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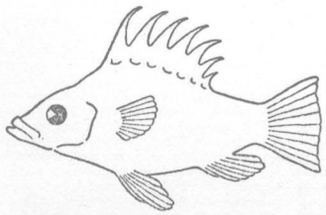
SEARS FOUNDATION FOR MARINE RESEARCH
Number I

Fishes of the Western North Atlantic



PART ONE

LANCELETS

Henry B. Bigelow, *Museum of Comparative Zoology and*
Isabel Pérez Farfante, *Museo Poey,*
University of Havana

CYCLOSTOMES

Henry B. Bigelow *and* William C. Schroeder
Museum of Comparative Zoology

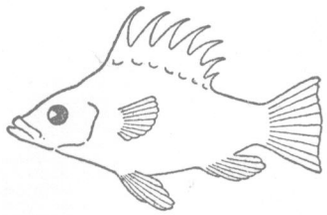
SHARKS

Henry B. Bigelow *and* William C. Schroeder

NEW HAVEN 1948

SEARS FOUNDATION FOR MARINE RESEARCH, YALE UNIVERSITY

Fishes of the Western North Atlantic



Editorial Board

NEW HAVEN 1948

SEARS FOUNDATION FOR MARINE RESEARCH, YALE UNIVERSITY

Albert E. Parr, *Editor*
Yngve H. Olsen, *Assistant Editor*

Preface

THE inhabitants of the waters of the earth have fascinated human beings ever since "God created great whales, and every living creature that moveth." Our interests have by no means been confined to the aesthetic or the gustatory; the reflections of Isaac Walton are an earnest of the composure and rapport with the universe that exists when fishes and their surroundings are contemplated; the mental relaxation of fly fisherman or surf caster needs no defense or explanation; the life of fishes, their migrations, their evolution, and the incredibly diverse facets of their activities, afford infinite opportunities for study by the scientist. In latter years man's curiosity about the inhabitants of "the water in the seas" has been increased and stimulated by his ever greater penetration into the deeps. Improved apparatus has enabled him to widen his sphere of effort and to capture fish for his markets farther from shore and deeper down than heretofore. With goggles and rubber fins he has pushed beneath the surface for momentary glimpses of those which live below; with diving helmet and diving suit he has gone deeper and investigated more closely; in the bathysphere he has dangled in the sea half a mile down and checked on the lives of the strange fishes which make their home in that dark and cold portion of the world.

Expeditions have gone forth with fishes as their prime consideration, and ichthyologists have studied what the expeditions brought back. Men and women in numerous laboratories have worked upon fisheries problems, while countless numbers of fishermen, professional and amateur, have added their bit to the knowledge of the whys and wherefores of our fishes. All this has produced an enormous quantity of information and lore which lies scattered in countless publications. The reason for the present series of volumes is to correlate the contents of the rich storehouse of knowledge relating to the fishes that live in the waters of the western North Atlantic.

This volume, the first of a series, describes the lancelets, the hagfishes and the lampreys, and those most interesting animals, the sharks. It has been written on the premise that it should be useful to those in many walks of life—to those casually or vitally interested in the general phenomena of life in our waters, to the sportsman whose interests are closely associated with pleasure and relaxation, to the fisherman whose livelihood depends upon knowledge of where fishes are gathered together, as well as to the amateur ichthyologist and the professional scientist. Special stress has been given to the relationship of the fishes to ourselves—in most cases this relationship is to man's advantage, but the present volume also carries this theme in reverse—some sharks will attack man!

Introduction

HALF a century ago Jordan and Evermann's *Fishes of North and Middle America* was published, and up to the present time these volumes have continued to be the only comprehensive descriptive account dealing with western Atlantic fishes. With the progression of years this work has become less available and more obsolete, which is understandable in view of the scientific advances made during the intervening decades.

Vast numbers of papers, both scientific and popular, have appeared since 1896–1900 —the dates of issuance of Jordan and Evermann's work. Numerous new genera and species have been described; many groups of fishes have been subjected to detailed study and revision, especially within the last two decades; new viewpoints on classification and phylogeny have been presented; much additional information has been published on life histories and habits of many species, and some regional studies of the fish faunas have been made. However, this new information remains widely distributed in numerous books and periodicals.

Since our knowledge of the fishes on this side of the Atlantic has reached a point of relative stability, particularly with regard to purely descriptive accounts, the present time seems especially suitable for a publication which embraces all of our knowledge of the fish fauna of this region. To bring together and synthesize this scattered ichthyological information and to make it available to both the public and to marine biologists is the primary purpose of this work.

