Pogonophora in the Western Atlantic Ocean

Abstract. The occurrence of pogonophoran worms of the genus *Siboglinum* off the east coast of Florida is reported. Their presence in association with pennatulids is noted, and compared with a similar instance in the Bering Sea. This association is probably due to similar ecological requirements.

In the course of examining octocorals collected by U.S. Fish and Wildlife Service vessels off the southeastern United States (*1*), some examples of pogonophoran tubes were observed which are believed to be the first record of the phylum Pogonophora from the Western Atlantic. The Pogonophora, or beard worms, are peculiar wormlike deuterostomes (*2*). The collection was made at 28°23′ N, 79°56′ W, off the east coast of Florida in 94 fathoms of water, by the M/V *Silver Bay*, 1 February 1961 (station 2725). Ivanov (*3*) reports no finds from the east coast of North America.

Some fragments of extremely fine tubes with a diameter of 0.13 mm (Fig. 1, left), containing only macerated remains of the animals, seem to fall near *Siboglinum minutum* Ivanov as defined in Ivanov's key to pogonophoran tubes (*3*), although the latter is known from the Bering Sea and very probably is different from the present material. The slender tubes were associated with larger annulated tubes 2 mm in diameter, consisting of segments with widely spaced funnel-like expansions suggestive of certain pogonophores but which probably belong to polychaete worms of the family Chaetopteridae.

This pogonophoran material was associated with the pennatulid *Stylatula elegans* (Danielssen), around the polyp leaves of which the slender tubes of the beard worms were entangled. In this connection, it is interesting to note that pogonophores collected in the Bering Sea by the U.S. Fish Commission steamer *Albatross* were similarly associated with pennatulids and were represented by an extremely slender species of *Siboglinum* (Fig. 1, right), possibly *S. pusillum* Ivanov, which was also found associated with chaetopterid polychaetes inhabiting tubes strikingly similar to those of certain pogonophores. The fact that a soft substrate is required both by pennatulids and by pogonophores, together with the natural tangle provided by the spicules and polyp leaves of the sea pens, no doubt accounts for the close association of these animals in dredge hauls.

Historically, these *Albatross* pogonophores are of interest because they were collected 4 August 1890 (station 3308), several years earlier than the original specimens of *Siboglinum* taken by the *Siboga* expedition. As Hyman (*2*) suggests, it is likely that these animals have frequently been overlooked, hence they may be represented in even earlier *Albatross* dredgings that remain unstudied in the U.S. National Museum (*4*).

FREDERICK M. BAYER
Institute of Marine Science, University of Miami, Miami, Florida

References and Notes

1. I am indebted to Harvey R. Bullis, base director, Gulf and South Atlantic Exploration and Gear Research Base, U.S. Fish and Wildlife Service, Pascagoula, Miss., for the opportunity to study this material.
2. L. H. Hyman, *The Invertebrates* (McGraw-Hill, New York, 1959), vol. 5.
3. A. V. Ivanov, *Pogonophora* (Zool. Inst., Acad. Sci. U.S.S.R., Fauna U.S.S.R., n.s. 75, 1960).
4. This report is contribution No. 397 from the Marine Laboratory, University of Miami.

