Changes in genetic systems are of great importance for human life. They can, as an acute effect be responsible for the death of cells, as well as for developmental damage or death of organisms. Mutations can also be involved in late radiation effects such as cancer induction or premature ageing. Generally, one distinguishes (Fig. 1) between mutations visible through the light microscope, such as changes in the number or in the structure of chromosomes, and point or gene mutations which cannot be detected by usual microscopical methods and are caused mainly by base damage.

Because cancer induction can be based on unicellular events, point mutations and chromosome aberrations, such as, translocations, can be the initial point of transformation.

The influence of local energy deposition on genetical damage is of great importance not only for fundamental interest but also for problems concerning human radiation risks. It is certainly important to know how large the genetical RBE (relative biological effectiveness) of neutrons from nuclear weapons is or what the effects of high energy particles from space are. The effect of heavy ions mainly on inactivation of cells are partly unexpected from a conventional point-of-view (see Kraft 1987).

Differential behaviour of misfusion and nonfusion events in mutation induction by peak pions (Fritz-Niggli et al 1985) stimulated us to further investigations of the dependence of different types of mutation on linear energy transfer. A useful tool for this are heavy ions. We chose for our studies mutations involving fusion and mutations not connected with fusion. (Fig. 2) For one type, namely, translocations, two events are always responsible: first, fragmentation and then fusion of the fragments. Normal fusion represents repair, restitution; misfusion, such as, combination of foreign pieces of chromosomes means misrepair and mutation (translocation). These types of mutations persist in vital cells and can participate in late effects.
such as, damage in immunological behaviour, premature ageing and mainly in cancer induction.

In our preliminary experiments with heavy ions at the GSI (Gesellschaft für Schwerionenforschung, Darmstadt, Germany) with argon, krypton and xenon-ions with a LET (linear energy transfer) of between about 1100, and 4800 keV/μm we found a drastic decrease of RBE against 140 kVp X-rays for dominant lethality and recessive lethals in germ cells of D. melanogaster. For these endpoints the RBE falls far below 1. After examining 1935 germ cells, irradiated as immature spermatids with 5-120 Gy, for misrepair events, only one single translocation was found. Experiments with heavy ions at GSI are complicated because of their low range in tissue (below 0.5 mm). This does not allow experiments with adult stages of Drosophila. To further test the results on qualitatively different induction of germ cell mutations, experiments with heavy ions of different LET were carried out with adult Drosophila melanogaster at the LBL (Lawrence Berkeley Laboratory) of the University of California.

![Diagram of chromosome mutations](image)

**Fig. 1.** Different types of mutations