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.

1. Bertalanffy, T. von, and Piroxzynski, W. J., *Science,* 1951, v113, 599.
2. Kleiber, M., PROC. SOC. EXP. BIOL. AND MED., 1938, v38, 793.
3. Kleiber, M., *Physiol. Rev.,* 1947, v27, 511.
4. Dixon, M., *Manometric Methods as Applied to the Measurement of Cell Respiration and other Processes,* 2nd ed., Macmillan, New York, 1943.
5. Kleiber, M., PROC. SOC. EXP. BIOL. AND MED., 1941, v48, 419.
6. ———, *Hilgardia,* 1932, v6, 315.
7. Krebs, H. A., *Biochim et Biophys. Acta,* 1950, v4, 249.
8. Korr, I., *J. Cell. Comp. Physiol.,* 1939, v13, 175.
9. Mitchell, H. H., and Haines, W. T., *J. Agr. Res.,* 1927, v34, 927.

Received December 13, 1951. P.S.E.B.M., 1952, v79.

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

MILES D. MCCARTHY AND JERRY W. DRAHEIM. (Introduced by I. S. Ravdin.)
From the Harrison Department of Surgical Research, Schools of Medicine, University of Pennsylvania, Philadelphia.

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-

* Allocated by the National Research Council, Subcommittee on Shock. (P.V.P. Schering-Batch GA-P.V.P.-111; Dextran C.S.C. Lot 84665A; O.P.G. Don Baxter S152AY).

TABLE I. Postburn Survival Rates for Various Infused Groups of Rats Burned at 90°C for 35 Seconds, 32 ± 2% Total Body Surface.

Infusion fluid, %	Infused with 10% body wt postburn: 4%, 2 hr; 3%, 5 hr; 3%, 10 hr				Infused with 4% body wt postburn: 2%, 2 hr; 2%, 5 hr		
	No. rats	% survival, postburn 8 hr	24 hr	10 days	No. rats	% survival, postburn 8 hr	12 hr
Untreated controls	40	20	0	0			
NaCl 1.4	20	80	80	75			
1.2	20	70	70	70	6	50	0
.9	20	80	70	60	6	0	0
P.V.P. .875	20	95	65	65			
1.75	9	89	33	33			
3.5	12	50	33	33	6	50	0
4.5	12	58	8	8			
O.P.G. 5	12	50	33	25	6	17	0
Dextran 1.5	6	83	0	0			
6	6	66	0	0			

molecular solutions have been found to be less efficacious in promoting 10-day survival than the saline solutions. The latter were found to show greater efficacy as the percentage of NaCl was increased from .9% to 1.2% and 1.4% respectively.

Material and methods. White rats of the Wistar strain, weighing between 190 and 210 g, have been used as the test animals. All rats received a back burn under ether anesthesia of 32 ± 2% of the total body surface and the experiments were usually conducted on 12 rats at a time. Prior to burning, the animals were segregated at random into several equal groups to permit testing of 2 or more infusion fluids simultaneously along with an untreated control group. Following the burn all rats were placed in individual wire mesh cages. Infusions were made at the rate of approximately 1 cc per minute through a small skin incision into the saphenous vein at postburn intervals of 2 hours, 5 hours, and 10 hours. Food and water were withheld from all animals for a period of 12 hours postburn. After this interval food and water were offered *ad lib.* Survival rates were recorded at the following postburn intervals: 8, 12, 24, 48, 72 hours and 10 days. The macromolecular materials were all suspended in isotonic saline. Hematocrit samples were obtained as previously described(2) from the lateral tail vein of several animals in each infused group.

Results. Table I shows the survival percentages for rats receiving the several different infusion fluids administered as 10% of the body weight and as 4% of the body weight. These data demonstrate that a) a 10% infusion volume is necessary for survival, b) hypertonic saline solutions are more effective in promoting survival than isotonic solutions, c) solutions of increasing concentrations of the macromolecular substances become less effective in promoting survival.

A specific type of anaphylactic-like reaction was noted in the Dextran infused rats which was much less pronounced than similar reactions following Dextran infusions in normal animals(3). Thus, the rat proved to be a relatively unsuitable species in which to test Dextran and further testing of this material was discontinued.

