
Kingdom Plantae

## *What Is a Plant?*

Nearly all plants are autotrophs - organisms that produce their own food. All plants are eukaryotes and are multicellular. Most plant cells are surrounded by cell walls made of cellulose.

## Adaptations for Living on Land

- Obtaining Water and Other Nutrients
- Retaining Water
  Cuticle: Waxy, waterproof layer covering the leaves of most plants.
- Transporting Materials
  Vascular Tissue: A system of tube-like structures through which water, minerals, and food move.
- Support
  Rigid cell walls and vascular tissue strengthen and support large bodies of plants.
- Reproduction
  All plants undergo sexual reproduction that involves fertilization, the joining of a sperm cell with an egg cell. The fertilized egg cell is called a zygote. There are adaptations for fertilization in water or in dry environments.

## *Classifying Plants*

Plants are divided into two major groups:

### Nonvascular Plants

They lack a well-developed system of tubes for transporting water and other minerals.

- They do not have roots for absorbing water from the ground.
- They obtain water and other minerals directly from surroundings.
  Materials pass directly from cell to cell. Materials do not travel very far or very quickly.
- Most of them live in damp, shady places.
- They have thin cell walls. They cannot grow more than a few centimeters tall.

### Vascular Plants

- They are better suited to life in dry areas.
- Materials are moved quickly and efficiently through the plants body.
- Vascular tissue provides strength, stability, and support.
- They are able to grow quite tall.

### Origin of Plants

- Scientists studied fossils.
- Scientists compared chemicals in plants and other organisms - plants, algae, and bacteria.

## *Complex Life Cycles*

They include two different stages:

### Sporophyte Stage

The plant produces spores, tiny cells that can grow into a new organism. The spore develops into the gametophyte.

### Gametophyte Stage

Plant produces two kinds of sex cells - sperm cells and egg cells.

## *Plants Without Seeds*

### Nonvascular Plants

Three Major Groups:

#### Mosses

- There are more than 10,000 species, the most diverse nonvascular group.
- They live in damp, shady places.
- They have thin, root-like structures called rhizoids that anchor the moss and absorb water and nutrients.
- The sporophyte generation grows out of gametophyte - a slender stalk with a capsule at the end. The capsule contains spores.

### Liverworts

- There are more than 8,000 species.
- They often grow as a thick crust in moist rocks or soil beside stream.
- The leaf-like gametophyte looks like a liver. *Wort* in Old English means "plant".
- The sporophyte is too small to see.

### Hornworts

- There are fewer than 100 species.
- They are seldom found on rocks or tree trunks.
- They usually live in moist soil, often mixed in with grass plants.
- They are named for the slender, curved structures that grow out of the gametophytes - these are the sporophytes.

## Seedless Vascular Plants

Characteristics of Seedless Vascular Plants

- They can grow tall. The cells making up vascular tissue have strong cell walls; they provide strength and stability.
- They need to grow in moist surroundings. When gametophytes produce egg and sperm cells, there must be enough water available for fertilization to take place.

## Ferns

- There are more than 12,000 species.
- They have true stems, roots, and leaves.
- The stems of most ferns are underground. Leaves grow upward from the top side of stems, roots grow downward from the bottom of stems and leaves.
- Leaves and fronds are divided into smaller parts that look like leaves. The upper surface is coated with a cuticle that helps retain water.
- The sporophyte stage has spores in tiny spore cases on the underside of mature fronds.
- Fern gametophytes are tiny plants that grow low to the ground.

## Horsetails

- There are very few species on earth today.
- Their stems are jointed. Long, coarse, needle-like branches grow in a circle around each joint. Small leaves grow flat against the stem just above each joint.
- Stems contain silica, a substance also found in some sand. Colonial Americans used these plants to scrub pots and pans (scouring rushes).

## Club Mosses

- They have true stems, roots, and leaves.
- They have a similar life cycle to ferns.
- There are only a few hundred species.
- They are not like true mosses; they have a vascular system.
- They are sometimes called ground pine or princess pine.
- They grow in moist woodlands and near streams.

## *What Is a Seed Plant?*

- Seed plants outnumber seedless plants ten to one. We use them for food, clothing, and shelter; they produce much of the oxygen we breathe.
- They have vascular tissue.
- They use pollen and seeds to reproduce.
- They have true roots, stems, and leaves.
- Life cycles include both sporophyte and gametophyte stages.
- The plants you see are sporophytes. Gametophytes are microscopic.

## Vascular Tissue

- Phloem is vascular tissue through which food moves.
- Xylem is vascular tissue through which water and minerals move.

## Pollen and Seeds

- Pollen is made up of tiny structures that contain the cells that will later become sperm cells.
- The Seed is a structure that contains a young plant inside a protective covering; it is protected from drying out.

# *How Seeds Become New Plants*

## Seed Structure

- An embryo is the young plant that develops from the zygote, or fertilized egg.
- Cotyledons, in some seeds, store food for the embryo.
- The seed coat is the outer covering. It protects the embryo and its food from drying out.

## Seed Dispersal

Scattering of seeds takes place by several methods:

- Seeds pass through digestive system of animals, or seeds cling to their fur.
- Water carries them away.
- Seeds have structures that catch the wind. https://youtu.be/Kd5qCNH_g3Q
  Dipterocarpaceae seeds
  https://youtu.be/ZjQs3GWgtgY https://youtu.be/c-2f-sDHoHs
  Origami Model - Helicopter https://youtu.be/Jg96vdhUC34
  Robotic Helicopter https://youtu.be/p8X-f5KoD3I
- Some plants have structures that eject seeds. https://youtu.be/NsIojj4PzAo

## Germination

The embryo begins to grow again and pushes out of the seed.

- It begins with absorbing water, then roots grow downward, and stems and leaves grow upward.
- When leaves are seen, it is called a seedling.

## Roots

- They anchor a plant.
- They absorb water and minerals.
- They sometimes store food.

### Types of Roots

#### Fibrous Root System

- It contains many similarly sized roots.
- It is a dense, tangled mass like in grass, corn, and onions.

#### Taproot System

- It contains one long, thick main root.
- Smaller roots branch off main root like in carrots, dandelions, and cacti.

### Structure of a Root

**Root Cap** protects the tip of root as it grows through the soil.

### Root Hairs

- They grow out of the roots' surfaces.
- They increase the surface area of root and absorb large amounts of water and minerals.
- They help anchor the plant.

### Vascular Tissue

- Xylem carries water and nutrients upward to stems and leaves.
- Phloem transports food manufactured in leaves to the roots where it is used for growth or stored.

## Stems

- They carry substances between roots and leaves.
- They provide support, holding up leaves so they are exposed to the sun.
- They all contain xylem and phloem.

