HORT/AGRO 689: Molecular & Biological Techniques in Plant Breeding

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This Course is Not:

- A molecular biology course
  - Students should have an understanding of basic molecular biological techniques used in plant improvement
  - Techniques will be covered, but focus will be on Applications of the technology, not Development
- A genetics course
  - Students should have an understanding of the principles of genes (including structure & function) and heritability

This Course Is:

- A review of special tools and techniques that can be applied to a plant breeding program with a focus on the role of genetics
- An introduction to the applications of new technologies, including molecular biology, from a plant breeding perspective
- (Hopefully) An interactive investigation of special considerations to the application of these new technologies

Required Reading

- J. Knight. 2003. A dying breed. Nature. 421:568-570

Important Events in Plant Improvement

- 1865: Gregor Mendel lectures & then publishes "Experiments with Plant Hybrids" (in 1866) where he describes how traits are inherited and the Laws of Inheritance:
  1) Segregation
  2) Independent Assortment
- 1869: DNA Identified in white blood cells
- 1900: Rediscovery of Mendel's work:
  - Tschermark: Did not understand the concepts of Dominance, Phenotypic ratios or observation & theory
  - deVries: Inferred Mendel's 1st Law, but did not separate gene transmission & expression
  - Correns: Clearly understood Mendel's data; Dominance = analagen; segregation is a pair of factors; understood 9:3:3:1 ratio's; but he did confuse segregation within a trait to segregation between traits

Important Events in Plant Improvement

- 1904: Gene Linkage demonstrated
- 1905 – 1908: Modifier genes described
- 1909: Relationship between genes & proteins
- 1913: First genetic map constructed
- 1920's: Hybrid cultivars adopted
- 1926: Pioneer Hi-Bred formed
- 1928: Transformation observed in bacteria
- 1935: Pure DNA isolated
- 1941: One gene – One enzyme hypothesis
- 1953: Molecular structure of DNA discovered

Important Events in Plant Improvement

- 1953: Plasmids observed to transfer genetic markers between bacteria
- 1959: Gene regulation established in the DNA sequence
- 1966: Genetic code deciphered
- 1969: First gene isolated
- 1972: First recombinant DNA created
- 1972: First successful DNA cloning performed
- 1973: First recombinant DNA organism created
- 1978: RFLPs are discovered
- 1980: PCR technique invented
- 1984: DNA fingerprinting developed

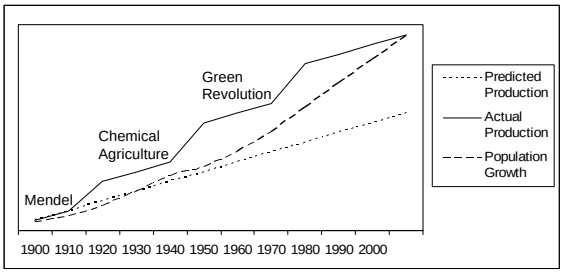
Discoveries Usually Take Time to Reach Potential

- 1838: Theory of totipotency developed
- 1939: Carrot callus cultures cultivated
- 1959: Plants regenerated from carrot cultures
- 1946: Source of dwarfing gene sent to US
- 1962: Dwarfing gene used to start the Green Revolution
- 1943: Mexican Agricultural Program initiated
- 1957: Mexico became self-sufficient in wheat production
- 1951: Barbara McClintock reported her work on transposable elements in maize
- 1983: Barbara McClintock received Nobel Prize for work on transposable elements

History of Modern Plant Breeding

- Mendelian Genetics – early 1900s
  - Resulted in Hybrid Cultivars
- Chemical Agriculture – 1940s
  - Allowed more freedom for breeders to select high yielding, high quality genotypes
- Green Revolution – 1960s
  - Combined Modern Varieties with Chemical Fertilizers

World's Food Supply vs. Increasing Population



Modern Agriculture has not been readily accepted

➢ **LUTHER BURBANK**

"We have recently advanced our knowledge of genetics to the point where we can manipulate life in a way never intended by nature."

"We must proceed with the utmost caution in the application of this new found knowledge."

- **1906**

Resistance to the Green Revolution

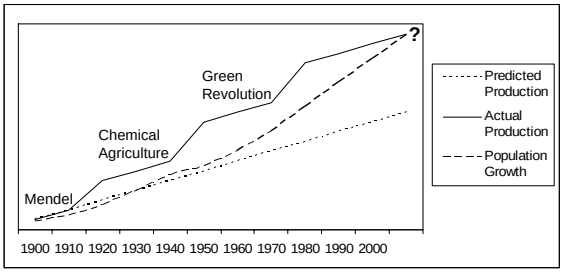
- India resisted the importing of "exotic" wheat in 1965:
  - These varieties would "destroy Indian agriculture" warned scientists.
- The Minister of Agriculture allowed for the use of the new varieties because of the crisis facing Indian agriculture:
  - Predictions gave the country two years before wide-spread famine engulfed the country.
- Within two years, a bumper crop helped feed the nation

(http://www.observerindia.com/news/200011/24/commentary03.htm)

Resistance to Chemical Agriculture

- No References to resistance prior to wide-spread use (acceptance)
- Indiscriminate use of Chemical Agriculture probably poses the greatest risk to public health of all modern farming practices

World's Food Supply vs. Increasing Population



Where will the next major advance in Agricultural Production come from?

- Plant Breeders will likely play a major role:
  - 2 of the 3 major advances in the 20th Century were directly attributable to plant breeding
- Modern Biotechnology is poised to provide a major advance:
  - But only if this basic science is understood and used by the applied sciences
  - Plant Breeders are the logical avenue for the application of biotechnology

Uses of Cell & Molecular Biology in a Breeding Program

- Source of Genetic Variation
  - The Ultimate Driving Force Behind All New Technologies
- To Speed Variety Development
  - Faster Source for Genetic Variation
  - Faster, more Efficient Assimilation of Traits
  - High Through-put Screening
- To Improve Quality
  - Purity/Hybridity Testing

Modern Plant Breeding Tools

- Tissue Culture Applications
  - Micropropagation
  - Germplasm preservation
  - Somaclonal variation & mutation selection
  - Embryo Culture
  - Haploid & Dihaploid Production
  - *In vitro* hybridization – Protoplast Fusion
  - Industrial Products from Cell Cultures

Reading Assignment:

D.C.W. Brown, T.A. Thorpe. 1995. Crop improvement through tissue culture. World Journal of Microbiology and Biotechnology. 11(4):409-415

D.R. Miller, R.M. Waskom, M.A. Brick & P.L. Chapman. 1991. Transferring *in vitro* technology to the field. Bio/Technology. 9:143-146