College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

School Garden Basics Workshop For Educators

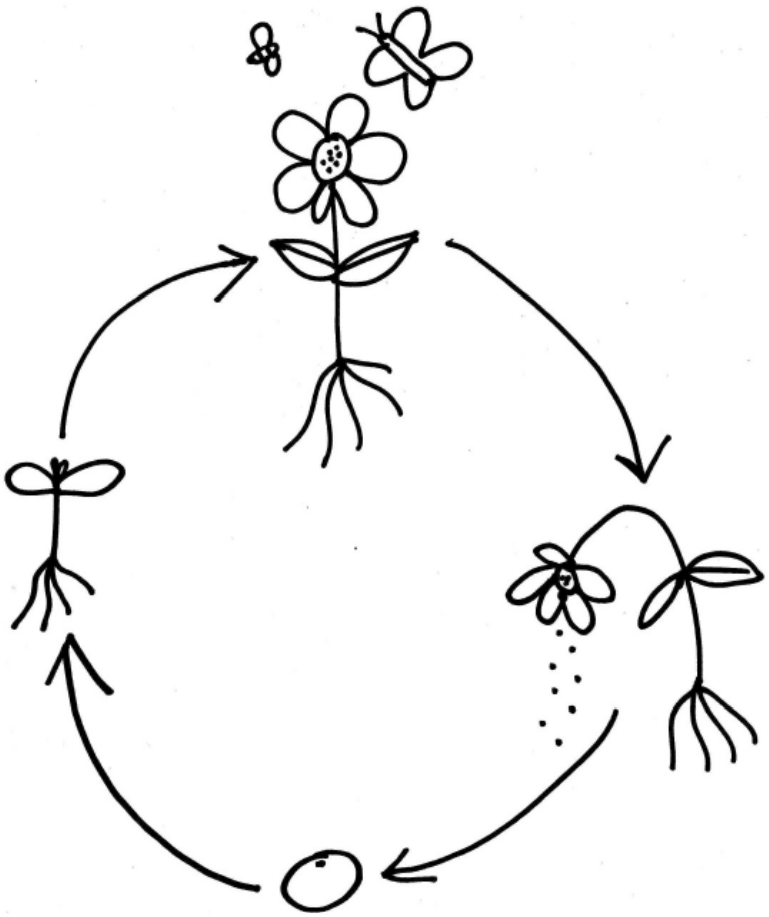
The Life of Plants

by O'ahu Master Gardeners in cooperation with Kōkua Hawai'i Foundation

Objectives: To Explore…

- Plant life cycle
- Types of garden plants
  - Length of growing season (annual, perennial, biennial)
  - Forms of leaves, stems, & fruit of flowering plants (monocot vs dicot)
- Plant structure and function
  - Roots (absorption, anchorage, storage)
  - Stem (support, nutrient transport, storage, & sometimes production)
  - Leaves (photosynthesis, transpiration, respiration)
  - Flowers (reproduction)
  - Seeds (embryo dispersal & perhaps dormancy)

The Plant Life Cycle



What is the first stage of plant life?
Is there a first stage?

A seed is like a baby that needs a lot of love and care.

When you plant a seed in the soil it becomes a sprout. Sprouts are like young children that need lots of energy to grow.

If that sprout gets lots of sun, rain, and nutrients, it becomes an adult and produces flowers and pollen.

Once the flowers have been pollinated and become mature, the plant begins to wither and return it's body to the soil to nurture the next generation.

Plant Life Cycle Length

- Annual – grows from the seed, blooms and sets seed; dies in one growing season
- Biennial - blooms and sets seeds in two growing seasons
- Perennial – lives for three or more growing seasons

Plant Types: Annuals

Short Lived

Examples: lettuce, peas, carrots, corn.

Often grown from seeds (requiring pollination).

Will die after seeds mature.

UH Manoa Sugar Pea

Plant Types: Biennials

Biennial vegetables normally require two years from seed to flowering. Biennials may survive longer in Hawai'i because of warm weather.

Examples: parsley, beets, Brussels sprouts, cabbage, carrots, cauliflower, celery, chard, collard, endive, kale.

Dinosaur kale

Plant Types: Perennials

Long-Lived, Continuously Producing

Examples: sweet potato, taro, banana.

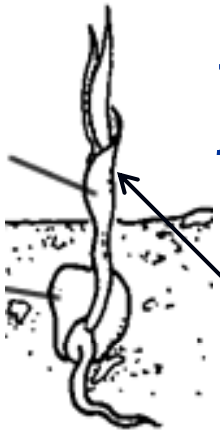
Often grown from cuttings or division

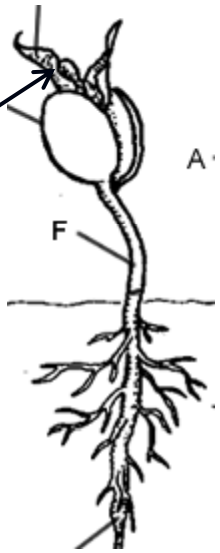
Most common life cycle

for Hawaiian native plants

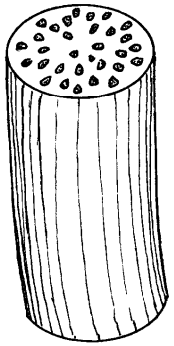
‘Uala – sweet potato

Monocots and Dicots





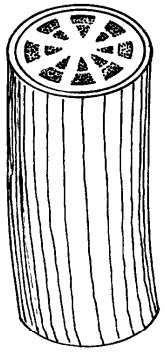
Monocot (grasses)		Dicot (broadleaf)
one	**Seed leaves**	two
parallel veined	**Leaves**	net veined



