PHYLUM MOLLUSCA

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PART 1. INTRODUCTION, CLASSIFICATION, GLOSSARY, AND REFERENCES

INTRODUCTION

(Figure references in this chapter are to Plates 18 and 19)

Among the relatively few patterns of animal construction (Phyla) which have been highly successful, in terms both of numbers and of diversity of habitats, is the molluscan plan. Along with the Chordata and the Nematoda, the Mollusca must rank just after the Arthropoda in terms of evolutionary "success". Most molluscs are readily recognizable -- the soft body within a hard calcareous shell is usually diagnostic (as is the extensive use of ciliary and mucous mechanisms in feeding, locomotion, and reproduction). The basic molluscan plan of structure and function is remarkably uniform throughout the group, but there is no single standard molluscan shape. An extreme diversity in external body form has been based upon this plan -- clam, chiton, snail, and squid are all molluscs. In an evolutionary sense, the molluscan plan has proved plastic, and the adaptive modifications of structure and function to fit particular environmental circumstances provide material for a wide variety of biological studies.

There are probably about 90,000 living species of molluscs, mostly belonging to the three major classes, Gastropoda, Bivalvia, and Cephalopoda. In the molluscan fauna of the Woods Hole area, the majority of orders and superfamilies are represented, but students and visiting investigators should note that certain groups are absent and others represented by a single common species. For example, in the class Gastropoda, no two gilled aspidobranchs (Haliotidae, Fissurellidae, etc.) occur, and of the one gilled aspidobranchs only the limpet Acmaea testudinalis is available. There are no shallow water trochaceans (the group including Margarites and Tegula) such as are common on other coasts. Representatives of the class Scaphopoda ("tusk shells", e.g. Dentalium) can only be dredged from deeper water and are not available for experimental studies. Although most bivalve groups are well represented, including three typical genera of the subclass Protobranchia, the subclass Septibranchia is not found locally. Among the Cephalopoda, neither octopods nor sepioids are available locally, though Octopus has been dredged from deeper water offshore.

This chapter includes an outline classification of Mollusca, a glossary of terms relating particularly to shelled forms, some general references, a short section on local amphineurans and cephalopods, and detailed keys and annotated lists of species for the two large groups, the shelled gastropods and the bivalves. For nudibranchs and other shell-less ophistobranch gastropods, see Chapter 15.

Much molluscan systematics in the past has been based on shell characteristics, and previously available keys have been almost entirely conchological - the vital soft parts and environmental circumstances being ignored. We have deliberately tried to design the present keys to be used on molluscs collected alive - and therefore they will not be so useful for the identification of stray empty shells found cast up on the beach. We feel, however, that by using such characters as the siphons of bivalves, we have created less artificial keys. We have tried to use criteria of more fundamental biological significance than the detailed dimensions of shells, and attempted to avoid the artificial separation of naturally related genera. In almost all cases, the specific names used follow those of Abbott (1954). Occasionally, where a well known generic name is no longer correctly applied to a particular species, we have given this after an "equals" sign in parentheses, e.g. (= Venus). These "former" genera should be clearly distinguished from the few subgenera quoted, which are placed in parentheses following accepted usage.

The outline classification given below is that which has been used in teaching

at Woods Hole for three years, and reflects modern reconsideration of phylogeny in the light of functional morphology (see, for example, the classification of the bivalves). Typical genera (local if possible) are given in parentheses, and are marked "*" if species occur in the Cape Cod area, "n" if non-marine.

OUTLINE CLASSIFICATION OF THE MOLLUSCA

A. Class MONOPLACOPHORA . . . . . .(Neopilina)

B. Class AMPHINEURA

I. Subclass APLACOPHORA . . . . . (*Chaetoderma)

II. Subclass POLYPLACOPHORA . . . . . .(*Chaetopleura)

C. Class SCAPHOPODA . . . . . (*Dentalium)

D. Class GASTROPODA

I. Subclass PROSOBRANCHIA

a. Order Archaeogastropoda (Diotocardia or Aspidobranchia) . . . . . (*Acmaea)
b. Order Mesogastropoda (Monotocardia I or Taenioglossa) . . . . . .(*Littorina, *Lacuna, *Crepidula)
c. Order Neogastropoda (Monotocardia II or Stenoglossa) . . . . . .(*Busycon, *Nassarius, *Urosalpinx)

