

rhythmical contractions in cases in which morphine sulphate did establish them, it appears to us that dilaudid is not as active as is morphine in establishing and stimulating rhythmical contractions in the excised longitudinal segments of the ureter and of Bell's muscle of the cat.

8440 P

Relation Between Basal Metabolism and Minute Volume of Circulation.

ARTHUR C. KERKHOF. (Introduced by George Fahr.)

From the Department of Medicine, University of Minnesota, Minneapolis.

One of the main functions of the circulation is the transportation of oxygen. *A priori*, reasoning would indicate that there is a close correlation between oxygen consumption and rate of oxygen transportation. Grollman¹ expressed this supposed relationship in his "cardiac index" which correlates minute volume at rest with square meters of body surface. He defines "cardiac index" as the minute volume per square meter of body surface. In a large series of determinations on normal individuals, he found that his "cardiac index" was 2.2 liters per square meter of body surface. The standard deviation in this series of determinations was 0.3. Grollman's cardiac index does not take into account the variability in the basal metabolic rate of normals. As we know, this rate varies —15 to +15 in any large series of normal cases. Believing that a better cardiac index could be obtained by taking into consideration the basal metabolic rate, we have constructed a formula which fits the determination somewhat better than the Grollman index. Our formula which was developed from our own data is minute volume = $2.2A(\frac{100 + \text{BMR}}{100})$ where A = the body surface in square meters and BMR is the basal metabolic rate expressed in the usual way. In other words, we would define cardiac index as the minute volume per square meter body surface at 0% basal metabolic rate. When this formula is used to calculate the minute volume, it is found that the determined minute volume will differ only very slightly from the calculated minute volume. In our work we did not confine ourselves solely to normal persons. We used not only a

¹ Grollman, *The Cardiac Output of Man in Health and Disease*. Charles S. Thomas, 1932.

TABLE I.
Determinations of Minute Volume and Cardiac Index.

Date	Case	B.M.R. %	Body sur- face m. ²	Cardiac Index (Minute vol. in L. per m ² body surface at 0% B.M.R.)		Remarks
				Minute vol., liters		
Normals.						
	R.C.	—28	1.66	3.2	2.67	
	L.G.	—19	1.49	2.6	2.15	
	H.H.	—15	1.77	3.5	2.32	
	He.Ho.	—16	1.78	3.46	2.30	
	C.J.	—21	1.98	3.59	2.29	
	M.K.	+12	1.95	4.43	2.02	
	L.P.	—13	1.49	2.88	2.22	
	"	+23	1.49	3.93	2.14	(Temp. 105°)
	G.R.	+4	2.63	6.4	2.33	
	G.R.	—½	2.63	5.73	2.16	
	R.S.	—5	2.42	5.45	2.36	
	T.V.	—5	1.78	3.46	2.03	
Myxedema Cases.						
2-11-35	C.C.	—37	1.94	2.5	2.01	
2-21-35	"	—19	1.94	3.3	2.09	On thyroid medication
2-26-35	"	—18	1.94	3.7	2.32	" " "
3- 7-35	"	—14	1.90	3.76	2.30	" " "
11-14-35	M.E.	—42	1.76	2.30	2.25	
11-15-35	M.E.	—38	1.76	2.17	1.98	
2-15-35	A.J.	—15	1.73	3.6	2.44	" " "
2-16-35	"	—13	1.73	3.2	2.12	" " "
3- 1-35	"	—10	1.71	3.56	2.31	" " "
3- 4-35	"	—18	1.71	2.8	1.99	" " "
3-25-35	"	—8	1.70	3.37	2.15	" " "
3-28-35	H.K.	—3	1.58	3.24	2.12	" " "
4- 3-35	C.K.	—40	1.83	2.38	2.16	
4-12-35	C.K.	—40	1.83	2.30	2.09	
1-29-35	A.P.	—20	1.93	3.05	1.97	
1-30-35	"	—26	1.93	3.20	2.23	
2-14-35	"	—19	1.83	3.30	2.22	" " "
2-28-35	"	—10	1.83	3.25	1.96	" " "
3- 1-35	"	—12	1.83	3.87	2.39	" " "
3- 6-35	"	+24	1.81	5.36	2.38	On thyroid medication (after adrenalin)
3-19-35	"	+2	1.81	4.07	2.20	On thyroid medication
12- 8-34	A.S.	—35	2.18	2.84	2.00	
12-13-34	"	—35	2.18	2.80	2.00	
12-24-34	"	—19	2.18	3.50	1.98	On thyroid medication
1- 5-35	"	+6	2.13	4.58	2.03	" " "
1-12-35	"	+5	2.14	4.50	2.00	" " "
4-25-35	"	+12	2.09	4.87	2.07	" " "
Hyperthyroid Cases.						
2-23-35	Cl.Cr.	+25	1.72	5.2	2.41	
2-26-35	"	+18	1.72	5.49	2.70	
2-13-35	G.T.	+29	1.44	4.10	2.20	On Lugol's solution
2-14-35	"	+14	1.44	3.40	2.07	" " "
2-15-35	"	+14	1.44	3.80	2.31	" " "

Average Cardiac Index = 2.2 ± 0.17

large number of normals with basal metabolic rates varying from -28 to +12 but also determinations on cases of hyperthyroidism, on cases in which artificial fever had increased the basal meta-

bolic rate during the fever, on myxedema cases before and after treatment, on patients whose basal metabolic rate had been changed by reduction in diet, and on cases in which basal metabolic rate had been increased following adrenalin injections, etc. (Table I.) We excluded all cases of valvular heart disease, of heart failure from any cause, and cases showing anemia. The basal metabolic rates in the cases which could not be called normal varied between -42% and $+29\%$. In our series, the standard deviation was 0.17 and the coefficient of variation was 8%. In other words, the variability has been reduced by one-half from Grollman's¹ findings with his cardiac index. We believe that our formula expresses a law of physiology which has no greater variations than other laws of biology; namely that transportation of oxygen is keyed to oxygen consumption.

8441 P

Transmission of Rabbit Papillomatosis by the Rabbit Tick,
Haemaphysalis leporis palustris.

C. L. LARSON, J. E. SHILLINGER AND R. G. GREEN.

From the Department of Bacteriology and Immunology, University of Minnesota, and the Bureau of Biological Survey, U. S. Department of Agriculture.

Rabbit horns occurring on cottontails and on jack rabbits were described by Seton.¹ He reported specimens collected in Oklahoma, Nebraska, and Colorado. Transmission of these tumors was accomplished by Shope, who described them as infectious papilloma. Shope further showed that the causative agent is to be classed as a filtrable virus,² and succeeded in transmitting tumors to domestic rabbits.³

Our first attempts to transmit the infection to domestic rabbits were unsuccessful and we were unable to demonstrate any intracellular structures which might be termed inclusion bodies. Subsequently we succeeded in transmitting the tumors to cottontail rabbits,⁴ domestic rabbits,⁵ and to snowshoe hares.⁶ More recently Beard and

¹ Seton, E. T., *Life Histories of Northern Animals*, Vol. I. Charles Scribner's Sons, New York, 1909, p. 672.

² Shope, R. E., *J. Exp. Med.*, 1933, **58**, 607.

³ Shope, R. E., *Proc. Soc. Exp. Biol. and Med.*, 1935, **32**, 830.

⁴ Green, R. G., and Shillinger, J. E., *Reports Minnesota Wildlife Disease Investigation*, February, 1934, **1**, 13, 14. Mimeographed U. S. Dept. Agriculture.

⁵ *Ibid.*, July, 1934, **60**, 61.