were no longer observed in rats 25 days and older since serum T_4, T_3, and TSH concentrations were similar in both groups. Iodide administration had no effect on the serum concentrations of T_4 and TSH in the mothers, although a small but significant increase in serum T_3 was observed in the iodide-treated mothers.

These studies suggest that the perinatal rat thyroid is susceptible to the chronic inhibitory effects of iodide on thyroid hormone synthesis. Resistance to the iodide-induced hypothyroidism develops later in neonatal life. It appears that synthesis rather than release of T_4 and T_3 is impaired by excess iodide, since the concentrations of T_4 and T_3 in the thyroid are decreased in the iodide-susceptible neonates. Iodide may also inhibit thyroglobulin synthesis and degradation as reported in adult rats (*15*). The absence of goiter development in spite of the increased serum TSH concentration may be a result of the thyroid tissue being damaged by excess iodide administration, as has been reported in guinea pigs and hamsters (*16*).

Although the iodide intake in the rat was high, it was not much different from the pharmacologic doses administered to humans (150 to 880 mg per day). It may, therefore, be postulated that pharmacologic quantities of iodide administered to women during pregnancy and lactation may induce transient hypothyroidism in the fetus and the newborn. Damage to the developing neonatal brain by hypothyroidism and the significance of the early recognition of hypothyroidism during neonatal life have been emphasized (*17*). The present findings in the perinatal rat and the occurrence of human fetal hypothyroidism following iodide ingestion during pregnancy strongly suggest that pharmacologic doses of iodide should not be given to human pregnant and nursing mothers.

Upon completion of the present studies, it was reported that premature infants bathed with Betadine, an iodine-containing antiseptic agent, develop transient hypothyroidism (*18*). The similarity of these observations in humans to the present findings in the perinatal rat suggests that the perinatal rat provides an excellent model to study the mechanism whereby iodides induce hypothyroidism during perinatal life.

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Giant Interneurons Mediating Equilibrium Reception in an Insect

Abstract. *In the burrowing cockroach* Arenivaga, *two giant interneurons in each connective of the ventral nerve cord provide gravity orientation information. The interneurons receive input from plumb bob-like equilibrium receptors on the ventral surface of the cerci. Our results support the theory that the cerci of cockroaches are specialized equilibrium organs.*

Insects use modes of locomotion requiring precise equilibrium information, yet until recently they were considered to lack receptors such as statocysts sensitive specifically to spatial position and acceleration. Behavioral evidence supports the theory that during terrestrial locomotion proprioceptors at a variety of loci signal joint position and limb loading from which the central nervous system is able to extract information regarding spatial orientation (*1*). However, located on the cerci of certain crickets and cockroaches are pendulous sensilla which may serve that function (*2*, *3*). Those of the cricket show plane preference, and recordings made from the sensory neurons indicate that the impulse frequency is related to the angle of inclination of the sensilla and the animal (*4*). In this report we present physiologic evidence that giant interneurons in the ventral nerve cord of the polyphagid cockroach *Arenivaga* in conjunction with similar specialized sensilla on the cerci are integral parts of a receptor system signaling spatial position.

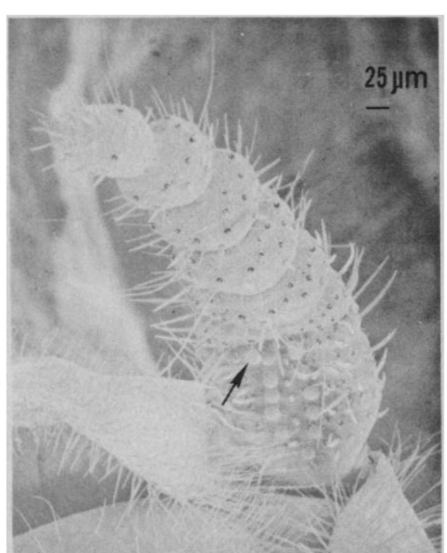

Fig. 1. Ventral view of the right cercus of an adult male cockroach *Arenivaga*. The plumb bob-like sensilla (note arrow) arranged in two rows are equilibrium receptors.

