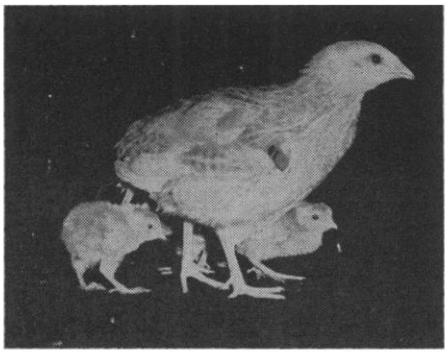

Fig. 3. Adult albino female and newly hatched chicks. The "ghost spotting" can be seen on the wing and back of the adult, and the faint stripes on the back of the chick, both apparently due to structural color only.

outs," failing to find the food and water at the time when yolk sac nutrients became depleted. While disease or suboptimum care cannot be ruled out, and the intial inbreeding necessary to establish the strain may have brought other, non-linked lethal genes to phenotypic expression, it seems most likely that the albino gene itself is semilethal.

Mutations to albinism have been reported to occur in the turkey (*3*) and in several breeds of chicken: white Wyandotte (*4*), Plymouth Rock (*5*), and single-comb white Leghorn (*6*). In these birds, the gene was found to be sex-linked, and in some cases produced only imperfect albinism—that is, some melanin was found in the eye, although the feathers were white. Mutant barred Plymouth Rock birds exhibited "ghost barring" on some feathers. Such birds had bright pink pupils with the iris varying in color from pink to chocolate to pale blue. The mutation was semilethal in some instances, while viability of albino birds was normal in other cases.

It is suggested that the new gene be designated *al*, and its allele for normal (wild type) color, Al^{+}. This designation follows the pattern set for sex-linked albinism in chickens and turkeys by Hutt and Mueller (*3*). It is not yet known in the present case whether low viability or semilethality may be part of the phenotypic expression of the gene for albinism. The appearance of the trait could be explained by the hypothesis of a single mutation in the first albino bird, or her sire.

The "ghost spotting" of the wing and back feathers of albino quail (Fig. 3) appears to be due to structural color only (Fig. 1). The eyes of several albino and normal chicks were enucleated at hatching, fixed in Bouin's fluid, and sectioned at 8 μ. Viewed unstained with dark M phase contrast optics, the eyes from albino birds showed no trace of black pigment in the pecten, retina, or choroid (Fig. 2). A very small amount of light-brown pigment was detected in the ciliary body and iris in one case. Presence of a minimum amount of melanin could explain the dull reddish-brown appearance of the iris in some of the white birds now maturing.

Albino males, from backcross matings, show at maturity no trace of the russet breast pigmentation characteristic of normal male *Coturnix*. Preliminary results of matings between such white male birds and albino females confirm the hypothesis presented. White chicks only were hatched; thus, the white parents are shown to breed true for the trait.

JEAN K. LAUBER

Department of Animal Sciences,
Washington State University,
Pullman, Washington 99163

References and Notes

1. F. Nelson, J. K. Lauber, L. Mirosh, *Poultry Sci.*, in press.
2. Special thanks are due to Mrs. Eleanor A. S. Pruett, without whose special care few of the albino chicks could have been reared to maturity.
3. F. B. Hutt and C. D. Mueller, *J. Hered.* **33**, 69 (1942).
4. D. C. Warren, *ibid.* **24**, 379 (1933).
5. C. D. Mueller and F. B. Hutt, *ibid.* **32**, 71 (1941).
6. F. B. Hutt and C. D. Mueller, *Am. Naturalist* **77**, 181 (1943).
7. This is Scientific Paper No. 2583, Washington Agricultural Experiment Stations, Pullman.

8 September 1964

Mirror Display in the Squirrel Monkey, Saimiri sciureus

Abstract. *Male squirrel monkeys may display the erect phallus under various conditions of courtship, aggression, and salutation. One variety will display consistently to its reflection in a mirror. Such display has a typical pattern and can sometimes be triggered by reflection of but one eye. A mirror display test has been designed for experimentation on the brain.*

Squirrel monkeys (*Saimiri sciureus*) are among the most common primates of Central and South America. They are the smallest of the Cebidae and comprise several closely related species (*1*). We have found them most useful for studies of the brain and behavior and have prepared a brain atlas for such work (*2*). Figure 1 shows the faces of two varieties most commonly used in this laboratory. The circumocular patch of the animal on the left is lighter and comes to a peak like a Gothic arch. In contrast, the eye patch of the animal on the right is rounded above like a Roman arch. Accordingly we informally distinguish these two types as Gothic and Roman.

