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Botany Defined

What is botany?
The Merriam-Webster dictionary defines botany as “a branch of biology dealing with plant life”.

The Botanical Society of America defines botany as “the scientific study of plants”.

What do botanists do?
The field is very broad (there are so many aspects of plants to study) and scientists in botany focus on either specific plant groups or plant processes. Some botanists work in labs on cellular research while others work outdoors creating inventories and conducting very large scale investigations. Plant biology specialties include anatomy, biochemistry, phytochemistry, biophysics, cytology, ecology, genetics, molecular biology, morphology, paleobotany, physiology, systematics, systems ecology and taxonomy (Botanical Society of America, 2011).

Applied Plant Sciences:
Agriculture—the science, art, or practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products (Merriam-Webster, 2011)

Agronomy—crop and soil sciences. Agronomists make practical use of plant and soil sciences to increase the yield of field crops.

Biotechnology—using biological organisms to produce useful products. Plant biotechnology involves inserting desirable genes into plants and having those genes expressed.

Breeding—development of better types of plants. Breeding involves selecting and crossing plants with desirable traits such as disease resistance.

Economic Botany—plants with commercial importance. Economic botany includes the study of harmful and beneficial plants and plant products.

Forestry—forest management for the production of timber, and conservation.

Horticulture—the production of ornamental plants and fruit and vegetable crops. Landscape design is also an important subdiscipline in horticulture.

Plant Pathology—diseases of plants. Plant pathologists are concerned with both the biological aspects of disease and with disease management, or control.
Plant Systematics
(Systematics is the study of the evolutionary history and relationships among plants)

The Plant Kingdom (adapted from: The Usborne Internet-Linked Library of Science World of Plants)

Plants are arranged in large groups called divisions. The plant kingdom has two main divisions: plants which contain fluid-carrying vascular tissues, and plants which do not. These divisions then break down into smaller categories, based mainly on the plant’s reproductive structures.

Vascular plants

Vascular plants are divided into two categories: those which produce seeds, and those which do not. Plants which produce seeds can be divided into two further groups. The gymnosperms and the angiosperms.

In gymnosperms, the seeds are not contained within a fruit. There are four types of gymnosperms.

Conifers are usually tree-sized plants, with waxy needle-like or scaly leaves. They produce cones, which contain their seeds.

Cycads produce very large cones. These grow in the middle of a circle of spiky leaves.

Ginkgoes are direct relatives of ancient seed-carrying plants. They produce fleshy cones and have soft, fan-shaped leaves.

Gnetae are a small group of plants that grow in very hot areas. They mostly have tough, leathery leaves.

Angiosperm is the name given to the many thousands of different flowering plants. They all produce seeds which are enclosed within a fruit of some kind. Flowering plants can be divided into two further groups: monocotyledons and dicotyledons.

Monocotyledons have one cotyledon (simple first leaf). Their vascular bundles are scattered throughout the stem.

Dicotyledons have two cotyledons. Their vascular bundles are arranged in a regular pattern inside the stem.

Seedless vascular plants have a simple structure, and do not produce flowers. They reproduce using spores.

Horselails produce spores inside cones. Their leaves are arranged in rings around the stem.

Ferns reproduce either by producing rhizomes or by making spores. These are produced on the underside of the fern’s leafy fronds.

Club mosses are related to ferns. Their spores are carried in tight, club-shaped spirals at the end of their stalks.

Non-Vascular Plants

Plants without vascular tissue, such as mosses and liverworts, are known as bryophytes. They are usually small, with single-celled root-like structures, and simple leaves. They have no flowers and therefore reproduce using spores. Most live in damp, shady places.

Mosses on a rock

Liverwort

Summary of divisions in the plant kingdom

All plants

Non-vascular plants

Vascular plants

Plants without seeds

Plants with seeds

Gymnosperms

Angiosperms

Conifers

Ginkgoes

Gnetae

Monocotyledons

Dicotyledons

FAIRCHILD TROPICAL BOTANIC GARDEN
Plant Taxonomy - scientific names

(Taxonomy is the study of identifying, naming and classifying plants)

**Individual**
- Theobroma cacao L.
- Quercus virginiana Mill.
- Cacao
- Live Oak

**Classification**
- Kingdom: Plantae (plants)
- Division (Phylum): Trachyophyta (vascular plants)
- Class: Angiospermae (flowering plants)
- Order: Malvales
- Family: Malavaceae (hibiscus family)
- Genus (pl. genera): Theobroma
- Species: cacao
- Authority: L. (Linnaeus)

- Kingdom: Plantae
- Division (Phylum): Magnoliophyta
- Class: Magnoliopsida
- Order: Fagales
- Family: Fagaceae
- Genus: Quercus
- Species: virginiana
- Authority: Mill.

