CHAPTER 5 Transposon

5.1 Three principle classes of transposable elements

5.2 The mechanism of transposition

5.3 The genetic effects of transposition

Transposon

A transposon **(transposable element)** is a DNA sequence able to insert itself (or a copy of itself) at a new location in the genome, without having any sequence relationship with the target locus.

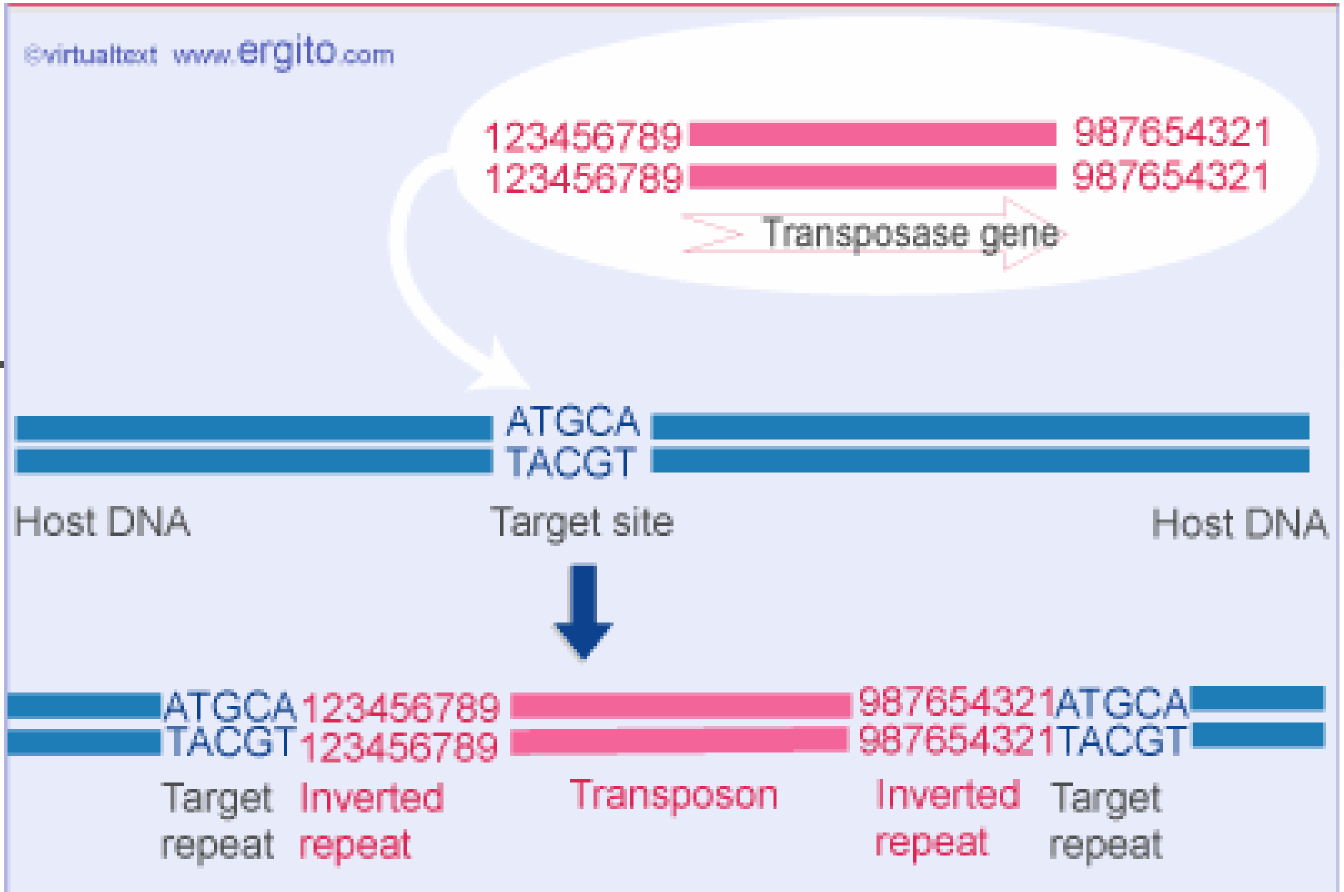
转座(transposition)：转座子的转移过程叫转座。

5.1 Three principle classes of transposable elements

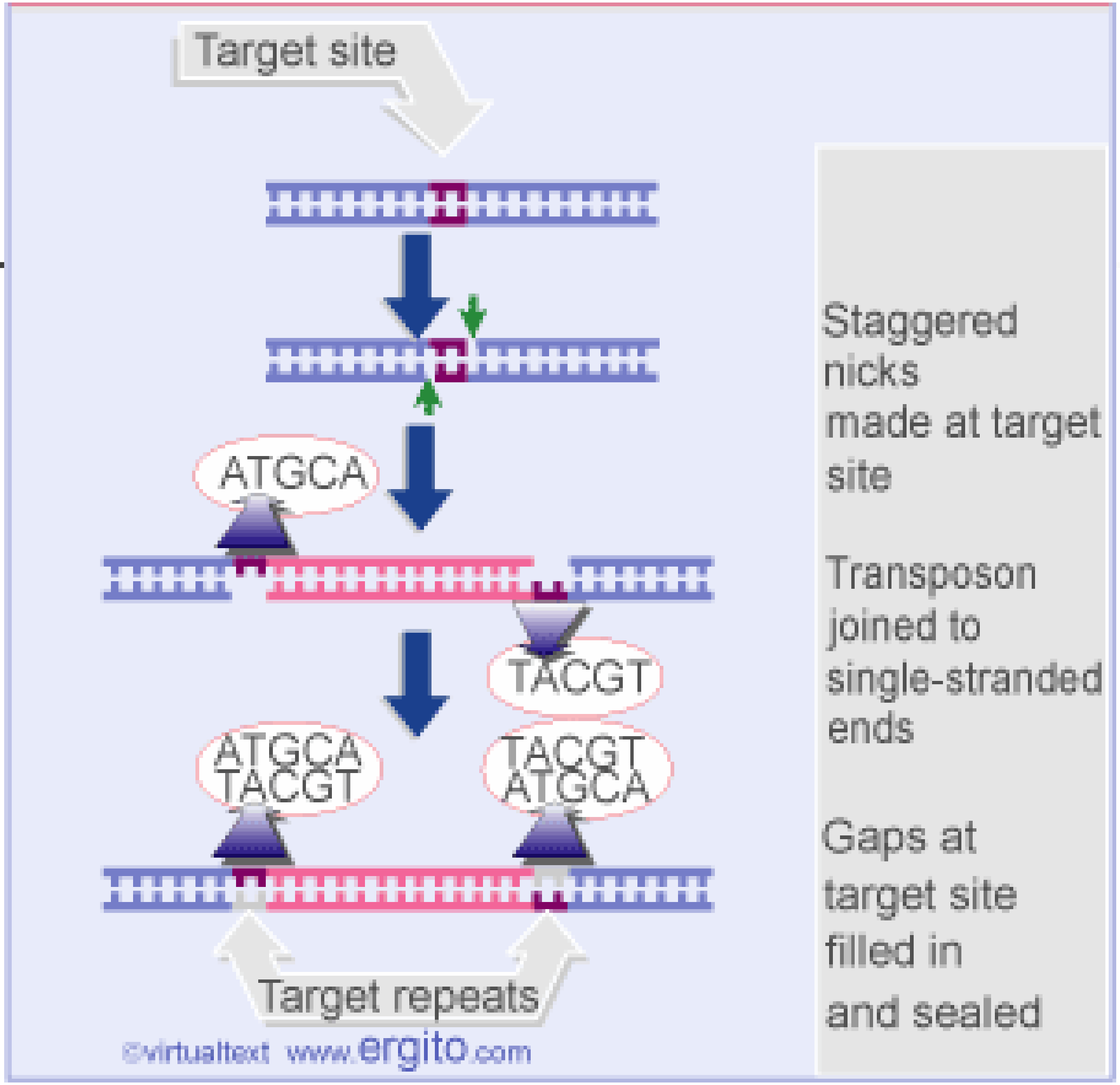
1. **Insertion sequence**（IS, 插入序列）
2. **Composite Transposon**（复合转座子）
3. **TnA Family Transposon (TnA**家族）

Insertion sequence（IS ，插入序列）

1. 最简单的转座子;
2. 两端具有短的末端反向重复序列(inverted terminal repeats)。
3. IS只编码参与转座作用的转座酶（transposase）。
4. 当IS转座时，基因组DNA上的靶点序列出现倍生，在IS两侧各有一段相同的靶点序列，为同向重复。
5. IS转座频率为10^{-3}-10^{-4}/世代。



			Overall length	Target selection
IS1	9 bp	23 bp	768 bp	random
IS2	5 bp	41 bp	1327 bp	hotspots
IS4	11-13 bp	18 bp	1428 bp	$AAAN_{20}TTT$
IS5	4 bp	16 bp	1195 bp	hotspots
IS10R	9 bp	22 bp	1329 bp	NGCTNAGCN
IS50R	9 bp	9 bp	1531 bp	hotspots
IS903	9 bp	18 bp	1057 bp	random


