Mutations (1)

What are mutations?

A change in the usual DNA sequence at a particular gene locus.

Causes of mutations

- Mutations result from **errors during DNA replication** or direct **damage to DNA** (such as may be caused by exposure to radiation or carcinogens).

- Mutations may also result from **insertion or deletion** of segments of DNA due to **mobile genetic elements**.

- Mutations may or may not produce **apparent** changes in the observable characteristics (phenotype) of an organism.

Impact of mutations

- Mutations play a part in both **normal and abnormal** biological processes including **evolution, cancer**, and the **development of the immune system.**

- A mutation can result in **many different types** of changes in sequences.

- Mutations in genes can either have **no effect**, **alter the product** of a gene, or **prevent** the gene from functioning properly or completely.

Mobile genetic elements

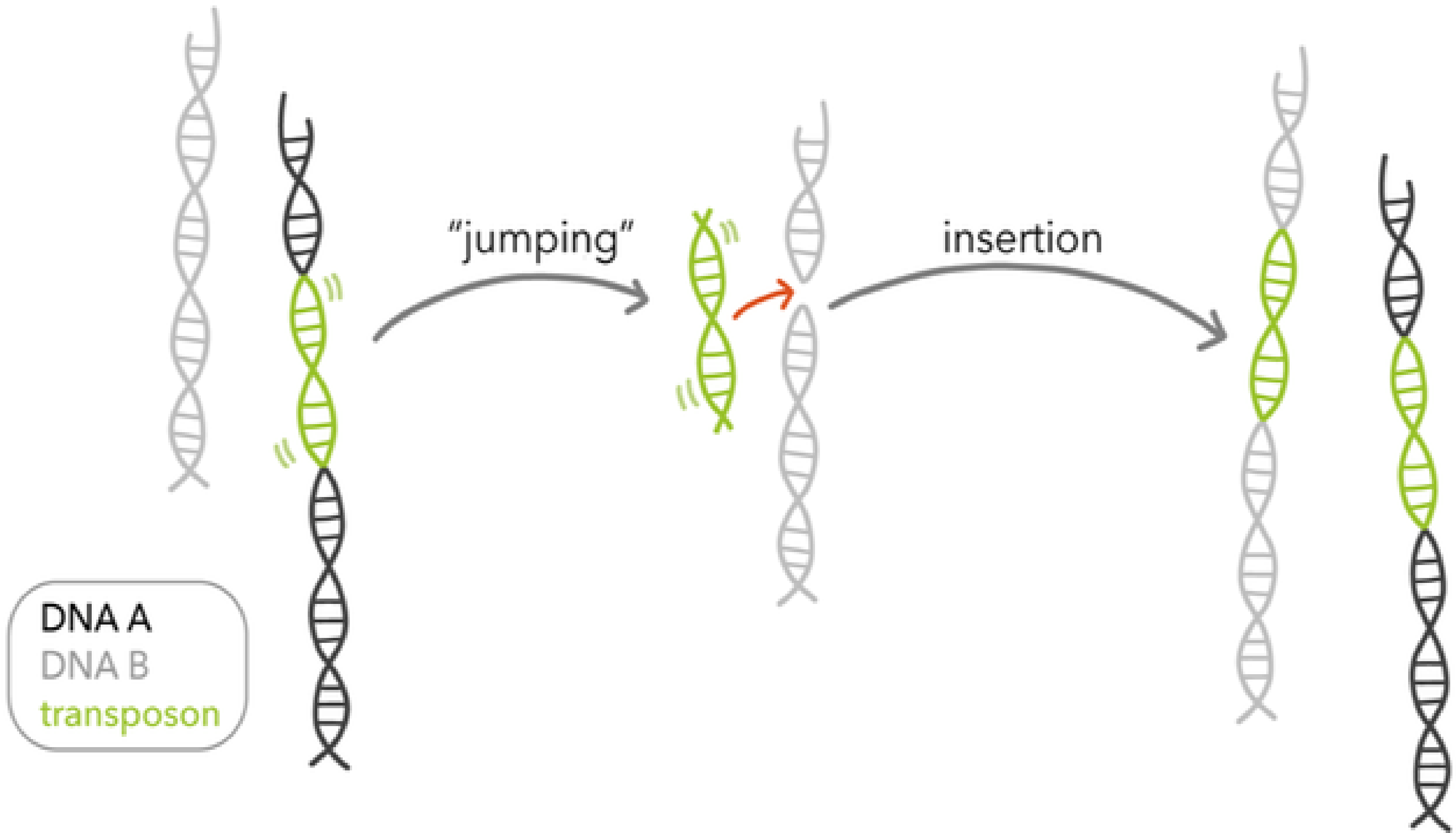
- These are sequences of DNA that can move from one place to other in the genome, and these make up a major fraction of the genetic material of plants and animals.

