during the repair of broken pieces mutation rather then the chromosomal aberration results.

Evidence for the existence of leading or repair process comes from the fact that a continuous dose of radiation is more effective then an intermutant one. Besides the dose of irradiation the physiologi-cal state of the cell too is important for effective mutagenesis. Irradiation of higher oxygen concentration is more effective. Water molecules are ionised by irradiation into hydroxyl ions.

$$H_2O + \text{irradiation} \longrightarrow H + OH$$

In the presence of oxygen, hydrogen peroxide is easily produced from hydrogen atoms.

$$H_2 + 2O_2 \longrightarrow 2HO_2$$

$$HO_2 + H \longrightarrow H_2O_2 \text{ (hydrogen peroxide)}$$

This H_2O_2 is highly reactive and may be responsible to induce mutations. Therefore, irradiation is a highly mutagenic because of its direct and indirect effects.

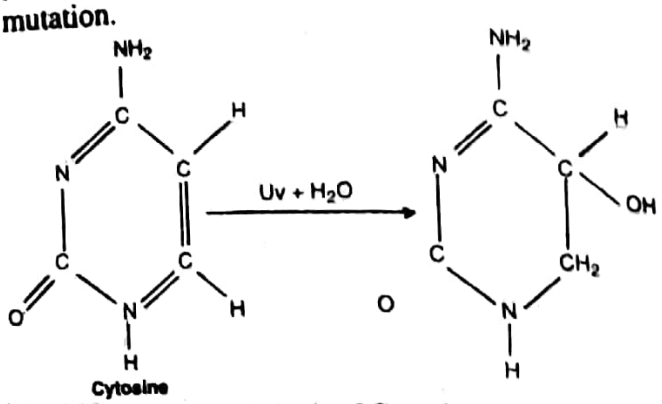
(ii) Non-ionizing radiations or U. V. irradiation—It has got a single tool *i.e.*, Ultra Violet-rays (UV) **Altenburg** (1934) found that UV radiation (too is mutagenic. UV-rays are not as effective) as X-rays because they are non-penetrating and are partly absorbed by the protoplasm. UV has been found to be very useful for inducing mutation because they can be irradiated at a unicellular stage and they have a thin nuclear membrane.

Mostly Ultra Violet-rays cause gene mutation, although chromosomal aberration is also reported by its application due to reversible and irreversible changes caused by its own activity.

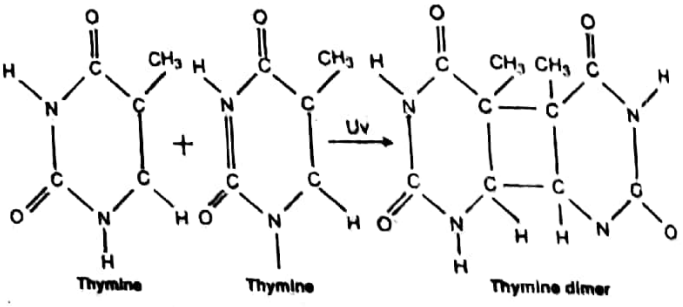
The mutation effects, however, do not fit in the target theory, since the relationship between mutation rate and *uv*-rays doses is not generally linear.

Action—UV light is absorbed by DNA and its bases, particularly by Thymine and Cytosine. UV hydrates cytosine by inserting a water molecule into the C = C double bond and joins together two thymine bases after disrupting their double carbon bonds, resulting into the formation of a **'thymine dimer.'** In Vitro studies of micro-organisms indicate that thymine dimerization is the main cause of UV mutagenesis. Such dimers would distort the DNA helix and interfere with proper replication.

Experimental evidences suggest that the possibilities that UV acts also on various DNA precursors and enzyme which in turn affect mutation.



Hydrolysis of Cytosine



Formation of Thymine dimer

(iii) Photodynamic mutagenesis—This mutagenesis may proceed, like UV mutation, by means of aberrent repair process. Visible light may generate a variety of photo-products in cells even in the absence of the added dyes. Unsensitized photodynamic mutagenesis in **E. Coli** may proceed both dependently and independently of oxygen.

(iv) Heat—This type of mutagenesis was obtained by **Muller** and **Altenburg** in **Drosophila.** High temperature and also mild heat at low pH can be highly mutagenic. Base pair substitution is produced but the mechanisms are unknown. A number of reactions occur inducing depurination and conversion of C to U. In favour of this agent a Washington Newspaper once ported "Tight underwear is more dangerous than the nuclear bomb fall out." Because men's testes under tight underwear are at higher temperature.

Dr Nidhi Kumari
Bot dept.

