Polyploidy

I. Types of polyploidy

   A. Autopolyploidy: more than 2 genetically identical genomes
   B. Allopolyploidy: combines the genomes of more than one species
   C. Intermediate situations, e.g. segmental allopolyploids
   D. Ancient polyploidy followed by chromosomal repatterning and restoration of diploid-like chromosome behavior "diploidization"

II. Frequency of Polyploidy

   A. 30-35% (Stebbins) - 70-80% (Lewis) of angiosperms
      depends if only "multiples" within a genus are counted or if \( n > 10 \) is counted
   B. Support for higher estimate
      1. Smaller stomata in Miocene fossils supports higher estimate
      2. Evidence for genome duplication *Arabidopsis* \( n = 5 \)
   C. Common in ferns [20% in North America] but not conifers

III. Genetics of Polyploids

   A. Allopolyploidy & Isozymes
      1. fixed heterozygosity
      2. disomic inheritance
      AAaa X AAaa   - > AAaa

   B. Autopolyploidy & Isozymes
      1. subset of progenitor's alleles
      2. tetrasomic inheritance
      AAaa X AAaa   - > 1 AAAA
      8 AAAa
e.g. *Tolmiea menziesii*

C. Gene silencing

1. Isozyme evidence:
   
a. high chromosome numbers in ferns but "diploid" isozyme numbers (e.g. *Botrychium*, an "old polyploid")

b. reduction of gene expression

2. DNA evidence:
   
a. pseudogenes indicated by indels and nonsense mutations

b. transcriptional & post-transcriptional silencing [epigenetic]

D. Acquisition of new function

a. accelerated rates of aa substitution in one orthologue

b. may be obscured by "long branches"
   [i.e. divergence of orthologues]

IV. Multiple origins of polyploids

A. Different fixed heterozygote genotypes in allotetraploids

B. Different cpDNA haplotypes

C. Different ITS repeats through concerted evolution

D. Documented in *Tragopogon*, *Brassica* triangle, various ferns

E. results in polyphyletic species, if independent polyploids are interfertile

Hybridization and Introgression

hybridization = \[ F_1 \]

“crosses between genetically differentiated taxa”

introgression = \[ F_2 \text{-backcrosses} \]
“movement of genes between species (or other well-marked genetic populations) mediated by back-crossing”

I. Outcomes of Hybridization

   A. Asexual reproduction
   
   B. Permanent translocation heterozygosity or odd polyploidy [partial sterility]
   
   C. Allopolyploidy
   
   D. Diploid Speciation

II. Hybrid zones

   A. Observed in many species

   Longstanding questions:
   
   1. primary speciation or secondary intergradation?
   
   2. Source of new species or just "evolutionary noise"?

   B. Ecology of hybrid zones

   1. Often in intermediate habitats
   
   2. Often in disturbed habitats
   
   3. Conservation concerns over loss of endemics due to hybridization with a widespread taxon

   e.g. Norway spruce swamping Serbian spruce

III. Documenting Hybrids

   A. Morphological analysis

   1. Biplots
   
   2. Principle components analysis

   reduces a data set of many characters to 1,2, or 3 new "composite" characters

   First principle components axis =
the combination of characters that captures maximal variation in the data set


**B. Diploid Hybrid Speciation**

considered uncommon, < 10 documented cases

1. fertile F1

2. Stabilization of hybrid segregants

3. How does it become reproductively isolated?
   a. postmating: recombinational speciation via chromosomal rearrangements
   b. premating: ecological divergence
      e.g. habitat or pollinator

4. Polarity assessment can be problematic, because ploidy level cannot be used as a clue to parentage

**IV. Introgression**

"genetic exchange between hybridizing species"

**A. Asymmetry of gene flow**

1. Nuclear genes transferred, cpDNA not
   e.g. Long-distance pollen movement (dispersed)

2. Chloroplast capture: cpDNA transferred, not nuclear genes
   e.g. compatibility asymmetry

**B. Gene trees vs. species trees as a diagnostic tool**

**C. Crop - weed complexes and genetically modified organisms**

   e.g. maize and teosinte
   *Zea mays* ssp. *mays* & ssp. *mexicana*