The first volume of FISHES OF THE WESTERN NORTH ATLANTIC brings to fruition, at least in part, a plan which was conceived at New Haven some years ago. With the establishment of the Sears Foundation for Marine Research at Yale University in 1937, funds became available for publication, and a group of interested ichthyologists met to discuss the preparation of a work such as is here presented. To lay a firm groundwork and to initiate production, the Editorial Board was formed, the members of which are Charles M. Breder, Jr., Samuel F. Hildebrand, Albert E. Parr, William C. Schroeder, John Tee-Van, and, until his death in 1944, the late J. R. Norman of the British Museum (Natural History). Assisting the Editorial Board is an Advisory Committee: William Beebe (New York Zoological Society), Rolf L. Bolin (Hopkins Marine Station), William K. Gregory (American Museum of Natural History), Carl L. Hubbs (Scripps Institution of Oceanography), Daniel Merriman (Bingham Oceanographic Laboratory), George S. Myers

(Stanford University), John T. Nichols (American Museum of Natural History), Luis Howell-Rivero (University of Havana) and Leonard P. Schultz (U.S. National Museum).

The articles in this and subsequent volumes, which will be co-operatively produced by many ichthyologists, are intended to be critical reviews or revisions of each group rather than perfunctory compilations or mere reprintings of previously published works. An outline of the general classification has been prepared, based on widely accepted schemes of classification (such as that used at the British Museum). Standards for both the text and the illustrations have been formulated so as to achieve a fairly uniform treatment for all volumes. Under each species will be found both the distinctive characters which set it apart from its nearest relatives, a detailed description, as well as discussions of its color, size, general habits, abundance, range, relation to man (that is, its economic importance, danger to man, sporting qualities, etc.), and its occurrence in the western Atlantic. Since the publication will be used by lay persons as well as by ichthyologists and marine biologists, the use of highly technical words and phrases has been avoided as far as possible. Because of the large number of references which are included in a study of this nature, particularly in the "Synonyms and References," abbreviations have been used throughout. References to periodicals are listed and abbreviated in accordance with the standards established in *A World List of Scientific Periodicals, Published in the Years 1900–1933* (Oxford University Press, Second Edition, 1934), and an approximate consistency has been developed for books and periodicals not listed in that publication. The final volume will contain a complete and extended bibliography. Common names which are most generally used have been included; for future volumes it is possible that the recommendations of the Committee on Common Names of the American Fisheries Society will be available.

The geographical range of FISHES OF THE WESTERN NORTH ATLANTIC embraces the western half of the North Atlantic, including the adjoining gulfs and seas, from Hudson Bay southward to the Amazon River. But this range is not strictly adhered to in all instances; a number of species living close to the outer borders of the region covered by this publication are included, particularly when their inclusion assists in a more adequate understanding of the group under consideration. Brackish water species are included, and naturally those which are cosmopolitan. As far as oceanic forms are concerned, pelagic species are treated in full, while the strictly deep-sea (bathypelagic) fishes are referred to only in keys and by references to the more recent reports describing these animals. Two factors dictate this decision: 1) The relative paucity and incompleteness of our knowledge of these animals, and 2) the fact that they rarely, if ever, come within the provenance of the nonspecialist in fishes, since special vessels and gear are required to effect their capture.

The map which accompanies this first volume is by no means complete. Since it was prepared before the manuscript was finished, all the localities given in the text could not be included, particularly in such heavily worked areas as New England. However, it will

