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H. P. Kramer

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Radiation Effects on Bacteria. R. Weatherwax.

The effects of ultraviolet light and x-rays upon bacteria are being investigated. Two strains of bacteria, Escherichia coli B and its radiation resistant mutant B/r are being used.

In most of the experiments the criterion of death has been the inability of an irradiated organism to give rise to a macroscopically visible colony after incubation for 24 hours on an agar plate. The most consistent results have been obtained in experiments in which the organisms are irradiated in a saline suspension and then spread on the surface of the solid nutritive medium for incubation.

Exponential survival curves have been obtained for both organisms with x-rays (Fig. 1) and for strain B with ultraviolet light (Fig. 2). Strain B/r however shows a sigmoid survival curve with ultraviolet light (Fig. 2). These results are qualitatively similar to those obtained by other investigators with these two organisms.

Various explanations for the mutation to radiation resistance can be devised and experiments to test some of these explanations are being carried out. One interpretation of the exponential or "one-hit" survival curves obtained with irradiated bacteria has been that the death of the organism results from the production of a lethal mutation. Recent cytological work with bacteria has shown that well defined nulear-like structures can be demonstrated in practically all species and that these structures undergo very regular divisions preceding the division of the cell. In some stages of growth, particularly during the early stages of growth of cells transferred to a fresh medium, the nuclear divisions appear to occur at a greater rate than the division of the cell itself and in favorable material four or more of the nuclear bodies may be seen in what seems to be a single cell. If these structures do represent nuclei or chromosomes and are thus carriers of the bacterial genes and if the effect of radiation is the production of a lethal mutation in one of these genes then it should be possible to obtain a correlation between the changes in the number and distribution of these structures and the changes in the radiation sensitivity of the bacterium. The mutation to radiation resistance might also be shown to involve a permanent change in the number or distribution of the nuclear bodies.

Cytologically no difference between B and B/r can be seen when the two organisms are examined under the same conditions of growth. Thus there is no immediate cytological explanation of the mutation to radiation resistance. Localization, however, of the radiation effect within the nuclear structures still seems possible with strain B in x-ray experiments.

Young, actively growing cells of strain B which can be shown to contain two, or at the most four, nuclear bodies are about two times more sensitive to the lethal effect of x-rays than the resting cells containing only one nuclear structure. Strain B/r has not yet been investigated in this regard.

With ultraviolet light however growing cells of strain B show an increase of 15 or 20 times in sensitivity over that of the resting cells. This increase in sensitivity appears very quickly upon the beginning of growth on fresh medium and increases rapidly to the maximum figure by the time the cells have made their first division. This sensitivity then characterizes the population throughout the logarithmic phase of the growth curve and it is only when the culture reaches the stationary or resting stage of growth that these cells return to their original sensitivity. Strain B/r on the contrary shows no such increase in sensitivity during growth and on the contrary may actually increase slightly in resistance to ultraviolet light.

Differences in the amount and distribution of cytoplasmic constituents such as nucleoproteins which might partially shield the nuclear bodies from ultraviolet light and differences in the way these constitutents are redistributed in growing cells are suggested as a possible explanation of the differences in the radiation resistance and the changes in radiation resistance of B and B/r. Such shielding materials would not be effective against the higher energy x-ray photons or secondary electrons.

Li^8 Production for Various Elements. C. Wright.

Evidence for the emission of Li^8 from various target elements was first observed by Segrè and Wiegand. Short lived α emission was seen and it was thought that this resulted from Be^8 which had transmuted from Li^8 by β^- emission. The scheme of Fig. 3 illustrates this mode of decay. In recent work by the speaker this decay scheme has been verified.

The results of Segrè and Wiegand were obtained with solid radiators. However, the range of the α-particles that one wants to count is so short (1 mg/cm^2) that only an extremely shallow surface layer of material acts as an effective radiator. The cross section for the process is so low that a larger volume of effective radiator is needed for good statistics than that which is achieved with solids. For this reason, counting tubes were used that were filled with the material under examination in gaseous form. Thus it is possible, with counting tubes one and a half feet in length, to expose 30 mg/cm^2 to the beam and therefore to increase the yield by a factor of about thirty.

Fig. 4 shows the counting arrangement. It consists of two tubes. The first one filled with CH_4 serves as a beam monitor and the second one is used to observe the relative cross section of the gas contained in it with respect to carbon. The deflected proton or deuteron beam from the cyclotron is turned on for periods of eight seconds. After the shutdown of the cyclotron, counting starts and continues for eight seconds. The decay constant, and from this, the half-life, is found by recording the number of counts as a function of time. For various elements that were examined, C, A, Ne, Kr, the half-life for the α-emission was found to be the same, .88 second, which is the β^- half-life of Li^8. This represents the strongest evidence for the postulation of an intermediate $Li^8 \xrightarrow{\beta^-} Be^8 \rightarrow 2\alpha$ decay chain. The evidence for the decay of Be^8 consists of the energy spread observed among the emitted α-particles. This is a characteristic of the decay of Li^8 into Be^8 and hence to 2 α's. The energy spread, $\Delta E \sim 3$ Mev., also explains by the uncertainty principle, the negligible half-life for the emission of the two α-particles since $\tau \sim \frac{\hbar}{\Delta E}$.

