In this regard gangliosides seem to be best qualified, because they are concentrated in synaptic terminals (Wiegandt, 1968; Dekirmenjan & Brunngraber, 1969; Morgan et al., 1973; Eichberg et al., 1974). These glycosphingolipids contain different numbers of sialic (neuraminic) acid (NeuAc), as a result they can carry a more or less strong negative charge and form chelate complexes with divalent cations, especially with $\text{Ca}^{2+}$. Therefore gangliosides are assumed to play a specific functional role in essential neuronal events (Rahmann, 1978, 1980; Rahmann et al., 1977; Risner, 1977). The general conclusion from these investigations is: the lower the ambient temperature—the higher the degree of sialylation of neuronal gangliosides.

In an earlier study the brain ganglioside composition of a hibernator (golden hamster) during the torpor phase had also been investigated (Hilbig & Rahmann, 1978, 1979; Rahmann & Hilbig, 1979). The gangliosides showed slight polysialylation effects during torpor. But since golden hamsters do not belong to true hibernators (Eisentraut, 1956) were taken for the examination. The present study investigates the brain ganglioside composition of hibernating dormice (Glis glis) in comparison to their normothermic counterparts.
concentration and especially the composition of the whole brain and seven different brain parts in normothermic and hibernating dormice (Glis glis).

MATERIALS AND METHODS

Source, maintenance and acclimation of animals

Twenty-four adult wild normothermic and hibernating dormice (Glis glis) and for comparison 10 adult laboratory rats of inbred colonies (Wistar, Han.) were investigated. Hibernation was induced by transferring the dormice from room temperature (ambient temperature $T_s = 22 \pm 2°C$; dark–light cycle; 14:10) to a dark cooling chamber at $T_s = 6 \pm 2°C$. Two animals were kept in one cage each and provided with nest materials, food (Altromin pellets, apples, acorns) and water ad libitum.

Dormice are true hibernators having a very critical sleeping temperature (18°C; Eisentraut, 1956), a low body temperature in torpor (lowest temperature about 4–0°C; König, 1960) and extremely long sleeping phases (about 7 months). After 4 weeks in the cold all animals fell into hibernation. In intervals of about 4 weeks they woke up again to eat apples because their air in the cooling chamber was relatively dry. But then they fell into torpor quickly again.

Brain preparation and analytical procedure

The dormice were killed by decapitation in successive 3-week periods after falling into torpor in order to find out chemical change and torpor length. The brain preparations of dormice and rats were carried out on ice. The different brain parts (cortex, cerebellum, pons, medulla oblongata, bulbus olfactorius, brain stem and regio quadrigemina from midbrain) were removed immediately and deep frozen to below about 40°C; K/Snig, 1960) and extremely long sleep phases (about 7 months). After 4 weeks in the cold all animals fell into hibernation. In intervals of about 4 weeks they woke up again to eat apples because their air in the cooling chamber was relatively dry. But then they fell into torpor quickly again.

| Table 1. Content of proteins, sialoglycoproteins and gangliosides from whole brains of laboratory rats, normothermic and hibernating fat dormice (± SEM) |
|---------------------------------|-----------------|-----------------|-----------------|
| Protein (mg/g fresh wt) | 100.0 ± 3.5 | 110.8 ± 4.6 | 105.9 ± 3 |
| Sialo glycoprotein (µg NeuAc/g fresh wt) | 254.6 ± 8.1 | 212 ± 21.0 | 210.0 ± 10.0 |
| Ganglioside (µg NeuAc/g fresh wt) | 88.5 ± 42.0 | 749.0 ± 71.0 | 647.2 ± 34.0 |

RESULTS

For a first characterization of hibernation-induced changes in brain gangliosides of dormice, the concentrations of proteins, sialoglycoproteins and gangliosides of the whole brain from normothermic dormice were determined and compared with corresponding values of laboratory rats. The results presented in Table 1 indicate that the content of proteins in rats, normothermic and hibernating dormice is in the same range. But the content of sialylated glycoproteins is about 12% less in normothermic and hibernating dormice. The average concentration of gangliosides in dormice (about 750 µg NeuAc/g fresh wt) is about 15% lower than that in rats (about 890 µg NeuAc/g fresh wt) and during hibernation it decreases to 650 µg/g fresh wt.