2 April 1962

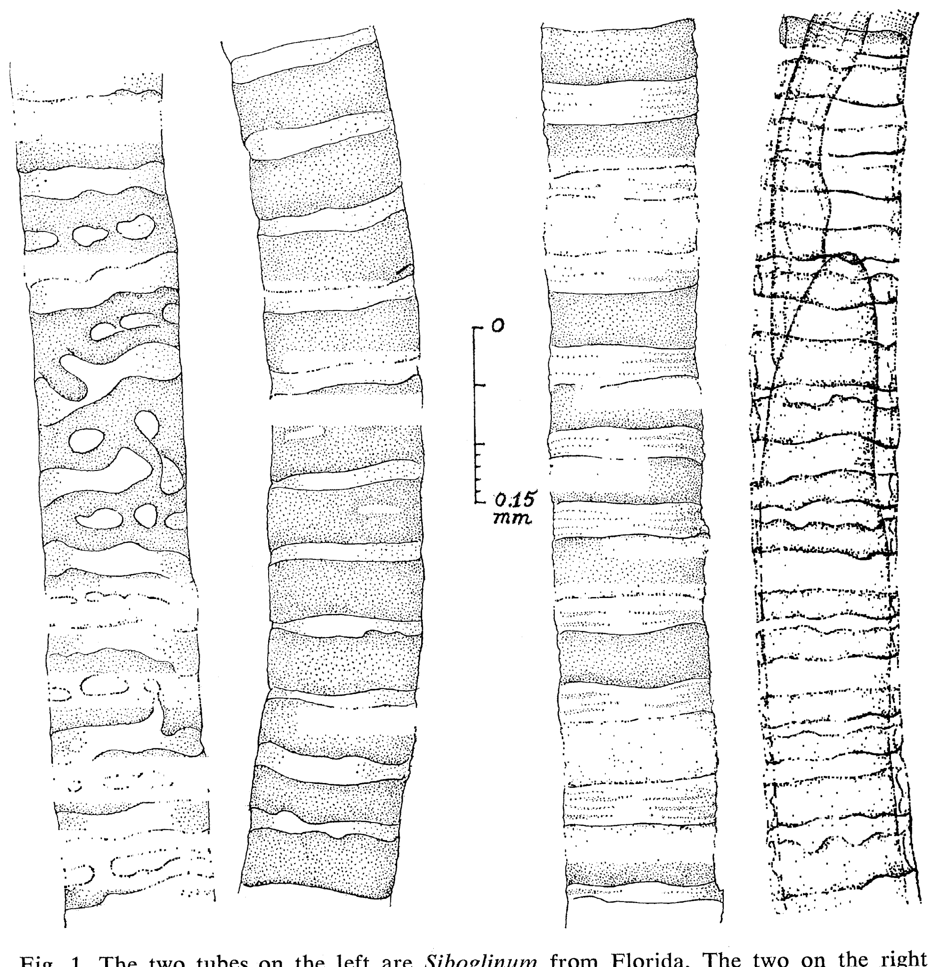

Fig. 1. The two tubes on the left are *Siboglinum* from Florida. The two on the right are from the Bering Sea. The tubes on the far left and far right are the proximal parts, the right one showing the protosome and base of the tentacle of the contained worm. The two center tubes are the distal parts.

Intercellular Connection between Smooth Muscle Cells: the Nexus

Abstract. High-resolution electron microscopy has revealed that the regions of contact between smooth muscle cells from dog intestine are areas of fusion of adjacent cell membranes. For morphological and functional reasons this type of contact between excitable cells has been termed a nexus.

The question of the discreteness of smooth muscle cells has been revived with the advent of modern electrophysiological recording techniques and electron microscopy. Electrically, smooth muscle cells behave as if their interiors were connected (*1*). Mark described two kinds of bridges between uterine smooth muscle cells (*2*): those with protoplasmic continuity and those traversed by membranes. Thaemert found only the former type in rat stomach and proposed calling them "anastomotic intercellular bridges" (*3*). Mark's second type of bridge has been described by Bergman (*4*) as occurring in rat ureter and by Prosser *et al.* (*5*) in several other smooth muscles. This discrepancy in morphological description, the lack of data from high-resolution electron microscopic studies, and the need for physiological correlations prompted the work we now report (*6*).

Smooth muscle was obtained by removing 2.0-cm segments of jejunum from anesthetized dogs. Rings of circular muscle were dissected free and incubated in Krebs-Henseleit solution at 37°C for 2 hours to allow them to recover both electrical and mechanical responsiveness after dissection. Portions of the exposed muscle were fixed in 1 percent buffered potassium permanganate and embedded in Vestophal. Serial sections were stained for 18 hours with 2 percent uranyl acetate.

Discrete regions of intercellular contact occur in muscle which is both electrically and mechanically active prior to fixation. These regions vary in size and represent mutual extensions of adjacent cells or extensions of single cells abutting neighboring cells (Fig. 1). Their frequency is difficult to determine; however, several can be observed in a single section of a muscle cell. No continuity of cytoplasm between adjacent cells is discernible. In fact, even at low magnification when the junction lies parallel to the incident electron beam, the cell membranes of both cells are seen to traverse the region. We have never observed cytoplasmic continuity with either osmic or permanganate fixation.