Vascular system

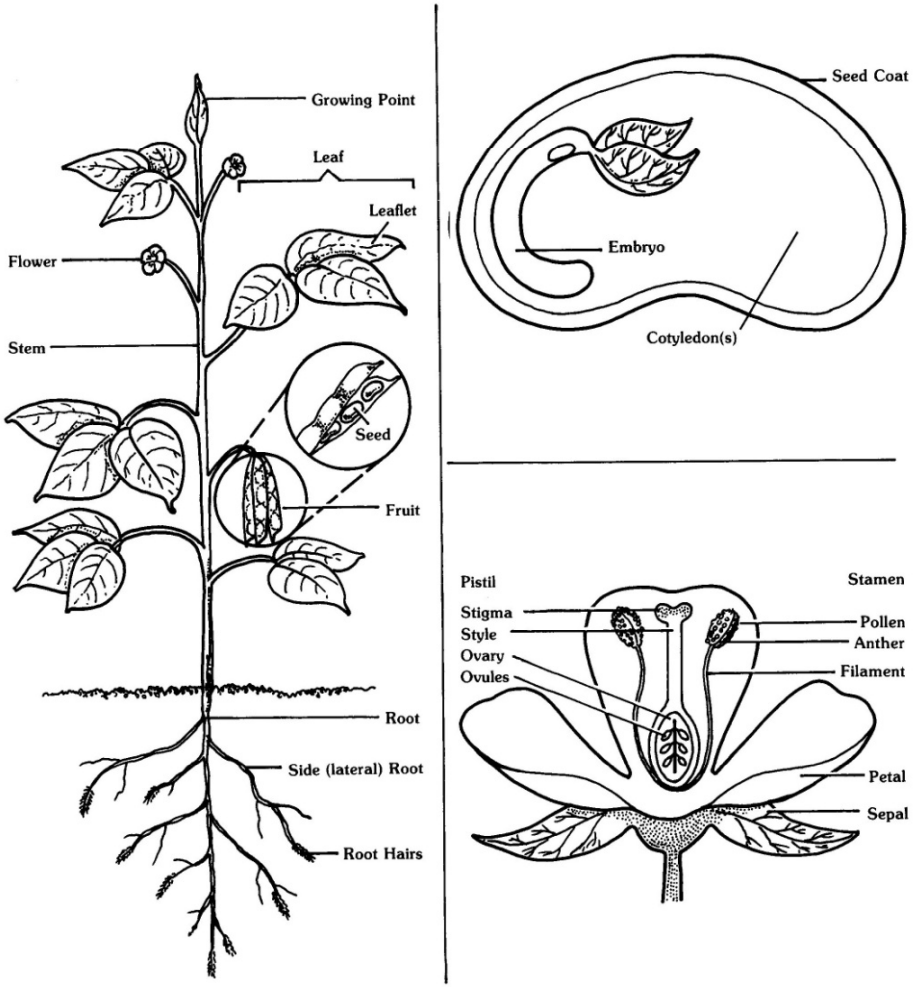
xylem & phloem paired

xylem and phloem form inner & outer rings



Plant Structure and Function

- Roots
- Stems
- Leaf
- Flower
- Seed

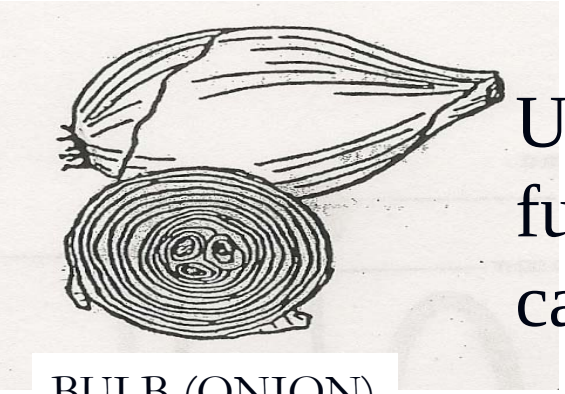


Roots: underground stem that absorbs water and nutrients

Three major functions:

- **Absorption** – bringing up water and nutrients from the soil
- **Anchorage** – attaching and holding the plant in the soil
- **Storage** – holding starches, sugars, and moisture for plant use at a later time

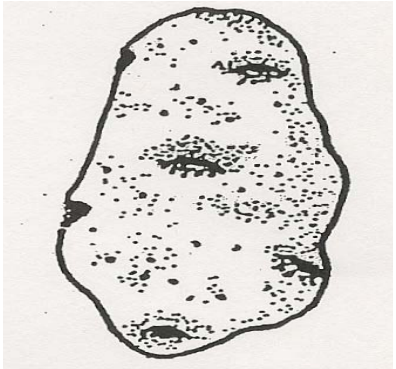
Underground Storage



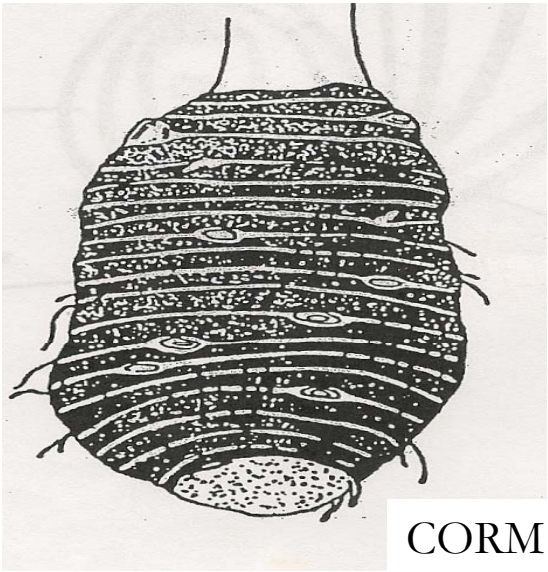
BULB (ONION)

Underground stem that functions as a **storage** for carbohydrates and sugars

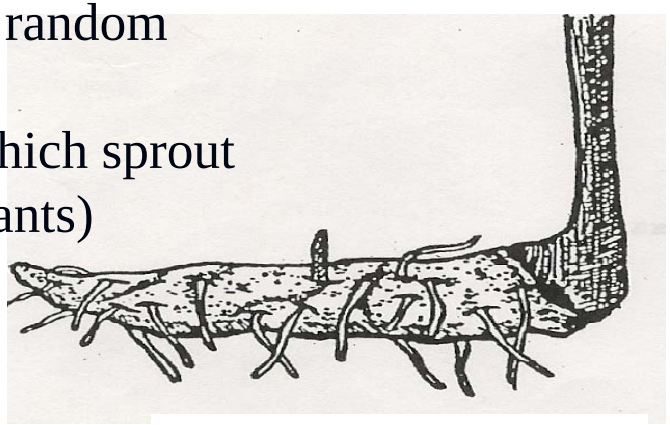
Bulb – has many layers (onion)
Corm – has nodes in a circular pattern (taro)
Tuber – has eyes in a random pattern (potato)
Rhizome – runners which sprout leaves (many grass plants)



TUBER (POTATO)



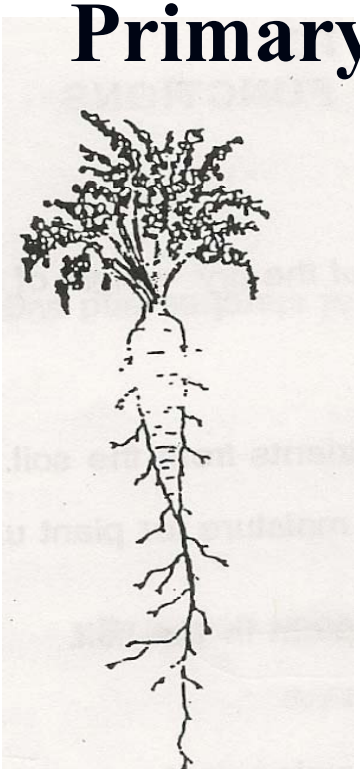
CORM (TARO)



RHIZOME (GINGER)

