Plants have to start from something

- Sexual: A product of pollination leading to seeds.
- Asexual: A clone, i.e. a crown, bulb, rhizome, cuttings, etc.

What is the purpose of seeds?

- maintaining variability of offspring
- dispersal of offspring away from parent
- survival of plant (genetics) through difficult conditions over space and time.
Seed Anatomy
- Embryo - miniature plant in an arrested state of development
- Endosperm - food supply (can be comprised of proteins, carbohydrates, fats)
- Seed coat - hard outer covering that protects from disease and insects; also repels water
- Temperate seeds measure winter temperatures

Cut away seed
- Seeds contain protected miniature plants. This seed is a dicot with two seed leaves.
- Root apex at lower left
- Root connected to hypocotyl where cotyledons are attached
- Seed coat
- Endosperm

Seed Dormancy
Prevents germination under poor conditions for growth
Caused by:
(1) hard seed coat
(2) immature embryo
(3) chemical inhibitors in seed and fruit
Native plant seed dormancy

Most non-cultivated (selected) plant seeds have complex mechanisms that prevent germination right after the seeds mature.

Not as true for native seeds in the tropics

Stratification to break dormancy

- Cold temperature exposure crucial for most native temperate plants
- Each species has its own requirements
- Manipulated by nurseries doing seed propagation = stratification

What’s going on inside the seed?

- Plant hormones active:
  - CK (cytokinins) create embryo etc.
  - GA and IAA support cell division and elongation
  - ABA controls dormancy – as it erode, the seed can sprout with the right conditions

Weed seeds are special

- Deeply complex dormancy processes
- Ability to survive in ground for many years = "seed bank"
- Measure the passage of years
Cold dormancy is rare in domesticated species: Why?

Vegetable seed dormancy

Most vegetable seeds have little or no inherent seed dormancy as they mature since it has been bred out of them over thousands of years.

Scarification

- Artificially breaking down the seed coat to allow water to enter:
  - Mechanical
  - Acid bath (digestion mimic)
    - Dilute acidic solutions. Read plant propagation books for more info
  - Hot water
    - Put in 200 degree F water
    - Allow to soak overnight
    - Sow soon, keep moist
    - This can kill some seeds

Other germination factors
Seed germination requirements

- Activation of embryo within seed
- Preceded by water penetrating seed coat
- Oxygen, favorable temperature cycle, and (in some species) light required
- Other cues like fire, digestion, etc.
Several big concerns

- Germination percentage
- Vigor at germination
- True to type
- No seed borne disease present

Germination percentage

- Germination percentage is not always a true reflection of the vigor of the seed.
- Germination occurs when several key conditions are met: adequate moisture, appropriate temperature (varies for each species), oxygen (can be reduced by too much soil moisture), light, and dormancy regulators release embryo to grow.

Seed storage

- **Store cool and dry**!
- Storage life of seeds:
  - Beans: 3 years
  - Beets/chard: 4
  - Cabbage group: 5
  - Carrots: 3
  - Corn: 2
  - Onions/leeks: 1-2
  - Squash: 5+
  - Tomato/pepper: 4

Cool and dry

- Cool and dry are the best storage regimes.
- Dry is crucial – each 1% decrease in seed moisture (between 5-14%) nearly doubles storage life.
- Each 10°F decrease in temperature between 32 °F and ~100 °F also doubles storage life.
- If you can only control one factor, keep seeds dry!
Seedling vigor

- Vigor tests are becoming more common for vegetable seeds
- Vigor can be affected by
  - Maturity at harvest
  - Age of seed
  - Mechanical injuries
  - Seed borne disease
  - Storage environment
  - Genetic factors

Seed storage details

- Storage life affected by the condition of seed when it comes into storage
- As seeds age, both germination and vigor decline
- **Vigor declines faster than germination**!
- Use more seed in the furrow if it is older seed – results cold be poor

