venous side to the aortic arches, while the shunting of oxygen rich blood towards the pulmonary circuit could be larger. However, under conditions of unrestricted cutaneous respiration the difference in oxygen content between blood from the sinus venosus and the pulmocutaneous arches was small. It is concluded that a selective distribution of blood traversing the amphibian heart is possible and actually present in spite of the lack of a correlative anatomical separation.

KJELL JOHANSEN

Institute for Experimental Medical Research,
University of Oslo,
Ullevaal Hospital,
Oslo.

[1] Noble, G. K., *J. Morph.*, **40**, 341 (1925).
[2] Hazelhoff, E. H., *Experientia*, **8**, 471 (1952).
[3] Brücke, E., *Denkschr. Akad. Wiss. Wien*, **3**, 335 (1952).
[4] Vandervael, F., *Arch. Biol., Paris*, **44**, 577 (1933).
[5] Foxon, G. E. H., *Proc. Zool. Soc. London*, **116**, 565 (1947).
[6] Simons, J. R., and Michaelis, A. R., *Nature*, **171**, 801 (1953).
[7] de Graaf, A. R., *J. Exp. Biol.*, **34**, 143 (1957).
[8] Steggerda, F. R., and Essex, H. E., *Amer. J. Physiol.*, **190**, 320 (1957).
[9] White, F. N., *Anat. Rec.*, **135**, 129 (1959).
[10] Scholander, P. F., and van Dam, L., *J. Cell. Comp. Physiol.* **48**. 529 (1956).

Heart Mechanism in a Conchostracan, *Limnadia lenticularis* (L.)

THE present evidence suggests that the crustaceans can be divided in two groups according to the mechanism of their heart beat: branchiopods which have a myogenic heart; the other crustaceans with their neurogenic hearts, thus resembling the heart of other arthropods[1-4]. The branchiopods so far investigated include cladocerans (*Daphnia*[3,5-9], *Simocephalus*[3]) and anostracans (*Artemia*[3-4], *Eubranchipus*[4]). So far, nothing was known about the physiology of the heart in Conchostraca and Notostraca[3].

One of the few European species among Conchostraca, *Limnadia lenticularis*, originally described by Linnæus in 1758 on the basis of Finnish material, is occasionally found in Finland, always as a temporary inhabitant of rock pools with acid, humified fresh water on the rocky islands in the southwest archipelago. Females living in some pools in the vicinity of the Lohm Marine Biological Station were collected for experiments. The occurrence of *Limnadia* in this locality in June, 1960, was pointed out by Mr. Aatos Petäjä.

The heart of *Limnadia* is tubular, extending through 4 entire segments, open at both ends and equipped with 4 pairs of slit-like lateral ostia. The blood is drawn through the posterior opening and the ostiæ and forced by simultaneous contraction of the entire heart to move forwards and out through the opening at the anterior end of the heart. The anterior part with the first pair of ostia is situated on the place of attachment of the animal to its shell. This part of the heart is larger and apparently more effective than its other parts.

Ether (1/2–1/4 saturated aqueous solution), acetylcholine (10^{-2}, 10^{-3}, 10^{-4}) and adrenaline (10^{-3}, 10^{-4}, 10^{-5}) were externally applied at temperatures of 11–13° C. and 18–20° C. and the heart-rate recorded *in situ*. The heart-rates recorded previously after the application of the drugs and those of animals kept continuously during the experiment in the solvent served as controls. The control heart-rates ranged from 26 to 53 min.$^{-1}$ at 11°–12° C. and from 86 to 125 min.$^{-1}$ at 19° C. for females with a shell length of 10–11 mm.

When immersed in the ether solution, the movements of the telson, the legs, antennæ and the gut ceased in about 20 min., while the heart continued to beat at unchanged frequency. Acetylcholine was without any effect, observable for 1 hr. Adrenaline in concentrations of 10^{-4} and 10^{-5} in 15–20 min. caused an increase of about 50 per cent in the heart-rate. Adrenaline 10^{-3} caused a transient increase of the heart-rate and afterwards a decrease which in 40 min. from the beginning of the experiment resulted in a complete arrest of the heart, this arrest being reversible.

These observations suggest that the heart-beat is myogenic in Conchostraca, as in the other branchiopods studied. As the cessation of active leg movement and the closure of shell caused by mechanical stimulation were found to be accompanied by a rapid decrease in the heart-rate, the heart probably is under nervous control in Conchostraca. Anostraca seem to lack cardioregulatory nerves[4]. Further knowledge on the physiology of Conchostraca[10] would be interesting from the comparative point of view.

KARI LAGERSPEIZ

Department of Zoology and
Lohm Marine Biological Station,
University of Turku,
Finland.

[1] Krijgsman, B. J., *Biol. Rev.*, **27**, 320 (1952).
[2] Krijgsman, B. J., and Krijgsman, N. E., *Nature*, **165**, 936 (1950).
[3] Needham, A. E., *Nature*, **166**, 9 (1950).
[4] Prosser, C. L., *Biol. Bull.*, **83**, 145 (1942).
[5] Lévy, R., *C.R. Soc. Biol., Paris*, **97**, 1602 (1927).
[6] Suomalainen, P., *Ann. Zool. Soc. Vanamo*, **7**, 3 1 (1939).
[7] Sollmann, T., and Webb, W., *J. Pharm. Exp. Ther.*, **71**, 261 (1941).
[8] Baylor, E. R., *Biol. Bull.*, **83**, 165 (1942).
[9] Bekker, J. M., and Krijgsman, B. J., *J. Physiol.*, **115**, 249 (1951).
[10] Fox, H. M., *Proc. Roy. Soc.*, B, **143**, 203 (1955).

Rate of Replacement of the Molluscan Radula

DURING investigations of the mechanism of secretion and replacement of the molluscan radula an attempt was made to determine the rate of replacement. Carriker[1] collected the fæces of *Lymnaea stagnalis* and counted the number of broken radula teeth present—over 23 days he collected 613 teeth. As there are approximately 100 teeth in a transverse row it can be calculated from Carriker's figures that approximately 0·266 row of teeth is formed a day. This is obviously a minimum figure. It was decided to use an operative technique—*Lymnaea stagnalis* 2·5–3·5 cm. long were anæsthetized using 'Nembutal' and *M.S.* 222 (Sandoz)[2], an incision was made behind and below the left tentacle and the tip of the radula gland was cauterized over a small area. The survival-rate was very low; out of 93 animals only 11 survived for a sufficient length of time. The animals were killed over a period of 10 weeks and the radula isolated. Only the undamaged part of the radula gland continued secreting after the operation. The number of new rows were counted where possible, but in the case of two animals no new growth occurred while the old radula was shed at the normal rate. In these cases the number of remaining transverse teeth rows were subtracted from the average number of transverse rows (110) found in normal individuals.