Table 1. Coefficients of accumulation of Sr^{90}, Cs^{137}, and Ce^{144} in some marine organisms.

Specimen	Coefficients of accumulation					
	Living weight			Dried weight		
	Sr^{90}	Cs^{137}	Ce^{144}	Sr^{90}	Cs^{137}	Ce^{144}
Green and red algae	1–6	4–10	300–900	10–30	40–50	2600–4500
Brown algae	20–40	30	340	150–280	200	2500
Zostera	3	2	180	30	20	1800
Actinia	1	10	165	9	60	1500
Mytilus						
Soft body	0.7	10	360	4	80	2600
Shells	6	0	43	6	0	43
Total	6	3	33	6	20	60
Crustacea	3–8	10	230	10–35	30	670

algae and mollusks of the Black Sea are in agreement with the results of similar studies on algae in the Atlantic Ocean (*3*) and oysters in the Pacific (*4*).

After the death of the organism, and in the process of decomposition of the algae *Cystoseira barbata*, the accumulated Sr^{90} returns to the sea water (Fig. 1), and the values of the coefficients of accumulation fall, approximating unity. The same is true for other brown algae. The coefficients of accumulation for Sr^{90} in green and red algae do not change at the time of the death of these organisms, but remain near unity. Cesium-137 and Ce^{144} not only remain in the amount which had been absorbed during the life of the organisms, but are absorbed in additional quantities from the solution onto the remaining debris (Fig. 1).

If we designate the coefficients of accumulation for Ce^{144} as K_{Ce} and for Sr^{90} as K_{Sr}, and the maximum permissible concentration in water for man (*6*) for Ce^{144} as C_{Ce} and for Sr^{90} as C_{Sr}, then $K = K_{Ce}/K_{Sr}$. K will be in the order of 10 to 100; and $C = C_{Ce}/C_{Sr}$ will be in the order of 10,000; hence C/K gives values in the order of 100 to 1000. In other words, despite the low coefficients of accumulation of Sr^{90} in marine organisms which are used as food, Sr^{90} is more dangerous to man (about 100 to 1000 times) than Ce^{144}, which has high coefficients of accumulation, when both are present in the same concentration in sea water. The same is apparently true for all other mammals which feed on sea organisms.

High coefficients of accumulation of Ce^{144} in living organisms and in their organic remains indicate it is less mobile than Sr^{90} with its low coefficient of accumulation in mass bottom organisms and its ability to return into the seawater (when the coefficients of accumulation are greater than 1). Cesium-137 occupies an intermediate position. However, there is a possibility of Ce^{144} being retained in the upper layers of the ocean by plankton (*7*). Strontium-90 is a constant source of Y^{90}, which has high coefficients of accumulation in marine organisms (*5*). By using the concept of zones of accumulation of radioactivity in water reservoirs (*8*), it is possible to classify Sr^{90}, in contrast to Ce^{144}, in the group of elements not forming a distinct zone of polyaccumulation. Obviously it is necessary to take into consideration these characteristics of Sr^{90}, and also the most recent oceanographic information (*1, 9, 10*), when one is discussing problems of disposal of highly radioactive wastes of the nuclear industry into the depths of the sea, and the Black Sea in particular. According to the latest data (*10*), the time interval for the rise of bottom waters to the surface in the Black Sea is from 60 to 130 years. In the course of this time period Sr^{90} radioactivity would diminish 5 to 30 times.

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Editor's note: Translation from the Russian was done at our request by Mrs. R. G. Ernsberger of the translating unit of the National Institutes of Health, Bethesda, Md. The English version was approved by the author.

Slowing of Heart Rate after Septal Self-Stimulation in Rats

Abstract. Heart rate, recorded continuously from rats trained to press a bar for intracranial electrical stimulation of their septal areas, fell consistently after brain stimulation. Interpretation of the rewarding effect of septal stimulation had previously been limited by the absence of any data on the autonomic effects of the stimulation. The results of this study suggest that the rewarding effect may possibly be produced by a parasympathetic (quieting) reaction of the autonomic nervous system to septal stimulation.

Heart-rate recording was chosen as a first step in the physiological investigation of intracranial self-stimulation (i) because of the clear way in which it reflects the balance between sympathetic and parasympathetic influences, (ii) because a method for recording the heart rate of the free-roving rat was available, and (iii) because Hess's previous studies of septal stimulation in the cat had revealed slowing of the heart rate (*1*).

