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Marine Shells of the Southwest Coast of Florida

By

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It is perhaps a more fortunate destiny to have a taste for collecting shells than to be born a millionaire.

R. L. S.

INTRODUCTION

Some fifth of a century ago when I first saw a Florida beach, with its multitudes of shells they seemed worthy of attention only as adding variety to the general attraction of the seashore; but within a few tides times the lion's paw, the angel's wing, the fighting conch and the calico shell had acquired individuality and stimulated an interest that must enrich any experience which includes them.

The abundance and variety of southern Florida's molluscan fauna is unexcelled by any other in America, and by but few areas of like extent anywhere. This circumstance is due to a combination of ecological factors related to latitude, sufficient bathymetric range for slight differences of water temperature, characters of sea bottom, and some local modifications of salinity due to drainage of fresh water from the Okeechobee basin and other areas. The littoral region has many genera characteristic of sand, mud and weedy bottom. Oysterbars, sandbars and mangrove-flats, and in deeper water rock and coral reefs and outcroppings of hardpan have their peculiar associations of molluscs and other marine animals. Species native to a more southerly province overlap some which have a more northerly range, and some genera common on the southern Atlantic Coast are established along the Gulf Coast without continuity of any of their species around the southern tip of the Florida Peninsula.

All descriptions apply to specimens which were taken alive or in such fresh and perfect condition that a local station may reasonably be assumed. All measurements refer to average sizes, adult shells, and all illustrations are of recently collected specimens.

The study collections upon which the descriptions are based has been placed in the Thomas R. Baker Museum at Winter Park, Florida.

The 'List of Marine Mollusca from Labrador to Texas', by Charles W. Johnson (Boston, 1934) is used as the basis of classification and nomenclature. Free use has been made of available conchological literature.

Acknowledgment of valuable assistance is made with pleasure to Dr. Henry A. Pilsbry, to Dr. Paul Bartsch, to Dr. Harold A. Rehder, to Richard F. McLean and Jeanne S. Schwengel. Thanks are due to George W. Underhill and George W. Underhill, Jr. for skillful use of boats and dredges.

Dr. Eugene W. Gudger has been kind enough to read the manuscript and offer many helpful suggestions.

L. M. P.

Sanibel Island, Florida.

GENERALIA

Shelled molluscs belong to one of the most ancient groups of animal life. Five hundred million years ago there lived in the Cambrian period of the earth's geologic history snails with shells so complex and perfect that their presence can be explained only by the existence of ancestral forms in a period far more distant. These fossil remains are of great importance in the study and chronological interpretation of the earth's geologic past. Their presence in stratified rocks determines the periods in which successive layers of sediment were deposited in ancient seas, and the evolution of primitive molluscan shells may be traced through these sedimentary deposits to the shells of Recent families and genera. Certain shells from Tertiary deposits in the Okeechobee and Caloosahatchee basins are of types which persist in the living molluscan fauna of Florida waters.

Emanuel Mendes DaCosta[1], one hundred and sixty-three years ago wrote:—

> The study of shells or testaceous animals is a branch of Natural History, though not greatly useful in human economy, yet perhaps by the infinite beauty of the subjects it treats of, is adapted to recreate the seneces and insensibility to lead the amazed admirer into the contemplation of the glory of the Divinity in their creation.

The British conchologist George Perry, expressed a like feeling in the introduction of his 'Conchology, or the Natural History of Shells', published at London in 1811. The sentiment was not unique, for the symmetry and beauty of shells have suggested many forms in art and architecture, and in some parts of the world their use as objects of utility, ornament and symbolism is presently continuous with the practice of early man. North American Indian tribes which practiced totemism used shells (*Cypræa moneta*) in their ritual of death and resurrection and so recently as eighteen forty-eight to the eighties, Maplewood Institute for Young Ladies, at Pittsfield, Massachusetts, listed Conchology in its regular curriculum as a subject of cultural value to its students.

1 Ills. of Fossil and Recent Shells.

Certain elementary principles must be understood before an intelligent approach can be made to the study of shells. It is a matter of common knowledge that animals differ widely in appearance and anatomical structure. These differences form the basis of classification of all animal forms—first into two principal groups—invertebrates and vertebrates, or those forms without a backbone and those possessing one. These groups are divided into phyla (Gr., *phylon,* meaning race or tribe). Each phylum is subdivided on the basis of anatomical structure into groups which show the increasingly closer relationships which establish class, order, family, genus and species.

The phylum Mollusca (Lat., *mollis,* soft, having reference to the soft body), is fifteenth on the scale of increasing complexity of structure among the invertebrates. It has, perhaps, more than 100,000 species, a greater number than any other group of animals excepting the Arthropoda, which includes the insects and crustaceans.

Molluscs have no supporting skeleton, but with few exceptions they have developed a protective calcareous structure, the shell,[2] which has evolved into a number of highly differentiated forms. The shell is a part of the animal, and failure to consider this relationship and the relationship of molluscs to other animal species, deprives the student of one of the great advantages and pleasures of his avocation.

The shell is secreted by a specialized part of the mollusc's body called the mantle, which envelops the soft structures like a closely wrapped cape, and whose external, secreting surface is in intimate contact with the internal surface of the shell. The secreted shell substance consists of about five per cent of an organic matrix called *conchyolin* impregnated with mineral salts taken from the sea water, principally carbonate of lime and small amounts of magnesium. The conchyolin, which is elaborated and secreted by the mantle, provides a framework for deposition of the mineral salts, and in an unimpregnated state forms an external

2 Dr. Samuel Johnson's Dictionary gives eight meanings for the word "shell". The second is "The covering of a testaceous or crustaceous animal." The word is of Saxon origin—scyll or scell—meaning rough, homespun.

covering for the shell which affords protection against chemical injury from corrosive substances which the water may hold in solution; it is called the *epidermis* or *periostracum*. Differences in structural arrangement of the shell elements produce differences in quality and appearance of the shells—viz. opaque, porcelaneous, polished.

A rudimentary shell is present when the young mollusc leaves the egg capsule, or is developed very soon thereafter, this *nucleus* rapidly increases its size by the addition of new shelly matter but is generally lacking in features which characterize older shells. Sculpture is formed and color and pattern are added by the secreting edge of the mantle, and any injury to this soft organ may result in some degree of deformity of the shell and partial loss of pattern and color. Alternating periods of growth and inactivity are often defined by an axial ridge or varix which represents the outer lip of a previous aperture in univalve shells, and in lines or ridges of growth parallel to the margin of bivalve shells. All irregularities about the apertures and margins of shells are produced by corresponding irregularities in the edge of the mantle, and remain as sculptural features of the shell as new growth proceeds. Immature shells often differ from adult specimens of the same species; juvenile shells are usually thin, have thin lips and are lacking in the color and finished sculpture that ornament the adult shell. These differences are sometimes so marked that the identity of young shells has been unrecognizel and independent specific rank given them.

Actual attachment of the mollusc to its shell is effected by means of strong muscles. In gasteropods, one powerful muscle is firmly fixed to the columella near the apex of the shell; in the pelecypods one or two muscles are attached at opposite points in the two valves, contraction of these muscles keeps the valves tightly closed.

Color is present only on the surface of shells and is believed to be influenced by food and exposure to light. Shells from warm and shallow waters are usually more brightly colored than shells of species inhabiting the colder depths, and in most fixed bivalves the upper, exposed valve is the more highly colored.

Molluscs have well developed systems for nutrition, respiration, circulation, excretion and reproduction—all under the control of a nervous system. Many of them have organs of special sense; in some instances even a structure analogous to the ear, which keeps the animal in touch with its surroundings and aids in maintaining its equilibrium. Many molluscs are sensitive to light and respond actively to any change in its intensity; some possess compound eyes with structures definitely comparable to those of the eyes of higher vertebrates.

Dr. Paul Bartsch, of the U. S. National Museum, claims for the Mollusca first rank in complex organization and intelligence among the invertebrates, and in consideration of the squid and octopus, believes that they surpass some groups of the lower vertebrates.

The food habits of molluscs are varied. Some gasteropods are predatory and carnivorous, others are vegetarian; some are parasitic upon starfish, sea cucumbers, corals, sponges and other molluscs; some pierce the egg capsules of their own and other species to prey upon the contained ova and embryos. The food of the pelecypods consists of minute plants and animals taken into the digestive tract with indrawn currents of water.

In some groups of molluscs the sexes are separate, in which case the male is usually the smaller. In other groups the molluscs are bisexual and there are some examples of true hermaphroditism.

Phosphorescence is a property of certain molluscs. The Roman naturalist Pliny remarked this emission of light, and wrote of the *Dactylus* (pholads), 'it is the property of these fish to shine brightly in the dark, when all other lights are removed, and the more moisture they have, the brighter is the light they emit. In the mouth even, when they are being eaten, they give forth their light and the same too when in the hands; the very drops, in fact, that fall from them on the ground or on the clothes, are of the same nature. Hence it is beyond a doubt, that it is liquid that possesses this peculiar property, which, even in a solid body, would be ground for considerable surprise'.[3]

[3] Historia Naturalis, Book IX, Chapter 33.

There is little definite knowledge of the age attained by molluscs. The great size of some gasteropods presupposes many years of life, and the enormous valves of the East Indian *Tridacna* are the growth of man's three score years and ten, and more. Some of the pelecypods reach reproductive maturity within twelve months and oysters are known to live for fifteen years.

The phylum Mollusca is divided into five classes:-Amphineura, Pelecypoda, Scaphopoda, Gasteropoda, Cephalopoda. Further subdivision expands each class through order and family, to genus and species. Shells of genera belonging to the Amphineura, Pelecypoda, Scaphopoda and Gasteropoda are considered in this manual.

The system of scientific nomenclature in general usage is binomial. Latin or Greek words are generally used for generic and specific names. Occasionally proper names, names of localities, or words from a language other than Greek or Latin are chosen, but are always given in Latinized form.

Each genus possesses a distinctive name, always capitalized—viz. *Oliva*. The name of a species consists of the name of its genus, followed by its own distinguishing name, both in italics; next is appended the name of its author whose original published description or definition clearly established the species,—viz. *Oliva sayana* Ravenel. Variations of a species sufficiently well defined and constant to merit subspecific distinction as a variety are given a third name which is interpolated between the specific name and the name of the sponsor,—viz. *Oliva sayana citrina* Johnson.

The terms genotype, holotype and paratype are used in reference to the establishment of genera and species. As defined by Schenck and McMasters, Procedure in Taxonomy, 1936, the genotype is the single species upon which a genus is based. The holotype is the single specimen taken as 'the type' by the original author of a species. The paratype is a specimen other than the holotype, used as the basis of a new species.

COLLECTION AND PREPARATION OF SPECIMENS

Shells of many—probably most—of the molluscs whose habitat is the nearby sea bottom may be found at some time on the open beaches. Shore collecting is profitable in proportion to the regularity and persistence of the search, it will afford a considerable variety of excellent specimens and at any time a happy coincidence of time and tide may bring a rare treasure to the hand of the collector.

Collecting is best at low tide. Large shells are oftenest found along the beaches near high-water mark and wherever there is an accumulation of sea-wrack. After a quiet tide many minute shells lie among the fine detritus left by the ebb tide in ridges along the beach and in any small depressions in the sand. Living molluscs are often washed ashore and many individuals of very small species cling to the rough surface of stranded shells or hide within the cavities of sponges and among the branches of hydroid colonies and seaweed. Pieces of water-logged wood, wave worn shells and lumps of coral are worth careful examination for specimens of such boring genera as *Martesia, Lithophagus* and *Gastrochæna. Rupellaria, Coralliophaga* and *Modiolus* may be found in cavities not of their own making. A bread sponge may harbor a colony of the uncommon *Ostrea permollis.* Specimens of a parasitic *Melanella* may be found attached to the tough integument of holothurians (sea cumbers), and the dainty *Erato maugeriæ* may share space on the rough valves of *Atrina* with several different species of other small univalves and attached bivalves.

The shell of one living *Atrina rigida*, picked up at random after a windblown tide, yielded the molluscs listed below together with egg cases of *Anachis avara similis, Cantharus tinctus* and *Muricidea multangula,* and many individuals of other invertebrate groups:—

Anachis avara similis, Anachis obesa, Anomia simplex, Arca occidentalis, Cantharus tinctus, Ischnochiton papillosa, Monili-

spira monilis, Rubellatoma diomedea, Crepidula fornicata, Erato maugeriæ, Modiolaria lateralis, juvenile specimens of *Murex rufus* and *pomum, Ostrea virginica floridana* and *Urosalpinx perrugatus.*

At the fortnightly times of high tides coincident with the changes of the moon, the ebb exposes a wide extent of beach and leaves dry for a short while many bars and flats of inland waters. At such times specimens of many littoral species may be found alive and perfect, and localities may be explored which are inaccessible in ordinary circumstances. Old pilings of wood or cement and clumps of living and dead oyster shells should be examined; logs and stones turned over; but always and everywhere any object that has been moved should be replaced in its original position; do not expose to drying and needless death the many small creatures that have been disturbed by the search.

Beyond the limits of the beaches search for living molluscs must be based upon some knowledge of their habits and stations—stations having reference to the particular conditions of environment which are congenial to various species. Association of certain species of molluscs with definite characters of environment is almost invariable. Thus species of *Cerithidea, Cerithium, Marginella, Melongena, Anomalocardia, Polymesoda* and several small Tellinas coinhabit tidal salt flats and the intertidal zone of inside waters. *Littorina, Melampus* and *Truncatella* live about salt marshes, often out of water for long periods. *Ostrea* and *Modiolus* live about the mangrove fringes of the flats and bayous and are out of water at extreme low tide. *Barnea truncata* is likely to be found in black mud near mangroves, while *Barnea costata* lives in deeper water, usually where there is an admixture of gravelly bottom with a substratum of marl or silt.

On grassy bottom are found *Modulus, Pyrene, Cerithium, Bittium, Rissoina, Marginella, Smaragdia* and at certain seasons, *Pecten.* On sandy bottoms, living buried beneath the surface with siphons extended upward into the water are *Chione, Venus, Transenella, Pitar, Macrocallista, Lucina, Tellina, Mactra, Tagelus;* and preying largely on these bivalves *Natica, Polynices, Terebra, Conus, Nassarius, Muricidea* and *Urosalpinx* move freely about. Wherever *Venus mercenaria* is found there also are *Busycon* and *Fasciolaria*. *Eupleura* is often associated with a bottom weed known commonly as 'rolling moss'.

Dentalium, Corbula, Nucula, Nuculana, Lyonsia and *Cuspidaria* are found in soft, oozy bottoms beyond low tide mark, although *Lyonsia* is also found in shallow water. On outcroppings of hardpan and about reefs associated with corals, corallines and sponges are found *Murex, Cancellaria, Leucozonia, Xenophora, Trivia* and *Maculopeplum junonia,* with *Chama, Pseudochama, Echinochama, Spondylus* and *Ostrea spreta* and *limacella. Pecten gibbus* is a Gulf species, apparently living in large, scattered and migratory colonies in from three to seven fathoms of water. After a northwest blow it is frequently one of the most abundant shells on the beach. With this *Pecten* are associated *Pecten raveneli* and *Pecten ziczac,* but in relatively small numbers, and in depths of five fathoms and more are *Pecten nodosus* and *fragosus. Pecten gibbus irradians* is a common bay species. In many localities it is sufficiently abundant to be dredged for the market.

Many species, among them *Cantharus tinctus, Muricidea multangula* and *ostrearum, Fasciolaria gigantea, tulipa* and *distans, Strombus pugilis, Murex rufus, Chione cancellata* and some of the Lucinidæ are common at varying depths both in inside and open waters.

A seasonal variation in numbers of individuals is evident in the case of some genera notably *Pecten, Oliva, Murex* and *Fasciolaria,* probably coincident with the spawning period when they seem to seek more shallow water. Spawning of molluscs is observed in the Florida region from November to midsummer, but the season of reproductive activity for individual species is not continuous through this long period. There seems also to be a difference in the abundance of certain pelecypods from year to year as suggested by the presence of their shells on the beaches in great numbers, or their almost total absence for several years; notable examples of this circumstance are *Pecten muscosus, Chione cancellata, Spisula solidissima similis,* and *Arca occidentalis.*

For collecting beyond beach limits some equipment is necessary.

Convenient containers are needed for shells, and pails for living material—nonmetal if animals are to be kept alive for any length of time. Jars and vials should be provided for rare, small or delicate specimens—some containing fifty per cent alcohol if it is desired to preserve the animal. Forceps, knife and pocket lens are useful.

Work in shallow water at low tide requires a long-handled shovel and a sieve approximately in size twenty-four by eighteen inches, by some three inches in depth. Its bottom should be of good wire screen, sixteen squares to the inch. It is well to have the bottom reinforced with heavier and larger mesh screen. Place a shovelful of sand or mud in the sieve and wash thoroughly, examine what remains for small molluscs; many of these and other small sand-dwellers will be seen. Repeat this digging and sifting at successive depths in the same spot in order to learn what species live near the surface and which ones burrow more deeply. Continue this process at increasing distances out from shore and in bottoms of different character. Slightly different conditions within a circumscribed locality will afford congenial stations to various species of molluscs. In protected inside waters with varying depths and character of bottom a great number of species find favorable circumstances and attain prefect development.

The frame of a crab net rather tightly covered with good quality fine-meshed net or coarse scrim is very useful for collecting these species which live among grass or seaweed. The net should be used with a scooping movement, just escaping bottom.

Baited traps may be set and left for twenty-four hours, at least overnight since many molluscs are nocturnal feeders. When set in water deep enough to cover the trap, the location should be marked by a buoy. Shrimp, crab and fish are best for bait, though dead molluscs and bits of meat will attract carrion feeders. Sand fleas (Hippidæ) have proven exceedingly attractive bait to *Oliva*.

Dredging is the only method of taking living shells of other than shallow water species. By this means material is secured which is otherwise inaccessible, or at best represented by occasional beachworn specimens. The type of dredge shown in the frontispiece is satisfactory for general work; the cutting blades should be at an angle of about one hundred and sixty-five degrees with the bottom of the dredge and the dimension between top and bottom not less than ten inches. Scallop dredges and tangles have also been used successfully, and a short section of cast iron pipe with a perforated bottom and suitable means of attachment for chains and tow rope is advantageous for learning characters of bottom. Dredges are drawn behind a motor boat with a stout rope twice or three times as long as the depth of water—the deeper the water the greater the proportionate length of the tow rope. Five or six feet of galvanized iron chain is attached to each arm of the dredge and joined with a swivel to the towing rope. When dredging is undertaken in depths of water exceeding four or five fathoms a weight should be attached to the tow rope about ten feet ahead of the dredge A float should also be attached to the dredge to mark its location in case the tow rope should break.

Everything that comes up in the dredge should be carefully inspected. Starfish, sea urchins, sea cucumbers, hydroids and seaweeds may be placed in a pail of fresh water for a time—small molluscs that may be upon them will fall to the bottom of the container. Dead shells of *Atrina* afford lodgment to many chitons and small gasteropods; *Erato* is often found in the crevices of compound zoöid colonies, *Simnia* clings to gorgonians and exactly matches them in color. *Pteria* and *Pinctada* are attached by a byssus to other shells, to each other, sometimes in large numbers of all sizes together. *Pecten muscosus* is almost always covered by a growth of sponge which is firmly established upon the scaly ribs of the bivalve shell. It is interesting to observe that the brilliant yellow and orange colored specimens of this *Pecten* are generally embedded in sponge of a purple tint.

It is essential to note and record carefully the locality and depth of water from which specimens are secured, and it is also well to record the date. Specimens which cannot be assigned to a definite locality have no value to a collection.

Cleaning shells has no fascination comparable to the satisfaction of collecting them, but this work must be done thoroughly if the specimens are to be preserved and enjoyed in a permanent collection. Boiling best accomplishes removal of the soft parts. Many collectors prefer to place specimens in warm water and bring to the boil, allowing from two to thirty minutes boiling according to the size of the shells. Highly polished shells should be dropped into boiling water and permitted to remain not more than three minutes. After the shells are sufficiently cool to be handled the soft parts may be removed by gentle traction, taking care not to leave a part of the animal in the apex of a univalve shell; in such event a few drops of ten per cent solution of formaldehyde left in the shell for a few days will deodorize and harden what soft parts remain. Small specimens may be placed as collected in fifty per cent alcohol and the hardened animal tissue subsequently removed from the shell with an appropriate instrument. Very small shells may be washed clean and left to dry without removal of the animal parts, or placed in a jar of fresh water, shaken well from time to time and the water frequently renewed until the macerated soft parts are washed away.

After removal of the animal, mechanical cleaning is next to be undertaken by scrubbing with a fairly stiff brush and by the use of some small, sharp instrument to remove calcareous deposits, worm tubes, barnacles, etc., care must be exercised to avoid injury to delicate sculpture. Immersion in one of the several commercial cleaning fluids similar to Javelle water, effectively aids mechanical cleaning by loosening the attachments of limy encrustations. Muriatic acid is useful but must be handled with care on account of its corrosive and destructive properties. A solution of one part of commercial acid to three parts of fresh water is sufficiently strong for general use. Shells should not be permitted to remain for more than a few seconds in the acid bath before washing and careful inspection; the bath may be repeated if desired or further application of acid made with a brush interrupted by frequent thorough rinsings. The hands should be protected from contact with the acid.

After specimens are thoroughly cleaned and dried, a film of very thin oil may be applied to preserve the surface lustre. Shells which have naturally a very high polish may have their surfaces protected by a thin coating of colorless lacquer or an aqueous solution of gum arabic, though this is not necessary. The epidermis and valve ligaments may be kept from excessive drying by soaking the shell for a time in a weak solution of calcium chloride, equal parts of glycerine and water or some other hygroscopic agent. The operculums of univalves should be glued to bits of cotton and adjusted in proper relation to the apertures of the shells from which they were removed. Bivalve shells may be closed and so maintained until the hinge is dry enough to resist opening, otherwise the valves are quite certain to become separated.

Chitons are best handled by placing them in a vessel of sea water as collected until they can be extended on a firm surface and held flat by binding or light pressure until well dried; or they may be left in a shallow dish of sea water until quite relaxed when the water is poured off and the chitons allowed to dry slowly. Unless some such method is followed chitons will contract themselves into a veritable ball from which it is impossible to reduce them without injury.

The characteristic specific features and the intrinsic beauty of shells are best exhibited in well prepared specimens, but every collection should include a few shells of each species in the undisturbed natural condition, with epidermis intact and incrustations and barnacles unremoved.[4]

Some definite plan of classification should be adopted for the cabinet, and each group of specimens should be clearly labelled with the name, the date and the locality in which they were collected.

[4] The scientifical collectors, or naturalists, are always desirous of having the shells in their rough state, or just as they are fished. This method, though extremely useful, is not to be absolutely followed; not only because their beauties would be lost, but also on account that the different species could never be truly defined. However, as a medium, I would advise all collectors to have some shells of each genus in their rough state, while the others should display their beauties by all the accomplishments of art.—Emanuel Mendes DaCosta, 1776.

SYSTEMATIC DESCRIPTIONS

Class **AMPHINEURA**

The foundation of this distinct class of the Mollusca is the complete bilateral symmetry of its members. The name Amphineura (from the Greek combining form, *amphi,* both, on both sides; and *neuron,* nerve) refers to the balanced arrangement of the nervous system. The two orders of this class, the Aplacophora—not bearing plates—and the Polyplacophora—bearing many plates, are based upon the absence or the presence of a shell, and the naked molluscs of the first order are the simplest and most lowly organized members of the phylum Mollusca.

The Polyplacophora or chitons have a multivalve shell which covers and protects only the dorsum of the animal's flattened and elongated body. The unprotected ventral surface is equipped with a broad, sucker-like muscular foot, admirably adapted for creeping and for adhering tightly to the firm surfaces of rocks, shells and corals over which most chitons browse in search for their vegetable food of algæ and diatoms. Chitons are native to all seas, usually at moderate depths. They are sluggish creatures, generally nocturnal in habit and appear to avoid light by hiding during the daytime in crevices, dead shells and under rocks. Some are said to return to a chosen resting place after each feeding excursion. Their size ranges between five and one hundred and fifty millimeters.

The sexes are separate. Some species lay their eggs singly or in unattached strings, some others retain the ova within the mantle cavity until the shell is formed.

In some tropical countries the muscular foot of large chitons is used as food. Natives of some of the West Indian islands call it 'sea beef', and either eat it uncooked or make of it the chief ingredient in a savory loblolly. In the far north chitons are a reputed cure of seasickness, but only when swallowed alive.

The remarkable ellipsoidal shell of the chitons covers only the dorsum of the animal. It is multivalvular, consisting of eight, thin plates or valves, transversely wide, gently arched from side to side and longitudinally keeled in the midline. Each valve articulates with the valve next behind it with a slight overlap toward the posterior end. All the valves are held together and in relation to each other by a girdle of tough, leathery tissue which surrounds the entire periphery of the articulated valves. The overlap of the valves facilitates bending—and the chiton's defensive attitude is assumed by approximating end to end for protection of the vulnerable body. Just so in the early Dark Ages armor plates were fastened to leather, often by rivets; the leather foundation gave flexibility to the coat of mail.

When the valves are separated, which is easily done by a short soaking in fresh water, the head and tail plates are seen to differ from the six intermediates. The anterior valve is roughly semicircular with a median elevated apex. The posterior valve is much like the intermediates, but slopes abruptly to a rounded margin. The intermediate valves are rectangular in outline and show three more or less well defined areas upon their outer surface; along the keeled mid-ridge of the shell is the *jugal* or *dorsal* tract, on each side are the *pleural* tracts, which in some genera are demarcated from the *lateral* tracts by an oblique line from near the center of the posterior valve margin toward the outer end of the anterior margin; the sculpture of these areas is important in diagnosis. The valves of most chitons have projecting plates at the free edges which are covered by, and serve as attachment for the girdle.

The structure of the valves is highly interesting; there are two layers; a quite compact inner stratum and an outer, superficial layer which is perforated by many minute canals perpendicular to the surface, which contain specialized sense organs. In some species these organs have the form of eyes, possessing cornea, lens, pigment layer and retina.

Species of three genera belonging to this class are described.

Order **POLYPLACOPHORA**

Family **ISCHNOCHITONIDÆ**

Genus **ISCHNOCHITON** Gray, 1847

Ischnochiton[5] **papillosa** C. B. Adams Plate 1, fig. 1

Length, 6—8.5; breadth, 5—6 mm. Color mottled olive green or brown. The sides slope gently and convexly from a moderately keeled mid-ridge. An umbo, central and rounded, on posterior valve. Central and lateral areas of intermediate valves are ill defined, uniformly and thickly dotted with minute papillæ. The narrow girdle is covered with fine overlapping scales and bears small tufts of shining spicules at each end and on each side. Interior of the shell white.

I. papillosa is often found with *Chætopleura apiculata* adhering to dead shells of *Atrina*.

Genus **CHÆTOPLEURA** Shuttleworth, 1853

Chætopleura[6] **apiculata** Say Plate 1, fig. 2

Length, 17—25; breadth, 10—16 mm. Color varies through buff to ashy-gray or brown, either unicolored or regularly patterned in a darker shade. Occasional specimens are uniformly red or orange color. The dorsum is sharply keeled, the sides slope rather abruptly and are convex. Well marked oblique lines separate central from lateral areas on each intermediate valve. The central areas bear finely beaded longitudinal riblets. The lateral areas are clearly defined and irregularly dotted with numerous rounded tubercles. The girdle is narrow, with scattered, transparent hairs. Interior white, greenish or grayish.

Family **ACANTHOCHITIDÆ**

Genus **ACANTHOCHITES** Risso, 1826

Acanthochites[7] **pygmæa** Pilsbry Plate 1, fig. 3

Length, 10—20; breadth, 5—10 mm. Color pale or deep olive or gray-green. Less oval and a little more slender than *Chætopleura apiculata*. Dorsal areas well marked, rather flat and moderately keeled. The sides are flat and sloping and quite evenly covered with small papillæ. The girdle partly covers the valves

[5] Gr., *ischno*, slender, *chiton*, a girdle; Lat., *papilla*, nipple

[6] Gr., *chaites*, haired, *pleura*, side; Lat., *apiculus*, dim. of apex

[7] Gr., *akantho*, thorn; Lat., *pygmæus*, pygmy

and bears nine small tufts of silvery bristles, evenly spaced, on each side, and a sparse beard of bristle on each end.

This chiton is usually found in shallow water, adhering to dead shells, or crawling in sand near shore line, an unusual habit for a member of this group.

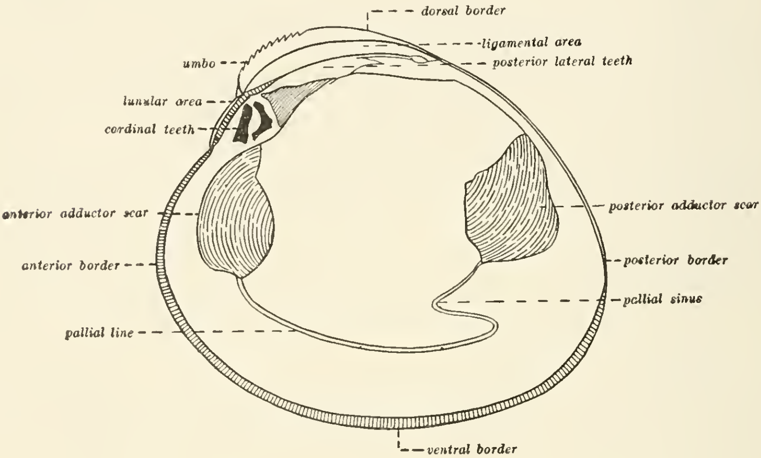


Fig. 1. Diagram showing the characteristic features of a pelecypod

Class PELECYPODA

The class Pelecypoda (Gr., *pelekys,* axe; *podos,* foot) is inferior to the Gasteropoda in numbers of genera and species, but in numbers of individuals it surpasses all other divisions of the Mollusca. Along parts of the North Atlantic Coast where *Mya arenaria* finds congenial circumstances, the littoral area may be almost paved with successive generations of this bivalve mollusc. On the Gulf beach of Sanibel Island, Florida, wind and tide pile up great banks of shells which consist preponderatingly of *Noëtia ponderosa,* and from time to time incredible numbers of young *Chione cancellata* are washed ashore. Less frequently living *Barnea costata* are stranded on the beach by hundreds when some unusual tidal current has undermined a colony of them.

Pelecypoda are without distinct heads and the organs of special sense are not highly developed. The mantle conforms to the shape of the shell. It covers the viscera and contains between its two lobes the gills and mouth parts; its posterior edges are modified to form simple or tubular openings—the siphons—through which currents of water are received into and expelled from the animal's body. Those genera which burrow most deeply have the longest siphons, but in almost every instance the siphons may be completely withdrawn into the shell[8]. Most pelecypods possess a flexible, muscular foot well adapted for digging and limited locomotion; in many genera there is a special gland in the foot whose viscous, adhesive secretion hardens on contact with water to form a *byssus*. The byssal threads issue from between the valves of the shell and become attached by their distal ends to some solid support. The byssus usually consists of fine, silken-like threads (*Atrina* and *Mytilus*), in some species of the genus *Arca* it resembles thin kid-skin, or it may become thick and solidified in other species of this genus. In many of the pelecypods a byssus is present in juvenile but not in the adult stage, and in certain genera a byssus appears during the late embryonic development.

The food supply of pelecypods is the microscopic plant and animal life of the seas. Currents of water pass through the siphons into the mantle cavity to be depleted of their content of nutriment and oxygen; the waste water, bearing the products of excretion, is expelled in the same manner.

Most pelecypods are unisexual, some are true hermaphrodites, but a number of species have been found to exhibit alternately male and female phases of reproductivity.

Bivalve molluscs generally bury themselves in sand or mud. Members of some genera bore into wood, concrete, shells or coral—into almost any nonmetallic substance—and remain imprisoned in these burrows for the duration of their lives (*Teredo*, *Martesia*). A few genera, as *Modiolaria*, attach themselves to the tissues of other animals, though never as parasites, while others are truly parasitic.

Anomia, Chama, Ostrea and *Spondylus* are attached by one valve. *Pecten* and *Lima*, by a rapid flapping of the valves of their shells, expel a jet of water with sufficient propulsive force to drive

[8] Small pin fish in an aquarium have been seen by the author to nip off the siphons of *Tagelus*, *Tellina* and *Donax* as they were projected above the sand bottom into the water. At the first touch the siphons would be withdrawn, when they reappeared the fish would attack again and eventually the exhausted molluscs were exposed and completely devoured.

themselves through the water for considerable distances.

The Pelecypoda have shells of two joined valves which enclose and protect their soft bodies. In some cases the relative size of the mollusc to its shell is disproportionately large—as in *Barnea*—and in other instances the valves are rudimentary, and calcareous tubes are secreted about the elongated body, as in *Teredo*. The two valves of the pelecypod shell are joined together by a hinge and maintained in apposition by strong muscles attached to the inner surface of each valve at opposite points. Like the gasteropod shell, the shape of the pelecypod shell is that of a modified cone, flattened from side to side and variously distorted in other dimensions. The apex of each valve is the beak or umbo; the umbos generally point forward with the tips close together and are usually anterior to the hinge ligament. In a few genera, they are directed backward, notably *Donax* and *Nucula*.

An equilateral shell has the umbos at or very near the center of the upper margin of the shell (*Spisula*). An inequilateral shell has the umbos much nearer one end of the shell than to the other (*Arca*). The terms *equivalve* and *inequivalve* refer to the relation of the valves to each other in regard to size. The *dorsal* margin is that which bears the hinge and umbos. The *ventral* margin is directly opposite the umbos, while the *anterior* and *posterior* margins are respectively the front and hinder ends of the shell.

Most authorities measure the length of a bivalve shell by a line from the extreme anterior margin to the extreme posterior margin; the height or altitude is measured by a line from the umbos to a point immediately opposite on the ventral margin. Thickness or diameter is the greatest dimension between the two sides of the closed valves.

In most pelecypod shells the two valves are held together below the beaks by a hinge consisting of interlocking teeth—depressions in the margin of one valve receiving the teeth from the opposite valve. These teeth are distinguished as *cardinals,* which are those immediately below the umbos; and the *anterior* and *posterior laterals* which are on the respective sides of the cardinals. The teeth are not always identical in every species of a particular genus, but show various modifications in development and position. The *hinge ligament* is a tough band which fastens the two valves together along a line immediately adjacent to the umbos. This ligament is composed of two distinct parts; the outer portion—the ligament proper—which is usually external and may be seen when the valves are closed; and the inner portion which is cartilaginous and elastic. The ligament proper is inelastic, while the cartilage is highly elastic and compressible, and in its position of rest tends to keep the two valves of the shell slightly separated. Together the two parts of the hinges act in opposition to the strong adductor muscles which close the shell and tend to maintain approximation of the valves so long as they remain contracted.

The more or less heart-shaped depression, close to and anterior to the umbos is the *lunule*. A corresponding area posterior to the umbos is the *escutcheon*. The latter occurs in but few genera.

The inner surfaces of the valves show certain impressions or scars, marking the sites of attachment of adductor muscles. When there are two muscles there are two impressions in each valve, the *anterior* and *posterior muscle impressions*. When there is but one adductor muscle scar it is the posterior which is present. The line which roughly parallels the shell margin some little distance from the edge is the *pallial line*, and the inward recession or indentation of this line is the *pallial sinus*.

To distinguish between right and left valves the shell is held with the ventral margin downward and the umbos pointing away from the observer the hinge ligament will be behind the beaks. The valve on the right side is the right valve and the one on the left side is the left valve. Examination of a single valve shows the umbo pointing to the left when the left valve is seen from the outer side, and toward the right when the inner side is observed. The reverse is true of those genera whose umbos are directed posteriorly. The pallial sinus is always nearest to the posterior end of the shell, and the greatest length is generally behind the umbos.

White and light colored bivalves sometimes show a pink or purplish tint, deepest on the inner surfaces of the valves. Heilprin noted this staining and attributed it to some process of ferric oxidation. Since the atypical coloration is usually seen in the shells of living, sand-burrowing bivalves—not in gasteropod shells—it is suggested as perhaps due to the purple secretion of *Tethys* or some tubicolous worm. The purple colored secretion has been observed to settle in the saucer-shaped depressions in the sand about the projecting siphons of *Barnea costata* whose shells oftenest show this pink tint. It is possible that the purple secretion which accumulates in these depressions is taken through the siphons into the mollusc's mantle cavity, and either stains the inside of the shell by contact or by a process of excretion. Dead shells of both univalves and bivalves sometimes acquire such a stain, probably by contact with the purple secretions of various marine creatures which settle in depressions where shells are also apt to lodge.

Class **PELECYPODA**
Order **PRIONODESMACEA**
Family **SOLEMYIDÆ**

The distribution of the Solemyidæ is from Nova Scotia around peninsular Florida and to the West Indies. Their distinguishing feature is the heavy, glossy periostracum which extends well beyond the free margins of the shells in distinct scallops. This family is not very well known to collectors, the author has seen but three specimens in many years.

Genus **SOLEMYA** Lamarck, 1818
Subgenus **PETRASMA** Dall, 1908

Solemya occidentalis[9] 'Deshayes' Reeve

Alt., 9; lenght, 25 mm. Equivalve, inequilateral, thin and fragile; umbos suppressed; dorsal margin horizontal; epidermis light chestnut brown with radiating lighter lines. The epidermis extends beyond the shell margins in deep, rounded scallops with the angles between the scallops at terminations of the light radiating lines; this striking feature of the species gives it the common name 'awning shell'.

Sandy stations. Shallow water.

[9] Lat., *solea,* sole, bottom, Gr., *mys,* muscle; Lat., *occidentalis,* pertaining to the west.

Family NUCULIDÆ

The family Nuculidæ is represented in all seas. On the Atlantic Coast it is taken from Laborador to Florida and the West Indies, and its range in depth is also great. The molluscs have some unusual anatomical features and are very elegant little shells.

Genus NUCULA Lamarck, 1799

Nucula proxima[10] Say Plate 1, figs. 4, a, b

Alt., 5; length, 6.5 mm. Equivalve; very obliquely inequilateral with the greatest length parallel with posterior border; umbos small and approximate, directed backward. Surface smooth with thin, pale greenish-brown epidermis. Sculpture of indistinct growth lines and delicate radiating striæ. Margins rounded, ventral margin finely crenate within. Hinge is angular with a fossette for internal ligament at angle; twelve comblike teeth anterior to umbos and eighteen posterior. Interior of valves pearly; anterior and posterior muscle scars; simple pallial line.

Dredged in sandy-mud bottoms in from one to six fathoms. Both *Nucula* and *Nuculana* are eaten by bottom-feeding fish.

Family NUCULANIDÆ

This family is very close to the Nuculidæ and was formerly included in the same group. The Nuculanidæ have a wide range in distribution, depth and temperature but are most numerous in cold seas.

Genus NUCULANA Link, 1807

Nuculana acuta[11] Conrad Plate 1, fig. 5

Alt., 5; length, 10 mm. Equivalve; extremely inequilateral; posterior to the umbos the shell is rostrate and prolonged to an acute tip; umbos small, closely approximate and directed backward. Thin, brownish periostracum; sculpture of well impressed grooves almost parallel with the ventral margin, but not extended over the slightly depressed rostrum which bears fine longitudinal striæ. Ventral margin rounded and smooth, dorsal margin posterior to umbos concavely curved. Hinge angular, a triangle fossette below umbos; numerous chevron-shaped teeth anterior and

[10] Lat., *nucula*, little nut; *proximus*, nearest

[11] Lat., *nucula*, with *ana*, suffix meaning concerned with; *acutus*, from *acuere*, to sharpen

posterior to fossette. Anterior and posterior muscle scars, pallial line sinuated; interior polished, not nacreous.

There is an aberrant form of *N. acuta* differing from the type in an entire absence of concentric sculpture. Specimens of each type are commonly taken together.

Dredged from sandy-mud bottom in one to six fathoms.

Family ARCIDÆ

The family Arcidæ is well represented from Maine to Florida and the Gulf Coast by species living in relatively shallow water, and by less common species taken at varying depths up to about three hundred fathoms of water. Some members of this group creep about and burrow in sand or mud; some frequent reefs and hard bottom; many attach themselves to some stable point of support by a byssus which can be cast off and quickly removed. Often many individuals are attached to one *Atrina* and to each other. Shells of *Atrina rigida* seem to be especially favored by *A. occidentalis* and *A. umbonata*. Young Arcas climb the sides of an aquarium by means of their byssal threads, as do young *Mytilus* also.

The molluscs of this family are very sensitive to changes in intensity of light and will close the shell immediately when a shadow falls upon it, this light-sensitiveness is a protection from birds flying above and against the near approach of predatory enemies in the sea. Arcas are said to be the principal food of *Murex*, and the shallow water species are liked by fish and sea gulls.

The blood of molluscs, as a rule, is colorless, but some of this group have red blood whose color is due to a compound of iron.

Shells of the Arcidæ may be equivalve or not equivalve, and are usually thick, with a heavy periostracum. They are radiately ribbed and sometimes cancellated. The umbos are directed forward in most genera and more or less separated from each other by a flat, rhomboidal area which is engraved with lines in various angular patterns. The margins may be smooth or dentate, sometimes crenate within. The hinge is characteristic, a row of comb-like teeth along the dorsal margin of each valve for the greater part of its length. The inner surfaces of the valves show unequal anterior and posterior muscular impressions, a pallial line but no pallial sinus.

Genus ARCA Linné, 1758

Arca[12] **auriculata** Lamarck Plate 1, figs. 6a, b

Alt., 40—45; length, 60-65; diam., 35—40 mm. Altitude and diameter great in proportion to length. Shell thick, heavy, dirty white with an abundant silky, brown epidermis; equivalve; inequilateral, longest posteriorly; umbos well apart, recurved and directed forward; hinge area widest directly in front of umbos. About twenty-eight rounded ribs with cross sculpture of fine, elevated ridges—almost obsolete in intercostal spaces; the five or six, anterior ribs have a central longitudinal furrow. Hinge margin straight, ventral and anterior margins rounded, posterior margin sinuous. Fine comblike teeth. Interior of valves smooth, white, sometimes pink-tinted in umbonal region; inner margin with deep indentations corresponding to ribs and interspaces. Well impressed muscle scars and pallial line. A short, thin, dark green byssus composed of narrow flat strands expanded in fan-shape at distal end to several times its width at byssal notch. In the young mollusc the byssus consists of only a few threads.

Dredged in three to six fathoms.

Arca transversa Say Plate 1, figs. 7a, b

Transversely oblong, rhomboidal, thirty-two to thirty-five ribs placed at nearly the length of their own diameter distant from each other. Apices separated by a long, narrow space, and situated at the termination of the posterior third of the length of the hinge margin; extremities of hinge margin angulated; anterior edge, superior moiety rectilinear; posterior edge rounded; inferior edge nearly rectilinear, or very obtusely rounded; on the hinge space one or two angulated lines are drawn from the apex, diverging to the hinge edge. Length less than seven-twentieths of an inch, breadth one and one-fifth inches . . . Known by apex being situated opposite one-third distance from posterior termination of hinge margin.[13]

A small *Arca* (pl. 2, fig. 7C) differing in certain definite characters from the established type of *Arca transversa* Say is found on both the Atlantic and Gulf coasts of Florida. Shells of the two types are commonly associated without differentiation; comparison in regard to shape, relative proportions, sculpture and dentition reveals differences which seem to be sufficiently well marked and constant to warrant distinction.

Both types are found on sandy bottoms. The depth range of

[12] Lat., *arca*, a chest; *auricula*, dim. of *auris*, ear

[13] Say's description, read July 24, 1821. Journal Academy of Natural Sciences, vol. 2, pt. 2.

A. transversa appears to be less than that of the aberrant type.
From the littoral zone to six fathoms.

Arca[14] **secticostata** Reeve — Plate 2, fig. 8

Alt., 50; length, 90; diam., 45 mm. Heavy, white, thick brown epidermis. Equivalve; inequilateral; umbos somewhat incurved and flattened; hinge margin straight, anterior and ventral margins rounded, posterior margin straight and obliquely angled with hinge margin. Thirty-five ribs which markedly widen as they diverge, a deep central groove in each rib which does not extend over umbos and is absent from the rounded posterior ribs; fine ribbing crosses both ribs and the concave intercostal spaces. This fine, transverse ribbing serves—as in other Arcas—for attachment of the scales of the epidermis. Hinge of the type. Interior of valves show delicate linear markings; margins dentate. Well impressed muscle scars and pallial line. Byssus long, thin, flat and broken up into many narrow strands.

From two to five fathoms.

Subgenus **NAVICULA** Blainville, 1818

Arca[15] **occidentalis** Philippi — Plate 2, figs. 9a, b

Alt., 50; length, 90; diam., 43 mm. Yellowish-white, streaked and patterned with brown, occasional albino specimens; heavy, shaggy, brown epidermis; equivalve; inequilateral; umbos slightly incurved, widely separated. Hinge area flat and broad; hinge margin straight; anterior and posterior margins oblique, posterior margin sinuous; ventral margin slightly rounded with wide byssal notch below umbos. About twenty-six distinct, narrow, rounded ribs with finely ribbed, flat interspaces; fine lamellar ridges cross both ribs and interspaces. Hinge of the type; interior smooth and purple colored; margins defined by a purplish-brown, polished band, slightly indented posteriorly; muscular and pallial impressions clear. A strong, thick byssus.

From three to seven fathoms.

[14] Lat., *sectilis*, from *secare*, to cut—refers to the cut ribs
[15] Lat., *occidentalis*, pertaining to the west

Arca umbonata[16] Lamarck Plate 2, fig. 10

Alt., 30; length, 64; diam., 34 mm. Dull white, concentric shaded markings of brown; shaggy epidermis, heaviest behind. Shell not thick and somewhat translucent. Equivalve; inequilateral, sharply carinate posteriorly; umbos prominent, recurved, widely apart. Hinge margin straight with a little upward curve at posterior end; anterior and posterior margins sinuous, ventral margin rounded with byssal notch below umbos. Six to eight definite ribs on the posterior keel, remainder of surface finely and rather irregularly cross-ribbed by growth lines. Typical comb-toothed hinge. Margins and internal surface of valves smooth, dull purple. Muscle scars and pallial line typical. Shells often covered with a growth of sponge.

From three to seven fathoms.

Subgenus **BARBATIA** Gray, 1847

Arca candida[17] Gmelin

Alt., 25; length, 35; diam., 15 mm. White, translucent, a soft, shaggy, brown epidermis covers the shell except over the umbos and is heaviest posteriorly. Equivalve; nearly equilateral; umbos high, near together and strongly recurved; hinge area narrow, flat, ill defined; hinge margin almost straight. Anterior and ventral margins rounded, posterior margin strongly curved outward. Sculpture of numerous fine, close ribs, stronger posteriorly, all crossed by growth lines. Hinge of the type, but not strong. Interior smooth, white, finely lined; margins smooth. Pallial line and muscular scars present. Specimens from the Gulf of Mexico are somewhat smaller and thinner than Atlantic types.

Dredged at two fathoms.

Subgenus **ACAR** Gray, 1847

Arca[18] **reticulata** Gmelin Plate 3, fig. 11

Alt., 7; length, 20; diam., 10 mm. White, fairly thick, with thin, light colored epidermis. Equivalve; inequilateral, keeled at posterior end; umbos recurved and closely approximate; hinge area small, margin straight; ventral margin slightly curved with

16 Lat., *umbo*, beak, tip
17 Lat., *candidus*, white
18 Lat., *reticulum*, dim. of *rete*, a net

byssal notch below umbos; anterior margin curved, posterior margin strongly curved and pointed at junction with ventral margin. Reticular sculpture of radiating ribs crossed by stronger, concentric, almost lamellar growth lines. Interior white, smooth, margins finely crenate; muscle scars and pallial line well defined. Byssus comparatively large, thick and flattened.

Taken about reefs.

Arca adamsi E. A. Smith — Plate 3, fig. 12

Alt., 7; length, 12; diam., 5.5 mm. Shell white, sometimes brownish; inequilateral, moderately thick; umbos well above hinge margin, anterior to middle, rounded and obtuse. Anterior margin rounded, posterior margin oblique, hinge and ventral margins parallel. Strong posterior rostration. Sculpture of lamellate or beaded ribs and growth lines, less prominent over umbos and central area. About eight anterior and twelve posterior teeth. Margins finely crenate.

Dredged from rough bottom about reefs.

Genus **NOETIA** Gray, 1847

Noëtia ponderosa[19] Say — Plate 3, fig. 13

Alt., 42; length, 60; diam., 36 mm. White, thick, heavy; strong, black epidermis; equivalve; obliquely inequilateral; umbos well separated, incurved; sides of hinge area slope obliquely downward to a straight margin; hinge of the type. Posterior margin almost straight, carinate; anterior and ventral margins rounded. Thirty-two flattened, radiating ribs and fine, concentric intercostal sculpture which is absent from the umbos. Interior smooth, marginal indentations correspond with ribs; very strong muscular impressions. Simple pallial line. No byssus.

On sand and gravel bottoms, often about rock reefs. Living *Gorgonia* often attached to shell.

Genus **GLYCIMERIS** DaCosta, 1778

Glycimeris[20] **pectinata** Gmelin — Plate 3, figs. 14a, b

Alt., 21; length, 21; diam., 11 mm. Rounded and ribbed, suggesting a fan-shape; dull white with irregular brown cross-markings; thin, brownish epidermis; equivalve; equilateral; central,

[19] Lat., *ponderosus*, a weight

[20] Gr., *glykys*, sweet, with *meris*, share, part; Lat., *pecten*, a comb

small, pointed umbos; margins rounded; about twenty-four rounded ribs with narrow interspaces, ribs on anterior and posterior parts of shell much smaller than median ribs; fine reticulate sculpture on umbos of unworn shells; hinge area very narrow, hinge teeth follow the rounded edge of margin and incline obliquely outward. Interior smooth, sometimes purple stained; anterior margin crenate. Impressions of two adductor muscles and pallial line present. No byssus.

Dredged from sand and gravel bottoms in three to six fathoms.

Family PINNIDÆ

The Pinnidæ are native to warm and temperate seas and moderate depths. They live partly buried in the sea bottom, securely anchored by a long-haired byssus, whose individual golden brown strands are so fine and silky that the nobility of ancient Greece and Rome were proud to possess a garment woven from them. It has been said that the Golden Fleece which lured young Jason to Colchis in the heroic days of Greece, was a garment made of the spun byssuses of a Mediterranean species of this family. Gloves and other articles made from byssuses of the same *Pinna* may be seen today in Italy, but rather as objects of interest than as articles of luxurious apparel.

Extra large 'scallops' offered in the markets are apt to be the adductor muscles of these molluscs masquerading as the true scallop, which is the muscle of *Pecten*.

Black pearls are sometimes found in the mantle of *Pinna* or as baroques on the nacreous lining of its valves. A little crab (*Pinnotheres*) lives commensally in the mantles of *Pinna* and *Atrina*—some old tales recite the benefit the crab was believed to bestow upon its host by pinching him when a little fish entered between the gaping valves.

Shells of the Pinnidæ are large, trigonal, with sharp apices at the anterior extremities. Posterior borders extremely rounded and somewhat gaping; dorsal margins straight or with slightly concave curvature; ventral margins rounded; hinge teeth are present on the dorsal margin, and a long linear ligament is lodged in a trench extending about two-thirds of the marginal length. The quality of the shell is brittle and translucent, a nacreous layer which scales off readily, covers about two-thirds of the interior of the valves. Impressions of two muscles and pallial line are distinct. In the genus *Pinna* the valves are medially sulcate; valves of *Atrina* lack such sulcation.

Genus **ATRINA** Gray, 1840

Atrina[21] **rigida** Dillwyn Plate 3, fig. 15

Length, 250; width, 130 mm. Shell with characters of the family. Olive brown; outer surface bears about fifteen elevated ribs, with intercalations of smaller ribs posteriorly; ribs not well developed towards apex and ventral border. Each rib bears a series of sharply elevated, tubular or semi-tubular spines, the spines—like the ribs—are lost on the umbonal and ventral portions of the shell. A fine, long, silky byssus.

Atrina serrata[22] Sowerby Plate 3, fig. 16

Length, 260; width, 140 mm. Shell with characters of the family. A little larger than *A. rigida,* with posterior margin less rounded. Surface sculpture of closely placed ribs bearing deeply curved, semi-erect scales which are much reduced over ventral and umbonal areas.

Both species of *Atrina* are common on the beaches after blows, found from low tide mark to six fathoms.

Family **PTERIIDÆ**

The modest exterior of the shells of the Pteriidæ belies the family's claim to high distinction, for one of its genera includes the great pearl oyster of the South Seas and the *Pinctada* which responds to the exquisite skill of Japanese pearl culture. The secretion of nacre is a function common to all the members of this group. An occasional free pearl, but oftener a baroque, is found in the native species of *Pinctada.*

The Pteriidæ are molluscs of warm seas and moderate depths. Their shells are variable in shape and size, very inequivalve; inequilateral—often winged with a byssal notch.

21 Lat., *atrium,* an opening; *rigere,* to be stiff
22 Lat., *serra,* a saw

Genus **PTERIA** Scopoli, 1777

Pteria[23] **colymbus** Bolten Plate 4, fig. 17

Average alt., 35; length, 55 mm., many individuals exceed these dimensions. Shell is inequivalve, inequilateral, eared, obliquely winged toward posterior. Color brown with lighter, radiating bands; fresh shells have a light colored periostracum, lamellar in growth, with spiny projections along the light radiating bands often extended in a fringe beyond the shell margin. Umbos well anterior to middle, not projecting above cardinal margin. Ventral margin oblique, rounded, byssal notch near anterior ear; posterior margin concave; hinge margin straight with posterior ear short or greatly elongated. Two small cardinal and one lateral tooth in each valve; a single muscular impression, large, almost central. Interior of valves nacreous, pearly lining does not extend to free margins. Byssus of silky, brown threads.

Common on beaches. Dredged in three to seven fathoms.

Pteria cornea[24] Reeve

Alt., 18; length, 25 mm. 'Obliquely oblong, rather convex, olive, horny, smooth wing, rather broad. A plain olive, horny shell, moderately winged, attaching itself to *Gorgonia*.'—*Conchologica Iconica.*

Genus **PINCTADA** Roeding, 1798 (**MARGARITIFERA** Humphrey, 1797)

Pinctada[25] **radiata** Leach Plate 4, fig. 18

Average: Alt., 45; length, 43 mm. Shell somewhat quadrate, slightly oblique; thin, flattened, byssal notch under anterior ear of right valve; posterior ear not defined from posterior margin. Outer layer of shell laminated, with scaly projections concentrically arranged; this ornamentation is lacking in many specimens. Brownish color; occasionally a fine green color replaces the brown tone. Single lateral teeth in left valve, double laterals in right. Interior nacreous; wide, polished border about margins.

Common on beaches. Dredged with *Pteria colymbus.*

23 Gr., *pteron*, wing; *kolymbos*, a diver
24 Lat., *cornu*, horn
25 Span., *pintado*, marked with spots?

Family **OSTREIDÆ**

Ancient kitchen middens composed mainly of oyster shells and found in many parts of the world which were inhabited by primitive man testify to the importance of this mollusc in the economy of that era, and no mollusc of our own time enjoys greater gastronomic popularity. Oyster culture has a record and a tradition from the first century B.C. and the patrician Roman of that time was able to discriminate between the favors of oysters from different 'vivaria'[26].

Like the Lucrine beds of old Italy certain locations in America are famous for the flavor of their oysters, and oyster culture in the United States is estimated to have an annual value to growers in excess of $15,000,000, including a considerable export trade to Europe.

Distribution of the family is general in warm and temperate seas. They are all marine, and after the larval state is past they are permanently affixed by the left valve of the shell to some base of support. The shells are generally inequivalve with inconspicuous, curved umbos. The hinge has an internal ligament lodged in a triangular fosse; no cardinal teeth; a single muscular impression and an indistinct pallial line. The structure of the shell is lamellar, the interior is smooth and polished but not nacreous.

In the shallow tidal waters of Southwest Florida the common oyster forms reefs and bars of considerable size and of some importance to the navigation of small crafts. Along the shores of the bayous and creeks the pendant branches of mangrove trees are weighted with clumps of living oysters; many of these oysters are killed during a season of excessive rainfall when drainage into the creeks is sufficient to reduce the normal salinity of the water below the point of the mollusc's requirement.

[26] Common people are indifferent about the *manner of opening Oysters*, and the times of eating them after they are opened; nothing however is more important in the eyes of the experienced Oyster eater. Those who wish to enjoy this delicious restorative in its utmost perfection must *eat it the moment* it is opened, and with its own gravy in the under shell; if not *Eaten while absolutely Alive*, its flavor and spirit is lost . . . . . . The true lover of an Oyster will have some regard for the feelings of his little favorite, and will never abandon it to the mercy of a bungling operator, but will open it himself, and contrive to detach the Fish from the shell so dexterously that the Oyster is hardly conscious that he has been ejected from his Lodging, till he feels the teeth of the piscivorous Gourmand tickling him to death.—Cook's Oracle, Harper, 1830.

Genus **OSTREA** Linné, 1758

Ostrea[27] **virginica** Gmelin Plate 4, fig. 19

Size variable according to locality and food supply. Shape irregular-elongate, sometimes nearly circular. The shell is fixed at the umbonal region of the left valve which is larger and deeper, but shorter, than the flattened upper valve; the umbo of the left valve is lengthened and strong and may be directed either forward or backward. Umbo of right valve is short. Both umbos have a central channel in their approximate surfaces for ligamentary attachment. The surface of the lower valve is lamellate and folded; that of the upper valve is lamellate, ribbed and often spiny. Margin more or less deeply serrate. Interior of valves smooth with a central spot of deep purple and a prominent subcentral muscle scar.

Oysters are preyed upon by carnivorous molluscs, *Busycon, Melongena, Fasciolaria,* and many are eaten by sheepshead from the fringes of oyster bars, mangrove roots and pilings.

Ostrea limacella[28] Lamarck (**O. frons** Linné) Plate 4, fig. 20

Small, size variable up to alt., 45; length, 25 mm. Shells are rosy-brown, characterized by a broad, longitudinal midrib with lateral transverse folds in a pectinate arrangement from midrib to margins. The attached valve bears several curved processes which embrace the stem of a gorgonian or some other twiglike support, and attach the shell securely in its long axis. Shell margins deeply serrate, points interlocking. Interior white, polished. Hinge, muscular impression and pallial line of the type.

Dredged in four to six fathoms—usually about reefs.

Ostrea spreta[29] d'Orbigny (**O. cristata** Born) Plate 4, fig. 21

Alt., 40; length, 40 mm. Irregular, often rounded, attached valve deep, free valve rather flattened; surface of both valves folded into deep, radiate plications which extend to margin of shell and there form acute, interlocking serrations. Umbo of attached valve definitely longer than its fellow. Interior white, polished; often a callus deposit at site of the single muscle scar. Clasping processes simiar to those of *O. limacella* are developed on the lower valve, but are frequently expanded into pillar-like

27 Lat., *ostrea*, from Gr., *osteon*, bone

28 Fr., *limacelle*, the shell of *Limax*

29 *Sprote*, from Anglo-Saxon *sprote*, a sprout, spring

attachments when the shell rests upon a flat surface—often valves of *Atrina* and *Pteria*.

Dredged with *O. limacella*.

Ostrea permollis[30] Say — Plate 4, fig. 22

Alt., 30; length, 20-26 mm. Shell flattened, very variable in shape and outline, usually rounded but sometimes almost quadrangular. Moderately thin, translucent, golden color with delicate epidermis; parts of the shell which are exposed lack the golden hue. Almost equivalve, umbos flattened to plane of valves and abruptly recurved to right and left on respective valves. Distinct growth lines. Interior white. This oyster lives embedded in the substance of the 'bread sponge'.

Family SPONDYLIDÆ

The two American East Coast genera of the family Spondylidæ are distributed in warm waters southward from North Carolina, through the West Indies, and in the Gulf of Mexico to Texas. The genus *Spondylus* includes the 'thorny oyster', one of the most extraordinary of marine shells in its development of protective spines and in brilliancy of color.

The shells are inequivalve, attached by the right valve which is larger and deeper than the upper left valve. The hinge is of peculiar interest, it is unusually strong and permits only limited separation of the valves; there is a central ligamentary fossette and two cardinal teeth in each valve, the teeth articulate with sockets in the opposite valve.

Genus SPONDYLUS Linné, 1758

Spondylus[31] **ictericus** Reeve — Plate 5, fig. 23

Alt., 70; length, 55 mm. Shell rounded, trigonal, irregular; colored in shades of red and orange; inequivalve; eared; fixed by a triangular area at umbonal extremity of right valve, the surface of this triangular area is white with a deep longitudinal slit for the lodgment of a portion of the elastic ligament. The fixed valve is normally deeper than its fellow, but is frequently flattened in whole or in part by pressure from adjacent reef structures; its

30 Lat., *per*, very; *mollis*, soft
31 Gr., *spondylus*, vertebra; Gr., *icterikos*, jaundice .

surface bears many foliate lamellæ. The upper valve is radiately ribbed; prominent ribs alternating with delicately ribbed interspaces which show slightly stronger ribs in the center. The primary ribs bear many sharp, spinose processes; the intermediate ribs show a similar tendency, often expressed as a beading. Margin rounded. Hinge of two very strong cardinal teeth in each valve and a powerful elastic ligament. Interior of valves smooth, pink or lavender tinted, margins red-bordered and crenate. Single muscle scar, simple pallial line.

On reefs in five or more fathoms. Best taken by use of a tangle.

Genus **PLICATULA** Lamarck, 1801

Plicatula[32] **gibbosa** Lamarck Plate 5, fig. 24

Alt., 25; length, 24; diam., 10 mm. Shell solid, thick, irregular, roughly trigonal in shape with apex at umbos; widest at junction of lateral and ventral margins. Ground color white with fine pencillings of reddish brown. Slightly inequivalve with small, flat area of attachment near umbo of right valve. Each valve has an equal number of strong radiate plications sometimes slightly serrate, lateral margins minutely serrate. Hinge typical of family. Interior of valves white, plicate towards margin. Single, subcentral, laterally placed musclar impression, often a little elevated. Simple pallial line.

Dredged in two to six fathoms.

Gastrochæna burrows into the valves of living *Plicatula*, and small shells of *Rupellaria typicum* have been found in its cavities, in one instance an individual of each species was in one burrow. The author has found living *Gastrochæna* in burrows which had no communication with the outer surface of the valve.

Family **PECTINIDÆ**

All seas have representatives of the Pectinidæ, and their bathymetric range is from shallow water to profound depths. Shells of many species are brightly colored in shades of red, yellow, rose, pink and purple. The molluscs are sensitive and active and able to change not only position but also location by a rapid opening

32 Lat., *plicatus*, folded, *ula*, fem. dim.; *gibbus*, a hump

and closing of the shell valves. At rest they lie upon the right valve which is often colorless or paler than the left valve, and when the mollusc is undisturbed the valves of the shell remain slightly separated, showing the closely plaited mantle edge studded with brilliant metallic-blue eyes placed at intervals corresponding to the scallops in the shell's margin.

Aristotle and Pliny were acquainted with several species of this group and made the comparison of the ribbed shells to the teeth of a comb. It is quoted from Pliny that little fleets of scallops may be seen floating upon the surface of the sea, with one valve raised to make a sail, but this phenomenon has not been noted since Pliny's time.

The life time of Pectens is thought to be about two years. Reproductive maturity is reached within a year.

The shells are free, equivalve or inequivalve; equally or subequally eared, with a byssal notch under the anterior ear of the right valve; hinge margin straight; hinge has an internal cartilage fixed in a triangular fosse in each valve; some species show small insignificant lateral teeth; umbos central. Surface usually ribbed and margins scalloped; single muscular impression, subcentral and near posterior margin; simple pallial line. Pectens are byssiferous in the juvenile stage and some species retain this quality through adult life.

Genus **PECTEN** Osbeck, 1765

Pecten[33] raveneli Dall — Plate 5, figs. 25a, b

Alt., 40; length, 45; diam., 12 mm. Color varies through shades of pink to purple with a few rare gold colored individuals. This is one of the 'fan shells'. Hinge margin straight; ears subequal; umbos flat, central; ventral margin an almost perfect semicircle. Upper valve flat with median area slightly depressed, deeply colored with irregular dark markings; about twenty-two rounded, radiating ribs with wider interspaces, fine concentric growth lines; interior of valve smooth with margin beyond pallial line showing elevated ribs corresponding to external interspaces, each rib with a median sulcus. Lower valve deeply concave, pink tinted without, pinkish margin within; ribs

[33] Lat., *pecten*, a comb; dedicated to Dr. Ravenel, conchologist

with a central groove and wider than those of the upper valve. Inequivalve, margin of lower valve extends beyond that of the upper valve. Single muscle scar; simple pallial line.

Pecten ziczac[34] Linné Plate 5, fig. 26

Alt., 55; length, 55; diam., 13 mm. Color range similar to that of *P. raveneli*, but with lower valve tinted only toward ears and umbo. Inequivalve, margin of lower valve extends beyond margin of upper valve. Upper-left-valve flat with central concavity; about thirty-five flattened, radiating ribs—alternate ribs more prominent; smooth lateral areas of about 8 mm. width; inner surface of valve white, dark border and deep stain about ears and umbo. Lower valve deeply concave, ribbed; external ribs broad and separated by narrow grooves, internal ribs with central sulcus. Interior white.

P. raveneli, P. ziczac and *P. muscosus* are taken together in five to seven fathoms depth.

Subgenus **CHLAMYS** (Bolten) Roeding, 1798

Pecten muscosus[35] Wood (**Pecten exasperatus** Sowerby) Plate 5, fig. 27

Alt., 48; length, 46; diam., 18 mm. Surface spinose, rough; valves uniformly colored; color range through brown, red, orange, lemon and apricot shades. Almost equivalve; ears unequal. Each valve bears about twenty prominent ribs with very finely ribbed interspaces; ribs closely set with small, sharp, projecting scales; marginal scallops correspond to ribs. Interior of valves ribbed and tinted with a pale shade of exterior color. This *Pecten* is usually covered with a growth of sponge, and adult individuals are usually attached by a byssus.

Stormy blows often bring this *Pecten* to the beaches in great numbers.

Subgenus **ÆQUIPECTEN** Fischer, 1886

Pecten gibbus[36] Linné Plate 6, fig. 28

Alt., 50; length, 52; diam., 25 mm. Shell with family characters. Color and pattern of bright or dull pinks and reddish-

[34] Ger., *zickzack*, origin uncertain; a series of sharp turns in a course.
[35] Lat., *muscus*, moss.
[36] Lat., *gibbus*, a hump.

purples on white ground, very variable; pure yellow specimens occur and some blending of the two types is seen. The upper valve is always more gayly colored; interior delicately tinted in accord with exterior coloration. Right-lower-valve deeper and umbonal elevation a little higher than in left valve. About twenty rounded, radiating ribs, smooth area below ears. Concentric sculpture of fine laminations. Deep marginal scallops formed by the ribs interlock and overlap.

Taken only in the Gulf in more than three fathoms. Common on the beaches after blows.

Pecten gibbus irradians[37] Lamarck Plate 6, fig. 29

Alt., 75; length, 75; diam., 34 mm. Shell with family characters. Right valve more deeply concave, humped in umbonal region. Upper valve mottled gray or brown on white, lower valve white with gray or brown near umbo; a variant type is orange or lemon color. Nineteen to twenty-three ribs, narrow ribbing over lateral areas and auricles. Fine concentric laminations crossing ribs and interspaces. Marginal interlocking of ribs exaggerated.

This is a lagoon type which is often taken for market. It appears to spawn in shallow water among eel and turtle grass. Very young individuals are found attached to grass blades by threads of byssus.

Subgenus **LYROPECTEN** Conrad, 1862

Pecten nodosus[38] Linné Plate 6, fig. 30

Alt., 95; length, 100 mm. Shell with family characters. Almost equivalve, ears unequal; eight or ten large primary ribs, both surface ribs and the wide interspaces uniformly and narrowly ribbed; knoblike nodes developed at more or less regular intervals on the primary ribs—this character is very variable; ears and lateral areas finely ribbed; concentric sculpture of fine lamellæ, strongest in intercostal spaces but sometimes wanting. Interior of valves radiately channeled, smooth, reddish colored—deepest near margins.

[37] Lat., *irradiare*, to irradiate.

[38] Lat., *nodus*, knot.

Dredged, usually on hard bottom in five to eight fathoms. Very young individuals of less than ten millimeters have been taken in five to six fathoms. Not uncommon on the beach after a northwester.

Pecten nodosus fragosus[39] Conrad

Smaller than *P. nodosus,* height rarely more than 60 mm. Color reddish-brown. Seven or eight ribs, seldom more, six of which are prominent and nodose; narrow, finely laminate interspaces without longitudinal sculpture. Lower valve definitely flattened. Distinguished from *P. nodosus* by its longer and less numerous ribs, narrow, transversely laminate interspaces and flattened inferior valve.

Taken with *P. nodosus.*

Family LIMIDÆ

The living molluscs of the family Limidæ possess a delicacy and vivacity which makes them especially attractive subjects for observation. Most of them are red or orange color, with a veil-like, closely plaited mantle which bears numerous extensile, filamentous tentacles which are almost constantly in motion. In an aquarium *Lima* may be seen to move quite easily over the glass surface by fixing the free extremities of several tentacles, then by contracting them the animal is drawn into a new position. Limas can also swim—as do Pectens—by a rapid flapping of the shell valves; the action is performed very effectively, for the valves may be separated to an extreme degree and approximated with sufficient force to propel the creature rapidly through the water with a motion which suggests the wingbeat and flight of birds. The writer has seen a swimming *Lima inflata* caught by the expanded tentacles of a sea anemone and immediately ingested.

Some species of *Lima* construct funnel-shaped nests from fragments of shell, bits of debris and seaweed, and if removed therefrom the owner is said to return to his home.

The family is represented in all seas and has a considerable range in depth.

[39] Lat., *fragosus,* rough, broken.

Genus **LIMA** (Bolten) Roeding, 1798

Subgenus **LIMARIA** Link, 1807

Lima[40] **inflata** Lamarck Plate 6, fig. 31

Alt., 25; length, 16; diam., 8 mm. Shell obliquely oval, inflated, pure white and fragile, translucent valves in contact only at ventral border, with a very thin, brownish periostracum. Equivalve; inequilateral, auriculate, anterior margin straight, posterior and ventral margins rounded, hinge margin oblique. Umbos prominent, central, small and sharp. Sculpture consists of delicate, unequal ribs and obscure, concentric growth lines; ribs are scarcely elevated in umbonal region and toward the margins they bear small toothlike imbrications which render the name *Lima* appropriate. Hinge partly external, a portion of the ligamental area is visible below the umbos; no hinge teeth. Interior of valves polished, single muscle scar, subcentral and near posterior margin; simple pallial line; margins finely serrate. The molluscs secrete very delicate byssal threads.

Family **ANOMIIDÆ**

The Anomiidæ are native to warm and temperate seas all over the world, and to depths beyond the littoral zone to about twenty fathoms.

In the adult stage the mollusc is fixed; the young *Anomia* has a bivalve shell and is a free-swimming creature until a byssus is secreted and sedentary life begun. At an early stage in the development of the shell a notch appears in the margin of the right valve, this notch is deepened by progressive marginal growth until it finally becomes an opening more or less isolated from the shell margin and in position to allow passage of a byssus which becomes calcified and permanently fixed. A strong muscle unites the inner surface of the byssal plug with upper valve of the shell.

Genus **ANOMIA** Linné, 1758

Anomia[41] **simplex** d'Orbigny Plate 6, fig. 32

Alt. to 40; length to 44 mm. Shell fixed, inequivalve, usually subcircular and conforming to the contour and sculpture of its base. Structure lamellar, translucent, color golden or silvery with a lustrous exterior and nacreous lining. Upper valve slightly convex, interior with transverse ligamentary fossette and

[40] Lat., *lima*, a file; *inflatus*, from *inflare*, to inflate.
[41] Gr., *anomos*, without law.

muscle impressions. Lower-right-valve flattened, with byssal sinus near apex; sinus not closed at marginal border. Pallial line indistinct.

Dredged in one to six fathoms.

Genus **PODODESMUS** Philippi, 1837

Pododesmus[42] **decipiens** Philippi Plate 6, fig. 33

Shell larger than *Anomia*—up to 45 mm. Inequivalve, superior valve convex, exterior brownish, rough, with narrow, irregular riblets, sometimes scaly; concentric growth lines. Inferior valve adapted to shape of its support; byssal sinus similar to *Anomia;* pearly lining; one muscle scar.

Taken with *A. simplex.*

Family **MYTILIDÆ**

The Mytilidæ is a large and widely distributed family, best represented in cold seas but having various genera which are adapted to warmer waters. Some European members of the family rank near the oysters and clams in economic importance, mussels having been cultivated for food along the French and Belgian coasts for several centuries. All mussels are edible, but they are not generally esteemed in the United States as food, but are much used as bait for bottom-feeding fish.

Some species make a nidus from fragments of debris entangled by byssal threads, and others form cavities in wood or coral. The family is byssiferous.

The shells are equivalve, longest from umbonal region to opposite margin; not auriculate; very inequilateral with sharp umbos. There is a linear hinge ligament, either marginal or partly internal; teeth are absent or very feeble; impressions of two adductor muscles—the anterior small, the posterior large and indistinct. Pallial line almost always simple. Interior of valves polished but not nacreous and often of a purple color. The ventral border gapes for passage of a byssus. All have an epidermis.

Genus **MYTILUS** Linné, 1758

Subgenus **HORMOMYA** Morch, 1853

Mytilus[43] **recurvus** Rafinesque Plate 7, fig. 34

Alt., 30; length, 40 mm. Color dark purplish; shell strongly and obliquely upcurved; umbos anterior, acute, terminal. Hinge

42 Gr., *podos*, foot, *desmos*, ligament; Lat., *decipere*, to deceive.
43 Lat., *mytilus*, a sea mussel.

margin concave, slightly sinuous; anterior and ventral margins sharply curved and continuous; posterior margin rounded. Valves finely and closely ribbed, umbos smooth. Interior dark purple, nacreous, margins finely crenate with byssal sinus.

Common in shallow water, often among roots of mangrove trees.

Mytilus exustus[44] Linné Plate 7, fig. 35

Alt., 10; length, 28 mm. Shell color bluish-gray with bright brown; epidermis thin, brown. Surface finely ribbed. Shell oblique, inflated below hinge margin which is short and straight; ventral margin long, almost straight. Interior purple, nacreous, color pale about borders, margins crenate.

Common on the beach attached to *Atrina* and to each other. Dredged in three to six fathoms.

Genus **MODIOLUS** Lamarck, 1799

Modiolus[45] **tulipus** Linné Plate 7, fig. 36

Alt., 33; length, 65 mm. Shell moderately thick, translucent, smooth except for incremental lines; color brown or yellowish brown, with red undertone. Epidermis glossy brown, shaggy toward posterior end. Umbos anterior, incurved, closely approximate, not terminal. Shell inflated, slightly carinate above, a shallow sulcus below. Interior pink near umbos, purple, nacreous. Epidermis reflected over smooth margins.

This is a nest building species. Common on Gulf beach, dredged in three to seven fathoms.

Subgenus **Brachidontes** Swainson, 1840

Modiolus demissus[46] **granosissimus** Sowerby Plate 7, fig. 37

Alt., 30; length, 65 mm. Shell brown with thin brown epidermis. Sculpture of fine ribs cut transversely into granules; lower anterior portion of valves smooth. Umbos inconspicuous, anterior, not terminal, often eroded through to nacreous layer. Hinge margin slightly convex, other margins slightly rounded. Byssal opening below. Interior purple, nacreous, margins crenate.

44 Lat., *exustus*, past part, of *exurere*, to burn up.
45 Lat., *modiolus*, a small measure.
46 Lat., *demittere*, to send away; *granosus*, full of grains.

A shallow water species, often found on oyster bars.

Modiolus citrinus[47] (Bolten) Roeding Plate 7, fig. 38

Alt., 14; length, 38 mm. Shape resembles *Mytilus exustus*, larger and more slender; bluish-gray covered with bright yellow epidermis. Surface ribbed, smooth anteriorly. Umbos small, round, incurved. Interior white stained with purple, margins smooth, epidermis reflected internally.

Not ordinarily found on the beaches. Dredged in three to six fathoms.

Subgenus **AMYGDALUM** Megerle von Mühlfeld, 1811

Modiolus aborescens[48] Dillwyn Plate 7, fig. 39

Alt., 8; length, 22 mm. Shell fragile, smooth, polished and iridescent, greenish color; thin, transparent epidermis. Inconspicuous umbos, anterior, not terminal. Hinge margin straight. Valves rounded. Interior nacreous, margins smooth.

Found in mud between tide marks, usually in inside waters.

Subgenus **GREGARIELLA** Monterosato, 1883

Modiolus opifex[49] Say Plate 7, fig. 40

Alt., 7; length, 17 mm. Shell smooth save for growth lines, oval, attenuated to a rounded point posteriorly. Shell light colored covered with brown epidermis. Valves carinated to form a flat hinge area; epidermis fringed and ragged along the keel. Interior pearly.

Dredged, taken from cavities in fragments of rock and coral.

Genus **BOTULA** Mörch, 1853

Botula castanea[50] Say Plate 7, fig. 41

Alt., 6; length, 15 mm. Shell oblong, smooth, inflated, purplish beneath shining brown epidermis, purplish within. Anterior margin rounded; posterior margin rounded, umbos high, subterminal. Depressed byssal notch anterior to center.

Shallow and moderate depths.

Botula fusca[51] Gmelin Plate 7, fig. 42

Alt., 4; length, 12 mm. Shell oblong, smooth, inflated, dark

47 F., *citrine*, yellow, from Lat., *citrus*, citron tree.
48 Lat., *aborire*, to dwarf.
49 Lat., *opifex*, an artificer.
50 Lat., *castanea*, chestnut.
51 Lat., *fuscus*, tawny.

brown shining epidermis. Anterior extremity rounded; posterior extremity with high, rounded umbos, subterminal and almost in contact. Juvenile shells have a more or less rhomboidal outline.

Shallow to moderate depths.

Genus **LITHOPHAGA** (Bolten) Roeding, 1798

Lithophaga[52] **antillarum** d'Orbigny

Alt., 12 or more; length up to 50 mm. Shell white with thick, dark brown epidermis. Much elongated oval, date-shaped. Dorsal and ventral margins nearly parallel, anterior and posterior margins rounded. Umbos suppressed. Fine basal ribbing, growth lines most pronounced posteriorly. Interior white.

This is a boring species. Sometimes found in lumps of coral on the beach, dredged in living coral and in rock from reefs.

Lithophaga bisulcata[53] d'Orbigny — Plate 8, fig. 43

Alt., 11; length, 38 mm. Shell with polished brown epidermis, usually covered with a rough, brownish-colored calcareous coating. Shell date-shaped; posterior margin smoothly rounded, but epidermis and its calcareous coating prolonged beyond the rounded shell margin to a blunt point. Umbos small, pointed, at anterior end of hinge margin. Each valve has two oblique sulcations directed posteriorly from dorsal margin. Interior brown.

Burrows in coral, rock, other shells, cement. Found in both shallow and deep water.

Lithophaga aristata[54] Dillwyn — Plate 8, fig. 44

Alt., 14; length, 30 mm. Shell cylindrical, dull white, brittle, similar to *L. bisulcatus* in shape and general character; no sulcation of valves; the posterior prolongations of the valves cross in a scissor-like manner.

The mollusc burrows in coral.

Genus **MODIOLARIA** Beck, 1838

Modiolaria[55] **lateralis** Say — Plate 8, fig. 45

Alt., 5.5; length, 12 mm. Thin, fragile, pale brown, with thin, shining epidermis. Shell inflated, slightly carinate posteriorly.

52 Gr., *lithos*, stone; *phagein*, to eat.
53 Lat., *bis*, twice; *sulcare*, to furrow.
54 Lat., *arista*, arm.
55 Lat., *modiolus*, with suffix *arius* to form generic name.

Umbos small, rounded, recurved. Valves finely ribbed at each end with a smooth central area. Margins serrate at ends of ribs, smooth with byssal notch between groups of serrations. Pearly lining.

Usually attached to ascidians, in the crevices of zoöid colonies, on shells of *Atrina*, etc.

Order ANOMALODESMACEA

Family PERIPLOMATIDÆ

The east American genera of the Periplomatidæ are distributed along the coast from Labrador to Florida and the West Indies. The shells are all white and fragile. The most interesting character of the Periplomas is the extence of a small triangular-shaped lithodesma which is within the shell and lies between the spoon-shaped tooth and the anterior cardinal margin. The molluscs are hermaphroditic.

