# Week 2: Foundations of Plant Growth: From Seed to Nutrition

## Objectives

* Understand basics of farming in small spaces.
* Identify and start various plant seeds.
* Comprehend plant life cycles and growth stages.
* Familiarize with key plant families and root systems.
* Grasp plant nutrition and appropriate fertilizer use.

## Handouts

* Nutrition of Plants
* Plant Families
* Stages of Plant Growth
* Garden Journal Week 2

## Lesson Outline

### What Farming and Gardening Looks Like

***Handouts and Video***

* [Inside Indiana's first hydroponic shipping container farm](https://www.youtube.com/watch?v=pLWb4aD9v2Y&ab_channel=WTHR) *(3 minutes)*

### Understanding the Beginning of Every Plant - Seeds

**Types of Plant Seeds:**

1. **Orthodox Seeds**: Dry and freeze resistant; stored in seed banks. E.g., grains, sunflower, lettuce.
2. **Recalcitrant Seeds**: Sensitive to drying or freezing. E.g., oak, chestnut, and many tropical species.
3. **Viviparous Seeds**: Germinate while still on the parent plant, like mangroves.
4. **Monocot Seeds**: Have one embryonic leaf (cotyledon). E.g., corn, wheat, rice.
5. **Dicot Seeds**: Feature two embryonic leaves (cotyledons). E.g., beans, sunflower, peanuts.

**Seed Starting Methods:**

1. **Direct Sowing**: Planting directly into garden soil; preferred by many plants.
2. **Indoor Seed Starting**: For climates with short growing seasons; start in pots, then transplant outdoors.
3. **Soaking**: Softening hard-coated seeds in water before planting for easier germination.
4. **Stratification**: Mimicking a cold period for certain seeds (like temperate plants) by storing them cold and moist, often in a fridge.
5. **Scarification**: Altering the seed coat, like with sandpaper or a knife, to assist embryo emergence. Beneficial for seeds like morning glory.
6. **Division**: Multiplying plants by splitting a plant into multiple parts with their own roots and shoots.
7. **Cuttings**: Propagating plants using parts of the stem or leaf to encourage rooting.

**Tip:** Always mimic a seed’s natural habitat when starting it. Desert seeds might need heat while rainforest seeds might prefer high humidity. Research each seed type for optimal germination conditions.

### Understanding Plant Life Cycles: Annuals, Biennials, and Perennials

#### Types of Plant Life Cycles:

1. **Annuals:**
   * **Description:** Complete their life cycle in one growing season: seed ➔ flower ➔ seed. After seeding, the plant dies.
   * **Examples:** Tomatoes, peppers, marigolds, sunflowers.
   * **Remember:** They last just one season; replanting is necessary yearly.
2. **Biennials:**
   * **Description:** Their life cycle spans two seasons. Leaves and stems form in the first year; flowering and seeding occur in the second.
   * **Examples:** Carrots, foxgloves, some parsley species.
   * **Remember:** Growth in the first year, flowering and seeding in the second.
3. **Perennials:**
   * **Description:** Live for multiple years, flowering and seeding many times. Some die back in winter and regrow in spring, while others are evergreen.
   * **Examples:** Rose bushes (shrub), oak trees, peonies, hostas.
   * **Remember:** A long-term garden addition, but some might need replacement over time.

#### Stages of Plant Growth:

1. **Seed:** Beginning phase with an embryo and stored food, protected by the seed coat.
2. **Germination:** The seed swells upon water absorption, cracking the seed coat. The embryo grows using stored food, forming initial root and shoot.
3. **Seedling:** With the shoot's growth, the first true leaves appear. The plant is now a seedling that conducts photosynthesis. Roots further diversify.
4. **Vegetative Growth:** The plant heightens, producing more leaves and expanding its root system.
5. **Flowering:** Post vegetative phase, plants flower, marking the reproductive phase.
6. **Pollination:** Pollen transfer from one flower's male part to another's female part, facilitated by wind, water, or animals.
7. **Fruit and Seed Formation:** Successful pollination results in fruit bearing seeds inside. The fruit protects and aids seed dispersal.
8. **Seed Dispersal:** Mature seeds spread through wind, water, or animals.
9. **Dormancy:** Seeds may not instantly germinate, entering a dormant phase. They activate with favorable conditions, renewing the cycle.

