On the Neural Gland, Nerve-Ganglion and Dorsal Tubercle of *Herdmania pallida* Lahille (the Typical Monascidian of the Indian Seas).

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THE monascidian *Herdmania pallida* Lahille[1] (*Rhabdocynthia pallida* Herdman) is dissected and studied as a type of the Tunicata in almost all the Universities of India, Burma and Ceylon. But no published account of its anatomy exists. Teachers and students usually seek help from accounts of *Ascidia*[2] and *Ciona*, the European monascidians, which are totally inadequate for a study of the Indian form *Herdmania*. The author has completely worked out the Anatomy, Histology, Bionomics and Distribution of this animal, a monograph on which will soon appear for use in the Indian Zoological Laboratories.

During the investigation a number of new and unexpected features have been found, but, in this article, the author confines himself to the structure, relationship and homology of the neural gland, nerve-ganglion and dorsal tubercle of *Herdmania pallida*. It may be mentioned here that, though a study of these three organs forms a very important part of the dissection of the ascidian in the graduate and post-graduate courses in Zoology, in India, their morphology has been wrongly interpreted for a decade or more since the substitution of ascidians from Tuticorin and Ennur for those formerly obtained from Naples and Plymouth.

The neural gland, nerve-ganglion and dorsal tubercle are all situated in the intersiphonal region of the animal, the former two lying imbedded in the mantle and the last projecting into the branchial cavity, in the prebranchial zone (Fig. 1). In the European forms *Ascidia* and *Ciona* the nerve-ganglion is situated dorsally to the neural gland (Fig. 2), but in *Herdmania* the nerve-ganglion always lies ventrally to the neural gland (Fig. 1). This change in position is attended with an alteration not only in the general lay-out of the three organs but also in their size, form and structure.

The *neural gland*, lying just above the nerve-ganglion, is a light brown oval structure about 4 mms. long, 2 mms. wide and 1 mm. thick. The gland consists of a large number of branching tubules given out towards its periphery from a few central tubes which open into a long non-ciliated canal running along the whole length of the gland (Figs. 3 and 4). At its anterior end this canal leads into a duct that passes downwards, between the nerves given out from the ganglion, and opens into the antero-dorsal region of the branchial cavity by a wide

