TRANSPOSABLE ELEMENTS

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Sem- IV

What are transposons

- **Transposable elements,** also known as **transposons** or **"jumping genes,"** are DNA elements that move (or transpose) within the genome and between genomes, from bacteria to humans providing new genetic raw material for evolution.

Barbara McClintock (1902-1992)
Cold Spring Harbor Laboratory, NY

Nobel Prize in Physiology and Medicine 1983

"for her discovery of mobile genetic elements"

- **Studied transposable elements in corn (*Zea mays*) 1940s-1950s**
  (formerly identified as mutator genes by Marcus Rhoades 1930s)

- **Also known for work demonstrating crossing over as part of the chromosomal basis of inheritance.**

Discovery of Transposable Elements in Maize

Kernels on an ear of corn. The spotted kernels on this ear of corn result from the interaction of a mobile genetic element (a transposable element) with a corn gene whose product is required for pigmentation.

Tomatoes come in a great variety of shapes, sizes, and colors. Elongated tomoatoes in some varieties are produced by a duplication that arose as a result of the presence of the transposable element *Rider*. [Photolibrary.]

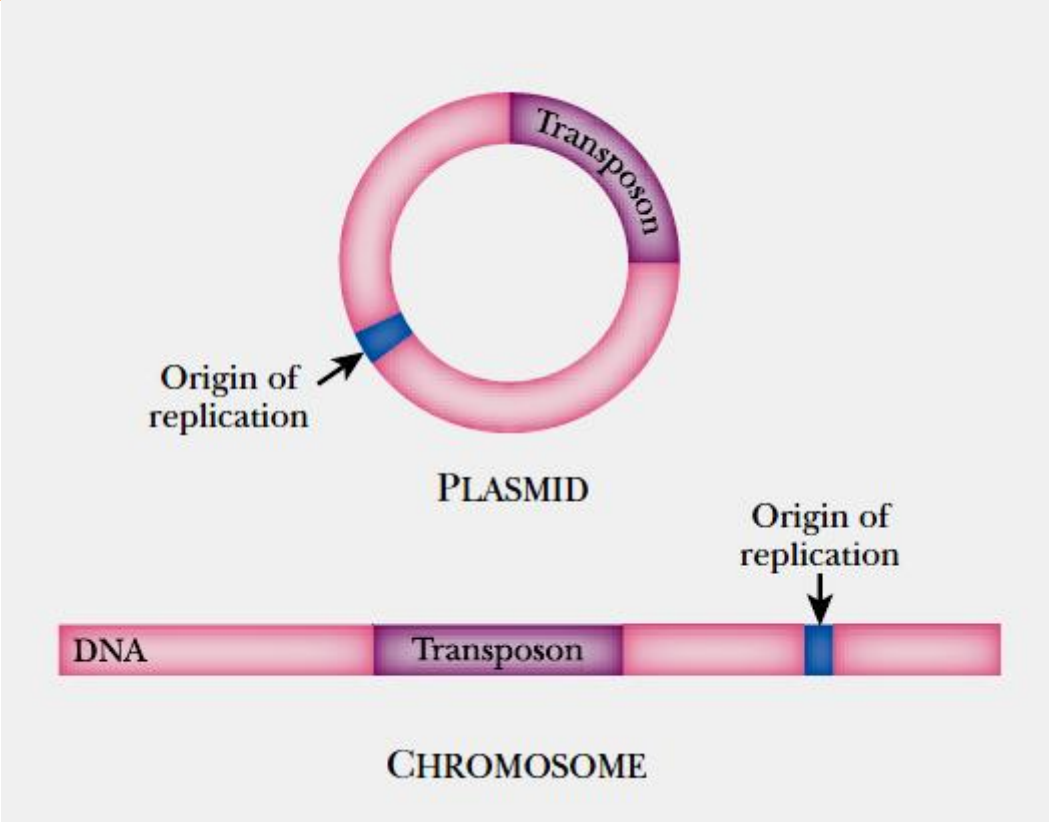
Transposable element

- DNA sequencing of genomes from a variety of microbes, plants, and animals indicates that transposable elements exist in virtually all organisms.
- Surprisingly, they are by far the largest component of the human genome, accounting for almost 50 percent of our chromosomes.
- Despite their abundance, the normal genetic role of these elements is not known with certainty.

