DAVID SANKOFF, University of Ottawa

Evolution in a cup

Plants evolve differently from other living forms. True the basic mechanism of DNA mutation from generation to generation is universal, with its substitutions, insertions and deletions in long strings ("chromosomes") of the four bases A,C,G and T. And like other organisms, chromosomes (each considered as a series of a few hundred or thousand distinct genes) may change by inverting segments of any length or by moving segments from one chromosome to another or to a different position on the same chromosome. But plants also evolve by autotetraploidization, duplicating their entire genomes, creating an extra copy of every chromosome and every gene within a single new genome. Or by allotetraploidization, combining two highly similar genomes into one, with two distinct subgenomes. Virtually every existing flowering plant has had one, two or more tetraploidizations in its history. Following such whole genome duplications (or triplications, etc.), the augmented genomes lose most of the extra genes, from one subgenome or the other, over a period of many generations, by a process known as fractionation. The arabica coffee genome was formed by the allotetraploidization of robusta coffee and another species, eugenioides, hundreds of thousands of years ago. A CIRCOS representation of the three species, appropriately arranged chromosome by chromosome in a single circular configuration, with chords connecting homologous chromosomal fragments in two genomes or subgenomes, captures the entire evolutionary history of arabica. In it we can see displayed the robusta-eugenioides speciation many millions of years ago, their more recent allotetraploidization, and the effects of fractionation.