Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Define fruit and describe its functions.
2. Compare and contrast the basic types of fruits and identify examples of each.
3. Examine fruit development and maturation and identify the parts of a fruit.
4. Describe how seedless fruits are produced.

List of Resources. The following resources may be useful in teaching this lesson:

- Corresponding E-unit(s). Danville, IL: CAERT, Inc. www.mycaert.com

List of Equipment, Tools, Supplies, and Facilities

- Copies of sample test
- Visuals from accompanying masters
- Copies of student lab sheet
- Fruit samples
Terms. The following terms are presented in this lesson (shown in bold italics):

- achene
- aggregate fruits
- berry
- capsule
- caryopsis
- dehiscent fruits
- disseminated
- drupe
- endocarp
- exocarp
- follicle
- fruit
- hesperidium
- indehiscent fruits
- legume
- mesocarp
- multiple fruits
- nut
- nutlet
- parthenocarp
- pepo
- pericarp
- pomes
- pyxis
- samara
- simple fruits
- stenospermocarp
- uricle

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Display a variety of fruits, such as a tomatoes, apples, soybean pods, filberts in a shell, and ears of corn. Ask students what these fruits have in common. They might say that they are food that we eat. Guide the discussion until students recognize that the items are all fruits of plants.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Define fruit and describe its functions.

Anticipated Problem: What is a fruit and what functions does it serve?

I. After fertilization in flowering plants, the ovule develops into a seed. The surrounding ovary wall enlarges and forms a fruit around the seeds. Technically, a fruit is a mature, ripened ovary. The two main functions of fruit are to prevent the seeds from drying and to disperse the seeds. The fruit may be either fleshy or dry.

A. Fleshy fruits, such as tomatoes and apples, hold juices that prevent the seeds from drying until they are mature. Fleshy fruits also serve to help disperse the seeds.

1. For example, some animals are attracted to the nutritious fruit and eat the seeds along with the fleshy fruit.
2. The seeds pass through their digestive tract and are dispersed, or disseminated, away from the parent plant.

3. This dissemination of seed is an important evolutionary trait for the survival of the plant species.

B. Although dry fruits are not fat and juicy like the tomato, they do help prevent the seeds from drying.

1. Dry fruits have other means of dissemination.

2. For instance, the dandelion has evolved a dry, feathery fruit to take advantage of the wind for dissemination.

Many techniques can be used to help students master this objective. Have students read selections from the recommended resource. Have them take notes during their reading and during the ensuing class discussion. Make use of a PowerPoint presentation during classroom discussions.

Objective 2: Compare and contrast the basic types of fruits and identify examples of each.

Anticipated Problem: What are the basic types of fruits?

II. There is a great diversity of fruits. Three major divisions include simple fruits, aggregate fruits, and multiple fruits.

A. Simple fruits develop from a single ovary of a single pistil. Simple fruits are often classified as being fleshy or dry.

1. Fleshy fruit are juicy. Berries, hesperidium, pepo, drupes, and pomes are categories of fleshy fruits.
   a. A berry has an entirely fleshy ovary. Tomatoes, dates, blueberries, bananas, peppers, and cranberries are examples of berries.
   b. Hesperidium have a leathery rind. Examples include oranges, grapefruits, lemons, and limes.
   c. A pepo is a type of fruit defined by hard rind and a fleshy inner matrix. Watermelons, cantaloupe, squash, and pumpkins are pepos.
   d. A drupe is a fruit with a fleshy exterior and a single hard, stony pit surrounding the seed. Cherries, peaches, olives, and plums are examples of plants with drupes.
   e. Pomes have a fleshy exterior and a center with papery carpels. Apples and pears are pomes.

2. Dry fruits may be indehiscent or dehiscent.
   a. Indehiscent fruits are those that do not split open at maturity and are usually one- or two-seeded. Some types of indehiscent fruits are achenes, caryopsis fruit, samaras, nuts, uricles, and nutlets.
      (1) An achene is a single-seeded fruit with seed attached at only one place to the pericarp. Sunflowers and buckwheat are achenes.
Caryopsis fruit is similar to an achene; however, the pericarp sticks or clings to the seed. Corn, rice, barley, rye, amaranth, sorghum, oat, and wheat have caryopsis fruit.