In addition to sensory hairs (trichobothria) and sensory bristles (sensilla chaetica), the ventral surfaces of the cerci of the burrowing cockroach *Arenivaga* sp. (*5*) possess sensory structures shaped like tiny plumb bobs. Those of adult animals are arranged in two rows of seven or eight sensilla (Fig. 1). Each sensillum consists of a dense sphere positioned at the distal end of a slender shaft which inserts into a singly innervated socket (*6*). To determine if interneurons are activated by changes in spatial position via these sensilla, we obtained electrophysiological recordings from the nerve cord during controlled displacement of the insect (*7*).

When the cockroach is maintained in the primary orientation, the giant interneurons are inactive except for sporadic neural activity presumably evoked by air movement of trichobothria. This neural activity is increased to phasic bursts when a series of air puffs from a pipette is directed at the cerci (Fig. 2A). If the animal is rolled about its longitudinal axis, rhythmic activity is immediately evoked from other smaller giant interneurons (Fig. 2B). During roll to the left, two interneurons in the right connective produce action potentials. Upon changing the direction of roll to the right the two interneurons in the right connective are soon inactivated, but as the roll angle approaches the primary orientation the two in the left connective begin to fire. Note that as the angle of roll increases, the frequency of firing of action potentials by the interneurons also increases, and when the insect is maintained at a particular roll position (45° left in this case) the appropriate interneurons fire tonically.

If the cockroach is pitched from the primary orientation, the same two pairs of giant interneurons are activated but in a different combination (Fig. 2C). During pitch forward, the smaller interneuron in each connective fires, but when pitched backward the larger interneurons respond. The frequency of firing increases with the displacement angle, and when the insect is maintained at a particular pitch position (45° forward in this case) the interneurons fire tonically. Rotations between the roll and the pitch axes are signaled by variations in the ratio of activity of the two pairs of interneurons. These physiologic data indicate that *Arenivaga* sp. is apprised of its spatial position by which interneurons are active, the ratio of their activities, and their frequencies of firing (*8*).

We hypothesized that the giant interneurons receive their input from the plumb bob-like cercal sensilla, with the latter functioning as equilibrium receptors sensitive to spatial position. To test this hypothesis, we observed the interneuron responses to displacements after the removal of these sensilla from both cerci. Whether the insect was maintained in the primary orientation, rolled, or pitched (Fig. 2D), the interneurons fired erratically, the activity no longer correlated with spatial position. This demonstrates that these sensilla respond to changes in the cockroach's equilibrium and signal displacements from the primary orientation via the two pairs of giant interneurons. Although they have been called trichobothria (*3*) we are renaming the plumb bob-like receptors "tricholiths" to better reflect their function.

The giant interneurons in insect nerve cords have been the subject of extensive research for 40 years. Using *Periplaneta americana* (L.), an agile surface-dwelling cockroach lacking tricholiths, and, more recently, various species of crickets as experimental material, investigators have described many of the cellular aspects of these interneurons. Unfortunately, the exact role that the interneurons, and the long filiform trichobothria of the cerci which drive many of them, play in the behavior of these insects remains unknown. The accrued knowledge from many experiments has led to speculations that (i) the giant fibers mediate escape reflexes when tactile disturbances or air currents impinge on the cercal trichobothria or (ii) they are part of a sound receptor system (*9*). However, behavioral experiments reported by Fraser (*10*) suggest strongly that the trichobothria of