Genus PERIPLOMA Schumacher, 1817

Periploma[56] inæquivalvis Schumacher Plate 8, fig. 46

Alt., 8.5; length, 14 mm. Shell light and fragile, white. Inequivalve, left valve smaller; inequilateral, posterior extremity truncated and a little gaping. Umbos very small, near posterior extremity and directed posteriorly. An oblique ridge or keel from umbo to posterior end of ventral margin. Concentric growth lines. Interior pearly; one spoon-shaped tooth in each valve for the reception of hinge cartilage.

Found in sand bottoms near low tide mark. Preyed upon by *Marginella apicina*.

Family PANDORIDÆ

Distribution of the Pandoridæ is quite general in all seas, on the East American coast they are found from the Arctic Ocean to the Gulf of Mexico.

The shells are small and usually free, inequivalve, roughly semilunar, white or brownish with a thin periostracum. The umbos are inconspicuous and the hinge consists of lamelliform

[56] Gr., *peri*, around, about; *ploimos*, fit for sailing?

plates which take the place of teeth, and an internal ligament lodged in an oblique sulcus. There is a lithodesma. Non-byssiferous.

Genus **PANDORA** Hwass, 1795

Pandora[57] **trilineata** Dall — Plate 8, figs. 47a, b

Alt., 15; length, 29; diam, 3.5 mm. Shell white, smooth, growth lines parallel with ventral margin. Thin, light colored, polished epidermis. Slightly inequivalve; very inequilateral; umbos at extreme anterior end, not projecting. Hinge internal, below umbos, lamellar plates replace teeth; a ligamentary fossa is present. Posterior part of shell much prolonged, with a scimitar curve upward, posterior margin flattened. Anterior margin round, truncate; ventral margin rounded and prolonged. Shell much narrowed toward posterior extremity. Right valve flat, left convex, each with a narrow oblique ridge near anterior extremity. Oval impressions of two adductor muscles, pallial line simple, discontinuous.

Dredged in two fathoms off Blind Pass, Sanibel Island.

Subgenus **KENNERLIA** Carpenter, 1864

Pandora bushiana Dall — Plate 9, fig. 48

Alt., 6; length, 14; diam., 1.5 mm. Shell white, smooth, delicate epidermis; right valve flat or concave, left valve convex. Inequilateral, short and rounded anteriorly, prolonged posteriorly. Umbos minute. Anterior and ventral margins rounded; posterior margin extended, nearly straight. A linear demarcation between anterior and posterior portions of valves; slightly carinate behind. Sculpture of growth lines. Hinge like others of the type. Pearly interior, two muscle scars; indistinct, simple pallial line.

Dredged in the Gulf off Sanibel Island between four and six fathoms.

Pandora arenosa[58] Conrad (**P. carolinensis** Bush) — Plate 9, fig. 49

Alt., 5.5; length, 12; diam., 1.5 mm. General features like *P. bushiana*, shorter, with ventral margin more convex. Right valve

[57] Gr., *pan*, all, *doron*, gift—*Pandora*, all-gifted, a mythological person.

[58] Lat., *arenosus*, sandy.

concave, with fine, radiating, engraved lines. Left valve convex, smooth.

Dredged in the Gulf with *P. bushiana*.

Family LYONSIIDÆ

The family Lyonsiidæ has genera in both the Atlantic and the Pacific oceans, most of them in deep water. Shells are small, fragile and pearly.

The lower west coast of Florida has two species of the genus *Lyonsia*.

Genus LYONSIA Turton, 1822

Lyonsia[59] **floridana** Conrad — Plate 9, fig. 50

Alt., 7.5; length, 16; diam., 5 mm. Shell fragile and translucent, pearly; very thin papery epidermis; inequivalve, left larger, its umbo higher than its fellow; inequilateral, prolonged, narrowed, truncated and open posteriorly. Umbos minute, pointed, in contact. Dorsal margin concave behind umbos. Shell surface shows incremental lines, with radiate wrinkles and marginal folds of the epidermis. Hinge without teeth, a small submarginal groove for ligament and lithodesma posterior to umbos. Interior pearly, two muscular impressions, indistinct pallial line. Delicate byssus.

Found in muddy bottom in shallow water.

Lyonsia beani[60] d'Orbigny — Plate 9, fig. 51

Alt., 8; length, 23; diam., 9 mm. Shell pearly, smooth; brownish, radiately striate epidermis. Shape irregular, inequivalve, inequilateral, prolonged and widened behind, posterior margin rounded, gaping. Umbos anterior, small, close. Hinge and interior of the type.

Found in deeper water than *L. floridana*; frequently in sponge or attached by very delicate byssal threads to other shells.

Family CUSPIDARIIDÆ

Most members of the family Cuspidariidæ are inhabitants of profound depths; they are native to all seas, but are seldom seen except with dredged material. The shells are small, white, with thin epidermis; pyriform; slightly inequivalve, left valve larger

[59] Genus dedicated to the naturalist, W. Lyons.
[60] A. S., *bean*, from a Gothic word meaning to puff up.

and of greater convexity; inequilateral, round and inflated anteriorly, posterior portion beaked, gaping. There is an external linear ligament, and an internal cartilage placed in a small spoon-shaped fossette. Hinge teeth variable. Two muscle scars, pallial line has small sinus.

Genus **CUSPIDARIA** Nardo, 1840

Subgenus **CARDIOMYA** A. Adams, 1864

Cuspidaria[61] **gemma** Verrill and Bush — Plate 9, fig. 52

Alt., 3.5; length, 6 mm. Shell fragile, thin, white; smooth epidermis. Delicate concentric growth lines; four radiate ribs —one almost in center of sheil, three posterior to center. Rounded ventral margin, angulated termination of ribs. Posterior end of shell prolonged Right valve has one lateral tooth.

Dredged at one to two fathoms in blue mud.

Order **TELEODESMACEA**

Family **CYRENIDÆ**

The Cyrenidæ are in general fluviatile and brackish water molluscs. Most abundant in temperate regions.

Genus **POLYMESODA** Rafinesque, 1820

Subgenus **PSEUDOCYRENA** Bourguignat, 1855

Polymesoda[62] **floridana** Conrad — Plate 9, fig. 53

Alt., 17; length, 21 mm. Shell and margin rounded, smooth, lusterless, thin epidermis; white to purple, often banded in the two colors; umbos rounded, near together. Hinge with three cardinal and two lateral teeth. Interior smooth, colored like exterior; two muscle scars, simple pallial line.

Found on tidal flats and in bayous.

Polymesoda[63] **floridana protexta** Conrad — Plate 9, fig. 54

Similar to *P. floridana,* longer, slightly keeled posteriorly, ventral margin has posterior sinuosity.

Family **GOULDIIDÆ**

The family Gouldiidæ is generally distributed through all seas. Species of the genus *Crassinella* are found from New England

61 Lat., *cuspidis,* pointed end; *gemma,* a bud.
62 Gr., combining form *poly,* many, and *meso,* in middle.
63 Lat., *pro,* before and *textus,* structure.

southward to the West Indies and in the Gulf of Mexico.

Genus **CRASSINELLA** Guppy, 1874

Crassinella mactracea[64] (Linsley) Plate 9, figs. 55a, b

Alt., 8; length, 9 mm. Shell small, flattened, triangular, equivalve, thin epidermis; brownish-red with darker brown. Flattened, concentric ribs. Umbos apical. Two cardinal teeth in left valve, one in right valve; two lateral teeth in each valve. Interior smooth, often two broad purple rays; two muscle impressions; simple pallial lines; smooth margins.

From less than one to six fathoms.

Family **CARDITIDÆ**

The Carditidæ are native to northern, temperate and warm seas and to moderate depths. All have solid equivalve shells, usually ribbed.

Genus **CARDITA** Bruguière, 1792

Cardita[65] **floridana** Conrad Plate 10, fig. 56

Alt., 24; length, 38; diam., 20 mm. Shell solid, heavy. Porcelanous; creamy ground color, maculations of brown; sand colored equidermis; equivalve; inequilateral, oval, longest posteriorly. Umbos small, umbonal region high, curved inward; small, depressed lunule; fifteen to eighteen, strong radiating ribs, lamellated or beaded by transverse growth lines—less prominent in intercostal spaces. External hinge ligament. Hinge oblique strong cardinal teeth, right valve has one anterior lateral, left valve one posterior lateral tooth. Interior pure white, smooth. Two muscular impressions and simple pallial line well impressed. Margins dentate corresponding to ribs.

Found in the bays, where specimens are more uniformly dark colored and less thick than shells taken in the Gulf. From shallow water to four fathoms.

Genus **VENERICARDIA** Lamarck, 1801

Subgenus **PLEUROMERIS** Conrad, 1867

Venericardia tridentata[66] Say Plate 10, fig. 57

Alt., 7; length, 6.3; diam., 4.5 mm. Shell rather thick, cordiform, light brown irregular color markings. Equivalve, almost equilateral; umbos small, round. Small lunule. About sixteen

64 Gr., *maktra*, a kneading trough.

65 Gr., *kardia*, heart.

66 Lat., *tri*, from *tres*, three; *dens*, tooth.

to eighteen beaded, radiating ribs, no sculpture in intercostal spaces. Two cardinal teeth in left valve, separated by a triangular socket which receives single cardinal tooth of right valve. Interior purple, two muscle scars, simple pallial line, margins crenate.

Taken in three to seven fathoms.

Subgenus **PTEROMERIS** Conrad, 1862

Venericardia perplana[67] Conrad — Plate 10, fig. 58

Alt., 7; length, 6; diam., 2 mm. Shell small, obliquely trigonal; bluish-gray with zigzag markings of brown. Equivalve, inequilateral. Twelve or fourteen smooth radiate ribs which increase in width toward margin. Umbos sharp. Two cardinal teeth in left valve, one in right valve. Interior purple brown; two muscular impressions and simple pallial line; margins dentate within .

Dredged in one to seven fathoms.

Family **CHAMIDÆ**

Members of the family Chamidæ are native to warm and tropical seas. All have fixed, heavy, inequivalve shells with spiral umbos and an external ligament. Fixation by either the right or left valve is a generic character; the fixed valve is always deeper. Shells of Chamidæ are frequently attacked by the burrowing sponge *Cliona* and are often mined by boring molluscs.

Genus **CHAMA** Linné, 1758

Chama[68] **congregata** Conrad — Plate 10, fig. 59

Alt., 25; length, 27 mm. Shell fairly thick, orbicular, attached by left valve which is larger and deeper than the upper valve and with its umbo well above ligamentary area. Umbos turn to right when shell is observed in its attached position. Area of attachment variable, on a flat surface it is apt to include almost entire lower valve. Sculpture of elevated, radiating ridges and more or less foliate lamellae along concentric growth lines; usually red, with colors deepest on ridges and foliations; there is also a pure yellow form. An external ligament which follows curve of the umbos. Hinge with one heavy cardinal tooth in up-

[67] Lat., *per*, prefix meaning completely, with *planus*, flat.
[68] Lat., *chama*, cockle; *congregare*, to congregate.

per valve, opposite socket in lower valve. Interior white with tinting of exterior color; two muscle scars, simple pallial line; margins very finely crenate, closely approximate.

Found adhering to shells of *Atrina rigida*, *Arca occidentalis* and *A. auriculata* but rarely to other arks, and to dredged fragments of reef rock. Common on valves of *Atrina* on the beaches; dredged from one to seven fathoms.

Chama macerophylla[69] Gmelin Plate 10, fig. 60

Average alt., 40; length up to 90 mm. General characters those of *C. congregata*, but larger and heavier, valves deeper and without radiate ridges, and having the lamellar foliations fluted and more developed on both upper and lower valves. Color types vary through shades of pink, yellow and combinations of the two colors. Margins crenate within.

Frequently adherent to valves of *Atrina*.

Genus **PSEUDOCHAMA** Odhner, 1917

Pseudochama[70] **radians variegata** Reeve Plate 10, fig. 61

Alt., 40; length, 35 mm. Attached by right valve; spiral twist of umbos to left when shell is viewed in attached position, umbos slightly more prominent than in *Chama*. Attachment to its support often by lamellar processes instead of a flattened valve surface. Sculpture of both ridges and foliations. Internal margins finely crenate. Other characters typical of family. *Pseudochama* is seldom attached to other shells.

Taken about reefs in four to seven fathoms.

Genus **ECHINOCHAMA** Fischer, 1887

Echinochama[71] **arcinella** Linné [72] Plate 10, fig. 62

Alt., 40; length, 35 mm. Shell thick, globular, white with brown stains near umbos; equivalve; valves and umbo curve forward; wide, deeply impressed lunule. Each valve bears seven or eight strong ribs with erect, slender, tubular spines. Surface of both valves including lunule, covered with beadlike papillæ.

[69] Gr., *macros*, long in extent, with *phyllon*, leaf.

[70] Gr., *pseudes*, false; Lat., *radians*, pres. part. of *radiare*, to emit rays; past part. of *variegare*, to variegate.

[71] Lat., *echinus*, hedge-hog; *arcus*, bow, *ella*, dim. suffix.

[72] The Florida *Echinochama* has fewer radial ribs than the genotype. If a valid subspecies it will be called *E. arcinella cornuta* Conrad.—*Pilsbry and McGinty, Nautilus, vol.* 51, *No.* 3.

Hinge ligament partly internal. Each valve has one cardinal tooth. Interior white or purple; two muscle scars, simple pallial line, margins scalloped and finely crenate. Juvenile shells are attached by a small area near right umbo; adults usually free.

Family UNGULINIDÆ

The Ungulinidæ is a small family with close affinities to the Lucinidæ. Their distribution is through northern seas almost to tropical waters.

The shells are equivalve, globose, the umbos prominent, directed forward. The hinge usually has two cardinal teeth in each valve, sometimes but one or none. Ligament internal or partly so. Two elongate muscle scars and simple pallial line.

Genus TARAS Risso, 1826

Taras punctata[73] Say — Plate 11, figs. 63a, b

Alt., 14; length, 15.5; diam., 10 mm. Shell lucinoid, thin, white, translucent; very thin periostracum. Umbos prominent, approximate; no lunule; anterior margin slightly concave immediately below umbo. Surface of valves smooth, faint concentric striations and microscopic radial striae. Two cardinal teeth in left valve, the anterior bifid; two in right valve, the posterior bifid. Interior of valves usually shows opaque, punctate spots, most evident near umbonal region. Anterior and posterior muscular impressions. Simple pallial line, often with slight irregularities. Pallial lines more removed from shell margin than are outer borders of the muscular impressions. Shell margins smooth.

Taken in depths of six to one hundred twenty-five fathoms.

Subgenus PHYLCTIDERMA Dall, 1899

Taras semiaspera[74] Philippi

Alt., 8.5; length, 8; diam., 5.5 mm. Shell small white, very globose; umbos small depressed. Opaque punctations over valve

[73] Lat., *punctus,* point.
[74] Lat., *asper,* rough.

surfaces, on exterior of valves the opaque points are slightly elevated. Other characters correspond to *T. punctata.*

Dredged in six fathoms.

Family LUCINIDÆ

Molluscs of the family Lucinidæ are generally distributed in subtropical and tropical seas, only one genus has accommodated itself to the rigors of Arctic seas and to great depths. Their normal range is from the littoral region to deep water. The animal has a long, slender foot well adapted for digging in sand and for moving from place to place.

Shells of the Lucinidæ are round or lentiform, compressed, equivalve and subequlateral. The umbos are small, but definite and point forward; the lunule is small and clear-cut. The ligament internal or semi-internal, hinge teeth are variable and the shells of some genera are edentulous. The interior of each valve shows two muscular impressions and a pallial line.

Genus LUCINA Bruguière, 1797

Subgenus ANODONTIA Link, 1807

Lucina[75] pectinatus Gmelin 1792 Plate 11, fig. 64

Alt., 55; length, 58 mm. Shell pale yellow, lenticular, very thin periostracum; rostrate posteriorly, also a slight anterior rostration. Umbos small, approximate. A small lunule, not evenly halved between the two valves. Margin rounded, smooth. Sculpture of concentric, lamellate ridges and delicate parallel ribbing in interspaces. A submarginal ligament; two cardinal teeth in left valve, one in right; one anterior and one posterior lateral in left valve. Opposite sockets in right valve. Interior yellow; narrow anterior and posterior muscle scars. Inner margins finely crenate.

Inhabits muddy sand at no great depths.

Subgenus LUCINISCA Dall, 1901

Lucina nassula[76] Conrad Plate 11, fig. 65

Alt., 9.5; length, 10 mm. Shell small, white, rounded, almost equilateral; umbos small; lunule impressed. Elegant reticulate

75 Lat., *lux, lucis,* light; *pectinare,* to comb.

76 Lat., *nassa,* a basket for catching fish.

sculpture of radiating ribs and about twenty concentric, lamellate ridges. Cardinal and lateral teeth present. Interior white, margins finely serrate.

Common in shallow water.

Subgenus **PSEUDOMILTHA** Fischer, 1887

Lucina floridana Conrad — Plate 11, fig. 66

Alt., 36; length, 34 mm. Shell white, porcelanous, with thin brownish, papery periostracum. Orbicular, compressed, equivalve, subequilateral. Umbos small, pointed; oval lunule. Sculpture of inequidistant concentric growth lines. Hinge margin thick, edentulous. Interior white. Muscle scars and pallial line of the type. Wide, finely crenate border.

Common in shallow water.

Subgenus **PARVILUCINA** Dall, 1901

Lucina multilineata[77] Tuomey and Holmes — Plate 11, fig. 67

Alt., 5.5; length, 5 mm. Shell small, round, solid, white, valves thick, thin epidermis. About twelve, broad, radiating ribs crossed by prominent concentric ridges; lunule impressed, not ribbed. Umbos small. Small cardinal and lateral teeth in right and left valves. Inner margin finely crenate.

Found in sand and muddy bottom from shallow to deep water.

Lucina amiantus[78] Dall

Alt., 6.5; length, 6 mm. Shell small, white, globose. Valves not thick, thin periostracum. Lunule small, impressed; umbos in contact; delicate reticulate sculpture. Small cardinal and lateral teeth. Margins very finely crenate.

Inhabits mud and sand bottom from shallow to deep water.

Genus **CODAKIA** Scopoli, 1777

Codakia[79] **orbiculata** Montagu — Plate 11, fig. 68

Alt., 11; length, 12 mm. Shell small, white, obliquely rounded—not globose, thin periostracum; lunule small; umbos in contact. Sculpture of numerous radiating ribs, some bifid, and some intercalation of riblets near margin; fine concentric lines and

[77] Lat., *multus*, many; *lineare*, to reduce to a straight line.
[78] Gr., *amiantos*, unstained.
[79] Lat., *cauda*, tail, with termination *ia; orbis*, orb.

coarser growth lines cross ribs. Small cardinal and lateral teeth. Free and inner margins crenate.

A shallow water species, found in sand.

Genus LORIPINUS Monterosato, 1883

Subgenus PEGOPHYSEMA Stewart, 1930

Loripinus[80] **chrysostoma** Philippi

Alt., 50; length, 53 mm. Shell subglobose with rounded margins; exterior white, interior brilliant orange color, deepest near margins. Umbos not prominent; hinge margin extended anteriorly to a faint lunule. Sculpture of growth lines. Hinge edentulous; ligament bright scarlet in fresh specimens. Margins smooth.

Inhabits sandy bottom at moderate depths.

Loripinus schrammi Crosse — Plate 12, fig. 69

Alt., 70; length, 80; diam., 55 mm. Shell white, globose, brownish periostracum. Umbos rounded, in contact, sometimes worn. Strong, coarse, concentric growth lines. Hinge edentulous, ligament strong, brown. Interior surface of valves rough, anterior muscular impression transversely elongate. Margins smooth.

Inhabits moderate depths.

Family LEPTONIDÆ

Molluscs of the family Leptonidæ all have small shells. They are usually thin and somewhat translucent, equivalve, with a tissue-like periostracum. Most of its genera are viviparous.

Genus ERYCINA Lamarck, 1806

Erycina[81] **floridana** Vanatta — Plate 12, figs. 70a, b

Alt., 5.25; length, 7.50; diam., 2.0 mm. Shell small and symmetrical, white, translucent and very fragile. Flattened, equivalve, subequilateral. Umbos sharp, small but distinct. Anterior and posterior margins evenly rounded, dorsal margin slightly convex, ventral margin almost straight. Concentric sculpture of delicate growth lines with coarser lines at intervals. Hinge has small fossette below umbos, one divergent cardinal tooth,

80 Lat., *lorum*, strap, thong; *pes*, foot, hence *loripes*, bandy-legged; Gr., *chrysos*, golden; *stoma*, mouth.

81 *Erycina*, a name of Venus.

one anterior and one posterior lateral tooth. Two oval muscular impressions and simple pallial line.

Dredged in five fathoms .

Family CARDIIDÆ

The Cardiidæ are molluscs native to all seas, living in sand at moderate depths. Some genera are strictly marine, others are adapted to brackish water. A long, geniculate foot and two large siphons are prominent characters.

The shells are equivalve, variable in shape and sculpture, but all are cordiform when observed from either end. All have a periostracum, an external ligament, cardinal teeth, simple pallial line and serrate or crenate margins.

Genus CARDIUM Linné, 1758

Cardium[82] **isocardia Linné** Plate 12, fig. 71

Alt., 55; length, 84 mm. Shell subequilateral, light color splotched with brown, thin epidermis; umbos round, approximate. About thirty radiating ribs, all bearing short, sharp, semi-erect, curved processes. Cardinal and lateral teeth present. Interior smooth, handsomely colored in shades of salmon-pink and purple. Margins deeply serrate, interlocking. Albino specimens are not uncommon.

Cardium muricatum[83] **Linné** Plate 12, fig. 72

Alt., 44; length, 38 mm. Shell with general characters of *C. isocardia;* yellowish with irregular maculations of brown; about thirty-two ribs, ten or twelve central ribs almost or quite smooth, others strongly spinose. Interior yellow.

Subgenus DINOCARDIUM Dall, 1900

Cardium robustum[84] **Solander** Plate 12, fig. 73

Alt., 110; length, 82 mm. Shell large, 'robust', oblique, yellowish brown irregularly maculated with reddish brown, posterior area flattened, dark and polished. Umbos rounded, approximate, the opposed surfaces frequently worn smooth. About thirty-five strong, flat ribs; stout external ligament; one cardinal

82 Gr., *kardia*, heart; *isos*, similar.

83 Lat., *muricatus*, from *murex*, a pointed rock or stone.

84 Lat., *robustus*, hard, strong.

tooth in each valve, with two anterior lateral and one posterior lateral in right valve and a contrary arrangement in left valve. Interior reddish brown. Margins serrate.

Genus **PAPYRIDEA** Swainson, 1840

Papyridea[85] **spinosum** Meuschen Plate 13, fig. 74

Alt., 28; length, 35 mm. Shell thin, transversely elongate, gaping at posterior end; ground color light mottled with rosy brown; brownish periostracum; pure yellow specimens occur. Numerous low, flat ribs, smooth over central area, slightly spinose over anterior portion, sharply spinose posteriorly and prolonged beyond the gaping margin. Cardinal and lateral teeth. Interior pinkish, sometimes rayed with darker shade.

Genus **LÆVICARDIUM** Swainson, 1840

Lævicardium[86] **serratum** Linné Plate 13, fig. 75

Alt., 65; length, 54 mm. Shell oblique posteriorly downward, of alabaster-like quality, ivory color, brown or ashen epidermis; umbos round, traces of narrow ribs. Cardinal and lateral teeth. Interior cream color, often pinkish. Internal margins finely serrate.

Lævicardium mortoni Conrad Plate 13, figs. 76a, b

Alt., 16; length, 15 mm. Shell small, thin, smooth, slightly oblique toward posterior angle; cream color irregularly patterned with brown; umbos round, flat. Faint concentric striations. Interior yellow with more or less brown, conspicuously dark at posterior border. Internal margins finely crenate.

Family **VENERIDÆ**

The Veneridæ have claim to distinction beyond any others of the pelecypods. The name, from the goddess Venus, suggests the elegance of form and color for which shells of this tribe are remarkable, and as if grace and beauty of form or color were not enough, many of them are elaborately sculptured as well.

The Veneridæ first appeared in remote geologic ages, while in Recent times this family has attained the culmination of pelecypod

[85] Lat., *papyrus*, paper; *spina*, thorn.
[86] Lat., *lævis*, smooth; Lat., *serra*, a saw.

development. It is now the largest pelecypod family in number of genera and species, and of widest distribution in depth and range. They are native to all seas, and wherever man has found them he has taken the animals for food and the shells for use and ornament. In ancient times the shells of a Mediterranean species were worn as an emblem of Aphrodite, and among some South Sea tribes shells of other species are now worn as personal adornment with the same symbolism.

The animals are burrowers, but do not dig deeply into the sand and are never fixed; they move about freely by means of a flattened tongue-shaped foot.

Shells of most genera of the Veneridæ are of a graceful rounded oblong or oval form, equivalve, frequently marked with chevron-shaped lines of brown on a white surface, and distinctly ribbed or grooved along the lines of growth. Some are cancellated by radiate ribbing. There are three diverging cardinal teeth in each valve, with variable lateral teeth, and duplex muscular impressions. They are solid, porcelanous in texture, sometimes heavy.

Some of the smallest and some of the largest bivalves belong to this family.

Genus DOSINIA Scopoli, 1777

Subgenus DOSINIDIA Dall, 1902

Dosinia[87] **elegans** Conrad — Plate 13, fig. 77

Alt., 63; length, 72 mm. Shell orbicular, flattened, ivory color; transparent, brownish periostracum. Prominent umbos, curved forward; small lunule. Sculpture of regular, alternating ribs and grooves. Hinge margin thick, ligament partly submarginal; cardinal and lateral teeth present; pallial sinus oblique and angulate; margins smooth.

Genus TRANSENELLA Dall, 1883

Transenella[88] **conradina** Dall — Plate 13, fig. 78

Alt., 9; length, 17; diam., 4.5 mm. Shell small, smooth, round-

[87] N. Lat., *dosin*, a species of Senegal, Afr.
[88] Lat., *transennæ*, net, lattice.

ed, rostrate and extended at posterior end. White with fine zigzag markings of pale brown, often purple at posterior end; thin periostracum. Lunule well defined, escutcheon obscure. Three cardinal teeth in each valve, middle right tooth bifid; one left posterior lateral tooth with opposite socket in right valve. Interior polished, white, washed with yellow or pink, purple at posterior end. Pallial sinus oblique with rounded extremity.

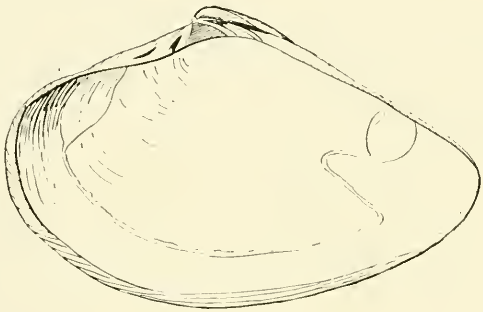


Fig. 2. Diagram showing the characteristic features of Transenella

Characteristic of the genus *Transenella* is a series of grooves on inner aspect of the slightly bevelled valve margins. These grooves cut diagonally across the line of growth and may be best observed with magnifying lens.

Transenella cubaniana Plate 13, fig. 79

Alt., 8.5; length, 11; diam., 4.5 mm. Shell pure white, rarely flecked with brown; trigonal, less rostrate than *T. conradina.* Sculpture of fine impressed, concentric lines. Inner margin obliquely engraved.

Transenella stimpsoni Dall Plate 13, fig. 79A

Alt., 9.5; length, 13; diam., 6 mm. Shell small, trigonal, rounded, moderate posterior rostration; milky white or bluish color with brown streaks and chevron markings. Umbos prominent, a little anterior ot middle; smooth, oval lunule defined by an incised line. Sculpture of fine concentric grooves. Hinge of the type. Interior white to purple, polished. Pallial sinus extends to middle of valve. Inner margin grooved.

Genus **GAFRARIUM** (Bolten) Roeding, 1798

Gafrarium[89] **cerina** C. B. Adams Plate 13, fig. 80

Alt., 10.5; length, 13; diam., 4 mm. Shell small, flattened, trigonal, waxy cream color with zigzag pencillings of light brown; umbos small, acute, almost central. Fine concentric striations and radiate striæ over anterior and posterior areas. Hinge with three cardinal and one anterior lateral tooth in each valve. Interior polished, white, purple-tinted in umbonal region; pallial line with slight posterior sinuation. Margins smooth.

Genus **MACROCALLISTA** Meek, 1876

Macrocallista[90] **nimbosa** Solander Plate 13, fig. 81

Alt., 60; length, 115 mm. Shell smooth, thick, inequilateral, elongate oval, pink-tinted fawn color with radiate block-patterned bands of darker shade; thin, glossy epidermis. Umbos depressed, long external ligament. Lunule impressed, oval, purplish. Faint concentric and radiate striations. Hinge of the type. Interior smooth, salmon-pink; pallial sinus reflected, wide at base, angulate at tip. Smooth margins.

These molluscs live buried in sand just beyond low water mark, they lie obliquely to the surface with the location of the burrow marked by a broad slit in the sand. Gulls and terns dig out and devour them in large numbers.

Macrocallista maculata[91] Linné Plate 13, fig 82

Alt., 50; length, 52 mm. Shell smooth, rounded, moderately thick, translucent; inequilateral; fawn color with irregular maculations of brown; thin, glossy periostracum. Umbos small; lunule small, impressed. Interior polished, white, coloration often

89 Gr., root *kop*, to take, grasp—Lat., *capere*, to take—Spanish, *gaffa*, hooking; *cerinus*, wax-colored.

90 Gr., *macros*, long in extent; *Callista*, a nymph; Lat., *nimbus*, rain cloud.

91 Lat., *macula*, a spot or stain.

shows through; pallial sinus long and rounded; margins smooth. Other features of the type.

Genus **PITAR** Römer, 1857

Pitar[92] **albida** Gmelin — Plate 14, fig. 83

Alt., 14; length, 14; diam., 8 mm. Shell small, white, rounded, inequilateral thin periostracum; umbos small, prominent; lunule defined, but not the escutcheon; fine concentric striations. Interior polished, white; pallial sinus slightly ascending, rounded at extremity; margins smooth.

Shells of this genus have a groove within the margin of right valve posterior to the hinge, and a similar groove in the left valve margin anterior to the hinge.

Pitar simpsoni Dall — Plate 14, fig. 84

Alt., 15; length, 18; diam., 8 mm. Shell with characters of *P. albida*, more plump, with concentric striæ and growth lines more definite; epidermis a little chalky. Color white or bluish with tent-like pencillings of yellow-brown. A smooth ovate lunule, colored like shell. Purple within except at margins; pallial sinus deep.

Pitar fulminata[93] Menke

Alt., 14; length, 15 mm. Shell similar in shape and proportion to *P. albida*, with which bleached dead shells are frequently confused. Ground color white with radial zigzag pencillings of bright brown, periostracum chalky.

Sandy bottom from low-water mark to twenty-five fathoms.

Genus **CYCLINELLA** Dall, 1902

Cyclinella[94] **tenuis** Récluz — Plate 14, fig. 85

Alt., 24; length, 24.5; diam., 14 mm. Shell white, translucent, orbicular; moderately thin, delicate periostracum; umbos small, directed forward; concentric growth lines and fine striations. Submarginal hinge ligament; cardinal teeth of the type. Interior white, pallial sinus ascending, rounded extremity. Margins smooth.

[92] *Pitar*, a word of African vernacular; Lat., *albus*, white.
[93] Lat., *fulminatus*, from *fulminare* to strike with lightning.
[94] Gr., *kylos*, a circle, *ella*, dim. suffix; Lat., *tenuis*, thin.

Genus **CHIONE** Megerle von Mühlfeld, 1811

Chione[95] **cancellata** Linné — Plate 14, fig. 86

Alt., 33; length, 38; diam., 18 mm. Shell rounded, inequilateral, posterior margin lengthened and convex; anterior margin short, slightly concave. Cream color or grayish with zigzag pencillings or triangular patches of brown. Umbos round, not prominent. Lunule well impressed, with brown markings; escutcheon smooth, excavated, marked with brown lines. Strongly lamellate concentric sculpture crossing rounded, radiating ribs, the lamellæ separated by interspaces about four and twenty-five hundredths millimeters wide. Interior smooth, yellow, purple or a combination of the two colors. Pallial sinus short, angular. Inner margins crenate. Other features those of the type.

Chione intapurpurea[96] Conrad — Plate 14, fig. 87

Alt., 30; length, 35; diam., 21 mm. Shell with shape and general characters of *C. cancellata.* Deep cream color with heavy angular markings of brown. Ventral margin strongly convex; lunule impressed, brown; escutcheon almost flat, brown. Many close, rounded, concentric ribs, somewhat lamellate anteriorly, strongly lamellate over posterior area. Not all ribs extend to margins of lunule and escutcheon; radial sculpture of impressed lines which do not cross ribs but are well defined in interspaces and on lateral aspect of ribs. Interior smooth, purple—deepest near posterior border and muscle scars. Inner margin crenate. Other characters those of the type.

This *Chione* is preyed upon by a purple-colored, five-armed starfish; several other species of starfish are taken coincidently but none have been observed to attack this clam.

Dredged in three to six fathoms on gravelly bottom.

Chione granulata[97] Gmelin

Alt., 21; length, 24; diam., 12 mm. Shell with characters of the genus. Yellowish-cream color with four radiating bands of purple-brown. Squarish spots and indefinite dark markings; thin epidermis; umbos small; lunule small, ribbed. Numerous

95 Lat., *Chione*, a mythological personage; *cancellatus*, latticed.
96 Lat., *inter*, within; *purpura*, a purple dye.
97 Lat., *granum*, grain.

radiate ribs of curious structure; posterior side of each rib rises at an angle of about forty-five degrees from plane of valve surface to meet the anterior elevation of rib which rises at an angle of about fifteen degrees; crest of rib is sharply angled. The angular ribs are cancellated by closely placed, impressed sulcations; sculpture less pronounced in central area. Interior purple. Margins plicate in accord with ribs.

Chione grus[98] **Holmes** Plate 14, fig. 88

Alt., 7; length, 10; diam., 5 mm. Shell small, transversely oblong, inequivalve, grayish white with brown pencillings, a broad ray of purplish-brown at posterior border; thin epidermis, shaggy at posterior margin. Small lunule, brown; obscure escutcheon. Surface cancellated by radiate and concentric ribbing. Interior white, deep purple at posterior border; pallial sinus oblique, angular; margins finely crenate.

The animal has two united, henna colored, fringed siphons.

Genus VENUS Linné, 1758

Venus[99] **mercenaria Linné** Plate 14, fig. 89

Alt., 100; length, 110 mm. represents size of average adult shell, individuals attain much greater dimensions and considerable weight. Shell grayish-white, heavy, thick, solid and porcelanous; inequivalve, umbos far forward; strong external ligament; lunule and escutcheon well defined; margins rounded. Sculpture of close, lamellar, concentric ridges. Hinge margin thick, with strong cardinal teeth and a rugose area in each valve. Interior smooth, white, often violet color at anterior and posterior margins. Pallial sinus small, angular. Inner margins crenulate.

This is the common edible clam of the Atlantic Coast. Its distribution is from Nova Scotia southward to Yucatan.

Some of the variations from the original type which have received subspecific names are noted below with condensed descriptions from Proceedings of the U. S. National Museum, vol. xxvi, pp. 376-77.

[98] Gr., *grus*, *griers*, gritty, granulose.

[99] Lat., *Venus*, goddess of love; *mercenarius*, reward, money, hence the *Venus* of commerce.

Venus mercenaria var. **notata**[100] Say Plate 14, fig. 90

This form is marked by zigzag brown blotches and lines and is destitute of purple coloration internally.

Venus mercenaria var. **alba**[101] Dall

In this form the interior is like *notata* and the exterior destitute of colored lineation.

Venus campechiensis[102] Gmelin

The largest and most ponderous species of the family. Shell with high, inflated umbos, blunt ends; white, young shells often with zigzag lineations of brown. Surface sculpture of dense, low, thin, concentric lamellation.

Venus campechiensis albo-radiata Sowerby

Shell with broad brownish rays on a paler ground.

Genus **ANOMALOCARDIA** Schumacher, 1817

Anomalocardia[103] **cuneimeris** Conrad Plate 14, fig. 91

Alt., 12; length, 18; diam., 8.5 mm. Shell small, lengthened and rostrate posteriorly. Vari-colored from pure white through shades of brown and green with brown lineations; smooth glossy periostracum. Umbos small, lunule distinct, escutcheon depressed. Prominent rounded concentric ridges and suggestions of radiate lines. External ligament. Interior light purple at posterior margin, pallial sinus small, angular. Inner margins crenate.

Genus **PARASTARTE** Conrad, 1862

Parastarte[104] **triquetra** Conrad Plate 14, fig. 92

Alt., 4; length, 2.75; diam., 2.5 mm. Shell minute, trigonal, equilateral; white or purple with glossy epidermis. Umbos high, umbonal region inflated; small lunule, no escutcheon. Fine, concentric striations. Interior purple or white, pallial line sinuous, margins crenate.

Family **PETRICOLIDÆ**

All members of the family Petricolidæ are burrowing molluscs.

100 Lat., *notata*, marked.
101 Lat., *albus*, white.
102 From *Campeche*, Mexico.
103 Lat., *anomalus*, uneven; *cuneus*, a wedge.
104 Gr., prefix, *para*, beside; *Astarte*, a genus of molluscs; Lat., *triquetrus*, having three sides.

Most of them make for themselves increasingly larger cavities in hard clay, coral, calcareous rock, etc., until adult size is attained.

Two siphons provide for in and out flowing currents of sea water bearing food and oxygen.

Distribution is general through warm seas.

The shells are oval-elongate, slightly gaping behind, with an external ligament and two or three cardinal teeth, no laterals; two muscular impressions and a definite pallial sinus.

Genus PETRICOLA Lamarck, 1801

Petricola[105] **lapicida** Gmelin — Plate 15, fig. 93

Alt., 20; length, 21 mm. Shell white, rounded, oblique toward posterior angle, thin periostracum. Umbos round, recurved. Sculpture of fine zigzag striations and concentric growth lines; roughened wavy ridges over posterior area. External ligament extends under umbos. Interior white, polished; small, pointed pallial sinus.

Genus RUPELLARIA Fleurian, 1802

Rupellaria[106] **typicum** Jonas — Plate 15, fig. 94

Alt., 20; length, 25 mm. Shell rough, white, rather thick, unequally rounded, inequilateral, prolonged and gaping posteriorly; thin periostracum. Umbos rounded, not prominent, curved forward. About forty rounded, elevated ribs, much narrower over anterior area. One strong cardinal tooth in right valve, two in left. Interior white; shallow, rounded pallial sinus; margins smooth within, crenate without.

Genus CORALLIOPHAGA Blainville, 1824

Coralliophaga[107] **coralliophaga** Gmelin — Plate 15, fig. 95

Alt., 13.5; length, 25 mm. Shell thin, white, rounded-oval; thin, papery epidermis; umbos inconspicuous, near anterior extremity. Surface finely ribbed except over upper anterior area; growth lines lamellate posteriorly. Interior white, smooth; shallow, pointed pallial sinus; margins delicate, crenate.

The animal lives in burrows of other molluscs, sometimes sev-

[105] Lat., *petra*, stone; *colere*, to inhabit; *lapis*, rock; *cida*, suffix meaning a killing

[106] Lat., *rupes*, rock; *typica*, type.

[107] Coral; Gr., *phagein*, to eat.

eral in one cavity, and occasionally with the original owner.

Family TELLINIDÆ

The 'tellins' are remarkable for the length and mobility of their slender, delicate siphons, and the long and powerful foot. They bury themselves to a greater depth in sand than most other pelecypods, and are able to retract the siphons entirely within the shell.

Some five hundred species are known and the family is represented in all seas.

The shells are usually equivalve, flattened, rounded in front of umbos, more or less pointed and rostrate behind. The umbos are small and inconspicuous. The external ligament is strong and prominent, teeth variable. The shells of many species are beautifully colored and polished and many are finely sculptured.

Genus TELLINA Linné, 1758

Tellina[108] **interrupta** Wood — Plate 15, fig. 96

Alt., 25; length, 48 mm. Shell flattened, rounded in front; posterior portion is rostrate, truncate and bent toward the right from plane of shell. Umbos suppressed, almost median; ligament external, posterior to umbos. Color grayish suffused with lavender and pale brown with angular pencillings of brown. Strong, elevated, concentric sculpture. Two cardinal teeth and two lateral plates in each valve. Interior polished, yellowish, with white, translucent border. Pallial sinus deep, rounded; inner margins finely crenate.

Tellina lineata[109] Turton — Plate 15, fig. 97

Alt., 14; length, 30 mm. Shell flattened; white or pink. White form has an anterior 'epaulette' of pink. Surface iridescent, with numerous, minute concentric striations, thin epidermis. Umbos small, sharp. Ventral and anterior margins rounded, posterior portion wedged-shaped, slightly flexuous, margin almost straight. Color of interior and exterior alike; a wide, confluent pallial sinus almost touches anterior muscle scar. Margins

108 Gr., *telline*, a kind of shellfish.
109 Lat., *linea*, line.

smooth.

The two forms are found together in sandy bottoms.

Subgenus **ARCOPAGIA** Leach, 1827

Tellina lintea[110] Conrad — Plate 15, fig. 98

Alt., 8; length, 18.5 mm. Shell small, flattened, white, anterior and ventral margins rounded; posterior area rostrate; margin straight, truncate. Umbos pointed, a little behind center. Concentric sculpture of delicate slightly lamellar ridges. Cardinal and lateral teeth in right valve, cardinals only in left valve. Interior smooth, muscular impressions polished; pallial sinus rounded, confluent. Margins thin, smooth.

Tellina alternata[111] Turton — Plate 15, fig. 99

Alt., 27; length, 45 mm. Shell flattened, rounded anteriorly, slightly narrowed and keeled posteriorly; umbos pointed, not prominent. External ligament; sculpture of concentric, deeply impressed sulci, equidistant and parallel; every alternate sulcus disappears at angle of keel. Quality of shell is translucent, showing the yellow and pink lines of the highly polished interior; thin glossy periostracum. Three cardinal teeth in right valve. Interior shows rays of deeper color near anterior and posterior bordes, and a linear callus thickening behind anterior muscle scar. Smooth margins.

Subgenus **MOERELLA** Fischer, 1887

Tellina martinicensis[112] d'Orbigny

Alt., 8.5; length, 10.5; diam., 5.25 mm. Shell small, white and smooth within and without, epidermis pale brownish, thin, wrinkled. Umbos acute, ligament inconspicuous. Anterior margin straight near umbo, rounded below ventral margin very convex; posterior margin straight near umbo, suddenly slopingto posterior angle. Slight posterior rostration. Anterior and posterior lateral teeth in each valve, distant from umbo.

[110] Lat., *linteus*, linen.
[111] Lat., *alternare*, to alternate.
[112] *martincensis*, of Martinique.

Subgenus **ANGULUS** Megerle von Mühlfeld, 1811

Tellina magna[113] Spengler

This is the largest of the Atlantic Tellinas, it reaches a length of seventy-five mm. The shell is smooth, flattened, the upper valve broadly rayed with yellow, lower valve white with yellow tint near umbo. Umbos small, posterior to middle; anterior portion longer and rounded, narrow and angulated posteriorly.

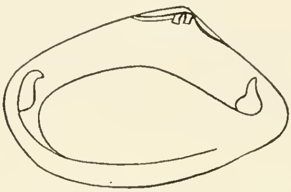


Fig. 3. Tellina tenera Say

Tellina tenera[114] Say

Alt., 8; length, 13 mm. Shell small, inequilateral, polished, thin and pellucid, white or pinkish, iridescent, very delicate concentric striations and thin epidermis. Small umbos posterior to center; prominent external ligament; margins rounded at anterior, shorter at posterior with nearly straight edge. Two cardinal teeth in each valve, anterior laterals developed, posterior weak. Interior smooth; large rounded, confluent pallial sinus which almost extends to anterior muscular impression. Margins smooth.

Tellina versicolor[115] Cozzens

Alt., 8.25; length, 17 mm. Shell small, white, iridescent, sometimes rayed with pink; striated with fine growth lines. Inequivalve, shorter and slightly rostrate posteriorly. Umbos not prominent; dorsal margin concave posterior to umbos. External ligament yellow brown. Hinge with strong right anterior lateral tooth. Interior polished, iridescent, engraved with extremely fine, radiate striations. Pallial sinus confluent to within 0.75 mm. of

113 Lat., *magnus*, great.
114 Lat., *tener*, tender.
115 Lat., *versicolor*, *versare*, to change with, *color*, color.

anterior muscular impression.

Tellina sayi (Deshayes) Dall

Alt., 9; length, 14 mm. Shell small, white, opalescent, sometimes shows iridescence and concentric striation. Postumbonal margin straight, ligament yellow-brown. Posterior angle acute. Anterior lateral tooth flattened. Interior white, polished. Pallial sinus confluent, tip 1 mm. from anterior muscle scar.

Tellina rubricata[116] Perry

Length, 8; width, 4.1 mm. Shell small, thin, slightly translucent, with delicate, glossy epidermis; oval, rostrate and moderately attenuated posterior to the small umbos. Its color is pale pink with rays and extremely minute pencillings of deeper pink, the tint becoming paler toward the margin, with the widest and most deeply colored ray over the posterior rostration. The valves are sculptured with fine, closely placed, equidistant, concentric threads, continuous over rostrum to the posterior border, with some intercalation of threads at the umbonal ridge; the interspaces are a little wider and somewhat irregular and growth lines more evident near margin. Immediately posterior to umbos the border is slightly concave, the posterior extremity is narrow and bluntly rounded; the ventral border curves gently to the rounded anterior extremity and the anterior border rises in a straight line to the umbos. The external hinge ligament is yellow-brown. The right valve has two cardinal teeth, an anterior and a strong posterior lateral; the left valve has a bifid anterior with a weak posterior cardinal and feeble anterior and posterior laterals. The interior is polished and tinted in shade of the exterior; the posterior adductor scar is impressed, the pallial sinus confluent with the pallial line almost to the anterior muscular impression, the tip distant from it one-half millimeter and the upper border one and a half millimeters below the umbo.

Tellina mera[117] Say

Alt., 8.75; length, 14 mm. Shell white within and without, rounded-oval smooth, but not polished; very delicate, elevated,

[116] Lat., *rubricatus*, marked with red.
[117] Lat., *mare*, sea.

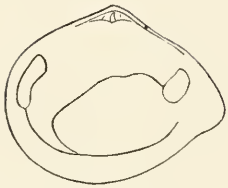


Fig. 4. Tellina mera Say

concentric striations. Umbos sharp, almost central, forming an angle in outline of shell. Ligament reddish, not prominent. Shell rounded and longer anterior to umbos; posterior end shorter, obtusely angulated with convex ventral margin. Two cardinal teeth in each valve and a single prominent lateral tooth in left valve.

Tellina tampaënsis Conrad

Alt., 11; length, 15 mm. Shell small, smooth, pale salmon-pink; very delicate concentric striations and fine radial markings, thin iridescent epidermis. Umbos sharp, making a definite angle in outline of shell; ligament prominent. Anterior margin rounded, ventral margin convex, posterior margin sloping to a blunt point. Three cardinal and an anterior lateral tooth in each valve. Pallial sinus confluent, almost reaching anterior muscular impression.

Tellina pauperata[118] d'Orbigny

Alt., 6; length, 12 mm. Shell small, white, polished but not iridescent; fine concentric striations and bands of varying opacity. Umbos small, acute; anterior border long and straight, posterior short, straight, with slight rostration and rounded extremity. Ligament light brown. Interior white, polished, with faint radial striation. Pallial sinus confluent, tip nine-tenths of a millimeter from anterior muscle scar.

Tellina promera[119] Dall

Alt., 10; length, 15 mm. Shell white, smooth, fine threadlike, concentric striæ, thin brownish epidermis. General shape like *T. tampaënsis*, but more convexly rounded at anterior end and

[118] Lat., *pauperare*, to make poor.
[119] Lat., *pro*, forth; *mare*, sea?

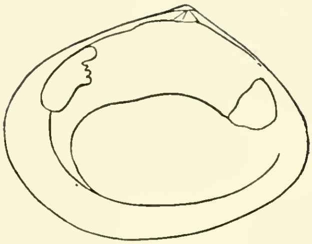


Fig. 5. Tellina promera Dall

more flexuose posteriorly; pallial sinus large, confluent, extends within one millimeter of anterior muscle scar.

Tellina similis[120] Sowerby

Alt., 18; length, 22 mm. Shell more regularly oval than most of the Tellinas. Pale pink or rosy, rayed with a deeper shade. Surface sculpture of fine concentric lines and delicate oblique striations. Umbos almost central, ligament small. Pink within; lateral teeth developed.

Genus **MACOMA** Leach, 1819

Macoma constricta[121] Bruguière Plate 16, fig. 100

Alt., 33; length, 50 mm. Shell subequivalve, dull white, sculpture of incremental lines, brownish epidermis heaviest near margins. Umbos bluntly pointed; ligament long, narrow. Anterior and ventral margins rounded; posterior area flexuose, inclined toward right, with a notch in ventral margin anterior to the flexure. Feeble cardinal teeth, laterals not developed. Long, confluent pallial sinus.

Macoma tenta[122] **souleyetiana** Récluz

Alt., 10.5; length, 18mm. Shell inequilateral, small and fragile, white or yellowish, slightly iridescent; fine, concentric lines and very delicate radial striations visible both within and without under magnification. Umbos small, sharp; ligament small. Anterior and ventral margins rounded, posterior margin shorter, straighter and flexuose. Hinge margin very frail, two cardinal teeth in left and one in right valve, one right posterior lateral

120 Lat., *similis*, like.
121 Lat., *constrictus*, drawn tight.
122 Lat., *tentis*, stretched out.

tooth. Pallial sinus confluent, its end two and three-quarters millimeters from anterior muscle scar.

This is a southern variety of *M. tenta* Say.

Subgenus **PSAMMACOMA** Dall, 1900

Macoma brevifrons[123] Say Plate 16, fig. 100A

Alt., 14; length, 25 mm. Shell oval, inequilateral, white to salmon-pink or yellowish; smooth, definite growth lines. Umbos small, anterior to middle, small ligament. Anterior margin short and abrupt with submarginal undulation, posterior area flexuose. Right valve with two cardinal teeth, one in left; no lateral teeth. Interior tinted like exterior; pallial sinus partly confluent, three millimeters from anterior muscle scar.

Genus **STRIGILLA** Turton, 1822

Strigilla[124] **carnaria** Turton

Alt., 12.5; length, 15 mm. Shell smooth, glossy, pale rose color, deepest over umbos; slightly inequilateral, umbos rounded, small lunule; margins smooth and rounded. Surface sculpture of extremely fine striæ, evenly radiating in central area, oblique over anterior area, meeting central striations in acute angles; oblique and wavy over posterior area. Two cardinal and two lateral teeth in right valve, one cardinal and two weak laterals in left valve. Interior deep rose pink. Upper border of pallial sinus makes a continuous line between anterior and posterior muscle scars.

Genus **TELLIDORA** Mörch, 1856

Tellidora cristata[125] Récluz Plate 16, fig. 101

Alt., 22; length, 26 mm. Shell shining white, much flattened, right valve the more convex. Thin brownish periostracum. Trigonal, with extremely convex ventral margin, anterior border excavated, posterior border almost straight; the anterior and posterior borders of each valve bear a series of sharp serrations. Umbos acute, almost central. Concentric incremental growth somewhat lamellate and terminating in the marginal serrations; lamellations stronger toward

[123] Lat., *brevis*, short; *frons*, forehead, front.
[124] Lat., *strigil*, a scraping tool; *carnis*, flesh.
[125] Lat., *crista*, crest.

margin. Pallial sinus wide, partly confluent.

Family SEMELIDÆ

The molluscs of this family are native to all warm seas, few of its members have become adapted to cold waters. One Atlantic species of the genus *Abra* has a range from the Arctic Ocean to the West Indies, at increasingly greater depths toward the south.

The animals live deeply buried in sandy mud, usually at moderate depths, and are able to desert the old burrows and bury themselves anew by use of the strong, pointed foot. The two siphons are slender, separate and about five times the length of the shell.

The shells are compressed, rounded or slightly oval, with a slight posterior flexure, and a short external ligament, very thin epidermis.

Genus SEMELE Schumacher, 1817

Semele[126] **bellastriata** Conrad — Plate 16, fig. 102

Alt., 18; length, 23 mm. Shell inequivalve, longest anteriorly. Ground color light, with irregular radiate markings of dull purple, visible also within. Umbos small, pointed, approximate. Sculpture of strong, close, concentric ridges cancellated by finer, radiating ribs, strongest toward posterior. Two cardinal and two lateral teeth in each valve. Interior polished, purple or yellow-tinted.

Dredged in four to seven fathoms.

Semele proficua[127] Pultney — Plate 16, fig. 103

Alt., 28; length, 30 mm. Shell orbicular, almost equilateral, color creamy-pink with indefinite darker markings. Umbos small, a small lunule and a small obliquely excavated escutcheon which contains the ligament. Fine concentric lines and delicate radial striations. Interior of valves smooth, stippled with pink and purple.

From three to six fathoms.

126 *Semele*, mother of Bacchus; *bellus*, beautiful; *striatus*, striped.
127 Lat., *proficuus*, useful.

Semele purpurascens[128] Gmelin — Plate 16, fig. 104

Alt., 30; length, 34 mm. Shell subequilateral, greatest length anterior to umbos. Margins rounded, umbos small, pointed. Ground color cream, with irregular blotched pattern of soft purple, some specimens are deep yellow The color markings of this shell tend toward a radiate pattern, those of *S. proficua* tend to be transverse. Clear-cut concentric sculpture which fades toward posterior margin. Interior of valves deeply colored purple or yellow, fading at margin where external color and pattern show through.

Taken with other Semeles.

Semele nuculoides[129] Conrad — Plate 16, fig. 105

Alt., 4.25; length, 6.25 mm. Shell small, white, not thin; inequilateral, longest and a little oblique anteriorly; small, approximate umbos; margins rounded. Concentric sculpture of fine, close, equidistant, elevated threads, more delicate over umbonal region, stronger toward margin, with some intercalated riblets which do not extend to posterior margin. Interior polished; anterior muscular impression mitten-shaped; posterior round; pallial sinus deep, rounded, the tip five-tenths millimeter from anterior adductor scar. Margins smooth.

Dredged at six to seven fathoms.

Genus ABRA (Leach) Lamarck

Abra[130] **æqualis** Say — Plate 17, fig. 106

Alt., 10; length, 12.5; diam., 4.5 mm Shell small, smooth, white, polished, with thin epidermis Orbicular, well rounded, slightly oblique Umbos small, pointed, approximate. Numerous very minute concentric striations near margins, but absent from umbonal area. Two small cardinal teeth in right valve, one developed and one vestigial tooth; left valve has remote grooves instead of lateral teeth.

Incredible numbers of this mollusc are sometimes washed upon the Gulf beaches after a prolonged northwest blow. Dredged in two to six fathoms.

[128] Lat., *purpura*, purple.
[129] Lat., *nucula*, nut.
[130] Span., *abra*, a bay; Lat., *æqualis*, even.

Abra lioica[131] Dall

Alt., 6.5; length, 8; diam., 3.5. Shell small, fragile, opaque-white, polished, extremely thin epidermis. Umbos small, definite, nearest posterior margin which deviates slightly to the right. 'Sculpture *solely* of concentric growth lines which are accompanied by a different degree of transparency in the shell'. Teeth as in *A. æqualis.*

Abra lioica is proportionately longer and more oblique than *A. æqualis* and lacks the groove on the right anterior dorsal margin which is present in *A. æqualis*

Dredged in three to six fathoms.

Genus CUMINGIA Sowerby, 1833

Cumingia[132] **tellinoides** Conrad — Plate 17, fig. 107

Alt., 10; length, 12; diam., 5 mm. Shell thin, white, long-oval, rounded in front. Slightly rostrate behind. Posterior margin straight, directed obliquely downward, slightly gaping. Umbos pointed, posterior to center. Concentric sculpture of numerous threadlike ridges. Each valve has one small cardinal tooth, a central spoon-shaped fossette and elongated anterior and posterior laterals. Interior white, highly polished. Pallial sinus deep and rounded.

Cumingia coarctata[133] Sowerby — Plate 17, fig. 108

Alt., 11; length, 16; diam., 8 mm. Shell white, irregular, inflated; thin epidermis. Umbos acute, posterior to center. Anterior margin high and rounded, posterior margin more abrupt, slightly gaping Small, concentric, definitely lamellar ridges, more widely apart than those of *C. tellinoides.*

Both these species of *Cumingia* are of nesting habit, specimens are often found in the cavities of sponges and clumps of debris.

Family DONACIDÆ

Species of the genus *Donax* of this family are the most abundant bivalves along much of the Florida Coast. Their shells are

[131] Gr., *leios*, smooth.

[132] Dedicated to the naturalist, Hugh Cuming, who discovered *Conus gloria maris.*

[133] Lat., *coarctare*, to press together.

the principal component of the coquina rock so extensively used in building and road making in the far South.

Their stations are in sandy bottoms of shallow coastal waters, and the molluscs are no less liked in broth and chowder for human delectation than by certain fish and ducks which consume them in great numbers.

'Coquinas' live buried just below the surface of sandy sea bottoms with the two delicate siphons projected into the water. In a quiet tide pool the siphons respond to every movement of the water, bending and recovering like a field of grain before the wind.

The foot of *Donax* is strong, sharp and pointed, and when the animals are dislodged from their shallow burrows they are able to bury themselves before a succeeding wave washes them away.

The family is distributed through all warm seas.

Genus DONAX Linné, 1758

Donax[134] variabilis Say — Plate 17, fig. 109

Alt., 11; length, 19 mm. Shell smooth, not glossy; equivalve, inequilateral, somewhat wedged-shaped. Umbos low, at summit of posterior slope, directed backward. External ligament behind umbos. Elongate anteriorly, short and slightly truncate posteriorly; concentric growth lines and fine radiate striations which become strong and elevated over posterior area. Cardinal and lateral teeth present. Interior smooth, faintly colored, margins finely crenate.

The range of color of *Donax* is remarkable. White and green, shades of red, brown, lavender, purple and yellow, variously rayed and plaided make the shells among the most colorful objects upon the beach.

Family SANGUINOLARIIDÆ

The molluscs of this family were formerly placed among the Tellinas, with which group their range, habits and shells suggest kinship, but anatomical differences rank them independently. The

134 Gr., *donax*, a sea scallop; *variabilis*, variable.

group has world-wide distribution in shallow and moderate depths.

Like the Tellinas and Semeles the animals have long siphons, strong foot and bury themselves in sandy sea bottoms.

Genus TAGELUS Gray, 1847

Tagelus gibbus[135] Spengler Plate 17, fig. 110

Alt., 16; length, 43; diam., 7.5 mm. Shell equivalve, subequilateral, subcylindrical, elongate. White, smooth, with glossy, brownish periostracum; umbos postcentral, suppressed. Dorsal and ventral margins nearly parallel and in contact only opposite umbonal region; anterior and posterior margins bluntly rounded, gaping. Cardinal, but no lateral teeth in each valve. Interior white, polished, duplex muscular impressions; deep pallial sinus.

Littoral zone to moderate depths.

Tagelus divisus[136] Spengler Plate 17, fig. 111

Alt., 15; length, 38; diam., 6.5 mm. Shell with general characters of *T. gibbus*, slightly more slender, with a slight concavity in middle of ventral margin. Shell light-colored, rayed with purple. A strong central ray indicates position of a nearly obsolete internal rib. Interior purplish, polished.

Littoral zone to moderate depths.

Family SOLENIDÆ

The family Solenidæ is represented in almost all seas in the sandy bottoms of coastal waters. Along the Atlantic seaboard from Newfoundland to Texas members of this family are known as 'razor clams'. All are edible, but the strong, cylindrical foot enables them to bury themselves so rapidly and so deeply that capture is difficult.

Genus ENSIS Schumacher, 1817

Ensis[137] **minor** Dall Plate 17, fig.112

Alt., 15; length, 70 mm. Shell equivalve, greatly elongate, gently arched, dorsally concave. Umbos at anterior end of dorsal margin, subterminal. Anterior margin blunt, posterior slight-

135 Lat., *gibbus*, hump.
136 Lat., *dividere*, to divide.
137 Lat., *ensis*, sword.

ly narrowed, bluntly rounded. Color bluish-white with purple bands parallel to posterior margin and limited to the postdorsal area; a narrow, dark band at anterior margin; polished, yellow-brown epidermis. Hinge with cardinal teeth, and a lateral plate in left valve. Interior milky-white; impressions of two adductor muscles; shallow pallial sinus. Smooth margins.

In sandy bottoms—on sand bars in shallow water and at moderate depths.

Family MACTRIDÆ

Members of this family are native to the sandy shores and moderate depths of all seas and in favorable situations become very abundant. They are edible, but have a slightly acrid, peppery taste.

The shells are equivalve, some of them slightly subequilateral, transversely elongate, more or less inflated in the umbonal region. Two ligaments, one external, and an inner cartilaginous ligament lodged in a spoon-shaped fosse posterior to the bifid cardinal tooth. Two muscular impressions and a pallial sinus.

Genus MACTRA Linné, 1767

Subgenus MACTROTOMA Dall, 1894

Mactra[138] **fragilis** Gmelin — Plate 17, fig. 113

Alt., 35; length, 50 mm.; specimens up to eighty millimeters have been recorded. Shell oval, slightly inequilateral. White, with close, narrow concentric ridges and pale brown epidermis heaviest over posterior rostration. Umbos rounded, almost central. Anterior and posterior margins sloping to join rounded ventral margin; rostrate and gaping behind. Interior white, rounded pallial sinus, smooth margins.

Genus SPISULA Gray, 1838

Subgenus HEMIMACTRA Swainson, 1840

Spisula[139] **solidissima similis** Dillwyn — Plate 17, fig. 114

Alt., 50; length, 70 mm.; specimens have been taken up to ninety millimeters. Shell oval; nearly equilateral; smooth,

138 Gr., *maktra*, a kneading trough.

139 *Spisula*, probably from von Spix, German naturalist; Lat., *solidus*, solid; *similis*, like.

creamy, with thin, glossy, light brown periostracum which is thicker at posterior and reflected over the free margin. Umbos acute, anterior to midline. Cardinal teeth and hinge fosse typical, lamellar lateral teeth with opposite deep socket. Muscular impressions above center of shell; pallial sinus short; margins faintly crenate.

Genus MULINIA Gray, 1837

Mulinia[140] lateralis corbuloides Deshayes Plate 17, fig. 115

Alt., 11.5; length, 13.5; diam., 6.5 mm. Shell small, trigonal, white, glossy, brownish epidermis. Umbos high, inflated. Anterior and posterior margins slope abruptly, posterior longer, slightly concave. Flat posterior rostration. Cardinal and lateral teeth and typical fossette. Short, oblique pallial sinus.

Genus ANATINA Schumacher, 1817

Anatina[141] lineata Say Plate 18, fig. 116

Alt., 41; length, 50 mm. Shell, white, thin and fragile; thin, glossy, transparent epidermis; inequilateral, anterior portion broadly rounded, posterior portion demarcated by a cordlike radial rib; margin reflected and gaping Umbos high, directed backward. Sculpture of delicate, irregular, elevated concentric ridges. Teeth and fossette of the type.

Subgenus RAETA Gray, 1853

Anatina canaliculata[142] Say Plate 18, fig. 117

Alt., 68; length, 70 mm. Shell cordiform, thin, white, inequilateral, obliquely prolonged forward. Umbos high, inflated, directed backward. Posterior margin sinuous and gaping. Sculpture of evenly spaced, rounded concentric ribs, fine striations in intercostal spaces and delicate, irregular radial etching. Hinge of the type. Interior white, smooth; pallial sinus deep, narrow and reflected downward at tip.

140 Lat., *mulus*, a hybrid animal (?); *lateralis*, side; *corbula*, little basket.

141 Lat., *anatinus*, pertaining to a duck; *linea* ,line.

142 Lat., *canaliculatus*, channeled.

Family CORBULIDÆ

Members of the Corbulidæ are widely distributed in most of the temperate seas and through a considerable range in depth.

The shells are small, trigonal, white with brownish epidermis. Subequilateral, posterior portion longer, narrow and rostrate. Extremely inequivalve, the right valve is usually both larger and deeper and more or less overlaps the free margin of the left valve. The umbos are high, inflated, anterior to the middle of the shell and directed backward. The right umbo is generally higher than the left. The surface of the valves is concentrically ribbed. Right valve has one prominent, curved, cardinal tooth and a socket for its reception in opposite valve. The interior is chalky-white, with two muscular impressions and a slightly sinuated pallial line.

Genus CORBULA Bruguière, 1797

Corbula[143] **contracta** Say — Plate 18, fig. 118

Alt., 5; length, 9; diam., 6.25 mm. Anterior border short and rounded; posterior extremity rostrate, narrow and bluntly pointed. Ventral margins contracted with concave sinuosity near center. Surface ribbing of elevated threads separated by wider interspaces, occasional growth bands near border.

Corbula caribæa[144] d'Orbigny — Plate 18, fig. 119

Alt., 4.5; length, 8.5; diam., 4.5 mm. Adult shells inflated, juvenile often compressed. Right valve margin projects beyond and almost encloses left valve, especially toward posterior end. Umbos incurved Posterior extremity prolonged and pointed. A slightly flattened area anterior to umbos. Posterior rostrum at right angle with plane of valves, oval when viewed from above. A few fine radiating striations, concentric ribs less well marked over posterior slope. Base rather flattened, almost without sculpture.

From four to six fathoms.

Corbula cubaniana[145] d'Orbigny

Alt., 4.75; length, 8.5; diam., 3 mm. Shell with pink 'epau-

143 Lat., *corbula*, little basket; *contractus*, drawn together.
144 Caribbean.
145 Of Cuba.

lettes' radiating from umbos, some specimens entirely pink. Almost equivalve, right valve a little deeper and its umbo a little higher than left valve, margin slightly overlapping. Posterior rostration pointed at base.

From three to six fathoms.

Corbula krebsiana C. B. Adams — Plate 18, fig. 120

Alt., 5.1; length, 6.1; diam., 3.5 mm. Shell decidedly trigonal and extremely inequivalve; right valve sharply rostrate; umbos rounded; inflated; closely ribbed.

From four to seven fathoms.

Corbula swiftiana C. B. Adams — Plate 18, fig. 121

Alt., 5.5; length, 9; diam., 4.5 mm. Shell almost equilateral; right valve deeper and a little longer; overlapping of margins most marked in young shells. Posterior rostration sharply marked, the flat area of each valve in same plane. Umbos sharp. Umbos and anterior and posterior radial ridges opaque milky-white. Faint radiate striation. Egg cases of some small gasteropod are often seen on the posterior extremity of these shells, and the shells are often bored near umbos.

From less than one to six fathoms.

Family SAXICAVIDÆ

Members of this family are distributed in all seas from circumpolar oceans to the Indies.

The molluscs bore into sponge, limestone, etc., sometimes making deep burrows. Free individuals are anchored by a byssus.

The shells are variable in shape from adaptation to surroundings, inequivalve, usually oblong. The surface is rough, with brownish epidermis.

Genus SAXICAVA Fleuriau de Bellevue, 1802

Saxicava[146] **arctica** Linné — Plate 18, fig. 122

Alt., 13; length, 25; diam., 10 mm., average measurements of undistorted specimens. Shape and proportions so modified by external conditions that adequate description is difficult. Shells chalky-white; thin, brown epidermis which scales off readily when dry. Umbos anterior, rounded; posterior portion elongate,

146 Lat., *saxum*, rock; *cavare*, to make hollow.

rostrate, gaping. Irregular, concentric sculpture, rostum defined by rough, angular ridges. One cardinal tooth in each valve. Two muscular impressions, anterior pointed-oval, posterior irregular. Pallial sinus not entire, sinuated.

Family GASTROCHÆNIDAE

Molluscs of this family are of burrowing habit. They penetrate for a considerable distance into coral, shells or limestone, or construct a flask-shaped shelter from bits of debris and grains of sand. An excavated burrow and its tunnel of communication with the outside are lined with a smooth, calcareous deposit which generally projects its distal extremity a few millimeters beyond the stone or shell, like a little stovepipe from a roof. Many individuals may burrow into one piece of coral in association with *Lithophaga* and *Rupellaria.*

The shell does not entirely enclose the animal's body, it is thin and fragile, white, equivalve but very inequilateral. The umbos are small and anterior. The valves are in contact only along dorsal and posterior borders, yawning widely at the ventral border. The hinge is edentulous, and there is an external ligament, two unequal muscular impressions and a deep pallial sinus.

Viewed separately the valves are seen to be twisted from plane of the long axis. It is this torsion which produces the extreme anterior gaping.

Genus GASTROCHÆNA Spengler, 1783

Gastrochæna[147] **ovata** Sowerby — Plate 19, figs. 123a, b

Alt., 5.75; length, 12 mm. Shell narrows rather sharply toward posterior extremity; concentric sculpture of closely placed, slightly lamellate threads, not equidistant. Interior of valves with definite central, longitudinal ridge.

Burrows often found in shells in *Spondylus* and *Plicatula.*

Gastrochæna stimpsonii Tryon

Alt., 6.25; length, 13 mm. Anterior border a little reflected outward causing a notched appearance. Surface sculpture only

[147] Gr., *gaster*, stomach; *cheino*, gape or yawn; Lat., *ovatus*, from *ovum*, egg.

of incremental lines. No interior rib.

Usually found in coral.

Family PHOLADIDÆ

The Pholadidæ is a family of penetrating molluscs, its distribution is through all seas, and some of its members are able to penetrate any substance softer than their own shells. When once established in its burrow, the essential circulation of sea water is maintained through the mollusc's two large siphons.

The shells are white, thin and brittle, with thin epidermis; much elongated, generally narrowed toward the posterior end, equivalve, gaping at one or both ends. The umbos are inconspicuous, rounded and placed anteriorly. The antero-dorsal margin is more or less reflected over the umbonal region. There is no well-defined ligament, but a posterior accessory plate is present. The sculpture consists principally of prominent rib and striations. The hinge is edentulous. Each valve has an internal apophysis in the umbonal region. Thin, membranous ligaments unite the valves anteriorly, and posteriorly below the accessory plate.

Genus BARNEA (Leach) Risso, 1826

Barnea costata[148] Linné — Plate 19, fig. 124

The common name 'angel's wing' is beautifully appropriate to the sculptured, white perfection of this shell.

Alt. to 95; length to 150 mm. Valves inflated, broadly gaping posterior to middle. Radiate ribs, most widely separated over anterior area, and crossed by strong growth lines produce a rough, denticulate sculpture. Margins thin, sharp, denticulate. A spoon-shaped apophysis within umbonal cavity. Interior smooth with reverse pattern of exterior sculpture.

Colonies of these molluscs live beyond low water mark, in individual burrows sometimes several feet deep. Burrows are easily identified by the appearance of two large, united, circular siphons at the sand level.

[148] Lat., *costa*, rib.

Barnea truncata[149] Say Plate 19, fig. 125

Alt., 38; length, 60 mm. Shape similar to *B. costata*, but valves truncate behind. Delicate, slightly denticulate sculpture of fine ribs and growth lines; posterior area almost smooth. Umbonal apophysis narrow and curved.

The molluscs live in colonies between tide marks and in shallow water, often in the black mud about mangrove roots.

Genus MARTESIA Leach, 1825

Martesia cuneiformis[150] Say Plate 19, fig. 126

Alt., 11; length, 20 mm. Shell broadly wedge-shape, anterior aspect cordiform; divided into anterior and posterior areas by an oblique sulcus. Anterior area ribbed by toothed ridges; posterior area shows only growth lines. The posterior shield (protoplax) is lanceolate with a median, longitudinal furrow and oblique radiating sulci.

The molluscs usually bore into wood, sometimes into soft rock.

Martesia striata[151] Linné Plate 19, figs. 127a, b

Alt., 10; length, 35 mm., in favorable circumstances 50 mm. Shell narrowly cuneate prolonged posteriorly; anterior aspect cordiform, with sinuous, crenulate ridges and delicate radial sculpture; posterior area shows only wavy growth lines. A narrow, shallow sulcus separates the two areas. The protoplax is normally trilobed, in young or stunted specimens the lateral lobes may be suppressed and the shield somewhat trigonal.

This *Martesia* penetrates hard wood.

Subgenus DIPLOTHYRA Tryon, 1862

Martesia caribæa d'Orbigny

Maximum length, 17 mm. This *Martesia* has been found in limestone rock and in other shells, e. g. oyster. It is smaller than *M. cuneiformis* and *striata,* with less posterior narrowing. Radial sulcus well defined; anterior area shows fine wavy lines whose undulations form delicate radiating riblets, posterior to

149 Lat., *truncatus*, cut off.
150 Lat., *cuneus*, wedge; *forma*, form.
151 Lat., *striatus*, channeled.

sulcus are delicate, undulating growth lines. Shape of protoplax variable, often urn-shaped with upcurved, parallel sulci over lower part.

Family TEREDIDÆ

Teredo is a name given by Pliny to a wood-eating worm. Even before Pliny's time the shipworm was recognized as an agent of destruction to wooden ships, and today the ravages of this mollusc in wooden structures is a costly matter; no wood is known to be wholly resistant to attack. Shipworms have been cultivated in soft wood, and collected for food when the desirable size is attained. Their distribution is world-wide.

The molluscs of this family have evolved a very aberrant form; they are elongate, wormlike, with only the anterior extremity covered by the small, bivalve shell.

The life history of no one species is fully known; some discharge the ova into the sea, some are viviparous. The larvæ all have bivalve shells, and swim freely for a short time but soon attach themselves to some wooden structure and begin excavation of the long tunnel which is to be the permanent home. There is evidence that the wood-boring is effected by use of the shell as a file, and also that the accumulation of saw dust is ingested by the shipworm and has some food value. The burrows are long, and follow the grain of the wood except at the point of entrance and where another burrow or a knot is encountered.

The anterior, shell-bearing portion of the mollusc's long body lies at the bottom of the burrow; the siphon end is at the opening, and when complete, the burrow is smoothly lined with an adventitious, calcareous tube.

The shell is white, globose and gaping, its external surface bears many diversely sculptured teeth. The posterior end of the mollusc bears a pair of calcareous structures called pallets, which may be advanced or withdrawn to close or open the mouth of the tube. Characters of the shell and distinctive features of the pallets are necessary factors in differentiating species. Reference to a collection is necessary for specific determination.

Class SCAPHOPODA

This is the smallest class of the Mollusca. The anatomical structure of its members differs so widely from that of other members of the phylum that it was not until 1819 that scaphopods were established as molluscs and separated from those marine worms which secrete calcareous tubes. Scaphopods show definite relationship to gasteropods in the possession of a univalve shell and a radula, and to the pelecypods in similarity of the foot and lack of a distinct head. The animals are eyeless, nonoperculate, carnivorous and unisexual. They are found in all but polar seas and their bathymetric range is from less than one fathom to abyssal depths.

The name Scaphopoda, derived from the Greek *scapha*, boat; *pod*, foot, is descriptive of the pointed burrowing extremity belonging to molluscs of this class. The shape of the foot suggests a vessel's sharp prow or ploughshare, and differences in the development of its tip present important family characters. Small carnivorous molluscs are their worst enemies and shells are frequently found which have been bored near the apex.

The shells are tubular, nonspiral, open at both ends and generally tapered toward the posterior end. All growth takes place at the anterior—larger—end and the posterior extremity is truncated as growth proceeds at the opposite end. The size of the shells varies from two or three to one hundred seventy-five millimeters. This type of shell is characteristic of the group and is found nowhere else among the Mollusca.

Scaphopod shells have been used as ornaments and as charms against the evil eye, and among the Indian tribes of Northwest America, strings of the perfect shells of a Pacific species of *Dentalium* represented the 'gold standard' until superseded by the more practical advantage of the Hudson's Bay Company's blankets.

Family DENTALIIDÆ

The molluscs of this family live partly buried in the sand or ooze of the sea bottom. They assume a position oblique to the surface with the siphon end of the shell projecting in order to provide for free circulation of the currents of sea water necessary to the creature's existence. From the larger, buried end of the shells, the animal extrudes the foot and numerous long, delicate filaments, club-shaped at their tips. These filaments feel about in the sand and capture small prey, usually foraminifera but sometimes very small bivalves, which are carried to the mouth parts.

This family has but one genus, *Dentalium;* all its species have elongate, tapering, tubular shells, more or less curved in the long axis; they are open at both ends and diminish regularly in diameter from the large anterior opening to the small posterior orifice. The anterior opening is simple, sharp-edged, never contracted nor reflected. The posterior end of the shell is truncated and its opening may be simple, notched, or slit and sometimes furnished with a small supplementary tube extended from the orifice in the direction of the long axis of the shell. The dorsal aspect of the shell is concave.

Most of the Dentaliums are white, a few are tinted with pale salmon-pink or a green tone near the apex, but any coloration soon fades after the death of the animal. The quality of the shells varies from a dull, chalky surface to a high polish. Apical characters, sculpture and the degree of curvature of the shells are important features in the determination of species.

Genus DENTALIUM Linné, 1758

Dentalium[152] laqueatum Verrill Plate 20, fig. 128

Alt. to 45; diam., 3.5 to 6 mm. Anterior part of shell only slightly arched, tip sharply curved. Aperture circular and fluted. Opaque-white. Apex is angled by nine to twelve strong ribs with equal sized, concave intercostal spaces. The ribs become broader and interspaces less concave toward the anterior extremity. Very fine longitudinal lines on the ribs of unworn shells, and almost microscopic reticulation over the entire surface. Apical notch or

[152] Lat., *dens, dentis*, tooth; *laqueo*, to adorn with panelled surface.

slit on convex side, often obliterated. A supplementary tube is present only in young shells.

Dredged in four to seven fathoms.

Dentalium texasianum Philippi — Plate 20, fig. 129

Alt. to 30; average 25; diam., 2 mm. Shell more strongly curved posteriorly than in anterior portion. Hexagonal in section except when development of extra ribs results in a somewhat circular and fluted aperture. Dull, dirty white; strong and solid. Six or seven ribs at apex with broad, flat intercostal spaces showing growth lines and intercalated ribs . No apical notch or slit, but usually a supplementary tube.

Dredged in two to seven fathoms.

Subgenus **ANTALIS** H. and A. Adams, 1854

Dentalium pseudohexagonum[153] (von Ihering) Henderson — Plate 20, fig. 130

Alt., 28; diam., 2 mm. Gently and evenly curved; section circular, fluted externally. Tip not notably slender. White, not polished. Nine elevated, rounded ribs with number increased by secondaries, but none are prolonged to the anterior end of shell. Wide, flat intercostal spaces crossed by strong growth lines. No apical notch.

Dredged in less than one to five fathoms.

Dentalium disparile[154] d'Orbigny — Plate 20, fig. 131

Alt., 14 to 28; diam., 2 mm. Regularly and moderately curved throughout its length. Section circular, showing marginal riblets. Dull white. Tip slender, hexagonal—the angles extended into six or more narrow primary ribs which separate concave intercostal spaces. There are two broad interspaces with a median rib on the concave aspect of shell, and three narrow spaces on the side convexly curved. Some secondary ribbing is present and there are inconspicuous growth lines. No notch, but often a supplementary tube.

From one to five fathoms.

153 Gr., *pseudes,* false.
154 Lat., *dispar,* unequal.

Subgenus **GRAPTACME** Pilsbry and Sharp, 1897

Dentalium eboreum[155] Conrad Plate 20, figs. 132a, b

Alt., 25 to 38; diam., 2 to 2.75 mm. Slender; evenly and moderately curved; very much reduced in diameter posteriorly. Circular in section. White, salmon-pink in fresh shells; surface shining and polished, occasionally with opaque patches. Apical third of shell is sculptured with about twenty exceedingly fine and delicate riblets which fade into the smooth surface. Growth lines obscure. There is a narrow and deep apical slit on the convex side, frequently lost by wear and breakage; a supplementary tube is often present which shows the typical deep, narrow slit.

From one to six fathoms.

Subgenus **LÆVIDENTALIUM** Cossmann, 1888

Dentalium callipeplum[156] Dall

The shell is characterized by strong and even curvature and rapid increase in diameter. Strong, thin, polished, cream color, entirely lacking in sculpture. Shallow apical notch or indication of one on the concave side. Section is circular. Extreme alt., 62; diam., 5 mm.

