

signs associated with inanition (Asdell and Crowell 1935). It is clear that rats kept at 34°C are able to strike a balance between food intake and energy expenditure, very similar to that reached by animals at lower temperatures.

Although rats in all groups used fat stores during lactation, the effect was greatest in the rats kept at 34°C. Moreover, rats in this group were the only ones to show a decline in body weight and a reduction in protein synthesis over this period (PennyCUik 1964*b*). Human subjects undertaking increased activity under desert conditions consumed more food to meet the demands of work (Consolazio *et al.* 1960) but rats kept at 34°C were apparently unable to increase their food intake sufficiently to compensate for the demands of lactation.

Appetite appears to be controlled by the feeding and satiety centres of the hypothalamus (Brobeck 1955, 1960). These in their turn are thought to be affected by body temperature (Brobeck 1948, 1960), gastric motility (Quigley 1955), arteriovenous differences in levels of glucose (Mayer 1955) and other metabolites (Dowden and Jacobson 1960), levels of fat stores (Bruce and Kennedy 1951; Kennedy 1952-53, 1955) and emotional factors (Mayer 1960). These have been reviewed by Andersson and Larsson (1961). Of the five factors mentioned, only two have been suggested as possible mechanisms by which heat could cause a depression of food intake, viz. increased body temperature (Brobeck 1948) and reduced gastric motility (Mitchell and Edman 1951). Though these may contribute to the reduction of appetite in the heat, it is unlikely that they could explain wholly the reduction in food intake for no rise in body temperature was observed in the animals at 34°C, though their food intake was well below that of animals at lower temperatures (PennyCUik, unpublished data). Gastric motility is known to be influenced by arteriovenous differences in glucose levels (Stunkard and Wolff 1954) which may well have been different in animals at the three different environmental temperatures used in the present study.

Differences in arteriovenous levels of glucose and other metabolites seems to be a much more likely mechanism by which appetite could be controlled at high environmental temperatures. Activity is known to be reduced at 34°C (Howard *et al.* 1959), so too is growth, and there is some evidence that metabolic activity is also affected (Mefferd, Nyman, and Webster 1958). All these factors would tend to raise venous metabolite levels and reduce arteriovenous differences in the concentration of these metabolites.

Fat percentages in the bodies of virgin and lactating animals at the three temperatures used suggest that control of appetite by the level of the fat stores of the body is more complex than was originally postulated by Kennedy (1952). Although rats at all three temperatures lost fat during lactation, this effect was most marked in those kept at 34°C. Either lactation altered the level at which these stores were set or control of appetite by this means was eliminated. High environmental temperature apparently increased the fat mobilization due to lactation. Circulating hormonal levels are known to be altered during lactation (Benson *et al.* 1959) and these in their turn are known to influence the metabolic pathways of fat metabolism and rates of fat storage and mobilization (Barnett and Ball 1960; Engel and White 1960; Odum 1960). Heat may well influence the magnitude of the fat store through a similar mechanism.

The possibility that heat may also influence the feeding and satiety centres through impulses from skin receptors does not appear to have been investigated, though the only known case in which food intake was increased at high environmental temperatures was in the experiments of Consolazio *et al.* (1960) where the subjects were fed in an air-conditioned dining room.

Though the evidence is limited, results for experiments with suckling animals [where food is used almost exclusively for growth (Kennedy 1957)] lend no support to the suggestion that reduced food intake at high environmental temperatures is due in part to increased metabolic efficiency. When that part of the caloric intake devoted to pup growth was added to the caloric value of the fat removed from maternal stores during lactation, the cost of producing 1 g of pup tissue was almost identical for animals at 27 and 34°C.

On the other hand, in growing animals kept at 34°C, where energy expenditure on activities other than growth was reduced, the efficiency of utilization of food was greater than at 21 or 27°C. These results are in agreement with those of Mills (1945) for mice and are not inconsistent with those of Johnson (quoted by Warwick 1958) for pigs acclimatized to 90°F (32.2°C) from weaning onwards. It would appear then that for temperatures up to 34°C, rats acclimatized to the higher temperatures, showed greater efficiency of food utilization than those acclimatized to lower temperatures. The optimum temperature for growth, on the other hand, appeared to be close to 27°C.

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