II. Subclass OPISTHOBRANCHIA (key to shell-less forms is in Chapter XV)

a. Order Cephalaspidea . . . . . .(*Acteon, *Philine)
b. Order Anaspidea . . . . . (*Haminoea, *Aplysia)
c. Order Thecosomata (Thecosomatous Pteropods). . . . (*Cavolina)
d. Order Gymnosomata (Gymnosomatous Pteropods). . . . .(*Clione)
e. Order Sacoglossa . . . . . .(*Elysia)
f. Order Acochlidiacea . . . . . (Hedylopsis)
g. Order Notaspidea . . . . . (Pleurobranchus)
h. Order Acoela (Nudibranchia). . . . (*Acanthodoris, *Aeolidia)

III. Subclass PULMONATA

a. Order Basommatophora . . . . . (*Melampus, n*Lymnaea)
b. Order Stylommatophora . . . . . (n*Cepaea)

E. Class BIVALVIA (Lamellibranchia or Pelecypoda)

I. Subclass PROTOBRANCHIA . . . . . (*Nucula, *Yoldia, *Solemya)

II. Subclass LAMELLIBRANCHIA (no longer used to designate whole class)

a. Order Taxodonta . . . . . (*Anadara)
b. Order Anisomyaria. . . . . .(*Mytilus, *Chlamys, *Crassostrea)
c. Order Heterodonta . . . . . .(*Tellina, *Mercenaria)
d. Order Schizodonta . . . . . (n*Anodonta, n*Unio)
e. Order Adapedonta . . . . . (*Mya, *Ensis)
f. Order Anomalodesmata . . . . . .(*Lyonsia, *Pandora)

III. Subclass SEPTIBRANCHIA . . . . . (Cuspidaris)

F. Class CEPHALOPODA

I. Subclass NAUTILOIDEA (TETRABRANCHIA) . . . . . .(Nautilus)

II. Subclass AMMONOIDEA . . . . . (entirely extinct)

III. Subclass COLEOIDEA (DIBRANCHIA)

a. Order Decapoda . . . . . (*Loligo)
b. Order Octopoda . . . . . .(*Octopus)
c. Order Vampyromorpha . . . . . .(Vampyroteuthis)

GLOSSARY OF MOLLUSCAN TERMINOLOGY

Adductor muscle(s): The major muscles (usually two in number) of the bivalve body, inserting on each valve, the contraction of which closes the shell valves.
Aspidobranch ctenidium: (Gastropods) A "shield" or "feather shaped" gill with leaflets or filaments alternating on either side of the axis (figs. 1, 2)
Body whorl: The last and largest whorl which terminates at the aperture (Gastropods)(fig. 9)
Byssus: (Bivalves) A permanent (or more usually temporary) attachment of tough organic threads secreted from a gland in the foot.
Callus: A local area of shell thickening (a callus may occur near the umbilicus in certain snails).
Cardinal teeth: Hinge teeth immediately below the umbo.
Chondrophore: (Bivalves) An internal shelf near the hinge line, often spoon shaped which bears the "resilium", or internal ligament in certain groups of clams.
Columella: The thickened axis of the shell about which the whorls are developed (Gastropods)(fig. 9).
Concentric sculpture: Centering around the umbo and parallel to the shell margin (Bivalves).
Ctenidia (sing. - ctenidium): The characteristic gills, present and structurally homologous in all major groups of the Mollusca.
Dimyarian: (Bivalves) With two approximately equal adductor muscles (figs. 5, 17).
Exhalent siphon: (Bivalves) The more dorsal (nearer the hinge line) tubular extension of the mantle edge through which water passes out from the mantle cavity, actually from the so-called "suprabranchial chambers" above and within the gill lamellae.
Foot: The muscular locomotory organ in all molluscs. (In Cephalopoda it is represented by the siphon and possibly the tentacles).
Growth lines or rings: (Bivalves) Lines concentric to the umbo on each valve which mark the successive positions of the shell margin during earlier growth.
Heteromyarian: (Bivalves) With two markedly unequal adductor muscles (figs. 7, 16).
Hinge teeth: See cardinal teeth, lateral teeth.
Inhalent siphon: (Bivalves) The more ventral tubular extension of the mantle edge through which food bearing water is drawn into the mantle cavity.
Inhalent siphon: (Gastropods) The gutter shaped extension of the thickened edge of the mantle through which water is drawn into the mantle cavity in some snails.
Labial palps: Paired ciliated triangular flaps on either side of the mouth in bivalves.
Lamellar gills: Enlarged, flattened plate-like gills (ctenidia) which form the feeding organs of most bivalves (figs. 7, 8).
Lateral teeth: Hinge teeth (anterior and posterior to the cardinals).
Ligament: The elastic horny hinge of the bivalve shell.
Longitudinal sculpture: Crossing the direction of growth of the whorls, essentially axial to the spiral (Coiled gastropods).
Lunules: (Bivalves) Heart shaped impressions (fig.28) in the midline of the shell anterior to the umbones (Venerid clams).

