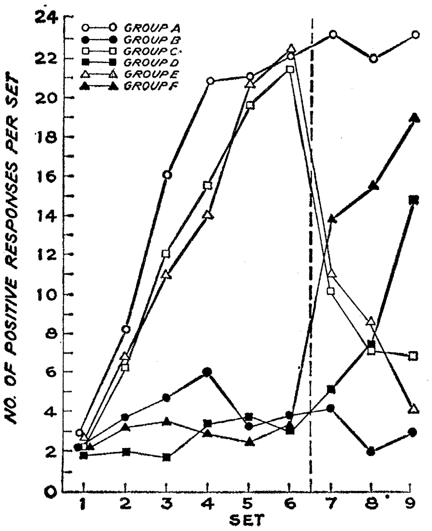

Fig. 2. The mean of each group per set on consecutive days for a total of 225 trials. The series for each group was divided into the first six sets (150 trials) and the last three sets (75 trials) according to the subject's orientation during the UCS. Group A, cathodal-cathodal; group B, anodal-anodal; group C, cathodal-no UCS; group D, no UCS-cathodal; group E, cathodal-anodal; and group F, anodal-cathodal.

inhibited conditioning. Further analysis of the effects of anodal UCS and its interaction with cathodal conditioning is needed.

No specific mechanism for the dependence of conditioning rate on orientation in the UCS field can be proved at this time, but several alternatives can be considered. Viaud (*6*) has shown that the stimulus threshold to an electrical field depends on the orientation in the field and that the planarian is, in fact, more "sensitive" in cathodal orientation than in anodal orientation. Viaud also confirmed the earlier evidence (*5*) that planarians always migrate toward the cathode and showed that this applies to segments as well as to the intact animal. Halas *et al.* (*9*) have recently shown that more shocks of presumably aversive intensity are required to cause a planarian to reverse his direction of travel when moving toward a cathode than when moving away from the cathode. These results may be a reflection of the galvanotropism of planarians. However, neither galvanotropism nor a difference in sensory threshold can explain our results, since the conditioned response achieved was cessation of motion toward and active turning away from the cathode. A related explanation, that the planarian "perceives" anodal and cathodal UCS as qualitatively different stimuli, appears doubtful in view of the active interference between the two types of UCS in the alternated group (group G). Furthermore, at the stimulus intensity used, all subjects showed a distinct UCR, regardless of orientation in the field. Nevertheless, this hypothesis deserves further study, since the planarian UCR consistently begins with a withdrawal of the end of the body nearest the anode (*6*, and our own observations); conversely, according to the reports of human subjects partially immersed in water (*10*), a shock is always felt in the portion of the body nearest the cathode, regardless of orientation. The recent paper of Shafer and Corman (*11*) adds further support to previous observations of differential sensitivity and motor responses to direct current depending on orientation, and emphasizes the importance of stimulus intensity.

Another explanation is that the formation of the physical correlate(s) of the conditioned response is directly affected by the polarity of the electrical UCS. There is ample direct evidence that d-c fields applied directly to the central nervous system of higher animals have a very strong influence on conditioning (*12*). It would be of considerable interest to know whether a pulsed or constant d-c field could influence the rate of learning of an operant response by planarians (*13*; *14*).

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Cerebral Cortex: A Sensorimotor Amalgam in the Marsupialia

Abstract. ***In the cerebral cortex of the opossum and the wallaby there is a complete and coincident overlap of the sensory and the motor representations of the body. Within this sensorimotor area it is not possible to draw the line which in other mammals separates a primarily sensory area from a primarily motor area.***

Since Sherrington and Grünbaum (*1*) demonstrated in anthropoid apes that the central fissure demarcates the "precentral" motor area which lies in front of it, and since Cushing (*2*) demonstrated in humans that a "postcentral" sensory area lies behind it, it has been possible to establish a dividing line homologous with the central fissure in all mammals investigated. This dividing line was confirmed when it became possible with electrical recording techniques to map in detail the sensory areas in animals; Woolsey (*3*) then showed that organization within the sensory area behind was a mirror image of that within the motor area in front. Although movements have been elicited on stimulation of the "sensory" area and tactile impulses have been recorded from the "motor" area, the existence of two spatially separate areas, each with a pre-eminent function, is not challenged.

These facts of organization of the sensory and motor areas of the cortex were established entirely in placental mammals. That the mode of cortical representation is different in marsupial mammals was shown by a recent study in our laboratory (*4*) of the details of cortical localization in 40 opossums (*Didelphis virginiana*). It was found that a single area contained both the sensory and the motor representations of the various body parts, and that this area was not divisible into a more sensory portion and a more motor portion as in previously studied mammals.