**Herbaceous stems** are soft, containing no wood.

**Woody stems** are hard and rigid, containing several layers of tissue.

**Bark** is made up of an outer protective layer and an inner living layer of phloem. The outmost layer is cork.

The **cambium** divides to produce new xylem and phloem; xylem makes up the "wood", sapwood is active xylem, and heartwood is inactive. It provides support.

### Annual Rings

One pair of light and dark rings represents one year's growth. Xylem cells in the spring are large, produce a wide, light brown ring; in summer cells are small, produce a thin, dark ring.

Wide rings = rainy years
Narrow rings = dry years

## Leaves

They capture the sun's energy and carry out the food-making process of photosynthesis.

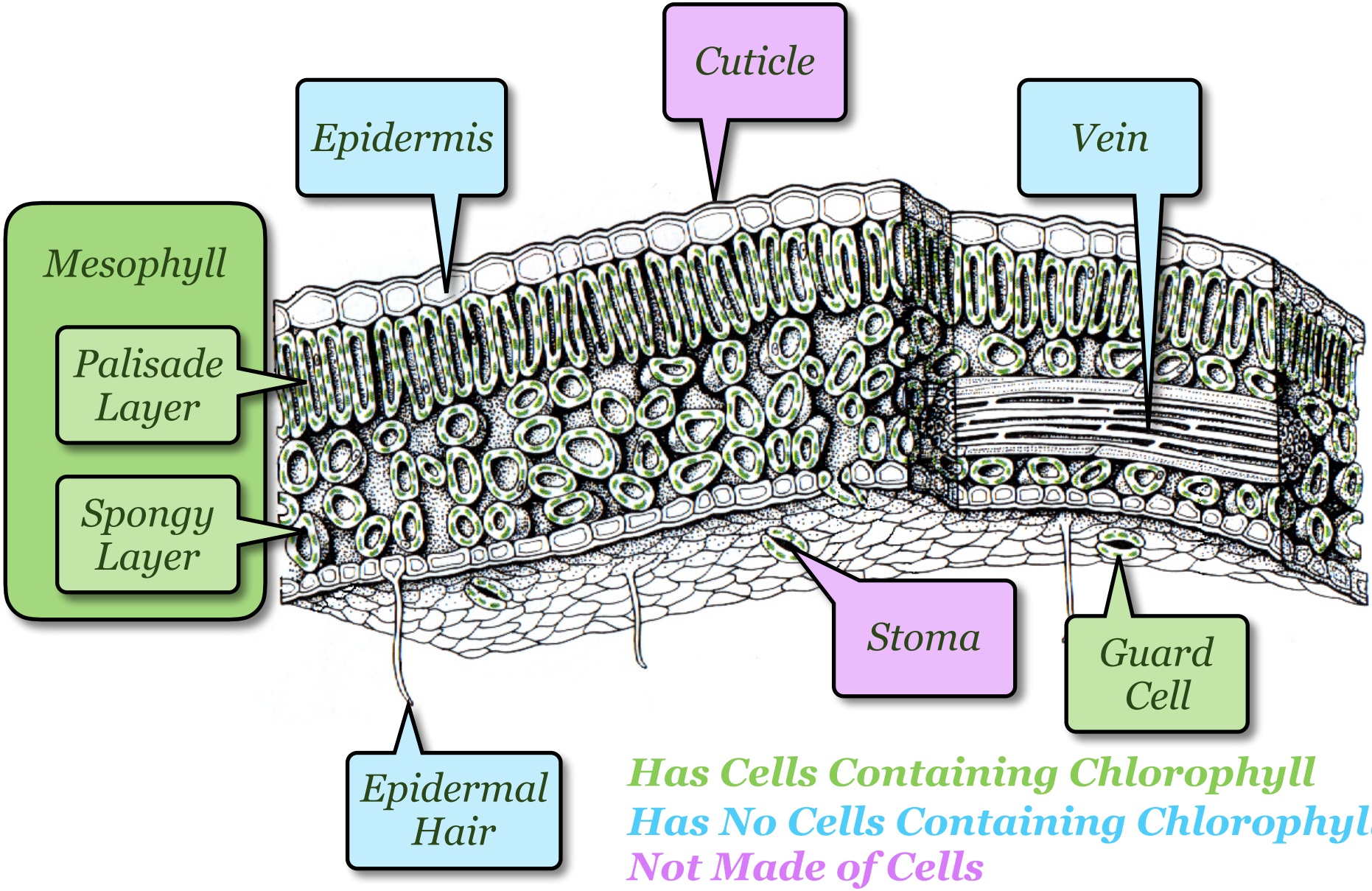
### Leaf and Photosynthesis

Leaf cells with the most chloroplasts are located near leaf's upper surface. Carbon dioxide enters through stomata. Water absorbed by the roots travels up the stem to the leaf through xylem. During photosynthesis, sugar and oxygen are produced. Oxygen passes out through stomata. Sugar enters the phloem and travels throughout the plant.

### Controlling Water Loss

Transpiration is the process by which water evaporates from a plant's leaves. Plants control transpiration by opening and closing stomata.

# Structure of a Leaf




***Has Cells Containing Chlorophyll***
***Has No Cells Containing Chlorophyll***
***Not Made of Cells***

# *Gymnosperms and Angiosperms*

## Gymnosperms

A seed plant that produces naked seeds. They are called "naked" because they are not enclosed in a protective fruit. Many have needle-like or scale-like leaves and deep-growing root systems. These are considered the oldest type of seed plant.

### Four groups exist today:

**Cycads** look like palm trees with cones as large as a football.

**Conifers** are the largest and most diverse group. They keep their leaves or needles year round.

**Ginkgoes** have only one species that still exists, *Ginkgo biloba*.

**Gnetophytes** live in hot deserts and tropical rain forests. They can be trees, shrubs, and vines.

## Reproduction of Gymnosperms

Male cones produce tiny grains of pollen - the male gametophyte. Pollen contains the cells that later become sperm cells. Female gametophytes develop in structures called ovules. An ovule contains an egg cell. The female cone contains at least one ovule at the base of each scale.

**Pollination** is the transfer of pollen from the male structure to the female structure, usually by wind.

**Fertilization** takes place after the ovule closes and seals in the pollen and the scales close. Then the sperm cell and egg cell combine. The fertilized egg develops into the embryo part of the seed.

**Seed Development** takes place as the female cone remains on tree and increases in size for up to two years until it is mature.

**Seed Dispersal** takes place when the seed is mature. The scales open, the wind shakes the seeds out of the cone, and carries them away. Some cones, like the those on the lodgepole pine, only open with extreme heat; it depends on periodic fires to start the process of seed dispersal.