  A major type is **transposons** or **jumping genes.**

- They may have been important in the **evolution** of genomes.

- For example, more than a **million copies of the *Alu* sequence** are present in the **human genome**, and these sequences perform functions such as **regulating gene expression.**

*	An *Alu* element is a short stretch of DNA originally characterized by the action of the ***Arthrobacter luteus*** **(Alu) restriction endonuclease.**


"jumping"
insertion
DNA A
DNA B
transposon

- Another effect of these mobile DNA sequences is that when they move within a genome, they can **mutate or delete existing genes** and thereby produce **genetic diversity**.

- Lethal mutations lead to death but nonlethal mutations **accumulate within the gene pool** and increase the amount of genetic variation.

- The abundance of genetic changes within the gene pool is **reduced by natural selection; "more favorable" mutations accumulate** and result in adaptive changes.

For example, a butterfly may produce offspring with new mutations.

The majority of these mutations will have no effect; but **one might change the color** of one of the butterfly's offspring, making it harder (or easier) for predators to see.

Neutral mutations

- **Neutral mutations** are defined as mutations whose effects **do not influence** the fitness of an individual.
- These can increase in frequency over time due to **genetic drift**.
- **Genetic drift** (also known as **allelic drift**) is the change in the frequency of an **existing gene variant (allele)** in a population.
- It is believed that the **overwhelming majority** of mutations have no significant effect on an **organism's fitness**.

* In simple terms fitness of an individual means ability to reproduce.

Classification of mutations

There are several ways of classifying mutations.

One classification can be:

(1) Spontaneous mutations (molecular decay)

(2) Mutations due to error-prone replication

(3) Errors introduced during DNA repair

(4) Induced mutations caused by mutagens

Common types of mutations

Induced mutations

Induced mutations are alterations in the gene **after it has come in contact** with mutagens and environmental causes.

These include:

1. Base Substitution

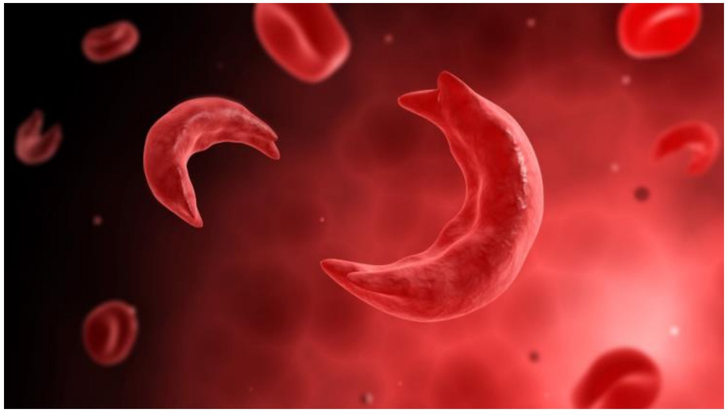
A base substitution is a mutation that **exchanges one base for another** (i.e., a change in a single base such as switching an A to a G).

Such a substitution could:

1. **Change a codon** to one that encodes a **different** amino acid and cause a **small change** in the protein produced.

   It is called **missense mutation**.

   For example, **sickle cell anemia** is caused by a substitution in the **beta-hemoglobin gene** (GAG codon changing to GTG) which alters a single amino acid in the protein produced.



2. **Change a codon** to one that **encodes the same amino acid** and causes no change in the protein produced.