When analysing the content of proteins, sialoglycoproteins and gangliosides in different brain parts (cortex, cerebellum, brain stem, medulla, pons, olfactory bulb and regio quadrigemina) of normothermic and hibernating dormice (Table 2) the following results were obtained: there are no differences between active and hibernating dormice concerning the protein concentration in any of the brain parts. Only one statistically significant decrease in the amount of sialoglycoproteins (medulla) during hibernation appeared. On the other hand the ganglioside content was shown to be significantly reduced in the pons, olfactory bulb and midbrain of the hibernators.

On the basis of these results it was of special interest to analyze the ganglioside pattern of defined brain regions in normothermic and hibernating dormice in comparison to that of the homeothermic rats (Fig. 1). First the ganglioside pattern of cortex and cerebellum from normothermic dormice is more polar than that of rats. In the cortex of rats the relative portion of the G01 fraction is about 32% of the total pattern, while
Effects of hibernation on ganglioside composition of dormice

Table 2. Content of (a) proteins (mg/g fresh wt); (b) sialoglycoproteins (µg NeuAc/g fresh wt); and (c) gangliosides (µg NeuAc/g fresh wt) in different brain structures of normothermic and hibernating dormice

<table>
<thead>
<tr>
<th>Structure</th>
<th>(a) proteins</th>
<th>(b) glycoproteins</th>
<th>(c) gangliosides</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normothermic</td>
<td>Hibernating</td>
<td>Diff. -%</td>
</tr>
<tr>
<td></td>
<td>$T_a = 22^\circ$C</td>
<td>$T_a = 6^\circ$C</td>
<td></td>
</tr>
<tr>
<td>Cortex (a)</td>
<td>107.3 ± 3.1</td>
<td>109.6 ± 3.9</td>
<td>1</td>
</tr>
<tr>
<td>Cortex (b)</td>
<td>262 ± 23.2</td>
<td>264 ± 13.4</td>
<td>1</td>
</tr>
<tr>
<td>Cortex (c)</td>
<td>845 ± 66</td>
<td>872 ± 45.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Cerebellum (a)</td>
<td>107.5 ± 2.2</td>
<td>108.3 ± 2.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Cerebellum (b)</td>
<td>248 ± 11</td>
<td>228 ± 9.5</td>
<td>7.9</td>
</tr>
<tr>
<td>Cerebellum (c)</td>
<td>776 ± 27</td>
<td>733.7 ± 26.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Brain stem (a)</td>
<td>112.4 ± 3.7</td>
<td>107.8 ± 3.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Brain stem (b)</td>
<td>231 ± 12.4</td>
<td>218.5 ± 14.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Brain stem (c)</td>
<td>946.5 ± 49.6</td>
<td>852.5 ± 42.7</td>
<td>10</td>
</tr>
<tr>
<td>Medulla oblongata (a)</td>
<td>126 ± 7.8</td>
<td>124.3 ± 3.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Medulla oblongata (b)</td>
<td>199 ± 11.4</td>
<td>181.3 ± 8.1</td>
<td>8.9</td>
</tr>
<tr>
<td>Medulla oblongata (c)</td>
<td>629 ± 22.4</td>
<td>626.7 ± 46.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Pons (a)</td>
<td>121.3 ± 5.8</td>
<td>122.2 ± 3.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Pons (b)</td>
<td>196.8 ± 6.6</td>
<td>163.3 ± 7.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Pons (c)</td>
<td>702 ± 34</td>
<td>528 ± 14.8</td>
<td>24.8</td>
</tr>
<tr>
<td>Bulbus olfactorius (a)</td>
<td>107.6 ± 7.2</td>
<td>106.5 ± 3.2</td>
<td>1</td>
</tr>
<tr>
<td>Bulbus olfactorius (b)</td>
<td>250 ± 16.7</td>
<td>243.8 ± 20.8</td>
<td>8.5</td>
</tr>
<tr>
<td>Bulbus olfactorius (c)</td>
<td>822 ± 37.6</td>
<td>618 ± 33</td>
<td>24.8</td>
</tr>
<tr>
<td>Regio quadrigemina (a)</td>
<td>116.5 ± 5.2</td>
<td>117.9 ± 3.7</td>
<td>1</td>
</tr>
<tr>
<td>Regio quadrigemina (b)</td>
<td>234.5 ± 12</td>
<td>230 ± 10.6</td>
<td>2</td>
</tr>
<tr>
<td>Regio quadrigemina (c)</td>
<td>837 ± 47.3</td>
<td>676.9 ± 39.5</td>
<td>19.2</td>
</tr>
</tbody>
</table>

