or "depot" fat, and can be used only at the expense of burning some of the nonfat tissue as well. The great majority of spring birds which had made the critical northward flight from Central or South America were in excellent condition. For example, most of the spring parula warblers still had a fat index well above 0.3 (Fig. 1). Ornithological evidence, in fact, strongly suggests that under favorable weather conditions spring migrants do not stop at the first landfall but continue inland for as much as 300 kilometers (*6*). We have seen specimens (which presumably had encountered unfavorable winds) that had exhausted the depot fat and had been forced to burn an appreciable amount of nonfat tissue along with the remaining fat. The water index of such specimens was not reduced, but was sometimes higher, possibly due to the loss of nonfat weight. Contrary to the suggestion of Yapp (*7*), we believe that fuel, not dehydration, is the limiting factor in long migrations as long as weather conditions remain favorable for sustained flight.

It is evident that the lipid bioenergetic system, as evolved in migratory birds, has several advantages over the usual glycogen energy system. The available energy is greater per unit of weight, the storage capacity is greater, and water balance is facilitated, because fat, unlike protein or carbohydrate, can be stored "dry" yet yields water on combustion.

Preliminary studies of the fatty-acid composition of migratory fat in our laboratory indicate that there is nothing particularly unusual about the nature of the fat itself (*8*). As might apply to the depot fat of animals in general, unsaturated fatty acids C_{18-1}, C_{18-2}, and C_{18-3} make up more than two-thirds of the stored lipids while the saturated acids C_{14}, C_{16}, and C_{18} comprise most of the rest. Differences seem to be more related to species and diet than to migratory status, although the subject requires more study. The arrangement of enzyme systems, however, must be in some way unique to account for the rapid storage and utilization of lipid without change in tissue structure. One of the purposes of this report is to point out how studies at the ecological levels of organization can pinpoint relationships which would not be evident at the molecular level, but which must also be studied at this level if the mechanisms responsible for the relationships are to be understood.

EUGENE P. ODUM
DAVID T. ROGERS
DAVID L. HICKS

Department of Zoology,
University of Georgia, Athens

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Gonadal Dosages in Investigative Radiography

Abstract. *Using radiation-sparing and radiation-limiting techniques, gonadal (skin) dosages in the course of investigative radiography averaged under 0.3 milliroentgen for a set of radiographs, a value less than the irreducible background dosage for 1 day.*

Although there have been numerous reports on gonadal radiation dosages in the course of diagnostic radiography (*1*), no data have been given for purely investigative studies where optimal radiation-sparing and radiation-limiting techniques were in constant use.

To remedy this, we have accumulated new data on skin dosages in the gonadal region from 244 subject determinations made in the course of radiographic studies of bone growth, physical development, and body composition. Fast film (duPont type No. 508), forced development, par-speed intensifying screens, and 3 mm aluminum-equivalent filtration were used to spare radiation dosages, and a variety of lead-rubber gonadal shields (*2*) and a rectangular Picker collimator cone were used to limit the area of irradiation.

Radiation measurements were made on a model 687 Victoreen transistorized minometer II, exceeding the manufacturer's recommended warm-up period by 15 minutes. A set of three pocket-sized dosimeters was used in each subject determination to minimize the root-mean-square response error. Within the limits of the radiographic techniques actually used, there was no need to correct the dosimeter readings for reduced efficiency at short exposures, or for saturation at high milliroentgen-per-second rates. This was verified by repeated calibration studies made at stepwise intervals from 1/60 of a second to 1 second (*3*).

Table 1. Gonadal (skin) dosage from investigative radiography.

Age (yr)	Subjects (No.)	Radiographs (No.)*	Average dosage† (mr)
3–6	30	2.5	0.13
6–9	39	3.8	0.15
9–12	47	3.4	0.21
12–15	27	2.9	0.17
15–18	24	3.3	0.24
8–10	25	Chest	0.20
21–22	17	Chest	0.15
41–75	35	Hand	0.16

* Numerical values are averages of radiographs of the subject's hand, head, forearm, knee, ankle, or chest. † From three dosimeter readings per set of films per subject.

Since the skin dosages to the gonadal area for individual radiographs fell well below 0.1 mr under the conditions of our studies, we were obliged to group different sets of radiographs on the same individual, reading out immediately upon insertion of each of the three dosimeter chambers. As shown in Table 1, these showed an increase in gonadal dosages from infancy through adulthood, paralleling the increase in peak kilovoltage and milliampere-seconds that is necessary in larger and in radiographically denser subjects. Radiographs involving the thoracic region tended to result in higher gonadal dosages than those involving the extremities and the head or the head alone. No single gonadal dosage was as high as 0.3 milliroentgen.

In general, gonadal (skin) dosages for a set of investigative radiographs of the same individual taken under the conditions described averaged between 0.15 and 0.30 milliroentgen per subject. Taking the irreducible background radiation as 100 to 300 mr/year, depending upon altitude (*4*), these values are equivalent to less than the radiation load of 1 day of normal living.