*Just remember: King David Came Over For Good Soup*

**Other terms**
- Subspecies: subsp.
- Variety: var.
- Cultivar (cultivated variety):
  - cv “Malay dwarf” or “big boy”

**Hybrids**
- Species hybrid:
  - Cattleya skinneri X guatemalensis
- Variety hybrid:
  - Maypan (Malay dwarf X Panama tall)
The purpose of the Latin or botanical name of a plant is to provide some information that distinguishes it from other plants. The specific epithet applied to the plant is often helpful in describing the plant. The specific epithet can tell us the color of the flowers, the height of the plant, whether the leaves are long and thin or short and fat, whether the plant is prickly, where it comes from (which might give us a clue as to how hardy it is), what sort of conditions it occurs in naturally, whether it's a climber or creeping, whether it's deciduous, has a bulb, is edible - or whatever else the person who found it thought most remarkable, noteworthy and unique about it. Like many other languages, Latin assigns genders to all its nouns and adjectives have to agree with the gender of the noun they describe. In plant names, therefore, those that are deemed masculine will end in -us, those that are feminine will end in -a, and those that are neutral will end in -um (plus some odd ones with other endings). To simplify things, only the feminine endings have been used here, but if you come across a plant with much the same name, but ending in -us or -um, the meaning is similar.

These are some of the specific epithets often applied to plants we grow in our gardens, specific epithets are always written in Latin.

alba = white
alpina = from the alps
altissima = tallest
america = from America
arctica = from the arctic
argentea = silvery
aurea = golden, yellow
azurea = blue
borealis = from the north
caurulea = blue
campanulata = campanulate, like a bell
canadensis = from Canada
chilensis = from Chile
chinensis = from China
coccinea = red
densiflora = dense-flowered
flava = yellow
foetida = with an unpleasant smell
gigantea = giant

Notes:

glabra = smooth
grandiflora = large-flowered
integri folia = entire, undivided (leaves)
japonica = from Japan
lanceolata = lance-shaped (leaves)
macrophylla = with large leaves
mexicana = from Mexico
microphylla = with small leaves
officinalis = with herbal uses
pendula = hanging
quercifolia = oak-leaved
rotundifolia = round-leaved
rubra = red
sativa = cultivated
semperviva = perennial
stellata = starry
sylvestris = of woods
tomentosa = tomentose, woolly
trifoliata = trifoliate, with three-lobed leaves
**Plant Taxonomy - plant labels**

**Laminated label**
- **Common name**: Live Oak
- **Family**: Fagaceae
- **Botanical name**: Quercus virginiana
- **Native range**: S.E. United States

**Metal “credit card” label**
- **Accession number**: 2002-0438 E
- **Family**: ARECACEAE
- **Common name**: HETEROSPATHE ELATA
- **Native range**: MALASIAN
- **Botanical name**: Sagisi palm

2002 means this plant was acquired in 2002
0438 means it was the 438th plant to be acquired in 2002
E means that this individual was the 5th plant of that group
Plant Morphology - vocabulary

(Plant morphology is the study of macroscopic plant forms such as leaves, roots and stems)

**Shoot System**
- Stem: Node
- Internode

**Buds:**
- Apical Bud
  - Apical meristem (growing point)
  - Axillary Bud (lateral bud)

**Leaf:**
- Blade
- Petiole
- Stipule

**Simple Leaf**
**Compound Leaf:** Pinnate or Palmate

**Leaf arrangement (at each node):**
- Alternate
- Opposite
- Whorled

**Root System**
- Primary root or tap root
- Lateral (branch) root
- Adventitious root

**Vascular Tissues**
- Xylem (wood): water movement
- Phloem (inner bark): food movement
- Cork (outer bark)

**Plant Growth**
- Embryo
- Germination
- Seedling
- Primary growth (elongation)
- Secondary growth (thickening):
  - Vascular cambium (wood & bark)
  - Cork cambium (cork)

