The Application of Genomic Resources in Wheat Breeding
• 17 Gb genome
• 42 chromosomes
• 100,000 genes
• Highly repetitive
• Allopolyploid
What Do Genome Sequences Offer?

• A resource for reference based mapping
  • Unlimited source of DNA markers for MAS/genomic selection

• Physical intervals for quantitative trait loci

• A roadmap of genes

• Candidate genes for traits = perfect markers

• Discovery and exploitation of new alleles
What is Genomics?

The study of genomes and their function

- **Structural genomics**: Examines the physical nature of genomes
- **Comparative genomics**: Compares the structure of genomes within/between different individuals or species
- **Functional genomics**: Studies expression and function of the genome
Cost to Sequence a Human Genome

-99.999%
Priorities in Wheat Breeding

• Increase Yields – **Profitability**
• Durable disease and pest resistance – **Yield Stability**
  • Wheat Rusts – new virulence
  • FHB – symptoms/mycotoxins,
  • insect pests (midge, sawfly)
• Abiotic stresses
  • Drought, heat stress
• Nutrient use efficiency
• End-use quality - **Marketability**
Annual Yield Gains Lag Future Demand

- **Genetic gain**: 0.8% / year
- **On farm yield**: 1.5% / year
- **Global need by 2050**: 2.4% / year
Bridging the Yield Gap With Genomics
Harnessing the Diversity of Wheat

2018 - Chinese Spring Genome

Decreasing Sequence Contiguity

10 Genomes
- Core and Pan Genomes
100 Genomes
- 10X Genomics
- Structural/PAV
1000 Genomes
- Low coverage WGS
- Haplotypes
10,000 Genomes
- Exome Sequencing
- RNA Seq
- Reduced representation
- SNPs/Alleles

http://www.10wheatgenomes.com/
Genotyping

**Single Marker:**
- Agarose Gel
  - SSR (short sequence repeat)
  - CAPS (cleaved amplified polymorphic sequence)
- Fluorescent Dye
  - KASP (kompetative allele specific PCR)

**Marker Arrays:**
- 9K SNP array (Illumina)
- 90k SNP iSelect array (Illumina)
- 820k SNP array (Axiom)
- Breeder array

**Sequencing:**
- GBS (genotype by sequencing)
- Exome (gene space from genomic DNA)
- RNAseq (gene space from mRNA)
Marker Assisted Selection

Unlocking Global Genetic Diversity

Genomic Diversity Analysis:
Narrowing genetic diversity an issue for evolving pests and pathogens of wheat
Predictive Selection

Genotyping

Phenotypic Data

Multivariate Statistics

Predictive Models

Actual vs. Predicted Yield

PREDICTIVE BREEDING
Summary: Impact of Genomics on Breeding

• Reference sequences are the starting point for integrated genomics

• Characterizing the full diversity of the species, and wild relatives

• Identifying the function of genes, and assigning marker trait associations

• Shift in towards predictive breeding strategies combined with classical plant breeding approaches
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