RESPONSE OF THE AMES TEST TO DIFFERENT TYPES OF IONIZING RADIATION

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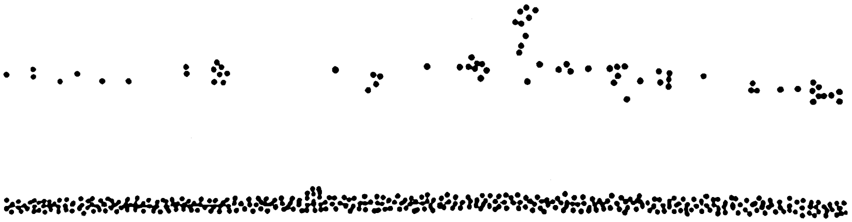

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INTRODUCTION

The delayed exposure method (1) was used for the Salmonella mutagenicity test, to perform experiments with tester strain TA2638 exposed to 6 different types of ionizing radiations. The radiations which were employed, covered a wide range of LET from γ-rays to heavy ions of 1 700 keV/μm: Co- γ-rays, 140kV x-rays, 5.4keV characteristic x-rays, 2.2MeV protons, 3.1MeV α-particles, and 18MeV/u Fe-ions. The modified method (1,2) with irradiations 6 hours after plating results in substantially enhanced yields of mutations, and reduces thus the relative contribution of the spontaneous revertants.

RESULTS

All survival curves are consistent with exponential relations. Even for the γ-rays and the higher energy x-rays there is no indication of a shoulder. With decreasing photon energy, slopes are increasing. Because of the marked differences of effectiveness, different dose scales had to be used. Fig.3 serves to facilitate the comparison. The highest effectiveness for inactivation is found with 5.4keV x-rays (slope: 0.033/Gy), the lowest effectiveness with 18MeV/u Fe-ions (slope: 0.006/Gy). The numbers of revertants per plate were consistent with linear dependences on absorbed dose. Inactivation corrections were not necessary, since the largest inactivation fraction corresponding to any of the points in the mutation studies was only 0.25. The mutagenicity, too, increases with decreasing photon energy; the comparison is facilitated by Fig.4. As in the inactivation experiments, the soft x-rays were most effective (doubling dose 2.3Gy), whereas the Fe-ions were far less effective (doubling dose: 11.4Gy).

DISCUSSION

A description in terms of LET, although largely empirical, can bring out essential features of the results. In the two panels of Fig.5 the RBE for inactivation and mutation is plotted versus the dose average of unrestricted LET. The averages of LET for the different radiations are taken from the work