Notes:
Plant Morphology - leaves, stems, roots

- shoot tip (terminal bud)
- epidermis
- bud
- node
- vascular tissues
- ground tissues
- flower
- young leaf
- withered cotyledon
- seeds (inside fruit)
- root
- lateral root
- root hairs
- root tip
- root cap

Courtesy of University of Illinois at Chicago
Leaf Classification

Though it is easier to identify most plants from their flowers or fruits, some plants can easily be identified by their leaves. To identify a plant based on its leaves, you must recognize the diversity of leaf types and know the terminology for different leaf patterns, shapes and arrangements.

**Simple leaf pattern**

Simple leaves are whole, undivided leaves growing from a bud on the stem. The node is the place on the stem where the leaves are attached. You will always find a bud at a node, which is the growing point.

**Compound leaf patterns**

Compound leaves are divided into leaflets, growing from one axillary bud on the stem.

### ONCE COMPOUND LEAVES

- **Pinnately compound**
  - bud
  - petiole
  - stem

- **Palmately compound**
  - bud
  - petiole
  - stem
Leaf Classification continued

Compound leaf pattern continued...

**TWICE COMPOUND LEAF**

- leaflet
- rachis
- stem
- bud
- petiole

Basic leaf shapes

- linear
- oval
- oblong
- ovate
- obovate
- deltoid
- cordate
- elliptical
- lanceolate
Leaf Classification continued

Leaf arrangement
Nodes can have one leaf or many leaves, often in the following arrangements:

- **alternate** (one leaf per node)
- **opposite** (two leaves per node)
- **whorled** (three or more leaves/node)

Leaf Margins

- Entire
- Undulate
- Serrate
- Doubly Serrate
- Dentate
- Crenate
- Lobed (Pinnately)
- Parted (Pinnately)
- Lobed (Palmately)

Courtesy of Fairchild Tropical Botanic Garden

Courtesy of Scarborough School Department

Courtesy of University of Minnesota
The vascular system in plants is similar to our circulatory system. Just as we depend on our circulatory system to deliver nutrients and oxygen to our cells, plants rely on their vascular system to deliver water and nutrients to their cells. A plant’s vascular system is comprised of two main types of vascular tissue:

1. **Xylem** – Xylem conducts water and dissolved minerals absorbed from the soil through the plant. Xylem tissue is made up of vessels that are connected end to end to move water around quickly. Xylem also has a secondary function of support.

2. **Phloem** – Nutrients produced in the leaves during photosynthesis are transported by the phloem and distributed in the plant in sieve tubes. The cells are arranged in columns and connected by sieve plates, which are cell walls with tiny holes.

Xylem and phloem are often arranged in **vascular bundles**, surrounded by tissue called **cortex**. The phloem and xylem are divided by the cambium, narrow-walled cells which generate more phloem and xylem cells through mitosis.

![Diagram of the vascular system](image-url)
Plant Anatomy

(Plant anatomy is the study of microscopic plant structures such as cells and tissues)

Location of vascular tissue

Dicotyledons: In young dicots, the vascular system is arranged in bundles and has a regular pattern. In older plants, the bundles join and build the vascular cylinder. The surrounding tissue is called cortex.

Monocotyledons: In monocots, the vascular system is more random.

Cross section of a dicot stem

Cross section of a dicot root

Courtesy of University of New Mexico
Plant Anatomy - secondary growth

While stems and roots thicken with new secondary xylem and secondary phloem the plant becomes woody.

**Secondary growth:** New fluid-carrying tissues are formed on the inside of the vascular cylinder while additional protective tissue is generated on the outside.

**Secondary tissue:** During the production of secondary tissue, the cambium forms a cylinder and starts to produce more xylem and phloem through mitosis.

Notes:

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[Image of plant anatomy diagram]

Courtesy of Wikipedia
Plant Anatomy - secondary growth cont.

**Annual rings:** In the spring, growth spurs and produces “soft” wood with wide cells called **spring wood** while hard, dense **summer wood** is produced in summer and towards the end of the growing season.

**Bark:** The bark is built by the cork cambium which is dividing constantly. When the cells are pushed outward by newly generated cells, they die off and form the bark. Bark cannot stretch; instead it rips and gives each tree species its unique appearance.

