ployed in picking up wheat *both require that the monkeys carry the sweet-potato and the sand to the beach in their two hands so that they have to walk on their feet* [my italics]. It is often observed that they can cover a distance of from 20 to 30 meters in from 5 to 6 minutes."

Although I am puzzled by the extremely slow movement implied by a time of 5 or 6 minutes to travel 20 or 30 meters, the rest of Kawai's account presents no problems. It could be objected that the improved bipedalism in this group of Japanese macaques resulted from imitative learning of the bipedal behavior of their human observers during the last decade. On the other hand, other groups of Japanese monkeys have been under close human observation for equal periods without becoming notably bipedal; the environmental stimulus to bipedal locomotion seems to be unmistakably linked to food carrying. Miyadi (*10*, p. 785) in a review of studies of Japanese monkeys shows a photograph of a macaque standing upright in the sea, holding a food-tray; he does not state the locality, nor does he explain how tray-carrying behavior came to be used for food washing in this instance.

The hypothesis I advanced in 1961 was perhaps too much intertwined with the idea that meat carrying alone could have provided a sufficient stimulus to habitual bipedalism in a prehominid primate. We now have evidence that food washing in the sea, or even the handling of large amounts of wild fruit, can elicit bipedal locomotion under appropriate conditions. Hardy's hypothesis (*11*) of an "aquatic past" for man was doubtless extreme, but some of his notions seem less improbable in the light of Kawai's remarkable report. In many parts of Southeast Asia, macaques have taken up a beachcombing existence; I am not aware of any reports of bipedal locomotion to an unusual degree among these littoral primates, but perhaps previous observers did not pay sufficient attention to the matter. If beach-dwelling macaques should prove to have postural and locomotor habits significantly different from their hinterland kin, along with their obviously distinctive dietary pattern, this would be evidence of considerable importance.

One of the few nonprimate mammals known to use extrasomatic objects as tools (aside from materials assembled for nest or dam building) is the sea otter, who does so in order to crack open mollusk shells. For a very long time, man has preempted the best littoral environments for food gathering in those parts of the world also inhabited by the pongids; there do not appear to be any reports of chimpanzee beachcombers, for example. If the littoral environment were as favorable to the emergence of bipedalism, and other human-like behaviors, as it seems to have been for the Koshima macaques, perhaps this may help to explain the stone hurling and apparently other confusingly human attributes of the hairy creatures encountered around 480 B.C. on the West African coast by the Carthaginian explorer Hanno, from whose account we derive the word *gorilla* for an animal which is more likely to have been the chimpanzee (*12*).

I am not suggesting that mankind stems from malacophagous macaques or chimpanzee beachcombers, nor that our bipedalism was acquired in Lamarckian fashion. For natural selection to operate on the skeleton and musculature, a sustained change of habit, presumably in a new environment, must have preceded the onset of significant changes in gene frequencies. If there are ecological situations in which bipedal locomotion enhances the survival of breeding populations of primates, and in which individuals differ genetically with respect to phenotypically different bone and muscle features which are relevant to bipedal locomotion, evolutionary changes in the direction of more efficient bipedalism should occur. In the case of the hominids, we know that such changes have indeed taken place. The reports of occasional bipedalism among wild or semiwild apes and monkeys, and of the Koshima macaques in particular, indicate the kinds of conditions which, if sufficiently prolonged, might have served to get the forelimbs of our ancestors off the ground for good.

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References and Notes

1. G. W. Hewes, *Am. Anthropol.* **63**, 687 (1961); C. F. Hockett and R. Ascher, *Current Anthropol.*, in press; J. Napier, in *Classification and Human Evolution*, S. Washburn, Ed. (Aldine, Chicago, 1963).
2. A. Kortlandt, *Sci. Am.* **206**, 128 (1962).
3. J. Goodall and H. Van Lawick, *Natl. Geograph. Mag.* **123**, No. 3, 272 (1963).
4. Motion picture film (unedited) lent to me by J. A. Gavan, Medical College of South Carolina, Charleston, Dec. 1961.
5. M. Kawai, *Primates* **4**, 113 (1963).
6. General reports on the studies of the Japanese Monkey Center are to be found in J. E. Frisch, *Am. Anthropol.* **61**, 584 (1959); K. Imanishi, *Current Anthropol.* **1**, 393 (1960); and D. Miyadi, *Science* **143**, 783 (1964).
7. S. L. Washburn, in *The Evolution of Man's Capacity for Culture*, J. N. Spuhler, Ed. (Wayne State Univ. Press, Detroit, 1959); in *Classification and Human Evolution*, S. L. Washburn, Ed. (Aldine, Chicago, 1963).
8. In a paper by J. R. Napier [*Discovery* (Mar. 1963), p. 12], there is a photograph by J. Goodall which shows a chimpanzee preparing a twig prior to using it as a termite-extracting implement.
9. J. A. Gavan (Health Center, Univ. of Florida, Gainesville) can provide the information on the location of this film.
10. D. Miyadi, *Science* **143**, 783, 785 (1964).
11. A. Hardy, *New Scientist* **7**, 642 (1960).
12. M. Cary and E. H. Warmington, *The Ancient Explorers* (Penguin Books, Harmondsworth, 1963).

