mechanism for people of all ages who might have a physical, mental, or emotional disability.

Garden by age

The guide is organized into four levels, which correspond to the age-graded member levels as follows:
Level A: 10-11 year olds
Level B: 12-13 year olds
Level C: 14-16 year olds
Level D: 17-18 year olds

Content

This guide contains:

- Additional background information not found in the youth manuals
- An easy-to-use reference table
- Group activities that use the experiential learning model and can be done at club meetings, project workshops, or school or camp programs.

Activities in this guide supplement the youth manuals. They are organized into six general categories that allow you to choose a broad topic related to what youth are currently learning about in their manuals. The categories are:

- Plant science
- Garden planning
- Planting a garden
- Garden care
- Harvest and storage
- Careers

Other features include answers to questions asked in the youth manuals (Solutions, page 71) and additional information, ideas, and support (Resources, page 80).

Developing project and life skills

The garden curriculum is designed to help youth develop both project skills and life skills. Project skills are specific to the garden subject matter, such as learning how to plant seeds or make a compost pile. Life skills relate to the process a member undergoes when doing an activity and are useful long after the member completes the project. One such example is decision making.

Project skills

The content of this curriculum has a broader focus than in previous versions. The curriculum primarily focuses on skills related to vegetable gardening, but it is also designed to help youth develop project skills across the six general categories listed under Content.

Life skills

The life skills involved in this project are grouped into three major categories: competency, coping, and contributing. Levels A and B focus primarily on developing competency and coping life skills. Contributory life skills are introduced in Level C and expanded in Level D.

Life skills learned through 4-H

Competency	Coping	Contributing
Acquiring knowledge Using scientific methods Mastering technology Making career decisions Managing resources Communicating	Recognizing self-worth Relating to others Making decisions Solving problems Dealing with change	Applying leadership skills Taking community action Volunteering Conserving the environment

Experiential learning

"Learning by doing" is one of the main reasons 4-H is so widely recognized and respected in the field of informal education. The garden curriculum follows an experiential learning model. Experiential learning is more than just doing activities. It involves discussing the activity, drawing conclusions from it, and applying them to the real world.

Activities in the youth manuals are designed to help the 4-H member work through the entire experiential learning process as they do each activity and record their answers. Group activities in this leader/helper's guide list each step along with what to do and sample questions to ask. This is useful as you help members do and process the activity.

How it works

Do

1. **Experience** – Begin with a concrete experience. This can be an individual or group activity that involves doing something.

Reflect

2. **Share** – Next, get the group or individual to talk about what they experienced when they were doing the activity. Share reactions and observations. Talk freely.

   Sharing questions:
   What did you do?
   What happened?
   How did you feel to…?
   What was most difficult? Easiest?

3. **Process** – Discuss how the activity creates questions.

   Processing questions (use information generated from sharing questions):
   What problems or issues seemed to occur over and over?
   What similar experience(s) have you had?

Apply

4. **Generalize** – Find general trends or common lessons in the experience. Identify the important points that apply to the "real world."

   Generalizing questions:
   What did you learn about yourself through this activity?
   What did you learn about making decisions (or other life skills)?
   How do the major themes or ideas relate to real life and not just the activity?
   How did you go about making your decision?

5. **Apply** – Talk about how the new information can be applied to everyday life or sometime in the future.

   Applying questions:
   How can you apply what you learned (making decisions) to a new situation?
   How will the issues raised by this activity be useful in the future?
   How will you act differently in the future as a result of this activity?

Youth learning characteristics

The following characteristics are common to children in four age-graded levels. However, children develop at their own pace, and all characteristics are not observed in all children at the same age. We hope you find this outline helpful as you work with youth of

different ages. *(Written by Judith Myers-Walls, associate professor, Child Development and Family Studies, Purdue University, and adapted from* Ages and Stages of Child and Youth Development *by Judith Myers-Walls and Jeanne Kerns.)*

