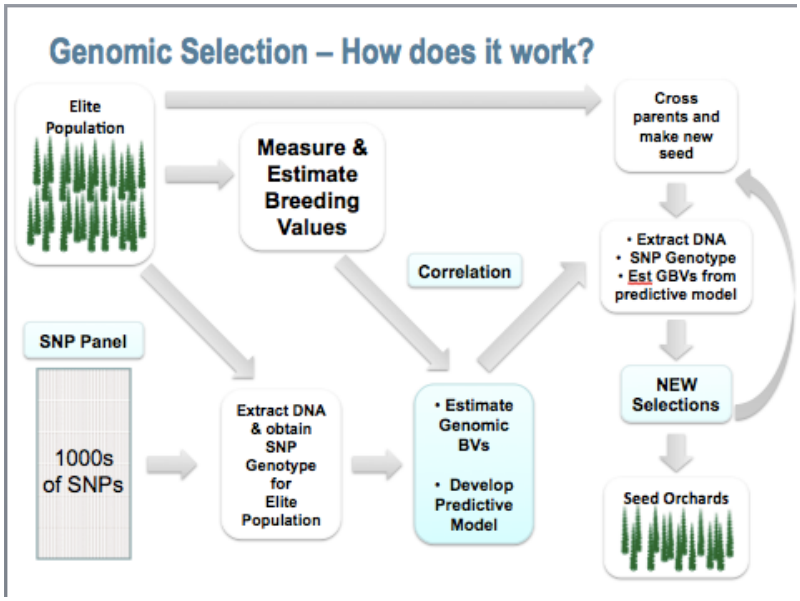
Genomics and Related Technologies – Where Does it all Fit?

What is genomics?

- Genomics is the study of the **genome** (the total DNA sequence of an organism). It's a discipline that uses tools to sequence, assemble and analyse the function and structure of the genome and to create fine-scale physical maps (as opposed to functional genomics which focuses on single genes).
- The **genotype** (the inheritable genetic information) "codes" for the **phenotype** (the outward manifestation of the tree, i.e. growth rate, disease susceptibility, wood properties etc). That is, the genotype provides the instructions to the cells to produce the phenotype.
- Because of past mutation, genomes vary between individuals, thus genotypes and their corresponding phenotypes also vary. This is the fundamental basis of genetic variation

Why invest in genomics?

- Genomics can greatly speed up deployment of improved stock (e.g., RNC-resistant material).
- Genome sequences provide the ability to read genetic text at the highest resolution possible. Genomic selection is an application that offers tremendous potential for breeding schemes, enabling early selection for multiple traits.
- Basically, scientists look for genetic 'markers', such as "SNiPs" (Single Nucleotide Polymorphism markers) that are associated with phenotypic traits of interest, such as disease resistance (see diagram below).
- The technology is expensive, but not nearly as expensive is it used to be a few years ago, and results in large amounts of data and the need for powerful computers (bioinformatics).



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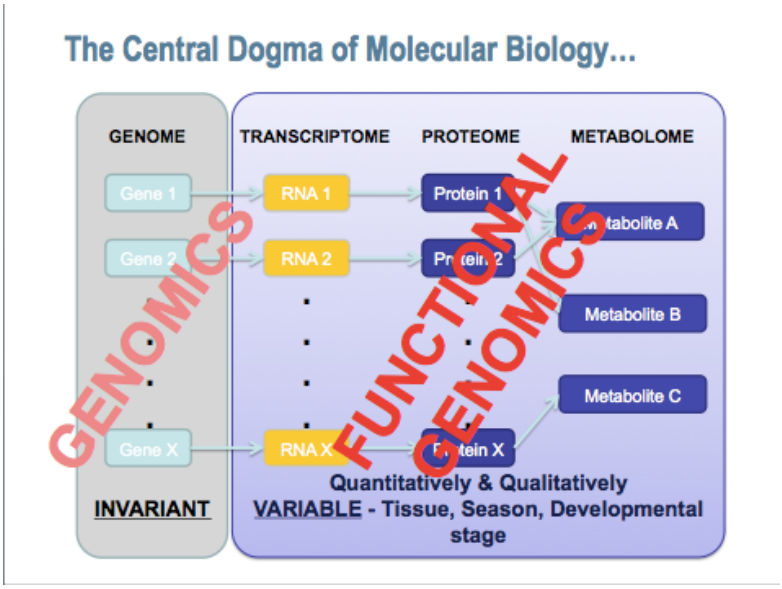
Why can't I just rely on using genetics and breeding?

- It's slow, and doesn't allow for fast response to challenges such as new disease incursions
- Genomics builds on traditional selective breeding concepts but is infinitely more powerful and will become even more so as our knowledge of gene function increases.

What is functional genomics and why should we care?

- Functional genomics is a branch of genomics that uses various technologies to analyse the function of genes. Metabolomics is one such tool and it analyses the metabolites produced by the cells and relates this to the genome. Transcriptomics analyses RNA and Proteomics analyses proteins. All these tools provide "microphenotype traits" as opposed to "macrophenotype traits" (tree size etc), which are what are normally measured in forestry (see diagram).
- See diagram below. DNA makes RNA that makes protein that collectively interact to make metabolites.
- Functional genomics can be applied to identify underpinning variation in disease response (for example); this adds to phenotype information and enables enhanced genetic selection for disease resistance planting stock.



What's the importance of Phenotyping?

- Good phenotype data, such as growth rate, form, density, disease resistance etc, is required to optimize the application of genomics. Knowledge of both the phenotype (what a tree looks like and does) and the genotype (its genetic makeup) is critical.
- This is shown in the diagram below, which describes how the current Scion and RPBC proposals fit together.
- There is already a great deal of data available with genetic trials, but the opportunity is there to rapidly and inexpensively collect additional data from trees growing outside trial sites using remote sensing technology.

Final Word

- The three bottlenecks in breeding currently are (1) adequately inexpensive and accurate phenotyping, (2) rate of generation turnover (= breeding cycle length), and (3) selection intensity.
- The current Scion and RPBC proposals under consideration will address these bottlenecks and enable more rapid progress towards enhanced disease resistance and increased productivity.