in dormice it is only about 27%. On the other hand the $G_{Tb}$ in rat cortex forms 24.5%, in that of dormice it is 28.4%. In dormice, however, an additional highly polar penta-sialo ganglioside fraction ($G_{pt}$) occurs. In the cerebellum with its more polar gangliosides a similar tendency can be seen: again there is a lower concentration in mono- and disialogangliosides in dormice, whereas in the polar tetrasialoganglioside ($G_{otb}$) a difference from 8% (rat) to 14% (dormouse) is found as well as the additional polar $G_{pt}$-fraction. From these data it can be concluded that the basic composition of the different brain regions is to a certain extent similar in both species. Nevertheless the dormice have more polar ganglioside fractions in comparison with the rat.

Now it was of great interest to investigate whether there might be any variations in the ganglioside pattern of different brain regions from hibernating compared with normothermic dormice (Table 3 & Fig. 1). Generally, in all brain regions investigated, there is an increase of the higher sialylated tri- and tetrasialo-ganglioside fractions ($G_{Tb}$ and $G_{otb}$) in hibernating dormice compared with that of the normothermic counterparts. These differences, which are partly due to concomitant decrease especially in the $G_{Dn}$- and $G_{Dn-}$fractions were shown to be highly significant in the older brain structures of the pons, regio quadrigemina (midbrain), oblongated medulla and brain stem, but not in the olfactory bulb. In the phylogenetically more modern structures (cortex, cerebellum)

![Fig. 1. Chromatograms of ganglioside mixtures of cortex and cerebellum from rat (B) and dormouse (A) in comparison with standards; development of the plate with chloroform-methanol-10$^{-3}$ mol MgCl$_2$ solution-NH$_3$ = 60:36:8:0, by vol. Bands were visualized with resorcinol reagent.](image-url)
these differences were less distinct. Furthermore the
brain ganglioside patterns of dormice did not depend
on the length of torpor, thus indicating that in dor-
mice the onset of a polysialylation of the midbrain
gangliosides takes place early in the hibernation
phase.

**DISCUSSION**

The present data reveal that the brain ganglioside
pattern of the normothermic, active fat dormouse in
comparison to that of the laboratory rat is more
polar, due to a relatively larger amount (2–15\%)

Table 3. Relative proportion of ganglioside-bound NeuAc to different ganglioside fractions in whole brain and various brain parts of normothermic and hibernating fat dormice

