sponding to changes in pCO_2 or changes in pH. It is obvious that elevating pCO_2 and circulatory changes are highly correlated and that the vagi are the efferent pathway for the response. There are several possible sources of vagal input. Mammals utilize chemoreceptors to sense acid-base changes; the existence of peripheral chemoreceptors in the dogfish is a possibility. Chemoreceptors could be anywhere in the circulatory system, but the most probable locations would be in the venous circulation or in the gill vasculature. The vagal input could be olfactory. If olfactory receptors were sensitive to pH changes they would be stimulated by the acidic seawater circulating through the nares of the fish. It is also possible that high pCO_2 and low pH are noxious stimuli to the nervous system and elicit a generalized vagal response.

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1968 #21

GLUTAMINE SYNTHETASE IN LOWER VERTEBRATES

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As part of a general study of the comparative biochemistry of nitrogen metabolism the distribution of glutamine synthetase was examined in tissues from a variety of lower vertebrates. The survey was prompted by two contradictory reports in the literature: the finding of an increase in glutamine concentration in blood leaving the liver of the carp (Pequin, Arch. Sci. Physiol. 21:193, 1967) and the reported absence of glutamine synthetase, the only enzyme known to be involved in the de novo synthesis of glutamine, from all tissues except brain of lower vertebrates (Wu, Comp. Biochem. Physiol. 8:335, 1963). In the glutamine synthetase assay hydroxylamine replaces ammonia and the formation of γ-glutamylhydroxamate is measured colorimetrically. Activity was found in all tissues examined (see Table 1). Hepatopancreas and tail mus-

Table 1

GLUTAMINE SYNTHETASE ACTIVITY IN LOWER VERTEBRATES
(μmoles GHA formed/hr x g fresh weight at 37°)

Species	Brain	Liver	Kidney	Skeletal muscle
Myxocephalus scorpius	423 ± 10	40*	121 ± 23	not assayed
Anguilla rostrata	561 ± 118	69† ± 7	106† ± 14	not assayed
Squalus acanthias	423 ± 25	97 ± 12	168 ± 3	not assayed
Xenopus laevis	127 ± 9	65*	98 ± 6	157 ± 46
Rana catesbiana	274 ± 41	97 ± 12	127 ± 11	63 ± 6
Chrysemys picta	525 ± 50	82*	115 ± 6	not assayed
Rat	81 ± 15	249 ± 15	45 ± 6	< 20

*Values uncertain for technical reasons.

†Represent minimal values because of non-linearity of assay.

Values are means ± S.E.M. of four to six animals except for liver values of M. scorpius (1), X. laevis (3) and C. picta (2).

cle of an invertebrate (Homarus americanus) also showed activity (228 and 108 μmoles/hr x g at 37°C respectively). The liver of a hagfish (Myxine glutinosa) did not (one specimen only). Data for the rat are included in the table for comparison. The lower vertebrates show an enzyme pattern that is different from the rat: activity is highest in brain and lowest in liver. The significance of the relatively high activity in kidney of the lower vertebrates is not clear. Our success in demonstrating the enzyme was largely due to the inclusion of an ATP regenerating system in the assay and incubation for short times (< 5 min). These two factors helped overcome the known inhibitory effect of ADP which is rapidly produced by ATPases present in the crude homogenates.

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1968 #22

METABOLISM OF ETHYL m-AMINOBENZOATE (MS 222) IN THE DOGFISH, Squalus acanthias

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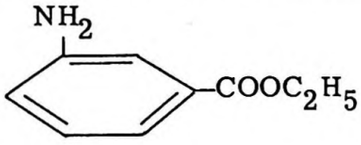
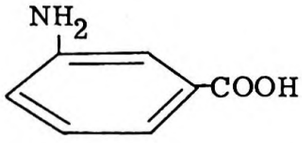
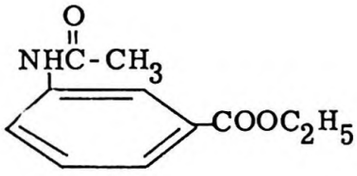
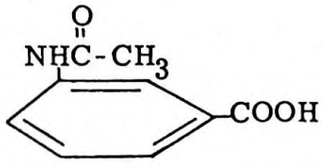
In 1967 (This Bulletin, 7:51) we established that MS 222 (I) was cleared by the gill at the rate of 10 ml/min per kg. The major portion of injected drug disappeared within 2 hours. However, a small amount of diazotizable amine was excreted in urine for longer periods, and amine was found in relatively high concentrations in the kidney. The structure of the drug suggested obvious metabolites, due to acetylation of the amine and cleavage of the ester. Table 1 shows the structures. All drugs were injected into the tail vessels.

Table 1

STRUCTURE OF MS 222 AND METABOLITES

Compound	Structure	Name
I		Ethyl-m-aminobenzoate (MS 222). MS 222 is the methane sulfonate.
II		m-aminobenzoic acid
III		Ethyl-m-acetylaminobenzoate
IV		Ethyl-m-acetylaminobenzoic acid