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Lecture – 12

Mutagenic agent and Induction of mutation

by

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Mutagens

Chemical Mutagens

Physical Mutagens

→ Alkylating agents-

Ethylmethane Sulphonate (EMS), Mustard gas

→ Deamination agents-

Nitrous acid

→ Base Analogues-

5-Bromouracil(5-BU)
2-Aminopurine(2-AP)

→ Acridines-

Acriflavin, Proflavin

→ Other chemical mutagens-

Hydroxylamine(HA), Sodium azide

Mutagenic to both replicating and nonreplicating DNA

Mutagenic to only replicating DNA

Ionizing

Nonionizing

UV rays

Particulate

α -ray, β -ray,
Fast and Thermal neutrons

Nonparticulate

X- ray, γ - ray



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Physical mutagens: Include various types of radiations

- a) Ionizing radiations:** They work through the release of ions. They have deep penetrating capacity. Eg: x-rays, γ -rays, α -particles etc.
- b) Non-ionizing radiations:** They function through excitation and have a very low penetrating capacity. They are used for studies on bacteria and viruses. Eg. UV rays.

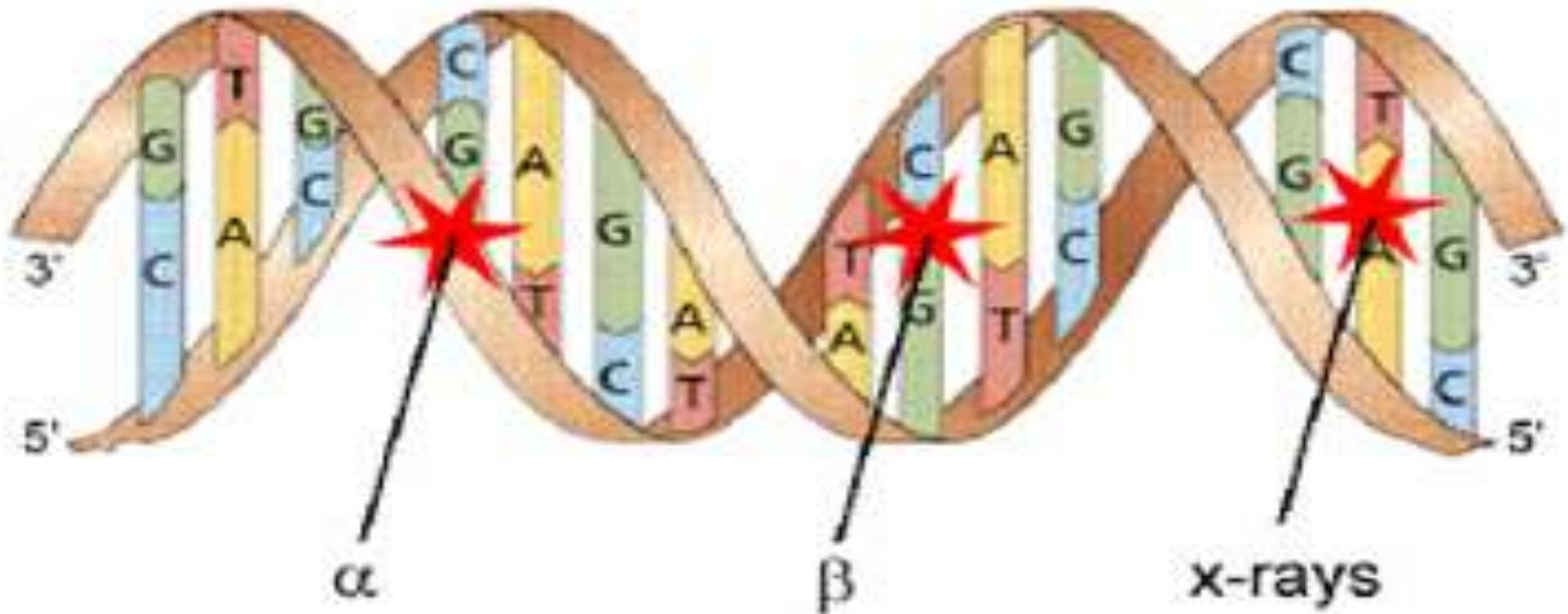
Sources of physical mutagens:

- Gamma garden
- Gamma green house
- Vertical gamma irradiation facility
- Horizontal gamma irradiation facility
- X-ray machine
- Isotopes
- Small portable irradiators, accelerators and cyclotrons
- Nuclear reactors



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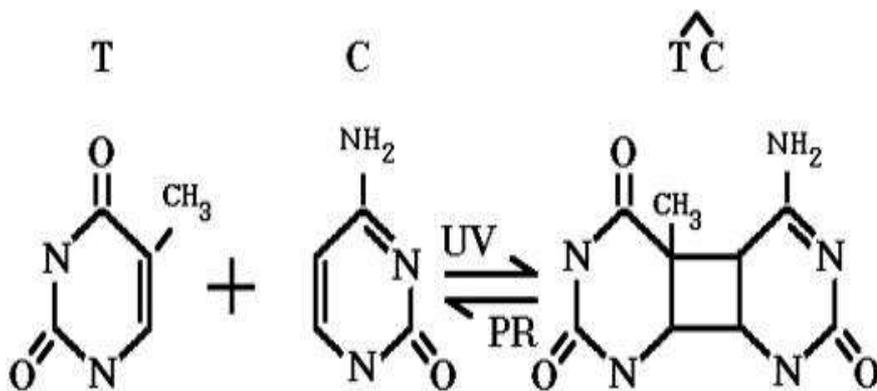
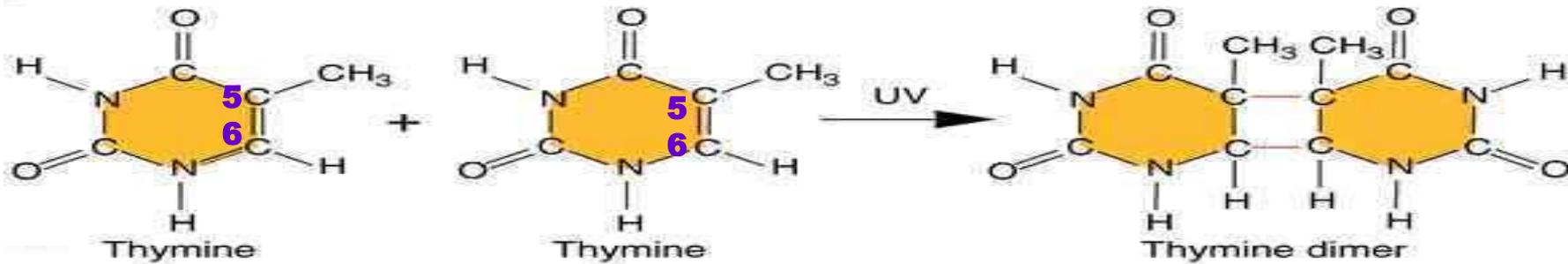
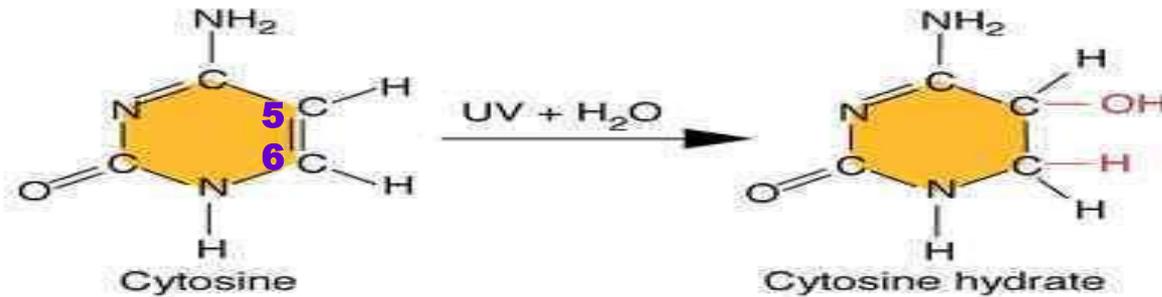
Direct effect of radiation on DNA



In the figure alpha particle breaks the "backbone" of the DNA, the beta particle breaks hydrogen bonds, and X-rays damage bases. However in fact all three types of radiation can cause all three types of direct damage.