Notes:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Even though leaves are very thin to the naked eye, a cross section of a leaf under a microscope reveals several cell layers. The top most layer of a leaf is called the **upper epidermis**. This protects the leaf and may be covered by a waxy cuticle.

The next layer is the **palisade mesophyll**, which is a layer of closely packed cells that are rich in chloroplasts and are the primary site of photosynthesis in the leaf. The third layer is the **spongy mesophyll**, a layer of loosely packed photosynthetic cells.

On the lower epidermis are openings in the leaf called **stomata**, which are controlled by “doors” called **guard cells**. Stomata permit the exchange of moisture and gases between the leaf and atmosphere.

---

**Plant Anatomy - internal leaf structure**

![Diagram of leaf structure](image)

**Stomate**

**Guard Cell**

**Palisade mesophyll**

**Epidermis**

**Spongy mesophyll**

**Vascular tissue (xylem/phloem)**

*Courtesy of Usborne Publishing Ltd.*
Plant Cytology

(Plant cytology is the study of plant cells-their structure, function and life history)

Plant cells differ in several ways from animal cells, but the most obvious difference is the presence of a cell wall, which animal cells lack. This wall helps in maintaining the structure of the plant.

The chloroplasts within the cell are the site of photosynthesis.

The large vacuole performs several functions, one of which is to maintain turgor pressure so the cell doesn’t collapse.
Plant Physiology - photosynthesis

(Plant physiology is the study of the functions and vital processes of plants)

**Photosynthesis**

Photosynthesis is the process that converts solar energy to chemical forms of energy that can be used by biological systems.

**Photosynthesis** is directly or indirectly the source of all of our food and is responsible for establishing and maintaining the oxygen content of our environment.

\[
\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{O}_2 + \text{C}_6\text{H}_{12}\text{O}_6
\]

**The Basics**

Leaves are nature’s food factories. Carbon dioxide from the air is taken in through the stomata of the leaves, and the roots absorb water from the soil. The carbon dioxide and water are combined using solar energy. This process produces glucose, a simple sugar. Plants use most of this food (glucose) to produce energy for growth. The food that is not needed right away is stored in the cells as starch.

**Step 1**: Solar energy is absorbed by pigments (primarily chlorophylls and carotenoids), found in the leaves of plants. Solar energy is converted into chemical energy that the plant can use.

**Step 2**: The chemical energy is used to assemble sugars like glucose (C$_6$H$_{12}$O$_6$). Glucose and other sugars are linked into sucrose, starch and other carbohydrates. These are transported from the leaf to other parts of the plant for immediate use or storage.

**Pigments are colorful compounds**

Pigments are chemical compounds that have the ability to absorb certain wavelengths of visible light. The wavelengths of light that they cannot absorb either pass through or are reflected. Wavelengths that are reflected appear “colorful.” Flowers, corals and even animal skins contain pigments that give them unique colors.

Chlorophylls are pigments found in the chloroplasts of the leaves. Chlorophylls absorb blue and red light, but reflect green and yellow light; therefore the plants appear green.

Carotenoids (which absorb blue-green light) cannot transfer sunlight energy directly to the photosynthetic pathway, but must pass their absorbed energy to chlorophyll. For this reason, they are called accessory pigments.
Plant Physiology - photosynthesis cont.

Since each pigment reacts with only a narrow range of the light spectrum, plants produce several kinds of pigments, each absorbing a different color, to capture more of the sun’s energy.

Photosynthesis and respiration
A the majority of photosynthetic productivity occurs in open oceans, mostly by oxygenic prokaryotes. Without photosynthesis, the oxygen in the atmosphere would be depleted within several thousand years. It should be emphasized that plants respire just like any other higher organism, during the day this respiration is masked by a higher rate of photosynthesis.

Virtually all oxygen in the atmosphere is generated through the process of photosynthesis. Obviously, all respiring organisms (including plants) utilize this oxygen and produce CO₂. Thus, photosynthesis and respiration are interlinked, with each process depending on the products of the other.

Respiration
Respiration is the process by which sugars are broken down to release carbon dioxide, water and energy. Oxygen is consumed in this reaction and the overall process can be summarized as:

\[
\text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{ENERGY}
\]

In terms of gas exchange, respiration and photosynthesis have opposite effects.