Our studies of these monkeys have revealed that the male may display the erect phallus in a variety of situations, four of which have been identified as (i) aggressive, (ii) courtship, (iii) distant, and (iv) mirror display (*3*). In the communal situation the displaying animal makes a forward encounter with a female or another male, spreads the thigh, and thrusts the erect phallus towards the face of the other animal. Display to a female presumably serves as a signal in courtship behavior, as it is seen preceding attempts at copulation. In the case of two males, however, it appears to be primarily an aggressive act because it occurs in exerting and establishing dominance. If the recipient does not remain quiet and submissive during the display, it may be viciously assaulted. In social groups the quantification of the number of aggressive displays among respective males has provided a better measure of dominance than the outcome of rivalry for food (*3*).

We have observed no significant differences in the pattern of the aggressive and courtship display among various squirrel monkeys. However, the same is not true of distant display and its counterpart mirror display. Distant display is so-called because it is performed at a distance between two or more animals, seemingly as a kind of greeting. Among separately caged animals housed in close quarters it is precipitated when cages are rearranged or when a new monkey is introduced. This display appears to be peculiar to the Gothic monkey (Fig. 1, left) which also performs a similar display to its reflection in a mirror. Typically it will approach the mirror, climb the side of the cage, vocalize softly with the corners of the mouth retracted and the head tilted to one side, spread one thigh, and make a number of thrusts forward with the tumescent phallus. At the same time there may be a few spurts of urine. During and after the display it will frequently scratch various parts of the body with its fore and hind paws. A

1.5-cm mirror reflecting only one eye is sometimes sufficient to trigger the display.

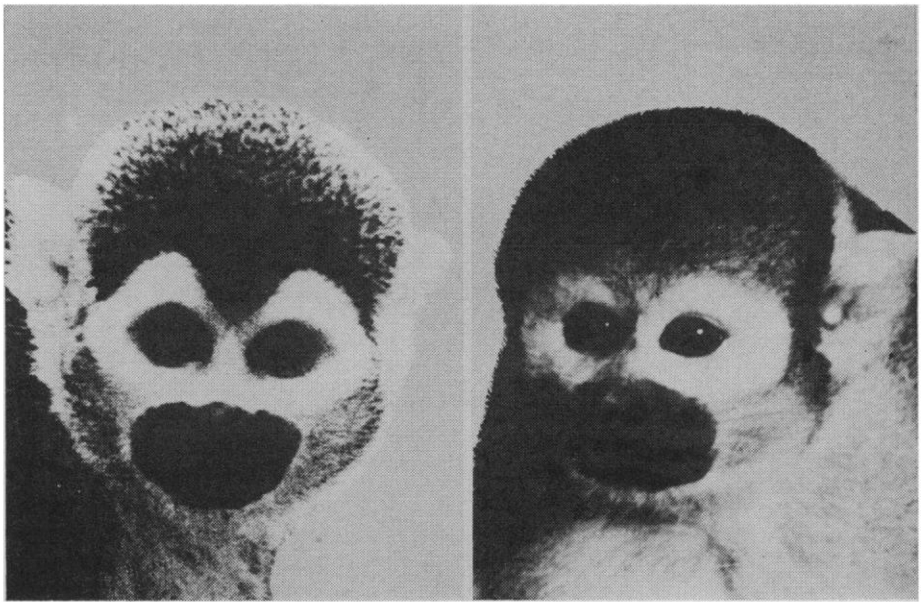

Fig. 1. The variety of male squirrel monkey which shows consistent mirror display is on the left. It is distinguished from the male on the right by a lighter circumocular patch which is pointed above like a Gothic arch. The circumocular patch of the variety on the right is rounded above like a Roman arch.

Ethologists have pointed out that the courtship display of some male fishes and birds is indistinguishable from their aggressive display. It is of evolutionary interest to find a parallel situation in an intermediate primate such as the squirrel monkey. As the display appears to represent an unlearned (instinctual) behavioral pattern, it affords an opportunity for studies on the cerebral localization of such behavior in a primate. At present we are taking advantage of the display pattern to investigate neural mechanisms underlying the integration of autonomic and somatic functions in visually guided sociosexual behavior. For this purpose the mirror display is of special interest because it excludes olfactory, auditory, and somatic stimuli that otherwise would have to be controlled. Accordingly we have devised a mirror display test for assessing the effects of brain lesions or other experimental manipulations.

In a responsive male one can expect dependable performance if it is kept visually isolated from other monkeys and tested in its home cage. Routine testing is therefore conducted in the home cage behind which is a mechanically elevated panel for revealing a full length mirror. The observer activates the electrically driven panel with a push button, and the desired duration of exposure to the mirror is automatically controlled by a timer and relays. For assessing effects of brain lesions it is statistically desirable to conduct at least 30 consecutive pre- and postoperative tests.