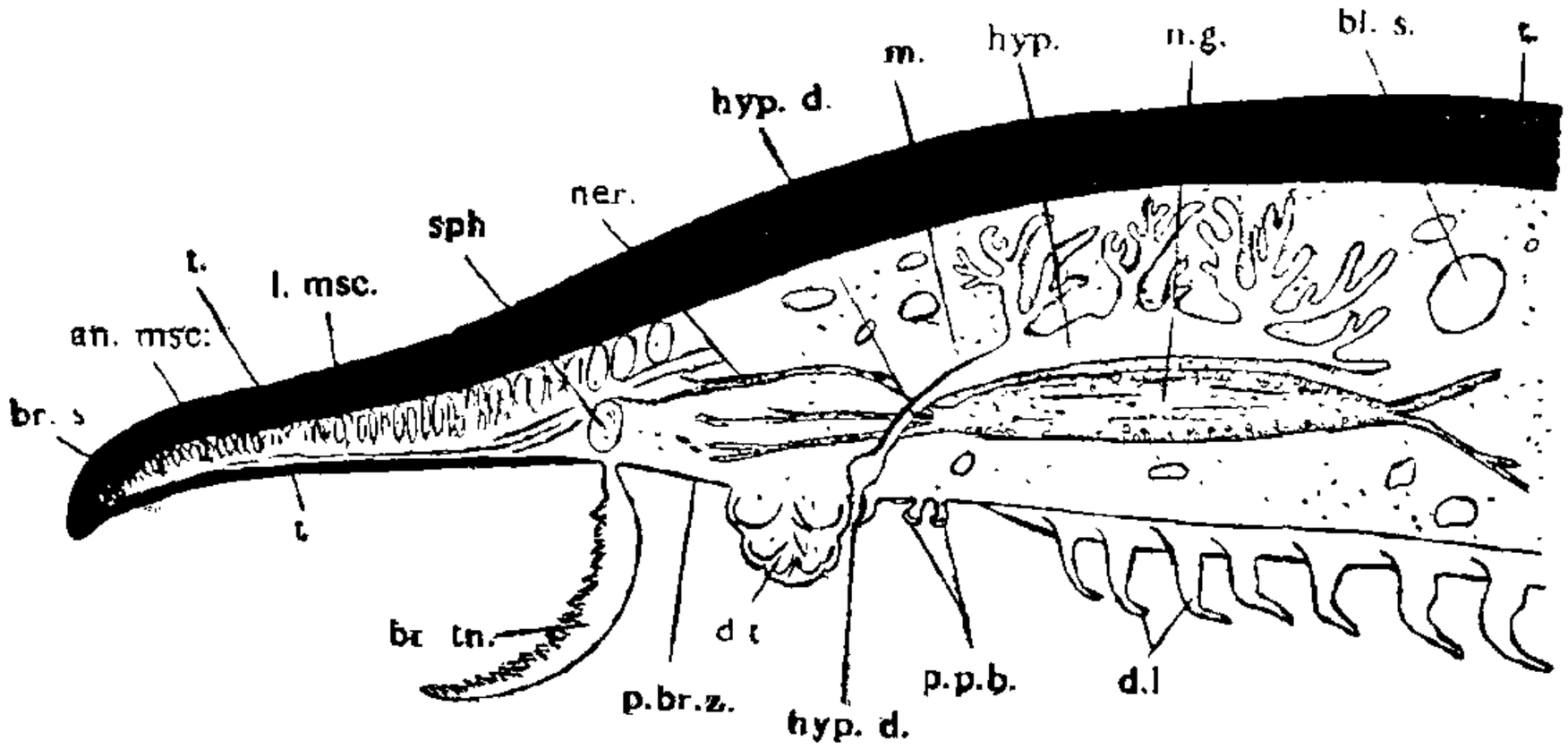

Fig. 1.

Longitudinal section of the neural gland, nerve-ganglion and dorsal tubercle of *Herdmania pallida*.

br. tn.—branchial tentacles; *d.l.*—dorsal lamina; *d.t.*—dorsal tubercle; *hyp.*—neural gland; *hyp.d.*—neural duct; *n.g.*—nerve-ganglion; *p.p.b.*—peri-pharyngeal bands.

[1] *C.R. Assoc., Franc. Sess.* 16, 1888, **2**, 677.

[2] *L.M B.C, Memoirs, Ascidia*, 1899.

ciliated funnel-shaped opening at the middle of the basal part of the dorsal tubercle. This wide funnel is absent in *Ascidia*. The lumen of the gland as well as its ducts are lined with a single layer of small non-ciliated rounded cells containing large nuclei. The rest of the gland consists of a large number of small dark granulated cells with large nuclei, some scattered blood-corpuscles and some blood-sinuses traversing the substance of the gland (Figs. 1, 3 and 4). A large