High-resolution micrographs of the regions of contact between smooth muscle cells reveal that the plasma membranes of adjacent cells fuse (Fig. 2). The plasma membrane, as demonstrated with permanganate fixation, appears as two dark lines approximately 75 to 80 A thick, separated by a less opaque inter-region. At the region of junction, the outer dark lines of the cell membranes join to form a single dark line. The thickness of this single dark line is approximately 25 to 30 A. If this were merely juxtaposition of the adjacent membranes, the central dark line should be nearly double the thickness of that observed. Thus, apparently there is a true fusion of the outer lamellae of adjacent cell membranes at these regions of contact (Fig. 3). Further, this implies a lack of extracellular fluid between cells at these regions. Recently, Robertson (*7*) has described a similar morphological relationship in the median giant-to-motor synapse of the abdominal ganglia of the crayfish. However, employing osmium fixed material, he was unable to decide "whether a complete or even partial fusion of unit membrane occurs . . . ."

There are both morphological and functional reasons for denoting the intercellular contacts described here by the unique term, the *nexus*. The term "intercellular bridge" has been put to various uses for describing morphological relationships with and without protoplasmic continuity (*8*). Already verbose, "intercellular bridge" needs further adjectives to make it specific. By

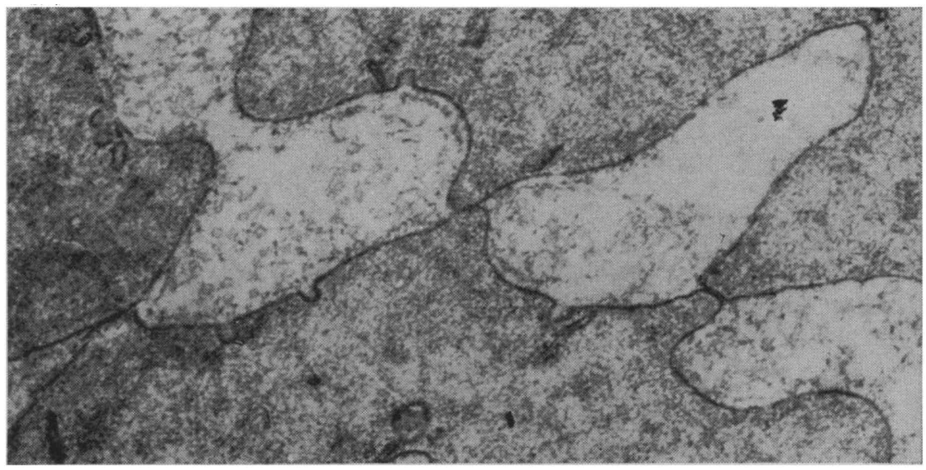

Fig. 1. Cross section of three smooth muscle cells showing three nexuses (× 29,500).

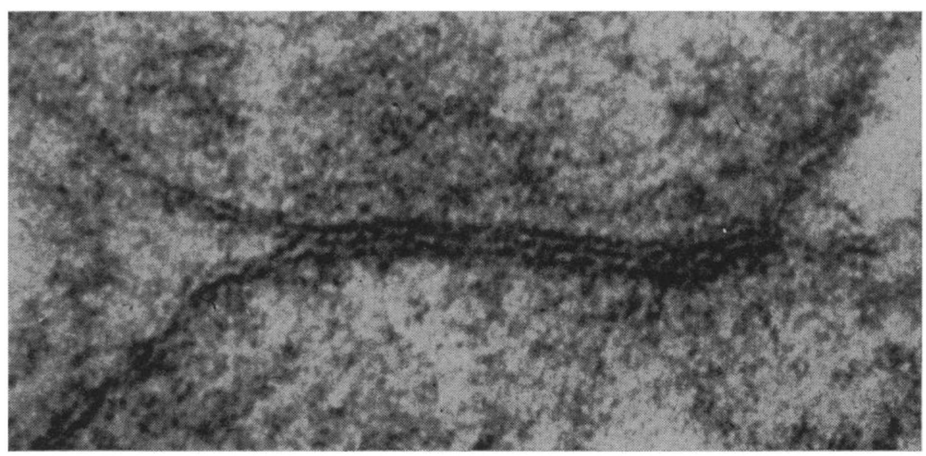

Fig. 2. Higher magnification of nexus in lower left-hand portion of Fig. 1. Outer lamellae of cell membrane fuse (× 324,000).

