

The concentration of adrenaline and noradrenaline in the brain and the heart of the goldfish, *Carassius auratus*

SIR,—It was previously found by Östlund, Bloom & others (1960) and Euler & Fänge (1961) that catecholamines were present in the heart of some cyclostomata. The heart of *Mixine glutinosa* contains a high concentration of adrenaline and noradrenaline and is stimulated after the administration of noradrenaline (Bloom, Östlund & others, 1961). The heart of *M. glutinosa* has no innervation (Augustinsson, Fänge & others, 1956); however, fibre-like connections were observed between the chromaffin cells (Bloom & others, 1961). Adrenaline and noradrenaline were also found in the heart of some elasmobranchs and teleosts (Östlund, 1954; Euler & Fänge, 1961; Brodie & Bogdanski, 1964). Both amines produced dilatation of the gill vessels in teleosts (Fänge, 1962).

Neither catecholamine-containing cells nor adrenergic fibres were detected in the hearts of some teleosts (cod, trout, pike and plaice) by Falk, Mecklenburg & others (1966) but Bogdanski, Bonomi & Brodie (1963) found catecholamines to be present in the heart of *Carassius auratus*—the goldfish. We now report the concentration of noradrenaline and adrenaline in the heart and encephalon of *Carassius auratus* (var. *Brasilienensis*).

The experiments were done on adult fish of either sex, of body weight about 4.5 g. The encephalon and the heart were dissected, put on a filter paper, weighed, and kept at -30° . The estimations of catecholamines were made on the same day. The hearts and encephalons of two animals were separately pooled for each estimation. Recoveries of adrenaline and noradrenaline in pure solutions ranged from 75 to 92%. This investigation was made during September, 1966. Adrenaline and noradrenaline were extracted as proposed by Euler & Lishajko (1961), and estimated spectrophotofluorimetrically (Aminco Bowman) (Bertler, Carlsson & Rosengren, 1958).

TABLE 1. CONCENTRATION OF NORADRENALINE AND ADRENALINE IN THE ENCEPHALON AND THE HEART OF THE GOLDFISH *Carassius auratus* (Var. *Brasilienensis*)

				Adrenaline	Noradrenaline
<i>Encephalon</i>					
Females	..	..	..	0.45 ± 0.04	0.12 ± 0.02
Males	..	..	..	0.41 ± 0.03	0.11 ± 0.02
<i>Heart</i>					
Females	..	..	..	0.23 ± 0.02	0.28 ± 0.02
Males	..	..	..	0.20 ± 0.02	0.27 ± 0.02

Each value is a mean (\pm standard error) from 6 estimations. The results are not corrected for recovery. The approximate weight of encephalon was of 60 mg and that of the heart of 110 mg.

The experiments showed that in the encephalon of both sexes the concentration of adrenaline was higher than that of noradrenaline, with a ratio of 3.4 to 1 (Table 1), while in the heart, the concentrations are about the same.

A higher concentration of adrenaline was found in the brain and the heart of the toad (Östlund, 1954; Falck, Häggendal & Owman, 1963; Jofre, 1967). It is supposed that adrenaline is a neurotransmitter in this species (Læwi, 1937; Falck & others, 1963; Azuma, Binia & Vischer, 1965). Perhaps this might also be true of the brain of the fish, but not of the heart where there is a substantial amount of noradrenaline present.

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Disulfiram and some effects of amphetamine in mice and rats

SIR,—The recent findings, that amphetamine releases noradrenaline in a physiologically active form (Glowinski & Axelrod, 1965, 1966) and that its central effects are blocked by α -methyl-*p*-tyrosine, an inhibitor of tyrosine hydroxylase (Weissman & Koe, 1965; Hanson, 1966; Weissman, Koe & Tenen, 1966; Randrup & Munkvad, 1966), seem to support the view that amphetamine acts indirectly and that the action is exerted through the catecholamine mediator.

Disulfiram has been found to inhibit the β -hydroxylation of dopamine to noradrenaline (Musacchio, Goldstein & others, 1966). It seemed interesting to examine the influence of this substance on some amphetamine effects.

Mice of two strains, R_3 and C_{57} BL, and also Wistar rats were used. Disulfiram was administered intraperitoneally 2 hr before an experiment. Spontaneous motor activity in single mice or rats was registered during one to two hr with a photoelectric meter. (\pm)-Amphetamine sulphate (5 mg/kg s.c.)

TABLE 1. THE EFFECT OF DISULFIRAM ON THE AMPHETAMINE-INDUCED MOTOR HYPERACTIVITY IN MICE

Strain	Disulfiram i.p. mg/kg	Activity counts	Inhibition %	P
R_3	—	911 (\pm 107.8)	—	—
"	100	403 (\pm 97.1)	55.8	<0.01
"	200	281 (\pm 65.4)	69.2	<0.001
"	400	60 (\pm 11.2)	93.4	<0.001
C_{57} BL	—	1013 (\pm 53.2)	—	—
"	50	466 (\pm 60.4)	54.0	<0.001
"	100	376 (\pm 52.3)	62.9	<0.001

Disulfiram was injected 2 hr, (\pm)-amphetamine sulphate (5 mg/kg s.c.) $\frac{1}{2}$ hr before the experiment. The activity was recorded in single mice during $\frac{1}{2}$ hr sessions. Figures represent the means of 10 mice.