Mutations

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What Are Mutations?

- Changes in the nucleotide sequence of DNA
- May occur in somatic cells (aren't passed to offspring)
- May occur in gametes (eggs & sperm) and be passed to offspring

Are Mutations Helpful or Harmful?

- Mutations happen regularly
- Almost all mutations are neutral
- Chemicals & UV radiation cause mutations
- Many mutations are repaired by enzymes

Are Mutations Helpful or Harmful?

- Some type of skin cancers and leukemia result from somatic mutations
- Some mutations may improve an organism's survival (beneficial)

Types of Mutations

1. Chromosome Mutations

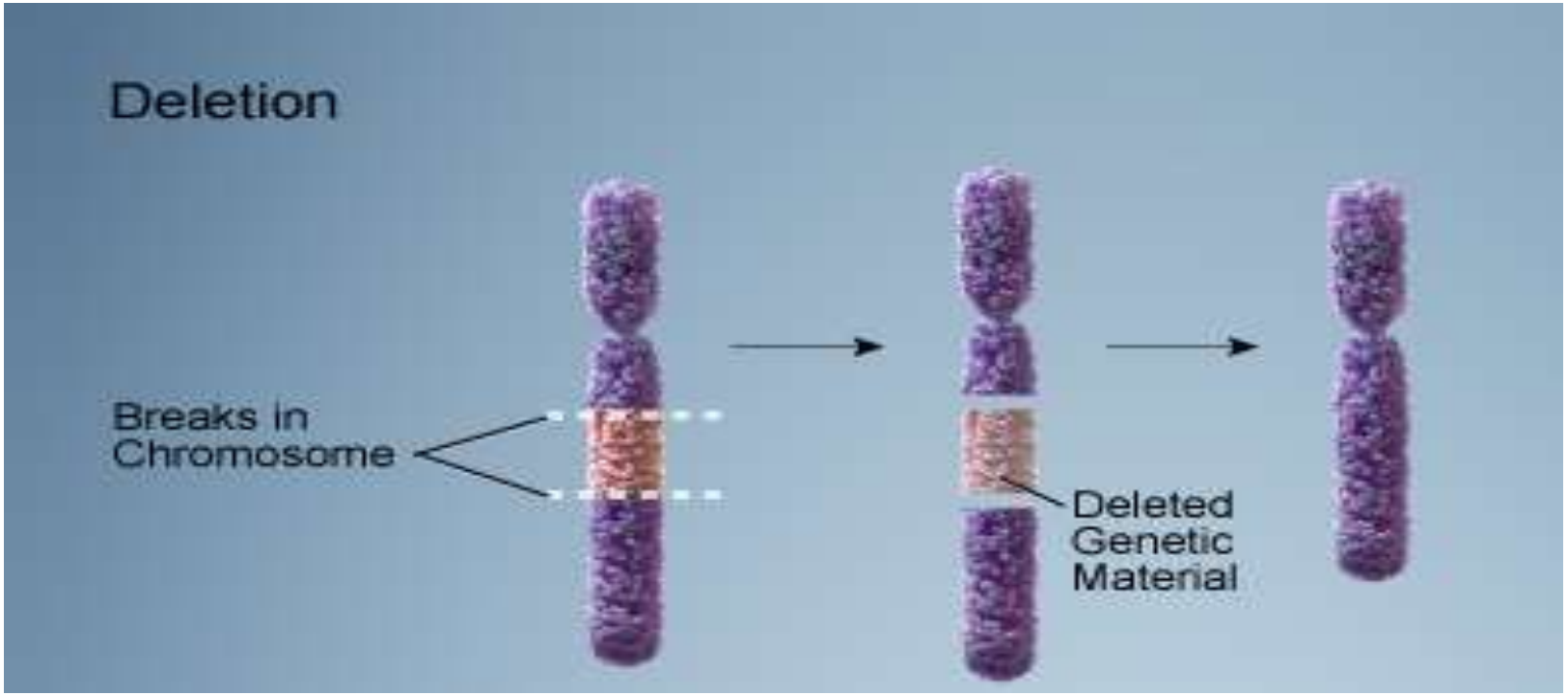
- May Involve:
  - **Changing the structure** of a chromosome
  - The **loss or gain** of part of a chromosome

Chromosome Mutations

- Five types exist:
  1. Deletion
  2. Inversion
  3. Translocation
  4. Nondisjunction
  5. Duplication