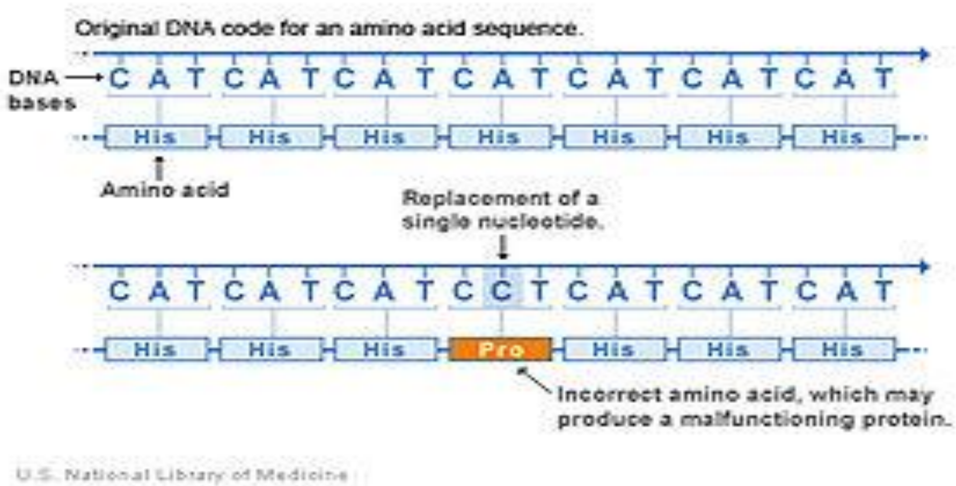
   These are called **silent mutations**.

3. **Change an amino-acid-coding codon** to a single **"stop" codon** and cause an incomplete protein.

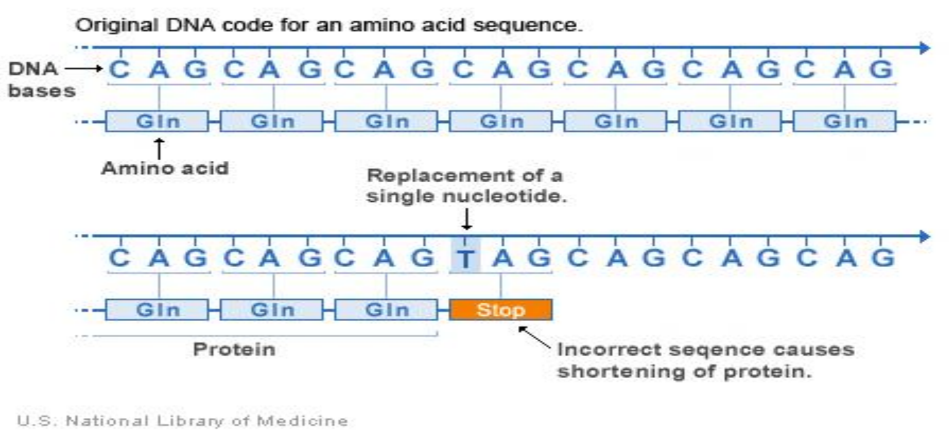
   This can have serious effects since the incomplete protein probably won't function.

   This is called **nonsense mutation**.

Missense mutation



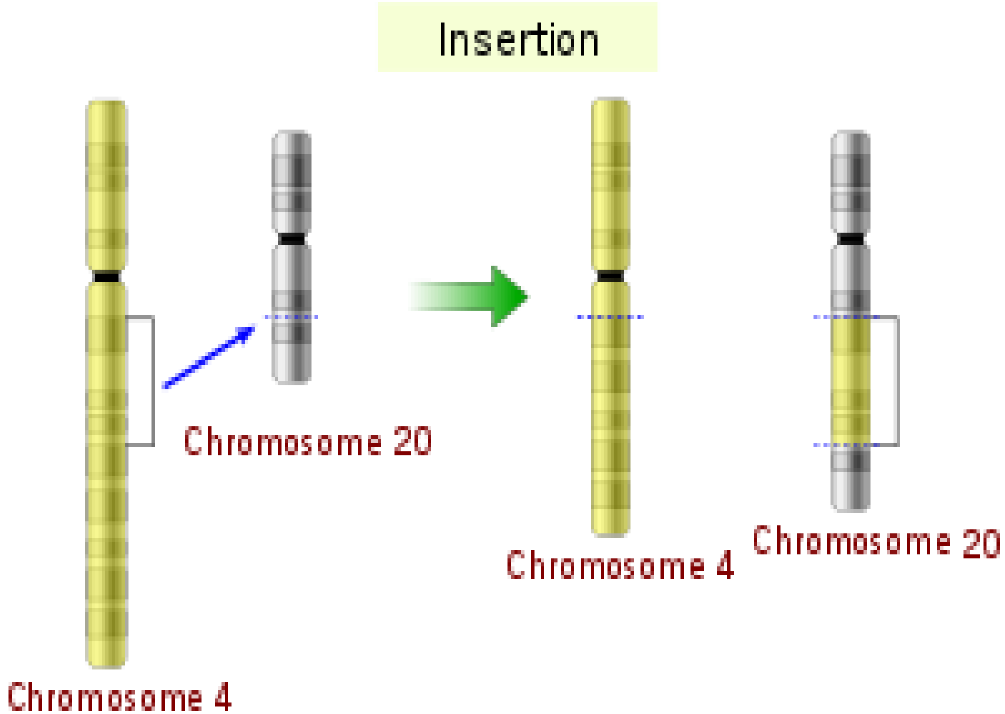
Nonsense mutation



Now let us look at **some other natural ways** of mutations:

Insertion

Insertions are mutations in which **extra base pairs are inserted** into a new place in the DNA.