In order to obtain curves of yield against exciting energy, foils of various thicknesses were interposed between the first and the second counting tubes.

Since for all elements, the relative cross section with respect to carbon was measured, the absolute cross sections could be calculated as soon as the absolute cross section for carbon was determined. This was done by recording the beam current from the cyclotron continuously with an ionization chamber and thus determining the number of particles in the beam during unit time as a function of time. With a complete knowledge of the variation in beam intensity during the eight second time interval during which the cyclotron was turned it was possible to correlate the number of particles counted after the cyclotron was turned off with the beam strength, on the basis of a half-life of .88 seconds for the decay of Li^8.

The excitation functions for the production of Li^8 from C, A, and Ne are sketched in Fig. 5.

It is thought that in the lighter elements C, N, etc. Li^8 is left after the necessary number of particles are evaporated from the parent nucleus and that Li^8 is ejected from the nuclei of the heavier elements A, and Kr.

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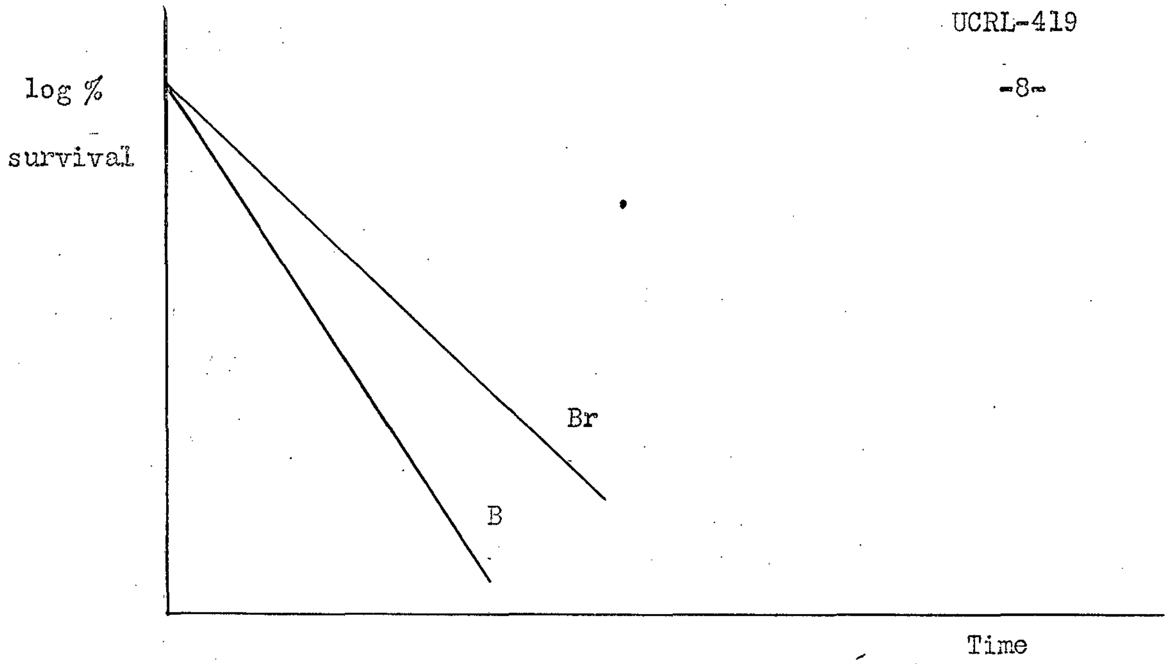
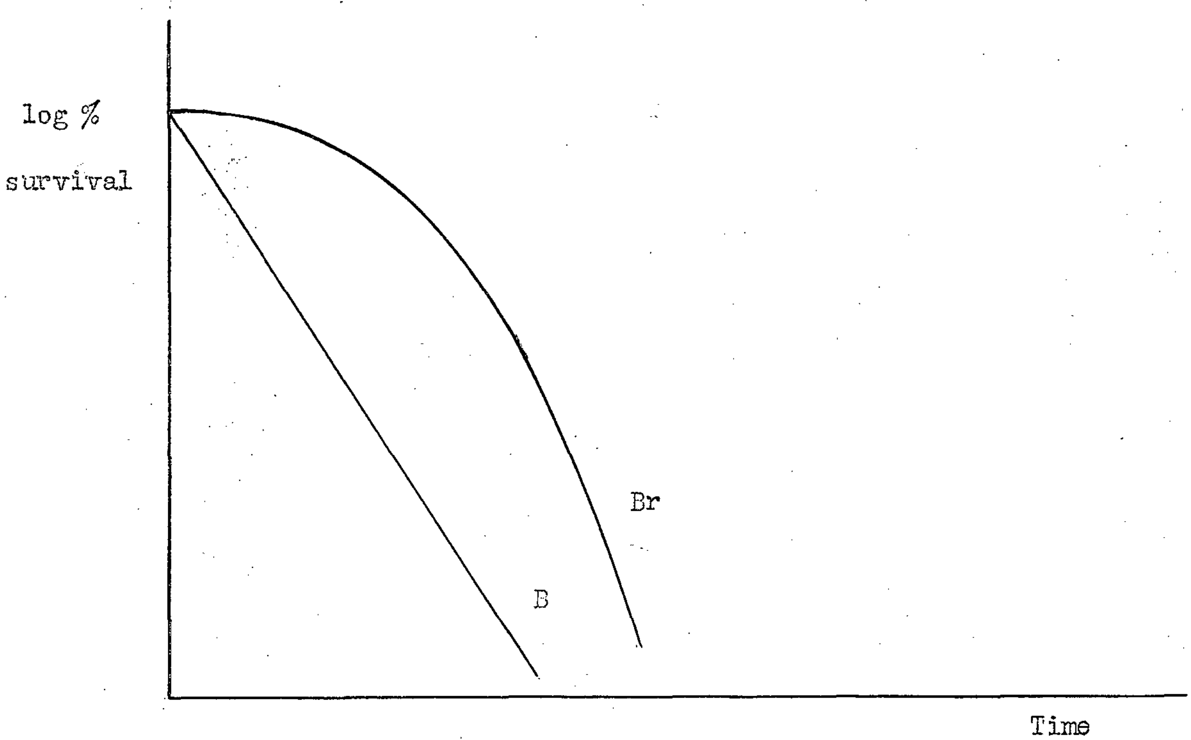


