Paul Gepts, Agronomy and Range Science, 2-7743,
plgepts@ucdavis.edu

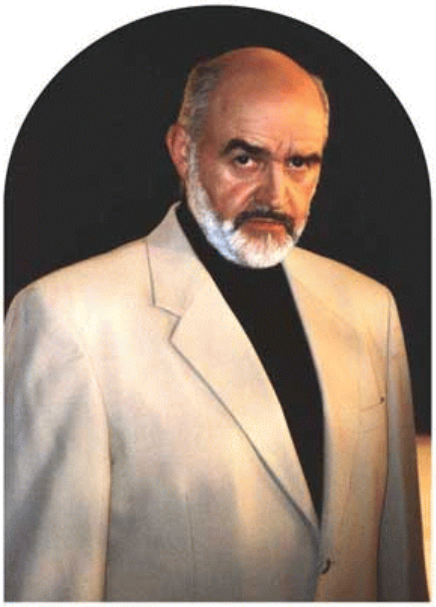
Brief review of last lecture

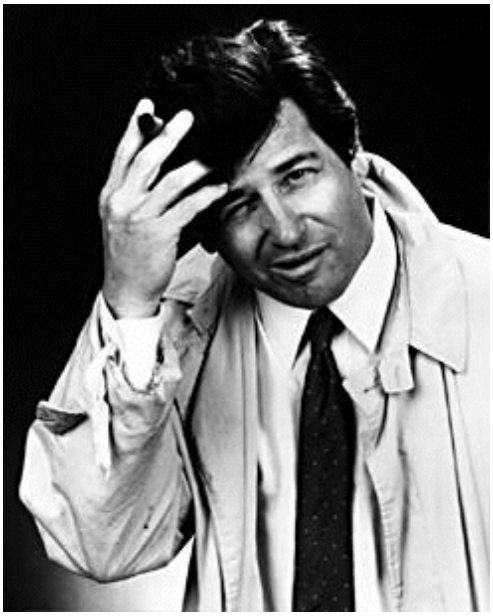
- Goals of crop improvement
- Crop improvement = genetics/breeding + agronomic practices
- Genetic diversity:
  - < Raw material of plant breeding
  - < Types of genetic diversity:
    - – Types of materials: wild, heirloom or landraces, etc.
    - – Gene pools: I - IV
    - – Centers of origin and domestication
    - – Gene banks
- Phases in crop improvement
  - < Assembly and recombination of genetic diversity
  - < Selection and development of varieties
  - < Release, distribution, and commercialization of new varieties

Selection and testing to identify superior recombinants

- Concepts:
  - Genotype and phenotype
  - Heritability
  - Qualitative and quantitative traits
- Classifying selection methods

Genotype-Phenotype





Heritability

- The proportion of observed variation, which is due to genetic causes, the remainder being due to environmental causes
- $H_{BS} = F_G^2 / (F_G^2 + F_E^2) = F_G^2 / F_P^2$
- Examples of *H* values:
  - < Yield: low: 0.2-0.3
  - < Seed weight: high: 0.7-0.8

Qualitative vs. Quantitative Traits

- Definitions:
  - < Scoring
  - < Number of genes and environmental influence
    - – Qualitative: single gene, “no” environmental influence
    - – Quantitative: $2 genes, environmental effect
- Examples of qualitative and quantitative traits

Classification of selection methods

- Two major criteria:
  - < Reproductive system
  - < End-product: type of variety
- Reproductive system:
  - < Cross-pollinated
  - < Self-pollinated
  - < Vegetative reproduction
- End-product:
  - < Pure lines, synthetic varieties, OP, Hybrids

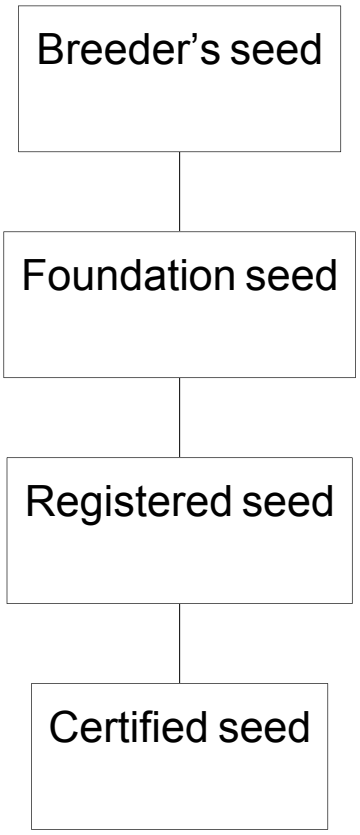
Breeding methods according to Reproductive System and Types of Varieties