Direct effect of radiation (UV-ray) on DNA

Resulted in Pyrimidine dimers and pyrimidine hydrates



Thymine-cytosine dimers

➤ Dimrization prevents normal base pairing and disrupts continuous new strand formation during replication (causes skin cancer, called **Xeroderma pigmentosa**).

➤ Interfere DNA "repair" mechanisms



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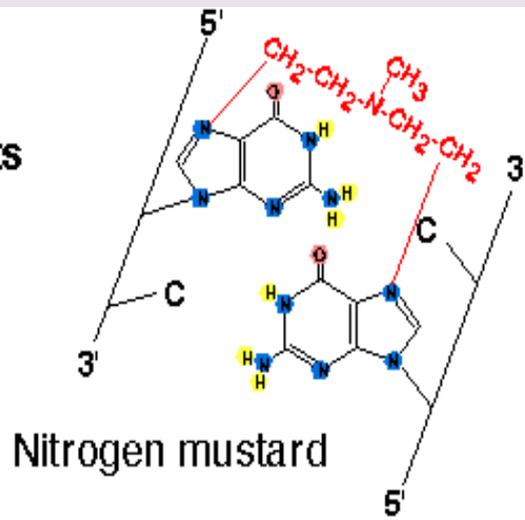
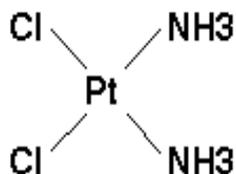
Effect of chemical mutagens

1. Alkylating agents

- ❖ This is the most powerful group of mutagens and mainly used to induce mutations in cultivated plants.
- ❖ **Transfer their alkyl group to the DNA base and phosphate** . It induces mutation by..
- ❖ Produce **phosphat triester** which interfere with DNA replication and causes breakage in the sugar-phosphate backbone.
- ❖ The alkylation product **7-ethyl guanine** is believed to be pair with thymine(T) in place of cytosine(C), it leads to **GC- AT transition**.

Crosslinking Agents

cis-platin



- ❖ **Depurination** (dissociation of 7-ethyl guanine) may prevent the replication or may incorporate wrong base in DNA strands.

