# Seeds and Seed Germination

## Seeds

Objectives of today's lecture:

- Learn about the structure and composition of seeds
- Learn how seeds are used in horticulture
- Learn what happens during germination of seeds and the factors that influence this process

## Seeds

- Seeds are normally the product of sexual reproduction

Pollination
↓
Fertilization
↓
Embryogenesis
↓
Mature seed

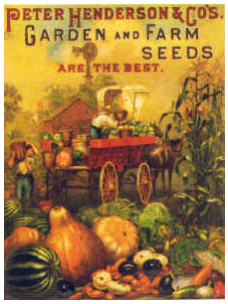
## Seeds

- Some seeds are produced without pollination, called **apomixis**. Examples include many citrus crops, mango, Kentucky bluegrass
- The plants produced from apomictic seed are genetically identical to the maternal plant - clones

Pollination
↓
Fertilization
↓
Embryogenesis
↓
Mature seed

## Seeds are for propagation

- The biological function of seeds is for propagation of the species
  - This is also one of the major functions of seeds in horticultural practice
  - What else are seeds used for?




## Seeds are the major source of food for the world

- Cereal crops: wheat, rice, corn, barley, oat, rye, millet, sorghum
- Pseudo cereals: buckwheat, amaranth
- Oil crops: soybean, sunflower, canola, other mustards
- Pulses: lentils, chickpeas
- Beans: navy, pinto kidney, fava, lima, butterbean, pigeon pea

## Top US seed Crops (2001)

- Corn- 9.51 billion bushels
- Sorghum (for grain) – 515 million bushels
- Rice – 213 million  hundred weight
- Soybeans- 2.89 billion bushels
- Wheat 1.4 billion bushels
- Oilseed- 80 million tons

## Seeds are alive!

- To function in propagation, seeds must be ***alive***
- Seeds respire (slowly)
  - consume $O_2$, produce $CO_2$ and $H_2O$
- Seeds have a finite lifespan
  - They cannot be stored indefinitely

## Seeds are alive!

- Seeds of many tropical plants remain viable for only a short time, a few days
  - Tropical plants grow in environments that do not have a winter season through which seeds must survive before the spring growing season. There is a cost in dormancy.
- Other seeds remain viable for a very long time, in some cases more than 100 years
  - Common feature of many weeds
  - Seed storage experiment at Michigan State

## General features of seeds

A number of structural features are common to almost all seeds

- Embryonic axis
  - Root and shoot, in a miniature form
- Food reserves
  - Allow seedling to grow before it is capable of performing photosynthesis
- Seed coat
  - Provides protection from the environment

## Monocots and Dicots

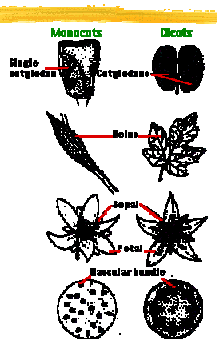
- Flowering plants (angiosperms) are divided into 2 groups based on seed structure
  - Dicotyledonous plants with two seed leaves
  - Monocotyledonous plants with one seed leaf

**Angiosperms**
**flowering plants**

- **Dicots** 200,000 species — **includes beans, roses, cacti, melons, citrus**
- **Monocots** 50,000 species — **includes grasses, lilies, orchids, palms**

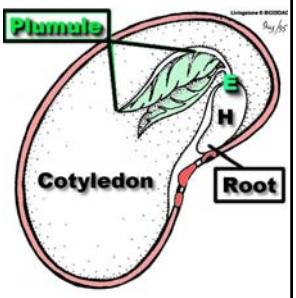
## Monocots and Dicots

- In addition to differences in seed morphology, there are a number of other common differences between monocots and dicots



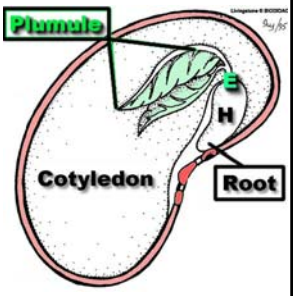
## A typical seed of a dicotyledon

- Embryonic axis (plant in miniature)
  - Plumule - first true leaves
  - Hypocotyl/Epicotyl - embryonic stem (H/E)
  - Radicle - embryonic root




## A typical seed of a dicotyledon

- Cotyledons (seed leaves for storage of food reserves)
  - Proteins
  - Starches, carbohydrates
  - Lipids, oils




## A typical seed of a dicotyledon

Exterior structure

- Seed coat for protection
- Hilum
  - where seed was attached to mother plant, "botanical belly button"
- Micropyle
  - where tube that carried pollen to the egg was attached

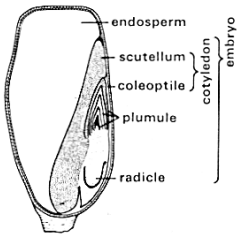
## A typical seed of a monocotyledon

Embryonic axis

- Plumule - first true leaves
- Radicle - embryonic root

Coleoptile

- Protective cap over plumule

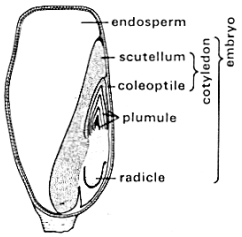



## A typical seed of a monocotyledon

Scutellum

- Transfer of food from endosperm to seedling

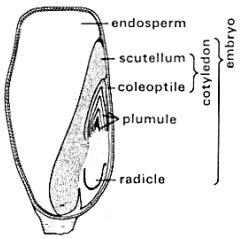
Coleoptile and scutellum are equivalent to cotyledons in a dicot