Occasional fresh beach specimen.

Family **SIPHONODENTALIIDÆ**

Members of the three West Atlantic genera of this family are molluscs of deep water. Their shells are not likely to be taken in the course of general collecting. Prominent features resemble those of the Dentaliidæ.

Class **GASTEROPODA**

The Gasteropoda (Lat., *gaster*, stomach; Gr., *pod-*, foot), are numerically the largest division of the Mollusca and their shells are the most varied in form. The animals are highly organized—all have distinct heads and usually cephalic tentacles and structurally complex eyes. The senses of touch and smell are

155 Lat., *ebur*, ivory.

156 Gr., *kalos*, beautiful; Lat., *peplus*, skirt or shawl.

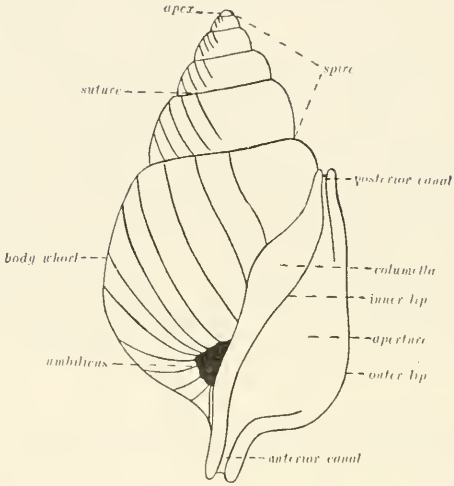


Fig. 6. Diagram showing the characteristic features of a gasteropod

highly developed. Some gasteropods are unisexual, some are hermaphrodites and a few are viviparous. Most of them deposit their spawn in capsules whose shape is characteristic of their species, in other cases the ova are extruded in a cordlike or ribbon-like matrix of gelatinous material.

A curious structure possessed in common by the Gasteropoda, the Amphineura and the Scaphopoda, is the radula or lingual ribbon. This is a chitinous band within the mouth or pharynx having upon its outer surface many, and usually very small, teeth. The radula is moved back and forth by special muscles or used with a gimlet-like action. It serves to pierce the shells of captured molluscs, to tear and shred the food of the carnivores and as a rasp in case of the vegetable feeders. This structure has no analogue in any other group of animals.

The gasteropod shell consists of one unit and is called univalve in distinction from the pelecypod shell which has two units and is called bivalve. The univalve shell may be regarded as a cone spirally twisted about its central axis or columella. Almost any possible modification of this cone may develop, from the flat and expanded *Sinum* to the slender elongated *Terebra* or the tentlike *Fissurella.*

Modifications of the primary cone produce shells which vary widely in the relative proportions of different parts, but all have certain features in common which it is needful to know in order to proceed with classification. The living mollusc bears the shell with the apex posterior and the aperture downward, but for the purpose of examination the univalve shell should be held with the apex upward and the aperture facing the observer. The apex is the extreme top of the shell and in many cases is the nucleus or embryonic shell with which the young mollusc emerged from the egg. Below the apex are several turns or whorls, separated by more or less deeply impressed sulci called sutures. These sutures may be shallow or deeply cut, and the whorls themselves may be convex or more or less flattened. The last and largest whorl is called the body whorl, in which is the aperture or mouth of the shell through which the animal extrudes the foot and the parts concerned with feeding. All the whorls together, exclusive of the body whorl, form the spire. To count the whorls place the shell with the aperture downward and count every whorl up to but not including the apical whorl.

The whorls show great variety in shape and sculpture. Some are flat and smooth, hardly showing microscopic markings, and from this simplicity the range broadens to include forms of the greatest complexity. The purpose of this sculptural decoration is considered to be protective, though nothing is certainly known of the reasons for such wealth of form, pattern and color as is exhibited by gasteropod shells.

The aperture may be of any shape between round or oval and the long, narrow slit with parallel margins as seen in *Conus* and *Oliva.* The outer lip may be thin or thickened, plain, dentate or alate. There may be a notch at either or both the top and the lowest part of the aperture, and one or both of these notches may be prolonged into canals. Sometimes the upper (posterior) notch is absent, and often the lower (anterior) notch is produced into a canal of variable length, which may be open along one side or closed throughout its entire extent. The columellar or inner lip may be perfectly simple and smooth or folded into plications which are often characteristic of the group to which the shell belongs. An entire, simple aperture denotes a vegetable feeder, but the rule is not invariable. Most proboscidiferous molluscs whose shells have canaliculated apertures are carnivorous and prey upon their own relatives, especially bivalves, whose shells they attack at the most vulnerable point and nearest to the essential organs.

The columella is the central pillar or column which passes through the shell from base to apex. It is the axis about which the whorls revolve and near its apex is affixed the columellar muscle which is the sole attachment of the mollusc to its shell. Contraction of this muscle retracts the animal into its shell and brings the operculum into position to close the aperture.

Most gasteropods have operculums. The operculum is a special cuticular development upon the foot, and is placed precisely over the end of the strong muscle which attaches the mollusc to the columella of its shell. The operculum more or less completely closes the shell's aperture when the mollusc is retracted within, and it may be held in this position for a long time if the animal is alarmed or exposed to drying. Generally the operculum is adapted to the shape of the aperture. In structure it may be corneous and of a brown or yellowish color; or calcareous, when it is usually white or tinted with pinkish, brownish or green coloration. Operculums vary much in shape and thickness, they are rudimentary in some genera and in others entirely lacking. There is a nucleus from which growth proceeds concentrically or excentrically; the position of the nucleus differs in different genera and is of importance in classification.

The usual turn of the gasteropod shell is to the right—dextral—showing the aperture on the right side when the shell is held with the apex upward. Some species are normally sinistral—the spiral turns leftward from the apex, placing the aperture on the left side when the shell is held apex upward. Species which are normally dextral may develop sinistral abnormalities and species which are normally sinistral sometimes present a right spiral.

Anomalies of the gasteropod shell are not uncommon, they appear more frequently than among the shells of the Pelecypoda or the Amphineura. *Busycon contrarium* often shows deformities and duplications of the canal for its entire length, but rarely any deformity of the body of the shell. Embryonic shells still in the egg capsule have been observed by the author which show the same deformities as those seen in semi-adult and adult specimens; this does not seem to have been previously noted. Many individuals show deformities of the whorls which are due to the inclusion of barnacles or boring molluscs.

Albinism is observed in *Busycon*, *Murex*, *Strombus*, *Oliva*, *Urosalpinx* and *Muricidea* and the operculum of such a shell is of a much paler color than the normal type.

Many gasteropods leave trails in sandy sea bottoms which are as distinctive to the experienced collector as trails in the snow are to the hunter. *Natica*, *Polynices*, *Melongena*, *Busycon*, *Fasciolaria*, *Terebra*, *Oliva*, *Olivella*, *Nassarius* and *Cerithium* all leave characteristic footprints and generally may be turned out from the sand as the trail's end.

Along the Southwest Florida coast and on the outlying islands are many midden sites of the aboriginal key-dwellers, and in these mounds are found numerous implements made from the shells of *Fasciolaria* and *Busycon*. These shell tools have holes for handles and some of them show marks of the thongs which bound these handles in position. Smaller shell tools may have been used to break the shells of living conchs which were used for food. The middens are mainly of oyster shells.

Order ARCHÆOGASTEROPODA

Family ACMÆIDÆ

Atlantic species of the genus *Acmæa* occur from far north to Florida and the West Indies. In general they are molluscs of the littoral region, living among sea grasses and weeds or upon rocks; few deep water species are known. The animal has eyes placed at the upper part of the base of its long, cylindrical tentacles and has a proboscis bordered with fringelike processes.

The shells are conical, oval and open at base, more or less depressed; apex not perforate, inclined forward, nearest to the anterior border of the shell. The interior is concave—saucer-like.

Genus **ACMÆA** Eschscholtz, 1830

Acmæa antillarum[157] Sowerby,

Alt., 6; length, 20; width, 11 mm. Summit well elevated, not acute; surface with numerous diverging rays of blue-gray on a lighter background. Interior blue-white with alternating dark and light markings about the margin and with a horseshoe muscular impression open toward the front.

Family **FISSURELLIDÆ**

This is a widely distributed family of molluscs all of which share the characters of short snout, cylindrical, pointed tentacles with eyes near their outer basal portions, and a large oval foot. The animals are vegetable feeders and move about freely.

The shells are conical, oval at base, patelliform, either perforate at the apex or having a notch or slit in the anterior margin. The external surface is ribbed or cancellated and the margins may be crenulated or smooth. The interior of the shell is smooth and the apical perforation is usually defined by a circumscribed, elevated callus.

Their distribution is through all except Arctic seas and the range in depth is very great.

Genus **LUCAPINA** Gray, 1857

Lucapina[158] **adspersa** Philippi — Plate 21, fig. 133

Alt., 3.5; length, 15; width at middle, 10.5. Shell conical, oblong-oval, depressed, slightly narrower in front; color white or grayish with seven to nine broad rays of darker color. Summit anterior to middle, perforation oval, almost the shape of aperture. Side-slopes moderately convex. Alternately larger and smaller radiating ribs cancellated by strong concentric ridges. Interior

157 Gr., *acme*, point, prime; of the Antilles.

158 Lat., *lucanus*, a beetle; *ad*, prefix expressing motion, direction; *sperse*, Archaic, meaning to disperse.

bluish-white, strong callus about perforation which is truncate behind, with a tint of green laterally. Margins crenulate.

Lucapina cancellata[159] Sowerby Plate 21, fig. 134

Alt., 4; length, 16; width at middle, 11.5 mm. Shell conical-depressed, oblong-ovate, summit anterior to middle, aperture oval. Color white or grayish, rayed with darker shade, sometimes mossy-green. Radiating riblets alternating in size, cancellated by strong, regular, concentric ridges, nodular at intersections with ribs. Interior white, callus about perforation dark-colored and slightly truncate behind.

Genus **LUCAPINELLA** Pilsbry, 1890

Lucapinella limatula[160] Reeve Plate 21, fig. 135

Alt., 3.5; length, 15; width at middle, 9 mm. Shell small, flattened, oblong, wider posteriorly; summit almost central, shape of orifice corresponds to marginal outline. Color an irregular blending of light and dark gray, often with more or less dull rose. Radiating ribs alternately large and small in front; laterally and behind three small riblets alternate with larger ribs which separate wider interspaces than those of anterior portion of shell. Regular concentric, laminate ridges form semi-erect, curved scales at rib intersections. Interior white, somewhat translucent to external coloration; callus about perforation narrow, entire; anterior and posterior margins crenulate.

Genus **DIADORA** Gray, 1821

Diadora[161] **alternata** Say Plate 21, fig. 136

Alt., 12; length, 22; width at middle, 19 mm. Shell rather thick, oblong-oval, conical. Color white or buff with markings of light and dark gray. Summit anterior to middle; anterior slope straight or slightly concave, posterior slope convex. Orifice keyhole shaped, excavated. Sculpture of three small ribs between two larger radiating ribs, crossed by concentric, lamellar ridges which become semi-erect curved scales at intersections of ribs.

[159] Lat., *cancellatus*, latticed.
[160] Lat., dim. of *lima*, file.
[161] Gr., *dia*, through; *dora*, hide, fur.

Interior white, polished, translucent to exterior coloration. Heavy callus about aperture which is truncate behind with a depression immediately posterior; margins finely and regularly crenulate. Only anterior and posterior margins in contact with flat surface.

Diadora listeri[162] d'Orbigny — Plate 21, fig. 137

Alt., 12; length, 38; width at middle, 25 mm. Shell corresponds to *D. alternata* in general characters, but is larger and heavier. Sculpture of alternately larger and smaller ribs deeply cancellated by strong, cordlike concentric ridges. Interior white; margins crenulate with the denticulations arranged in pairs.

Family TROCHIDÆ

The iridescent nacre which enters so largely into the composition of trochid shells gives them status among the 'elegant families.' In many species a dark periostracum conceals the intrinsic beauty of their lustre from without, but the pearly lining of the interior is always evident.

The animals are more or less brightly colored in shades of red or terracotta the head bears two tentacles and between them are two curiously flattened palmettes; a thick fold along each side of the foot gives attachment to a number of tendril-like processes which are always in motion when the creature is active and create an impression of delicacy and daintiness. These herbivorous molluscs are often found among seaweeds.

The shells are variable in shape, some are regularly conic or pyramidal, some turbinate and some heliciform. The shape of the aperture is also variable. The operculum is corneous, round, multispiral, with a central nucleus.

The many genera of this group are widely distributed through all warm seas, most abundantly in the littoral region though some have been dredged from considerable depths.

Genus CALLIOSTOMA Swainson, 1840

Calliostoma[163] **euglyptum** A. Adams — Plate 21, fig. 138

Alt., 21; width of base, 20 mm. Shell conical, imperforate;

[162] Dedicated to Lord Lister ?
[163] Gr., *kallos*, beauty; *stoma*, mouth; *eu*, well; *glyphein*, to carve.

rosy-brown with darker and lighter flammules and patches usually based on sutural lines. Apex dark red, a dark marking outlines apical whorls. Spire rather evenly conic. Four or five whorls; shoulders of lower whorls rounded. Sutures slightly incised. Base nearly flat. Sculpture of finely beaded spiral lirations, alternately larger and smaller; the penultimate whorl bears from seven to ten and the base from ten to twelve of these liræ, those upon the base separated by very finely striated interspaces. Aperture simple, quadrate, nacreous within; columella oblique, thickened at base. Operculum corneous, thin, circular, multispiral, with central nucleus.

Dredged at four to six fathoms.

Calliostoma veliei Pilsbry Plate 21, fig. 139

Alt., 11; width of base, 9 mm. Shell conical, imperforate, whorls not rounded, angulate; shoulder below middle of whorl. Ground color yellowish, with more or less regularly spaced longitudinal flammules of pinkish-purple; base unicolored. Apex sharp. About five whorls with spiral sculpture of beaded liræ, the most prominent lirations at shoulder of whorls. Numerous liræ, alternately larger and smaller over base. Sutures clearly defined. Aperture simple, quadrate, nacreous within; outer lip bluntly angled in accord with shape of whorls. Columella short, oblique, thickened at base. Base of shell not quite flat, umbilicus wanting. Operculum of the type.

Dredged at from three to six fathoms.

Calliostoma jujubinum[164] **perspectivum** (Koch) Philippi
Plate 21, figs. 140a, b

Alt., 15.5; width of base, 15 mm. Shell more smoothly conical and whorls less defined than in *C. euglyptum* and *C. veliei*. Color brown or reddish-brown with quite regularly distributed buff-colored flammules. Apex sharp, dark-colored. Four to six whorls, sculptured with closely placed spiral liræ, strongest at shoulders of whorls and alternately larger and smaller over body whorl. Sutures not well defined. Aperture simple, quadrate, angled at outer base, nacreous within. Columella concavely curved; base deeply perforate, a coarsely-beaded spiral lira out-

[164] Gr., *zizyphon*, an edible fruit; Lat, *perspectivus*, to look through.

lines the umbilicus. Operculum of the type.

Not uncommon on beaches, dredged in three to six fathoms.

Family CYCLOSTREMATIDÆ

The Cyclostrematidæ is a family of small molluscs whose range includes all seas and depths of less than one to many hundred fathoms.

The shells are white or corneous, sometimes transparent, with no trace of a nacreous layer; their form is turbinate, depressed, deeply umbilicate, with an almost circular aperture and simple, sharp lip. The operculum is corneous, similar to the trochid operculum.

Genus CYCLOSTREMA Marryatt, 1818

Cyclostrema[165] **sanibelense** Pilsbry, 1939 — Plate 22, figs. 141a, b

Alt., 1.1; diam., 0.9 mm. Shell is low-turbinate, base flattened and somewhat funnel-like around the narrow umbilicus. Color slightly off white, moderately translucent; thin, papery periostracum. About three and a half rounded whorls; upper whorls almost smooth; spiral threads with wider interspaces begin on penultimate whorl, increasing in number to seven on body whorl; the interspaces are crossed by occasional faint growth lines. The aperture is simple, oblique and a little flattened above; outer lip thin; columella a little thickened with a short parietal callus below. The operculum is corneous, multispiral, much resembling the operculum of *Calliostoma*.

Dr. Pilsbry remarks that this *Cyclostrema* is one of the smallest Florida gasteropods known. The series of more than sixty specimens collected on different occasions shows that they are adult shells. The species is apparently near *C. granulum* Dall, from Samana Bay, Santo Domingo, but the shell has fewer spiral threads and is more depressed, the *C. granulum* being as high as wide.

Genus LYDIPHNIS Melvill, 1906

Lydiphnis trilix[166] Bush — Plate 22, figs. 142a, b

Alt., 1.0; diam., 2.3 mm. Shell white with very thin periostra-

[166] Lat., *tri*, three; *lixa*, flowing (lines).
[165] Gr., *kykyos*, circle; *trema*, aperture.

cum; turbinate, much depressed, apex slightly elevated. Two or three whorls, evenly convex at shoulder, flattened above and below sutures not channeled. Aperture rounded, simple, oblique in outline and oblique in relation to vertical axis of shell; outer lip thin. Whorls are almost destitute of sculpture, a few lightly incised spirals and often a slight puckering below sutures; base shows one well incised spiral near outer margin and one or two others less defined. Umbilicus deep and funnel-shaped, showing turn of whorls to apex.

Dredged in four fathoms, Gulf of Mexico off Sanibel Island. Occasional beach specimens.

Genus COCHLIOLEPIS Stimpson, 1858

Cochliolepis[167] **striata** (Stimpson) Dall Plate 22, fig. 142C

Alt., 1.3; greatest diam. of base, 7.25 mm. Shell auriform, greatly flattened, widely umbilicate, thin and horn-colored. Nuclear whorl and apex not elevated. Two rounded whorls increasing in size to aperture which is expanded and oblique with posterior portion of sharp outer lip somewhat prolonged over shoulder of body whorl. Interior of aperture smooth and shining. External surface engraved with fine parallel striations.

This mollusc is parasitic upon certain annelids.

Family TURBINIDÆ

Genera of the family Turbinidæ are native to tropical and subtropical seas. The animals somewhat resemble the trochids in the possession of palmettes and the lateral cirri. They are herbivorous, and confined by this habit to depth zones in which marine vegetation can flourish. Their principal food is said to be marine algæ.

The shells are rather heavy and solid, turbinate or trochiform, in shape, not umbilicate; external surface is rugose or smooth with thin epidermis; the aperture rounded, oval or subtetragonal with a simple lip. Operculum is calcareous, flat on inner surface, externally convex.

[167] Gr., *cochlias*, snail, snail shell; *lepis*, scale.

Genus **TURBO** Linnè, 1758

Turbo[168] castaneus Gmelin Plate 22, fig. 143

Alt., 30; diam., 25 mm. Shell oblique-ovate, solid, with thin periostracum; color varies through gray, orange and chestnut-brown, usually maculated with darker or lighter markings on light or dark background. Spire conic, about one-third of altitude. Five or six rounded whorls; sutures channeled; sculpture of strongly beaded spiral liræ of varying size, with fine incremental lines in interspaces. Aperture nearly circular, nacreous within; outer lip sharply crenulate; columella white, with white callus; peristome continued below. Not umbilicate. Operculum calcareous, inner surface flat, chestnut color; convex externally and often stained with a green or brown tint.

Very rarely specimens of a dark green color are found, this coloration seems not to be due to any extrinsic cause.

Not uncommon on grassy bottoms of littoral zone.

Family **NERITIDÆ**

Special interest attaches to the Neritidæ on account of their adaptation to diverse conditions of environment. Some of its genera are exclusively marine, and prefer rocky stations, some are restricted to brackish water, other are fluviatile, while some are able to maintain themselves for long periods without wetting. The animals are herbivorous and have the unusual habit of placing their eggs upon their own shells and those of other molluscs.

The shells are globular or subglobular with the body whorl more or less expanded, the spire short and inconspicuous, semilunar aperture and simple outer lip. The operculum is calcareous and is furnished with an apophysis which articulates with the opposite portion of the columella.

Genus **SMARAGDIA** Issel, 1869

Smaragdia[169] viridis Linné Plate 22, figs. 144a, b

Alt., 8; diam., 5 mm. Shell small, smooth, translucent, obliquely-oval, subglobular, imperforate. Color grass-green or yellowish-green, unevenly maculated with white in an interrupted longitudinal arrangement; a narrow, sharp pencilling of dark maroon

[168] Lat., *turbo,* a top; *castanea,* chestnut.

[169] Gr., *smaragdos,* emerald; Lat., *viridis,* green.

color usually outlines the white spots on the side toward the apex or toward the columella; occasionally some black appears in the color pattern and some few specimens are unicolored. A thin, glossy epidermis gives an appearance of elegance to this small shell. The apex is minute, scarcely elevated, about two whorls, body whorl much enlarged and expanded. Aperture simple, semilunar, outer lip thin, sharp; columella oblique, finely denticulate; columellar region wide, greenish, overlaid with a polished, translucent callus. Operculum calcareous, green, nucleus excentric near lower-inner margin, a strong bifid apophysis at lower columellar angle and a longitudinal fossa in the columellar margin.

The animal is green, with eyes placed at outer bases of pointed, cylindrical tentacles.

This is a marine member of the family, usually found among sea grasses at moderate depths.

Order MESOGASTEROPODA

Family EPITONIIDÆ

All seas afford habitats to members of this widely distributed family, but the greatest number and diversity of species are found in West Indian waters. They are predatory, carnivorous animals, usually frequenting sandy stations where abundance of animal food is available. The cephalic end of the mollusc bears two long, pointed, mobile tentacles, an invaginable trunk and two black eyes placed on the summits of small tubercles at the outer bases of the tentacles.

The shells are turriculate, usually white and polished, with many convex ribbed whorls which gradually and regularly increase in size from apex to base. The aperture is nearly circular with a thickened, reflected lip, which will eventually become a new varix. Base is perforate but umbilicus is usually concealed by an expansion of the inner margin. The thin, corneous operculum entirely closes the aperture.

Genus **EPITONIUM** (Bolten) Roeding, 1798

Subgenus **NITIDOSCALA** de Boury, 1909

Epitonium[170] **angulatum** Say

Alt., 19 mm. Shell white, polished; apex sharp, nuclear whorls rounded, smooth; from seven to eleven convex whorls, not in contact; about nine equidistant, rather thick, longitudinal, lamellar ribs continuous over sutures and angulated at sutural line. Aperture rounded, with a reflected, lamellar border.

Epitonium fragilis[171] Gray

Shell minute, imperforate; about twelve varices; nucleus glassy, bulbous, consisting of three to five whorls; five additional rounded, regular whorls; suture well impressed; color white. Length, 4.5-6 mm.

Palm Beach and Punta Rassa, Florida.[172]

Epitonium denticulatum[173] Sowerby — Plate 22, fig. 145

Alt., 18 mm. Shell white, not polished; apex acute, nuclear whorls smooth; about eight convex whorls, not in contact and spirally striate, with microscopic engraved, longitudinal lines which do not cross the striations. Nine to eleven subcontinuous, moderately elevated ribs, each with a sharp denticle near the suture above. One or two ribs on each whorl stronger and heavier than their fellows. Aperture rounded, margin thickened.

On sandbars and sandy bottoms in moderate depths.

Epitonium humphreysii Kiener — Plate 22, fig. 146

Alt., 17 - 22 mm. Shell white, polished; apical whorl only without ribs; whorls about seven, convex, not in contact, smooth save for occasional growth lines; nine or ten well-elevated, fairly thin, lamellar ribs, continuous over sutures to apex; each rib with a definite angle and a notch at junction with opposite rib of preceding whorl. Aperture rounded, with thickened marginal lamella. Operculum pale amber. Animal white. Juvenile shells more pyramidal in outline than adult specimens.

On sandbars and sandy bottoms at moderate depths.

170 Gr., *epitonion*, peg, turncock; Lat., *angulatus*, angled.
171 Lat., *fragilis*, frail.
172 The author has not seen this shell. Description is quoted from East Coast American Shells, by Maxwell Smith.
173 Lat., *denticulus*, dim of *dens*, tooth.

Epitonium lineatum[174] Say

Alt., 12 - 14 mm. Early whorls white, later whorls brownish; glossy but not highly polished; apical whorls smooth; six to eight contiguous whorls, moderately convex, with two spiral chestnut-brown bands—the lower more deeply colored and partly concealed by the suture in upper whorls. Body whorl usually with elevated spiral line below periphery; from thirteen to nineteen cordlike, subcontinuous ribs, with heavier, more elevated ribs at intervals. Aperture rounded, peristome thick and heavy with a decided flexure at junction of outer lip with body whorl.

Found with other Epitoniums.

Epitonium multistriatum[175] Say Plate 22, fig. 147

Alt., 12 mm. Shell white, glossy, imperforate; apical whorls smooth and translucent. Seven or eight convex whorls, in contract. Ribs are continuous, over upper three whorls they are close and threadlike, becoming more elevated and more widely separated on succeeding whorls; about sixteen ribs on body whorl. The intercostal spaces are clearly engraved with fine, close spiral lines. Aperture oval, margin thickened.

On sandy bottoms in two to six fathoms.

Epitonium tollini Dall Plate 22, fig. 148

Alt., 10 - 15 mm. Shell white, glossy, elongate, slender; nuclear whorls smooth. Eight or nine very convex whorls, not contiguous. Ribs lamellar, moderately elevated, equidistant, variable in number—from seven to eleven on body whorl. Intercostal spaces without spiral sculpture. Aperture slightly oval.

Sandy bottoms, moderate depths.

Family MELANELLIDÆ

Members of the family Melanellidæ belong for the most part to the fauna of tropical and subtropical seas; many species are native to West Indian, Caribbean and Florida waters. Some Melanellidæ are parasitic upon the integument or within the intestinal canal of echinoderms and holothurians, 'where they creep about with much vivacity.' Other species live in commensalism

174 Lat., *lineatus*, marked with lines or stripes.
175 Lat., *multi*, many; *striatus*, channeled.

with sea urchins, and, according to Fischer, perhaps nourish themselves on the excrements of their companions.

The cephalic extremity of the mollusc is equipped with a retractile trunk, a pair of tentacles and eyes at the outer base of each tentacle.

The shells are small, smooth and elegantly polished, generally elongate and produced to a sharp apex; the spire is frequently deflected from the vertical axis. The aperture is pyriform or oval and the operculum, when present, is corneous with a few spiral turns.

Genus MELANELLA Bowdich, 1822

Melanella[176] **conoidea** Kurtz and Stimpson Plate 23, fig. 149

Alt., 10 mm., spire about 0.8 of altitude. Shell highly polished, white, translucent, imperforate, smoothly conic in outline. Apex acute; thirteen flat whorls; body whorl subangulate at periphery; sutures faintly incised. Aperture pyriform, widest at base, acute-angled above; outer lip sharp. Columella concave. Operculum corneous, entirely closes aperture.

As observed in an aquarium, the molluscs are active and fearless; they move quite rapidly over the bottom sand or over the sides of a glass vessel, and by means of a mucus filament, secreted by a pedal gland, they are able to sustain themselves and creep beneath the surface film or on top of the surface of the water. The animal extends and retracts the long, mobile snout, but the head is rarely protruded beyond the shell's aperture; the pinpoint black eyes are easily seen through the translucent shell.

Melanella intermedia[177] Cantraine Plate 23, fig. 150

Alt., 7 - 12 mm., spire about 0.7 of altitude. Shell polished, white—often brownish; slender, conic, sometimes slightly curved; imperforate. Apex acute, twelve or thirteen flattened whorls, body whorl evenly rounded; sutures not clearly defined. Aperture pyriform, widest below; outer lip sharp; columella concave, produced into a thickening of lower lip margin.

[176] Gr., *melanos*, black; *konoeïdes*, cônical.
[177] Lat., *intermediatus*, in the middle place.

Subgenus **LIOSTRACA** H. and A. Adams, 1853

Melanella bilineata[178] Alder Plate 23, fig. 151

Alt., 8 mm. Shell polished, white, often brownish at base; slightly flattened in antero-posterior diameter; imperforate. Apex acute, nuclear tip rounded and prominent; about ten flattened whorls with two faint lines at middle and one below sutures. Sutures fairly distinct. Aperture entire, oval, outer lip sharp, columella concave.

Melanella hemphilli Dall Plate 23, fig. 152

Alt., 5 mm. Shell slender, conic, imperforate; chestnut-brown, polished and pellucid. Apex acute, nuclear whorl prominent; about eight flat whorls; sutures distinct, a narrow line below sutures. Aperture oval, narrow, entire, outer lip sharp; columella slightly concave.

Genus **NISO** Risso, 1826

Niso interrupta[179] Sowerby Plate 23, fig. 153

Alt., 14 mm. Shell conic-pyramidal, thin, polished, translucent. Apex acute, ten or eleven whorls, body whorl angulate at periphery. Color pale cocoa-brown, with occasional flame-shaped patches of darker color; each whorl defined by a fine reddish-brown line; the sharp outer lip of oval aperture outlined by a similar pencilling. Resting periods in the growth of the shell marked by reddish lines crossing whorls at sites of previous apertures. Base of shell convex, deeply umbilicated by a conical depression. Operculum pale yellow, entirely closing aperture.

Animal white, with long, slender tentacles, black eyes posterior to base of tentacles. Very active and mobile, moves backward as readily as forward and can reverse position in its own length.

Family **PYRAMIDELLIDÆ**

The name of this family, formed from the name of its genus *Pyramidella* (Lat., *pyramis*, pyramid), is suggestive of the characteristic shape of the shells which are pyramidal or conic in

178 Lat., *bis*, twice; *lineatus*, lined, striped.
179 Lat., *Nisus*, king of Megara?; *interruptus*, interrupted.

outline, turriculate, with an auriform or oval aperture and simple outer lip which is usually sharp. The columella may or may not be plicate. The operculum is corneous, adapted in shape to the aperture and in the case of those species whose columella is plicate, the inner edge of the operculum is appropriately notched.

The apices of shells of the Pyramidellidæ are heterostrophic; the embryonic shell, which forms the nucleus and the first one or more whorls of the spire, is coiled in the direction opposite to that of subsequent growth. The normal revolution of the whorls about the columella is dextral, the apical whorls are sinistral; Fischer states that there is no known instance of complete sinistrosity among the group. In addition to this unusual character, the apical portion of the shell is tilted from the vertical axis and the apex with some fraction of the immediately succeeding whorls is more or less depressed into the whorl next below.

The animals are provided with curious tentacles, shaped like the ears of a donkey and covered within their concavity and near the extremities with delicate, minute hairs which are continually in motion. A long, thick trunk can be extruded from an opening directly above the base of the tentacles, and just external to the bases of the tentacles is a pair of sessile eyes.

Distribution of members of this group is general in warm seas from the intertidal zone to considerable depths. Most species inhabit sandy bottom.

Genus **PYRAMIDELLA** Lamarck, 1799

Subgenus **LONGCHÆUS** Mörch, 1875

Pyramidella[180] **crenulata** Holmes — Plate 23, fig. 154

Alt., 15; spire, 9 mm. Shell smoothly elongate-conic, imperforate; pale brown, polished, translucent, with irregular mottlings of darker and lighter coloring; columella dark brown. Apex acute; twelve or thirteen flat whorls, body whorl rounded; sutures horizontally channeled, V-shaped; interior slope and margin crenulate. Aperture entire, reniform, outer lip sharp; columella sinuous, two oblique folds. Basal margin of outer lip continued into a rounded cord encircling base to upper termination of columellar lip, where it becomes a prominent, flattened plication

[180] Lat., *pyramis*, pyramid; *crenulatus*, finely notched.

passing horizontally across the columella. Operculum corneous, color of shell, notched to accommodate folds of columella.

Common on sandbars and sandy bottom in shallow water; dredged in Gulf of Mexico at two to six fathoms. Gulf specimens are often uniformly pink.

Genus **TURBONILLA** Risso, 1826

Subgenus **STRIOTURBONILLA** Sacco, 1892

Turbonilla[181] **dalli** Bush Plate 23, fig. 155

Alt., 8; spire, 6.25 mm. Shell milky-white, glossy, elongate-conic. Apex of about two nuclear whorls obliquely tilted from vertical axis; twelve convex whorls, the lower three slightly flattened. Strong, slightly oblique axial ribs, not continuous over sutures, sixteen to eighteen on body whorl. Intercostal spaces excavated, not extended to sutures and spirally striate with fine lines. Sutures impressed, distinct. Aperture simple, outer lip sharp, rounded; columellar lip straight, thickened, not plicate, upper margin oblique. Axial ribs extend over base to umbilical region.

Found on sandy bottom at moderate depths.

Turbonilla hemphilli Bush Plate 23, fig. 156

Alt., 10 - 12 mm. Shell buff or pale brown with waxy lustre, often with wide dark band below suture. Apex acute with about two nuclear turns, oblique tilted; twelve to fourteen whorls, only slightly convex, flattened at periphery. Sutures distinct, impressed. Eighteen or nineteen almost vertical axial ribs, extending to, but not crossing sutures, interspaces about width of ribs, spirally striate. Aperture like that of *T. dalli* to which the species is closely allied.

Found on sandy bottoms at moderate depths.

Turbonilla conradi Bush Plate 23, fig 157

Alt., 10 - 12 mm. Shell buff or pale brown with waxy lustre, often with wide dark band below sutures. Apex acute, two nuclear whorls almost transverse to vertical axis; twelve to fourteen whorls, only slightly convex, lower whorl slightly overlaps one above. Sutures incised, distinct. Axial ribs not crossing sutures,

[181] Lat., dim. of *turbo*, a top.

eighteen to twenty-two on body whorl, almost vertical, sometimes curved. Intercostal spaces about width of ribs, spirally striate. Base with three fine incised spiral lines and concentric striations. Aperture as in other Turbonillas.

Mainly a littoral species.

Turbonilla[182] punicca Dall Plate 23, fig. 158

Alt., 7 - 8 mm. Shell pale waxen-buff at tip, deepening to clear red-brown on body whorl. Shape slender, elongate-conic. Nuclear whorls transverse; twelve or thirteen whorls, slightly and evenly convex. Sutures narrow, incised. Sixteen to eighteen strong, nearly vertical ribs, almost obsolete on body whorl. Interspaces about width of ribs, with fine, closely placed spiral striations. Aperture entire, columellar lip thickened.

Moderate depths on sand and mud bottoms.

Turbonilla incisa[183] constricta Bush Plate 23, fig. 159

Alt., 6 - 8 mm. Shell waxen-buff, spire almost unicolored, dark band over lower portion of whorls. Shape slender, elongate-conic. One and a half smooth nuclear whorls tilted obliquely to vertical axis; ten flattened convex whorls; postnuclear whorl with fine, close vertical threads; next whorl shows stronger threads with beginning definition of interspaces; succeeding eight whorls show increasing strength of ribs and intercostal striations; about twenty-five ribs on body whorl. With magnification, the intercostal striation is seen to consist of six to eight flattened cords which do not cross the ribs and which are separated by excavated interspaces of almost equal width. Aperture of the type.

Found with *T. puniceu* and other Turbonillas of moderate depth range.

Genus PERISTICHIA Dall, 1889

Peristichia[184] toreta Dall Plate 23, fig. 160

Alt., 10.5 mm. Shell white or yellowish, elongate-conic; two smooth, glassy nuclear whorls tilted more than transversely from vertical axis. Thirteen slightly convex whorls with strong, bead-

182 Lat., *puniceus*, red, purple.
183 Lat., *incisus*, cut; *constrictus*, drawn together.
184 Gr., *peri*, around; *stickos*, a row or line.

ed, spiral sculpture. Sutures distinct, wide, with a fine, undulating thread above the middle. Each whorl shows above the suture a roundly beaded spiral cord, above this cord is an interspace of almost equal width, next above is a second beaded spiral of size almost equal to the first, next a narrower interspace and a third, smaller beaded spiral immediately adjacent to the suture. Axial ribs over each whorl cross the interspiral spaces and extend as radii over the rounded base. A strong fold from the top of the columella is continued around base of shell to form the lowest crenulation of outer lip. Aperture ovate, outer lip sharp, crenulated by external sculpture, three internal liræ. Operculum pale yellow, animal white.

From three to six fathoms.

Genus **ODOSTOMIA** Fleming, 1817

Odostomia[185] acutidens Dall

Alt., 4; alt. of spire, 1.6 mm. Shell yellowish-white, glossy, solid, pyramidal with aperture extended beyond base. Apex acute; five or six rounded whorls, base of body whorl rounded; sutures defined but not channeled. Whorls without sculpture save for growth lines. Aperture entire; outer lip sharp, rounded into columella below. Columella distinct with polished callus above, one sharp, horizontal, almost median tooth, a groove posterior to columella but no umbilicus.

This *Odostomia* is not common; it inhabits muddy flats.

Subgenus **MENESTHO** Möller, 1842

Odostomia bisuturalis[186] Say — Plate 23, fig. 161

Alt., 4; alt. of spire, 3 mm. Shell elongate, conic-pyramidal, base extended; milky-white, thin pale brown epidermis. Apex of about two whorls partly embedded in first postnuculear whorl; seven or eight flattened whorls, shouldered at sutures. Sutures well defined. A strong, deeply cut spiral, parallel with suture, is engraved on upper portion of each whorl. Aperture oval, upper angle acute, base rounded into slender columella which has one oblique fold well within aperture. Operculum corneous, brown.

Inhabits muddy sand flats.

[185] Gr., *odon, odontis,* tooth; *stoma,* a mouth: Lat., *acutus,* acute; *dens,* tooth.

[186] Lat., *bis,* twice; *sutura,* sew or stitch—seam.

Odostomia impressa[187] Say Plate 23, fig. 162

Alt., 4 mm. Shell milky-white, elongate-conic; small nuclear whorls partly embedded in succeeding turn. Six or seven flattened-convex whorls, outline indented by sculpture; sutures channeled. Whorls sculptured with three equidistant, deeply cut spiral grooves, themselves impressed with very delicate spiral striations. Aperture ovate, simple, angled above; outer lip sharp. The outer lip of adult shells is somewhat flaring, aperture narrowed within. Columella has one oblique fold. Base shows about seven, narrow spiral grooves.

O. impressa is generally found about oyster bars among clumps of oysters.

Odostomia trifida[188] Totten Plate 23, fig. 163

Alt., 4-5 mm. Shell white, glossy, thin, translucent; yellowish periostracum; conic-ovate; nuclear whorls small, partly embedded in following turn. Eight whorls, moderately convex, slightly shouldered at summit; sutures distinct. Sculpture of three deeply cut inequidistant, and one faint spiral line. Aperture elongate-oval, upper angle acute; outer lip thin, its interior showing reverse of external sculpture; columella with one strong oblique fold above middle. Base rounded, narrowed below, impressed with about ten unequal, inequidistant striæ. Operculum corneous, brown.

Inhabits mud and sand flats, often among sea grasses.

Subgenus **CHRYSALLIDA** Carpenter, 1856

Odostomia seminuda[189] C. B. Adams Plate 23, fig. 164

Alt., 3.75-4 mm. Shell elongate-conic; milky-white, glossy. About two smooth nuclear whorls obliquely embedded in next succeeding whorl. Six or seven slightly convex whorls, shouldered at summit, body whorl rounded; sutures distinct. Whorls or nodules by four low, broad, equidistant ridges. Aperture sculptured between sutures by axial ribs cancellated into beads somewhat auriform, outer lip simple, thick within, thin at edge,

187 Lat., *impressus*, pressed.
188 Lat., *trifidus*, three-cleft.
189 Lat., *semi*, half; *nudus*, naked.

showing external sculpture reversed in relief; columella flexuose with a strong oblique fold well within aperture. Base and body whorl below periphery engraved with clear-cut spiral grooves. Operculum pale brown.

Associated with other Odostomias.

Family NATICIDÆ

The family Naticidæ is one of the subdivisions of the Mollusca called Platypoda, which means 'broadfoot'. The propriety of the name is evident when individuals of the species *Natica, Polinices* or *Sinum* are seen ploughing through the sandy sea bottom in quest of prey.

Characteristic of the group is the highly distensible oval foot which overflows and almost conceals the entire shell when the animal is expanded. A well-developed cephalic disc, or propodium, is reflected over the head of the animal and the anterior border of the shell. The sense of smell and touch are apparently keen, but eyes are absent or subtegumental. The radula is well developed in all species of the Naticidæ, and by its use a neat round hole is drilled through the umbonal region of the shells of bivalve molluscs which constitute the food of this voracious and predatory race.

The shells are subglobular or depressed and auriform, the body whorl is much expanded and the aperture correspondingly large, not canaliculate, with a simple, sharp outer lip.

The group has a wide distribution from Arctic to Antarctic seas.

Genus NATICA Scopoli, 1777

Natica[190] **canrena** Linné — Plate 24, figs. 165a, b

Alt. up to 45 mm. Shell subglobular, smooth; adult specimens thick. Apex small, spire depressed, body whorl expanded. Pale and deep fawn color disposed in revolving bands, with zigzag markings of dark brown, strongest over upper part of shell; base white; thin, glossy periostracum. Aperture semilunar, simple; columella oblique, reflected, notched at umbilicus. Deep umbilicus more or less filled with entering callus. Operculum calcare-

190 N. L., *natica,* buttock.

ous, internal surface fawn color, externally white with about six deeply cut channels parallel with external margin; columellar margin finely serrate.

Inhabits sandy bottoms beyond low tide mark. Animal preys upon bivalves and has been seen to devour dead fish.

Natica pusilla[191] Say Plate 24, fig. 166

Alt., 4-6 mm. Shell small, sturdy, subglobular; spire depressed, body whorl large. Color white or a shade of fawn, with faint chestnut markings and obscure bands. Aperture semilunar, outer lip sharp; columella oblique, thick; reflected columellar callus pressed into umbilicus which appears as an arcuate depression. Operculum calcareous, smooth.

This smallest of the Florida Naticas is often confused with young *N. canrena*. Its depth range is from low water mark to fifteen fathoms.

Genus **POLINICES** Montfort, 1810

Polinices[192] **lactea** Guilding

Alt., 25 mm. Shell rounded, obliquely ovate; white, thin yellowish epidermis. Spire depressed, body whorl expanded; sutures distinct; surface smooth, faint growth lines. Aperture semilunar; columella oblique; heavy reflected callus partly filling deep umbilicus. Operculum corneous, amber or claret color.

Dredged in four to six fathoms.

Polinices duplicata[193] Say Plate 24, fig. 167

Alt., 45 mm., largest Gulf specimen measured, alt. 62, diameter 74 mm. Shell subglobular, smooth; spire more or less depressed—much individual variation in this character. Body whorl large, sutures distinct. Color bluish- or ashy-gray, not always uniformly tinted; a dark presutural band about first few whorls. Surface smooth, fine growth lines; thin, glossy periostracum. Aperture semilunar, outer lip sharp, protracted above; columella oblique; umbilicus deep, partly closed by dark-colored callus; interior of aperture usually dark-colored, lustrous. Operculum corneous, dark amber color.

Found with *N. canrena* up to about three fathoms.

191 Lat., *pusillas*, very small.
192 Gr., *Polynices*, son of Oedipus; Lat., *lacteus*, milky.
193 Lat., *duplicatus*, doubled.

Genus **SINUM** (Bolten) Roeding, 1798

Sinum[194] **perspectivum** Say Plate 24, fig. 168

Shell auriform, depressed to altitude of a few millimeters; greatest diameter of base approximates 35 millimeters. Apex and spire flattened to plane of body whorl. Color milk-white; thin, yellowish, papery epidermis. About three whorls; sutures faintly impressed. Surface sculpture of numerous well-engraved, subequidistant, revolving, slightly wavy lines and fine longitudinal lines of growth. Aperture wide, rounded; outer lip sharp, finely crenulate. Operculum corneous, very minute.

In the living animal, only a small portion of the upper surface of the shell is exposed.

Sandy bottom in shallow water.

Sinum maculatum[195] Say

Shell a little smaller and less depressed than *S. perspectivum*, with two maculated bands of chestnut-brown about the upper whorls.

Family **LAMELLARIIDÆ**

The molluscs which constitute this family bear shells which are similar in general characters to those of the genus *Sinum*, but very much smaller, more delicate in structure, and without an operculum. The shells are almost or wholly covered by a reflection of the mantle.

The animals are carnivorous and are usually found in association with compound ascidians, Hydrozoa and Alcyonaria; their eggs are deposited among the folds and in the crevices of colonies of these animals. Some of them are brightly colored and their general appearance is usually more suggestive of a nudibranch or a platyhelminth than of a shelled mollusc.

Distribution of the family is chiefly in cold seas, but some species are native to warm waters.

Genus **LAMELLARIA** Montagu, 1815

Lamellaria[196] **cochinella** Perry

[194] Lat., *sinus*, a bend or hollow; *perspectivus*, *perspicere*, to look through.

[195] Lat., *maculatus*, spotted.

[196] Lat., dim. of *lamina*, plate, leaf, layer; Fr., *cochinille*, Castilian red.

Alt., 6; greatest diam., 4; greatest thickness, 3; height from upper angle of aperture to apex, 1.5 mm. Shell auriform, oblique; pure white with glossy, diaphanous epidermis. Apex and succeeding whorl extremely small, nucleus depressed; second whorl larger, convex; body whorl convex, widely expanded; sutures incised, distinct. Above periphery of body whorl are two faint, revolving, incised lines, with a less distinct, interrupted line nearer suture; delicate incremental lines form longitudinal striations over entire surface. Aperture wide, entire; sharp outer lip somewhat protracted into a thin callus over lower convexity of whorl above. Columella evenly concave.

A number of individuals of this species were found associated with colonies of compound ascidians dredged in four to six fathoms off Captiva and Sanibel islands, Florida. The mollusc is brilliant red, the reflected mantle entirely covers the shell. The general appearance of the animal and its undulating movement suggest a nudibranch or a flatworm more than a shelled mollusc.

Genus MARSENINA Gray, 1852

Marsenina globosa[197] Perry — Plate 24, fig. 169

Alt. from base of columella, 14; from base of expanded lip, 15.5; greatest diam., 14; extreme thickness, 9.25 mm. Shell thin, translucent, milky-white; glossy, diaphanous epidermis. Apex and apical whorls very small, extremely thin; two small whorls, the second enlarging abruptly into body whorl which constitutes about eight-tenths of the extreme altitude. Whorls oblique, convex, inflated; sutures impressed. Surface shows only fine incremental lines. Aperture wide, obliquely expanded; outer lip thin, sharp; columella incurved, concave at center. Interior smooth, iridescent; sutural impressions and cavity of spire visible when shell is viewed from base through the open umbilicus.

Holotype collected by Jeanne S. Schwengel from Pine Island Sound, Florida.

Family XENOPHORIDÆ

A most extraordinary habit of the molluscs of this family is intimated by the name of its genus *Xenophora*. The word is a

197 Lat., *globosus*, globular, spherical.

compound of the Greek combining form *xeno* from *xenos*, guest or stranger; and *phoros*, from *phorein*, to bear. Only the very deep water species of *Xenophora* fail to disguise their shells externally by attaching to them foreign objects, such as shell valves, coral and fragments of rock. When the animal is at rest upon the sea bottom only a small mass of rough debris is to be seen, not in the least suggestive of the active, intelligent mollusc that so protects itself.

The animals also present a remarkable combination of physical characters; they possess the foot of *Strombus*, the radula of *Calyptræa*, an operculum similar to that of *Thais* and shells which resemble in shape those of *Trochus*.

Distribution of the family is confined to warm seas.

Genus **XENOPHORA** Fischer de Waldheim, 1807

Xenophora[198] **conchyliophora** Born Plate 24, fig. 170

Alt., 35; diam. of base about 40 mm. Shell is trochiform, imperforate, apex sharp; whorls flattened, base slightly concave, body whorl sharply carinate at union with base. Surface roughly striate from growth lines; color variegated brown and cream, base brown. Aperture symmetrical, large, oblique; outer lip sharp and continuous with carina of body whorl. Columella short, stout, curved. Operculum corneous, suboval, thin, slightly concave. Characters of shell above the base are concealed by the 'agglutinated strangers' affixed in fairly regular rotation about the whorls. Shells, bits of rock, living and dead coral are indiscriminately utilized, but preference seems accorded to valves of pelecypod shells. These are always attached by their convex surface.

Several living *X. conchyliophora* kept in an aquarium, affixed only left valves of *Chione cancellata* to their shells, although other bivalve shells and bits of gravel were available. Additions to the defensive armor were made at night, suggesting that the species may be nocturnal in habit.

Living specimens dredged in three to six fathoms on gravelly bottom about reefs.

[198] Gr., *xenos*, combining form meaning guest, stranger; *phorein*, to bear; *konche*, shell.

Family CALYPTRÆIDÆ

Distribution of members of this family is common to all seas, from shallow water to considerable depths.

The molluscs are sedentary and adhere tenaciously to the surfaces of rocks or shells where they become accidentally located in the very early stages of their growth. That portion of shell or stone immediately beneath the foot of the animal often becomes dissolved or worn away, leaving an oval depression.

Genus CALYPTRÆA Lamarck, 1799

Calyptræa[199] **centralis** Conrad — Plate 24, figs. 171a, b

Alt., 2; diam. of base, 5.5 mm. Shell thin, conic, cap-shape; white, with transparent epidermis. Apex sharp, excentric, spiral, tilted from vertical, nuclear whorls glassy. Sculpture of growth lines concentric to round base; sometimes fine radial striations from apex to base. Basal aperture round, margin sharp. Interior polished; thin spiral septum from base to apex. Molluscs adherent to other shells.

In depths of one to more than fifty fathoms.

Genus CRUCIBULUM Schumacher, 1817

Crucibulum[200] **striatum** Say — Plate 24, fig. 172

Alt., 12; diam. of base, 25 mm. Shell conic, cap-shape; apex laterally excentric, beaked; anterior declivity of shell convex, posterior concave. Color brown or brownish. A smooth area about summit defined by a sutural line indicates early spiral growth; below this line are feeble radiating ribs. Basal aperture, somewhat oval, margin very finely crenulate. Interior polished, brown; a white, funnel-shaped internal septum below apex. Animal adherent, shell free.

From about three to more than a hundred fathoms.

Family CREPIDULIDÆ

The distribution of this family is world-wide throughout warm seas at moderate depths. The adult molluscs are always affixed, probably permanently; the shell is not attached and, like *Anomia*, varies considerably in its form by reproducing any irregularities of the surface it rests upon.

The ova are deposited in grapelike bunches and retained be-

199 Gr., *kalyptra*, covering for the head; Lat., *centralis*, center.
200 Lat., *crucibulum*, an earthen pot; *striatum*, striped.

neath the shell until the larvæ emerge. The animals of *Crepidula* undergo a change of sex during the process of normal growth; in young stages male attributes predominate, but as development proceeds this reversal of sex becomes complete. Groups of *Crepidula* may contain small male individuals, some in transitional stages and others which have attained full reproductive maturity.

Genus **CREPIDULA** Lamarck, 1799

Crepidula[201] **fornicata** Linné Plate 25, fig. 173

Length to 40; width to 26 mm. Shell oval, very oblique, with rounded margins and flattened spire; apex inclined to right, submarginal; body whorl constitutes almost entire shell. Color varies through shades of brown, frequently arranged in stripes or blotches; thin yellowish epidermis. Surface shows only growth lines. Interior polished, mottled purple-brown and white; internal horizontal diaphragm is concave, white, translucent, extending to middle of aperture, its free margin slightly sinuous. Convexity and consequent depth of shell are very variable, some individuals are flattened, others highly convex. Adherent to the outer, convex, surface of other shells; sometimes in tiers of successively smaller individuals.

From one to six fathoms.

Crepidula glauca[202] **convexa** Say

Length, 12; width, 8 mm. Shell resembles *C. fornicata* but is much smaller, more convex, side of shell toward which apex inclines is more nearly vertical. Internal septum deep-seated and convex.

Found attached to the convex surfaces of other shells. The author has seen great numbers of these small molluscs attached to blades of eel grass on the tidal flats of Sanibel Island.

Crepidula plana[203] Say Plate 25, fig. 174

Length to 30; width to 16 mm. Shell flattened, oblong-oval, white; yellowish epidermis. Apex terminal, directed to left, depressed to surface plane. Smooth but for coarse growth lines. Interior polished; diaphragm almost half the length of shell, highly convex toward free margin, edge concave at center, usually notched at one side.

C. plana may be attached to almost any submerged object;

[201] Lat., *crepidula*, a small sandal; *fornicatus*, vaulted.
[202] Gr., *glaukos*, green-blue.
[203] Lat., *planus*, level, flat.

within bottles, to the interior of univalve shells, on oyster and scallop shells and attached to the upper surface of shells of its own species. Wherever the mollusc may be attached, the growing shell becomes adapted to the curvature and sculpture of its resting place—externally concave within the apertures of univalve shells, ribbed on scallop shells, margins indented when some obstacle to lateral growth is encountered.

Its depth range appears to be considerable.

Crepidula aculeata[204] Gmelin Plate 25, figs. 175a, b

Length, 20-30 mm. Shell with general characters of other Crepidulas. Outer surface with irregular, radiate, tuberculate or spiny ribs. Color brown or brownish. Interior polished, brown and white, diaphragm white, edge-shape.

From one to seven fathoms.

Family TRUNCATELLIDÆ

The molluscs of this family generally make their habitats about the shores of warm and temperate seas. They are able to remain for many days out of water and some species have become almost terrestrial.

Genus TRUNCATELLA Risso, 1826

Truncatella caribæensis[205] Sowerby Plate 25, fig. 176

Alt., 7 mm. Shell cylindrical, slightly narrowed toward truncate apex. Pale amber color with transparent epidermis. About four flattened convex whorls, axially ribbed, ribs strongest near the impressed sutures; body whorl slightly carinate below. Aperture oval, a little oblique; outer lip reflected; columellar lip thickened. Operculum corneous, pale brown.

Abundant on weedy bottoms of littoral regions; often found beneath logs, stones, etc.

Family RISSOINIDÆ

The Rissoinidæ is a family of small marine molluscs native to warm and temperate seas and to moderate depths.

Genus RISSOINA d'Orbigny, 1840

Rissoina[206] **bryerea** Montagu Plate 25, fig. 177

Alt., 5-5.5 mm. Small, rather thick, fusiform shells; white or

[204] Lat., *aculeatus*, from *acus*, needle.

[205] Lat., *truncatus*, truncated, cut off; of the Caribbean.

[206] Dim. of *Rissoa*, genus dedicated to the naturalist Risso; Lat., *bryon*, moss.

faintly yellowish with thin epidermis. Apex acute, nuclear whorls smooth; six or seven convex whorls; sutures shallow. Sixteen to twenty strong axial ribs; equal, smooth interspaces. Aperture oval, entire; outer lip thick, a little flaring. Operculum corneous, pale brown, having an internal apophysis which articulates with columellar lip.

Abundant on grassy bottoms in shallow water. Often found on eel grass.

Rissoina lævigata[207] C. B. Adams

Alt., 4 mm. Shell fusiform, small, smooth, glossy, pellucid-white, sometimes with opaque spots; thin, transparent epidermis. Apex small, prominent; nine or ten slightly convex whorls; sutures shallow, incised, with opaque borders. Aperture oval, entire; outer lip thick, a little flaring. Operculum corneous, light amber color.

Less common than *R. bryerea.* Found on grassy bottom beyond littoral zone.

Family SKENEIDÆ

The Skeneidæ is a family of small molluscs including genera distributed from Greenland to Florida and the West Indies.

Genus ADEORBIS Wood, 1842

Adeorbis beaui[208] Fischer — Plate 25, figs. 178a, b

Alt., 4.75; extreme diameter of base, 11.5 mm. Shell rather thick, pure white, flattened, almost discoid. About three whorls; sutures channeled, body whorl sharply keeled at periphery and base; spiral sculpture of five, nearly equidistant strong ribs, with fine threadlike ribbing in interspaces. Between suture and uppermost strong rib is a broader band of fine ribbing; between peripheral and basal ribs the surface is smooth, showing only lines of growth. Aperture rounded, entire. Base with delicate spiral and growth lines; deep, funnel-shaped umbilicus open to apex. Operculum corneous, light brown.

Occasionally found on beaches. Dredged in three fathoms.

Adeorbis supranitidus[209] Wood

Alt., 0.75, diam. of base, 2.25 mm. Similar to *A. beaui* in gen-

[207] Lat., *lævigatus*, made smooth.

[208] Lat., *ad*, to, toward; *orbis*, circle; dedicated to M. Beau, friend of Fischer.

[209] Lat., *supra*, above; *nitidus*, shining.

eral features. Sculpture less clear-cut, a definite keel near umbilicus. Aperture flattened above.

Family LITTORINIDÆ

This is a family of widely distributed, amphibious molluscs, living in the littoral zone, often above high tide mark.

The animals are remarkable for the curious foot; the plantar surface of the foot is centrally divided by a longitudinal cleft and the two sides are alternately advanced when the creature is in active motion.

Genus LITTORINA Ferrusac, 1822

Littorina[210] **mespilum** Philippi — Plate 25, fig. 179

Alt., 10 mm. Shell spiral, subglobose, smooth; chestnut color, either unicolored or banded with darker shade. Apex sharp; about three convex whorls. Aperture rounded, entire; outer lip simple; columella rather thick, flat; shallow umbilical depression. Operculum corneous.

Subgenus MELARAPHE (Megerle von Mühlfeld) Menke, 1828

Littorina angulifera[211] Lamarck — Plate 25, fig. 180

Alt., 25-30 mm. Shell thin, conic, imperforate; apex acute, about six convex whorls; slightly channeled sutures. Ground color cream, with flammules of dark brown above and below the sutures, oblique brown bands on body whorl and revolving pattern of brown dashes. Spiral sculpture of irregular, inequidistant engraved lines. Aperture rounded oval; outer lip thin, sharp, protracted above; columella with central groove in lower portion. Operculum corneous, amber color, thin and flexible.

Common above high tide mark on branches of mangrove trees, old wharves and pilings.

Family TURRITELLIDÆ

The shells of the Turritellidæ are well described as 'little towers', since the spire surmounts the body by many times its height.

Distribution of the family includes all seas.

[210] Lat., *litus*, the seashore; *mes*, middle; *pilus*, a hair.
[211] Lat., *angulus*, angle, corner; *ferre*, to bear.

Genus **TURRITELLA** Lamarck, 1799

Turritella[212] subannulata acropora Dall Plate 25, fig. 181

Alt., 30-42; diam. of base, 7-10 mm. Shell regularly conic, imperforate; spire elongate, apex acute. Fifteen flattened whorls with distinct median keel, less prominent on lower whorls; sutures not well defined. Color whitish, pinkish or pale violet, more or less patterned with longitudinal brown flammules, and brown dots upon the spiral ridges; nucleus pink in living specimens. Sculpture over whorls and base of closely placed primary and secondary spiral ridges and fine microscopic striations. Aperture rounded, entire, oblique in relation to vertical axis of shell; outer lip thin, protracted above; columella thin, concavely curved. Operculum corneous, thin, amber color.

Dredged living in three to six fathoms south of Sanibel Island to Little Carlos Pass, Florida.

Family **VERMETIDÆ**

Both the molluscs of this family and their shells differ very strikingly from others of their kind. The animal is vermiform and elongated, and the loosely coiled shell protects the worm-like body in its entire length· The molluscs are entirely sedentary and the shells are usually attached to coral or rock, growing within sponges, or—as is the habit of *Vermicularia spirata*—gregarious, living in colonies with the coils of the shells intertwined.

The animal has short tentacles and snout, eyes placed on the outer sides of the tentacles. They are unisexual and fertilization of the ova is accomplished by water-borne sperm.

One of the marine snails called *Vermetus* feeds in a manner peculiar to itself. It has largely lost the power of movement but uses the mucus, which such creatures normally employ to lubricate their movements, to catch its food, throwing out a sheet of sticky mucus in which fine particles and animals are entangled, and after a time drawing this with the collected food back into its mouth.[213] The author has seen *V. spirata* in an aquarium feed in this manner.

212 Lat., *turris*, tower; *sub*, under, below; *annulus*, ring; Gr., *akros*, end, extremity; *poros*, passage, pore.
213 The Seas, Russell and Yonge.

Shells of the Vermetidæ are free or fixed. The young shells are regularly spiral, easily confused with *Turritella*, after an inch or less of growth the whorls become more and more irregular and loosely coiled, gradually increasing their diameter. The aperture is round, a circular, corneous operculum is usually present.

Distribution is confined to warm and temperate seas.

Genus **VERMETUS** (Adanson) Daudin, 1800

Subgenus **PETALOCONCHUS** H. C. Lea, 1843

Vermetus[214] **irregularis** d'Orbigny Plate 26, fig. 182

This is a reef building species. Dr. W. H. Dall observed patches twenty to thirty feet across, with tops nearly at water level and scarcely dry at low tide. The individual shells are loosely coiled, contorted and inextricably intertwined—only the juvenile tips show any regularity of growth. The external surface usually bears longitudinal ribs which are wrinkled and roughened by circular growth lines. The aperture is round, sharp. Color is reddish-chestnut, whitened outside by calcareous deposits; interior smooth, highly polished.

Vermetus, species; near **V. radicula** Stimpson? Plate 26, fig. 183

Found living in sponge. Shell is translucent, septate within early whorls. Color brown, purple, pink or white corresponding to color and shade of individual mollusc. Apex is sharp, about five white, acutely carinate, contiguous whorls, followed by loose coils becoming increasingly more distant and irregular. Longitudinal sculpture of one strong keel continuous with carina of juvenile whorls; on one side of this keeled rib is a series of small ribs separated by finely ribbed interspaces, threadlike ribbing over remainder of surface; wrinkled, annular growth lines. Aperture round; sharp oblique margin; diameter about six millimeters. Small, concave, corneous operculum.

[214] Lat., *vermis*, worm.

Genus VERMICULARIA Lamarck, 1799

Vermicularia spirata[215] Philippi Plate 26, fig. 184

Color brown, paler toward aperture. Apex of juvenile shell acute, nucleus glassy; about six regular whorls preceding the long loosely-coiled portion of shell. Sculpture of longitudinal ribs which form definite keels; smaller parallel ribs and fine interspatial striations; rough, annular growth lines. Aperture round, diameter eight to twelve millimeters. Operculum corneous, circular, entirely closes aperture.

V. spirata is eaten by *Fasciolaria distans; Trivia pediculus* has been seen by the author to devour large numbers of the veligers of *Vermicularia.*

Family CÆCIDÆ

This is a group of minute molluscs generally distributed through warm and temperate seas at moderate depths. The shells are not likely to be found unless carefully looked for in sifted sand or accumulations of fine detritus on the beaches between tide levels and the sand which may be shaken from sponges.

The embryonic shell is a spiral of two or three whorls, succeeding development is into a horn-shaped tube—the 'bovi-cornu' stage· These juvenile phases of the shell are successively truncated as further growth proceeds; the shell when adult is small, tubular, arcuate, with a circular aperture and an externally convex septum which closes the apical end.

Genus CÆCUM Fleming 1817

Cæcum[216] **floridanum** Stimpson Plate 26, fig. 185

Length, 2; diam., 0.6 mm. Shell white, arched; from twenty to thirty sharp, elevated, annular ribs separated by interspaces which become wider toward aperture and are finely, longitudinally striate. The apical septum is slightly convex with minute, laterally placed mucro. Corneous operculum.

Cæcum carmenensis de Folin

Alt., 2; at summit, 0.3; diam. at base, 0.55 mm. Shell white or whitish; conic, regularly increasing in diameter from summit to base; slightly swollen towards aperture. Aperture always contracted, margin not thickened, oblique. Surface with very fine,

[215] Lat., *spira*, a coil.
[216] Lat., *cæcus*, blind.

delicate, transverse striations. The septum is characteristic; claw-shaped, directed to right of plane of truncation; lateral margin nearly straight. Operculum?

Genus **MEIOCERAS** Carpenter, 1858

Meioceras[217] **nitidum** Stimpson — Plate 26, fig. 186

Length, 2-2.5; diam. at center, 0.75 mm. Shell small, polished, translucent, brown or brownish, arcuate, dorsal convexity greatest. Aperture circular, oblique, sharp-edged; apical end smaller; apical plug convex. Operculum corneous.

Often found on eel grass.

Family **MODULIDÆ**

Members of this family are native to warm seas. Three species are recorded from Florida.

Genus **MODULUS** Gray, 1842 and 1847

Modulus[218] **modulus** Linné — Plate 27, fig. 187

Alt., 12; diam. of base, 17 mm. Apex acute, spire of about three small whorls, depressed; body whorl large with sloping shoulder and definite peripheral keel. Color yellowish-white with brown markings, brownish epidermis. Sculpture over upper portion of shell consists of low revolving ridges and ten radiating ribs which terminate at peripheral keel. Base has six or eight strong revolving ribs separated by deep grooves which are striate by growth lines. Umbilicus small, deep. Aperture round below, oblique to vertical axis, angled at keel of body whorl; outer lip thin, crenulate. Columella with sharp horizontal basal tooth. Operculum corneous.

Modulus modulus floridanus Conrad — Plate 27, figs. 188a, b

Alt., 13; diam. of base, 14 mm. General characters of *M. modulus;* whorls more convex, peripheral keel less marked, about fifteen radiating ribs. Aperture round, oblique to vertical axis. Columellar tooth slightly oblique, a little smaller and lower than in *M. modulus.*

Both *M. m. floridanus* and *M. modulus* are common on grassy bottoms in shallow, protected waters.

[217] Gr., *meiosis*, to make smaller; *keras*, horn.
[218] Lat., *modulus*, a measure.

Family TRIPHORIDÆ

Some hundred species are included in this family of small molluscs. Their distribution is general through warm and temperate seas. With members of the related family Cerithiopsidæ, they have a considerable range in depth.

The shells are sinistral, slender, with many whorled, elongate spire, a somewhat contracted body whorl with small aperture and short recurved canal.

Genus TRIPHORA Deshayes, 1824

Triphora[219] **perversa nigrocincta** C. B. Adams Plate 27, fig. 189

Alt., 11 mm. Shell small, sinistral, cylindro-conic. Apex acute. Dark brown; faded shells pale brown with dark revolving band. From twelve to fifteen whorls, not well defined; sutures slightly excavated. Sculpture of three sometimes four roundly beaded spirals; with a lens, beads are seen to be light-colored, lower part of body whorl with strong revolving ridges. Aperture oval, oblique, deep posterior notch, short, recurved anterior canal; outer lip thin, sharp, a little flaring. Operculum corneous.

In fully adult shells both the anterior canal and posterior notch become completely tubular, and growth of the body whorl continues for about one-half turn beyond closing of canals. In juvenile shells the base of the body whorl is flat, the aperture simple; all stages of development of adult characters of aperture and canals may be seen in a series of specimens.

From one to thirty fathoms.

Family CERITHIOPSIDÆ

Shells of the Cerithiopsidæ are small, cylindrical, many whorled with spiral sculpture and short anterior canal.

Distribution principally in northern and temperate seas at considerable depths.

Genus CERITHIOPSIS Forbes and Hanley, 1849

Cerithiopsis[220] **greeni** C. B. Adams Plate 27, fig. 190

Alt., 4.5 mm. Shell small, cylindrical, 'swollen in the middle', apex acute. Color dark reddish-brown. Ten to twelve whorls;

[219] Gr., *tri*, twice; *phora*, from Gr. *phorein*, to bear, denoting a group which bears a special feature; Lat., *perversus*, turned the wrong way; *niger*, black; *cinctus*, encircled.

[220] Gr., *keration*, little horn—irregular form; *opsis*, appearance.

sutures excavated. Spiral sculpture of three rows of tubercles, so placed that an effect of longitudinal ribbing is produced; interspaces and sutures with fine striations. Aperture oval, outer lip sharp; short, oblique anterior canal. Operculum corneous.

Subgenus **LASKEYA** Iredale, 1918

Cerithiopsis subulata[221] Montagu Plate 27, fig. 191

Alt., 10-14 mm. Shell small, brown cylindrical, apex acute, ten to fifteen flat whorls; sutures distinct, channeled. Axial ribs cancellated by two strong grooves into nodulous spirals, three on whorls of spire, four on body whorl. General effect of sculpture spiral rather than longitudinal. Base slightly concave with two prominent spiral ridges. 'Aperture small, subquadrate, about one-sixth of shell, canal less than one-half of aperture, columella spirally twisted'. Operculum corneous.

From one to fifteen fathoms.

Genus **SEILA** A. Adams, 1861

Seila[222] **adamsii** H. C. Lea Plate 27, fig. 192

Alt., 10 mm. Shell brown, elongate cylindrical, apex acute; ten to fourteen, flat whorls regularly increasing in size; sutures distinct, excavated; sculpture of three equal-sized spiral ridges, flattened on top; concave interspaces with very fine spiral striations above ridges and delicate axial striations which do not cross ridges. Body whorl has four spirals, one smaller ridge at circumference of base. Aperture oval; outer lip crenulated with external sculpture; anterior canal central, short, open, recurved. Operculum corneous.

Common in shallow water. Often found about oyster bars, within large dead shells.

Family **CERITHIIDÆ**

The Cerithiidæ are molluscs of tropical and semitropical seas. Many of the species are littoral, living among sea grasses and weeds; others frequent rocky bottoms in deeper water.

The animals are vegetarian and the sexes are separate. A pedal gland secretes threads of mucus by means of which the molluscs can attach themselves to any convenient object, or hang suspended beneath the surface film of water.

221 Lat., *subula*, an awl.
222 Gr., *seira*, cord?

Shells of the Cerithiidæ vary in form within certain limits; all are elongate, many whorled, with a small oblique aperture and a short anterior canal.

Genus **CERITHIUM** Bruguière, 1789

Cerithium[223] **algicolum** C. B. Adams Plate 27, fig. 193

Alt., 20-27 mm. Shell white with brown markings usually disposed in more or less revolving pattern. Spire elongate, tapering to acute apex; eight to ten convex whorls, angulated by axial ribs; sutures narrow, incised. Sculpture of eight or ten indefinite longitudinal ribs or varices, interrupted at sutures and angulated at periphery of whorls; a nodular spiral line immediately below suture on body and penultimate whorls. Three beaded spirals below periphery of body whorl, fine spiral threads between the stronger sculpture; a thickened varix opposite aperture. Aperture oval, oblique, outer lip thin, crenulate; anterior canal short, oblique; columella with transverse fold above which defines a short posterior channel. Base with spiral cords. Operculum corneous, light brown.

From below tide mark to one and one-half fathoms.

Cerithium floridanum Mörch Plate 27, fig. 194

Alt., 30-35 mm. Shell white with spirally striate pattern of brown; thin epidermis. Spire elongate, apex acute; sutures not well defined; ten or twelve whorls crossed by elevated, interrupted nodular ribs, sharply angled at periphery of whorls; unequal spiral ridges separated by incised lines over entire external surface of shell; a thickened varix opposite aperture. Aperture oval, oblique; outer lip thickened, crenulated by spiral sculpture; anterior canal short, oblique; posterior canal defined by fold at upper part of columella.

C. floridanum is often confused with *C. algicolum*. The former is more slender, with more elongate spire, fewer ribs, about eleven on penultimate whorl—*C. algicolum* has about 16. Sculptural features stronger and more distantly spaced; outer lip thickened.

From extreme low tide mark to five fathoms.

[223] Gr., *keration*, little horn—irregular form; N. L., *algicola*, living on seaweed.

Cerithium variabile C. B. Adams Plate 27, fig. 195

Alt., 12 mm. Shell dark brown or grayish-white; apex and first few turns often white. Apex acute; about eight slightly convex whorls; sutures distinct, a little excavated. Sculpture of seven or eight beaded spirals on body whorl, three rows on whorls of spire; fine revolving striations in interspaces. A strong varix on body whorl opposite aperture. Aperture oval, outer lip sharp at edge, thick and crenulate within; interior of aperture white. Anterior canal short, posterior angle of aperture scarcely sinuate. Operculum of the type.

The animal has a white foot, body mottled black and white, black eyes surrounded by white circles and placed a little behind bases of the tentacles.

Shallow water beyond low tide mark. Often about oyster bars.

Cerithium minimum[224] Gmelin Plate 27, fig. 196

Alt., 13 mm. Shell rather stout and rotund, black, ashen or bluish-gray, sometimes ferrugineous—often with dark or light sutural bands. Six to eight whorls sculptured with low longitudinal ribs unequally nodulated by spiral ridges; fine spiral threads in interspaces. Aperture oval, lip sharp; interior of aperture dark-colored. Basal canal sharply deflected to left.

C. minimum nigrescens Menke is the specific name given to the black, unicolored type

Very common and abundant between tide marks.

Cerithium minimum septemstriatum[225] Say Plate 27, fig. 197

Alt., 12 or 13 mm. Shell a little more slender than *C. minimum,* similar in general characters. Dark-colored with white sutural band. Longitudinal ribs nodulated by elevated spirals. Longitudinal ribs sometimes bifid over base of body whorl.

Found with *C. minimum.*

Cerithium muscarum[226] Say Plate 27, fig. 198

Alt., 25 mm. Shell white with 'fly-specks' of chestnut brown or almost uniformly brown. Apex acute; sutures incised, undu-

224 Lat., *minimus,* the least.
225 Lat., *septem,* seven; *striatus,* striped.
226 Lat., *musca,* a fly.

lating; ten convex whorls crossed by ten or eleven axial ribs, interrupted at sutures, slightly nodulated by spiral ridges. A strong varix opposite aperture. Spiral sculpture of equidistant elevated ridges and fine interspatial striations over whorls and base. Base defined by a strong cord. Aperture of the type, basal canal reflected to left.

Abundant on grassy bottoms in shallow water.

Genus CERITHIDEA Swainson, 1840

Cerithidea costata[227] Da Costa Plate 28, fig. 199

Alt., 12 - 15 mm. Shell brown, darker band below sutures. Spire turreted, apex acute; nine or ten convex whorls; sutures distinct, marked by spiral threads. About fifteen curved, longitudinal ribs over each whorl, not continuous across sutures. Aperture oval, notched or channeled at base.

Shallow, brackish water. Tidal salt flats.

Cerithidea scalariformis[228] Say Plate 28, fig. 200

Alt., 20 - 25 mm. Color light fawn, spirally banded with brown, occasionally with white. Spire tapering, apex usually truncated. Sutures well impressed, defined by narrow threads. Ten convex whorls crossed by numerous, closely placed, slightly curved ribs; on body whorl ribs terminate at periphery. Spiral sculpture of whorls indistinct. Aperture rounded, lip thickened, reflected, with flattened margin. Columella straight. Position of anterior canal indicated by a shallow notch. Base with strong spiral cords.

Common on tidal salt flats.

Cerithidea turrita[229] Stearns Plate 28, fig. 201

Alt., 10 - 12 mm. Shell pale fawn color with lighter band about periphery of whorls, periostracum rather thick. Spire turreted, apex acute. About ten convex whorls with numerous longitudinal ribs terminated at base of body whorl by a single spiral thread. Aperture oval; anterior canal shallow.

Tidal flats and near low water mark.

227 Lat., *costatus*, from *costa*, rib.
228 Lat., *scala*, ladder, staircase.
229 Lat., *turris*, tower.

Genus **BITTIUM** Leach, 1847

Bittium varium[230] Pfeiffer Plate 28, fig. 202

Alt., 5-6 mm. Shell thin, grayish-white or buff-colored; apex acute, spire tapering; seven or eight flattened convex whorls; sutures well defined. Sculpture of delicate, slightly curved longitudinal ribs nodulated by fine spiral grooves. Aperture oval, lip not thickened, a well-developed varix posterior to lip. Anterior canal not defined. Base spirally grooved.

Common in shallow water on grassy bottoms.

B. varium gibberulum Adams is dark brown with smaller body whorl 'varicosely gibbous,' and sculpture more sharply cut than in the typical *B. varium.*

Family **STROMBIDÆ**

The Strombidæ constitute an interesting family of about one hundred species distributed through warm seas, usually in shallow water. Almost no other group of molluscs rivals it in the variety of form and beauty of color of its shells. It is represented in American waters by the single genus *Strombus.*

The animals live between low tide mark and ten fathoms on sandy or gravelly bottom where their carrion food can be found in abundance. 'Strombs' are scavengers and are equipped with acute senses of sight and smell and exceedingly strong jaws and teeth. The sexes are separate.

The foot of *Strombus* is long, narrow and strong, bearing a terminal, clawlike operculum, too small to close the aperture of the shell, but making of the foot a very efficient prop on which the creature can raise itself, and by awkward, jerking movements fall to one side or forward. This ungainly mode of progression enables *Strombus* to move about, and stranded individuals seem to make some effort to regain the water.

Shells of the Strombidæ are large, thick and solid, with short, conical spire, acute apex and large body whorl with a long, narrow aperture which is notched or canaliculate both anteriorly and posteriorly. The outer lip is thick, expanded or alate, and in some

[230] Lat., of obscure origin; *varius,* diverse.

genera its outer margin is deeply indented like the spread fingers of a hand. Living shells have a brownish periostracum which quickly scales off with exposure and drying. The color of the shells is usually a combination of pale shades of brown and buff, and the polished inner surface of the lip shows beautiful blendings of pale pink, orange, purple and sometimes a greenish tinge.

Genus **STROMBUS** Linné, 1758

Strombus[231] **pugilis** Linné — Plate 28, fig. 203

Alt., 80 mm. Shell pyriform, solid and heavy; color ranges through shades of ivory and brown, often disposed in banded or zigzag patterns; brownish periostracum. Spire of eight whorls, eight-tenths altitude of shell; body whorl large, smooth, narrowed toward base where it is spirally striate· Early whorls with strong revolving ribs and longitudinal ribs which become prominent, spinous tubercles about shoulders of later whorls. Sutures distinct, lower whorl appears to slightly overlap prec eding whorl. Aperture straight, narrow; lip thickened, alate, protracted above with deep notch at suture; a rounded notch near base and a deep recurved, basal notch. Interior polished, beautifully colored in shades of orange, salmon-pink, purple and brown. Columellar callus polished, reflected over front of body whorl.

Strombus pugilis alatus[232] Gmelin — Plate 28, fig. 204

Corresponds to *S. pugilis* in general characters. Distinguished by total absence of shoulder tubercles on whorls of body and spire. The series of transitional specimens from extremes of the two types is so complete that it seems doubtful if the shell is entitled to specific rank.

Occasional specimens of fresh juvenile and adult shells of *Strombus costatus inermis* are found on the Gulf beaches of Captiva and Sanibel islands, also infrequent worn specimens of *Strombus gigas*.

Family **OVULIDÆ**

The molluscs of this family resemble and are closely akin to the animals of the Cypræidæ.

231 Gr., *strombos*, a spiral shell so named by Aristotle; Lat., *pugil*, a boxer.

232 Lat., *alatus*, winged.

The shells are ovoid or fusiform, with a straight linear opening, canaliculated at each extremity of the shell.

Distribution is in warm and temperate seas. The animals prey upon gorgonians to whose stems and branches they adhere very closely.

Genus SIMNIA (Leach) Risso, 1826

Simnia uniplicata[233] Sowerby — Plate 28, fig. 205

Alt., 15 - 20 mm. Shell tapering at each extremity, smooth, polished; color varies with that of the *Gorgonia* upon which it preys—yellow or a shade of purplish-red; color fades with drying and exposure to light; apex of shell twisted backward over nucleus and extended into a short canal. Lip thickened in adult specimens. One columellar fold near apex.

Family CYPRÆIDÆ

The molluscs of this family are remarkable for the beauty of color, high polish and the symmetry of form of their shells. 'Cowries' are everywhere considered 'elegant shells,' specimens of the genus *Cypræa* are eagerly desired by collectors and the shells of certain tropical species still serve as units of monetary currency in some parts of the world.

All species are native to warm seas.

Worn shells of *Cypræa exanthema* and *C. exanthema cervus* are occasionally found upon the beaches of Southwest Florida.

Genus TRIVIA Gray, 1842

Trivia[234] **pediculus** Linné — Plate 28, fig. 206

Alt., 12 - 15 mm. Shell subglobular with longitudinal dorsal groove and fine transverse ribbing; extremities obtusely rounded. Aperture linear, canaliculate at extremities, transverse ribs continuous over involuted lips. Flesh-colored with spots and mottlings of brown.

Animal is grayish, mantle with pin-dots of red, foot gray, eyes at outer bases of tentacles.

Taken on grassy bottoms near passes in Pine Island Sound, Lee County, Florida. Dredged in the Gulf of Mexico in three to seven fathoms.

233 Lat., *uni*, *unus*, one; *plicatus*, folded.
234 Lat., *trivialis*—*tri*, three, *via*, way; *pediculus*, louse.

Genus ERATO Risso, 1826

Erato[235] **maugeriæ** Gray Plate 28, figs. 207a, b

Alt., 6 mm. Shell small, polished, greenish-gray or olive-green, white about lip margin; shape much like *Marginella*. Spire inconspicuous, depressed; body whorl large, rounded, narrowed toward base. Aperture elongate, outer lip thick, lirate within; a basal notch but no posterior notch.

