

Enzymes of Carbohydrate and Amino Acid Metabolism in Liver, Brain and Kidney of *Macaca mulatta*

Although primates have been utilized as experimental animals increasingly in the past decade, relatively little is known of the quantitative aspects of their biochemistry, particularly tissue biochemistry and enzymology. The present study was inaugurated at the Wisconsin Regional Primate Research Center as a part of a larger study on the enzymology of the developing *Macaca mulatta*. The present study describes the levels of nine different enzymes in 3 tissues of 1-year-old animals of this species.

data was tyrosine transaminase⁹ but the activity was recorded on the basis of protein rather than per gram wet weight.

SCHMIDT and SCHMIDT⁷ have reviewed the literature covering enzyme activities in human liver. Enzyme levels were recorded on a weight basis for 4 of the 9 enzymes we assayed in monkey liver. The level of tyrosine transaminase was about the same in both species, and the level of rhesus hexokinase was in the range reported for the human.

Enzyme activities in liver, brain and kidney from 1-year-old *Macaca mulatta*

Enzyme	μ moles substrate metabolized/h/g tissue*		
	Liver	Brain	Kidney
Malic enzyme (E.C. 1.1.1.38)	34.3 \pm 12.3 (4)	31.1 \pm 5.9 (6)	25.5 \pm 5.8 (5)
Phosphogluconic dehydrogenase (E.C. 1.1.1.43)	442.0 \pm 26.8 (5)	167.0 \pm 4.0 (4)	471.0 \pm 18.3 (5)
Glucose-6-phosphate dehydrogenase (E.C. 1.1.1.49)	233.0 \pm 33.2 (5)	49.8 \pm 11.3 (4)	251.0 \pm 64.5 (4)
Tyrosine transaminase (E.C. 2.6.1.5)	22.7 \pm 3.1 (6)	1.9 \pm 0.2 (4)	4.8 \pm 1.1 (5)
Ornithine transaminase (E.C. 2.6.1.13)	43.7 \pm 6.7 (4)	7.7 \pm 2.4 (4)	22.0 \pm 2.0 (4)
Hexokinase (E.C. 2.7.1.1.)	38.2 \pm 6.9 (5)	33.5 \pm 2.5 (5)	43.6 \pm 5.8 (6)
Glucokinase (E.C. 2.7.1.2.)	119.0 \pm 14.5 (4)	16.7 \pm 3.0 (6)	30.4 \pm 7.5 (6)
Serine dehydratase (E.C. 4.2.1.13)	82.9 \pm 5.3 (4)	10.7 \pm 3.0 (6)	22.4 \pm 2.9 (6)
Histidase (E.C. 4.3.1.3)	10.1 \pm 2.6 (5)	0.4 ^b \pm 0.2 (5)	0.6 ^b \pm 0.3 (4)

*+ S.E.M. (No. of animals), ^b values not significantly different from zero activity by the method of assay².

Methods and materials. The animals utilized in these studies were one-year-old *Macaca mulatta* monkeys raised at the Wisconsin Regional Primate Research Center and fed a standard diet¹. Animals were sacrificed by exsanguination. Brain, liver and kidney tissues were removed immediately after death and placed on ice. 20% homogenates were prepared utilizing a Polytron homogenizer. Homogenates were prepared in 0.05M Tris buffer, pH 8.2, 0.14M KCl with 10⁻⁴M dithiothreitol. High speed supernatant solutions were prepared by centrifugation. All enzyme assays with the exception of ornithine transaminase were carried out on this high speed supernatant fraction. Assays for ornithine transaminase were carried out on whole homogenates.

Assays of serine dehydratase, tyrosine transaminase, malic enzyme, phosphogluconic dehydrogenase, glucose-6-phosphate dehydrogenase, histidase, glucokinase and hexokinase were all carried out by automated procedures previously described^{2,3}. The assay of ornithine transaminase was carried out by the procedure described by PERAINO and PITOT⁴.

Results and discussion. As seen from the data of the Table the activities of all enzymes tested were at a reasonable level of significance with the exception of histidase in the brain and kidney. These activities are somewhat similar to those described in rodents in the same tissues with the possible exception of serine dehydratase activity in kidney which does not occur in the rat⁵. The high level of glucokinase in the liver is similar to other animals, including humans^{6,7}. The activity listed as glucokinase for brain and kidney is probably hexokinase, type II, which has a somewhat lower affinity for the substrate than types I and, therefore, by the assay procedure would show as glucokinase⁸. The data of ornithine transaminase is quite similar to that seen in the rat except that in the rodent the specific activity in the kidney is considerably higher than that in the liver⁴.

Data on enzyme levels of monkeys is scarce. The only one of the 9 enzymes assayed by us for which we found

Glucose-6-phosphate dehydrogenase and glucokinase activities were considerably higher in rhesus than in human liver which may reflect dietary differences in the 2 species¹⁰.

Résumé. Les activités de 9 enzymes ont été définies dans le foie, le cerveau et le rein du rhesus. L'activité de la sérine déhydrase, qui ne se manifeste pas dans le rein du rat, a été observée dans le rein du singe. Les activités de la tyrosine transaminase et de l'exokinase dans le foie du rhesus se montrèrent semblables à celles du foie humain, mais les activités du glucose-6-phosphate déhydrogénase et de la glucokinase furent plus élevées que dans le foie humain.

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