Breeding method	Self	Cross
Introductions	Yes	Yes
Pure-line	Yes	Inbreds for hybrid varieties
Pedigree	Yes	For parents of hybrids
Mass selection	Occasionally	Often
Bulk populations	Occasionally	Occasionally
Backcross	Yes	Yes
Hybrid varieties	Occasionally	Yes
Recurrent selection	Occasionally	Yes
Synthetic varieties	Occasionally	Yes

Release, distribution, and commercialization of new cultivars

- Seed certification
- “Technology package”
- Intellectual property rights:
  - < Plant variety protection
  - < Plant and utility patents

Seed Certification



Produced by breeder: very valuable because source of future increases

From breeder's or foundation seed

Only in some states

Sold to farmers for commercial production

- Varietal purity
- High seed germination
- Free of diseases and pests
- Free of extraneous materials: weed seeds, soil, etc.

Intellectual Property Rights (IPR)

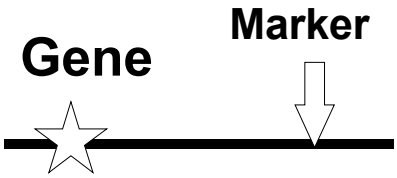
- Plant Patent: US Patent Office
  - < Since 1930
  - < Only clonally propagated
- Plant Variety Protection: USDA PVP Office
  - < UPOV Conventions: 1970, 1994
  - < (Certified) seed can only be sold with permision of owner
  - < Novel, distinctive (even traits w/o agronomic interest); after 1994: also “essentially derived” are protected
  - < Only inbred materials, no hybrids; only seeds and plants
  - < Farmer’s, breeder’s, and research exemptions
- Utility Patent: US Patent Office
  - < Since early 1980s
  - < Broader than PVP:
    - – More than one variety (More than one species!)
    - – All plant biological material as well as processes and include protection for recombinant processes, genes, culture techniques and plant parts
    - – A new invention, involve an inventive step, and be able to be replicated by a person skilled in the art.
    - – No “look-alikes” (”substantial equivalence”)
    - – No exemptions except non-profit research
    - – “Safer” and costlier protection

New plant breeding technologies

- Marker-assisted selection
- Plant transformation

Marker-assisted selection

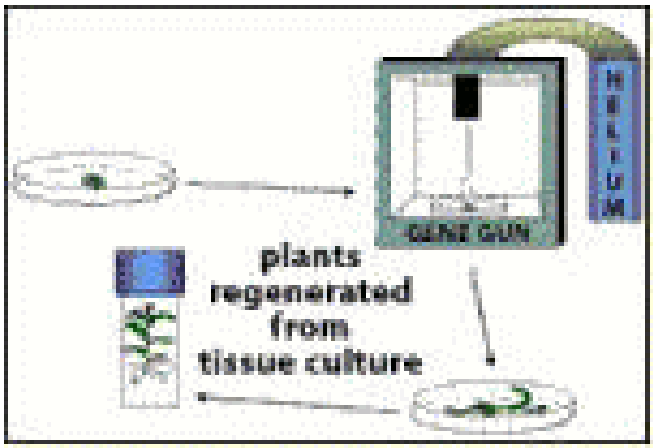
- Indirect selection with molecular markers



