Introduction to Plant Breeding

Master Gardener Training
Start with a seed
Germplasm
Germplasm

The greatest service which can be rendered to any country is to add a useful plant to its culture

-Thomas Jefferson
Fairchild was responsible for bringing the cherry trees from Japan to D.C.
Wild apples came From Kazakhstan, a species called *Malus sieversii* is the likely ancestor

Apples were likely moved along the Silk Road to Europe, where they crossed with crabapples and generated more variation

European settlers brought apple to the U.S. They grafted on to New World *Malus* trees and seedlings in later years were selected
Introduction of the tomato into Italy.
Germplasm

...is both the genetic material (genes, groups of genes, chromosomes) that controls heredity and the tissues, organs, and organisms which express variation contained in that genetic material.

-from NPGS (National Plant Germplasm System)
National Plant Germplasm System

- Coordinated by USDA
- Contains more than 500,000 accessions
- Accession can be
  - population, line, cultivar, individual plant, clone, etc.
- All germplasm in NPGS available free
- Used by US and world scientists
- Comprised by 4 major areas
  - Plant Introduction
  - Plant Collection
  - Information Systems
  - Germplasm Advisory Groups
Seed Banks

Kathy Reitsma
Ames, IA
Creating Variation
Make a cross
You must get to the floral parts before the plant pollinates itself or is pollinated by another plant.
This often means opening the flower long before it is ready
• Most of our crops can be classified as cross pollinated or self pollinated
• Cross pollinated means that an insect or wind normally carries pollen from one plant to another in order to fertilize it
• Self pollinated means that the plant will pollinate and fertilize itself

• *Both types require that you cross one plant with another in order to generate variation that you will use as the basis of your selections!*

• Vegetatively-propagated plants still need to be flowered in order to create new variation that is heritable
If the flower is bisexual, you may need to remove the anthers before you make your cross
Floral Biology

Stigma

Ovary

Nectaries

Anthers

Petals
Corn stigma
Squash ovary, ovules, pistil
Ovules and unfertilized ovules
Female (left)
Male (right)
of hubbard squash
You can create variation by making a cross and creating new recombinants.

You can also introduce variation by bringing in new types.
The part of the plant of greatest interest to man is the part that is modified the most. - J.R. Harlan
Centers of Origin

- Eight major centers of origin for cultivated plants

1 China  
2 India  
2a Indo-Ma  
3 C. Asia  
4 Near East  
5 Medit.  
6 Ethiopia  
7 Mexico  
8 S. Amer.  
8a Chile  
8b Brazil
The crossing phase may require specialized equipment and pollinators.
Methods
Generations:

Year 1   P1 x P2
Year 2   F1
Year 3   F2

S1 families if self pollinated
F3 if intermated
Generations:

Year 1  P1 x P2
Year 2  F1
Year 3  F2

Too much inbreeding, beyond S6, may be deleterious
Backcross
Backcross Breeding

• Essentially a method for improving an established variety that is deficient in only one or a few characteristics
• The backcross generations converge on a single genotype
• Only breeding method in which the results are both predictable and repeatable
Requirements

- A satisfactory recurrent parent, usually an established cultivar
- A donor parent with a desirable characteristic
- A sufficient number of backcrosses to reconstitute the recurrent parent
Backcross squash

Recurrent parent
Butternut squash.
Great flesh color.

Donor parent
Yellow rind color

F1
Rounder shape, but buff brown

James Nienhuis
F2 population of “Buttergold”

Appears to segregate as single gene recessive
- note bicolor fruit.
Implementation

- A cross is made between the ‘Donor’ and ‘Recurrent’ parent, then the F1 and subsequent generations are crossed (backcrossed) to the recurrent parent.
- The backcross generations converge on a single genotype.
- The genetic contribution of the ‘Donor’ parent will be halved each generation.
Pedigree
Pedigree selection

• Pedigree, as the name implies, provides a record of the lines of descent of all individuals in each generation.

• The accumulation of information is important when decisions need to be made regarding keeping or eliminating a line.
Requirements

• Two parents
  – Choice of parents is critical, as you invest a lot of time and resources in each pedigree
    Complementary in strengths and weaknesses
Implementation

You will observe lots of segregation if you cross two very different parents, and sometimes that variation will aggregate in different groups.
Implementation

• Composite seed from each F2 plant, and grow out F3 families
  – Select among and within families in early generations
  – Select only among families in later generations
Features of Pedigree selection

- After inbreeding and testing lines can be bulked and released as cultivars.
- It’s fun and flexible
- When a superior family is identified, you can trace back in the pedigree and select in earlier generations
Negative features

• Maximum productivity is established in F2 generations
• Minimum recombination
Recurrent Selection
Recurrent Selection

• Cyclical procedure designed to increase the frequency of favorable alleles in populations

• Especially useful for:
  – Quantitatively inherited traits
  – Maintaining genetic variance
  – Adapting exotic germplasm
Three phases

The phases may represent different generations, or may be combined:

1) Develop population structure

2) Evaluation

3) Recombination among only selected genotypes
Illinois High-low oil and protein experiments
Evaluation and Selection