## Angiosperms

**Flowering Plants** produce flowers and seeds enclosed in fruits.

Structure of Flowers

**Function - Reproduction**

**Sepals** - leaf-like structures enclosing flower bud.

**Petals** - colorful leaf-like flower parts after the bud opens.

**Stamen** - male reproductive part https://youtu.be/LjCzPp-MK48

- **Filament** - thin stalk
- **Anther** - top of the filament where pollen is produced

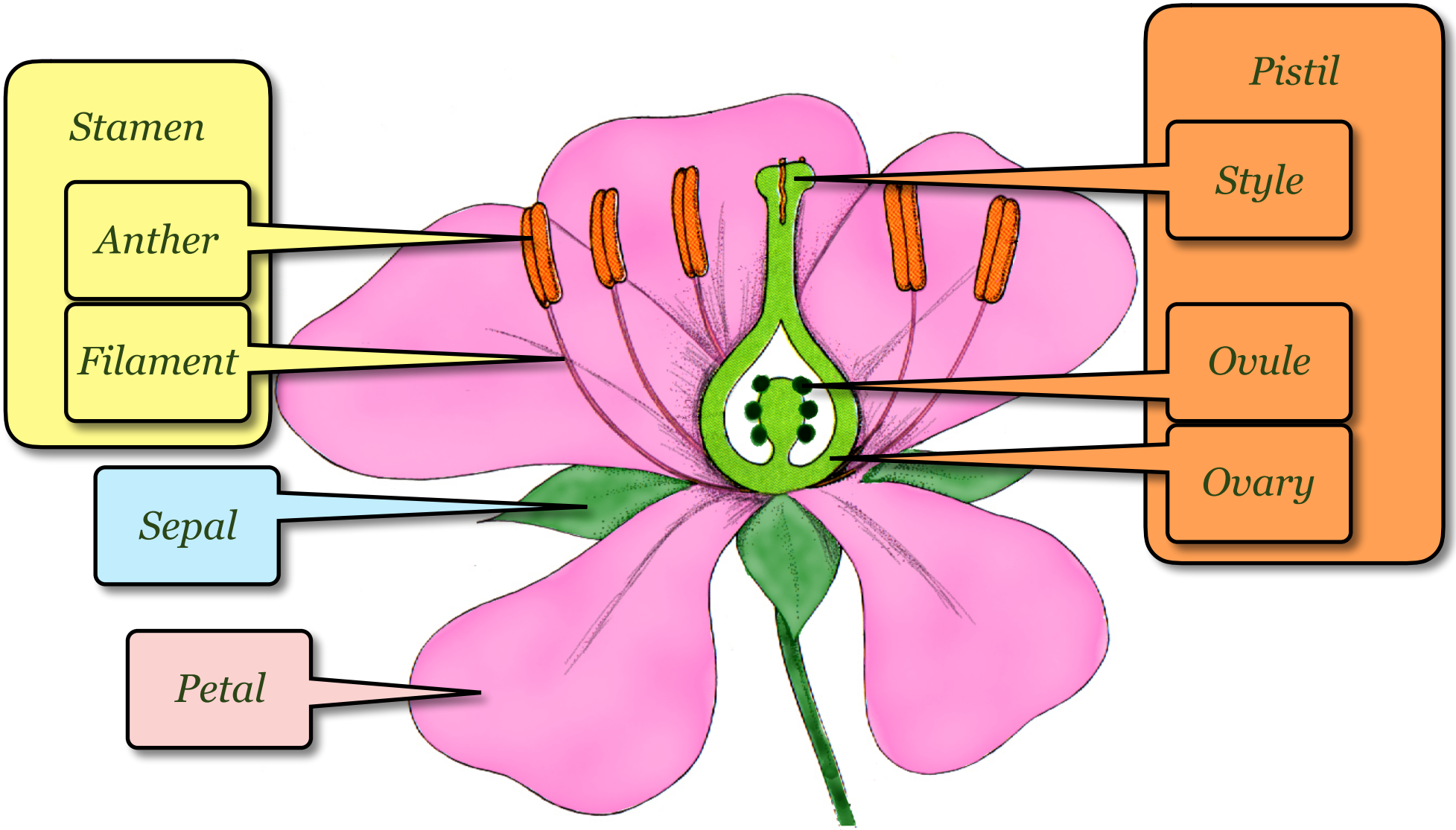
**Pistil** - female reproductive part, center of the flower

- **Stigma** - sticky tip
- **Ovary** - hollow structure at the bottom, contains ovules
- **Style** - slender tube connecting stigma and ovary

**Pollinators** - color, shape, and scent attract insects and other animals. These organisms insure that pollination occurs.

https://youtu.be/MQiszdkOwuU

# Basic Flower Structure



## Reproduction in Angiosperms

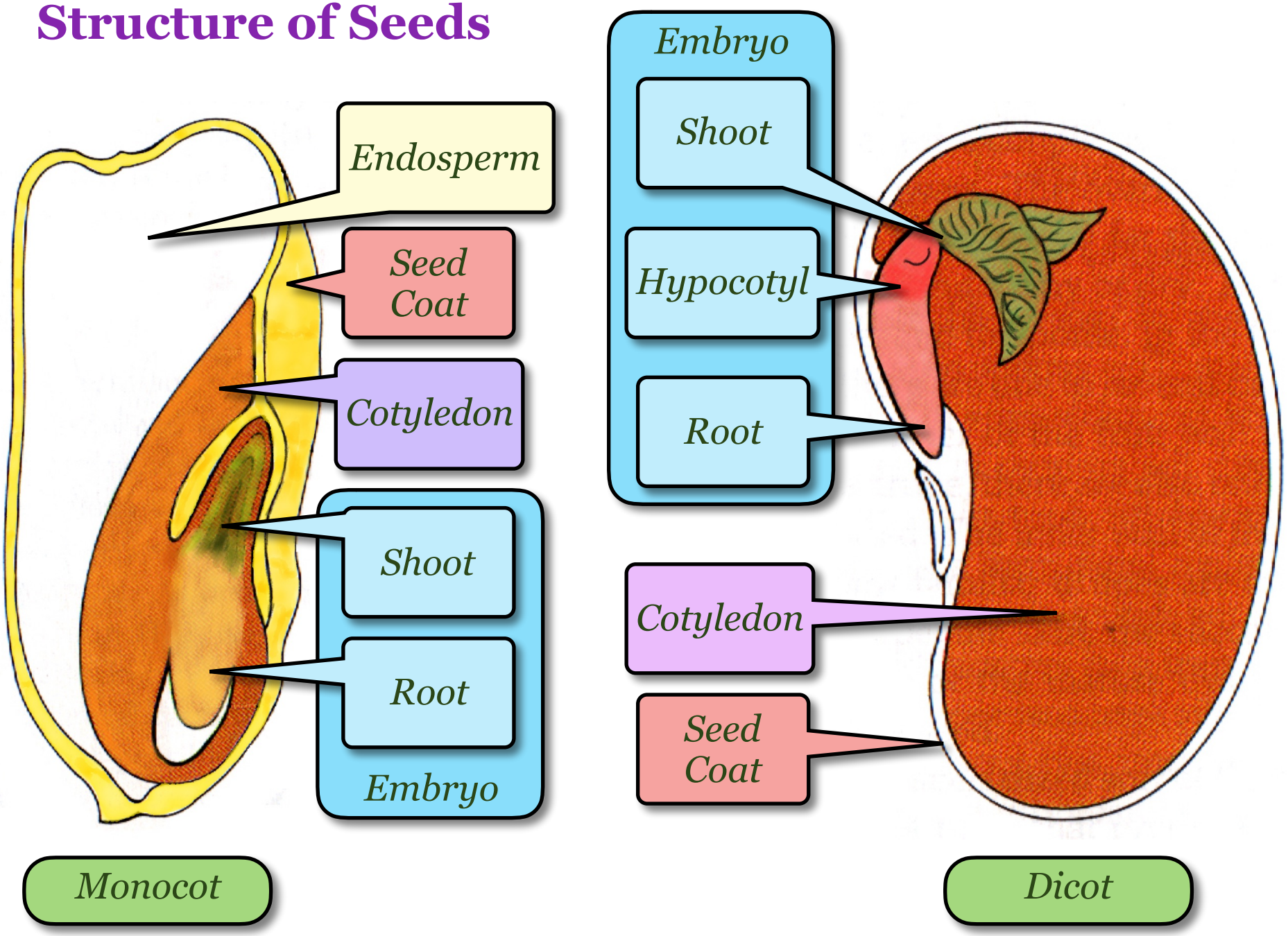
**Pollination** takes place when a grain of pollen falls on the stigma. Wind, animals, insects transfer pollen.

