variability in the caries incidence of adults in essentially good health. This lends added support to the hypothesis that there is a hereditary factor in susceptibility to caries.

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Life-Shortening by Whole- and Partial-Body X-irradiation in Mice

The fact that ionizing radiations, in whole-body doses which cause little or no immediate morbidity, shorten the life span of animals has been demonstrated in many experiments. With such evidence as a background, it has been argued that *partial-body* exposure, in man as well as in experimental animals, would have a life-shortening effect in strict proportion to exposure dose or integral dose (*1*). Although this concept is misleading for a variety of theoretical reasons, specific experimental evidence relating to life-expectancy after partial-body exposure has not previously been available.

The present data, taken from an experiment designed for another purpose (*2*), illustrate the different potencies of partial- and whole-body x-ray exposure in shortening the life of the mouse. Uniparous female CAF_1 mice (the F_1 generation from the cross, BALB/c females × A/He males) were irradiated at 170 days of age and 26.0 ± 1.4 g body weight. The radiological factors were 250-kvcp x-rays, HVL of 0.55 mm Cu; whole-body exposure dose rate in tissue, 73 r/min; partial-body exposure dose rate in tissue, 53 r/min.

All mice received only a single x-ray dose, with the exception of the 1200-r whole-body treatment which was given as four 300-r fractions 2 weeks apart. All groups (Table 1) were irradiated or sham-irradiated while under moderate Nembutal anesthesia. The whole-body doses were given as described previously (*3*). Mice to be exposed to partial-body irradiation were placed on their backs on 1/16-in. lead sheet, fixed in place with masking tape, and shielded from above (over their ventral surfaces) with ⅛ in. lead sheet. Three different partial-body fields were used: (i) bilateral thorax—from clavicles to tip of xiphoid process; the weight of the tissue irradiated in this field averaged approximately 7.6 g. (ii) Right hemithorax—same as i except for shielding over the left half of the chest; mean irradiated weight, 3.5 g. (iii) Pelvis—the region posterior to a line 1.5 cm anterior to the base of the tail; mean irradiated weight, 5 g.

The exposure doses in tissue given in Table 1 were estimated by placing the sensitive volume of a 100-r Victoreen ionization chamber, surrounded by rice bolus, in a typical exposure field. The dose in the shielded regions was no greater than 4.4 percent of that in the exposed fields, as determined by placing ionization chambers at different points under the shielding while tissue-equivalent bags of rice were being irradiated in the exposure fields. Half the mice receiving 1800 r of partial-body irradiation were irradiated to the right thorax only, the other half to the pelvis as well.

Most of the animals were allowed to die spontaneously, but some (22 percent) were sacrificed when they were moribund. Except the 1200-r whole-body group in which the first death occurred 85 days after the final 300-r fraction, there were no deaths before 169 days postirradiation. Consideration of the data in Table 1 leads to the following comments.

Whole-body exposure. Three hundred roentgens and 560 r both shortened life significantly and to about the same extent. In consequence, the decrement in life span per 100 r (Table 1) is greater at the lower dose. The phenomenon of increased sensitivity of female mice per unit dose, as dose decreases in the range from 600 to 200 r, has been noted previously (*4, 5*). It has been suggested (*5*) that this is somehow related to the peculiarly great sensitivity to x-rays of the mouse ovary.

Partial-body exposure. Per unit of tissue dose, partial-body exposure to the pelvis or chest, or both, was much less effective than whole-body exposure, especially after 300 to 750 r.

Small and large doses. In the whole-body experiments the smallest dose was more effective per unit dose than the larger ones. The smaller partial-body exposures, however, were less effective per unit dose than the larger ones. (The ovaries were not within the fields of partial-body exposure.) Extrapolation of the data for partial-body exposure suggests that, at still lower doses—for example, 100 r—the effectiveness per unit dose may be so reduced as to be negligible. It is of interest to note that doses tested in the present study are hundreds to thousands of times greater than those used in human radiological diagnosis (*6*). Moreover, the total dose built up from repeated diagnostic exposures is fractionated and therefore presumably of diminished effectiveness.

Integral doses. Per unit integral dose, whole-body exposure may shorten life more or less than partial-body exposure, as is shown in the last column of Table 1. In the case of partial-body exposure to one region, the decrement in life span

Table 1. Survival of female mice after whole-body (WB) and partial-body (PB) exposure.

Treatment	Integral dose (kg r)	No. of mice	Mean survival time ± SE (days)*	Decrement in life span per unit dose	
				day/100 r	day/kg r
Control		34	676 ± 25		
300 r, WB	7.8	35	549 ± 24	42	16
560 r, WB	14.6	43	556 ± 23	21	8
1200 r, WB (4 × 300 r)†	31.2	43	429 ± 21	21	8
750 r, bilateral thorax	6.3	34	661 ± 26	2	2
1800 r, right thorax	7.7	20	567 ± 39	6	14
600 r, right thorax + pelvis	5.6	38	660 ± 23	3	3
1200 r, right thorax + pelvis	11.1	40	583 ± 28	8	8
1800 r, right thorax + pelvis	16.7	20	501 ± 37	10	10

* Mean ages may be determined by adding 170 to the mean survival times. SE, standard error of the mean survival time.
† The tabulated figures referring to survival and life span decrement are based on the time elapsed from the beginning of irradiation. Computed from the day on which the final 300-r fraction was given, the last 3 columns of this row would read 387 ± 21 days, 24 days/100 r, and 9 days/kg r, respectively.

per unit dose was not constant. To understand the various results, each must be considered on the basis of the particular lesions involved.

The present data indicate how varied the life-shortening effects of partial- and whole-body exposure can be and the difficulties in attempting to extrapolate from one to the other. They also indicate how tenuous the quantitative estimates of life shortening in man must be when they are based on the relatively incomplete data currently available for experimental animals.