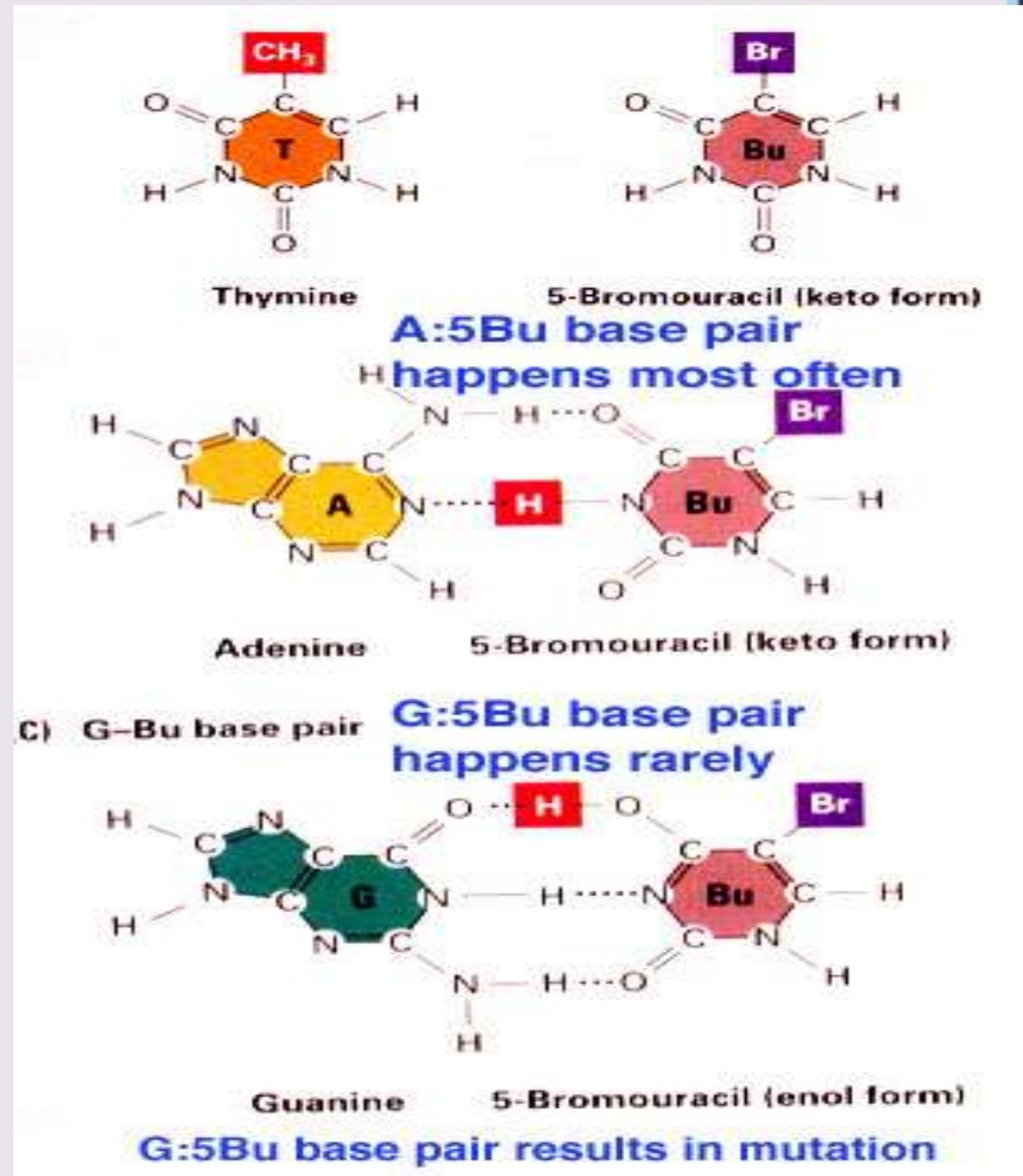
Eg: DMS, EMS, NMU, NEU, MMS

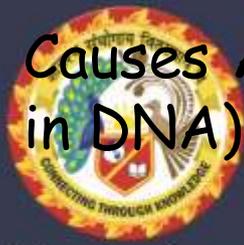


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2. Base analogues

- These are chemicals which are very similar to DNA bases, such chemicals are sometimes incorporated in DNA in place of normal bases during replication.
- Thus, they can cause mutation by wrong base pairing.
- An incorrect base pairing results in transitions or transversions after DNA replication.
- Eg: 5-bromouracil, 3-bromodeoxy uridine, 2-amino purine.

