beam oscilloscope. A bandpass of 0.8 Hz to 10 kHz was employed in order to visualize both gross slow wave evoked potentials and the auditory neurophonic.

Results. The AN is seen as a waveform whose basic frequency is identical to that of the stimulus. It may appear to be as pure a sinusoid as the original stimulus and is easily observed at frequencies between 500 Hz and 2500 Hz. This particular characteristic does not differentiate the AN from the CM. Evidence that the AN is of neural origin comes from 3 other observations.

First, it has a latency (Figure, A). The latency is appropriate for the level of the auditory system from which it is recorded. The AN appears immediately following the gross evoked potential at the site in question (Figure, B). For example, in simultaneous recordings, the AN can be observed to occur with a latency of approximately 2 msec at the trapezoid body and 3.5 msec at the inferior colliculus. Second, the amplitude of the AN is generally greater to contralateral than ipsilateral stimulation above the level of the decussation of the trapezoid body (Figure, A and B). This finding, which is well known for evoked potentials also, cannot be explained on the basis of presumed volume conduction from the cochlea, for such volume conduction would produce greater amplitudes on the ipsilateral side. Thirdly, the AN decreases in amplitude gradually as barbiturate anesthesia is deepened, until death, when it disappears. This amplitude reduction is paralleled by that of the evoked potential. Additional evidence to support the contention that the AN is synaptically transmitted is provided by the finding that its susceptibility to the action of barbiturates is greater at successively higher levels of the auditory system (Figure, C).

Sites from which we have successfully recorded the AN include the trapezoid body, superior olivary complex (including both the medial and lateral superior olivary nuclei), and the lateral lemiscus. The AN may be seen in the inferior colliculus, but cannot be definitively differentiated from pre-synaptic lemniscal activity. We have observed the AN in the medial geniculate body, but it is of small amplitude. Further, it is seen only in the ventral portions of this nucleus, in the region of the entrance of the fibers from the brachium of the inferior colliculus. We are inclined to believe that the AN at this high level of the auditory system is generated by lateral lemniscal fibers which are known to bypass the inferior colliculus.

Discussion. Some characteristics of the AN have been noted in order to emphasize its neural origin. Previous studies have carefully investigated the phenomenon, particularly with regard to its upper limits and relationships to stimulus intensity and frequency[3–5]. None of our observations are at variance with these reports. Some other observations consonant with the findings of BOUDREAU also have been reported[6–8].

The AN has been referred to as 'wave activity'[3], the 'following response'[6], and even the 'frequency following response'[7,8]. We consider none of these terms to be satisfactory because they fail to indicate that the phenomenon is of neural origin. Additionally, 'frequency following response' is restrictive and may be misleading because the phenomenon 'follows' amplitude as well as frequency[5]. We have chosen the term 'auditory neurophonic' because it indicates that the phenomenon is similar to the CM in closely reproducing the actual physical stimulus but is of neural origin and is not restricted to one locus in the auditory system. Finally, the terminology 'auditory neurophonic' (AN) parallels the phrase 'cochlear microphonic' (CM), as does the phenomenon itself[9].

Résumé. Nous avons remarqué dans le système auditif central des ondes qui ressemblent aux ondes microphoniques cochléaires (MC) en imitant étroitement le stimulus. Notre étude montre qu'elles sont d'origine neurale parce que: 1°) l'amplitude est souvent plus grande en réponse à la stimulation contralatérale au niveau du corps trapézoïde; 2°) il y a une latence en rapport avec le système auditif examiné; 3°) une anesthésie progressive cause la dépression de l'onde et finalement sa disparition avec la mort. Nous proposons le terme de phénomène «neurophonique auditif» (NA).

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The Effect of Catecholamines and Nicotine on the Transmembranal Potential of Frog Liver Cells

The pharmacological effects of neuroamines and other drugs on excitable tissues (neurons, muscles, glands) are associated with changes in their membrane potential. We have observed that the resting potential of the liver cell is sensitive to the action of exogenously administered drugs such as epinephrine for which the liver is one of the target organs.

Materials and methods. The liver of unfed, 25–35 g frogs (*R. pipiens*), anesthetized with urethane (4 g/kg) was exposed and kept moist with Ringer's solution. Intracellular recordings were made using KCl micropipettes. 10–100 cells were sampled before and at various intervals after drug administration. 4–8 frogs were used at each dose level. The monoamine oxidase inhibitor (MAOI), pargyline and urethane were administered via the ventral lymphatic sac; other drugs were injected i.m. Results were analyzed using the 't'-test.