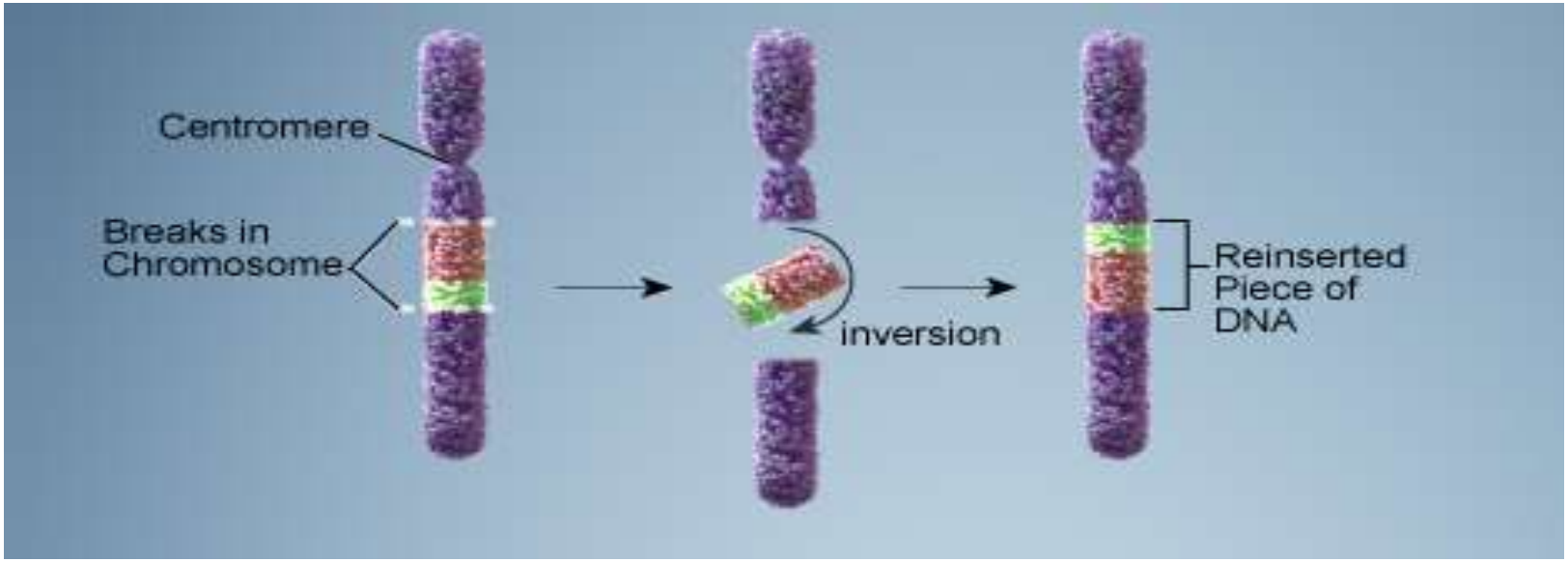
Deletion

- Due to **breakage**
- A **piece** of a chromosome is **lost**



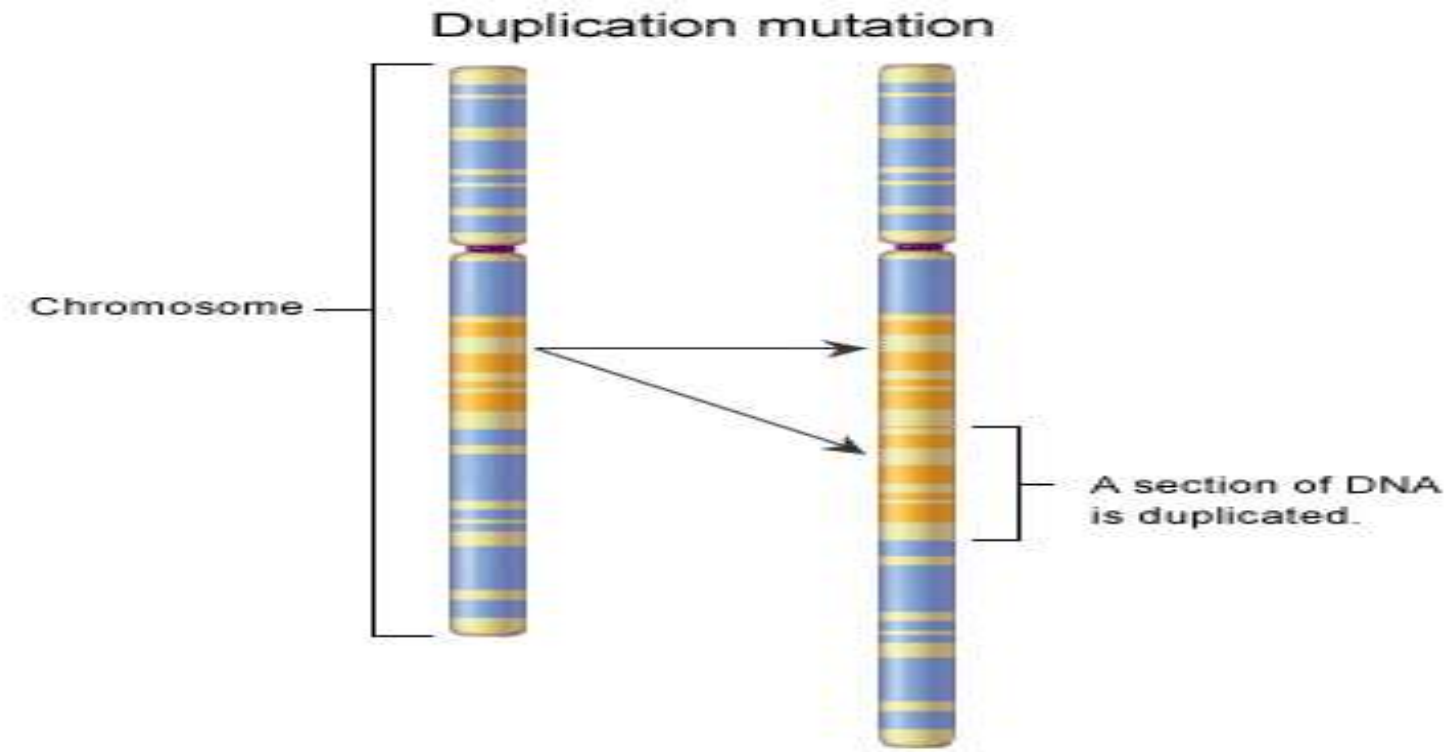
Inversion

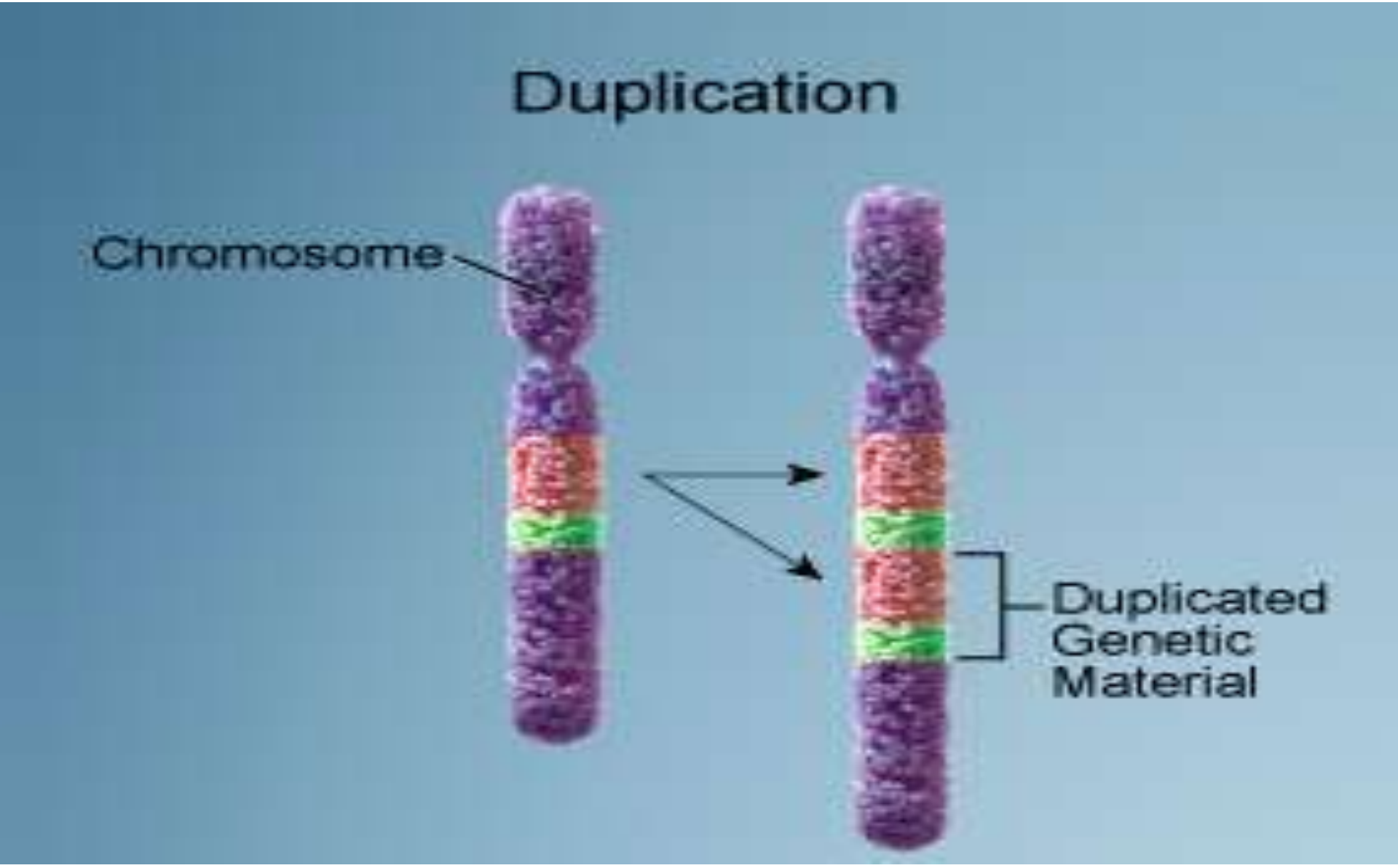
- Chromosome segment **breaks off**
- Segment flips around **backwards**
- Segment **reattaches**