The animal is definitely phototrophic in aquarium and is able to creep beneath surface film. Body mottled brownish, mantle grayish with metallic-red spots, similar to mantle of some Marginellas.

Dredged in two to seven fathoms. Generally found among rugosities of zoöid colonies or clinging to valves of *Atrina*.

Family CASSIDIDÆ

Distribution of members of this family is general in warm seas and through shallow to moderate depths. Sandy stations are preferred by all species of the Cassididæ, where many bivalves fall victim to their predatory habits and voracious appetites.

The animals possess eyes, formidable jaws, a radula and a voluminous foot which participates in the secretion of the shell.

The type shell is ventricose and solid, with a large inflated body whorl and a short, but well-elevated spire. The aperture extends the length of the body whorl and is prolonged into a short, sinistrally curved canal. The outer lip is thick, often reflected, and usually dentate within. The columella is plicate or granulose.

Genus SEMICASSIS Mörch, 1852

Semicassis[236] **gibba** Gmelin Plate 29, fig. 208

Oval shell with rather acuminate spire, shell pink to nearly white, with six series of squarish cinnamon spots, those at suture and extreme base often smaller, irregular or weak. Deeply grooved spirally, the moderately convex or sometimes nearly flat raised cords being much wider than the grooves, seventeen to nineteen on last whorl, second from suture generally narrow. Upper four or five cords generally crossed by narrow tubercles, these may be weak or practically absent. A few have a varix preceding that at the lip by about a whorl, more or less. Large specimens from 75 to 80 millimeters long.[237]

The operculum is pale brown, semilunar with plications radiating from nucleus near inner border to the finely dentate outer border.

[235] Gr., *Erato*, muse of poetry.

[236] Lat., *cassis*, helmet; *gibbus*, a hump.

[237] Pilsbry, H. A. and McGinty, T. L.: Nautilus, vol. 52, No. 3. Condensed description.

Semicassis gibba abbreviata[238] **Lamarck**

Shell similar to *S. gibba* but always small, length about 35 to 44 mm., very solid, nearly white with faint spots or none, with narrow axial fold crossing the spirals throughout. Frequently a strong varix on front of the last whorl . . . . a rather dubious 'subspecies' being based on size and solidity.[239]

One fresh juvenile shell of *Cassis madagascarensis* has been dredged in four fathoms off Sanibel Island.

Family TONNIDÆ

A family of molluscs with close affinities to the Cassididæ, also distributed in warm seas and preferring sandy bottoms.

The animals are notable for the extreme length of the siphon, the large foot and the reputed ability to secrete sulphuric acid.

Genus FICUS (Bolten) Roeding, 1798

Ficus[240] **papyratia** Say — Plate 29, fig. 209

Alt., 90 mm. Shell thin, translucent, pear-shaped, brownish or bluish-gray; thin periostracum. Spire very short, depressed, top of shell flattened; body whorl expanded above, narrowed into a moderately long, straight anterior canal. Sutures linear, slightly depressed. Sculpture of revolving cordlike ribs, wide interspaces with an almost centrally placed narrower rib and fine laterally placed threads. Entire surface closely cancellated by fine growth lines. Aperture well open, length and width of body whorl; outer lip sharp; columella concave at center. Interior polished, golden-brown. No operculum.

Common on beaches after blows. From one to four fathoms.

Very rarely worn specimens of *Tonna galea* are washed upon the beaches of Sanibel Island.

Family CYMATIIDÆ

This family comprises the 'triton shells,' one of which was the 'wreathed horn' of the ancient sea god, son of Poseidon and Amphitrite, the horn which he blew upon to calm the waves.

The animals of the family are brightly colored and possess a gland which secretes colored fluid of brilliant tint, in some instances a green color and in others a fine blue.[241]

The molluscs are native to warm and temperate seas.

[238] Lat., *abbreviatus*, shortened.
[239] *Ibid.*
[240] Lat., *ficus*, fig; *papyraceous*, made of paper.
[241] Fischer, P.: Manual of Conchology.

Genus **CYMATIUM** (Bolten) Roeding, 1798

Subgenus **MONOPLEX** Perry, 1811

Cymatium[242] **costatum** Born Plate 29, fig. 210

Alt., up ot 150 mm., shoulder of body whorl almost median. Shell solid; about seven convex whorls, rapidly increasing in size from acute apex. Taffy-color; clear brown epidermis with longitudinal reflections whose edges bear numerous hairlike processes. Sculpture of strong revolving ribs, equally wide interspaces and incised lines; ribs somewhat nodular over upper whorls. Sutures distinct. Aperture oval, prolonged into straight, open, anterior canal; outer lip thickened, margin scalloped by external ribs, slightly reflected inward, convexity of scallops brown. Columella sinuous finely plicate, brown between plaits. Interior polished, ribbed. Operculum corneous, brown.

The animal is a greenish mustard-yellow, black-spotted.

Several living specimens have been found on Sanibel beach after storms.

A few worn shells of *C. aquitilis, C. cyanocephalum* and *C. femorale* have been found on Southwest Florida beaches, but a local origin is improbable.

Order **STENOGLOSSA**

Family **MURICIDÆ**

The family Muricidæ has adapted itself to as wide and diverse a range of habitat and distribution as any member of its phylum. Every sea has genera peculiar to its depth and temperature, but the great majority of the thousand odd species are found in tropical or subtropical waters.

The cannibalistic Muricidæ prefer to live on gravelly bottom, about coral or rocky reefs where an abundance of other molluscs provides a sufficiency of food to satisfy their carnivorous appetites; both pelecypods and gasteropods being acceptable victims. *Murex, Eupleura* and *Urosalpinx* are enemies to the oyster; *Arca* is a favorite food of *Murex*, which attacks it by thrusting the tough proboscis between the ark's open valves in such a manner as to prevent closure while the animal is being eaten alive. Aristotle wrote of *Murex* that the mouth is armed with a sort of trunk

242 Gr., *kymation*, dim. of *kyma*, wave; Lat., *costatus*, ribbed.

comparable to those of the fly or rather those of the gadfly.

B. B. Woodward wrote that those Murices which have spines about the aperture have one spine directed inward which is used as a knife. Bivalve prey is gripped by the powerful foot and the shell margin pressed against the spine until it is driven like a wedge between the two valves, forcing them apart.

The Muricidæ possess a special glandular structure whose secretion affords a royal shade of purple when appropriately treated. This property of the Muricidæ was known to early races of the Mediterranean people, who made from certain of these molluscs the Tyrian purple dye.

The shells of this group of molluscs are thick and solid, with moderate spires terminating in sharp apices. The body whorls are relatively large and the round, or rounded apertures are produced into straight, partly closed canals or notches; no posterior cord or notch is present. The shell surface is rough, and usually bears longitudinal rows of more or less tuberculate or spiny protuberances, useful as protection against fish and other predatory enemies.

Genus **MUREX** Linné, 1758

Murex[243] **cabritii** Bernardi Plate 30, fig. 211

Alt., 50 - 55 mm. Smooth, thin periostracum. Unicolor, flesh or deeper pink; spire of four and a half convex whorls, nucleus very minute; body whorl rounded; aperture prolonged into straight, partly closed anterior canal more than half the height of shell. Sculpture of three equidistant strong axial ribs bearing sharp spinous processes; between these ribs are low rounded ribs; revolving channels render ribs slightly nodulous. Sutures distinct. Aperture oval, outer lip crenulate; columellar callus continuous with canal wall. Two rows of sharp spines, usually six, on canal. Operculum light brown, corneous. The delicate spinous processes may be only partially developed or absent, in beach specimens they are usually broken. Beautiful and perfect specimens are taken by the divers of the Tarpon Springs sponge fleet; fresh shells have been found on Sanibel beaches and one living specimen dredged off Marco, Fla.

Depth range twenty-five to one hundred and sixty-four fathoms.

243 Lat., *murex*, the purple shellfish.

Murex messorius Reeve Plate 30, fig. 212

Alt. up to 35 mm. General characters of shell similar to those of *M. cabritii;* smaller, spines short or absent, often curved, usually three spines on upper part of canal on columellar side. Anterior canal less than half the height of shell, curved backward, almost or entirely closed at base of aperture. Color brownish-pink—often brown-banded; hispid epidermis. Operculum light amber color.

Murex messorius[244] **rubidus** Baker

Shell slightly smaller than *M. messorius.* Color uniform rose-pink.

Subgenus **CHICOREUS** Montfort, 1810

Murex rufus[245] Lamarck Plate 30, fig. 213

Alt. up to 70 mm. Shell with general characters of the group. Young shell-pink or orange, remaining as colored apex in adult. Ground color ivory, spiral pencilling of brown. About seven convex whorls, sutures distinct. Sculpture of low, rounded, interrupted ribs and strong, equidistant spiral cords expanded into three varices of delicate acanthus-leaf processes, continued almost to base of canal; interspaces with revolving threads. Columellar collar about inner lip of oval aperture. Canal curved backward, almost closed, expanded and flattened below.

Dredged in three to seven fathoms. Not uncommon on beaches. Occasional specimens in inside waters.

The type of this shell from the Gulf of Mexico has been called *M. rufus salleanus* A. Adams.

Subgenus **PHYLLONOTUS** Swainson, 1833

Murex pomum[246] Gmelin Plate 30, fig. 214

Alt. up to 80 mm. Shell thick, rough; ivory color with mottlings and revolving stripes of brown; light epidermis. Spire about three-tenths of altitude; body whorl large, sutures distinct. Three prominent, equidistant varices; others less well developed; revolving sculpture of strong cords and fine threads, cords expanded into lamellæ or short spires over the prominent varices. Aperture large, rounded, an internal sulcus parallel to outer lip;

244 Lat., *messorius*, a harvester; *rubidus*, red.

245 Lat., *rufus*, red.

246 Lat., *pomum*, apple.

interior smooth, tinted with purple, brown and pink; outer lip crenulate. Columellar callus reflected over body whorl, upstanding columellar collar. Canal short, deep, almost, or quite closed; flattened, curved backward from aperture. Operculum brown.

Three to seven fathoms. Not uncommon on beaches.

Genus **EUPLEURA** H. and A. Adams, 1853

Eupleura[247] caudata sulcidentata Dall — Plate 31, fig. 215

Alt., 25 mm. Shell with acute apex. Spire of five or six whorls, about one-third height of shell. Color white, brown, frequently in banded pattern, varices usually white. Body whorl not proportionately large. Whorls acutely keeled; sutures distinct. Sculpture of plicate lamellar varices, one at outer lip and one immediately opposite on body whorl give a flattened appearance to shell. Aperture small, oval, prolonged into a straight nearly closed, tapering canal, slightly recurved backward; outer lip thickened by plicate lamellar varix. Operculum corneous, clear amber color with two broad bands of dark amber radiating from center of outer margin.

From littoral zone to six fathoms.

The animal is white with opaque mottlings, pin-point black eyes placed on tentacles three-fourths of the distance from base.

Eupleura nitida[248] Broderip — Plate 31, fig. 216

Alt., 17.5 mm. Color chocolate-brown with a few revolving white bands, varices white. Spire of five whorls, apex acute, apical whorls loosely coiled, body whorl not relatively large; whorls sharply shouldered. Sutures distinct. Longitudinal sculpture of low, round ribs and two lamellar varices on body whorl; last two whorls of spire with two spiral cords at periphery, upper cord at shoulder of whorl; four, spiral cords on body whorls, four below in more oblique spiral. Revolving sculpture overlays longitudinal ribs; on body whorl cords expand into plicate lamellar varices at outer aperture and on columellar sides of whorls. Rudimentary development of var-

247 Gr., *eu*, well; *pleura*, a rib; *cauda*, a tail; *sulcus*, a furrow; *dentatus*, toothed.

248 Lat., *nitidus*, shining.

ices on penultimate whorl. Aperture small, oval, interior white-banded dark brown; outer lip bordered by expanded white varix; five small tubercles at base of varix. Operculum brown.

One living specimen dredged in six fathoms off Redfish Pass, Lee County, Florida.

Genus **TRITONALIA** Fleming, 1828

Tritonalia[249] **cellulosa** Conrad — Plate 31, fig. 217

Alt. up to 22 mm. White, sometimes brown about ribs, thick epidermis. Spire sharp, five whorls, about one-third of entire height. Body whorl fairly large, sutures well defined. Prominent, angular axial ribs, five on body whorl; two strong revolving ribs on each whorl of spire; six on body whorl, interspaces cancellated by longitudinal threads; revolving sculpture overlaps longitudinal ribs. Aperture oval prolonged into short backward curving nearly closed canal, interior purplish; outer lip thin, crenate; heavy varix immediately interior. Each varix on body whorl terminates in a former recurved canal, in fully adult and perfect shells four canals of an earlier period of growth are evident at base of shell. Operculum brown.

Dredged in two to six fathoms. Occasional specimens in inside waters.

Genus **MURICIDEA** Swainson, 1840

Muricidea[250] **ostrearum** Conrad — Plate 31, fig. 218

Alt. up to 30 mm. Shell purplish, light sutural band, edges of revolving cords white. Brownish epidermis. Spire of five increasingly larger, well-shouldered whorls; body whorl not disproportionately large, sutures distinct. Six to nine axial ribs; whorls of spire with two spiral cords, one at shoulder nodulous at crossing of varices, one below, equidistant between shoulder and suture; body whorl with about ten spirals distributed to base of canal. Whorls angulated by peripheral spiral, smooth above to suture. Aperture oval, purple within; outer lip thin, columellar lip callus, crenate, lirate within. Anterior canal short, straight,

249 Gr., *Triton*, a sea demigod; *cellula*, a little cell.

250 Lat., *murex*, the purple shellfish; *idea* suffix to form names of groups, etc.; *ostrearum*, of oysters.

open. A notch at columellar side of canal indicates site of previous canal aperture. Operculum corneous, brown, fusoid with apical nucleus.

Two types of this shell are observed. The less common variety is taken in one to six fathoms and differs from the described types in the following respects. The shell is white without and within; a little longer and heavier than the dark type; incremental lines stronger; body whorl with six strong revolving ribs, between the pairs of first and second, and fifth and sixth strong spirals is a smaller cord; less strong spirals to base of canal; whorls above periphery are ribbed with five spirals. The operculum is blond—very pale straw color. Animal cream color.

Subgenus **PSEUDONEPTUNEA** Kobelt, 1882

Muricidea multangula[251] Philippi — Plate 31, fig. 219

Alt. up to 32 mm. Ground color cream, flecked and spirally striate with brown, occasional specimens unicolored orange; epidermis pale brown, hispid in fresh shells. Spire about half of altitude, five whorls below two smooth nuclear whorls; body whorl large, sutures distinct, slightly excavated, whorls well separated. Sculpture of seven strong rounded varices interrupted at sutures angled at periphery of whorls, not extended to base of body whorl. Revolving sculpture of fine threads over entire surface, stronger spirals at intervals below periphery of whorls. Aperture oval, outer lip thin, crenate; canal short, open. Operculum corneous, fusoid.

From littoral zone to five fathoms.

Genus **UROSALPINX** Stimpson, 1865

Urosalpinx[252] **perrugatus** Conrad — Plate 31, fig. 220

Alt. to 25 mm. Shell somewhat fusiform, white or cinereous, dark-colored between varices which are often touched with yellow. Six slightly keeled whorls and large smooth nucleus. Body whorl moderate size, sutures distinct. Longitudinally ribbed; spirally striate; sculpture strongest below periphery of whorls. Aperture oval, dark-colored within, outer lip thin, crenate. Canal

251 Lat., *multum*, much; *angulus*, angle.

252 *Uro*, combining form from Gr. *oura*, tail; *salpinx*, trumpet; F. *perruque*, from Pr. *perucat*, with dressed hair.

short, straight, open, slightly curved backward. Operculum yellow, nucleus at outer border.

Two to six fathoms.

Urosalpinx tampaënsis Conrad Plate 31, fig. 221

Alt. to 25 mm. Shell brownish or cinereous, general features of *U. perrugatus.* Spire of four whorls below nucleus. About ten longitudinal ribs, strong overlying spiral cords on body whorl below periphery, two on whorls of spire; shoulder of whorls without spirals, sculpture is well elevated with excavated spaces between axial ribs and revolving cords. Outer lip deeply crenate.

Littoral region to about one fathom.

Family COLUBRARIIDÆ

The molluscs of this family were formerly included among the Tritonidæ. Distribution of its genera is through temperate and warm seas.

The shells are fusiform, spire elongate, long oval aperture, short recurved canal·

Genus COLUBRARIA Schumacher, 1817

Colubraria[253] **lanceolata** Menke Plate 31, fig. 222

Alt., 27 mm. Shell slender, yellowish-white, maculated with brown; thin epidermis. Six low-convex whorls tapering to sharp apex, nuclear whorls dark brown. Body whorl more than half the height of shell, sutures distinct. Cancellate sculpture of fine longitudinal ribbing and elevated spiral threads; each whorl crossed by one or two strong varices. Aperture long-oval, outer lip thickened by a strong varix; columella arcuate, callus elevated into a collar. Short, recurved canal. Operculum corneous, fits aperture.

Dredged from rocky and gravelly bottom in three to five fathoms.

Family PYRENIDÆ

The members of this family are distributed through warm and temperate seas, comparatively few are adapted to cold waters. Their range in depth is from the littoral zone to some six hundred and fifty fathoms. They are beautiful little molluscs, numerous

253 Lat., *colubrinus,* pertaining to a serpent; *lanceola,* little lance.

in both species and individuals.

The shells are small, often smooth, without striking pattern of color of sculpture, generally ovate or fusiform, with narrow aperture and a short anterior canal. The columellar lip has a tubercle at its lower part and the outer lip is usually thickened and crenulated within. The operculum is corneous, nucleus at base or near middle of outer margin.

Genus **PYRENE** (Bolten) Roeding, 1798

Subgenus **COLUMBELLA** Lamarck, 1799

Pyrene[254] **rusticoides** Heilprin Plate 31, fig. 223

Alt., 28 mm. Small, ovate, smooth; white ground color maculated and reticulated with bright chestnut-brown; soft, hispid epidermis. Six or seven, convex whorls, spire short, acute; body whorl more than half of height, sutures distinct. Fine equidistant spiral striations, much stronger over lower portion of shell. Aperture narrow, length of body whorl; outer lip thickened, its inner margin with a central convexity, crenulate with purple stain in intervening sulci. Columella curved, deep notch near base, denticulate below with dark stain between teeth. Operculum corneous, small.

Shallow water. Often among grasses and about old pilings.

Genus **ANACHIS** H. and A. Adams, 1853

Anachis[255] **avara semiplicata** Stearns Plate 31, fig. 224

Alt. to 16 mm. Shell slender, fusiform; greenish or grayish, finely reticulated with chestnut; thin epidermis. About eight low-convex whorls; spire acuminate; twelve ribs on upper part of body whorl, spiral striations over lower portion; traces of ribs on penultimate whorl. Sutures distinct. Aperture length of body whorl; narrow, short, straight canal. Outer lip thickened, thin at extreme edge, denticulate within; columella curved above, no notch, columellar callus polished. Operculum small, oval.

Abundant in shallow water among grasses and weeds.

Anachis avara similis[256] Ravenel Plate 31, fig. 225

Alt. to 10 mm. Characters of shape and color those of *A. ava-*

[254] Gr., *pyren*, stone of a fruit; *rusticus*, of the country.
[255] Gr., *ana*, to, up?; *avarus*, greedy; *semi*, half; *plicatus*, folded.
[256] Lat., *similis* like.

ra semiplicata, about one-third smaller; six whorls. Seventeen or eighteen axial ribs, intercostal spaces spirally striate, strongest below. In juvenile specimens body whorl is slightly angulate at base.

Abundant on grassy bottom in shallow water.

Anachis obesa[257] C. B. Adams Plate 32, fig. 226

Alt., 4 - 6 mm. Shell small, ventricose, rotund. Five whorls, spire almost half of height; sutures distinct, excavated. Axial ribs, intercostal spiral striations. Aperture oval, oblique; outer lip thin in young specimens, thickened and denticulate in adult. Base of columella denticulate.

Abundant on weedy bottoms. Many found among branching hydroid colonies and on shells of living *Atrina*.

Genus **MITRELLA** Risso, 1826

Mitrella[258] **albella iontha** Ravenel Plate 32, fig. 227

Alt· to 10 mm. Shell uniformly light or amber, light forms often flecked or pencilled with chestnut; dull brownish epidermis. Seven or eight whorls, spire elongate, acuminate, whorls flattened sutures distinct. Fifteen or sixteen well-elevated axial ribs, extending to periphery of body whorl; very faint or no spiral striations in intercostal spaces. Base of body whorl smooth, strong spirals below, revolving about canal. Aperture oval; short, slightly oblique anterior canal. Other characters of the type. Shell more slender, spire more elongate and acuminate than *A. avara similis* with which species it is easily confused. The uppermost denticle of the outer lip in *A. iontha* is definitely larger and more prominent than its fellows.

Abundant in shallow water among weeds and grasses.

Mitrella lunata[259] Say Plate 32, fig. 228

Alt., 6 mm. Shell smooth, polished, light-colored or amber with crescentic markings of chestnut below sutures. Sutures shallow, whorls of little convexity. No sculpture save spiral striations at base. Other characters of the type·

M. lunata duclosiana d'Orbigny is a southern form of this spe-

[257] Lat., *obesus*, fat, stout.
[258] Lat., *mitra*, a liturgical headdress; *albus*, white; *ella*, dim. suffix.
[259] Lat., *lunatus*, crescent-shaped.

cies. It is dark reddish-brown or yellowish with one or more series of 'sublunate markings' on body whorl.

Common and abundant on weedy bottoms of littoral zone.

Family NASSARIIDÆ

The family Nassariidæ is represented in all seas. They are small animals but none the less destructive of other molluscan life through their carnivorous appetites and predatory habits. Animals of *Nassarius vibex* have been seen by the author to pierce the egg capsules of *Muricidea floridana* and devour the contents.

The shells are ovate, more or less rotund with acuminate spire, short anterior canal and extensive columellar callus. The operculum is corneous, unguiculate, its edges often irregular or serrate.

Genus NASSARIUS Dumeril, 1805

Nassarius[260] ambigua antillarum d'Orbigny Plate 32, fig. 229

Alt., 15 mm.; spire, 9 mm. Shell conic-ovate, cream-white with scattered brown markings in interrupted spiral bands, often a dark band at sutures; thin epidermis. Seven whorls, shoulders almost at right angles to vertical axis of shell; whorls strongly ribbed from apex to base, eleven ribs on body whorl. Overlaid spiral sculpture of closely placed ridges. Aperture oval, outer, lip thick in adult, thin in juvenile specimens, sharply crenate within, with smaller marginal denticulations· Columella arcuate, small horizontal plications, pronounced callus. Anterior canal open, recurved.

Dredged in four to six fathoms.

Nassarius consensa[261] Ravenel Plate 32, fig. 230

Alt., 12-14 mm· Cream-white with faint markings of purplish-brown, darkest between ribs. Spire half height of shell. Seven ribbed, convex whorls; about nine ribs on body whorl; fine spiral threads cross ribs and interspaces. Aperture oval, strong varix posterior to outer lip. Other characters of the type.

Dredged in three to six fathoms.

[260] Lat., *nassa*, a basket for catching fish; *ambiguus*, wavering; of the Antilles.

[261] Lat., *consensus*, agreement.

Nassarius vibex[262] Say Plate 32, fig. 231

Alt., 10 - 14 mm. Shell conic-ovate, apex acute, nuclear whorls dark; body whorl ventricose; sutures shallow. Cream-white, yellowish, flecked with brown; occasional dark brown individuals. About seven, flattened whorls without distinct shoulders. Axially ribbed, twelve ribs on body whorl; spirally striate by coarse threads which cross and crenate ribs. Aperture oval, outer lip with thick varix, crenate within; columella arched, crenate below, callus expanded over body whorl. Anterior canal short, recurved.

Common and abundant in littoral region, both on sandy and grassy bottoms. Often congregates in large numbers on egg ribbons of *Busycon contrarium.*

Family BUCCINIDÆ

This family is best represented in northern seas. Its genus *Buccinum* is circumboreal. But one species belonging to the genus *Cantharus* is reported from the southwest coast of Florida

Genus CANTHARUS (Bolten) Roeding, 1798

Cantharus[263] **tinctus** Conrad Plate 32, figs. 232a, b

Alt., 28 mm. Shell smoothly ovate, six whorls, spire evenly conic; body whorl large, sutures indistinct. Variegated color pattern of blue-gray, chocolate and chestnut browns, yellow and milky-white; darkest at apex; one of the few shells showing a definite blue coloration. Axial ribs more or less well developed, eleven on body whorl; revolving larger and smaller ridges cross both ribs and interspaces. Aperture long-oval; outer lip thick in adult—thin in juvenile—specimens, edge and interior crenate. Columella arched, one strong fold near upper angle of aperture. Anterior canal almost straight, slightly recurved. Operculum corneous, pyriform, apical nucleus.

Fairly common in littoral regions on grassy bottoms, about submerged pilings, logs and oyster bars, and in open water to six fathoms.

Family NEPTUNEIDÆ

This group is represented among the molluscan fauna of polar, temperate and tropical seas. As would be expected from such

[262] Lat., *vibex*, the mark of a blow.

[263] Gr., *kantharos*, drinking cup; Lat., *tinctus*, painted.

diverse conditions of environment, ecological influences have resulted in great diversity of form among members of the group.

Genus **BUSYCON** (Bolten) Roeding, 1798

Busycon[264] **contrarium** Conrad (**perversum** of authors)

Plate 33, fig. 233a; Plate 34, figs. 233 b, c

Alt· to 300 mm. Shell sinistral, pyriform. Young specimens vary in color through fawn, brown and gray tones, often centrally banded with light color, epidermis brownish; old living shells usually without color, worn and covered with a growth of marine algæ. Albino specimens are not uncommon. Spire short, body whorl large, shoulder of whorls tuberculate or smooth; sutures distinct, slightly channeled. Revolving sculpture of coarse threads. Aperture large, widely open, prolonged into a long, straight, open canal. Columella a little sinuous, outer lip sharp, lirate within. Operculum ovate.

Deformities of shells of *B. contrarium* are more frequently encountered than in the shells of any other species of gasteropod found in this region. The most common abnormalities involve the long canal, which may be contorted and bent in almost any direction and at any angle. Occasional specimens show partial or complete duplication of the canal.

The author has observed a few embryonic shells from fresh egg ribbons which show abnormalities of development similar to those seen in some adult shells of fifty to a hundred millimeters height.

An aberrant form of *B. contrarium*, plate 34, figs. 233 b, c, is found in a fairly circumscribed area of the Gulf of Mexico toward the eastern end of Sanibel Island. Shells and living molluscs of this type have not been found elsewhere in the vicinity. The shells approach the type of *B· kieneri* Philippi. They are thicker, heavier, more solid, the shoulder wider and more sloping, the peripheral tubercles stronger and more widely spaced, the spire flatter, aperture wider and canal much shorter than in the common *B. contrarium*. The columella is thick, with a tumefaction at the site of the columellar thickening of *B. kieneri*, plate 34, figs. 233,

264 Gr., *busycon*, a large, coarse fig; Lat., *contrarius*, *contra*, against.

D. E. The prominent characters of this shell are the squat outline —a reversed pyramid; its weight and solidity; the decidedly great proportion of shoulder breadth to the total height and the thick, swollen columella.

Busycon pyrum[265] Dillwyn Plate 33, fig. 234

Alt., 90 - 100 mm., occasional specimens up to 130 mm. Shell pyriform, outline smooth, no sculpture other than coarse and fine spiral ridges, more oblique below. Ground color cream, longitudinal streaks of chestnut brown, thin epidermis. Spire short, body whorl large, sutures wide and deeply channeled. Aperture wide, prolonged into straight, open canal. Operculum oval, corneous, brown.

Sandy bottoms from littoral zone to four fathoms.

A sinistral specimen of *B. pyrum* is described by Burnett Smith, Nautilus, vol. 52, No. 3.

Genus **MELONGENA** Schumacher, 1817

Melongena[266] **corona** Gmelin Plate 33, figs. 235a, b, c, d

Alt. to 110 mm. Shell ovate, short spire; large, inflated body whorl. Spirally banded with white, brown and amber shades in irregular arrangement. Shoulder of whorls sloping, slightly concave; periphery of body whorl and one or more preceding turns with one, two or three rows of sharp, semitubular spines; lamellar extension of spines cross shoulder and sutures to body of whorl above. The spines may be horizontal, crest incurved, or rarely, recurved; always at site of an earlier aperture. A row of spines, single, double or treble may encircle base of shell, marking locations of notches at bases of former apertures. Aperture wide, oval; deep, recurved notch at base. Outer lip simple; columella twisted, thin columellar callus. Operculum oval, dark brown. Shells often covered by an adventitious growth of marine algæ.

Common and abundant in shallow water; prefers muddy bottom.

The shells of *M. corona* are exceedingly variable in size, relative proportions, development of spines and in color; types inter-

[265] Lat., *pyrum*, pear.
[266] Fr., *melongene*, eggplant; Lat., *corona*, crown.

mediate between extreme variations may usually be found in any locality where the molluscs are abundant.

The varieties most important to students interested in west Florida types are *M. corona inspinata* Richards, which has square shoulders without trace of spines or tubercles. Taken near Sarasota.

M. corona perspinosa Pilsbry, attains large size, shoulder spines horizontal, one, two or three rows; well-developed basal series of spines. From Tampa Bay to Lossman's River.

M. corona subcoronata Heilprin, less height and greater width than *M. corona,* one series of horizontal shoulder spines, and one basal series.

Busycon contrarium is very destructive to the common edible clam and to scallops. It has been seen preying upon *Ostrea, Atrina, Spisula, Fasciolaria* and it probably attacks any mollusc which its large foot can hold and manipulate.[267]

Melongena is actively predatory upon both pelecypods and gasteropods, and as many as eight individuals have been seen together devouring a living horseshoe crab. The animals respond within a very short interval of time to a current-borne taint—always approaching in a direct line and against the current, toward the anticipated meal.

The following account of the attack of *Melongena* upon the large bay scallops was given by a Sanibel net fisherman—'Out on the flats when we are sitting in the boat waiting for the tide to turn, we can see the crown conchs creepin' up on the scallops on the bottom; the old conch will slide up to about three or four

267 'A bivalve—in described instance an oyster—was held in the foot with the hinge behind the canal, in case of clam, the hinge was toward the columella, but in both cases the edge of the bivalve was left free. Busycon rests on foot with canal directed upward at angle about 30 degrees. The foot is strongly contracted about six times a minute, and the edge of the oyster is brought against the inner edge of the lip with considerable pressure and then drawn inward and toward the canal. A small piece is chipped from the edge of the oyster shell and the process is repeated until a gap is made large enough to admit the radula which then tears out the flesh. This method of getting at the animal explains the roughened and chipped condition of the lip of Busycon, and the chipped oyster and clam shells. Occasionally I have found a live quahog with its edge much chipped, so the whelk does not always succeed.'—*Feeding Habits of Busycon,* Shields Warren, Vol. 30, Nautilus.

inches from the scallop and then leap on him—they hold the scallop in their foot and stick their trunk through the little nick below the scallop's ear. The scallop flaps his shell to get away but this only gives the conch the chance to get his trunk in deeper.'

Family FASCIOLARIIDÆ

This family, whose members are generally distributed throughout warm seas, counts among its species one of the largest known univalve shells, *Fasciolaria gigantea* Kiener. Other species of the group have shells of diminishing size to the one inch altitude of a small *Leucozonia.*

The animals are sluggish in movement and somewhat timid, although they are both predatory and carnivorous pelecypods and gasteropods are indiscriminately attacked by them. They have been seen to prey upon *Strombus, Melongena, Venus* and *Pecten.* In some localities it is known as the 'pepper conch.'

The shells of this group are strong and thick, fusiform with conic spire and straight anterior canal; the aperture is generally long-oval, the outer lip simple, not thickened and the columella plicate. The operculum is corneous, oval, acute at the apical nucleus.

Genus FASCIOLARIA Lamarck, 1801

Fasciolaria[268] gigantea Kiener Plate 35, fig. 236

Alt. to 600 mm. Color warm, deep salmon-pink, often lighter in shade; occasional albino specimens in which the operculum is a very light brown; interior smoky or bright pink; thick, deciduous epidermis. About ten shouldered whorls; apex bluntly rounded, spire elongate, body whorl large. Sculpture of revolving cords separated by grooves; strong growth lines. Shoulders nodulous or not. Aperture wide, oval, contracted at base into a slightly oblique, relatively short and narrow open canal. Outer lip lirate within; columella incurved with three oblique plications above mouth of canal. Animal brilliant red.

From shallow water to five fathoms.

Fasciolaria gigantea reevei Jonas

Alt. to 150 mm. General character of *F. gigantea,* smaller, thinner; early whorls with nodulous shoulder similar to the type

268 Lat., *fasciola,* a band; *giganteus,* gigantic.

species, body whorl with smooth shoulder, not ribbed nor nodulous.

Found on the Gulf Coast of Florida with *F. gigantea.*

Fasciolaria tulipa[269] Linné Plate 35, figs. 237a, b

Alt. to 150 mm. Shell fusiform, seven to nine convex whorls; well-defined sutures; ground color light with interrupted spirals of brown, more or less maculated with brown or amber color. Very thin periostracum. Revolving sculpture of flat ridges and shallow grooves, strong and wrinkled below sutures; regularly spaced growth lines. Aperture long-oval, outer lip simple, finely lirate within. Columella inflected, with two oblique folds below. Canal short, open, oblique.

From littoral zone to five fathoms.

Fasciolaria tulipa scheepmakeri (Dunker) Melvill corresponds with the type in all general characters. Its surface is rugosely sculptured with spiral ribs and ridges.

Fasciolaria distans[270] Lamarck Plate 35, fig. 238

Alt., 75 mm. General characters of *F. tulipa;* but smaller, smoother, ashy or bluish-gray with longitudinal stripings of white; about fourteen narrow revolving dark brown lines; spiral sculpture at base only.

Genus **LEUCOZONIA** Gray, 1847

Leucozonia[271] **cingulifera** Lamarck Plate 35, fig. 239

Alt., 40 mm. Shell pale brown to black, light band near base, thin epidermis; fusiform, about eight whorls, sutures distinct; spire conic, lower three whorls angulated at periphery by about ten low rounded ribs; spiral sculpture of coarse and fine threads. Aperture oval, outer lip simple, lirate within; columella white, four oblique plications; anterior canal oblique, not curved. Operculum of the type. Animal color of 'raw beef.'

Dredged about rocks and coral reefs in four to six fathoms.

269 N. L., *tulipa,* a flower.
270 Lat., *distans—antis,* standing apart.
271 Gr., *leukos,* white; Lat., *zona,* a girdle; *cingula,* belt; *fere,* to bear.

Family XANCIDÆ

A group of molluscs native to warm oceans. Included in this family is the 'Chank-shell,' sacred to the Hindus, and often portrayed in the hand of the god Vishnu.

Genus VASUM (Bolten) Roeding, 1798

Vasum[272] **muricatum** Born Plate 36, figs. 240a, b

Alt., 60; diam. at periphery of body whorl, 42 mm. Shell heavy, solid, white; thick, rugose brownish epidermis. About eight whorls; apex acute, spire rises abruptly from penultimate whorl. Sutures not well defined; outline of body whorl triangular, base narrow, shoulder nearly flat above periphery; about ten broad, rounded ribs produced into sharp, prominent tubercles at periphery of body and penultimate whorl. Revolving longer and smaller ridges; two or three series of spinous processes about base. Aperture long, rather narrow, recurved notch at base; outer lip crenulate with external sculpture. Columella with five, unequal central folds. Umbilical notch at base. Operculum corneous.

Fresh shells dredged about reefs and rocky bottom in four to six fathoms.

Family VOLUTIDÆ

The shells of many members of this family are rare and expensive. Little is known of the habits of the animal. They are believed to be carnivorous, and Australian and South American species have been found in shallow water feeding upon *Mytilus.*

Distribution of members of the family is confined to tropical and subtropical seas.

Genus MACULOPEPLUM Dall, 1906

Maculopeplum[273] **junonia** Hwass Plate 36. fig. 241

Alt., 45; extreme alt. about 140 mm. Shell smooth, elongate-ovate; pinkish-ivory with revolving rows of rich mahogany-red squarish spots. About five whorls; apex rounded, brown; spire short, sutures distinct. Early whorls finely ribbed, cancellated by spiral threads. Aperture elongate, notched at base, outer lip simple, sharp. Columella involute, with four oblique folds. No

272 Lat., *vasum*, a vessel; *muricatus*, sharp, prickly.

273 Lat., *macula*, spot; *peplus*, an upper garment; *Juno*, consort of Jupiter

operculum. The animal is strikingly marked with velvety-black spots and blotches on an ivory-pink ground color.

Living specimens from thirty to seventy millimeters height have been dredged about rocky reefs about one and three to four miles off Blind Pass, Sanibel Island. Many shells are taken by the sponge divers of Tarpon Springs. *M. junonia* has been taken in eight fathoms from Tampa Bay to the Florida keys and one living specimen was dredged in the Gulf Stream off Palm Beach, Florida.

Family MARGINELLIDÆ

The molluscs of this family are small sand dwellers, living only in warm seas with a range in depth from the intertidal zone to a thousand fathoms.

Many of the animals are beautifully marked with spots of brilliant color; the foot is large, the siphon long and the mantle is reflected over the greater part of the shell.

The shells are highly polished, porcelanous with an extremely short spire and large rounded body whorl. The aperture is long and narrow, the outer lip thickened and the columella is always plicate. Operculum usually absent.

Genus MARGINELLA Lamarck, 1801

Marginella[274] **apicina** Menke — Plate 36, fig. 242

Alt., 12 mm. Shell small, smooth, polished; ivory or yellow, usually with three brownish spiral bands, several reddish-brown spots on outer lip. Spire short, flattened, body whorl large, shoulder convex, aperture almost length of shell, narrow, notched at base; outer lip thickened—thin in young specimens; columella with four sharp folds below.

Shallow water. In sand or on grassy bottoms.

The small molluscs are very alert and active and respond quickly to the presence of food in the neighborhood. They are carnivorous.

Marginella apicina virginea Jousseaume is a pure white or flesh-colored form of *M. apicina*.

[274] Lat., dim. of *margo*, rim, margin; *apex—icis*, apex.

Marginella aureocincta[275] Stearns — Plate 36, fig. 243

Alt., 4 mm. Shell translucent, white, usually with two amber-colored spiral bands. Fusiform, spire elevated, body whorl a little more than half height; sutures distinct, overlaid with glossy enamel. Aperture almost length of body whorl, narrow, wider at notched base. Outer lip thick, columella with four oblique folds.

Common and abundant on grassy and sandy bottoms, often creeping over marine grasses.

Marginella denticulata[276] **opalina** Stearns — Plate 36, fig. 244

Alt., 8 mm. Shell smooth, polished, light or dark amber color, often with band of darker color; fusiform, five whorls; spire elevated, body whorl contracted at base, suture distinct. Aperture little more than half height of shell; outer lip thick, columella with four oblique plications.

With other Marginellas. Often among marine grasses.

Marginella minuta[277] Pfeiffer

Alt., 2.5 mm. A minute *M. apicina.* White, translucent, polished. Outer lip finely denticulate within, columella with four oblique folds.

Marginella veliei Pilsbry — Plate 36, fig. 245

Alt. to 14 mm; body whorl, 9 mm. Shell smooth, translucent, highly polished, pale yellow; five whorls; spire moderately elevated, body whorl long. Sutures distinct, enameled; a fine parallel line below sutures. Aperture long, widest at notched base; outer lip thick, sinuous—with internal convexity near middle. Columella with four oblique folds below.

In shallow water sandy stations. Often within dead shells. Dredged in one to five fathoms.

Subgenus **CYPRÆOLINA** Cerulli-Irelli, 1911

Marginella lacrimula[278] Gould — Plate 36, fig. 246

Alt., 2.25 mm. Shell minute, polished, translucent, white. Spire obscure, depressed, covered by enamel. Body whorl rounded. Aperture long, narrow, curved above; outer lip protracted

275 Lat., *aurum*, gold; *cinctus*, girdled.
276 Lat., *dens*, *dentis*, tooth; *opalus*, a precious stone.
277 Lat., *minutus*, small.
278 Lat., *lacrima*, a tear.

beyond apex, fine denticulations within. Columella with four oblique folds.

In shallow water—usually among grasses.

Family OLIVIDÆ

The Olividæ is a family of tropical and subtropical distribution. Warm seas of both hemispheres have representative genera whose species vary in size, but share in the family characters of a large foot divided transversely into an anterior propodium and a voluminous posterior portion which is reflected well over the sides of the shell.

The shells are smooth and highly polished; usually subcylindrical and short-spired with a greatly lengthened body whorl and long, narrow aperture. No operculum.

Genus OLIVA Bruguière, 1789

Oliva[279] sayana Ravenel Plate 36, fig. 247

Alt., 50 - 60 mm. Shell subcylindrical, polished and shining. Ground color cream or grayish, overlaid with angular pattern of brown with pale-tinted central band, darker markings above and below. Spire short, acute, nucleus minute, glassy, opaque; five or six whorls, 'enroulé'; body whorl lengthened, about five-tenths of altitude; one plicate revolving fold near base. Sutures deeply channeled. Aperture long, obliquely notched at base; outer lip thickness of shell, not reflected. Columella plicate below, slightly sulcate above. No operculum.

Oliva sayana citrina[280] Johnson

A golden yellow or pale yellow form of *O. sayana* peculiar to the Gulf Coast of Florida. Pure albino specimens occur, but are rare.

Oliva lives in sandy stations. The animals are gregarious and move in large groups from one location to another. They burrow about an inch beneath the surface of the sand, with only the extreme tip of the long slender proboscis exposed and the broken

[279] Lat., *oliva*, olive.
[280] Lat., *citrinus*, yellow.

trail in the sand is like that of a mole in soft earth.[281] Forward movement is by alternate advance and rest periods.

A number of specimens of both types of *Oliva* have been found which have a strong revolving cord at or near the center of the body whorl· The cord is continuous from columella to edge of outer lip.

Genus **OLIVELLA** Swainson, 1840

Olivella pusilla[282] Marrat Plate 36, fig. 248

Alt. to 12 mm. Shell almost a miniature *Oliva,* spire more produced, aperture shorter. Very mutable in color and pattern. Individuals vary through ashy shades and brown, unicolored, banded with white or finely reticulate with chestnut-brown. Less common color variations are dark brown and pure golden-yellow. Corneous operculum, thin, semiovate apical nucleus.

Common in shallow water, usually in sand. A bay species.

Olivella floralia[283] Duclos Plate 36, fig. 249

Alt. to 15 mm. Shell fusiform, more slender with more elevated spire than *O. pusilla.* Five or six whorls; white, apex dark or yellowish, body whorl often faintly marked with dull bluish-gray. Operculum of the type.

Sandy stations in shallow water. Not often taken in inside waters·

Olivella blanesi Ford Plate 36, fig. 250

Alt. to 8; diam., 3.1 mm. Shell white, translucent; ovate. Five whorls, body whorl rotund; spire rather sharp; suture channeled. Aperture half the altitude of shell, angulate above, widest below middle, with wide basal notch. Columella 'very short, vertical, cylindrical and smooth, making a decided angle with a parietal wall, forming a deep sulcus.'

The species is described as having three spiral series of irregularly formed crimson spots, one of very small spots at the suture, the other at center and base, the rest of the surface showing a fine

281 Mr. Ernest H. Noyes, at Naples, Florida, has taken living *Oliva* in a Lyman trap baited with sand fleas. F. Lyman, Lantana, Florida writes—'For many years we have had frequent reports from Palm Beach pier that fishermen catch *Oliva* on hooks while fishing for pompano. Sand fleas are used one hundred per cent for pompano bait.'

282 Lat., *pusillus*, very little.

283 Lat., *floris*, flower.

reticulation of the sand color. This color character seems to fade very quickly in dead shells.

On sand flats beyond low tide mark. In beach drift.

Family TEREBRIDÆ

The Terebridæ is a family of carnivorous molluscs native to tropical and subtropical seas, principally in shallow water and generally in sandy stations.

The shells are elongate and tapering, with whorls regularly increasing in size. A short aperture terminating in a recurved basal notch.

Genus TEREBRA Bruguière, 1798

Subgenus STRIOTEREBRUM Sacco, 1891

Terebra[284] dislocata Say — Plate 37, fig. 251

Alt. to 40 mm. Shell elongate, tapering regularly to acute apex; color an indefinite blend of ashy-blue and brownish tones, apex dark. About fifteen flattened whorls, sutures distinct. Sculpture of close longitudinal plicature cancellated by spiral grooves; nodulous band below sutures. Aperture small, outer lip thin. Columella short, recurved into basal notch. Operculum corneous, translucent, yellowish, apical nucleus.

Abundant on sand bars exposed at extreme low tide.

Terebra concava[285] vinosa Dall — Plate 37, fig. 252

Alt. to 22 mm. Shell with general characters of *T. dislocata;* Smaller, upper whorls thin, color bluish-gray with vinous tint, sometimes maculations of reddish-brown, apex dark; about thirteen whorls. Sculpture of delicate longitudinal plications and spiral grooves; small subsutural band. Operculum brown.

Most common in inside bays.

Terebra protexta[286] Conrad — Plate 37, fig. 253

Alt. to 30 mm. Shell with general character of other Terebras. Thirteen to fifteen whorls; lower portion of whorls brown, sutural band light. Longitudinal plications convex over whorls, spiral sculpture obsolete or wanting over sutural band. Operculum red-brown or claret color.

Dredged in three to six fathoms.

[284] Lat., *terebra*, a boring tool, *e.g.* auger; *dislocatus*, dislocated.
[285] Lat., *concavus*, hollow; *vinum*, wine.
[286] Lat., *pro*, before; *textus*, texture.

Family CONIDÆ

The families Terebridæ, Conidæ and Cancellariidæ compose a group of animals which share a quality unique in the phylum mollusca—the possession of poison glands. The venomous secretion of these glands passes through a long duct into a minute channel in the teeth of the radula, and certain tropical species of *Conus*, have been known to inflict dangerous and even fatal wounds upon human beings. Natives of South Pacific islands insist that some of the cones 'spit poison' an an enemy.

The cones constitute a large family of many species, almost all native to tropical seas. Their stations are about reefs and rocky bottoms of moderate depths; some shallow water species have adopted sandy stations.

The animals are predatory and carnivorous, drilling through the shells of other molluscs in order to reach the soft parts.

The shells are distinguished for rich colors and varied patterns and elegant inversely conic shape. The whorls are rolled upon themselves below a small, sharp apex, the narrow aperture is as long as the body whorl and usually notched near the suture. The operculum is disproportionately small, corneous, unguiform, with apical nucleus.

Genus CONUS Linné, 1758

Conus[287] **proteus** Hwass — Plate 37, fig. 254

Alt. to 70 mm. Shell smooth, inversely conic, white, with revolving interrupted bands of orange or chestnut-colored markings; thick brownish, translucent epidermis. About ten whorls, first two or three whorls of spire rise sharply from a flattened shoulder of shell. Sutures distinct. Sculpture of growth lines and a few spiral threads at base. Aperture length of body whorl, notched at suture, outer lip thin, outer and inner lip parallel, recurved notch at base. Operculum brown, very small.

Dredged in three to six fathoms. Not uncommon on sand bars of inside waters.

[287] Lat., *conus*, cone; *Proteus*, a sea god able to assume many diverse shapes.

Conus floridanus Gabb Plate 37, fig. 255

Alt. to 50 mm. Shell with general characters of *C. proteus*. About twelve whorls, spire acute, well elevated, ascent of whorls terraced. Mottled and obscurely banded in yellow and white, scattered brown spots. Epidermis thin, brownish.

Conus stearnsi Conrad[288] Plate 37, fig. 256

Alt. to 18 mm. Shell with characters of the type. Color grayish, mottled with brown or olive-green, narrow spirals of white and brown dots and dashes. Eight whorls, spire elevated, ascent of whorls terraced. Shoulder of body whorl sharply keeled, upper half of whorl smooth, spirally grooved below. Aperture narrow, outer lip sharp, convexly curved forward. Very small operculum.

In shallow water, generally on grassy bottom.

Conus pygmæus Reeve Plate 37, fig. 257

Alt. to 30 mm; diameter at shoulder almost half of altitude. Shell with characters of the type. Bluish white, obscure violet brown mottling, narrow spirals of alternate chestnut and white dots and dashes, interior violet-tinted; thin epidermis. Spire elevated, terraced, shoulder sharply keeled, slightly overhanging, upper one-fifth of body whorl usually smooth, strong revolving bands and grooves below. Aperture with wide, deep posterior notch.

Conus melvilli Sowerby Plate 37, figs. 258a, b

Alt., 13; max. width, 6.5 mm., length of body whorl 10 mm. Apex obtuse, sloping spire of four whorls below apex; shoulder rounded, body whorl narrowed to width of two millimeters at base. Sutures slightly canaliculate. Aperture narrowed above, regularly increasing in width to base of shell; outer lip thin, sharp. Ground color bluish-white with closely placed revolving, chestnut-colored striations, faint near the shoulder, stronger over expanded

[288] From the quoted description it will be seen that the name '*Conus pealii*' is incorrectly applied to the common small cone generally so designated. '*Conus pealii*. New species. Pl. 3, Fig. 3. Shell conical; whitish, marked with light yellow irregular stripes: these markings on the whorls give them a nodulous aspect, being alternately white and yellow; spire acute; the whorls coroneted at their edges; body whorl transversed throughout with deep transverse grooves, forming regular rounded ribs; less than an inch, and half as broad.' Trans. Albany Inst. vol. 1, 1830, Art. XIII,

portion of body whorl, becoming elevated threads over narrowed basal portion. Light brown, irregular markings in clouded longitudinal bands; color much deeper about sutures and base. Chestnut stain well within aperture. The epidermis is pale brown. The operculum of the type.

The species is founded on a single shell collected at Key West in 1873, by J. Cosmos Melvill. The new specimen was dredged in six fathoms off Little Carlos Pass, Lee County, Florida, in April, 1938. It is believed to be the second, and only living specimen to be recorded. Sowerby's description in the Conchologia Iconica coincides in every detail, save size, with the new shell which is evidently juvenile.

Beach specimens of *C. mus* and *C. verrucosus* have been found on the Gulf beaches of Southwest Florida, but there seems little evidence for a local station.

Family **TURRIDÆ**

The family Turridæ is reported in all seas but certain of its groups are restricted to a limited range. Its species are difficult to identify and classify and individuals of any one species are seldom abundant.

The shells are of many and varied forms; usually fusiform with elongate spire, straight anterior canal and posterior notch or slit. The strongest sculpture is longitudinal. Most of its genera are operculate.

Genus **FENIMOREA** Bartsch, 1934

Fenimorea moseri Dall — Plate 38, fig. 259

Max. alt., 30; body whorl, 15.5; max. diam., 10 mm. Shell elongate-turreted, rather thick; color varies from rose-pink to a waxy-cream color; thin yellowish epidermis. About ten whorls crossed by eleven axial ribs; ribs slightly keeled and retractively curved above periphery of whorl, constricted and drawn together at base of body whorl. Revolving sculpture of fine threads from apex to base; fine incremental lines. Aperture two millimeters in diameter; posterior sinus round, broad, subsutural; anterior canal short, straight. Columella white, strong reflected callus below. Operculum corneous, amber color, apical nucleus.

Dredged in six fathoms off Little Carlos Pass and Sanibel Island, Florida.

Genus **CERODRILLIA** Bartsch and Rehder, 1939

Subgenus **CERODRILLIA** Bartsch and Rehder, 1939

Cerodrillia[289] **clappi** Bartsch and Rehder Plate 38, fig. 260

Alt., 11.8 mm.; greatest diam., 4.5 mm. Shell smaller and more slender than *C. thea* and *C. perryæ*. Elongate-turreted, waxy-white with a faint fawn-colored band 'anterior to the broadest expansion of the axial ribs', and a broader band at periphery of body whorl; wide interspaces with faint spirals, and miscroscopic growth lines. Aperture oval, short anterior channel, hardly more than a deep notch; edge of outer lip strongly convex with deep posterior sinus and shallow anterior notch; a stout varix immediately posterior. Columella with fine, very faint threads, heavy callus above· Operculum light amber color.

Dredged in four to seven fathoms off Sanibel and Captiva islands, Florida.

Cerodrillia perryæ Bartsch and Rehder Plate 38, fig. 260A

Alt., 12.9; greatest diam., 5.3 mm. Shell elongate-turreted, flesh colored, a broad golden-brown band, from middle of turns to a little beyond periphery. Eight and a half whorls . . . Post-nuclear whorls moderately rounded, marked by strong, distinctly spaced, broad axial ribs, which on early whorls are best developed at periphery; in later whorls the hump is a little anterior to the middle . . . Spaces separating the ribs are broad and shallow with microscopic incremental lines and faint spiral striations . . . Base moderately long, marked by feeble spiral threads wh increase in length from periphery and develop into five equal and almost equally spaced cords on the columella. Outer lip with notch anterior to the summit · . . backed by a heavy varix. Anterior channel profound; . . . columellar callus extends up on parietal wall.

C. thea differs from this species in being of uniform chocolate-brown, with axial ribs shorter and broader, the knobs more pronounced.[290]

Dredged in five fathoms off Sanibel Island, Florida.

289 Gr., *keros*, wax; D., *drillen*, to bore.

290 Bartsch and Rehder: Proc. U. S. National Museum. vol. 87, No. 3070. Description given is condensed from the original.

Cerodrillia thea Dall Plate 38, fig. 261

Alt., 15 mm. Shell fusiform, surface waxy. 'Color of strong tea', thin epidermis. Eight convex whorls crossed by nine to eleven varices, strongest at periphery of whorls; faint spiral threads at base of body whorl. Sutures distinct. Aperture oval, more than half length of body whorl; outer lip curved forward, deep subsutural notch, shallow notches near base. Short, straight anterior canal. Interior of aperture dark-colored, polished. Columella with narrow callus. Brown corneous operculum.

From littoral zone to fifteen fathoms. Fairly common about sand bars of inside waters.

Subgenus **LISSODRILLIA** Bartsch and Rehder, 1939

Cerodrillia schroederi[291] Bartsch and Rehder Plate 38, fig. 262

Alt., 5 mm. An unusually large specimen has an altitude of 7.8; greatest diam., 22 mm. Shell small, turreted, elongate, waxy opaque-white.

Postnuclear whorls appressed at the summit, slightly rounded, marked by very slightly retractively curved, broad, rounded axial ribs, which are as broad as the spaces that separate them. Of these ribs ten occur on the first, eleven on the second, twelve on the third, and on the last two-thirds of a turn these become quite obsolete . . . They pass over the periphery and evanesce at the insertion of the columella. The ribs and intercostal spaces are marked by scarcely perceptible lines of growth. Base moderately long, marked by feeble continuations of axial ribs and inconspicuous spiral striations. Columella without spiral cords. Aperture elongate-oval, decidedly channeled anteriorly; outer lip with a profound sinus immediately below the summit and a weak stromboid notch anteriorly; inner lip covered with a heavy callus which extends over the parietal wall.[292]

Dredged on sandy bottoms in five to seven fathoms off Sanibel and Captiva islands, Florida.

Genus **MONILISPIRA** Bartsch and Rehder, 1939

Monilispira[293] **leucocyma** Dall Plate 38, fig. 263

Alt., 14; greatest diam., 4.75 mm. Shell chocolate-brown, prominent nodules cream-colored. Apex light brown; elongate-turreted, about ten whorls. First two nuclear whorls smooth, third obscurely ribbed; postnuclear whorls with a subsutural

291 Dedicated to Lt. Seaton Schroeder.

292 Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

293 Lat., *monile*, necklace; *spira*, a coil, twist; Gr., *leucos*, white; *kyma*, wool.

nodulose spiral cord and a duplex nodulous cord at periphery of whorls; the interspace concave with fine spiral striations. Below the duplex spiral of body whorl are about five nodulose spiral cords and numerous spiral threads. Very fine spiral striation in interspaces. Aperture elongate-oval, outer lip varicosely thickened in adult, posterior sinus moderately broad and deep, situated in concave subsutural space. Anterior canal short, straight. Columella straight, smooth callus. Operculum acute-ovate, apical nucleus.

From the littoral zone to six fathoms. Not uncommon in colonies, about sand bars of inside waters.

Monilispira monilis Bartsch and Rehder Plate 38, fig. 264

Alt., 13; max. diam., 5 mm.

Shell elongate-turreted, chestnut-brown except for the tubercles, which are pale yellow, the interior of the aperture reflecting the coloration of the outside. The first two nuclear whorls are smooth, followed by a turn in which there are moderately strong, retractively curved axial riblets, which are about as wide as the spaces that separate them; following this is the postnuclear sculpture. Postnuclear whorls with a spiral cord immediately below the summit and a broad tuberculated cord immediately above the suture. The latter is marked by a secondary cord, which coincides with the crest of the tubercles and a little heavier one immediately anterior to the major portion of the tubercles. This on the early turn falls into the suture, but on the last whorl is slightly posterior to it. Of the tubercles twelve are present on the first of the postnuclear turns, ten on the second, third, and fourth, eleven on the fifth and sixth, and six on the last half of the last turn. In addition to the above sculpture, the entire spire and base are marked by numerous, closely spaced, spiral threads, which in combination with the slightly weaker incremental lines lend to the surface, under high magnification, a somewhat fenestrated aspect. Base moderately long, marked by three tuberculated spiral cords. Columella stubby, marked by nine spiral cords, which range from as strong as the last basal to mere threads at the tip of the columella; aperture irregularly pyriform, decidedly channeled anteriorly; outer lip with a very deep sinus a little below the summit whose edge is reflected. Posterior to the sinus there is a heavy hump, anterior to the sinus the outer lip is protracted into a clawlike element, which is rendered sinuous by the external sculpture; inner lip reflected over the columella as a very heavy callus, which extends up on the parietal wall.[294]

Dredged in four to seven fathoms off Sanibel Island, Florida. Found on living *Atrina* stranded on beach after a 'blow'.

[294] Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

Genus **MANGELIA** Risso, 1826

Mangelia plicosa[295] C. B. Adams Plate 38, fig. 265

Alt., 6 - 8 mm., spire about half of altitude. Shell dark amber-brown under dull grayish epidermis. Six or seven whorls, sutures distinct; eleven or twelve, strong axial ribs rendered nodulous by numerous revolving ridges. Aperture semilunar; outer lip thickened, with posterior varix in adult; posterior sinus shallow, rounded, subsutural; interior dark. Anterior canal short. No operculum.

In shallow water. Usually on muddy and grassy bottom.

Genus **KURTZIELLA** Dall, 1918

Kurtziella atrostyla[296] Dall Plate 38, fig. 266

Alt., 7; spire, 4.1 mm. Shell opaque milky-white with brown stain on columella, brown sutural band, often brown coloration of outer lip, occasional brown specimens. Six whorls, keeled at shoulder. Eight or ten axial ribs and fine spiral striations. Aperture and short anterior canal slightly oblique; outer lip with shallow, rounded posterior notch. No operculum.

A littoral species. Occasionally taken at two to four fathoms.

Kurtziella cerinella[297] Dall Plate 38, fig. 267

Alt., 10.5; spire, 5.5 mm. Shell slender; spire elongate, tapering. Waxy-cream color or yellowish; thin epidermis. Seven or eight whorls, shoulder sloping to acute keel; sutures distinct, wavy. Six or seven axial ribs; spiral sculpture of fine and very fine threads over entire surface. Aperture almost semilunar; outer lip with shallow notch at angle of whorl. Anterior canal extremely short. No operculum.

Most common and abundant turrid of Florida's West Coast. Shallow water to moderate depths on sandy bottom. Shells often studded with egg cases of some small gasteropod mollusc—probably *Olivella pusilla.*

Kurtziella perryæ Bartsch and Rehder Plate 38, fig. 268

Shell minute, elongate-turreted, milk-white with a creamy tinge. The first nuclear turn is well rounded, smooth. This is followed by a turn marked by closely spaced axial riblets and four spiral cords, the latter

[295] Dedicated to the naturalist Mangili; Lat., *plicare*, to fold.
[296] Lat., *atro*, from *ater*, black; Gr., *stylos*, a pillar.
[297] Lat., dim. of *cerinus*, wax-colored.

rendering the axial riblets roundly nodulose at their junction. The third cord is a little anterior to the middle and forms an angle. Postnuclear whorls appressed at the summit, marked by very strong axial ribs, which become enfeebled toward the summit and extend anteriorly on the last whorl to the columella. These ribs are more strongly pronounced on the middle of the turns, which they angulate. Of these ribs, twelve occur on the first, eleven on the second, ten on the third, fourth, and fifth, and five on the last half of the last turn. The ribs are only about half as wide as the spaces that separate them. In addition to these strong ribs, slender, very regular, closely spaced axial threads are present, which are crossed by spiral threads of equal strength, the junctions of which produce slender rounded nodules, that give to the entire surface of the shell a decidedly granulose effect. This type of sculpture also characterizes the base where the spirals are a little more distantly spaced and the nodulation less pronounced. Columella short and stubby, marked by rather rough oblique lines. Aperture oval, strongly channeled anteriorly with a deep sinus immediately below the summit, whose outer edge is somewhat thickened and reflected. Anterior to the sinus the outer lip is produced into a clawlike element. Inner lip appressed to the columella as a callus extending over the parietal wall.[298]

Sandbars in shallow water.

Genus **STELLATOMA** Bartsch and Rehder, 1939

Stellatoma[299] **stellata** Stearns Plate 38, fig. 268A

Alt., 7 mm., spire a little less than half of altitude. Shell elongate, ovate, turreted. Color yellowish, usually banded about sutures and body whorl and tinted about outer lip and columella with violet-brown. About six whorls; postnuclear whorls with straight shoulder sloping to angled keel, convex below, sutures distinct. About eleven axial ribs extending to base of body whorl, spiral threads below and fine spiral striations in intercostal spaces. Aperture semiovate; anterior canal extremely short; outer lip thickened, with posterior varix and a small denticle at anterior angle of the shallow, subsutural posterior sinus. Columella with one obscure internal fold.

Sandy station from shallow water to three fathoms.

Genus **PYRGOCYTHARA** Woodring, 1928

Pyrgocythara[300] **hemphilli** Bartsch and Rehder . Plate 38, fig. 269

Shell small, elongate-ovate, varying in ground color from chestnut-brown to wax yellow, usually with a pale zone at the angle of the shoulder. The outer lip and base of the columella may be orange or dark purplish orange. Nuclear whorls slender, the first 1.5 smooth, succeeded by about two-tenths

[298] Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

[299] Lat., *stella*, star; Gr., *tomos* section.

[300] Gr., *pyrgos*, tower.

of a turn that shows slender, retractively curved, axial riblets, which in turn are followed by the postnuclear sculpture. Postnuclear whorls moderately well rounded, appressed at the summit. The postnuclear whorls are marked by very strong, sinuous axial ribs, which taper at the summit and evanesce on the columella. Of these ribs 10 occur on the first and second, 9 on the third and fourth, 10 on the fifth, and 9 on the last. In addition to the axial ribs, the entire surface of the shell is marked by microscopic incremental lines. The spiral sculpture consists of a low, rounded, obsolete keel, which occupies the middle of the turns on the first four whorls but falls a little posterior to this on the rest of the shell. This produces a decided shoulder on the whorls. Anterior to the shoulder three ill-defined spiral cords are present on all but the last two whorls, on which there are four, the penultimate having four, while on the last turn intercalated cords appear between these. Base rather long, marked by the continuation of the axial ribs, which become slightly enfeebled anteriorly and the same type of sculpture as that characterizing the shell anterior to the angle. Columella stout, about as long as the base, marked by obliquely slanting, closely approximated, spiral cords, which vary in size and spacing. Aperture narrowly auriculate, decidedly channeled anteriorly and posteriorly. The anterior channel is deep and well rounded and is situated immediately below the summit. The lip posterior to the sinus is somewhat thickened. Anterior to the sinus the lip is much thickened but tapers to an edge and is slightly protracted. The inside of the outer lip immediately anterior to the channel bears a decided denticle. The inner lip is appressed to the columella as a small callus and thickened on the parietal wall.[301]

Genus **CRASSISPIRA** Swainson, 1840

Crassispira[302] tampaënsis Bartsch and Rehder Plate 38, fig. 270

Alt., 22; max. diam., 7.3 mm. Ten whorls.

Shell elongate-turreted, chestnut-brown; interior of the aperture livid. The first nuclear whorl is well rounded, smooth, succeeded by a fraction of a turn in which faint, closely spaced, retractively curved, axial riblets are present, which in turn merges into the postnuclear sculpture. Postnuclear whorls rendered somewhat shouldered at the summit by a strong spiral cord, which is followed anteriorly by a broad siphonal channel, anterior to which the whorls are marked by strong, somewhat sigmoid, axial ribs extending to the insertion of the columella. These ribs are about half as wide as the spaces that separate them; of these, 19 are present on the last turn and 17 on the antipenultimate, the early whorls being eroded in the type. In addition to the axial ribs, the whorls are marked by fine incremental lines, which are decidedly retractively curved in the subsutural channel. The spiral sculpture consists of deeply incised lines, which leave the spaces between them as slightly elevated, flattened ribs; of these, 3 cross the axial ribs posterior to the suture. The base, which is moderately long, is similarly marked, and here the incised lines are broader and separate 4 well-differentiated cords, which render the axial ribs nodulose at their junction. Columella short and stout, marked by 9 spiral cords, which decrease in width from the insertion of the columella anteriorly. Aperture elongate pear-shaped; outer lip with a profound sinus a little

301 Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

302 Lat., *crassus*, thick, fat; *spira*, coil, twist.

below the summit; anterior to the sinus it is protracted into a clawlike element with a mere indication of stromboid notching anteriorly; the inner lip extends over the columella as a broad callus leaving a narrow umbilical chink at its anterior end. A callus extends over the parietal wall.[303]

Crassispira tampaënsis bartschi Perry Plate 39, fig. 271

Alt., 24; max. diam., 7; spire, 13 mm. Shell elongate, turreted, chocolate or mahogany-brown. Nucleus and postnuclear whorl smooth. Riblets and faint spiral striations begin on first half of following turn; succeeding whorls bear increasingly stronger ribs and spirals. Eleven whorls, sutures distinct, wavy. A strong, undulating subsutural cord angulates summit of whorls above a wide concave sulcus; the sulcus shows one, two or three unequal spiral threads overlying retractively curved incremental lines. Below sulcus the axial ribs extend to suture below. Ribs and interspaces crossed by three elevated ridges separated by wider interspaces. On body whorl eight strong revolving ridges cross and nodulate the axial ribs; interspaces have fine spiral threads. Nine revolving cords below, beginning at columella. Aperture pyriform, dark within; outer lip with moderately deep notch in the subsutural sulcus. Columella callus. Anterior canal slightly oblique. Operculum dark, shape of aperture, apical nucleus.

This subspecies differs from *C. tampaënsis* in having definite spiral threads in the subsutural sulcus, one or two more axial ribs, more generally distributed spiral striation and the uniformly dark-colored aperture.

Dredged in four to seven fathoms, with *C. tampaënsis*.

Crassispira sanibelensis Bartsch and Rehder Plate 39, fig. 272

Alt., 25.8; max. diam., 9.9 mm. Seven or eight whorls.

Shell elongate-turreted, brown, with the intercostal spaces flesh-colored, the edge of the aperture corresponding to the dark color outside, but the interior is livid. First nuclear whorl smooth, followed by a turn with rather closely spaced axial riblets and an indication of spiral threads with the possibility of nodules at their junction. Postnuclear whorls moderately rounded, appressed at the summit, marked by broad, low axial ribs, which terminate at the anterior extremity of the broad siphonal channel. These ribs are broader than the spaces that separate them. In addition there are numerous threadlike incremental lines. The spiral sculpture consists of heavy cords of which the first one is on the shoulder anterior to the summit. Two strong cords appear anterior to the sutural sinus on all but the last two of the remaining turns; on these, three cords are present that render the broad axial ribs nodulose, the nodules having their long axis parallel with the spiral sculpture. In addition to the coarser spiral sculpture, mic-

303 Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

roscopic spiral lines are present on the entire surface. Base moderately long with a narrow umbilical chink at the tip, marked by four spiral cords, which slightly decrease in size anteriorly. Columella stout, stubby, with six heavy cords and several slender threads anterior to these. Aperture oval, decidedly channeled anteriorly with a deep sinus immediately anterior to the cord at the summit. Anterior to the sinus the outer lip is protracted into a clawlike element that bears a series of nodules corresponding to the cords on the outside; inner lip heavy and reflected over the columella. A callus extends over the parietal wall joining the heavy cord at the summit.[304]

Genus **GLYPHOTURRIS** Woodring, 1928

Glyphoturris[305] **rugirima** Dall Plate 39, fig. 273

Alt., 8; spire, 4.5 mm. Shell small, turreted; white with brownish markings in revolving lines and about sutures. Eight whorls; nucleus and postnuclear whorl smooth, next whorl rounded with narrow, sharp riblets and fine spiral threads. Succeeding whorls with strong, rounded axial ribs, sharply keeled at shoulder of whorls; eight ribs on body whorl extending to base of shell. Strong spiral cords and fine threads overlay axial ribs and extremely fine and closely placed grooves cross the revolving sculpture producing a fine granulation of the entire surface. The extreme delicacy of this sculpture is apparent only in living specimens. Aperture widest at middle, anterior canal short, well open, widest at base; outer lip with thick posterior varix, a low internal varix within; sinus broad, rounded. Columella with one obscure oblique fold. No operculum.

Dredged in two to six fathoms. Occasionally found living on sandy bottoms of shallow bays.

Genus **RUBELLATOMA** Bartsch and Rehder, 1939

Rubellatoma[306] **diomedea** Bartsch and Rehder Plate 39, fig. 274

Alt., 9.7; max. diam., 4.0 mm.

Shell elongate-turreted. Nuclear whorls bright chestnut-brown, the rest of the whorls with a broad brown band covering the posterior half of the whorls. There is a second broad band a little less wide immediately anterior to the periphery followed by a pale zone of almost equal width, while the tip is chestnut-brown. The interior of the aperture shows the exterior coloration. The first 1.5 nuclear whorls are smooth, the succeeding half turn is marked by slender, retractively curved, axial riblets followed by the post-

[304] Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

[305] Gr., *glyphein*, to carve; Lat., *turris*, tower; *ruga*, a wrinkle; *rima*, cleft, fissure.

[306] Lat., *rubellus*, reddish.

nuclear sculpture. Postnuclear whorls appressed at the summit, with a decided angle, the crest of which occupies the anterior fourth between the summit and suture. The whorls are marked by strong sinuous axial ribs, which attain their highest elevation at the angulation and taper gently toward the summit and columella where they evanesce. Of these ribs, 12 occur on the first postnuclear turn, 9 on the second, third and fourth, 10 on the fifth, and 7 on the last seven-tenths of a turn. The axial ribs are not quite so wide as the spaces that separate them. The entire surface of the shell is marked by numerous incremental lines and equally strong spiral striations, the combination of which gives to the surface a feebly fenestrated pattern. Base rather long, marked by the same sculpture as that which characterizes the spire. Columella short, stubby, marked by incremental lines and weak spiral threads. Aperture elongate-ovate, decidedly channeled anteriorly, with the posterior sinus shallow immediately below the summit. Outer lip somewhat thickened behind the edge, sharp at the edge, slightly protracted anteriorly at the notch and marked like the spire; the inner lip is appressed to the columella as a callus extending up on the parietal wall.[307]

Family CANCELLARIIDÆ

This is a small family most of whose species are native to warm seas and moderate depths.

The shells are medium-sized, oval, with short spire and plicate columella. No operculum

Genus CANCELLARIA Lamarck, 1799

Cancellaria[308] **reticulata** Linné Plate 39, fig. 275

Alt. to 50; shell ovate, yellowish-white, irregularly banded and plaided with rusty brown; thin epidermis. Six whorls; spire short, apex acute, body whorl rounded, narrowed below. Sutures distinct. Strong reticulate sculpture of low, rounded, somewhat oblique longitudinal ribs and flattened, revolving bands; intersections more or less nodular. Aperture lunate; a recurved notch or short canal at base; outer lip simple, sharply crenate within. Columella with three folds revolving deeply into aperture, lower two oblique, upper nearly horizontal. Columellar callus extended over body whorl. Narrow umbilical groove at edge of callus.

Dredged in three to six fathoms. Common beach shell. Occasionally, albino specimens.

307 Bartsch and Rehder: Proc. U. S. National Museum, vol. 87, No. 3070.

308 Lat., *cancellare*, to make like a lattice; *reticulatus*, reticulate.

Cancellaria conradiana Dall — Plate 39, fig. 276

Alt., 25 - 30 mm. Shell more slenderly ovate with relatively higher spire than *C. reticulata*. White with scattered maculations of light brown. Apex acute, nuclear whorls yellowish, glossy. Spire terraced. Reticulate sculpture clear and sharp. Columella has three plications. One revolving band forms a sharp lamellar ridge above columella. Other characters of the type.

Dredged in five to seven fathoms.

Order PLEUROCOELA

Family ACTÆONIDÆ

The members of this family are small molluscs of world-wide distribution, having a long history in the geologic past. Most of the species are from deep water.

The shells are of small size, ovate, with short, elevated spire, large body whorl with the aperture produced and widened below. The columella has one oblique fold.

Genus ACTÆON Montfort, 1810

Actæon[309] **punctostriatus** C. B. Adams — Plate 39, fig. 277

Alt., 3 - 6 mm. Shell small, thin, white, or faint rosy brown, thin epidermis. Spire elevated. Nucleus a little tilted from vertical axis. Four rather convex whorls; body whorl large, sutures deeply channeled. Sculpture of one or more revolving, subsutural grooves, body whorl smooth below suture with revolving, incised, punctate striations over basal half. Aperture about half length of shell, wide and produced at base. Columella with one strong oblique fold. Operculum corneous.

From one to sixty-three fathoms.

Family ACTEOCINIDÆ

This is a family of small molluscs native to warm seas.

The shells are small, cylindrical or fusiform and characterized by elevated spire with mammillar nucleus, channeled sutures and plicate columella.

Genus ACTEOCINA, Gray, 1847

Acteocina canaliculata[310] Say — Plate 39, fig. 278

Alt., 3.5 mm. Shell small, cylindrical, thin, white, translucent. Four or five whorls, sutures deeply channeled. Spire depressed,

[309] Gr., *Aktaion*, a huntsman; Lat., *punctum*, point; *striatus*, striated.
[310] Lat., *canaliculatus*, channeled.

apex mammillar, deflected from vertical axis; body whorl large. Aperture long, narrow, widened and slightly produced at base; outer lip arched forward. Columella with strong, oblique basal fold. No operculum.

Family SCAPHANDRIDÆ

Distribution of the species of this family is through a wide geographic and bathymetric range. They are small and medium-sized molluscs with shells of variable forms.

Genus CYLICHNA Lovén, 1847

Subgenus CYLICHNELLA Gabb, 1872

Cylichna[311] **bidentata** d'Orbigny Plate 39, fig. 279

Alt., 2.6; diam., 1.4 mm. Shell minute, cylindrical, smooth, white, shining. Spire depressed, concealed; body whorl narrowed above and below. Aperture narrow, widened and produced below, outer lip sharp, arched forward. Columella short, one oblique fold at base, a nodular thickening below.

Near low water mark.

Family BULLIDÆ

This family is represented by species native to all warm seas and adapted to a considerable range in depth. The animals are carnivorous and some members of the group are said to ingest their prey alive and whole.

The shells are of small to medium size, oblong-cylindrical, spire involute, apex perforate, aperture longer than body whorl, much expanded at base; outer lip thin, sharp. Columella arcuate, with produced white callus; no plications.

Genus BULLA Linné, 1758

Bulla[312] **occidentalis** C. B. Adams Plate 39, fig. 280

Alt., 20 - 25 mm. Shell smooth, with microscopic striations; oblong-cylindrical. Apex deeply perforate; variable in size, thickness. Mottled and obscurely banded with brown on light background, thin, delicate epidermis. Aperture narrowed near periphery of body whorl, produced and expanded below.

Sandy stations in shallow water.

[311] Gr., *kylix*, a drinking cup; Lat., *bidentatus*, with two teeth.
[312] Lat., *bulla*, bubble; *occidentalis*, of the west,

Bulla striata[313] **Bruguière** Plate 39, fig. 281

Alt., 20 - 30 mm. Shell with general characters of *B. occidentalis,* apical perforation slightly larger; spirally striate within; narrow spiral grooves about base, sometimes a few at shoulder of body whorl. Columellar callus faintly brown-stained.

Sandy stations in shallow water.

Bulla amygdala[314] **Dillwyn** Plate 39, fig. 282

Alt. to 40 mm. Shell smooth, solid, oblong-cylindrical, narrowed at vertex, mottled and obscurely banded with purplish brown on light background; thin, rather dull epidermis. Apical perforation large, spirally striate within. Surface without spiral striation, sometimes a few impressed revolving lines at base and vertex. 'Outer lip thick, heavily calloused where it rises from vertex; outer portion straight, not convex, base broadly rounded. Columella arcuate, with very heavy reflexed crescentic callus, the outer edge of which is well raised from the whorl throughout, leaving a chink behind it; parietal callus strong, white; interior lined with a white callus.'[315]

Fresh shells have been found on beaches of Sanibel, Captiva and Bonita Beach, Florida.

Family AKERIDÆ

A family of widely distributed small molluscs usually found in shallow water of bays and estuaries.

The animals are carnivorous. The shells somewhat resemble those of *Bulla* in shape, but are thin and fragile, unicolored, white, pinkish, amber or greenish.

Genus HAMINŒA Turton and Kingston, 1830

Haminœa[316] **succinea Conrad** Plate 39, fig. 283

Alt., 10 mm. Shell small, fragile, cylindrical, pale amber or white. Spire involute, vertex with small deep umbilicus. Body whorl widest at base; surface evenly striate with minute, wavy spiral lines. Aperture long, narrow, expanded below; outer lip thin, sharp. Columella arcuate, one weak fold above middle.

313 Lat., *striatus*, striated

314 Lat., *amygdala*, almond.

315 Tryon, G. W. and Pilsbry, H. A.: Manual of Conchology.

316 Lat., *hamus*, hook?; *succinum*, amber.

In shallow water on sandy bottoms.

Haminœa antillarum guadelupensis Sowerby Plate 39, fig. 284

Alt. to 18 mm. Shell thin, translucent, very pale amber or greenish; thin epidermis. Ovate-globose, slightly narrowed at vertex. Spire involute, vertex imperforate. Surface shows irregular growth lines, and almost microscopic fine, close, revolving striations. Aperture narrow above, widely expanded at base; outer lip thin, sharp, extended beyond vertex and recurved to join with a prolongation of the columellar callus. Columella deeply arcuate with a small fold above middle.

Beyond low tide mark—often in tide pools or about the inlets of creeks and bayous.

Family APLYSIIDÆ

The free swimming animals of this family bear little external resemblance to any gasteropod mollusc. The shell is wholly internal and consists of little more than a subtriangular, shelly plate.

The species common along the Southwest Florida Coast is *Tethys wilcoxi* Heilprin, locally called 'sea hare' or 'sea pigeon'. The animal is from a hundred to a hundred and fifty millimeters long, soft-bodied, patterned with a varied mixture of opaque sea-green, olive-gray and purple in irregular blotches and spots. The cephalic end is narrow and has a pair of earlike tentacles. The lateral lobes of the mantle are used in swimming. The animals secrete large amounts of deep purple fluid.

The shell is thin and flexible, translucent, heavy, subtrigonal with the apex posterior and sharp, the anterior border rounded, shallow notch near apex.

Order BASOMMATOPHORA

Family ELLOBIIDÆ

This is a family of amphibious molluscs. Most of its members can remain indefinitely out of water if sufficient moisture is otherwise available. Many of them are inhabitants of salt marshes and localities subject to periodic inundation of tidal water.

Genus **AURICULASTRUM** Fischer, 1883

Auriculastrum[317] **pellucens** Menke Plate 39, fig. 285

Alt., 15 mm. Shell oblong-oval, white with brownish epidermis. About four whorls; spire conic, elevated; body whorl large, sutures distinct. Smooth, faint growth lines. Aperture more than half length of shell, evenly rounded at base. Columella short with two oblique folds.

