Variability of the high band distribution was significantly greater than for the low band distribution for each subject (F ratio, two-tailed test, 5-percent level).

For the entire group of eight subjects, the force level of the first response following each change in the exteroceptive cue was significantly altered in the appropriate direction (that is, higher or lower) from that prevalent prior to the stimulus change (two-tailed sign test, 5-percent level). In other words, "double discrimination" behavior involving emission of force appropriate to the value of a specific exteroceptive cue, was effectively established (*3*).

J. M. NOTTERMAN
D. E. MINTZ

Department of Psychology, Princeton University, Princeton, New Jersey

References and Notes

1. B. F. Skinner, *Behavior of Organisms* (Appleton-Century, New York, 1938).
2. J. M. Notterman, in *J. Exptl. Psychol.* **58**, 341 (1959), provides a description of the apparatus involved in this study.
3. This research was supported by the Office of Naval Research, Physiological Psychology Branch, under contract NONR 1858 (19).

19 October 1961

Strain and Sex Differences in Serum Cholesterol Levels of Mice

Abstract. Five inbred strains of mice differed significantly in serum cholesterol level. Cholesterol levels ranged from 128 mg/100 ml in C57B1/6 mice to 208 mg/100 ml in C3H mice. Cholesterol level was significantly higher in males than in females. The cholesterol level of 2-month-old mice did not differ from that of 1-year-old mice.

In recent years hundreds of papers have dealt with environmental, and in particular, dietary factors determining the level of serum cholesterol in man and animals (*1*). By contrast, only a handful of studies have dealt with hereditary factors influencing cholesterol level. This paper is a report on serum cholesterol levels in five inbred strains of mice. Between-strain variation in serum cholesterol was significantly higher than within-strain variation. Since all five strains were maintained under identical laboratory conditions, this finding suggests an important genetic component in the determination of serum cholesterol level in mice.

Sixteen mice from each of the five inbred strains listed in Table 1 were tested. Information about these strains is contained in a report of the Committee on Standardized Genetic Nomenclature for Mice (*2*). Within each strain two age groups were formed, one of young animals (mean age, 66 days) and the other of old animals (mean age, 377 days); both groups contained four males and four females. This resulted in a factorial design of 5 strains $\times$ 2 sexes $\times$ 2 age levels. All mice were raised and maintained on Purina mouse breeder chow with free access to food and water. Five hours before a blood sample was taken, the food was removed from the cages. A sample of 0.2 ml of blood was drawn by retrobulbar cavernous sinus puncture. Serum cholesterol was determined colorimetrically by an adaptation of the method of Caraway and Fanger (*3*) by means of a Beckman/Spinco ultramicro analytical system (*4*).

Table 1. Serum cholesterol levels in five strains of mice.

Strains	Serum cholesterol (mg/100 ml): Females, Young	Females, Old	Males, Young	Males, Old	Age groups pooled (N = 8): Means, F	Means, M	S.D., F	S.D., M
C57B1/6JLs–a^{t}a	115	107	144	144	111	144	29.2	29.6
DBA/1	134	120	210	184	127	197	18.9	20.2
SEC/1GnLs–Sese	133	162	199	235	148	217	29.4	27.2
SEC/2Gn–Dse/dse	149	144	235	213	146	224	10.6	22.9
C3H	179	183	223	247	181	235	32.4	20.6
Overall means	142	143	202	205	143	203	24.1	24.1

To determine the reliability of the colorimetric method used, each blood sample was divided in two and each half was analyzed separately. The reliability coefficient was .98. In analyzing variance, the two samples obtained from each mouse were averaged. Of the three main factors (strain, sex, age), only strain and sex contributed significantly to total variation. Neither age nor any of the interaction terms reached significance at the 5-percent level.

Mean values for the various groups are presented in Table 1. A significant separation of mean values for certain strains is apparent. This separation is clearest for C57B1/6 and C3H, the two extreme strains of this study. Table 1 also shows consistent and significant ($P < .001$) differences between females and males. In each of the five strains tested cholesterol level was higher in males than in females.