Transposable element

- Scientists are able to exploit the ability of transposable elements to insert into new sites in the genome.
- Transposable elements engineered in the test tube are valuable tools, both in prokaryotes and in eukaryotes, for genetic mapping, creating mutants, cloning genes, and even producing transgenic organisms.

Transposable Elements are Never Free



Transposable elements are stretches of DNA able to move from one position to another, but are always found within a DNA molecule such as a bacterial plasmid (top) or a eukaryotic chromosome (bottom). Transposons do not contain their own origin of replication, but rely on the host DNA to provide this feature.

Transposable elements in prokaryotes

- **<u>Two Types:</u>**

1. **Insertion sequence (IS) elements**

2. **Transposons (Tn)**

IS element

- An insertion sequence (IS), or **IS element**, is the simplest transposable element found in bacteria.
- An IS element contains only genes required to mobilize the element and insert it into a new location in the genome.
- IS elements are normal constituents of bacterial chromosomes and plasmids.

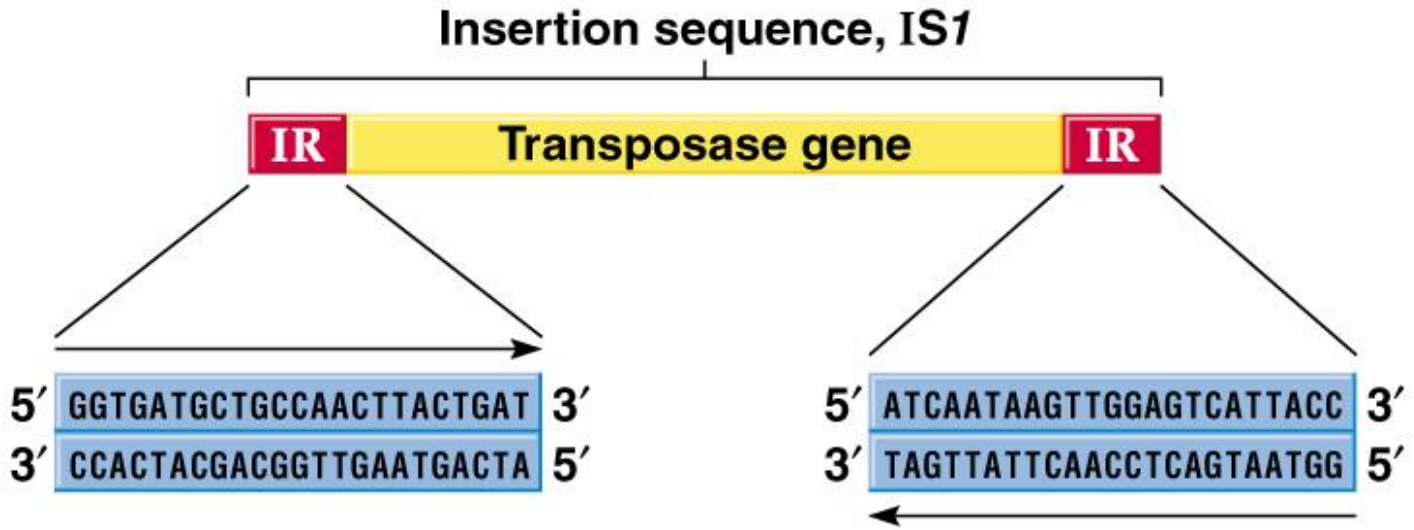
IS Elements

Integration of an IS element may:

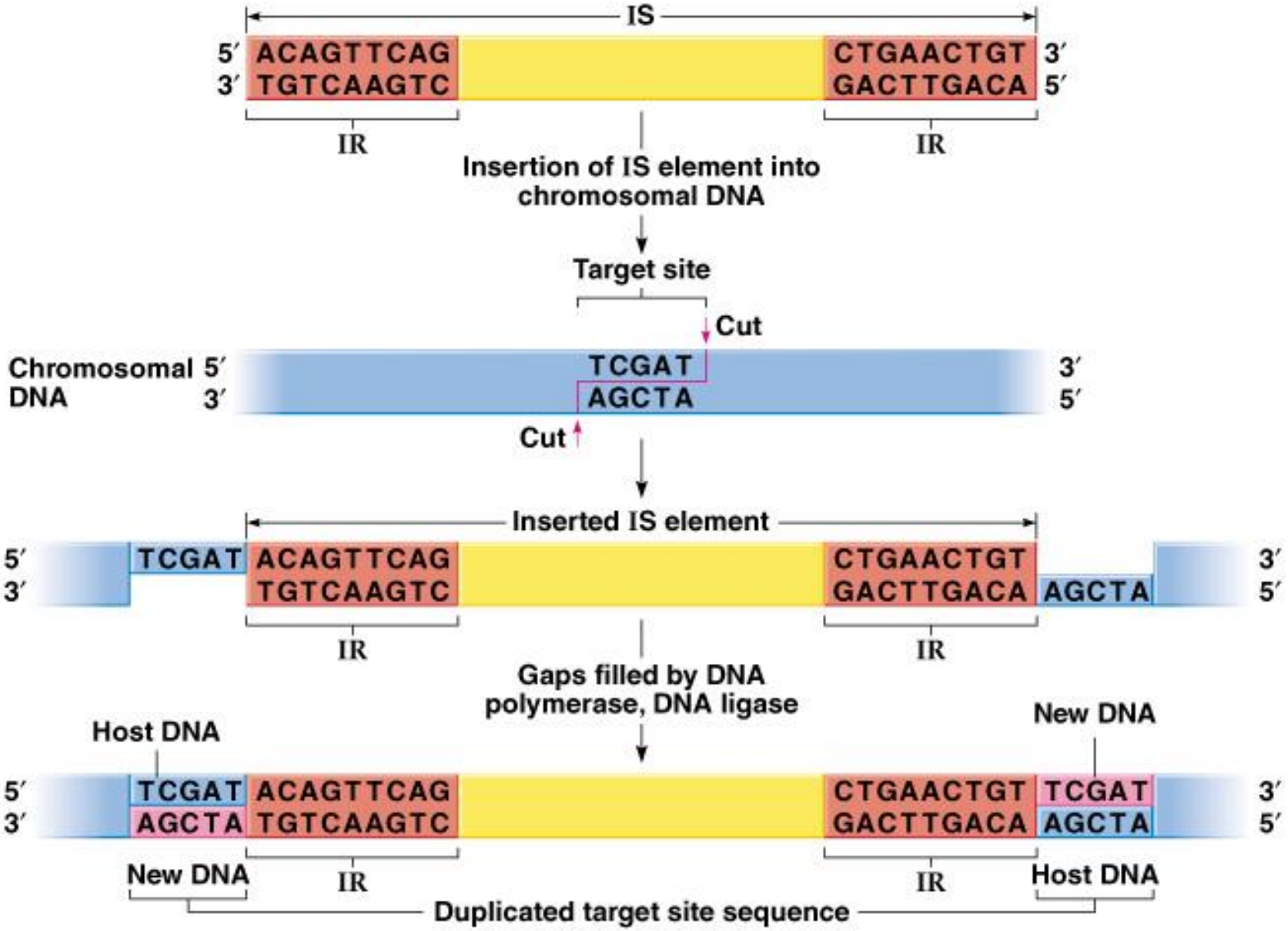
- **Disrupt coding sequences or regulatory regions.**
- **Alter expression of nearby genes.**
- **Cause deletions and inversions in adjacent DNA.**
- **Result in crossing-over.**

Insertion sequence (IS) elements:

1. **Simplest type of transposable element found in bacterial chromosomes and plasmids.**
2. **Encode gene (transposase) for mobilization and insertion.**
3. **Range in size from 768 bp to 5 kb.**
4. **IS1 first identified in *E. coli*' s glactose operon is 768 bp long and is present with 4-19 copies in the *E. coli* chromosome.**
5. **Ends of all known IS elements show inverted terminal repeats (ITRs).**



Integration of IS element in chromosomal DNA.

