and is different from the protection given by lipopolysaccharides (5). It is probably based on some other immunological reaction, possibly on enhancement of specific antibody production.

Whether the slight effect observed by cow's milk given in combination with sublethal doses of virulent staphylococci is based on the same mechanism is not known at this time.

The experimental results reported here (6) are not to be considered applicable to breast-fed infants without appropriate further direct studies.

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Electrical Activity in Single Myocardial Cells of Limulus polyphemus

Abstract. Single cells of the heart of *Limulus* were examined *in situ* with conventional microelectrodes. Resting and action potentials were measured in a total of 20 animals, with 25 penetrations per heart during normal spontaneous activity. Resting-potential values averaged 45 millivolts. Action potentials showed a rapid upstroke and a prolonged plateau. A small, irregular burst of electrical activity occurred during the plateau phase, a discharge presumably associated with the "neurogenic" character of the heartbeat. There was no significant overshoot, nor was there any topographical localization of action-potential "types."

The heart of *Limulus polyphemus*, the king crab, is generally regarded as an example of the "neurogenic" type of cardiac tissue. This view is based on the assumption that the heartbeat does not originate in specialized muscle tissue, as is true of the "myogenic" heart but, rather, that the initiation of activity is relegated to neural elements contained in the ganglionic chain embedded on the dorsal surface of the heart.

The electrocardiogram of *Limulus* has been extensively analyzed, and three phases of electrical activity have been described—a fast and a slow component associated with the depolarization and repolarization, respectively, of the myocardium, and a rapid oscillatory discharge coincident with neural activity from the cardiac ganglia (1). This report describes the electrical activity associated with the heartbeat as recorded from single cells of the myocardium of *Limulus*.

Specimens of adult *Limulus polyphemus* measuring approximately 4 in. in diameter were used. The dorsal surface of the exoskeleton covering the heart area was carefully dissected free. The heart was maintained intact and *in situ*; natural sea water was used to bathe the tissue. In several specimens the heart was exposed by a ventral dissection to make sure that injury to the tissue by a dorsal exposure did not reduce the magnitude of the measured potentials. Findings on 20 animals, with 25 penetrations per heart, are reported. Conventional microelectrodes with tips of less than 0.5 μ outside diameter were used. The recordings were photographed from the screen of a cathode-ray oscilloscope.

The resting potential of individual cells averaged 45 mv. An action potential accompanied each beat of the heart, as shown in Fig. 1. The contour of the action potential resembles that generally described for vertebrate myocardia (2), being distinguished by a prolonged phase of repolarization, or "plateau." A distinguishing feature of the action potential of *Limulus* heart is the burst of an oscillatory discharge which occurs during the plateau phase. The onset of this activity can occur at the moment the action-potential peak is attained (Fig. 1*B*), or it can start just as the repolarization phase begins (Fig. 1*A*). The duration of the action potential—the time from onset to the point of 90-percent return to the original resting level—averaged 430 msec. Rise time—the time required for the potential to rise from 10 to 90 percent of maximum amplitude—averaged 14 msec.

The burst of activity which occurs after the rising phase of the action potential appears to be the neural activity of ganglionic pacemakers, described by others during external recordings (1). This oscillation occurs just after the action potential reaches its peak, but it may be suppressed until the onset of the plateau phase. The frequency of this discharge varies as the initial high rate decreases toward the end of the plateau. As the plateau declines, activity ceases, at about 23 mv, but it is followed by one last single discharge which has a somewhat larger amplitude than those comprising the neural burst.

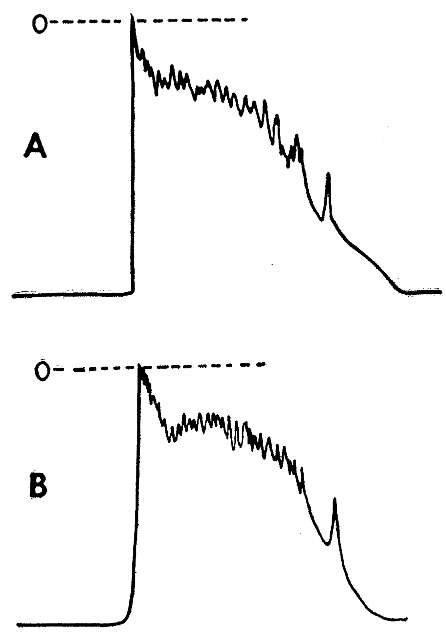

Fig. 1. Single-cell action potentials recorded from the heart of *Limulus polyphemus* (¼ in. on the ordinate equals 10 mv; 3/16 in. on the abscissa equals 100 msec). The ganglionic burst starts at the onset of the plateau in *A* and appears just after the peak of depolarization is reached in *B*.

The electrical activity in single cells of the myocardium in *Limulus polyphemus* is strikingly similar to that found in the cardiac ganglion of the lobster (3). The initial depolarization signaling the onset of the myocardial action potential reflects the synchronous discharge of pacemaker neurons within the ganglion. The persistent neuronal discharge during the plateau phase resembles the activity of "follower" neurons, the large motor neurons located in the anterior portion of the ganglion.

Each segment of the heart has been examined with an intracellular electrode, but there is no indication that there is a pacemaker component such as is found in vertebrate "myogenic" hearts. Differences in contour of the action potentials indicative of conducting or pacemaker tissue were not observed (4).

