

UNIT 1: Grocery Store Botany

Introduction

In reviewing science texts and California Science Standards, we found plant form and function primarily focused on activities for elementary and middle school students. However, we see high school biology teachers could relate aspects of Grocery Store Botany to learning of ecology and genetics. The plants used for Grocery Store Botany are all flowering plants. As you read through the text you will notice [brackets] indicating a photo of a plant is available on the Resource CD.

Our format is in the form of a dialogue involving questions. Asking good questions is a skill, one that we want to foster in our students. Ask the following questions about a vegetable salad, is this a vegetable salad? What is the difference between a fruit and a vegetable? How do we know that a vegetable is a fruit? Is a tomato a vegetable? Do tomatoes contain seeds? Why did you say yes, or why did you say no? ---- Carrots and potatoes are initially taken from the ground. Are they both roots? ---- Why or why not? When you eat celery, what are you consuming? Are you eating part of a stem? Or a leaf? ---- Are beans a fruit or a seed? ---- What do you eat when you consume an artichoke? These are kinds of questions one may ask to pique student interest and to give them ammunition for discussion in class and at home. Read on for answers to these questions.

What is a plant? One definition is that a plant is a living thing that cannot move voluntarily, lacks sense organs, and usually produces its own food via photosynthesis. However, there are flowering plants that are not photosynthetic and are saprobic (Gr. sapos = rotten), surviving by using organic matter for sustenance. An example is the snow plant (*Sarcodes sanguinea*) (Figure 1).



Figure 1. *Sarcodes sanguinea*.

To exemplify a generalized flowering plant, what parts would you show and label in a drawing or in a photograph? Let's look at a buckeye (*Aesculus californica*) (Figure 2). **Roots** anchor it into the ground. A **shoot** consisting initially of a **primary stem** is above ground. Stems bear leaves. **Leaves** typically consist of a flat **blade** extending from a "stem" portion, the **petiole** (Latin petiolus = little foot, little stalk). When eating celery, one is eating the petiole, particularly when eating the part below the leafy material. Leaves are attached to **nodes** (L. nodus = knot, knob, swelling). In the upper angle between the leaf and stem a **bud** typically occurs. **Buds** are growth zones producing new branches and attendant structures. Approaching maturity, **flowers** are produced from flower buds that may be aggregated into clusters called **inflorescences** (l. infloresco = to begin blooming). From here, we will look at plant parts available in vegetable gardens and the grocery store.



Figure 2. California buckeye root and shoot system.

Roots: Roots are anchoring and absorbing organs. A more detailed study of root structure and function is beyond the scope of this document. We can observe the initial or **primary root** while the plant is still within the seed (Figure 3). Upon germination, the primary root may form a **taproot system** growing downward and producing **lateral** or **axillary roots** as seen with the buckeye (Figure 2). A carrot (*Daucus carota*) [photo] is a good example of a **taproot**. In other cases, a taproot is ephemeral and replaced by numerous secondary roots forming a **fibrous root system** (Figure 4). Grasses exemplify a fibrous root system.

Figure 3. Faba bean root emerging.



Figure 4. Fibrous roots of the annual blue grass (*Poa annua*)



Absorption of water and minerals are fundamental root functions. Here, surface to volume relationships come into play. Consider what often happens when one transplants seedlings? Often new transplants wilt if the roots are damaged and/or it is very hot and dry. Students may sprout bean seeds and observe the fine root hairs showing when germination occurs in protective glassware like a moist Petri dish. Root hairs are the primary absorbers of the root. The amount of surface produced by root hairs and attendant roots is phenomenal and may be an order or more in magnitude greater than that of the aerial portion of a plant. For high school students, a mathematical activity could focus on area to volume relationships, which are important in biology.

The culinary value of roots to humans is due to roots being organs of nutrients. Examples are carrots [photo], beets (*Beta vulgaris*) [photo], and sweet potatoes (*Ipomoea batatas*) [photo]. The storage cells are thin-walled and, therefore, not woody. These thin-walled cells collectively constitute **parenchyma** (Gr. parenchyma = anything poured in beside > para = beside, enchyma = infusion). Virtually, all soft plant tissue is parenchymatous. Parenchyma occurs in both roots and stems.