## A typical seed of a monocotyledon

Endosperm

- Food reserve and storage
  - Proteins, oils and starches



## Diversity among seeds

- Seeds are very diverse
  In terms of size
  - Begonia and Impatiens seed weigh 10-20 micrograms (millionths of a gram)
  - Coconuts weigh more than a kilogram, seeds of related palms weigh more than 15 kgs

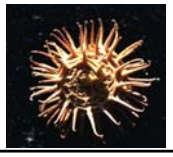

## Diversity among seeds

In terms of adaptation

- To survive various environments until conditions are favorable for germination

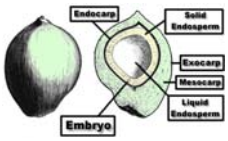
In terms of method of distribution

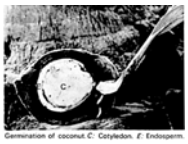
- By animals, wind, water



## Diversity among seeds

Distribution of coconut seeds by water



## Seed dormancy

- Maintains seed during adverse growth conditions (cold, drought)
- Lower metabolic rate
- Energy cost to reverse dormancy
- Maintained by hormone abscisic acid (ABA) / reversed by hormone gibberelic acid (GA)
- Stratification
- Scarification

## How long can a seed remain dormant

500 year old lotus seeds germinated!

Other seeds last a year or less

## Germination of seeds

**A complex series of steps involving:**

A. Uptake of water
B. Utilization of stored reserves
C. Development and expansion of the embryonic axis
D. Establishment of a seedling capable of sustained, independent growth

## Germination of seeds

**A.** Uptake of water - ***imbibition***

- Seeds are normally desiccated (~10% water)
- Desiccation allows seed to remain dormant
- Water uptake starts process of germination

## Germination of Seeds

Other important factors to consider at beginning:

- Temperature requirement
  - Some seed require a minimum temperature to germinate, e.g. tomato will not germinate below 10˚C (50˚F)
- Increased respiration
  - More oxygen is required for metabolism

## Germination of seeds

**B.** Utilization of stored reserves

- In cotyledons or endosperm tissue
- During germination, enzymes are made that convert stored reserves (large molecules) into compounds that can be used by the seedling (smaller molecules)
  - starches → sugars
  - lipids, fats → sugars
  - proteins → amino acids

## Germination of seeds

**C.** Expansion and growth of seedling
- Root radicle elongates down, hypocotyl expands up
- Establishment of root system and emergence of shoot

- Transport of compounds into growing seedling through vascular system
  - These compounds have two functions
    - Support respiration in the embryo
    - Provide a source of building blocks (carbon, nitrogen, etc.) for the seedling

## Germination of Seeds

**D.** Establishment of Seedling

- will discuss next lecture in more detail

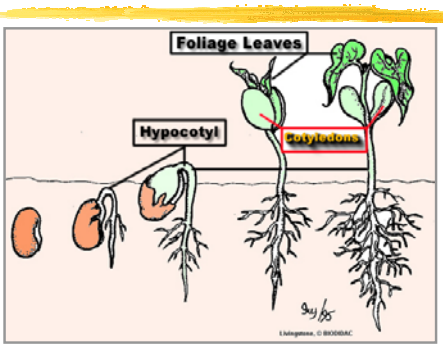
## Activity

- Living Necklace (aka –baby plant)

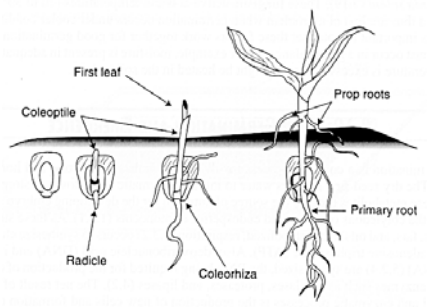
- You will germinate a seed
  - Hint – you get to care for and observe it in the process!

- You will need:
  - 1 Bag
  - 1 String
  - 1 Cotton ball
  - Few drops water
  - 1-2 Seeds

## Germination of dicot seeds




## Germination of monocot seeds




## Seed germination and the conversion of starches into sugars is important

Mature barley plants

Barley grain

The malting process Barley is germinated and enzymes produced in the seed convert starches to sugars

Germination is arrested by heating and drying the grain. The dry malt is the starting material for brewing

## The importance of converting starches into sugars during germination

**Sugars are extracted from the malt and mixed with yeast, hops and other flavoring ingredients. During fermentation, the sugars produced during germination of the barley grain are converted to alcohol**

## Conclusions

- Seeds are alive but dormant
- Comprise an embryonic plant and stored reserves
- Germination requires
  - Water - for imbibition
  - Oxygen - for respiration
  - Suitable temperature
- Outcome of successful germination is a seedling capable of independent growth