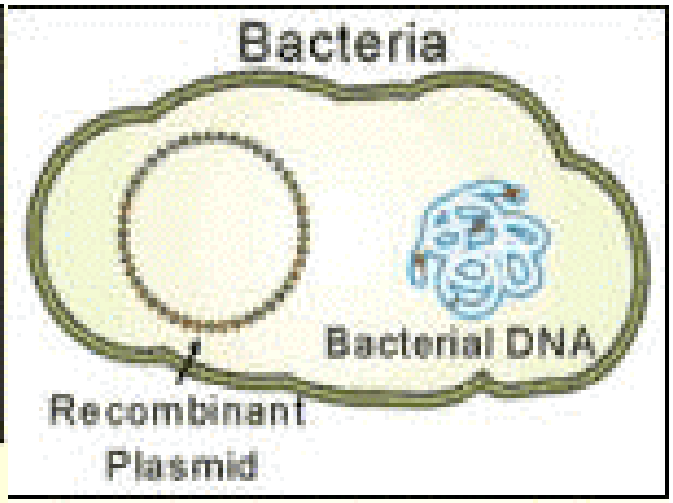
- When?
  - < Higher heritability
  - < Cumbersome screening
  - < Genetic interactions
- Two-fold selection:
  - < For the gene from donor
  - < For the genetic background of the recipient
- Plants and animals

Genetic Engineering

Two major transformation methods



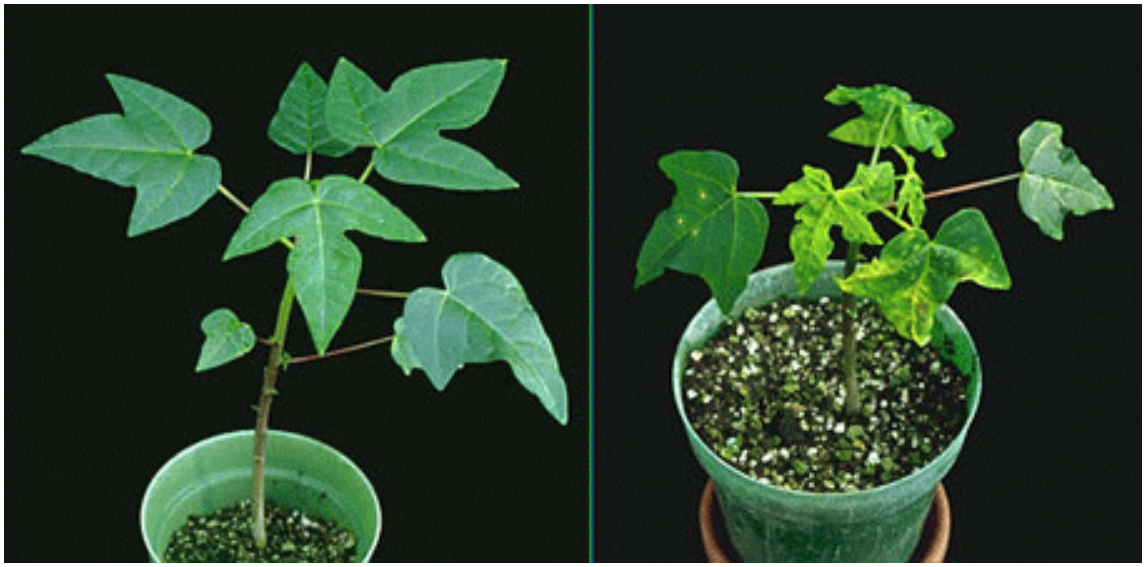
Gene gun transformation begins by growing cells in tissue culture, bombarding the cells with gene coated gold particles in the gene gun, selecting out transgenic cells on selection media, and regenerating the transgenic cells into plants.



Agrobacterium that contain a plasmid recombinant with the gene of interest are added to a solution containing callus cells

- Constructs:
  - < Gene(s) of interest
  - < Promoter
  - < Selectable marker
- 'Event': insertion of a particular transgene into a specific location on a chromosome.
  - < No disruption of important genes
  - < High level of expression
  - < Stable expression

Example of Use of Transgenics



Transgenic papaya inoculated with PRSV from Hawaii (left) and nontransgenic papaya inoculated with PRSV from Hawaii (right). Transgenic papaya contain a coat protein gene of the virus.