Shoots: Shoots of flowering plants typically bear buds, stems, leaves, and, when mature, flowers and floral products. A faba bean or horse bean (*Vicia faba*) exemplifies the first apparent leaves, the **cotyledons** (Gr. kotyle = cup-shaped; kotyledon = cup-shaped cavity, hollow) laden with nutrients (Figure 5). The **hypocotyl** (Gr. hypo = below, under, beneath) attaches below the cotyledons and becomes the root. The portion above the cotyledonary attachments is called the **epicotyl** (Gr. epi- = on, upon) from which the aerial portion of the plant will develop.

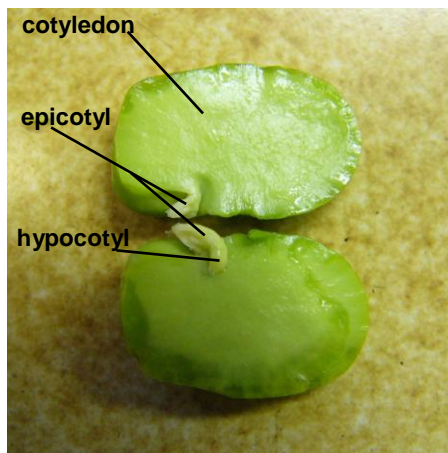


Figure 5. First apparent leaves, cotyledons, in the faba bean.

Stems: The primary functions of stems are for support and conduction of nutrients. The latter function involves conduction up and down stems, respectively, to and from leaves to other locations. Like in roots, conducting systems consist of vascular tissues, **xylem** (Gr. xyle = xylon = wood) and **phloem** (Gr. phloios = bark of tree). Xylem is the major supportive tissue in woody plants. Xylem's other major function is in moving water and minerals from the soil to the leaves. Phloem's major conductive function is in moving manufactured materials like sugars to the leaves where they are needed or stored.

A secondary function of some stems is food storage. A most useful storage stem for humanity is the potato. Let's examine some different kinds of stems, including some common stems that contribute to part of our cuisine.

Rhizomes (Gr. rhiza = rhizoma = root): Rhizomes are underground stems. However, etymologically, the term rhizome infers a root, but botanically, a rhizome is a stem. What is going on? In this case a stem is behaving like a root, by being subterranean. Why do botanists say rhizomes are stems? ---- Do roots have buds or leaves? ---- If a subterranean element has either buds or leaves then it is a stem. Can you think of a

rhizome that adds spice to our cooking? ---- An example is ginger (*Zingiber officinale*) [photo]. Its fleshy rhizomes bear thin scale-like leaves when removed from the ground. Ginger prepared for the grocery store usually has had its scaly leaves removed. The leaf scars are somewhat ring-like and indicate the position of nodes. As is typical of nodes, a bud occurs in the leaf axil. The internodes are very short.



Figure 6. Rhizome of ginger (*Zingiber officinale*) with leaf scars that look ring-like.

Tubers (L. tuber = tumor, knob, hump): Is the potato (*Solanum tuberosum*) [photo] a modification of a stem or swollen rhizome? Recall that stems bear nodes where buds occur. What is an “eye” of a potato? ---- The “eye” is a lateral bud, an attribute of stems. Is the typical potato collected on the ground’s surface or do we dig for it? ---- We dig for ours. Potatoes are often grown from pieces of tuber bearing an “eye” that produces a new plant. These tubers harvested from underground are propagated from tuber cuttings and, therefore, arise from rhizomes, underground stems. The Irish potato or white potato is grown from seed and produces tubers at the tips of **stolons**, stems growing along the surface of the ground as opposed to underground.

Plants, collectively, can reproduce both sexually and asexually. The advantage of asexual reproduction for agriculture means plants can reproduce by cloning, advantageous for uniform crops and production, but can lead to disasters if the plants are exposed to disease or pests.

A major historical event, the Potato Famine of Ireland, involved a tuber. However, this tuber originated in South America. The Spanish learned about the potato from indigenous groups living in the Andes Mountains. The Spanish brought it back to Europe where it was warmly received and became a major staple, particularly in Ireland. When the plant was exposed to disease, the staple crop began to die, devastating the Irish people.

Stolons (L. stolo = shoot or branch, stolonis = of a branch): Stolons also called runners are stems growing along the surface of the ground. Good examples of stoloniferous plants are strawberries (*Fragaria* spp.) [photo].