Near high tide mark. Often about mangrove stumps and bunch grass

Genus **MELAMPUS** Montfort, 1810

Melampus[318] **coffeus** Linné Plate 39, fig. 286

Alt., 18 mm. Shell ovate, smooth; about five whorls *enroulé*; spire low-conic; body whorl ample, sutures distinct. Color brown or fawn, narrow cream-colored band at shoulder, two below, equidistant, lower about middle of body whorl; thin epidermis. Aperture length of body whorl, widest below; outer lip thin, crenate within, recurved at base into columella and slightly thickened to form rim of umbilical depression. Columella short with two white folds, upper heavy, stout, with shallow furrow on its lower aspect.

The shade and banded pattern of this shell are variable, the shoulder band appears constant and there is often a light band near base.

Common in mud or tidal flats, often climb bushes and grasses. *Melampus* is eaten in large numbers by migratory ducks.

Melampus coffeus gundlachi Pfeiffer

Alt., 12 mm. Shell with general characters of *M. coffeus*. Smaller, a little more slender; banded on spire and body whorl with brown on light ground, base light; some specimens lack all banded pattern. Epidermis rather thick and opaque. Columella with two folds, lower oblique, upper horizontal, lamellar.

317 Lat., *auricula*, ear; *pellucidus*, clear, bright.
318 Gr., *melos*, black; *pous*, foot.

Genus **DETRACIA** Gray, 1840

Detracia[319] **bulloides** Montagu

Alt., 11 mm. Shell smooth, ovate, rather slender, about ten whorls; spire one-third of altitude. Color brown with variable pattern of obscure transverse bands and longitudinal wavy lines of cream color; epidermis dark shining-opaque. Aperture almost length of body whorl, narrow above; outer lip thin, white crenations some distance from edge. Columella with one strong basal fold, deep rounded notch above.

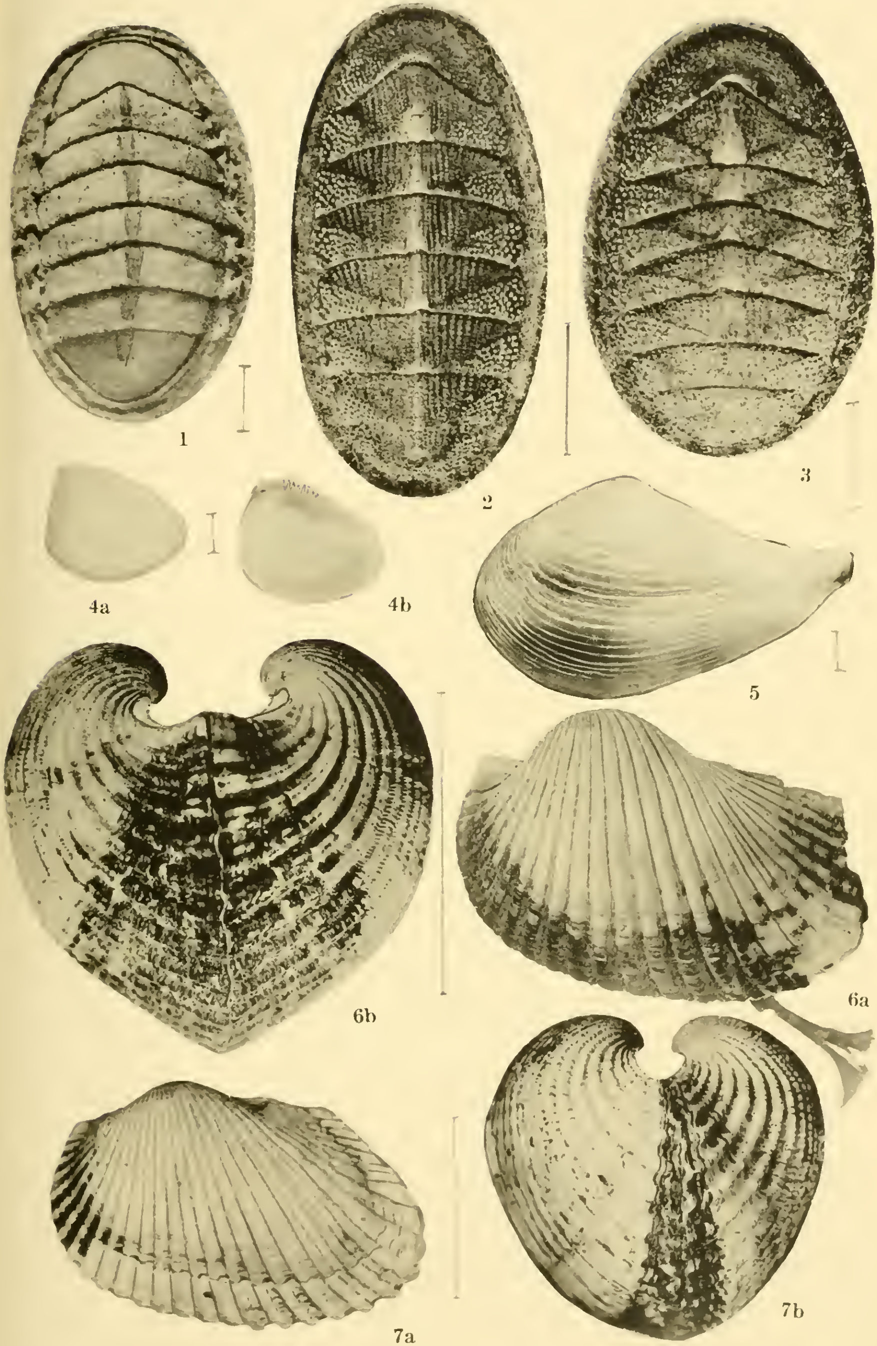
Near high water mark. Usually under wood, stones, etc.

[319] Lat., *detrahere*, to take away.

PLATES

PLATE I (I)

EXPLANATION OF PLATE 1 (1)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2
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4a
4b
5
6a
6b
7a
7b

PLATE II (II)

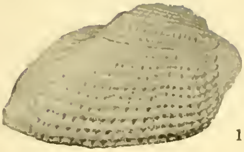
EXPLANATION OF PLATE 2 (2)

Figure		Page
7C.	**Arca transversa** Say Aberrant type	29
8.	**Arca secticostata** Reeve	30
9.	**Arca occidentalis** Philippi Fig. a both valves; Fig. b byssus	30
10.	**Arca umbonata** Lamarck	31


7C
8
9a
9b
10

PLATE III (III)

EXPLANATION OF PLATE 3 (3)



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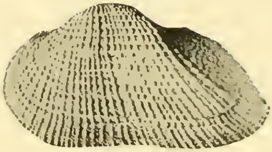

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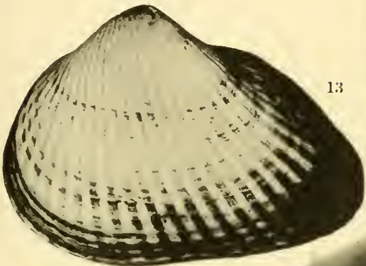

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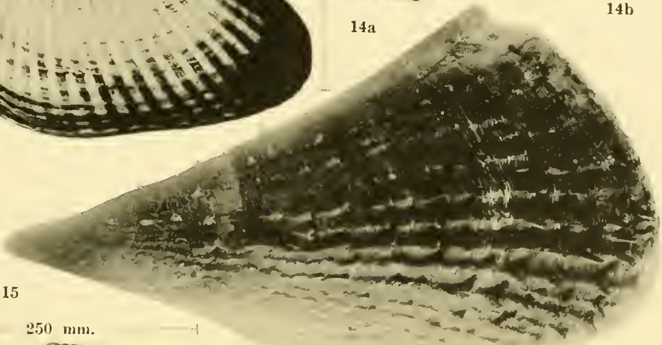
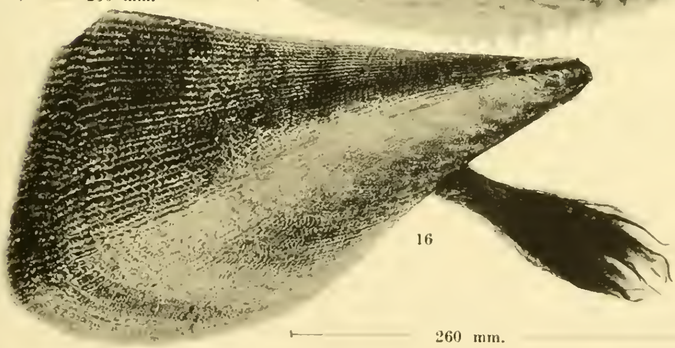
14a

14b



15

250 mm.



16

260 mm.

PLATE IV (IV)

EXPLANATION OF PLATE 4 (4)

17
18
21
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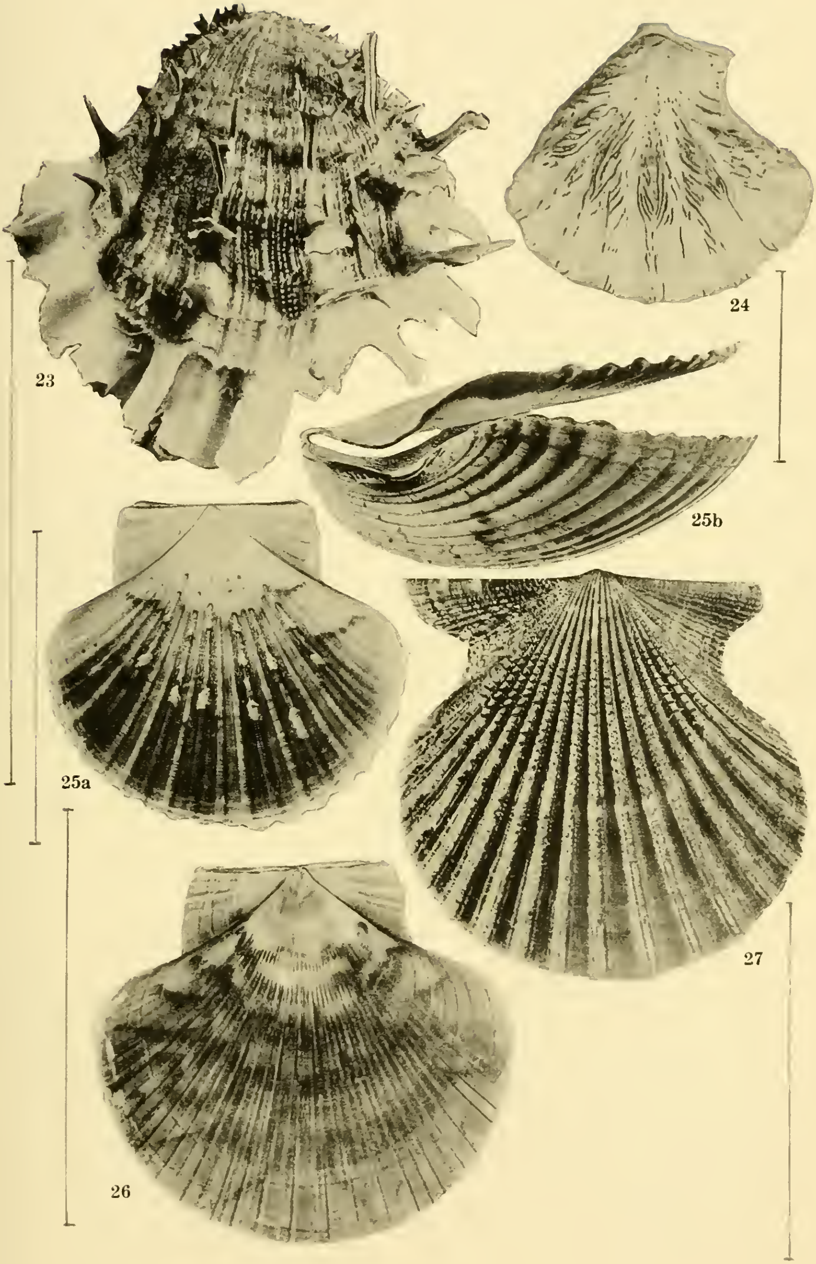
PLATE V (V)

EXPLANATION OF PLATE 5 (5)

Figure		Page
23.	**Spondylus ictericus** Reeve	38
24.	**Plicatula gibbosa** Lamarck	39
25.	**Pecten raveneli** Dall Fig. a view of upper valve; fig. b lateral view.	40
26.	**Pecten ziczac** Linné	41
27.	**Pecten muscosus** Wood	41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25b
25a
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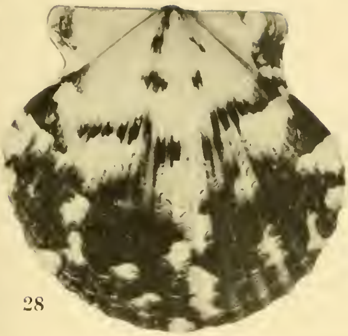
PLATE VI (VI)

EXPLANATION OF PLATE 6 (6)



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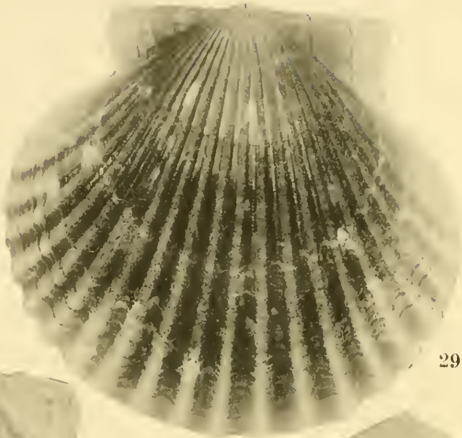

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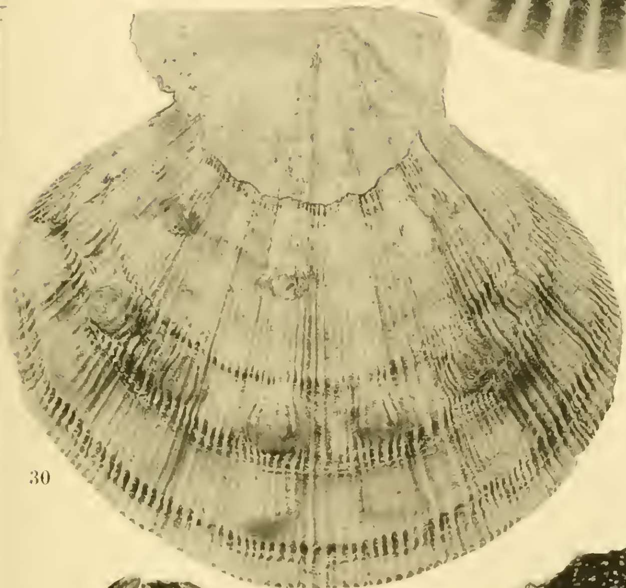

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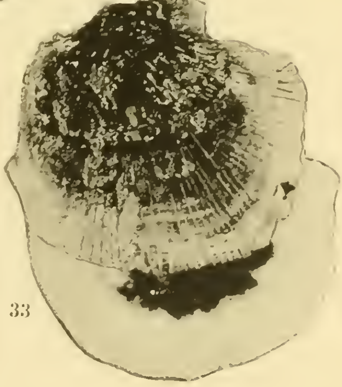

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PLATE VII (VII)

EXPLANATION OF PLATE 7 (7)

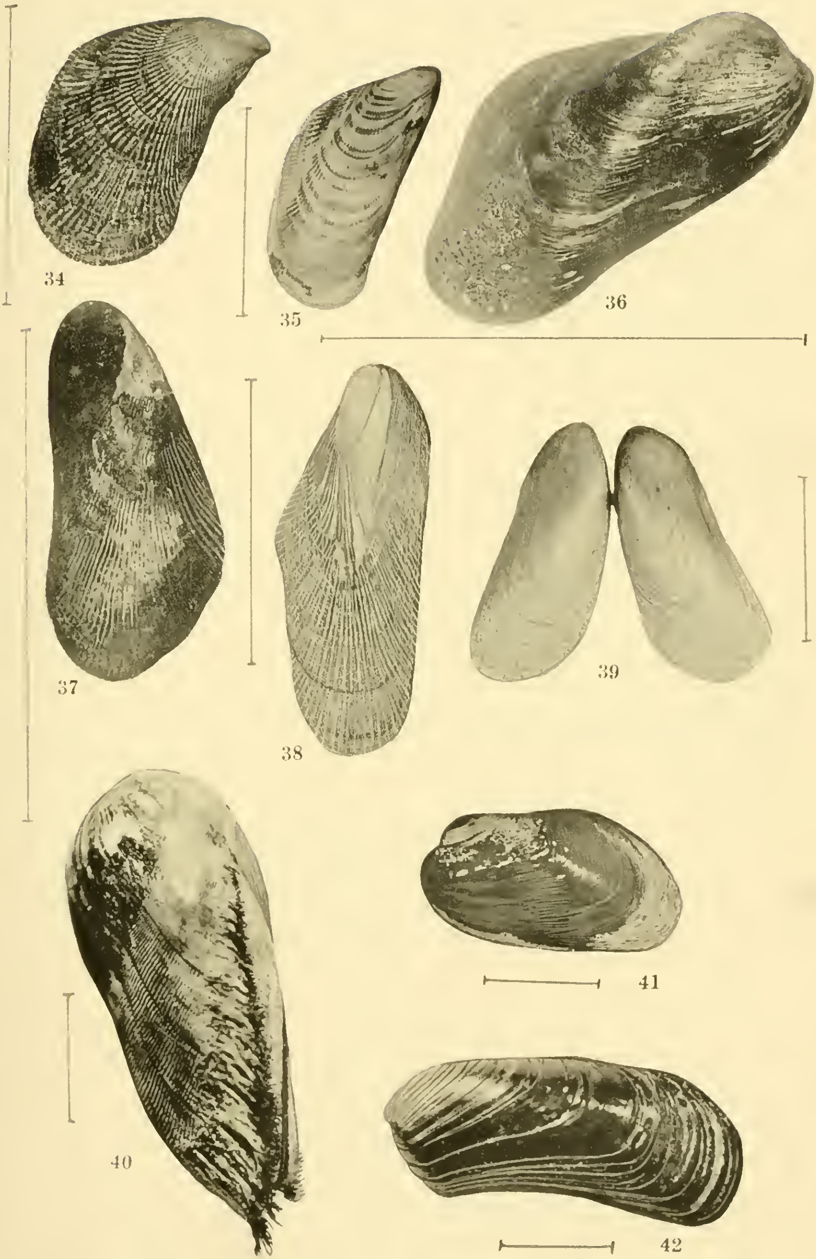
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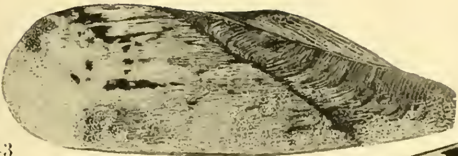
PLATE VIII (VIII)

EXPLANATION OF PLATE 8 (8)



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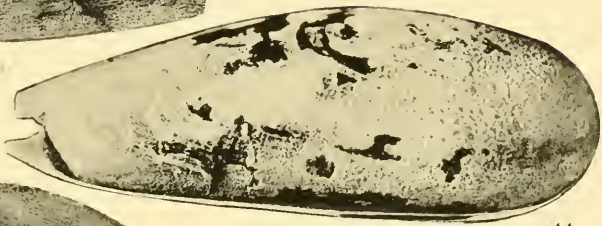

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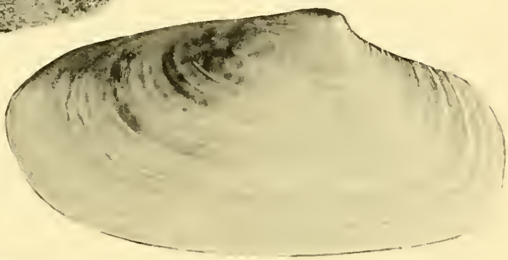

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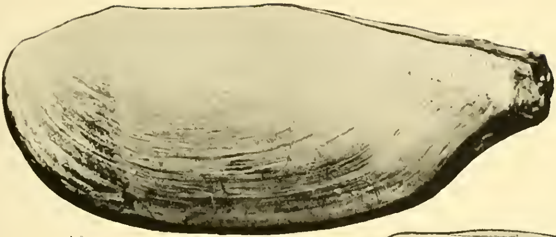
47a

47b

PLATE IX (IX)

Explanation of Plate 9 (9)

Fig. a exterior view; fig. b interior view.



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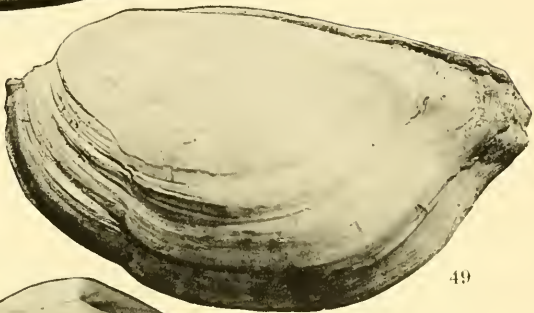

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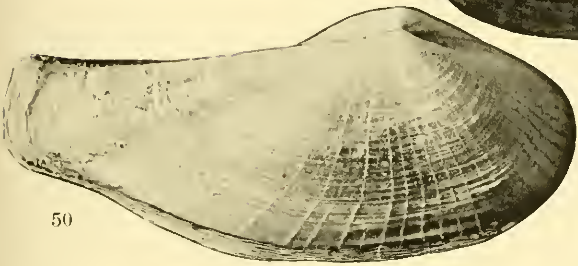

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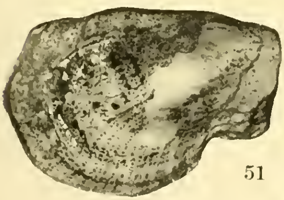

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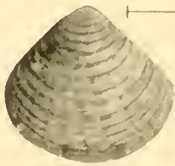

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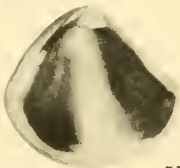

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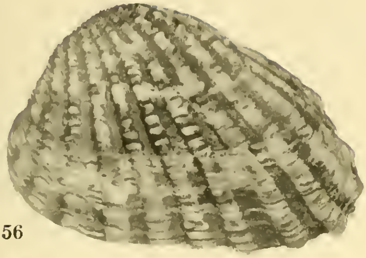
PLATE X (X)

EXPLANATION OF PLATE 10 (10)



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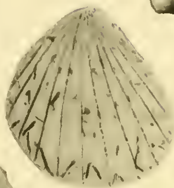

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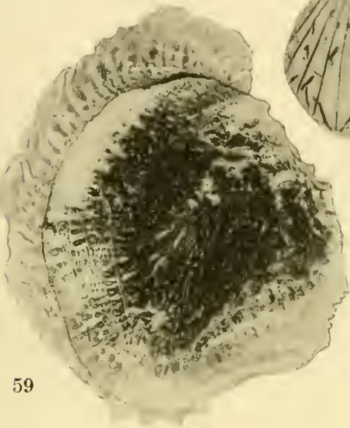

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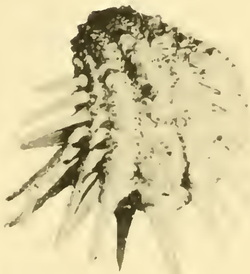

62

PLATE XI (XI)

EXPLANATION OF PLATE 11 (11)


63a
63b
65
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PLATE XII (XII)

EXPLANATION OF PLATE 12 (12)

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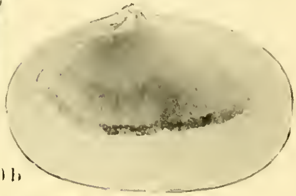
70a



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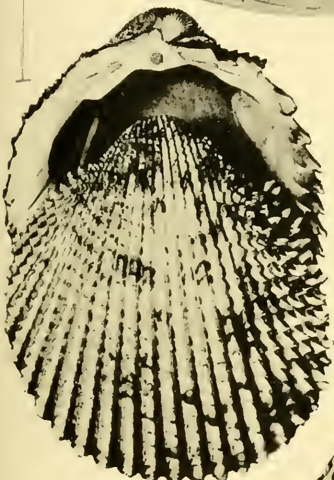

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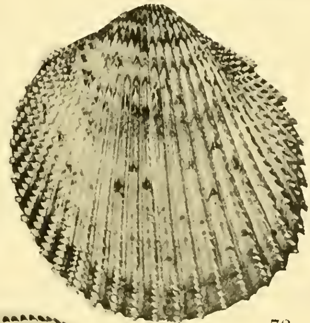
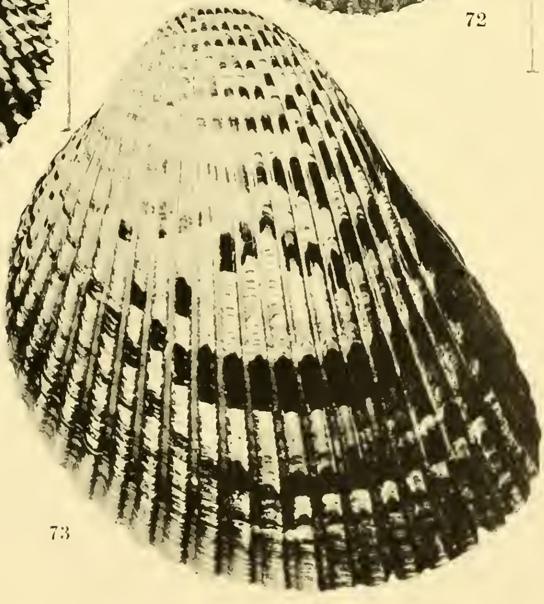


72

110 mm.



73

PLATE XIII (XIII)

EXPLANATION OF PLATE 13 (13)

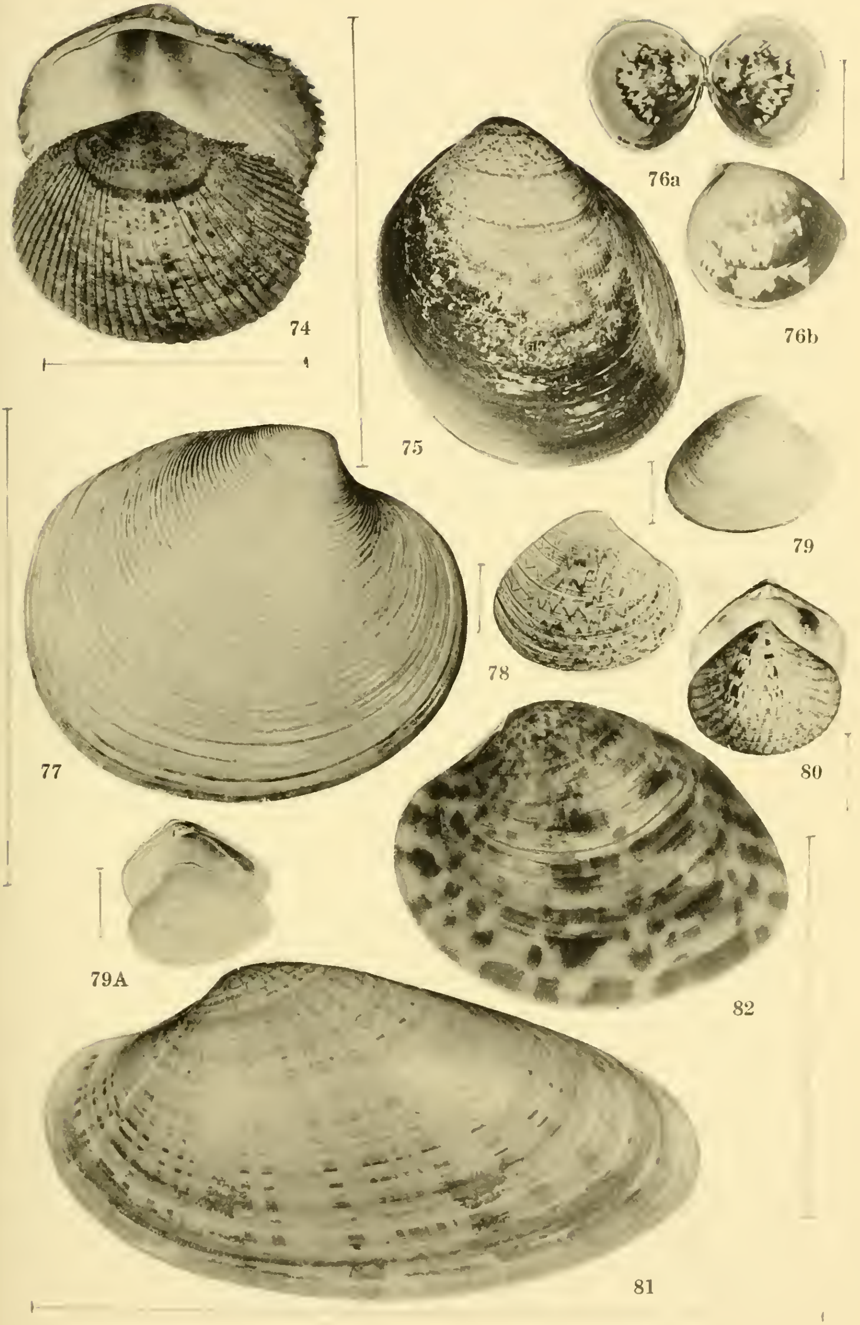
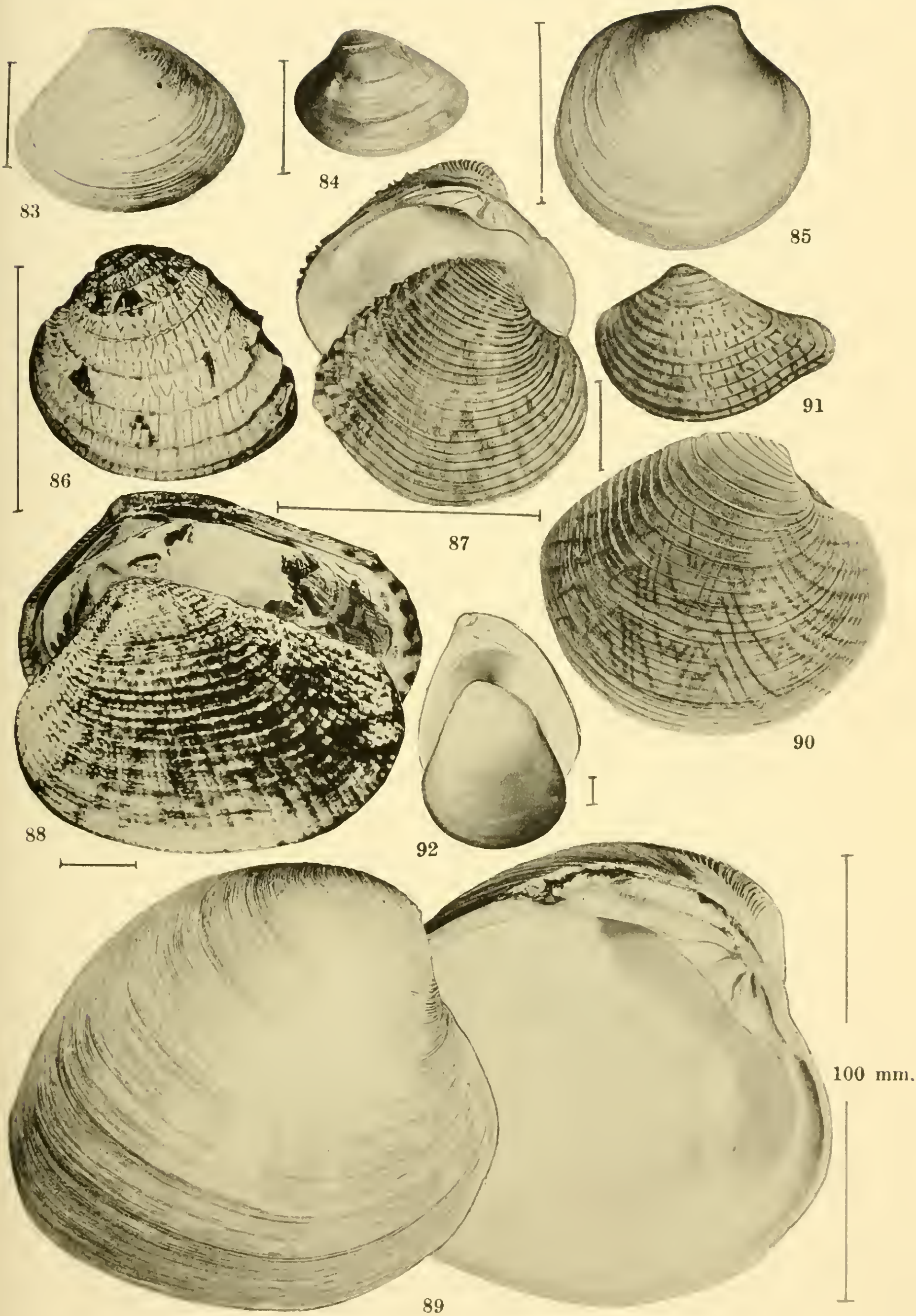

74
75
76a
76b
77
78
79
79A
80
81
82

PLATE XIV (XIV)

EXPLANATION OF PLATE 14 (14)

Figure		Page
83.	**Pitar albida** Gmelin	65
84.	**Pitar simpsoni** Dall	65
85.	**Cyclinella tenuis** Récluz	65
86.	**Chione cancellata** Linné	66
87.	**Chione intapurpurea** Conrad	66
88.	**Chione grus** Holmes	67
89.	**Venus mercenaria** Linné	67
90.	**Venus mercenaria notata** Say Young.	68
91.	**Anomalocardia cuneimeris** Conrad	68
92.	**Parastarte triquetra** Conrad	68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100 mm.

PLATE XV (XV)

EXPLANATION OF PLATE 15 (15)

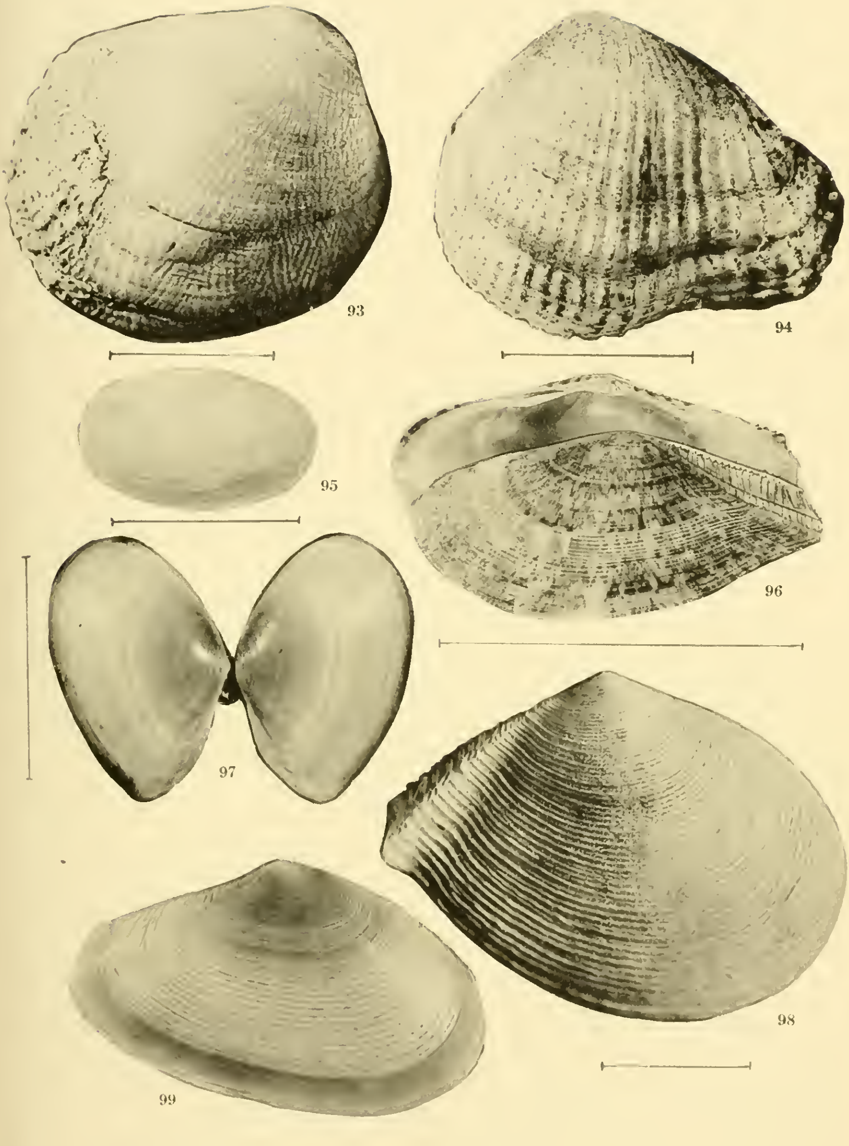
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PLATE XVI (XVI)

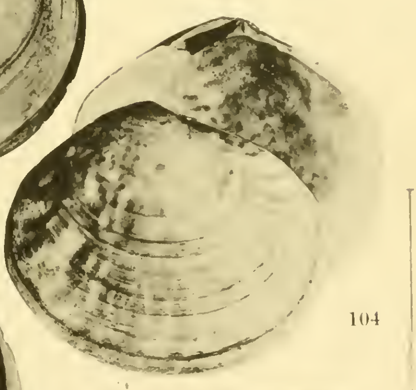
EXPLANATION OF PLATE 16 (16)

100

100A

102

101



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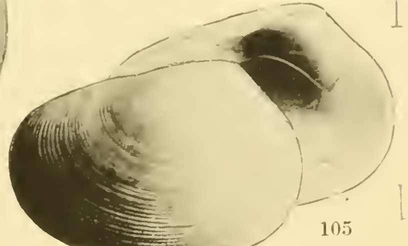
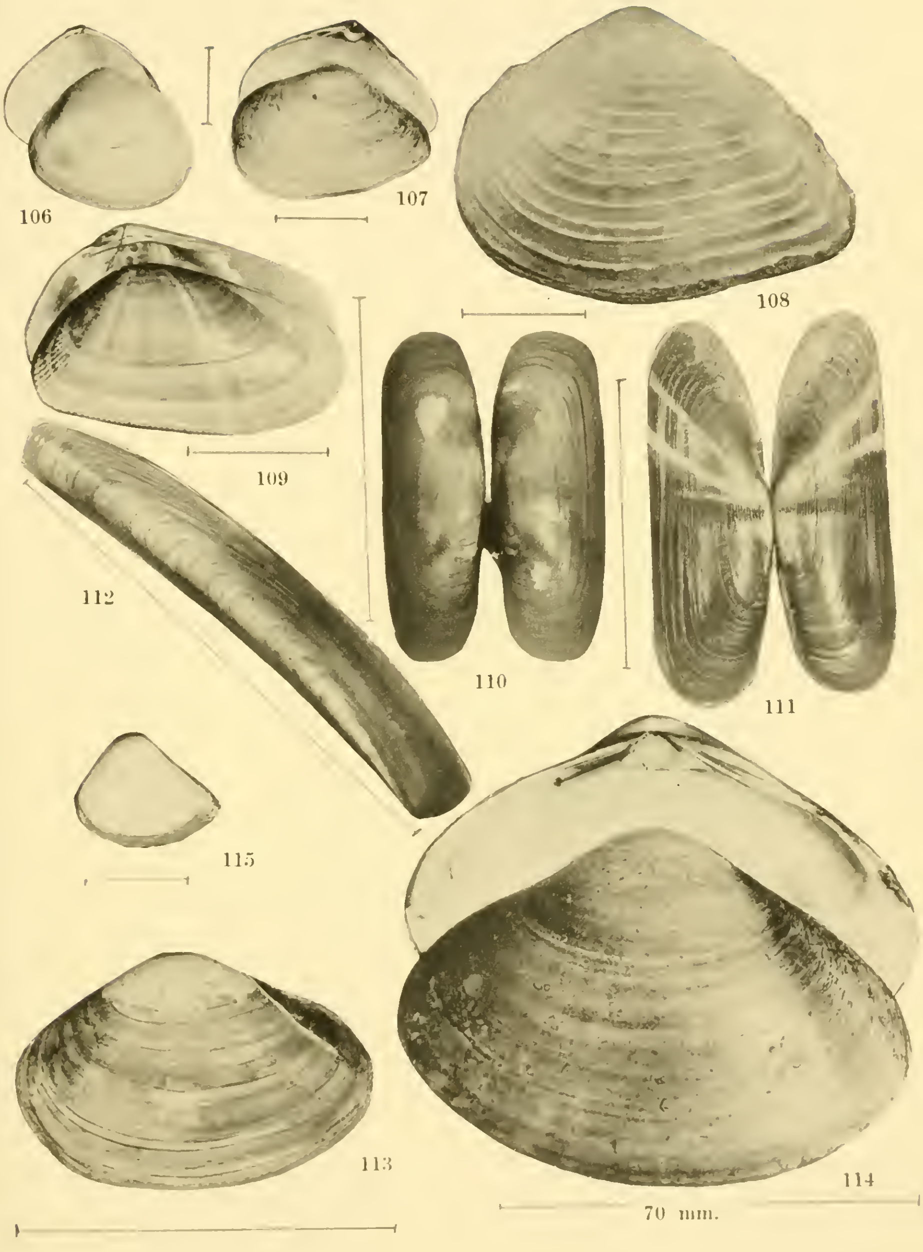


105

PLATE XVII (XVII)

EXPLANATION OF PLATE 17 (17)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107
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112
113
114
115
70 mm.

PLATE XVIII (XVIII)

EXPLANATION OF PLATE 18 (18)

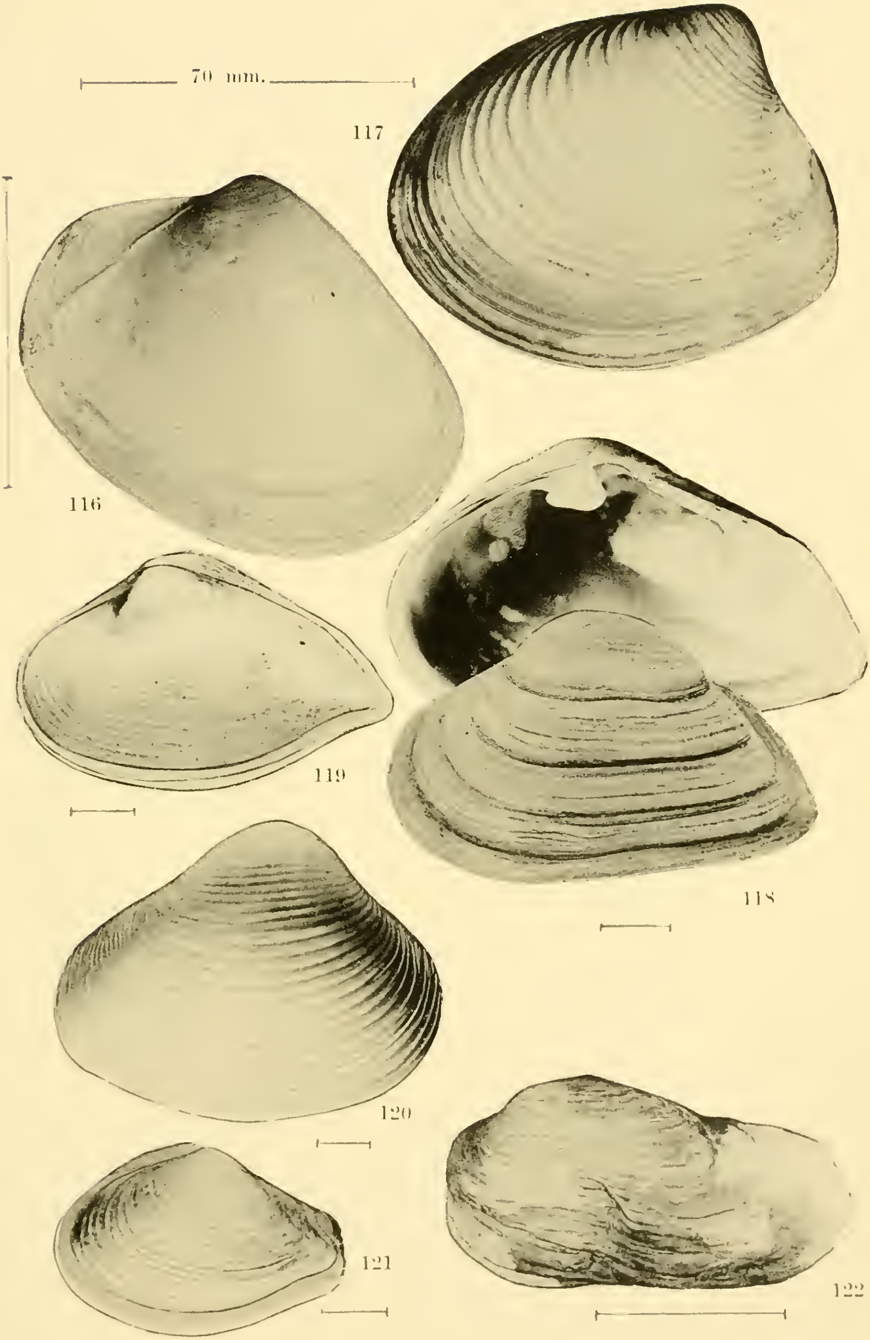

70 mm.
117
116
119
118
120
121
122

PLATE XIX (XIX)

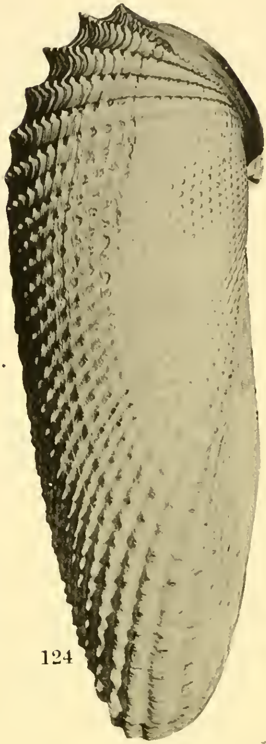
EXPLANATION OF PLATE 19 (19)

Figure		Page
123.	**Gastrochæna ovata** Sowerby Fig. a exterior view of left valve; fig. b interior view of right valve.	86
124.	**Barnea costata** Linné	87
125.	**Barnea truncata** Say	88
126.	**Martesia cuneiformis** Say	88
127.	**Martesia striata** Linné Fig. a umbonal view both valves together; fig. b molluscs burrowed in wood.	88


123a

150 mm.


123b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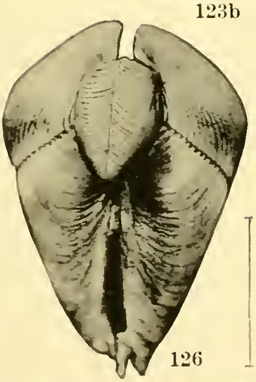
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127a

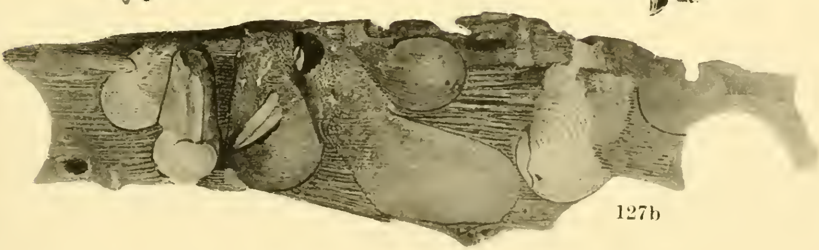
127b

PLATE XX (XX)

EXPLANATION OF PLATE 20 (20)

Figure		Page
128.	**Dentalium laqueatum** Verrill	91
129.	**Dentalium texasianum** Philippi	92
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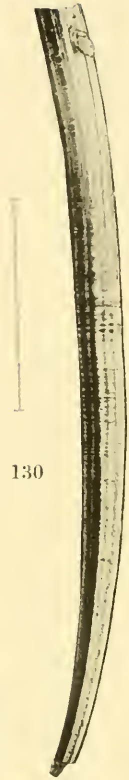

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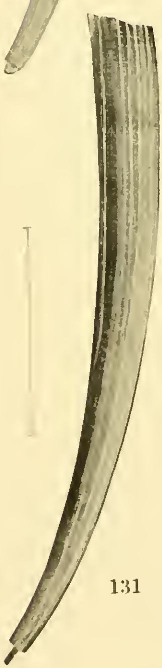

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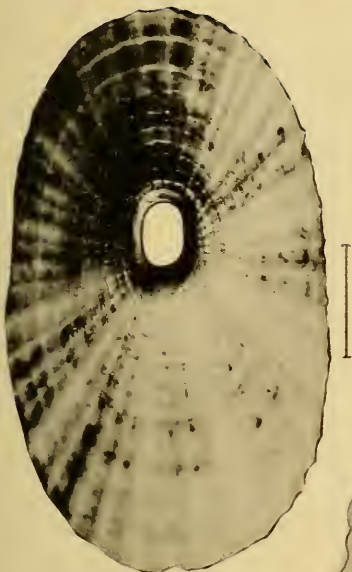

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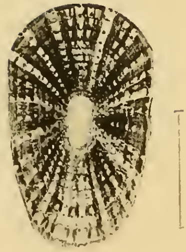

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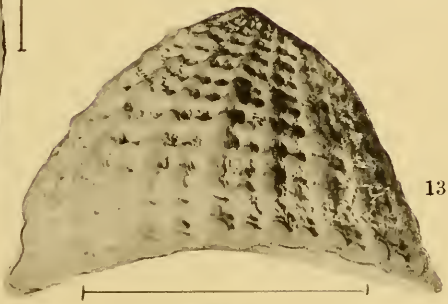

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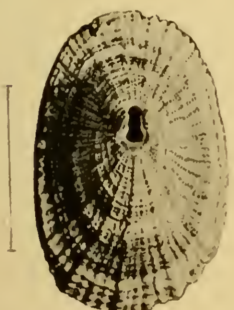

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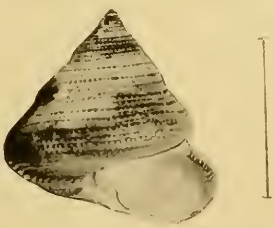

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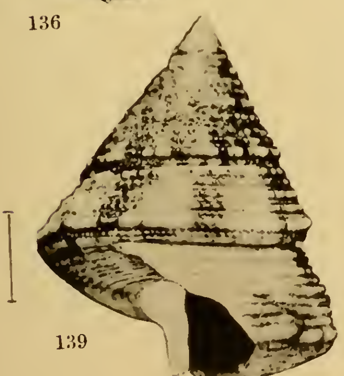

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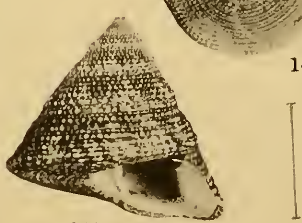

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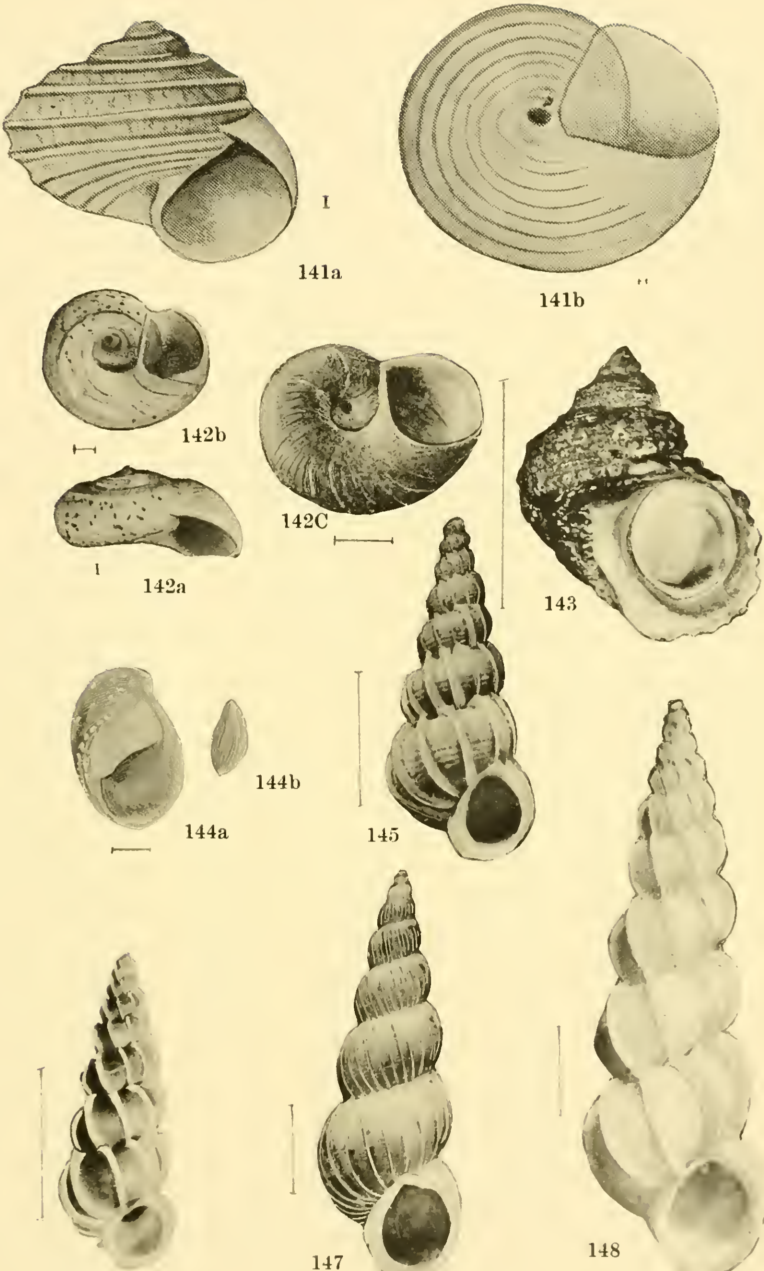
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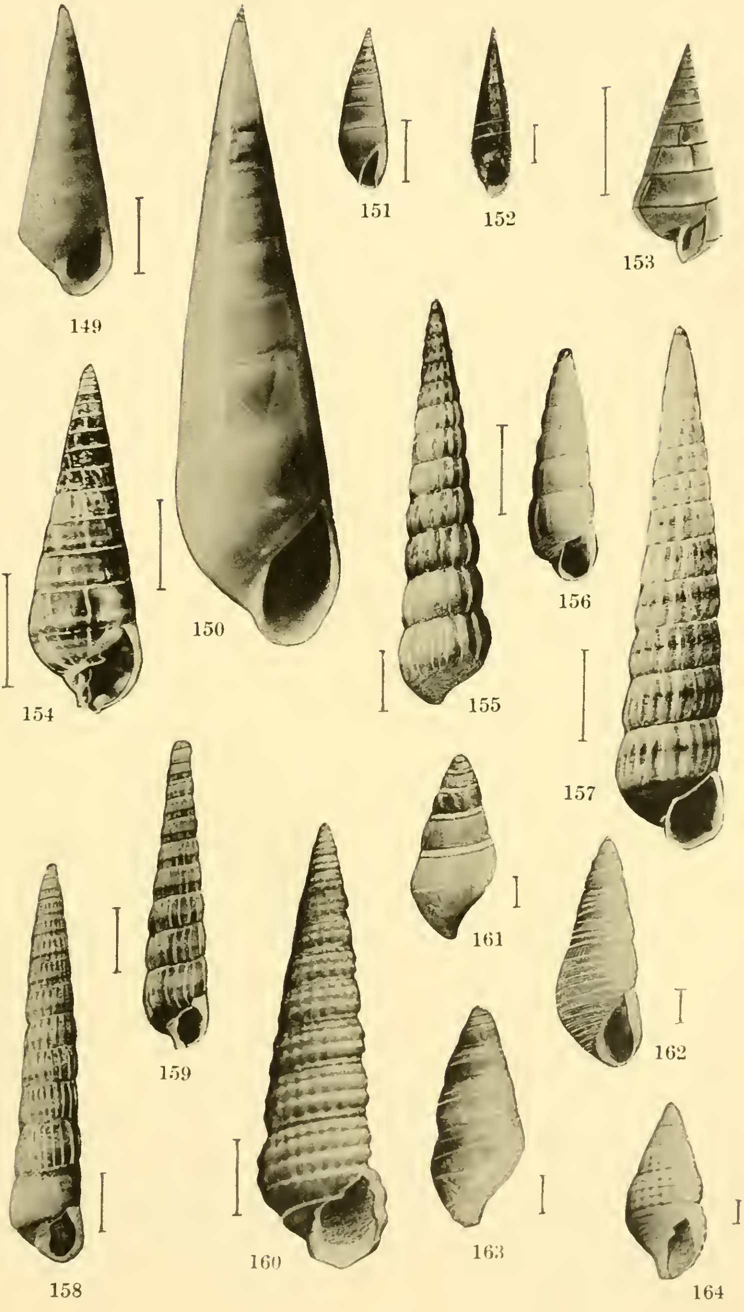
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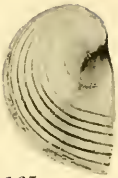

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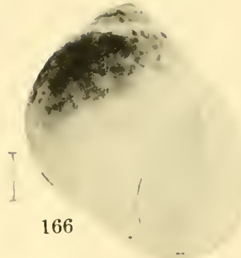

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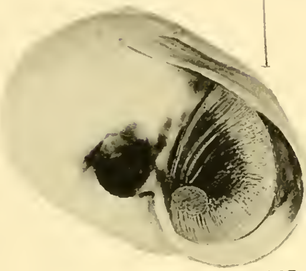

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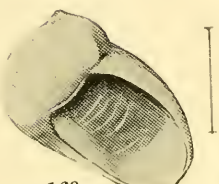

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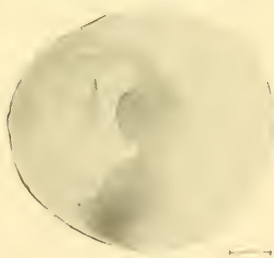

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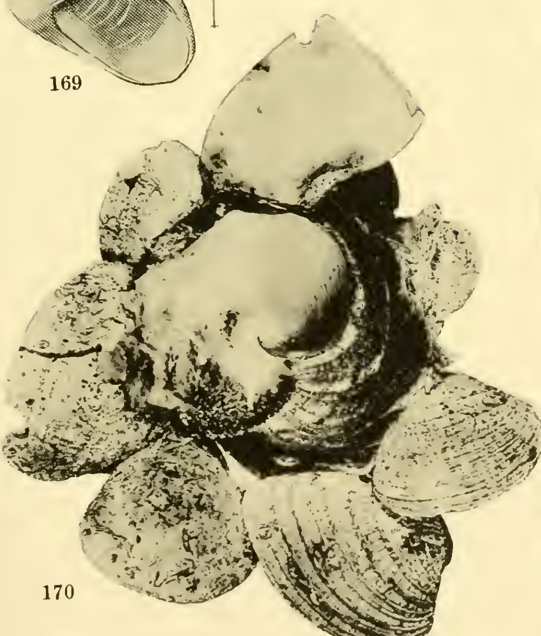

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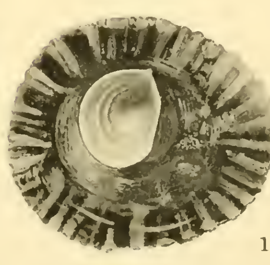

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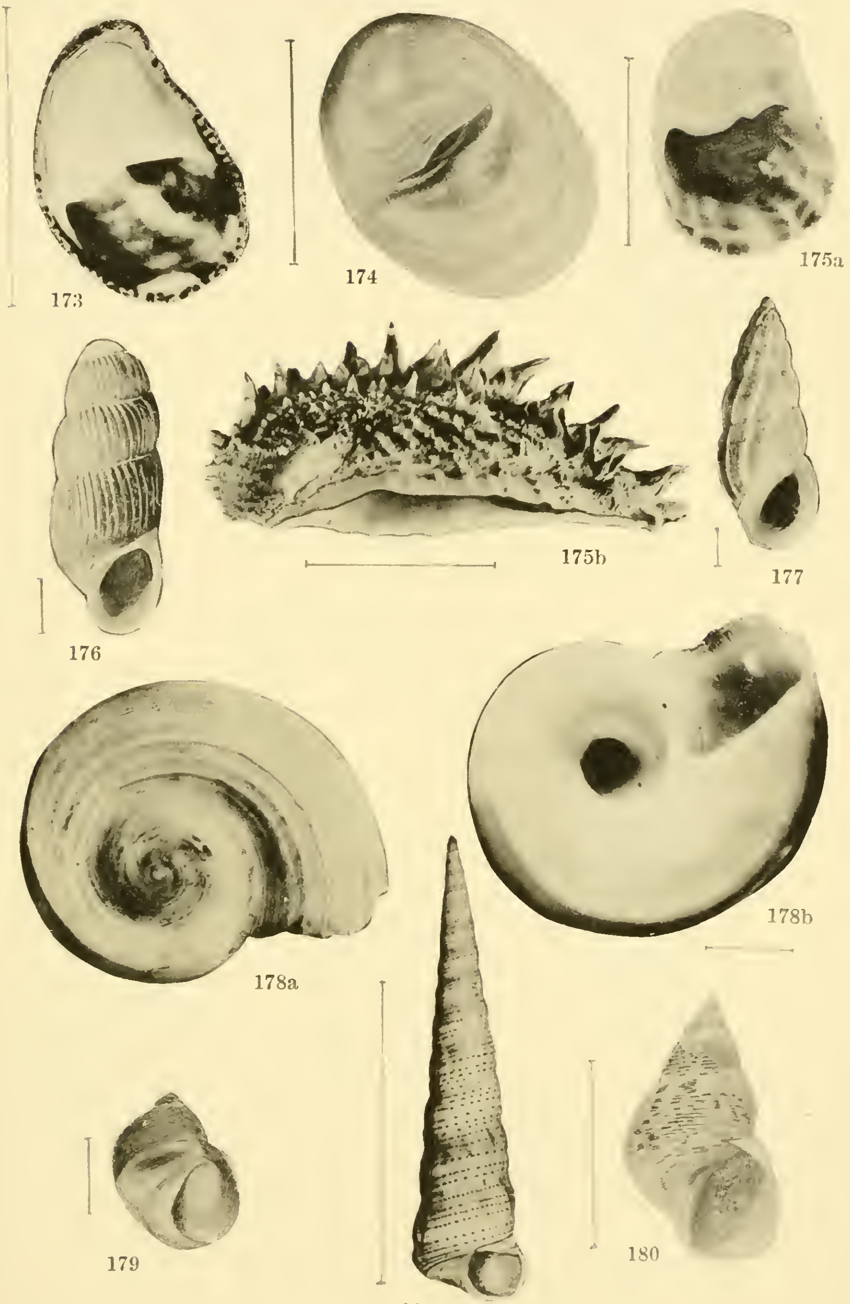
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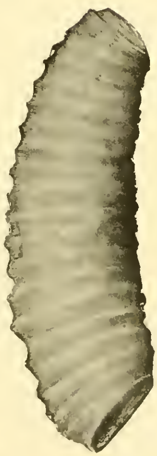

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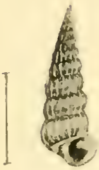

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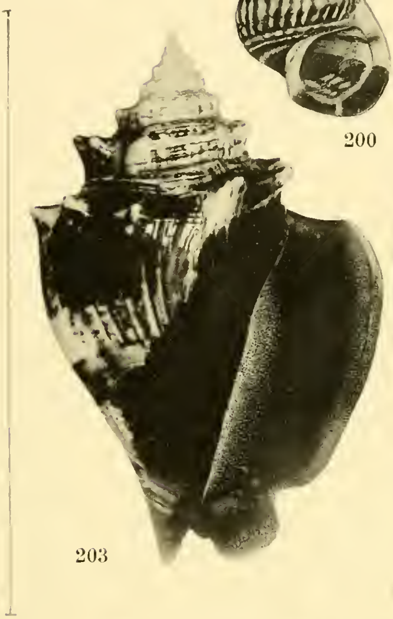

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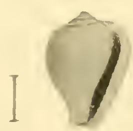

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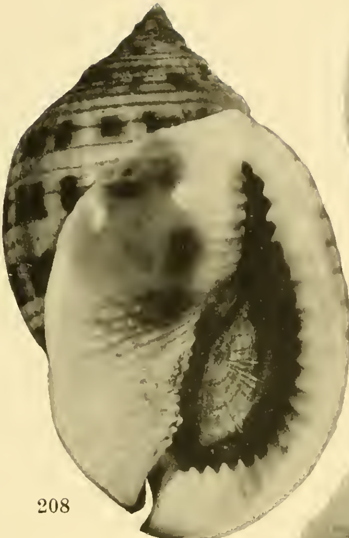

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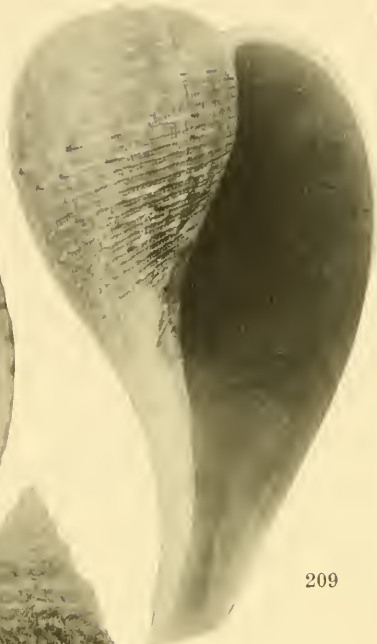

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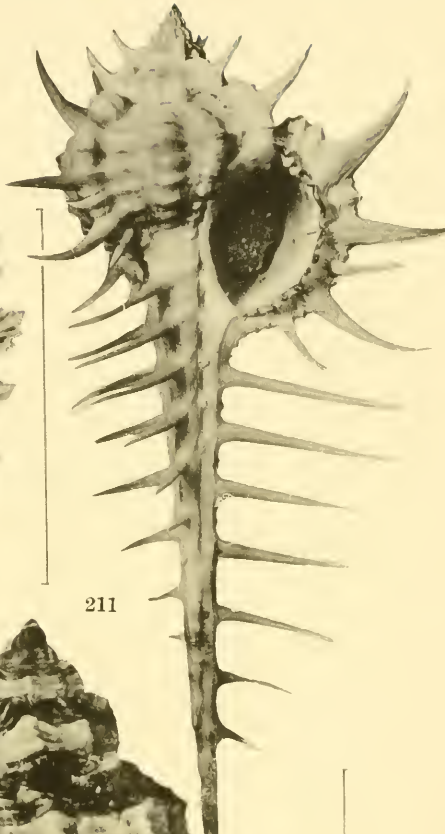

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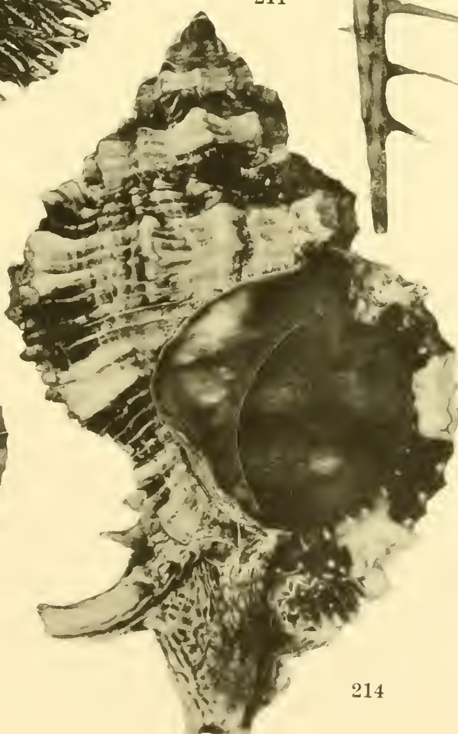

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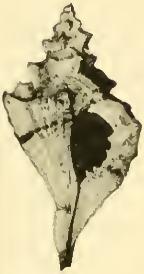

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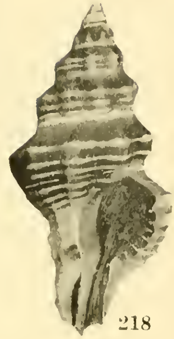

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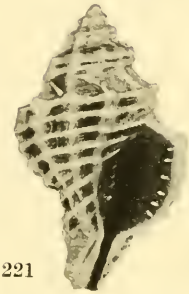

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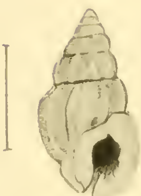

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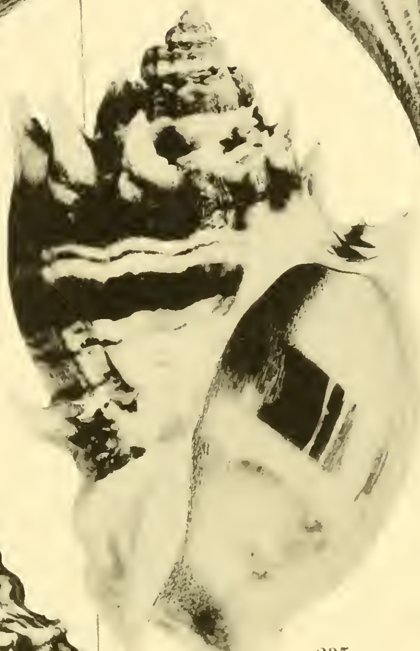

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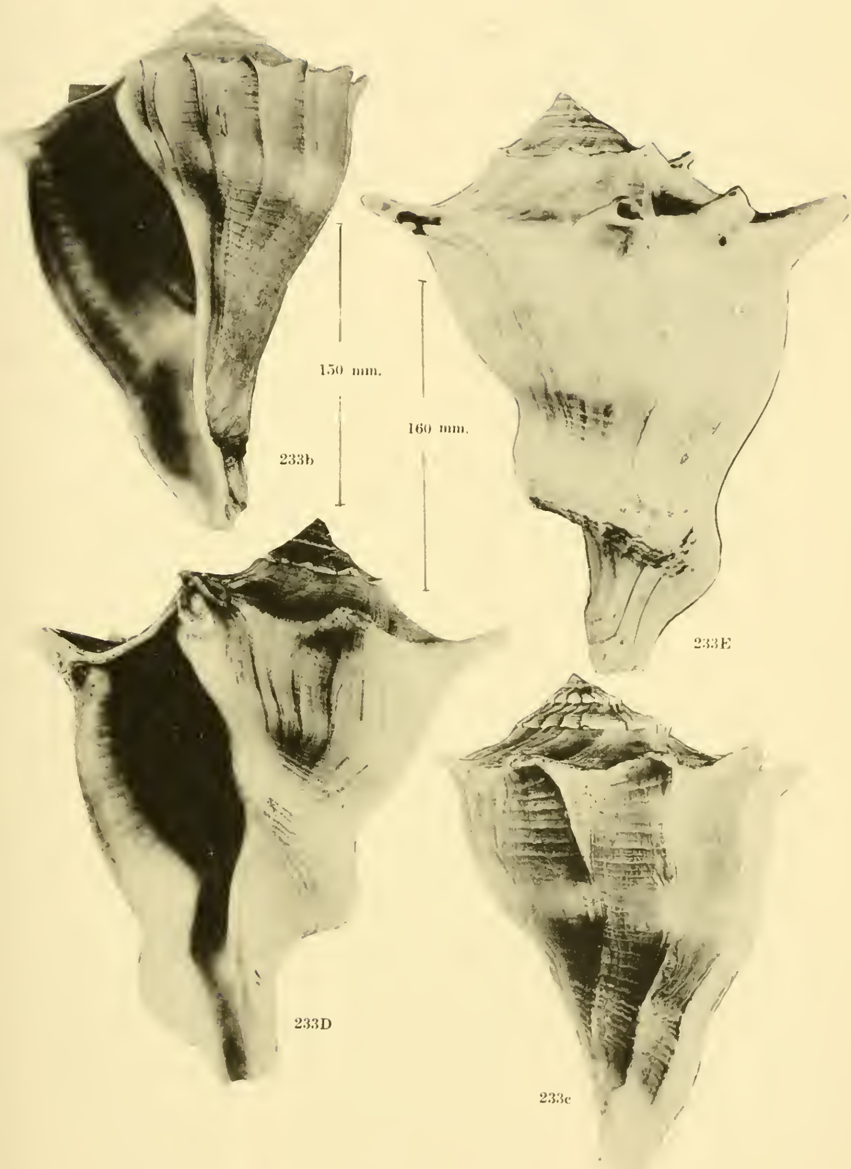
150 mm.
160 mm.
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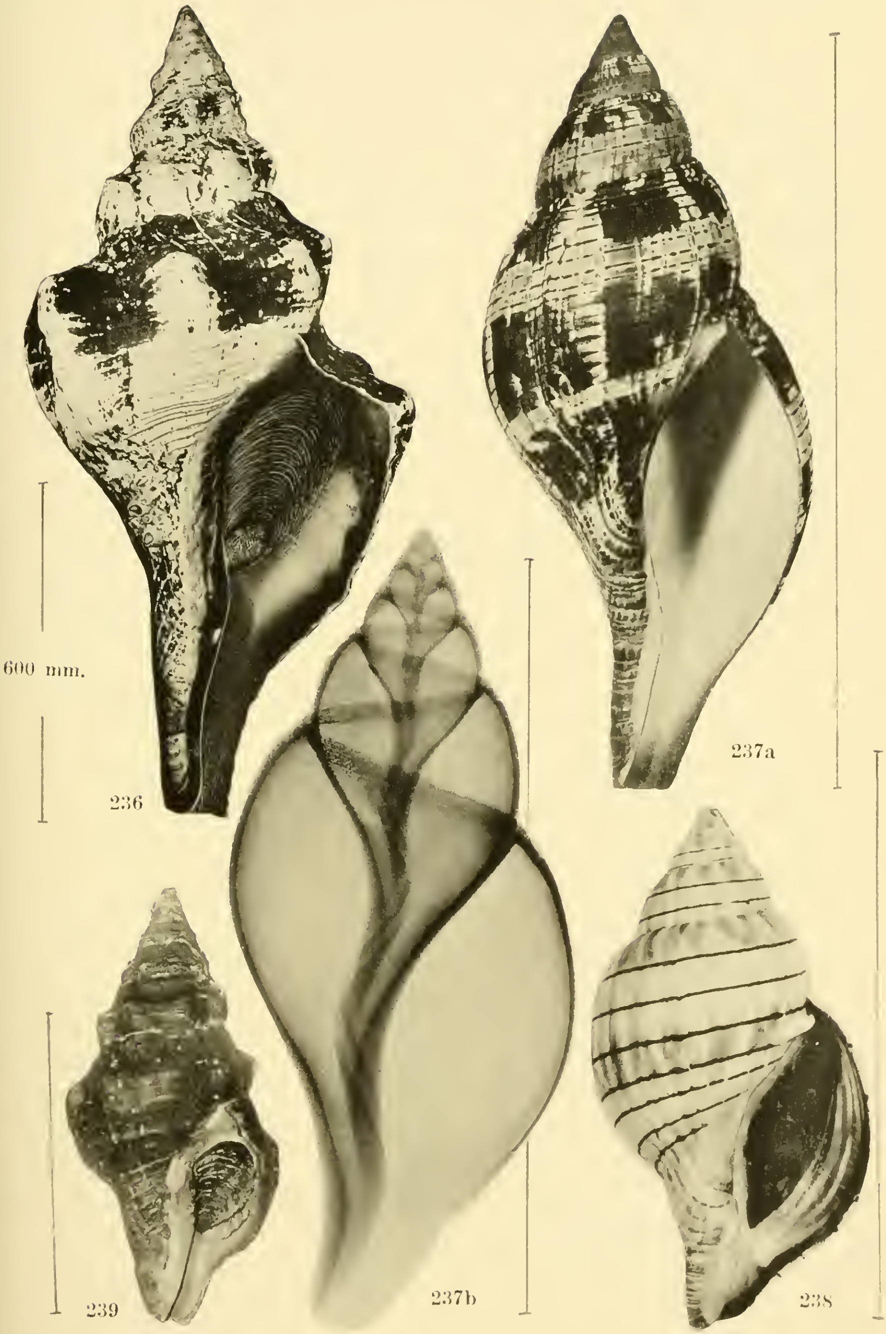
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Some Fossils from the Edwards Formation of Texas

By
William Clyde Ikins, M.A.
and
Stephen Edmund Clabaugh, B.S.

November 22, 1940

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U. S. A.

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SOME FOSSILS FROM THE EDWARDS FORMATION OF TEXAS

By

William Clyde Ikins, M.A.
and
Stephen Edmund Clabaugh, B.S.*

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The writers wish to thank the Department of Geology of The University of Texas for the use of its equipment.

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The camera lucida drawings were prepared by Mr. Clabaugh

INTRODUCTION

All the fossils described and figured in this paper were collected from a single locality in the Edwards formation in Kerr County, Texas. This locality is the crest of a low hill on the fence line separating the Allen and Strohacker ranches, about one-half mile southwest of the H. B. Allen ranchhouse on Bushwhack Creek, approximately 10 miles southwest of Kerrville. The zone in which organic remains are abundant occurs about 50 feet above the base of the massive limestone beds of the Edwards

* The University of Texas, Austin, Texas.

formation. Among the described species encountered are the following:—*Cottaldia rotula* Clark, *Phacoides acute-lineolata* (Roemer), *Trochus texana* Roemer, *Natica (Amauropsis) avellana* Roemer, *Nerinea austinense* Roemer, *Cerithium procteri* Cragin, and *Cerithium austinense* Roemer. There are also numerous corals and abundant rudistid and caprinid pelecypods. The fauna is characterized by the great number of species of gastropods.

This work is not an attempt to describe the fauna of the Edwards formation, or even that of the horizon from which these specimens were collected. At present the fauna of the Edwards has received very little study, due in part to the fact that the formation is usually present as a hard crystalline limestone from which it is difficult or impossible to obtain well-preserved fossils. The preservation of the fossils at the locality described above is unusual, for the shell material has been replaced by silica, and weathering of the limestone has freed specimens which are nearly perfect in detail. Mr. Carl Chelf of the Texas Memorial Museum has made extensive collections from a similar zone in the Edwards formation near Georgetown, Texas. It is probable that other similar occurrences will be found in the future, and that the fauna of the Edwards will become well known.

CONDITIONS OF DEPOSITION

The rock from which the fossils described in this paper were collected, consists of friable, poorly indurated calcareous material which contains an abundance of limonite. It represents a local reeflike deposit in which there is an abundance of organic remains. After the material was deposited, percolating waters filtered through the sediments and deposited crystalline calcite, which in turn was replaced by various types of silica. Some of the quartz occurs as pseudomorphs after the calcite. The fossils which have been completely replaced by quartz, weather out in an excellent state of preservation.

SYSTEMATIC DESCRIPTIONS

Phylum **PROTOZOA** von Siebold
Class **SARCODINA** Buetschli
Subclass **RHIZOPODA** Dujardin
Order **FORAMINIFERA** d'Orbigny
Family **LITUOLIDÆ** Brady

Genus **AMMOMARGINULINA** Wiesner

Ammomarginulina whitneyi, n. sp. Plate 1, figs. 1a, 1b

Description. Test large, early planispiral stage prominent, later stage uncoiled, uniserial; compressed throughout; coiled stage involute with three or four chambers visable, uniserial chambers few in number, flattened, crescent-shaped or semicircular; sutures slightly depressed, not distinct, sutures at base of uniserial chambers arched or curved upward; wall thick, composed of medium fine sand; aperture of adult narrow, linear, terminal, surrounded by slightly raised margin.

Dimensions.—The holotype is 2.1 mm. long., 1.4 mm. wide and about 0.5 mm. thick. Somewhat larger specimens have been observed.

Genus **LITUOLA** Lamarck

Lituola edwardsensis, n. sp. Plate 1, figs. 2a, 2b, 2c

Description.—Test large, early stages planispiral, later uncoiled, uniserial, and straight, followed by somewhat irregular uniserial arrangement of last few chambers; coiled chambers few in number, globular or spherical, rapidly increasing in size; uniserial chambers globular or slightly elongate; final chambers more loosely attached, elongate, tending to be flask-shaped, not in exactly straight series; wall thick, composed of medium to coarse sand, much cement, labyrinthic interior; aperture of coiled and early uniserial stages simple, rounded, large, in center of septal face, in later stages aperture cribrate.

Dimensions.—This species attains a length of more than 12 mm. and a width of 2.5 mm. Length of holotype, 11 mm.; width, 2.4 mm.

Phylum **ECHINODERMATA** (Lamarck) Cuvier
Subphylum **ECHINOZOA** Leuckart
Class **ECHINOIDEA** Bronn
Order **CENTRECHINOIDA** Jackson
Suborder **AULODONTA** Jackson
Family **HEMICIDARIDÆ** Wright
Genus **GONIOPYGUS** Agassiz

Goniopygus saleniaformis, n. sp. Plate I, figs. 3a, 3b, 3c, 3d

Description.—Test circular in outline; sides inflated, abactinal surface gently convex; adactinal surface almost flat.