<table>
<thead>
<tr>
<th>Structure</th>
<th>Ganglioside fraction</th>
<th>Normothermic ($T_s = 22^\circ\text{C}$)</th>
<th>Hibernating ($T_s = T_b = 6^\circ\text{C}$)</th>
<th>Significance (t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole brain</td>
<td>$G_{M3}$</td>
<td>$0.85 \pm 0.14$</td>
<td>$1.26 \pm 0.07$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{M2}$</td>
<td>$1.12 \pm 0.18$</td>
<td>$1.06 \pm 0.06$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{M1}$</td>
<td>$12.1 \pm 0.4$</td>
<td>$11.98 \pm 0.45$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{03}$</td>
<td>$3.5 \pm 0.18$</td>
<td>$3.8 \pm 0.13$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{t}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$G_{O15}$</td>
<td>$21.7 \pm 0.8$</td>
<td>$19.83 \pm 0.37$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{O16}$</td>
<td>$23.6 \pm 0.4$</td>
<td>$22.8 \pm 0.48$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{T15}$</td>
<td>$29.4 \pm 0.33$</td>
<td>$29.9 \pm 0.46$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{T16}$</td>
<td>$7.46 \pm 0.6$</td>
<td>$9.2 \pm 0.7$</td>
<td>NS</td>
</tr>
<tr>
<td>Bulbus olfactorius</td>
<td>$G_{M3}$</td>
<td>$1.77 \pm 0.24$</td>
<td>$1.8 \pm 0.19$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{M2}$</td>
<td>$1.27 \pm 0.37$</td>
<td>$1.17 \pm 0.15$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{M1}$</td>
<td>$8.14 \pm 0.25$</td>
<td>$8.75 \pm 0.2$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{O3}$</td>
<td>$3.54 \pm 0.34$</td>
<td>$3.8 \pm 0.15$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{t}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$G_{O15}$</td>
<td>$22.44 \pm 0.46$</td>
<td>$20.42 \pm 0.5$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{O16}$</td>
<td>$23.02 \pm 0.38$</td>
<td>$22.06 \pm 0.48$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{T15}$</td>
<td>$34.73 \pm 0.69$</td>
<td>$35.27 \pm 0.85$</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td>$G_{T16}$</td>
<td>$5.47 \pm 0.4$</td>
<td>$6.56 \pm 0.27$</td>
<td>NS</td>
</tr>
</tbody>
</table>
### Table 3—continued.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Ganglioside fraction</th>
<th>Normothermic ((T_0 = 22°C))</th>
<th>Hibernating ((T_0 = T_s = 6°C))</th>
<th>Significance (t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM₃</td>
<td>1.43 ± 0.1</td>
<td>1.4 ± 0.16</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GM₂</td>
<td>0.55 ± 0.07</td>
<td>0.69 ± 0.07</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GM₁</td>
<td>11.44 ± 0.47</td>
<td>11.52 ± 0.32</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₃</td>
<td>2.38 ± 0.09</td>
<td>2.49 ± 0.09</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GD₁₁₆</td>
<td>26.82 ± 0.46</td>
<td>25.49 ± 0.4</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₁₁₇</td>
<td>27.05 ± 1.13</td>
<td>24.39 ± 0.83</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GT₁₁₆</td>
<td>28.24 ± 0.6</td>
<td>29.4 ± 0.43</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₀₁₁₆</td>
<td>4.07 ± 0.22</td>
<td>5.73 ± 0.57</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₁</td>
<td>0.5 ± 0.1</td>
<td>0.84 ± 0.17</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Cerebellum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM₃</td>
<td>0.73 ± 0.02</td>
<td>0.77 ± 0.03</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GM₂</td>
<td>1.34 ± 0.22</td>
<td>1.16 ± 0.09</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GM₁</td>
<td>6.98 ± 0.35</td>
<td>7.28 ± 0.39</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₃</td>
<td>4.57 ± 0.29</td>
<td>4.8 ± 0.17</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₂</td>
<td>2.87 ± 0.26</td>
<td>2.47 ± 0.1</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>GD₁₁₆</td>
<td>11.69 ± 0.26</td>
<td>11.6 ± 0.32</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₁₁₇</td>
<td>24.4 ± 0.95</td>
<td>22.09 ± 0.77</td>
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</tr>
<tr>
<td>GT₁₁₆</td>
<td>34.97 ± 1</td>
<td>33.3 ± 0.78</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₀₁₁₆</td>
<td>14.1 ± 0.4</td>
<td>16.4 ± 0.63</td>
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<td></td>
</tr>
<tr>
<td>G₁</td>
<td>1.17 ± 0.16</td>
<td>0.97 ± 0.08</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Regio quadrigemina</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM₃</td>
<td>1.76 ± 0.24</td>
<td>1.03 ± 0.09</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GM₂</td>
<td>1.05 ± 0.2</td>
<td>0.66 ± 0.06</td>
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<td></td>
</tr>
<tr>
<td>GM₁</td>
<td>9.65 ± 0.43</td>
<td>11.2 ± 0.33</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₃</td>
<td>3.17 ± 0.06</td>
<td>3.38 ± 0.17</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GD₁₁₆</td>
<td>16.21 ± 0.7</td>
<td>13.97 ± 0.69</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₁₁₇</td>
<td>32.28 ± 0.8</td>
<td>28.25 ± 1.1</td>
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<td></td>
</tr>
<tr>
<td>GT₁₁₆</td>
<td>28.85 ± 0.66</td>
<td>31.22 ± 0.72</td>
<td>P &lt; 0.01</td>
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</tr>