Seed emergence issues

- Gravity
- Soil texture
- Soil temperature
- Plant soil diseases and insects
- Crusting
- Crows

Seed germination and soil temperature

| Soil Temperature Conditions for Vegetable Seed Germination (in Degrees) |
|---|---|---|---|---|
| Area | Temperature | Depth | Distance | Insects |
| Soil | 15 | 20 | 25 | 30 |
| Lime | 10 | 15 | 20 | 25 |
| Phosphate | 5 | 10 | 15 | 20 |
| Nitrogen | 0 | 5 | 10 | 15 |
| Sulfur | -5 | 0 | 5 | 10 |
| Potash | -10 | -5 | 0 | 5 |
| Iron | -15 | -10 | -5 | 0 |
| Zinc | -20 | -15 | -10 | -5 |
| Copper | -25 | -20 | -15 | -10 |
| Manganese | -30 | -25 | -20 | -15 |
| Boron | -35 | -30 | -25 | -20 |
| Calcium | -40 | -35 | -30 | -25 |
| Magnesium | -45 | -40 | -35 | -30 |

Soil and water management is crucial for optimal seedling vigor and emergence.
Seed emergence and soil temperature

How to improve soil temperature for seed emergence

- Patience in planting and use of a soil thermometer
- Raised beds
- Clear plastic over soils
- Row covers

Heat really matters

- What a plant will tolerate and what a plant thrives in are two different things
  - Cool season crops: Can grow at <50°F but much better at 65°F. Tolerate frost. Peas, spinach, cole crops
  - Warm season crops need 60°F and thrive at 70-80°F
- Soil temperature effects
- Air temperature effects

How does clear plastic over soils help?

- Functions like a mini-greenhouse
- Rapid soil temperature rise
- Removed to plant or transplant
- Sometimes put back until the seed just starts to emerge – depends on temperatures expected
- Emerging crop can be covered with row covers to increase heat
Row covers

- Lightweight fabrics
- Improve day temperatures ~ 6-8 degrees
- Improve night temperatures ~ 3-4 degrees
- Can encourage slugs and weeds
- Used widely in commercial vegetable growing

Soil crusting

- Significant issue with clay soils
- Soil surface seals, slowing or preventing seed emergence
- Seeds run through their sugars and die or get diseased
- Small seed (carrots, lettuce, beets, etc. most susceptible)
- Prevention: build up organic matter in soils, potting soil over seeds in the furrow, row covers, transplants.

So why might you love transplants?

Virtues of transplants

- Heat embedded in their growth – start as the season is warming up
- More weed competitive
- Can get spacing right
- Earlier harvest
- Negatives
  - Expensive re labor
  - Specialized structure/equipment
Transplant size

- Depends a bit on transplant conditions, i.e. potential transplant stress.
- Generally, larger transplant "plugs" will produce a crop faster.
- Crop uniformity
- Must be hardened off
- Row cover after transplanting
- Weed competitive
- More than you think will transplant

Seed media selection

- Minimum 3" deep pot
- Wild seed: 2 parts peat/coir 1 part perlite (grit)
- Annual vegetables and flowers: Use a seeding commercial mix

Plug trays

- Bigger plug sizes seem better
- Commercial growers are transplanting crops that weren’t even considered transplantable 15 years ago, i.e. onions, beans, corn, and carrots (!!).

Hardening Off

- Harden off transplant seedlings to acclimate to
  - Wind
  - Intense light
  - Fluctuating temperatures
- Increase exposure time to direct sun, ambient temperatures, and wind in stages by moving seedling trays outside and then back into the protected growing area.
Vegetable seeds: Varieties, hybrid breeding, and seed saving

Seed topic areas
- What constitutes a variety?
- How do you get information on whether it will perform well in your garden?
- Seed saving

What is a variety?
A named “type” of a vegetable species, having certain distinguishing characteristics (taste, shape, color, size, length of season, etc.), being adapted to certain climates and soils, being resistant (or not!) to certain pests/diseases.
Also termed “cultivar” (cultivated variety).
A variety can be “open pollinated” (OP), a hybrid, or rarely in horticulture, genetically modified (GMO)