Overall, the plant life cycle is a continual process of growth, reproduction, and renewal.

***Handouts and Video***

* Stages of Plant Growth

### Plant Families and Their Common Examples in Farms or Gardens

Plant families group plants by shared characteristics. Recognizing these families aids gardeners and farmers, as plants within the same family often share growing needs and potential pests or diseases. Here's an overview:

1. **Asteraceae (Sunflower Family)**
   * Characteristics: Composite flowers consisting of many tiny ones.
   * Examples: Sunflower, lettuce, marigold, daisy, chrysanthemum.
2. **Brassicaceae (Mustard Family)**
   * Characteristics: Four-petaled cross-shaped flowers.
   * Examples: Broccoli, cabbage, cauliflower, radish, mustard.
3. **Fabaceae (Legume Family)**
   * Characteristics: "Pea-like" flowers; often pod-bearing.
   * Examples: Beans, peas, lentils, peanuts, clover.
4. **Lamiaceae (Mint Family)**
   * Characteristics: Square stems and aromatic leaves.
   * Examples: Mint, basil, oregano, rosemary, sage.
5. **Rosaceae (Rose Family)**
   * Characteristics: Five-petaled flowers; many bear fleshy fruits.
   * Examples: Rose, apple, pear, strawberry, almond.
6. **Solanaceae (Nightshade Family)**
   * Characteristics: Contains alkaloids; many are edible and cultivated.
   * Examples: Tomato, potato, bell pepper, eggplant, tobacco.
7. **Apiaceae (Carrot Family)**
   * Characteristics: Umbrella-shaped flower clusters or umbels.
   * Examples: Carrot, parsley, celery, dill, coriander.
8. **Cucurbitaceae (Gourd Family)**
   * Characteristics: Vining plants with tendrils; bear fleshy fruits.
   * Examples: Cucumber, pumpkin, melon, squash, zucchini.
9. **Poaceae (Grass Family)**
   * Characteristics: Cereal producers with narrow leaves, jointed stems.
   * Examples: Wheat, rice, corn, oats, barley.
10. **Rutaceae (Citrus Family)**
    * Characteristics: Aromatic oils present in leaves, fruits, and bark.
    * Examples: Orange, lemon, lime, grapefruit.

Grasping these families equips individuals for better gardening and farming experiences.

***Handouts and Video***

* Plant Families

### Root Types and Their Functions

Plant roots are integral for nutrient and water absorption, anchoring the plant, storing energy, and even asexual reproduction in some species. The specific root system of a plant provides insights into its habitat preferences, evolutionary traits, and growth behaviors.

1. **Taproot System**

* **Characteristics:** Dominated by one main vertical root from which smaller secondary roots branch out.
* **Functions:** Reaches deeper water sources; stores nutrients and food.
* **Examples:** Carrot, radish, beet.

2. **Fibrous Root System**

* **Characteristics:** Multiple similar-sized roots that grow outward, creating a mat-like structure.
* **Functions:** Prevents soil erosion; efficiently absorbs surface water.
* **Examples:** Grasses, maize, wheat.

3. **Adventitious Roots**

* **Characteristics:** Grow unexpectedly from non-root regions, like stems or leaves.
* **Functions:** Provides support, stores food, and assists in propagation.
* **Examples:** Ivy, sweet potato, banyan trees.

4. **Aerial Roots**

* **Characteristics:** Free-hanging roots not anchored in soil.
* **Functions:** Facilitates breathing in swampy areas or absorbs moisture from the air.
* **Examples:** Mangroves, orchids.

5. **Pneumatophores**

* **Characteristics:** Roots that grow upward, often seen above ground or water.
* **Functions:** Aids in gas exchange in waterlogged environments.
* **Examples:** Mangrove trees.

