S1.Zickler was the first person to demonstrate gene conversion by observing unusual ratios in *Neurospora* octads. At first, it was difficult for geneticists to believe these results because they seemed to contradict the Mendelian concept that alleles do not physically interact with each other. However, work by Mary Mitchell provided convincing evidence that gene conversion actually takes place. She investigated three different genes in *Neurospora.* One *Neurospora* strain had three mutant alleles: *pdx-1* (pyridoxine-requiring), *pyr-1* (pyrimidine-requiring), and *col-4* (a mutation that affected growth morphology). The *pdx-l* gene had been previously shown to map in between the *pyr-1* and *col-4* genes. As shown here, this strain was crossed to a wild-type *Neurospora* strain.

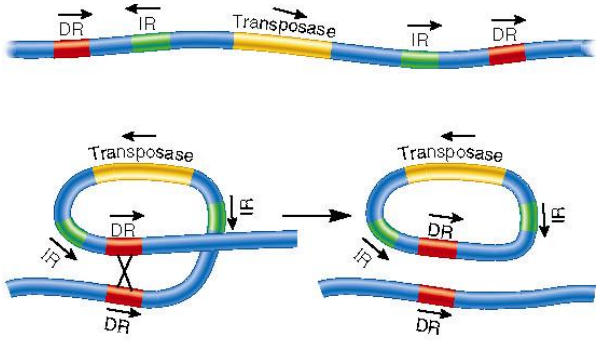
$$pyr\text{-}1\ pdx\text{-}1\ col\text{-}4 \mid pyr\text{-}1^{+}\ pdx\text{-}1^{+}\ col\text{-}4^{+}$$

She first analyzed many octads with regard to their requirement for pyridoxine. Out of 246 octads, two of them had an aberrant ratio in which two spores were *pdx-1* and six were *pdx-1*$^{+}$. These same spores were then analyzed with regard to the other two genes. In both cases, the aberrant asci gave a normal 4:4 ratio of *pyr-1: pyr-1*$^{+}$ and *col-4:col-4*$^{+}$. Explain these results.

Answer: These results can be explained by gene conversion. The gene conversion took place in a limited region of the chromosome (within the *pdx-1* gene), but it did not affect the flanking genes (*pyr-1* and *col-4*) located on either side of the *pdx-1* gene. In the asci containing two *pdx-1* alleles and six *pdx-1*$^{+}$ alleles, a crossover occurred during meiosis I in the region of the *pdx-1* gene. Gene conversion changed the *pdx-1* allele into the *pdx-1*$^{+}$ allele. This gene conversion could have occurred by two mechanisms. If branch migration occurred across the *pdx-1* gene, a heteroduplex may have formed, and this could be repaired by mismatch DNA repair as described in figure 17.7. In the aberrant asci with two *pdx-1* and six *pdx-1*$^{+}$ alleles, the *pdx-1* allele was converted to *pdx-1*$^{+}$. Alternatively, gene conversion of *pdx-1* into *pdx-1*$^{+}$ could have taken place via gap repair synthesis as described in figure 17.6. In this case, the *pdx-1* allele would have been digested away, and the DNA encoding the *pdx-1*$^{+}$ allele would have migrated into the digested region and provided a template to make a copy of the *pdx-1*$^{+}$ allele. Note: Since this pioneering work, additional studies have shed considerable light concerning the phenomenon of gene conversion. It occurs at a fairly high rate in fungi, approximately 0.1 to 1% of the time. It is not due to new mutations occurring during meiosis.

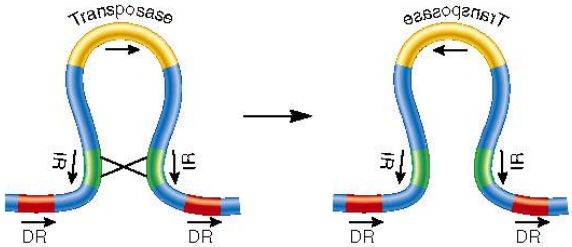
S2. Recombination involves the pairing of identical or homologous sequences, followed by crossing over and the resolution of the intertwined helices. On rare occasions, the direct repeats or the inverted repeats within a single transposable element can recognize each other and undergo genetic recombination. What are the consequences when the direct repeats recombine? What are the consequences when the inverted repeats recombine?

Answer:



Most of the transposable element has been excised.

(a) Recombination between direct repeats

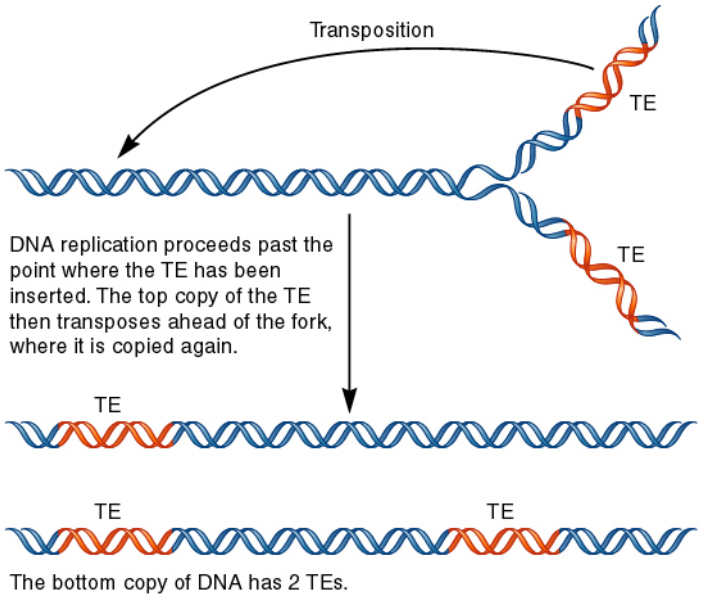


The sequence within the transposable element has been inverted.
Note that the transposase gene has changed to the opposite direction.

(b) Recombination between inverted repeats

S3.Replicative transposons are duplicated when they transpose, while cut-and-paste TEs are simply removed and placed in a new location. Based on these mechanisms, you might think that cut-and-paste TEs would have difficulty increasing in number. Interestingly, this is not the case. The reason why is because transposition frequently occurs during DNA replication. Explain how the number of copies of a cut-and-paste TE can increase in number within a single chromosome if transposition occurs during chromosomal replication.

Answer: The diagram shown here illustrates how this can occur.



As shown here, a chromosome containing a single transposon is in the process of DNA replication. After the replication fork has passed the transposon, one of the TEs transposes to a new location that has not yet replicated. Following the completion of DNA replication, one of the chromosomes has one TE while the other chromosome has two TEs. This second chromosome contains an additional TE compared to the parental chromosome. In this way, cut-and-paste TEs can increase in number.