Target site
ATGCA
TACGT
ATGCA
TACGT
TACGT
ATGCA
Target repeats
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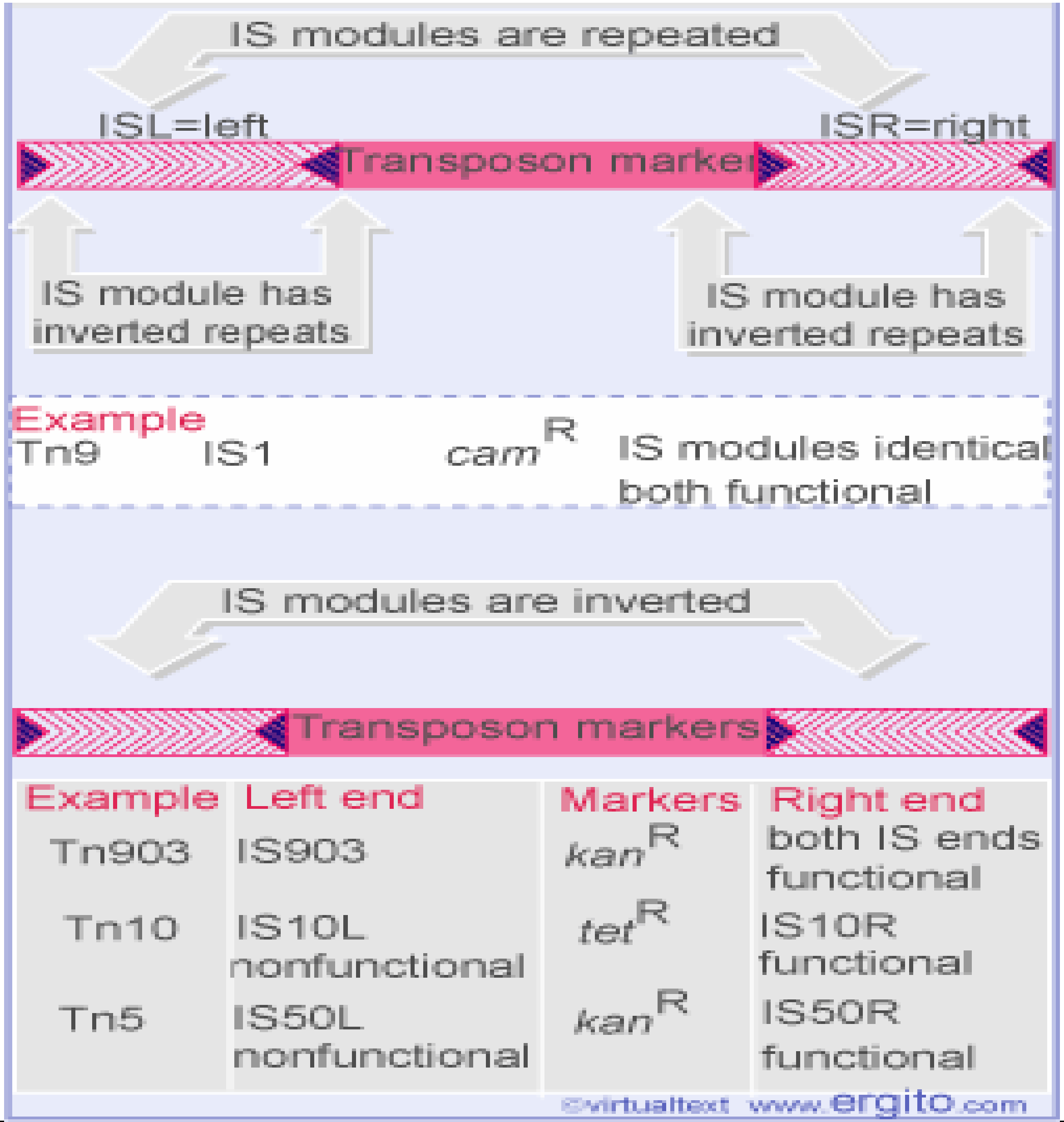
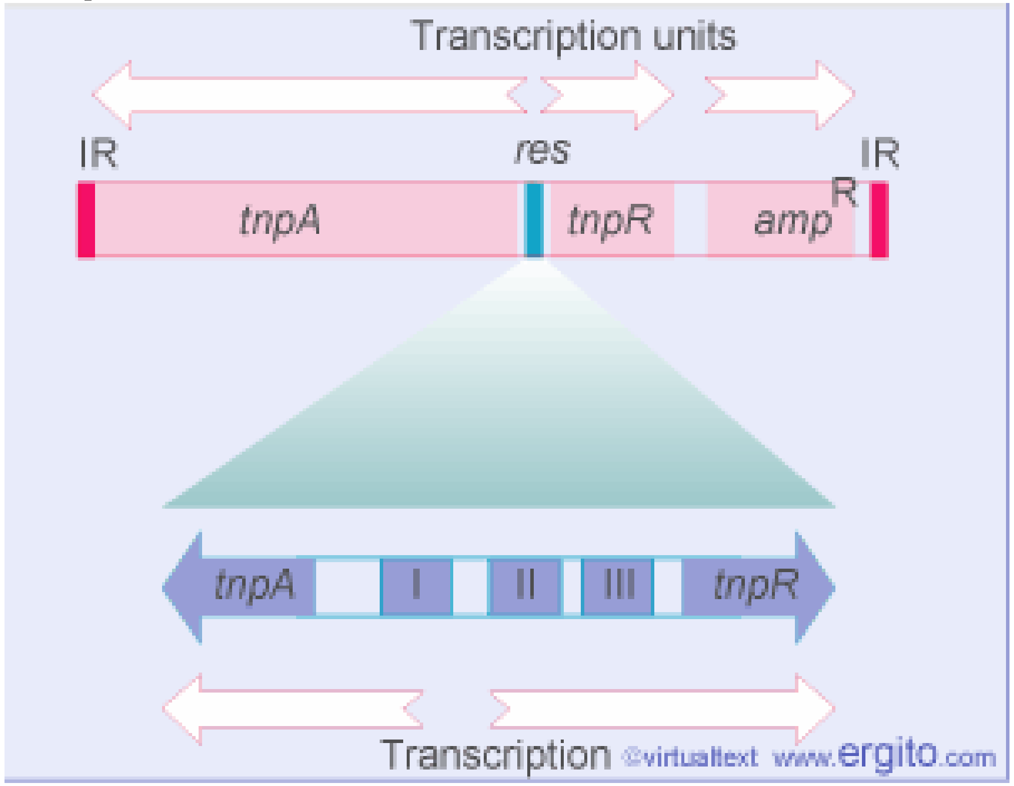
Staggered nicks made at target site
Transposon joined to single-stranded ends
Gaps at target site filled in and sealed

Composite Transposon（复合转座子）



TnA Family Transposon



IR:末端反向重复;
tnpA: 转座酶(Transposase)

