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Coefficient of Thermal Conduction: Homogenized Tissues: Thermal Conduction and the Rate of Blood Flow

THE coefficient of thermal conductivity has already been measured for slices of various dog tissues[1], and found to vary from $0{\cdot}6 \times 10^{-3}$ for fresh lung to $5{\cdot}5 \times 10^{-3}$ for fresh muscle. The same apparatus can be used for measuring K for homogenized tissues; in general, these have values of K which vary less from each other than do those for tissue slices.

The technique used is the same as that already described, except that chamber II of the apparatus is filled with homogenized tissue instead of fresh tissue slices. The homogenization is carried out for 5 min in a Waring blender; the homogenized tissues are then transferred to plastic centrifuge tubes and spun for 15 min at $10^3 g$ to free them from air. The measurement of K is made after three relaxation times for the tissue have elapsed; chamber I is kept at 28° C, the temperature in chamber II is initially 20° C, and the quantity of heat passing through it to chamber III (initially at about 6° C) during the fourth and fifth relaxation times is found. The steady-state equations are applied to this to find K.

The average values of $K \times 10^3$ (6 determinations for each tissue) for the homogenates are: muscle 3·6, liver 2·5, brain 1·6, and lung 2·0. These can be compared with the values of $K \times 10^3$ for tissue slices: muscle 5·5, liver 3·3, brain 1·7, and lung 0·6. Homogenization thus reduces the value of K for muscle and liver to about 70 per cent, affects the value of K for brain only a little, and raises the value of K for lung by about three-fold. The value of K for water is $1{\cdot}5 \times 10^{-3}$, which agrees well with the accepted value. In all cases the variation from the average is not more than ± 10 per cent; this applies to both tissue slices and tissue homogenates.

The conclusion is that the thermal conduction in tissues such as muscle and liver is reduced by homogenization, heat being able to move better in the presence of structural pathways than in their absence; in the case of brain, homogenization makes little difference, and the effect of homogenization in the case of lung is clearly due to the removal of air.

With reference to the hypothermic state in which blood at low temperatures is pumped into the circulation, it is known that all parts of the body are not cooled equally. This may be the result of the flow in some regions or organs being greater than that in others, the result of some tissues conducting heat to a greater extent than do others, or the result of both factors. Suppose that the rate of cooling of an organ, $\Delta\theta/\Delta t$, is entirely dependent on the extent to which it is a thermal conductor. If it is supplied with a constant flow of cold blood, $\Delta\theta/\Delta t$ should be highly and positively correlated with the coefficient of thermal conductivity K; if the correlation is small, $\Delta\theta/\Delta t$ cannot be largely dependent on K, and the conclusion must be that the flow of the blood through different organs varies.

The rate of cooling of a tissue is measured by perfusing cold blood into the femoral artery of the dog and collecting the venous return from the superior jugular and femoral veins. This return is measured in ml./min, and passes to a disk oxygenator, then through a DeBakey rotary pump, then to a Brown–Harrison heat exchanger, and then back to the animal. Calibrated needle thermistors are placed in the tissues in which the rate of cooling is to be measured; these are usually the brain, lung, liver, muscle, and kidney, and thermistors are also placed in the arterial and venous streams. The flow of blood is 10–50 ml./min/kg of the animal's body-weight, and is constant for the time Δt, which is usually an interval of 10–20 min from the beginning of the perfusion of cold blood. The temperature of the tissues falls during this interval and tends to approach that of the arterial blood, the form of the falling temperature curve being that of Newton's law of cooling, that is, log θ being linear with time.

The coefficient of thermal conductivity K is measured for each tissue as already described[1]; $\Delta\theta/\Delta t$ is then correlated with K. The coefficient of correlation r is $0{\cdot}364 \pm 0{\cdot}181$, that is, it is scarcely significant, and so the conclusion is that the rate of cooling of the tissues is determined by the different rates of flow of cold blood through them, and not to a significant extent by their thermal conductivity, variable though this is (a ten-fold variation).

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BIOCHEMISTRY

Physical Significance of Michaelis Constants

Briggs and Haldane[1] showed that for the reaction sequence $E + S \rightleftharpoons ES \rightarrow E + P$, the same form of initial rate equation is obtained by the steady-state assumption as by the more restrictive equilibrium assumption of Michaelis and Menten[2]. It was evident, therefore, that the Michaelis constant, K_m, defined[3] as the substrate concentration with which half the maximum rate is attained, is not necessarily equal to the substrate constant, K_s, the dissociation constant of the enzyme–substrate complex. Nevertheless, it is still sometimes assumed[4,5] that the Michaelis constant