The ambulacra are straight, widening gently from 1 mm. at the apical disk to 3 mm. at the ambitus, then narrowing to 2 mm. at the peristome. The surface is ornamented with two alternating rows of imperforate, mammillated, noncrenulate tubercles, ten in each row. Granules are arranged on the inner margins of the plates so as to form an irregular zigzag line between the tubercles. The pores are round, uniserial, becoming irregular below the ambitus.

The interambulacral areas are wider than the ambulacral areas, being 2 mm. wide in the plocogenous zone, 4.5 mm. in the median zone, and 2.5 mm. at the peristome. Each consists of two rows of large alternating plates, eight to the row. Each plate is ornamented with a smooth boss which supports a large imperforate mamelon. Granules are arranged such that there is one in the upper adradial corner, one in the lower adradial corner, and three on the median margins. Milliaries occur between the granules on the median margins of the plates.

The peristome is large and circular in outline. The basicoronal plates bear ten moderately developed branchial incisions which divide the peristome into ten almost equal parts.

The apical system is subpentagonal and elevated above the rest of the shell. It is composed of five ocular plates and five genital plates, in addition to which there is a suranal plate. The oculars are deltoid and are relatively straight on the outer margins. The genitals extend only slightly farther than the oculars. Each genital has rounded sides and is bluntly pointed. The suranal plate is in line with the left anterior genital plate. On the inner margin of the suranal plate and on the inner margins of the posterior genital and of the right anterior genital there is a depressed area in which there rests a mamelon. The left lateral and right anterior genitals do not show this ornamentation. All five of the genitals are perforate on their outer margins. The periproct is circular in shape. The madreporite is located in the right anterior genital plate and is V-shaped.

Remarks.—This species resembles members of the family *Saleniidæ* in that it possesses a suranal plate in the apical system. It has not been stated that the genus *Goniopygus* might possess a suranal plate. However, the characters of this species, such as the position of the perforations in the genitals, the straightness of the ambulacra and interambulacra, the character of the tubercles, and the remainder of the apical disk other than the suranal plate, point to the genus *Goniopygus*. As only one specimen was found, the presence of the suranal plate does not appear to be of generic significance as it may be due to some abnormality. The writers propose that the genus *Goniopygus* be emended to include such forms.

This species differs from *Goniopygus texanus*, n. sp., in that it possesses a suranal plate, has only three tubercles on the inner margin of the genitals, has ten interambulacral tubercles instead of eight, and has eight interambulacral tubercles instead of seven.

Dimensions.—Diameter at ambitus, 12.5 mm.; height, 7 mm.; apical disk, 5 mm.; peristome, 7 mm.

Goniopygus texanus, n. sp. Plate 1, figs. 4a, 4b, 4c, 4d

Description.—Test circular in outline, subconical; abactinal surface quite elevated, sides slightly inflated; adactinal surface flattened.

The ambulacra are straight and narrow, widening gently from 0.8 mm. at the apical disk to 3 mm. at the ambitus, then narrowing to 1 mm. at the peristome. Surface ornamented with two alternating rows of imperforate mammillated tubercles, about eight in each row. The pores are round, uniserial, becoming irregular upon reaching the peristome.

The interambulacral areas are wider than the ambulacral areas, being 2 mm. wide in the plocogenous zone, 3 mm. in the median zone, and 1.8 mm. at the peristome. Each consists of two rows of large alternating plates, seven to the row. Each plate contains a large imperforate mamelon which rests upon a smooth boss. Granules are arranged on the margins of the plates such that there is a scattered irregular row between the tubercles.

The peristome is large, wider than half the diameter of the test, and circular in outline. The basicoronal plates bear ten moderately developed branchial incisions which divide the peristome into ten almost equal parts.

The apical system is large and possesses a strongly developed pentagonal symmetry. It consists of five ocular plates and five genital plates. The oculars are small and notched on their outer margins. The genitals are elongate, pointed and perforate on their outer margins, and arranged to form a perfect star. Each genital is in contact with the periproct which is located in the center of the system. On the inner margin of four of the genitals there is a depression in the center of which there is a small mammillated tubercle. The left anterior genital does not possess such a tubercle. The madreporite is located on the outer portion of the right anterior genital plate and is more or less V-shaped. The periproct is ovoid to elliptical in shape.

Remarks.—This species shows some resemblance to *Goniopygus zitteli* Clark, which is also from the Edwards formation, but it is much smaller, has only eight ambulacral tubercles instead of eighteen to twenty, has only seven interambulacral tubercles instead of ten to twelve, and has only four tubercles on the inner margins of the genitals instead of five.

Dimensions.—Diameter at ambitus, 10.5 mm.; height, 5 mm.; apical disk, 5.5 mm.; peristome, 6 mm.

Family **CENTRECHINIDÆ** Jackson

Genus **COTTALDIA** Desor

Cottaldia rotula Clark Plate 1, figs. 5a, 5b, 5c

Cottaldia rotula Clark. Clark and Twitchell, 1915, U. S. Geol. Sur. Mon. 54, p. 57, pl. XX, figs. 1a-d.
Cottaldia rotula Clark. Whitney, 1916, Bull. Amer. Paleont., vol. 5, No. 26, p. 9, pl. IV, figs. 1-10, pl. V, figs. 1-2.
Cottaldia rotula Clark. Adkins, 1928, Univ. of Texas Bull. 2838, p. 279, pl. XXIII, fig. 3.
Cottaldia rotula Clark. Smiser, 1933, Journal of Pal., vol. 7, No. 2, p. 145, pl. 19, figs. 16, 17.

This interesting species, first described by Clark, and later so well described and figured by Professor F. L. Whitney has not heretofore been recorded from the Edwards. As pointed out by Professor Whitney, during its development it undergoes considerable change in form and proportions as well as in ornamentation. The specimen collected is apparently an adult.

Description.—Test of medium size, depressed, and circular in outline.

The ambulacral areas are widest at the ambitus. Surface ornamented with mammillated, crenulate, perforate tubercles arranged in transverse rows of two tubercles on each half of the area. A ring of granules is situated around each pair of tubercles. The pores are round, uniserial, and become crowded and irregular near the peristome.

The interambulacral areas are broad, about three times as wide as the ambulacral areas. The surface of each area is ornamented with alternating rows of tubercles each containing at least seven mammillated, crenulate, perforate tubercles in each half of the area at the ambitus. A ring of granules encircles each areola. The number of rows of tubercles is reduced toward the apical system and peristome.

The peristome is small, decagonal, and the branchial incisions are only moderately developed.

The apical disk is not preserved, but it was apparently about 4 mm. in diameter.

Dimensions.—Diameter at ambitus, 18.5 mm.; height, 13 mm.; apical disk, 4 mm.; peristome, 7 mm.

Phylum **MOLLUSCA** Cuvier
Class **GASTROPODA** Menke
Subclass **STREPTONEURA** Spengel
Order **ASPIODOBRANCHIA** Schweigger
Suborder **RHIPIDOGLOSSA** Troschel
Family **STOMATIIDÆ** Gray
Genus **STOMATIA** Lamarck

Stomatia texana, n. sp. Plate 1, figs. 6a, 6b, 6c

Description.—Shell trochoid, depressed; composed of three rapidly expanding whorls; spiral angle about 117°; sutures well defined; aperture elliptical, columella thin and simple; surface ornamented with three sharp, well-defined spiral lines or carinations located on the outer margin of the whorl. These are so arranged that the largest, located on the periphery, is separated anteriorly from the other two by a shallow furrow. Each whorl covers the largest carination of the preceding whorl, so that only the two smaller are visable on the spire. The upper surface of the whorl is ornamented with fine growth lines transversed by very fine spiral lines.

Remarks.—This species does not closely resemble any species yet described in this country. *Stomatia aspera* d'Orbigny from the Cretaceous of France is similar in general appearance, but it does not possess the carinations, and has a lower spire.

Dimensions.—Height, 4 mm.; width, 10 mm.

Family **TROCHIDÆ** Adams
Genus **MONODONTA** Lamarck

Monodonta texana, n. sp. Plate 2, figs. 1a, 1b

Description.—Shell small, turbinate, thick; composed of seven whorls; spiral angle of early stage about 80°, decreasing to about 50° in the adult whorls; sutures moderately deep and quite distinct; upper surface ornamented by about five to six revolving rib omposed of distinct nodes; lower surface marked by about ten milar ribs which are smaller and less distinct; aperture reniform, outer lip thickened, simple, inner lip smooth, not calloused; columella ending below in a distinct tooth.

Dimensions.—Height, 13 mm.; width, 10.5 mm.

Family NERITIDÆ Lamarck

Genus NERITA Linnæus

Nerita edwardsensis, n. sp. Plate 2, figs. 2a, 2b

Description.—Shell small, thick, rounded and composed of three whorls; spire moderately low, angle about 100°; sutures shallow; upper surface ornamented by numerous thin, projecting oblique ribs; under surface ornamented by several indistinct spiral lines composed of small nodes; aperture crescentic, outer lip thickened, with a slight toothlike projection on the anterior margin, inner lip broadly calloused, bearing about five distinct teeth of almost equal size.

Dimensions.—Height, 15 mm.; width, 17 mm.

Genus PILEOLUS Sowerby

Pileolus whitneyi, n. sp. Plate 2, fig. 3a, 3b, 3c

Description.—Shell small, discoidal, depressed; summit slightly elevated, ornamented by about 40 more or less equally developed radiating ribs; margin thin, dentate; base convex, tumid near the middle; aperture small, within the margin of the base, semilunar, outer lip curved; inner lip straight, bearing seven distinct teeth.

Remarks.—Sowerby in his description of this genus in 1823 stated that the spiral is internal and very short. On this basis he placed it in the Neritidæ. However, sections of this species failed to reveal any trace of coiling.

Dimensions.—Height, 10 mm.; lateral diameter, 11.5 mm.; posterior-anterior diameter, 5.2 mm.

Order CTENOBRANCHIATA Schweigger

Suborder PLATYPODA Lamarck

Superfamily PTENOGLOSSA Gray

Family SOLARIIDÆ Chenu

Genus SOLARIUM Lamarck

Solarium pseudoplanorbis, n. sp. Plate 2, figs. 4a, 4b, 4c

Description.—Shell small, thick, discoidal, spire very low; whorls four, rounded; smooth externally except for faint growth lines or ridges close to the spiral suture and the umbilicus; umbilicate posteriorly; umbilicus approximately equal in width to one-fourth the diameter of the shell; bordered by a distinctly crenulate ridge on the inner margin of which is a deep furrow; aperture rounded, outer lip thinner than the shell wall.

Remarks.—This species is somewhat similar to *Solarium planorbis* Roemer, also from the Edwards formation. However, it is much smaller, less nearly planispiral, the furrow in the umbilicus is more prominent, and the aperture more rounded. In his description Roemer makes no mention of the aperture of *S. planorbis*, but his figures show the species to be almost planispiral, with the aperture quadrate and elongated in the place of coiling.

Dimensions.—Height, 2.5 mm.; width, 7 mm.

Superfamily **TÆNIOGLOSSA** Bouvier
Family **CERITHIIDÆ** Menke
Genus **CERITHIUM** Adanson

Cerithium bushwhackense, n. sp. Plate 2, figs. 5a, 5b

Description.—Shell turreted, thin, composed of ten whorls, moderately convex, spire slightly inflated, angle of early stage near 40° decreasing in adult stage to about 28°; sutures distinct; aperture oblong, with well-developed backwardly curved canal; outer lip unknown; inner lip smooth, slightly calloused; surface ornamented by numerous small, gentle, longitudinal ribs which do not extend to the anterior margin of the whorl. Below the suture on the anterior portion of the whorl are two spiral lines of small nodes. The longitudinal ribs are transversed by very fine revolving striæ. Anterior surface of whorl nearly smooth.

Dimensions.—Height, about 35 mm.; width, 11 mm.

Cerithium kerrvillense, n. sp. Plate 2, figs. 6a, 6b

Description.—Spire elevated, composed of about ten whorls, spiral angle about 25°; sutures distinct, sinuous; aperture rounded; columella simple with short curved canal at base; inner lip prominent, projecting slightly; outer lip thickened, simple; whorls characterized by strong longitudinal costæ, usually seven to each volution. The prominent longitudinal costæ and the interspaces tend to alternate in position in adjacent whorls so that they are seldom aligned vertically. On the last formed body whorl only the transverse costa approximately 180° removed from the aperture and the one adjoining the aperture are prominent, but these two are quite pronounced. The costæ and the interspaces are traversed by six or seven prominent revolving lines, between each pair of which is a fine sharp line.

Remarks.—This species does not resemble any other species known to the writers, but upon close examination it may be seen to have certain characteristics in common with *C. austinense* Roemer with which it commonly occurs. Both have six to eight prominent spiral lines per whorl with intercalated fine lines. However, the longitudinal costæ of the whorl of *C. austinense* are aligned vertically so that the shell has a subprismatic appearance.

Dimensions.—Height, 43 mm.; width, 17 mm.

Cerithium roemeri, n. sp. Plate 2, figs. 7a, 7b

Description.—Shell turreted, about eight whorls, each moderately convex; spire straight, angle about 23°; sutures deep and well defined; aperture subquadrate; acute posteriorly-anteriorly; short anterior canal; columella simple; lip unknown; surface ornamented by very fine faint growth lines which are slightly inclined. These lines are traversed by four thin, sharp, prominent spiral ribs. These are spaced such that the first and the fourth are quite near the suture, and the remaining part of the whorl is equally divided into three broad sunken bands by the other two. In the youthful portion of the shell the suture is poorly developed or lacking, and the ribs are formed of partially fused rows of small tubercles.

Remarks.—This species resembles *C. ataxense* d'Orbigny from the rudistid beds of the Cretaceous of France in general appearance, but our species has four revolving ribs whereas that species cannot be considered to have more than three. Also, the anterior canal of our species is more extended than that of *C.*

elaxense.

Dimensions.—Height, 35 mm.; width, 12.5 mm.

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PLATES

PLATE I (40)

EXPLANATION OF PLATE 1 (40)

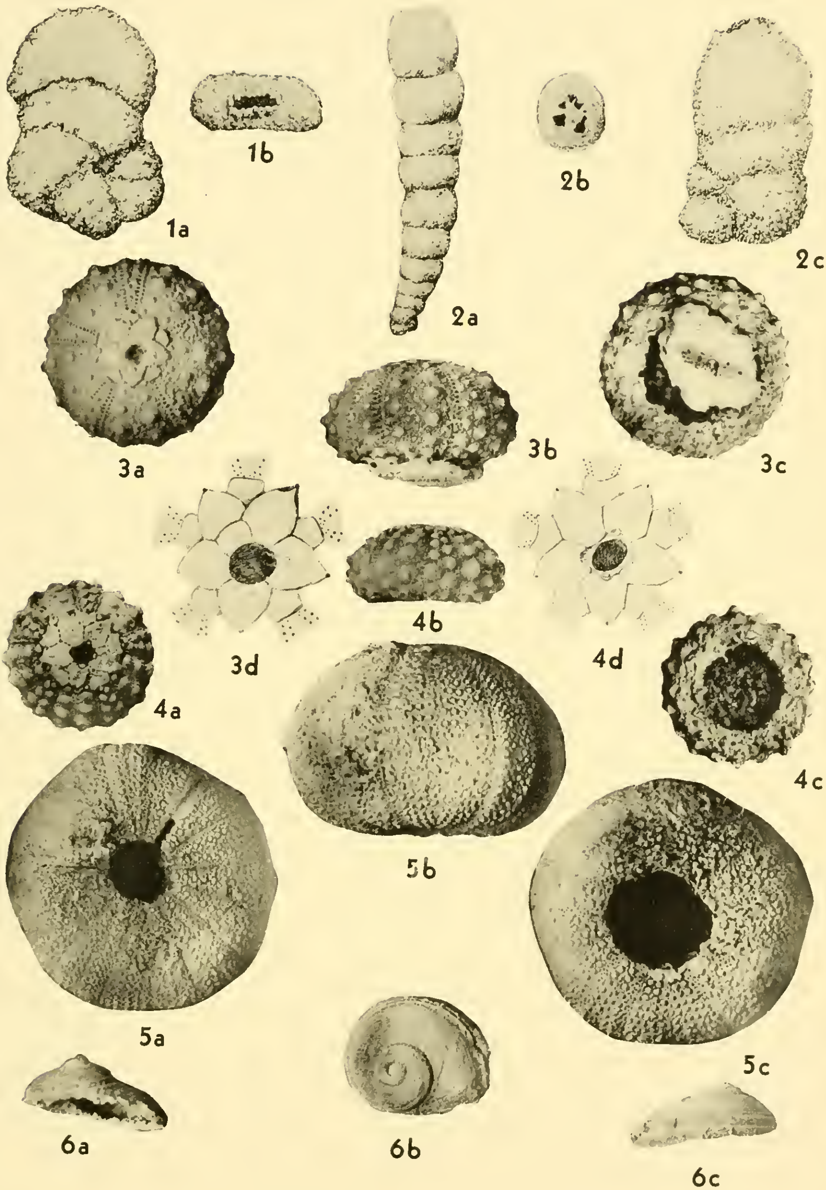
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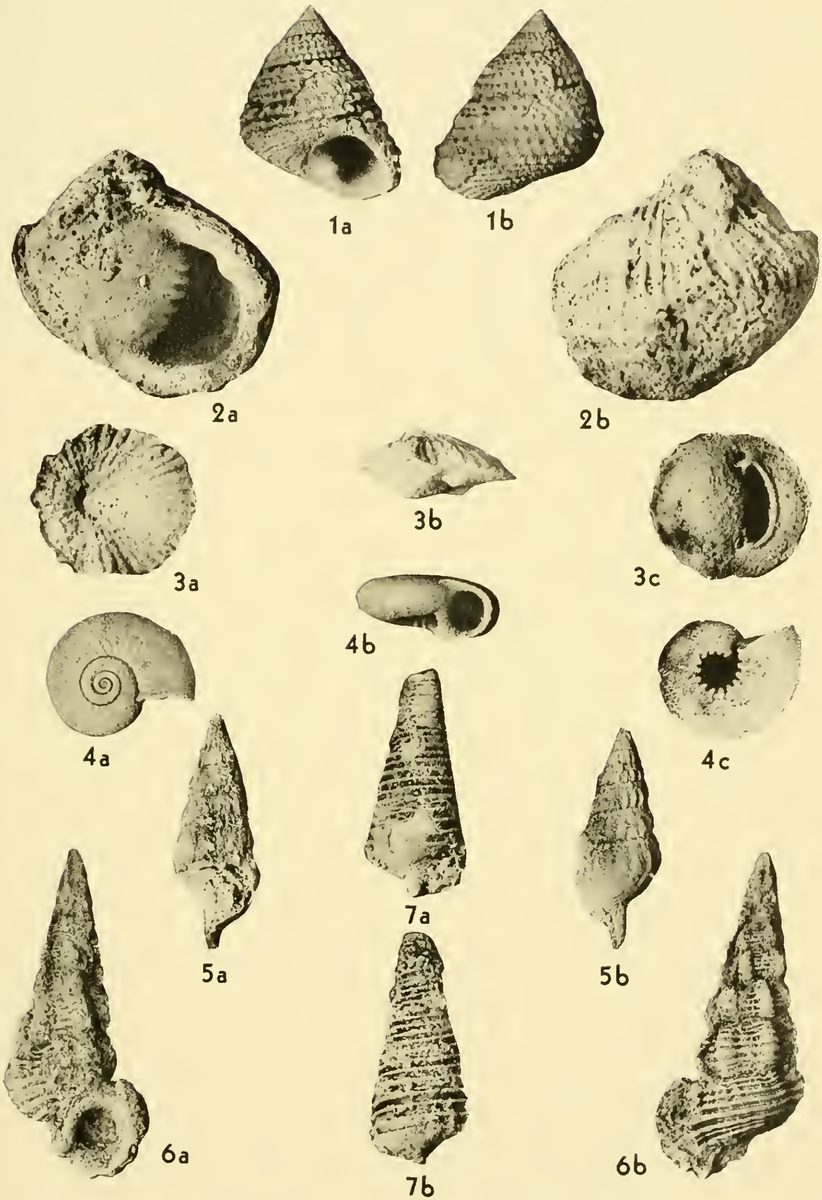
PLATE 2 (41)

EXPLANATION OF PLATE 2 (41)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Upper Cretaceous Corals from Cuba

By

John W. Wells

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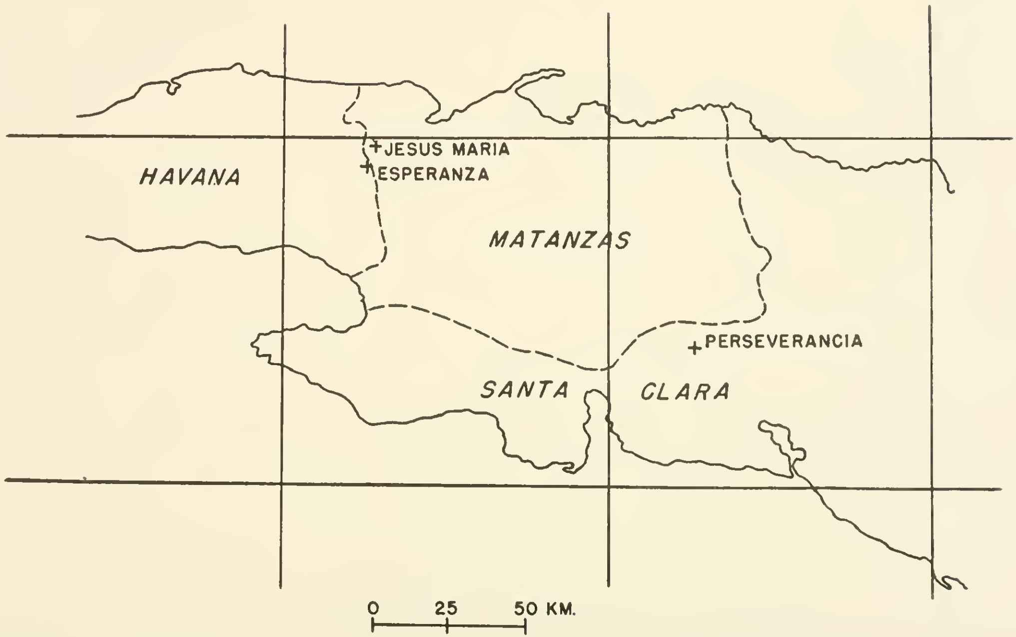


Sketch map of the central part of Cuba showing localities of Upper Cretaceous corals described.

UPPER CRETACEOUS CORALS FROM CUBA

By

JOHN W. WELLS

INTRODUCTION

The scleractinian corals described here consist of two small collections made several years ago from Upper Cretaceous rocks at three localities (see outline map) in Cuba by Norman Weisbord and Roy E. Dickerson, by whom they were kindly offered to the writer for description. They proved to be particularly interesting because they are the first corals of this age to be described from this area[1] and also because of their close relationships with the now fairly well-known and distinctive Upper Cretaceous coral fauna of Jamaica. The writer appreciates the opportunity of studying these corals and hopes that future collecting in Cuba will add to this small contribution.

SYSTEMATIC DESCRIPTIONS

Family ASTROCŒNIIDÆ

Genus ASTROCŒNIA Milne Edwards and Haime, 1848

Astrocœnia dickersoni, n. sp. Plate 2, fig. 4

Description.—Encrusting; corallites polygonal; calices closely fused, with single beaded walls or separated by shallow grooves, averaging 2.75 mm. in diameter, ranging from 2.0 to 3.0 mm. Septa scarcely exsert, upper margins beaded, in three hexameral cycles (24 septa). The septa of the first two cycles extend to the columella; those of the third are rudimentary. The septa of the second cycle are slightly thinner and less prominent than those of the first. Basal and marginal epitheca present. Columella small and styliform.

1 The presence of corals has been noted in the Big Boulder Bed member of the Habana formation (U. Cretaceous-Maestrichtian) in Havana Province by R. H. Palmer (Jour. Geol., xlii, 1934, p. 131).

The holotype is a small colony from 3 to 8 mm. thick encrusting both sides and the edge of a molluscan shell fragment.

Specimen.—Paleontological Research Institution.

Occurrence.—Ravine one kilometer west of Central Perseverancia, Santa Clara Province (Dickerson).

Remarks.—Only two other species of this genus are now known to occur in the Caribbean Upper Cretaceous: *A.* sp. *cf. A. ramosa* E. and H. Gerth[2], an octameral form from the Seroe Teintje limestone of Curacao, and *Astrocœnia* sp. Gerth from the same locality and also octameral. There are no species of the genus known from the Upper Cretaceous of eastern North America, and from the hexameral species of the European Upper Cretaceous the new Cuban form is distinguished by the larger corallites and by the union of the septa of the first two cycles with the columella. Three hexameral species were described from the Upper Cretaceous of southern India by Stoliczka[3]: *A. pumila* (Arrialoor group), *A. reussiana* (Ootatoor group), and *A. retifera* (Ootatoor group). Only the last has any resemblance to *A. dickersoni,* but has the third septal cycle well developed instead of rudimentary.

Family AGARICIIDÆ

Genus TROCHOSERIS Milne Edwards and Haime, 1849

Trochoseris catadupensis Vaughan, 1899 Plate 1, fig. 1

Trochoseris catadupensis Vaughan, 1899, Bull. Mus. Comp. Zool., Harvard, xxxiv, p. 242, pl. 39, figs. 5, 6; Wells, 1934, Proc. U. S. Nat. Mus., lxxxiii, p. 78, pl. 2, figs. 9, 10.

Description.—Solitary, trochoid, expanding rapidly from the base of attachment, calice broad and shallow with elongate fossette. Epitheca absent; wall externally costate. Septa very thin and nearly equal in thickness, numerous, with upper margins finely and regularly beaded, imperforate except for those of the higher cycles, united by regularly disposed synapticulæ throughout their extent and by their inner ends. Columella very small,

2 Gerth, H.: *Beitrage zur Kenntniss der mesozoischen Korallenfauna von Sudamerika,* Leidsche Geol. Med., iii, 1928, pp. 3-4.

3 Stoliczka, F.: *The Cretaceous Fauna of Southern India. The Corals or Anthozoa,* Pal. Ind., iv, 1873, pp. 26-28, pl. 4, f. 7; pl. 5, figs. 2, 3, 4,

elongate, trabecular, with papillose surface. Dissepiments absent or very rare.

Dimensions.—

	Height	*Diameters*	*Septa*
Specimen a	20 mm.	39 x 48 mm.	ca. 560
Specimen b	15 --	ca. 40 --	ca. 350

Specimens.—Paleontological Research Institution.

Occurrence.—Cuba: with an Upper Cretaceous (Campanian) rudistid fauna in a field about 350 meters west of Central Jesus Maria, about 20 kilometers southwest of Matanzas, Matanzas Province (6 specimens) (Weisbord).

Jamaica: Upper Cretaceous (Campanian) rudistid limestone near Catadupa.

Remarks.—A striking thing about this species is the large number of septa compared with the size of the corallum,—from 7 to 8 more or less complete cycles.

One specimen shows the *Cyathoseris*-condition, with four centers, the result of circumoral budding close to the original center.

Family **HAPLARÆIDÆ**

Genus **HAPLARÆA** Milaschewitsch, 1876

Haplaræa ? discrepans, n. sp. Plate 1, fig. 2

Description.—Solitary, elongate-cornute, usually slightly compressed, probably free in ephebic stages, exterior apparently covered by a thin, easily-eroded epitheca. Wall mostly parathecal (dissepimental), partly synapticulothecal, imperforate except near the calice. Costæ thin, united by thin exotheca. Calice usually elongate but circular in some specimens, shallow. Septa numerous, thin and laminar, arranged in at least 5 complete cycles (96) and usually with some part of the sixth, irregularly perforate throughout their extent, not filling up basally to any extent, those of the higher cycles usually uniting by their inner ends to those of the preceding cycles. Upper margins of septa probably beaded. Endotheca vesicular, extensive basally but present only near the wall in upper parts of the corallum. Synapticulæ simple, irregularly distributed, fairly abundant in the mural and columellar regions. Columella feeble, usually elongate, formed by a few detached inner septal trabeculæ.

Dimensions.—

	Height	*Diameter*	*Septa*
Holotype	46 mm.	28 x 33 mm.	*ca.* 120
Paratype	27 --	20 x 30 --	*ca.* 100
Paratype	33 --	21 --	*ca.* 100

Specimens.—Holotype and 7 paratypes, Paleontological Research Institution.

Occurrence.—Ravine one kilometer west of Central Perseverancia, Santa Clara Province (Dickerson).

Remarks.—The generic position of this new form is perplexing. The irregularly porous septa indicate a position in the Haplaræidæ, but the cornutiform shape of the corallum is not like that of either of the two solitary haplaræid genera,—*Haplaræa* Milaschewitsch and *Physoseris* Vaughan. Instead, it is more like that of *Epistreptophyllum* Milaschewitsch, a solitary calamophylliid, but the septa are much more porous than in any of the agariciöid corals. The endothecal dissepiments are not so extensively developed as in *Physoseris* and the septa are more porous than in that genus. All the structures correspond to those of *Haplaræa* except for the form of the corallum, which is normally cylindrical with a broad basal attachment in *Haplaræa* and cornutiform and eventually free in the new species. It is doubtful whether this difference justifies generic separation from *Haplaræa*.

All the specimens are considerably worn, hence the presence or absence of an epitheca cannot be ascertained, nor can the beaded upper septal margins be seen. The septa are thinner than usual in the fungiöids and because of poor preservation the type of trabecular structure cannot be definitely determined,—whether simple or compound. In some specimens the septa on the inner side of the curvature of the corallum are considerably thickened by stereome, giving the appearance of the thick, compounl trabeculæ characteristic of the Haplaræidæ and related families. It is probable that the trabeculæ are compound, but this uncertainty, together with the cornutiform corallum, makes the reference to *Haplaræa* tentative. The coral may prove to be nearer *Epistreptophyllum.*

Family LEPTOPHYLLIIDÆ

Genus LEPTOPHYLLIA Reuss, 1854

Leptophyllia sanchez-roigi, n. sp. Plate 1, fig. 3

Description.—Solitary, low, turbinate, fixed by a small spreading base. Corallite wall nonepithecate, synapticulothecal, nearly imperforate, externally costate with beaded costæ corresponding to all septa. Calice with deep, elongate fossette and highly exsert septa. . Septa composed of small compound trabeculæ, regularly porous especially internally and near the calice, those of higher cycles more so than those of the lower ones, united by simple synapticulæ in the columellar and mural regions. Number of septa in holotype, about 192 (6 complete cycles); in paratype about 100 (5 complete cycles and part of sixth). Columella small elongate, deep in the fossette, papillose. Dissepiments very feeble, observed only in the vicinity of the wall.

Dimensions.—

	Height	*Diameter*
Holotype	20 mm.	44 x 48 mm.
Paratype	21 --	33 x 37 --

Specimens.—Holotype and 2 paratypes, Paleontological Research Institution.

Occurrence.—Ravine one kilometer west of Central Perseverancia, Santa Clara Province (Dickerson).

Remarks.—This species is readily distinguished from *L. agassizi* Vaughan[4] from the Upper Cretaceous of Jamaica by its much larger size, different form, proportionally fewer and much thicker septa, and from *Trochoseris catadupensis* by the fewer but thicker septa. The columella is unusually well developed for this genus, whereas the synapticulæ are relatively few.

Family CYCLOLITIDÆ

Genus PARACYCLOSERIS Wells, 1934

Paracycloseris elizabethæ Wells, 1934 Plate 2, fig. 1

Paracycloseris elizabethæ Wells, 1934, Proc. U. S. Nat. Mus., lxxxiii, p. 86, pl. 3, figs. 5-10; pl. 5, figs. 1, 2.

Specimens.—Paleontological Research Institution.

[4] Vaughan T. W.: Mus. Comp. Zool., Harvard, Bull. xxxiv, 1899, p. 242, pl. 40, figs. 1-4.

Occurrence.—Cuba: ravine one kilometer west of Central Perseverancia, Santa Clara Province (3 specimens of *forma robustum*, 7 of *forma turbinatum*, and 25 of *forma typicum*) (Dickerson); near Esperanza, about 10 kilometers east of Madruga, Havana Province (3 specimens of *forma robustum*) (Weisbord).

Jamaica: Upper Cretaceous (Campanian) rudistid limestone near Catadupa (type locality).

Mexico: Upper Cretaceous (Cardeñas beds), San Luis Potosi.

Remarks.—Thirty-eight specimens referable to this species have been examined, 35 from the Santa Clara locality, and 3 from the Esperanza locality. Some of them show considerable individual variation from the two type specimens described by the writer from Jamaica in 1934, and now three growth-forms can be distinguished: *forma typicum*, *forma robustum*, and *forma turbinatum*. The typical discoidal specimens, 25 in number, all from Central Perseverancia, are all smaller than the Jamaican types, but show no other differences. The dimensions of a few follow:

	Height	*Diameter*
Jamaican type	10 mm.	29.5 mm.
,, ,,	3.5 --	26.0 --
Cuban specimen	7 --	21 --
,, ,,	6 --	16 --
,, ,,	4 --	10.5 --

Forma robustum.—Distinguished by the cylindrical form with a broad, somewhat convex base (Plate 2, figs. 5c, 5d). This form was derived from typical individuals which continued upward growth after peripheral growth had slowed down or ceased. Six specimens of this form were found. The dimensions of 3 well-preserved ones follow:

	Height	*Basal Diameter*	*Calicular Diameter*
Santa Clara	16 mm.	18 mm.	20 mm.
Havana	15 --	20 --	20 --
,,	15 --	20 --	20 --

Forma turbinatum.—Seven specimens of this form, all from the Central Perseverancia locality, are turbinate in form (Plate 2, fig. 5e), as compared with the discoidal to patellate typical form, expanding rapidly, but less so than in the latter, from a small basal attachment, the axis of growth being slightly curved. Dimensions of three specimens:

Height	Calicular Diameter
15 mm.	18 mm.
14 --	15 x 16.5 --
10 --	11 --

Family **PORITIDÆ**

Genus **GONIOPORA** de Blainville, 1830

Goniopora reussiana (Duncan), 1865 Plate 2, fig. 2

Porites reussiana Duncan, 1865, Q. J. G. S. London, xxi, p. 8, pl. 1, fig. 2; 1868, Q. J. G. S. London, xxiv, p. 25; Vaughan, 1899, Mus. Comp. Zool., Harvard, Bull. xxxiv, p. 249.

Goniopora jamaica 1 Bernard, 1906, Cat. Madrep. Brit. Mus. (N.H.), iv, p. 159.

Goniopora reussiana Wells, 1934, Proc. U. S. Nat. Mus. lxxxiii, p. 90, pl. 4, fig. 18; pl. 5, figs. 4, 5.

Specimens.—Paleontological Research Institution.

Occurrence.—Cuba: Ravine one kilometer west of Central Perseverancia, Santa Clara Province (3 specimens) (Dickerson); near Esperanza, about 10 kilometers east of Madruga, Havana Province (2 specimens) (Weisbord).

Jamaica: "Upper Clarendon District" (Duncan's type); Upper Cretaceous limestone, Cambridge-Catadupa R.R. cut.

Remarks.—Five Cuban specimens of this species were examined, all having the septa and calicular structures of typical *G. reussiana*. Three are nodular in growth-form, one is massive-encrusting, and one is subcolumniform (figured). Typical *G. reussiana*, judging from the two or three known specimens from Jamaica, has a ramose corallum, and the Cuban specimens may represent a variety or growth-form. Until more specimens are at hand to show the amount of variation of growth-form within the species, and such variation is often very great in the poritid corals, they are left in that species.

Family **FAVIIDÆ**

Genus **MONTASTREA** de Blainville, 1830

Montastrea cubana, n. sp. Plate 2, fig. 3

Description.—Corallum plocoid, nodular or subhemispherical, up to 5 cm. in diameter with a height of 25 cm. Corallites cylindrical, averaging 6 mm. in diameter, calices projecting slightly, united by short, thin costæ, some of which may be confluent across the intercorallite spaces which average 1.5 mm., and by thin, subtabular exotheca. Corallite walls thin, septothecal. Septa thin, 24 in number, arranged in three regular cycles, laterally sparsely spinose, probably dentate lightly on their upper margins. Those of the first two cycles are subequal and extend about two-thirds the distance from the wall to the axis of the corallite where their inner edges may bend to one side and unite to form an irregular ring or tube above the level of the top of the columella. In many corallites this tubelike structure is absent and the first two cycles extend to the center where they unite to form a feeble columella. In some corallites the columella appears to be absent entirely. The 12 septa of the third cycle are about one-half as long as those of the first two cycles. The endotheca is thin and cellular.

Specimens.—Holotype and 2 paratypes, Paleontological Research Institution.

Occurrence.—Ravine one kilometer west of Central Perseverancia, Santa Clara Province (Dickerson).

Remarks.—This species is distinguished by the lightness of all structures and by the frequent development of an "inner wall" from the septal extremities. This structure is formed by the bent inner ends of the septa and not by dissepiments as in the case of the *aulos* of rugose corals. In many corallites it is not present and the septa extend to the center of the corallite to form a columella. A suggestion of a similar condition can be found in some specimens of the living *M. annularis*[5].

The only species with which this need be compared is *M. schindewolfi* Wells[6] (erroneously made the type of a new genus, *Prodiploastrea*, by the writer, and now considered by him a synonym of *Montastrea*), from the Upper Cretaceous rudistid limestone of Jamaica. *M. schindewolfi* has the same light structures and growth-form, but the average size of the corallites is only 3.5 mm. and the number of septa frequently in excess of 24 (up to 32); the columella is feeble and straggly.

[5] See Vaughan, T. W.: Bull. U. S. Nat. Mus., 103, 1919, pl. 81, fig. 1a.

[6] Wells, J. W.: Proc. U. S. Nat. Mus. lxxxiii, 1934, p. 89, pl. 4, figs. 21, 22.

Family CARYOPHYLLIIDÆ

Genus TROCHOCYATHUS Milne Edwards and Haime, 1848

Trochocyathus sp. cf. T. mississippiensis Wells

Trochocyathus mississippiensis Wells, 1933, Bull. Amer. Paleont., vol. xviii, p. 216, pl. 14, figs. 22, 23.

Description.—Solitary, bowl-shaped, free, with circular calice. Septa in 4 complete cycles, uniting regularly, with pali apparently before all but the last cycle. Columella small, papillose. Exterior of corallum unknown.

Dimensions.—

Height	*Diameter*
3.5 mm.	9.0 mm.
2.5 --	7.0 --
2.5 --	7.0 --
2.5 --	6.5 --

Specimens.—Paleontological Research Institution.

Occurrence.—Ravine one kilometer west of Central Perseverancia Santa Clara Province (4 specimens) (Dickerson).

Remarks.—All the specimens are internal moulds, and positive identification is not possible, but the only species now known from America with which they can be compared is *T. mississippiensis* from the *Exogyra ponderosa* zone (Campanian) of Mississippi, referred to above. The only notable difference is that the Cuban specimens are much broader in proportion to their height, but this may be partially due to the difference in mode of preservation.

PLATES

PLATE I (42)

EXPLANATION OF PLATE 1 (42)

Figure	Page
1. **Trochoseris catadupensis** Vaughan	6
Matanzas Province: 1, 1a, calicular and lateral aspects, ×1; 1b, calicular aspect of another specimen, ×1; 1c, portion of calice of another specimen, ×2.
2. **Haplaræa ? discrepans,** n. sp.	7
Santa Clara Province: 2, lateral aspect of holotype, ×1; 2a, horizontal section of several septa, ×2.
3. **Leptophyllia sanchez-roigi,** n. sp.	9
Santa Clara Province, holotype: 3, 3a, calicular and lateral aspects, ×1; 3b, horizontal section of septa midway between calice and base, ×2; 3c, polished section midway between calice and base, ×1.

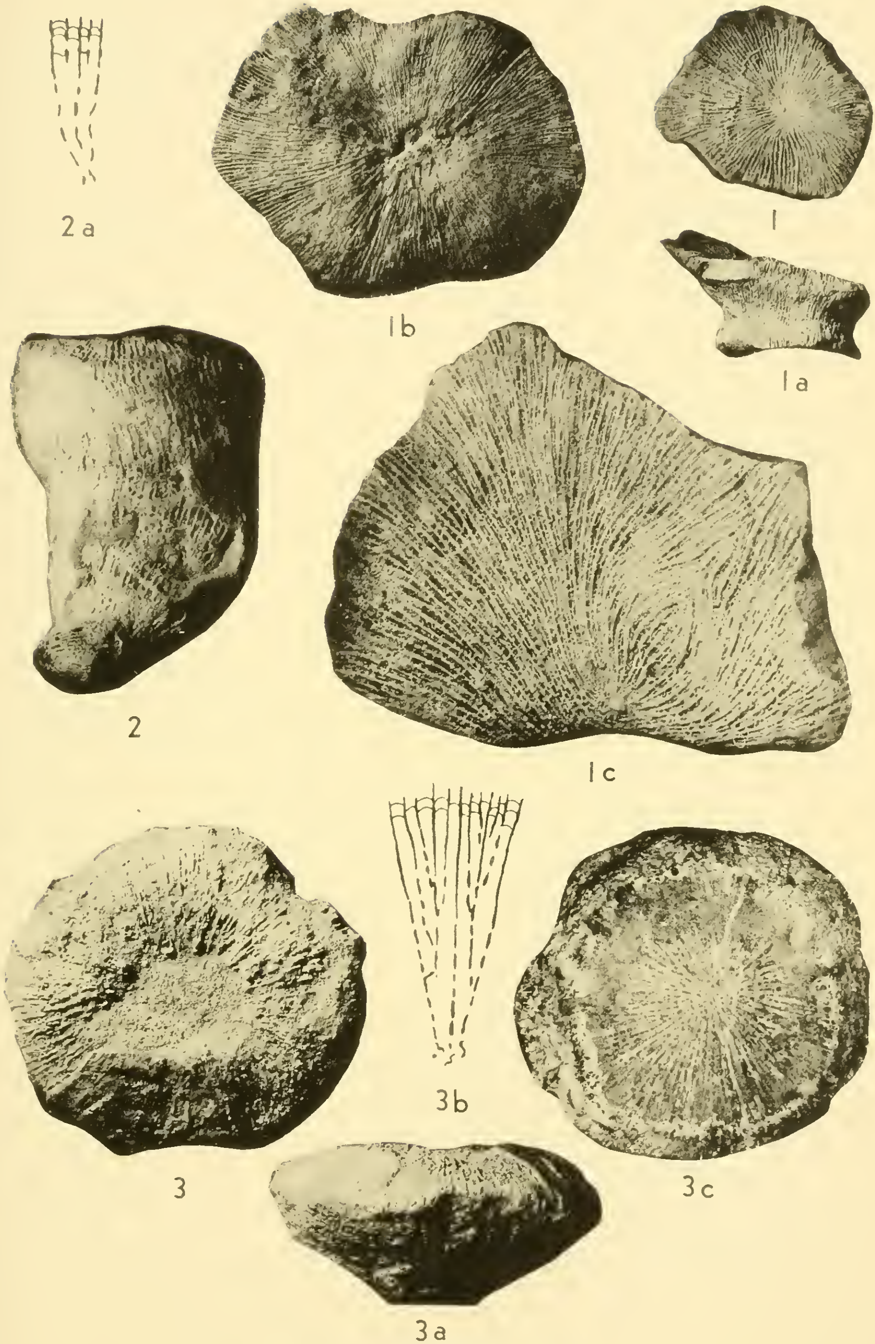
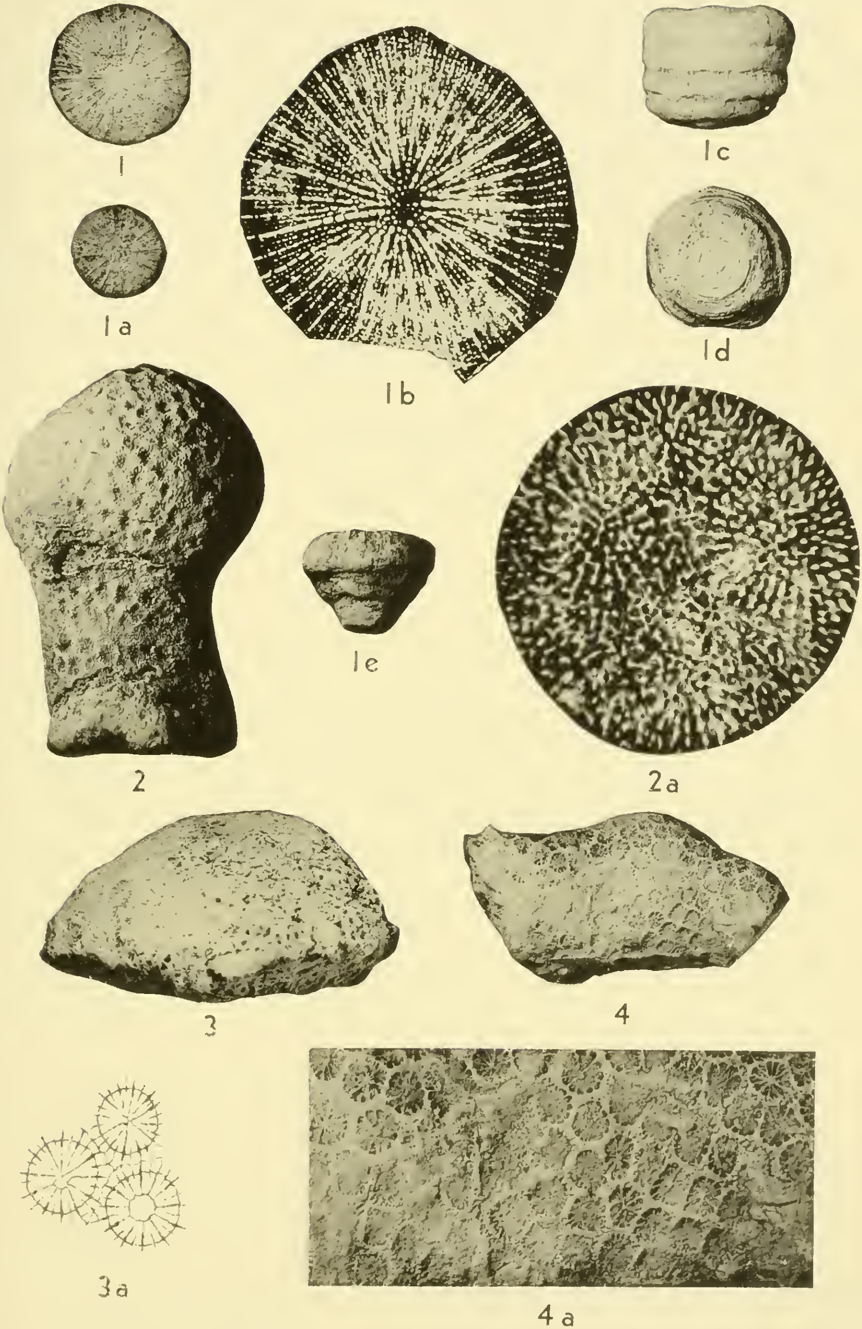

2a
1b
1
1a
2
1c
3b
3
3c
3a

PLATE 2 (43)

EXPLANATION OF PLATE 2 (43)


1
1a
1b
1c
1d
1e
2
2a
3
3a
4
4a

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Cretaceous and Eogene Corals from Northwestern Peru

By

John W. Wells

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CRETACEOUS AND EOCENE CORALS FROM NORTHWESTERN PERU

By

JOHN W. WELLS*

INTRODUCTION

The collection of corals described in this paper was made several years ago by A. A. Olsson in the course of field work in northwestern Peru, and to him the writer is indebted for the opportunity of examining this interesting material. One species from the collection, *Turbinolia olssoni* from the middle Oligocene Mancora formation, has already been described elsewhere[1] by the writer. Other collections of corals from the same region have been described by T. W. Vaughan[2] and E. W. Berry[3].

Olsson's terminology and classification[4] of the Cretaceous and Tertiary formations of northwestern Peru have been followed in the table herewith given of the distribution of species of fossil corals in northwestern Peru and elsewhere in this paper.

* Department of Geology, The Ohio State University.

1 Wells, J. W.: *Coral studies: Part 1, Two new species of fossil corals*, Bull. Amer. Paleont., xxiii, 1937, pp. 237-239, pl. 35, figs. 1, 2.

2 Vaughan, T. W.: *Description of the species of corals from the Negritos formation.* In Bosworth, T. O.: *Geol. and Palæont. N. W. Peru*, 1922, pp. 126-135, pls. 21-23.

3 Berry, E. W.: *Shorter contributions to the paleontology of the Eocene of northwestern Peru.* I. *Solitary corals*, Wash. Acad. Sci., Jour., xix, 1929, pp. 236-237, 4 figs.

4 Iddings, A. and Olsson, A. A.: *Geology of northwest Peru*, Am. Ass. Petrol. Geol., Bull., xii, 1928, 1-39, figs., pls., and table.

5 Olsson, A. A.: *Contributions to the Tertiary paleontology of northern Peru*, Bull. Amer. Paleont.:

Pt. 1. *Eocene Mollusca and Brachiopoda*, vol. xiv, 1928, 50-154, pls. 6-31.
Pt. 3. *Eocene Mollusca*, vol. xvii., 1930, 1-96, pls. 1-12.
Pt. 4. *The Peruvian Oligocene*, vol. xvii, 1931, 97-164, pls. 13-33.

Species	Pananga ls.	Monte Grande form.	Negritos form.	Salina form.	Restin form.	Talara form.	Chira form.	Mancora form.
Cretaceous								
Astrocœnia peruviana, n. sp.	x							
Montastrea parinasensis, n. sp.		x						
Eocene								
Stephanocœnia peruviana Vaughan			x	x	x			
Stephanocœnia storrsi, n. sp.					x			
Madracis vaughani, n. sp.					x			
Trochoseris gerthi, n. sp.					x			
Goniopora nomlandi, n. sp.					x			
Oculina peruviana Vaughan				x				
Oculina olssoni, n. sp.					x			
Paracyathus peruvianus Vaughan				x	x			
Lophosmilia yabei, n. sp.					x			
Haimesiastræa peruviana Vaughan			x	x				
*Haimesiastræa humilis Vaughan			x	x				
Haimesiastræa distans Vaughan				x	x			
Peruviastrea peruviana Vaughan				x				
*Flabellum, sp. Berry						x		
Balanophyllia piuræensis, n. sp.					x			
*Balanophyllia, sp. Berry						x		
*Dendrophyllia peruviana Vaughan				x				
Oligocene								
Stylophora chiræensis, n. sp.							x	
Cyclomussa concinna, n. gen., n. sp.							x	
*Turbinolia olssoni Wells								x

Table of the species of Cretaceous and Eogene corals of northwestern Peru and their stratigraphic distribution. (Starred species not considered in detail in this paper.)

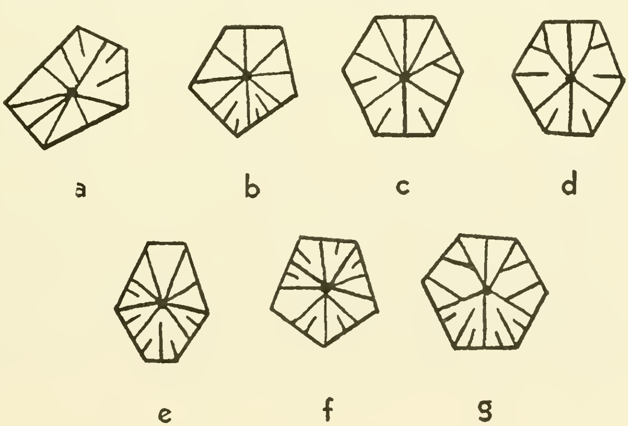
I. CRETACEOUS

Family ASTROCŒNIIDÆ

Genus ASTROCŒNIA Milne Edwards and Haime, 1848

Astrocœnia peruviana, n. sp. Plate 1, fig. 1

Description.—Corallum lobate, with more or less vertical columniform ramose extensions, the whole forming an irregular clump. The lobes are closely appressed, often in contact, varying in diameter from 1.5 to 3.5 cm. Calices deep, polygonal in outline with acute margins, averaging slightly less than 1.5 mm. in diameter. Septa thick, faintly spinose laterally, upper margins unknown, variable in number and arrangement. The primary plan is hexameral, with 12 septa in two cycles, of which the 6 primaries extend to the columella, and those of the second less than halfway. Usually, however, two of the second cycle septa lying in adjacent systems at one end of the calice also extend to the columella, or these two septa may unite with the primaries next them (text fig. 1, b, c, d). In some cases 4 septa of the third cycle are developed in two systems at one end of the calice, giving a total of 16 septa (text fig. 1, g). Some corallites may have only 11 septa (text fig. 1, a) (8 reaching columella), 14 septa (text fig. 1, e) (8 reaching columella), or 15 septa (text fig. 1, f) (8 reaching columella). Thus the septal arrangement is secondarily octameral. Columella small, styliform, deep in the calice. Endothecal dissepiments present but thin and sparse.



Text figure 1. Diagrams of cross-sections of corallites of *Astrocœnia peruviana* to show variation in septal arrangement, ×10.

Specimens.—Holotype and paratypes, Paleontological Research Institution.

Occurrence.—Pananga limestone, Lower Cretaceous (upper Aptian), Pan de Aymar, near La Brea, northwestern Peru.

Remarks.—With the present species, a total of 16 species of *Astrocœnia* is now known from the Lower Cretaceous of the Western Hemisphere. Of these *A. hexamera* Fritsche[6] (Chile), *A. harrisoni* (Gregory[7]) (Venezuela), *A. globosa* Felix[8] (Mexico), *A. whitneyi* Wells[9] (Texas), *A. guadalupæ* Roemer[10] (Texas), *A. nidiformis* Cragin[11] (Kansas), and *A. budaënsis* Wells[12] (Texas), are distinguished by the presence of three complete cycles of septa (24); *A. colliculosa* Gerth[13] (Argentina), *A.* sp. *cf. A. regularis* Gerth[14] (Argentina) and *A. minima* Fritsche[15] (Chile), have 20 septa decamerally arranged in two series; *A. scyphoidea* Wells[16] (Texas) and *A. bellensis* Wells[17] (Texas) have two cycles of septa, hexamerally arranged (6/6); while *A. pattoni* Wells[18] (Texas) has 16 septa octamerally arranged (8/8) and calices 1 mm. in diameter. Of the two remaining species, *A.* sp. *cf. A. triboleti* Gerth[19] (Argentina) is ramose, with 16 to 20 septa (810/8-10) in calices ranging from 0.75 to 1 mm. in diameter, and *A. hispaniensis* Imlay[20] (northern Mexico) is massive, with 16 to 20 septa (8-10/8-10) in calices from 1.5 to 2 mm. in

6 Fritsche, H.: Neues Jahrb., B. B., 1924, p. 318, pl. 3, fig. 7.

7 Gregory, J. W.: Geol. Mag., lxiv, 1927, p. 442, pl. 13, fig. 2.

8 Felix, J.: Palæontographica, xxxvii, 1891, p. 156.

9 Wells, J. W.: Jour. Paleont., vi, 1932, p. 230, pl. 31, fig. 6; pl. 32, figs. 1, 2; pl. 37, fig. 1.

10 Wells, J. W.: Bull. Amer. Paleont., xviii, 1933, p. 156, pl. 5, figs. 11-13.

11 Twenhofel, W. H.: Kansas Geol., Surv., Bull. No. 9, 1924, p. 51, pl. 10, fig. 4.

12 Wells, J. W.: Bull. Amer. Paleont., xviii, 1933, p. 160, pl. 6, fig. 3.

13 Gerth, H.: Leidsche Geol. Med., iii, 1928, p. 7, pl. 1, fig. 6.

14 *Ibid.*: 1928, p. 8.

15 Fritsche, H.: Neues Jahrb., B. B., 1924, p. 318, pl. 4, fig. 2.

16 Wells, J. W.: Jour. Paleont., vi, 1932, p. 231, pl. 32, fig. 3; pl. 33, fig. 3.

17 Wells, J. W.: Bull. Amer. Paleont., xviii, 1933, p. 158, pl. 6, figs. 5, 6.

18 *Ibid.*: 1933, p. 158, pl. 6, figs. 1, 2.

19 Gerth, H.: Leidsche Geol. Med., iii, 1928, p. 7.

20 Imlay, R. W.: Bull. Geol. Soc. Amer., li, 1940, p. 138, pl. 1, figs. 21, 22.

diameter. *M. peruviana* is therefore readily distinguished by its growth-form, and small calices (1.5 mm.) with 12 to 16 septa (6-8/6-8).

Family **FAVIIDÆ**

Genus **MONTASTREA** de Blainville, 1830

(**ORBICELLA** Dana, 1848)

Montastrea parinasensis, n. sp. Plate 1, fig. 2

Description.—Corallum forming small nodular masses up to 5 cm. in diameter and 4.5 cm. high. Corallites small, averaging 1.3 mm. in diameter, cylindrical, with thin, septothecal walls externally costate. The costæ are thin and short, meeting those of adjoining corallites across the very narrow intercorallite spaces (0.5 mm. or less) along a vertical line of exotheca, so that the corallites when weathered often appear polygonal in outline. Exotheca subtabular, regularly spaced. Calices apparently shallow. Septa 24 in number, laterally granulated, arranged in three cycles. Those of the first cycle (6) are larger and thicker and meet in the center of the corallite. Second cycle septa slightly thinner than those of the first and usually not reaching the axis but often fusing with those of the first. Third cycle septa very short, thin, and usually free internally. Columella formed by the fusion of 6 primary septa, very feeble. Endotheca cellular.

Specimens.—Holotype and 4 paratypes, Paleontological Research Institution.

Occurrence.—Monte Grande formation, Upper Cretaceous (probably Maestrichtian), Quebrada Monte Grande, Parinas Valley, Department of Piura, Peru.

Remarks.—The specimens upon which this new species is founded are not well preserved,—the interior is badly crystallized and the exterior much worn. The structures are all thin and the upper margins of the septa either crushed or worn so that the presence or absence of dentations was not definitely observed; they were almost certainly present, however.

The delicacy of the skeletal structures reminds one of *M. schindewolfi* Wells[21] of the Campanian of Jamaica, but the corallites

[21] Wells, J. W.: U. S. Nat. Mus., Proc., lxxxiii, 1934, p. 89, pl. 4, figs. 21, 22.

are much smaller, with fewer septa, and nonconfluent shorter costæ. Pijpers described as *Orbicella*, sp. B[22], a *Montastrea* from the uppermost Cretaceous Ricon formation of the island of Bonaire which has very small corallites (1-1.4 mm.), but has fewer septa and more widely spaced corallites than *M. peruviana.*

II. EOCENE

Family SERIATOPORIDÆ

Genus STEPHANOCŒNIA Milne Edwards and Haime, 1849

Stephanocœnia peruviana Vaughan

Stephanocœnia peruviana Vaughan, 1922. In Bosworth, Geol. & Palæont. N. W. Peru., p. 133, pl. 23, figs. 1, 1a, 2, 2a.

Specimen.—Paleontological Research Institution (1 specimen).

Occurrence.—Basal Restin formation (lower Lobitos formation of Bosworth), one mile north of Negritos, Peru, (Olsson) (Vaughan's paratype).

Salina formation (Clavilithes series), middle Eocene, near Negritos, (Vaughan's holotype).

Negritos formation (Turritella series), lower Eocene, near Negritos, (Vaughan).

Remarks.—One small worn fragment corresponds very closely to Vaughan's description and figures, except that all the septa appear to be decamerally arranged in two series, the 10 larger reaching the columella. Some of the calices in Vaughan's figures show such a decameral arrangement.

Stephanocœnia storrsi, n. sp. Plate 1, fig. 3

Description.—Corallum forming small nodular or encrusting masses. Corallites small, prismatic, closely united. Corallite wall relatively thick, subacute at the top and beaded by the upper part of the septa, somewhat thickened by stereome. Calices shallow, polygonal, averaging 1 mm. in diameter, often somewhat less. Septa 16 in number, octamerally arranged in two series, nonexsert, thick, laterally strongly granulated. The first series of 8 septa extends to the columella and unites around it, with palar protuberances forming a single crown of 8 tubercles. The second

[22] Pijpers, P.: Geogr. Geol., Meded., Phys.-Geol. R., No. 8, (Utrecht), 1933, p. 75, figs. 148, 149.

group of 8 septa is shorter and thinner, free along the inner edge or rarely fused to the first series. The inner margins of all the septa are strongly dentate or lacerate. Columella small, a single tubercle, probably not as prominent as the palar tubercles, but stouter. Endotheca thin and scarce.

Specimen.—Holotype, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—This species is remarkable for the octameral arrangement of the septa, unusual in this genus, and which, together with the small size of the corallites, serves to distinguish it from *S. peruviana* Vaughan, previously discussed, and from other species of the genus.

Genus **MADRACIS** Milne Edwards and Haime, 1849

Madracis vaughani, n. sp. Plate 1, fig. 4

Description.—Corallum ramose, with cylindrical or very slightly compressed branches from 2.5 to 7 mm. in diameter, evidently tapering gradually to a blunt point, branching at an angle of about 45°. Calices circular, or elongate in the direction of the branches, or appressed and polygonal, usually flush with the surface and nonprotuberant, averaging 1.75 mm. in diameter (maximum, 2 mm., minimum, 1.25 mm. near tips of branches), margins faintly costulate. Surface of the dense peritheca, where developed between calices, faintly vermiculate or granulose, with no trace of ridges or grooves between corallites, usually from 0.5 to 1 mm. wide between calices. Septa nonexsert, margins smooth, usually 20 in number, decamerally arranged. Ten larger septa extend to the columella, around which they fuse to form a platform; their upper margins descend abruptly to the level of this platform about halfway between the wall and columella. The 10 smaller septa are often rudimentary, mere ridges on the inner corallite wall surface, and are completely absent in smaller calices near the tips of the branches.

Specimens.—Holotype and 22 paratypes, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—Four species have been previously described from the Eocene of the Americas, all of them from the middle Eocene of the Gulf Coastal Plain of the United States. None has been described from rocks of this epoch in regions outside this area. The present form is distinguished by its ramose corallum from *M. herricki* Wells[23]; the other three, *M. ganei* Vaughan, *M. pohnsoni* Vaughan, and *M. gregorioi* Vaughan[24], are all ramose with thicker branches. The species nearest *M. vaughani* appears to be *M. gregorioi*, which has appressed polygonal or separated circular calices (average diameter, 2.5 mm.), slightly thicker branches (5-11 mm.) and similar septal arrangement (10/ rudiments of the others).

Family AGARICIIDÆ

Genus TROCHOSERIS Milne Edwards and Haime, 1849

Trochoseris gerthi, n. sp. Plate 1, fig. 5

Description.—Corallum low and turbinate, flaring rapidly from an expanded base of attachment. Dimensions of the holotype: height, 7 mm.; calice 15 x 18 mm. Wall septothecal, imperforate, nonepithecate, with low subacute beaded costæ, alternating in size. Calice elliptical, broad and shallow, with a small elongate fossette. Septa slightly exsert, numerous, thin, nearly equal except for those of the 6th cycle, laterally granulated, marginally faintly beaded, united by rare synapticulæ, 112 in number, comprising 5 complete cycles and 16 septa of the 6th. Those of the higher cycles unite by their inner ends of those of the lower cycles, except for the first two cycles which have their inner ends free. Columella deep, very weak. Dissepiments developed only basally.

Specimen.—Holotype, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—The only other American Eocene species of this genus is *T. meinzeri* Vaughan[25] of the upper Eocene of Cuba. It is much larger than *T. gerthi*, and has much more abundant syn-

[23] Wells, J. W.: Bull. Amer. Paleont., xx, 1934, p. 161, pl. 19, figs. 1, 2.
[24] Vaughan, T. W.: U. S. Geol. Surv., Mon., xxxix, 1900, pp. 128-130, pl. 13, figs. 1-12.
[25] Vaughan, T. W.: U. S. Nat. Mus., Bull., 103, 1919, p. 426, pl. 106, fig. 2.

apticulæ and more exsert septa, but the two may be closely related. All the structures correspond very closely to those of the genotype, *T. distorta* (Michelin), of the middle Eocene of Europe.

Family **PORITIDÆ**

Genus **GONIOPORA** de Blainville, 1830

Goniopora nomlandi, n. sp. Plate 1, fig. 6

Description.—Corallum small, subspherical or nodular, fixed by a small encrusting base, encrusting in earlier stages, the mature colony rarely more than 30 mm. high or 35 mm. in diameter. Calices 3.5-4.0 mm. in diameter, polygonal in outline, varying considerably in depth from very shallow to 1 mm. in depth. Calicular walls thin and acute in deeper calices, but appearing thick, low, and rounded in shallower ones, composed of one ring of mural synapticulæ and trabecular pillars. Septa 24 in number, arranged according to the gonioporid plan, composed of three trabecular pillars besides the mural one, with weak palar trabeculæ before the first cycle of septa (6). Columella composed of a single trabecular pillar; below the floor of the calice it forms a tangle with the palar trabeculæ. The two palar trabeculæ lying in the axial plane are usually larger than the rest and with the columella form a prominent row of three papillæ in the calice. Synapticulæ sparse outside of the mural ring in the upper parts of the corallites, more abundant below.

Specimens.—Holotype and 40 paratypes, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—The only Antillean Eocene described species of *Goniopora* is *G. taberi* Wells[26] from the upper Eocene of Cuba. This is a subramose species with smaller (average diameter, 2.75 mm.) calices and with septa composed of more (4-6) trabecular elements. *G. vaughani* Nomland[27] from the Californian Eocene is an encrusting form with smaller (average diameter, 2.7 mm.) calices.

[26] Wells, J. W.: Bull. Amer. Paleont., xx, 1934, p. 155, pl. 18, figs. 5, 6, 7.

[27] Nomland, J. O.: Univ. California Pub. Geol., ix, 1916, p. 68, pl. 3, figs. 18, 19.

The habit of *G. nomlandi* is like that of *G. websteri* (Bowerbank[28]), a species very abundant in the middle Eocene at localities on Bracklesham Bay, Sussex, England. In fact, there is practically no difference between the two except for the slightly larger calices(usually more than 4 mm.) and presence of occasional septa of the 4th cycle in *G. websteri.*

Family OCULINIDÆ

Genus OCULINA Lamarck, 1816

Oculina olssoni, n. sp. Plate 2, fig. 1

Description.—Corallum dendroid, composed of irregularly-shaped branches varying in size from 3 mm. in young branches to more than 11 mm. in older, basal branches. Calices protuberant, especially on young branches but also to some extent on the older ones (1 mm. more or less), averaging 2.5 mm. in diameter (maximum, 3 mm.), about 1 mm. in depth, and from 2 to 6 mm. apart, faintly costate near the margins. Peritheca solid, faintly costulate or striate. Corallites filled with stereome to within a short distance of the bottom of the calices. Septa thin, marginally faintly dentate, 12 in number, in two cycles; those of the first prominent, reaching the columella, those of the second about half as long. Paliform lobes indistinct but apparently present before the first cycle. Columella parietal and weak, formed by fused inner ends of primary septa.

Specimens.—Holotype and 36 paratypes, all fragments of branches, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—This species is readily distinguished from *O. peruviana* Vaughan[29] from the Salina formation (middle Eocene) near Negritos, by the absence of the 12 septa of the third cycle.

[28] See Milne Edwards, H. and Haime, J.: *Brit. Foss. Cor.*, Paleont. Soc., London, 1850, p. 38, pl. 7, fig. 1.

[29] In Bosworth, T. O.: Geol. Palæont. N. W. Peru, 1922, p. 127, pl. 21, figs. 2-5.

Family CARYOPHYLLIIDÆ

Genus PARACYATHUS Milne Edwards and Haime, 1848

Paracyathus peruvianus Vaughan Plate 2, fig. 2

Paracyathus peruvianus Vaughan, 1922. In Bosworth, Geol. Palæont. N. W. Peru, p. 126, pl. 21, figs. 1, 1a, 1b, 1c.

Specimens.—Paleontological Research Institution (3 specimens).

Occurrence.—Type locality, Salina formation (lower Clavilithes series of Bosworth), middle Eocene, three-fourths of a mile southeast of Negritos, Peru.

Basal Restin formation, middle Eocene, one mile north of Negritos (Olsson).

Remarks.—Three individuals, one fairly complete and two represented by fragments, are referred to this species. The dimensions of the best specimen are: height, 9 mm.; calice, 9 x 10 mm., —about the same proportions as Vaughan's holotype but smaller. The septa in this same specimen number 48, with traces of additional ones in one or two systems. The columella is composed of about a dozen tubercles which merge with the pali as is typical of the genus.

Genus LOPHOSMILIA Milne Edwards and Haime, 1848

Lophosmilia yabei, n. sp. Plate 2, fig. 3

Description.—Solitary, turbinate, fixed by an expanding base. Wall septothecal, nonepithecate, covered by faint, subacute, beaded costæ which alternate slightly in size, corresponding to the septa, but they are much obscured by thick stereome deposits and are obsolete basally. Diameter near the base, 4.75 mm.; approximate calicular diameters, 8 x 10 mm.; height, more than 8 mm., probably about 12 mm. (base and calice damaged). Calice somewhat compressed, with deep, elongate fossette. Septa forming 4 complete cycles, with the 5th developed in some of the end-systems, regularly unequal beyond the first two cycles, moderately thick, laterally strongly granulated or spinose, with some of those of the 3d and 4th cycles uniting regularly to those of the 2d and 3d respectively. Upper margins and degree of exsertness indeterminable from the only specimen. Columella deep in the fossette, a thin, granulose, slightly wavy lamellar plate about 2.5 mm. long, united basally to one of the primary septa lying in the longer calicular axis, but otherwise free.

Specimen.—Holotype, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—The single specimen is incomplete,—the base broken away and the calice badly damaged, but the characters are so clear-cut that there can be little doubt that it is correctly placed generically.

This is a particularly interesting form, for it is the fifth species to be described of this very rare coral. The other species are: *L. cenomana* (Michelin), 1845[30], from the Cenomanian of Le Mans, France, *L. texana* (Vaughan)[31], 1903, from the Buda limestone (Cenomanian) of central Texas, *L. fusca* (Vaughan)[32], 1907, from a depth of 148 fathoms (temp. 65° F.), in the Hawaiian Islands, and *L. telegraphica* (A. Milne Edwards)[33], 1861, an unfigured species from a telegraph cable laid between Sardinia and Algeria, depth 2000-2800 meters (temp. about 55° F.).

Notes on the genus Lophosmilia.—In 1933 the writer placed the two species *Parasmilia texana* Vaughan and *Placotrochus fuscus* Vaughan in the same genus[34],—*Placotrochus*. *Placotrochus*, however, proved to be a flabellid coral with purely epithecal wall. Later, in the Michelin Collection in the Paris Museum, he found a tophomeotype of *Caryophyllia cenomana* Michelin, the genotype, by monotypy, of *Lophosmilia*. This specimen is generically identical with *P. texana* and *P. fuscus*, as was also another topotype in the D'Orbigny Collection (No. 6708),—the type of *Actinosmilia* d'Orbigny[35], 1849. The writer has not seen specimens of *L. telegraphica*, the monotype of A. Milne Edwards'[36]

30 Michelin, H.: Icon Zoöphyt., p. 198, pl. 50, fig. 8.

31 Wells, J. W.: Bull. Amer. Paleont., xviii, 1933, p. 40, pl. 7, figs. 5-9; pl. 3, figs. 18-25.

32 Vaughan, T. W.: U. S. Nat. Mus., Bull. 59, p. 66, pl. 4, figs. 2, 3.

33 Milne Edwards, A.: Ann. Sci. Nat., Zoöl., (4), xv, p. 156.

34 *Op. sup. cit.*: 1933, pp. 40-41.

35 d'Orbigny, A.: *Note sur des polypes fossiles*, p. 6.

36 *Op. sup. cit.*: p. 156.

genus *Thalassiotrochus* (the types are said to be in l'École des ponts et chaussées, Paris), but on the basis of the latter's description it is almost certainly *Lophosmilia.*

Several species attributed to *Lophosmilia* are more properly placed elsewhere. *L. rotundifolia* Milne Edwards and Haime[37], a Recent Caribbean species, has a columella that is essentially spongy and swollen, often trilobed and secondarily solidified by stereome. It is the genotype of *Oxysmilia* Duchassaing[38].

L. tenuicaulata and *L. magnocaulata* Gregory[39], from the Middle Jurassic of Cutch, are species of *Codonosmilia* Koby[40], a rhipidogyrid coral, and with which Gregory compared his two species, stating that they showed a lamellar columella that was said to be lacking in *Codonosmilia.* Koby, in his discussion of the genus, stated that a columella was absent in *Codonosmilia,* but specimens of *C. radiata* (Quenstedt) from Nattheim seen by the writer in 1934 in the Ewald Collection in the Museum für Naturkunde in Berlin show a very small lamellar columella deep in the calice.

Family HAIMESIASTRÆIDÆ

Genus HAIMESIASTRÆA Vaughan, 1900

Haimesiastræa distans Vaughan Plate 2, fig. 4

Haimesiastræa distans Vaughan, 1922. In Bosworth, Geol. & Palæont. N. W. Peru, p. 132, pl. 22, figs. 5, 5a.

Specimens.—Paleontological Research Institution (2 fragments).

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru, (Olsson).

Salina formation (Clavilithes series), middle Eocene, near Negritos, (Vaughan).

Remarks.—This species, as indicated above, is represented by two fragmentary specimens. The better of these represents the distal portion of a branch 19 mm. in length and about 5 mm. in

37 Milne Edwards, H. and Haime, J.: Ann. Sci. Nat. Zoöl., (3), ix, 1849, p. 247, pl. 5, fig. 3.

38 Duchassaing, P.: Rev. Zoöph. Spong. Antill., 1870, pp. 26-27. Duchassaing apparently was using De Fromentel's name for an hypothetical genus having these characters (Pal. franç., Terr. crét., Zoöph., 1870, p. 582).

39 Gregory, J. W.: Pal. Indica, ser. 9, vol. ii, 1900, pp. 37-39, pl. 3, figs. 5-6; pl. 4, figs. 1, 2.

40 Koby, F.: Pol. jur. Suisse, 1888, p. 455.

diameter at its proximal end. All the structures agree closely with Vaughan's description and figures.

Genus **PERUVIASTREA** Vaughan, 1922

Peruviastrea peruviana Vaughan — Plate 2, fig. 5

Peruviastrea peruviana Vaughan, 1922. In Bosworth, Geol. & Palæont. N. W. Peru, p. 129, pl. 21, figs. 6,7.

Specimens.—Nine topotypes, Paleontological Research Institution.

Occurrence.—Base of Salina formation, middle Eocene, near Negritos, Peru.

Remarks.—The specimens are 9 portions of thick ramose fragments. Some show very clearly details of internal and external structure, but little can be added to Vaughan's description. The peritheca appears solid on the surface, but is cellular below, suggesting secondary changes. The corallite cavities are crossed by somewhat distant subtabular endothecal dissepiments and do not fill up with stereoplasm. In thin section the columella does not appear as a solid axial style but is formed by the partial fusion of the 6 primary septa, and in some corallites it is almost nonexistent. The heavy styliform columella seen in the calices is thus probably the result of post-mortem changes similar to the peritheca. If this is correct the genus *Peruviastrea* cannot be maintained as a genus apart from *Haimesiastræa*.

Family **DENDROPHYLLIIDÆ**

Genus **BALANOPHYLLIA** S. V. Wood, 1844

Balanophyllia piuræensis, n. sp. — Plate 2, fig. 6

Description.—Corallum turbinate and straight, expanding gradually from a broad expanded basal attachment. Exterior nonepithecate, marked by well-developed, slightly alternating, somewhat vermiculate, rounded costæ. Those corresponding to the 12 septa of the first two cycles slightly larger than the rest. Wall perforate more or less regularly between the costæ, especially near the calice, usually filling up below, about .1 mm. thick. Calice compressed, deep. Septa about 60 in number, in four complete cycles with the fifth developed in parts of two systems, apparently at one end of the longer calicular axis. Septa arranged in the characteristic manner of the dendrophylliids (Pourtalès plan), those of the first two cycles equal in size, exsert and prominent around the calice. Columella small, deep in the calice, elongate, spongy. Dimensions of the holotype: height, 16 mm.; calice, approximately 9 x 14 mm.; depth of calice, about 6 mm.

Specimens.—Holotype and two paratypes, Paleontological Research Institution.

Occurrence.—Basal Restin formation, middle Eocene, one mile north of Negritos, Peru.

Remarks.—The holotype, the best-preserved specimen, lacks about one-half of the calice, and the upper part of the corallum may have been somewhat flabelloid, as in *B. desmophyllum* Milne Edwards and Haime[41], a species occurring in the middle Eocene of southern England and the Gulf Coast of the United States[41], and to which the new species is very closely related. It differs, however, by the somewhat vermiculate costæ and fewer septa. *Balanophyllia,* sp. Berry[42], from the upper Eocene Talara formation in northern Peru, has a cornutiform, strongly curved corallum with very small basal attachment and is probably related to *B. inauris* Vaughan[43] of the middle Eocene of New Jersey.

III. OLIGOCENE

Family SERIATOPORIDÆ

Genus STYLOPHORA Schweigger, 1819

Stylophora chiræensis, n. sp. Plate 3, fig. 2

Description.—Corallum with a massive base several centimeters thick, on the upper surface of which are low proliferations and the bases of branches. Height of holotype, 45 mm.; greatest diameter, 75 mm.; diameter of proliferations, 5 mm., with the same height; diameter of the branches, 5 to 10 mm. Calices small, numerous, shallow, sunken or marked at the surface by sharp circular rims; average diameter, 0.75 mm., spaced about 0.25 mm. apart. Septa in one cycle of six, two of them often

[41] Vaughan, T. W.: U. S. Geol. Surv., Mon., xxxix, 1900, p. 164, pl. 18, figs. 11-13a.
[42] Berry, E. W.: Wash. Acad. Sci., Jour., xix, 1929, p. 236, figs. 3, 4.
[43] *Op. cit.*: p. 171, pl. 19, figs. 12-14.

larger than the remainder and uniting from opposite sides to divide the corallite. No traces of a second cycle, while a few calices show only three septa equally spaced. Columella low and styliform. Endothecal dissepiments tabular, spaced about 0.6 mm. apart. Cœnenchyme cellular below, solid and spinose or granulose on the surface between the calices, and with no trace of a dividing ridge or groove between corallites. In thin section a definite boundary can be seen between the cœnenchymatal exotheca of adjoining corallites.

Specimen.—Holotype, Paleontological Research Institution.

Occurrence.—Chira formation, lower Oligocene, near Casa Saman, Chira Valley, northern Peru.

Remarks.—The characters given above will not, perhaps, always serve to identify this species, since they are based upon the basal portion of what may have been a bushy colony. In such cases the appearance of the corallites on the branches is usually different from that of those on the base.

Stylophora is a fairly common coral in the Tertiary of the Caribbean area and its borders. Vaughan[44] indicates the presence of 20 species having a total stratigraphic range from lower Eocene through Miocene. The Oligocene species, including the new one described here, may be separated by the following key:

I. Calices 1 mm. or more in diameter—
  A. Septa in one cycle of 6 .... *S. imperatoris* Vaughan
  B. Septa in two cycles of 6 each—
    1. Corallum ramose .... *S. macdonaldi* Vaughan
    2. Corallum massive; calices 1 mm. in diameter—
      a. Calices about 1 mm. apart .... *S. canalis* Vaughan
      b. Calices about ½ mm. apart .... *S. ponderosa* Vaughan
II. Calices less than 1 mm. in diameter—
  A. Septa in one cycle of 6—
    1. Branches small, about 2.5 mm. in diameter; calices about 1 mm. apart .... *S. minutissima* Vaughan
    2. Branches from 5 to 10 mm. in diameter; calices from 0.25 to 0.5 mm. apart .... *S. chiraensis* Wells
    3. Branches flattened, about 10 x 35 mm. in section; calices from 0.5 to 1 mm. apart .... *S. panamensis* Vaughan
  B. Septa in two cycles of 6 each; branches flattened; calices about 1.5 mm. apart .... *S. goethalsi* Vaughan

44 Vaughan, T. W.: U. S. Nat. Mus., Bull., 103, 1919, p. 334.

Family MUSSIDÆ

Genus CYCLOMUSSA, n. gen.

Characters of genus.—Solitary mussoids, cupoloid to low cylindrical, free, with slightly convex base and highly exsert septa. Wall septothecal and parathecal, partially epithecate, costate. Septa stout, with large dental lobulations. Columella well developed, spongy. Dissepiments highly developed.