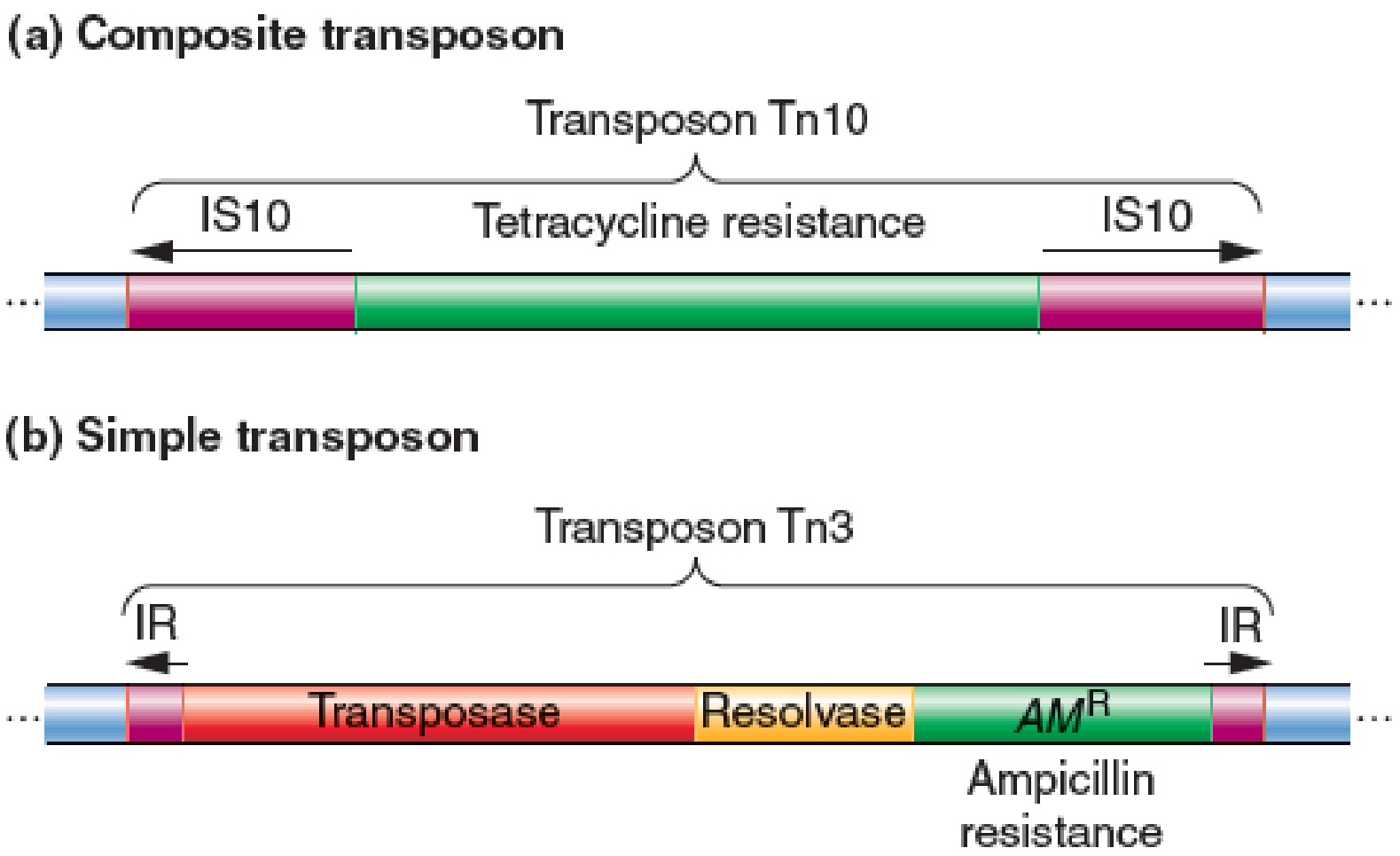


Transposons

There are two types of bacterial transposons.

