Module 3: Genetic Markers

Introduction

This module introduces genetic markers: what they are, how marker technologies have changed through time, and how they are used as descriptive tools for genetic applications. The emphasis will be on the markers themselves, rather than on analytical approaches of marker data. Analytical methods are introduced in Module 4. Module 3 builds upon introductory materials (from Mod 1 & 2) and provides the technical background of marker development and detection, serving as a basis for understanding marker analyses and applications to be introduced in Modules 4 onward. Given the current prevalence of markers derived from DNA polymorphisms, Module 3 also describes the role of bioinformatics in processing, assembling and assessing sequence information from a variety of sources.

Key Messages

- Genetic markers provide a means to track the inheritance of genes across generations and their behavior within populations.
- Genetic markers are diverse, including: Mendelian morphological markers, biochemical markers, and a variety of DNA-based markers. Markers can be either dominant or co-dominant, and can be used to track nuclear or organellar genes
- The type and availability of genetic markers has largely been driven by detection methods, including PCR and sequence polymorphisms
- Bioinformatics tools are essential for processing and analyzing sequence data. These tools include generic applications as well as custom-built platforms.

Outcomes

Course attendees will:

- learn how marker technologies have evolved from distinct Mendelian visual traits to modern DNA sequence polymorphisms
- understand how detection methods have gone hand-in-hand with the development of new marker technologies
- be able to assess trade-offs among types of marker technologies in terms of ease of application, marker numbers and throughput, and marker inheritance (dominant vs. co-dominant)
- gain familiarity with standard analytical tools for assessing DNA sequence variation

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Outline

I) Introduction to genetic markers
   A) What is a genetic marker?
   B) How are genetic markers useful?
   C) Historical developments and utility

II) Marker overview: types, historical applications, examples, limitations
   A) Morphological markers
   B) Cytological markers
   C) Biochemical markers
      1) Diverse types: Blood typing, Secondary compounds, Pigments, Monoterpenes
      2) Allozymes
   D) Nuclear vs. organellar markers

III) DNA markers (emphasis on SNPs, below)
   A) General discussion strategy to include (for each marker type)
      1) What they are and how they work
      2) What's needed to develop and implement marker detection system
      3) What technology('s) allowed their development??
      4) Advantages and disadvantages...
      5) Historical context (Where we've come in 20-30 years)
   B) RFLPs (pre-PCR)
   C) PCR-based: random targets (RAPDs, AFLP, etc)
   D) PCR-based: targeted amplification (SSRs, PCR-RFLPs, SCARs, ESTPs)

IV) Genomic-scale sequence-based methods (SNPs)
   A) Marker Development
      1) Sequence resources, reagents and approaches
      2) Genes, genomes, and genome architecture
      3) Processing sequence data: bioinformatics
      4) SNP-calling and validation
   B) Genotyping platforms and strategies

V) Lab (concurrent sessions)
   A) Continue Day 1 exercises
   B) Examples of DNA chromatograms, base-calling, etc
      1) Generation and analysis of individual sequences
      2) Phred/Phrap algorithms
   C) Assembler and alignment algorithms