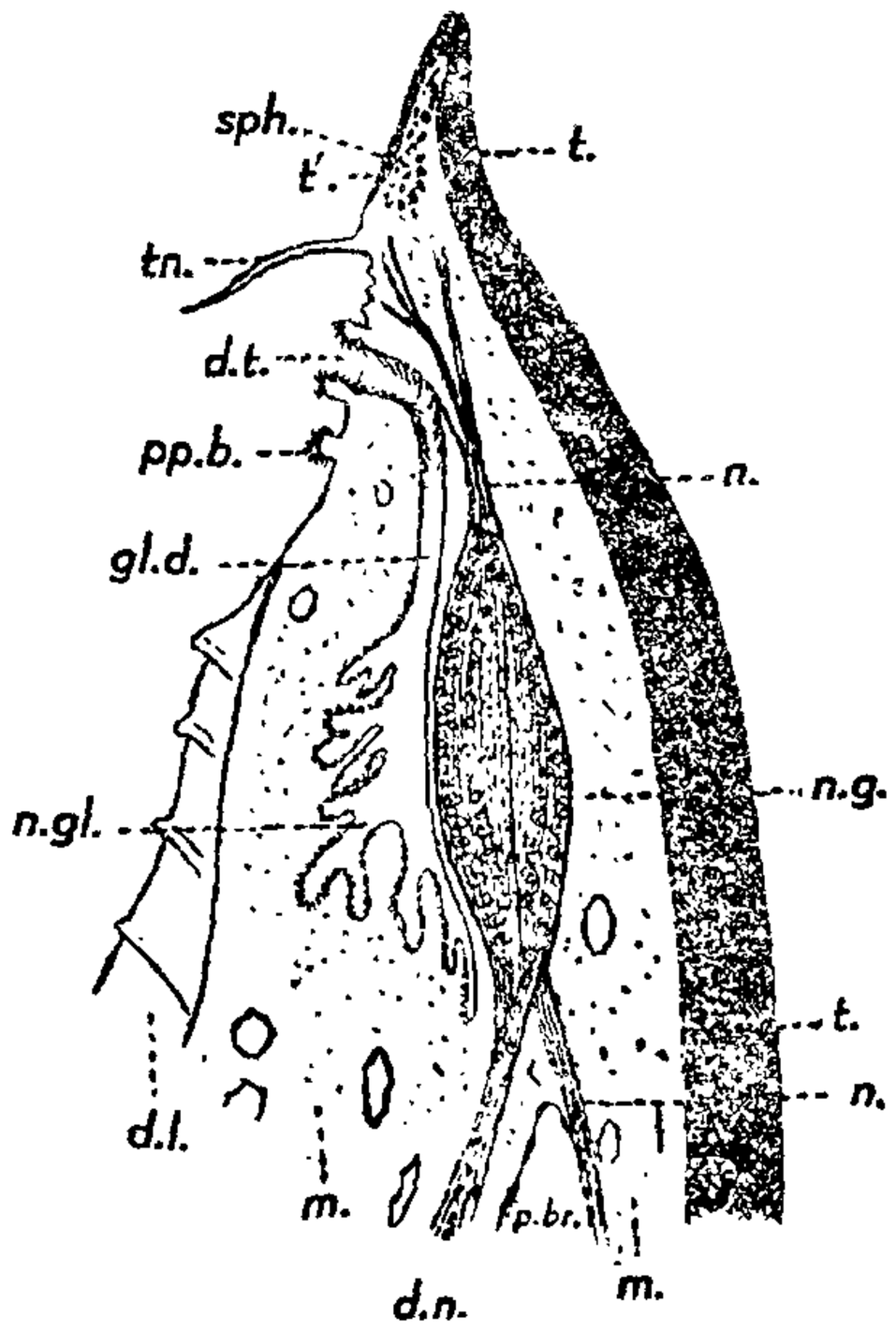

Fig. 2.

Longitudinal section of the nerve-ganglion, neural gland and dorsal tubercle of *Ascidia* (from Parker and Haswell).

n.g.—nerve-ganglion; *n.gl.*—neural gland; *d.t.*—dorsal tubercle.

number of cells filled with dark granules are discharged into the lumen of the gland, from where they pass out, through the main duct, into the branchial cavity. The dark granules are excretory products absorbed by the cells. The ciliated cells, lining the funnel-shaped opening, are of the same kind as those covering the dorsal tubercle, the cilia being about double the length of the cells themselves.

The *nerve-ganglion* forms an elongated, solid pinkish mass—about 4 mms. long and 1 mm. thick—lying ventrally to the neural gland. It gives off three nerves anteriorly (*i.e.*, towards the branchial siphon) and two posteriorly (*i.e.*, towards the atrial siphon) (Fig. 1). Of the three anterior nerves two are stouter than the third, and these, soon after their origin from the ganglion, diverge and run, one on each side of the posterior margin of the branchial siphon, along the base of the circle of tentacles. They thus approach each other on the ventral side of the branchial siphon and end in fibres that branch but do not anastamose. All along their length they send branches into the tentacles and to the muscles and inner epithelium of the siphons. The third nerve, which is finer than the other two, arises in between them and runs towards the branchial aperture, obliquely across the wall of the siphon, sending nerve-fibres to the muscles and the epithelium of the siphon. The two nerves arising from the posterior end of the ganglion diverge and encircle the base of the atrial siphon, sending branches to the muscles and the epithelium of the atrial siphon. The ganglion consists of an outer covering of very large cells with large nuclei and a main central zone of a loose fibrous matrix in which a large number of bi-polar and multi-polar nerve cells are imbedded. The large cells of the outermost layer—"the ganglion cells"—are oblong in outline and contain thickly granulated cytoplasm in which is imbedded a large nucleus. The central zone consists of a mass of inter-lacing nerve fibres in which a large number of nerve cells with two or more dendrites are scattered.

