Table 1. Plasma corticoid responses to limbic stimulation.

Patient	Location of stimulation	17-Hydroxy-corticoids in plasma: maximum change from control amount (%)	Time
1	R-CA 2 hippocampus (histopath.)	−28	1-hour specimen only
2	R-basolateral amygdala (histopath.)	+12	1-hour specimen only
3	R-hippocampus (stereotaxic)	−88	30-minute specimen
3	L-subiculum hippocampus (histopath.)	−90	15-minute specimen
3	R-basolateral amygdala (stereotaxic)	+360	15-minute specimen
3	L-basolateral amygdala (histopath.)	+232	15-minute specimen
4	Anterior to L-amygdala (histopath.*)	+415	30-minute specimen
4	L-anterior hippocampus (histopath.*)	−18	15-minute specimen
4	L-CA 1 hippocampus (histopath.)	−100	15- and 30-minute specimens

* Unverified.

15 times each, in alternate minutes, for a total stimulus period of 30 minutes. The hourly urinary 17-hydroxycorticosteroids for both control and stimulation days are shown in Fig. 2; corticosteroid excretion was 454-percent higher in the 1st-hour urine on the stimulation day than on the control day. Histopathologic study of this patient's left temporal lobe after surgical excision showed the electrode tip to have been located in the basolateral amygdala.

It was suggested (*1*) that the findings then reported were consistent with observations by others of increased corticosteroid levels in the adrenal venous effluents of cats after stimulation in the anteromesial amygdala (*4*); stimulation in the basolateral amygdala resulted in decreased corticosteroid release. From our current histopathologic data we can state that stimulation of the basolateral amygdala in humans increases corticosteroid levels in plasma (patients 2, 3, 5); this response is probably not confined to the basolateral area, but may result from more diffuse stimulation of other areas in the region of the amygdala (patient 4). This finding is somewhat at variance with the reported experiments on cats (*4*), wherein different rates of corticosteroid release followed stimulation of anteromesial and basolateral amygdala.

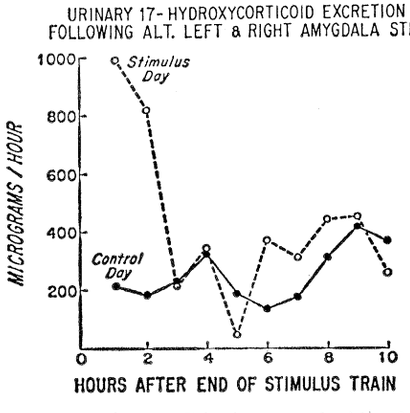

Fig. 2. Urinary 17-hydroxycorticoids after amygdala stimulation in patient 5.

Recent data on the "limbic system–midbrain circuit," of which the amygdala-hypothalamus connections are a part, suggest that the functional state of the hypothalamus, as manifested by endocrine phenomena, reflects activation or inhibition of neural mechanisms of this circuit, mechanisms which are "diversified and potentially of reciprocal sign," consistent with the structural heterogeneity of this circuit (*5*). Our data from studies of man indicate that stimulation in the region of the amygdala—and basolateral amygdala stimulation in particular—leads to increases in corticosteroids in plasma and urine, and that hippocampal stimulation leads to decreases in corticosteroids in plasma.

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23 May 1966

Pressure Regulation in the Middle Ear Cavity of Sea Lions: A Possible Mechanism

Abstract. *The mucosa lining the cavity of the middle ear of sea lions contains a complex network of venous channels and sinuses. During dives the pressure within the middle ear may be equalized with that in the external auditory meatus either by the distention or depression of the mucosa due to the presence or absence of blood in the sinuses.*

If the pressure of the air in the middle ears of mammals is unequal to that of the environment, the tympanic membrane suffers a decreased sensitivity to the reception of sound vibrations (*1*). More important is the fact that severe injury can occur if the difference between these pressures exceeds a certain limit (*2*). Sea lions have a mechanism which allows them to adapt to extreme changes of pressure in their middle ear cavities.

Two Steller sea lions (*Eumetopias jubata*) and the heads of two California sea lions (*Zalophus californianus*) were embalmed with 10 percent formalin; their vascular systems were injected with colored latex. One of the Steller sea lions was injected through the posterior vena cava; all of the other specimens were injected through the external jugular vein. The middle ears were grossly dissected, and microscopic sections of the muscles and mucosa were prepared.

The portion of the temporal bone forming the ventral aspect of the middle ear cavity in sea lions is a flat, uninflated, relatively thick bone compared to that of terrestrial mammals. Numerous foramena perforate the bone and carry many veins into the middle ear cavity to the mucosa. The basic morphology of the inside of the cavity is similar to that of the typical mammalian middle ear. The Eustachian tube runs from the anterio-ventral aspect of the middle ear to the nasal cavity. The tensor tympani and stapedius muscles are both present. The ratio of the area of the tympanic membrane to that of the footplate of the stapes approaches 1:1 instead of 21:1 which is their ratio in man (*3*). The stapes is also correspondingly larger relative to the malleus than it is in most terrestrial mammals.