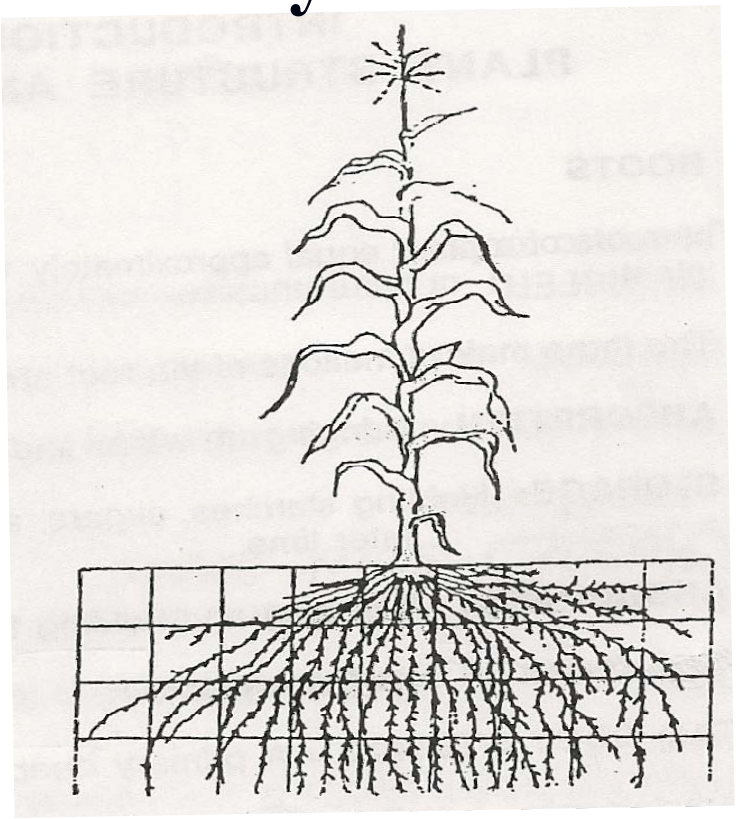
Root types

Primary /Tap



A primary deep growing root
Ex. carrot

Secondary /Fibrous



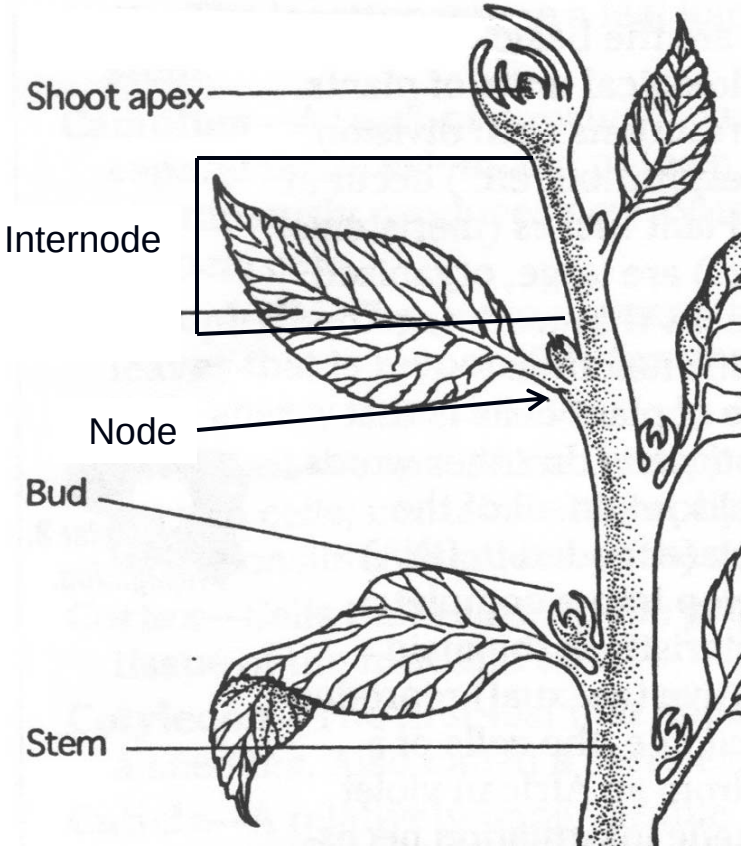
a network of smaller roots in the upper soil layers
Ex. corn

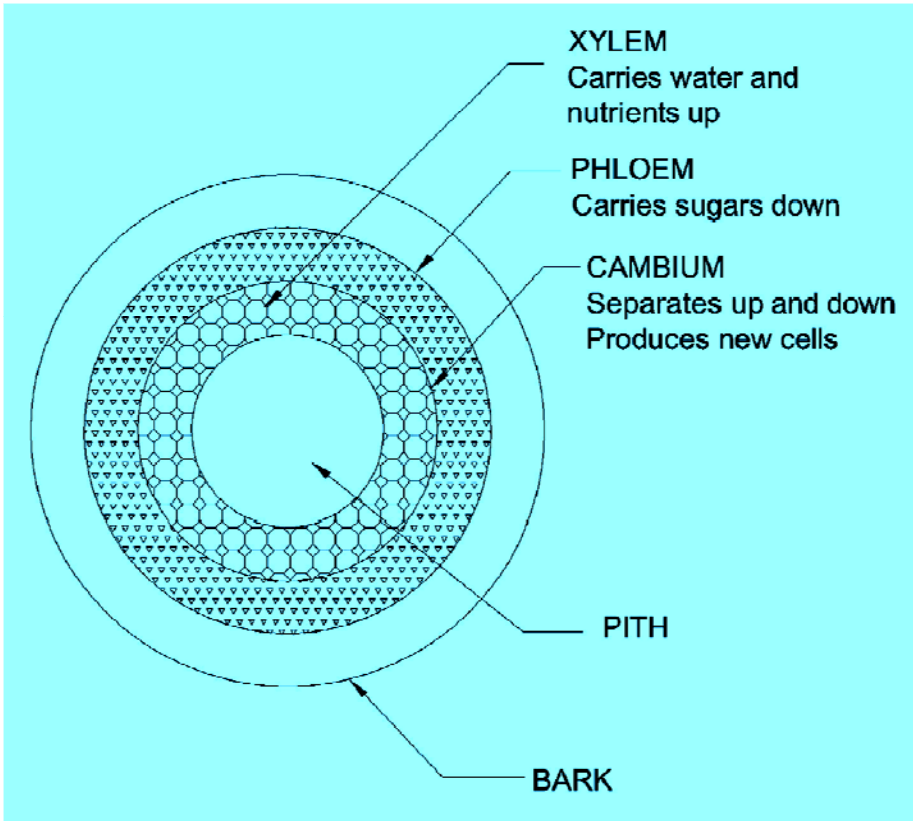
Stem: part of a plant above the ground that supports buds and leaves

Functions:

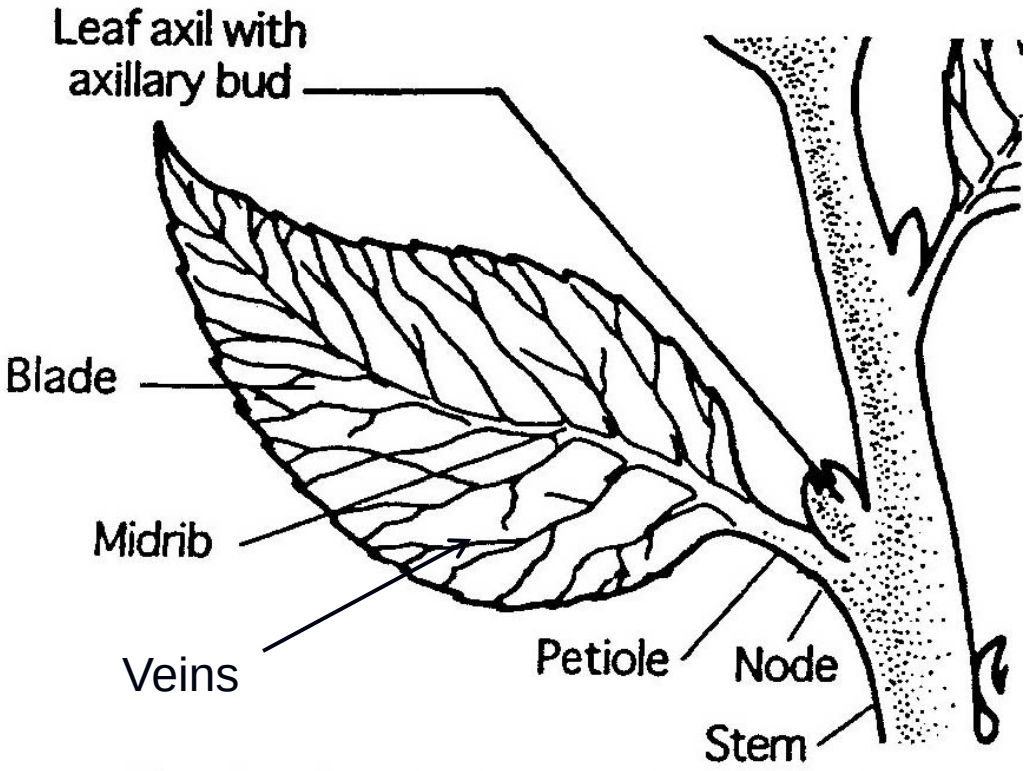
- **Support** – of leaves, flowers, and fruit
- **Transfer up** – of plant nutrients and water
-
- **Transfer down -** of starches and sugars
- **Storage** – of water, starches and sugars, especially in modified stems