tnpR:解离酶(resolvase)
Amp^R :β-内酰胺酶
I,II,III:解离酶结合位点

TnA家族转座子的转座机制是复制转座

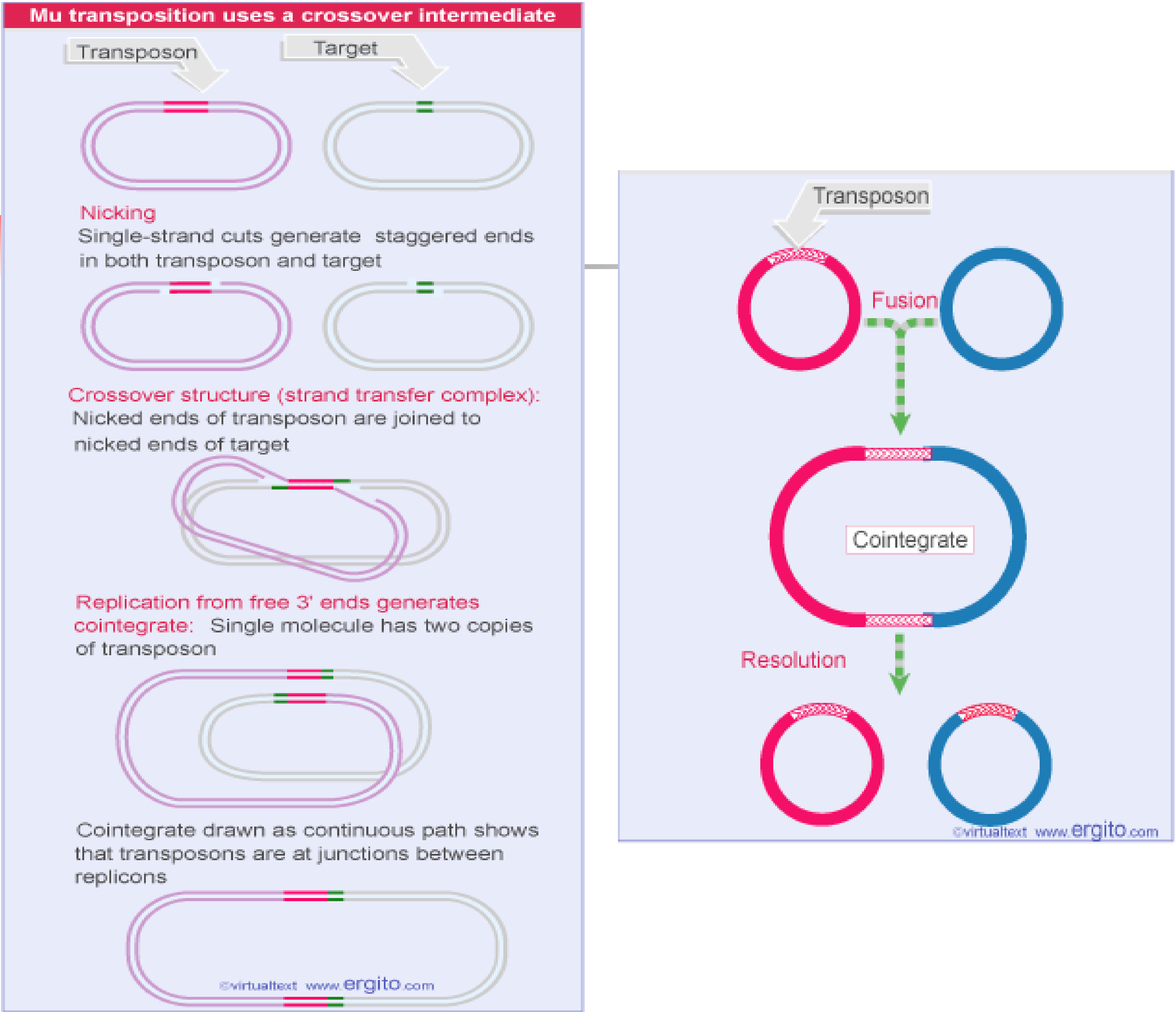
Replicative transposition of TnA requires a transposase to form the cointegrate structure and a resolvase to release the two replicons.

5.2 The mechanisms of transposition

- Replicative transposition（复制型转座）
- Nonreplicative transposition（非复制型转座）
- Conservative transposition（保守型转座）

复制型转座

Replicative transposition describes the movement of a transposon by a mechanism in which first it is replicated, and then one copy is transferred to a new site.


