1 hour to 5 weeks. Slow repair was again demonstrated for X-rays, but was not found with neutron irradiation. In contrast, there was significant rapid repair of sublethal damage (Elkind type) found after 1 hour with neutrons.

The implication of these results, if they were general and not limited to the mouse lung, is that the r.b.e. for neutrons would increase as the overall treatment time was increased. This would mean (*a*) no advantage in sparing late normal tissue damage with neutrons by extending the treatment time, and (*b*) that retreatment after neutrons might be even more hazardous than after X-rays.

## Effects of fractionated irradiation with 300 kV X-rays and 15 MeV neutrons on the rat spinal cord

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The development of CNS damage is one of the most severe complications of radiotherapy, and for clinical application of fast neutrons, r.b.e. values are required. Experiments on the rat spinal cord have been performed to study the r.b.e. for the development of paralysis over a clinically relevant dose-range. Male WAG/Rij rats were locally irradiated on the lumbosacral spinal cord with average daily doses of 86·5 rad ($D_n = 83{\cdot}4$ rad; $D\gamma = 3{\cdot}1$ rad) up to 2500 rad in 29 fractions. At the lowest dose used, 1990 rad in 23 fractions, 50 per cent of the rats developed paralysis. This showed that no increase in tolerance is obtained when a neutron dose on the spinal cord is administered in 23 fractions instead of in 5 fractions. In contrast, the tolerance dose of X-rays shows a strong increase with decreasing doses per fraction, resulting in an r.b.e. of 3·6 at a neutron dose of 86·5 rad/fraction.

Preliminary results indicated that with an increasing number of fractions, the latent period decreases for the same total neutron dose, a phenomenon not observed for X-rays. A noteworthy side-effect of irradiation with neutrons is the induction of lymphosarcomas. These tumours developed in 4 per cent (5/125) of the rats, irradiated with doses in the range of 1500–2500 rad, after a mean latent period of 200 days, and in only 0·3 per cent (3/1000) of the X-irradiated rats after a mean latent period of 500 days.

## The effect of X-rays and 14 MeV neutrons on the growth of the mouse tibia

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The epiphyseal disc of the long bones is responsible for longitudinal growth. Considerable changes in this disc occur with ageing: change in the number of clonogenic cells; changes in growth-rate; rate of apposition of bone; changes in vascularization and due to this also changes in oxygenation. All these factors may modify the radiosensitivity and the absorption of X-rays and neutrons. As a consequence, the final effects can differ substantially for irradiation at different ages. In this context, it was interesting to compare the effect of X-rays and neutrons at two different ages. Dose-effect curves for X-rays and neutrons were obtained for mice that were one or three weeks old at the time of irradiation.

Two parameters were evaluated: the ratio between the length of the treated tibia and that of the untreated controls at a selected time after irradiation; and the ratio between actual growth and potential growth. This last parameter takes into account the growth that has already occurred at the moment of irradiation. When the first parameter was used, both X-rays and neutrons were more effective in mice irradiated at the age of 1 week. For the second parameter X-rays up to a dose of 1000 rad had the same effect in mice of 1 and 3 weeks old. Afterwards the 1-week-old mice were more sensitive.

For neutrons, 1- and 3-week-old mice showed more or less the same sensitivity. R.b.e. values were derived from the two parameters mentioned above. As expected, r.b.e. values in both cases decreased with increasing neutron dose. For the ratio length after