In these studies, the equivalent of 3 mm of aluminum filtration was in-

cluded in the cone-filter combination. Further, both radiation-sparing and radiation-limiting methods were employed to an extent that might be considered impractical in purely diagnostic radiography. Nevertheless, it is clear that a well-planned series of investigative radiographs (with careful shielding) can drastically reduce gonadal exposure from levels currently reported (*5*) to a fraction of the irreducible daily background radiation at sea level.

STANLEY M. GARN
FREDERIC N. SILVERMAN
ANN A. DAVIS

Fels Research Institute,
Yellow Springs, Ohio

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Electroencephalographic Desynchronization in Irradiated Rats with Transected Spinal Cords

Abstract. *Rats with transected spinal cords showed electroencephalographic desynchronization and exhibited behavioral arousal in response to x-irradiation of the whole body or the head only, at dose rates between 0.5 and 1.5 roentgens per second. Neither arousal nor desynchronization occurred when only the body of the animal was exposed. Results indicate that neither the circulatory system nor the vagi are essential to the arousal reaction to x-irradiation.*

Hunt and Kimeldorf (*1*) recently demonstrated that behavioral arousal can be produced in rats by exposure of either the head or the body to small doses of x-irradiation for periods as short as 1 second. Garcia *et al.* (*2*) found that electroencephalographic desynchronization occurred in rats within 1 second of the onset of whole-body irradiation, and Hunt and Kimeldorf (*1*) reported comparable latencies for the arousal response to ex-lambda and bregma. Two weeks were

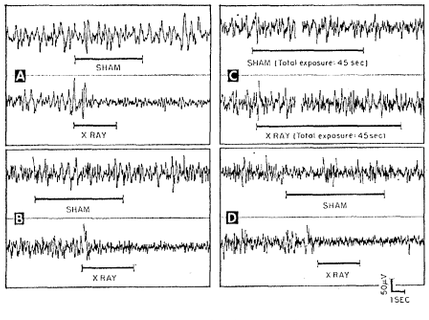

Fig. 1. Electroencephalographic responses of rats to x-irridiation. *A*, Rat with transected spinal cord; irradiation of the whole body. *B*, Spinal transection; irradiation of the head only. *C*, Spinal transection; irradiation of the body only. *D*, Rat that had received sham operation; irradiation of the body only.

posure of only the head or only the body. These latencies are short enough to suggest that exposure to x-rays produces arousal by a direct action on sensory receptors or on the nervous system or by a direct action on both. However, this conclusion was not definitely established by the experiments cited and it is conceivable that primary effects on, or agents transmitted by, the circulatory system secondarily produce neural activation and behavioral arousal. Here we report the results of a study of the electroencephalograms of rats which were exposed to x-irradiation over the whole body, the head only, and the body only after their spinal cords had been transected. The primary objective was to study the mechanism through which the arousal response to x-irradiation is mediated.

Chronic implants of bipolar silver or copper electrodes were made in 60 male Sprague-Dawley rats that were 90 to 180 days old at time of operation. All electrodes were placed epidurally and were located 2 to 3 mm to the left or right of the sagittal suture and about half way between allowed for postoperative recovery. Subsequently, all rats were habituated for 4 hours per day for at least 4 days in cylindrical, Lucite radiation-exposure chambers (7.5 cm in diameter and 26 cm long) before being used in an experiment. Prior to a session of exposures to x-rays, the rats were anesthetized with ether, an incision made in the back of the neck, and the spinal cord surgically sectioned at a level between C5 and T2. After transection of the spinal cord the wound was packed with cotton thoroughly soaked with 1 percent procaine hydrochloride and the skin incision was closed. The sham operations performed on control animals were similar but the spinal cord was not severed. All the rats were put in the Lucite chambers which were then carefully placed in an electrically shielded cage located in the field of the x-ray machine. Cortical electrodes were connected by electrically shielded leads to an electroencephalograph located in a room adjacent to that containing the x-ray unit. A General Electric maxitron x-ray unit operated at 250 kv (peak) and 25 ma (filtration half-value layer, 2.3 mm of copper) was used. During an experiment the x-ray unit remained on at all times and a silent, hydraulically operated shutter was used to control the exposure interval. A lead plate, 0.6 cm thick, was used to shield that part of the animal which was not to be irradiated. Prior to each experiment a Philips type 37471 dosimeter was used to determine dose rates and to check the adequacy of the lead shield. Dose rates used were 0.5, 1.0, and 1.5

Table 1. Number of spinal-transected rats and sham-operated controls showing electroencephalographic desynchronization* on the first two trials.

Dose rate (r/sec)	Trial		Rats tested (No.)
	No. 1	No. 2	
Cord transected; whole body exposed			
0.5	4	5	7
1.0	4	4	5
Cord transected; head only exposed			
0.5	14	17	22
1.0	9	7	11
1.5	6	6	7
Cord transected; body only exposed †			
0.5	0	0	22
1.0	0	0	11
1.5	0	0	7
Sham operated; body only exposed			
1.0	5	4	8

* A change in the pattern of the electroencephalogram from one of high voltage and low frequency to one of low voltage and high frequency.
† The same groups as used above for exposure of head only.