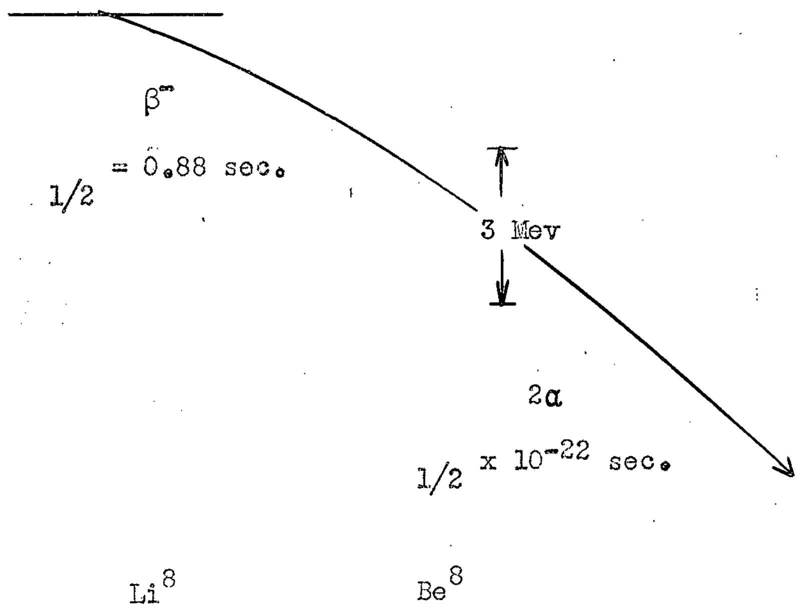
Survival curves for B and Br under
x-ray exposure

Figure 1



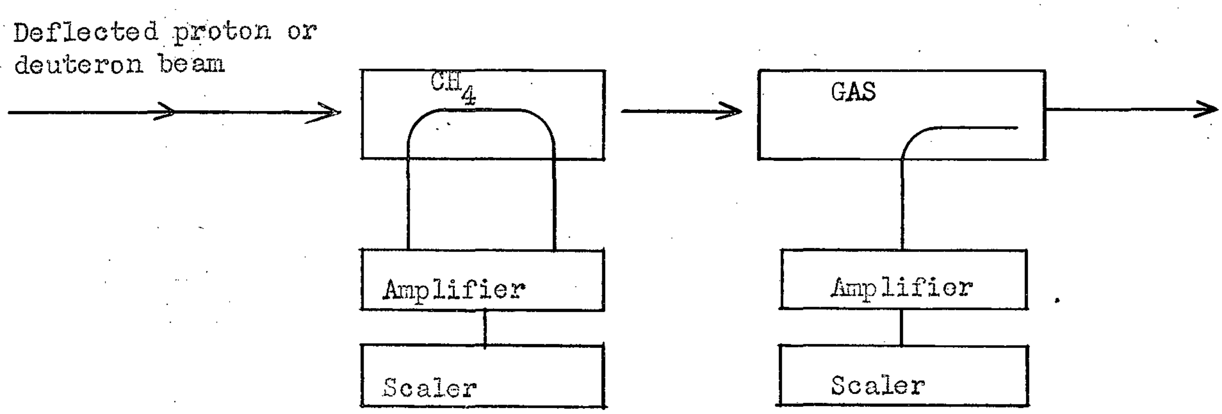
Survival curves for B and Br under
ultraviolet exposure

