LETTERS TO THE EDITORS

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Metabolic Water and Desiccation

THE utilization by the body of ingested food substances and of tissue reserves yields among other things quantities of metabolic water. As the complete combustion of 100 gm. of fat produces about 110 gm. of metabolic water, whereas 100 gm. of carbohydrate yields only 55 gm. of water, fat reserves and fatty foods are believed to be particularly valuable as a protection against desiccation. This contention would appear to be supported by the fact that many animals which exist in deserts have large reserves of fat.

I believe that the idea that fat is primarily a protection against desiccation is based on fallacies. Terrestrial animals, which have evolved eventually from aquatic forms of life, are always apt to suffer from desiccation, and many well-known mechanisms for water conservation exist. Respiration always presents a difficulty, and a serious loss of water often takes place from the surface of respiratory organs. The more a terrestrial animal takes in oxygen, during respiration, for its metabolism, the more water there will be lost in the (practically saturated) expired air; this is equally true of insects and mammals. In man, the water lost from the lungs is generally greater than the total production of metabolic water. When desiccation is the limiting factor (and animals usually die from lack of water long before their food reserves are exhausted) the significant figure is not the amount of metabolic water produced for unit consumption of any reserve, but the amount of metabolic water produced for unit oxygen uptake. When burning fat, to produce 100 gm. of metabolic water, 255 gm. of oxygen must be absorbed; to produce 100 gm. of metabolic water from carbohydrate only 213 gm. of oxygen need be used. I believe therefore that an animal living on fat may actually be worse off as regards the production of metabolic water than one living on carbohydrate.

The same conclusion may be arrived at in a different way. Fat has a much higher calorific value than carbohydrate, but while for every 1,000 calories produced by burning fat only 120 gm. of water are produced as a by-product, when carbohydrate is burnt 130 gm. of water are manufactured for the same calorific yield. Thus if an animal performs the same sort of activities on a predominantly fatty diet, it will actually produce less water than on a predominantly carbohydrate diet.

There is one way in which the conclusion given above may need to be modified. Possibly when an animal is metabolizing fat it may obtain the extra oxygen, not entirely by increased ventilation, but partly by an increased utilization of the oxygen in the blood, with a consequent reduction of the venous blood to a level lower than that found when carbohydrate is burned. We do not know that this actually happens, for there appears to be little information concerning the composition of venous blood when different food substances are used. If it does, however, carbon dioxide production in relation to the control of ventilation must be considered. 244 gm. of carbon dioxide are produced for each 100 gm. of metabolic water manufactured from fat, and 293 gm. of carbon dioxide for 100 gm. of water from carbohydrate, so ventilation (largely controlled by carbon dioxide) and therefore evaporation from the lungs may actually sometimes be greater when carbohydrate is being used. This does not invalidate the conclusions given above concerning the amounts of water produced for each calorie when different foodstuffs are burned, and without further work it is very doubtful whether such differences in the oxygen content of the venous blood of normal resting individuals are to be found. In general then, it is clear that fat cannot in a given time give appreciably more metabolic water than carbohydrate, and most of the evidence suggests that it gives considerably less.

The only advantage of fat over carbohydrate under conditions where desiccation is likely (in deserts or lifeboats at sea) is that a smaller weight will have a higher calorific value and will give more water of metabolism than the same weight of carbohydrate. However, carbohydrate foods are generally less bulky, more easily stored and non-perishable; furthermore, very fatty diets are likely to give nausea and acidosis.

Desert animals store fat in their bodies because fat is the only food substance which animals can store in any quantities. But they store the fat as a food and not as a water reserve, for in deserts starvation is as great a danger as desiccation. In fact, many animals avoid desiccation by living in burrows where an almost saturated micro-climate is found even although the outside air may be extremely dry.

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Biology of Young Salmon (*S. salar*, Linn.)

IN the period immediately preceding the outbreak of the present War a close study had been made of the biology of young salmon, that is, salmon parr (*S. salar*), in various localities of Great Britain and Ireland [1-9]. It seems advisable in the existing conditions of war to review these investigations and particularly those carried out on the Welsh Dee. The accompanying figure correlates in one picture much of the work done on this river; the results obtained in other localities are not very different.

It would appear from all these investigations that rapid growth is related to feeding only at or above a particular temperature-level and may, moreover, be checked in the male by the later stages of gonad growth and spawning. Gonad development in the male is correlated with an accumulation of fat reserves following rich feeding and apparently also with a particular temperature-level. Spawning in the male is correlated with a rapid fall in temperature and a falling off in the amount of food taken (and available). Fat reserves are used up in the young male in the production of gonad but not in the female. An increase in the amount of food taken is not followed *at once* by an accumulation of mesenterial fat reserves, nor apparently an improvement in 'condition', ($K = W/L^3$), but the laying down of mesenterial fat is soon followed by testis development in the males. Smolt migration begins during the early phase of acceleration of growth in body-length, and appears to receive an early impulse about the time of the rise in river temperature from the minimum. A close relation exists between river and sea temperature at the time of migration. There is no information available yet on metabolic state at the time of