**Fertilization** is the sperm cell from pollen joining with an egg cell inside an ovary. The zygote develops into the seed's embryo. Other parts of the ovule develop into the other parts of the seed.

### Fruit Development and Seed Dispersal

As the seed develops, the ovary changes into a fruit. Apples, cherries, tomatoes, and squash are all fruits. Animals eat fruits and disperse the seeds.

# Structure of Seeds



## Types of Angiosperms

Angiosperms are divided into two major groups, monocotyledons and dicotyledons. These names have been shortened to monocots and dicots. Cotyledons provide food for a growing embryo. *Mono* means "one" and *di* means "two".

**Monocots** are angiosperms that have one seed leaf. They include grasses such as corn, wheat, and rice. Lilies and tulips are also monocots. Their flowers have three petals or multiples of three. Their leaves are long, narrow, and have veins that run parallel to one another. Bundles of vascular tissue are usually scattered randomly throughout the stem.

**Dicots** are angiosperms that have two seed leaves. Roses, violets, dandelions, oaks, maples, beans, and apples are examples of dicots. The flowers of dicots have four or five petals or multiples of these numbers. Their leaves are usually wide with branching veins. Their stems have bundles of vascular tissue arranged in a ring.

### Seed Plants in Everyday Life

Products from seed plants are all around you.

**Gymnosperms** are the sources of paper, lumber, turpentine, rayon clothing fibers, rosin

**Angiosperms** are an important source of food, clothing, medicine, furniture, and other products.

## *Plant Responses and Growth*

**Tropisms** are plants responding by growing toward or away from stimuli (touch, light, gravity). https://youtu.be/Zq3UuHlPLQU
https://youtu.be/DF-b6TsO1DM

### Touch

This response is called thigmotropism. Thigmo means "touch". Vines coiling around objects is an example.

### Light

This response is called phototropism. Photo mans "light". Growing toward light provides more energy from photosynthesis.
https://youtu.be/eu_l80m7K20

### Gravity

This response is called gravitropism. Roots show positive gravitropism; they grow in the direction of gravity's pull. Stems show negative gravitropism.

## Hormones and Tropisms

**Hormones** are chemicals produced by a plant that affects how the plant grows and develops.

**Auxin** speeds up the rate plant cells grow. It builds up in shaded parts of plant, so the shaded part of plant grows longer and the stem bends toward the light. https://youtu.be/--C0921z9K4

### Hormones Control Tropisms:

Germination; the formation of flowers, stems, leaves; the shedding of leaves; and the development and ripening of fruit are all controlled by hormones in plants.

# Seasonal Changes

## Photoperiodism

This is a plant's response to seasonal changes in the length of night and day.

### Fall or Winter

Short-day plants flower when nights are longer than their critical night length.

### Spring and Summer

Long-day plants flower when nights are shorter than their critical night length.

**Day-Neutral Plants** have a flowering cycle that is not sensitive to periods of light and dark.

**Dormancy** is a period when an organism's growth or activity stops. It helps plants survive freezing temperatures and lack of water. During cooler weather and shorter days, leaves stop producing chlorophyll, the yellow and orange pigments become visible, and the plant produces more red pigments. Sugar and water are transported out of the leaves and eventually the leaves fall to the ground.

## Life Span of Angiosperms

**Annuals** complete a life cycle within one growing season. Marigolds, wheat, cucumbers are examples.

**Biennials** during the first year grow roots and very short stems and leaves. The second year, the stems lengthen, the plant grows new leaves, and it flowers and produces seeds. Carrots, parsley, celery are examples.

**Perennials** flower every year. Some have leaves and stems that die each winter and they produce new ones each spring. Most are woody perennials with woody stems that live through the winter.

# Germinating Seeds of *Phoenix dactylifera*

**Background**

Date palms are dioecious, which means that each plant is either male or female. Females are more desired because they will bear fruit. Only one male plant is needed to pollinate many females. The pollen grains can easily travel by wind to pollinate the females. Date farms hand pollinate trees to ensure higher crop yields.

Growing date palms by seeds results in plants that are not true-to-type, meaning the seedlings will develop into palms with fruits that may be smaller and of lesser quality than the parent. Only about half of the seeds that germinate will be the desired females. Commercial farms and nurseries prefer vegetative propagation to get larger, high quality fruits. This can be done through tissue culture in a laboratory setting or by offshoot rooting of young date palms. Growing date palms from seed can produce good ornamental plants - until they become too large!

To grow date palms, remove the seeds from the dates, and rinse the seeds clean of any excess flesh. Make sure you eat the dates!

Soak the seeds in water for 24 to 48 hours to allow the strong seed coat of the date seeds to take in water.

-EITHER-

Sow the date seeds (rough side down) about 1" depth in a small pot filled with soil. Lightly water the soil ensuring moisture at the seed's depth, while being careful not to over-water the soil.