Strain differences in cholesterol level have previously been reported by Mayer and Jones (*5*) and by Zomzely and Mayer (*6*). Mayer and his co-workers were primarily interested in cholesterol levels in obese mice. They compared obese strains of mice with various non-obese control strains and found cholesterol levels ranging from 160 to 200 mg/100 ml in obese mice, and levels of 70 to 140 mg/100 ml in control animals. Because of their primary interest in problems of obesity, Mayer and his collaborators failed to compare control strains among each other. Mayer's work centered around strains with known metabolic defects. We selected randomly five strains from 13 strains maintained in our colony. Yet, within these randomly chosen strains we detected a range of cholesterol levels comparable to that found by Mayer. It can be expected that if more strains of mice were screened, cholesterol levels would be found to be normally distributed among strains.

The almost identical cholesterol levels in the SEC/1 and SEC/2 strains, two sublines of the SEC strain, will be noted. As such, similarity of sublines is expected, and it supports the argument for a genetic determination of the trait under investigation. It should be mentioned, however, that these particular sublines were reproductively isolated for more than 56 generations (*2*). Apparently the genes determining cholesterol level were in homozygous condition before these two sublines of the SEC strain were formed.

One of our most striking findings is that the cholesterol level is significantly higher in males than in females. Yet, in our search of the literature we did not find any reference to such a sex difference in mice. To be sure, Carpenter and Mayer (*7*) and Zomzely and Mayer (*6*) mention a sex difference in yellow mice. But in their case the situation was reversed: obese yellow females showed higher cholesterol levels than males.

Two-month-old and one-year-old groups of mice were included in our design because we expected to detect age-related changes in cholesterol level

(*8*). This expectation was not borne out: within the age range tested, age did not appear to affect cholesterol levels. It will be necessary to extend the age range and to study more strains of mice before a definitive statement concerning the age variable can be made. As in all cases where the result takes on the form of "no difference," special caution is necessary before any generalizations are made (*9*).

JAN H. BRUELL
Behavior Genetics Laboratory, Western Reserve University, and Highland View Hospital, Cleveland, Ohio

ALEX F. DAROCZY
HERMAN K. HELLERSTEIN
School of Medicine, Western Reserve University

References and Notes

1. R. P. Cook, Ed., *Cholesterol* (Academic Press, New York, 1958).
2. Committee on Standardized Genetic Nomenclature for Mice, *Cancer Research* **20**, 145 (1960).
3. W. T. Caraway and H. Fanger, *Am. J. Clin. Pathol.* **25**, 317 (1955).
4. Details of this procedure are described in *Technical Bull. No. 6077 C* of Beckman Instruments, Inc.
5. J. Mayer and A. K. Jones, *Am. J. Physiol.* **175**, 339 (1953).
6. C. Zomzely and J. Mayer, *Nature* **182**, 1738 (1958).
7. K. J. Carpenter and J. Mayer, *Am. J. Physiol.* **193**, 499 (1958).
8. L. E. Schaefer, D. Adlersberg, A. G. Steinberg, *Circulation* **17**, 537 (1958).
9. This work was supported in part by a grant from the Cleveland Heart Society and by grant G-14410 from the National Science Foundation. While contributing to this research one of us (A.F.D.) was supported by cardiovascular training grant HT 5052 (C8) from the U.S. Public Health Service.

19 October 1961

Strontium-90 and Cesium-137 Absorbed by Rice Plants in Japan, 1960

Abstract. About 60 percent of strontium-90 contained in polished rice in 1960 is due to root absorption from soil. The amount of cesium-137 absorbed by rice plants directly from fallout during the period between ear-shooting and harvest is assumed to be about 20 percent of total cesium-137 in the plant.

Numerous studies have been focused on the problem of the relationship between fallout rate and plant contamination (*1*). In order to investigate the mechanism of radioactive strontium and cesium contamination of rice, which is consumed in great quantity in Asian countries, samples of rice plants growing in the autumn of 1960 were analyzed for Sr^{90} and Cs^{137} (*2*). For comparison, groups of rice plants were covered with polyethylene sheets during the period between ear-shooting and harvest, in order to eliminate floral absorption of current fallout activity. Contents of Sr^{90} and Cs^{137} were determined for plants in the open and for those under cover. The results are summarized in Table 1.