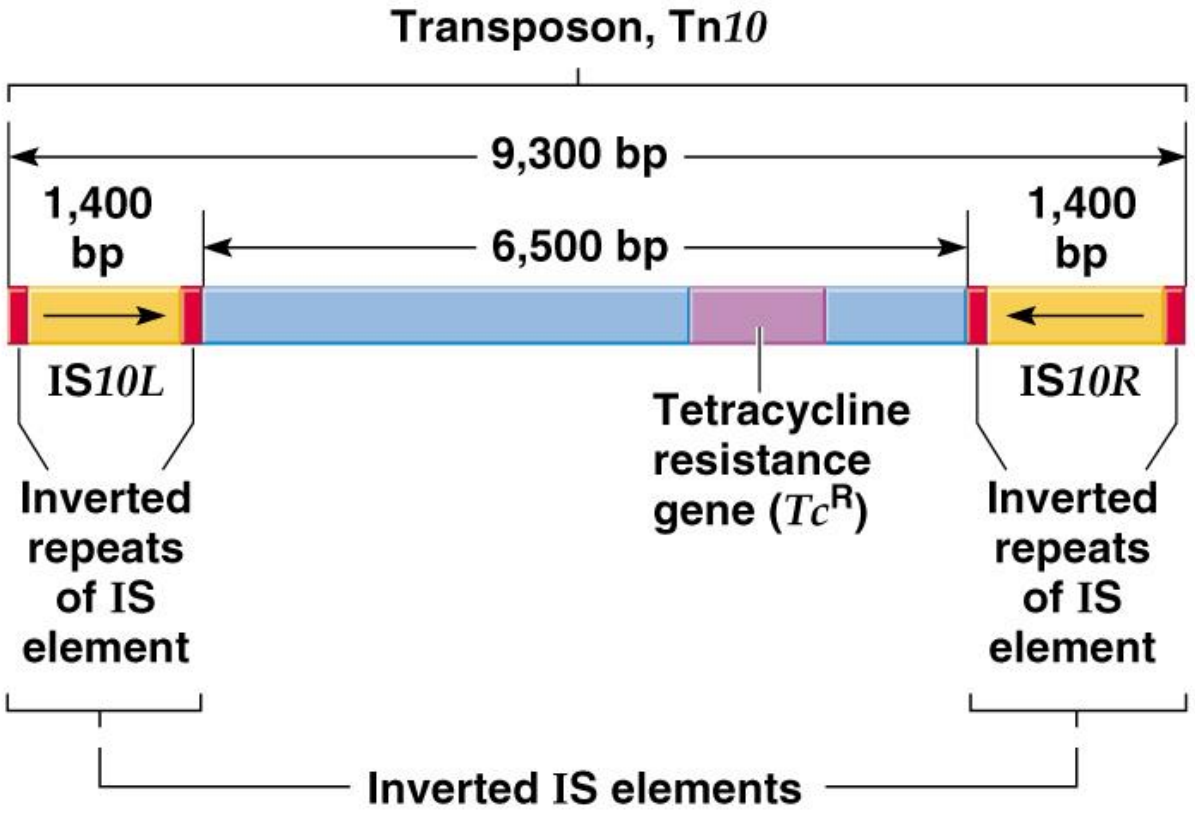
- **Composite transposons** contain a variety of genes that reside between two nearly identical IS elements that are oriented in opposite direction and, as such, form is called an **inverted repeat sequence.**
- **Simple transposons** also consist of bacterial genes flanked by inverted repeat sequences, but these sequences are short (<50 bp) and do not encode the transposase enzyme that is necessary for transposition. Thus, their mobility is not due to an association with IS elements. Instead, simple transposons encode their own transposase in the region between the inverted repeat sequences in addition to carrying bacterial genes. An example of a simple transposon is Tn3,

Structural features of composite and simple transposons



Composite transposons (Tn):