Genotype.—*Cyclomussa concinna,* n. sp.

Remarks.—This little mussoid coral is readily distinguished by the form of the corallum. Its relations to the other solitary mussoids are shown by the following analytical key:

I. Epitheca present—
- A. Epitheca strong; corallum turbinate .... *Antillia*
- B. Epitheca weak; corallum cupulo-cylindrical .... *Cyclomussa*

II. Epitheca absent—
- A. Wall septothecal—
  - 1. Corallum turbinate .... *Circophyllia*
  - 2. Corallum ceratoid .... *Leptomussa*
- B. Wall parathecal—
  - 1. Monocentric, turbinate .... *Acanthophyllia*
  - 2. Some monostomatous budding; form uncertain .... *Apostrophyllum*

Homomorphic with, and strikingly like *Cyclomussa,* is *Indophyllia* Gerth[45] of the upper Oligocene and Miocene of Java and Borneo, but which is a faviid coral related to *Antillophyllia* and *Trachyphyllia,* corals with finer septal dentations and two trabecular fan-systems.

Cyclomussa concinna, n. sp. Plate 3, fig. 1

Description.—Corallum cupoloid to low cylindrical, with broad, slightly convex base, fixed in early stages to a small shell or other object, later covering this and expanding laterally forming a broad free base. Diameter ranging from 23 to 35 mm.; height from 10 to 27 mm.; dimensions of largest cylindrical specimen: h—27 mm., d—27 mm. Wall in early discoidal stages septothecal, later parathecal and not differentiated from the endothecal dissepiments. Costæ subequal with a single marginal row of strong beads which merge into acute lobulate dentations toward the calice. Epitheca represented by narrow bands or shreds forming light cingulations. Septa composed of compound trabeculæ, highly exsert with lobulate sharp dentations, about 11 in

[45] Gerth, H.: Samml. Geol. R. Mus. Leiden, n. f., i, 1921, p. 405.

number, broad compressed-conical peripherally, tall and cylindro-conical near the columella, axis of trabecular divergence nearly horizontal. Septal arrangement hexameral with the 24 septa of the first three cycles largest, equal, and extending to the columella. Total number of septa variable, between 70 and 80, thus comprising 4 complete cycles with the 5th developed in most of the systems. Columella well developed, circular or elliptical in outline, trabecular, formed of interlacing trabecular processes from the inner ends of the septa, about 5 mm. in diameter when circular, its upper surface lying in a shallow fossette. Endothecal dissepiments cellular, richly developed. Exotheca developed but scarcely distinguishable from the endotheca.

Specimens.—Holotype and 10 paratypes, Paleontological Research Institution.

Occurrence.—Chira formation, lower Oligocene, near Casa Saman, Chira Valley, northern Peru.

PLATE 1 (44)

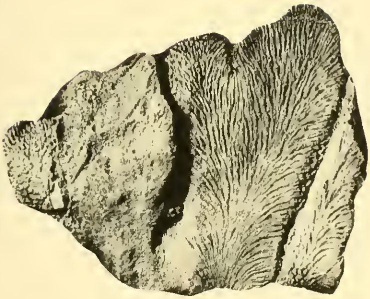
EXPLANATION OF PLATE 1 (44)

CRETACEOUS CORALS

Figure		Page
1.	**Astrocœnia peruviana** Wells Pananga limestone: 1, lateral view of holotype corallum, ×0.5; 1a, transverse thin section of holotype, ×2.	5
2.	**Montastrea parinasensis** Wells Monte Grande formation: 2, corallum of holotype, ×1; 2a, transverse section of three corallites, ×6.	7

EOCENE CORALS

3.	**Stephanocœnia storrsi** Wells Restin formation: Calicular surface of holotype, ×2.	8
4.	**Madracis vaughani** Wells Restin formation: 4, holotype, ×1; 4a, same specimen, ×2; 4b, paratype, ×1; 4c, same specimen, ×2.	9
5.	**Trochoseris gerthi** Wells Restin formation: 5, 5a, lateral and basal aspects of holotype, ×1; 5b, calice of holotype, ×2.	10
6.	**Goniopora nomlandi** Wells Restin formation: 6, lateral aspect of holotype, ×1; 6a, paratype, ×1; 6b, paratype, ×2.1.	11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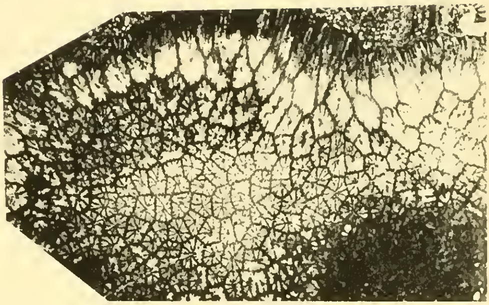
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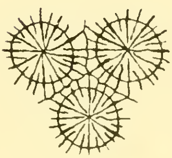
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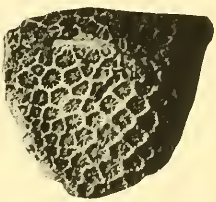
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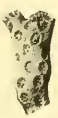
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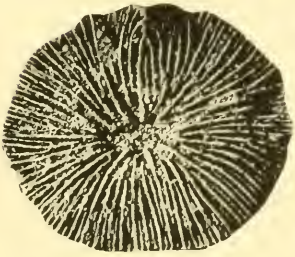
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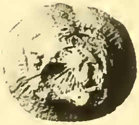
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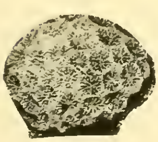
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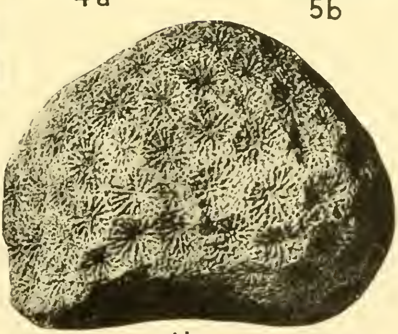
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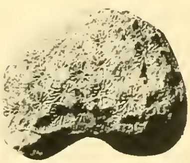
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PLATE 2 (45)

EXPLANATION OF PLATE 2 (45)

EOCENE CORALS

Figure		Page
1.	**Oculina olssoni** Wells Restin formation: 1, lateral aspect of holotype, ×1; 1a, calices of holotype, ×2; 1b, paratype, ×1; 1c, paratype, natural section of corallite just below calice, ×2.	12
2.	**Paracyathus peruvianus** Vaughan Restin formation: 2, calice, ×2; 2a, lateral aspect, ×1.	13
3.	**Lophosmilia yabei** Wells Restin formation: 3, worn calice of holotype, ×1; 3a, same, ×2; 3b, transverse section of holotype near base, ×3.	13
4.	**Haimesiastræa distans** Vaughan Restin formation: 4, distal portion of branch, ×1.	15
5.	**Peruviastrea peruviana** Vaughan Salina formation: 5, terminal portion of ramose branch, ×1; 5a, same, ×2; 5b, transverse thin section just below junction of two branches, ×2.	16
6.	**Balanophyllia piuræensis** Wells Restin formation: 6, end aspect of holotype, ×1; 6a, lateral aspect of same, ×2.	16

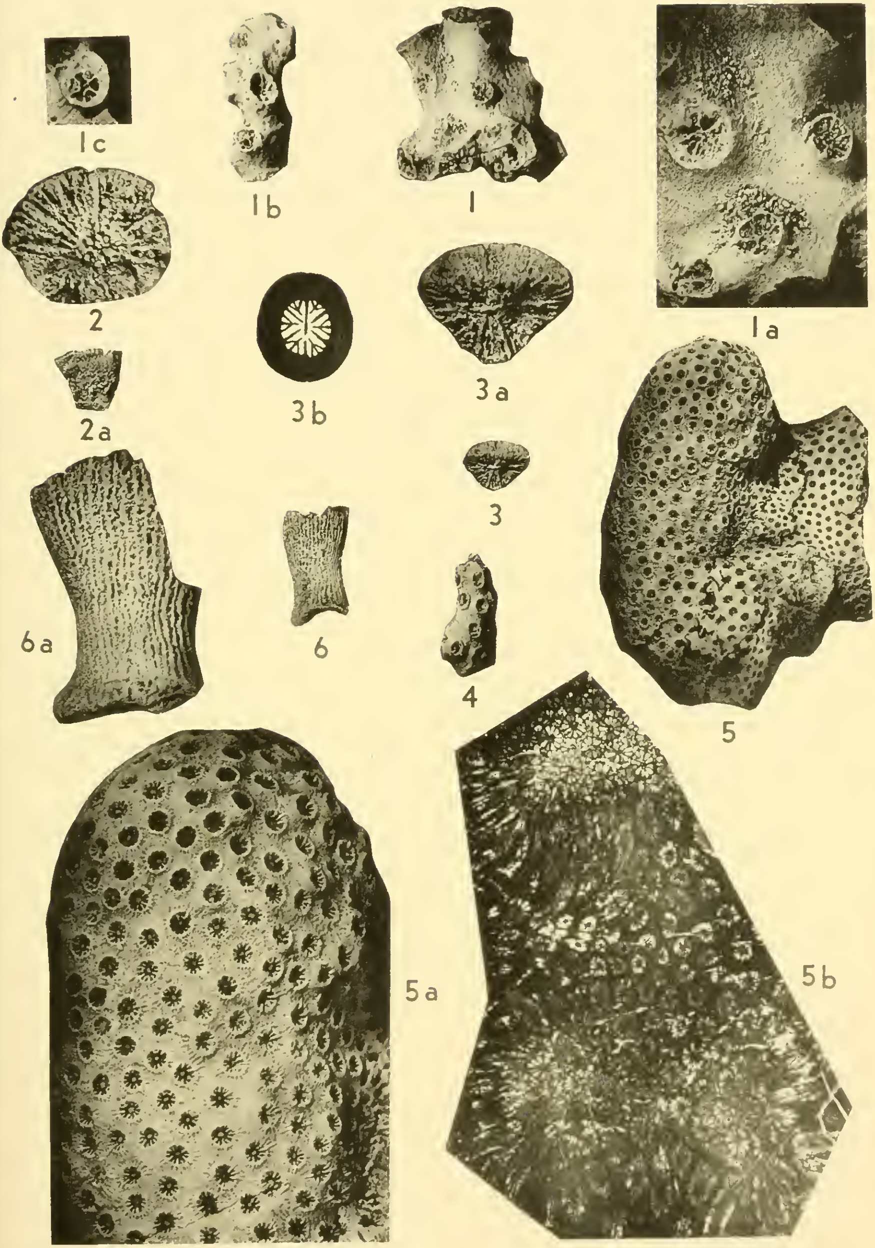
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PLATE 3 (46)

EXPLANATION OF PLATE 3 (46)

OLIGOCENE CORALS

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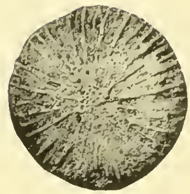

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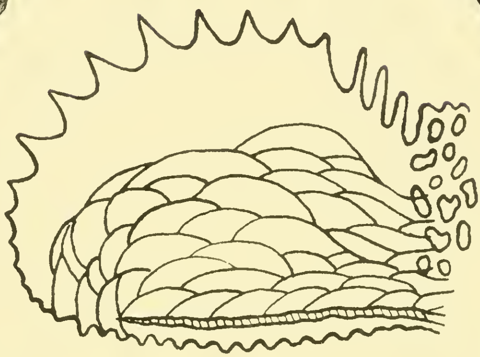

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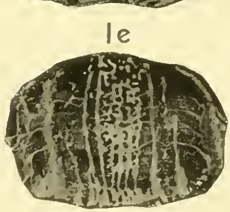

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Some Palmate Lagenidæ from the Lower Cretaceous Washita Group

By

Alfred R. Loeblich and Helen Tappan

Tulane University, New Orleans, Louisiana

March 16, 1941

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Ithaca, New York

U. S. A.

SOME PALMATE LAGENIDÆ FROM THE LOWER CRETACEOUS WASHITA GROUP

Alfred R. Loeblich, Jr.[1] and Helen Tappan[2]
Tulane University, New Orleans, Louisiana

INTRODUCTION

During the past few years the writers have been engaged in a monographic study of the Foraminifera of the Washita group of northern Texas and southern Oklahoma. A number of palmate species have been encountered, many of which seem to be excellent index species. While numerous references to *Frondicularia* and *Palmula* have been made for the Upper Cretaceous of the Gulf Coast, the Lower Cretaceous faunas have been largely neglected, only one species of *Frondicularia* having been previously described (Tappan, 1940, p. 111, pl. 17, figs. 13a-14). The writers have recorded a total of 14 species for these two genera as well as 4 other palmate species, referred to *Flabellinella*, from the Washita group of northern Texas and southern Oklahoma. As many of these species are rather large and occur abundantly, it is surprising that they have not been recorded by previous workers.

One of the species of *Frondicularia* was originally described from the Gault (Albien) of Germany, and occurs in the equivalent beds in England and France. There are numerous other species of *Frondicularia* as well as a species of *Palmula* at that horizon in Europe, which are very similar to the new species of those genera here described. It is therefore somewhat surprising to note that only this one species of *Palmula* has been recorded from the Albien or Gault, although 9 species of that genus are here recorded from beds of equivalent age on the Gulf Coast. The geologic range of the genus *Flabellinella* is extended into the Lower Cretaceous, as all previous records were from the Upper Cretaceous.

[1] Arrangement of names is alphabetical, no seniority implied.
[2] Mrs. Alfred R. Loeblich, Jr.

Types.—All types are to be deposited at the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts, so as to be available to workers in the field, but are in the writers' collection pending the completion of a monograph on the Foraminifera of the Washita Group. Cushman Catalog numbers for all types will be given in this future monograph. Paratypes are in the writers' collection.

Acknowledgments.—The writers are indebted to Dr. J. A. Cushman for reading the manuscript, offering valuable suggestions, and checking the species with type material at his laboratory. Acknowledgment is also made of a grant from the Graduate Research Fund of Tulane University to cover a portion of the expense of the plates.

All samples were collected, washed and picked jointly by the writers. Illustrations are camera lucida drawings by Helen Tappan.

LOCALITIES

HTL—4. *Main Street formation* (*lower*).—In the west bank of head water branch of Paw Paw Creek, beneath the bridge, south of the road, between two railroad viaducts in the 100 Block Owing Street, in the southeast part of the city of Denison, Grayson County, Texas.

7. *Main Street formation.*—Roadcut on the east side of U. S. Highway 75, on the north bank of Chuckwa Creek, 1 mile north of Durant, in the SW ¼, SW ¼, Sec. 21, T. 6 S., R. 9 E., Bryan County Oklahoma.

13. *Duck Creek formation.*—On the west bank of the Red River, on the southwest side of Horseshoe Bend, in the SW ¼, Sec. 22, T. 8 S., R. 2 E., Love County Oklahoma.

22. *Weno formation.*—In the north bank of a tributary to Corcoran Creek, west of the road along the section line between Sections 11 and 12, in the SE ¼, Sec. 11, T. 8 S., R. 2 E., Love County, Oklahoma.
25. *Denton formation.*—In the creek bank in Munson Park, just west of U. S. Highway 75 and just north of the exit from the park, 1.1 miles north of the Main Street of Denison, Grayson County, Texas.
27. *Duck Creek formation.*—In the east bank of Duck Creek, east of U. S. Highway 75, 2 3/4 miles north of the Main Street of Denison, Grayson County, Texas.
28. *Fort Worth formation.*—On the north bank of the Red River, just east of the bridge on U. S. Highway 75, in the SW ¼, Sec. 25, T. 8 S., R. 7 E., Bryan County, Oklahoma.
31. *Grayson formation.*—Along the hillside and in the banks of a small creek at the proposed road of Fifth Avenue, between Nelson and Sheppard Streets, in the southeast part of the city of Denison, Grayson County, Texas.
32. *Main Street formation.*—In the banks of Little Mineral Creek, 500 feet south of the bridge on the Locust Road, about 1 mile southeast of Fink (locally called Georgetown), Grayson County, Texas.
34. *Duck Creek formation (Type locality).*—In the banks of Duck Creek and in the railroad cut where the St. Louis and San Francisco Railroad comes close to the creek, 2 3/4 miles north of the city of Denison, Grayson County, Texas. This locality is downstream from Station HTL—27.
35. *Duck Creek formation.*—In a roadcut on the east side of the road, just inside the entrance to Forest Park, 0.4 miles due north of the northeast corner of the campus of Texas Christian University, in the city of Fort Worth, Tarrant County, Texas.

36. *Main Street formation.*—In roadcuts for about one-fourth mile, on the road leading eastward to Grayson Bluff from the Fort Worth - Denton highway, about one mile east of the highway, $3\frac{1}{2}$ miles northeast of Roanoke, Denton County, Texas.
37. *Main Street formation.*—In a deep roadcut on the Denton-Aubrey road, about 0.1 mile south of the bridge over Clear Creek, 4.8 miles by road northeast of the Denton County courthouse square, in Denton, Denton County, Texas.
38. *Duck Creek formation.*—In a low, north-facing cliff, forming the south bank of Hickory Creek, 150 feet north of the road leading northwest from Krum to Trinity Farms, 8 miles northwest of Krum, Denton County, Texas.
46. *Paw Paw formation.*—In the roadcut and on the side of the hill along the west side of the Forth Worth-Burleson highway, where it swings southward near the top of the hill, one-fourth mile southeast of where the Fort Worth - Everman Road turns from the Fort Worth - Burleson Highway, southeast of Fort Worth, Tarrant County, Texas.
47. *Weno formation.*—On the south bank of a small gully flowing northward to empty into a tributary of Sycamore Creek which was dammed to form Katy Lake, one-fourth mile east of and below the Katy Lake Dam, southeast of Fort Worth, Tarrant County, Texas.
51. *Main Street formation.*—In a low, east-facing creek bank, west of the Joshua - Cleburne road at the northern edge of the town of Cleburne, Johnson County, Texas.
55. *Main Street and Paw Paw formations.*—In roadcuts on the western edge of the Federal Narcotic Farm, southeast of Fort Worth, Tarrant County, Texas.
57. *Duck Creek formation.*—In a roadcut on the east side of U. S. Highway 77, just south of the bridge across the Red River, in Cooke County, Texas.

58. *Paw Paw formation.*— In a roadcut, north of the road in the 100 block Owing Street, just east of two railroad underpasses in the southeast part of the city of Denison, Grayson County, Texas. This locality is just east and across the road from Station HTL—4.

60. *Duck Creek formation.*— In a low, north-facing cliff, forming the south bank of a small creek, a short distance north of the road, 0.1 mile east of the bridge crossing the creek, 0.9 mile east of Fink (locally called Georgetown), in Grayson County, Texas.

64. *Grayson formation.*—In a roadside ditch at the east boundary of the NE ¼, Sec. 19, T. 7 S., R. 7 E., east of the road and 0.3 mile south of the northeast corner of the section, northeast of Woodville, Marshall County, Oklahoma.

66. *Grayson formation.*—On the west bank of Shoal Creek, just south of the bridge of 34th Street and just north of a small fault, in the city of Austin, Travis County, Texas.

SYSTEMATIC DESCRIPTIONS

Order **FORAMINIFERA**

Family **LAGENIDÆ**

Subfamily **NODOSARIINÆ**

Genus **PALMULA** Lea, 1833

Palmula acuta Loeblich and Tappan, n. sp. Plate 1, figs. 3-4

Description.—Test large, broad, much compressed, early portion coiled, possessing a slight keel; 6 to 7 chambers in the coiled portion followed by very acutely chevron-shaped uniserial chambers, 8 occurring in the holotype, the last chamber extending slightly more than one-half the length of the test; sutures raised, somewhat thickened, especially centrally, slightly curved in the coiled portion; wall calcareous, smooth; aperture terminal, radiate. Length of holotype, 2.34 mm.; greatest breadth, 1.09 mm., greatest thickness through coiled portion, 0.15 mm.; greatest thickness through uniserial portion, 0.12 mm. Length of paratype, 0.87 mm.; greatest breadth, 0.43 mm.; greatest thickness through coiled portion, 0.12 mm.; greatest thickness through uniserial portion, 0.08 mm.

Remarks.—*P. acuta*, n. sp., is somewhat similar to *P. suturalis* (Cushman), but differs in the much flatter test and more acutely arched chambers, giving rise to a narrower test. It differs from *P. leai*, n. sp., in the smaller size, more compressed test, more elevated and more acutely arched sutures and in possessing a smaller coiled portion.

Locality.—Holotype from the Duck Creek formation, from the lower 5 feet of the formation at Station HTL—34; paratypes in a dark-gray marl, alternating with thin limestone beds, from 5 feet to 12 feet above the base of the formation at the same station, and from the middle of the exposed Duck Creek formation at Station HTL—27.

Palmula decorata Loeblich and Tappan, n. sp. Plate 1, fig. 5

Description.—Test large, elongate, sides nearly flat, greatest width about three-fifths the distance from the coil to the aperture; early coiled portion with 9 chambers in the holotype, and possessing a keel, followed by 7 chevron-shaped uniserial chambers, with rounded periphery, chambers increasing gradually in size as added; sutures much elevated and thickened, especially in the central portion of the uniserial stage, slightly curved in the coiled part and ornamented with raised bosses, crossed by somewhat elongate nodes in the central part of the uniserial stage, wall calcareous, surface smooth between the sutures; aperture terminal, radiate. Length of holotype, 3.41 mm.; greatest diameter of coil, 0.74 mm.; greatest breadth of uniserial portion, 1.09 mm.; greatest thickness through coil, 0.47 mm.; greatest thickness of uniserial portion, 0.43 mm.

Remarks.—This species differs from *P. simplex* Cushman, to which it is similar in form, in the much larger size, less compressed test, distinct keel in the coiled portion and the elevated sutures and ornamentation of the entire test.

Locality.—Holotype from marl bed between two limestone ledges in the basal Main Street formation at Station HTL—4; paratype from the basal Main Street formation at Station HTL—32.

Palmula dentonensis Loeblich and Tappan, n. sp. Plate 2, fig. 1

Description.—Test large, broad, thick, early portion coiled and possessing 8 to 9 chambers, followed by 8 uniserial chambers in the holotype, last chamber extending about three-fifths the length, greatest breadth of test midway to two-thirds the distance from the coil to the aperture, periphery rounded; sutures slightly curved in coiled portion, thickened and slightly raised, in the uniserial portion chevron-shaped and greatly thickened centrally; wall calcareous, smooth, a large raised boss at center of coiled portion; aperture terminal, radiate. Length of holotype, 3.10 mm.; greatest breadth, 1.77 mm.; greatest thickness through coiled portion, 0.60 mm.; greatest thickness through uniserial portion, 0.35 mm.

Remarks.—This species differs from *P. suturalis* (Cushman) in the narrower and much thicker test, rounded periphery, comparatively larger coiled portion with large central boss and much less elevated sutures. It differs from *P. limbata*, n. sp., in the narrower test, larger coiled portion, single central boss and less elevated sutures.

Locality.—Holotype from Denton formation, in a 1.5-foot blue-gray marl with yellow sandy shale bands, between two shell breccias of *Gryphea washitensis* Hill, 2 feet below top of exposed section at Station HTL—25; paratypes in the yellow marl above the upper shell breccia at the same locality.

Palmula howei Loeblich and Tappan, n. sp. Plate 2, figs. 4-7

Description.—Test large, elongate, megalospheric forms generally narrow, rarely somewhat flared, microspheric forms flared, periphery rounded, early portion coiled, late portion uniserial; chambers numerous, 9 to 10 chambers forming a cristellarian coil in the microspheric form, followed by 7 uniserial chambers in the holotype, 5 to 6 chambers, including the prominent globular proloculum, forming a more vaginuline coil in the megalospheric form, followed by about 9 uniserial chambers, greatest width of megalospheric test about one-fifth to three-fifths the distance from the coil to the aperture, greatest width of microspheric form one-fifth the distance toward the aperture; sutures distinct, slightly depressed, acutely chevron-shaped, slightly thickened centrally; wall calcareous, smooth; aperture terminal, radiate.

	Holotype Fig. 6	Paratype Fig. 5	Paratype Fig. 4
Length	1.57 mm.	3.63 mm.	1.53 mm.
Greates breadth	1.03	0.79	0.78
Maximum thickness through coiled portion	0.08	0.14	0.12
Maximum thickness of uniserial portion	0.14	0.14	0.12

Remarks.—This species is similar to *P. budensis* (Hantken) in general size and outline but has a more definitely coiled early portion and relatively higher and more acutely arched uniserial chambers. The megalospheric Fort Worth specimens have more embracing chambers, giving rise to a broader test than in the Duck Creek forms.

This species is named in honor of Dr. Henry V. Howe, in recognition of his work on this genus.

Locality.—Holotype from the Duck Creek formation, in the upper ten feet exposed, consisting of alternating thin limestones and thicker marls, at Station HTL—57; paratypes from the lower part of the formation at the same locality; paratypes from middle and upper Duck Creek formation at Station HTL—13, upper Duck Creek formation at Stations HTL—34 and HTL—35, and from the upper and lower part of the exposure of the Fort Worth formation at Station HTL—28.

Palmula leai Loeblich and Tappan, n. sp. Plate 1, figs. 1-2

Description.—Test large, broad, compressed, early portion coiled and possessing a slight keel, 12 chambers in the microspheric coil, 7 in the megalospheric coil, later portion uniserial with acutely chevron-shaped chambers and rounded periphery, 15 uniserial chambers in the holotype, test increasing continually in width, sutures slightly raised, somewhat thickened, especially centrally, slightly curved in the coiled portion; wall calcareous, smooth, slight boss in central portion of the coil; aperture terminal, radiate. Length of holotype, 4.33 mm.; greatest breadth, 1.98 mm.; greatest thickness through coiled portion, 0.17 mm.; greatest thickness through uniserial portion, 0.19 mm. Length of paratype, 2.37 mm.; greatest breadth, 1.63 mm.; greatest thickness through coiled portion, 0.19 mm.; greatest thickness of uniserial portion, 0.14 mm.

Remarks.—This species is somewhat similar in general form to *P. instabilis* (Terquem) but differs in the much larger size, shorter and more enrolled coiled portion and more flaring test. This species differs from *P. howei*, n. sp., in the wider test, raised rather than depressed sutures, more lenticuline coiled portion, rather than vaginuline as in *P. howei*, and in the presence of a slightly raised central boss.

The species is named in honor of Mr. Isaac Lea, the author of the genus.

Locality.—Holotype from the basal 5 feet of the Duck Creek formation at Station HTL—34; paratypes from lower part of the Duck Creek formation, but above the type horizon, at the same station; paratypes from the lower and middle part of the formation at Station HTL—27.

Palmula leptata Loeblich and Tappan, n. sp. Plate 2, fig. 2

Description.—Test large, elongate, compressed, greatest width midway between the coil and aperture, early portion coiled, lenticular in cross-section and possessing a keel, later portion uniserial with rounded periphery; chambers numerous, low, increasing gradually in size as added, with 10 chambers in the coiled portion of the holotype, followed by 7 uniserial chambers, last chamber extending approximately one-third the length of the test; sutures nearly straight in coiled portion, acutely chevron-shaped in the uniserial portion, thickened and slightly raised; wall calcareous and smooth, raised boss in center of coiled portion; aperture terminal, radiate. Length of holotype, 2.48 mm.; greatest breadth through coiled portion, 0.45 mm.; greatest breadth of uniserial portion, 0.79 mm.; greatest thickness through coiled portion, 0.29 mm.; greatest thickness through uniserial portion, 0.17 mm.

Remarks.—This species is similar in proportions to *P. simplex* Cushman, but differs in the larger size, more lanceolate outline, more acutely arched later chambers, which extend farther back down the sides of the test, in the slightly raised sutures and the presence of the central boss in the coiled portion.

Locality.—Holotype from the Duck Creek formation, in a dark-gray marl, alternating with thin limestones, from 5 feet to 12 feet above the base of the formation, at Station HTL—34; paratype from the top of the exposure of the Duck Creek formation, at Station HTL—27.

Palmula limbata Loeblich and Tappan, n. sp. Plate 1, figs. 6-10

Description.—Test large, broad, compressed, maximum width fr m one-fou th to two-thirds the distance from the coiled portion to the aperture, varying with the length of the specimen, periphery rounded; early portion coiled and containing 7 to 9 chambers, possessing a keel, later portion uniserial with acutely chevron-shaped chambers, 10 uniserial chambers being present in the holctype which is incomplete; sutures thickened and much raised, especially in the early portion, appearing slightly beaded in places, somewhat curved in the coiled portion; wall calcareous and smooth, slightly concave between the sutures in the early portion. 6 to 8 raised bosses present at central portion of coil; aperture terminal, radiate.

	Holo ype Fig. 6	Paratype Fig. 7	Paratype Fig. 8	Paratype Fig. 9	Paratype Fig. 10
Length	4 07 mm.	1.98 mm.	2.64 mm.	2.74 mm.	2.21 mm.
Greatest breadth	1.77	1.94	1.82	1.70	1 55
Maximum thickness through coil	0.47	0.33	0.43	0.41	0.41
Maximum thickness through uniserial portion	0.37	0.16	0.21	0.35	0.31

Remarks.—This species differs from *P. suturalis* (Cushman) in the much larger test, thicker coiled portion, raised bosses and beaded sutures of the central portion, and the tendency for the sides to become parallel, as shown in the holctype.

Locality.—Holotype from the Main Street formation, in the zone of *Exogyra arictina* Roemer, alternating thin limestones and thicker light-gray marls, near the top of the exposure at Station HTL—36; paratype of fig. 10 is from the same locality; paratypes of figs 7. and 8 from the Main Street formation, in a 2-foot marl zone between limestone ledges at the base of the formation at Station HTL—4; paratype of fig. 9 from the lower Grayson formation in zone of *Exogyra arictina* Roemer, at Station HTL

—64; this species has also been recorded from the Main Street formation at Stations HTL—7, 32, 37, 51 and 55, and from the lower Grayson at Station HTL—31.

This species is very abundant, especially in the Main Street formation, and should be an excellent index for the Main Street and lower Grayson formations.

Palmula lozoi Loeblich and Tappan, n. sp. Plate 2, fig. 3

Description.—Test large, broad, early portion lenticular and coiled, possessing a keel, later uniserial with sharply truncate periphery, greatest width of test approximately midway between coil and aperture; chambers numerous, slightly concave between the sutures, about 9 in the coiled portion, followed in the holotype by 4 low, chevron-shaped uniserial chambers that extend far down the sides of the test, last chambers extending approximately two-thirds the length of the test; sutures raised and thickened, slightly curved in the coiled portion; wall calcareous, smooth, raised bosses at center of coiled portion; aperture terminal and radiate. Length of holotype, 2.35 mm.; greatest breadth, about 1.55 mm.; greatest thickness through coiled portion, 0.41 mm.; greatest thickness through uniserial part, 0.23 mm.

Remarks.—This species somewhat resembles *P. pilulata* Cushman, but differs in its smaller size, less compressed test, more acutely angled later chambers and therefore narrower test, less curved sutures in the early portion and thicker and more highly elevated sutures of the later portion. It differs from *P. limbata*, n. sp., in possessing a larger coiled portion, which is lenticular in cross-section and possesses a keel.

This species is named in honor of Mr. Frank Lozo, Jr., of Texas Christian University, in recognition of his work on the Lower Cretaceous Foraminifera of Texas.

Locality.—Holotype from the Paw Paw formation, in the upper two feet of yellow marl, just below the Main Street formation, at Station HTL—55.

Palmula tarrantensis Loeblich and Tappan, n. sp. Plate 2, figs. 8-12

Description.—Test relatively small, much compressed, subrhomboidal in outline, periphery rounded on the distal border of the last chamber, truncate at lower margin, bordered on each edge by a keel which fuses at the base into a single acuminate point; much reduced coiled portion, consisting of only two chambers, later chambers acutely chevron-shaped, up to 5 in number, last chamber extending back from two-thirds to seven-eighths the length; sutures distinct, slightly depressed; wall calcareous, surface smooth, proloculum often ornamented with a faint longitudinal rib, second chamber with one or two faint ribs, later chambers may be crossed by a few indistinct ribs; aperture terminal at the end of a short neck.

	Holotype Fig. 11	Paratype Fig. 10	Paratype Fig. 9	Paratype Fig. 12	Paratype Fig. 8
Length	0.97 mm.	0.74 mm.	0.6 mm.	———	1.26 mm.
Breadth	0.47	0.35	....	0.37 mm.	0.68
Thickness	0.06	0.08	....	....	0.10

Remarks.—This species is very similar in form and structure to *Palmula didyma* (Berthelin), which was originally described as a *Frondicularia*, and later referred to *Flabellina* by Chapman and Eichenberg, as both species have a much reduced coiled portion. *Palmula tarrantensis*, n. sp., differs from *P. didyma* (Berthelin) in its slightly larger size, specimens with the same number of chambers being from one-fifth to one-third larger, in possessing more elongate early chambers, less acutely angled uniserial portion, rounded periphery and the presence of surface ornamentation.

Locality.—Holotype and paratypes from the lower Paw Paw formation, in a fossiliferous brownish marl at Station HTL—46; paratype from the lower Weno formation at Station HTL—47.

Genus FRONDICULARIA Defrance, 1826

Frondicularia cushmani Loeblich and Tappan, n. sp. Plate 3, fig. 4

Description.—Test small, subtriangular in outline, sides flat, periphery sharply truncate with a faint rib along each margin, which is extended at the proloculum into an acuminate point; proloculum ovate, with a strong central longitudinal rib, remainder of chambers low, chevron-shaped, extending back so that they are on a line with the apertural end of the proloculum; sutures distinct, slightly thickened; wall calcareous, smooth, except for faint longitudinal ribs crossing the central portion of the chambers, and the central rib of the proloculum; aperture terminal, radiate, at the end of a slight neck. Length of holotype, 1.03 mm.; greatest breadth, 0.76 mm.; greatest thickness through proloculum, 0.12 mm.; greatest thickness through chevron-shaped chambers, 0.08 mm.

Remarks.—This species is similar in appearance to the associated *F. ungeri Reuss*, but differs in the flatter base, due to greater overlapping of the chambers, and the presence of ribs on the surface of test. This species differs from *F. questphalica* Reuss in the flatter base, somewhat smaller size, single rib on the proloculum and fewer number of ribs elsewhere on the test, which are parallel to each other rather than radiating from the proloculum.

Locality.—Holotype from the Paw Paw formation, in a fossiliferous brownish clay, from 5 feet to 10 feet above the base of formation, at Station HTL—46; paratypes from the uppermost Paw Paw formation, in a yellowish and slightly calcareous clay, just beneath the basal ledge of the Main Street limestone, at Station HTL—58.

Frondicularia hilli Loeblich and Tappan, n. sp. Plate 3, figs. 2-3

Description.—Test small, lanceolate, sides flat to slightly concave centrally but not much compressed, periphery sharply truncate, with a slight rib at each margin; proloculum elongate to ovate, rest of chambers sharply chevron-shaped, slightly concave between the sutures, increasing gradually in width as added, last chamber extending back approximately one-third the length; sutures distinct, slightly thickened, very slightly elevated; wall calcareous, smooth between the sutures, a faint median rib present on one side of the test of the holotype, but not recognizable on the other side, very faint lateral ribs may also occur; aperture terminal, radiate, at the end of a slight neck, earlier apertures being visible through the test. Length of holotype, 1.92 mm.;

greatest breadth, 0.47 mm.; greatest thickness, 0.12 mm. Length of paratype, 1.97 mm.; breadth 0.46 mm.; greatest thickness, 0.19 mm.

Remarks.—This species is closest in general outline to *Frondicularia archiaciana* d'Orbigny var. *strigillata* Pagg, but differs in having an elongate and smooth proloculum and much fainter ribs on the remainder of the test. The ribs cross the chambers more directly in *F. hilli*, n. sp., rather than at first following the sutures, and are not as prominent at the sutures as in *F. archiaciana* var. *strigillata*.

This species is named in honor of Mr. R. T. Hill, in recognition of his excellent work on the Cretaceous of this region.

Locality.—Holotype and paratype from the basal 5 feet of the Duck Creek formation at Station HTL—34.

Frondicularia ungeri Reuss Plate 3, figs. 5-7

Frondicularia ungeri Reuss, 1863, Sitz. Akad. Wiss., Wien., vol. 46, p. 54, pl. 4, figs. 11a-b.
Frondicularia ungeri Berthelin, 1880, Geol. Soc. France, Mem., ser. 3, vol. 1, Mem. 5, p. 61, pl. 4. fig. 4.
Frondicularia ungeri Chapman, 1894 Jour. Roy. Micr. Soc., p. 157, pl. 3, fig. 16; 1899, Ann. Mag. Nat. Hist., ser. 7, vol. 3. p. 302.
Frondicularia ungeri Egger, 1900, Bayer. Akad. Wiss. München, Abh., vol. 21, Abt. 1, p. 89, pl. 13, figs. 10-11; 1908, Naturw. Ver. Passau, vol. 20, p. 29, pl. 1, figs. 6, 15-16.
Frondicularia ungeri Chapman, 1917, Geol. Surv. Western Australia, Bull. 72, ser. 6, No. 11, p. 31, pl. 6, fig. 56.
Frondicularia ungeri Eichenberg, 1933, Niedersächs geol. Ver., Jahresber., 25, Folge 1, p. 8, pl. 6, fig. 1.

Description.—Test small, sides flat, periphery sharply truncate, lateral edges excavated centrally, producing faint ribs at the angles of the lower margin of the test, periphery more rounded above; proloculum globular to somewhat elongate, rest of chambers low, chevron-shaped and compressed, last chamber extending back two-thirds to four-fifths the length of the test; sutures distinct, somewhat thickened, varying from faintly depressed to slightly elevated; wall calcareous, smooth, no ornamentation other than a single central rib crossing the proloculum longitudinally; aperture terminal, radiate, at the end of a slight neck.

	Hypotype Fig. 5	Hypotype Fig. 6	Hypotype Fig. 7
Length	0.74 mm.	0.87 mm.	1.18 mm.
Breadth	0.25	0.33	0.64
Maximum thickness through proloculum	0.17	0.17	0.12
Maximum thickness above proloculum	0.12	0.06	0.06

Remarks.—The type specimen figured by Reuss is very similar to the megalospheric form from the Paw Paw shown in fig. 6, but has one less chamber. The length of the equivalent number of chambers in the Paw Paw specimen is the same as that of the holotype. Our figure 7 referred to this species, is microspheric and much more complete than the holotype. Both Reuss and Eichenberg record this species as rare in Germany; Chapman records it as common in some zones at Folkestone, England, and rare in others; Berthelin records it as common at Montcley, France.

Locality.—Hypotypes have been recorded from the following localities: Middle Duck Creek formation at Station HTL—13; upper part of the Weno formation exposed at Station HTL—47; lower part of exposed Weno formation at Station HTL—22; lower Paw Paw formation in a fossiliferous brownish marl at Station HTL—46; middle part of the exposure of the Paw Paw formation at Station HTL—55. Very small megalospheric forms, similar to that shown in fig. 5, occur in the upper Grayson formation at Station HTL—90.

Frondicularia sp. A. Plate 3, fig. 9

Description.—Test small, subovate in outline, somewhat compressed, periphery rounded; proloculum subglobular, later chambers chevron-shaped, extending far back down the sides of the test; sutures distinct, depressed; wall calcareous, proloculum thickened centrally so that it seems to possess a very coarse rib, a lightly raised longitudinal rib crossing the central portion of the later chambers; aperture terminal, radiate. Length, 1.28 mm.; greatest breadth, 0.87 mm.; greatest thickness, 0.08 mm.

Remarks.—The figured specimen is somewhat irregular in development as the third chamber fails to embrace both sides of the test; however, both the second and all later chambers are frondicularian in character. At present too few specimens have been encountered for specific determination.

Locality.—Figured specimen from the upper 10 feet of the Duck Creek formation, in a zone of alternating thin limestones and thicker marls, at Station HTL—57. We also have recorded this species from the Duck Creek formation, in a gray shale from 47 to 52 feet above the base, at Station HTL—13.

Frondicularia sp. B. Plate 3, fig. 8

Description.—Test medium in size, subovate in outline, periphery rounded; proloculum elongate, rest of chambers low and chevron-shaped, extending back about two-thirds the length of the test; sutures distinct, faintly depressed; wall calcareous, surface smooth, with a single rib crossing the proloculum longitudinally and extending toward the aperture, bifurcating at the distal end of the second chamber and continuing as two low ribs, rest of surface with very faint ribs crossing the chambers but not continuing across the sutures, no ribs present toward the margins of the test; aperture terminal, radiate. Length, 1.46 mm.; greatest breadth, 1.09 mm.; greatest thickness, 0.06 mm.

Remarks.—This species is similar to *F. microdisca* Reuss, but differs in the presence of the central pair of ribs and the lateral ribs, although Chapman figured a specimen, which he referred to this species, that possessed faint lateral ribs, although not the median pair. We do not yet have a sufficient number of specimens for specific description.

Locality.—Figured specimen from the Duck Creek formation, in a three-foot light-yellow marl, with some thin marly limestone, at the top of the exposure at Station HTL—27.

Genus **FLABELLINELLA** Schubert, 1900

Flabellinella delicata Loeblich and Tappan, n. sp. Plate 2, figs. 17-19

Description.—Test small, lanceolate, much compressed, periphery sharply truncate; early portion as in *Vaginulina*, with 4 to 6 chambers, later portion with chevron-shaped chambers, up to 6 in number, increasing gradually in size as added, last chamber extending back from one-third to nearly one-half the length of the test, chambers low, slightly convex between the sutures; sutures distinct, very slightly depressed; wall calcareous, surface smooth, aperture terminal, radiate, at the end of a short neck.

	Holotype Fig. 17	Paratype Fig. 18	Paratype Fig. 19
Length	1.22 mm.	1.16 mm.	0.70 mm.
Length of vaginuline stage	0.47	0.35	0.31
Greatest breadth	0.35	0.45	0.29
Greatest thickness	0.06	0.08	0.06

Remarks.—This species is somewhat similar in appearance to *Palmula jurensis* (Franke), which possibly should also be referred to *Flabellinella*, but differs in possessing a globular proloculum, and in that the vaginuline chambers do not extend as far back toward the proloculum. The uniserial chambers are somewhat higher and do not extend as far back along the test as in *P. jurensis*.

This species also somewhat resembles *F. plana*, n. sp., but differs in its smaller size, less thickness, in having depressed rather than raised sutures, and in general a shorter vaginuline stage. Frondicularian chambers in *F. delicata* become symmetrical early in development.

In contrast to other species of *Flabellinella* found in the Washita group, no *Vaginulina* similar to the early stages of this species has been found to occur with it. While this species occurs in the Duck Creek formation, a *Vaginulina* similar to its early stage occurs in the much younger Paw Paw formation, but no *Flabellinella* stage is found in the Paw Paw, comparable to the Duck Creek species.

Locality.—Holotype from the lower Duck Creek formation, in a zone of thin alternating limestones and marls, from 18 to 23 feet above the base, at Station HTL—34; figured paratypes from the middle Duck Creek formation, from 35 to 39 feet above the base, in light yellowish-gray marls, alternating with nodular limes, at the same locality; paratypes also from 12 to 18 feet above the base at the same locality, and from the lower and middle Duck Creek formation at Station HTL—13 and the middle Duck Creek at Station HTL—57.

Flabellinella plana Loeblich and Tappan, n. sp. Plate 2, figs. 13-15

Description.—Test large, broad, sides flat, periphery sharply truncate; early portion as in *Vaginulina*, possessing 8 chambers in the holotype, later portion with chevron-shaped chambers, increasing in size as added, and with much greater thickness, 10 chevron-shaped chambers occurring in the holotype; sutures distinct, slightly thickened, appearing faintly depressed in the early vaginuline stage, later somewhat raised; aperture terminal, radiate, at the end of a slight neck.

	Holotype Fig. 13	Paratype Fig. 15	Paratype Fig. 14
Length	2.54 mm.	2.50 mm	
Length of vaginuline stage	0.62	1.10	
Greatest breadth	0.85	0.80	
Maximum thickness	0.21	0.16	0.17 mm.
Maximum thickness, including breadth of third angle		0.33	0.37

Remarks.—The early vaginuline stage of this species is quite similar to *Vaginulina kochii* Roemer, with which it is associated. Because of the great number of specimens found, both in widely separated localities and through a considerable thickness of sediments in the Duck Creek formation, it is considered to be a valid species, rather than abnormal specimens of *V. kochii* Roemer. It differs somewhat from *V. kochii* in the more coiled early portion, and is more wedge-shaped in edge view, due to the thinner vaginuline chambers and thicker later chambers, and also differs in the slightly depressed early sutures.

It is interesting to note that Chapman (1898, p. 14, Pl. 2, fig. 13) recorded a single specimen from the Gault of Folkestone, England, referred to the species *Vaginulina truncata* Reuss var. *robusta* Berthelin and Chapman, which had a frondicularian stage. He called this specimen a "bigeneric outgrowth."

In the type horizon of this species, where it is fairly common, two specimens (figs. 14-15) show a supplementary angle in the later frondicularian stage. Thus a transition from *Vaginulina* to *Frondicularia* to a triradiate form, such as was called *Tribrachia* by Schubert, is shown. As only two specimens of this type were found they are not considered distinct, but merely mutations or "freaks."

F. plana, n. sp., differs from *F. zitteliana* (Egger) in the flat sides, sharp periphery, raised sutures, lower and wider chambers and broader test, especially in the frondicularian portion.

Locality.—Holotype and paratypes from the upper Duck Creek formation, in alternating limes and marls at Station HTL—38; also recorded from the middle Duck Creek formation at HTL—13 and 27, in the lower and middle Duck Creek formation at HTL—34, in the lower part of the exposure of the Duck Creek at HTL—35 and in the lower Duck Creek at Stations HTL—57 and 60.

Flabellinella plana Loeblich and Tappan var. **striata** Loeblich and Tappan, n. var. Plate 2, fig. 16

Description.—Test large, elongate, thick, periphery somewhat rounded but with carinate edges; proloculum round and somewhat inflated, early chambers vaginuline in character, 6 in the holotype, later portion with chevron-shaped chambers, 5 in the holotype, sides flat to slightly concave centrally; sutures slightly thickened, raised, with chambers depressed between; wall calcareous, surface ornamented with numerous fine ribs crossing all the chambers, including the proloculum; aperture terminal, radiate, at the end of a short neck. Length of holotype, 2.79 mm.; length of vaginuline stage, 1.38 mm.; breadth, 0.72 mm.; thickness, 0.23 mm.

Remarks.—This variety differs from *F. plana*, n. sp., in possessing numerous ribs across the chambers and is thus similar in the early stages to *Vaginulina kochii* Roemer var. *striolata* Reuss and may represent a development from that variety.

Locality.—Holotype from the Duck Creek formation, in a gray shale, from 47 to 52 feet above the base, at Station HTL—13; paratype from middle Duck Creek, from 29 to 35 feet above the base at Station HTL—34. It is rare at both localities.

Flabellinella (?) sp. Plate 3, fig. 1

Description.—Test large, narrow, sides flat, but not much compressed, periphery sharply truncate, with a faint rib at the angles; early portion as in *Vaginulina*, with 6 chambers in the figured specimen, later chambers chevron-shaped, but not perfectly symmetrical, chambers low, increasing gradually in size as added; sutures distinct, slightly thickened; wall calcareous, surface smooth; aperture terminal, radiate. Length of figured specimen, 1.87 mm.; length of vaginuline stage, 0.78 mm.; breadth, 0.35 mm.; thickness, 0.16 mm.

Remarks.—The early vaginuline stage of this species resembles closely a *Vaginulina* which occurs in the same beds; the frondicularian chambers are not perfectly symmetrical and only a few specimens have been found. Therefore the species is here referred to *Flabellinella* questionably, as it may represent merely a "freak" *Vaginulina.*

This form differs from *F. plana,* n. sp., in the less globular proloculum and narrower form, in both the vaginuline and frondicularian stages, and less coiling in the early part.

Locality.—Figured specimen from the basal 5 feet of the Duck Creek formation at HTL—34. We also have recorded this species from 47 to 52 feet above the base of the Duck Creek formation, in a gray shale, at Station HTL—13.

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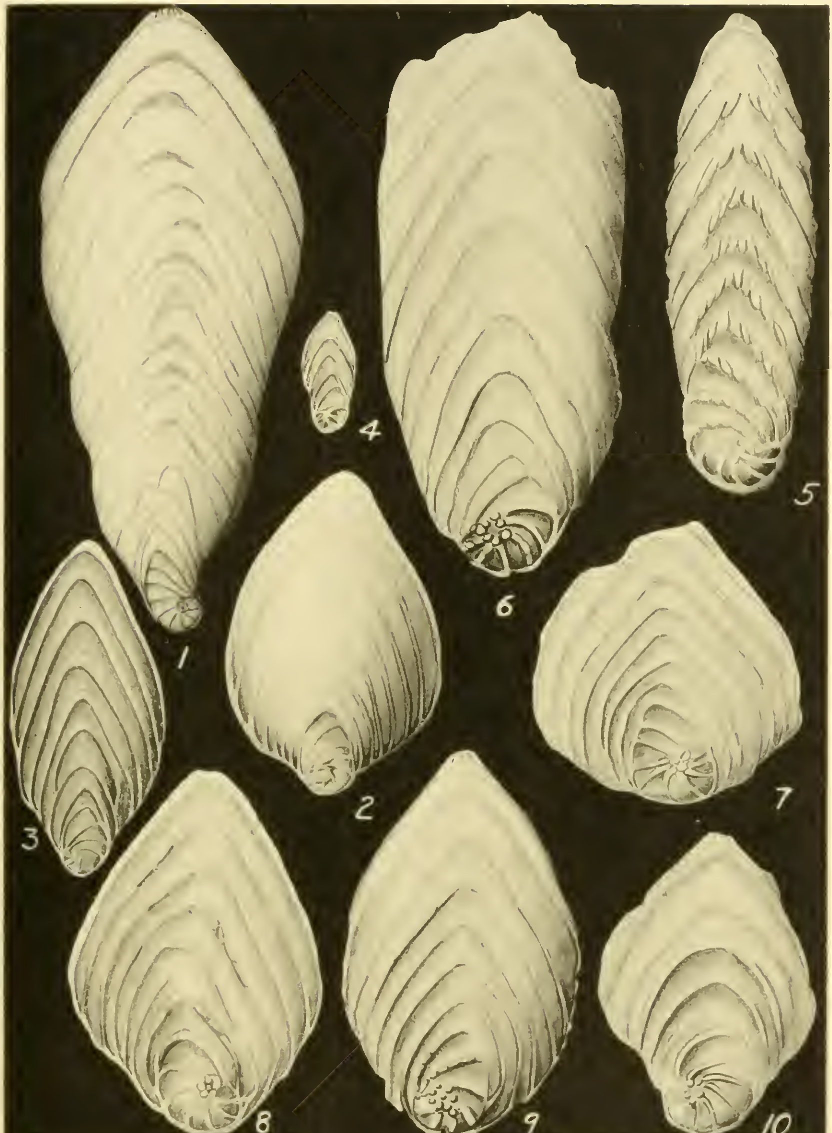
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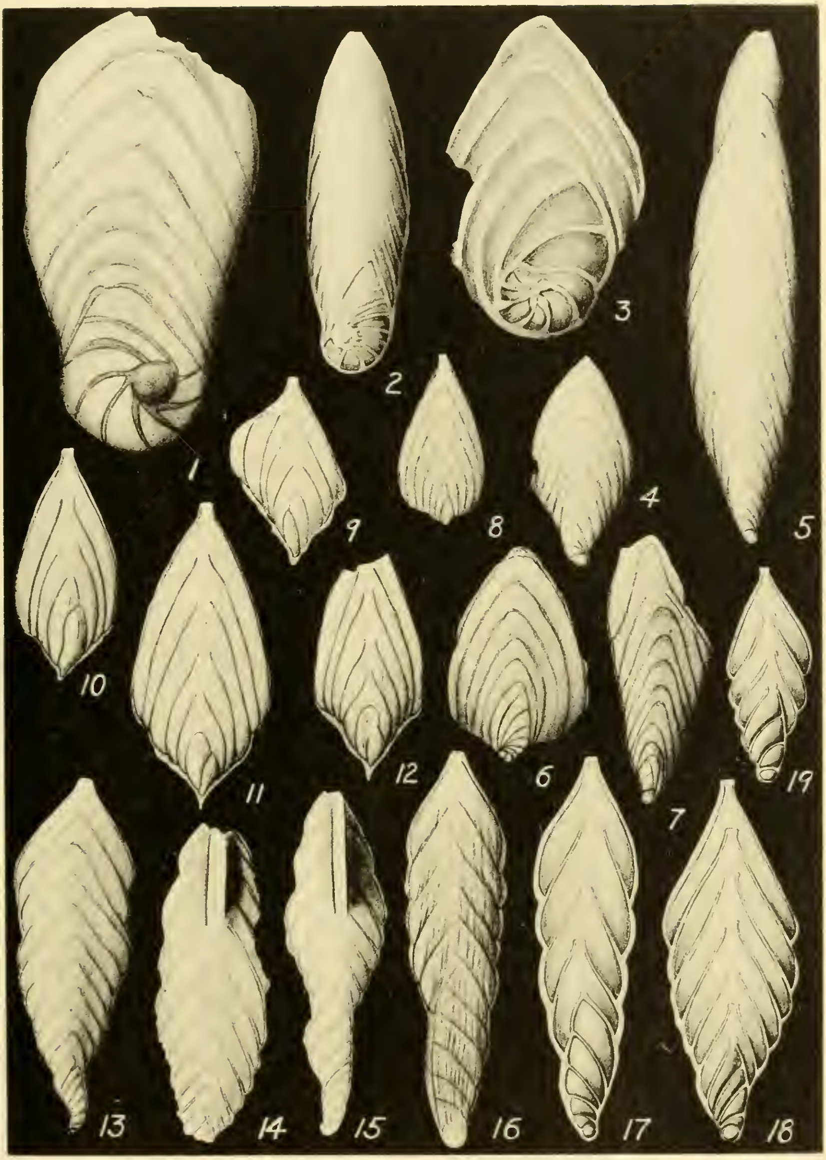
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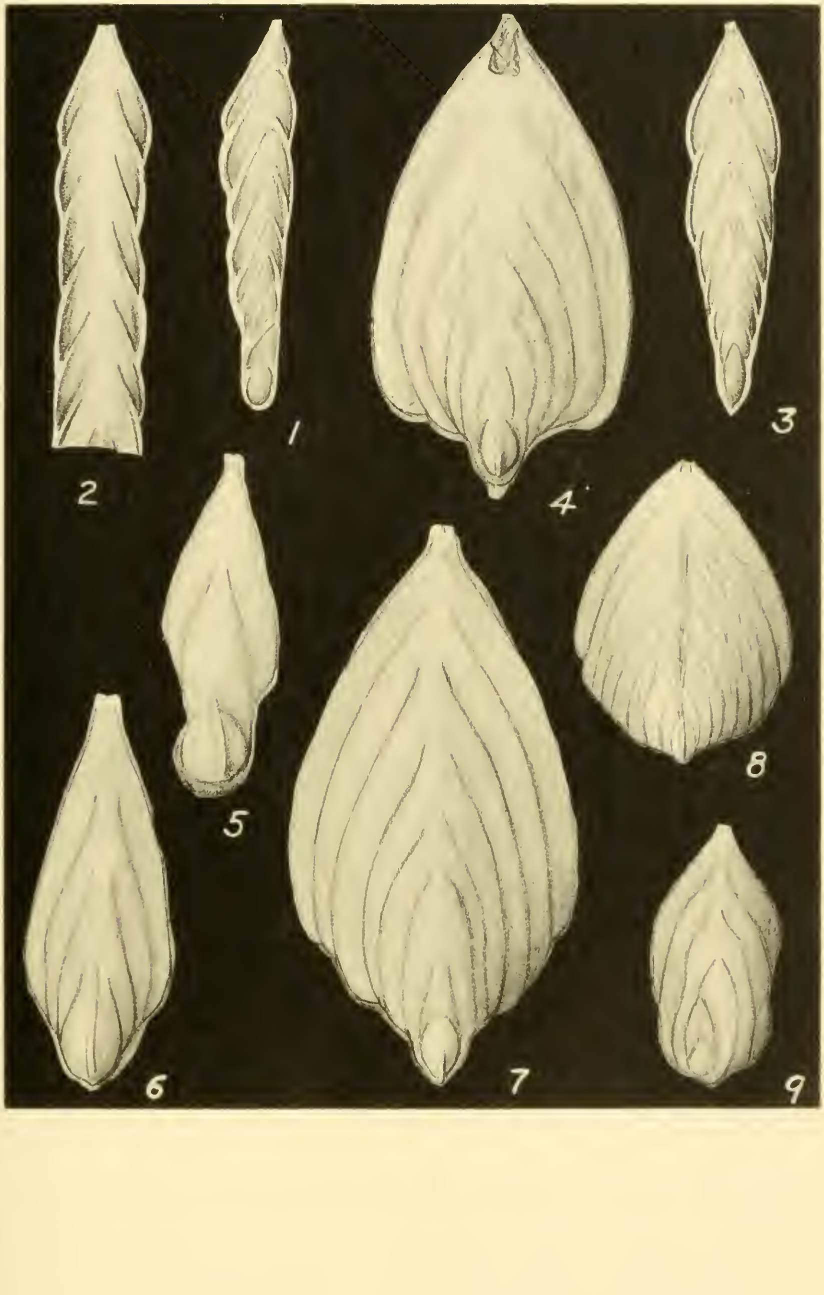
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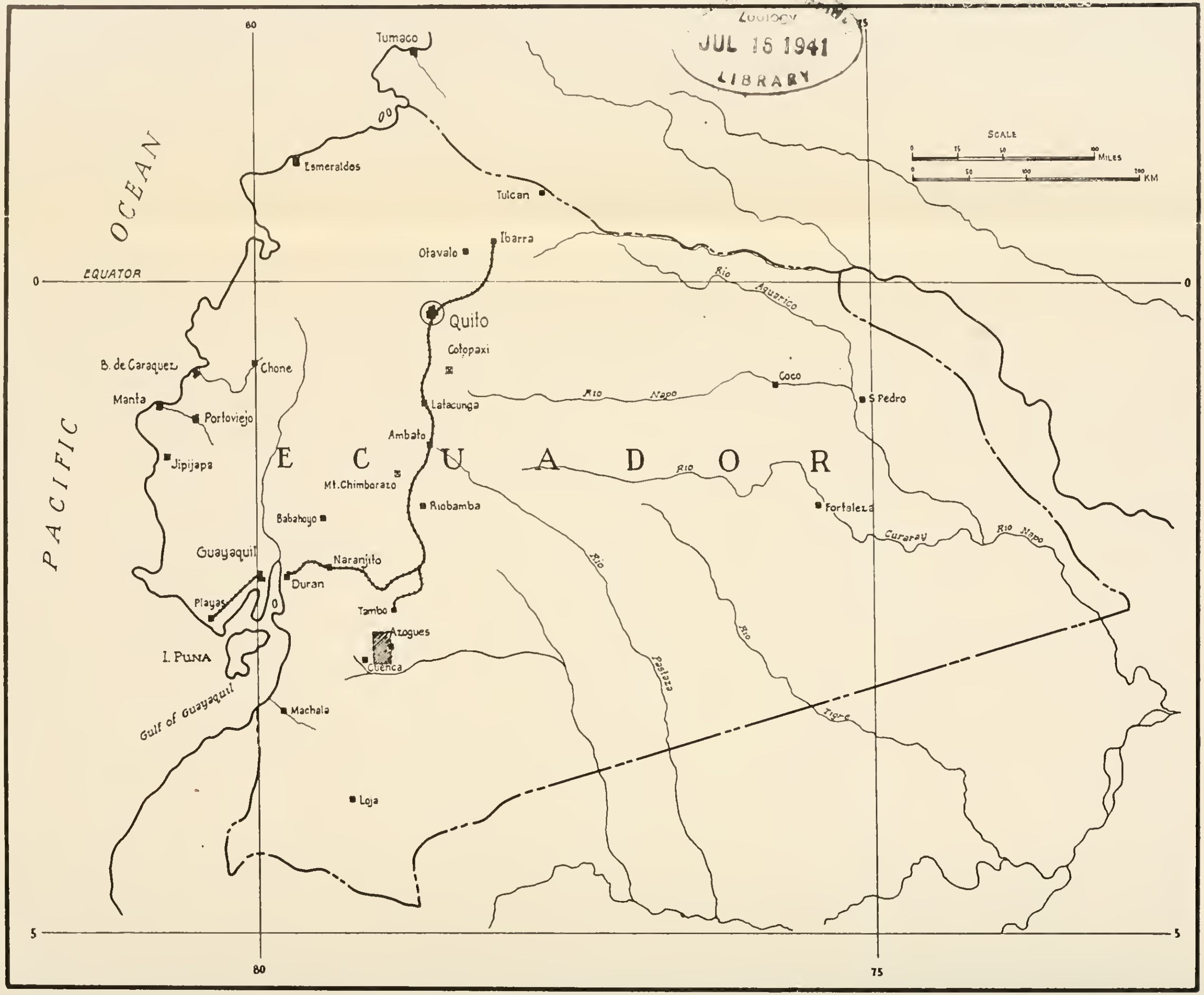

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THE GEOLOGY AND PALEONTOLOGY OF THE CUENCA—AZOGUES—BIBLIAN REGION PROVINCES OF CANAR AND AZUAY, ECUADOR

By

R. A. Liddle and K. V. W. Palmer

July 7, 1941

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PART I. GEOLOGY

By

R. A. Liddle

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INTRODUCTION

In Ecuador, between the Cordillera Oriental de los Andes on the east and the Cordillera Occidental de los Andes on the west, lies a great inter-montane depression extending from Otavalo near the Colombian border on the north southward through Quito, Latacunga, Ambato, Riobama, Cajabamba, Biblián, Azógues, Cuenca, and Loja near the border of Peru. High divides or *paramos* extending east and west across this great depression separate it into several more or less isolated valleys. In these high valleys, varying from 8,500 to 9,500 feet above sea level, Indians till their small fields, gather fruits and berries, shepherd their flocks, and pan the rivers for gold as their ancestors have done for centuries past.

A *paramo* in the Tambo-Cañar region on the north, and in the Girón-Loja region on the south, isolates a large valley in the southern part of Ecuador that is usually referred to as the Cuenca Basin from the city of Cuenca located on beautiful Rio Matadero which is joined at the city by several smaller but equally clear, swiftly flowing, cold streams.

Until a few years ago Cuenca could be reached only by pack trail. The southern, and direct route to the coast, reached Naranjal on Rio Guayas 70 kilometers below Guayaquil; the northern route led through Azógues, Biblián, Cañar (the region from which the so-called "Irish" potato was introduced to the world) and thence northwestward over the Cordillera Occidental and down the western slope to Guayaquil. A spur from the narrow-gauge main line connecting Guayaquil, the port of the country, with Quito the inland capital, leaves the main line at Sibambe and crosses the highest part of the *paramo* a short distance north of Tambo which is the present rail head. Three times a week an *autocarril* covers the 75 kilometers from Sibambe to Tambo in three hours barring landslides which occur frequently in the deep, ash-walled cuts during the rainy season. On alternating days the *autocarril* returns from Tambo to Sibambe. During the hot, rainy season when the port of Guayaquil is unpleasant, frequent *autocarriles* make the trip in one day directly from Guayaquil to Tambo. From Tambo a gravelled mountain road passes through Cañar, Biblián, Azógues, and Cuenca to Girón where it now terminates. Plans have been made to extend the road over the *paramo* south of Girón into Loja as a part of the Pan-American Highway. Work is under way to connect Cuenca directly with Naranjal on the coast, following approximately the old pack trail. If this short route to Naranjal and Guayaquil is completed it will greatly benefit both Guayaquil and Cuenca.

At Puente del Descanso, half-way between Cuenca and Biblián, a branch road to "El Oriente", the eastern and disputed provinces of Eucador, follows the gorge which Rio Paute or Rio Tomebamba as it is also known has cut through the igneous and metamorphic Cordillera Oriental. This road has a southern branch passing through Gualaceo and terminating at Sigsig, a small village containing an Indian burial ground famous for its pottery and gold ornaments. The northern branch follows down Rio Tomebamba or Rio Paute to the village of Paute at the edge of the Jivaro Indian country.

The Cuenca Basin (a redundant term as *cuenca* is the Spanish word for basin) is a healthful, semi-arid valley through which flow clear, cold streams that drain into the Amazon through Rio Santiago and Rio Marañon. The narrow gorge which Rio Paute has cut through the Cordillera Oriental, and through which all drainage from the basin passes into the Amazon system, is the main gateway from the basin to "El Oriente". Rain is sparse in the Cuenca Basin and falls in February and April. On the surrounding cloud-capped mountains which range from 15,000 to more than 20,000 feet above sea, rainfall is more abundant though there is little vegetation because of the altitude. The ashy soil is fertile in the valleys wherever water is available.

The climate of the Cuenca Basin is uniformly 60° Fahrenheit but during rainy months the cold is penetrating. Especially is this true because there are no means of heating. On sunny days the climate is stimulating, though the sunlight is intense. In the shade it is peculiarly cool—a cold that is especially noticeable at high altitudes in the tropics.

Of the wild plants, cacti and agaves are most common. Wild flowers include morning glories, daisies, sweet peas, and an abundance of small lupines which grow in the fields of wheat and potatoes. Cultivated flowers, in great varieties, grow luxuriantly—geraniums reaching a height of four feet and full-blown roses measuring six inches across.

The Indians cultivate wheat, potatoes, and corn. They have orchards of apples, pears, peaches, sweet lemons and a species of orange. In some places where gardens are irrigated, vegetables common to temperate climate, such as carrots, lettuce, cauliflower, tomatoes and onions are grown. Wild blackberries in giant clusters on luxuriant bushes and countless trees of a species of sweet, black cherry grow along roads and fences.

For plows the Indians use large, crudely hewn forked roots of trees, drawn by oxen. These merely scratch the ground. On steep mountain slopes plowing is extremely difficult. Wheat is harvested by women who pluck the heads from the stalks; threshing is done on patches of hard ground, by driving oxen over the heads of grain. Winnowing is in true Biblical style.

Horses and cattle are scarce, and as llamas do not thrive below 10,000 feet elevation, most burdens are carried on the backs of Indians.

The valley of Cuenca Basin and the lower slopes just above are thickly inhabited by Indians who cultivate their fields, care for their sheep, make pottery, weave brightly colored *ponchos* and skirts from native wool, and great numbers of "Panama" hats out of fibre brought up from the lowlands.

ACKNOWLEDGMENTS

For sixty years geologists have visited the Cuenca Basin. Some like Wolf, Sheppard, and Bushnell have published their observations and have permitted their collections of fossils to be described. Others like Wasson, Olsson, and Dickerson, who because of the confidential nature of their work at the time it was done could not publish their findings, have now made their collections available to us and have given us the benefit of their observations together with critical discussions of questionable problems. Their unpublished information has furnished us with new fossil localities and critical stratigraphic data.

Our expedition into the Cuenca region was due primarily to the efforts of Mr. Theron Wasson, Chief Geologist of The Pure Oil Company, Chicago, Illinois and to Mr. A. L. Bowden of Pittsburgh, Pennsylvania. Manuscript maps of Cuenca Basin made in 1920 by Mr. Wasson served as an invaluable guide to structural conditions of the area.

Dr. Roy E. Dickerson, Chief Geologist of the Foreign Division of the Atlantic Refining Company, Philadelphia, Pennsylvania has checked our maps and indicated the localities of his collections.

Mr. Axel A. Olsson of Gloversville, New York has studied our report and maps. His detailed criticism, based on twenty-five years of original geological and paleontological work in Central and South America, especially in Peru, Ecuador, and Colombia, which have made him pre-eminent in the geology and paleontology of Latin America, amounts to active collaboration.

Mr. James O. Crittenden of Sewickley, Pennsylvania, for whom the examination of the Cuenca Basin was made, has generously consented to make this information available to others interested in the region.

AREA EXAMINED

The area studied and mapped in detail in the present examination is described accurately by the official denouncement published in "Registro Official", Quito, Viernes, 23 de Setiembre de 1938, No. 37, as follows:

Primera.—Area: Limites de la concesion.—Extension.—El area o extension total de la concesion solicitada, ubicada en las provencias del Azuay y Cañar sera de TREINTA MIL HECTAREAS y estara compredida dentro de un paralelogramo rectangular que medira veinticinco kilometros de Sur a Norte y doce kilometros de Este a Oeste. —El punto de partida para la determinacion de los linderos sera el centro geometrico del Puente del Descanso. Los linderos Sur y Norte de la concesion orientados exactamente de Este a Oeste, estaran situados, respectivamente, a una distancia de nueve y dieciseis kilometros de este punto, y los linderos Oriental y Occidental, cuyo rumbo exacto sera el Norte astronomico, estaran situados, respectivamenta, a una distancia de tres y nueve kilometros del mismo punto.

In addition to the area designated in the official description of the concession as quoted above, considerable contiguous region was examined in order to obtain a more comprehensive understanding of the geology of the concession itself.

METHODS AND ACCURACY OF WORK

Mr. M. A. Navarro of Quito kindly furnished a map which showed accurately the location of Puente del Descanso with reference to the astronomically determined position of the city of Cuenca. With the geographic position of Puente del Descanso accurately fixed, a stadia traverse was run from Puente del Descanso to the church in Chuquipata. From this measured base a triangulation system was established over the concession. Using these triangulation points, topographic features and rock outcrops were located by direct measurement, secondary triangulation, or by re-section. Wherever feasible triangulation was used in preference to stadia measurements because of the greater sped and accuracy of this method in rugged terrain, and because of a lack of skilled assistants.

Mapping was done on a scale of 1:50,000 (1 cm=500 m). This scale is adequate to show geological data in sufficient detail, and at the same time to allow the entire concession, together with control points, to be placed on a single plane table sheet.

TOPOGRAPHY AND DRAINAGE

Rio de Azógues which heads north and west of Biblián, flows southeast as far as the village of Azógues, then turns south to Puente del Descanso where it joins Rio Chaullabama to form Rio Tomebamba or Rio Paute as it is also known. It has carved out a valley averaging four kilometers in width and has removed recently deposited volcanic ash and debris, thus exposing the igneous core of the Azogues anticline and Miocene ? sediments which surround it.

Rio Deleg and its tributary Rio Ayancay, which join Rio de Azógues above Puente del Descanso, have eroded valleys in the western part of the concession. In these valleys are the villages of Ayancay and Deleg. Between these valleys are ranges of rugged hills dipping steeply westward. They are formed by the Rio de Azógues sandstone, and locally are capped by unstratified volcanic ash and debris.

Sparse vegetation, little rainfall, and the resistance of the sandstones and some of the shales facilitate geological observations. Some of the igneous intrusions are fairly hard andesite which stand out sharply. The igneous core of the Azógues anticline, however, was a very soft andesite which has decomposed readily into highly colored clays that form the soil of much of the valley of Rio de Azógues south of the Cerro Cojitambo-Chuquipata andesite intrusion. Bedrock can be found, though, in most *quebradas* and on steep inter-drainage divides.

STRATIGRAPHY

IGNEOUS ROCKS

Igneous rocks of several types are exposed on the concession and in the adjacent territory. Andesite is the most prevalent type, and there are several varieties of it, varying in texture, color, and composition. East of Puente de Descanso there is a basalt mountain known as Cerro Tahual. It is formed by an intrusion of dark-gray, hard, compact, finely crystalline, vitreous basalt which breaks with a conchoidal fracture. Weathered surfaces are stained by limonite. Farther east toward Gualaceo and Paute are many varieties of basalt and andesite associated with metamorphosed sediments.

ANDESITE

Cerro Cojitambo, a sharp pinnacle of light-gray to mauve andesite flecked with dark-green to black hornblende which stands 500 meters above the valley, is but the western conspicuous end of an igneous intrusion which reaches southeastward to Chuquipata. The eastern part forms a low, rounded ridge on which are scattered gigantic residual boulders and ejecta whose conchoidal fracture and medium softness permit their being worked into building stone.

Cerros Abuja, the greater and the lesser, are two ash- and lava-covered cones with excellently preserved craters. They are situated immediately northeast of the village of Azógues, and their intrusion into Miocene ? sediments has tilted these shales steeply to the west and northwest in the vicinity of Azógues.

Some of the pumice of Cerro Abuja is creamy white in color and splits readily into thin slabs which are used in paving and building.

Cerro El Shalal, a sharp ridge, formed by a great dike, standing 300 meters above the surrounding country lies east of Biblián. It begins far north of the town of Biblián, passes east of it and on southward over the Biblián-Azógues road, across Rio de Azógues toward the west end of Cerro Cojitambo. Its length is at least six kilometers, and its width from 500 to 750 meters. The andesite of El Shalal is pinkish in color and contains many more visible crystals than the harder hornblende andesite of Cerro Cojitambo. Ash, pumice, and volcanic breccia are plentiful on the flanks of El Shalal. Contact metamorphism in the shales and shaly sandstones on the east side of Cerro El Shalal, where the Biblián-Azógues road cuts through the centre of the intrusive mass, is very evident. The shales here are highly colored by mineralization from brown to pink, and all tints to purple and maroon. In some places the thinly bedded, ashy shales are slaty and very dense, with a decided baked appearance. This baked appearance was noted also in the shales of the same formation at the southwest end of Cerro Cojitambo.

In Rio Hunancay and in *quebradas* southwest of Chuquipata and northwest of Puente del Descanso, and forming the core of the Azógues anticline, are deeply weathered igneous rocks, extremely shattered, and cut by myriads of quartz and calcite veins. The weathered rock becomes deep purplish red, maroon, grayish green, or bluish, and so intense is the weathering that it is difficult in places to determine the true character of the original rock. Associated with this deeply weathered rock are highly tenaceous clays which are derived directly from it. Beds of gray ash are also in contact with the more massive igneous intrusions. In contact with the igneous core on the west in Rio Hunancay are gray, thinly bedded, ashy, splintery shales. Some are almost as thin as paper and show the effects of heat and pressure. They stand at steep angles, are vertical, or are overturned. In the greenish or grayish white, ashy slates are veins, lenses, and bands of creamy gray silica.

Westward from the igneous core of the Azógues anticline as exposed in Rio Hunancay the shales dip conformably under greenish sandstones and shales full of volcanic ash and small fragments of igneous rocks. The westward dip varies from 50° to 80°. Many layers of volcanic ash with quartz bands along joints and cracks occur in these shales and ashy sandstones which grade upward without interruption into typical Rio de Azógues sandstones and ash. Upward in the Rio de Azógues sandstone section shales diminish and well-bedded, grayish white, black-flecked, ashy sandstone becomes more massive and dominant.

In a *quebrada* one kilometer north of Rio Hunancay, sticky clays and sands with much ashy material, but showing no alteration, dip steeply westward away from the igneous core of the structure. In the shales are thin seams of brown coal. Seepages of oil were reported to exist at this locality, but no trace or odor of petroleum could be found.

The age of the igneous core of the Azógues structure and the Cerro Cojitambo-Chuquipata intrusion are definitely younger than the Cuenca shales, for these beds have been noticeably affected both lithologically and structurally by the igneous intrusions.

METAMORPHIC ROCKS

PALEOZOIC OR MESOZOIC

Paute Series

Name.—Olsson[1] has applied the term Paute series, from Rio Paute in the Province of Azuay, Ecuador to a complex series of quartzites, slates, and shales cut by quartz veins and intruded by basic igneous rocks which form the core of the Cordillera Oriental along the east side of the Cuenca Basin.

Physical character.—East of the basalt intrusion known as Cerro Tahual are sediments in various stages of metamorphism associated with intrusions, chiefly of basic igneous rock. Shales and sandstones must have predominated in the original material. Some of the shales now are but slightly altered; others are phyllitic or schistose and in the gorge of Rio Paute they are intruded by lentils of dark-gray andesite. Mica, chlorite, and garnet are the most common types of schist. The sandstones are usually quartzitic. Quartz and calcite stringers and veins are common. Shales increase at the expense of other rocks eastward toward Paute. In this direction also, alteration seems to be less intense for the slates are gradually replaced by shales. These slates are usually black or gray whereas the softer shales are red, green, or yellow. All beds stand at high angles, are overturned, or are crumpled. Olsson considers that these intensely deformed and squeezed rocks in general dip westerly toward the great Cuenca graben. Our observations confirmed his.

Stratigraphic position.—Unconformably capping the Paute series are thick deposits of unstratified ash and volcanic debris which have been ejected from volcanoes to the north in relatively recent times. This mantle makes it difficult to study the partly concealed Paute series which makes up the core of the Cordillera Oriental. At its western edge the Paute series is in dirct contact with a large basic dike which forms Cerro Tahual. This dike may have ascended along a great fissure as Olsson considers its western edge to be in fault contact with the Rio de Azógues sandstone. It is possible that beneath the cover of unconformably overlying ash the great basalt intrusion of Cerro Tahual may connect with the basalt outcrop southeast of Azógues.

[1] Olsson, A. A.: Letter to R. A. Liddle, January 3, 1941.

Age and correlation.—No clue to the age of these rocks could be found, for if they once contained fossils that evidence seems to be lost through alteration. However, it would not be surprising if they are in part Eocene locally altered by heat and pressure generated during mountain forming movements and by igneous intrusions. It is possible that some of these beds originally were Cretaceous sediments, but were Middle Cretaceous rocks involved there should be an abundance of marmolized limestone. Farther east and northeast, and also southwest where unmetamorphosed Lower Cretaceous is present, there are metamorphic rocks nearby which doubtless are of Paleozoic age.

Olsson[2] has called attention to the resemblance of these less metamorphosed slates and shales to the Girón series of Colombia and to the Amotape shales of Peru, thus suggesting their Paleozoic age.

As several thousand feet of altered rocks are grouped in the Paute series it may be that the range in age is great—possibly including Paleozoic and Mesozoic beds. Careful examination of the section exposed along Rio Paute may result in fossils being found. Well-preserved fossils in Venezuela have been discovered, after diligent search, in rocks altered even more than those of the Paute series.

Extent and thickness.—Only an approximation of the thickness of the Paute series can be made. The intensely disturbed section is further complicated by igneous intrusion and by overlap of recently deposited ash and debris. Unless there is more duplication of section because of faulting and overturned beds than is now suspected there must be 4,000 feet of partly altered sedimentary rocks in the Paute series.

Topographic expression and local details.—No attempt was made to map or even trace the areal extent of the Paute series. It is known to have a width of at least 50 kilometers reaching from the western foothills of the Cordillera Oriental at Cerro Tahual eastward into the main body of the range and a known length of several hundred kilometers. It may extend the entire

[2] Olsson, A. A.: *loc. cit.*

length of Ecuador forming the core of the Cordillera Oriental, though in most areas being concealed by volcanic ash and debris for it has been observed at many localities in the range. If Olsson's correlation of the Paute series of Ecuador with the Girón series of Colombia and the Amotape series of Peru is correct the extent of these rocks is greatly increased.

South of Cuenca in the upper course of Rio Tarqui true marbles are found; they may be derived from Middle Cretaceous limestones. The so-called pink marbles of Cuenca are not true marbles, but are calcareous sinter or travertine deposited by thermal springs which have their origin in the great fault zone along the eastern foot of the Cordillera Occidental, and which have come to the surface through the Rio de Azógues sandstone.

SEDIMENTARY ROCKS

Conglomerates and conglomeratic sandstones, locally with highly fossiliferous horizons; clays and sandy shales with selenite, carbonaceous matter and even workable beds of brown coal; gray, ashy, siliceous, slaty shales with chert bands and nodules; bedded, ashy, coarse sandstone; un-stratified volcanic ash and debris; river gravels and residual soil from igneous intrusions comprise the sedimentary rocks in the Cuenza-Azógues-Biblián region. All of these brackish- and fresh-water deposits evince a marginal condition such as a shallow inland sea, lagoon, or estuarie at the mouth of some large river.

MIOCENE ?

Biblián Sandstones and Conglomerates

Name.—Wolf[3] in 1879 and in 1892 applied the name, "Arenisca de Azógues" to all sedimentary rocks of the Cuenca-Azógues-Biblián region regardless of age. Sheppard[4] in 1934 assigned the term Biblián sandstones and conglomerates to sediments which comprise —

[3] Wolf, Teodoro: *Viajes Cientificos por la Republica de Ecuador II. Relacion de un Viaje Geognostico por la Provincia de Azuay,* 1879, p. 55. Guayaquil, Ecuador.

————*Geografia y Geologia del Ecuador,* Leipzig, Germany, 1892, pp. 244-254.