Duplication

- Occurs when a gene **sequence is repeated**

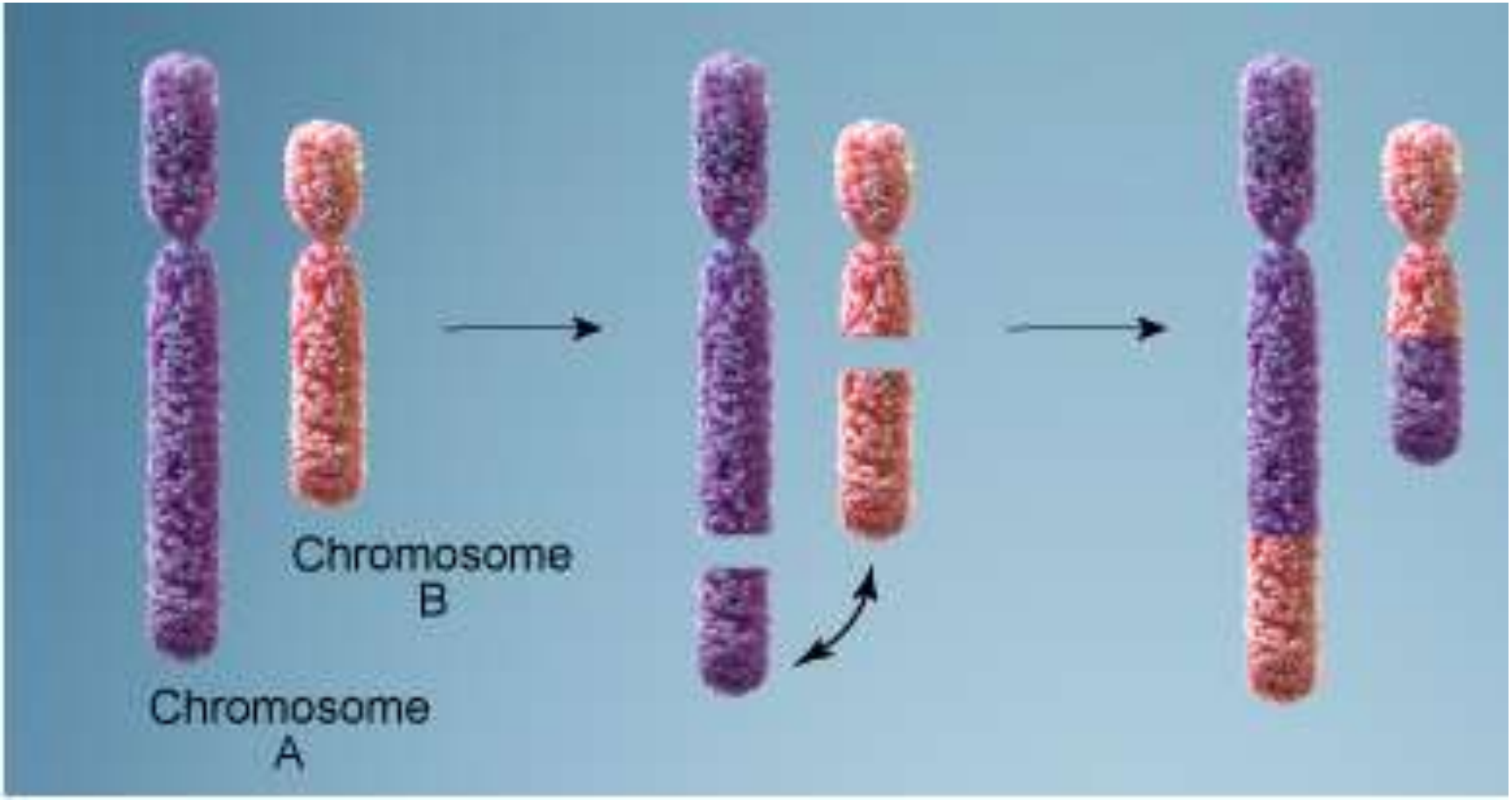



Duplication
Chromosome
Duplicated
Genetic
Material

Translocation

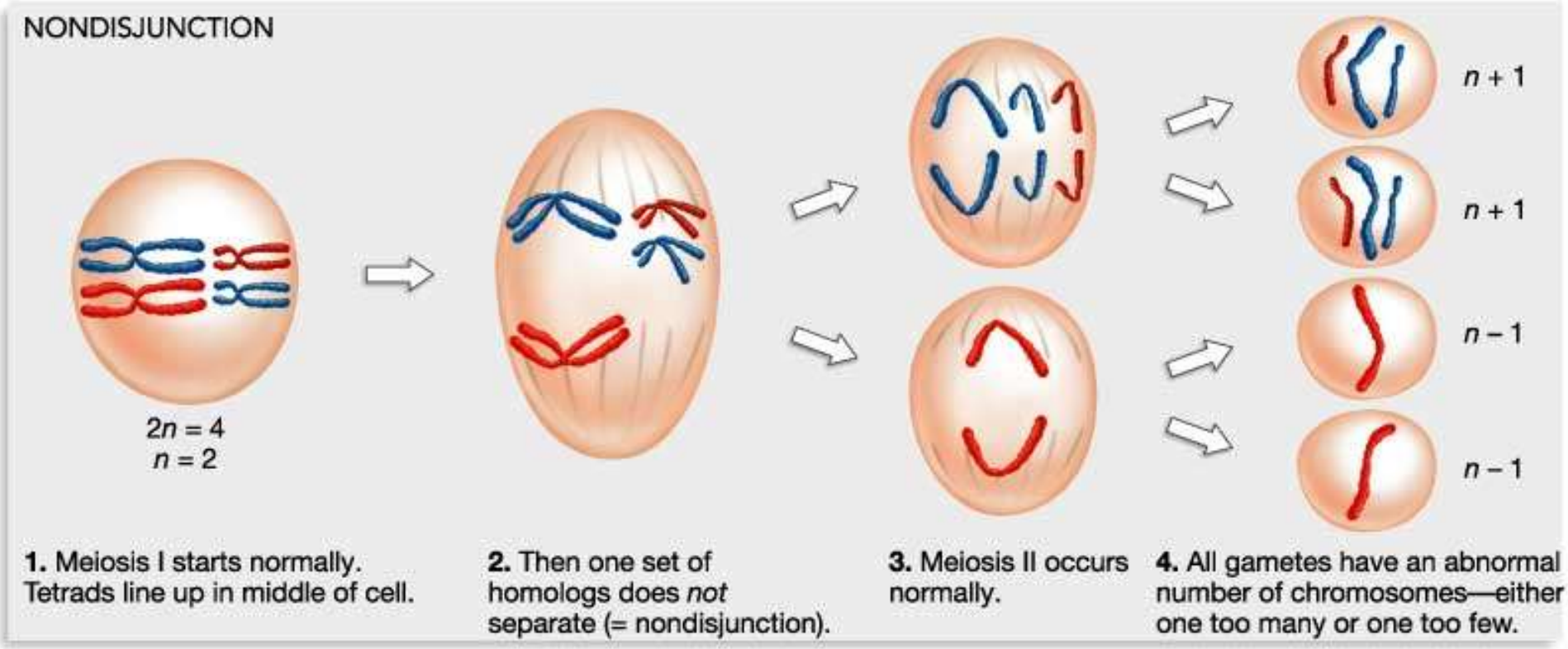
- Involves **two chromosomes** that aren't homologous
- **Part** of one chromosome is **transferred to another** chromosomes