Mu transposition uses a crossover intermediate
Transposon
Target
Nicking
Single-strand cuts generate staggered ends in both transposon and target
Crossover structure (strand transfer complex):
Nicked ends of transposon are joined to nicked ends of target
Replication from free 3' ends generates cointegrate: Single molecule has two copies of transposon
Cointegrate drawn as continuous path shows that transposons are at junctions between replicons
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Transposon
Fusion
Cointegrate
Resolution
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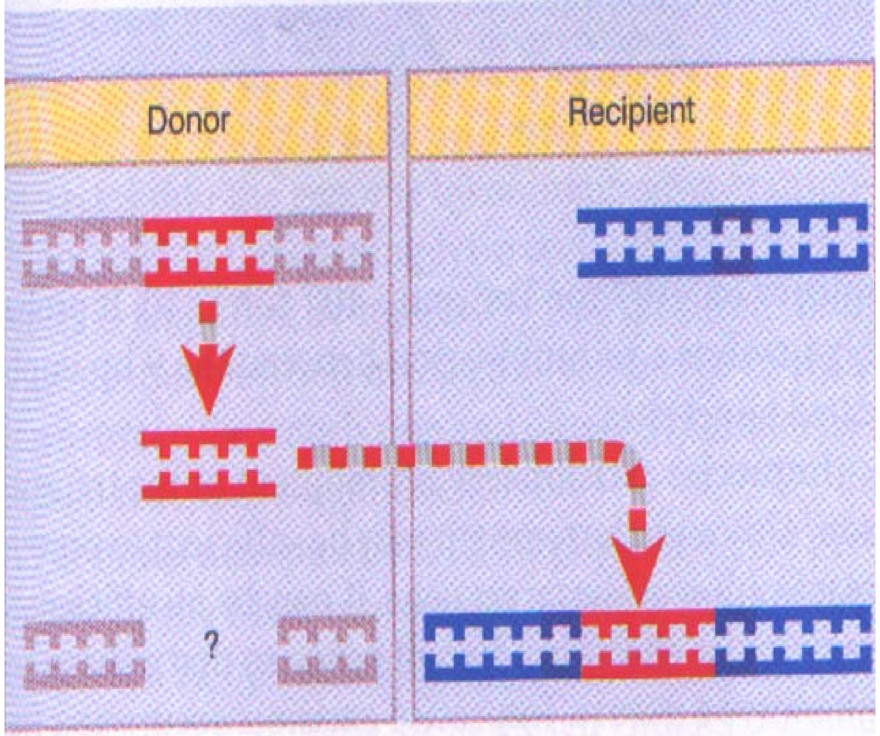
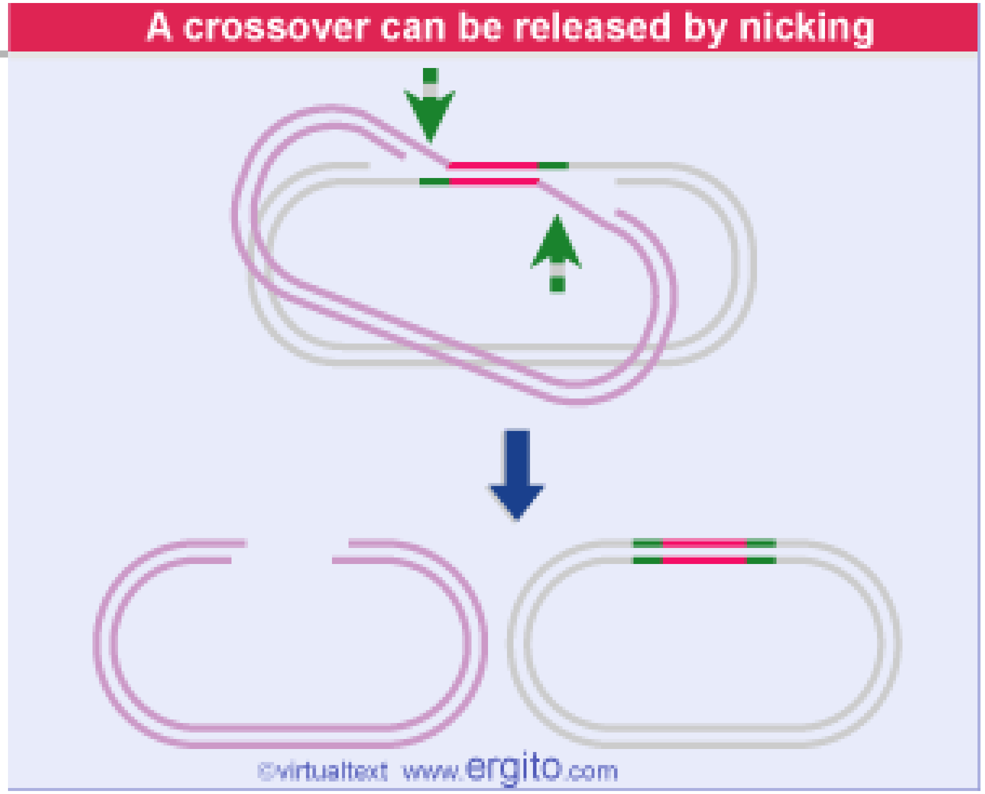
非复制型转座

Nonreplicative transposition describes the movement of a transposon that leaves a donor site (usually generating a double-strand break) and moves to a new site.

Figure 15.6 Nonreplicative transposition allows a transposon to move as a physical entity from a donor to a recipient site. This leaves a break at the donor site, which is lethal unless it can be repaired.

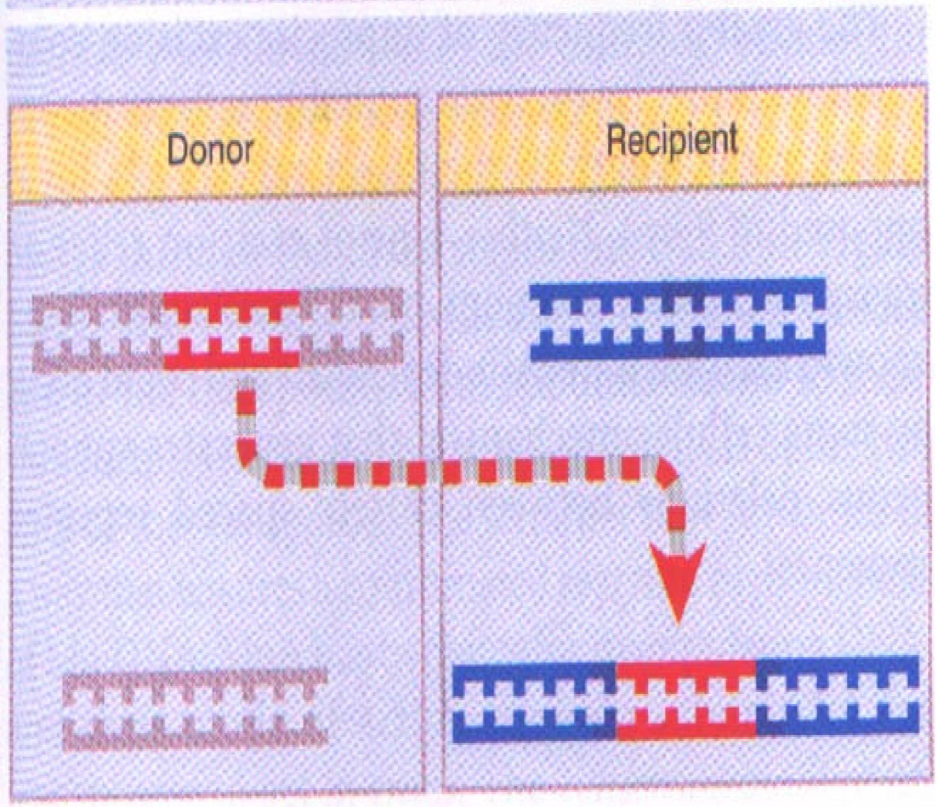




保守型转座

Conservative transposition describes another sort of nonreplicative event, in which the element is excised from the donor site and inserted into a target site by a series of events in which every nucleotide bond is conserved.