Stem structure - dicots

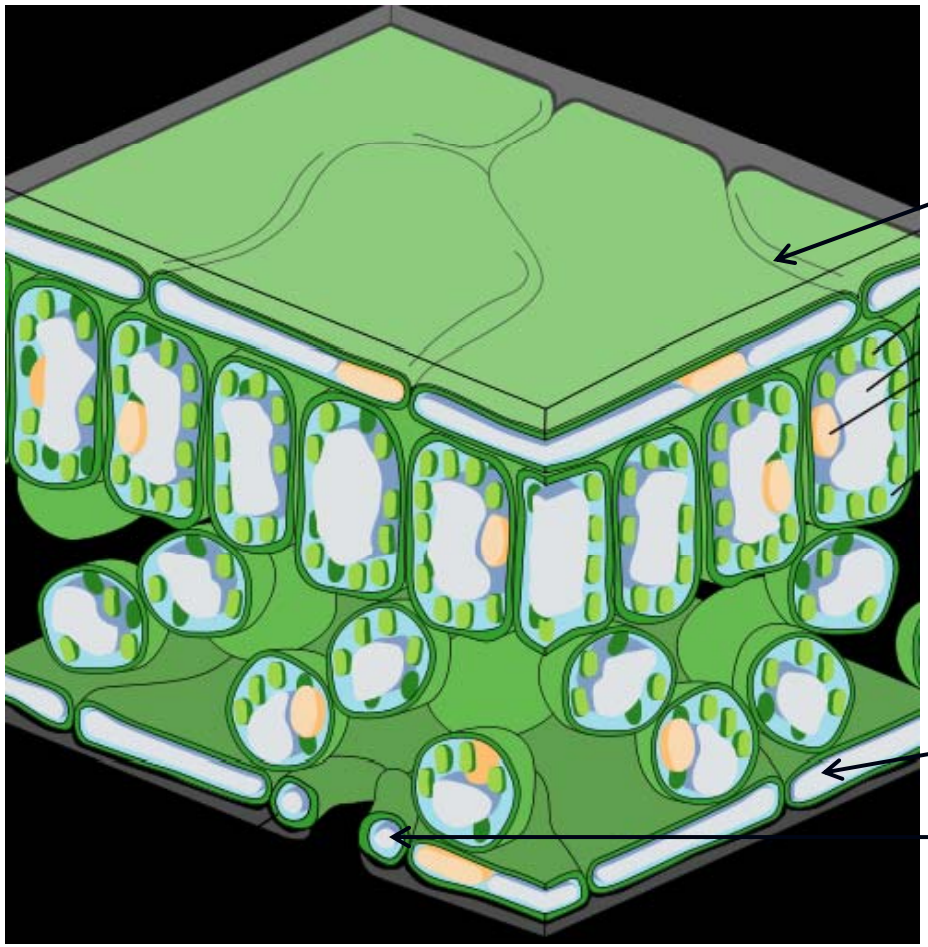




Leaf Structure



Leaf layers



Upper epidermis
protective top layer

Mesophyll layers
Middle layers that contain chlorophyll (green stuff)

Lower epidermis
Contains guard cells

Stomata – tiny openings
Allow passage of water, oxygen, and carbon dioxide

Leaves: part of the plant containing chlorophyll that makes food via photosynthesis

Functions:

- **Photosynthesis –** the use of sunlight to produce plant food
- **Transpiration –** the loss of water vapor to cool the plant
- **Respiration –** process of converting sugars and starches to energy

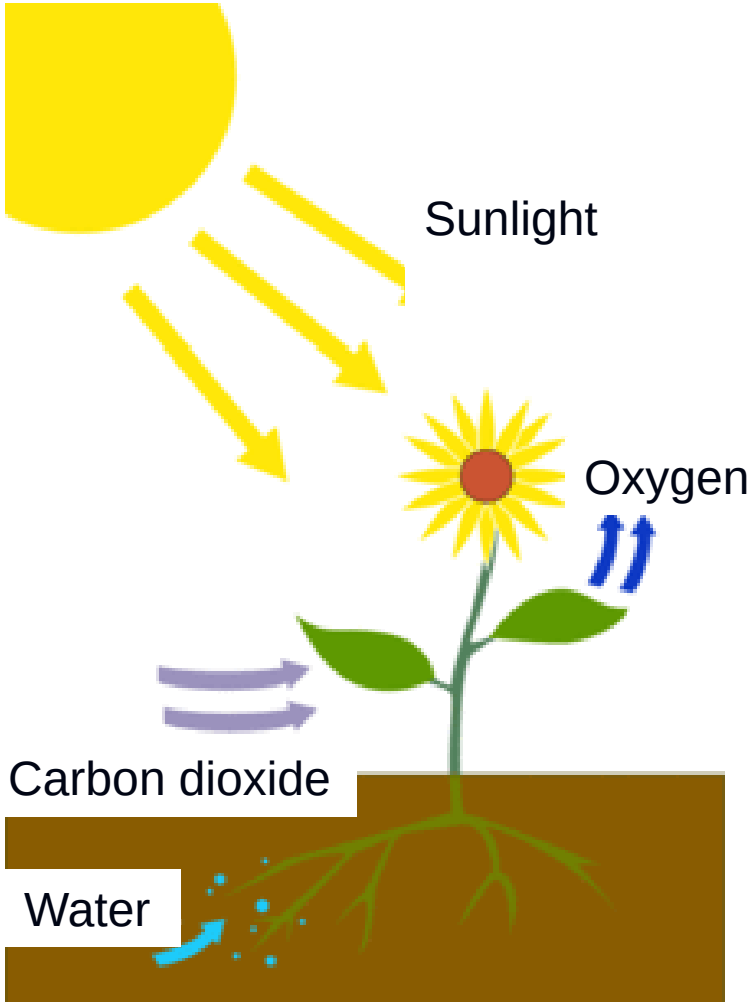
Photosynthesis

The energy from sunlight is captured in the chlorophyll and combines with carbon dioxide and water.

The energy from the sun separates carbon dioxide into carbon and oxygen.

Carbohydrates (starches and sugars) are formed from carbon, oxygen, and water to build leaves, stems, roots, and seeds.

Oxygen is released to the atmosphere as a byproduct of photosynthesis

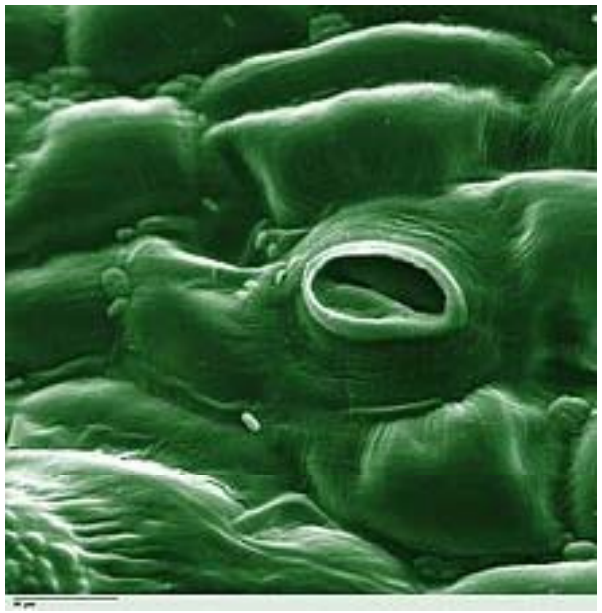


Transpiration

Water vapor is lost from leaves through the open stomata. As water is lost, more water is pulled up from the roots.

The transfer of water accomplishes:

- Transporting minerals from the soil throughout the plant
- Moving sugars and plant chemicals
- Cooling the plant through evaporation
- Maintaining cell firmness



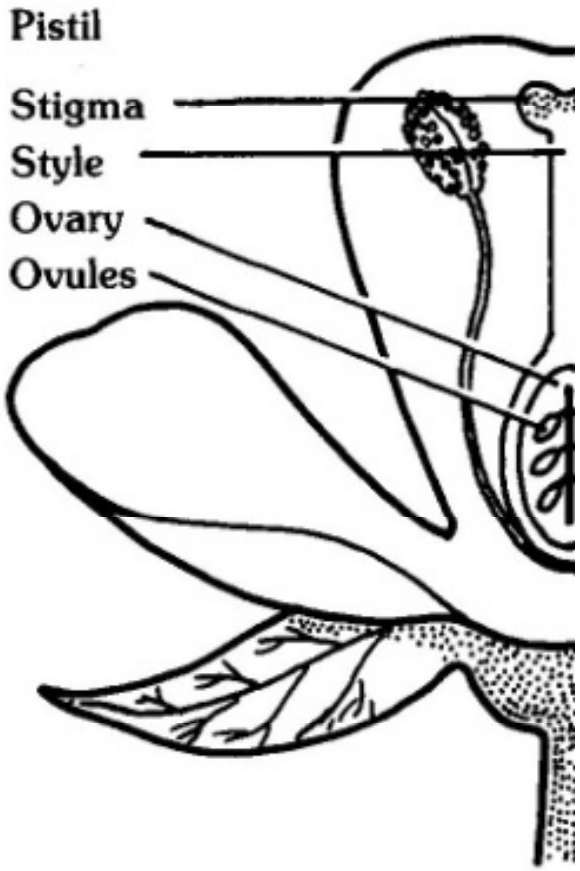
Open stoma on tomato leaf

Respiration

The chemical process of converting sugars and starches to energy is called oxidation, similar to burning wood for heat.

