PART II

A STUDY OF THE THERMOGLYCEMIC RESPONSE IN YOUNG MAMMALS
Introduction

Pigeons are homoiothermic under conditions of small changes in the ambient temperature, but when subjected to higher air temperature, the body temperature rises with an increase of blood sugar level. It has been reported that in the ontogenetic scales of thermoregulatory evolution animals born naked with little or no fur on the body at birth usually suffer from a defective thermoregulation. This is seen in baby rabbits and human babies, but guineapigs which are born fully clothed with fur have little difficulty in temperature regulation (Gulick, 1937). In view of the defective thermoregulation in birds and baby rabbits an attempt has been made in the present part to investigate whether the latter also show a thermolympemic and hyperthermic response on short exposure to higher ambient temperature.

Experimental Methods

Baby rabbits, each weighing 300-350 g, were used. All the animals were fasted for 14 hours before the experiments were conducted. Forty baby rabbits were housed in individual cages in a room with an average temperature of 32°C. Rectal temperature, which gives a good measure of average core temperature (Hardy, 1953-54) was determined by a clinical thermometer and heart rates by an electrocardiograph of Sanborn Visocardiette type. Blood sugar was estimated from ear vein blood by a modification of Somogyi's reagent No. 2 (Somogyi, 1931; Maolagan, 1940) as described in Part I. The animals were handled as gently as possible at the time of exposure and of drawing of blood samples so as to prevent the development of any abnormal emotional state.
Pig 1: Blood sugar level of baby rabbits controlled at 32°C and exposed to higher ambient temperature of 42°C or 45°C for 2½ hours.

**Fig. 1.** Blood sugar level of baby rabbits controlled at 32°C and exposed to higher ambient temperature of 42°C or 45°C for 2½ hours.
After some days in the controlled environment the baby rabbits were divided into two groups. One group was exposed to 42°C and the other to 45°C in a constant temperature chamber for 2\frac{1}{2} hours. The standard error of the temperature fluctuation in the chamber was never greater than ± 0.2°C and the walls of the chamber were within ± 1°C of the ambient temperature. After the period of exposure was over, blood was collected and measurements made as already described.

**Results**

The results of subjecting the baby rabbits to 42°C or to 45°C on their rectal temperature and heart rate are presented in Table 1. There was a slight but significant increase in rectal temperature of the rabbits at a lower ambient temperature, while the rise was not proportional to the ambient temperature. Electrocardiograms showed a significant increase of heart rate, although the tachycardia at the higher temperature was out of proportion to the hyperthermia. The effect of high ambient temperature on the blood sugar level of the baby rabbits is also shown in Table 1. There was a thermoglycemic response both at 42°C and 45°C ambient temperature. A linear regression between ambient temperature in degree centigrade and sugar in mg. per 100 ml. blood shows that for each degree rise in ambient temperature there is a corresponding rise of 3.4 mg. blood sugar, and this value is also true for a similar thermoglycemic response in pigeons (Part I).

The effect of high ambient temperature on the blood sugar level and rectal temperature of the baby rabbits have also been represented in Figs. 1 and 2, respectively.
Fig. 2. Rectal temperature of baby rabbits served as control at 32°C and subjected to 42°C or 45°C ambient temperature for 2½ hours.
Temperature characteristic $\alpha$ in calories (Crozier, 1924) has also been calculated for a difference of blood sugar from 42-32°C and from 45-32°C, from the formula, as described in previous part. The temperature used in the calculation is the extrinsic ambient temperature and not the intrinsic temperature.

Discussion

It has been reported by Buchanan and Hill (1947) that development of temperature regulation may be correlated with development of myelination in nerve fibres in hypothalamus. A two-day old mouse is essentially a poikilothermic animal (Stier and Pincus, 1928); at ten days a mouse regulates in intermediate air temperatures, and at twenty days in extreme temperatures. Development of temperature regulation in man may take several years (Burton, 1939). Baby rabbits were subjected to short exposures of high ambient temperature in chambers sufficiently ventilated to exclude much changes in humidity and their rise of body temperature and of blood sugar level was similar to that of pigeons (Part I); under these conditions there is neither any change in body temperature nor in blood sugar level in the adult rabbits. The similarity of behaviour between the birds and the baby mammals in the ability to regulate body temperature at a narrow range of air temperature shows that the baby mammals, although homoiothermal, are so only in a narrow range (stenothermal) and not in a wide range (not euthermal) as in the adult mammals. It appears that in the gradual evolution of stages from poikilothermal, heterothermal and (stenothermal and euthermal phases of) homoiothermal, the stenothermal phase is an obligatory one in the ontogenetic evolution of thermoregulation.
Effect of exposure of baby rabbits controlled at 32°C to high ambient temperature of 42°C or 45°C for a period of 2½ hours on the rectal temperature, heart rate and blood sugar level in mg./100 ml.

<table>
<thead>
<tr>
<th>Ambient temperature</th>
<th>32°C</th>
<th>42°C</th>
<th>45°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectal temperature °C</td>
<td>38.0 ± 0.6</td>
<td>39.0 ± 0.5</td>
<td>38.4 ± 0.6</td>
</tr>
<tr>
<td>Heart rate/minute</td>
<td>235.0 ± 7.5</td>
<td>313.0 ± 8.8</td>
<td>366.0 ± 8.2</td>
</tr>
<tr>
<td>Blood sugar</td>
<td>66.6 ± 6.0</td>
<td>98.7 ± 6.1</td>
<td>115.1 ± 7.6</td>
</tr>
</tbody>
</table>

Blood sugar mg.% = 3.4 times ambient temperature in °C + 2.5 (valid from 32°C to 45°C)

*Temperature characteristic μ in calories (Crosier, 1924) was calculated for a difference of blood sugar from 42°C to 32°C and from 45°C to 32°C from the formula,

\[ \mu = 0.456621 \left( \frac{T_2 - T_1}{K_2 - K_1} \right) \log \frac{K_2}{K_1} \]

where \( K_2 \) is blood sugar at higher temperature and \( K_1 \) at lower ambient temperature.
and the baby mammals have not passed this stage, while the adult mammals have evolved into the final euthermal phase of homiothermal stage. As in the pigeons there is also a greater correlation of the thermoglycemic response, in the baby rabbits, with the rise of ambient rather than of the rectal temperature, as shown by greater slope of the former and this indicates that the hypothalamus is stimulated more effectively, in these animals too, by the peripheral thermoreceptors than by the blood temperature.

The temperature characteristic u in calories is also studied at two different temperatures to investigate if there are different "master reactions" at these points and also to find out if the proposition that changes of ambient temperature may affect the u value as in vivo experiments (Brody, 1945) is true in these animals. The similarity of the two values does not indicate different master reactions and from the low values of the temperature characteristics, it cannot be concluded that ambient temperature affects these master reactions in the same way as in the in vitro tissue slice experiments (Sadhu, 1959).

Summary

Baby albino rabbits housed at 32°C were subjected to an ambient temperature of 42°C or 45°C for a period of 2½ hours. They showed a hyperthermic and tachycardic response both at 42°C and 45°C. The rise of rectal temperature was not proportional to the ambient temperature, while tachycardia at the higher temperature was out of proportion to the hyperthermia. There was a thermoglycemic response both at 42°C and 45°C and there is a greater correlation of the thermoglycemia with the rise of ambient temperature than with the corresponding rise of rectal temperature.
Temperature characteristic $\mu$ in calories has been calculated for a difference of blood sugar from 42°C to 32°C and from 45°C to 32°C.