bone, which is related to the ratio in the diet[6]. It may well be that a particular foodstuff, such as brown trout muscle, has a high ratio of strontium-90 activity/g calcium, but because it makes a minor contribution to the total calcium in the diet, the mean dietary ratio of strontium-90/g of calcium may be little affected. At the calculated level of 0·005 μμc. strontium-90/g in muscle of brown trout from water at 20 mg/l. of calcium and 1·0 μμc. strontium-90/l., the ratio of μμc. strontium-90/g calcium will be 35·5. But since this item of the diet only contributes 3·1 mg calcium per day to a mean daily total intake of 1·2 g (ref. 7), the influence on the mean dietary ratio of strontium-90/g of calcium will be small.

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Biological Half-life of Vitamin B_{12} in Plasma

BY kinetic analysis of isotope experiments using tracer doses of radioactive vitamin B_{12}, Reizenstein[1] has deduced that the biological half-life of vitamin B_{12} in the plasma is about 6 days. Confirmation of this finding has been obtained by a different approach. Working with injected doses of radioactive vitamin B_{12} in the range 50–1,000 μg, a linear relationship with a coefficient of correlation differing significantly from zero was found between the logarithm of the amount of injected vitamin B_{12} retained in the body and the time in days for the serum vitamin B_{12} level to fall to the pre-injection level, the lower limit of normal, in patients with pernicious anæmia[2]. The regression equation was $Y = 17{\cdot}0886x - 0{\cdot}4270$ when Y = the time in days and x = the logarithm of the retained dose. From this information it can be calculated that the biological half-life in the plasma of the radioactive vitamin B_{12} retained in the body was 5·14 days and that the velocity constant (k) is 0·1347 days^{-1}. The closeness of the estimates is satisfying particularly as they were obtained by totally different experimental methods. The short biological half-life in plasma contrasts sharply with that in the liver, which has been calculated to average about 12 months.

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A Fast-Neutron Source for Radiotherapy

ONE of the factors which may determine the effectiveness of an X-ray treatment is the oxygen tension in the tumour to be destroyed, in that the radiation is relatively less effective in killing the anoxic cells at the centre. This was demonstrated by Gray *et al.*[1], who also showed that the biological effects produced by 2·3-MeV neutrons are much less dependent on the local oxygen tension. Biological investigations using 6-MeV neutrons from the cyclotron at Hammersmith Hospital[2-9] have demonstrated this same effect and have led Fowler and Morgan[2] to suggest that fast neutrons should be more effective in destroying tumours than X-rays, in that neutrons would be relatively more efficient in killing the less well oxygenated cells.

The degree to which the biological effect of ionizing radiation is sensitive to oxygen tension decreases as the local ionization density increases so, for this reason, it would be desirable to use low-energy neutrons. However, it is clear that the optimum neutron energy would have to be based on a compromise between the increase of penetrating power and the decrease of ionization density with increasing energy.

Up to the present the only sources of fast neutrons giving sufficiently high output for radiotherapy have been cyclotrons[2,10], and although valuable pioneer work has been done with these, it is unlikely that such large, complicated and expensive machines would come into general use for radiotherapy, even if it was conclusively proved that neutron therapy was more effective than X-ray therapy.

The reaction ^{3}H (d n) ^{4}He (often referred to as the D–T reaction) gives 14-MeV neutrons, and since large neutron yields can be obtained at accelerating voltages of 100–200 kV, offers the prospect of developing a simple and compact source for radiotherapy.

There appears to be little information about the penetrating properties of broad beams of neutrons. Extrapolation of the calculated depth dose values published by Snyder and Neufeld[11] shows that for 14 MeV neutrons at a source skin distance of 50 cm the absorbed dose 10 cm deep is about 70 per cent of the maximum dose, which occurs at a few mm. This is in reasonable agreement with the recent measurements of Smith and Boot[12]. Thus the neutron beam would give a dose distribution inside a patient comparable to that produced by a beam of 4-MV X-rays.

The neutrons from the D–T reaction are emitted isotropically from the target and the output is usually stated in the form of the total rate of emission. An acceptable output for radiotherapy would be the biological equivalent of an X-ray tube giving 50 rads/min at 50 cm source-skin distance. This would require a total emission of 10^{12} neutrons/sec.

Quite independently of these considerations, recent studies at The Services Electronics Research Laboratory has shown that it should be possible to achieve neutron outputs of 10^{12}/sec with the D–T reaction in a sealed-off tube comparable in size with a conventional X-ray tube. The only major additional equipment required to operate such a tube would be a 150-kV generator, and thus the complete apparatus would be not any larger or more complex than a conventional X-ray set.

Sealed-off neutron tubes[13,14], in which the ion source and accelerating gap are contained within an envelope with no differential pumping, have a practical advantage over conventional sources in which differential pumping is utilized. In practice the output from a conventional neutron source using the D–T reaction decreases during operation due to a rapid dilution of the tritium in the target by deuterium. A useful target life of less than 1 h is common for outputs of 10^{10} neutrons/sec. However, in a sealed-off neutron tube it is practicable to use a mixture of deuterium and tritium in both ion source and target so that a constant circulation of the gas mixture occurs with constant proportions of deuterium and tritium. A tube using such a mixture has been shown to have a life of many hundred hours at 10^8 neutrons/sec[15] and recently this has been further demonstrated in the Services Electronics Research Laboratory with a neutron tube operating for many hours at 10^{10} neutrons/sec with no significant change in output. An evaluation of the other problems of sputtering and target cooling has been made and it is concluded that outputs up to 10^{12} neutrons/sec should be practicable.