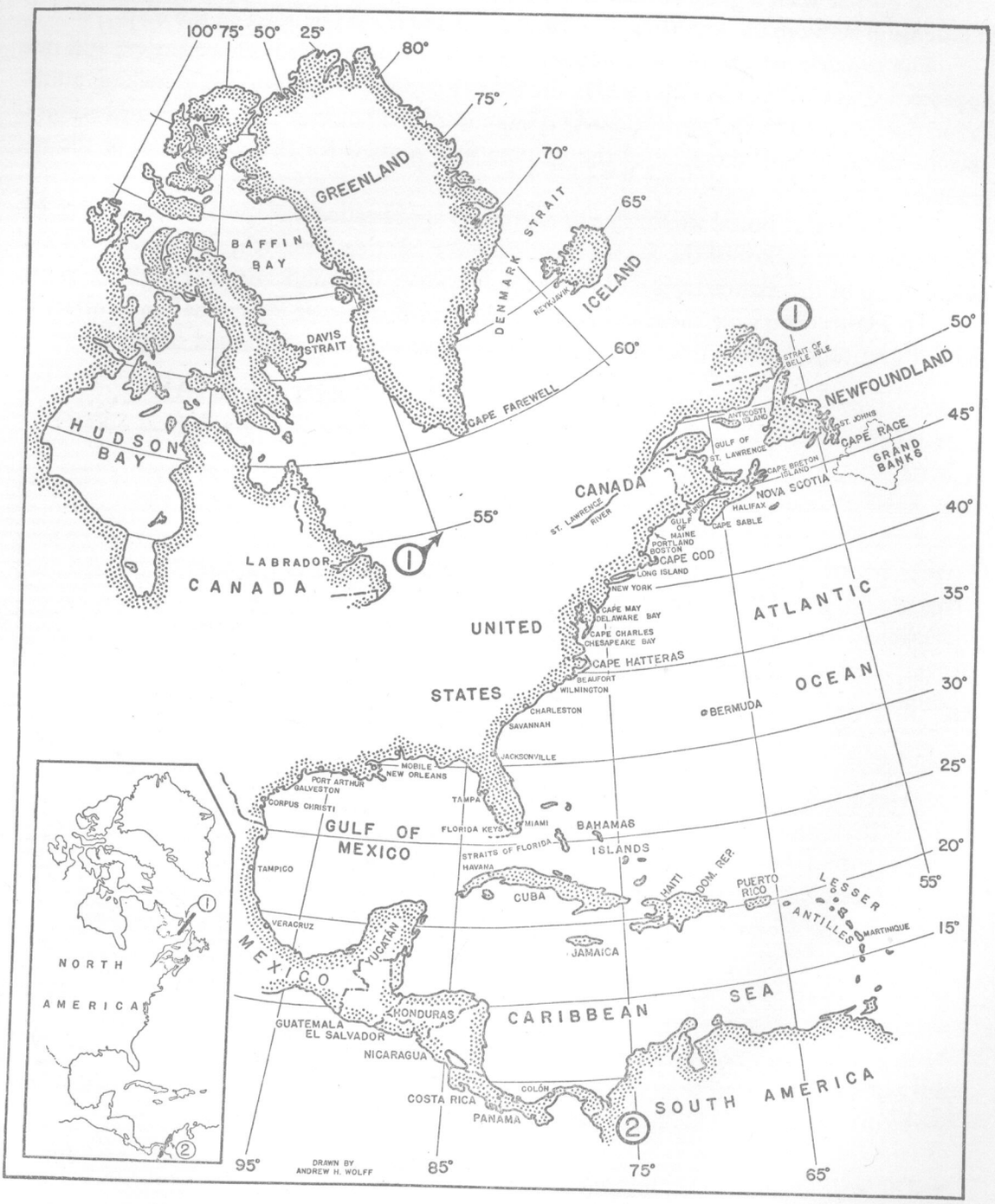
serve to give at least a general idea of locations; in future volumes there will be a closer relationship between the localities given in the text and those included on the map.

The expense incurred in the preparation of this volume has been extensive, and due appreciation and thanks are extended to the Sears Foundation for its share in making publication possible and to the institutions that supported the work of the authors and editors. Income derived from the sales of the volume will be used for the production of the remainder of the publication.