Figure 15.7 Conservative transposition involves direct movement with no loss of nucleotide bonds; compare with lambda integration and excision.



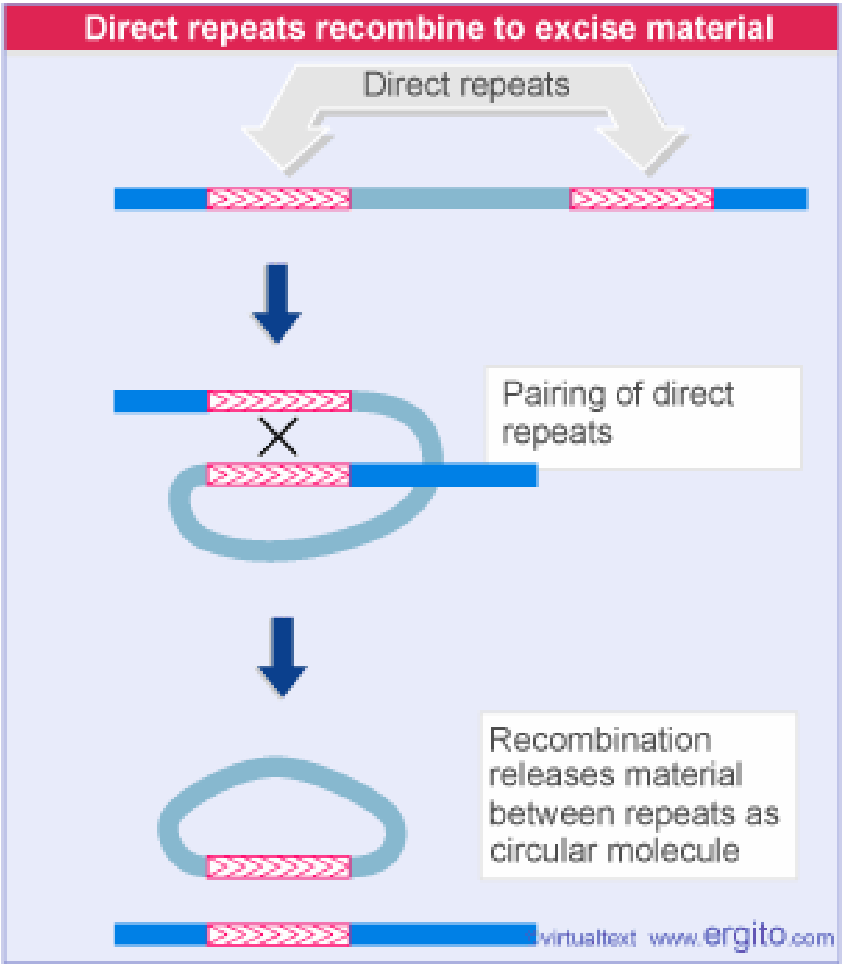
The elements that use **conservative transposition** mechanism are large, and can mediate transfer not only of the element itself but also of donor DNA from one bacterium to another. Although originally classified as transposons, such elements may more properly be regarded as **episomes**.

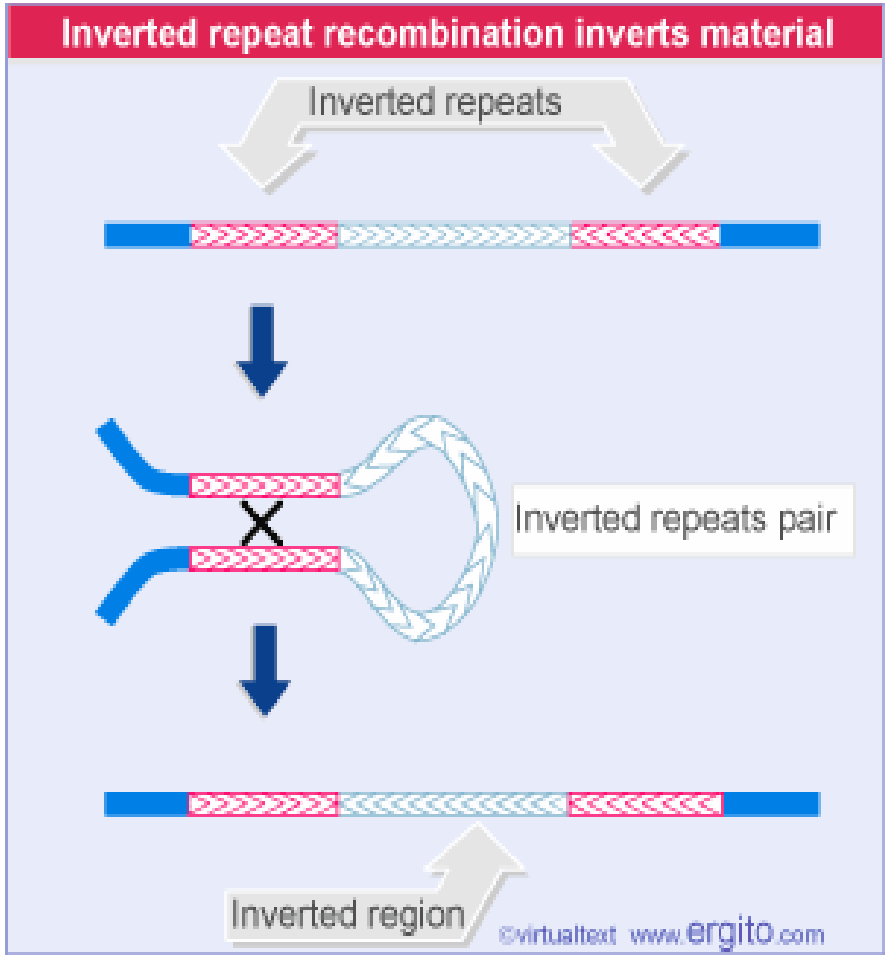
5.3 The genetic effects of transposition

The discovery of transposon breaks through the concept that the location of a gene is unchanged in the chromosome.