-OR-

Wrap the date seeds in a moist paper towel and put them in a plastic bag. Place the bagged seeds in a warm place, at least 75°F. Date seeds need to be only slightly moist. Be sure not to over water the seeds. If any mold appears, change the paper towel.

After about two weeks, small white roots will begin to appear from one side of each of the date seeds. The germinated seeds may then be planted in small or medium-sized pots filled with a palm or cactus potting soil if they were sprouted in paper towels.

Potting soil for date palms:
Palm or cactus potting soil mixes are a good choice for planting date palms. As an alternative, you may add one part sand and/or vermiculite to three or four parts generic potting soil to provide good aeration and drainage. Adding peat moss to the soil will help the soil retain moisture if it is draining too well.

Once you have date palm seedlings established, you must transplant them gradually to larger and larger pots. Transplant your date palms when you notice that they are outgrowing their containers or growing roots out from under the containers. Be sure to water the palms well before and after transplanting, and avoid transplanting them into significantly larger pots. The palms may be transplanted into the ground if your climate is appropriate. The date palms may be kept in large pots somewhere receiving maximum sunlight. It may be possible to keep the date palms indoors near a window that receives direct sunlight, although their growth will likely be diminished.

# *Supermarket Botany*

http://www.csu.edu.au/faculty/science/herbarium/Supermarket%20Botany/safari3/index.html?dhtmlActivation=inplace

Tap the blue URL above.  When the page opens, follow the directions online and on the following pages to complete the challenge.

Assignment
FIRST - On the title page, bottom right corner, "Do you know what plant parts you are eating?" Tap on "Click here to find out." A "Disclaimer" will appear. On the bottom right, Tap "Back to the front page." Again, on the title page, bottom right corner, "Do you know what plant parts you are eating?" Tap on "Click here to find out." Then you can Tap on "Click here to start" in the box "Find out about plants and the parts they are made of before taking The Challenge."
Tap on "Vegetative Tissues (vegetables)" and answer the following questions.

1. Which plant parts are considered vegetative tissues?

1a. _____ Tap red word (Tap "Go back" after completing items.)

What are its three characteristics?

1.

2.

3.

Summarize the *Hint:*

1b. _____ Tap red word (Tap "Go back" after completing items.)

What are its three characteristics?

1.

2.

3.

Summarize the *Hint:*

1c. _____ Tap red word (Tap "Go back" after completing items.)

What are its three characteristics?

1.

2.

3.

3a.

3b.

Summarize the *Hint:*

(The extra website for *leaf structure* does not work.)

Tap "Go back"
Tap on "Sexual Reproductive Tissues (flowers, fruits, and seeds)" and answer the following questions.

2. Which plant parts are considered sexual reproductive tissues?

2a. _____ Tap red word (Tap "Go back" after completing items.)

What are names of the eight smaller parts listed?

1. 5.
2. 6.
3. 7.
4. 8.

2b. _____ Tap red word (Tap "Go back" after completing items.)

From what flower part does it develop?
What would you find inside?

2c. _____ Tap red word (Tap "Go back" after completing items.)

From what flower parts do these develop?
These are found inside of which larger flower part?

Tap "Go back"
Tap "A Tomato - fruit or vegetable?" This item is just reading. There is no writing required. After reading the information, tap "Go back"
Tap "Go back to the 'What do you want to do now?' page."
Tap on "Click here to start" in the box "The Challenge!"

What's on the shelf?
Follow the directions at the bottom of the page to fill out the following information and to complete *The Challenge*.

A carrot is a: _____
Why?
_____
_____
_____

A tomato is a: _____
Why?
_____
_____
_____

Bean pods are: _____
Why?

_____

_____

_____

An onion is a: _____
Why?

_____

_____

_____

A potato is a: _____
Why?

_____

_____

_____

Celery is a: _____
Why?

_____

_____

_____

Beetroot is a: _____

Why?

_____

_____

_____

Ginger is a: _____

Why?

_____

_____

_____

Lettuce is a: _____

Why?

_____

_____

_____

Broccoli is a: _____

Why?

_____

_____

_____

Peanuts (in the shell) are: _____

Why?

_____

_____

_____

Strawberries are: _____

Why?

_____

_____

_____

Cucumbers are: _____

Why?

_____

_____

_____

Peas (loose) are: _____

Why?

_____

_____

_____

Cauliflowers are: _____

Why?

_____

_____

_____

You have finished *The Challenge!*

How many did you get correct on the first try? _____. This number does not affect your grade. Thanks for completing this activity. Now you know a little more about what you are eating.

Close out of everything on the iPad and return it to the cabinet.

Please leave these papers on your table so they can be collected.

# *RADISHES LAB*

Follow the teacher's directions to set up the experiment using radish seeds, water, a paper towel, and an egg carton.

You will be expected to construct a lab report (spreadsheet) using the app NUMBERS on your iPad. Your final document must include the following items:

- An organized spreadsheet with complete data (growth stages) for days 1, 2, 3, and 4.
- A hypothesis - an explanation of what you think will happen with these seeds over the four-day period.
- A labeled photo of each growth stage that you observed.
- At least one graph that is helpful in interpreting the data and an explanation accompanying the graph that will help others to understand the significance of what is shown.

- Answers in complete sentences (notice "sentences" is plural) to the following questions:

    1. What plant part do you think that the radicle becomes?

    2. Why do you think the root hairs develop so early in the growth stages?

    3. Why do you think the cotyledon is sometimes called the "seed leaf"?

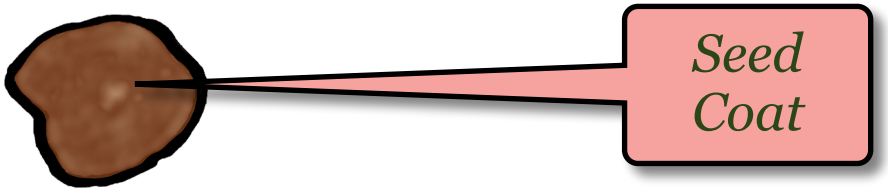
    4. What plant part do you think the hypocotyl will become? What evidence leads you to this conclusion?

