

### Brain gangliosides: variation in sialic acid concentration among eight mammalian species

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Sialic acids play an important role in brain development and in the transmission and storage of information in the central nervous system (1). In this study, we determined the concentration of bound and free sialic acid in ganglioside extracts of brain cortex in eight different mammals at several stages of development. These comparisons are unique and have implications for evolutionary development and learning ability. Sialic acid was determined by the thiobarbituric acid assay described by Lorant (2) and modified by Aminoff (3).

The concentration of bound sialic acid in gangliosides and free sialic acid in the brain cortex of human, chimpanzee (*Pan troglodytes*), rat (*Rattus norvegicus*), mouse (*Mus musculus*), rabbit (*Oryctolagus cuniculus*), sheep (*Ovis aries*), cow (*Bos indicus*), and pig (*Sus scrofa*) is shown in the table. Humans showed the highest content and there was no significant difference between human males ( $916 \pm 136 \mu\text{g/g}$ ) and females ( $865 \pm 77 \mu\text{g/g}$ ). Apart from the cow vs the sheep, the differences between species were statistically significant ( $P < 0.05$ ).

Species	Total SA ( $\mu\text{g/g}$ wet weight tissue)			Free SA ( $\mu\text{g/g}$ wet weight tissue)		
	Mean	SD	n	Mean	SD	n
Human	890 <sup>a</sup>	103	6	41 <sup>a</sup>	3	4
Rat	493 <sup>b</sup>	23	12	32 <sup>b</sup>	3	6
Mice	445 <sup>c</sup>	29	16	25 <sup>b</sup>	5	10
Rabbit	380 <sup>d</sup>	18	6	0		6
Ovine	323 <sup>e</sup>	43	6	0		6
bovine	304 <sup>e</sup>	14	6	0		6
pig	252 <sup>f</sup>	14	6	0		6

\*Data in the same column with different letters are statistically different ( $P < 0.05-0.001$ )

In the mouse, cow and sheep, total sialic acid concentration increased during maturation by 18-32% ( $P < 0.05$ ). In 2-year-old chimpanzee, the sialic acid concentration in the left lobe of the brain cortex was 25% higher than that of right lobe at 6 weeks of age ( $P < 0.05$ ). Free sialic acid was higher in the human brain cortex ( $41 \pm 3 \mu\text{g/g}$ ) than that of the rat and mouse ( $32 \pm 3$  and  $25 \pm 5 \mu\text{g/g}$  respectively), and absent from other species.

In the cortex of adult brain, the SA level decreased in the rank order of human, rat, mouse, rabbit, sheep, cow and pig. The human brain had 2-4 times more sialic acid than that of the other mammals, including the young chimpanzee. To our knowledge these comparisons have not been reported before. There are significant regional differences in the sialic acid concentration because the different brain regions perform different neurological functions. We found that brain sialic acid concentration increased with age but there were no sex differences in human brain tissue. We postulate that brain sialic acid concentration is an indicator of intelligence-learning ability and that environment and diet may influence sialic acid accumulation.

1. Susumu A. Gangliosides in the nervous system. *Neurochem Internat* 1983;5:507-37.
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3. Aminoff D. Methods for the quantitative estimation of N-acetylneuraminic acid and their application to hydrolysates of sialomucoids. *Biochem J* 1962;81:384-91.