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The Long Term Effects of Changes in the Environmental Temperature on the Body Growth

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THE EFFECTS of environmental temperature on body growth of mice as reflected by body weight have been reported by many authors (Sumner 1919, 1915; Sundstroem 1922; Ogle 1934; Biggers et al 1958; Hale et al 1959; Harrison et al 1959, 1969; Barnett et al 1963, 1965; Chevillard et al 1963 and others). The results of these authors conflict because they are either concerned with adaptation mechanisms to extreme temperature levels or with testing the response of the different animal genotypes under such levels. Studies on the long term changes in the environmental temperature on the body growth in mice are lacking.

MATERIALS AND METHODS :

Experimental Animals :– Strain A, albino mice, of both sexes, inbred (brother-sister mated) at King's College Hospital, London, S.E. 5 were used. They were weaned at 23 day old and at the age of 25 day were divided into 3 groups and maintained at 33° C (hot group), 21° C (control group) and 8° C (cold group) (16, 22 and 18 mice respectively). The animals were maintained in metal cages with wire mesh tops and were supplied with food (Oxoid Ltd., Laboratory Animal Diet, Diet 41 B - modified) and water ad libitum. They were weighed daily to the nearest 0.1 gm and followed for a period of 9 months.

The food and water consumption of the three groups were calculated weekly.

Three experimental environmental conditions were used :—

1. *Hot Environment* (hot room) : This consisted of an incubator (Gallenkemp Incubator, Size Three, Model I H-100) maintained at a constant temperature of 33° C. The air inside the incubator was stirred by a fan. In addition, air (20 ± 1° C) at a rate of 14 litre/min. was pumped through a water-filled plastic jar which was kept inside the incubator. Relative humidity ranged between 49% and 55%.

2. *Temperate Environment* (Control temperature) : was that of the Animal House maintained at 21 ± 1° C (although for short periods the temperature rose above this range during the summer of 1976).

3. *Cold Environment* (Cold room) : This consisted of a wood-walled incubator (Charles Hearson & Co. Ltd., London SE I.) fitted with a thermostat (Model C/5, Green house Thermostat, Humey, Byfleet, Surrey, England) to give a constant temperature of 8° C. This incubator was kept in a cold room at 4° C. Warmed air (20 ± 1° C, 14 litre/min.) was pumped into the incubator and this helped to maintain the small rise in temperature necessary to reach 8° C.

The temperature and humidity levels of the three environments were recorded and observed daily on thermohygrometers and maximum — minimum thermometers.

RESULTS :-

Fig. 1 shows the curves of growth in body weight of the three groups. During the first 16 weeks, the control group grew faster (0.9 gm/week) than the cold (0.8 gm/week) and the hot (0.6

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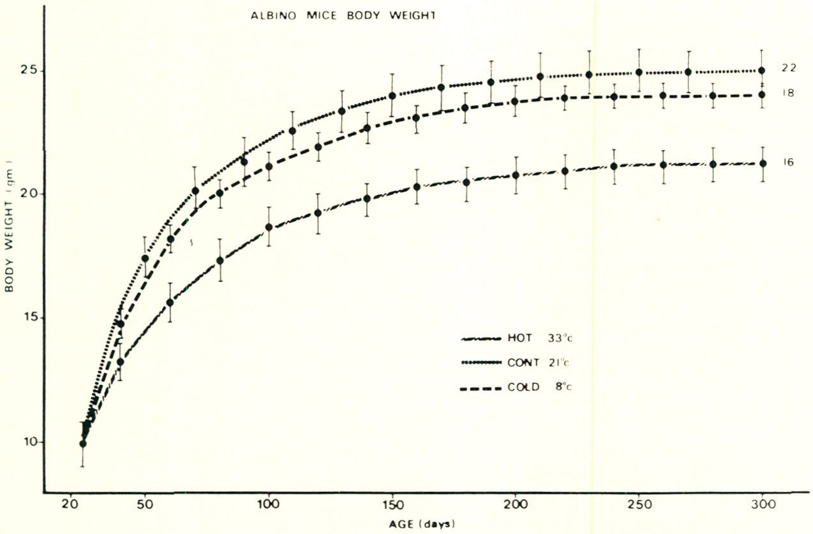


The curves of body weight of 3 groups of mice maintained 33° C, 21° C and 8° C.

gm/week) groups. After this, the growth rates were equal (0.1 gm/week) in the three groups.