Controlled oxidation in a living cell is called respiration. By this process, energy is used for cell growth and building new tissues. It is the opposite of photosynthesis. Respiration occurs in all life forms and in all cells.

Female Parts of Flower



Pistil (girl parts)

Stigma – the pollen receiving portion of the flower

Style – the stalk which holds the stigma and transfers pollen to the ovary

Ovary – the part where immature seeds are held before pollination and where mature seeds develop

Ovule – fertilized egg that develops into a seed

Male and Other Flower Parts

Stamen (boy parts)

Pollen - Powdery grains that contain the male reproductive cells

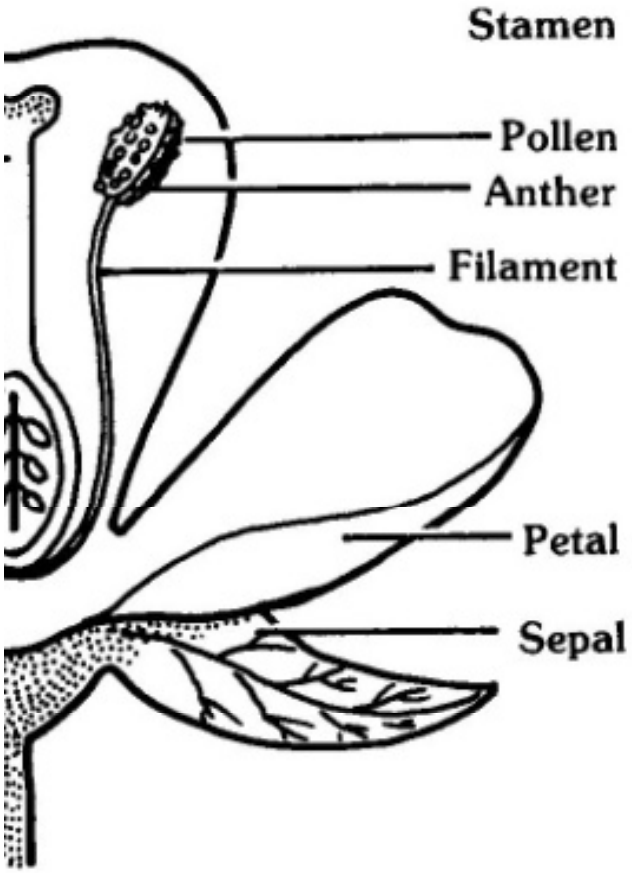
Anther – the pollen producing/bearing part of the flower (male)

Filament - the slender stalk which holds the anther

Other Parts

Petal – the modified leaves which protect the reproductive parts and attract pollinators

Sepal – modified leaves that enclose the petals and protect the flower before it opens

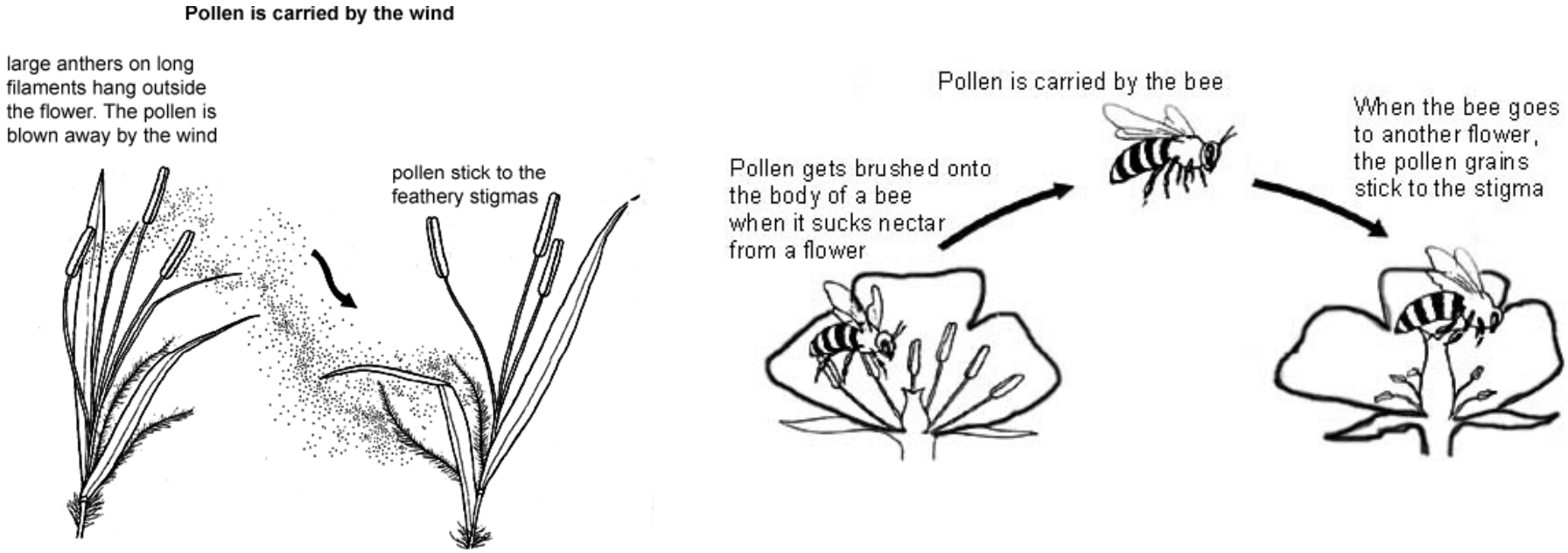


Activity

Dissect a flower

Pollination

The transfer of pollen from the anther to the stigma of a flower either by wind or pollinators



Pollinators

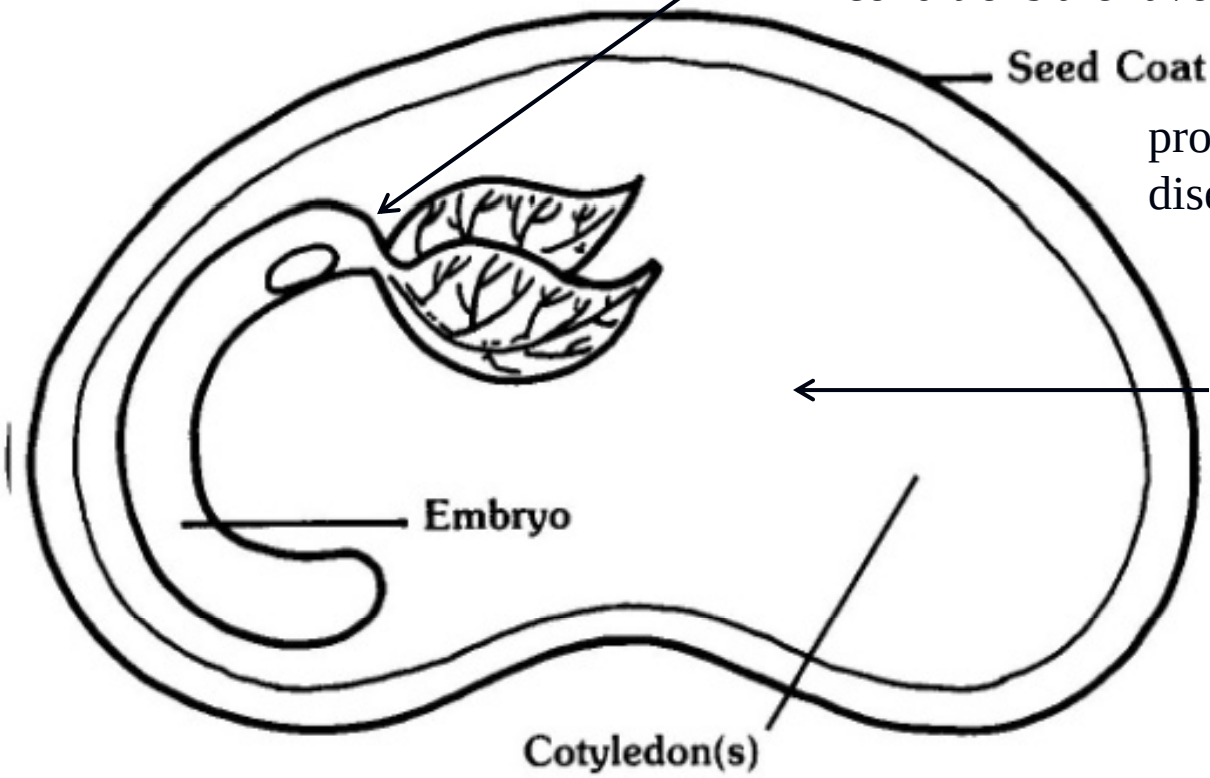
things which convey or deposit pollen of flowers including insects, birds, animals, and people

Especially Bees, Butterflies, & Birds

To attract pollinators, plant zinnias, cosmos, marigolds, sunflowers

Seeds

Embryo – a miniature plant in arrested state of development that will begin to grow when conditions are favorable.