Electrodes were implanted in the brains of seven 225-g male hooded rats by the method previously described by Olds and Milner (*2*). Michel wound clips with soldered bus-wire attachments were used as electrocardiograph electrodes. A recovery period of at least 3 days was allowed after operation before we started the two habituation sessions and the five subsequent 20-minute experimental sessions in the testing apparatus (Skinner box), all on consecutive days. The testing apparatus was similar to that previously described (*2*). A lever placed near the floor of the box actuated a microswitch in the stimulating circuit, so that by pressing it the rat received electrical stimulation delivered by a Grass model S4 stimulator set for biphasic electrical stimulation with a duration of 0.5 msec and a frequency of 100 cy/sec. Voltage (peak-to-peak) was set initially at 1.5 volts and was advanced as required, usually to 5 to 7 volts. A Hunter timer was used in the circuit to cut the current off after a period of 0.5 second if the rat continued to hold the lever down. In the initial stage when the experimenter was teaching the animal to self-stimulate, the experimenter stimulated the animal by activating the bar-depression mechanism from outside the test box. In the latter half of the fifth experimental session the current was turned off so that when the animal pressed the bar there was no electrical stimulation; this was the extinction procedure.

During experimental sessions, continuous tracings of electrocardiograms and bar-presses were taken on a Grass model 5A Polygraph, Microdot "Mininoise" triaxial cable (No. 50-3928) being used at the preamplifier end for electrocardiograph recording.

Figure 1 is a photomicrograph showing the electrode track in a stained and mounted section from the brain of subject 5 at the level of the anterior commissure. This electrode placement appeared favorable for producing high frequency of self-stimulation and very marked and consistent heart-rate slowing. The upper part of Fig. 2 is a photograph of the electrocardiographic tracing from the first part of the fifth session. Note the slowing of heart rate associated with self-stimulation (6 volts), and also the increased amplitude of the R wave. Both phenomena were typical of the rather gross electrocardiographic changes regularly observed after self-stimulation in this animal. Systematic quantitative analysis of the heart-rate data for this animal showed that mean heart rate for periods with self-stimulation was 442.2 beats per minute compared with 389.4 beats per minute for preceding periods without intracranial stimulation. Corresponding mean values for subjects 6 and 10 that also had the five full-training sessions were 451.2 and 442.8 for subject 6, and 428.4 and 400.8 for subject 10. All of these differences were highly significant statistically ($p < .001$).

The lower part of Fig. 2 shows the heart-rate deceleration produced in subject 7 by the experimenter's presentation of a 7.5-volt stimulation to the septal area. Note the skipped beat. This marked slowing with skipped beat was a reproducible phenomenon in this animal, just as it was in subject 8. Data from two training sessions were available for analysis in these two animals. For subject 7 mean heart rate during stimulation by the experimenter was 349.2 beats per minute compared with a mean of 414.6 beats per minute for the periods preceding stimulations. Corresponding mean values for subject 8 were 328.2 and 363.0 beats per minute, and again the differences were significant at the .001 level of confidence. In addition, the heart-rate slowing produced in subjects 7 and 8 by their own self-stimulation was highly consistent and was very reliable statistically.

For the three animals carried through to extinction, percentage bar-pressing [computed by the method of Olds and Milner (*2*, p. 421)] was from three to five times less than the percentage during reinforcement. Subject 5, the animal with the highest bar-pressing percentage (89.2), was also the animal showing the most striking heart-rate responses to stimulation (gross slowing in 31 consecutive self-stimulations). Comparison of histological findings for this animal (see Fig. 1) with those for

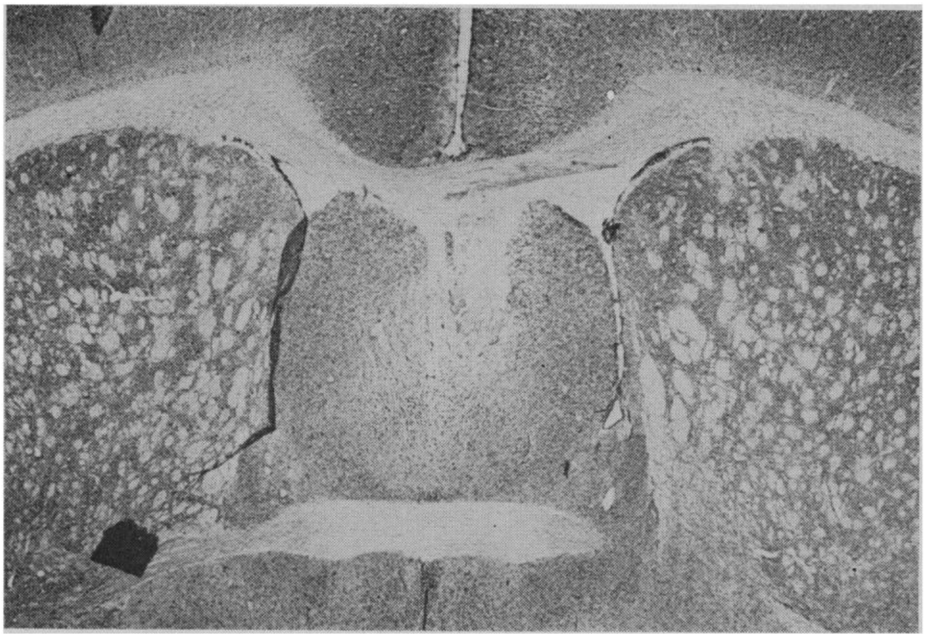

Fig. 1. Part of the electrode track in a brain section stained with cresyl-violet. The track made by the stimulating tip of the electrode is in the septal area to the right of the midline in this section which is at the level of the anterior commissure.