[4] Sheppard, G.: *Geology of the Interandine Basin of Cuenca, Ecuador,* Geol. Mag. vol. LXXI, No. 842, 1934, p. 364.

. . . . . . the lowest part of the stratigraphical sequence, and occurs along the Cuenca road by the river about 3 miles to the north of Azogues, and in other localities in the basin.

Following Sheppard, the term Biblián sandstone and conglomerate is here applied to 250 meters of conglomerates, sandstones, and shales which form the basal part of the exposed Miocene ? section three kilometers northwest of the village of Azógues.

Physical character.—Grayish brown conglomerates containing an abundance of igneous pebbles, coarse brown sandstones, soft clays usually yellow but ocassionally blue and maroon comprise the Biblián sandstones and conglomerates. The conglomerates and conglomeratic sandstones predominate, and standing out in contrast with the softer shales, give the impression that most of the formation is made up of these beds. Individual beds of *Sheppardiconcha bibliana* Marshall and Bowles, two feet thick are found. They seem to be formed exclusively by this fossil. Other clayey sandstones and even conglomerates carry a limited variety of gastropods and pelecypods. The clays are dense, unfossiliferous, and weather into very sticky mud.

There is little selenite in the Biblián sandstones and conglomerates, but fresh-water fossils are abundant. In the Cuenca shales just higher in the section there is a great amount of selenite, but no fossils except fish scales and plant leaves were found by Liddle. Also, in the dry season streams in contact with the Cuenca shales deposit incrustations of salt. These incrustations, together with the presence of selenite, indicate some salinity in the Cuenca shales. No evidence of salinity was noted in the Biblián sandstones and conglomerates. This change in the character of the water may explain the paucity of life in the Cuenca shales. Reefs of fossils several feet thick may be accounted for by sudden increase in salinity of water which killed them instantly.

Stratigraphic position.—The Biblián sandstones and conglomerates form the basal part of the Miocene ? section exposed in the Azógues region, and lie conformably beneath the Cuenca shales which are excellently exposed in and to the west of the village of Azógues. There is a gradual change upward from the

Biblián sandstones and conglomerates into the Cuenca shales, so that a more or less arbitrary boundary is established between the two formations at a point where the massive sandstones and conglomerates give way to shales and thinner sandstones.

Age and correlation.—Well-preserved fossils such as *Potamolithoides biblianus* Marshall and Bowles, *Sheppardiconcha bibliana* Marshall and Bowles, *Pomacea bibliana* Marshall and Bowles *Ecuadorea bibliana* Marshall and Bowles, and *Unio* (*Anondontites*), sp., in the conglomerate and conglomeratic sandstone beds of the Biblián formation conclusively indicate their fresh-water nature but give little clue to the age of the sediments in which they occur. However, as the Biblián sandstones and conglomerates lie conformably below the Cuenca shales which contain fairly thick and consistent beds of lignite or brown coal, they are considered to be of Miocene ? age. They certainly are not younger than Miocene, and the abundance of volcanic material in them suggests that they are younger than Eocene or Oligocene.

Marshall and Bowles[5] in describing these fossils, comment:

> At present there are no reliable data to establish the age of the deposits, but as none of the species and none of the genera except *Pomacea* occur in the recent fauna, it is probable that the age can not be later than Pliocene, and it may be earlier.
>
> The formation is exclusively of fresh-water origin, as all the species found require a fresh-water habitat.

Extent and thickness.—The Biblián sandstones and conglomerates occupy a relatively small area east of Cerro El Shalal and west of the area of outcrop of the Cuenca shales. Their principal area of exposure is the axis of a small, sharply folded anticline three kilometers northwest of Azógues. Approximately 250 meters of the Biblián sandstones and conglomerates are exposed, but their base has not been seen.

Topographic expression and local details.—The most prominent and important exposure of the Biblián sandstones and conglomerates is in the axis of a sharp fold three kilometers northwest of the village of Azógues. Rio de Azógues has at this place cut directly across the axis of the fold which shows in a vertical bluff 75 meters high in the south bank of the river. The road

[5] Marshall, W. B. and Bowles, E. O.: *New Fresh-water Mollusks from Ecuador,* Proc. U. S. Nat. Mus., vol. 82, No. 2946, 1932, p. 2.

from Azógues to Biblián, following along the north bank of the river, makes the locality readily accessible.

Without doubt the Biblián sandstones and conglomerates are an integral part of the same sedimentation as the Cuenca shales. Only an arbitrary boundary separates the two; but they are given distinct names because of their different lithologic composition and because several beds of the Biblián sandstones and conglomerates are richly fossiliferous, whereas only fish scales and plant remains were found by Liddle in the Cuenca shales. Dickerson, however, did collect some fossil shells from three localities in these shales.

Cuenca Shales

Name.—Wolf[6] in 1879 and in 1892 applied the name, "Arenisca de Azógues", to all sedimentary rocks in the Cuenca-Azógues-Biblián region.

Sheppard[7] in 1934 assigned the name, "Cuenca White Shales", to thinly bedded, carbonaceous, selenitic, sandy, ashy shales containing subordinate thin beds of brown sandstone which are exceptionally well exposed in and around the village of Azógues in the Province of Cañar. As a type locality the site is well chosen because of its accessibility and the excellence of the outcrops. However, it would have been more appropriate to have called them the Azógues shales.

Physical character.—The Cuenca shales are predominantly light in color, though where there is an excessive amount of carbonaceous matter they are dark-gray. In general they are light- to dark-gray, tan, yellow, light-brown, dense, well-bedded, clayey, with much carbonaceous matter, sulphur powder (Jarosite?), veins of iron oxide, and bands or layers of selenite over their surface exposures. The sandstones in the upper part of the formation are relatively unimportant. Locally, especially on the west side of the igneous core of the Azógues structure south of Cerro Cojitambo, the ashy shales have been compressed to the thinness of paper, and slightly baked. Here they carry considerable

[6] Wolf, Teodoro.: *op. cit.*
[7] Sheppard, G.: *op. cit.*

chert in bands, concretions, and lenses parallel with the bedding of the shales. An occasional piece of silicified wood also occurs in the shales in this area.

In the limited area of outcrop of the Cuenca shales south of the Cerro Cojitambo-Chuquipata intrusion only minor seams of lignitic coal are found. North and west of Cerro Cojitambo where a more complete section of these shales is present, and where they have not been metamorphosed by igneous activity, there are beds of brown coal from two to three meters thick.

Stratigraphic position.—The Cuenca shales lie directly on, and are completely conformable with, the Biblián sandstones and conglomerates. In fact they grade perfectly into each other. A clean contact between the Cuenca shales and the Rio de Azógues sandstone above them is difficult to find because the sandstone breaks down over the contact, as detrital, in most localities. In the few places where the contact has been found, the beds above and below it are so highly folded that the exact structural relation can not be determined. An exception is in the gorge of Rio Hunancay where both formations are in perfect conformity. Igneous activity is chiefly responsible for the local acute disturbances. It is known that over the region as a whole the Cuenca shales are no more highly disturbed than the overlying beds.

Age and correlation.—Only fish scales, leaf impressions, and lignite have been found by Liddle in the Cuenca shales, but since the shales lie with perfect conformity above the Biblián sandstone, it is believed that they are a part of the same deposition and intermediate in age—probably lower or middle Miocene. Dickerson, collected fossil fish scales from the Cuenca shales, 3.1 kilometers southeast of Biblián on the Biblián-Azógues road not far from fossiliferous horizons in the Biblián sandstone and conglomerate, and also shells from these shales just west of the bridge over Rio Azógues north of Chuquipata. As the thin, bituminous limestone on Arroyo Potrero from which Dickerson collected *Corbicula* (*Cyanocyclas*) *cojitamboënsis* and *Hemisinus peyeri dickersoni* is at the contact of Cuenca shales with the Cerro Cojitambo intrusion, the limestone may occur normally in the shales or it may be from an older, buried formation brought to the surface by the intruding andesite. Workable beds of lignite or brown coal in the Cuenca shales suggest an age not younger than Miocene.

Olsson[8] differs from Liddle in his opinion of the age of the Cuenca shales and the underlying Biblián sandstone and conglomerate though in his deposition cycle he says:

With the Miocene came a big change and the deposition of conglomerates and sandstones, later perhaps changing to shales.

This is a perfect description of the sequence of the Biblián sandstones and conglomerates with the overlying Cuenca shales. His comments on our report, which he kindly read, are:

My views as to the Oligocene age of the Cuenca shales are based on several different lines of thought. First, the resemblance of some of the fossils to species of the La Cira and Mugrosa of the Magdalena valley, the second is the close lithologic resemblance of the Cuenca shales to the Upper Oligocene beds of the coast, and thirdly the geologic history. Admittedly, none is conclusive or very convincing but the best we have for the present. There is a remarkable similarity of depositional conditions through the coastal Tertiaries of northern South America, indicating that the various changes which affected deposition, were of regional character. The Upper Oligocene was a time of very widespread deposition of black shales which extended in embayment form up the major river valleys. Only a few miles north of Cali in Colombia, we find the Vijes limestone of Oligocene age (probably Upper) composed entirely of Lithothamiums and marine fossils (Orbitoids, etc.). This shows the deep penetration of the Oligocene sea into the interior of Colombia. With the Miocene came a big change and the deposition of conglomerates and sandstones, later perhaps changing to shales. This means uplift or some vast disturbance of more than local significance, and it seems to me that it dates one of the major uplifts of the Andes as early Miocene. I believe that the Cuenca basin was more or less connected with the Gulf of Guayaquil through part of its history. The bulging coasts of Ecuador between Santa Elena and Manta and the northern coasts of Peru (Cabo Blanco and Parinas) are two major uplifts. Between them lies the Gulf of Guayaquil and it is quite conceivable that this gulf may have at one time extended much further east. Transverse trend lines in the older rocks support this view. It means, however, that the Western Range dates in its present form from the Miocene (probably a rejuvenated uplift.) This may seem to be a rather adventurous suggestion but there is much to support this view elsewhere in the Andean region of northern South America. In Venezuela, I saw the Miocene resting with great unconformity on Eocene, etc., on the Island of Margarita, the trend of the beds being at right angles to each other. Likewise, in northern Santo Domingo, the Miocene is also unconformable on the cut-off edges of Oligocene, or directly on the basement complex. All along the coast of Ecuador and Peru, there is some sort of stratigraphic break at the base of the Miocene.

I do not remember the occurrences of selenite at Cuenca, but this mineral in the form of plates is a common product of surface weathering of bituminous shales, especially in an arid country such as that of Cuenca. These beds contain more or less pyrite, the sulphuric acid of which uniting with

[8] Olsson, A. A.: *loc. cit.*

lime, results in the formation of gypsum. The Heath shales of Peru, although marine and full of forams. are strongly bituminous. Their surface outcrop is usually a mass of selenite plates but this subst nce was never encountered in drilling. I cannot help but think of the Cuenca basin in the same geographic setting as that in which the fresh-water Tertiaries of the Magdalena valley had their origin, and even to some extent those of the Colombian Llanos. Northward the Magdalena embayment communicated with the sea; to the south it formed a partially enclosed inland sea like that of the Maracaibo. The Oligocene and Upper Eocene beds are largely shales or merely fine-grained sandstones sometimes with coal, the Miocene very thick, coarse boulder conglomerates and in the top of these andesitic ash (Pliocene).

I agree that the Cuenca sediments were formed during one cycle of deposition beginning with the formation of the Biblián sandstones and ending with the Azógues. Don't you think that the Azógues sandstone was formed not so much as the end filling of the basin but coarse beds laid down as the result of a new era of disturbance and increased erosion? For this reason I would be inclined to regard the Azógues sandstone as Miocene although there is no evidence of a break between them. You mention the absence of fossils in the Cuenca shales. It is a general rule that in a section composed mostly of shales, that fossils occur only in the bottom portion where shallow or shore-conditions formed an environment most favorable to life. I had a talk with Bushnell who was then at Ancon before I visited Cuenca and from him learned of the Paccha locality as well as that along the road between Azógues and Biblián. I have not read Sheppard's paper recently so I do not remember just what he writes, but I aimed apparently to the same conclusion as you,—that the fossils come from a horizon near the bottom of the section (your Biblián sandstone). The fossils from Paccha were not found in place but they were very abundant in the stream bed and must have been washed out of beds not far away. Wolf likewise did not find his fossils in place.

There are two species of Corbiculas or Polymesoda in the Cuenca Tertiary. These mollusks live in brackish water near the mouths of rivers, where they empty into the sea. At Lake Maracaibo there are several species on Toas Island for instance, but I have never heard of them in entirely fresh waters. The presence of these two species at Cuenca is strong evidence of some sort of connection with the sea. I don't think we would find it in a lake which has become saline simply through dessication.

Until more fossils or other evidence is available, the age of the Cuenca beds cannot be fixed. Whether they are Oligocene, Miocene, or even Pliocene is still a matter of opinion, but it may be of interest to summarize our views.

Your view: The age is Miocene. The basin formed as a lake in a valley trough between the Eastern and Western ranges, its origin connected with the uplift of the Western Range. At times, the lake became saline through excessive evaporation.

My view: The Cuenca shales are Upper Oligocene age, the Azógues sandstones are Miocene. The Cuenca basin is one of a series of Tertiary basins lying between the Eastern and Western ranges, beginning with that of Loja and extending north into Colombia (Pastos, Rio Patia, Cali, etc.). At the time, the lands were low and the coastal zone widely transgressed by the Upper Oligocene seas in which shale deposition was mainly taking place. In Colombia (Cauca valley and the Magdalena) these basins became embayment arms of the sea and are fresh in the inner reaches. The Cuenca basin is of similar origin and was for a time in its history connected with the Gulf of Guayaquil.

Extent and thickness.—In the area to the north, northeast, and northwest of the Cerro Cojitambo-Chuquipata andesite intrusion the Cuenca shales are well developed, and though highly folded and possibly faulted have not been metamorphosed. South of the intrusion not more than 100 to 200 meters of the upper part of these shales are exposed as a thin rim around the igneous core of the Azógues structure. On the east side of the core the shales have not been altered but on the west side they have been compacted and bleached. North of the Cerro Cojitambo-Chuquipata intrusion there are at least 850 meters of the Cuenca shales exposed, though the entire thickness of the formation may be greater. Local detrital and alluvial covered areas make accurate measurements impossible.

Topographic expression and local details.—The Cuenca shales being less resistant to weathering than the Biblián sandstones and conglomerates or the Rio de Azógues sandstone are not topographically conspicuous.

Just west of the village of Azógues, hills 200 meters high on the north side of the highway are formed by these shales which contain a few sandstone beds that protect them from erosion. Little vegetation grows on the gypsiferous clay slopes. In spots the shales are darkened by carbonaceous matter.

South of the Cerro Cojitambo-Chuquipata intrusion, near the mouth of Rio Hunancay, just west of the highway, bare, yellow, selenitic clay hills are formed by a narrow belt of vertical Cuenca shales in contact with the igneous core of the Azógues anticline. West of the igneous core the Cuenca shales, though indurated by metamorphism, have such a narrow zone of outcrop that they are inconspicuous.

West, northwest, and southwest of Biblián the Cuenca shales contain manjack veins and beds of lignitic coal. A comment on samples of this coal from the Neunkircher Eisenwerk, Saar, Germany, furnished by Mr. M. A. Navarro of Quito, reads:

The sample looks only externally like a real coal. The higher H^2O and O contents, the greater proportion of volatile components, the low specific weight, the low proportion of C and H, the low heat value, and the behavior of the coal under the coke-test, all tend to indicate a coal geological-ly young. From its reaction under various solvents, from its appearance, and conchoidal fracture, and from all other properties, this coal should be classified as a *braunkohle* of the early Tertiary, similar to the Pechkohle of Bohemia and Bavaria.

Rio de Azógues Sandstone

Name.—In 1879 and again in 1892 Wolf[9] included in his "Arenisca de Azógues," all the sedimentary rocks of the Cuenca Basin, embracing a thick deposit of water-laid, cross-bedded, volcanic ash, mud, sand, and shale which forms the inside rim of the Cuenca-Azógues-Biblián valley. However, the upper part of the section as described by Wolf does not outcrop at the village of Azógues, but is well exposed on the east side of Rio de Azógues, especially between Chuquipata on the north and Puente del Descanso on the south. Wolf's term, "Arenisca de Azógues" is here restricted to the upper part of the sedimentary section described by him, and is emended to Rio de Azógues sandstone so that the formation will outcrop at its type locality. Other extensive areas of outcrop in the Cuenca region are indicated on the accompanying map.

Physical character.—As would be expected from the nature of the deposit the Rio de Azógues sandstone varies widely in character. Coarse, ashy sandstones predominate. In some places they are massively and regularly bedded; in other extremely cross-bedded and so extensively jointed that it is difficult to differentiate bedding from jointing. On freshly fractured surfaces the sandstone is light-gray, but it weathers slightly darker, usually to a brownish gray due to contained iron that infiltrates joint and bedding planes. While weathering the sandstone exfoliates and forms spheroidal boulders. Single sandstone beds reach 20 feet in thickness. Some layers are decidedly shaly or clayey and yellowish in color. Near the top of the formation, in the long cuesta which extends from Cerro Cojitambo southward on both sides of Rio Hunancay, are layers of perfectly round volcanic bombs varying from 2 to 75 centimeters in diameter.

The sand which comprises much of the Rio de Azógues sandstone along with the ash, is angular volcanic sand. In strict usage it is doubtful if the Rio de Azógues sandstone should be called a sandstone.

9 Wolf, Teodoro: *op. cit.*

Stratigraphic position.—In most places the contact of the Rio de Azógues sandstone with the underlying Cuenca shales is obscured by weathered detrital from the sandstone.

West of the main igneous mass of the Azógues anticline the Rio de Azógues sandstone appears to lie with perfect conformity above the Cuenca shales. Both formations are thought to be part of the same depositional cycle.

Age and correlation.—The Rio de Azógues sandstone is considered to be Upper Miocene in age. No fossils, except some silicified wood, were found by Liddle in this formation. However, in the deep gorge of the upper course of Rio Hunancay where the contact is splendidly exposed there is a gradual and uniform change from one into the other. Olsson, though, did find fossil shells in the Rio de Azógues sandstone between Puente del Descanso and Cerro Tahual, but unfortunately they have been lost. It would be interesting to compare them with fossils from the Biblián sandstone and conglomerate.

Sheppard[10] reports that he collected fossils from the "Azógues sandstone" at Paccha, near Cuenca, and at Biblián, and that these fossils were described by Marshall and Bowles[11]. The fossils from Paccha were not found in place, though according to Sheppard, they had not been transported far. Olsson[12] confirmed this on his visit to Quebrada Paccha where he collected highly weathered float which is a mass of *Corbicula (Cyanocyclas) pacchiana*, and *Neritina pacchiana*. Most of the surface rock at the locality in Quebrada Paccha where the float was collected is a part of the Rio de Azógues sandstone and it is not known for certain that the fossils actually occur in place in this formation. The Biblián sandstone and conglomerate may be exposed somewhere in the *quebrada*, and the fossils may come from that formation.

The fossils from Biblián definitely do not occur in the "Azógues sandstone" as Sheppard says, for his Biblián locality is his type section for the Biblián sandstone.

10 Sheppard, G.: *op. cit.*, p. 362.
11 Marshall, W. B. and Bowles, E. O.: *op. cit.*
12 Olsson, A. A.: *op. cit.*

Extent and thickness.—No accurate measurements of the Rio de Azógues sandstone could be made, but in several places as much as 650 meters were measured. It is probable that an ever greater thickness exists.

Topographic expression and local details.—The Rio de Azógues sandstone is fairly hard and resistant to erosion. It generally forms ridges around, and dips away from, the Cuenca-Azógues valley outside of a low area occupied by the soft igneous core and surrounding Cuenca shales, and inside of the high mountains of unstratified ash and debris which cover much of the inter-cordilleran region. Nearly vertical bluffs 500 meters high flank Rio Hunancay from its source just southwest of Cerro Cojitambo for four kilometers south until it cuts through the eastern wall to flow eastward into Rio de Azógues.

The principal difference between the Rio de Azógues sandstone and ash, and other volcanic ashes and debris of the inter-andean region, is that the Rio de Azógues sandstone and ash are definitely water-laid and have fairly well-developed bedding, whereas the surrounding ash and debris, some contemporaneous and some definitely younger in age, have no recognizable bedding and are more heterogeneous.

The Rio de Azógues formation was probably blown from numerous craters of the Cuenca-Azógues-Biblián region into a fairly large body of water. In this water the sand, ash, and clay settled. Streams with fluctuating currents must have flowed into this body of water to create the extreme cross-bedding which exists locally.

Near San Nicholas, between Deleg and Cerro Cojitambo, in the vertical and overturned beds of the Rio de Azógues sandstone, and striking north-south for two kilometers, is a bed of white to yellowish, amorphous silica containing crystals of quartz. It is the work of thermal springs which in this area were supersaturated with silica by the time they rose through the Rio de Azógues sandstone, whereas in the vicinity of Azógues and Cuenca, springs with much calcareous matter in solution rising through the same formation deposited great beds of pink travertine at the surface.

RECENT, UNSTRATIFIED ASH AND MUD; RIVER GRAVELS AND ALLUVIUM

Capping the Rio de Azógues sandstone on all sides of the Cuenca-Azógues-Biblián valley is a deposit of unstratified volcanic ash, mud, and conglomerate. The ash and mud are fairly hard; the conglomerate which is volcanic mud and ash full of angular fragments of igneous rock, is resistant.

Locally there are layers of volcanic bombs from a few centimeters to nearly a meter in diameter.

Over 100 meters of this material caps the Rio de Azógues sandstone on the high divide between Rio Hunancay and Rio Ayancay.

Some of the larger rivers in the region have built up small alluvial deposits of gravels, sand, and soil, but none is of magnitude.

STRUCTURAL GEOLOGY

CUENCA BASIN

The general structure of the Cuenca Basin is a north-south trending sharp trough or deep syncline bordered on the east and west by marginal faults downthrown basinward. Igneous intrusions along the marginal faults and within the basin itself, where one in particular forms the core of the Azógues anticline, complicate the area.

Olsson thinks that —

> Apparently these basins are either synclinal trough, or sunken fault blocks (grabens or ramps) and originated early in the Tertiary, perhaps in some cases in the Eocene; this is certainly true of the Magdalena embayment.

AZOGUES ANTICLINE

The principal structural feature of the Cuenca-Azógues-Biblián region is a north-south trending fold which is known as the Azógues anticline. The zone or belt of folding, of which the Azógues anticline is a part, has been observed for 25 kilometers in a north-south direction. However, in this distance it is broken and complicated by igneous intrusions. The largest and most involved in the fold are the Cerro Cojitambo-Chuquipata andesite mass, and the Cerro El Shalal andesite and ash mass.

South of the Cerro Cojitambo-Chuquipata intrusion the core of the Azógues anticline, about five kilometers long and two kilometers wide, is composed entirely of deeply weathered andesite which is exposed in the drainage that cuts from west to east across it. In the bed of Rio Hunancay there is an almost continuous exposure of green, greenish gray, gray, purple, and maroon, calcite-veined, weathered andesite. On uplands above stream beds this igneous rock, where decomposed, forms thin, highly colored, sticky clay soil which resembles sedimentary rock.

In contact with the igneous core of the Azógues anticline south of the Cerro Cojitambo-Chuquipata intrusion, on the east, south, and west are highly inclined, vertical, or overturned Cuenca shales of Miocene? age. On the east and south sides of the intrusion these ashy shales have not been altered though some mineralization has taken place. On the west, however, they have been baked and bleached considerably.

Outside of the narrow belt of Cuenca shales is the Rio de Azógues sandstone which dips outward to the east, south, and west from the axis of the structure, averaging from 40° to 60°. In a zone to the west of the upper course of Rio Hunancay the Rio de Azógues sandstone is vertical and slightly overturned to the west.

Capping the Rio de Azógues sandstone are unstratified ash, mud, and volcanic conglomerates.

North of the Cerro Cojitambo-Chuquipata igneous intrusion, which cuts diagonally across the Azógues uplift, a much thicker sedimentary section is exposed than is found to the south of the intrusion. In the core of a small, sharp fold trending north-south, located three kilometers northwest of the village of Azógues, fossiliferous, brackish- or fresh-water Miocene ? beds are exposed. This sharp fold in the sediments apparently is the northward extension of the broader main fold to the south of the intrusion.

The east flank of the northern fold dips three kilometers at about 45° from its axis to the village of Azógues where it is terminated by vertical beds, and by westward dip from the west flank of Cerro Abuja, a volcanic cone with well-preserved crater.

The west flank of the northern fold dips west from its axis at about 50° for less than a kilometer where vertical beds on the east flank of Cerro El Shalal, an andesite fissure dike, are encountered. Westward from El Shalal the Cuenca shales, containing fairly well-developed brown coal beds, dip westward at about 50°.

All igneous intrusions in the area have greatly influenced adjacent sedimentary rocks structurally, and to a less extent lithologically.

The intrusive mass of the Azógues anticline is definitely younger in age than the Cuenca shales for the shales have been partly metamorphosed along their contact with the igneous rock. Though the Rio de Azógues sandstone has been tilted sharply by igneous uplifts, at no place has it been found to be in direct contact with igneous rock. It is, therefore, not possible to determine if the igneous intrusions are later in age than the Rio de Azógues sandstone.

In much of the area south of Rio Machangara, and southeast of Rio Chaullabamba, the Rio de Azógues sandstone is so irregularly bedded, exfoliated, and capped with unstratified volcanic debris that observations for structure are not reliable. The same conditions prevail in the area west and northwest of Ayancay.

OIL SEEPAGES

In the vicinity of Quebrada Paccha there are small, erratic deposits of manjack or asphalt along joint and bedding planes in the Rio de Azógues sandstone. These asphaltic deposits have their source in sedimentary beds lying below, and concealed by, the Rio de Azógues sandstone. Fractures in the sandstone permit some of the asphalt to permeate upward where it can be found as a dessicated asphaltic residue in thin veins, and locally in small pockets, in the Rio de Azógues sandstone.

Though casual attempts are made to mine this asphaltic material no commercial deposits have been found.

Five hundred meters northwest of the hamlet of Unión, in the bed of Rio Ayancay, sticky, greasy, asphaltic material seeps to the surface along joints in bluish gray, weathered andesite at the contact of the andesite with the Cuenca shales on the west. A few meters east of the stream bed a pit dug two meters into the andesite found the rock so hard that blasting was necessary. At the surface, in the weathered andesite, the asphaltic matter was almost dry, but a meter below the surface it had the consistency of a heavy lubricating grease. Distillation of this grease afforded a gas-oil of dark color.

In the headwaters of Quebrada Pishumaza there are deposits of manjack in the Cuenca shales not far from beds of brown coal. Though other manjack deposits may exist in the area none was found.

The source of the oil in the Cuenca Basin is not known. Olsson suggests that it may have its origin in the upper part of the Cuenca shales which are decidedly bituminous, and that it may have been generated from these shales when the Azógues structure was squeezed, compressed, and intruded by igneous rock. This source is entirely possible but if the upper part of the Cuenca shales is the source there should be saturation in these beds between Azógues and Biblián where they are highly bituminous and much better exposed than at any other locality in the region. A second source may be oil-bearing, early Tertiary and even Cretaceous rocks which are petroliferous in contiguous areas, and may lie beneath the Cuenca Basin. This source may account for the more liquid seepage occurring at the contact of the igneous core of the Azógues anticline with sedimentary rocks, the oil having migrated up the contact from considerable depth and having accumulated in both Cuenca shales and andesite.

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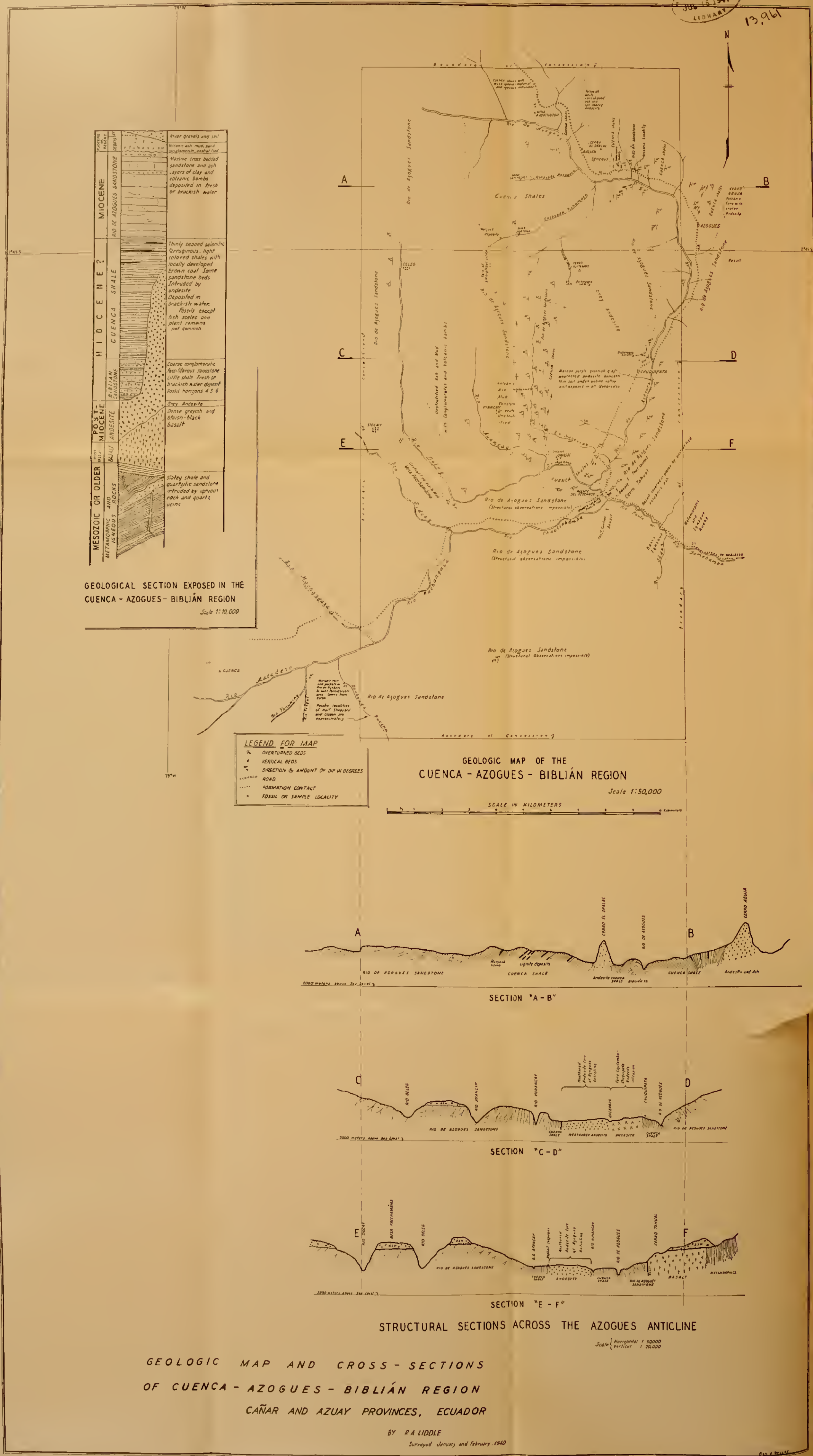
13,961
GEOLOGICAL SECTION EXPOSED IN THE
CUENCA - AZOGUES - BIBLIÁN REGION
Scale 1:10,000
MESOZOIC OR OLDER
POST-MIOCENE
MIOCENE ?
MIOCENE
METAMORPHIC AND IGNEOUS ROCKS
BASALT
ANDESITE
BIBLIAN SANDSTONE
CUENCA SHALE
RIO DE AZOGUES SANDSTONE
River gravels and soil
Massive cross bedded sandstone and ash layers of clay and volcanic bombs deposited in fresh or brackish water
Thinly bedded selenitic ferruginous, light colored shales with locally developed brown coal. Some sandstone beds. Intruded by andesite. Deposited in brackish water. Fossils except fish scales and plant remains not common
Coarse conglomeratic fossiliferous sandstone little shale. Fresh or brackish water deposit fossil horizons 4 5 6
Grey Andesite
Dense greyish and bluish-black basalt
Slatey shale and quartzitic sandstone intruded by igneous rock and quartz veins
LEGEND FOR MAP
OVERTURNED BEDS
VERTICAL BEDS
DIRECTION & AMOUNT OF DIP IN DEGREES
ROAD
FORMATION CONTACT
FOSSIL OR SAMPLE LOCALITY
GEOLOGIC MAP OF THE
CUENCA - AZOGUES - BIBLIÁN REGION
Scale 1:50,000
SCALE IN KILOMETERS
Rio de Azogues Sandstone
Cuenca Shales
AZOGUES
CUENCA
Basalt
SECTION "A - B"
SECTION "C - D"
SECTION "E - F"
STRUCTURAL SECTIONS ACROSS THE AZOGUES ANTICLINE
GEOLOGIC MAP AND CROSS - SECTIONS
OF CUENCA - AZOGUES - BIBLIÁN REGION
CAÑAR AND AZUAY PROVINCES, ECUADOR
BY R A LIDDLE
Surveyed January and February 1940

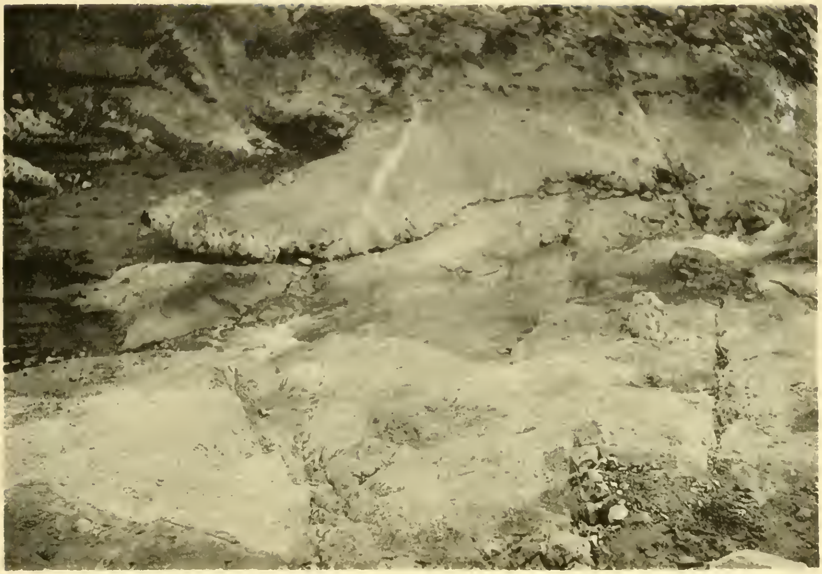

Fig. 1.—Deeply weathered, maroon, purple, greenish gray, massive soft andesite exposed in the core of the Azógues structure on Rio Hunancay. Veins of white chert and calcite cut the igneous mass.

Fig. 2.—Deeply weathered, vari-colored, soft andesite in the core of the Azógues structure on Rio Hunancay.

Fig. 1.—Massively bedded, brown, ashy sandstone and clay shale of the Rio de Azógues formation dipping westward on the western flank of the Azógues structure. The locality is on Rio Hunancay at the point where it turns eastward after flowing southward from near Cerro Cojitambo which can be seen indistinctly on the northern horizon in the background. Unstratified volcanic ash, mud, conglomerate, and bombs cap the mountains at the west side of the photograph.

Fig. 2.—Deep in the gorge of Rio Hunancay where it changes its course from south to east on the west flank of the Azógues structure. The sandstones are fairly massive, brown, ashy, and locally conglomeratic. The shales are brown to yellow, ashy, and fairly soft. The exposed horizon is in the lower part of Rio de Azógues formation, and the dip is west.

Fig. 1.—Thinly laminated, light-gray to white ashy shales of the Cuenca formation cut by layers and veins of white chert at the western edge of the igneous core of the Azógues structure in Rio Hunancay. The shales at this locality are vertical, or dip steeply westward away from the igneous intrusion.

Fig. 2—A north-south trending anticline of Biblián sandstone 4 kilometers northwest of Azógues on the Azógues-Biblián road. Rio de Azógues cuts eastward at the foot of the nearly vertical cliff. Locality 6 is on the western flank of this structure near its axis, and localities 4 and 5 are a short distance north on the highway from where the photograph was taken.

Fig. 1.—Thinly bedded, light-colored lignitic shales and inter-bedded soft, light-brown sandstones of the Cuenca formation outcropping in western edge of the village of Azógues.

Fig. 2.—Vertical, thinly bedded shales and sandstones of the Cuenca formation in contact with igneous rock at the southeast end of Cerro El Shalal on the Biblián-Azógues road.

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Fig. 1.—Composite photograph of Cuenca Basin looking north toward Cerro Cojitambo in the center background. At the right, east of the southward flowing Rio de Azógues, are massive beds of Rio de Azógues sandstone and ash dipping steeply eastward. Cuenca shales form the hill in the extreme right foreground (lower right corner). The surface of the entire center of the photograph as far north as Cerro Cojitambo is composed of highly colored clays weathered directly from vari-colored andesite which can be traced continuously in the lower course of Rio Hunancay as it flows from west to east across the middle of the area photographed and empties into Rio de Azógues. The Rio de Azógues sandstone and ash dipping steeply westward form the high ridge that lies just west of the upper course (south flowing in this locality) of Rio Hunancay. This ridge forms the skyline near the west background of the photograph, beyond which the dim outline of the rugged Cordillera Occidental can be seen on the far western horizon. The central part of the basin, averaging 9,000 feet above sea, is very fertile and intensely cultivated. In the left foreground are agave plants; in the center and right foregrounds yellow flowering lupines.

PART II. PALEONTOLOGY

By

K. V. W. Palmer

CONTENTS

INTRODUCTION

In February, 1940, Ralph A. Liddle, of Fort Worth, Texas, sent to the Paleontological Research Institution for study, a large collection of fossils from Ecuador. The material came from the center of the Azógues anticline, three kilometers northwest of the town of Azógues, Province of Cañar, Cuenca Basin in a conglomerate or conglomeratic sandstone.

The fossils represent the fresh-water fauna described by William B. Marshall and Edgar O. Bowles, published in 1932 in the Proceedings of the United States National Museum, from material collected by Dr. George Sheppard, Geologo del Estado, Ecuador, near Paccha and Biblián, Provinces of Azuay and Cañar, respectively. A relationship between the Biblián-Paccha fauna and that from Pebas, Peru was suggested by Marshall and Bowles and a probable Pliocene age was assigned. No species of mollusca in their collections were found to occur outside of the Cuenca area.

Dr. Roy E. Dickerson, Chief Geologist of the Atlantic Refining Company, made fossil collections in the Cuenca Basin, in 1927, which were sent to Dr. E. W. Berry, of Johns Hopkins University, who published in 1934, notes on the localities and paleobotany. The material consists of a compact, bituminous shale containing cycloid fish scales and a paper shale carrying similar fish scales, fragmentary molluscs, and plant remains. Berry identified a leaf to be the same as a species from the Loja Basin, Peru and gave a Pliocene age to both beds.

The fauna from the Dickerson localities discussed by Berry occurs in the Cuenca shales. These shales lie conformably above the sandstones and conglomerates which embrace the fossils described by Marshall and Bowles.

In addition to the fauna studied by Berry, Dr. Dickerson collected a small mass from a 4-inch seam of bituminous limestone near Cojitambo, Cuenca vicinity, Ecuador which includes two genera of mollusca.

The Cojitambo material was contributed by Dr. Dickerson for study in connection with this report and the descriptions of the forms are given.

The Biblián-Azógues-Cuenca region was studied and a private report made by Axel A. Olsson, of Gloversville, New York, in 1936. The report and collections of fossils which he made were generously turned over to the authors. The delineation of Mr. Olsson's fossils has been included in our paper.

Dickerson and Olsson indicated the localities where they obtained their fossils on Liddle's map, a reduction of which accompanies this account. We have endeavored to tie into Mr. Liddle's section as accurately as possible all additional information available.

The types and figured specimens and duplicate material upon which this faunistic study is based have been deposited by Messrs. Liddle and Olsson in the Paleontological Research Institution at Ithaca, New York. The Cojitambo specimens were donated to the Academy of Natural Sciences at Philadelphia, Pennsylvania, by Dr. Dickerson.

ACKNOWLEDGMENTS

Grateful acknowledgment is given Ralph A. Liddle who did the field work and who collected a large quantity of fossils from the Biblián-Azógues-Cuenca region. Without his notes, material and coöperation the report would not have been written. Special indebtedness is due Axel A. Olsson, who graciously turned over his report and fossils of the Cuenca area.

Thanks are extended to Dr. Harry S. Ladd of the United States National Museum for the loan of two topotypes of *Castalioides laddi* Marshall, from Venezuela, which he had from the Venezuela Gulf Oil Company; to Dr. J. P. E. Morrison of the United States National Museum who examined and sent notes on the types of *Castalioides*; and to Dr. E. W. Berry of Johns Hopkins University who identified a leaf from the Biblián sandstone, Azógues anticline.

LOCALITY AND FAUNAL LISTS

The following localities represent those from which the fossils studied personally have been obtained. The numbers assigned are those from the station book of the Paleontological Research Institution and are not those of the individual collectors. For location see the accompanying map.

1038. From center of the Azógues anticline, 3 kms. northwest of the town of Azógues, Province of Cañar, Ecuador. Localities 4, 5, 6. Sandstone, gray, weathered yellowish, iron stained, with some selenite. Collected by R. A. Liddle, February, 1940. Biblián sandstone.

Hemisinus (*Sheppardiconcha*) *biblianus* M. and B.
Potamolithoides biblianus M. and B.
Ecuadorea bibliana M. and B.
Diplodon liddlei, n. sp.
?*Monocondylæa azoguensis*, n. sp.
?*Monocondylæa pacchiana*, n. sp.
Anodontites olssoni, n. sp.
Cycloid fish scales (loc. 4)

1082. Directly on road from Biblián to Azógues in loose pieces for road construction, Province of Cañar, Ecuador. Probably locality 5 of Liddle. Sandstone gray, weathered yellowish, iron stained. Collected by A. A. Olsson, February, 1936. Biblián sandstone.

Hemisinus (*Sheppardiconcha*) *biblianus* M. and B.
Pomacea bibliana M. and B.
?*Monocondylæa pacchiana*, n. sp.
Anodontites olssoni, n. sp.
Trigonia varians Engelhardt[1]

1083. Near Paccha, along Quebrada Paccha, float in stream bed, Province of Azuay, Ecuador. Collected by A. A. Olsson, February, 1936. Gray sandstone and shale, weathered yellowish. Biblián sandstone.

Hemisinus (*Sheppardiconcha*) *biblianus* M. and B.
Ecuadorea bibliana M. and B.
?*Monocondylæa pacchiana*, n. sp.

[1] Identified by Dr. E. W. Berry, Johns Hopkins University.

1084. Near Paccha, along Quebrada Paccha, float in stream bed, Province of Azuay, Ecuador. Collected by A. A. Olsson, February, 1936. Light-gray, coarse sandstone, weathered whitish. Separated from 1083, until material is found in place, because of difference in rock matrix and faunal assemblage.

Corbicula (*Cyanocyclas*) *pacchiana*, n. sp.

Neritina pacchiana, n. sp.

Four-inch seam of limestone, highly bituminous, 400 meters S 25° W from Cojitambo, a prominent andesite hill in Arroyo Potrero where ulexite? occurs in shale. Collected by R. E. Dickerson, 1927.

Hemisinus peyeri dickersoni, n. var.

Corbicula (*Cyanocyclas*) *cojitamboënsis*, n. sp.

FAUNAL ANALYSIS

FORMATIONS

BIBLIAN SANDSTONE

In examining the localities of the forms described by Marshall and Bowles[2] as from the vicinity of the towns Biblián and Paccha, one finds that *Sheppardiconcha bibliana* is the only species listed from both localities. The following were described:

Sheppardiconcha bibliana M. and B.

Potamolithoides biblianus M. and B.

Pomacea bibliana M. and B.

Anodonites? sp.

Olsson collected *Sheppardiconcha bibliana*, *Ecuadorea bibliana* and ? *Monocondylæa pacchiana*, n. sp. at both localities confirming the presence of the same formation in each area. These species with those listed from localities 1038 and 1082 summarize the fauna known so far from the Biblián sandstone[3], the lower-

[2] Marshall, W. B. and Bowles, E. O.: U. S. National Mus., Proc., vol. 82, No. 2946, 1932.

[3] Sheppard, G.: Geol. Mag., vol. 71, 1934, p. 364.

most phase or section of the "arenisca de Azógues" of Wolf.[4] The Azógues sandstone is now restricted by Liddle to the uppermost part of the Azógues sandstone of Wolf, and emended to Rio de Azógues sandstone.

CUENCA SHALE

The following Dickerson localities in the Cuenca Basin were published by Berry[5], with a resumé of the fossils examined:

Biblián-Cuenca road on the right side of the Rio Azógues, 16 kilometers south of the town of Biblián and 3 or 4 kilometers above the juncture of the southerly flowing Rio Azógues with the northerly flowing Rio Gualubamba [Chaullabamba] to form the easterly flowing Rio Paute.

?*Potamolithoides biblianus* M. and B.
Streptomatidæ
Cyprinodont fish scales
Macrolobium tenuifolium Engelhardt

Three and one-tenth kilometers southeast of Biblián in the Azógues Valley and on the left side of the valley.

Cyprinodont fish scales

On the basis of the identification of *Macrolobium tenuifolium* and a suggested relation of the fish remains with species described from Loja, Ecuador, Berry believed that the Cuenca beds belonged to a similar inter-Andean continental deposit to that of Loja, Ecuador, of Pliocene age.

The localities of Dickerson occur in the Cuenca shales which lie stratigraphically above and conformably with the Biblián sandstone. Liddle collected fish scales, leaf impressions and lignite in the Cuenca shales.

RIO DE AZOGUES SANDSTONE

Fossils were found near Paccha, but not in place by Teodoro Wolf[6] and sent to Prof. H. B. Geinitz in Dresden, who identified *Cyrena* (2 or 3 species), *Cyclas* and *Paludina* and pronounced them of Wealden age. Undoubtedly the *Corbicula* (*Cyanocyclas*) *pacchiana* and *Neritina pacchiana* which Mr. Olsson collected in

[4] Wolf, T.: *Viajes cientificos por la Republica del Ecuador, II, relación de un viaje geognóstico por la Provincia de Azuay*, Guayaquil, 1879, p. 5; *Geografia y geologia del Ecuador*, 1892, pp. 244-253.

[5] Berry, E. W.: Washington Acad. Sci., Jour., vol. 24, No. 4, 1934, p. 184.

[6] Wolf, T.: *Geografia y geologia del Ecuador*, Leipzig, 1892, p. 253.

Quebrara Paccha came from the same formation as Wolf's material. *Cyanocyclas pacchiana* may be one of the species of *Cyrena* suggested by Geinitz.

Although *Cyanocyclas pacchiana* and *Neritina pacchiana* were found in Quebrada Paccha by Olsson, as well as the fossils listed in 1082, for temporary convenience we have listed them separately. It seems that if *Cyanocyclas* and *Neritina* were associated in the same faunule in Quebrada Paccha, as the species from the Biblián sandstone, localities 1038, 1083, 1082 and the collections of Sheppard, that some specimens of those genera would have been found at those localities. All the fossils collected by Olsson in Quebrada Paccha were found as float.

Liddle has pointed out that most of the surface rock in Quebrada Paccha is a part of the Rio de Azógues sandstone. It may be that the *Cyanocyclas* and *Neritina* came from the Rio de Azógues sandstone since they have not heretofore been found in the Biblián sandstone or Cuenca shales. This is only a suggestion and their proper position is not known until they have been found in place or can be correlated with a known section.

Sheppard[7] states that "similar and possible identical fossils to the above [those of Wolf] and collected from the same locality *in situ*" by him in 1931 were sent to Dr. Julia Gardner, United States Geological Survey who pronounced them upper Cenozoic and probably Pliocene in age. Unfortunately an analysis of the fauna studied by Dr. Gardner or the names of the genera were not given. As the generic names were not published we are at a loss to knew the relationship of Sheppard's collection to that of the material examined in this report. Since the fossils were found in place by Sheppard, a description and position of the sediments in which the fossils were found might have enabled a correlation of the fossils and a placement of them in the proper section or phase of the "arenisca de Azógues" of Wolf as segregated by Liddle.

UNCERTAIN POSITION

The position of the fossils, *Corbicula* (*Cyanocyclas*) and *Neritina,* found by Dickerson in a thin, bituminous limestone on

[7] Sheppard, G.: Pan-American Geol., vol. LIX, No. 2, 1933, p. 120.

Arroyo Potrero, near Cojitambo, is uncertain. The limestone is at the contact of the Cuenca shales and the intrusion of andesite, Cerro Cojitambo, where it may occur in the shales or its normal sequence may have been disturbed by the intruding masses.

HABITAT

The mollusks found in the Biblián sandstone, localities 1038, 1082 and 1083, indicate a fresh-water environment. *Hemisinus* is a typical fluviatile genus. The naiades, *Ecuadorea, Diplodon, Monocondylæa* and *Anodontites* belong to a fresh-water habitat. The South American "*Ampullaria*" species (*Pomacea*) have been described[8] "as fresh-water snails . . . inhabit slow-flowing rivers, often in places which dry in summer and if necessary spend the dry season buried in the ground." *Potamolithoides* is a fresh-water genus. The fish scales give no definite evidence as to their origin for they can be determined only as cycloid.

Presumably the fauna lived along some slow-moving stream or in the sluggist back waters of the rivers of the area.

The presence of *Corbicula* (*Cyanocyclas*) and *Neritina* introduces a possible brackish-water element. *Corbicula* is represented in nonmarine Cretaceous and Tertiary sediments in the interior of Western United States and in the marine beds of the coasts of North America. *Corbicula* in Africa, lives in rivers and lakes. *Cyanocyclas* (South American Corbiculas) are fluviatile or found in bays. *Neritina* is estuarine or fluviatile in habitat. The *Cyanocyclas* associated with *Hemisinus* in the Cojitambo material intimates that in that instance *Cyanocyclas cojitamboënsis* was confined to fresh-water. This may be true of the *Cyanocyclas pacchiana* and *Neritina pacchiana* or it may be that at certain times in the formation of the Biblián-Cuenca-Azógues sediments the waters became brackish.

AGE

Professor H. B. Geinitz, Dresden, on the basis of fossils sent him by Wolf from Quebrada Paccha assigned the "arenisca de Azógues" to the Wealden, lowermost Cretaceous.

[8] Crawford, G. I.: Linn. Soc. London, Proc., 149 Sess., pt. 2, 1937, p. 76.

Marshall and Bowles (1932) after studying the collection of Sheppard from near Biblián and Paccha stated that there were no reliable data to establish the age of the deposits, but because none of the genera except the *Pomacea* was found in the Recent fauna, they placed the beds as not later than Pliocene.

Professor Berry (1934) determined the age of the Cuenca deposits as Pliocene on the evidence of the fossil plants and fish being the same as those from Loja, Ecuador. Dr. Berry, identifiel for us a plant from loc. 1082, as that from the "Miopliocene of Colombia and Venezuela."

The present study reveals several new points which have not been published before.

The finding of *Cyanocyclas*, *Diplodon*, *Anodontites*, and *Neritina* modifies the statement of Marshall and Bowles that *Pomacea* was the only genus which was found common to the Recent.

Hemisinus peyeri dickersoni is the first and only form of mollusca to show a specific relationship outside of the Cuenca Basin. It belongs to the same group and allied to *H. eucosmius* Pilsbry and Olsson[9], of the Oligocene of Colombia but possesses characteristics nearer to *H. peyeri* (de Greve)[10] from Iquitos, Peru. The Iquitos beds are part of and of the same age as the Upper Amazon deposits of Pebas, Tres Unidos, Camana, and Paucarpata and Marañon, etc. The age of those deposits has been given by authors, as various ages from Oligocene to late-Pliocene. Greve (1938) summarizes the opinions and concludes that the age is still unknown but probably late Tertiary.

The age as given in this report to the Biblián-Azógues-Cuenca sediments places a possible Miocene time of deposition.

SYSTEMATIC DESCRIPTIONS

Family NERITIDÆ

Genus NERITINA Lamarck, 1816

Neritina pacchiana, n. sp. Plate 9, figs. 3, 4

Description.—Shell small, spire slightly elevated, columella callus thickened, more so anteriorly. Surface with bands of dark

[9] Pilsbry, H. A. and Olsson, A. A.: Acad. Nat. Sci. Philadelphia, Proc., vol. 87, 1935, p. 13, pl. 3, fig. 2.

[10] Greve, L. de; Schweizer. palæont. Gesell., Abh., Bd. LXI, 3, 1938, p. 104, pl. 4, figs. 7-11.

patches, irregular in size, some parts of the shell compactly covered with dark spots. The coloration is described from one specimen, the only shell retaining such features. The coloration is closest to that of certain color varieties of *N. virginea* L. of the West Indies to Brazil. Since the species of *Neritina* offer a wide variation in surface color markings, the pattern of one shell would not be enough for specific identification.

The shape of the species differs from the 5 fossil forms of the Upper Amazonian fauna in being more erect, *i. e.* the spire is above the line of the posterior margin of the aperture and not on the same level with it. Illustrations, descriptions and synonymy are given of the described Neritinas of the Tertiary beds of the Upper Amazonian area in detail by de Greve[11] in his monograph of the molluscan fauna of Iquitos, Peru and will not be repeated here. *N. pacchiana* does not have the spire elevated so much as the Recent, *N. virginea* Linné[12].

The species is associated with *Corbicula* (*Cyanocyclas*) *pacchiana* and small gastropods. The specimens of the gastropods are too poor for identification.

Dimensions.—Height, 6 mm.; greatest diameter, 4.5 mm.

Holotype.—No. 4009, Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1084 (Olsson).

Family HYDROBIIDÆ

Genus POTAMOLITHOIDES Marshall and Bowles, 1932

Potamolithoides biblianus Marshall and Bowles Plate 6, figs. 13, 14

Potamolithoides biblianus Marshall and Bowles, 1932, U. S. National Mus., Proc., vol. 82, No. 2246, p. 4, pl. 1, figs. 1-3; Wenz, 1939, Handbuch der Paläozoölogie, Gastropoda, Pt. 3, p. 574, fig. 1558.

This small "beehive" appearing shell is unique. It could easily be overlooked and mistaken for a small concretion or rounded mass of sandstone. To emphasize the general appearance an illustration of the back of the shell is included.

Marshall, published by Berry[13], identified doubtfully the species

[11] Greve, L. de; Schweizer. Palæont. Gesell., Abh., Bd. LXI, 3, 1938, pp. 60-68, pl. 5.

[12] Tryon, G. W., Jr.: Man. Conch., vol. X, 1888, p. 39, pl. 12, figs. 31-45.

[13] Berry, E. W.: Washington Acad. Sci., Jour., vol. 24, No. 4, 1934, p. 185.

in material from 16 kilometers south of the town of Biblián, along the Biblián-Cuenca road on the right side of Rio Azógues, Ecuador.

Dimensions.—Height, 4.5 mm.; greatest diameter, 4.5 mm.

Figured specimen.—No. 3995, Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1083 (Liddle).

Family **AMPULLARIIDÆ**

Genus **POMACEA** Perry, 1810

Pomacea bibliana Marshall and Bowles

Pomacea bibliana, 1932, Marshall and Bowles, U. S. National Mus., Proc., vol. 82, No. 2946, p. 4, pl. 1, figs. 4, 5.

Several specimens of this species of *Pomacea* (formerly known as *Ampullaria*) were collected by Mr. Olsson from the Azógues anticline locality. Although all are crushed, they are not flattened so much as the type specimen and show a greater height to the body whorl in proportion to the width. The species must attain considerable size, for one specimen has a height of 38 + mm.

Dimensions.—Height, 38 + mm.; greatest diameter, 30 + mm. crushed, largest specimen.

Specimens.—Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1082 (Olsson).

Family **THIARIDÆ**

Genus **HEMISINUS** Swainson, 1840

Section **LONGIVERENA** Pilsbry and Olsson, 1935

Hemisinus peyeri dickersoni, n. var. Plate 6, figs. 15-18

Description.—Shell small, whorls with deeply excavated sutures; surface ornamented with longitudinal ribs crossed by spiral ribs. There are four nodose spiral ribs on the whorls of the spire, the lowermost row of the tubercles may be weak; the tuberculate ribs extend over the body whorl to the periphery; below to the basal margin are 4 or more spiral ribs. The aperture has a shallow canal, the anterior margin is thickened which gives it a flaring aspect. This semblance is intensified on the syntype (Plate 1, fig. 16) by having the outer lip broken. The longitudinal ribs are curved and on the body whorl are distinct and reversed sigmoidal. At the intersection of the two systems of ribbing, prominent nodes or tubercles are produced.

This species is related to *Hemisinus peyeri* (de Greve)[14], fossil from Iquitos, Peru. Like *H. peyeri*, the form has more than two spiral ribs over the basal area of the body whorl. *H. peyeri* and *H. dickersoni* differ from *H. eucosmius* Pilsbry and Olsson[15] from the Mugrosa formation, Oligocene of the Magdalena Valley, Colombia, in that the Colombian species has two spiral ribs below the tuberculated ribs on the body whorl, with the remainder of the base smooth.

The three species belong in the section *Longiverena* which has a shell with spiral cords or grooves and axial folds or ribs. The triad are closely related in that they each bear four rows of tuberculated spiral ribs over the whorls.

The basal spiral ribs on *H. peyeri* appear to be sharper with wider interspaces than in the variety *dickersoni*.

H. peyeri dickersoni is unique in the collections so far published upon from the Cuenca Basin, in that it shows the closest specific relationship in the fauna to any other form outside of the area. The Iquitos, Peru beds, in which *H. peyeri* de Greve occurs is part of the well-known Upper Amazonian fauna which consists of fresh-water shells with perhaps a brackish water element[16]. The age is still unproven, the consensus of opinion being that it is late Tertiary.

Dimensions.—Height, 15 mm.; greatest diameter, 7 mm.

Syntypes.—Academy of Natural Sciences, Philadelphia, Pa.

Occurrence.—Four-inch seam of highly bituminous limestone, 400 meters S 25° W from Cojitambo, a prominent andesite hill in Arroyo Potrero, Cuenca vicinity, Ecuador. Roy E. Dickerson, coll. 1927.

[14] Greve, L. de: Schweizer. palæont. Gesell., Abh., Bd. LXI, 3, 1938, p. 104, pl. IV, figs. 7-11 as *Semisinus*.

[15] Pilsbry, H. A. and Olsson, A. A.: Acad. Nat. Sci., Philadelphia, vol. 87, 1935, p. 13, pl. 3, fig. 2.

[16] Greve, L. de: Schweizer. palæont. Gesell., Abh., Bd. LXI, 3, 1938, pp. 118-122, 126.

Subgenus **SHEPPARDICONCHA** Marshall and Bowles, 1932

Hemisinus (Sheppardiconcha) biblianus Marshall and Bowles

Plate 6, figs. 1-12

Sheppardiconcha bibliana Marshall and Bowles, 1932, U. S. National Museum, Proc., vol. 82, No. 2946, p. 3, pl. 1, fig. 6.

Hemisinus (*Sheppardiconcha*) *biblianus* (Marshall and Bowles) Wenz, 1939, Handbuch der Paläozoologie, Gastropoda, Bd. 6, Teil 3, p. 718, fig. 2077.

Individuals of this species are very abundant in the localities near Azógues and in Quebrada Paccha. At Liddle locality 5, they occur massed together. At locality 4, they are associated generally with bivalves. In the hundreds of specimens of the Liddle and Olsson collections of the species, only one shell was found with the aperture entire. The remaining portion of the specimen was broken. It was a large individual, with the greatest diameter of 19 mm., a size which the species commonly reaches at the Paccha locality.

The aperture of the species as revealed by this specimen is more ovate than round, with a short but deep and wide anterior sinus. The posterior line of the outer lip follows the line of longitudinal growth sinuosity, making a deep swing. The parietal and columellar areas are covered with a callus which extends to the margin of the anterior canal. One specimen shows a slight groove in the umbilical area.

The discovery of the specimen with the complete aperture and basal notch, reveals a shell related more to *Hemisinus* than originally believed. The holotype was not a perfect shell and the aperture was described as roundish. The genus differs from *Hemisinus* in lacking the posterior canal and in having a greater sinuosity in the lines of growth. *Hemisinus* (*Basistoma*) *edwardsii* (Lea)[17] has similar growth lines, deep suture, general shape, spiral ribs and wide anterior notch. *H. biblianus* differs from *Basistoma* in lacking the posterior notch or curve of the outer lip.

Many specimens in the Paccha material attain the greatest diameter of 15 mm. and more. There is also considerably more variation in the shells from Paccha than from near Azógues. Although many individuals were collected, perfect specimens are

[17] Lea, I.: Amer. Philos. Soc., Trans., n. s., vol. 10, 1853, p. 296, pl. 30, fig. 1, type species of *Basistoma*.

rare. The Paccha collection seems to be better preserved hence more of the specific characters may be determined through it. The growth lines become strongly developed and where the spiral ribs are worn, the longitudinal sinuous lines predominate over the spiral ribs, giving a different aspect to the shells. Superficial examination of the material of the species from the Azógues and Paccha localities gives one the impression that two forms might be represented. But I have carefully compared many specimens under the binoculars and believe they belong to the same species. The illustrations included herein are presented to show variation and pertinent points.

Hollis Hedberg[18] thought that he had from the upper Miocene or Pliocene near Santa Inez, Venezuela, a species of this genus. Hedberg's specimens appear more like some Cerithiidæ than allied to the present genus.

Dimensions.—Height, 25 mm. + (broken); greatest diameter, 10 mm. (medium specimens).

Figured specimens.—Nos. 3985-3994, Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1038 (localities 4, 5, 6 Liddle); 1082 (Olsson); 1083 (Olsson).

Family MUTELIDÆ

Genus ECUADOREA Marshall and Bowles, 1932

Ecuadorea bibliana Marshall and Bowles — Plate 7, figs. 1-6

Ecuadorea bibliana Marshall and Bowles, 1932, U. S. National Mus., Proc., vol. 82, No. 2946, p. 5, pl. 1, figs. 7, 8; Sheppard, 1938, Univ. Central Ecuador, An. t. 60, No. 304 original plate reproduced.

This species, described and illustrated by Marshall and Bowles, constitutes the type of a new genus, the relationship of which was thought to be between *Hyria* Lamarck (*Hyria auct.=Triplodon* Spix) and *Diplodon* Spix. The sculpture was well illustrated. Probably a lack of material prevented a definition of the dental characters. The dentition as shown by specimens in the Liddle and Olsson collections is nearer to that of *Diplodon* than to *Hyria*.

[18] Hedberg, H. D.: Geol. Soc. Amer., Bull., vol. 48, 1937, p. 2012, pl. 8, figs. 14, 15.

There is a long narrow pseudocardinal in the left valve with a socket on both sides; one short cardinal lies beneath the beak. The posterior part of the cardinal area is destroyed so that further details are obscured. The left valve has 2 long laterals with a narrow groove between. By etching a portion of the shell in the umbonal area of a right valve and excavating beneath the beak and hinge region, the presence of a pseudocardinal with two sockets in the left valve is revealed. The particular specimen (Pl. 7, fig. 5) is peculiarly marked with parallel grooves which trend in the same direction as the tooth. The dark area in the illustration just below the striations is made by erosion in the area of the muscle scar and is not a normal socket. The two dark areas on either side of the posterior end of the grooved tooth are sockets.

According to Simpson[19] striations of the teeth are not generic or even specific in value.

On the umbonal and mid-region of the shell, the pattern of sculpture consists of a trifold division. The sculpture anteriorly is weak followed by radiating folds with interspaces of about equal width. The radiating ribs form a general straight pattern which may be broken by the ribs forming a series of Vs. From the mid-line to a posterior fold, the radiating ribs are larger than anteriorly and curved anteriorly to the mid-line. They also may be arranged in Vs. Along the posterior dorsal margin, the ribs extend obliquely to the margin of the shell and to the direction of the other ribs. Ventrally the ribs die out and coarse concentric lines of growth predominate.

The genus *Castalioides* bears the closest similarity in sculptural pattern with *Ecuadorea*. This is apparent between *E. bibliana* and *Castalioides laddi* Marshall,[20] fossil from the State of Monagas, Venezuela. The two forms have the sculpture in a tripartite formation. That of *E. bibliana* extends further ventrad and has the lower sculpture broken. The hinges of the two genera differ. Through the courtesy of H. S. Ladd, of the U. S. Na-

[19] Simpson, C. T.: U. S. National Mus., Proc., vol. XVIII, No. 1068, 1896, p. 298.
[20] Marshall, W. B.: Washington Acad. Nat. Sci., Jour., vol. 24, No. 2, 1934, p. 78, figs. 1-4.

tional Museum, two specimens from material of the Venezuela Gulf Oil Co. were loaned the author. The specimens consist of both valves. Illustrations of *Castalioides laddi*, the hinge of which has not been figured previously, are included, (Plate 8, figs. 7, 8). These figures show the hinge characters and are inserted to show that the similarity of external features in the South American naiades which have umbonal radial sculpture must be used with caution in determining generic groups. *Ecuadorea* and *Castalioides*, have a similar pattern of ornamentation but differ in hinge structure. *Ecuadorea* has a long pseudocardinal in the left valve, that of *Castalioides* is short. *Castalioides* has two cardinals differentiated in the right valve with the anterior portion of the middle cardinal rugged. *Ecuadorea* probably has one or two slight cardinals in the right valve, but they cannot reach the size of the cardinal elements in *Castalioides*.

Pilsbry and Olsson[21] suggest that possibly *Triplodon latouri* Pilsbry and Olsson and *"Hyria" wheatleyi* Marshall[22] should be referred to *Ecuadorea*. The dentition of *wheatleyi* approaches that of *Ecuadorea*. *"T." latouri* occurs in the La Cira formation, upper Oligocene or lower Miocene of the Magdalena Valley, Colombia. The comparison of the Colombian species with *Ecuadorea* is based on similarity of sculpture and cannot be accepted as certain until the dentition of *T. latouri* is known. *"Hyria" wheatleyi* is living in the "Rio Negro, 1200 miles up the Amazon".

Sculpture suggesting a similar pattern as *E. bibliana* is seen on one specimen of *Diplodon santa mariæ* Simpson[23] a Recent species from Rio Itapoca, Brazil. But the hinges of the two species differ considerably in the cardinal area.

Dimensions.—Length, 43 mm.; height, 30 mm.; semidiameter, 11 mm.

[21] Pilsbry, H. A. and Olsson, A. A.: Acad. Nat. Sci., Philadelphia, vol. 87, 1935, p. 17.

[22] Marshall, W. B.: U. S. National Mus., Proc., vol. 69, No. 2638, 1926, p. 7, pl. 1, figs. 3, 5; pl. 3, fig. 1.

[23] Marshall, W. B.: U. S. National Mus., Proc., vol. 53, No. 2209, 1917, p. 386, pl. 52, fig. 6; pl. 55, figs. 1-4. Species figured in.

Figured specimens.—Nos. 3996-4000, Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1038, (loc. 4 Liddle); 1083 (Liddle).

Genus DIPLODON Spix, 1827

Diplodon liddlei, n. sp. Plate 8, figs. 1-5

Description.—Shell elongate-quadrate, plump, anterior end short, posterior end flaring dorsally with a narrow wing above the hinge line; posterior dorsal area concave, sloping ventrally; hinge with two pseudocardinals in the right valve, the lower tooth the larger, with a large socket between; correspondingly, a large pseudocardinal in the left valve; anterior adductor and retractor muscle scars preserved on paratype; umbones ornamented with radial ribs of short interlocking V-shaped pattern. The lower portion of the shell is sculptured with coarse lines of growth only.

This species differs from *Ecuadorea bibliana* Marshall and Bowles in the character of the hinge, shape of the shell and in the ornamentation. In *D. liddlei*, the pseudocardinals are nearer to the beak and are not so elongate and are inclined at a lesser degree to the hinge line than in *E. bibliana*. The pseudocardinals of *D. liddlei* in position and shape appear nearest to the form of *D. mogymirim* Ortmann[24] than has been observed in any other South American naiad illustration. *D. liddlei* has a quadrate shape, that of *E. bibliana* is subelliptical. The radial pattern of sculpture of *D. liddlei* is composed of small V-shaped ribs which interfinger so that they appear like large punctations. In *E. bibliana* the radial ribs are bolder in pattern, and form three sections, the ribs having a different direction of radiation in each portion and break along the ventral area of the radiation into small V-shaped lines.

Dimensions.—Length, 35+mm.; height, 28 mm.; semidiameter, 6 mm.

Types.—Holotype, No. 4003, paratypes, Nos. 4002, 4004, 4005, 4006, Paleontological Research Institution.

Occurrence.—P. R. I. sta. No. 1038 (loc. 4 Liddle).

[24] Ortmann, A. E.: Mem. Carnegie Mus., vol. VIII, No. 3, 1921, p. 520, pl. 37, figs. 4a, 4c.

Genus **MONOCONDYLÆA** d'Orbigny, 1835

?Monocondylæa azoguensis, n. sp. Plate 9, fig. 8

Description.—Shell quadrate, short, anterior and ventral margins rounded; dorsal margin high; posterior margin obliquely inclined posteriorly to about the mid-line, then it turns and is broadly rounded to the ventral margin. An obscure fold occurs from the umbonal area to the point of angulation of the mid-posterior junction. This is seen on the specimen and suggested in the illustration. It resembles the posterior folds of *Monocondylæa*. A second line is suggested from the posterior-ventral junction toward the umbo but crushing in that area indicates that the mark is not normal. The shell is smooth with no impression of radial sculpture on the beak. The anterior portion is not produced just below the beak as in most *Monocondylæa*. The hinge is not available and the specimens are poorly preserved.

This species is differentiated from the other forms in the collection by the short quadrate shape. The lack of radial sculpture separates it from *Ecuadorea bibliana* and *Diplodon liddlei*. Poor preservation may account for lack of sculpture.

Dimensions.—Length, 29 mm.; height, 25 mm.; semidiameter 5+mm. (cast).

Holotype.—No. 4012, Paleontological Research Institution.

Occurrence.—P. R. I. sta. No. 1038 (loc. 4 Liddle).

? Monocondylæa pacchiana, n. sp. Plate 9, figs. 1, 2

Description.—Shell medium, umbos low, dorsal line straight; posterior end broad, straight or slightly rounded, anterior end sloping, short; shell smooth; hinge unknown.

Most of the specimens are crushed but the species may be identified by the general rectangular form and smooth shell. It differs from *M. azoguensis* by its greater length.

The species occurs in the Biblián sandstone at 1038, locality 4 (Liddle) and Mr. Olsson collected it in float in Quebrada Paccha. The Paccha material is better preserved, hence the paratypes were selected from that locality.

Dimensions.—Length, 40 mm.; height, 33±mm.; semidiameter, 10 mm.

Types.—Syntypes, Nos. 4007, 4008, Paleontological Research Institution.

Occurrence.—P. R. I. sta. No. 1038, (loc. 4 Liddle); No. 1083 (Olsson).

Genus **ANODONTITES** Bruguière 1792

Anodontites olssoni, n. sp. Plate 9, fig. 7

Description.—Shell large, thick, umbos large, swollen; hinge line straight; posterior end slopes obliquely from the posterior termination of the hinge line to the rounded postero-ventral margin. Hinge unknown; surface smooth with conspicuous, radiating, undulating lines over the anterior portion of the shell from about the middle to almost the anterior margin, strongest ventrad; irregular stages of growth.

The specimens of this species are found mostly as casts, commonly that of both valves together, with one valve slipped below the other. The holotype has the dorsal line displaced. This may be the same species which Marshall and Bowles, (p. 6,) speak of as occurring in the Sheppard collection from near Biblián. Fragments of this large form were obtained by Mr. Liddle from loc. 4, Azógues anticline. In the material which Mr. Olsson got from the same area, probably loc. 5 of Liddle, this bivalve is very common.

The presence of the ventral radiating sculpture suggests that the species belongs in the group of *A. tortilis* (Lea)[25] *A. palmeri* Marshall[26] and *A. pittieri* Marshall,[27] living forms which occur from British Guiana, Colombia to Costa Rica, Colombia and Venezuela, respectively.

This species is the largest pelecypod in the Cuenca-Azógues-Biblián collections studied. It may be distinguished from the other bivalve species of the region, by its large size, large full umbos and radiating lines over the anterior ventral area.

25 Lea, I.: Amer. Philos. Soc., Trans., vol. 10, 1852, p. 291 pl. XXVIII, fig. 54; Simpson, C. T.: Descrip. cat. naiades, etc., 1914, p. 1417.

26 Marshall, W. B.: U. S. National Mus., Proc., vol. 77 No. 2825, 1930, p. 6, pl. 2, figs. 1, 4, 7.

27 Marshall, W. B.: U. S. National Mus., Proc., vol. 61, No. 2437, 1922, p. 6, pl. 1, figs. 9, 11; pl. 2, figs. 9, 12; pl. 3, fig. 6.

A large leaf impression is embedded in a rock sample next to a specimen of this species. The fossil plant was sent to Dr. E. W. Perry, of Johns Hopkins University who identified the species as *Trigonia varians* Engelhardt, "which was described originally from the Miopliocene of Colombia and Ecuador."[28]

Dimensions.—Length, 65 mm.; height, 46 mm.; thickness (both valves), 35 mm.

Holotype.—No. 4011, Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1038 (loc. 4 Liddle); 1082 (Olsson).

Family **CYRENIDÆ**

Genus **CORBICULA** Megerle v. Mülfeld, 1811

Subgenus **CYANOCYCLAS** Férussac, 1818

Corbicula (Cyanocyclas) pacchiana, n. sp. Plate 9, fig. 5

Description.—Shell medium in size, beaks high, shape trigonal; hinge with long, narrow laterals, surface entirely covered with coarse concentric ribs.

The material containing casts and impressions of the external sculpture of this species consists of a single mass of shells. One cast of a right valve reveals the existence of long narrow laterals which definitely places the species in the genus *Corbicula*. The South American Corbiculas are included under *Cyanocyclas*.

This *Cyanocyclas* bears a resemblance to *C. cuneata* "Deshayes" as figured in Prime.[29] The Paccha *Cyanocyclas* differs from *C. cojitamboënsis* in being less concave beneath the beaks.

Similar ribbing to *C. pacchiana* and *C. cojitamboënsis* is seen on *C. undulata* Marshall[30], Recent from the Bay of Colonia, Rio de la Plata, Uruguay.

There is no doubt but that this *Cyanocyclas* came from the same formation and might be one of the species of "*Cyrena* (2 or 3 species)" which Wolf[31] collected in the Paccha region and submitted to Geinitz in Dresden who pronounced the age Wealden.

28 Berry, E. W.: Personal communication, March 12, 1941.

29 Prime, T.: Smith. Misc. Coll., vol. VII, No. 145, 1865, p. 6, fig. 5. Species originally described by Jonas, 1844.

30 Marshall, W. B.: U. S. National Mus., Proc., vol. 72, No. 2699, 1927, p. 5, pl. 1, figs. 5, 6.

31 Wolf, T.: *Geografia y geologia del Ecuador*, Leipzig, 1892, p. 253.

Wolf's specimens were not found *in situ.*

Dimensions.—Length, 26 mm.; height, 23 mm.; semidiameter, 4+mm.

Holotype.—No. 4010, Paleontological Research Institution.

Occurrence.—P. R. I. sta. 1084 (Olsson).

Corbicula (Cyanocyclas) cojitamboënsis, n. sp. Plate 9, fig. 6

Description.—Shell small, beaks high, shape trigonal; hinge with long narrow laterals, surface entirely covered with coarse concentric ribs.

This species is associated with *Hemisinus peyeri dickersoni* which is abundant. Only a small amount of material is available but it is important in that *Cyanocyclas* and the section *Longiverena* of *Hemisinus* has not been found so far among the prolific individuals of the Biblián sandstone.

Corbicula (Cyanocyclas) was also found by Mr. Olsson in Quebrada Paccha. The material was meagre so that lack of many specimens limits complete knowledge of the form. The two Corbiculas may prove to be the same species. Because *C. pacchiana* seems to be less concave anteriorly beneath the beaks and because one cannot be sure of the formation from which *C. pacchiana* came nor the position of the limestone in which *C. cojitamboënsis* was found, the two forms are separated. The type of *C. pacchiana* is considerably larger than *C. cojitamboënsis.*

Dimensions.—Length, 16+mm.; height, 14+mm.; semidiameter, 4 mm.

Types.—Holotype and paratype, Academy of Natural Sciences, Philadelphia, Pa.

Occurrence.—Four-inch seam of highly bituminous limestone, 400 meters S 25° W from Cojitambo, a prominent andesite hill in Arroyo Potrero, Cuenca vicinity, Ecuador. Roy E. Dickerson, coll. Jan. 18, 1927.

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3. **Diplodon liddlei,** n. sp. ... 48

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Length, 32 mm.; height, 23 mm.; semidiameter, 9 mm.; Topotype from near Aragua de Maturin, District of Piar, State of Monagas, Venezuela; Venezuela Gulf Oil Company.

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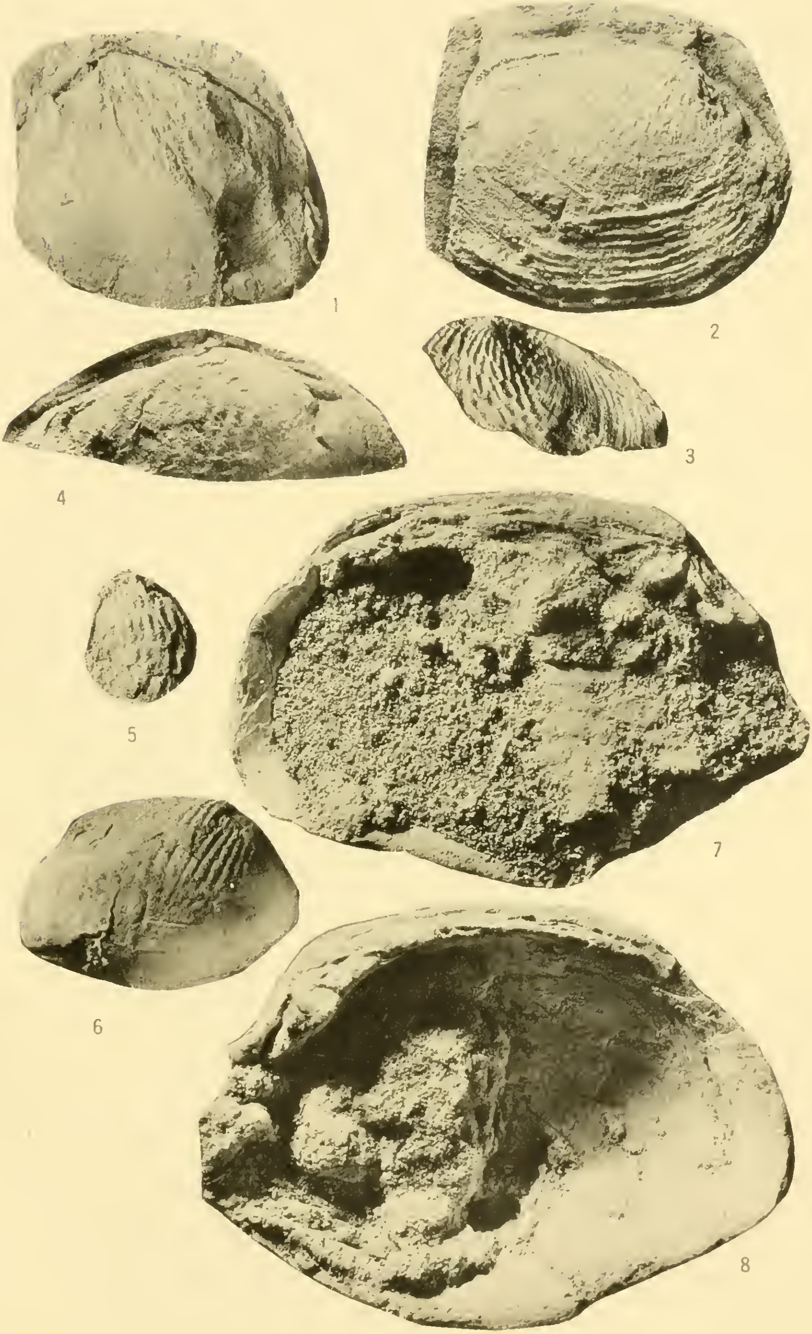
Same specimen as fig. 6. Figs. 7 and 8 included for comparison with the hinge of *Ecuadorea*.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