Seed Coat A hard outer covering that protects the seed from moisture, disease, and insects

Endosperm – contains food for the germinating seedling in the form of carbohydrates, fats, and oils.

Cotyledon(s) the seed leaves of an embryo or seedling

Seed Saving

- Plan to harvest during dry weather
- Seed should be allowed to mature as fully as possible
- Dry seed like lettuce may be harvested when almost dry and fully dried indoors
- Store dried seed in the refrigerator

- Experiment!
- Share!!

Make your own popcorn

CONCLUSION

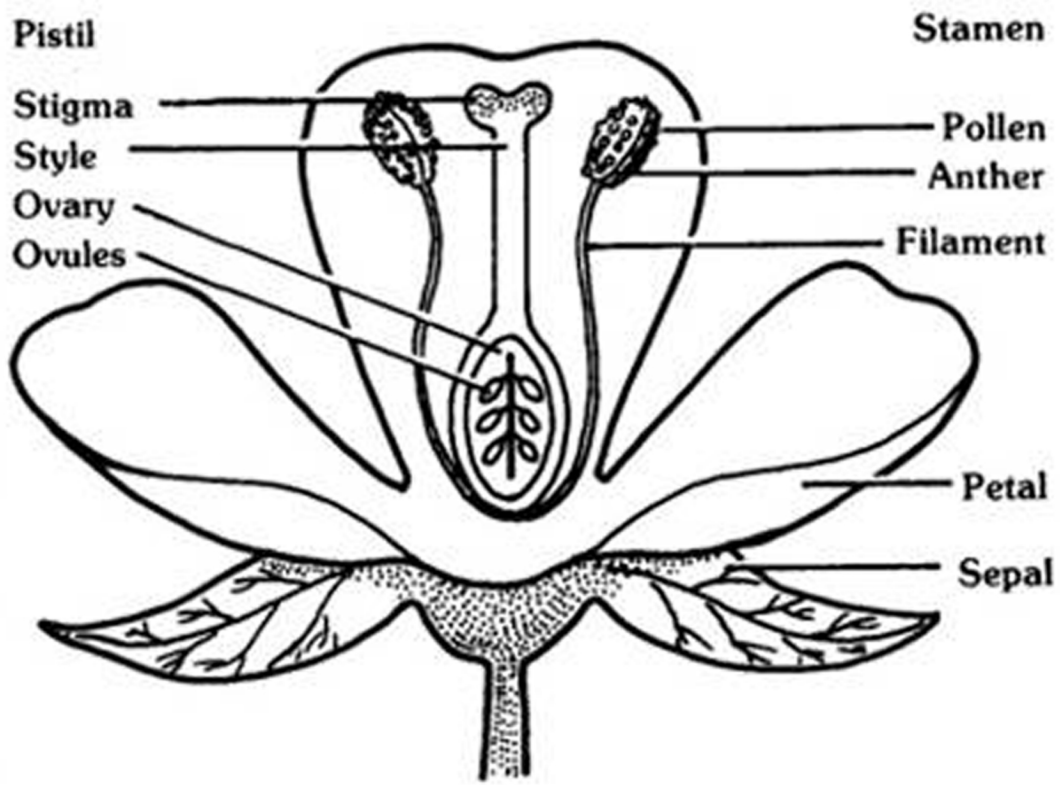
Plants are like People!

We care for them and

they care for us

Outdoor Activities

Plant Life Cycle Exercise


Pistil
Stamen
Stigma
Style
Ovary
Ovules
Pollen
Anther
Filament
Petal
Sepal

Saving Seed

by Dr. Theodore Radovich

Farmers and gardeners have saved their own fruit and vegetable seed for millennia. Saving seed from desirable plants is a fundamental act of agriculture and has resulted in thousands of fruit and vegetable varieties we have today. Seed saving takes time and other resources away from growing crops, and most commercial farmers prefer to purchase seed from companies that specialize in producing it. Still, many farmers and gardeners will save at least some of their own seed to select and preserve well adapted varieties that may not be available in the commercial market. Several vegetable varieties selected and saved by Hawaii farmers are available from the University of Hawaii Seed Program. This article highlights key points to be aware of when saving seed. For more details regarding seed saving please see the resources at the end of this article.

Figure 1. Organic seed production at the CTAHR Waimanālo Research Station. Foreground: 'Kewalo' tomato and 'Koba' green onion. Background: 'Hirayama' mustard

Let's talk about sex, baby.

Understanding the basic reproductive biology of plants is an important part of seed saving. The majority of plants outcross, which means that pollen from different flower(s) germinate on the stigma of the mother flower, travel down the style and fertilize the ovules. Outcrossing increases genetic diversity of the population, which increases the potential for adaption of the variety to future changes in environment. Many vegetable crops naturally outcross, including sweet corn, pumpkins, and eggplant. Different mechanisms have evolved to maximize the chance of outcrossing in vegetables. For example, male and female parts may be on separate flowers as they are in corn and cucumber (Fig 2), or even on separate plants (as in male and female papaya). In flowers with male and female parts, pollen shed may occur before or after the stigma is receptive or the style may be protrude beyond the anthers, increasing the potential for insect-mediated cross-pollination.

When saving seed from an open-pollinated variety there are several important things to keep in mind:

- Remove (rogue) off-types from the population.
- Isolate varieties of the same crop from each other. Isolation can be done in distance (660 feet for corn), in time (plant varieties so they flower at different times) or by bagging flowers (Fig 3).
- Save seed from as many individuals as possible. Minimum individuals recommended for most open-pollinated species is 80, although seed from as many as 200 individuals is recommended for corn to minimize inbreeding depression.