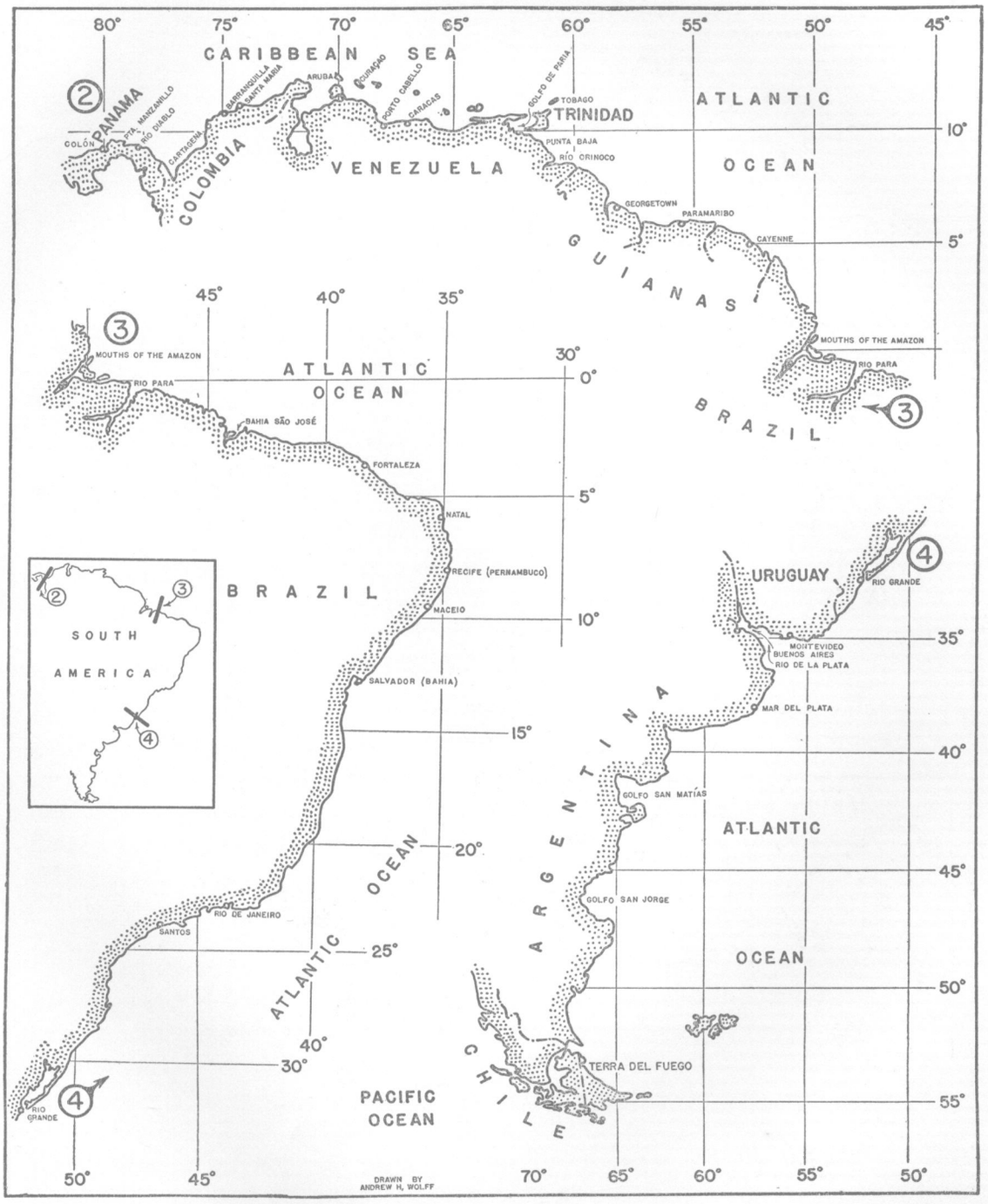
The Editorial Board would like to express its appreciation and gratitude to Yngve H. Olsen, Assistant Editor of the Sears Foundation for Marine Research, for his diligent and able editing of the manuscripts and for the guidance of the publication through the press.

To Henry Sears the members of the Editorial Board owe a personal and collective debt of gratitude for his understanding and for his unswerving continued support.

JOHN TEE-VAN
New York Zoological Society



North America



South America

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CHAPTER ONE

Lancelets

BY

HENRY B. BIGELOW *and* ISABEL PÉREZ FARFANTE

ACKNOWLEDGMENTS

We are indebted to Thomas Barbour and Leonard P. Schultz for putting the Lancelet collections of the Museum of Comparative Zoology and of the United States National Museum at our disposal for study. Also, hearty thanks are due to Gerardo Canet for preparing all the original drawings included here.

GENERAL DISCUSSION

The Lancelets of the western Atlantic Ocean are included in the present volume for convenience, following the precedent established in existing manuals of the fishes of various parts of the world. Actually they are not fishes at all, although fish-like in appearance, but belong to a separate subphylum (Cephalochordata) of the Chordata, since they are much simpler in structure than are any of the true vertebrates of the subphylum Euchordata, or Vertebrata.