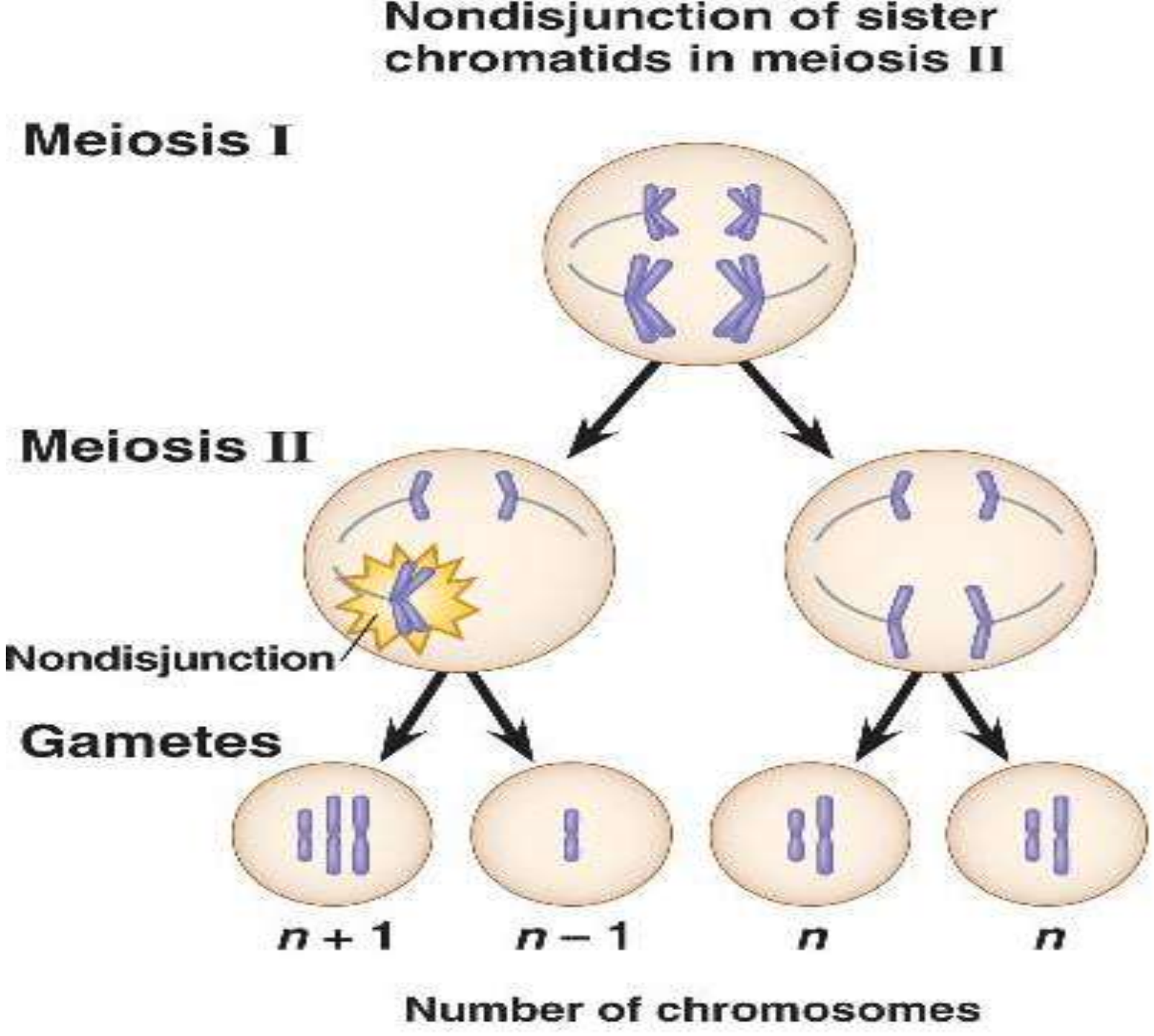
Translocation

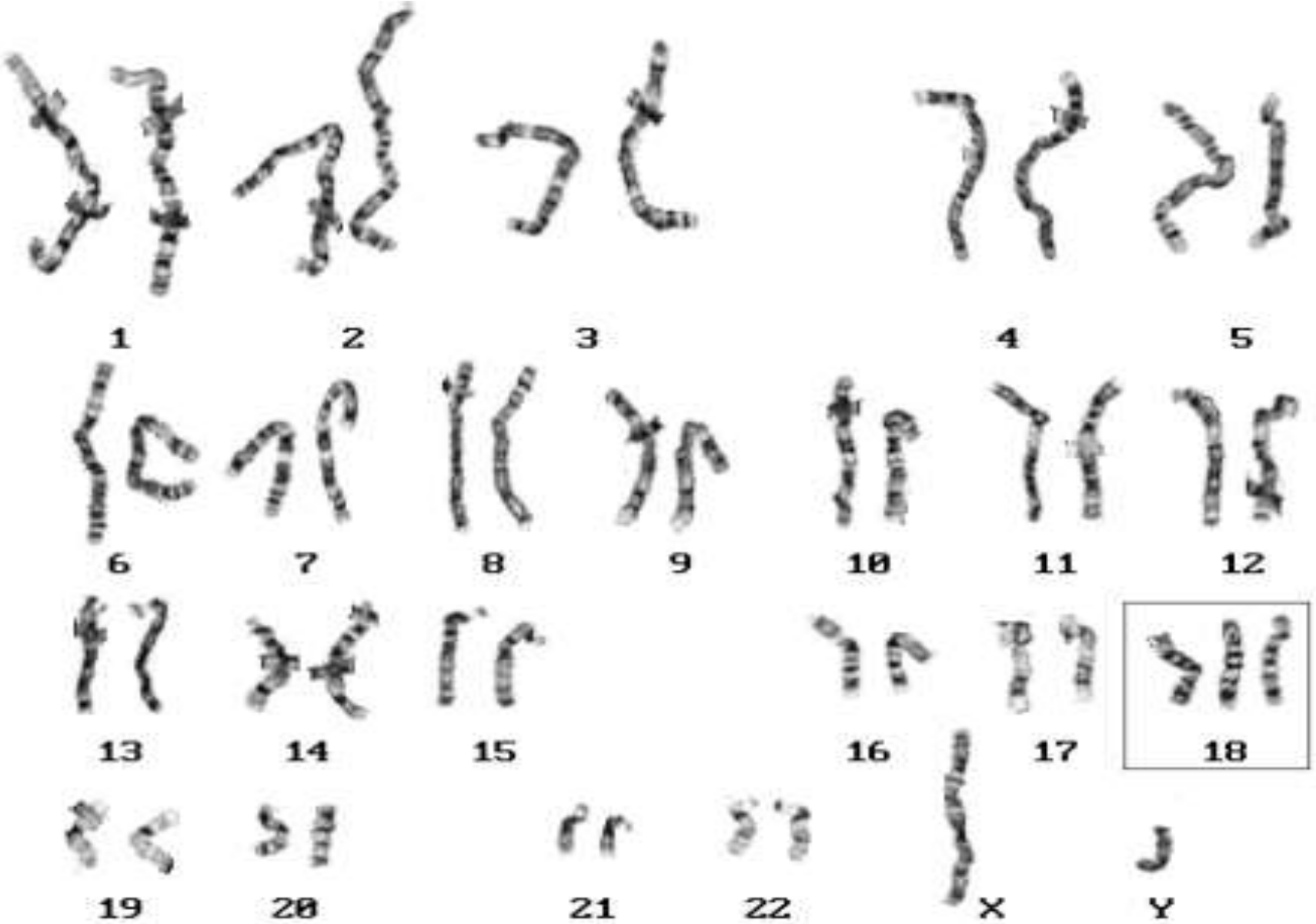


Nondisjunction

- **Failure** of chromosomes **to separate** during meiosis
- Causes gamete to have **too many** or **too few** chromosomes

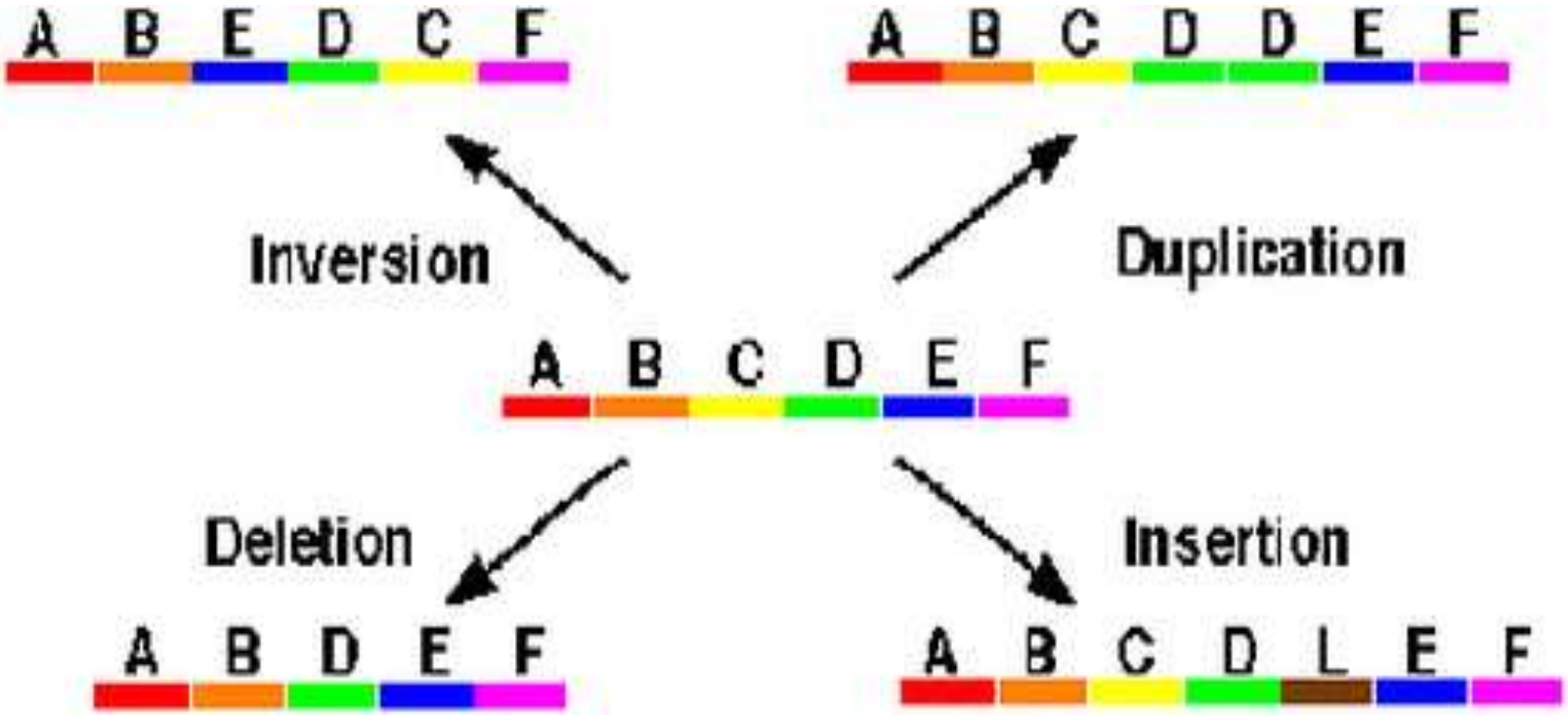

NONDISJUNCTION
2n = 4
n = 2
n + 1
n + 1
n – 1
n – 1
1. Meiosis I starts normally. Tetrads line up in middle of cell.
2. Then one set of homologs does not separate (= nondisjunction).
3. Meiosis II occurs normally.
4. All gametes have an abnormal number of chromosomes—either one too many or one too few.