    5. What were the most important ideas you learned from this experiment? Why were these so important?

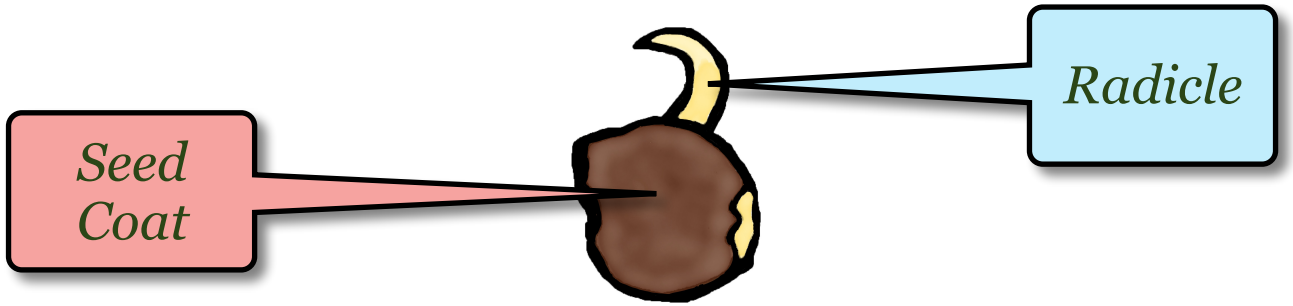
**Hypothesis**
Add a text box to the spreadsheet explaining in detail what you think will happen to the seeds through the next four days.

## Key to Radish Stages and Parts Identification

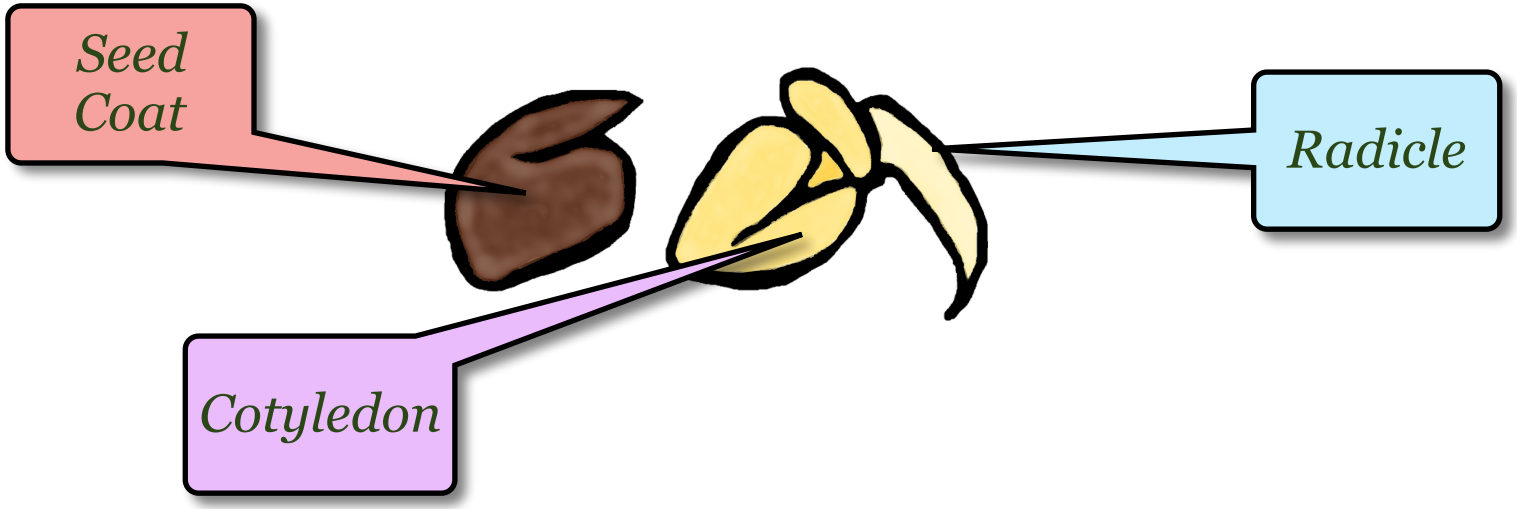
A. Unsprouted seed. Seed coat may be broken, but no radicle appears.