Table 1 shows the uniformly high scores of ten successively tested monkeys of the Gothic type and gives the incidence of various components of the display pattern. Penile erection, thigh spreading, and vocalization are the most constant manifestations, but urination and scratching may be expected in more than 50 percent of the trials. The behavioral sequence generally conforms to what has already been described. The display usually begins within 5 seconds, becomes most pronounced in 10 to 20 seconds, and, except for residual tumescence and some scratching, is largely over within 30 seconds. With continued exposure to the mirror for 2 minutes there may be a recurrence of the display, but this is quite variable. There may be a period up to 5 minutes before another presentation of the mirror will elicit a display, and an interval as long as 15 minutes before a reliable repetition. Until more is known about individual variation in this respect, we are limiting formal testing to two to three trials a day with at least 2 hours between trials.

We had variable success with the mirror test until we learned to distinguish responsive from unresponsive animals on the basis of their facial appearance. Table 1 includes for comparison the unsatisfactory outcome in testing eight consecutive animals of the Roman type. As a rule, this variety shows little interest in a mirror. If it reacts to its reflection at all, it will generally do so by bouncing and shaking the cage as though angry. Although erection may develop slowly, it is usually unaccompanied by a spreading of the thigh. Sometimes the manner of scratching is also atypical; one hind foot is thrust several times straight out across the ventral surface of the chest with such force as to unbalance the animal. A one-tailed median test (*4*) on the scores for the two groups of animals shows a statistically significant difference with respect to erection ($p = .01$), latency ($p = .005$), urination ($p = .01$), and thigh spreading ($p = .005$).

The difference in propensity of the two varieties to respond to the mirror was also manifest in an experiment in which a male of each type was provided with a self-operated panel. The Gothic type would operate the panel almost as many times to see its own reflection as another monkey. The Roman, on the

Table 1. Scores in the mirror display test for ten successively tested monkeys of the Gothic type (see Fig. 1, left) and eight of the Roman type (see Fig. 1, right).

	Range	Mean	S.D.	$s_{\bar{x}}$
	Ten Gothic monkeys; 30 trials each			
Erection	27–30	28.7	1.12	0.35
Latency <5 seconds	20–30	26.0	3.30	1.04
Thigh spreading	24–30	27.3	2.11	0.67
Vocalization	9–30	25.5	6.45	2.04
Urination	5–28	19.1	8.14	2.57
Scratching	9–22	16.4	4.14	1.31
	Eight Roman monkeys; 30 trials each			
Erection	0–30*	5.9	10.1	3.56
Latency <5 seconds	0–6	1.4	2.56	0.91
Thigh spreading	0–5	1.2	2.04	0.72
Vocalization	4–30*	16.2	9.05	3.20
Urination	0–29	3.9	10.2	3.60
Scratching	6–26	12.6	6.16	2.18

* One extreme animal with atypical display.

contrary, would work only to see another monkey.

There is no ready explanation for the difference between these two types of monkeys in the case of "mirror" display. The manner in which they are obtained commercially makes their territorial origin uncertain. Answers to inquiry suggest that the Gothic type is Colombian or Peruvian in origin, whereas the Roman is a native of Brazil. The Gothic type appears to correspond to Hill's description of *Saimiri sciurea petrina,* which is characterized by a pierrot-like face and is indigenous to northeast Peru (*1*). It will be of interest to learn whether or not there has existed any environmental difference between the Gothic and Roman type monkeys in regard to ancestral exposure to reflecting pools and streams from overhanging boughs.

PAUL D. MACLEAN
*Laboratory of Neurophysiology,
National Institute of Mental Health,
Bethesda, Maryland 20014*

References and Notes

1. W. C. O. Hill, *Primates. Comparative Anatomy and Taxonomy. IV. Cebidae, Part A* (Interscience, New York, 1960), pp. 250–322.
2. J. A. Gergen and P. D. MacLean, *A Stereotaxic Atlas of the Squirrel Monkey's Brain* (Saimiri sciureus) (U.S. Government Printing Office, Washington, D.C., 1962).
3. P. D. MacLean, *J. Nervous Mental Disease* **135**, 289 (1962); D. W. Ploog and P. D. MacLean, *Animal Behav.* **11**, 32 (1963).
4. S. Siegel, *Nonparametric Statistics for the Behavioral Sciences* (McGraw-Hill, New York, 1956), pp. 111–116.
5. I thank Drs. Samuel W. Greenhouse and Donald Morrison of the Biometrics Branch for statistical help and Mrs. Martha Oliphant and Mr. Matthew Kinnard for technical assistance.

