Hello everyone. My name is Khirman. Me aleena and Maryam are about to present you our topic mutation.

A **mutation** is a permanent alteration in the DNA sequence of an organism's genome. These changes can occur naturally or be induced, and they may affect a single DNA base, a gene, or even a larger segment of a chromosome, potentially altering the function or expression of genes.

Next, there are three basis to classify mutations which are:

1. Molecular nature
2. Phenotypic effect
3. Causative agents

Let’s explore gene mutations based on their **molecular nature**, which focuses on the specific changes occurring in the DNA sequence. This classification includes two main types: **base substitutions** and **insertions or deletions**.

**1. Base Substitution**

A base substitution occurs when a single nucleotide in the DNA sequence is replaced with a different one. While it may seem like a minor change, it can significantly impact the resulting protein or have no effect at all, depending on where it happens and the type of substitution.

There are two subtypes of base substitutions:

* **Transition**: This is the replacement of a purine base (adenine or guanine) with another purine, or a pyrimidine base (cytosine or thymine) with another pyrimidine. Because the chemical structure remains relatively similar, transitions are more common than transversions.
* **Transversion**: This involves the replacement of a purine with a pyrimidine, or vice versa. Transversions cause a greater structural disruption in the DNA, as the swap involves different base structures.

**2. Insertion and Deletion**

Insertions and deletions involve the addition or removal of one or more nucleotides from the DNA sequence.

* **Insertion**: This adds extra nucleotides into the sequence. Depending on the number of nucleotides inserted, this can disrupt the normal reading frame of the gene, leading to a frameshift mutation if the number of bases added is not a multiple of three.
* **Deletion**: This removes nucleotides from the sequence. Like insertions, deletions can cause frameshift mutations when the number of removed nucleotides isn’t divisible by three. This can lead to a complete alteration of the downstream amino acid

now let’s move on to the second way we classify mutations—**phenotypic .** Here’s a quick breakdown of the different types:

1. **Forward Mutation**: This is when a mutation changes a wild-type (normal) allele into a mutant allele, altering the gene’s original function.
2. **Reverse Mutation**: Also called a reversion, it restores a mutant allele back to the wild-type state or a functional state.
3. **Missense Mutation**: This type of mutation changes one amino acid in a protein to another, potentially altering the protein’s function or activity.
4. **Nonsense Mutation**: Here, a mutation converts a codon into a stop codon, leading to the premature termination of protein synthesis.
5. **Silent Mutation**: A mutation that changes the DNA sequence but does not alter the resulting amino acid, leaving the protein unaffected.
6. **Neutral Mutation**: This results in an amino acid change, but it has little to no effect on the protein’s structure or function.
7. **Loss-of-Function Mutation**: This reduces or completely eliminates the function of the gene or its product, often leading to a recessive phenotype.
8. **Gain-of-Function Mutation**: This mutation enhances or introduces a new activity to the gene product, often leading to a dominant phenotype.
9. **Conditional Mutation**: A mutation that has effects only under specific environmental conditions, such as temperature sensitivity.
10. **Lethal Mutation**: This type of mutation disrupts an essential function, leading to the death of the organism.
11. **Suppressor Mutation**: A second mutation that counteracts the effect of the first mutation, restoring partial or complete function.

Each of these types illustrates how genetic changes can manifest in different ways, depending on how they impact the gene, the protein, or the organism’s overall traits.

Now let’s dive into the third basis for classifying mutations, which is their **causative effect**. This classification focuses on how mutations originate—whether they occur naturally or are triggered by external factors. There are two main types: **spontaneous mutations** and **induced mutations**.

### 1. ****Spontaneous Mutation****

These mutations occur naturally without any external influence. They are the result of errors in DNA replication, repair, or recombination, or due to natural chemical changes like depurination (loss of a purine base) or deamination (conversion of cytosine to uracil). Spontaneous mutations are rare but essential for genetic diversity.

### 2. ****Induced Mutation****

Induced mutations are caused by exposure to external agents known as **mutagens**, which can be physical or chemical.

#### **Radiation as a Mutagen**

* **Ionizing Radiation** (e.g., X-rays, gamma rays): These can cause breaks in the DNA strands, leading to large-scale mutations.
* **Non-Ionizing Radiation** (e.g., UV rays): UV light induces the formation of thymine dimers, which disrupt the normal DNA structure and block replication.

#### **Chemical Mutagens**

Chemical mutagens interact with DNA and induce mutations through various mechanisms. Let’s look at some major types:

1. **Base Analogs**:  
   These are chemicals structurally similar to normal DNA bases. They can be incorporated into DNA during replication and cause errors.

* Example: **5-bromouracil (5-BU)** resembles thymine but can pair with guanine, leading to base-pair substitutions.

1. **Alkylating Agents**:  
   These add alkyl groups (like methyl or ethyl) to DNA bases, altering their pairing properties.

* Example: **Ethyl methanesulfonate (EMS)** alkylates guanine, making it pair with thymine instead of cytosine.
* Another example: **Mustard gas**, which can cross-link DNA strands, interfering with replication and transcription.

1. **Deaminating Agents**:  
   These remove amino groups from DNA bases, causing them to mispair.

* Example: **Nitrous acid** deaminates adenine, converting it into hypoxanthine, which pairs with cytosine instead of thymine.

1. **Hydroxylamines**:  
   These add hydroxyl groups to bases, modifying their pairing behavior.

* Example: **Hydroxylamine** specifically modifies cytosine, increasing its ability to pair with adenine, leading to transitions.

1. **Intercalating Agents**:  
   These molecules insert themselves between base pairs in the DNA helix, causing distortions that lead to insertions or deletions during replication.

* Examples: **Ethidium bromide**, **acridine orange**, and **proflavine** are common intercalating agents.

In summary, mutations classified by causative effect highlight whether they arise naturally or are induced by specific factors like radiation or chemicals. Chemical mutagens, in particular, provide a detailed insight into how various agents can alter the DNA structure and cause genetic changes.