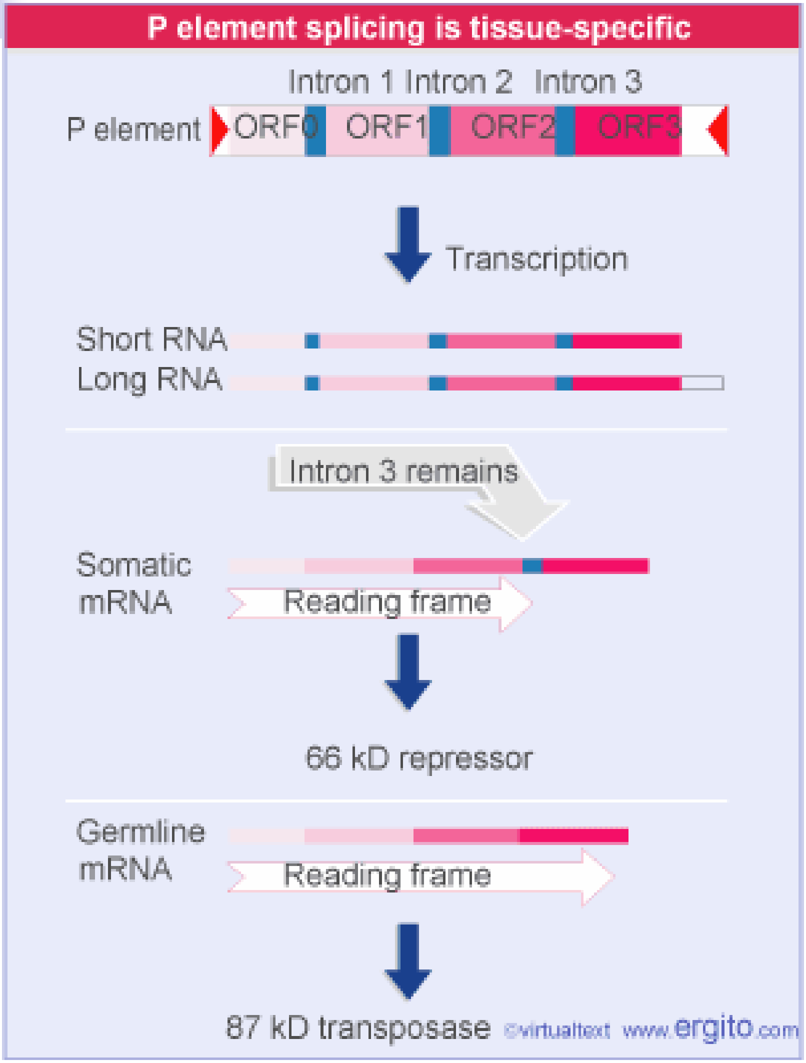
1. Make insert mutations by transposition
2. Produce novel genes by transposition
3. Induce DNA deletion or rearrangement
4. Improve the biological evolution