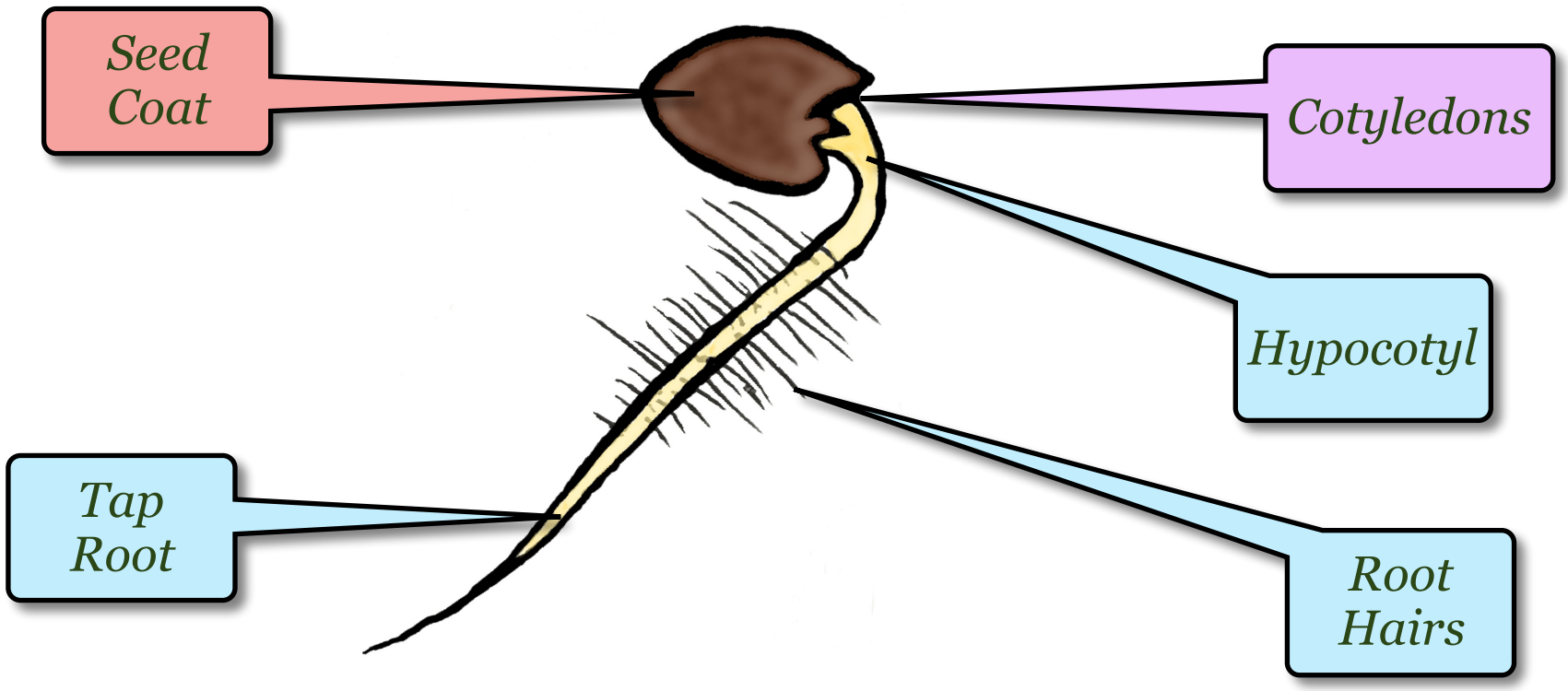

B. Radicle pokes through, but cotyledons remain closed in the seed coat.




C. Seed coat pops off as cotyledons begin to open like a book. No root hairs.

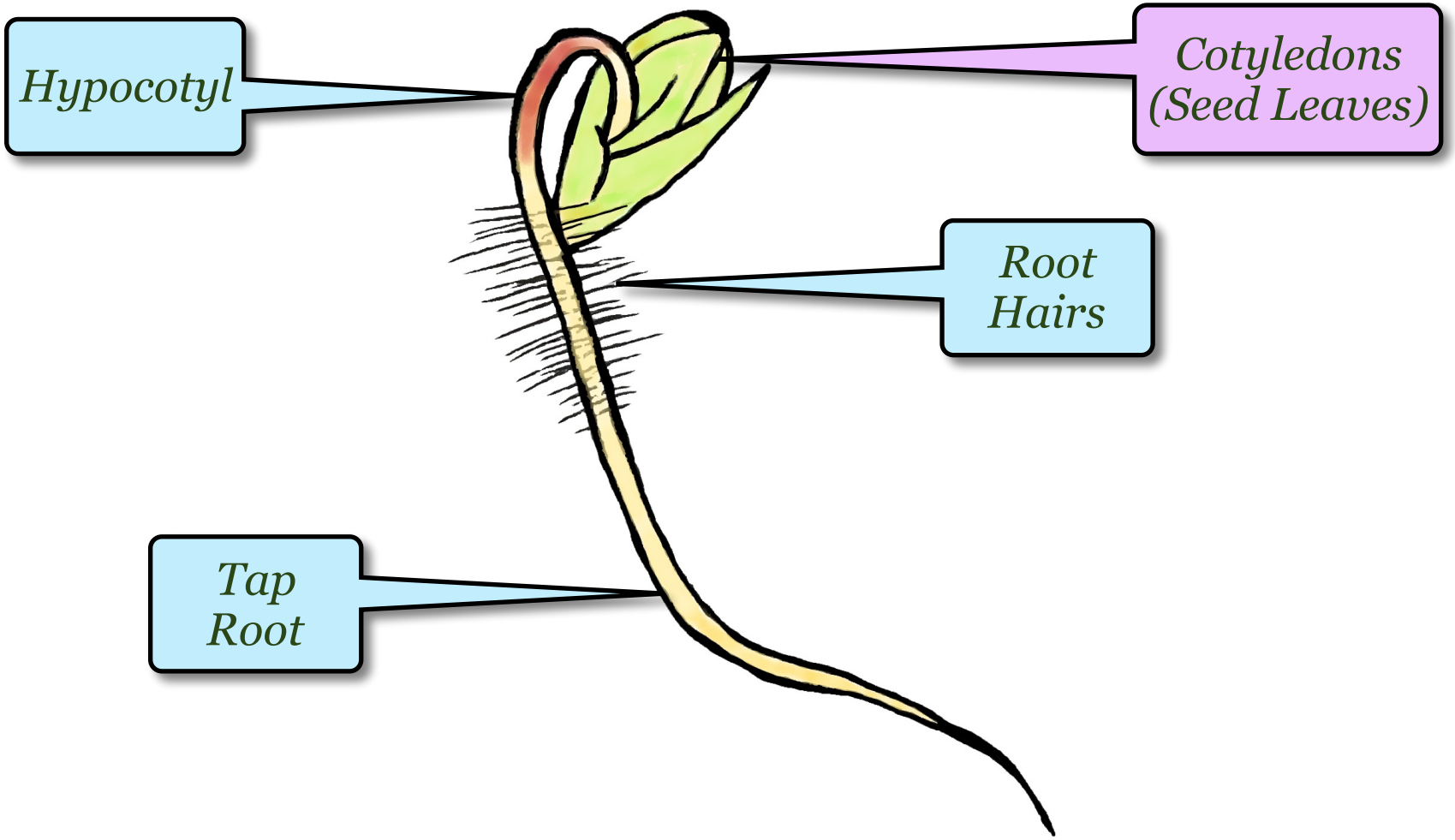


D. Root hairs grow from tap root. No red in hypocotyl, no green in leaves.

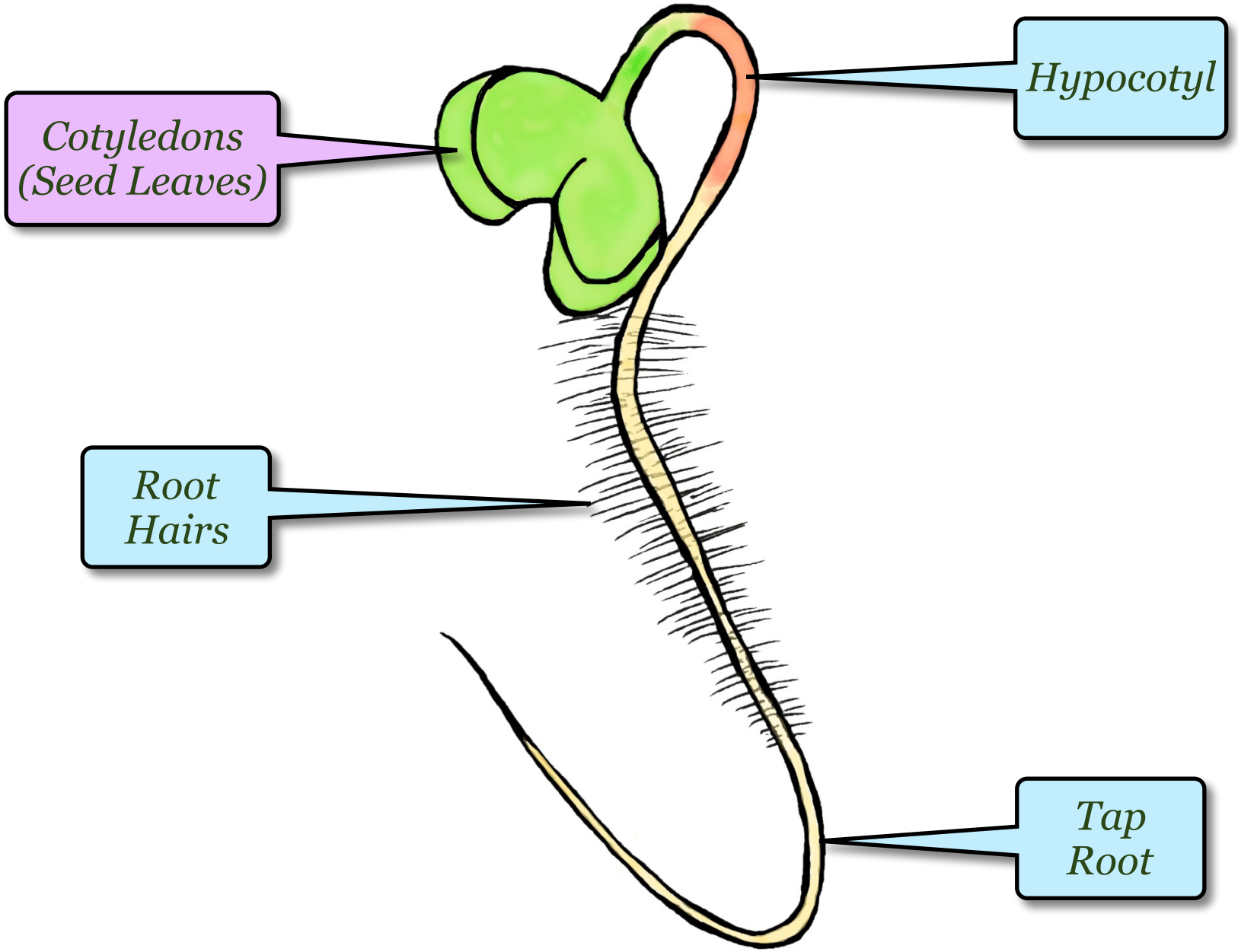



The seed coat may still be intact, but root hairs growing from the tap root makes this stage D.

E. Hypocotyl turning pink, cotyledons turning green. Sprout still has “bowed head”. It is still lying down on the paper towel.



F. Cotyledons “lift head” as hypocotyl lengthens. The seed leaves are stood up off of the paper towel.

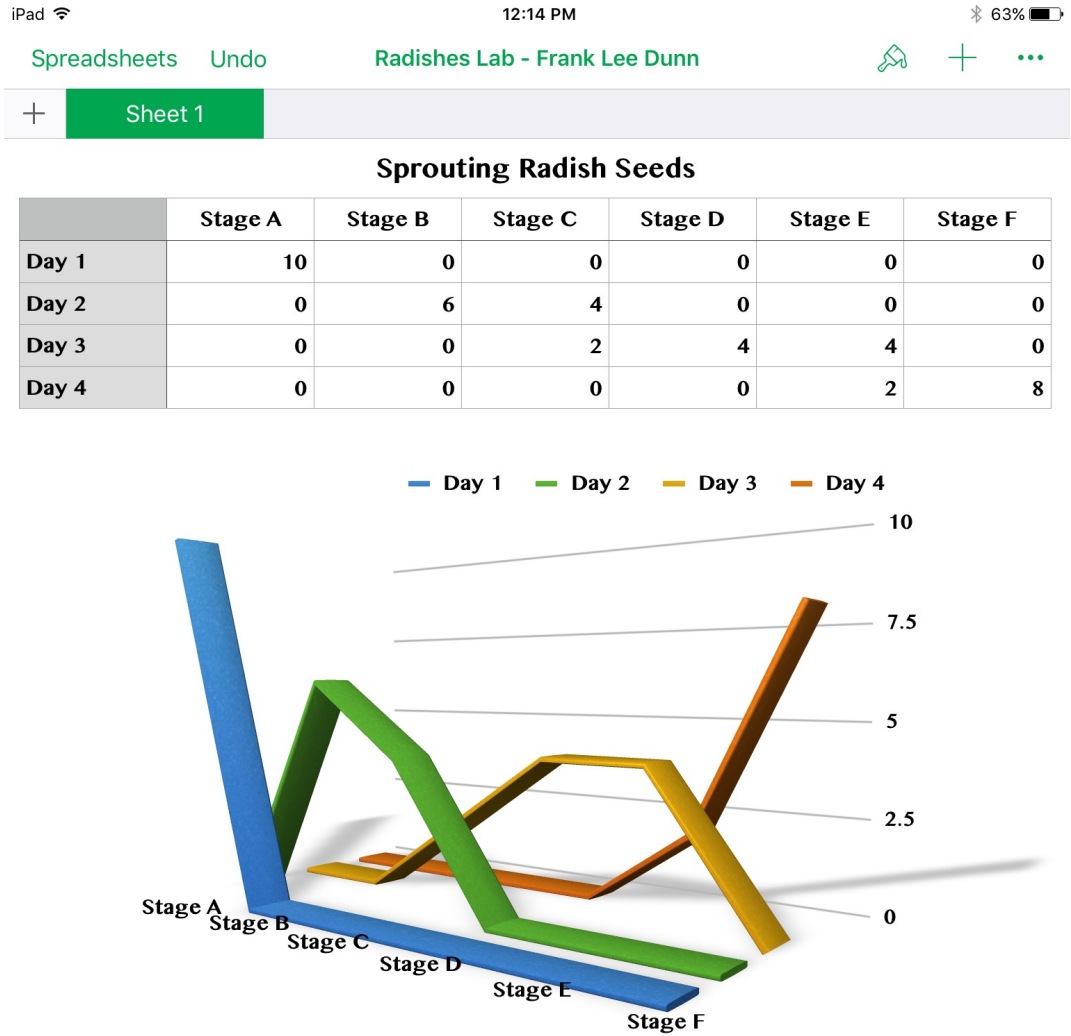


Each day of the lab, use the camera on the iPad to take photographs of the radishes in each of the growth stages. On each of the photographs that you took, label each stage with the names of the plant parts as follows:

A = seed coat
B = seed coat, radicle
C = radicle, cotyledon
D, E, and F = cotyledons, hypocotyl, root hairs, tap root (maybe seed coat)

## Example Spreadsheet to Record Data

Each day, record in the cells of your spreadsheet the number of seeds in each growth stage (A through F). Use this information to make a graph. Experiment with the graphs to find one that is most useful connected with your data and your conclusions. Add a text box explaining the importance of what is seen in the graph.




**Sprouting Radish Seeds**

| | Stage A | Stage B | Stage C | Stage D | Stage E | Stage F |
|---|---|---|---|---|---|---|
| Day 1 | 10 | 0 | 0 | 0 | 0 | 0 |
| Day 2 | 0 | 6 | 4 | 0 | 0 | 0 |
| Day 3 | 0 | 0 | 2 | 4 | 4 | 0 |
| Day 4 | 0 | 0 | 0 | 0 | 2 | 8 |

**Conclusions**

Add a text box (or text boxes) where you can write conclusions including answers to the five questions given at the beginning of this lab.