First-harvest lowland rice was kept under cover from 10 August until 1 October. Second-harvest samples were covered from 1 October until 7 November. Fallout rates of Sr^{90} during August, September, and October 1960 were 0.020, 0.062 and 0.031 mc/km^2 month (*3*). The fallout rates of Cs^{137} in October and November were 0.136 and 0.095 mc/km^2 month (*3*). The cumulative deposits of Sr^{90} and Cs^{137} were 20 and 55 mc/km^2 respectively. The annual rainfall is 1600 mm. The latitude is 35° 40′ N. Rice-paddy soil is an ordinary loam containing 0.25 percent calcium.

The ratio of the Sr^{90} content of polished rice in covered plants to that of control plants is 0.62. Therefore, about 60 percent of the Sr^{90} content of polished rice is assumed to have been absorbed from the soil, because strontium does not move readily from leaf to grain. In other words, the contribution of airborne seasonal fallout was about 40 percent of the total Sr^{90} contamination of polished rice. The data suggest that the Sr^{90} content of polished rice will be maintained at about 60 percent of the present level. It would decrease only at a very slow rate even if there were no more fallout.

Husks, bran, and leaves from covered plants have from 20 to 40 percent as much Sr^{90} as the same parts from control plants. These parts are more likely to absorb fallout directly, whereas the polished rice is protected by surrounding plant tissues.

Cesium-137 in covered and control samples of second harvest rice was analyzed by the dipicrylamine-cesium chloroplatinate method (*4*). The results (Table 2) show that the Cs^{137} content of the covered plants and of the control plants is almost the same. Cesium can be translocated easily from leaf to grain (*5*). Therefore, the Cs^{137} contents of polished rice, bran, and husks of covered samples did not reflect adequately a relationship between aerial and root absorption. In addition to Cs^{137} absorbed by the roots, the rice kernels contained Cs^{137} which had been deposited on leaves before the plants were covered, and which had then been translocated.

Table 1. Strontium-90 content (strontium units, micromicrocuries, or picocuries, of Sr^{90} per gram of Ca) of various parts of covered rice plants and controls. The rice is the lowland rice plant, which grows in a water paddy. The second-harvest rice plant grows rapidly, and permits two harvests a year.

Sample	First harvest		Second harvest	
	Control	Covered	Control	Covered
Leaf	60	43	71	29
Husk	216	82	286	53
Bran	254	90	245	46
Polished rice	53	33	24	15

Table 2. Cesium-137 content of rice plant (picocuries of Cs^{137} per kilogram of air-dried material).

Sample	Covered	Control	Covered / control
Leaf	370	440	0.8
Husk	116	144	0.8
Bran	287	389	0.7
Polished rice	27	24	1

For the whole rice plant, contribution of direct contamination from fallout during the period from ear-shooting to harvest (1 October to 7 November) is indicated as 20 percent of the total Cs^{137}. The plants were planted on 3 August; the growing period to the time of ear-shooting was about 2 months. The fraction of direct absorption of Cs^{137} from fallout activity which is transferred to cereal kernels has been considered by others to be proportionately greater because of the characteristic low availability of Cs^{137} once it is deposited in the soil. But in the case of lowland rice, there is higher availability of Cs^{137} from the paddy soil than from ordinary field soils. Paddy soil represents a special case because of its chemical characteristics when flooded (*6*).

RYUSHI ICHIKAWA
MASAKO ETO
MICHIKO ABE
National Institute of Radiological Sciences, Chiba City, Japan

References and Notes

1. R. Ichikawa *et al.*, *Science* **133**, 2017 (1961); J. D. Burton *et al.*, *Nature* **185**, 498 (1960); R. G. Menzel *et al.*, *Science* **134**, 559 (1961); G. M. Milbourn *et al.*, *J. Nuclear Energy* **10**, 116 (1959); H. Reissig, *Kernenergie* **3**, 390 (1959); J. Rivera, *Science* **133**, 755 (1961).
2. Special thanks are due to the kind help of Messrs. Suzuki, Miwa, and Igarashi, research officials of Chiba Agricultural Research Station.
3. M. Izawa *et al.*, unpublished data.
4. N. Yamagata *et al.*, *Analyst* **85**, 282 (1960).
5. L. J. Middleton, *Nature* **181**, 1300 (1958).
6. K. Tenshō *et al.*, *Soil and Plant Food* **6**, 176 (1961).

2 January 1962