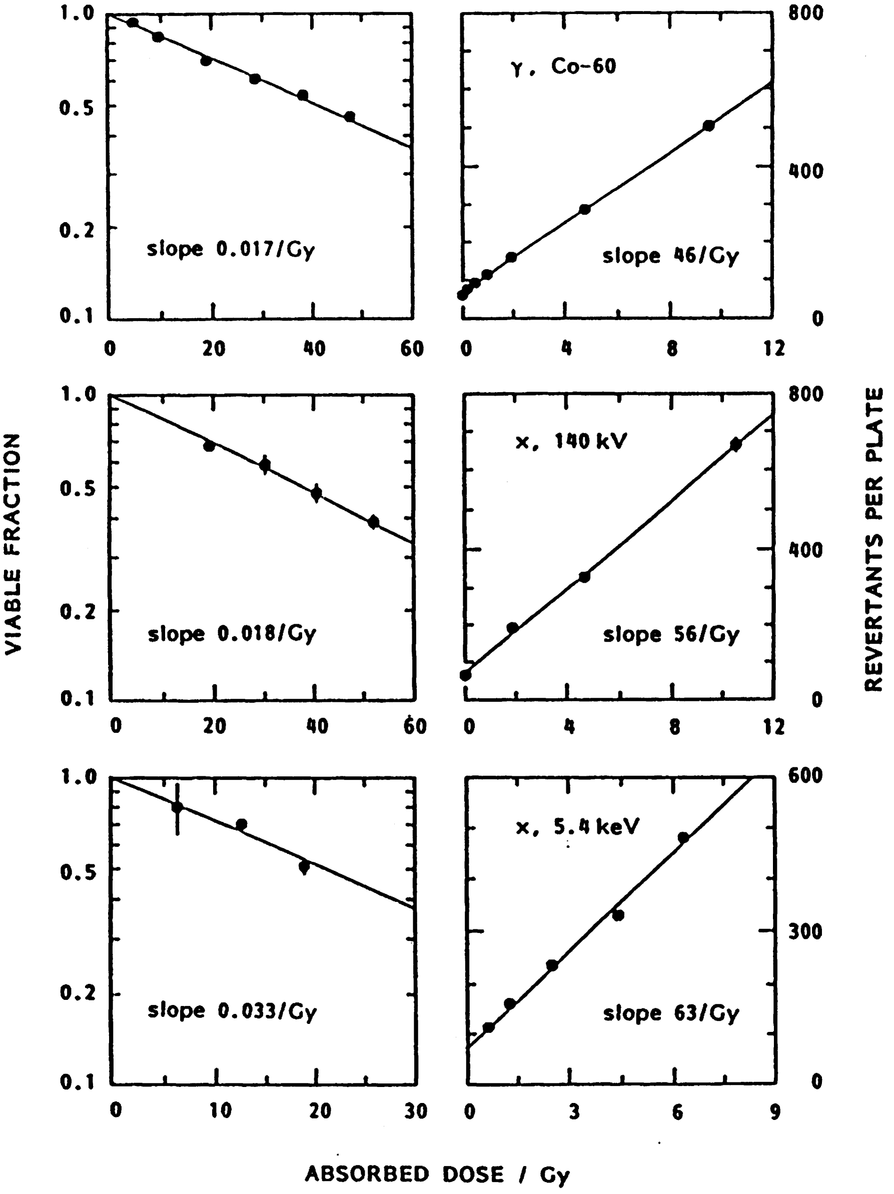

Fig.1 Viable fraction of bacteria (left panels) and number of revertants per plate (right panels) versus absorbed dose.

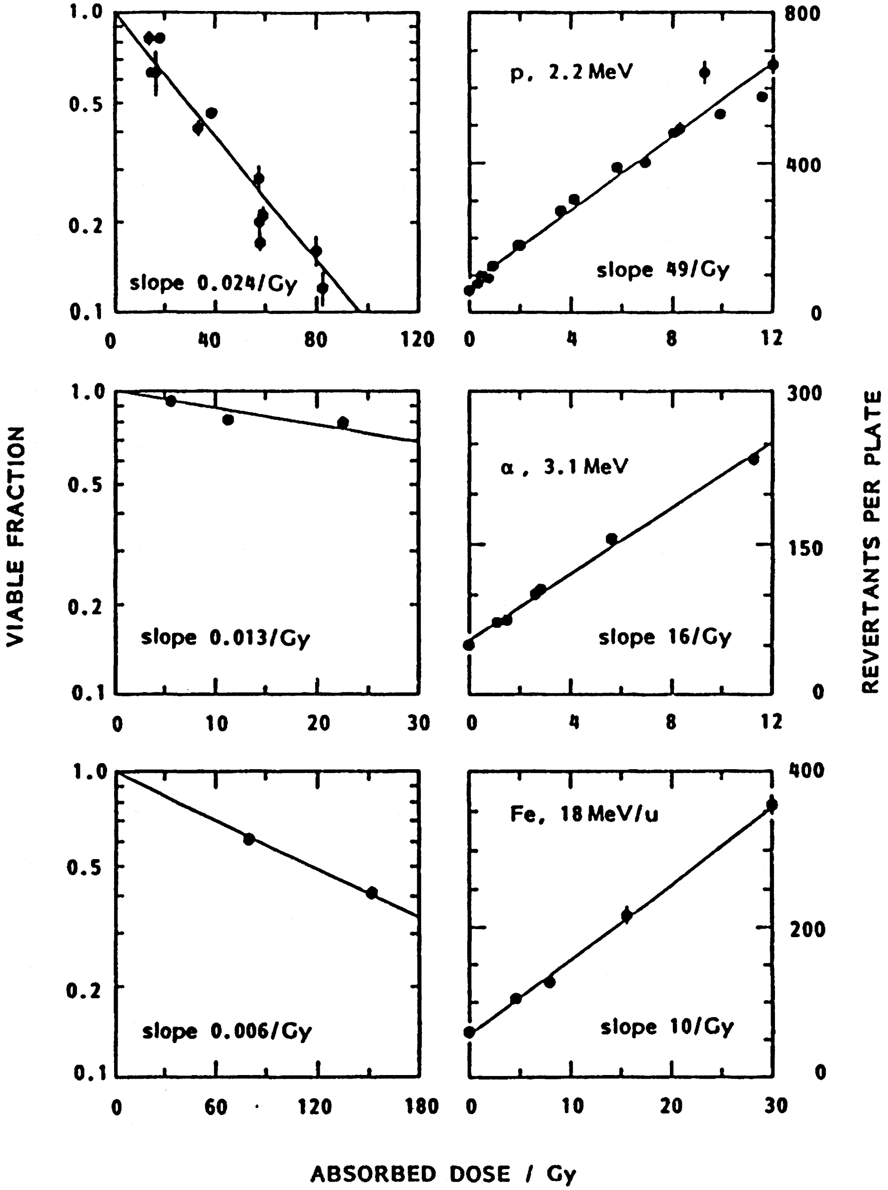

Fig.2 Viable fraction of bacteria (left panels) and number of revertants per plate (right panels) versus absorbed dose.