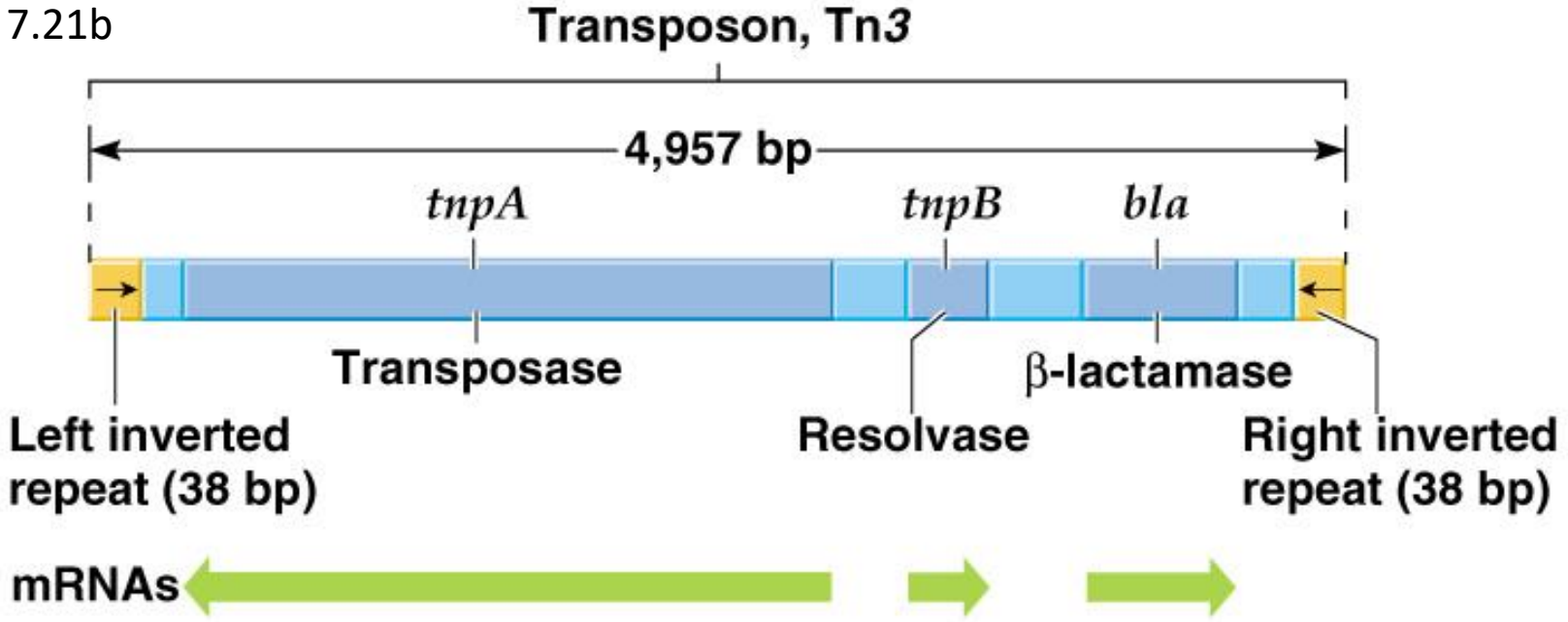
- Carry genes (example might be a gene for antibiotic resistance) flanked on both sides by IS elements.
- Tn10 is 9.3 kb and includes 6.5 kb of central DNA (includes a gene for tetracycline resistance) and 1.4 kb inverted IS elements.
- IS elements supply transposase and ITR recognition signals.



Noncomposite transposons (Tn)

- **Carry genes (example might be a gene for antibiotic resistance) but do not terminate with IS elements.**
- **Ends are non-IS element repeated sequences.**
- **Tn3 is 5 kb with 38-bp ITRs and includes 3 genes; *bla* (β-lactamase), *tnpA* (transposase), and *tnpB* (resolvase, which functions in recombination).**

Fig. 7.21b



There are several distinctions between bacterial **transposition** and other **recombinational mechanisms**.

1. Transposition does not require extensive DNA sequence homology. Transposition occurs normally when **RecA** is absent from a host, suggesting that **homologous recombination** events are not involved.

- 2. DNA synthesis is involved in bacterial **transposition**. **Transposition** always involves duplication of the target site, the short sequence (3-12 base pairs) at which the transposable element is inserted. In many instances the **transposable element** is itself replicated, with one copy being deposited in the new sequence and one remaining in the donor sequence.