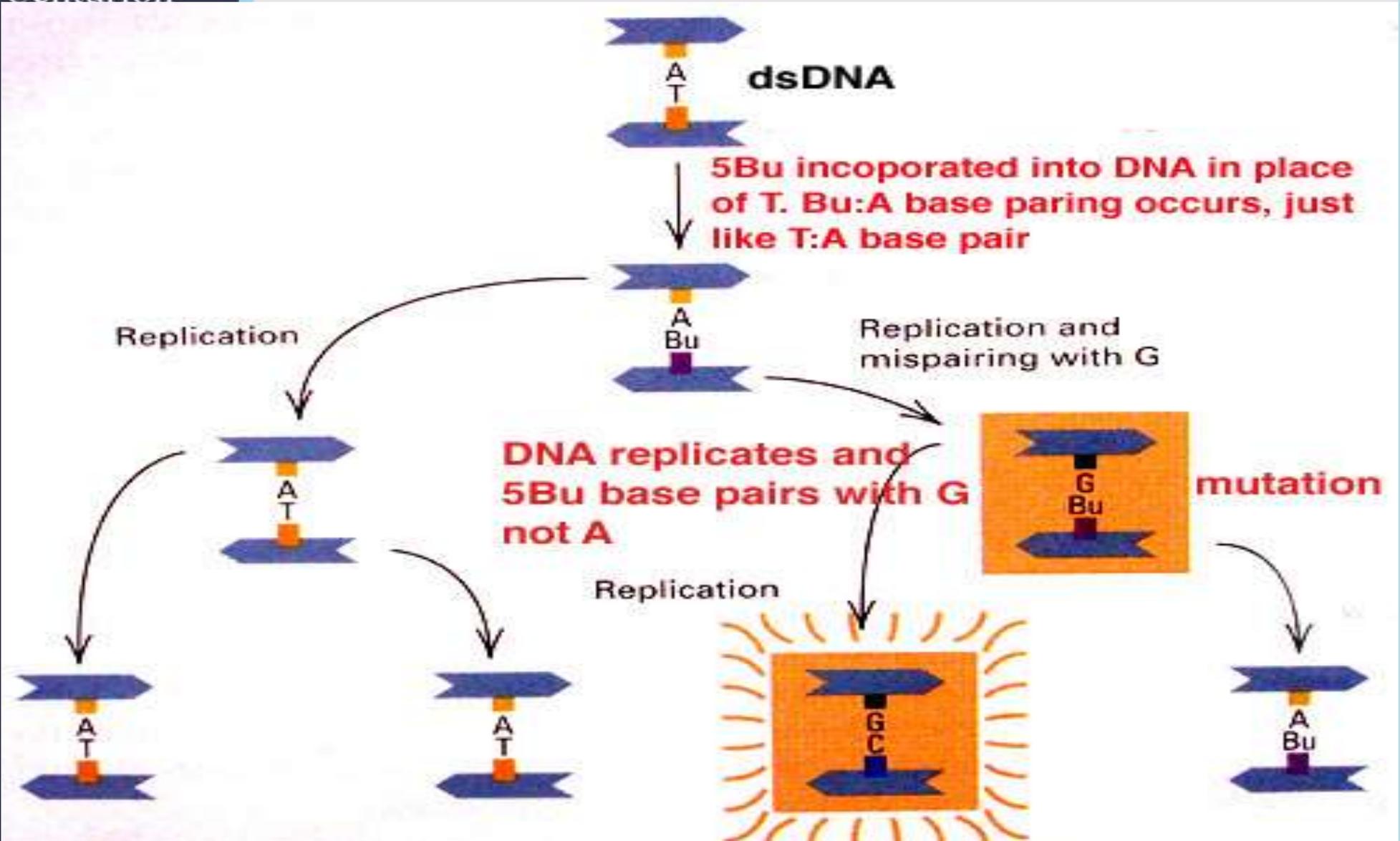




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Causes **AT-GC** (formation of enol form of 5-BU after incorporation in DNA) or **GC-AT**(incorporation of 5-BU in enol form) transition.

AT -GC transition.