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New Marine Horizon in the Conemaugh Formation

In the course of stratigraphic studies of the Pennsylvanian sediments of the Kiskiminetas Valley in western Pennsylvania, I have found a previously unrecognized marine shale in the Conemaugh formation. The name "Carnahan Run shale" is proposed for the new stratum, and the designated type locality is in Parks Township, Armstrong County, Pennsylvania, about 0.7 mile north of North Vandergrift.

The fossiliferous shale is found in an outcrop along a country road on the north slope of the first fork of Carnahan Run, about 0.1 mile southeast of Carnahan Run. At the type locality the shale is 5 feet in thickness, weathers brown, and is dark grey on fracture. The rock is calcareous, with numerous small flecks of mica. The new horizon is separated from the underlying Woods Run limestone of Raymond by 21½ feet of reddish-brown shale that carries fragments of fossil plants. There is no marked break in sedimentation between the Carnahan Run marine bed and the underlying shale. A similar reddish-brown shale is found above the Carnahan Run shale at the type locality, but a layer of yellow clay about 1 inch in thickness intervenes beween the two beds. At the outcrop, in the Carnahan Run shale, the fossils are for the most part preserved as molds; the calcium carbonate of the original shells has been leached out. Recognized species include the brachiopod *Juresania nebrascensis* and a gastropod, *Amphiscapha elleri* n. sp.

The Carnahan Run shale has also been noted in roadside exposures adjoining Pennsylvania State Highway Alternate 66 on North Vandergrift Hill, about 0.7 mile northeast of North Vandergrift, and approximately 0.5 mile from the type locality. There the marine shale is 1½ feet in thickness and is separated by 23½ feet of reddish-brown shale from the Woods Run limestone of Raymond, which outcrops below. Three inches of ferruginous clay separates the Carnahan Run shale from the overlying shales. The Ames limestone outcrops 126 feet above the Carnahan Run shale in this section, and the roof of the Upper Freeport coal, which marks the lower limit of the Conemaugh formation, is found 216 feet below the base of the new marine bed. Molds of *Amphiscapha elleri* n. sp. are characteristic fossils in the Carnahan Run shale at this locality.

At Gosser Hill, in Westmoreland County, across the river from Leechburg, Pennsylvania, about 2.7 miles west of the type locality, the Carnahan Run bed is 7 feet in thickness. At this place it is found 13½ feet above the Woods Run limestone of Raymond and occurs approximately 226 feet above the Upper Freeport coal. Fossils are numerous and well-preserved in the Carnahan Run shale at this locality; the exposure was found in a recent excavation, and the shells have not been leached out.

Prior to dealing with the Carnahan Run shale in relation to the marine limestones which intervene between it and the underlying Lower Bakerstown coal, I find it necessary to touch upon the nomenclature of the latter marine beds. Two limestones have been distinguished in this interval. One, the original Woods Run limestone, was named by Raymond (*1*) in 1910, and its type locality was designated as Woods Run, in what is now Pittsburgh, Pennsylvania. In 1929, Johnson (*2*) described a second limestone which in the Pittsburgh region occurs approximately 8 to 17 feet below the Woods Run limestone, but he did not name the bed or indicate a type locality. Subsequent workers have sometimes referred to the two strata as the Woods Run limestones or have distinguished them as the Upper and Lower Woods Run limestones.

To avoid confusion, I feel that the original name Woods Run should be retained, without modification, for the limestone which Raymond described in 1910, especially since it is now known that in some localities another marine bed, the Carnahan Run, closely overlies the Woods Run limestone of Raymond. For the limestone described by Johnson, which underlies the Woods Run, I propose the new name "Nadine limestone," and designate as the type locality Nadine, on the Allegheny River east of Pittsburgh, where its occurrence was noted by Johnson. To Johnson's description it may be added that the Nadine limestone carries marine fossils at the type locality, including the distinctive brachiopod *Chonetina flemingi plebia*.

The characteristics and relationships of the Carnahan Run shale, Woods Run limestone, and Nadine limestone in the Kiskiminetas Valley may be summarized as follows:

The Carnahan Run is a calcareous marine shale, 1½ to 7 feet in thickness, which is found about 126 feet below the Ames limestone, 13½ to 23½ feet above the Woods Run limestone, and approximately 216 to 226 feet above the Upper Freeport coal. Marine fossils noted to occur at this horizon include *Juresania nebrascensis, Meekospira peracuta, Pharkidonotus percarinatus, Metoceras* sp., and *Amphiscapha elleri* n. sp.; the latter species is abundant and characterizes the stratum.

The Woods Run is an impure, nodular, ferruginous limestone, ½ to 1½ feet thick. It outcrops approximately 151 feet below the Ames limestone, 18 to 20 feet above the Nadine limestone, and about 191 to 212 feet above the Upper Freeport coal. The bed is sparingly fossiliferous, with *Lophophyllidium proliferum* the commonest species, although *Shansiella carbonaria, Solenocheilus* sp., and *Ameura* sp. have also been noted at this horizon.

The Nadine is a relatively pure limestone, light to dark grey on fracture, 4 inches to 1½ feet thick. In outcrops in the vicinity of North Vandergrift, Pennsylvania, it occurs approximately 172 feet below the Ames limestone, 32 feet above the Cambridge limestone and 170 feet above the Upper Freeport coal. Marine fossils are not abundant, but *Chonetina flemingi plebia* is the commonest species and has been recognized at all outcrops of the limestone in the Kiskiminetas Valley. Associated forms include *Derbya crassa, Punctospirifer kentuckiensis, Neospirifer triplicatus, Marginifera splendens,* and *Rhombopora lepidodendroides.*

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