The *dorsal tubercle* is situated below the nerve-ganglion, in the pre-pharyngeal zone, near the junction of the peri-pharyngeal bands with the dorsal lamina. It consists of a broad base and two conical projections, each of which is formed of a spirally coiled lobe that tapers towards the summit of the tubercle (Fig. 1). In *Ascidia* and *Ciona* the tubercle is a simple horse-shoe-shaped structure, without the conical lobes, and is much smaller in size than in *Herdmania*. The basal part consists of a hemispherical concave lobe over which lies a convex dome-shaped lobe. In between the two spiral coils lie gaps or open channels which form a continuous open channel from the base of the tubercle to the tip of each cone (Fig. 3). The two channels of the two sides meet

under the dome-shaped hemispherical basal lobe, and form the concave base, in the centre of which the ciliated funnel opens. The general surface of the organ, except the bottom of the most proximal groove, is covered by a single layer of tall cylindrical

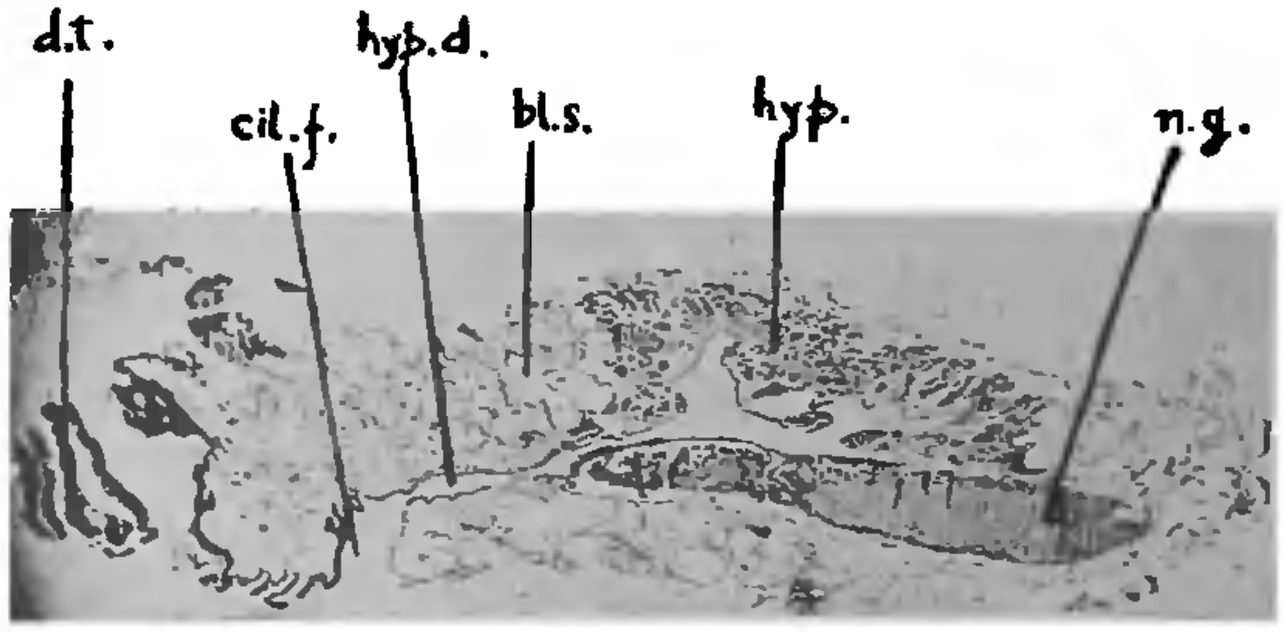

Fig. 3.

Photo-micrograph of a longitudinal section through the neural gland, nerve-ganglion and dorsal tubercle of *Herdmania pallida.*

bl.s.—blood-sinus; *cil f.*—ciliated funnel.

columnar epithelial cells copiously provided with very long cilia. The rest of the tubercle consists of loose connective tissue containing a large number of extensive blood-sinuses, connective tissue cells scattered throughout and a number of nerve-fibres