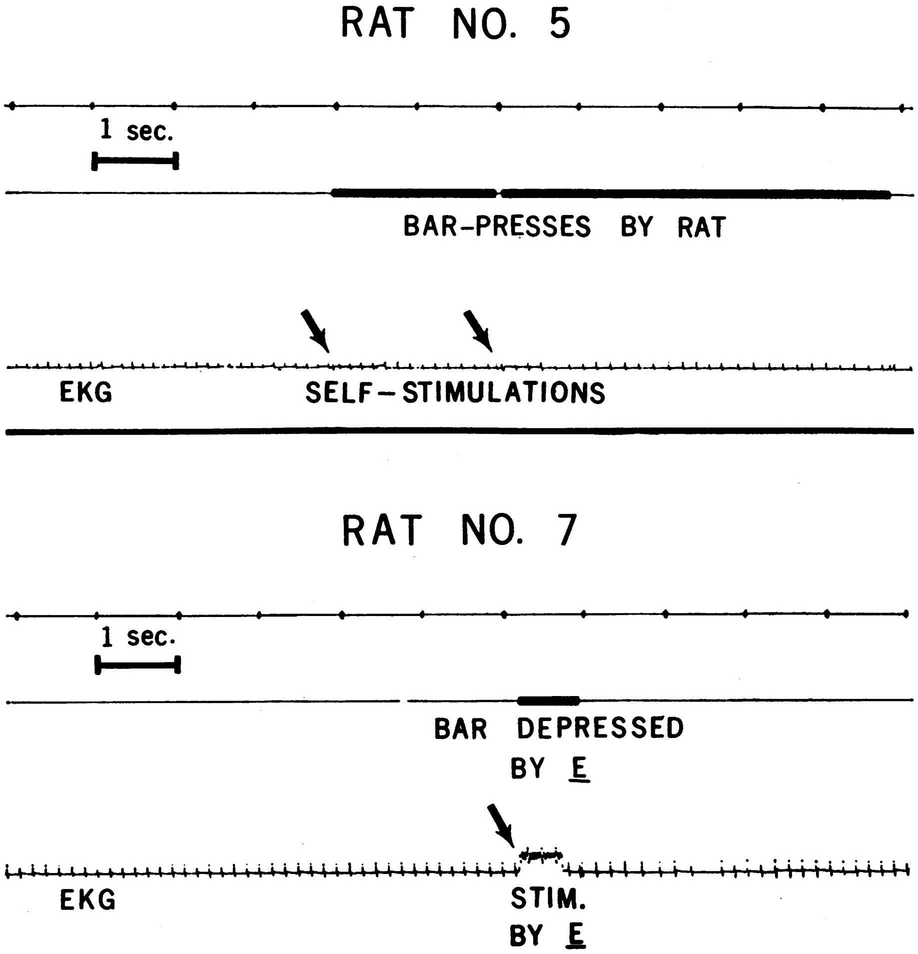

Fig. 2. Electrocardiogram tracings showing deceleration of heart rate produced by septal self-stimulation in animal 5, and by septal experimenter-produced (*E*) stimulation in the brain of animal 7. Arrows indicate the onset of stimulation, and duration of stimulation is shown by the artifact in the tracing. Other switching artifacts in the tracing occurred with onset and termination of bar-pressing. The top line is a time marker.

other animals showed that the electrode track had penetrated deeper into the septal area of this animal than it had in the others. This animal, like the others, showed no habituation of the heart-rate slowing response. No statistically significant change in heart rate was observed during extinction in any of the animals. Subject 10 pressed only briefly with relatively long intervals of nonpressing between bar-presses (acquisition and extinction percentages were 15.0 and 2.7, respectively, as compared with percentages of 40.7 and 12.6 for subject 6). Histological findings for subject 3, dropped from the experiment after one session for lack of promise, showed failure of the electrode to penetrate through the *corpus callosum* into the septal area. In subject 4, when experimenter-produced and self-stimulations from the one available session were combined, the difference between heart rate immediately before and immediately after stimulation was a statistically reliable one (again in the direction of heart-rate slowing after stimulation). In summary, all six animals with positive histological findings (that is, electrode track in the septal area) showed significant slowing of heart rate upon stimulation.