Hematocrit data presented in Table II demonstrate that the infused solutions of 1.4% NaCl produced a greater hemodilution followed by less hemoconcentration than 0.9% NaCl solutions. Greater hemodilution followed macromolecular infusions and hemodilution increased as the concentration of the P.V.P. solutions increased. Hemoconcentration was markedly reduced by infusions of 4% of the body weight of 3.5% P.V.P. solutions. Rats so treated all died, even though the hematocrit values of such rats were within the range of those of animals which survived following 10% infusion volumes.

Discussion. Earlier work in this laboratory

TABLE II. Average Preburn Hematocrit Values and Average Postburn Hematocrit Values as % of Preburn Hematocrits for Several Rats from Each Infused Group in Table I. Hematocrits taken just before infusion and 5 min postinfusion at the following postburn intervals.

Infusion fluid, %	Preburn	Postburn 2 hr Pre	2 hr Post	5 hr Pre	5 hr Post	10 hr Pre	10 hr Post	24 hr
I. Two hr (4% body wt infused), 5 hr (3% body wt infused), 10 hr (3% body wt infused).								
Untreated*	45.5(18)	115.5(18)	—	122.6(13)	—	Dead	—	—
NaCl 1.4	43.6 (7)	120.6 (7)	98.9 (7)	114.2 (5)	96.95(6)	101.7 (4)	76.8 (4)	74.5 (4)
1.2	42.5 (7)	123.9 (7)	97.8 (6)	120.1 (7)	100.6 (7)	109.2 (5)	85.7 (5)	79 (5)
.9	45.9 (7)	117.5 (7)	105.6 (7)	120.1 (7)	103.8 (6)	99.7 (4)	89.4 (4)	76.5 (3)
P.V.P. .875	45.1 (7)	116.9 (7)	79.8 (7)	109 (6)	85.2 (6)	101.6 (4)	70.5 (4)	89.2 (4)
1.75	43.1 (3)	116.1 (3)	84.1 (3)	115.1 (3)	84.4 (3)	107.4 (1)	74.2 (1)	72 (1)
3.5	45 (5)	122 (5)	64.5 (5)	102.7 (5)	68.4 (4)	Dead	—	—
4.5	43.8 (5)	111.5 (4)	60.3 (5)	99.1 (5)	59.5 (5)	104.7 (2)	70 (2)	Dead
O.P.G. 5	45.1 (6)	112.3 (6)	64.2 (6)	105.5 (5)	72.7 (5)	116.8 (1)	Dead	—
Dextran 1.5	44.7 (3)	119.7 (3)	107.7 (3)	112 (3)	74 (3)	Dead	—	—
6	41.6 (3)	116.6 (3)	94 (3)	113.6 (3)	57.8 (3)	Dead	—	—
II. Two hr (2% body wt infused), 5 hr (2% body wt infused).								
NaCl 1.2	44.6 (3)	119.5 (3)	117 (3)	116.5 (2)	106.8 (2)	Dead		—
.9	44 (3)	131.3 (3)	111.2 (3)	130.2 (2)	115.5 (1)	Dead		—
P.V.P. 3.5	42.6 (3)	123.1 (3)	79.7 (3)	108.4 (2)	79.7 (2)	Dead		—
O.P.G. 5	45.7 (3)	124.6 (3)	105.2 (3)	107.1 (1)	Dead	—		—

* Number in parentheses after each percentage indicates number of rats studied. Except for an occasional lost value, a change in these numbers indicates death of one or more animals.

(2) had indicated that a) this burn procedure was 100% lethal to untreated animals, b) infusion volumes of 10% of the body weight were necessary to promote survival, c) hypertonic saline (1.06%) solutions were more efficacious in promoting survival than normal physiological saline solutions. Consequently, in most of these experiments 10% of the body weight was infused in 3 stages postburn, 4% at 2 hours, 3% at 5 hours and 3% at 10 hours. In several experiments 4% of the body weight was infused in 2 equal volumes of 2% each at a 2- and 5-hour postburn interval. Accordingly, NaCl solutions of the following compositions were infused: 0.9%, 1.2% and 1.4%.

It should be kept in mind that the survival percentages recorded in this paper are not absolute, but represent relative positions with respect to efficacy in promoting survival. It has been our experience that many physical factors influence survival of severely burned rats, among these are handling of the animals and the season of the year. This latter factor is in part a temperature and humidity effect. The experiments reported herein were conducted between July 15 and October 1, during which period there was a room temperature range of 24.3-30.8°C, average 27.1°C; and a relative humidity range of 47-79%, average 63.7%. Survival percentages of all groups would be expected to show corresponding increases if similar experiments were conducted during the winter months.