The body weights of the control and cold groups were very similar and by the age of 300 days the controls were only 1.0 gm and 4.0 gm heavier than the cold and hot groups.

The food and water consumption for a litter of 5 mice/week were 125 - 175 gm. and 120 - 165 ml. in the control group, 445 - 610 gm. and 200 - 250 ml. in the cold group and 90 - 120 gm and 85 - 125 ml. in the hot group.

Fig. 2 shows a photograph of 2 mice at the age of 40 days. The upper (from the hot group) has a long tail and small body while the lower (from the cold group) has a shorter tail and longer body.

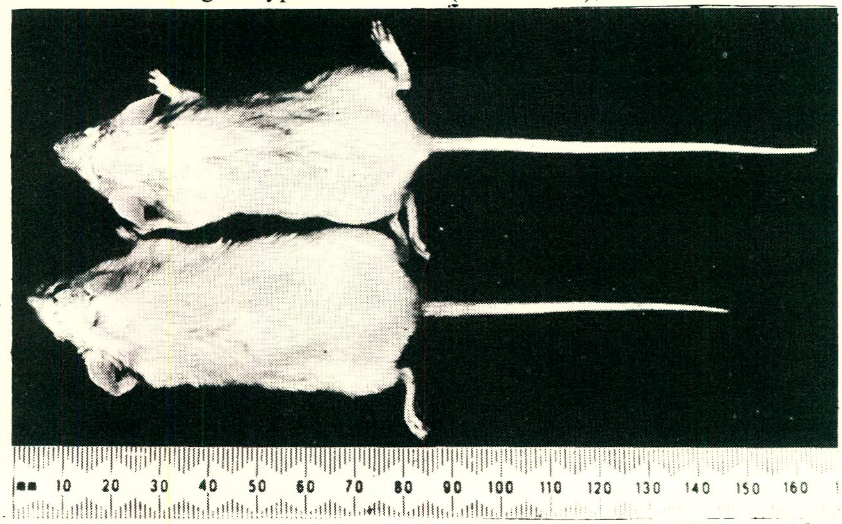
DISCUSSION :-

The relationship of growth of body weight to environmental temperature is controversial. The continuous exposure of experimental animals to low or high temperature has been said to result in reduced adult size (Sumner 1909, 1915; Sundstroem 1922; Ogle 1934; Biggers et al 1958; Barnett and Scott 1963), but there are some exceptions. For example, it has been shown in the works of Harrison et al (1959, 1969) that small animals achieve their greatest adult weight under conditions of heat.

The present results, which support the inverse relationship of body weight to environmental temperature were consistent with most authors (Sumner 1909, 1919; Sundstroem 1922; Ogle 1934; Hale et al 1959) and any divergence from other reports (Harrison et al 1959, 1969; Chevillard et al 1963; Barnett et al 1963, 1965) may be due to the use of different animal genotypes.

Generally, the enzyme-chemical reactions of the body are known to be greatly influenced by temperature and that the rates of these reactions may be increased (or decreased) with raising (or falling) temperature (Troshin 1967; Hart 1971). One may therefore conclude that the effects of changes in invironmental temperature on body growth may be reflected by changes in metabolic activities. According to Vant's Hoff's Law, these activities are raised 2-3 times in the hot reared mice than the other groups. But these mice were found to consume little amounts of food and water. It seems therefore, that the metabolic activities in the hot reared group were principally directed towards heat loss rather than body growth. In addition, the small bodies of these mice means that they have a relatively larger suface area in relation to their volume and this may facilitate heat loss (Scholander 1955).

In the cold group, several factors may influence the final adult body growth. It is now well established that under conditions of constant and continuous cold exposure, homeothermy is maintained through greater metabolic rate (Hart 1971), an increase in food



A Photograph of 2 mice at the age of 40 days. The upper (from the hot group) has long tail and small body while the lower (from the cold group) has a short tail and larger body.

consumption (Cottle and Carlson 1954; Barnett and Little 1965) and high rate of heat production for long periods (Depocase et al 1957). Because of this heat productioin, a decrease in shivering thermogenesis and an increase in non-shivering themogenesis becomes evident (Hart et al 1956, 1971; Bruck 1970). In general, homeothermy was adapted and adjusted and the metabolic demands were fulfilled and were directed towards body growth which provided the animals with better adaptive responses to the cold environment.