Results. Typical potentials for impalements of 5 min or longer varied between 30 and 60 mV. L-*Epinephrine* increased the resting potential at 0.1–0.5 mg and reduced it at even larger doses (Figure 1). The dose response curve was shifted to the left in fall (October and November) in

comparison to winter (February and March). Hyperpolarization was demonstrated in unanesthetized pithed frogs. Although *pargyline* (100 mg/kg) 24 or 48 h pretreatment failed to affect resting potential, it prevented the hyperpolarizing effect of epinephrine (e.g. 0.1 mg epinephrine increased membrane potential 21% in untreated frogs, and 1% in pargyline frogs; fall) without blocking high dose depolarization. Indeed, the hyperpolarizing effect of 0.5 and 1 mg epinephrine was reversed to depolarization by pargyline. Since low dose epinephrine (0.05 mg) was ineffective with and without pargyline, these results cannot be accounted for by a pargyline-induced shift to the left of the epinephrine dose response curve. The catecholamine releaser nicotine (0.5–0.9 mg) and DL-*norepinephrine* (0.1–2 mg) (Figure 2) induced small depolarization; DL-norepinephrine 0.05 mg did not alter resting potential. *Isoproterenol* (1 and 2 mg) slightly augmented resting potential. *Phenylacetaldehyde* (an analog of the MAO-catalyzed product of catecholamines) (0.5–4 mg/kg), i.m. or in the dorsal lymphatic sac, and *tryptaldehyde* (3-indoleacetaldehyde bisulfite 80–90% pure; balance mostly Na bisulfate) (5 mg) failed to affect transmembranal potential.

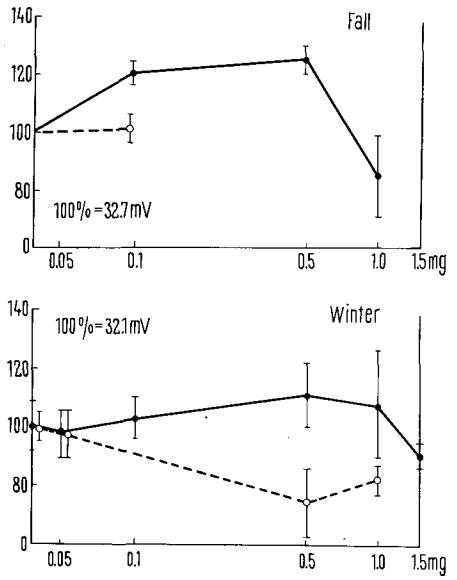

Fig. 1. Percentage change in liver cell membrane potential 10–30 min after the i.m. administration of L-epinephrine. Top: fall frogs. Bottom: winter frogs. Solid line: untreated animals. Broken line: frogs pretreated with pargyline 100 mg/kg.

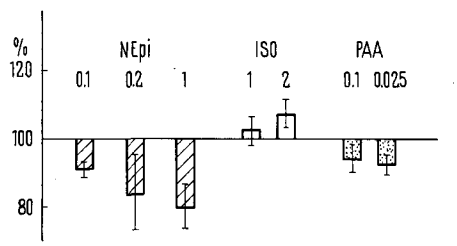

Fig. 2. Percentage change in liver cell membrane potential 10–30 min after the i.m. administration of DL-norepinephrine (NEpi) 0.1, 0.2 and 1 mg, isoproterenol (ISO) 1 and 2 mg, and phenylacetaldehyde (PAA) 0.1 and 0.025 ml.

Discussion. The depolarizing effect of norepinephrine and epinephrine (high dose) may be attributed to their vasoconstrictor effect because ischemia depolarizes liver cells[1]. The hyperpolarizing effect of lower doses of epinephrine on liver cells extends the list of tissues whose resting potential is enhanced by this amine: smooth muscle[2], central neurons[3], salivary glands[4], etc. In contrast to norepinephrine and isoproterenol, epinephrine has stronger metabolic effects, as well as hyperpolarization action on the liver; the two phenomena may be related. Since fairly large doses of the amines were necessary to affect liver resting potential significantly, the physiological significance of the effects described here is unclear. Epinephrine releases potassium from the liver[5] in exchange for sodium[6]; Ca is also released[7]. K-release can be dissociated for the hyperglycemic response[8,9]. Fasting prevents the hyperglycemic action[8], but it did not prevent the membrane effect in our frogs.

The ability of pargyline to block the action of epinephrine may be due to inhibition of liver enzymes other than monoamine oxidase, or epinephrine hyperpolarization may be mediated by a deaminated derivative of the amine. However, norepinephine failed to produce hyperpolarization although some but not all of its deaminated metabolites would be the same as for epinephrine. Moreover, phenylacetaldehyde and tryptaldehyde were inactive. Part of the metabolic effects of monoamines may be mediated by their aldehyde derivatives[10]. Some CNS effects of serotonin and tryptamine may be partly mediated by tryptaldehydes or other deaminated products[11–13,14].

Resumen. La adrenalina (0.1 a 0.5 mg/rana) hiperpolarizó los hepatocitos de *R. pipiens* y depolarizó a dosis mas altas. El inhibidor de la monoamino oxidasa pargilina (100 mg/kg, 24–48 h antes) impidió este efecto.

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