10-11-year-olds

- Active, full of energy, and anything but quiet. Activities should encourage physical involvement.
- Interests may change often, jumping from one thing to another. Activities divided into small pieces or steps work best.
- Fairly concrete thinkers; tend to be more attentive if they have an opportunity for hands-on learning (seeing and doing, rather than just listening).
- Just beginning to think logically and symbolically, and are beginning to understand abstract ideas. As they consider an idea, they think it is either right or wrong, fun or boring—little middle ground.
- Look for adult approval and have a strong need to feel accepted and worthwhile. Adults should provide lots of encouragement and recognize even small successes.
- Prefer individual evaluation over group competition. Instead of comparing success with others, youth prefer to know how much they have improved and what they should do better next time. They are easily embarrassed about doing either better or worse than their friend.
- Beginning to move out of the stage in which the satisfaction of completing a project often comes from pleasing the leader or parent rather than from the value of the activity itself.

12-13-year-olds

- Growth spurts might begin at this age with girls maturing faster than boys. These rapid changes make some teens uncomfortable with their changing body images.
- The approach of puberty begins a rollercoaster ride of hormones and emotions, presenting a major challenge to a young person's self-concept.
- Faced with so many changes, they hardly know who they are. They begin to test values and identities, and seek adults who are accepting and willing to talk about values and morals.
- Wanting a sense of independence from parents, they are concerned about being liked by friends. Peers' opinions on dress, music, and activities become more important than those of parents and other adults.
- Moving from concrete to more abstract thinking. They often reject ready-made solutions from adults in favor of finding their own. Small groups provide opportunities to test ideas.
- Adults should continue to avoid comparing young people with each other, being careful not to embarrass them. They want to be part of something that is important and that provides an opportunity to develop responsibility.
- Justice and equality are important issues. Judging of projects is viewed in terms of what is fair. They see ribbons as reflections of the individual's self-worth instead of feedback on a specific project.

14-16-year-olds

- Concerned with themselves and their peer group. Relationship skills become a priority. Many begin dating, and acceptance by members of the opposite sex might become important.
- Since many are becoming aware of their own special abilities and talents, this is a good time for introducing them to leadership roles.
- As they begin to think about the future and make realistic plans, their vocational goals often influence the activity they select.
- Mastering abstract thinking, they imagine new ways of doing things that sometimes challenge adults.
- They set their goals based on feelings of personal need and priorities, and likely reject goals that others set.
- Can initiate and complete tasks without supervision. Leader's role should be as advisor/coach.

17-18-year-olds

- Finishing up high school and moving on toward post-secondary opportunities.
- Future plans are important as they begin making the transition to adult life. Their goals for the future influence which activities they continue.
- In most cases, they determine their own schedule, and only general directions are needed when they are assigned familiar tasks.
- Close relationships develop as they become preoccupied with their need for intimacy.
- They make and carry out serious decisions, but still need adults for support and guidance.
- Adults no longer control their activities but should serve as resource people, helping to stimulate teens' thoughts.

Overview of Content in the 4-H Garden Curriculum

Level A

- When, where, and what to plant
- Make a plan and layout design for a garden or container
- Types of soil
- Cool- and warm-season vegetables
- Mark off a plot
- Soil preparation
- Soil mix for containers
- Sowing seeds – spacing and depth
- Rows vs. hills
- Thinning
- Seed germination/ parts of a seed; testing for germination; plant needs
- Plant parts: leaf, stem, and root form and function
- Garden tools/Safety
- Watering
- Weeding
- Mulching
- Garden friends and foes
- IPM
- When to harvest
- Using the harvest (eat, store, preserve – drying pumpkin seeds)
- Selling the harvest
- Tool care
- Clearing up for winter
- How plants are used (other than as food)
- Greenhouse/garden center (workers and manager)

Level B

- Changing plans to expand a garden or use a larger container or patio garden
- Seed varieties
- Similarities in family crops
- Rotation crops
- Seeds vs. cultivars
- Developing planting calendars
- Starting seeds indoors
- Transplanting cultivars
- Hardening off
- Protecting transplants from wind, too much sun, and frost.
- Plant properties (phototropism, geotropism)
- Plants from parts (bulbs, tubers, stems, leaf)
- More garden friends/ pests
- Preventive measures for pest control
- Composting
- Fertilizer (manure tea)
- IPM
- Specialty harvest (largest, most interesting, etc.)
- Storing crops
- Selling the harvest
- Preservation (freezing fresh and prepared foods)
- Using excess harvest (what to do with too much)
- Horticulture careers
- Farmer (including truck and roadside stands)

