A heavy particle comparative study.
Part II: cell survival versus depth.

Summary
Cell-survival measurements with depth of penetration were made for a series of incident doses of proton, helium, carbon, neon, argon, negative pion, neutron, and $^{60}$Co photon beams. Cultured human cells (T1) suspended in a gel-containing medium were used, and the measurements were found to be very useful in facilitating the design of ridge filters to produce iso-effects in the region of interest. Heavy charged particle beams (proton, helium, carbon, neon, and negative pion) were found to produce similar cell killing with depth of penetration. Because of saturation effects at higher LET, argon ions were less effective in killing aerated cells at depth, compared with other heavy charged-particle beams. Cell killing at depth in the region of interest, compared with that at the entrance, was not significantly different for single-field exposure when the Bragg peaks were broadened to cover a width of 10 cm. However, when two opposed fields with overlapping peaks were used, a large enhancement in killing was obtained in the peak region.

A heavy particle comparative study
Part III; OER and RBE

Summary
The results of a comparative study of heavy particles of interest in radiotherapy are reported in four parts. In this Part III, cell-survival measurements under aerobic and hypoxic conditions were made for various heavy particle beams. For heavy charged-particle beams, the measurements were made at the beam entrance (plateau), peak centre (10 cm wide peaks), and distal peak (1 cm from does fall-off).

Chinese hamster cell (V79) were used. Metabolic depletion was used to obtain hypoxia.

The results indicate that the differences in RBE between the entrance region and peak are not very large when the Bragg peaks are broadened to 10 cm. The RBE for argon ions remains the same at the entrance and peak centre, and the RBE at the distal side of the Bragg peak is significantly reduced compared to the peak centre and entrance region because of saturation effects at high LET.

The OER for protons not significantly different from that for X-ray. The OER for helium ions, carbon ions, and negative pions is larger, for neon ions is similar, and for argon ions is smaller when compared with fast neutrons. The OER values for heavy ions are higher than expected and could be due to a large delta-ray penumbra associated with the energy deposited by energetic heavy ions. The oxygen effect may depend upon energy deposition over distances of the order of nanometers.

A heavy particle comparative study
Part IV: acute and late reactions

Summary
The results of a comparative study of heavy particles of interest in radiotherapy are reported in four parts. In this Part IV, early skin reactions and late reactions (foot deformity) in mice for various heavy particles are reported. For heavy charged particles, the exposures were made at the entrance region (plateau) and centre of the peak (10 cm wide peaks). For $^{60}$Co γ-rays and fast neutrons (50 Mev D→Be), the exposures were made at the peak of the depth-dose curve.

The time-course of development of skin reaction and subsequent healing after exposure to heavy ions or $^{60}$Co γ-rays were remarkably similar, suggesting that skin damage and subsequent epithelial repopulation after exposure to heavy ions are not different from