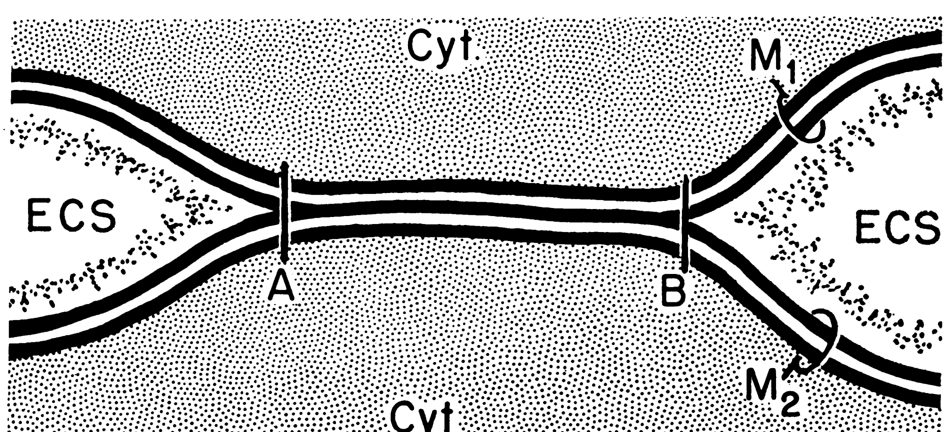

Fig. 3. Drawing of area shown in Fig. 2. *Cyt.*, cytoplasm of muscle cells; *ECS*, extracellular space; M_1 and M_2, plasma membranes of adjacent smooth muscle cells; *A* to *B*, nexus or region of fusion of plasma membranes.

the term nexus we mean a region where the plasma membranes of two excitable cells are fused. In smooth muscle fixed in permanganate, a nexus comprises three dark lines of uniform thickness separated by two lighter regions (Fig. 3). Wherever a nexus exists, the resulting direct fusion of the outer layers of the cell membranes without intervening extracellular space allows electrotonic spread of current from one cell membrane to another in a way similar to its spread along an axon. This is probably the mechanism for propagation in smooth muscle. The nexus might also occur in other excitable tissues. In the heart where propagation is apparently by electrotonic spread (*9*), some regions of the intercalated disc may in fact be nexuses (*10*). In the brain also there are interactions between groups of cells from which one might infer the existence of a nexal relation.

It is probable (*1*) that in smooth muscle current between active and inactive cell membranes is responsible for the propagation of action potentials. From the duration and velocity of action potentials in various smooth muscle cells it is inferred that many active cells are current sinks while many neighboring cells are current sources. Direct measurements on cat intestinal muscle corroborate this conclusion (*11*). Moreover, values obtained for action potentials and high potassium depolarization by the extracellular sucrose gap technique (*12*) approach the values obtained with intracellular microelectrodes. The success of the sucrose gap technique is due to the attenuation of current by increasing extracellular resistance between recording electrodes. The simplest equivalent circuit accounting for these data would have a direct electrical connection between cell interiors without intervening extracellular space. This, of course, is exactly what the nexus provides while maintaining cellular integrity.