Level C

- Consider the value of broadcast planting
- Consider the value of succession planting
- Planning an herb garden
- Plant companions
- Extending the season
- Soil structure/texture/ drainage
- Improving soil
- Broadcast planting
- Succession planting
- Herb companion planting
- Hybrids vs. standard forms
- Planting herbs
- Soil nutrients/organic fertilizers
- Soil management (conditioning/modifying pH)
- Flower form and function
- Self- and cross-pollination
- Photosynthesis
- Chlorophyll/Chromatography
- Soil pH/plant needs
- pH indicators
- Identifying insect damage
- Identifying weeds
- Other ways to water plants
- Dealing with animal pests
- Keeping records
- IPM
- Harvesting herbs
- Selling the harvest
- Preservation (canning vegetables, pickling; drying/freezing herbs)
- Storing/saving seeds
- Keeping records
- Growing vs. buying vegetables ($)
- Horticulture-related careers (soil scientist, entomologist, ecologist, etc.)
- Education/teaching
- Food industry careers related to vegetables

Level D

- Consider the value of intercropping and double-cropping
- More on vegetable companions
- Computer garden planning programs
- Space-saving ideas (raised beds, vertical garden, patio garden, shelving, square foot, etc.)
- Greenhouses
- When and how to plant by intercropping and double-cropping methods
- Cultivar trials to increase production
- Small garden strategies
- Intensive gardening/ square foot gardening
- Pollution/acid rain/ greenhouse effect
- Biotechnology/genetic engineering/plant breeders
- Diversity/seed banks
- Hydroponics/food in space/NSCORT
- Identifying plant diseases
- Nutrient deficiencies
- Sources of nutrients
- Organic vs. chemical fertilizers
- Power garden tools
- Pesticide safety
- Pest management plan
- IPM controls
- Financial records; determining profits/ losses
- Selling the harvest/ plan your own business /bank credit
- Preservation (pressure canning, drying vegetables)
- Winterizing power tools
- After the frost plan
- Botanist (cultivar trials with resistant varieties)
- Basic vs. applied research
- Self-analysis profile
- Skills vs. traits
- Using career resources
- Exploring interests

Helper's Guide

- Planning a garden
- Soil basics
- Making the most of garden space (broadcast, double-cropping, succession, and intercropping planting methods)
- Buying seeds, transplants
- Soil preparation for garden plots and containers
- Planting, thinning, watering, and seeds
- Transplanting cultivars for garden plots and containers
- General planting hints
- Summary of plant science: seeds, growing plant needs, plant cycle, roots, stems, food change, diversity
- Hydroponics
- Soil fertility
- Garden equipment
- Garden safety (equipment and supplies)
- IPM
- Managing weeds (mulching, cultivating, chemical)
- Managing plant diseases: noninfectious and infectious agents (cultural and chemical control)
- Managing insects (preventive practices, insecticides)
- Harvesting hints
- How to store vegetables
- Selling the harvest
- Ways to preserve vegetables
- Summary of careers related to gardening

Overview of Activities in the 4-H Garden Curriculum

Level A

Year 1

First You Plan	Planning a garden
Gardening Safely	Caring for yourself and your tools while gardening
Seeds Up Close	Parts of a seed, what they do
Plant It	Garden soil preparation
Take Time for TLC	Garden care – weeding, watering, mulching, inspecting
Is it Ready?	Harvesting the garden

Year 2

The Second-Year Garden	Cool- vs. warm-season crops
Change It Up	New planting methods
Beyond the Stem	The parts of a plant and what they do
Check Out the Veggies	Identifying vegetable products at the store
Use It Up	How to use harvested vegetables
Planting Your Career	Exploring careers, specifically those at a greenhouse

Level B

Year 1

Plant a Transplant	Planning to use transplants in a garden
Plan It Bigger	Creating a planting calendar
On the Move	How to plant transplants
Starting from Scratch	Starting seeds indoors
A-Maze-ing Plants	Plant responses to the environment
More Than Seeds	Growing plants from plant parts