A samara is usually single-seeded with a membranous wing. Examples are maple, elm, and ash.

A nut is hard, one-seeded fruit. Oak, walnut, filbert, and hickory produce nuts.

A uricle is like an achene, but the ovary wall fits loosely around the seed. Examples are finger millet and pigweed.

A nutlet is a small version of a nut. Birch and hornbeam are examples.

b. Dehiscent fruits are fruits that split open upon maturation. Dehiscent fruit types are legumes, follicles, capsules, and pyxis.

A legume (pod) is composed of a single carpel and has two longitudinal sutures. Soybeans, green beans, and peas are legumes.

A follicle is composed of a single carpel and splits open along one suture. Milkweed fruit is a follicle.

A capsule is composed of more than one carpel that are united and form many-seeded fruits. The fruit of okra and cotton are capsules. Plants in the mustard family have a specialized form of capsule called a silique.

A pyxis is a type of capsule with a lid that falls from the fruit. An example is purslane.

B. Aggregate fruits develop from a single flower that has many pistils. Multiple, usually fleshy fruitlets are attached to one receptacle.

1. Raspberries are an aggregate of drupes.
2. Strawberries are an aggregate of achenes.

C. Multiple fruits consist of a number of flowers that fused to form a mass. Pineapples are considered a multiple fruit.

Many techniques can be used to help students master this objective. Discuss the different types of fruits. Use VM–A as a visual aid during the discussion. Bring different types of fruits to class for students to examine. Have students categorize them. Assign LS–A.
Objective 3: Examine fruit development and maturation and identify the parts of a fruit.

Anticipated Problem: How do fruit develop and mature, and what are the parts of a fruit?

III. Many things happen from the time of fertilization to the ripened fruit.

A. To understand how a fruit develops, it is helpful to identify the parts of a fruit. The tissue that surrounds the seeds is called the pericarp, or fruit wall. Three major parts of the pericarp are the exocarp, mesocarp, and endocarp.

1. The exocarp is the outer wall of the fruit. The exocarp, sometimes called the epicarp, forms the tough outer skin of the fruit. It can be thick and tough, as in the case of oranges, or thin and soft, like a grape.

2. The mesocarp is the middle layer of the pericarp. It often makes up the bulk of the fruit and is fleshy.

3. The endocarp is the inner part of the pericarp. It surrounds the seed or seeds. It may be hard like a peach or soft like a grape.

B. The stages of fruit development are dictated by plant hormones.

1. As seeds develop inside the ovary wall, they produce cytokinins that migrate from the seed and promote cell division in the ovary wall. This results in added thickness to the fruit. The seeds follow up by producing gibberellins, which are exported to the wall of the ovary and cause rapid expansion of each of the cells. The combination of more cells and expanding cells leads to tremendous increase in the size of the ovary.

   a. Meanwhile, the plant produces abscisic acid, which causes the embryo in the developing seeds to become dormant. This prevents the seeds from sprouting inside moist, unripened fruit.

   b. Fruits that lack seeds can develop if a solution of gibberellic acid is applied to them. An example is Thompson seedless grapes. Thompson seedless grapes are treated about three times in the growing season with a dilute solution of gibberellic acid.

2. The developing ovules produce cytokinins that cause nutrients to be stored in the endosperm tissues of the developing seeds. In many species, these nutrients are later translocated to the cotyledons.

3. As the ovary wall thickens, the developing seeds begin to produce either gibberellins or auxins, depending on the species. These hormones cause cells to enlarge and the ovary wall to expand. The combination of cytokinins increasing the number of cells and gibberellins increasing the size of those cells leads to spectacular enlargement of the fruit.

