haemoglobin and red cell count were again within the normal range, their hearts were compared with those of normal individuals.

The findings indicate that nutritional anemia produces a true cardiac hypertrophy, the result of increased muscle fiber. The dried heart weights were found to be distinctly heavier, whether compared on the basis of age, weight, or length, the degree of enlargement based on the dry heart weights being inversely proportional to the degree of anemia. The ratio of dried heart weight to body length was found to average approximately the same for male and female in both normal and anemic groups, although a consistently higher ratio was observed amongst the latter. During the period of observation (24 to 44 days), the animals receiving the anemia correcting diet continued to show a high degree of hypertrophy in spite of the fact that the blood haemoglobin and red cell count had returned to normal.

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A Simple Method of Demonstrating Blood Circulation in the Wings and Wing-pads of the Cockroach, Periplaneta americana Linn.

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It has long been known that blood or hemolymph circulates in the wings of certain insects (Carus, Moseley, Brocher, and others). Most of these authors apparently observed the wing circulation with difficulty and were unable to identify completely the circulation scheme in a single insect wing at a given time. Such circulation diagrams, therefore, represent averages of a number of observations and conjectures based upon these. Brocher,[1] until recently,[2] saw the movement of individual blood cells only occasionally. Moseley[3] was unable to observe blood circulation in the forewing of the cockroach, *P. orientalis*.

The present paper reports a simple method of observing the details of blood circulation in the wings and wing-pads, as well as in the appendages and certain portions of the body, of the cockroach, *P. americana*.

[1] Brocher, F., *Arch. Zool. exp. et gen.*, 1916, **55**, 347.

[2] Brocher, F., *Rev. Suisse Zool.*, 1929, **36**, 593.

[3] Moseley, H. N., *Quar. J. Micr. Sci.*, 1871, **11**, 389.

Circulation in the forewing may be observed by placing the animal in a depression made in a piece of balsa wood; the depression should just fit the insect and should be of such depth as to leave the dorsal surface of the body slightly higher than the surrounding wood. The head and pronotum are retained by a piece of paper (Fig. 1, *p*) pinned to the wood (*w*); the abdomen and all but the forewing (F) to be observed are held in a similar manner by a piece of dull black paper (*b*). The wing (F) should be at an angle to the black paper (*b*), upon which is placed a movable piece of white kymograph paper (*k*) with the shiny surface uppermost, so that a beam of intense light (*l*) from a low voltage incandescent lamp (*L*) can be directed downward to the edge (*e*) of the kymograph paper, as shown by the arrow in Fig. 1. The details of circulation in the portion of wing lying just above the edge (*e*) of the white paper can be observed with the low power of the ordinary compound microscope; in order to observe circulation in other regions of the wing it is only necessary to move the edge (*e*) of the white paper to a point beneath the region to be observed and then to move the entire block of wood until the new region is in the beam of light and in focus through the microscope. By thus combining transmitted and reflected light the flowing blood becomes readily visible. The visibility of the blood depends almost entirely upon the reflection of light by the circulating blood cells. Both the absence of refractive bodies (cells) in the blood and the presence of much pigment in the wing tend to prevent the detection of wing circulation.

By means of this method, the scheme of circulation has been studied in the wings and wing-pads of *P. americana*. In general, the blood flows to the body in the anal veins excepting the first (i. e., in the posterior half of the wing) and from the body in the costa, subcosta, radius, media, cubitus, and first anal veins (i. e., in the anterior half of the wing). The blood flows in all of the main veins, intermediate veins, and cross channels. The flow may be very rapid and very constant in insects in good condition, when the animal remains quiescent in a snugly fitting depression chamber. Otherwise the flow may vary greatly, may stop completely, or may reverse in direction. Copious blood flow can be observed in both fore- and hind-wings to almost their distal extremities; the forewing is extended laterally to the flying position in order to expose the underlying hindwing. Extension of either wing in this manner tends to reduce wing circulation. The blood can be observed to enter the body from the outstretched wings, to enter the mesatergal

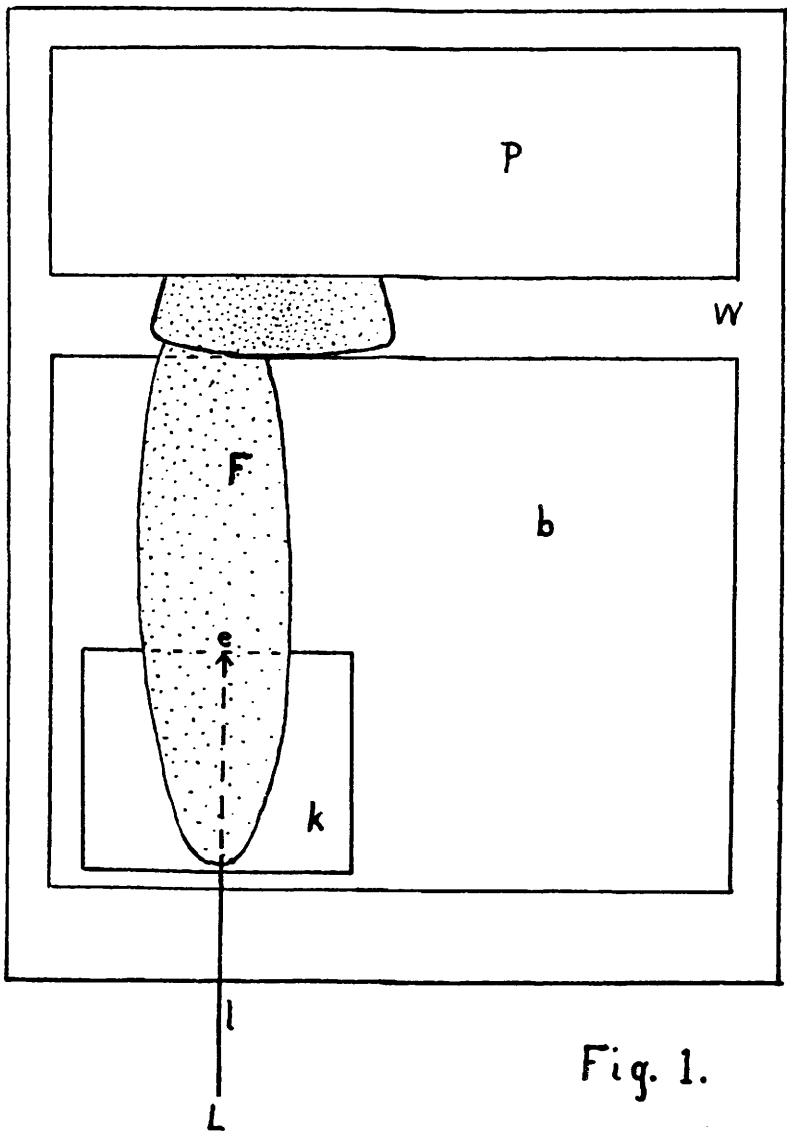

Fig. 1.

and metatergal pulsatile organs and to pass from these into the heart.

Wing circulation has also been detected by this method in *P. orientalis, P. fuliginosa,* and *Blatta germanica.*