MAYNARD M. DEWEY
Department of Anatomy,
University of Michigan, Ann Arbor
LLOYD BARR
Department of Physiology,
University of Michigan

References and Notes

1. E. Bozler, *Experientia* **4**, 213 (1948); C. L. Prosser and N. Sperelakis, *Am. J. Physiol.* **187**, 536 (1956); E. Bülbring, G. Burnstock, M. Holman, *J. Physiol. London* **142**, 420 (1958).
2. J. S. T. Mark, *Anat. Record* **125**, 473 (1956).
3. J. C. Thaemert, *J. Biophys. Biochem. Cytol.* **6**, 67 (1959).
4. R. Bergman, *Bull. Johns Hopkins Hosp.* **102**, 195 (1958).
5. C. L. Prosser, G. Burnstock, J. Kahn, *Am. J. Physiol.* **199**, 545 (1960).
6. Our work was supported by research grants A-3449 and A-3819 from the U.S. Public Health Service.
7. J. D. Robertson, *Ann. N.Y. Acad. Sci.* **94**, 339 (1961).
8. D. W. Fawcett, *Exptl. Cell Res. Suppl.* **8**, 174 (1961).
9. J. W. Woodbury and W. E. Crill, in *Nervous Inhibition*, E. Florey, Ed. (Pergamon, New York, 1961), p. 124.
10. F. S. Sjöstrand, E. Andersson-Cedergren, M. M. Dewey, *J. Ultrastructure Res.* **1**, 271 (1958).
11. L. Barr, "Electrical properties and sodium, potassium and chloride content of intestinal smooth muscle cells," thesis, Univ. of Illinois (1958).
12. G. Burnstock and R. W. Straub, *J. Physiol. London* **140**, 156 (1958); J. M. Marshall and A. I. Csapo, *Endocrinology* **68**, 1026 (1961).

18 May 1962

Patent Office Search Files: A Tool for Historical Research and Technological Development

Abstract. The classified search files of the U.S. Patent Office are useful for locating a desired patent record. The method of constructing these files, and the tools needed to enter the classification scheme at the proper locus, are described.

A recent article (*1*) has pointed out the value of the original records of the United States Patent Office as sources for the history of invention and technological property. These original documents are stored, and hence are not easily available for research and for browsing. As briefly noted in that article, in addition to the numerically (chronologically) arranged set of printed patents (as granted by the Office), a classified patent file is maintained in a public search room in the Department of Commerce building in Washington. With the proper tools of entry to this file, one can, for example, locate an invention without knowing the name of the inventor, his assignee (if any), or the date of the grant.

Three tools exist for entry into the classification hierarchy referred to in the Patent Office as the Classification Schedule. The first is a published list of five areas of invention, subdivided into over 300 classes and over 57,000 subclasses. This Schedule is printed in loose-leaf form (*2*) and is updated quarterly. It is constructed and maintained by the classification division of the Office. A manual of complex rules for its construction (*3*), though now out of print, is available for study in the Scientific Library of the Office. Since each patent in the file contains an evaluation of the contribution which the inventor has made to the art, the construction of the Schedule can be based upon this evaluation. In practice, patents containing like contributions are first grouped, then the relationships expressed in the differences between the groups are noted, and finally, these differences are used as a basis for establishing the subclasses.

The second tool, auxiliary to the first one, is a very extensive set of definitions of the subject matter contained in each class and subclass of the Schedule, including complex cross search notes for related subject matter, and for combinations and for subcombinations which have been separately classified. By proper definition, it is possible to create one and only one place for any combinatorial relationship which may exist at the time of definition, or which may be conceived at a later time. Although these "definitions" are not published or available for sale, a 12-volume set in loose-leaf form is maintained for the patent examiners, and is updated quarterly to conform with changes in the Schedule. Additionally, a set is available for consultation at the public search room.

A third tool is maintained for those who are unacquainted with the organization of this complex Schedule. It consists of an index to the Schedule, published therewith, which is maintained to aid one in entering the Schedule at either the proper place, or at a place where the search notes designate several other places for different inventions which might be described by a common term. Since this index is not generally used by professional patent searchers who almost uniformly rely on their knowledge of the intricacies of the Schedule, the index is revised only infrequently. It may, therefore, refer to classes or subclasses which have since been abolished, or from which the subject matter sought has been removed.

These classified files have other and important significance for those people, other than patent examiners and attorneys, interested in technical information (*4*). A report to a former Secretary of Commerce (*5*) stated:

". . . the files of the Patent Office comprise a veritable treasure house of information upon which much of our industrial progress has been based, including ideas whose significance may not be realized for years after the disclosures. They give today a clear indication of the present thinking of the most ingenious minds in the country