Class LEPTOCARDII

The notochord, extending the entire length of the body and persisting throughout life, is surrounded by a resistant sheath, this notochord and sheath forming a firm but flexible supporting structure. But there is neither protective skeleton nor cranium for the anterior part of the neural tube, no bony structures of any sort, and no jaws. The pharynx in the adult is surrounded by an atrial chamber, formed by the outgrowth and coalescence of two ridges (the metapleura) of the body wall; the pharynx opens into the atrium by a double series of gill slits, the number of which continues to increase throughout life; posteriorly, the atrial cavity opens to the exterior by a small aperture, the atriopore. The dorsal nerve tube terminates anteriorly some distance behind the anterior end of the notochord; it is much compressed laterally, and the only suggestion of a brain is that its axial canal widens anteriorly into a cerebral vesicle. The nerves given off by the neural tube (except

for the first two) are dorsal and ventral in origin, but the dorsal and ventral roots do not join, and there are no ganglia on the dorsal roots. The muscular system is segmented, the successive muscle blocks, or myotomes, being separated one from the next by septa of connective tissue, or myocomma. The final number of myotomes is established early in life, but the number is somewhat variable in every species. The gonads are segmented. The circulatory system is very simple; there is no heart, but the larger blood vessels are peristaltically contractile. There is a well developed coelom, or body cavity. The outer surface of the body is clothed with an epidermis consisting of a single layer of columnar epithelial cells, without scales or other hard epidermal structures, and without cilia except in the mouth, pharynx, atrial cavity and intestine. There are no eyes and no limbs. The sexes are usually separate although similar in external appearance, but hermaphrodites have been reported on several occasions. Development is described below.

The Lancelets differ from all the higher groups of fish-like animals—cyclostomes, elasmobranchs, chimaeroids, and bony fishes—in the following important morphological features.

A. Their epidermis consists of a single layer of cells of ectodermal origin in contrast to several layers of cells in all higher groups.

B. They have no hard epidermal or tooth-like structures of any sort.

C. They have no eyes, no external nostrils and no true ears.

D. When adult, the pharyngeal region with the gill clefts is enclosed, on the ventral side, in a so-called atrial cavity.

E. The gill clefts increase in number throughout life whereas in all the higher groups their number is fixed.

F. They have no specialized internal respiratory structures, no true brain, no heart, no trace of a cranium and no hard vertebral structures, cartilaginous or bony.

G. The notochord extends forward beyond the anterior end of the dorsal nerve tube.

H. Their blood is colorless, without red corpuscles.

I. The neural canal, entirely closed dorsally in higher vertebrates, extends through the dorsal wall of the nerve tube as a longitudinal fissure, reminiscent of the ectodermal infolding by which the tube is formed.

J. The excretory organs are nephridia-like rather than kidney-like, consisting of numerous (up to 91) pairs of tubules in the pharyngeal region, each discharging independently into the atrial cavity.

K. The gonads are numerous, compared to only a single pair in higher groups, and segmentally arranged; each discharges its products directly into the atrial cavity, there being no permanent genital ducts.

L. The lining of the intestine bears cilia.

The relationship that the Lancelets bear to the Cyclostomes and to higher fishes has been actively discussed, one view being that they represent the specialization of some primitive prevertebrate stage in evolution, another that they are degenerate descendants of some early type of vertebrate comparable to the Cyclostomes that have developed pe-

culiar adaptations for a very special mode of life. Perhaps the most that can be said at present is that possibly they may be "fairly close to the primitive types from which the vertebrates have arisen,"[1] although their atrial cavity has no parallel among the vertebrate series.[2]

Order AMPHIOXI

Description. This order includes all known representatives of the subphylum. They are slender, fish-like in external appearance, the body tapers at both ends and varies in length from one to eight cm. at maturity; they inhabit tropical and temperate seas. In the adult the buccal cavity, which leads into the mouth proper, opens on the ventral surface of the body a little behind the anterior end. It is bounded laterally by a pair of expanded muscular membranes, the so-called oral hood, the free edge of which bears 20 to 30 slender oral tentacles or cirri, each supported by a cartilaginous rod arising from a cartilaginous ring situated immediately behind the margin of the hood. Proximally, the inner surface of the oral hood bears a series of finger-like projections of ciliated epithelium, jointly forming the wheel organ, the ciliary action of which drives water inward through the buccal cavity to the mouth, and so to the pharynx. The mouth, at the bottom of the buccal cavity, is very small and surrounded by a vertical membrane, the so-called velum, from which several short velar tentacles project inward into the capacious pharynx. The linings of the pharynx, and of the vertical gill clefts that pierce its two sides, are clothed with cilia (those of the former having a complex pattern), the joint action of which is to drive the water from the mouth, along the pharynx, through the gill clefts and so out through the atrial cavity and atriopore. The pharynx serves chiefly as a feeding organ, as described below.