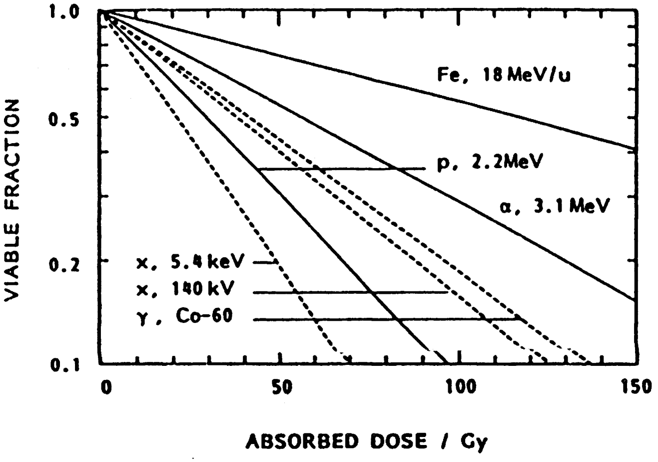

Fig.3 Exponential functions of dose fitted to the observed viable fractions of bacteria.

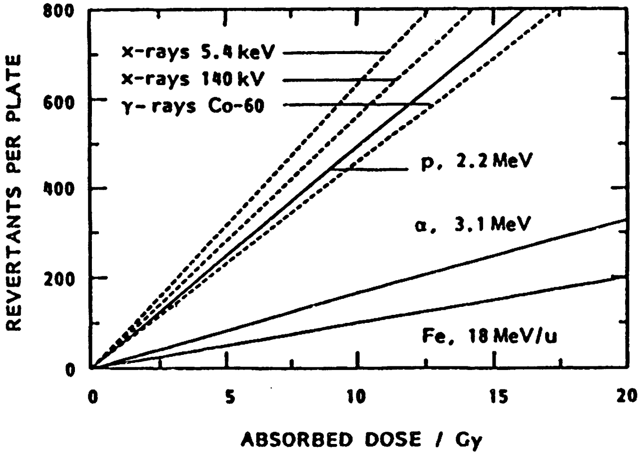

Fig.4 Linear regressions in dose of the observed numbers of revertants per plate.

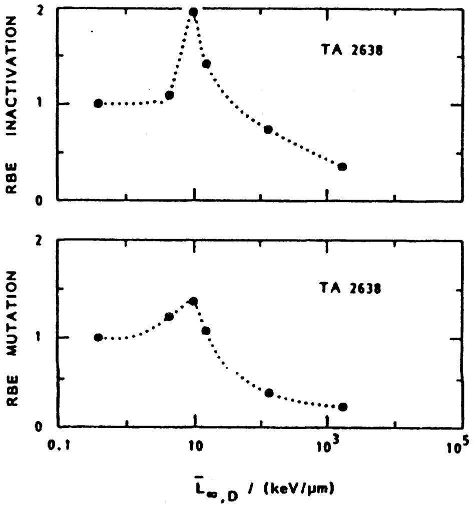

Fig.5 RBE for inactivation (upper panel) and mutation (lower panel) of the different radiations versus dose-averaged unrestricted LET.

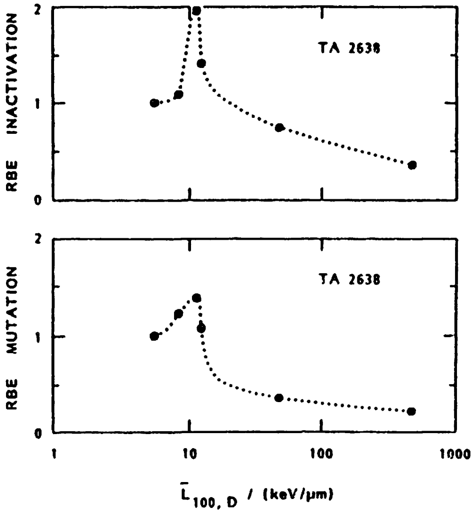

Fig.6 RBE for inactivation (upper panel) and mutation (lower panel) of the different radiations versus dose-averaged restricted LET.

of Harder and Blohm (3). Utilization of the dose average of unrestricted LET is unsatisfactory for Co- γ -rays, because it disregards the appreciable contribution to the fluence by high energy δ -rays. The limited range of the present study is not sufficient to model for the underlying processes; nevertheless one may consider the LET dependence further. On the basis of the present radiobiological understanding, it has been variously suggested that restricted LET with a small cut-off would be the more relevant parameter. It is therefore of interest to give additional plots with $\bar{L}_{100,D}$ as reference parameter, the two panels in Fig.6 provide such plots. The dose averages of LET for the photons are again taken from the work of Harder and Blohm (3). For the heavy particles the restricted LET values are derived by summing the contributions of the heavy particles and those of the δ -rays that exceed the cut-off energy. The inclusion of the δ -rays is essential for the protons. Without this contribution they would be assigned LET values which are substantially too low. The narrow peaks of the dependences of RBE on restricted LET make it doubtful, whether $\bar{L}_{100,D}$ is an appropriate reference parameter. They suggest that, apart from LET, the short range of the 5.4keV electrons plays a role.

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