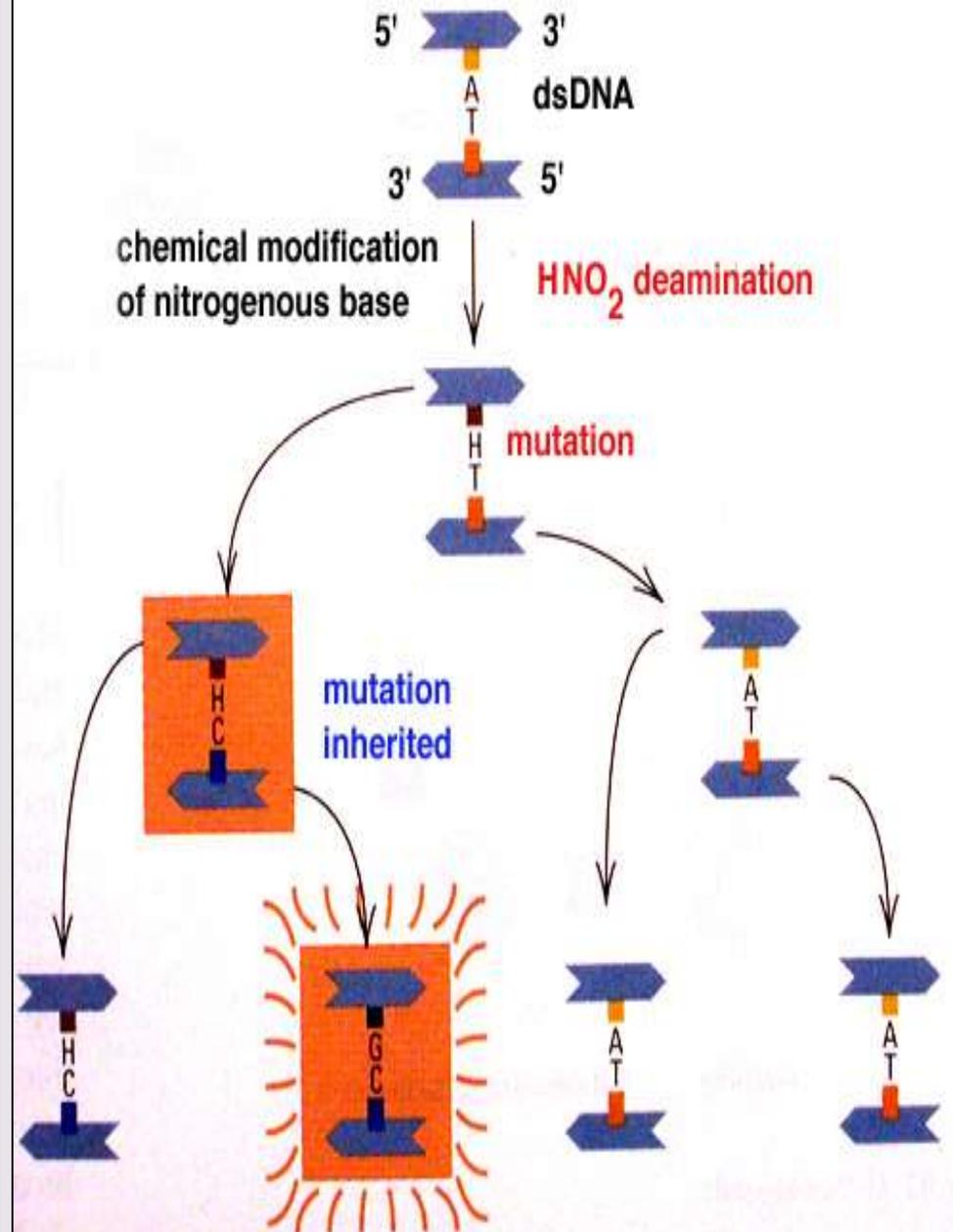
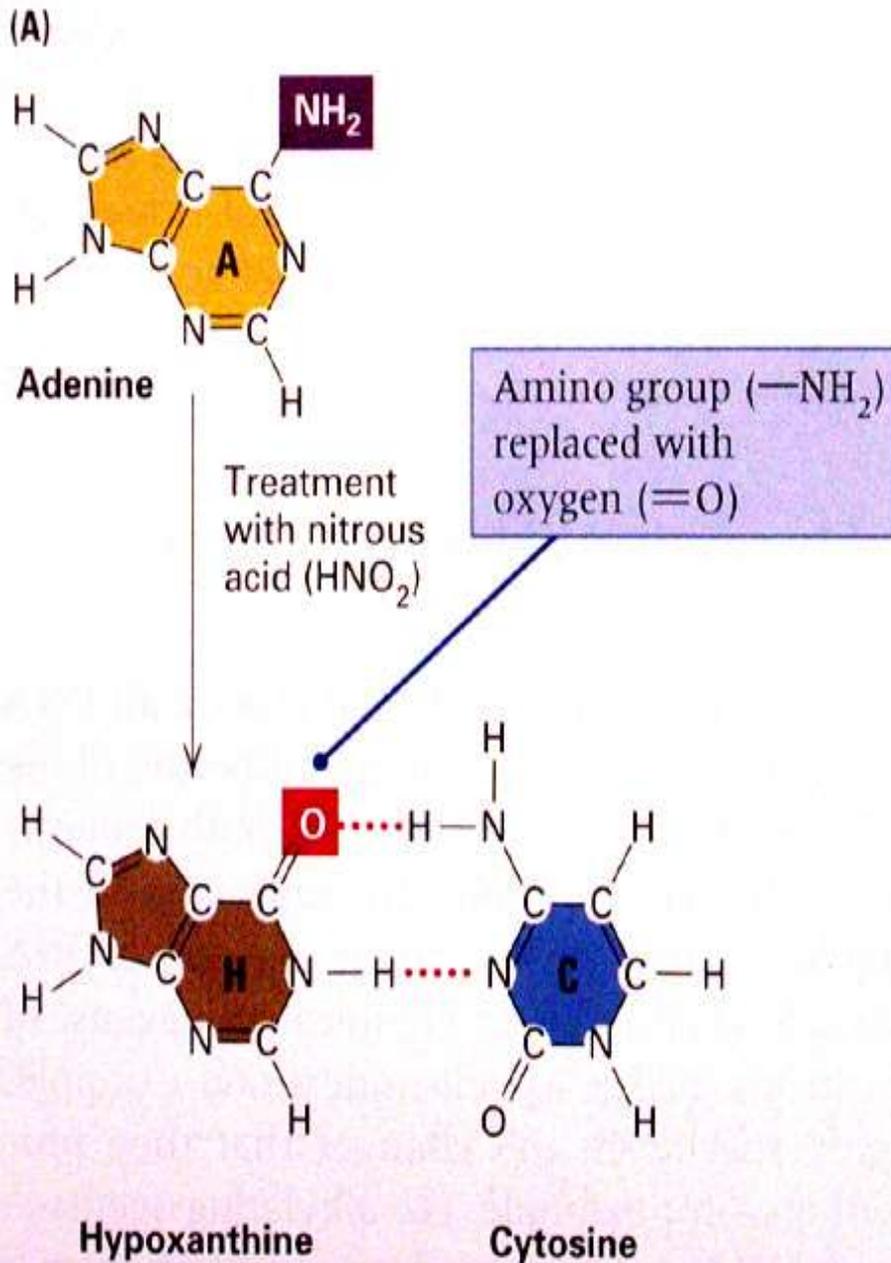
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3. Deaminating agents