6. **Haustorial Roots**

* **Characteristics:** Can penetrate other plants' tissues.
* **Functions:** Helps parasitic plants extract nutrients and water from their host.
* **Examples:** Mistletoe, dodder.

Recognizing different root systems is pivotal for botanists and anyone involved in agriculture or gardening. It helps in understanding a plant's requirements, making informed decisions about watering, planting depth, and choosing the right plants for specific soil conditions.

### Understanding Plant Nutrition

Plant nutrition delves into the essential chemical elements vital for plant growth. Just as humans rely on a balanced diet, plants depend on specific nutrients for growth, metabolism, and reproduction.

##### Significance of Plant Nutrition:

1. **Growth & Health:** Proper nutrition fosters robust growth, quality produce, and resilience against diseases.
2. **Photosynthesis:** Nutrients play an indispensable role in photosynthesis, the sun-driven process through which plants manufacture food.
3. **Metabolism:** Nutrients underpin various plant metabolic activities including respiration, energy generation, and growth.
4. **Reproduction:** Adequate nutrients guarantee efficient reproduction, leading to seeds that spawn healthy new plants.

##### Categories of Plant Nutrients:

**1. Macronutrients:** Needed in ample amounts.

* **Nitrogen (N):** Powers growth via its role in amino acids, proteins, and photosynthesis-related chlorophyll.
* **Phosphorus (P):** Crucial for energy transfer, and foundational for roots and flowers.
* **Potassium (K):** Influences enzyme activation, water absorption, and photosynthesis.
* **Calcium (Ca):** Shapes cell walls and aids in cell division.
* **Magnesium (Mg):** Integral to chlorophyll and thus, photosynthesis.
* **Sulfur (S):** Forms certain amino acids and vitamins.

**2. Micronutrients:** Essential but in minor quantities.

* **Iron (Fe):** Crucial for chlorophyll creation and photosynthesis.
* **Manganese (Mn):** Assists in enzyme activation and chloroplast formation.
* **Boron (B):** Supports cell division and sugar movement.
* **Zinc (Zn):** Facilitates production of specific enzymes and proteins.
* **Copper (Cu):** Catalyzes processes in respiration and photosynthesis.
* **Molybdenum (Mo):** Fundamental for nitrogen assimilation in legumes.
* **Chlorine (Cl):** Participates in cellular osmosis and ionic equilibrium.

Deficiency in these nutrients manifests in distinct symptoms, like yellowing leaves due to nitrogen scarcity or brownish-yellow leaf edges from potassium shortfall.

Grasping plant nutrition is pivotal in agriculture and gardening as it paves the way for soil and fertilizer optimization, ensuring plant vitality and peak yield.

***Handouts and Video***

* *Nutrition of Plants*
* [Plant Nutrition | Plants | Biology | FuseSchool](https://youtu.be/w_x-WDdQdxI?si=0Bre8rAv4bcKPOq8)

### Overview of Fertilizers and Their Types

Fertilizers are essential for supplying plants with vital nutrients. They come in various types based on their origin, composition, and application method. Let's explore these categories:

1. **Organic Fertilizers:**
   * **Source:** Plant or animal derivatives.
   * **Function:** Slow nutrient release via soil microbial activity.
   * **Examples:** Compost, manure, bone meal, worm castings.
   * **Benefits:** Enhances soil texture, retains moisture, fosters beneficial microbes.
2. **Synthetic/Inorganic Fertilizers:**
   * **Source:** Chemical formulations targeting specific nutrients.
   * **Function:** Dissolves in water for immediate plant uptake.
   * **Examples:** Urea, ammonium nitrate, superphosphate.
   * **Benefits:** Consistent nutrient levels, quick outcomes.
3. **Multipart Fertilizers:**
   * **Source:** Blend of different fertilizers for diverse nutrients.
   * **Function:** Offers balanced nourishment for plants.
   * **Examples:** Nutrient mixes for hydroponics or soil gardening.
   * **Benefits:** Customized for specific plant needs and growth stages.
4. **Fertilizer Stakes (Slants):**
   * **Source:** Solid, elongated fertilizers for direct soil insertion.
   * **Function:** Gradual nutrient dispersal with watering.
   * **Examples:** Tree spikes, stakes for pots or crops.
   * **Benefits:** Simplified application, consistent nutrient distribution.