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Repeated Homing Exhibited by a Female Pallid Bat

Abstract. A pallid bat (*Antrozous pallidus*) returned home from eight consecutive releases from six distinctly different directions and from distances ranging from 21 to 68 miles. This performance indicates that chance alone cannot be a major factor in homing, and that certain abilities possessed by this bat, and not simply randomness, must have been in operation.

For several years bats have been known to return to the point of capture after having been released elsewhere—an action usually reported as demonstrating homing ability and often interpreted as being the result of a "homing instinct." Several hundred bats, involving both Old World and New World species, have been marked in various ways and transported for distances up to 500 miles. Individuals have returned from distances as great as 450 miles (*1*), and the time of recovery has been as long as 5 years (*2*).

The majority of these experiments have been concerned with determining the percentage of bats returning to the point of original capture. Typical homing experiments, though the results are highly variable, usually show very low percentages of return, especially when the release points are several miles from the point of origin. These low percentages of return have been used to support the theory that so-called "homing ability" is simply the result of random dispersal from a release point, with individuals scattering in all directions, and with a few arriving home as a result of chance selection of the proper return route.

Little evidence in the literature can be used as an effective argument against randomness as an explanation for homing. Obviously, many other factors could contribute to low percentages of return, but at present it appears difficult to eliminate chance as one alternative. Rapid return flights, such as those reported by Cockrum (*3*) and by Mueller and Emlen (*4*), as spectacular as they may appear, could still be explained on the basis of chance since in both cases the rapid returns were accompanied by relatively low percentages of return. Even the extreme distance of return (450 miles) recorded by Smith and Goodpaster (*1*) with *Eptesicus fuscus*, which greatly lowered the probability of return by chance, did not eliminate the effect of randomness since the percentage of return was correspondingly low.

During the summer of 1960, we conducted a series of homing experiments with pallid bats (*Antrozous pallidus*) from a roost near St. David, Cochise County, in southeastern Arizona. During the analysis of results we found an interesting occurrence which casts serious doubt on the idea that mere chance is a major explanation of homing. While only a low percentage of pallid bats returned from any given experiment, it became evident that several individuals showed unusual consistency in their returns. The most spectacular of this group was a female (band number 10–51606) whose travels are summarized in Table 1 and Fig. 1. This female returned from eight consecutive releases from at least six distinctly different directions and from distances ranging from 21 to 68 miles. In the course of this study (between 28 May and 1 October) she had traveled a total of more than 450 miles.

Table 1. Summary of the homing of a female pallid bat. The recovery dates indicate only maximum possible time of return and should not be interpreted as actual "return dates." All releases and recoveries were made during the summer of 1960.

Release date	Release point	Recovery date
28 May	Sonoita	3 July
3 July	Mescal	17 July
17 July	Tucson	23 July
23 July	Nogales	6 Aug.
6 Aug.	near Willcox	27 Aug.
27 Aug.	Douglas	11 Sept.
11 Sept.	Duval Mine	17 Sept.
17 Sept.	Rodeo, N.M.	1 Oct.
1 Oct.	Mammoth	None

In all probability, the majority of these return trips were made from regions outside of the home range and therefore represent homing from unfamiliar territory. While no direct proof is available for this conclusion, our reasoning includes indirect evidence obtained both from experimentally determined flight speed and from an estimate of population home range based on banding records of members of this species (*5*). In no case do our data suggest the likelihood of an area of familiar territory which would approach a 50-mile radius in all directions—the approximate distance from which most of these returns were made. It is possible that the area of familiar territory might

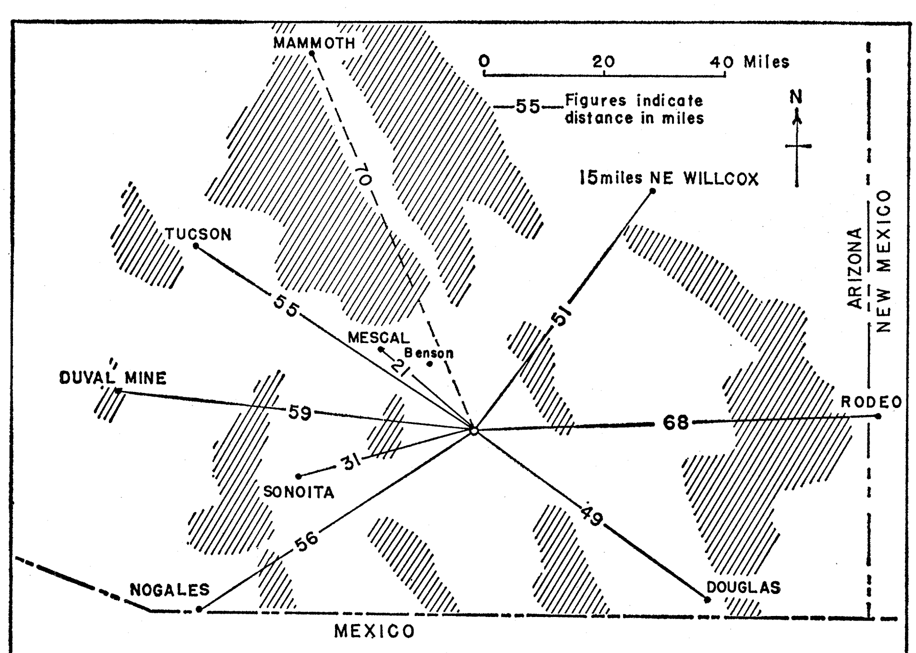

Fig. 1. Southeastern Arizona, showing spatial relationships of release points. The straight lines do not suggest actual routes taken on return trips. The bat was not recovered after its release at Mammoth. [Drafted by T. Shaman]