<tr>
<td>G₀₁₁₆</td>
<td>5.4 ± 0.53</td>
<td>8.7 ± 0.89</td>
<td>P &lt; 0.001</td>
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</tr>
<tr>
<td>Medulla oblongata</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GM₃</td>
<td>1.08 ± 0.22</td>
<td>1.36 ± 0.12</td>
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</tr>
<tr>
<td>GM₂</td>
<td>1.57 ± 0.01</td>
<td>2.07 ± 0.17</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GM₁</td>
<td>15.7 ± 0.45</td>
<td>16.19 ± 0.33</td>
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<td></td>
</tr>
<tr>
<td>GD₃</td>
<td>4.5 ± 0.17</td>
<td>4.6 ± 0.15</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GD₁₁₆</td>
<td>18.06 ± 0.66</td>
<td>15.08 ± 0.5</td>
<td>P &lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>GD₁₁₇</td>
<td>30.06 ± 0.75</td>
<td>28.7 ± 0.62</td>
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<tr>
<td>GT₁₁₆</td>
<td>25.9 ± 0.37</td>
<td>26.02 ± 0.34</td>
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<td>G₀₁₁₆</td>
<td>5.23 ± 0.44</td>
<td>6.17 ± 0.6</td>
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</tr>
<tr>
<td>Brain stem</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GM₃</td>
<td>0.96 ± 0.21</td>
<td>1.02 ± 0.1</td>
<td>P &lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>GM₂</td>
<td>1.07 ± 0.1</td>
<td>0.88 ± 0.1</td>
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<tr>
<td>GM₁</td>
<td>12.5 ± 0.48</td>
<td>13.2 ± 0.41</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₃</td>
<td>3.8 ± 0.1</td>
<td>4.5 ± 0.68</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>G₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GD₁₁₆</td>
<td>20.19 ± 0.66</td>
<td>20.58 ± 0.42</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>GD₁₁₇</td>
<td>31.44 ± 1.7</td>
<td>27.5 ± 1.33</td>
<td>NS</td>
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</tr>
<tr>
<td>GT₁₁₆</td>
<td>25.26 ± 0.5</td>
<td>26.37 ± 0.74</td>
<td>NS</td>
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<tr>
<td>G₀₁₁₆</td>
<td>4.6 ± 0.23</td>
<td>6.4 ± 0.53</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Pons</td>
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<td></td>
</tr>
<tr>
<td>GM₃</td>
<td>0.92 ± 0.14</td>
<td>1.06 ± 0.13</td>
<td>NS</td>
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</tr>
<tr>
<td>GM₂</td>
<td>1.67 ± 0.17</td>
<td>1.93 ± 0.17</td>
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</tr>
<tr>
<td>GM₁</td>
<td>16.43 ± 0.53</td>
<td>16.44 ± 0.36</td>
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</tr>
<tr>
<td>GD₃</td>
<td>3.94 ± 0.16</td>
<td>4.34 ± 0.12</td>
<td>NS</td>
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</tr>
<tr>
<td>G₂</td>
<td></td>
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<tr>
<td>GD₁₁₆</td>
<td>16.32 ± 0.31</td>
<td>14.2 ± 0.49</td>
<td>P &lt; 0.001</td>
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</tr>
<tr>
<td>GD₁₁₇</td>
<td>31.59 ± 0.84</td>
<td>27.77 ± 0.75</td>
<td>P &lt; 0.01</td>
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<tr>
<td>GT₁₁₆</td>
<td>24.16 ± 0.95</td>
<td>25.7 ± 0.82</td>
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<tr>
<td>G₀₁₁₆</td>
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<td>8.23 ± 0.58</td>
<td>P &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>G₁</td>
<td>1.05 ± 0.18</td>
<td>1.83 ± 0.67</td>
<td>NS</td>
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</table>
dependent on brain region) of the higher sialylated tri- and tetrasialoganglioside fractions. Moreover these investigations show that in hibernating dormice in comparison with their normothermic counterparts significant changes in the ganglioside pattern (polysialylation effects) occurred. These are most significant in those brain parts which are according to Reaves & Hayward (1979) the thermosensitive regions of the CNS (pons, brainstem, oblongated medulla, regio quadrigemina of midbrain), with the exception of the cortex which is inactive during hibernation (Kayser et al., 1951). Structures which are not involved in the thermoregulation (cerebellum, olfactory bulb) show no profound differences. Similar but not so distinct differences already had been shown for the whole brain of golden hamsters (Hilbig & Rahmann, 1979) but did not occur in the dwarf hamster (Phodopus sungorus; Hilbig et al., in preparation). Now it could be supposed that the differences in the sialylation (= polarity) degree of brain gangliosides shown above, directly corresponds with the ability of mammals to maintain their body temperature at a constant level, when the ambient temperature decreases. So in the fat dormouse as a true hibernator with extreme long torpor phases the degree of polysialylation is significant, followed by that of the golden hamster, which has only very short torpor phases. On the other hand, the dwarf hamster, which can tolerate extreme low temperatures (−30°C) in its natural habitat (Mongolian deserts) by changing the body temperature only for short circadian periods but never below 20°C (Heldmaier, 1979), doesn’t show typical variations of a polysialylation in the ganglioside metabolism.

