

natural vegetation has been destroyed by gross over-grazing and injudicious ploughing of natural grass-lands. In such places the contemporary local tree growth records will be found as a lengthening series of microscopic rings, just as in the period when the Pueblo culture was rapidly dying out. Dry spells may be inevitable, but their effects could largely be mitigated if we could,

through a better knowledge of climatic cycles, foretell their arrival, and prepare for them through a more conservative use of the local resources of grass and timber. It is to be hoped, therefore, that some research may be taken up to show how far such data can be used to solve Indian problems in human and climatic history.

On the Structure and Function of the Ascidian Test.

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THE present communication is intended primarily to supplement our knowledge of test of Tunicata, and secondarily to demonstrate that the test should not, as in the past, be regarded merely as an exoskeleton but should be considered as a medium for the communication of the animal with the outer world—comparable to the skin of the higher animals. The author's investigations were carried out on the test of the ascidian *Herdmania*, this animal being of a fairly large size and well represented in the coastal waters of South India.

The test of ascidians has been described by many authors in the past. Of recent years, Morgan¹ (1891) described the origin of the test cells; Herdman² (1899) gave a detailed account of the test in *Ascidia*; while Miss Herdman³ (1924) worked out the histology of the test of *Botryllus*. None of these investigators, however, makes any mention of the presence of nerve-cells or of any nervous mechanism in the test. The author⁴ has, however, demonstrated the presence of nerve-cells, nerve-fibres and receptor cells in the test of *Herdmania*.

The test, which except for the branchial and atrial apertures is the only part of the animal visible externally, surrounds the body of the ascidian and is about 4 to 6 mms. thick. At the postero-ventral end of the animal, however, the test is 2 to 3 cms. thick and constitutes a "foot" by which

the animal remains attached to the sea-bottom. It is soft and leathery, more or less translucent and on sectioning cuts like soft cartilage. As in other ascidians it is composed of tunicine⁵—a close ally of cellulose. The general substance of the test consists of a clear matrix in which are present a large number of cells, interlacing fibrils, minute spicules and branching and anastomosing vascular tubes.

Test Vessels.—There are two main blood vessels, the *sub-endostylar test vessel* and the *sub-intestinal test vessel*, which enter the test and ramify into innumerable fine branches in its substance sending a few large branches into the "foot". These test vessels branch, anastomose and send fine branches towards the outer surface of the test where they end in ovoid or rounded terminal knobs or ampullæ (Fig. 1). The ampullæ appear red in colour due to the presence of red pigment in the ectodermal cells which cover them. These ampullæ appear very close to the outer surface of the test and thus bring blood into close contact with the oxygenated water in which the animal lives. They, therefore, form an apparatus for accessory respiration, which may be compared with the cutaneous respiration in other animals. The only other description of a respiratory organ besides the branchial sac (pharynx), in Tunicata, is that of Herdman⁶ (1885).

The Spicules.—The spicules found in the test are of two types: the *microscleres*, which are very small in size, and the *megasccleres*, which are much larger. They are all calcareous and have a definite shape

¹ Morgan, "Origin of test cells in ascidians", *Journ. Roy. Micr. Soc.*, 1891.

² Herdman, W. A., "L. M. B. C. Memoirs", I, *Ascidia*.

³ Herdman, E. C., "L. M. B. C. Memoirs", XXVI, *Botryllus*.

⁴ A detailed account of the investigations will be published elsewhere.

⁵ Franchimont, "Sur la cellulose animale ou tunicine", *Compt. Rend. Acad. Sci.*, 89, 755-56.

⁶ Herdman, W. A., "On a new organ of respiration in the Tunicata", *Proc. Lit. Phil. Soc.*, 1885.