4. At about this stage, the enlarged ovary can be called a fruit, and the ovules have become mature seeds. The seeds have a drying seed coat (the former integument of the ovule) and contain a mature embryo. Abscisic acid causes the seed embryos to remain dormant. The seed embryos are prevented from
growing until the seeds have been removed from the fruit or the abscisic acid in the seeds breaks down.

5. Eventually, the fruit reaches full size. However, fruit at this stage tend to be sour (acid), mealy (starchy), green, hard, and lack fruity odor. Fruit needs to ripen before consumption. The ripening process could take a few days after picking or it could depend on an environmental cue.

6. Most species must produce ethylene in order for the fruit to ripen. Ethylene diffuses throughout the fruit tissue and into the atmosphere around the fruit.
   a. An increase in the rate of cellular respiration in the fruit cells and synthesis of new enzymes usually accompanies the ripening process.
   b. Warm temperatures also speed the process.
   c. The ethylene released by one ripening fruit can cause neighboring fruits to also ripen.

7. The manufactured enzymes break down complex cell compounds.
   a. Acidic materials are broken down by an enzyme called kinase, so the fruit is no longer sour.
   b. Amylase converts starches to sugars, and in the process the fruit becomes juicier.
   c. Hydrolases break down chlorophyll and large organic chemicals. With the chlorophyll gone, yellow pigments become visible, and red pigments may develop.
   d. Some of the large organic compounds become smaller molecules that give ripe fruit its odor.
   e. Pectinase depolymerizes pectin, which is the glue that holds cells together. Without it, the fruit becomes soft.

Many techniques can be used to help students master this objective. Lead a class discussion on the parts of a fruit and fruit development and maturation. Use VM–B as a visual aid during the discussion.

Objective 4: Describe how seedless fruits are produced.

Anticipated Problem: How are seedless fruits produced?

IV. Seedless fruits can develop in a number of ways.

A. In a process known as parthenocarpy, fruit may develop without fertilization. Seedless pineapples and cucumbers result when pollination fails to occur.
   1. Pineapples are self-infertile. In other words, pineapples require cross-pollination for seeds to set. Cross-pollination does not occur when a field is planted with just one variety. Many citrus fruits are seedless for the same reason.
   2. Cucumbers may produce seedless fruits if not pollinated. If pollination takes place, they produce seeds.
B. Technically, seedless grapes are not seedless. Normal pollination and fertilization occurs, but the embryos abort when they are young. Often, remnants of the seeds can be seen in the fruit. This process is called **stenospermocarpy**.

C. Bananas and seedless watermelons are seedless because the plants are triploid. Because they have three sets of chromosomes, meiosis fails to take place.
   1. The triploid banana varieties are propagated asexually by removing and planting offshoots.
   2. Watermelons are produced from seeds obtained by crossing diploid plants with tetraploid plants. The seeds from the cross are triploid. The triploid plants grow and produce fruit after being pollinated, but because they are sterile, they fail to produce seeds. Triploid plants must be grown near pollen-producing diploid plants.

   **Many techniques can be used to help students master this objective. Lead a discussion on how seedless fruits are produced. Bring samples of seedless fruits to class for students to inspect and sample.**

- **Review/Summary.** Use the student learning objectives as the basis for review and summary. Have students explain the content associated with each objective. Use their responses in determining which objectives and concepts need to be reviewed or taught from a different angle. The anticipated problems can be used as student review questions.

- **Application.** Use the included visual masters and lab sheet to apply the information presented in the lesson.

- **Evaluation.** Evaluation should be based on student comprehension of the learning objectives. This can occur during instruction, during review, or later as students apply the information. The sample written test can also be used.