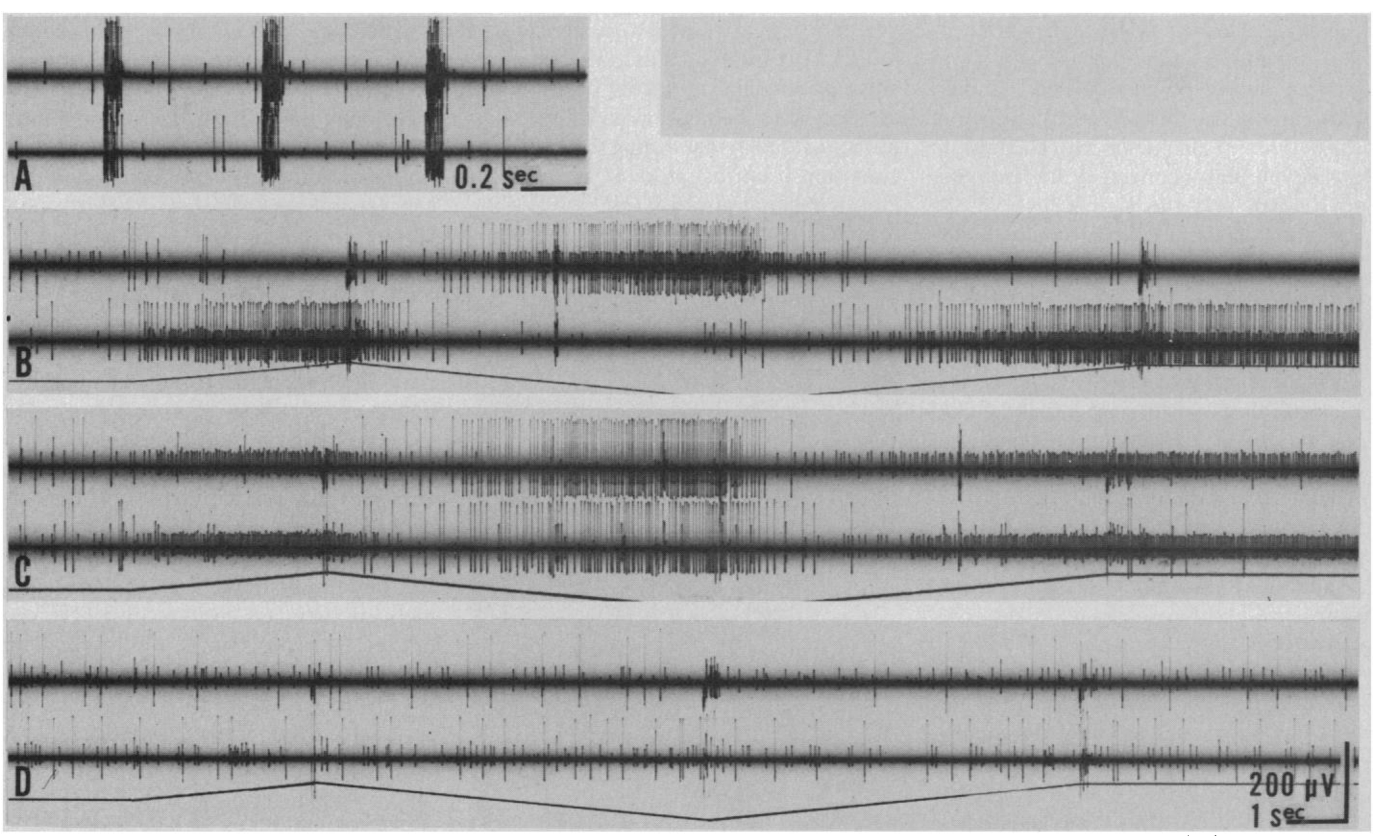

Fig. 2. Neural activity in the connectives of the ventral nerve cord of an adult female cockroach *Arenivaga*. In each record, the top trace was recorded from the left connective, and the middle trace from the right connective; the bottom trace monitors the orientation of the cockroach. All displacements start from the insect's primary orientation. (A) Phasic responses of giant interneurons in both connectives evoked by air puffs to the cerci. (B) Neural activity resulting from roll. The bottom trace indicates the direction of roll. The upward movement of the trace indicates roll to the left, downward movement roll to the right. (C) Neural activity resulting from pitch. Pitch forward is indicated by upward movement of the trace, pitch backward by downward movement. (D) Neural activity evoked by pitch after the tricholiths of both cerci have been removed. The responses driven by the tricholiths are no longer correlated with the stimulus [compare with (C)].

the cerci aid in the control of equilibrium and compensatory reflexes during flight. While the suggested roles of predator and sound detector remain possibilities, our findings lend support to the view that the cerci also function as equilibrium organs.