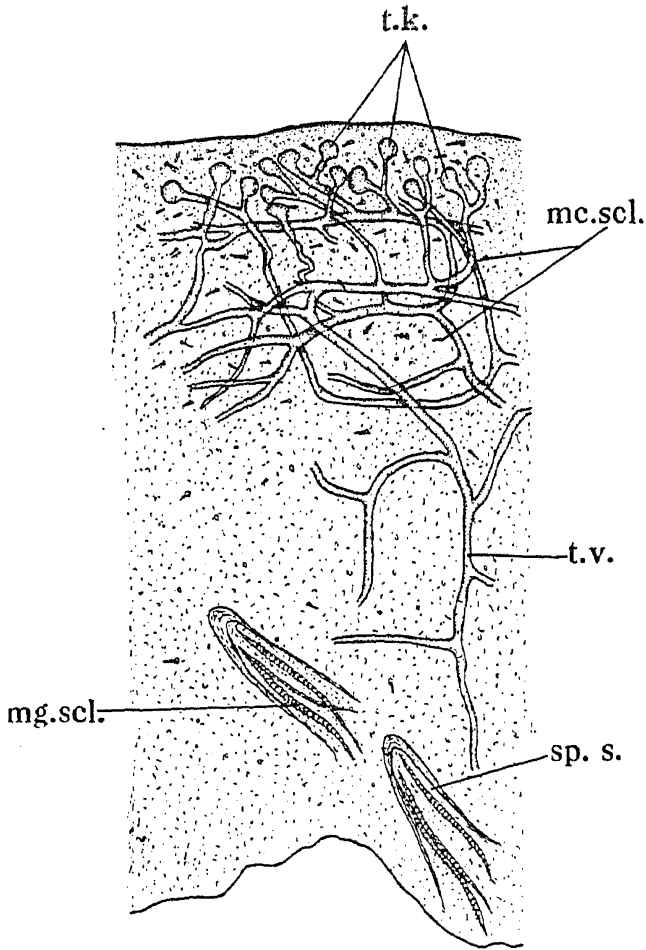


Fig. 1.

A vertical section of the test.—*mc. scl.*, microscleres; *mg. scl.*, megasccleres; *sp. s.*, spicule sheath; *t.k.*, terminal knobs; *t.v.*, test vessel.

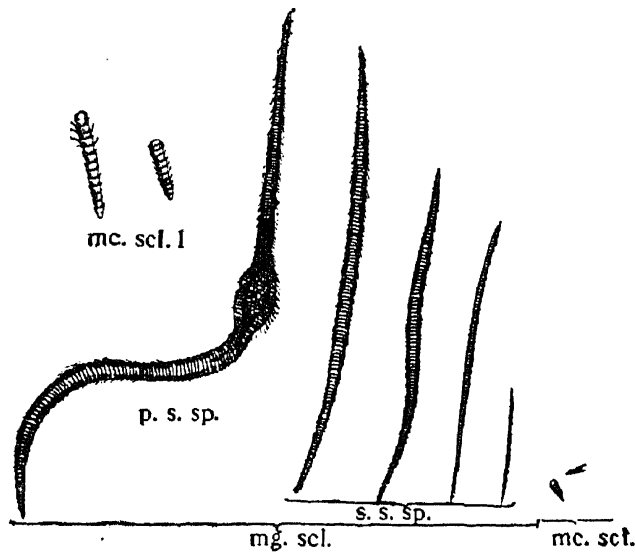


Fig. 2.

Spicules found in *Herdmania*.—*mc. scl.*, *mc. scl. 1*, microscleres; *mg. scl.*, megasccleres; *p. s. sp.*, pipette-shaped spicules; *s. s. sp.*, spindle-shaped spicules.

(Fig. 2). The microscleres are found in large numbers scattered throughout the test substance. Each spicule consists of a knob-like head and an elongated body bearing spines arranged in rings. Two kinds of megasccleres have been found: the *spindle-shaped*

and the *pipette-shaped* spicules. The spindle-shaped ones are enclosed in a connective tissue sheath and are present mostly in the postero-ventral half of the test, where they form a covering round the larger vessels traversing the test. As in the case of microscleres, each spicule has a large number of rings of spines. The pipette-shaped spicules are larger than the spindle-shaped variety and differ from them in having a swelling in the middle. They are, however, never found in the test, being confined mainly to the mantle. Herdman⁷ (1885) gave a description of calcareous spicules in Tunicata and later⁸ (1891) founded the genus *Rhabdocynthia* (*Herdmania*) on the presence of spicules. But he seems to have missed the pipette-shaped spicules altogether and has also made no mention of the exact structure, arrangement and distribution of the spicules.