Year 2

Wiggly Farm Acres	Benefits of worms in the garden, building a worm box
Let It Rot	Composting, making manure tea
One of a Kind	How to judge vegetables
Too Much to Eat!	Methods of preserving excess produce
On Your Own	Selling produce
What's in a Name?	Exploring careers in the field of horticulture

Level C

Year 1

Broadcast Your Garden	Using broadcast planting method
Stretch It Out	Planning for succession planting
Don't Forget Herbs	Planting herbs in a container
What's Under Your Feet?	Soil analysis
Keep on Planting	Planting a garden using succession planting
Thyme for Planting	Planting herbs in the garden

Year 2

Acid Basics	The impact of pH on the garden
Getting Green	Experimenting with photo-synthesis
Flower Power	Flower parts and cross-pollinating
Be a Bug Buster	Identifying insect damage
When Animals are Pests	Identifying animal pests
What's With Weeds?	Helping younger gardeners identify weeds

Year 3

Garden Cents	Keeping garden records
Lead the Way	Planning an educational event for younger gardeners
Let's Preserve	Various food preservation methods
Grow Your Career	Exploring more careers in horticulture
Are You a Teacher?	Planning a garden-related lesson plan; teaching as a career
Making Contacts	Jobs in the food industry

Level D

Year 1

Tight on Space	Intensive gardening techniques
It's In-Between	Intercropping as a planting method
All in the Row	Planting a garden with inter-cropping
Double Your Crops	Planning for double-cropping
Double Your Fun	Planting a garden with double-cropping
Garden in Your Computer	Exploring computer garden design technology

Year 2

The Air Up There	The effects of air pollution
Look Ma — No Soil!	Using hydroponics
Designer Genes	Genetically engineering plants
Looking Closely	Identifying plant diseases
Talk About It	Understanding fertilizers
Taking Action	Exploring integrated pest management, using pesticides

Year 3

Profit or Loss	Preparing garden finances
Save the Best	Exploring even more preservation methods
Growing A Business	Creating a business
All About You	Understanding personalities and careers
Research Plant Science	Exploring careers in plant research
Is It for Me?	Investigating a specific career

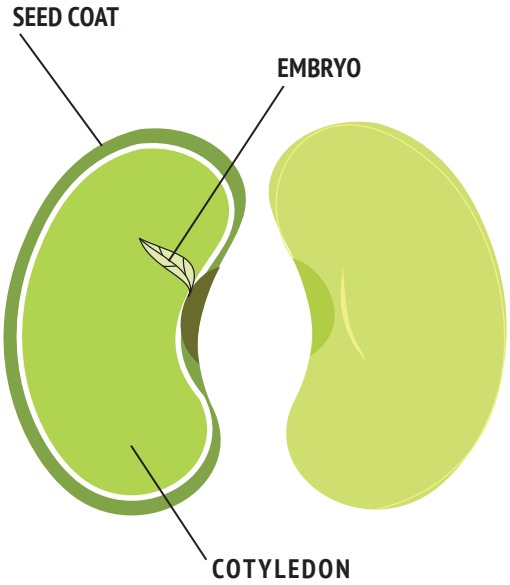
Plant Science

Background

About seeds

Basic components of seeds:

- Embryo – a tiny plant, complete with leaf, stem, or root parts
- Seed coat – protects the embryo



Seeds have a temporary food supply to nourish the embryo until the seedling grows leaves and the plant can make its own food. This food supply can be:

- Packed around the young plant, in which case it is called an endosperm
- Stored in special leaves called cotyledons

Most seeds are either monocots (one cotyledon) or dicots (two cotyledons).

When conditions are right for seeds to begin growing, the seed germinates. To germinate, all seeds require:

- Oxygen
- Water
- Proper temperature

Oxygen and water (for moisture) are initially taken in through the seed coat, through a tiny opening called the hypocotyl. Later, the root has this function. The embryo's cells begin to enlarge, and the seed coat breaks open. The root emerges first, followed by the shoot, which contains the stem and leaves.