18 September 1964

Puromycin Effect on Memory Fixation in the Goldfish

Abstract. *Puromycin injected intracranially into the goldfish produces impairment of memory for a shock-avoidance response. Intracranial injection of puromycin aminonucleoside, or of saline has no effect. Puromycin does not affect performance in naive or overtrained goldfish.*

There have been several recent reports that antimetabolites may affect learning or recall. Dingman and Sporn (*1*) reported that intracisternal injection of 8-azaguanine in the rat does not affect performance of a previously learned maze, but blocks acquisition of a new one. Chamberlain *et al.* (*2*) found that intraperitoneal injection of the same drug prolongs critical fixation time for the persistance of an asymmetry after section of the spinal cord. Flexner *et al.* (*3*) have shown that subcutaneous injections of puromycin into mice inhibit synthesis of brain protein but have no effect on learning and retention of simple or discrimination avoidance responses. More recently, Flexner *et al.* (*4*) found that injection of puromycin by a different route (intracerebral) into mice one or more days after a training session causes loss of memory of avoidance discrimination learning.

Table 1. Effect of puromycin on the shuttlebox response. Group A, fish injected with saline after trial 20 or not injected; group B, injected with puromycin after trial 20; group C, injected with puromycin aminonucleoside after trial 20; group D, injected with puromycin 72 hours before trial 1; group E was not injected. The results are expressed as the mean number of correct responses in 10 trials ± the standard errors.

Group	*N*	Trials		
		Day 1		Day 4
		1–10	11–20	21–30
A	36	1.31 ± .28	2.89 ± .43	4.56 ± .41
B	36	1.44 ± .30	2.86 ± .41	2.89 ± .34
C	23	2.04 ± .39	3.22 ± .57	5.13 ± .65
D	50	1.29 ± .25	2.48 ± .40	
E	31	1.26 ± .21	2.78 ± .36	

We have used a simple training apparatus in testing the effect of antimetabolites and physical agents on a relatively primitive vertebrate. In the experiments reported here, a simplified semi-automated version of the shuttle box for goldfish developed in Bitterman's laboratory was used (*5*).

Goldfish, 7.6 to 10 cm long, were obtained from Ozark Fisheries, Stoutland, Missouri. They were stored in 55-liter aquariums. The day before an experiment, they were transferred to individual clear plastic tanks measuring 13.3 by 18.7 by 9.5 cm (*6*). The fish were kept in continuous light and fed daily at noon.

The training apparatus consisted of six shuttle boxes made from clear plastic boxes measuring 12.4 by 30.1 by 7.6 cm deep (*6*). Each had a 12.4-cm paraffin-impregnated solid wooden barrier centered across the bottom, 3.2 cm high, 3.2 cm wide at the bottom, and 1.9 cm wide at the top. Two stainless steel mesh electrodes, 11.4 by 6.4 cm, were affixed to the sides near each end of the box. Two stimulus lights (Sylvania 120PSB) were mounted outside the box 1.3 cm from each end. The boxes were filled to a depth of 5 cm with aged tap water, leaving 1.9 cm of water over the barrier. The observer and apparatus were in a quiet, darkened room.

Trial cycles consisting of 20 seconds of light, 20 seconds of light coupled with shock, and 20 seconds of darkness. were controlled by a set of microswitches activated by a 1-rev/min cam. The shocks, 3 v a-c and 0.2 seconds long, were delivered at a rate of 40 per minute. A ratchet relay alternated the stimulus lights and shock after each trial. Thus the fish was trained to avoid shock by swimming over the barrier to the dark side of the box.

The responses of individual fish were recorded by direct observation. A correct response was scored when the fish crossed from the light to the dark end of the box before the onset of shock. Occasionally, a fish was out of position (on the dark side) at the start of a trial as he either failed to cross the barrier during the shock period on the previous trial, or crossed back between trials. This was scored as an incorrect response.

A 100-μl Hamilton syringe with a 1.3-cm 30-gauge needle was used to inject puromycin solutions or 0.154N NaCl into the cranial cavity just over the brain. The cranium was penetrated at the medial suture and in line with the posterior margin of the orbits. The needle was inserted 2 mm at an angle of about 45 degrees to the surface and directed posteriorly. This placed the tip in the midline over the tecta.

Two groups (A and B) of 36 fish each were given 20 trials, with 5 minutes of rest in darkness after every 5 trials. In group A, 18 fish were immediately injected with 10 μl of saline and the other 18 fish were not injected; all were placed in individual tanks (*7*). The other 36 fish (group B) were immediately injected with 90 μg of puro-