Test Cells.—The cells of the test are of many different kinds. Five different kinds of cells can be discerned in *Herdmania* (Fig. 3) besides the nerve-cells and receptor

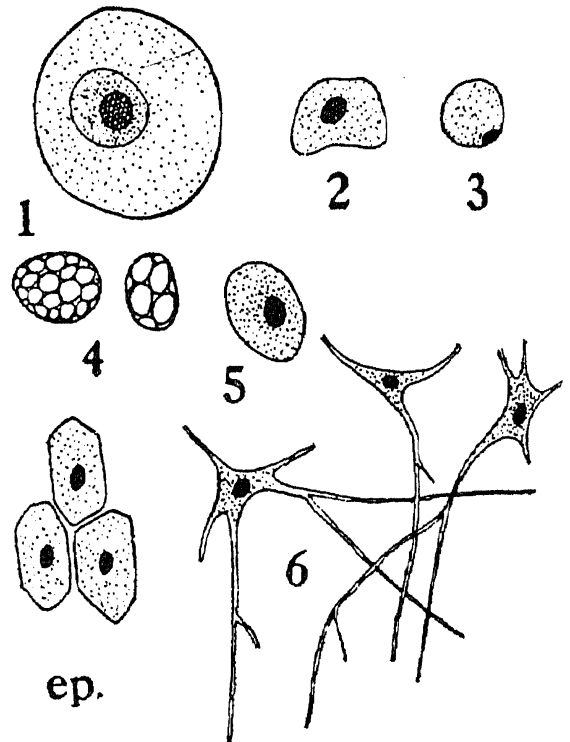


Fig. 3.

Cells found in the test.—1. Large eosinophilous cell; 2. Amoeboid cell; 3. Small eosinophilous cell; 4. Vacuolated cells; 5. Granulated cell; 6. Nerve cell; *ep.*, epithelial cells from an ampulla.

cells described later. The largest of these are (1) the few *large eosinophilous cells*,

⁷ Herdman, W. A., "The presence of calcareous spicules in the Tunicata", *Proc. Linn. Soc.*, 5, 1885.

⁸ Herdman, W. A., "A revised classification of the Tunicata", *Journ. Linn. Soc. Zool.*, 23, 575.

usually spherical in shape and staining a bright red with eosin. The cytoplasm consists of a thin homogeneous mass of fine granules and the nucleus is a large vesicular structure in the centre of the cell. Next to these in size are (2) the *amœboid cells*, which are few and far between. The most abundantly represented cells, however, are (3) the *small eosinophilous cells* each with an excentric nucleus. They are scattered throughout the substance of the test but are more abundant in the inner half of the test than the outer. Further, there are (4) the *spherical vacuolated cells*, each of which may consist of three to four chambers or may contain a large number of small vacuoles. A nucleus cannot be seen in these cells. Lastly, near the outer surface of the test are (5) a few *granular cells*⁹ with large nuclei, around which the nerve-fibrils of the test get specially concentrated. The large bladder-cells present in the test of *Ascidia*¹⁰ and some other ascidians are not represented in *Herdmania*, unless the small spherical vacuolated cells are to be regarded as remnants of them.

Nerve-cells and Nerve-fibres.—When an ascidian is kept in a tank containing fresh sea-water and the stimulus of contact applied to various parts of the external surface (test), the animal is seen to respond to the stimulus in a definite manner. On touching the siphons with a hard body they are seen to contract, usually closing the branchial and atrial apertures in this way. The rest of the test, however, is not so sensitive as the siphons. Nevertheless, a sharp pin-prick on the test of the body proper also causes an immediate contraction of the part stimulated followed by a general contraction of the siphons and the body proper. The idea naturally followed that nervous tissue should be present in the test to enable the animal to feel the prick. Quite thin sections of the test, properly stained, revealed on examination a large number of cells in the test substance which resemble very much the nerve-cells of the higher animals.

Each nerve-cell (Fig. 3, 6) is pyriform, triangular or polygonal in shape, contains a large nucleus and gives out two to six dendrites which get very much elongated, join similar processes from other nerve-cells

and form a network of nerve-fibrils in the matrix of the test. The nerve-fibrils thus serve to connect the various nerve-cells with one another. The nerve-cells are more numerous in the test of the siphons than in that of the body proper and more so in the outer part of the test than in the inner. This is as it should be, if we take into account the greater sensitivity of the siphons and the fact that stimuli always affect the outer part of the test first.