Systematic exploration of the cortex was made with points of observation 2 mm apart. Motor systems were studied by stimulation with bipolar electrodes using 60-cycle current. Successive stimuli at 2-minute intervals were given with increasing milliamperage until a threshold movement was obtained. Sensory systems were investigated with the evoked potential tech-

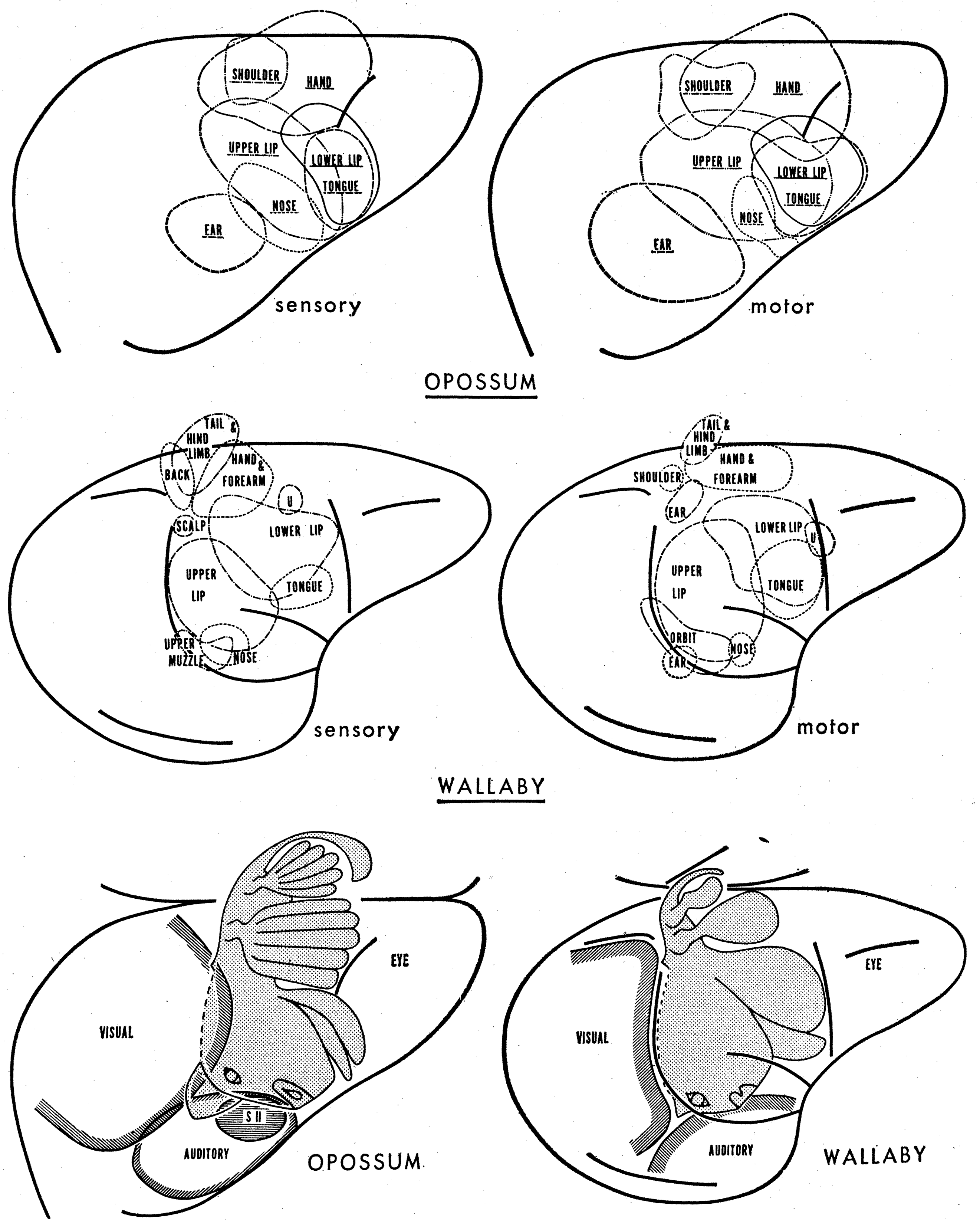

Fig. 1. Sensory and motor representation in the cerebral cortex of the opossum and the wallaby. Drawings show the neocortical surface of the right cerebral hemisphere with the frontal pole to the right. Fissures are indicated by heavier lines. The inferior border of the hemisphere sloping down from the frontal pole is the rhinal sulcus in each case. (Top) Opossum. Sensory centers for selected body parts shown on the left, and motor centers shown on the right. Note correspondence of locations. (Middle) Wallaby. Note correspondence of sensory and motor centers. Upper muzzle means the dorsal portion of the snout between the nose proper and the eyes. Orbit refers to eye closure. U indicates a small "upper lip area" separate from the main area. (Bottom) Homunculus-like pictures of sensorimotor body representation in the opossum and the wallaby. Above the lateral aspect of each hemisphere is a partial outline of the adjacent medial aspect which contains tail and hindlimb representations. The borders of visual and auditory areas are indicated. The small second somatic sensory area in the opossum is labeled S II. Stimulation in the region labeled "eye" gave responses from the eye.

nique in which a cortical electrode was used to record responses evoked by the light tap of a roving tactile stimulator.

On an outline of the brain shown in the top of Fig. 1, there is a topographic composite made from superimposition of locations of selected areas of sensory representation in 16 opossums.