Figure 2



Decay of Li^8

Figure 3



Counting Arrangement

Figure 4

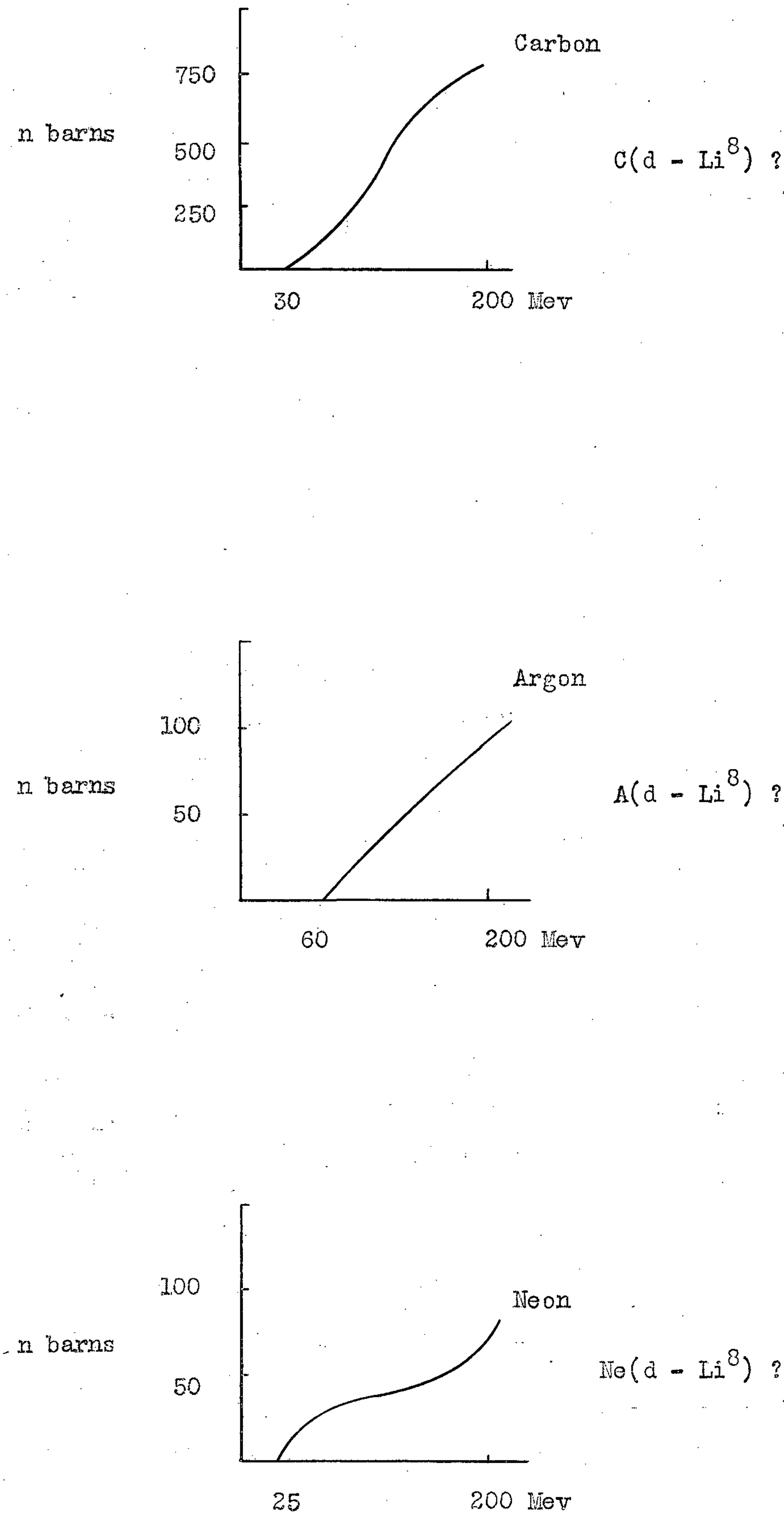

Carbon
750
n barns
500
250
30
200 Mev
C(d - Li8) ?
Argon
100
n barns
50
60
200 Mev
A(d - Li8) ?
100
Neon
n barns
50
25
200 Mev
Ne(d - Li8) ?

Figure 5