The mucous membrane lining the

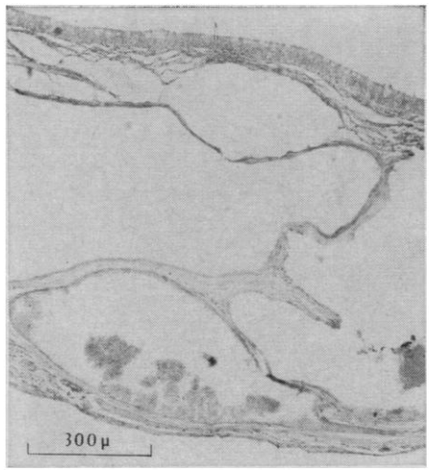

Fig. 1. The mucosa of the middle ear of a California sea lion (*Zalophus californianus*). Epithelial layer above and distended venous sinuses below; some of the sinuses contain red blood cells.

middle ear cavity of the sea lions is significantly different from that of terrestrial mammals. The mucosa is apparently attached to the underlying bone only in the area of the epitympanic recess, which houses the middle ear ossicles. Elsewhere it is unattached except where the many veins pass through the bone. The mucosa consists of three distinct layers which are visible grossly as well as microscopically. The inner layer is ciliated pseudostratified columnar epithelium interspersed with mucus-secreting goblet cells. The outer layer consists of thin, exceedingly tough, dense connective tissue in which the fibroblasts are tightly packed together. The much thicker middle layer consists of a highly complex network of venous channels and sinuses embedded in a matrix of loose connective tissue. This venous network is freely collapsible and distendable.

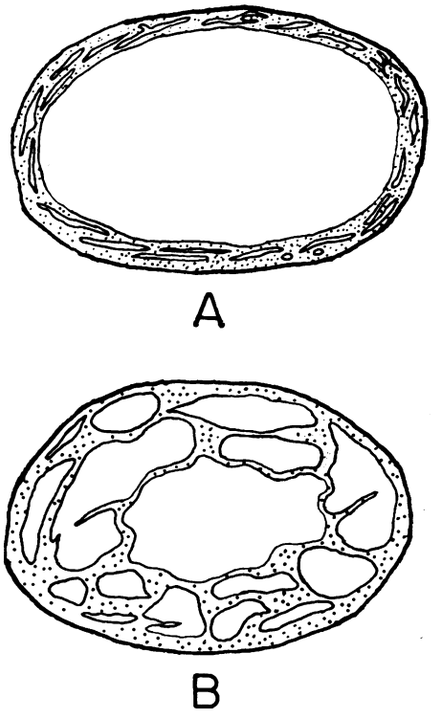

Fig. 2. Diagram of the mucosa of the middle ear of sea lions. (*A*) The venous sinuses are collapsed, and the mucosa is flat. (*B*) The venous sinuses are distended with blood which reduces the lumen of the middle ear cavity.

The blue latex injected into the posterior vena cava of the first sea lion had not penetrated the venous sinuses of the middle ear mucosa, probably because the flow was impeded by the valves of the jugular vein. The mucosa was relatively flat, and the venous network was collapsed. The latex was injected through the external jugular vein of the second sea lion, and sufficient pressure was exerted so that the latex colored the entire mucosa blue. Microscopic examination revealed large, dilitated sinuses, and the mucosa was greatly enlarged (Fig. 1).

The physiological significance of the mucosa of the middle ear is apparent if one considers the environment in which these animals live. During a dive the pressures exerted on sea lions are much greater than those usually experienced by terrestrial mammals. Also the rate of change of pressure occurs much more rapidly in water. A positive pressure in the middle ear is easily adjusted while a negative pressure is much more difficult to overcome (*4*). In adapting to small negative changes in the pressure of the middle ear in air, man swallows, which increases the pressure in the pharynx and helps force air up the Eustachian tube. In the water, scuba divers must resort to the valsalva maneuver (forced exhalation against a closed mouth and nostrils) in order to equalize the pressure. If the pressure is not equalized, a mere change of 3 m in depth can result in hemorrhage into the middle ear and sometimes in rupture of the ear drum (*2*).

The anatomical facts suggest that sea lions do not have to use such mechanisms as the valsalva maneuver to equalize pressure in the middle ear. When the sea lion is on the surface, the mucosa of the middle ear is flat, and the venous sinuses are collapsed (Fig. 2*A*). During a dive, as a negative pressure develops, the mucosa is sucked inward and the sinuses fill with blood (Fig. 2*B*). This probably causes the mucosa to expand, and it distends into the cavity, compressing the air until the pressure becomes equal to that on the outside of the body. During deeper dives, the remaining air space is probably restricted to the small epitympanic recess. Thus the tympanic membrane may remain functional and the ossicular chain of conduction of sound may maintain its integrity under water. This is significant since these animals use an active sonar under water (*5*). It is likely that the regulation of pressure in the middle ear of sea lions by the mucosa can operate purely passively and that it need not require nervous regulation. As a positive or negative pressure starts to develop, the venous sinuses could automatically collapse or distend with blood until equilibrium was established.

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28 March 1966

Sexual Behavior in the Male Rat

An article by R. D. Lisk (*1*) entitled "Inhibitory centers in sexual behavior in the male rat" contains the following statement which represents the major finding: "Small lesions placed near the diencephalic, mesencephalic junction, in either the lateral or medial mammillary region, resulted in an increase of copulatory behavior." I believe that this conclusion probably is valid, but, because the experimenter failed to observe the behavior of his animal subjects, other interpretations cannot be