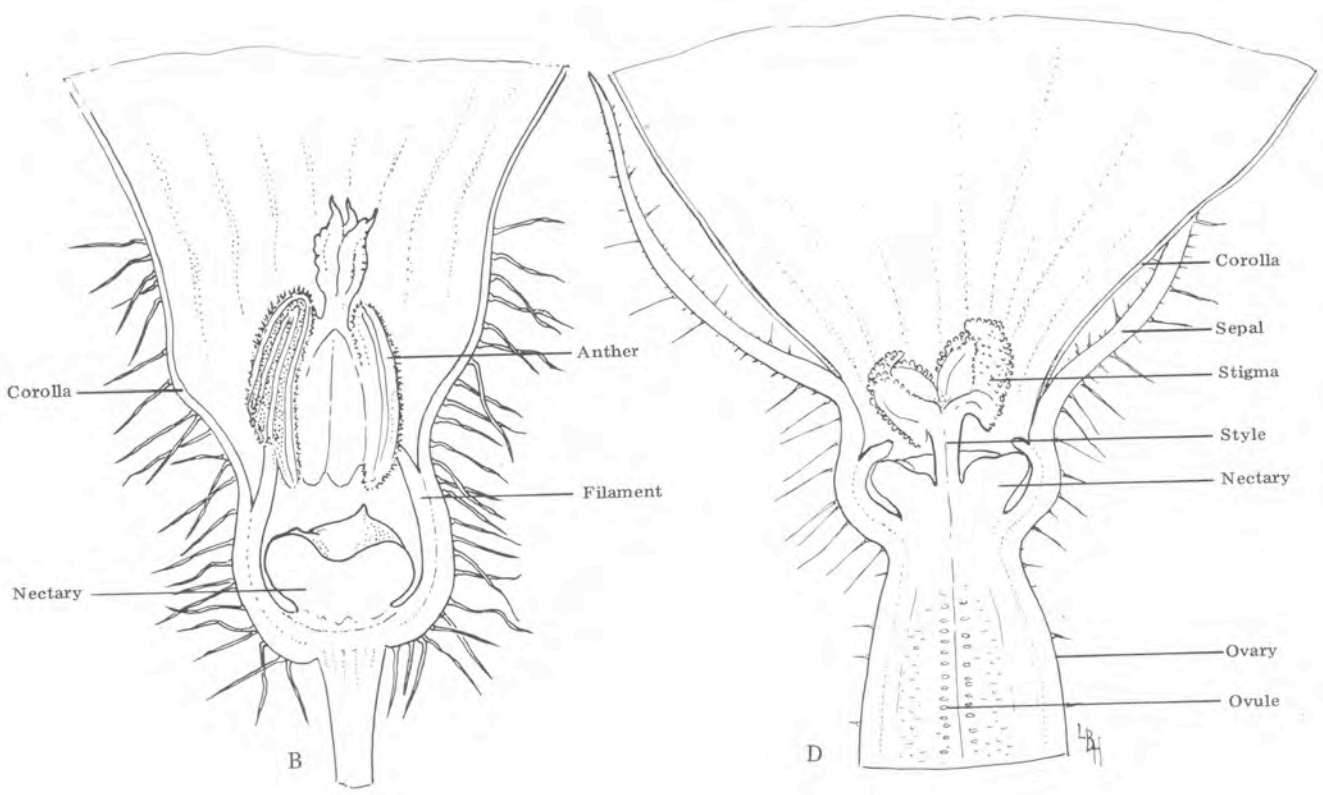


Figure 2. Longitudinal sections of cucumber flowers: Left) Male flower; Right) Female flower. From: ARS (1976).

Self pollinated species include peas, beans and lettuce. Most tomato varieties are also self-pollinating. The anthers on the flowers of self pollinated crops typically surround the pistil, and pollen shed often occurs before flowers open, ensuring self pollination. Isolation in self pollinated varieties is less of a concern than in open pollinated varieties, but outcrossing can still occur especially if plants are touching or pollinator populations are high and diverse in species. Recommended distances between self pollinated varieties of the same species are 10-15 feet. Seed should be saved from at least 15-50 individuals in self pollinating populations.

Hybridization refers to the controlled cross between individuals from two distinct varieties. Reasons for hybridization include hybrid vigor (increased yield), disease resistance and variety protection. Many commercial varieties are hybrids. Seed saved from hybrid vegetables may not germinate, or if so, will likely not produce uniform populations of individuals resembling the parent plants. For those interested in making their own hybrids and developing their own cultivars, see the reference by Allard (1999) and Deppe (2000).

Figure 3: Bagged papaya flowers

Special needs

Special considerations need to be made when growing plants for seed. Planting should be timed so that seed maturation occurs during dry weather, if possible. Plants will be in the field much longer when grown for seed than for food (e.g. 30 days vs. 120 days in lettuce). Spacing of seed crops should be wider than when grown for food to accommodate larger plant size and maximize airflow to reduce chance for disease.

Seed harvesting & cleaning

Seed should be allowed to mature as fully as possible on the plant, but mature seed should be harvested as soon as possible to avoid losses to birds, rain and disease.

In the case of dry seed like lettuce and beans, plants may be cut from the field when mostly dry and allowed to complete drying on benches in a well ventilated, covered structure like a green house, garage or barn. Seed matures sequentially (bottom up) on inflorescence, so some growers will walk through a field periodically and shake the inflorescence into a bucket or garbage can to collect the older most mature seed, and allow the rest to remain on the plant. Growers may also place woven weed mat around the base of plants to collect dropped seed. Once dried, the seed will need to be cleaned of its protective material. For small scale cleaning of dry seeds, an effective method is to simply put the seed heads in a cloth bag or pillow case and physically "stomp and grind" the dried inflorescence through the bag with your feet or hands to loosen the seed from the other material. Wind or fans may then be used to blow the lighter chaff away from the seed. Gently tossing the processed material up in the air using a shallow pan or basket outdoors with a strong breeze is a common strategy to do this.

Seed processing from fleshy fruits requires slightly different steps than dry fruits. Although tomatoes harvested for seed may be picked at the same maturity stage as used for eating, other fruits like cucumber and eggplant must be left on the plant for much longer than usual to ensure maturity when saving seed. If harvested too soon, seeds from immature fruit will not germinate or germinate poorly. Seed scooped out of fleshy fruits are best processed by fermenting in water to remove closely associated material and germination inhibitors. The most common process for small scale producers is to soak the seed in an excess of water for 2-3 days, stirring twice daily. In some cases (e.g. papaya) fairly intense agitation with a blender and rubber blade may be used (for more information, see Producing Organic Papaya Seed at YouTube). For larger seed cleaning operations, commercial enzymes are available to speed up the fermentation process. After the fermentation step, seeds are drained, rinsed, and dried on paper towels or screen. Seeds may then be air-dried, or a fan on low speed can be used. The details of seed processing varies with species. See the references section for more details.

Storage

Most growers are content to store seed from year to year, or for a few years at most. These growers follow the "Rule of 100." The Rule of 100 states that the sum of temperature (F) and Relative Humidity equal 100. For example, refrigeration at 50 F @ 50% relative humidity fit these criteria. Seed dried to 2-5% and stored in the refrigerator in an airtight container can maintain viability for decades. Ex-

ceptions to this rule include very large seeded species (e.g. avocado and mountain apple) and are called "recalcitrant." Most vegetable species follow the Rule of 100, and are thus called "Orthodox." For more details regarding seed saving, especially long term storage and "seed-banking", see Yoshinaga (2010), and cited references therein.

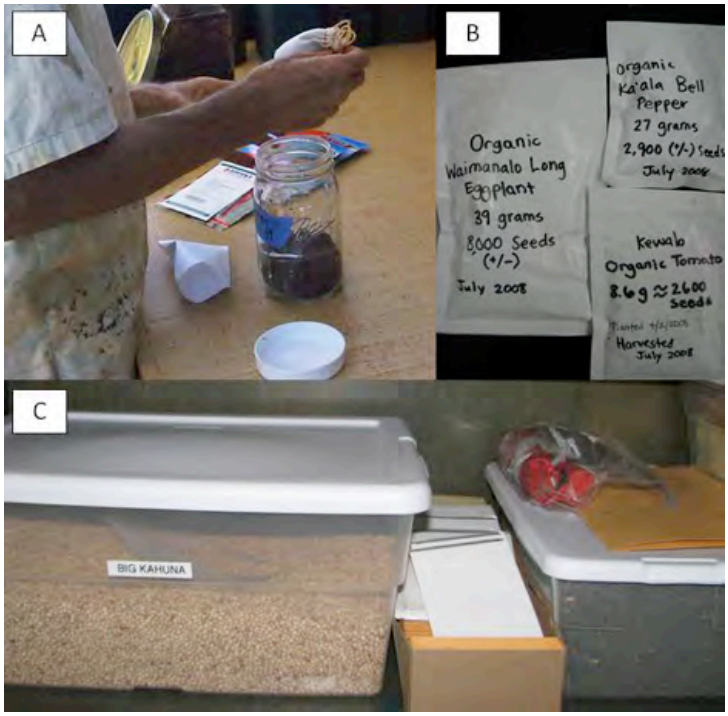


Figure 5. Seed may be stored for several years in glass jars (A), self sealing foil-lined packets (B) or sealable plastic containers (C).

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Vocabulary: life cycle

SCHOOL GARDEN EXPLORATION:

LOOKING FOR LIFE CYCLES

THIRD GRADE

Description

Students review the life cycles of plants, then team up in small groups to look for plants in the school garden that are at various stages of the life cycle. In fall, many vegetables reach maturity and are ready for harvest. Others have already been harvested, leaving behind tell-tale evidence of the completion of their life cycles. This lesson asks students to conduct a comprehensive inventory of the edible plants growing in the school garden, looking for evidence of the identity of unlabeled plants and proposing ways of continuing the life cycle of each plant.

Guiding Question

How do we get food from plants?

