control groups were combined when analyses for sex differences in conditioning proved nonsignificant. Furthermore, data for the four control groups were combined, since no statistical differences were found for these groups.

The performance of the four experimental groups was significantly superior to that of the control groups ($p < .002$ in a two-tailed Mann-Whitney U test for all comparisons). There were no significant differences in levels of performance of the 600-, 1200-, and 2400-msec groups. However, the performance of these groups did differ significantly from that of the 300-msec group, as indicated by an analysis of variance ($p < .01$, two-tailed test). The highest level of performance attained was 32 percent for the 1200- and 2400-msec groups. This level of performance is below that traditionally reported in the literature on classical conditioning of adult rats (*2*). However, in another investigation (*3*) a maximum performance of 39 percent was reported for classical conditioning; this is similar to the performance of the 2400-msec group. In the study reported here, the optimum interstimulus intervals for learning were found to be between 600 and 2400 msec, with the 1200-msec group manifesting the highest mean percentage of conditioning. This is in contrast to the finding, reported in the experimental literature (*2*), that the best interstimulus interval for learning in adult animals is between 300 and 600 msec. The higher percentage of learning found with longer intervals in the newborn rat may be due, in part, to the lack of maturation in neural development at this age, as compared to development in the older animal, and is probably related to the low degree of myelinization and the low speed of neural conduction concomitant with this stage of neural development. On the basis of this interpretation, a linear relationship between total mean percentage of conditioning and length of interstimulus interval would be expected—the longer the interval the larger the mean percentage of conditioning. It should be noted, however, that the experimental data show a curvilinear relationship for the four stimulus conditions, with the 1200-msec interval resulting in the greatest amount of conditioning. Such a curvilinear relation is similar to that reported in the literature for classical conditioning in the adult, but it differs markedly in that the peak is shifted to a longer interstimulus interval. The performance decrement found for the 300-msec group during the fifth trial block and for the 600- and 2400-msec groups during the sixth trial block may represent a fatigue reaction resulting from the massed presentation of stimuli. The need for additional research on the learning capacities of the newborn organism is clearly indicated (*4*).

D. F. CALDWELL
J. WERBOFF

Animal Behavior Laboratory, Lafayette Clinic, and Wayne State University, Detroit, Michigan

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Estimates of Energy Budgets for a Typha (Cattail) Marsh

Abstract. Yearly utilization of total solar radiation by a *Typha* marsh shows approximately equal allotment to reflection (albedo), evapotranspiration, and conduction-convection. Reflection during the growing season is proportionally lower because of greater light absorption by the vegetation. Photosynthesis is a negligible quantity, although in relation to visible radiation during the growing season it nearly equals reflection.

Measurements of production of above-ground organic matter, reflection of visible light, and evapotranspiration have been made for a *Typha* (cattail) marsh at Cedar Creek Natural History Laboratory, Bethel, Minnesota (*1*). These measurements, together with solar radiation data from the nearby weather station at St. Cloud, Minnesota, provide material for estimating the total energy budget of the marsh.

Mean total solar radiation measured by an Eppley pyrheliometer at the St. Cloud station from 1950–1959 is given in Table 1 for the growing season, May through September, and for the entire year (*2*). Visible radiation (390 to 760 mμ) was calculated as 50.4 percent of total radiation for the growing season on the basis of data in Tables 137, 148, and 170 of List's report (*3*) by the method outlined by Bray (*4*).

The mean net above-ground production of oven-dry organic matter of *Typha* over a 3-year period was 1360 g/m^2 per year. The energy content of this matter was 4340 g cal per gram, as measured by a Parr oxygen bomb calorimeter, for a net production of 590 g cal/cm^2 per year (*5*). Underground production could not be measured. The weight of underground material in 1957 was 2960 g/m^2 (*6*). Underground production of *Zizania aquatica*, a marsh annual, was 10 percent of above-ground matter. Underground production for *Typha*, which has a large and thick root and rhizome system, is estimated to be at least 20 percent of above-ground matter. Respiration is estimated to be about 15 percent of gross production, a value which represents the median respiration estimate from a wide survey of the literature. Consumption by animals is estimated to be about 1.0 percent of gross production, a value similar to that measured for tree leaves of an angiosperm forest by Bray. (*7*). When these estimates of underground production, respiration and consumption are used in the calculation, the gross photosynthetic production is approximately 842 g cal/cm^2 per year.

The reflection of visible radiation toward the zenith (visible albedo) in 1960 was 3.0 percent under a clear sky, with an incoming visible radiation of 110,870 lux. Total albedo for *Typha* was estimated by including measurements of reflection of infrared (760 to 5000 + mμ) from leaf and plant surfaces (*8–11*). These estimates were averaged for each interval of 200 mμ and weighted by the mean energy content of each interval as listed in Table 130 of List (*3*). The mean of these weighted values was 42 percent. This value, when averaged on a total energy basis with the measured reflection of 3 percent of the visible radiation, gave an estimate of total albedo for the *Typha* marsh of about 22 percent. No measurements of total albedo for a *Typha* marsh are available in the literature, but estimates of 26 percent for high fresh grass and 22 percent for wet grass by List (*3*) indicate that the estimate of 22 percent is within a reasonable magnitude.