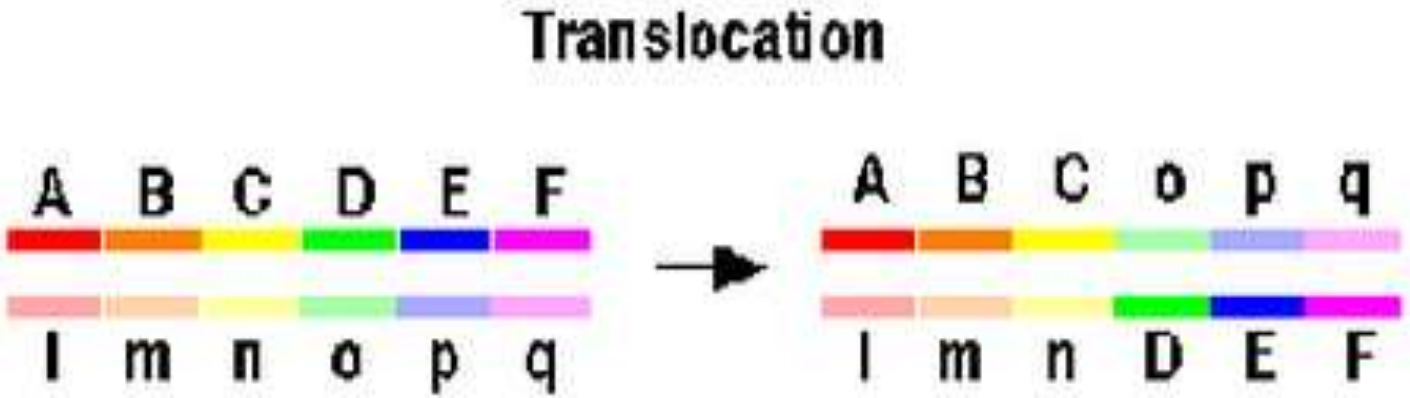

Nondisjunction of sister chromatids in meiosis II
Meiosis I
Meiosis II
Nondisjunction
Gametes
n + 1
n − 1
n
n
Number of chromosomes

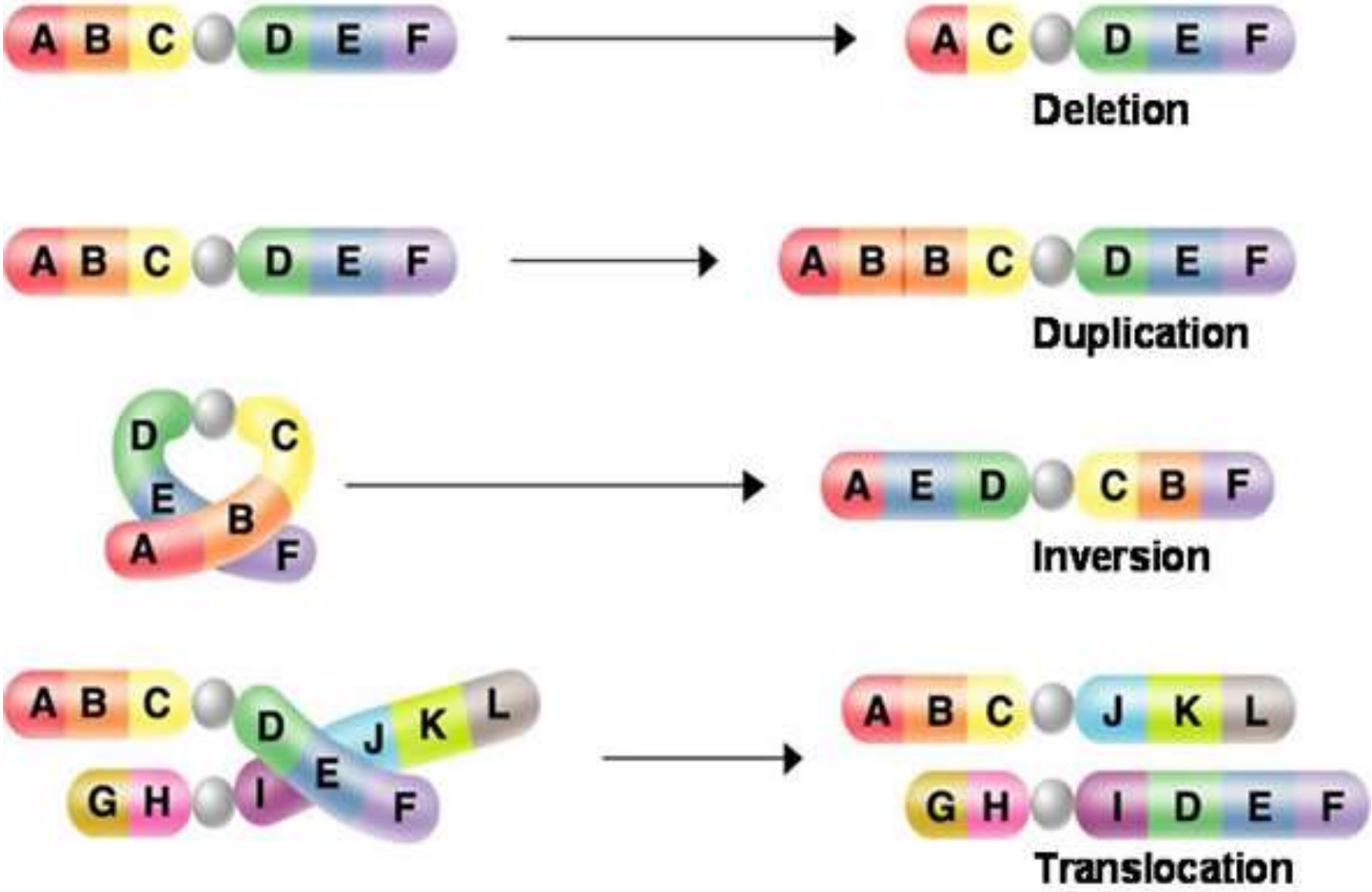


Karyotype: 47,XY,+18

Klinefelter's Syndrome 47 XXY


A B E D C F
A B C D D E F
Inversion
Duplication
A B C D E F
Deletion
Insertion
A B D E F
A B C D L E F

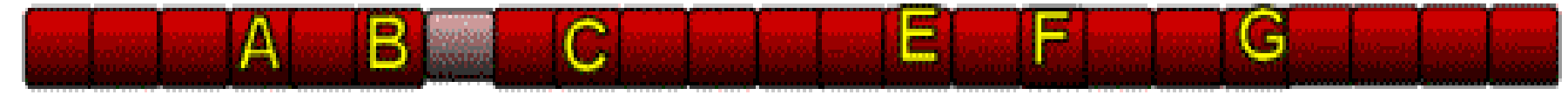

Translocation
A B C D E F
l m n o p q
A B C o p q
l m n D E F


A B C D E F
A C D E F
Deletion
A B C D E F
A B B C D E F
Duplication
D C E B A F
A E D C B F
Inversion
A B C D J K L G H I E F
A B C J K L G H I D E F
Translocation

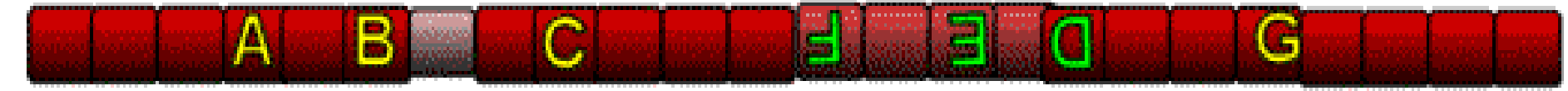
Original Chromosome

Duplication

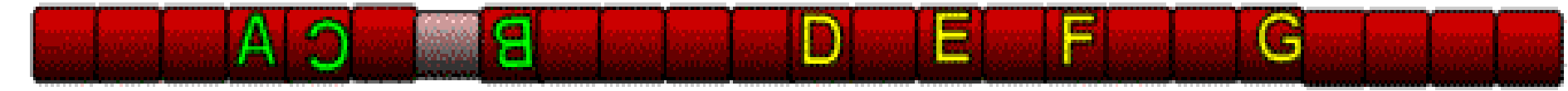
Deletion



Inversion



Inversion



2.Gene Mutations

- Change in the **nucleotide sequence** of a gene
- May only involve a single nucleotide
- May be due to **copying errors**, **chemicals**, **viruses**, etc.