#### Measuring Fertilizers:

1. **Nutrient Ratio:** Defined by the N-P-K values, indicating nitrogen (N), phosphorus (P), and potassium (K) percentages, respectively.
2. **By Weight:** Quantities in pounds or kilograms, common in agricultural sales.
3. **By Volume:** For liquid fertilizers, measured in liters or gallons.
4. **Application Rate:** The fertilizer amount per area, like pounds per acre or grams per square meter.

**Key Takeaway:** Choosing the right fertilizer and amount is crucial. Over-fertilization can damage plants and ecosystems, while under-fertilization may not yield the expected results. Always read instructions, test soil when possible, and consult experts for best practices.

## Garden Journal 2: The Life Cycle of a Plant

**Objective:** Explore and understand the different stages in the life cycle of a plant, from seed to fruit.

**Duration:** 15 to 20 minutes

**Instructions:**

1. **Introduction**: Begin by asking students if they've ever seen a seed grow into a plant and eventually produce fruits or flowers. This will help them recall and relate to personal experiences.
2. **Group Activity**: Distribute a variety of seeds to each group (bean seeds, sunflower seeds, etc.). Allow them to observe the seeds and discuss their thoughts on how these small seeds can grow into large plants.
3. **Journal Entry**: In their garden journals, students will:
4. Draw or represent the life cycle stages of a chosen plant: seed, germination, growth (seedling, mature plant), flowering, and fruiting.
5. Write a brief description of each stage, explaining what happens during that time.
6. Document any observations they had during the group activity, such as the size, shape, and texture of the seeds they observed.

**Class Sharing**: After the journaling activity, invite each group to present their life cycle drawings and descriptions. Discuss any similarities or differences between the various plants' life cycles.

***Handouts and Video***

* *Share and Discuss "Garden Journal Entry 2"*

## Activity: Planting Lettuce in a Mason Jar

**Activity Steps:**

1. **Preparing the Grow Medium:**
   * Soak rock wool cubes in water until no more bubbles emerge.
   * Use a pencil or toothpick to make a small hole in the rock wool for the seed.
   * Insert two lettuce seeds to ensure germination.
2. **Preparing the Nutrient Solution:**
   * Mix water with water-soluble fertilizer as per package instructions in a one-gallon jug.
3. **Setting Up the Mason Jar:**
   * Cover the mason jar with a black sock. Alternatively, wrap it in construction paper or spray-paint it to prevent light penetration.
   * Fill the jar with the nutrient solution, leaving about a 3-inch gap from the top.
   * Attach the canning lid rim without the metal seal.
4. **Planting:**
   * Place the soaked rock wool cube with seeds into a 2-inch net cup.
   * Use clay pebbles or pool noodle slices to fill gaps around the rock wool in the net cup to block light and prevent algae growth.
   * Insert the net cup into the mason jar ensuring the water touches the bottom but doesn’t submerge the net cup.
5. **Growth and Maintenance:**
   * Ensure water is accessible to seedlings through capillary action.
   * Refill water when necessary, but never more than half of the jar to prevent root rot.
   * Place the jar under light for 6-8 hours daily, not exceeding 12 hours.
   * Monitor growth and harvest the lettuce when ready.

## Materials

* **Grow Medium & Planting:**
  + Rock wool or similar grow medium
  + Lettuce seeds
* **Jar & Accessories:**
  + Standard mason jar with lid rim
  + 2-inch net cups
  + Black sock or alternative cover
  + Clay pebbles or pool noodle slices
* **Nutrient Solution:**
  + 1-gallon jug of water
  + Water-soluble fertilizer
* **Lighting:**
  + Light source (natural or lamp)