Receptor Cells.—The external surface of the test of *Herdmania* can be divided into (1) the vascular areas, which have numerous vascular ampullæ, and (2) the non-vascular areas which have no ampullæ. Sections through the vascular areas of the test, when properly stained, revealed the presence of fine nerve-fibrils leading distally into the polygonal ectodermal cells surrounding an ampulla, usually a single nerve-fibre terminating in each cell (Fig. 4). Proximally, these nerve-fibres run on for

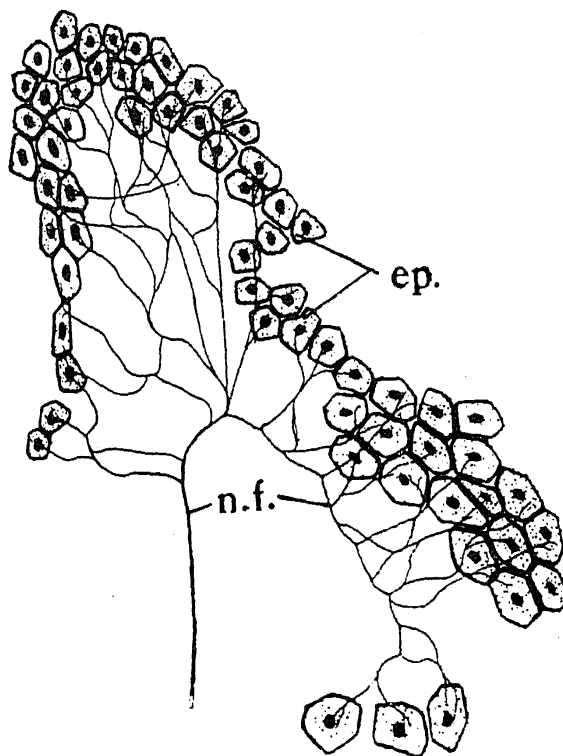


Fig. 4.

Nerve-fibres of an ampulla.—*ep.*, epithelial cells; *n.f.*, nerve-fibres.

some distance towards the base of the ampulla and then join to form a thicker nerve-fibril that runs on in the matrix of the test and is continued into the processes arising from the nerve-cells. It is quite clear, therefore, that in the vascular areas of the test, the epithelial cells surrounding the ampullæ form centres for the reception of stimuli. The nerve-fibrils communicate

⁹ See account of receptor cells.

¹⁰ Herdman, W. A., "L. M. B. C. Memoirs", I, *Ascidia*.

the stimuli to the nerve-cells. Experiments, however, showed that not only were the vascular areas of the test sensitive but that a pin-prick on the non-vascular areas of the test also produced similar effects though less marked in degree. Sections of the test through the non-vascular areas, revealed the presence of some ovoid cells, around which the nerve-fibrils of the test get specially concentrated. The presence of these cells in the non-vascular areas of the test, and their absence in the vascular areas, give additional proof that they have the same function here as that of the epithelial cells in the vascular areas.

Stimuli are, therefore, received by these receptor cells in the test and conducted by the nerve-fibrils which transmit them to the nerve-cells. Further, some nerve-fibrils from the nerve-cells pass into the mantle and finally join the nerves leading into the nerve-ganglion or brain. The instantaneous reaction to stimuli clearly shows that the nervous mechanism of the ascidian—though the nerve ganglion is said to be the degenerate representative of the larval brain and nerve-cord—is really very well developed.

Growth and Organisation of the Test.—The test in a living ascidian is continually worn at the surface. Growth takes place by the

formation of tunicine by the ectodermal cells lining the inner surface of the test and also by the mesodermal cells which migrate into the test through the walls of the test vessels and the vascular ampullæ.¹¹ The new test always gets organised by the immigration of the various kinds of cells into it. The test as a whole, therefore, not only serves for the protection and attachment of the animal (facts mentioned in most textbooks of Zoology) but also acts as a respiratory and a receptor organ.

Mention must be made here of the fact that this is the first time in the history of our knowledge of the Tunicata that a definite nervous mechanism has been demonstrated in the test or outer covering of these animals. 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. Acknowledgments are also due to Prof. N. J. Berrill of Montreal and Prof. E. S. Goodrich of Oxford for their kind suggestions. To Prof. K. N. Bahl of Lucknow he is very much indebted for taking keen interest in the progress of the work.

¹¹ Herdman, W. A., "I. M. B. C. Memoirs," I, *Ascidia*.

Theoretical Biology.