Deletion

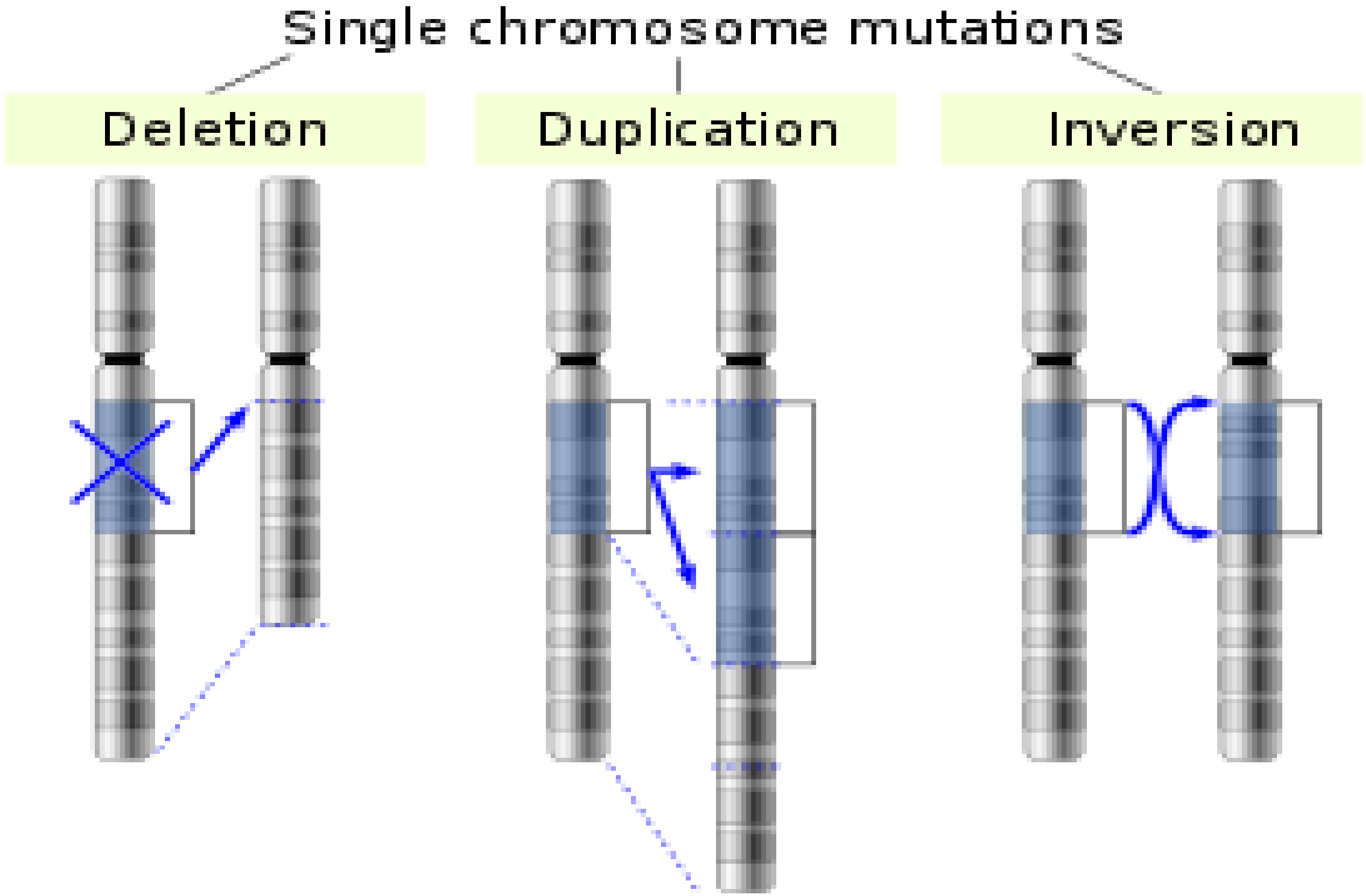
Deletions are mutations in which a **section of DNA is lost, or deleted.**

Duplication

A DNA sequence gets repeated.