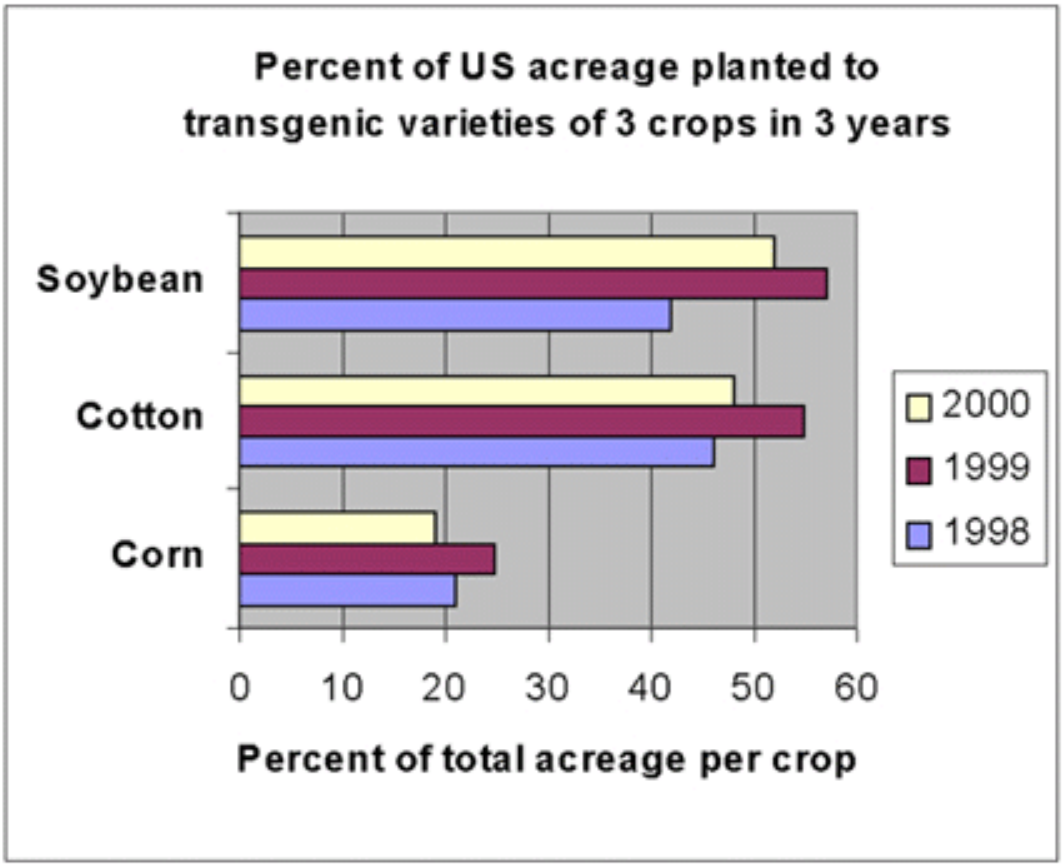
Rows of nontransgenic papaya (left)as compared to the resistance in rows of 'UH Rainbow' (right)

- GE Foods in the Market
  - < 60 to 70% of foods in US markets contain at least a small quantity of some crop that has been genetically engineered. But which ones?
  - < Fresh produce at a USDA Farmers Market in Washington, D.C. Which of these might be genetically engineered? Answer: only the yellow squash (front right).


Photo: USDA

- Am I eating genetically engineered foods?
  - < The Big Players: soybeans, corn, canola, cotton
  - < The Little Guys: potato, squash/zucchini, papaya, tomato, sugarbeets, rice, flax, radicchio
- GE bacteria, fungi, and yeast in food production
  - < Rennet: chymosin

http://www.comm.cornell.edu/gmo/crops/eating.html



http://www.colostate.edu/programs/lifesciences/TransgenicCrops/current.html

Transgenics: New Technology

- Potential benefits:
  - < Broadening genetic diversity
  - < Alternative control strategies for disease and pests
  - < Conservation tillage
- Potential concerns:
  - < Environmental
  - < Public health
  - < Ownership of food chain
  - < Limited range of agricultural practices

Lecture Summary

- Challenges to breeder:
  - < Genotype-phenotype
  - < Low heritability
  - < Quantitative traits
- Different breeding methods
  - < Reproductive system
  - < Type of variety
- Three phases of plant breeding
- Seed certification and intellectual property rights
- Newer methods in plant breeding