Gardeners like to grow multiple types of certain crops, enjoying the different colors, shapes, tastes, etc.
Market gardeners benefit from offering their clientele a nice range of choices.
Plant pollination basics

• Self-pollinating
  • Wheat, lettuce, beans, tomatoes, peas, peppers

• Cross pollinating
  • Corn, beets, squash family, carrots, cabbage family

Some species or families need more isolation than others

Open pollinated seed

• Open pollinated seed-saving is easy (more or less) with self-pollinating plants.

• It is a real challenge to save seed from cross pollinating plants because you have to control the crossing that occurs... unless you are growing only one variety (and have no neighbor gardens/farms within 2-3 miles growing the same plant)
What is an heirloom variety? 
An open-pollinated variety having some considerable ancestry and history of use.

Burpee’s Matchless tomato, Red Etna pepper and Sunshine pole bean

History of plant breeding from 4000 B.C. up to the 1940s

• Straight selection of the best plants
• Crossbreeding
  • Cross a high yielding variety of good eating characteristics with a variety of lesser characteristics but good disease resistance
• Backcrossing
  • Cross the resulting progeny again with the high yielding variety and select seed from plants that show both the yield/quality characteristics and the disease resistance.

Varietal purity

• Is it self or cross pollinating? Self pollinating species are easier to keep close to type since pollen at most moves very short distances (if at all out of the flower).
• Pollen from cross pollinating species may move hundreds of feet or even miles. An off type plant can produce pollen that reduces the varietal purity significantly.

Rise of the F1 Hybrids

• Increasing knowledge of hybrid vigor (heterosis)
• Ability to more quickly add specific characteristics (disease resistance, maturity time, seedless fruit, regional adaptability, etc.)
• Economic value to the company producing the seed
• Done with conventional breeding techniques (not genetically modified).
How were F1 hybrids created?

• Two stable varietal lines are created with conventional selection techniques.

• The lines are crossed in a controlled manner with one variety deemed the "pollen parent" and the other the female line (this is not easy!) The female can't produce pollen unless the species is pollen self-incompatible. You have to remove the anthers (usually with tweezers) before pollen starts to shed.
Cytoplasmic male sterility

Parental plants = round, yellow and wrinkled, green.
F1 generation = all uniformly round and yellow.
F2 generation = four different phenotypes, nine different genotypes.
Saving seed from the F1 will not yield uniform plants in subsequent generations.

General comments about seed saving
- Save seed from more than one good plant
- Save seed from the first emerging seedlings - can improve vigor
- Rogue out off-types (odd leaf patterns or growth habit) before flowering, if possible
- Harvest seed from healthy flowers/fruits that haven't been rained on (lowers the potential for seed-borne diseases).
- Somewhat contradictory to the above is to save seed from non-diseased plants where others have already succumbed.

Selection characteristics
- Yield
- Quality (incl. disease resistance)
- Earliness (not to be confused with bolting)
- Frost tolerance
- Other traits including insect resistance, drought tolerance, fruit cracking, general vigor, etc.
Variety performance information

- OSU or other published test results (in Google, type in "vegetable variety trials+oregon state university")
- Confidence in the testing of the company selling the seeds
- Accurate assessment of problems you have encountered
- Your own journal records

Family: Fabaceae

Crop Species:
- *Phaseolus acutifolius*: tepary bean
- *P. coccineus*: runner bean
- *P. lunatus*: lima bean
- *P. vulgaris*: common bean
- *Pisum sativum*: garden pea
- *Vicia faba*: fava bean

Seed saving: **Easy.** Largely self-pollinating. May be crossed by insects. For purity grow one variety, cage, or isolate by some distance.

