Stimulation of Limbic System of Brain in Waking Animals

Phylogenetic and cytoarchitectural studies, together with recent physiological investigations, suggest that the limbic system represents an early neural development involved in the higher control of the autonomic nervous system and in affectively determined behavior (*1, 2*). The limbic system has a marked influence over the viscera controlled by the autonomic system; hence the designation "visceral brain" is applied to it (*1*).

This paper (*3*) summarizes our studies on 29 cats and 13 monkeys (*Macacus*), in which multilead electrodes were implanted in both cerebral hemispheres in different parts of the limbic system (amygdala both anteromedial and basolateral nuclei, pyriform cortex, hippocampus, temporal tip, posterior orbital gyrus, and anterior cingulate gyrus). After recovery, these areas were stimulated electrically in unanesthetized waking animals. The parameters of stimulation used were 30-cycle-per-second square waves pulses of 0.2- to 1-millisecond duration and 3- to 8-volt intensity.

Affective behavior of the animals showed marked and varied changes on stimulation of different regions. Stimulation of temporal lobe structures, excluding the tip, made the majority of the animals agitated and fearful, but quieted some of them. Temporal tip stimulation of cats made them very irritable. Stimulation of temporal tip in monkeys and stimulation of posterior orbital cortex just rostral to temporal tip in cats made them very vicious and violent. On the other hand, cats with electrode locations further removed from the temporal tip, as well as monkeys, became very quiet during posterior orbital stimulation. Stimulation of the anterior cingulate caused convulsions followed by a typical rage reaction.

Certain somatic movements involving the ipsilateral facial, eyelid, orbital, and oral muscles, and rarely the limb muscles, and also dorsal retraction of the head were obtained by stimulation of all these regions. Contraversive turning of the head (*4*) was obtained only in 6 cats by stimulation of the amygdala, orbital cortex, and cingulate gyrus. Organized movements of "eating" automatisms (*5*) (sniffing, licking, chewing, biting, and chop-licking) were also obtained by stimulation of all the regions. The food intake was not increased by stimulation.

Stimulation of widespread points in all these structures produced signs of autonomic activity that included lachrymation, salivation, pupillary changes, movements of nictitating membrane, and more rarely urination and defecation. The volume of gastric secretion, as well as its HCl (free and total) and pepsin contents, was both increased and decreased by such stimulation; gastric motility was inhibited by stimulation of the temporal lobe structures, and both increased and inhibited by stimulation of the posterior orbital and anterior cingulate gyri. There was usually a rise in blood sugar level resulting from stimulation of all the limbic structures in the monkey; in the cat, there was a rise resulting from stimulation of all these structures except the anterior cingulate. Fall in blood sugar resulted only from stimulation of anterior cingulate gyrus in the cat. Changes in blood pressure were elicited on stimulation of all the different regions. In the majority of cases, stimulation of temporal lobe structures produced a fall, while stimulation of the temporal tip and posterior orbital and anterior cingulate gyri produced a rise. Changes in the respiration, on the other hand, could only be elicited from few points stimulated, and there was no relationship between these and the blood pressure changes. There was usually an inhibition of respiration (even apnoea in some) from stimulation of the anteromedial amygdala, while stimulation of different points in the orbital cortex, anterior cingulate, and temporal polar regions produced both inhibition as well as acceleration (*6*).

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References and Notes

1. P. D. MacLean, *Psychosom. Med.* 11, 338 (1949).
2. J. F. Fulton, *Frontal Lobotomy and Affective Behavior* (Norton, New York, 1951).
3. This investigation was supported by a grant from the Indian Council of Medical Research. The equipment was supplied by the Rockefeller Foundation of New York.
4. B. R. Kaada, *Electroencephalog. and Clin. Neurophysiol.* Suppl. 4, 235 (1953).
5. P. D. MacLean and J. M. R. Delgado, *ibid.* 5, 91 (1953).
6. Detailed results of these investigations will be published in *Indian J. Med. Research.*

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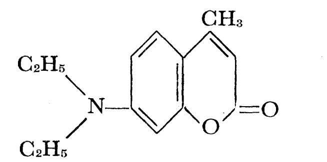
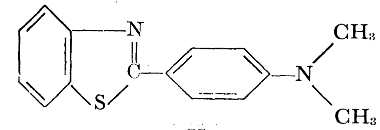
New Liquid Scintillation Phosphors

A number of "whiteners" used in laundry detergents and some other related compounds have been examined for liquid scintillation activity (*1*). Although none of the compounds reported here show properties superior to the best phosphors now available, they represent entirely new classes of compounds in this field and may, therefore, be of interest as a starting point for better compounds and in the study of the liquid scintillation process itself.

About 40 compounds were obtained from five companies: E. I du Pont de Nemours and Company; Ciba Company, Inc.; General Aniline and Film Corporation; American Cyanamid Company (Calco); and the Hilton-Davis Chemical Company. Two of these compounds showed special promise. These were 7-diethylamino-4-methylcoumarin (I) and 2(*p*-dimethylaminophenyl)benzthiazole (II).



I



II

Compound I was submitted by several companies and can be obtained commercially from a number of sources. Compound II was submitted by the Jackson Laboratory, Organic Chemicals Department, E. I. du Pont de Nemours and Company.

At the time these measurements were made, the liquid scintillator that gave best results in our laboratory consisted of 0.4-percent 2,5-diphenyloxazole (PPO) and 0.002-percent 1,6-diphenylhexatriene (PPHT) in toluene. The mean pulse height obtained using a cobalt-60 source with this phosphor, flushed with nitrogen, will be referred to as 100 percent. Since these measurements were made, a solution of 0.4-percent PPO and 0.01-percent 1,4-di(5-phenyl-2-oxazolyl)benzene (POPOP) has been used, which gives on this scale a pulse height of 121 percent.

Various preparations of compound I, tested as 0.4-percent solutions in toluene, gave pulse heights from 86 to 100 percent. Compound II gave pulse heights of 90 percent. These compounds were used as received without special effort at further purification. The addition of a secondary solute such as PPHT or POPOP had little or no effect on the scintillation properties of these solutions. In all cases, flushing with nitrogen to remove air increased the pulse height approximately 30 percent.

A number of other compounds showed less promise, but they still showed measurable scintillation activity. These included other amino coumarin derivatives, an amino derivative of benzoxazole, and a derivative of imidazolone.

A considerable number of compounds that were measurably soluble in water were screened for scintillation activity in water. Except for Cerenkov pulses, no activity was observed in any case, al-