7.4: Crossovers Allow Recombination of Linked Loci

Thus far, we have only considered situations with either no linkage (50% recombination) or complete linkage (0% recombination). It is also possible to obtain recombination frequencies between 0% and 50%, which is a situation we call incomplete (or partial) linkage. Incomplete linkage occurs when two loci are located on the same chromosome but the loci are far enough apart so that crossovers occur between them during some, but not all, meioses. Genes that are on the same chromosome are said to be syntenic regardless of whether they are completely or incompletely linked. All linked genes are syntenic, but not all syntenic genes are linked, as we will learn later.

Crossovers occur during prophase I of meiosis, when pairs of homologous chromosomes have aligned with each other in a process called synopsis. Crossing over begins with the breakage of DNA of a pair of non-sister chromatids. The breaks occur at corresponding positions on two non-sister chromatids, and then the ends of non-sister chromatids are connected to each other resulting in a reciprocal exchange of double-stranded DNA (Figure \(\PageIndex{4}\)).
Generally every pair of chromosomes has at least one (and often more) crossovers during meioses (Figure \(\PageIndex{5}\)).

\[Ab \quad \longrightarrow \quad \text{A} \quad \text{B} \quad \longrightarrow \quad \text{AB} \quad \longrightarrow \quad \text{aB} \]

\[aB \quad \longrightarrow \quad \text{a} \quad \text{B} \quad \longrightarrow \quad \text{ab} \quad \longrightarrow \quad \text{Ab} \]

**Figure \(\PageIndex{5}\):** A crossover between two linked loci can generate recombinant genotypes (AB, ab), from the chromatids involved in the crossover. Remember that multiple, independent meioses occur in each organism, so this particular pattern of recombination will not be observed among all the meioses from this individual. (Original-Deyholos-CC:AN)

Because the location of crossovers is essentially random along the chromosome, the greater the distance between two loci, the more likely a crossover will occur between them. Furthermore, loci that are on the same chromosome, but are sufficiently far apart from each other, will on average have multiple crossovers between them and they will behave as though they are completely unlinked. A recombination frequency of 50% is therefore the maximum recombination frequency that can be observed, and is indicative of loci that are either on separate chromosomes, or are located very far apart on the same chromosome.