The heavier body weights in the cold group compared with the hot group may in part be due to the heavier body organs (Hale et al 1959; Barnett et al 1963, 1965) but also to the different chemical body composition. The cold reared animals were reported to have more water and less fat, collagen, nitrogen, calcium and phosphorus than the hot reared mice (Barnett et al 1959, 1963, 1965: Himms - Hagen 1965). Although the body weights of the control and cold groups fell within the same range, the heavier body weights in the cold group than those of the hot group may also be due to changes in the thyroid activity. Increased thyroid activity in the cold-acclimatised animals is well known (Heroux 1969) and may lead to increase body weight, increase basal metabolism (Hart 1971) and increased tissue oxygenation of such organs as the liver, kidneys and muscles (Barker 1955; Weiss 1954, 1959).

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REFERENCES

Barker, S.B. (1955) Ann. Rev. Physiol., 17, 417-442.

Barnett, S.A.; Coleman, E.M. and Manly, B.M. (1959), Quart. J.Exp. Physiol., 44, 43-51.

Barnett, S.A. and Scott, S.G. (1963) J. Embryol. Exp. Morphol., 11, 35-51.

Barnett, S.A. and Little, M.J. (1965) Proc. Roy. Soc. London. Ser. B. 162, 492 - 501.

Barnett, S.A. and Widdowson, E.M. (1965) Proc. Roy. Soc. London. Ser. B., 162, 502 - 516.

Biggers, J.D.; Ashoub, M.R.; McLaren, A. and Michie, D. (1958), J.Exp. Biol., 35, 144-155.

Bruk, K.(1970) Non-shivering Thermogenesis and Brown Adipose Tissue in Relation to Age and Their Integration in the Thermo-regulatory System. In "Brown Adipose Tissue". Edited by Lindberg,O. American Elsevier Publ.

Chevillard, L.; Portet, R. and Cadot, M. (1963), Fed.Proc., 22, 699-703.

Cottle, W.and Carlson, L.D., (1954), Amer.J. Physiol., 178, 305 - 308.

Depocas, F.; Hart, J.S., and Heroux, O. (1957), J.Appl. Physiol. 10, 393 - 397.

Hale, H.B.; Meffered, R.B.; Vawter, G.; Foerster, E. and Criscuolo, D. (1959) Amer. J.Physiol., 196, 520 - 524.

Harrison, G.A.; Morton, R.J. and Weiner, J.S., (1959), Phil. Trans., B 242, 479 - 516.

Harrison, G.A. and Clegg, E.J. (1969), Environmental Factors Influencing Mammalian Growth. In "Pathology of Adaptation Mechanisms" Edited by Bajusz, E. Oxford, Pergamon.

Hart, J.S. (1971) Rodents. In "Comparative Physiology of Thermo-regulation". Edited by Whittow, G.C. Academic Press.

Hart, J.S.; Heroux, O. and Depocas, F. (1956), J.Appl. Physiol., 9, 404 - 408.

Heroux, O. (1969) Catecholamines, Corticosteroids and Thyroid Hormones in Non-shivering Thermogenesis Under Different Environmental Conditions. In "Pathology of Adaptation Mechanisms". Edited by Bajusz, E. Oxford, Pergamon.

Himms - Hagen, J.(1965) Can. J.Physiol. Pharmacol., 43, 379 - 403.

Ogle, C, (1934)) Amer. J. Physiol., 107, 635 - 640.

Scholander, P.F. (1955) Evolution, 9, 15-26.

Sumner, F.B. (1909) J.Exptl. Zool., 7, 97-155.

Sumner, F.B., (1915) J. Exptl. Zool., 18, 325-432.

Sundstroem, E.S., (1922) Amer. J. Physiol., 60, 397 - 447.

Trohin, A.S. (editor) (1967) The Cell and Environmental Temperature. Pergamon Press.

Weiss, A.K. (1954) Amer. J.Physiol., 177, 201 - 206.

Weiss, A.K. (1959) Amer. J.Physiol., 196, 913 - 916

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