When bacteria were labeled with tritiated thymidine (Fig. 3), 715 grains, or 71 percent, of a total of 1006 counted overlay bacteria.

Similar results were obtained with I^{125}-labeled bacteria when a physical developer consisting of *p*-phenylenediamine and sodium bisulfite in water was used (Fig. 2). This method yielded smaller grains, and of a total of 485 grains, 429, or 88 percent, overlay bacteria.

In view of this experience, I^{125} appears to have excellent potential for autoradiographic localization by the electron microscope (*7*).

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Rank of Mothers and Sons in Bands of Rhesus Monkeys

Abstract. *In bands of free-ranging macaques, adolescent males typically leave their mothers in the central part of the band and assume low social rank at the periphery. But the adolescent sons of high-ranking mothers may remain central and rise to high rank without becoming peripheral.*

Macaques live in large bands which include males, females, and young. Intensive studies of Japanese monkeys (*Macaca fuscata*) in their natural habitat indicate that young females remain in the central part of the band even after they become adult (*1*). Social rank among these females follows the order of rank among their mothers. Young males, on the other hand, retire to the periphery of the band at about the age of puberty. These adolescents rank below the older central males. I observed these same tendencies in an island colony of rhesus monkeys (*M. mulatta*), but with a notable difference. Some adolescent males remained central and while still subadult gained precedence over several older and larger males. In each instance the mother of the precocious male was the highest ranking female in the band, or nearly so.

Table 1. The social rank, age, and mother of subadult and older males, in bands of rhesus monkeys, June 1962. The number of individuals in the bands were: *A*, 134; *C*, 120; *E*, 44; *F*, 31; *H*, 35; and *I*, 18. The figures or letters in parentheses beside the age of each ranking male are the identification marks of the male son and his mother respectively.

Male rank	Age and identification of each ranking male in band					
	A	*C*	*E*	*F*	*H*	*I*
1	8 (14, ?)	10+ (JF, ?)	10+ (CL, ?)	10+ (66, ?)	7 (39, ?)	8 (96, ?)
2	5 (SO7, 119*)	6 (ES, AT*)	6 (95, dd)	6 (RO8, 65*)	4 (AG, 84*)	7 (127, ?)
3	4 (DW, 119*)	10+ (103, ?)	6 (R15, dd)	6 (CN, 76)	8 (DY, ?)	7 (45, ?)
4	4 (DV, 109)	5 (KC, DA)	6 (RO6, dd)	5 (ER, dd)	5 (S11, dd)	
5	8 (56, ?)	6 (132, CD)	4 (EJ, 128)	4 (CY, 22)		
6	8 (26, ?)	8 (63, ?)	5 (BC, ?)			
7	7 (08, ?)	8 (05, ?)	5 (BD, ?)			
8	8 (79, ?)	8 (27, ?)				
9	7 (121, ?)	7 (06, ?)				
10	6 (98, ?)	7 (01, ?)				

* Highest ranking female in the band.

These studies were made on Cayo Santiago, a wooded 37-acre islet situated half a mile off the southeast coast of Puerto Rico. The social behavior and ecology of these monkeys have been studied for several years (*2, 3*). All of the present animals are descendants of stock released on the island in 1938 (*4*). Although, over the years, a few hundred animals have been removed, natural population growth has been little disturbed since mid-1956. As of mid-1962 there were 382 monkeys constituting six stable bands of from 18 to 134 members. Each band comprised sexually mature females at least 4 years old and their young, adolescent males 3 to 5 years old, and adult males. Social rank among the animals was judged by observations of exchange of threatening and submissive gestures, and by precedence at food and water. The males ranked in a definite linear dominance hierarchy. Among females differences in rank were much less pronounced, but clear enough among the few highest and few lowest ranking animals. Ages of the animals were determined from their dentition during youth.

As Kawai (*1*) has shown for male Japanese macaques, I also found that the order of rank in rhesus monkeys tended to follow the order of age (Table 1). But in three bands I found notable exceptions in which a subadult or newly adult 4- to 6-year-old male outranked older- and larger males. These exceptions were most conspicuous in the largest band, *A*. The leader, or male No. 1, was 8 years old; males No. 2 and No. 3 were 5 and 4 years old, respectively. But the next five lower ranking males were 7 or 8 years old. Males No. 2 and No. 3, which had reached high rank precociously, were the sons of the same female. One was tattooed as her infant in 1957 (*3*), while the other associated closely with her since 1 year of age. This old mother was clearly dominant over all the other females in the band. In addition, the mother of male No. 4 was among the few top females and the close companion (perhaps the daughter or sister) of female No. 1.

In the second largest band, *C*, male No. 1 was over 10 years old and male No. 2 was 6 years old. The latter was the son of the highest ranking female, as judged by his early association with her. He outranked male No. 3, which was over 10 years old. Males No. 4 and No. 5, 5 and 6 years of age, were sons of two other high-ranking females. All three of the high-ranking 5- and 6-year-old males outranked several 7- and 8-year-old monkeys. A further example of a subadult reaching second highest male rank occurred in a small band *H*. Although only 4 years old, this male outranked an 8 year old. Again, the mother of male No. 2 was the highest ranking female. In another small band, *F*, male No. 2 was also the son of female No. 1, although he outranked no older animals. Finally, a minor example of precocious high rank occurred in band *E*, where the 4-year-old son of female No. 2 outranked two 5-year-old males. Neither of the latter two, however, had a mother in the band. In all instances where a 4- to 6-year-old male had precedence over older males (excepting semisolitary or other adults of exceptionally low rank for their age) the mother of the precocious male was of high rank in the same band. None of the peripheral or low-ranking adult males was known to have a mother of high rank. Admittedly, the mothers of the band leaders, or for that matter of any animals over 6 years of age, were unknown.