On the basis of these results only speculative assumptions can be made concerning the possible causal interactions of neuronal gangliosides in adaptation to lowered ambient temperatures. Goldman (1975) postulated that an increase in the unsaturation of fatty acids in phospholipids induces changes in the fluidity of the membrane in order to maintain membrane function under lowered temperature conditions. Cossins et al. (1977) reported that these changes in phospholipids happen within a few days after a transfer to lowered temperatures. On the other hand, according to our results (Hilbig & Rahmann, 1979; Rahmann, 1980) a compensatory reconstitution (de- or polysialylation) of neuronal gangliosides took place over much longer periods of about 5-7 weeks. Considering the data concerning the complexation ability of gangliosides together with Ca2+-ions (Probst et al., 1979; Rahmann et al., 1978) and the thermosensitivity of these complexes (Probst & Rahmann, 1980) it is more likely that during hibernation torpor the temperature changes influence neuronal gangliosides in a way that with decreasing temperatures more polar gangliosides of fractions are synthesized to form more stable Ca2+ complexes in the cold. These polar gangliosides probably maintain the neuronal membrane function, especially in its synaptic terminals comparable with the less sialylated gangliosides under homeothermic temperature conditions.

SUMMARY
The composition of the brain ganglioside pattern of normothermic dormice (Glis glis) is more polar (higher sialylated) than that of laboratory rats. When comparing normothermic with hibernating dormice a polysialylation of brain gangliosides can be shown which is most distinct in those brain regions, which regulate the temperature during hibernation torpor (pons, brainstem, oblongated medulla, parts of midbrain). The present results support the hypothesis according to which a lowering of the environmental temperature induces polysialylation effects in neuronal membranes.

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REFERENCES
Effects of hibernation on ganglioside composition of dormice


Key Word Index—Hibernation; fat dormouse; sialoglycoproteins; gangliosides.