Inversion

A DNA sequence gets **oriented in opposite direction**.

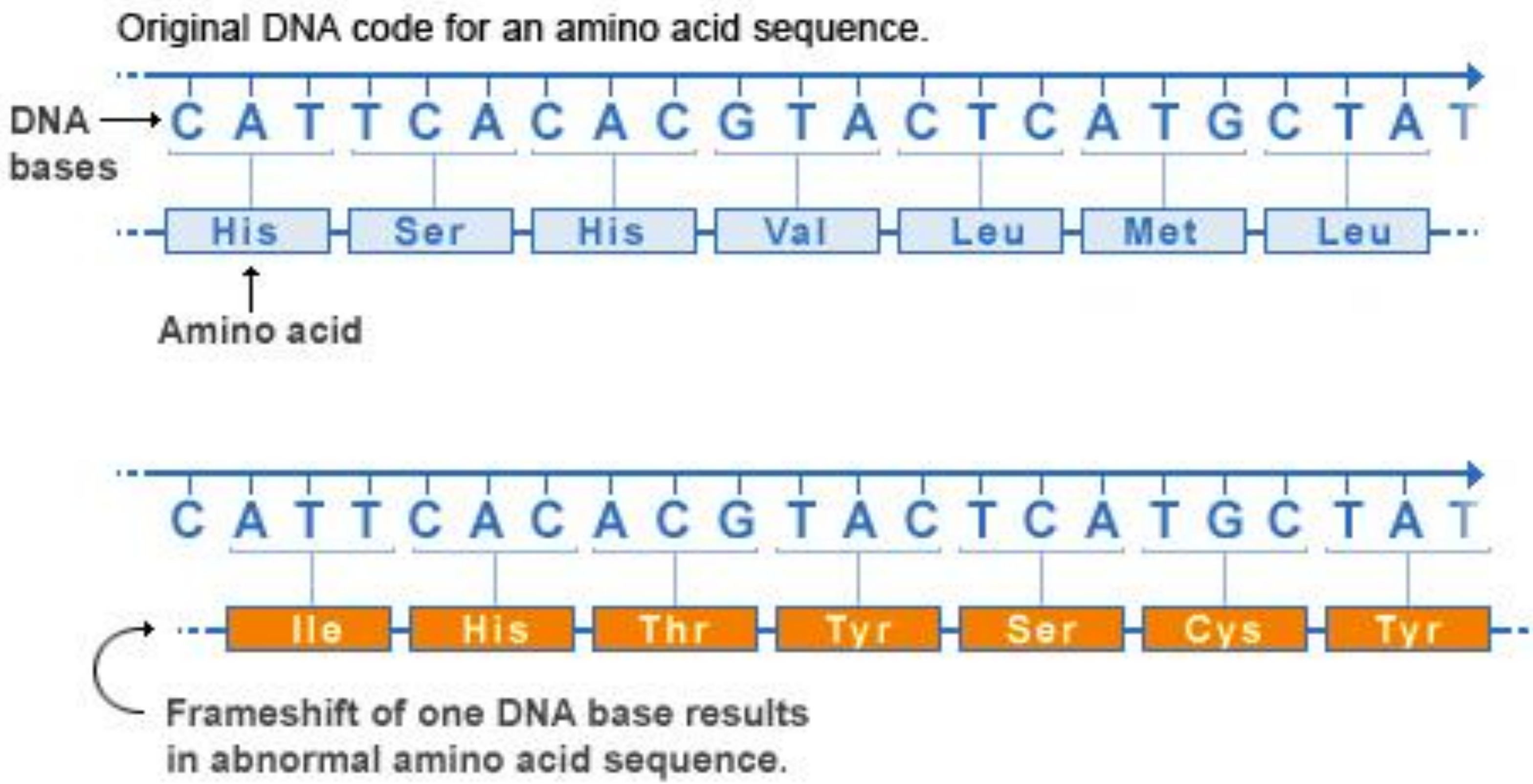

Single chromosome mutations
Deletion
Duplication
Inversion

Frameshift mutation

- This is due to **addition or deletion** of one or more base pairs resulting in **shifting of reading frame** on the ribosome.

- It results in **insertion of wrong amino acids downstream** from the mutation and in production of an **inactive protein**.

Frameshift mutation



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Thank You!