The results clearly show that septal stimulation, whether self-produced or presented by the experimenter, had the very consistent effect of slowing the rate at which the heart was beating. As far as heart rate is concerned, therefore, septal stimulation produced a parasympathetic or quieting effect with reinforcing properties. This finding is of interest in relation to the result of the study by Brady and Nauta (*3*) which, as Olds and Milner noted, "suggests that the septal area is a quieting system, for its surgical removal produced an extremely active animal" (*2*, p. 426).

The fact that a consistent, objectively recordable physiological change of this kind occurs in association with the act of septal self-stimulation is encouraging with respect to further experimental inquiries into the nature of reinforcement produced by intracranial stimulation, and into the problem of reinforcement generally (*4*).

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Fallout from Nuclear Detonations of February and April 1960

Abstract. A sharp increase in the ratio of strontium-89 to strontium-90 in rain was observed at Fayetteville, Arkansas, after the French nuclear detonations of February and April 1960. Experimental data obtained suggest the possibility that part of the debris from atom bombs detonated in the tropical region may enter the stratosphere.

It is generally accepted that atom bombs, such as those detonated at Reggan in the Sahara Desert on 13 February and on 1 April 1960, inject their debris solely into the troposphere, whereas debris from hydrogen bombs enter the stratosphere and cause the world-wide stratospheric fallout.

Although the French nuclear detonations caused seemingly small transient increases in fallout and the fresh debris will most likely add no more than a few tenths of a percent to the total world-wide fallout of long-lived fission products, the radioisotope injection into the atmosphere by the French nuclear detonations was of unique scientific interest in that the nuclear explosions occurred in the tropical region after a long suspension period of nuclear testing.

According to the global circulation model of air masses, proposed by Brewer and by Dobson (*1*), there is an upward flow of air in the tropical region, and hence a material transfer from the troposphere to the stratosphere is expected to occur. Thus, part of the debris from the atom bombs detonated in the tropical region may enter the stratosphere.

Kuroda and his co-workers (*2*) reported the results of the measurements of the ratios of radioisotopes in rain and snow collected at Fayetteville, Ark., during the nuclear test suspension period, which lasted for approximately 16 months after November 1958. As a result of these studies, we have obtained fairly accurate knowledge of the relative ratios of a number of fission products in the stratosphere prior to the French nuclear detonations.

We have continued the measurements of the barium-140, strontium-89, and strontium-90 contents in individual samples of rain and snow collected at Fayetteville, Ark. Radiochemical procedures used were essentially the same as those described by Kuroda (*3*). Because of the extremely small concentrations of the fission products in some of the recent rain samples, usually

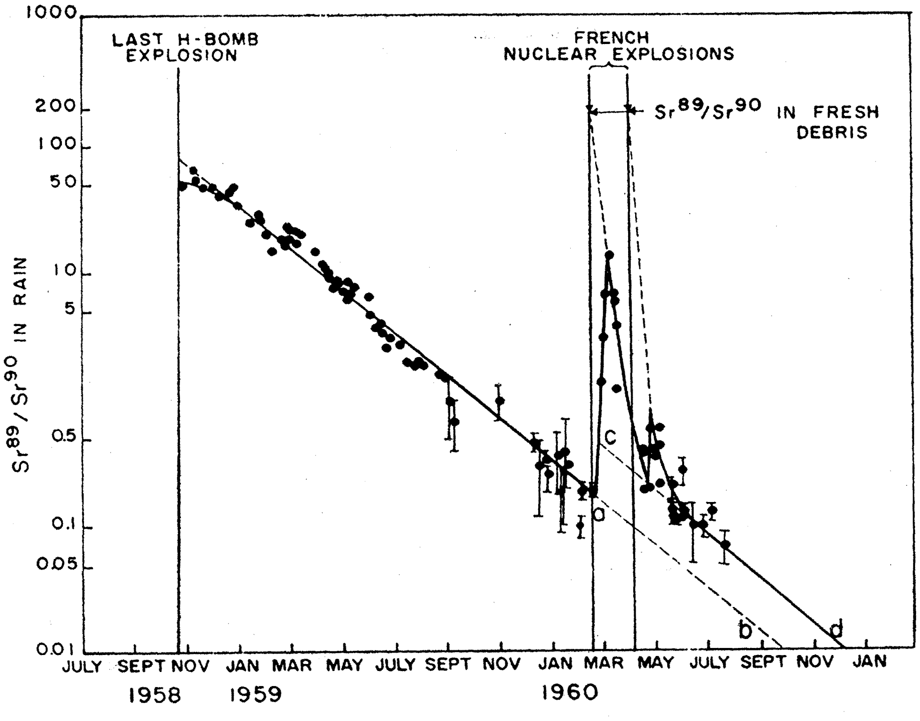

Fig. 1. Variation of the ratio of strontium-89 to strontium-90 in individual samples of rain and snow collected at Fayetteville, Arkansas, since November 1958.