Comparison may be made in the same figure with a composite, similarly made, of the areas of motor representation in five opossums. The medial surface of the hemisphere which contains the areas for hindlimb and tail is not shown. There is correspondence in location of sensory and motor representations of each somatic subdivision and it is seen that the area from which tactile responses from a body part were recorded is the same area in which stimulation elicited movement of that body part.

A study undertaken to see if this unique mode of cortical representation is a general characteristic of marsupials has now been completed on eight wallabies (*Thylogale eugenii*) imported from Australia. The brain in these smaller members of the kangaroo family is larger and more fissured than that of the opossum. Composites of the results in the wallaby, illustrated in the middle of Fig. 1, show a sensorimotor organization similar to that found in the more primitive opossum. The portion of the area for tail and hindlimb shown to extend above the outline of the lateral surface is located on the adjacent medial surface. Although a somewhat broader field is activated with cortical stimulation techniques, the correspondence of locations of sensory and motor representations is striking. In front of the lower lip representation in both sensory and motor studies were found small areas of upper lip representation (labeled U), probably related to elaboration of heightened function of the lips in this animal.

A homunculus-like figure on a brain outline is used in the bottom of Fig. 1 to picture the sensorimotor representation of the body form in each marsupial. In addition, each outline shows the boundary of the visual area as activated by a flash of light and the auditory area as activated by a click.

A small area (labeled S II) with complete body representation was found in the opossum within cortex that was also responsive to click. This is undoubtedly the second somatic sensory area that has been established, in a homologous position, in placental mammals. Although this area was not found in the wallaby, it is presumed to lie within the fissure bordering the sensorimotor area inferiorly. In each marsupial, stimulation in front of the sensorimotor area gave responses from the eyes which included eye movement, changes in pupillary caliber, retraction of the nictitating membrane, and closure of the eye. This area is probably homologous with the frontal eye fields found in placental mammals. In each figure the back is represented caudally with the limbs and mouth parts projecting rostrally, and it is noteworthy that this is the orientation shown by Woolsey (*3*) to be the basic pattern of somatic sensory area I in placental mammals (*5*).

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Insect Fecundity and Fertility: Chemically Induced Decrease

Abstract. *Ingestion of arsenite by braconid wasps, which have mature ovaries at eclosion, results in a nonselective lowering of egg production; of the eggs produced, the percentage of eggs hatched was not lowered. The effectiveness of the somatic tissues concerned with food assimilation and utilization was altered. The folic acid antagonist, methotrexate, inhibits developing gametes directly, so that differential destruction of gametes and death of zygotes occurs.*

Sublethal doses of arsenic have been shown to reduce the fecundity of various species of adult Diptera (*1*). Interesting speculations arise concerning the influence of this pesticide on natural populations of insects during the years that arsenicals were used in quantity on fields and orchards. The report (*1*) emphasized the necessity for determining more exactly the effects of pesticides and chemisterilants.

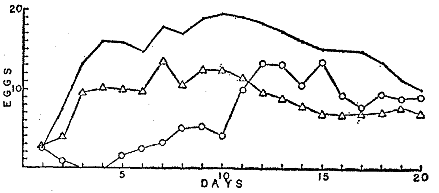

Fig. 1. Patterns of egg production in Habrobracon. The daily average number of eggs per female has been plotted for three samples of 20 females each. At the first feeding following emergence, experimental wasps ingested single, sublethal meals of either NaAsO$_2$ (0.005 percent) or methotrexate (0.006 percent) in sugar water. Controls received sugar water only. Dots, control; open triangles, sodium arsenite; and open circles, methotrexate.

By failing to develop, the immature ovaries of young adult flies react similarly to agents of diverse chemical nature and physiological influence (*2*). The parasitoid wasp known in genetic literature as Habrobracon (*Bracon hebetor* Say) provides a diagnostic basis for the cytological analysis of ovarian damage. In contrast to the Diptera typically used in sterilant experiments, wasps at eclosion have fully differentiated ovaries. Each of the synchronized polytrophic ovarioles, of which there are invariably four, contains a series of developing units ranging from oocytes in first meiotic metaphase to interphase oogonia. Thus differential effects upon specialized, transitional, and primitive cells can be easily assessed.

Figure 1 presents a comparison between the egg production of normal control wasps and those fed a sublethal dose of sodium arsenite (NaAsO$_2$), a most poisonous form of arsenic. The NaAsO$_2$ curve, one of a group obtained from a series of graded doses, shows that over a period of 20 days egg production is lower but parallel to control values. A similar decrease in egg production can be obtained with a variety of enzyme inhibitors. Dissected ovarioles from similarly treated wasps lacked degenerating cells, which suggests the occurrence of a general somatic debility instead of a specific cytological effect upon the germ line.

Also shown on Fig. 1 is the different result obtained after a single feeding of the folic acid antagonist (*3*), methotrexate. Dissection revealed that atrophy of nurse cells and degeneration of oocytes were responsible for the insect's failure to deposit eggs on days