The results of these experiments are in general agreement with those of Rosenthal (4); namely, that sodium chloride causes a significant reduction in deaths following burns, and that the majority of deaths occur within the first 24 hours following the burn. In several respects, however, these data are at variance with Rosenthal's findings. In our experience hypertonic saline administered by the systemic route promotes higher survival rates than 0.9% saline similarly administered, and the 10-day survival period indicated that the majority of rats which survived 24 hours, continued to do so.

Summary. 1. Ten-day survival percentages are recorded for severely burned rats, infused with saline and several macromolecular solutions and for the simultaneous untreated controls. a) Hypertonic saline solutions were more effective in promoting survival than isotonic saline solutions. b) Effectiveness of the macromolecular solutions in promoting survival decreased as the concentration of

these substances was increased. c) Due to the specific allergic reaction of rats to Dextran, the relative effectiveness of this plasma expander could not be ascertained. 2. Hematocrit data recorded in terms of per cent of initial values are given for several animals in all groups. a) Hypertonic saline solutions tend to maintain a cell-plasma ratio more nearly approaching the initial than isotonic solutions. b) Increased hemodilution followed infusions of the higher concentrations of macromolecular substances. c) Hemodilution in general cannot be directly correlated with survival; however, the lowest hemodilution values were found, except for saline, in those groups having the lowest survival percentage.

1. McCarthy, M. D., *J. Lab. and Clin. Med.*, 1945, v30, 1027.

2. McCarthy, M. D., Parkins, W. M., *Am. J. Physiol.*, 1947, v150, 428.

3. Voorhees, A. B., Baker, H. J., and Pulaski, E. J., PROC. SOC. EXP. BIOL. AND MED., 1951, v76, 254.

4. Rosenthal, S. M., *Public Health Rep.*, 1943, v58, 513.

Received December 27, 1951. P.S.E.B.M., 1952, v79.

Cyclophorase System, XXII. Cyclophorase System of Rabbit Heart Muscle.* (19374)

MILTON H. PAUL,† M. FULD,‡ AND E. SPERLING. (Introduced by P. W. Wilson.)

From the Institute for Enzyme Research, University of Wisconsin, Madison, Wisc.

Previous studies in this laboratory have dealt with the reactions involved in the complete oxidation of pyruvic acid, fatty acids and certain amino acids by the cyclophorase-mitochondrial (CM)§ system of rabbit liver and kidney(1-6). The present report deals with some properties of the CM system of rabbit heart muscle. The heart system (cat) has been studied by Ochoa(7) with special reference to the oxidation of α-ketoglutarate, and (in the rat) by Lehninger(8) and Potter (9) with reference to fatty acid oxidation and oxidative phosphorylation, respectively. From the standpoint of systematics, it is important to know how the CM system of heart muscle compares with those of kidney and liver with respect to properties and metabolic spectrum. The present report deals with some comparative studies along these lines.

Preparation of the CM system. The heart (obtained immediately upon sacrifice of the animal) is divested of its pericardial sac and auricular tissue, and packed in ice (average weight, 5 g). The iced, ventricular tissue is cut into small pieces, added directly to 75 ml of 0.9% potassium chloride (0°C) in the small, monel metal, Waring blendor and blendorized for one minute. The resultant suspension is passed through a double layer of gauze to remove fibrous tissue and then centrifuged at 3-5°C for 7 minutes at 2500 x g. After discarding the supernatant fluid, the residue (R_1H) is resuspended in cold 0.9% potassium chloride and centrifuged again for 5 minutes. The residue (R_2H) is now made up to 6 ml with 0.9% potassium chloride. The Qo_2¶ of these preparations range from 33-45. The R_2H accounts for about 40% of the oxidative activity of the original homogenate. It was found in some but not all cases that when the R_2H is supplemented with the supernatant of the first centrifugation, the original oxidative activity can be reached. Phase microscopy of the preparation disclosed nuclei and nuclear fragments in addition to mito-

* This investigation was supported by a grant from the Heart Institute of the National Institutes of Health.

† Present address: Army Medical Center, Washington, D.C.

‡ Present address: Graduate School of Public Health, University of Pittsburgh.

§ For the association of cyclophorase activity with mitochondria *cf.* Harmon, *J. Exp. Cell Res.*, 1950, v1, 382.

¶ μl oxygen absorbed/hr/mg dry wt of preparation in presence of α-ketoglutarate at 38°C.