Seeds have specific temperature requirements and/or preferences for germination. For example, tomatoes require warm temperatures of 70-75°F, but lettuce germinates better in cooler temperatures of 45°-65°F.

Seeds might need proper light conditions to germinate. Some seeds require light, but light inhibits others from germinating. A seed packet provides this information.

How seeds are treated during germination affects their chances of survival.

- If small seeds are planted too deeply, the young plants use up their food supply before reaching light (which the plant needs to make its own food) and die.
- Seeds planted in soil that is too dry might not get enough moisture to germinate.
- Seeds planted in soaking-wet soil might not get the oxygen they need to germinate, or the excess moisture might cause the seeds to rot.

Some seeds have hard seed coats. They germinate more quickly after being soaked or scarred (nicked) to allow water to enter the seed.

Some seeds fail to germinate. The reasons why include:

- Soil temperature is too low or too high.
- Soil has dried out.
- Seeds were planted too deeply.
- Seeds washed away during watering.
- Seeds were old and/or improperly stored.
- Poor soil-to-seed contact.
- Damping-off disease.

In Level A, Seeds Up Close, youth explore seed germination and identify the parts of a seed.

Basic plant needs

All living things have basic needs, and plants are no different. To thrive and grow, plants need:

- Light
- Water
- Mineral nutrients
- Air (carbon dioxide and oxygen)

Mineral nutrients are derived from the breakdown of rocks and other materials in the earth. Plants take these minerals from the soil (dissolved in water) or through fertilizers that people apply. Too much of a good thing can be as harmful as too little.

- Too much light during germination delays the process for certain seeds that prefer darkness.

- Too much water can prevent oxygen from reaching roots.
- Too much fertilizer can burn plants or cause plant cells to grow too quickly, resulting in weak, spindly, or dead plants.

In Level A, Beyond the Stem, youth explore what happens when a plant leaf cannot get sunlight.

Plant parts

Roots and stems help most green plants meet their basic need for nutrients and water. They form a special partnership.

Roots

Function

Roots are important in enabling plants to meet their basic needs because they:

- Provide support
- Anchor the plant
- Absorb necessary water and nutrients
- Might store sugar and their carbohydrates, which the plant can use (example, a potato plant with tubers)

Roots also have a special partnership with soil by:

- Assisting the long process of soil formation by breaking off tiny pieces of rock as plant roots grow through cracks in rocks
- Aerating and loosening soil when a plant's roots are alive
- Providing tunnels for burrowing insects and animals
- Contributing to the rich humus component in soil when the plant's roots are dead and decomposing
- Helping to protect topsoil from erosion (the wearing away of soil by the action of ice, water, or wind)
- Helping to absorb and recycle water when it rains

Sweet potatoes, carrots, beets, turnips, and radishes aren't just nutritious food sources for humans and other animals; they are plant-food storage roots. One-fifth of the world's sugar comes from the roots of sugar beets.

In Level A, Beyond the Stem, youth grow a carrot plant from the root instead of from seed.

Structure

There are two basic types of roots.

- Some plants have a primary *taproot* with a few smaller, hairy roots. Such long, strong roots reach deep into the soil to pull up nutrients and water from far below the surface. Carrots, sweet potatoes, beets, radishes, and turnips are taproots that expand in size and store sugars and starches.
- Other plants have a *fibrous root system*, a network of smaller roots and root hairs branching off the primary root. These networks can be extensive with more than a million branching roots covered with billions of root hairs. Beans and tomatoes have fibrous root systems.

Basic need	Purpose
Light	Required for photosynthesis so plants can make sugar (food). Triggers certain changes, such as flowering (photoperiodism) in certain plants.
Water	Carries dissolved nutrients into the plant through the roots. Required in photosynthesis. Helps plant release energy from stored food when needed (in respiration). Helps support stems and leaves by water pressure in plant cells, which are 65-95% water. Transports nutrients and gases into, around, and out of the plant.
Mineral nutrients (major nutrients—nitrogen, potassium, and phosphorus)	Used for growth, repair, and proper functioning.
Air	Required in photosynthesis (carbon dioxide is necessary to make food). Required in respiration (oxygen is necessary to release energy from a food).