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Behavioral-Neurochemical Correlation in Reactive and Nonreactive Strains of Rats

Abstract. *Male and female rats of the Maudsley reactive and Maudsley nonreactive strains were tested in the open-field to obtain ambulation and defecation scores. They were later killed, and their brains were dissected into five portions and analyzed for serotonin. Males defecated more and ambulated less than females, and nonreactive males ambulated more and defecated less than reactive males. These behavioral differences were significant* ($p < .05$). *A statistically significant difference was found for the amounts of serotonin in specific regions of the brain between males and females (males higher) and between reactive and nonreactive males (reactive higher). Significant negative correlations between serotonin values in specific regions of brain and ambulation scores were found in these animals viewed as a group or even within a given strain and sex.*

It has been shown by Maas (*1*) that two inbred strains of mice which differ emotionally as measured by a modification of Hall's open-field test (*2*) have significantly different concentrations of serotonin (5-HT) in a dissected portion of brain consisting of diencephalon, mesencephalon, and pons. The more emotional strain, BALBc/J, has higher concentrations than the less emotional strain, C57BL/10J, the values being 1.37 ± 0.046 and 1.07 ± 0.037 $\mu g/g$ ($p < .01$), respectively. In this report we present data on the 5-HT content of various areas of the brain in a different species, the rat. The animals were also tested for open-field behavior and the scores obtained were examined for correlations with the neurochemical measures.

Twenty-four male and 12 female rats were obtained, of which half were of the Maudsley reactive and half of the Maudsley nonreactive strains. All were of the 21st generation of brother-sister matings, descended initially from a heterogeneous group of albino rats selectively bred by Broadhurst for high and low scores of defecation in the open field (*3*).

The males were tested in the open field 2 days after their arrival in this country when they were approximately 4 months of age; they were tested again 2 weeks later. The females varied from 5 to 8 months of age when they arrived, pregnant, in late July 1963. They gave birth by mid-August and were tested in the open field 10 to 11 weeks after their arrival. All rats had previously been tested by Broadhurst in England. The open field consisted of asphalt-tile flooring enclosed by a circular wall of sheet-metal 45 cm high and 3.5 m in circumference, brightly illuminated in a quiet room. For testing, the animal was placed in the field, and the number of fecal boluses and number of meters traveled during a 2-minute trial were recorded. The animals were housed under uniform conditions and had unrestricted access to Purina Lab Chow and water. They were killed by decapitation, the males at 8 months and the females at 8 to 11 months, in groups of four or five animals, at least two from each strain. The dissections were performed on ice. The cerebellum was removed and saved; tissue caudal to the obex was discarded. A standardized portion composed of hippocampus, fimbria of hippocampus, and fornix was then pooled with a portion of the pyriform cortex and the underlying amygdaloid complex to form a limbic portion. All remaining tissue anterior to the optic tracts was removed and saved, and the resulting stem was divided into three areas by cuts immediately superior and inferior to the colliculi. Thus there were five portions to be analyzed for each rat: the limbic portion, the diencephalon, mesencephalon, pons, and a pool of brain tissue which had been set aside in arriving at the above dissections.

The tissues were homogenized in 0.1*N* HCl to provide a concentration of 100 mg of brain tissue per milliliter of HCl and were immediately frozen. Serotonin assays were made by a modification of Kuntzman's method (*4*).

Table 1. Serotonin (5-HT) values, defecation, and ambulation scores in Maudsley reactive (MR) and nonreactive (MNR) rats.*

Number, strain, and sex	Mean 5-HT (μg/g) Limbic	Mean 5-HT (μg/g) Total†	Mean fecal boluses	Mean ambulation (meters)
6 MR males	0.67	0.63	3.9	3.3
6 MNR males	0.50	0.54	0	6.4
	($p < .005$)	($p < .05$)	($p < .05$)	($p < .05$)
12 Males (means from above)	0.58	0.58	2.0	4.8
9 Females (means from below)	0.36	0.40	2.0	7.2
	($p < .01$)	($p < .01$)		($p < .01$)
5 MR females	0.37	0.40	4.0	7.1
4 MNR females	0.36	0.40	0	7.4
			($p < .01$)	

* *p* calculated on the basis of one-tailed *t*-tests except when differences between reactive and nonreactive strains within a given sex in terms of 5-HT values were calculated where it was necessary to employ two-way analyses of variance to compensate for significant variations in values from experiment to experiment. † Total 5-HT refers to the recalculated sum of diencephalic, mesencephalic, pontine and limbic portions.