Types of Gene Mutations

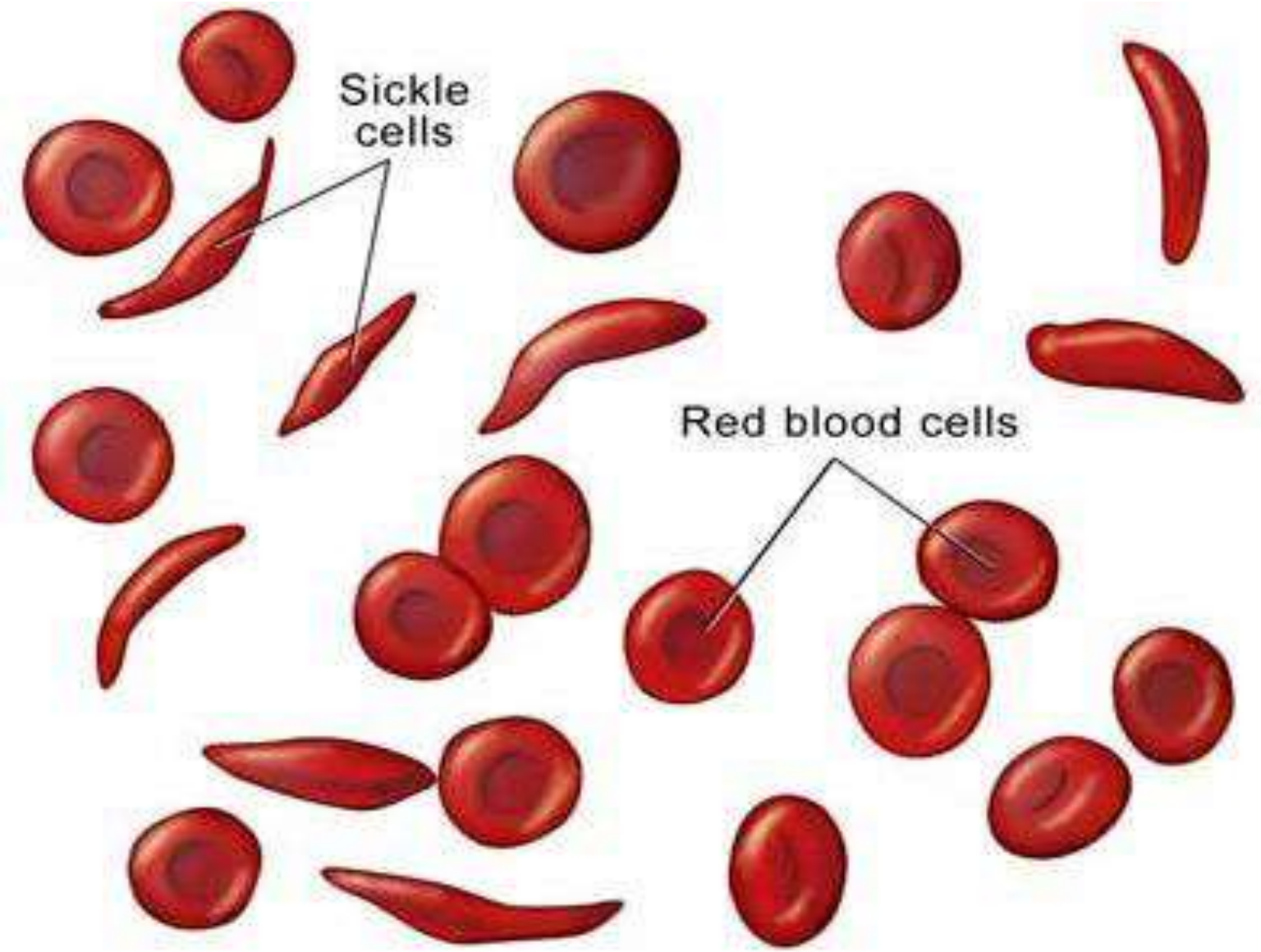
- Point Mutations
- Substitutions
- Insertions
- Deletions
- Frameshift

Point Mutation

- Change of a **single** nucleotide
- Includes the deletion, insertion, or substitution of **ONE** nucleotide in a gene.

Point Mutation

- **Sickle Cell disease** is the result of one nucleotide substitution
- Occurs in the **hemoglobin gene.**


Sickle cells
Red blood cells

(a) DNA point mutation can lead to a different amino acid sequence.

(b) Phenotype

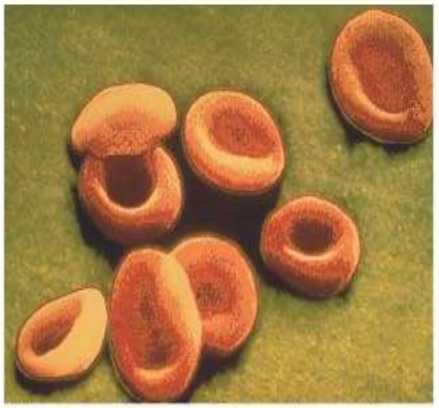
DNA sequence of non-template (coding) strand

5′ G T G C A C C T G A C T C C T G A G G A G 3′

Amino acid sequence

Valine – Histidine – Leucine – Threonine – Proline – Glutamic acid – Glutamic acid

Normal



Normal red blood cells

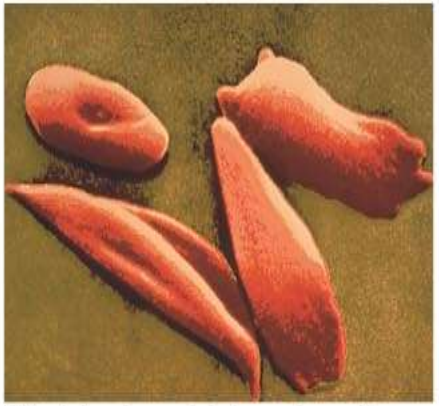
DNA sequence of non-template (coding) strand