Evidently, then, in long-established bands of rhesus monkeys, the sons of high-ranking mothers may attain high rank without going through the low-ranking peripheral stage characteristic of other males 3 to 5 years old. The high status of the precocious males seems to result from the influence of their high-ranking mothers. Possibly the tendency to achieve high rank is inherited. But inasmuch as mothers protect the young during at least the first 3 years of life, it could be that other animals of the band learn to give precedence to younger protected ones and continue to do so even after they are mature. Apparently a well-born male can become male No. 2 in his group without even engaging in a serious fight. Presumably he could then become leader if male No. 1 died, but perhaps not while the older and more experienced leader was robust. As an apparent example of such failure, a few months after the time of the statuses illustrated in Table 1, male No. 2 of bands *A* and *F* (both sons of female No. 1 in those bands) departed from their natal bands and became furtive, solitary males of low rank. Eventually they joined other bands, where they assumed low rank. High birth permits rapid advance in the social hierarchy, apparently, but it does not insure succession to leadership.

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7 June 1963

Swarm Orientation in Honeybees

Abstract. *A swarm of honeybees will move up to 75 m (250 feet) without its queen but only for 3 to 8 minutes. The swarm is aware of the presence of its queen, but the queen does not lead the swarm from one location to another. Bees return to a queen which cannot follow the swarm in flight and in fact are capable of finding a queen "lost along the way." The source of the odoriferous substance(s) responsible for a swarm's detection of its queen appears to be glands in her head.*

A honeybee (*Apis mellifera*) swarm ordinarily contains from 5000 to over 50,000 workers, zero to a few thousand drones, and one queen. Such swarms are part of the reproductive process; when in motion they occupy air spaces 15 to 30 m (50 to 100 feet) in diameter and 1.5 to 6 m in height. They move at a rate which varies from very slow to 19 to 24 km/hr (12 to 15 mi/hr) (*1*). A factor that unites the swarm in flight is the subject of this report.

Artificial swarms which behaved like normal swarms were made by confining worker bees and a queen in a wire-covered box about 50 by 20 by 15 cm (20 by 8 by 6 inches) for 2 to 3 days. After confinement the artificial swarms lose their orientation to their original home and, if shaken from their cage, immediately seek their queen and form a cluster about her. In these experiments, swarms containing at least 10,000 worker bees (0.8 kg or 2 lb) were used. Wooden crosses 1.5 m tall with cross-arms 0.6 m long (Fig. 1) were selected as the most convenient objects to which a swarm would orient.

Orientation was studied by carefully removing the queen (confined in a cage) from the swarm and placing her on a second cross 1.5 to 3 m away. This experiment was repeated eight times; in each case the swarm had been on the cross for at least 24 hours. In all instances the swarms moved to the cross with the queen in 46 to 245 minutes. The methods by which the swarms moved varied. The minimum time required for the first worker bee to find the queen at her new location was 30 seconds, while the maximum was 6 minutes. The movement of the workers from the original cross to the cross with the queen was gradual but constant in three cases, and took from 46 to 245 minutes. In five cases the bees moved gradually until from a third to half of the bees had moved. At this point the bees from the original swarm suddenly (within about 30 seconds) became airborne and in each case were joined in a loose flying swarm within 1 minute by the bees which had already moved over to the queen. In each case within 3 minutes the entire swarm started to settle on the queen and returned to normal within an average of 12 minutes. The total movement of workers appeared to be unidirectional, and in later experiments it was indicated to be odor-oriented.

Rarely does a swarm that has clustered in an unprotected spot remain there for more than a day or two. Thus it was expected that artificial swarms clustered on crosses would attempt to move. Lindauer (*2*), using natural swarms, has described the way in which scout bees find a new home and convey this information to the colony. In six instances we observed swarms that left their crosses under natural (unknown) stimuli. In each case the queen remained on the cross since she was confined in a small wooden wire-covered cage (a standard Benton mailing cage). Prior to moving, the swarms seemed to be quiet, and no more than 10 to 50 bees were seen flying slowly about the cluster. The initial stages of swarm movement were rapid, and the entire group of 10,000 or more bees were

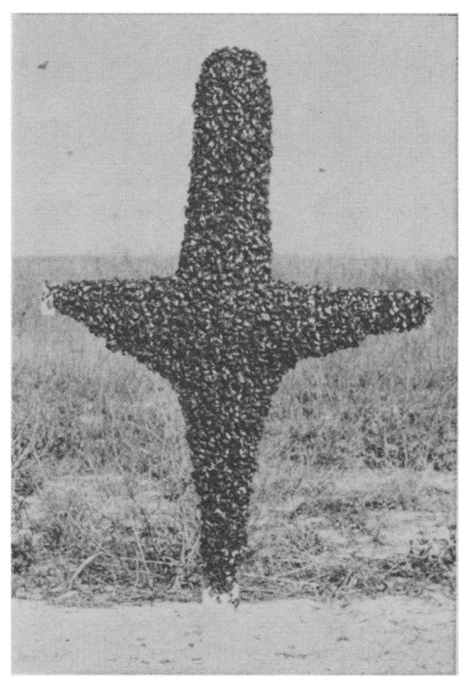

Fig. 1. Wooden crosses about 1.5 m high were convenient objects on which swarms would cluster. The queen in this swarm is confined in a cage placed on the middle of the cross arm.