All but one of the 36 rats which Broadhurst had tested in England for ambulation scores were retested in our laboratory and his scores and ours correlated positively ($r = 0.37$; $p < 0.025$). As shown in Table 1, the Maudsley nonreactive strain ambulated significantly more than the reactive strain ($p = 0.05$). This difference was primarily due to the males, as there was no significant difference between the females of the two strains when the data were broken down according to sex. Females ambulated significantly more than males, and this was primarily due to the relatively high ambulation scores obtained by the Maudsley reactive females.

Only in the limbic portions were there significant differences in the concentration of serotonin between the two strains (see Table 1). When male and female values were combined, the reactive strain had significantly higher ($p < .05$) 5-HT values but, here again, this difference was primarily accounted for by the difference between reactive males versus nonreactive males, as there was no significant difference between the females of the two strains. Males from both strains had significantly higher levels of 5-HT than the females ($p < .01$).

Combining values (Table 1) for the diencephalic, mesencephalic, pontine, and limbic portions and recalculating the amount of serotonin per gram of tissue on the basis of the relative weights of each portion again revealed a significant difference between the reactive and nonreactive males and, as before, combining the scores for the two strains within each sex revealed significantly higher values for the males. This total 5-HT value was representative of a dissection similar to the dissected portion Maas reported for male mice (*1*).

Pearson Product-Moment correlations were done by using ambulation scores matched against limbic and total 5-HT values. In addition to computing the correlations on the basis of the raw 5-HT scores, *z* scores (that is, deviation scores for 5-HT which also take into account the standard deviation in a given experiment) were also calculated and are presented in Table 2. For the rats that were killed ($n = 21$), these correlations were significantly negative —that is, the greater the ambulation, the less the serotonin. This was also true for the group of both male and female reactive rats, for the reactive males alone, and, partially, for the all male group. The correlations were not sig-

Table 2. Correlations between serotonin values and ambulation scores for Maudsley reactive (MR) and nonreactive (MNR) strains (n.s., not significant).

Population	*N*	r reqd. for *p* of 0.05	Limbic 5-HT Raw $r_{calc.}$	Limbic 5-HT Raw *p*	Limbic 5-HT *z* Score* $r_{calc.}$	Limbic 5-HT *z* Score* *p*	Total 5-HT Raw $r_{calc.}$	Total 5-HT Raw *p*	Total 5-HT *z* Score $r_{calc.}$	Total 5-HT *z* Score *p*
Entire MR and MNR	21	0.369	−0.487	< .025	−0.557	< .005	−0.531	< .01	−0.381	< .05
All males	12	.497	− .330	n.s.	− .747	< .005	− .422	n.s.	− .484	n.s.
All MR	11	.521	− .616	< .025	− .673	< .025	− .834	< .005	− .462	n.s.
MR males	6	.729	− .191	n.s.	− .793	< .05	− .793	< .05	− .592	n.s.

* See text for explanation of *z* scores.

nificant for other groups or subgroups although almost all were in the negative direction.

The difference between the strains in terms of serotonin content was in the direction predicted by earlier studies (*1*) with emotional and nonemotional strains of mice. The differences reported here are primarily due to males, with limbic portions showing this difference most prominently. The sex differences were consistent throughout—that is, males ambulated less and had higher limbic and total 5-HT values than females, while there was no significant difference between reactive and nonreactive females in ambulation and, correspondingly, no significant difference between reactive and nonreactive females in limbic or total 5-HT values.

When considering the significant negative correlations between the limbic 5-HT values and ambulation scores, it can be seen that when males and females are combined within a group a bimodal distribution may result with males clustered because of their high 5-HT value and low ambulation and females clustered at the opposite extreme. A similar bimodal distribution may result when both reactive and nonreactive rats are grouped together. Although this type of distribution has meaning in itself, it will also affect correlation coefficients. Because of this, it is particularly interesting that the correlations between behavior and the 5-HT content of the limbic portion within the reactive male group alone, which lacks this distribution bias, were significant. Thus, a Maudsley reactive male with a low ambulation score was statistically likely to have a higher 5-HT content in the limbic portion than a reactive male with a higher ambulation score.