(B) Chemical mutagenes—A vigorous search was made for chemicals that could induce mutations. For the first time in 1939 **Thom & Steinberg** reported that nitrous acid causes mutations in **Aspergillus**. In 1946 **Auerbach & Robson** induced mutation in **Drosophila** by using **'Sulphur mustards.'** In the same year **Rapaport** discovered mutagenic activity in a variety of carbonyl compounds. Mutagenic chemicals fall under 3 broad categories—

(1) Some chemicals may directly convert the resident DNA into DNA of another base sequence by a series of chemical and enzymatic reactions. Replication of DNA is not necessary for this conversion. The chemicals which bring about such changes are—

Nitrous acid
Nitrogen mustard
Diethyl sulphate (DES)
Ethyl methane sulphonate (EMS)
Ethyl ethane sulphonate (EES)
Nitrosomethyl urea (NMU)
Nitrosoguamidine (NTG)
Hydroxyl amine, etc.

Nitrous acid deaminates the bases of the genetic materials. Thymine is not affected by nitrous acid because it lacks the amino-group. Due to deamination cytosine is converted to uracil, adenine to hypoxanthine and guanine to xanthine. Uracil pairs with adenine and hypoxanthine or xanthine with cytosine.

Further replication lead to substitutions of 'A' by 'G' and 'T' by 'C' or vice-versa. Thus A = T and G ≡ C base pairs are replaced by G ≡ C and A = T respectively.

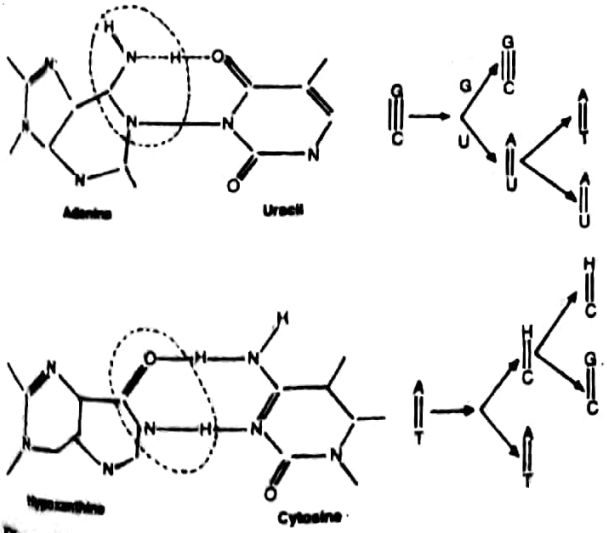


Fig. : Abnormal base pair as a result of pairing behaviour of deaminated bases and interconversions of A = T ⟷ G ≡ C during replication.

Imprecise replications may result into incorporation of wrong bases or addition or deletion of bases, thereby causing mutations.

(2) Some chemicals may get incorporated into DNA chain during replication and during further replication may result into abnormal bases. Replication errors are caused by the incorporation of base analogues or tautomeric forms of natural bases. Tautomeric shifts involve rearrangements of electrons and protons and consequently the 'normal amino' and 'keto' forms of bases are changed to 'imino' and 'enol' forms respectively. (Fig. A). This results in abnormal base pairs (Fig. B).

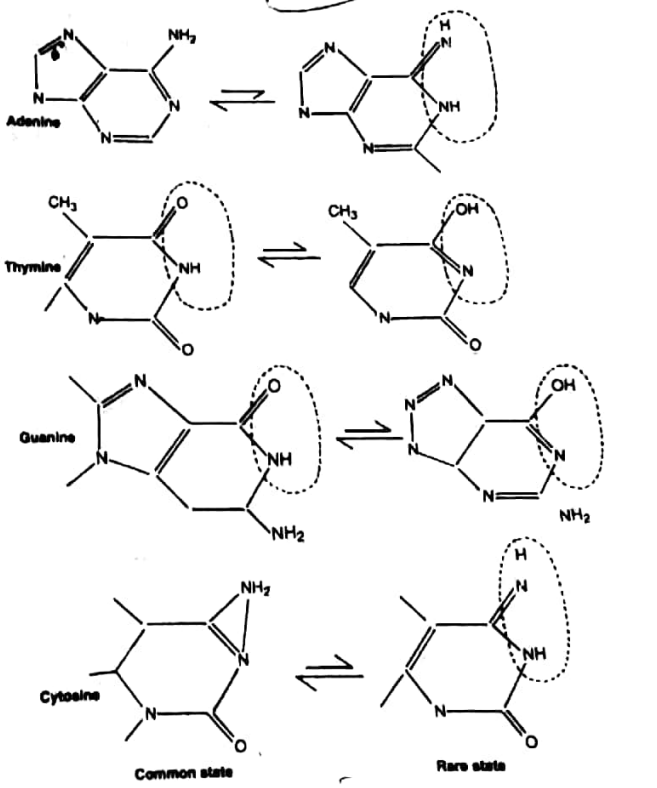


Fig. : Tautomerism of the bases of DNA.

(3) Acridine dyes cause addition or deletion of single base pairs by being complexed with DNA. Acridines, like 5-amino acridine and proflavin, get intercalated between two adjacent purines, thereby increasing the distance between them from 3·4Å to 6·8Å.