Transposons cause rearrangement of DNA

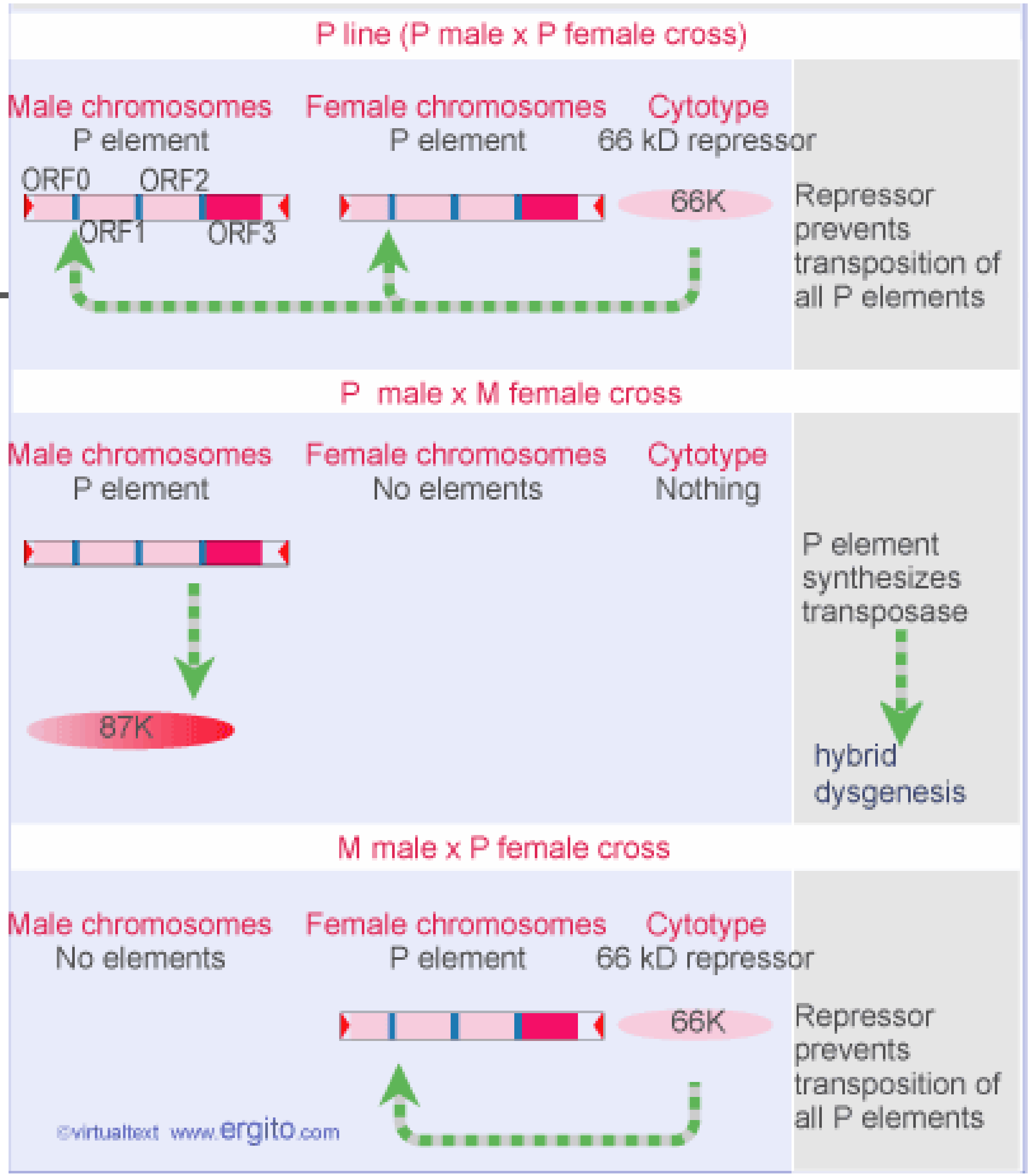




Transposition of P elements causes hybrid dysgenesis in *D. melanogaster*



Somatic cells contain a protein that binds to sequences in exon 3 to prevent splicing of the last intron The absence of this protein in germline cells allows splicing to generate the mRNA that codes for the transposase.


P line (P male x P female cross)
Male chromosomes
P element
ORF0
ORF2
ORF1
ORF3
Female chromosomes
P element
Cytotype
66 kD repressor
66K
Repressor prevents transposition of all P elements
P male x M female cross
Male chromosomes
P element
87K
Female chromosomes
No elements
Cytotype
Nothing
P element synthesizes transposase
hybrid dysgenesis
M male x P female cross
Male chromosomes
No elements
Female chromosomes
P element
Cytotype
66 kD repressor
66K
Repressor prevents transposition of all P elements
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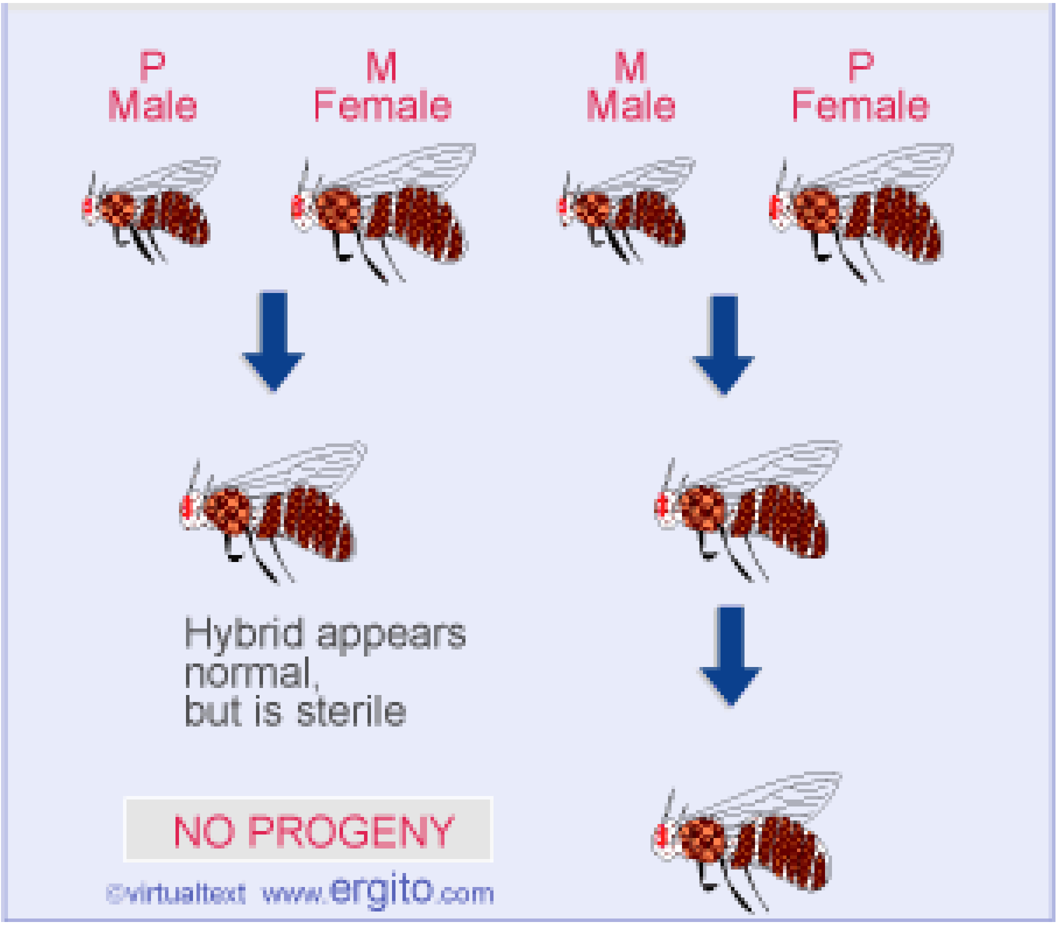
Transposition of P element contributes to Hybrid dysgenesis in two ways.

1. Insertion of the transposed element at a new site may cause mutations.
2. The break that is left at the donor site (Nonreplicative transposition) has a deleterious effect.


P
Male
M
Female
M
Male
P
Female
Hybrid appears
normal,
but is sterile
NO PROGENY
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