5′ G T G C A C C T G A C T C C T G T G G A G 3′

Amino acid sequence

Valine – Histidine – Leucine – Threonine – Proline – Valine – Glutamic acid

Mutant

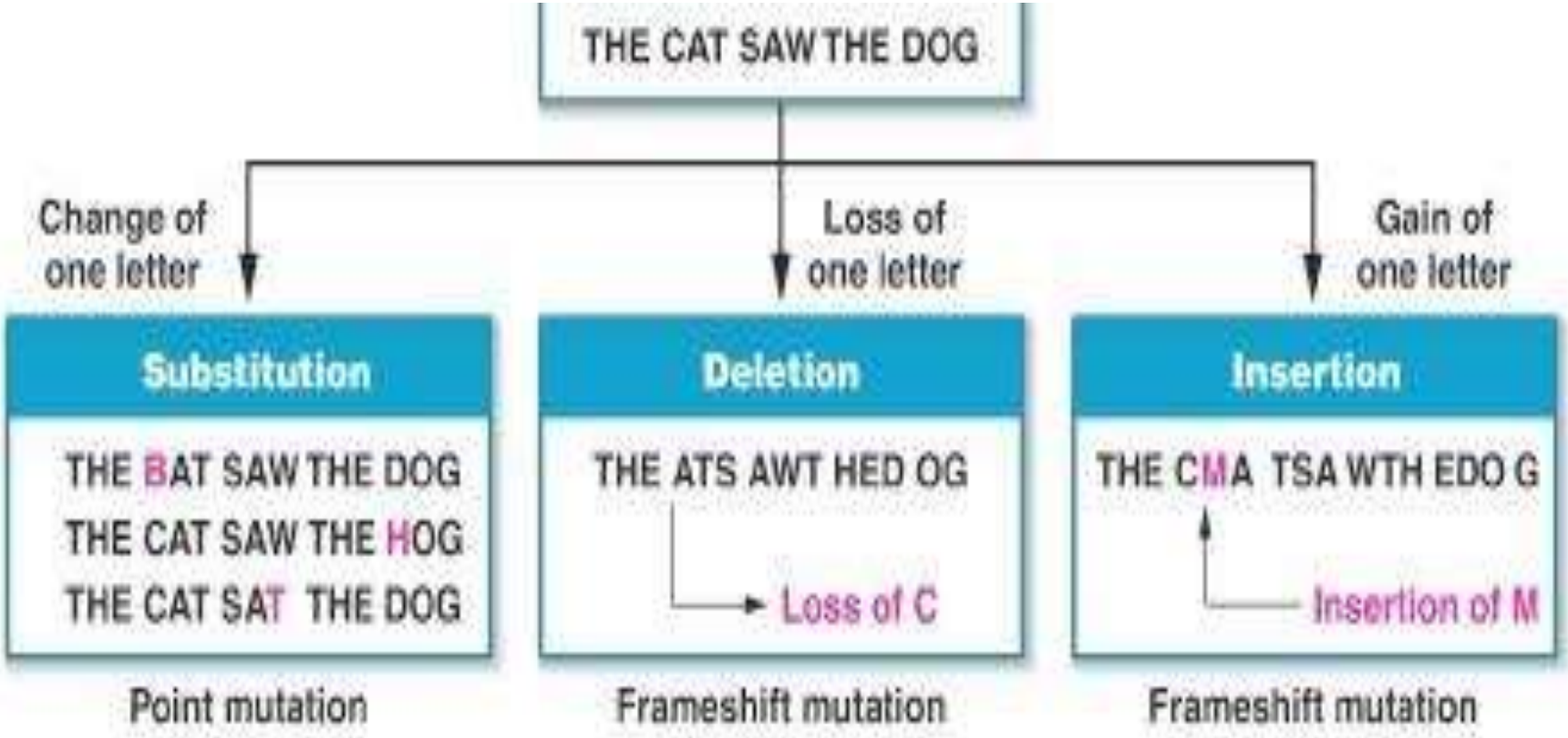


Sickled red blood cells

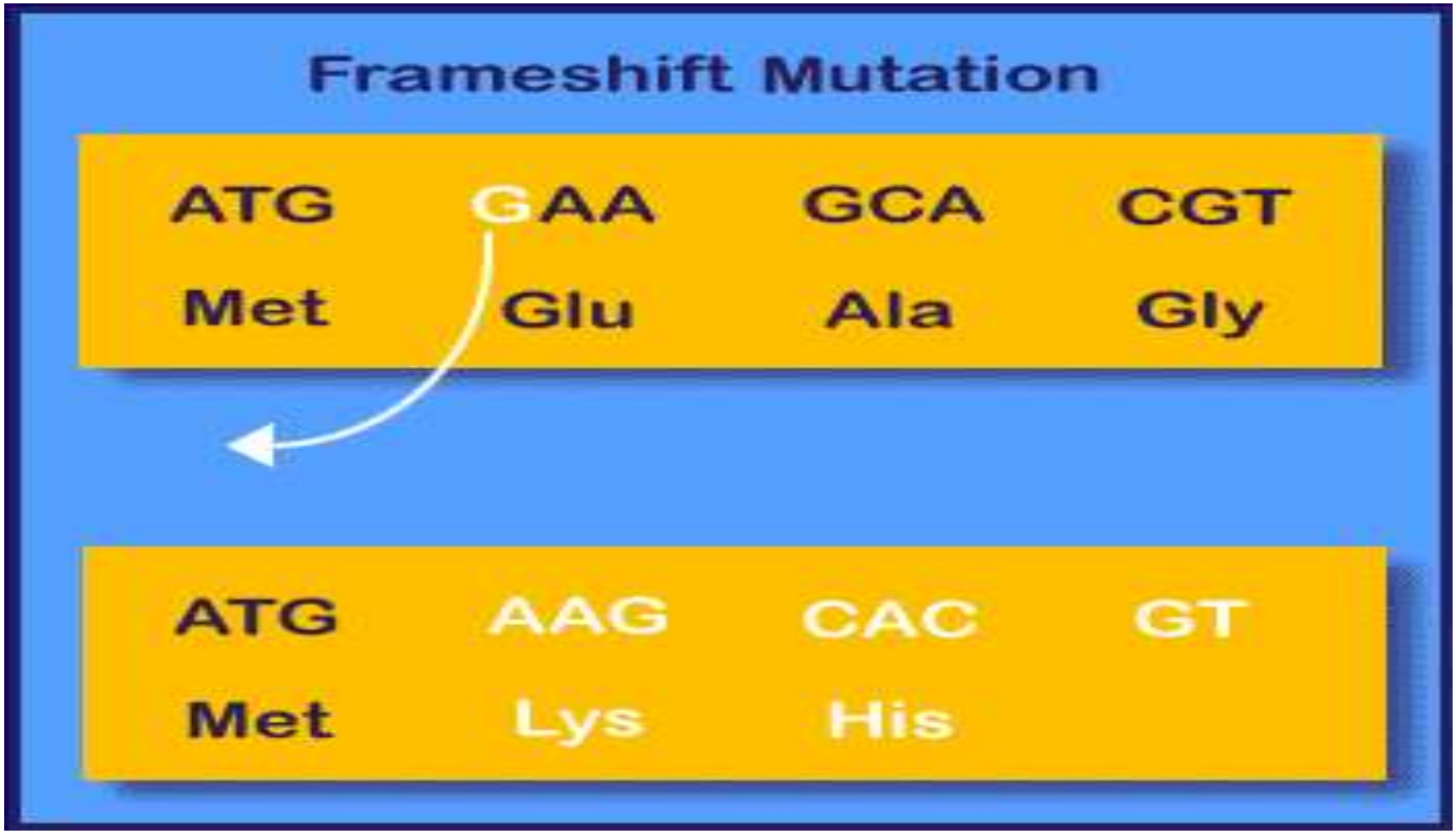
Frameshift Mutation

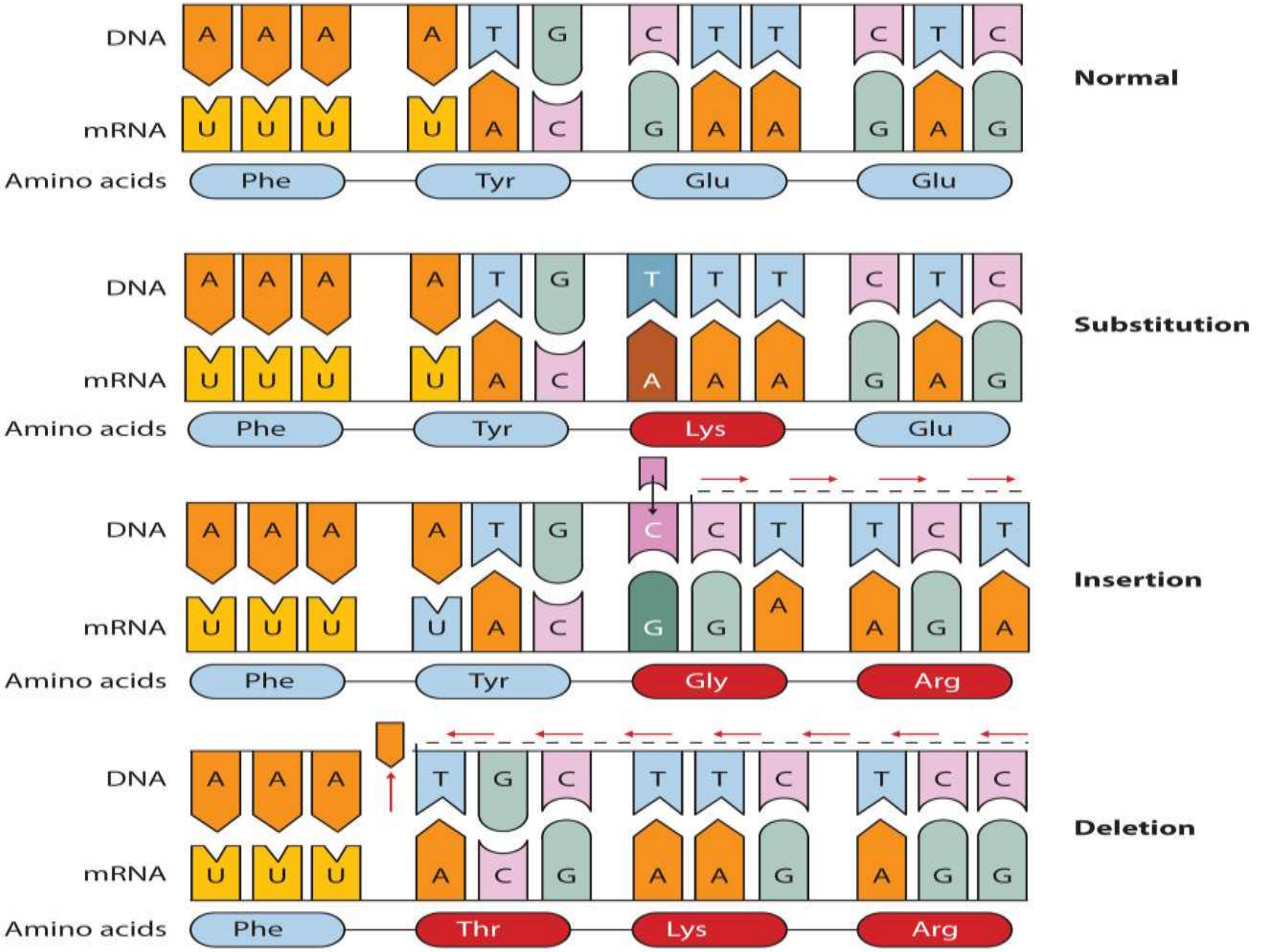
- **Inserting or deleting** one or more nucleotides
- Changes the "**reading frame**" like changing a sentence
- **Proteins** built **incorrectly**