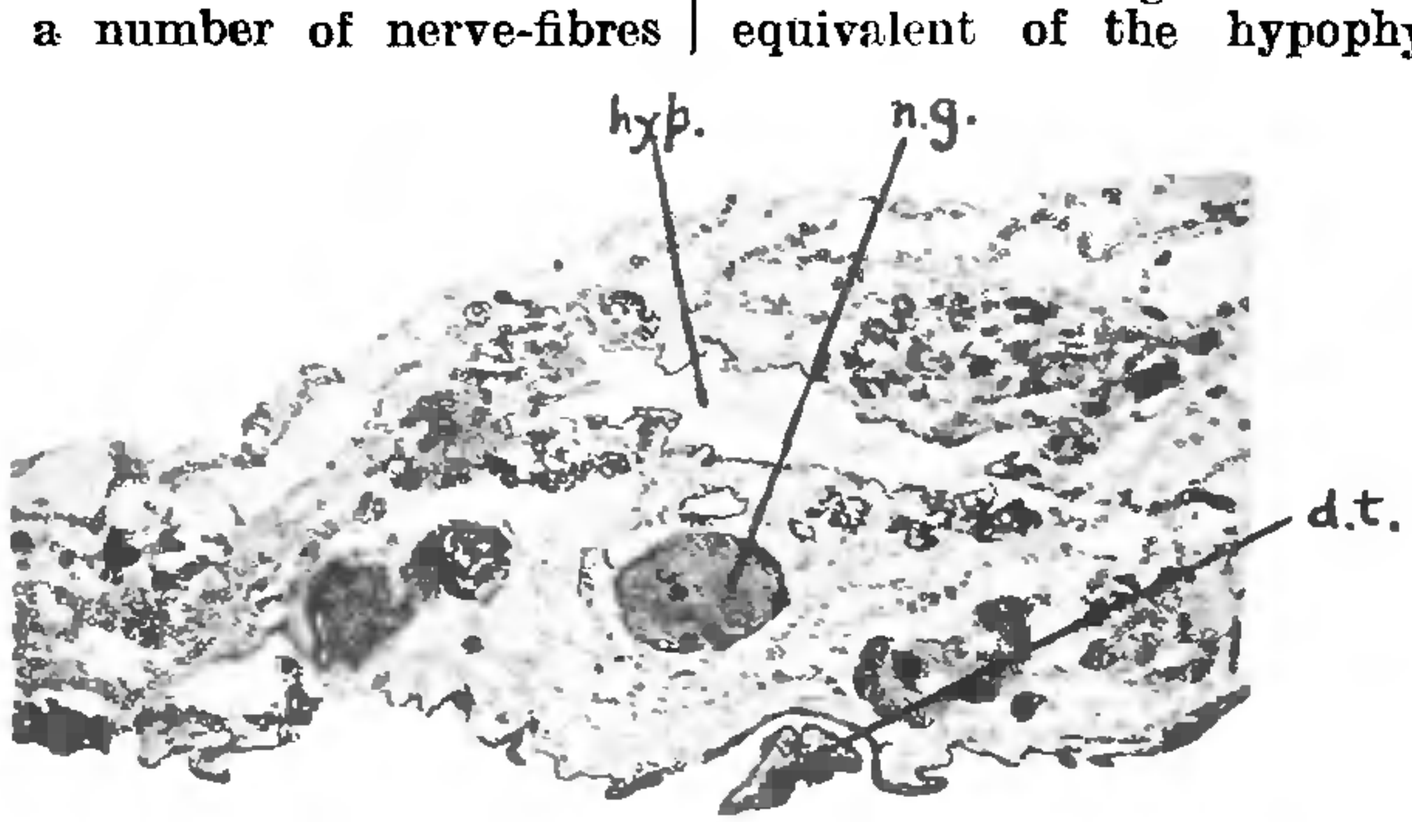

Fig. 4.

Transverse section through the neural gland, nerve-ganglion and dorsal tubercle of *Herdmania pallida* (Photo-micrograph).

that snpply the covering epithelium of the organ.

The homology and function of the neural gland and the dorsal tubercle have been subjects of much dispute. Early investigators described the dorsal tubercle and the ciliated funnel as an olfactory organ. Julin considered it merely as the opening of the neural gland. But the rich innervation of this organ, as Metcalf[3] and Hunter showed, points to a sensory function. The actual sensory function subserved may be gustatory or olfactory, or, as the author thinks, both—since both functions could be efficiently performed by a pre-pharyngeal sense-organ like the dorsal tubercle. Metcalf demonstrated that the opening of the neural gland into the pharynx is a modified neuro-pore and favoured the view put forward by Julin that the neural gland is the morphological equivalent of the hypophysis cerebri of vertebrates. Julin also suggested that the gland subserves an excretory function. Lacaze-Duthiers[4] tried to establish the theory that the neural gland secretes mucus which is poured into the pre-pharyngeal zone of the gut and serves the purpose of

[3] *J.R.M.S.*, 1901.