Since it is possible that a common denominator may regulate both the neurochemistry of the animal and the behavioral indices (for example, through genetic linkages), one cannot state that there is a cause and effect relationship between the differences or correlations presented here. To clarify the relationships further, studies in which crosses are made between the strains, and in which the progeny are analyzed for behavioral and neurochemical measures, would be helpful.

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References and Notes

1. J. W. Mass, *Science* **137**, 621 (1962); ———, *Nature* **197**, 255 (1963).
2. C. S. Hall, *J. Comp. Psychol.* **18**, 385 (1934).
3. P. L. Broadhurst, *J. Animal Behav.* **9**, 129 (1961).
4. R. Kuntzman, P. A. Shore, D. Bogdanski, B. B. Brodie, *J. Neurochem.* **6**, 226 (1961).
5. We thank Dr. Broadhurst for supplying the rats and giving suggestions about their maintenance; Dr. John Bartko and Dr. Joseph Tecce for their suggestions on the statistical material; and Mr. Harold Landis and Dr. Robert Colburn for their general suggestions.
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Insecticide Sevin: Effect of Aerial Spraying on Drift of Stream Insects

Abstract. *There was a rise in the rate of drift of aquatic insects in a stream contained within an area of woodland sprayed with Sevin for control of the gypsy moth. It appears from the pattern of drift that there was a drastic reduction of the standing crop of stream insects as a result of the spraying.*

Downstream drift has recently been recognized as an inherent characteristic of populations of certain stream insects (*1–3*). This drift is generally at a slow rate relative to the standing crop of individuals at any particular location. Gradual dissipation of headwater populations, which might be expected to result, is thought to be prevented by directed upstream movements of aquatic nymphs, terrestrial adults, or both (*2, 4*).

The common insecticide DDT, when allowed to enter a stream, has been observed in several studies (*5*) to cause a rapid and extensive rise in the drift rate. This rise is associated with a drastic depletion of the standing crop of bottom invertebrates. The stream organisms, most of which are normally able to resist being dislodged by currents, are apparently weakened or paralyzed by the insecticide and are easily swept away to eventual death, owing either directly to the toxicity or to predation by fish, damage by abrasion, settling in pools, and so forth.

While the effect of DDT on drift of aquatic insects has been insufficiently studied, its known toxicity to aquatic life and its other known or suspected deleterious effects have led to consideration and use of alternative formulations. One such product is Sevin (1-naphthyl-*N*-methyl carbamate). Although reported by the U.S. Department of Agriculture (USDA) to show little toxicity toward fish, mammals, and birds (*6*), the evidence concerning the effect of this insecticide on aquatic insects is scarce and contradictory. The USDA undertook field studies of Sevin in North Carolina in 1959, according to Burdick *et al.* (*6*), after which it was indicated in an unpublished report that there had been little or no effect on aquatic insects. Burdick *et al.*, however, reporting on an experimental study sponsored by USDA and the State of New York near Oneonta, noted a sharp rise in drift rate immediately after a stream had been sprayed, and a reduction (50 to 97 percent) of the standing crop. A publication of the Pennsylvania Department of Agriculture on the gypsy moth (*7*) states that Sevin "reportedly causes no loss of fish or wildlife," which presumably includes aquatic insects. No source for this information is given. Hoffmann (*8*) says that the apparent low toxicity of Sevin to fish recommends its use in important fishing streams, but he also requests field studies to evaluate the actual effect on fish-food organisms and fish.

An opportunity for further field evaluation of Sevin occurred this year. In May the Pennsylvania Department of Agriculture, in cooperation with the USDA, sprayed, by air, approximately 16,000 acres of woodland with Sevin for the control of the gypsy moth. The largest single tract (7775 acres) was immediately south of the Delaware Water Gap in northern Northampton County. Entirely enclosed within this area is the watershed of Slateford Creek, a small (flow when sampled was about 10 m^3/minute), stony, cold-water stream nearly completely canopied by trees from its diffuse beginnings in springs at the foot of Kittatinny Mountain to its mouth in the Delaware River at Slateford, Pennsylvania. The overall purpose of my study was to determine whether or not this spraying had an effect on the aquatic insects of this creek. Since the coarse stream bed was poorly suited for quantitative sampling of the bottom, observations were made of the drift rate. Allegheny Creek, a stream similar to Slateford Creek and about 11 km to the south, was used as a control.

Collections of drifting material in both Slateford and Allegheny Creeks were made continuously in Surber square-foot bottom sampler nets from approximately 7:00 a.m. on 11 May to approximately 7:00 a.m. on 26 May. Collected material was removed at 24-hour intervals. Two nets were placed