Frameshift Mutation

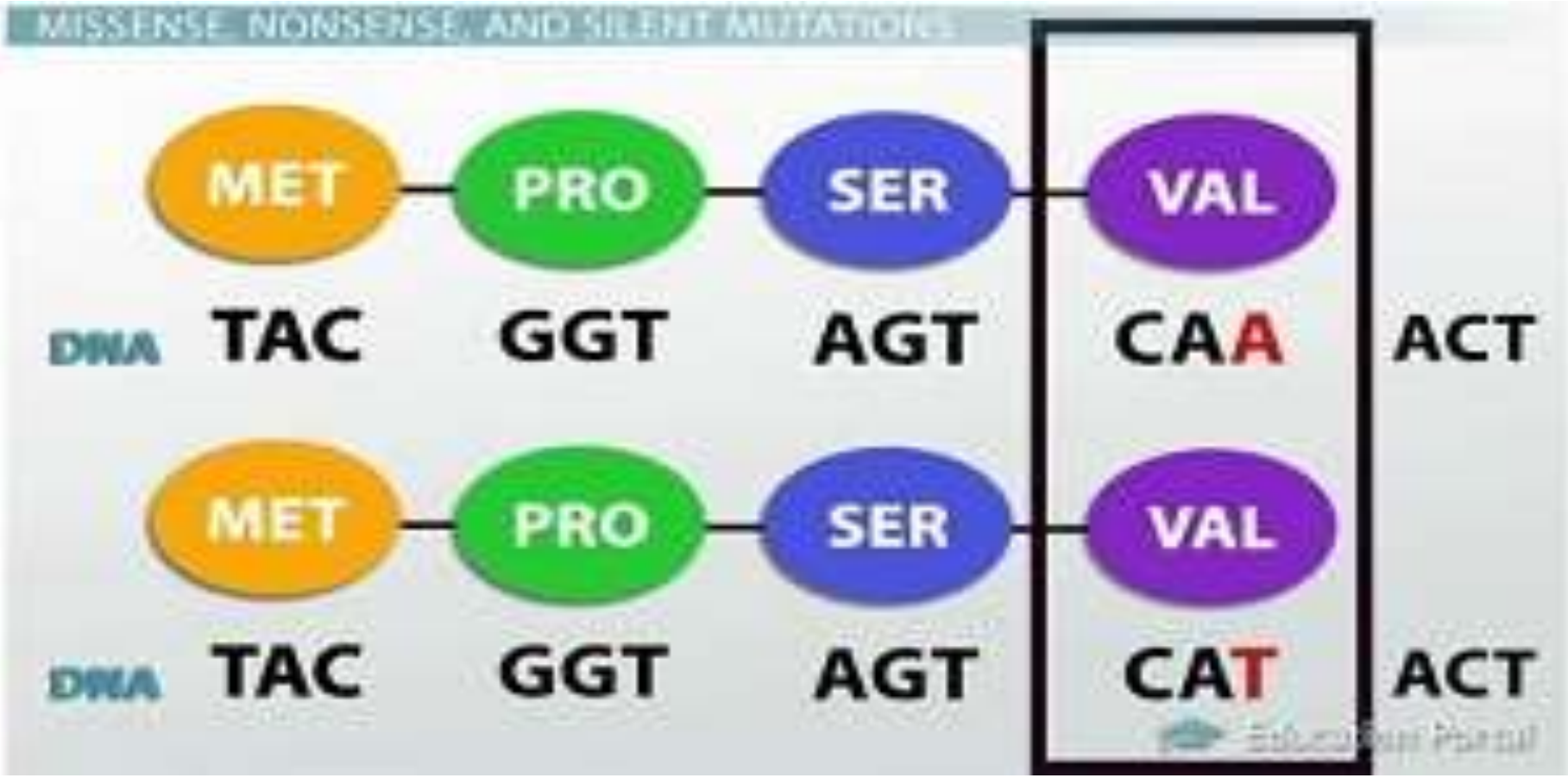


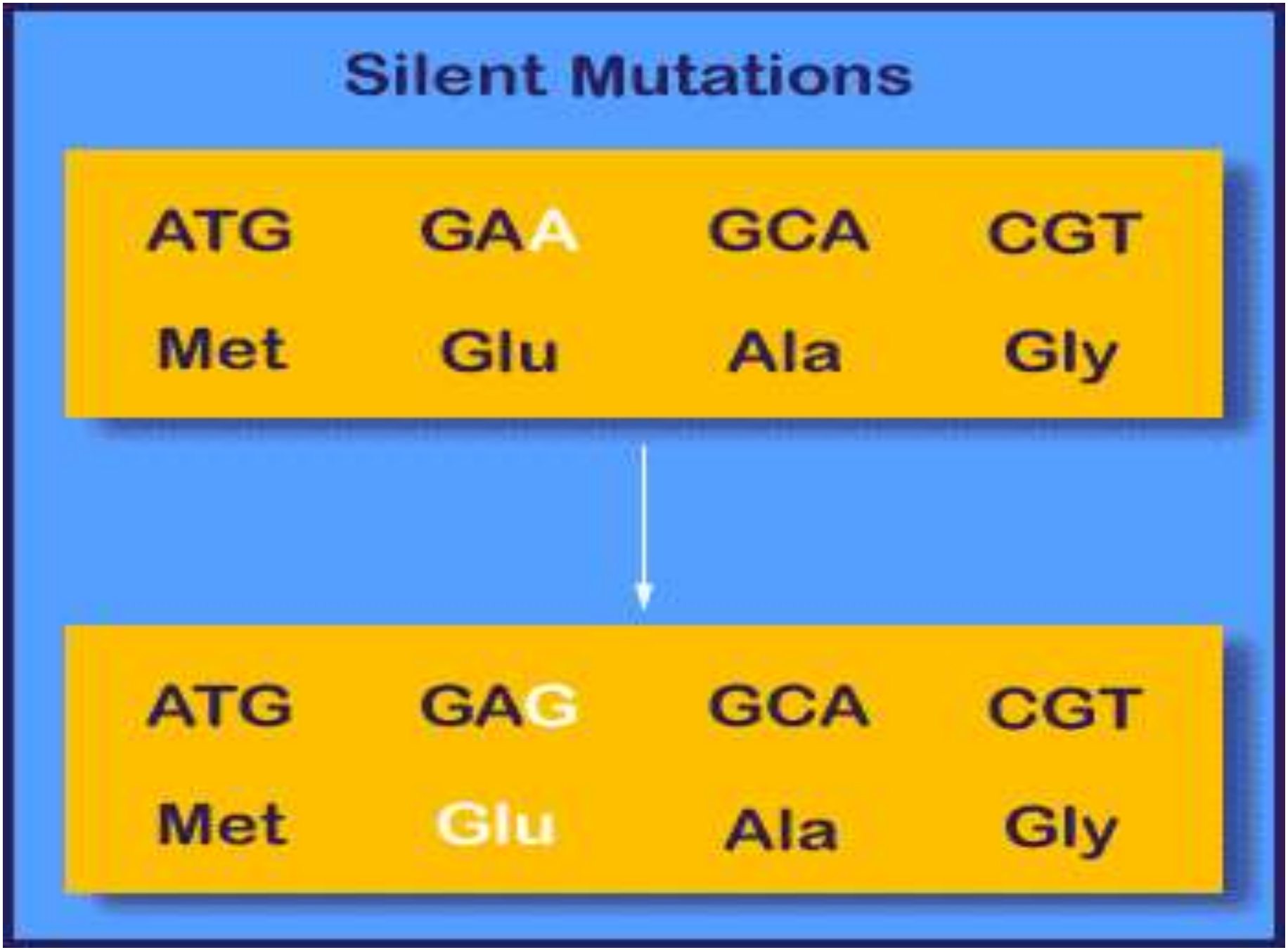
Amino Acid Sequence Changed




DNA
A A A A T G C T T C T C
mRNA
U U U U A C G A A G A G
Amino acids
Phe Tyr Glu Glu
Normal
DNA
A A A A T G T T T C T C
mRNA
U U U U A C A A A G A G
Amino acids
Phe Tyr Lys Glu
Substitution
DNA
A A A A T G C C T T C T
mRNA
U U U U A C G G A A G A
Amino acids
Phe Tyr Gly Arg
Insertion
DNA
A A A T G C T T C T C C
mRNA
U U U A C G A A G A G G
Amino acids
Phe Thr Lys Arg
Deletion

silent mutation




Silent Mutations
ATG GAA GCA CGT
Met Glu Ala Gly
ATG GAG GCA CGT
Met Glu Ala Gly

No change(Silent mutation)

Normal gene

GGTCTCCTCACGCCA

↓

CCAGAGGAGUGCGGU

Codons

↓

Pro-Glu-Glu-Cys-Gly

Amino acids

Substitution mutation

GGTCTTCTCACGCCA

↓

CCAGAAGAGUGCGGU

↓

Pro-**Glu**-Glu-Cys-Gly