Bulbs (L. bulbus = bulb): While preparing a meal, one may slice a plant that can drive you to tears. What comes to mind? ---- The humble onion (*Allium cepa*) [photo] may be

your example. The globose onion we see in the grocery store is a bulb. Bulbs are shortened stems bearing overlapping leaves modified for food storage. We eat the modified leaves. A longitudinal section best shows the overlapping leaves on a short stem bearing basal secondary or adventitious roots (L. *adventicus* = coming from abroad: in botany, said of structures in unusual - but not necessarily so unusual - places).

Garlic, *Allium sativum*, produces a different form of bulb. Distinct from the onion, the buds are greatly enlarged and are cloves enclosed by leaf sheafs [photo].

Corms (Gr. *kormos* = stump): If a plant does not store food in its leaves, then where is the food stored? ---- We are then left with either a stem or a root. If you were to consume the base of a gladiolus (*Gladiolus grandiflorus*) then you would consume a corm. A corm is a shortened expanded stem storing nutrients. In language arts, what is a gladiator? ---- What structure did a gladiator brandish? The scientific name of the sword fish is *Xiphias gladius*. ---- Consider giving all these terms to your class (if they are mature enough) as an assignment, including the term brandish.

What is a leaf? A leaf is a major synthetic organ of higher plants [photo]. Water and minerals absorbed by the roots are transported to leaves via the xylem of stems. Carbon dioxide is absorbed from the atmosphere and photosynthesis yields sugar. Leaves collectively vary in form. A typical leaf is divisible into a distal blade and a basal petiole. The terminology applicable to leaf form is diverse. Leaves are exit areas for transpiration of water into the atmosphere and desiccation is a concern for many plants. 'Bioengineering' of leaf architecture is critical to prevent water loss. Water loss is a function of leaf surface and shape. Area to volume relationships occur as in roots. Comparing the needle, leaf of a pine, with that of a typical flat blade leaf form is a means of infusing some mathematics into a botany activity.

What is a flower? A flower is a highly modified stem serving sexual reproduction. A generalized flower is borne on a basal stalk the **pedicel**. A lower whorl of green leaf-like structures, the **sepals** attach to the pedicel. Collectively, the sepals constitute the **calyx**. Next comes a whorl of **petals**, collectively forming the **corolla**. Next comes a ring of **stamens** each consisting of a basal **filament** and two terminal **anthers** producing **pollen**. Lastly, we find the **pistil** consisting of basal **ovary**, medial **style**, and terminal **stigma**. Pollen from the anthers must be transported to the stigma of the same kind of flower for pollination. Pollination results in fertilization of an egg cell in an immature seed, an **ovule** (L. *ovum* = egg; *ovulum* = small egg). The fertilized egg or **zygote** is the initial stage of the next generation producing flowers (See Unit 2 for more details on seeds and fruits).

What is a fruit? Botanically, a fruit is a mature ovary or a seed container. There are many different kinds of fruits. Examples often used are peaches (*Prunus persica*) [photo], bananas (*Musa* spp.) [photo], mangoes (*Mangifera indica*), etc. Some plants we consume contain seeds and are called vegetables, e.g., a tomato. What is a tomato? ---- Based on a botanical definition it is a fruit. What do you place in your mouth when you eat a sunflower "seed"? What are some examples of nuts? ---- You might think of the walnut (*Juglans regia*) [photo], pistachio nut (*Pistacia vera*) [photo], or almond (*Prunus dulcis*) [photo]. Could they be considered fruits? What about other types of "seeds"? What are we eating when we eat a peanut or ground nut (*Arachis hypogaea*)? Why are peanuts also called ground nuts? ---- Because peanut plants bury their fruits in the

ground. Fruits offer a fun opportunity to taste and explore different flavors (See Unit 2 for more details on seeds and fruits).

What is a seed? A seed is defined as a matured ovule. The etymology of the term ovule indicates that an ovule is a small egg (L. ovum = egg; ovulum = small egg). An ovule (or ovules) develops from the placenta (See Unit 2 for more details on seeds and fruits).

Activities in this unit include: Exploring Plant Parts with Grocery Store Plants, Language Arts and Grocery Store Botany, Geographic Origins of Plants and Twelve Important Food Plants, Wild Versus Cultivated Plants: Avocado and a Cousin, the California Laurel or Pepperwood, and Using the Sunflower Family (Asteraceae) for Integrating Life Sciences and Mathematics.