TO promote the study and work in the field of Theoretical Biology, a foundation for Theoretical Biology of animal and man, has been founded at the University of Leiden. In memory of the late Professor of Zoology, Van der Hoeven (1801–1888), the author of the "Philosophia Zoologica," it is called "Professor Dr. Jean van der Hoeven Stichting von theoretische biologie van dier en mensch". The chief objects of the foundation are (1) to arrange for lectures at the University of Leiden, (2) to bring to Leiden, biologists who are interested in theoretical biology into contact

with their colleagues in Holland and abroad, to bring about a contact for scientific purposes and organisations between theoretical biologists all over the world, for instance, by arranging international symposia on theoretical biology, (3) to publish articles on theoretical biology, and (4) to found a library on this subject. Directors of the foundation are Dr. C. J. van der Klaauw, Professor of General Zoology and Dr. T. A. T. Barges, Professor of Medical Anatomy, both at Leiden, and Dr. Adolf Meyer, Professor of Theoretical Biology at Hamburg.

Obituary.

Dr. Paul Brühl (1855—1935).

PROF. PAUL JOHANNES BRÜHL was born in Saxony on the 25th February 1855 and was the only surviving son of Michael Brühl. He finished his early education in German schools and colleges and joined the botanical touring party obtaining the travelling scholarship, as was customary during those days. He walked all the way through Central Europe, Asia Minor and Armenia after halting for a short period at Constantinople where he worked as a teacher for some time. During his tour he made valuable botanical collections. He reached India in 1881 and joined the Rajshahi College in 1882 as a teacher of Natural Sciences. In 1883 he married Annie Betts Fox. His botanical interest was known at this time and the reputed Botanist Sir George King, the then Superintendent, Royal Botanic Garden, Calcutta, got him transferred to the Bengal Engineering College in 1887. Here Prof. Brühl taught various subjects such as Chemistry, Physics, Geology including Mineralogy, Heat Engines and Agriculture. His vast knowledge in many subjects and more than fourteen languages and art of teaching and laboratory methods were of a high standard which soon gained explicitly all over this country. His popularity and sympathy towards his students and his keen interest in their welfare made Prof. Brühl's name a household word in many a Bengali house. His research work in Botany during his off time after the teaching work at the Engineering College found expression in such voluminous publications as *A Century of New and Rare Indian Plants* in collaboration with Sir George King. This work was published in the *Annals of the Royal Botanic Garden, Calcutta*, Vol. V, part II with 102-200 plates, most of which are Brühl's own sketches. His papers on "Plant Immigrants" is an important contribution towards the distribution of foreign plants in India. He officiated as the Principal of the Engineering College for some time. He retired from the Engineering College in 1912 and in recognition of his valuable and faithful service for forty years in the Government Educational Department, the title of Indian Service Order was conferred upon him by the Government

of Bengal. After his retirement from the Government service his interest for research work did not abate. In 1912 from October to March, he worked in Chemical Geology in the Indian Institute of Science, Bangalore. He was for some time teacher in Geology and Mineralogy at the Presidency College, Calcutta, and officiating Patent Secretary to the Government of India. At the request of the late Sir Ashutosh Mukerjee, he accepted the post of the Registrar, Calcutta University, in 1913, and worked as a Registrar, Controller of Examinations and Secretary of the Arts and Science Department of the post-graduate classes which was just developing at this time. He had also to offer his valuable suggestions in building up the Post-Graduate Laboratories and was subsequently entrusted to build up the Biological Laboratory of the Calcutta University and was appointed the University Professor of Botany. His scientific investigation was recognised by the University in offering him Doctor of Sciences as *Honoris Causa*. As a University Professor he is one of the pioneers in the investigations of the Lower Cryptogams and in forming the present Indian Botanical Society of India. Here, as a teacher of the post-graduate classes in Botany again, he was able to contribute a large number of papers in Botany—his much beloved subject—in collaboration with his students. As president of a Committee appointed by the Government of Bengal, his research work, financed by the Government of Bengal, on the eradication of Water Hyacinth from 1925 onwards resulted in the publication of many papers which suggested various avenues of investigation on this vital question.

Among his many publications his latest contribution entitled "A Census of Indian Mosses" published in the *Records of the Botanical Survey of India*, Vol. VIII, 1930, and his book on "Sikkim Orchids" are of the greatest value to the botanical investigation in India.

He has left one son and three daughters and many successful students, friends, colleagues and admirers to mourn his loss.

K. BISWAS.