[4] *Mem. Acad. Sci. Inst. France*, T. 45, 1.

entangling microscopic food particles brought in with the water current. But this theory can in no way be correlated with the facts: (1) that the main work of food collection is done not in the pre-pharyngeal zone but in the pharynx itself, (2) that the endostyle is the main mucus secreting organ and supplies the peri-pharyngeal zone with the necessary mucus, and (3) that cells containing dark granules are secreted into the cavity of the neural gland and are discharged therefrom into the branchial cavity. The structure of the neural gland in *Herdmania*, the fact that the secretion of the gland originates by the disintegration of cells proliferated from the endothelium of its walls and the presence of dark granules in the excreted cells, strongly indicate that the gland subserves an excretory function. The opening of this gland at the base of the sensory dorsal tubercle is, however, a problematical association. But, as Herdman[5] pointed out, this connection between the duct of a gland and a pre-pharyngeal sense organ may be a secondary and purely accidental relationship.

The relative position of the neural gland, nerve-ganglion and dorsal tubercle is also of phylogenetic importance. The dorsally situated neural gland of *Herdmania*, which belongs to the Cynthiidæ, has thus far been found in only one other family of ascidians —the Botryllidæ. But Botryllidæ are compound ascidians and as such can have no direct relation with the Cynthiidæ, which are simple ascidians, according to Herdman's system of Tunicate classification[6] followed in most text-books of Zoology. On the other hand, the similarity in the dorsally situated neural gland points to a common origin of the Cynthiidæ and the Botryllidæ. A number of other examples from Herdman's system of classification show an unnatural separation of forms admittedly allied. *Clavellina* and *Diazona* are more similar in structure to *Ciona* than to *Coelocormus* or *Perophora*.[7] These affinities can be proved embryologically also. It is certain, therefore, that the compound ascidians are not a closely knit group of ascidians obtained from one common stock, but that they have evolved separately from different simple ascidian stocks to which they are more closely related than to other compound ascidians.

The author wishes to express his thanks to Dr. Sundara Raj of the Madras Fisheries Department for placing the resources of the Tuticorin Fisheries Station at his disposal for the collection of material. To Professor K. N. Bahl he is very much indebted for taking keen interest in the progress of the work and for valuable criticism.

[5] *Proc. Roy. Soc. Edin.*, 1883, **12.**

[6] *Journ. Linn. Soc. Zool.*, 1891, **23.**

[7] Garstang, *Rep. Brit. Assoc.*, 1895, 718-19.

Obituary.

Shiv Ram Kashyap (1882-1934).

RAI BAHADUR DR. S. R. KASHYAP, B.A. (Cantab.), D.Sc. (*Honoris Causa*, Panjab), I.E.S., F.A.S.B., Professor of Botany, Government College, Lahore, and of the Panjab University and Honorary Professor of Botany, Hindu University, Benares, died suddenly at Lahore, on the 26th November, 1934, of heart-failure. Even half an hour before his death, he was attending to his work with his characteristic thoroughness.

To-day his country is the poorer by the loss of one of its best-known and best-beloved intellectuals. As a scientist, he was respected all the world over and as a teacher he will be mourned by a host of admiring students all over the country, many of whom are holding University Chairs in Botany and other important appointments. For ever, he will be looked upon as one of the chief makers of modern Indian Botany. His pioneer researches on Himalayan Liverworts will go down to posterity as a great scientific achievement which will keep alive his memory for ever.

In his early life, Kashyap had a brilliant and remarkable academic career which can seldom be rivalled. Born on 6th November 1882 at Jhelum of a family with a long record of meritorious military services, he matriculated from the Panjab University in 1899. In 1900, he joined the Medical School at Agra and received his Medical Diploma in 1904, topping the list of successful candidates and winning the First Medal. He then served for two years in the Medical Service of the United Provinces.

While still a student of the Medical School he appeared as a private candidate for the Intermediate science examination