Big Idea

Living and non-living things vary in their characteristics and properties.

Learning Objectives

At the end of this lesson, students will be able to name 5 fruits or vegetables that are growing in the garden and determine a plant's current stage of its life cycle.

Materials

School Garden Exploration Life Cycle Hunt worksheets – one for each group
Clipboards, pencils
Optional: Volunteers to assist small groups in the garden.

Preparation

Visit the garden before the lesson to determine what plants are at which stages of their life cycles. If you conduct this lesson early in the traditional academic year (early September), you may find relatively few plants that are just sprouting, but common fall-planted garden crops that you may see include lettuces, calendula, bok choi, radishes, and cover crops. Easier to find will be mature plants, including herbs, tomatoes, carrots, peppers, beans, chard, eggplant. Plants likely to be flowering include artichokes, tomatoes, beans, and winter squash/pumpkins. Plants likely to be bearing their fruits include apple trees, beans, cucumbers, eggplant, summer squashes and tomatoes.

Decide how many small groups of students will participate in the lesson.

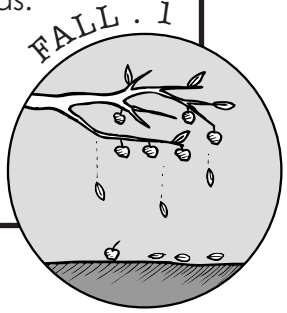
Print or photocopy School Garden Exploration Life Cycle Hunt worksheets (Optional: As an alternative to the worksheet you may prepare target lists for your students. Create one list of plants for each group. List specific plants for students to examine (such as: spinach, basil, pumpkin, tomato), so that the group visits plants at a range of stages and different groups visit different plants.)

Optional: Recruit and train volunteers.

Introducing the Lesson

Activate prior knowledge. Review the life cycle of a plant, from seed to sprout, which grows into a plant that flowers and may produce fruits, which hold more seeds. You may want to show a video clip available online, such as the slide show, *Life Cycle of a Plant*, created by a second-grade class and available at You Tube: http://www.youtube.com/watch?v=J1VnJuL7kT4.

Lesson time: 60 to 90 minutes



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LOOKING FOR LIFE CYCLES

THIRD GRADE

If many of your students were at your school in the previous academic year, you might also ask questions such as these: *Who has visited the school garden in past years? What did you find growing there? Did any of you plant seeds or starts in the garden last year? What do you remember planting? Have you gone back there to see how your plant is growing? Have you eaten anything from your plant?* Guide students to recall or understand that garden planting takes place during several seasons, with questions such as these: *Do all vegetable seeds get planted at the same time? Do they get harvested at the same time? What foods do you know of that people plant in the spring? Where would spring-planted foods be in their life cycle now, in the fall? Do you know of any foods we plant in the fall?*

Engage student interest. Tell students that today they are going to explore the school garden to find plants at different stages of their life cycles.

Procedure

In the classroom

1. *Prepare to visit the garden.* Assign students to teams. Hand each team the Life Cycle Hunt worksheet or your prepared target plant list, along with a clipboard. Make sure all group members have pencils. Review garden rules and how to observe plants without hurting them. (Optional: Assign volunteers to teams.)

In the garden

1. *Explore.* Allow groups time to complete their searches for plants at different stages of the life cycle. Circulate and/or encourage volunteers to help students figure out the names of any plants that may be unlabeled.

2. *Share.* Gather the class together. Have each group take the class to one of the plants the group found, and share their notes about the plant. Give all groups an opportunity to share, and ensure that the class examines a variety of plants, and visits plants at all available stages of the life cycle. As groups share, correct any misunderstandings, and add additional relevant information. For example, when you examine plants that have borne fruits, looks for evidence of plants that have been harvested. Help students find plants that are done with their life cycle, and note the signs, such as browning stems and leaves, that the plant has already finished its job of dispersing seeds to create new plants.

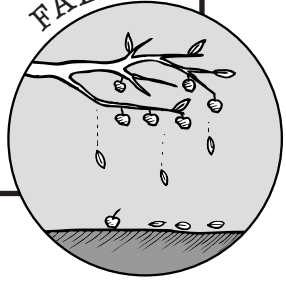
3. *Wrap-up* – Collect groups' worksheets. Return to the classroom and wash hands or clean up as needed.

Assessing Student Knowledge

Informally evaluate students' understanding by observing them as they search the garden, checking their responses on the Garden Exploration worksheets, and by asking questions during sharing time, such the following:

Did you discover anything during your explorations that surprised you?
Which plants seem ready to harvest? How could you tell?
Which plants seem to have been harvested already? What evidence did you find to support that?
When do you think that the immature, sprouting plants you found will be ready to harvest?
How could we, as gardeners, continue the life cycles of these plants into the next growing season?

Lesson time: 60 to 90 minutes



Vocabulary: life cycle

THIRD GRADE

Extensions
Revisit the same plants in the garden at intervals throughout the fall, to observe the continuation of their lives.

Books & Resources

Books:
Explore Life Cycles! by Kathleen M. Reilly, Illustrated by Bryan Stone (2011, Nomad Press) – Offers Projects, Activities, and Experiments

Life Cycle of a ... books These books, from Heinemann-Raintree publishers, include *Life Cycle of a Broad Bean*, *Life Cycle of a Pumpkin,* and *Life Cycle of a Sunflower.*

The Plant Cycle (Nature's Cycles) by Sally Morgan (2009, Powerkids Press)

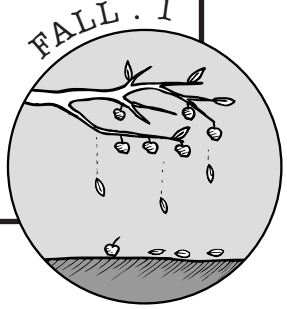
Plant Life Cycles (Nature's Patterns) by Anita Ganeri (2005, Heinemann-Raintree)

Wacky Plant Cycles by Valerie Wyatt, Illustrated by Lilith Jones (2000, Mondo Publishing)

Web Site:
Life Cycle of a Plant, created by a second-grade class and available at YouTube: http://www.youtube.com/watch?v=J1VnJuL7kT4

Lesson time: 60 to 90 minutes

OR. Dept. of Ed. Key Standards
3.1l.1 Compare and contrast the characteristics of offspring and parents.
3.2L.1 Compare and contrast the life cycles of plants and animals.



LIFE CYCLE HUNT WORKSHEET

Name _____ Date _____

THIRD GRADE

Search the school garden with your group. Find at least one example of each of the following. Carefully observe each plant you find, and write your team's notes about the plant here. If you find more than one plant, write about it on the back of these sheets.

1. A young plant that is just sprouting

   Name of the plant: _____

   Where in the garden is it located? _____

   What part(s) of the plant do people eat? _____

   Describe the plant. (Mention it's color, size, shapes of different parts of the plant, how it smells, and anything else you notice about it.)

   _____

   _____

   _____

   _____

2. A mature plant, without flowers or fruits

   Name of the plant: _____

   Where in the garden is it located? _____

   What part(s) of the plant do people eat? _____

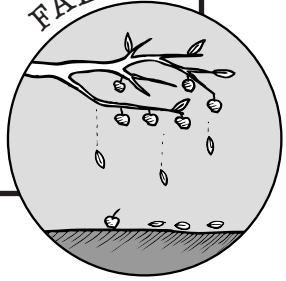
   Describe the plant. (Mention it's color, size, shapes of different parts of the plant, how it smells, and anything else you notice about it.)

   _____

   _____

   _____

   _____



LIFE CYCLE HUNT WORKSHEET

THIRD GRADE

Name _____ Date _____

3. A plant with flowers

Name of the plant: _____

Where in the garden is it located? _____

What part(s) of the plant do people eat? _____

Describe the plant. (Mention it's color, size, shapes of different parts of the plant, how it smells, and anything else you notice about it.)

_____

_____

_____

_____

4. A plant with fruits

Name of the plant: _____

Where in the garden is it located? _____

What part(s) of the plant do people eat? _____

Describe the plant. (Mention it's color, size, shapes of different parts of the plant, how it smells, and anything else you notice about it.)

_____

_____

_____

_____