- **Answers to Sample Test:**
  
  **Part One: Matching**
  
  1. j
  2. a
  3. f
  4. h
  5. d
  6. c
  7. i
  8. b
  9. e
  10. g
Part Two: Multiple Choice
1. c
2. a
3. c
4. a
5. c

Part Three: Short Answer
♦ Pineapples are self-infertile. In other words, pineapples require cross-pollination for seeds to set. Cross-pollination does not occur when a field is planted with just one variety. Many citrus fruits are seedless for the same reason.
♦ Cucumbers may produce seedless fruits if not pollinated. If pollination takes place, they produce seeds.
♦ Technically, seedless grapes are not seedless. Normal pollination and fertilization occurs, but the embryos abort when they are young. Often, remnants of the seeds can be seen in the fruit.
♦ Bananas and seedless watermelons are seedless because the plants are triploid. Because they have three sets of chromosomes, meiosis fails to take place. Watermelons are produced from seeds obtained by crossing diploid plants with tetraploid plants. The seeds from the cross are triploid. The triploid plants grow and produce fruit after being pollinated, but because they are sterile, they fail to produce seeds. Triploid plants must be grown near pollen-producing diploid plants.
Fruit Function and Anatomy

Part One: Matching

Instructions: Match the term with the correct definition.

a. achene  
f. follicle
b. berry  
g. hesperidium
c. capsule  
h. pomes
d. samara  
i. nut
e. drupe  
j. pepo

1. A type of fruit defined by a hard rind and a fleshy inner matrix
2. One-seeded fruit with seed attached at only one place to the pericarp; examples include sunflowers and buckwheat
3. Composed of a single carpel and splits open along one suture; an example is milkweed
4. Have a fleshy exterior and a center with papery carpels; examples are apples and pears
5. Usually single-seeded with a membranous wing; examples are maple, elm, and ash
6. Composed of more than one carpel that are united and form many-seeded fruits; examples are okra, cotton, and mustard
7. Hard, one-seeded fruit
8. Has an entirely fleshy ovary; examples are tomatoes, dates, bananas, and peppers
9. A fruit with a fleshy exterior and a single hard, stony pit surrounding the seed; examples are cherries, peaches, olives, and plums
10. Have a leathery rind; examples include oranges, grapefruits, lemons, and limes

Part Two: Multiple Choice

Instructions: Write the letter of the correct answer.

1. What type of dry fruit does not split open at maturity and are usually one- or two-seeded?
   a. Dehiscent fruits
   b. Disseminated fruits
   c. Indehiscent fruits
   d. Simple fruits
2. Raspberries and strawberries develop from a single flower that has many pistils and are considered to be _____.
   a. aggregate fruits
   b. dehiscent fruits
   c. multiple fruits
   d. simple fruits

3. Which part of a fruit makes up the bulk of the fruit and is fleshy?
   a. Endocarp
   b. Exocarp
   c. Mesocarp
   d. Pericarp

4. Which type of fruit is composed of a single carpel and has two longitudinal sutures?
   a. Legume
   b. Plumule
   c. Pyxis
   d. Uricle

5. _____ is produced in order for fruit to ripen.
   a. Abscisic acid
   b. Cytokinins
   c. Ethylene
   d. Gibberellins

Part Three: Short Answer

Instructions: Complete the following.

Give examples of the ways in which seedless fruits are produced.
TYPES OF FRUITS

SIMPLE

Fleshy

- Watermelon (pepo)
- Tomato (berry)
- Orange (hesperidium)
- Peach (drupe)

Dry

- Pea (pod)
- Okra (capsule)
- Sunflower (achene)
- Wheat (caryopsis)
- Walnut (nut)

MULTIPLE

- Pineapple
- Mulberry

AGGREGATE

- Raspberry
- Strawberry
Exocarp (skin)

Mesocarp (flesh)

Endocarp (hard pit wall)

Cotyledons of seed
Types of Fruits

Purpose

The purpose of this activity is to categorize common types of fruits.

Objective

Categorize common types of fruits.

Materials

- class notes and/or other reference resources
- lab sheet
- writing utensil

Procedure

Complete the following table using available resources.

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<thead>
<tr>
<th>Common Name</th>
<th>Plant Family</th>
<th>Monocot/Dicot</th>
<th>Type of Fruit</th>
<th>Place of Origin</th>
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