The integument is expanded as a single continuous finfold which extends along the ventral surface from close behind the atriopore, around the posterior end of the body, thence forward along the dorsal surface and around the anterior end of the latter, where it forms a snout or rostrum. The finfold thus surrounds the anterior end of the notochord and contains a lymph space; in the dorsal fin this is segmentally divided by vertical septa into a series of compartments known as fin-ray chambers and this is sometimes true of the ventral fin as well. These chambers are partially subdivided by so-called fin rays, the lateral and apical surfaces of which are free but the bases of which are connected with the continuous ridge of connective tissue that is derived from the roof of the neural sheath. The final number of rays and of ray chambers is established early in life, *i.e.*, at a small size, but is somewhat variable in all species. Anterior to the ventral fin the ventral surface of the body also bears a pair of prominent longitudinal ridges called the metapleura. As a result of their presence, the anterior part of the body is roughly triangular in cross section in adults, the dorsal fin forming the apex of the triangle, the two metapleura its other two

1. Romer, Man and Vert., 1941: 10.
2. The atrium of the Lancelets, while analogous to that of the tunicates, cannot be regarded as homologous with the latter, for the method of formation is very different.

angles, and the space between the latter forming its base, which is also the floor of the atrial chamber.

There is a rather conspicuous pigment spot at the anterior end of the nerve cord, which has been called an eye spot or median eye, but which appears not to be a light receptor. Also, an olfactory function has been ascribed to a small diverticulum from the cerebral vesicle, but it is doubtful whether this is correct.

Habits. Lancelets spend most of the time buried in the sand, in an oblique position, with the anterior end alone protruding.[3] If removed from the sand they swim actively, bending the body from side to side with a sinuous eel-like motion; it is with this same motion that they bore into the sand, which they do very rapidly. In most cases they burrow tail foremost, but they have been seen to do this with the anterior end foremost, in which case they then assume a U-contour to bring the anterior end out again from the sand. It seems that adults of the genus *Branchiostoma* seldom emerge spontaneously from the sand, or only for very brief periods, except at spawning time, for we find no record of their capture in tow nets.[4] But *Asymmetron* has been so taken (p. 21).

It has long been known that they feed on microscopic organisms which they strain out from the current of water that is drawn in through the mouth and driven by ciliary action through the gill apertures to the atrium, to be expelled through the atriopore. The buccal tentacles, folding over one another, prevent larger objects from entering. Particles small enough to pass through this screen are carried inward to the pharynx, where they become mixed with mucus and are driven against the gill bars. The cilia on the inner faces of the latter, beating in a ventro-dorsal direction, then drive the mingled food and mucus to the dorsal pharyngeal groove, along which it is swept to the oesophagus.[5] Feeding appears to be a continuous process. No doubt the diet includes whatever kinds of microscopic organisms may be available at any given time and place. The intestines of the European *Branchiostoma lanceolatum* have been found to contain diatoms chiefly, but also desmids, Foraminifera, Infusoria, Radiolaria, Cladocera and the eggs of various small invertebrates, as well as plant detritus.[6] Diatoms have also been reported from the intestines of Lancelets from Ceylon[7] and were again the most abundant item in the diet of young *Branchiostoma belcheri* at Amoy, China, although the adults also contained the larvae of tunicates, echinoderms and crustaceans.[8] At another time[9] this same species in the same general local-

3. For an excellent photograph of the European *Branchiostoma lanceolatum* in this situation, see Hagmeier and Hinrichs (Senckenbergiana, *13*, 1931: fig. 3b, 4b, facing p. 258).
4. Hensen (Ergebn. Plankton-Exped. Humboldt Stiftung, *1* A, 1892: 24–25) reported the capture of young Lancelets up to several centimeters long in plankton nets. But the fact that none so large were to be found subsequently in the collections (Goldschmidt, Dtsch. Sud-polar Exped., *11* Zool. 3, 1909: 235) suggests that the stated size was an error.
5. Condensed from a detailed account of the feeding mechanism in *Branchiostoma lanceolatum*, by Orton (J. Mar. biol. Ass. U.K., *10* [1], 1913: 19). For an account of the passage of food material through the gut, see Barrington (Philos. Trans., [B] *228*, 1937: 271).
6. For a list of the food of *B. lanceolatum* compiled from various sources, see Franz (in Grimpe and Wagler, Tierwelt N- u. Ostsee, Lief 7, 12b, 1927: 26).
7. Tattersall, in Herdman, Rep. Gov't. Ceylon Pearl Oyster Fish., Gulf of Manaar, pt. 1, suppl. 6, 1904: 221.
8. Chin, Philip. J. Sci., *75*, 1941: 393.
9. Reeves, Ginling Coll. Mag. for Jan. 1931: 29.