In both types of roots, the tiny root hairs provide surface areas for absorbing water and nutrients. They bridge the root and the water with dissolved nutrients in the soil. That's why transplanting young seedlings or transplants carefully is so important. A plant with damaged root hairs has difficulty meeting its water and nutrient needs. It's also why certain seeds should be planted outdoors when the ground warms up instead of started indoors for transplanting

in warmer weather. The roots of some plants, like beans and cucumber, are more fragile than others, like tomatoes.

Motion

Roots normally grow downward to meet a plant's nutrient and water needs. Roots are sensitive to gravity, and their downward growth from whatever their original position is called geotropism. In Level B, A-Maze-ing Plants, youth explore how to influence the direction of root growth or geotropism.

Stems

Stems are vital in enabling plants to meet their needs, because they:

- Link plant leaves and roots, enabling all plant cells to be within reach of water and nutrients
- Transport water and minerals, taken in by the roots, to leaves to help produce food
- Transport food produced in the leaves to other parts of the plant
- Support the plant if it's aboveground, allowing leaves to reach the light necessary to make food (photosynthesis)
- Serve as food storage sites

Water and dissolved nutrients move upward in stems against the force of gravity. Water moving into the roots pushes water up into the stem. When water evaporates (transpiration) through leaf openings (stomata), water is "pulled up" in stems. In Level A, Beyond the Stem, youth explore how the plant transport system works.

Structure

Stems come in many shapes and sizes, and they can be either soft or woody. However, they all serve the same type of transport functions. Not all stems grow above the soil. Underground stems (stolons) in potato plants also store food in tubers. In Level B, Not From Seeds Only, youth explore growing plants from plant parts, including potato tubers and garlic cloves.

Motion

Just like roots, stems respond to their environment to enable plants to meet their basic needs. Plant stems and leaves generally respond to light by bending toward it, which is called positive phototropism. Roots grow away from light, which is called negative phototropism. Some plants also can grow away from the light, but vegetables usually do not. This movement is triggered by a concentration of plant hormones called auxins. When light hits a plant, the side of a stem away from the light accumulates auxins. This causes cell growth on that side to lengthen and the stem to become longer; the plant stem bends toward the light.

Auxins are concentrated in the tip of the stem. When this growing point is cut (or pinched) off, the auxins allow the lower branches of the plant to grow. That is why pinching off tomatoes at the growing points encourages bushier growth. This is also a good practice with herbs so they grow bushier with more leaves instead of tall and leggy.

In Level B, A-Maze-ing Plants, youth explore how to influence the direction of stem growth or phototropism.

Leaves

Leaves have a critical function—they make food. They convert the energy in sunlight, together with air and water, to make the energy that green plants need to live. Leaves come in many different shapes and sizes but most have these parts:

Leaf part	Function
Stomata	Pores that open and close on the outer surface of most leaves. Allow carbon dioxide and oxygen to enter and leave the plant during photosynthesis.
Veins	Carry water, nutrients, gases, and other materials to and from all parts of a leaf to produce food and use energy. The food that leaves make travels through the veins to the stem and other parts of the plant for use and/or storage. Provide support for the leaf to help position its leaves to receive light.
Chloroplasts	Contain a green pigment, chlorophyll, necessary to trap light energy and allow photosynthesis to occur.

What is photosynthesis?

Photosynthesis is the process by which plants make their own food. Using light energy, plants convert water and carbon dioxide into a simple sugar called glucose. This sugar is the source of food for most plants and the humans who consume them. This is not the only benefit of green plants. Life on our planet would not exist without photosynthesis, because not enough oxygen would be replaced in the environment to support life. Plants produce approximately 100 billion tons of oxygen every year!

Photosynthesis is an ongoing process that takes place in two phases.

- The first phase is the light cycle, or light-dependent reactions, because light is required. The plant's leaves absorb light rays, and the chlorophyll traps this light energy. Water (taken up by the roots and transported to the leaves) is split into hydrogen and oxygen using the captured light energy. At the same time, carbon dioxide is taken in from the air through the stomata (leaf pores).
- The second phase is the dark cycle, or dark reactions, because light is not needed. In this phase, the hydrogen that was split from the water combines with the carbon dioxide to form glucose. The leftover oxygen is released into the atmosphere through the stomata. As oxygen is released, the stomata allow more carbon dioxide to enter so photosynthesis can continue.