Total albedo for the year was calculated to be 34 percent, an integration of the above value of 22 percent on a

Table 1. Estimated energy budgets for a *Typha* marsh.

Form	Growing season				Year	
	Visible radiation		Total radiation		Total radiation	
	100 g cal/cm^2	Percent	100 g cal/cm^2	Percent	100 g cal/cm^2	Percent
Solar radiation	379	100	760	100	1292	100
Photosynthesis	8.4	2.2	8.4	1.1	8.4	0.6
Reflection	11.4	3.0	167	22.0	439	34.0
Evapotranspiration and conduction-convection	359	94.8				
Evapotranspiration			292	38.4	413	32.0
Conduction-convection			293	38.5	431	33.4

total energy basis with an estimate of winter albedo of around 50 percent, a median value for total reflection from old snow (*3*).

Evapotranspiration was measured in 1958 by Lawrence, Pearson, Rogosin, and Bray in a circular steel watertight tank 1.14 m in diameter which was located in a nearby and similar *Typha* marsh. This tank lost 49.3 g of water per square centimeter by transpiration and evaporation during the growing season. Taking the estimate of Transeau (*12*) that 593 g cal is required to evaporate 1 g of H_2O at the mean temperature of a Midwestern growing season, the energy expended in evapotranspiration was 29,235 cal/cm^2.

For the entire year, it is reasonable to assume that the evapotranspiration of the *Typha* marsh was very similar to the annual precipitation of 96.6 cm, since the level of water in the marsh was at the stable water table and while it overflowed slightly in the spring, it also received some runoff water from higher ground. Energy expended in evapotranspiration throughout the year was, therefore, about 41,300 g cal/cm^2.

The above measurements and estimates are incorporated in Table 1 which shows energy budgets for both visible and total radiation during the growing season (May through September) and for total radiation for the entire year. Energy incorporated in photosynthesis, an almost insignificant factor, is eventually changed to heat in a stable plant community. The decreased importance of total and visible albedo in summer is due to the greater absorption of light by chlorophyll. The similarity of values for reflection, evapotranspiration, and conduction-convection for the year is notable.

An estimate of an energy budget for "green vegetation" for total radiation during the growing season months May–September 1949 by Penman (*13*) in England gave 1 percent for photosynthesis, 20 percent for reflection, 39 percent for transpiration, and 40 percent for conduction-convection. These predicted values are very similar to those of my study.

J. Roger Bray

Department of Botany, University of Toronto, Toronto 5, Ontario

References and Notes

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Distribution of Strontium in the Bovine Skeleton

Only limited information is available on the distribution of strontium in the bovine skeleton, although it is recognized that milk is one of the primary sources of strontium-90 in the human diet. Cattle can serve very efficiently as monitors of the human food supply. They furnish a significant portion of human nutrition through meat and milk, and they often serve as the last biological barrier between man and fallout. Cattle also serve as a monitor of the fallout available to animals because they eat largely unprocessed feedstuffs. If strontium is selectively deposited in the bovine skeleton, an erroneous evaluation of the strontium content of a cow would be possible, depending on the tissue examined. In experimental studies with domestic animals, it would also be desirable to follow strontium metabolism by successive bone biopsies. This technique would be most valuable if the bone sampled is representative of the entire skeleton.

Five Hereford cattle of different ages —a calf, a yearling, a 2-year-old, a 3-year-old, and a 6-year-old cow—were slaughtered in May 1960, to provide information on this problem (*1*). The cattle had spent their entire lives in northeast Nevada under range pasture conditions. Seven bones were removed from each animal: the rib, femur, thoracic and caudal vertebrae, frontal bone, incisors, and humerus. The rib, caudal vertebra, and incisors are easily obtained for routine bone biopsy. All bones were ashed; calcium and strontium were separated (*2*), and the amounts of calcium, strontium, and strontium-90 were determined for each bone (Table 1).

The incisors contained more calcium and less strontium-90 and the frontal bone was higher in both total strontium and strontium-90 than the other bones. Although the rib has been used frequently for determining strontium values, it is appreciably lower than the femur and the frontal bone in total strontium. However, other unpublished data from Nevada indicate that there is a high correlation (> .9) between the total strontium content of the rib and of the femur. These data suggest that either the femur, the humerus, or the thoracic or caudal vertebra can be taken as representative of the concentration of calcium and strontium in bovine bone. Of these, only the caudal vertebra is also easily adapted to bone biopsy techniques. The average concentration for the caudal vertebra did not differ more than 6 percent from the average for all bones sampled for any of the components studied.

The effect of the age of the animals on calcium and strontium concentrations in bovine bone is shown in Table 2. The calf had less calcium and strontium in its skeleton than the older animals. The concentration of calcium apparently reached equilibrium in the bovine skeleton at 1 year, while total strontium exhibited a progressive increase. Pieruccini *et al.* (*3*) reported that the total strontium content of human teeth decreased with age, but