- ❖ Nitrous acid (HNO_2) is potent deaminating mutagens, it leads to Oxidative deamination for the bases that contain amino ($-\text{NH}_2$) group which convert amino group to keto group, and thereby changes the hydrogen bonding pattern of bases.
- ❖ It induce transition in both direction, **AT** \longleftrightarrow **GC**
- ❖ Has strong mutagenic activity in a variety of viruses and microorganisms. But not useful in higher plants.

Base (amino form)	Deaminated to	Pairs with	Effect
Adenine(A)	Hypoxanthin	Cytosine	AT-GC transition
Cytosine(C)	Uracil	Adenine	GC-AT transition
Guanine(G)	Xanthin	Cytosine	No effect

Deaminating agents causes $AT \leftrightarrow GC$ transition



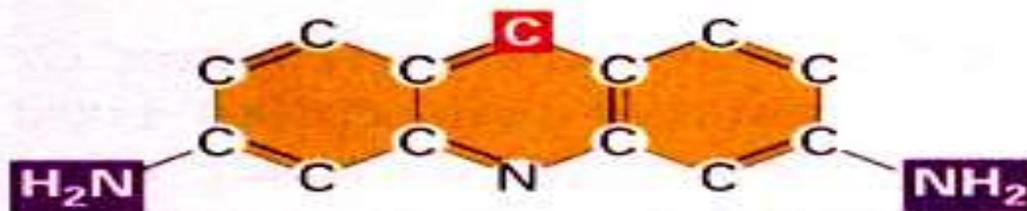


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4. Acridine dyes

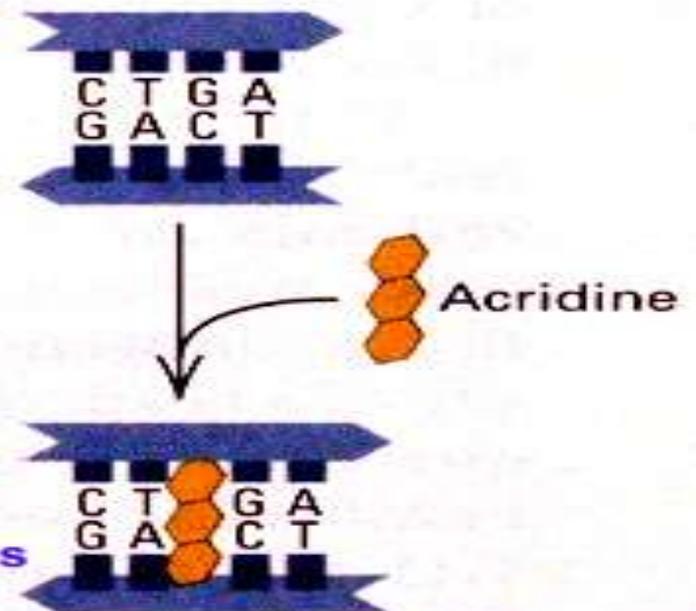
- ❖ Replication of intercalated DNA molecule often result in addition or deletion of one to few base pairs, which produces **FRAME-SHIFT MUTATION**.
- ❖ Acridine dyes are positively charged compound which increases the rigidity of DNA double helix as well as disturbs its configuration through **INTERCALATION**
- ❖ Eg: proflavin, acriflavin, acridine orange, etc

(A)



Proflavin

(B)



dye intercalated between
strands of DNA
causes deletions or duplications
or additions



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Materials used for treating with mutagens:

- Seeds,
- pollen,
- vegetative
- buds,
- whole plants,
- bulbils,
- tubers,
- suckers etc.

Detection of mutations in plants:

No. of plants exhibiting mutant
phenotype in M₂

$$\text{Mutation frequency (\%)} = \frac{\text{Total number of plants in M}_2}{\text{Total number of plants in M}_2} \times 100$$



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Significance of mutations in Plant Breeding:

1. When a variety is exceptionally good except for one or few characters.
2. When a recessive character is desirable and transfer of that character from wild species is difficult.
3. When a desirable character is linked with an undesirable character.
4. If there is no known source of resistance gene in the available germplasm
5. To create variability
6. To develop male sterile lines
7. To create variations in vegetatively propagated plants



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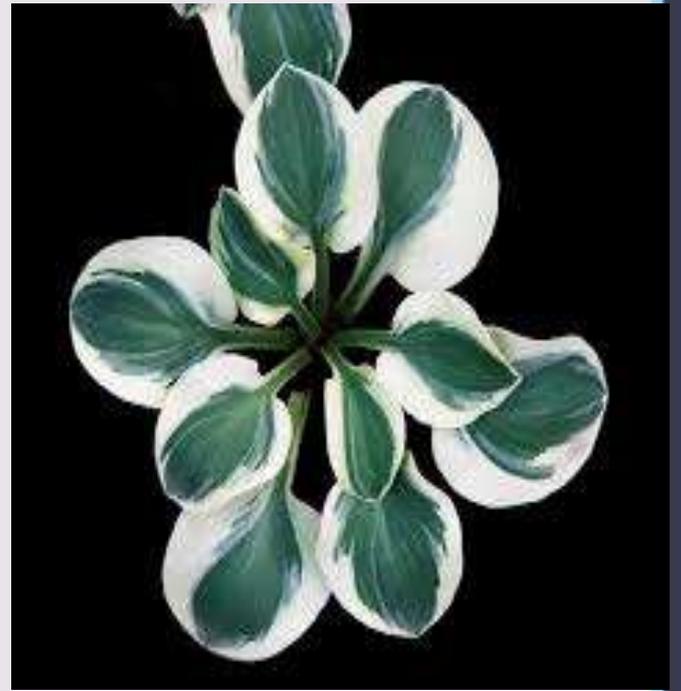
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Chimeras

Chimera is defined as a mixture of genetically diverse tissues in the same shoot. These tissues frequently form mosaic pattern.

- ❖ The most common and easily observed chimeras are leaf variegations observed in horticultural plants like Codium and Acalypha.
- ❖ The leaf variegations or chlorophyll variegations are due to plastid mutations, consisting of green and white or green and yellow patterning as also the patterning of anthocyanin distribution.





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Xenia and Metaxenia

Effect of the genotype of pollen grain on the phenotype of seed tissues (embryo and endosperm) or the genetic effect of pollen parent upon the embryo and endosperm of seeds in some plants.





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