Photosynthesis can be summarized as:
Carbon dioxide + water (*light* ⟶) glucose + oxygen

In Level B, Getting Green, youth explore photosynthesis and take a closer look at chlorophyll.

Respiration

Before a plant can use its food—stored in the form of the sugar glucose—the glucose must be broken down into a form the plant can use. During respiration, plant cells release the energy from glucose. Respiration is the same process that humans and other animals use. It is a series of complicated chemical reactions, just like photosynthesis.

Plant leaves absorb oxygen from the air and combine it with glucose. Then carbon dioxide is given off through the leaves. The plant can now use the energy released from the glucose. This glucose can also be changed and moved to other parts of the plant for use and storage.

- Individual molecules are combined to form larger, more complex molecules called carbohydrates, including:
  - Sucrose (commonly known as table sugar). This is the form in which carbohydrates are transported around the plant. It can be found stored in the roots of sugar beets and the stems of sugar cane.
  - Cellulose, which makes up the sturdy walls of plant cells. Cellulose is a common ingredient in biofuels like ethanol. Scientists are breeding plants with more cellulose, or cellulose that is easier to break down, to make renewable fuels easier, cheaper, and quicker to produce.
  - Starch, which is stored in plant leaves, stems (white potatoes), or roots (sweet potatoes) and can be broken down into simpler sugars for later use.
- Individual molecules can also be changed into fats and proteins that make up the materials in plant cells (in seeds such as peanuts and soybeans).

Flowers

Although people enjoy flowers for their beauty and fragrance, a flower's function is to produce seeds. All the attributes of a flower—its color, size, shape, smell, and so on—are important in producing seeds.

The transfer of pollen from male to female flower parts is called pollination. Some pollinators are:

- Bees
- Butterflies
- Moths
- Flies
- Beetles
- Birds
- Bats
- Wind

What happens during pollination?

When a grain of pollen lands on the stigma, a tiny tube grows from it and proceeds down the style into the ovary. Sperm cells travel through this tube to an ovule, and fertilization occurs. The fertilized ovule becomes a seed, and the ovary, a fruit. Without pollination and fertilization, fruit and seed production cannot occur in most plants.

The two types of flower are perfect and imperfect.

- Perfect flowers have both pistils and stamens. These parts are arranged to keep pollen from easily reaching the ovary of the same flower to

Next Generation Science Standards (NGSS)*

Gardening has many benefits. Youth not only learn to grow their own vegetables and herbs but also gain skills that benefit them in an academic setting.

This section links the 4-H garden project and Next Generation Science Standards (NGSS), making this curriculum a valuable tool for use in the classroom or at home. This chart organizes the standards by grade levels that correspond to each garden manual and its activities. Learn more about the Next Generation Science Standards at www.nextgenscience.org

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Level A, See Them Sprout

NGSS	Youth activity
3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.	• Seeds Up Close • Take Time for TLC • Is It Ready?
LS1.B: Growth and Development of Organisms Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.	• Plant It!
3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.	• The Second-Year Garden
3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.	• Beyond the Stem
4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.	• Change It Up

Level B, Let's Get Growing

NGSS	Youth activity
5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion and to maintain body warmth) was once energy from the sun.	• Starting from Scratch
5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.	• Let It Rot
5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.	• Wiggly Farm Acres
MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.	• Let It Rot
MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	• A-maze-ing Plants

Level C, Take Your Pick

NGSS	Youth activity
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	• Getting Green
HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	• Be a Bug Buster • When Animals are Pests • What's With Weeds?
MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.	• Keep on Planting ("Grow What You Know")
MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.	• Getting Green
MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.	• Flower Power
MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.	• Acid Basics • What's Under Your Feet?

Level D, Growing Profits

NGSS	Youth activity
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	• The Air Up There
HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.	• Designer Genes
HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.	• Designer Genes
HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	• The Air Up There