Since *Arenivaga* is a burrowing cockroach and some desert species have been found at depths of 60 cm (*11*), one might think that the tricholiths would be broken off during burrowing. The cerci of larvae and adult female specimens are contained within cavities in the abdomen. Those of adult males protrude prominently from the abdomen, but are afforded protection on the dorsal side by wings that overhang them. The tricholiths of the males are protected from soil contact on the ventral side by being located within a concave depression surrounded by trichobothria and sensilla chaetica. While there is some variation in the number of these pendulous sensilla normally found on the cerci of adult animals, missing or broken-off tricholiths are rare.

Tricholiths are not unique to *Arenivaga*. Similar pendulous sensilla have been identified on the cerci of three genera of crickets—*Achaeta*, *Gryllus*, and *Gryllotalpa* (*2*)—and several species of cockroaches in the family Polyphagidae (*3*). The insects listed are nocturnal, fossorial species that dig or live in impermanent burrows or "swim" through quasi-fluid soil or litter without leaving a tunnel. Such forms are less able to assess asymmetric tensions of the limbs in order to derive equilibrium information since the substrate collapses about them and does not provide a firm foothold. A discrete receptor system detecting spatial position would be a particularly desirable adaptation for these insects. Behavioral experiments should indicate the extent to which *Arenivaga* is dependent on the system for geotactic adjustments.

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Platelet Aggregation Induced by Ultrasound Under Specialized Conditions in vitro

Abstract. *Human platelets were induced by 2.1-megahertz ultrasound to form aggregates around gas-filled pores in membranes immersed in platelet-rich plasma. The spatial peak intensities required were only about 16 to 32 milliwatts per square centimeter. Ultrasound generated by a medical Doppler device, whose intensity exceeded this, induced aggregate formation under the same conditions.*

The findings reported here resulted from a search for systems and methods sensitive enough to detect biological effects of ultrasound under conditions characteristic of medical diagnostic practice. A procedure that yields reproducible results and is convenient to use would be valuable for investigating factors that determine any potential for hazard posed by medical use of ultrasound. It is not easy to find systems sensitive enough because of the low intensities typically used for diagnostic equipment.

In the approach reported here, we utilized hydrophobic membranes with straight-through pores a few micrometers in diameter (Nuclepore Corp., Pleasanton, California). The pores retain gas when the membranes are immersed in aqueous media. The gas pockets or bubbles are stable in the pores; they are small in size and, if they were formed as free gaseous bodies in the medium, would quickly shrink and disappear. When sonicated at megahertz frequencies, these stablized gas bubbles pulsate and thus provide a controlled form of acoustic cavitation in the medium. Cavitation has been cited as a major mechanism for the biological effects of ultrasound, but its occurrence in low-intensity experiments is often problematic. In our experiments this uncertainty was obviated by exposing stable bubbles to the medium via the porous membranes.

The biological subject in these studies was the human blood platelet. Platelets are present in large numbers in blood, and they contribute to blood coagulation by sticking to surfaces and aggregating to form a hemostatic plug at a site of blood vessel damage. During these processes they change in shape, release certain biochemicals from their cytoplasmic granules, and fuse together to form a semisolid mass. Platelets may be important in the pathogenesis of some thrombotic diseases. Agents that might cause unwarranted platelet aggregation in vivo may have a potential for producing serious effects. Williams *et al.* (*1, 2*) found that ultrasonic exposure can modify platelet morphology and function in vitro. In our experiments, suitable exposure of human platelet-rich plasma (PRP) to the ultrasonically activated gas-filled pores resulted in the formation of platelet aggregates near the pores.

The general procedures have been described (*3*). The PRP was prepared by centrifugation of fresh human whole blood (from an apparently healthy male donor) collected into trisodium citrate as anticoagulant. The PRP, containing roughly 300,000 platelets per microliter, was pipetted directly into a sample chamber, which had a 1-mm-wide strip of porous membrane mounted in it. The chamber was formed by two 15-μm-thick sheets of polyvinyl chloride film clamped between two circular plastic rings (inner diameter, 3 cm) and held about 0.5 ml of PRP. For this work, the porous membranes were 12 μm thick and contained pores 4 μm in diameter (standard deviation, 0.3 μm) of number density 720 mm^{-2}. After sonication, the strip was in-

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