Under favorable conditions, the overall rate of photosynthesis greatly exceeds the rate of respiration, therefore more carbon dioxide is consumed than released, and more oxygen is produced than consumed.

Notes:
Plant Physiology - photosynthesis cont.

LEAF CROSS SECTION

Mesophyll cell

Chloroplast

Stomata

CO₂

O₂

Vein

Mesophyll

1 μm

5 μm

CHLOROPLAST

Intermembrane space

Granum

Stroma

Thylakoid

Thylakoid space

Outer membrane

Inner membrane

©1989 Addison-Wesley Longman, Inc.

LIGHT REACTIONS

H₂O

Light

NADP⁺

ADP + Pᵢ

CALVIN CYCLE

CO₂

[CH₂O]

(sugar)

O₂

ATP

NADPH

Courtesy of Indiana University-Purdue University Indianapolis
Plant Ecology - defensive adaptations

(Plant ecology is the study of the relationships between plants and the environment)

Why do plants grow in a certain environment? Because they can! Each plant’s survival depends upon its ability to adapt to certain conditions.

1. **Thorns** (ex. Bougainvillea)- Modified short branches grown from axillary buds.

2. **Spines** (many cacti)- Modified leaves or parts of leaves, some are remnants of rigid petioles and midribs. When a plant (like a cactus) is covered in spines, photosynthesis occurs in the stem. Masses of spines reflect excessive sunlight.

3. **Stipules**- An adaptation from accessory leaf parts, located in pairs at the base of the petiole.

4. **Prickles** (ex. Roses)- Short, woody outgrowths arising from the epidermal tissue of stems, leaves and some species of fruit, arranged in irregular patterns within the internodes. Many are recurved with tips that point downward for protection and climbing support.

5. **Matted epidermal hairs**- Hairs on leaves or the stem provide protection against small herbivores like caterpillars, making the plant difficult to chew. Hair can also protect plants from sunlight and water loss.

6. **Epiphytes** (ex. Orchids & Bromeliads)- Plants that grow on other plants, without soil. These plants collect moisture and nutrients from the air and surrounding debris.

7. **Pigmentation**- Some plants use pigments to capture the attention of pollinators or to absorb different wavelengths of light after it has passed through green leaves.

Notes:
Plant Ecology - leaf, stem and root adaptations

Leaves are the main site of photosynthesis – the production of carbohydrates using energy from sunlight. Photosynthetic leaves are usually thin, have a large surface area, and are arranged and angled on the plant for maximum light absorption. However, they can be adapted for other purposes including food and water storage, support and defence.

- **Food storage**
  - Bulb
  - Onion (Allium cepa)
  - A very short stem axis with thick fleshy scale leaves.

- **Defence / water loss**
  - Spine
  - Opuntia inermis
  - Each leaf has become a woody and non-photosynthetic spine. The small surface area of the spine reduces water loss and protects the plant from herbivores.

- **Attraction**
  - Floral bracts
  - Bauhinia variegata
  - Leaves play the role of petals in attracting pollinators.

- **Carnivorous**
  - Venus fly trap (Dionaea muscipula)
  - Leaves are modified to form an insect trap.

Stems tend to be above ground, erect and self-supporting. They usually end in a bud and bear leaves, lateral buds and reproductive organs. Lateral branches arise in the axils of leaves (the angle between leaf and stem). There are many variations on ‘normal’ stems. They may be underground, prostrate, or serve as storage, reproductive or support organs.

- **Photosynthetic**
  - Phylloclade or cladode
  - Butcher's broom (Ruscus aculeatus)
  - Buds
  - Stem structure that looks and acts as a leaf.

- **Storage**
  - Rhizome
  - Ginger (Zingiber officinale)
  - Underground stem that grows horizontally below soil surface. Generally thick, fleshy or woody.

- **Storage**
  - Corm
  - Crocus (Crocus species)
  - A short, swollen (vertical) stem of several nodes and internodes. Develops at or below ground.

- **Climbing/support**
  - Tendril
  - Grape vine (Vitis species)
  - Deciding whether a tendril is a modified stem or leaf can be difficult. Its position and presence/absence of reduced scale leaves give clues.

Roots tend to grow downwards, away from light and towards water. As a general rule, they bear neither leaves nor buds. Their primary roles are anchorage, absorption and transport. However, roots have adapted to fulfil a variety of other functions including storage, support and aeration.

