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Velocity of Hemocyte Circulation in the Elytron of the Cockroach, *Periplaneta americana* Linn.

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Hemolymph movement in the wings of various insects has been observed by many workers,[1] but no reports on the speed of circulation of the contained hemocytes have come to the notice of the writers. Because of the function that the hemolymph may play in the exchange of respiratory gases through the wing membranes,[2] information which gives direct or indirect indication of hemolymph velocity is of interest. This paper reports the velocity of hemocyte movement in the subcostal cell of the right elytron of the cockroach, *Periplaneta americana* Linn.

The circulating hemocytes were observed by a technic which has been described.[3] In addition a strip of tinfoil was placed under the wing margin in order to reflect more light upward through the elytron. An ocular micrometer was used to measure the length of a portion of a selected hemolymph channel in the subcostal cell area. With the low power of the microscope the course of single hemocytes was followed throughout the length of this channel. The time required for a corpuscle to travel from one end of the measured path (1.7 mm.) to the other was noted by a stop-watch.

A total of 10 determinations with one minute intervals between measurements was made on each of 35 young adult specimens. The results are summarized in Table I.

Considerable variation in hemocyte velocities was encountered in this region of the insect wing. Sex was found not to be responsible for these fluctuations. Age and temperature were controlled factors. All specimens were in approximately the same age group; determinations were made at room temperature. So far it has not been found possible to measure simultaneously heart rate and hemocyte velocity in the wing. In a few cases, however, several series of alternate heart rate and hemocyte velocity determinations were made, but the 2 sets of measurements showed no relationship. Sometimes a fast heart would be associated with high hemocyte velocity;

1 Yeager, J. F., and Hendrickson, G. O., *Ann. Ent. Soc. Am.*, 1934, **27**, 252.

2 Portier, P., *Ve Congres International D'Entomologie*, Part II, 1933, 25.

3 Yeager, J. F., and Hendrickson, G. O., PROC. SOC. EXP. BIOL. AND MED., 1933, **30**, 858.

TABLE I.
Velocity of Hemocytes in Subcostal Cell of Roach Elytron.

No. of Animal	Maximum Rate (mm./min.)	Minimum Rate (mm./min.)	Aver. Velocity of 10 Determinations (mm./min.)
1	38.5	31.7	33.6
2	63.1	52.9	58.4
3	50.6	43.2	45.2
4	39.0	31.9	34.2
5	61.6	53.3	55.9
6	49.8	41.7	46.9
7	49.7	44.9	46.5
8	25.8	21.9	23.1
9	65.5	64.7	65.2
10	25.9	24.9	25.4
11	19.4	12.9	15.9
12	20.5	18.9	19.7
13	19.4	10.1	16.1
14	49.7	54.3	52.0
15	26.8	29.5	28.5
16	31.7	28.5	29.8
17	29.3	22.2	24.3
18	18.6	12.9	14.5
19	25.4	20.6	22.8
20	42.3	33.7	37.2
21	38.1	30.3	32.1
22	40.9	32.6	36.3
23	41.8	30.4	36.8
24	20.2	15.7	18.7
25	35.1	28.4	30.7
26	20.0	16.1	17.4
27	29.9	24.2	26.3
28	33.1	25.6	29.1
29	34.2	33.6	34.4
30	58.4	55.9	57.1
31	46.9	45.2	46.3
32	22.3	15.8	20.6
33	65.5	63.3	64.4
34	25.9	23.8	25.3
35	34.2	22.8	30.1

Mean of average velocities $\pm\sigma$ = 34.3 $\pm$ 14.4 mm./min.
Range of average velocities = 14.5 to 65.2 mm./min.
Highest single rate observed = 65.5 mm./min.
Lowest single rate observed = 10.1 mm./min.

sometimes with a low hemocyte speed. No fixed correlation could be established. If the specimen was made to struggle or was otherwise disturbed, the heart action would become erratic. With the same type of stimulation hemocyte movement would sometimes cease, or become either extremely fast or quite irregular in contrast to the normal steady flow. The width of the channel in which the cells moved was very nearly the same (approximately 0.07 mm.) in all specimens. If the channel became obstructed by bits of tissue or by temporarily quiescent hemocytes the specimen was discarded.

In comparison with blood velocity in man, the range of the average hemocyte speeds (14.5 to 65.2 mm./min.) is considerably

wider than the range of capillary flow rates in man (30 to 54 mm./min.[4]). However, from the standpoint of velocity, the flow in the insect wing channels much more closely approximates the capillary rate of flow in man than the speed of blood in large arteries such as the carotid in which velocities of 18,000 mm./min. (horse) and 15,600 mm./min. (dog) have been recorded.[4]

Summary. The average hemocyte velocity in the subcostal cell of the elytron of the cockroach, *Periplaneta americana* Linn., is 34.3 ± 14.4 mm. per minute. The range of normal average velocities extends from 14.5 to 65.2 mm. per minute. This range approaches the range of 30 to 54 mm. per minute found in the capillaries of man. The highest hemocyte speed observed was 65.5 mm. per minute; the lowest 10.1. No relationship was detected between variations in velocity and sex or the heart rate of the insects used for this study.

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Relation of Viscosity of Blood to Leucocyte Count, with Particular Reference to Chronic Myelogenous Leucemia.

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Studies of factors which influence the viscosity of the blood have been concerned chiefly with the effect of changes in the total volume of the red blood cells. Nygaard, Wilder and Berkson[1] have recently shown that, within certain limits, the relation between the viscosity of whole blood and the hematocrit value may be well expressed by a linear formula, providing statistical confirmation of similar observations made by Allbutt,[2] Austrian[3] and Bircher.[4] The probable importance of the white blood cells in contributing to significant changes in the viscosity of the blood has been considered by a number of workers. Bircher[4] stated that the white blood cells did not influence the viscosity of normal blood because of their

4 Howell, W. H., Textbook of Physiology, 11 edition, 1930, 493.

1 Nygaard, K. K., Wilder, M., and Berkson, J., *Am. J. Physiol.*, 1935, **114**, 128.

2 Allbutt, C., *Quart. J. Med.*, 1910, **4**, 350.

3 Austrian, C. R., *Bul. Johns Hopkins Hosp.*, 1911, **22**, 9.

4 Bircher, M. E., *J. Lab. and Clin. Med.*, 1921, **7**, 134.