Family: Chenopodiaceae

- Beets, spinach, chard
- **Possible.** All will cross with other varieties within each crop so isolation of 1/2 mile is important when they are in flower together.
- Beets and chard are biennial, spinach is an annual
- Harvest seed heads when dry. Spinach seed can be prickly. Beet seed is compound.

Family: Brassicaceae

Crop species:
- *Brassica juncea*: mustard greens
- *B. oleracea*: broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, kohlrabi
- *B. rapa*: turnip, Chinese cabbage, broccoli raab
- *B. napus*: rutabaga, canola (rapeseed)
- *Raphanus sativus*: radish

Seed saving: **Difficult.** Insect pollinated, largely self-incompatible. Save seed from more than one plant. Isolate by ½ mile or cage.
Family: Asteraceae

Crop species: 
*Lactuca sativa*: lettuce

Seed saving: Easy. Grown in Egypt by about 4500 BC. Largely self-pollinating. As flower opens, can be insect pollinated. Chance of cross-pollination by neighboring varieties not well known. Cage to ensure complete purity, or stagger planting times. USDA recommends 12 feet between varieties.

Family: Cucurbitaceae

Crop species: 
*Citrullus vulgaris*: watermelon 
*Cucumis melo*: muskmelon, cantaloupe, honeydew, casaba 
*Cucumis sativus*: cucumber 
*Cucurbita maxima*: squash (banana, hubbard, buttercup) 
*Cucurbita mixta*: squash (cushaw, silver-seeded gourds) 
*Cucurbita moschata*: squash (butternut, cheese, golden cushaw) 
*Cucurbita pepo*: squash (acorn, crookneck, scallop, spaghetti, zucchini, pumpkin)
## Curcurbit crossing relationships

- No crossing between genera

- Crossing between Cucurbita species:
  - C. maxima × C. moschata: yes
  - C. pepo × C. moschata: yes
  - C. pepo × C. mixta: yes
  - C. maxima × C. mixta: no
  - C. mixta × C. moschata: no

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## Seed saving:

**Difficult.** All species in this family have separate male and female flowers on each plant. All are insect pollinated and readily outcross with other varieties in same species. Isolate by ½ mile, or do hand-pollinating (flower bagging is easier than caging).

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## Family: Solanaceae

### Crop species:
- *Capsicum annuum:* sweet and chili peppers
- *Lycopersicon esculentum:* tomato
- *Solanum melongena:* eggplant
- *S. tuberosum:* potato

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## Tomatoes

**Seed saving: Easy.** Most tomatoes can be grown side by side with no crossing. Can’t save hybrids (well, sort of)  
To save seed, squeeze ripe fruit into container to collect seeds and surrounding gel.  
Allow gel to ferment for a few days. After this time, rinse resulting smelly goop to clean and isolate seeds, and then allow them to air dry.
Seeds and juice are squeezed into plastic cups, covered with a paper towel to prevent it from becoming a fruit fly paradise but still allowing air in so the fermentation process starts. After about a week the fermentation process is complete. This will help kill off unwanted diseases and produce a clean seed for next year's planting. The freshly fermented seeds are rinsed clean and put on a paper plate to dry for a couple weeks.

An alternative technique

- Scrape out the seeds onto paper towels which you have labeled
- Let dry for several days to a week
- Fold up paper towel and put in envelope
- Label envelope and put (along with others) into a freezer bag and freeze
- This technique will not reduce seed borne diseases

Peppers

Seed saving: Somewhat easy. All are capable of self-pollinating, but will also out-cross with insect assistance.

Isolate by at least 500 feet, or cage. May need flower agitation or hand pollination.

Bag individual flowers to prevent crossing.
Family: Apiaceae

Crop species:
- *Apium graveolens*: celery
- *Anethum graveolens*: dill
- *Coriandrum sativum*: coriander (cilantro)
- *Daucus carota*: carrot
- *Foeniculum vulgare*: fennel

Seed saving: **Difficult.** Self-incompatible. Insect pollinated. For purity, isolate by three miles, or cage, or hand pollinate.