- **Absorption**
  - Aerial roots
  - Epiphytic orchid (Dendrobium species)
  - Epiphytic plants grow on other trees using them for support. Their aerial roots rarely reach the soil so absorb water from rain or mist.

- **Aeration**
  - Pneumatophores
  - Mangrove (Sonneratia species)
  - Air-breathing roots have internal air spaces connecting with the submerged roots.

- **Attachment**
  - Ivy (Hedera helix)
  - Adventitious attachment roots grow from aerial stems, on the side in contact with a surface.

- **Support**
  - Prop roots
  - Malize (Zeaglay species)
  - Aerial roots grow down from the stem into the soil.

Courtesy of Royal Botanic Gardens, Kew
**Plant Morphology - flowers**

**Flower Vocabulary**

**Bud** - An underdeveloped flower.

**Sepals** - Small leaf-like structures that surround and protect developing flower buds. The sepals together make up the **calyx**.

**Petals** - Usually delicate and often brightly colored structures that surround the plant’s reproductive parts and attract pollinators. The petals together make up the **corolla**. If the petals and sepals are indistinguishable, they are called **tepals**. Monocots such as lilies have tepals.

**Nectar** - A sweet, sticky liquid that attracts pollinators such as insects or other animals.

**Pistil** - Female reproductive organ. This includes:
- **Stigma** - where pollen is deposited. Often sticky or feathery.
- **Style** - an elongated tube that the pollen moves through to reach the ovary.
- **Ovary** - where the ovules are produced, the site of seed development.

**Stamen** - Male reproductive organ. This includes:
- **Anther** - a sac-like structure at the apex where the pollen is formed.
- **Filament** - the stalk which supports the anther.

**Receptacle** - The end of the flower stem (or pedicel) where the flower parts are attached.
Plant Cytology - meiosis and mitosis

**MEIOSIS**
- Synapsis and crossing over occur
- Homologues align independently
- Homologues separate
- Daughter cells form
- Daughter nuclei are not genetically identical to parent cell

**MITOSIS**
- Chromosomes align at the metaphase plate
- Daughter chromosomes separate
- Daughter cells form
- Daughter nuclei are genetically identical to parent cell

Courtesy of TutorVista.com
Pollination & Fertilization

Courtesy of Science Kids
Plant Ecology - pollination syndromes

Most flowers need to receive pollen from a different flower to achieve successful fertilization. Since plants can’t just march over to one another and exchange pollen, they have evolved ways to attract pollinators to do the work for them. Pollinators have preferences, each being attracted to flowers with different characteristics.

<table>
<thead>
<tr>
<th>Pollinator</th>
<th>Flower depth/shape</th>
<th>Flower color</th>
<th>Flower scent</th>
<th>Time of floral opening</th>
<th>Reward</th>
<th>Examples:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird</td>
<td>Deep, wide tube</td>
<td>Bright red</td>
<td>None (Birds can’t smell!)</td>
<td>Day and night</td>
<td>Nectar</td>
<td></td>
</tr>
<tr>
<td>Bee</td>
<td>No depth or very shallow</td>
<td>Yellow, blue or purple</td>
<td>Fresh, sweet</td>
<td>Day and night</td>
<td>Nectar and/or pollen</td>
<td></td>
</tr>
<tr>
<td>Butterfly</td>
<td>Deep, narrow tube</td>
<td>Red, yellow or blue</td>
<td>Fresh, sweet</td>
<td>Day and night</td>
<td>Nectar</td>
<td></td>
</tr>
<tr>
<td>Moth</td>
<td>Deep, narrow tube</td>
<td>White or pale green</td>
<td>Strong, sweet</td>
<td>Night</td>
<td>Nectar</td>
<td></td>
</tr>
<tr>
<td>Fly</td>
<td>No depth, flat</td>
<td>Maroon or brown</td>
<td>Decaying flesh</td>
<td>Day and Night</td>
<td>Nothing (Flies are duped!)</td>
<td></td>
</tr>
<tr>
<td>Beetle</td>
<td>Flat to bowl shaped</td>
<td>Brown, purple or dull</td>
<td>Strong, fruity</td>
<td>Day and Night</td>
<td>Edible flower parts</td>
<td></td>
</tr>
<tr>
<td>Bat</td>
<td>Brush like or bowl shaped</td>
<td>Dull white or green</td>
<td>Strong, fermented, fruity</td>
<td>Night</td>
<td>Nectar</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>No depth or very little, reduced in size</td>
<td>Pale green or pale yellow</td>
<td>No smell</td>
<td>Day and night</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

The pollinators listed above are the most common groups of pollinators, however there are some flowers that are pollinated by other animals, for example rodents, small reptiles, ants and primates are known to pollinate flowers.

