Tissue Metabolism in Growing Birds.* (19372)

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Recently Bertalanffy and Pirozynski(1) have studied the metabolic rates of tissues from growing rats *in vitro* and related them to body size. They found a general decrease in oxygen consumption with increasing size which was less than would have been expected on the basis of "surface law" or "metabolic size." These results seem to indicate a lack of correlation between the metabolic rate of the whole animal and of its tissues *in vitro*.

In order to investigate the relation between *in vitro* tissue and whole animal metabolic rate, we have carried out tissue respiration trials with tissues from chickens of different age. Whereas rats have a high metabolic rate per unit weight shortly after birth which decreases with increasing age (Kleiber, unpublished), chickens have a low metabolic rate per unit weight after hatching, which increases during the first month(2). This contrast in metabolic rate in growing animals of these two species makes a comparison of their metabolism *in vitro* of interest to the general problem of body size and metabolic rate(3).

Method. Chickens were selected to form several age groups which would approximate the critical points on the basal metabolic rate curve. These groups were: Group I, 5-17 days, males; Group II, 27-34 days, males; Group III, mature laying females. Groups I and II were fasted 12-20 hours prior to the experiment at a controlled temperature of 33°C and Group III at 30°C. Oxygen consumption rates of slices and homogenates of liver and kidney were determined *in vitro* by Warburg's direct method(4). These measurements were made at 39.8 ± .2°C, which approximates the body temperature of birds.

Results. The oxygen consumption rate (cu mm, n.t.p. per hour) per mg dry tissue (Q_{O_2}) for slices and homogenates was calculated for each bird. A summary of each group is given in Table I.

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Discussion. In liver slices from a wide variety of mature mammals, Kleiber(5) derived the following regression equation relating oxygen consumption rate *in vitro* (Q_{O_2}) to body weight (kg): $Q_{O_2} = 5.43\ W^{-.21}$. When the liver slice data for mature hens is calculated to the same units of body weight, the relationship is close to that found in mammals: $Q_{O_2} = 6.41\ W^{-.21}$. It is also known that the metabolic rate of the whole mature chicken (and birds in general) fits the weight-metabolism curve established among mature mammals(6). Thus, the relationship between liver slice and whole animal metabolic rate per unit weight in mature chickens is the same as that in mature mammals.

When the oxygen consumption rates of the bird kidney slices are compared with those of mammals(7) it is obvious that they are much lower regardless of body size. This may result from a lesser ability of the chicken kidney to do osmotic work(8).

An intraspecific comparison of the tissue metabolic rate with that of the whole animal (Table I) in growing animals is quite different for the liver and kidney. Kidney tissue respiration (both slice and homogenate) is not significantly different between any of the groups studied. Apparently the metabolic rate of this tissue *in vitro* is independent of body size or whole animal metabolism; this seems generally to be the case in other species (1,7).

Liver tissue from chickens of different ages presented quite a variation in oxygen consumption rate. The liver homogenate Q_{O_2} of the very young (Group I) and mature (Group III) birds was about the same, that of the one month birds (Group II) was significantly greater than either. The liver slices of the one-month-old birds was also significantly greater than that of the mature birds. Although these changes in tissue metabolic rate are in the same direction as the changes in whole animal metabolic rate of birds of

TABLE I. Tissue and Whole Animal Basal Metabolic Rate of Chickens.

Group	Age (days)	No. per group	Body wt (g)	Liver Dry (%)	Liver Qo_2* Slice	Liver Qo_2* Homog.	Kidney Dry (%)	Kidney Qo_2* Slice	Kidney Qo_2* Homog.	kCal/day per:† kg	kg ¾	kg ⅔
I Chicks	5-17	16	66 ± 4	26.7 ± .3	—	1.61 ±.17	23.2 ±.4	—	1.52 ±.06	173	79	61
II Chicks	27-34	7	178 ± 12	25.6 ± .5	6.71 ±.42	4.31 ±.47	22.5 ±.3	10.71 ±.96	1.49 ±.14	201	110	88
III Hens	Mature	6	2350 ± 230	31.1 ±2.6	5.44 ±.28	1.88 ±.27	22.4 ±.3	9.22 ±.49	1.41 ±.17	73	87	93

* Qo_2 = mm^3 O_2 (ntp) consumed per hr per mg dry tissue.
† Whole animal basal metabolic rate; groups I and II, Kleiber(2); group III laying hen, Mitchell and Haines(9).

these ages, the curves are not parallel. The ratio: $\frac{\text{liver slice metabolic rate}}{\text{whole animal metabolic rate per unit wt}}$ increases in the older animals (proportional to the cube root of the body weight).

Conclusions. 1. Tissue respiration studies show that oxygen consumption rate of mature chicken liver slices fits body weight-tissue metabolic rate relationship derived by Kleiber (5) for mature mammals. The oxygen consumption rate of mature chicken kidney slices, however, is much lower than that of mature mammals(7). 2. The relationship between tissue and whole animal metabolic rate in growing chickens is different for the kidney and liver. The Qo_2 of kidney tissue (homogenate or slice) is essentially the same for all age groups of birds tested. The Qo_2 of liver tissue *in vitro* is the same for very young and mature birds, but is significantly higher in one-month-old birds. This same sequence has been noted by Kleiber(2) in the whole animal metabolic rate (per unit weight) of growing birds.

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Survival of Thermally Injured Rats Infused with Saline, Polyvinylpyrrolidone, Dextran and Oxypolygelatin. (19373)

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Using the standardized back burn procedure developed in this laboratory for the white rat (1), we have obtained additional information which demonstrates that intravenous NaCl solutions are effective in combating burn shock and promoting survival of these animals. Macromolecular solutions* of polyvinylpyrrolidone (P.V.P.), Dextran, and Oxypolygelatin (O.P.G.) have been tested simultaneously with the saline solutions and the macro-

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