It is important to realize that often there are exceptions to these general syndromes. For instance, some bird pollinated flowers are not red. These general pollination syndromes hold true for a great number of flowers. Also, there are some flowers that scientists consider to be “generalists”, meaning they attract many different pollinators and are not clearly trying to attract just one type.
Fruit Types

Botanically, a fruit is the ripened ovary of a seed plant (Merriam-Webster, 2011).

A vegetable does not contain seeds and does not result from sexual reproduction. Vegetables include carrots, onions, potatoes and lettuce to name a few.

I. Simple Fruits: A single ripened ovary from a single flower.
   A. Fleshy fruits:
      berry (tomato)
      pepo (pumpkin)
      hesperidium (orange)
      drupe (mango)
      pome (apple)
   B. Dry fruits:
      1. Dehiscent dry fruits:
         legume (wisteria)
         siliqua (cabbage)
         capsule (kapok)
         follicle (oleander)
      2. Indehiscent dry fruits:
         achene (sunflower)
         anthocarp (four o’clock)
         caryopsis (wheat)
         schizocarp (carrot)
         samara (maple)
         nut (oak)
         utricle (duckweed)

II. Aggregate fruits: A cluster or aggregation of many ripened ovaries produced from a single flower.
   (Ex: raspberries)

III. Multiple fruits: A cluster of many ripened ovaries produced by the coalescence of many flowers crowded together in the same inflorescence, typically surrounding a fleshy stem axis.
   (Ex: pineapple)

Plants produce different types of fruits, all with the same goal: to disperse their seeds and ensure successful germination for the next generation.

Plants depend on wind, water, and/or animals to help disperse their seeds.

For more information on fruit types visit:
http://waynesword.palomar.edu/fruitid1.htm

Notes:
Fruit Types Continued

Simple Fleshy Fruit - Drupe

Drupe is a type of fruit that consists of a fleshy or soft exocarp, a fleshy mesocarp, and a stony endocarp. Examples include plums, peaches, coconuts, cherries.

Aggregate Fruit

Aggregate Fruit develop from a single flower with many separate carpels, thus each produces a single fruit. As the individual fruits grow, they fuse together forming a single structure. Examples include strawberries and blackberries.

Numerous Female Flowers: Each composed of an individual monocarpous pistil (gynoeicum).

Multiple Fruit (Many Drupelets): Each seed-bearing drupelet from the ovary of one pistillate flower.

Multiple Fruit of the Black Mulberry (Morus nigra)
Plants get around! Before a plant establishes itself, it can travel far distances. Over time, plants have evolved unique ways to disperse their seeds. Seed dispersal increases the survival probability of a plant because it decreases the chance of overcrowding and competition among offspring.

The fleshy fruits produced by plants encourage dispersal by animals (including humans). Many plants also use wind and water as methods of seed dispersal.

Look at the seeds below and hypothesize what their method of dispersal might be.

**Alsomitra macrocarpa**

Dispersed by____________________________________

**Xanthium strumarium**

Dispersed by____________________________________

**Ceiba speciosa**

Dispersed by____________________________________

**Cocos nucifera**

Dispersed by____________________________________
Plant Physiology - germination

After the seed has been dispersed and conditions are favorable, the seed will break dormancy and begin to germinate. The diagram below illustrates the process of germination for two types of seeds.

**Corn Seed**
- Monocot
- Seed coat
- Endosperm
- Single cotyledon
- Leaf sheath
- First true leaves
- Embryonic root
- First leaf
- Leaf sheath
- Fibrous roots

**Bean Seed**
- Dicot
- Seed coat
- First true leaves
- Endosperm
- Two cotyledons
- Parallel veins
- Leaf sheath
- Two cotyledons
- Netlike veins
- Withering cotyledons
- Tap root

Notes:

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 Courtesy of Auburn University, College of Agriculture