Monomyarian: (Bivalves) Apparently with only a single large adductor muscle uniting the valves (fig. 18).
Operculum: A horny or calcareous plate attached dorsally to the posterior end of the foot in gastropods, which forms a trap door closing the aperture of the shell on withdrawal of the animal.
Pallets: Paired flat shelly plates (figs. 25-27) secreted at the distal end of the elongate siphons in the worm-like wood borers (important in species systematics).
Palp proboscides: Long ciliated grooved tentacles extending from the labial palps (found only in protobranchiate bivalves) (fig. 5).
Pectinibranch ctenidium: (Gastropods) A "comb shaped" gill with leaflets or filaments extending from one side of the gill axis only, the axis usually being fused to the "roof" of the mantle cavity (figs. 3, 4).
Radula: A tough chitinous ribbon bearing teeth of various forms, part of the buccal apparatus in all molluscs except bivalves, used to obtain food by a rasping, "licking" action.
Radial sculpture: Radiating from the umbo (Bivalves).
Ribs: (Bivalves) Radial sculpture.
Ribs: (Gastropods) Longitudinal sculpture.
Spiral sculpture: Running from the shell apex to the aperture along the whorls (Coiled gastropods).
Siphonal canal, siphonal notch: A tube-like extension or notch-like infolding of the lip of the aperture in a gastropod shell through which the inhalent siphon is extended in life (figs. 9, 12).
Sculpture: See concentric, longitudinal, radial, ribs, spiral.
Taxodont dentition: A long row of many small uniform teeth in the hinge line (Bivalves) (fig. 17).
Umbilicus: A pit or chink in the shell next to or within the base of the columella, occurring in gastropods in which the largest whorls are not closely wound against each other axially (fig. 10).
Umbo (pl. - umbones): (Bivalves) The apparent "apex" or "beak" of each valve around which "radial" growth has proceeded.

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PART 2. CLASSES AMPHINEURA AND CEPHALAPODA

Class Amphineura
(Chitons and Solenogastres)

The Polyplacophora (chitons) are more or less flattened animals bearing eight transverse calcareous plates dorsally. They possess a broad creeping foot, a well developed radula, and a variable number of paired ctenidia within the pallial grooves along each side of the foot. Chitons are typically found on hard substrates, such as the larger rocks of exposed shores or on shells in more protected waters.

The Aplacophora (Solenogastres) are small shell-less forms that might not be recognized as molluscs by the general student. They have not been reported from the Woods Hole region proper, but a few species are known from deeper waters off the New England coast, the most common being Chaetoderma nitidulum Lovén, 1845, from 50 meters or greater depths off Martha's Vineyard (Heath, 1918).

In contrast to Solenogastres, chitons are well known to zoologists, and in some regions make up a conspicuous element of the intertidal fauna. The forty genera of Polyplacophora are, however, largely Indo-Pacific, and the only member of the group common at Woods Hole is:

Chaetopleura apiculata (Say). "Common Eastern Chiton". Elongate-ovate; plates with 15-20 rows of raised beads in the central area, with fine diagonal sculpture on the margins; tan or brown in color, girdle with reddish-brown to green mottling and covered with scattered short "hairs"; up to 3 cm in length; very common in shallow waters on stones and shells.

A rarer species which has been reported taken from the gutters of Hadley Harbor is:

Ischnochiton (= Trachydermon) ruber (Linnaeus). "Northern Red Chiton". Elongate-ovate; surface of plates smooth except for growth lines, plates externally buff colored with reddish marblings, internally colored bright pink; girdle reddish-brown with minute elongate scales; up to 2.5 cm long; more common in deeper waters north of the Cape.

Class Cephalopoda

The only local cephalopods are the squids. The common species, regularly available for experimental work is:

Loligo pealei Lesueur. "Common Squid" or "Long-finned Squid". Fins more than half the length of the trunk (fig. 30); without eyelids; color translucent gray with obvious chromatophores (mostly red and black); up to about 60 cm long; common, Cape Cod southward.

Another squid occasionally but not regularly taken near Woods Hole is:

Ilex (= Ommastrephes) illacebrosus (Lesueur). "Northern", "Summer", or "Short-finned Squid". Fins about 1/3 length of the trunk (fig. 31); with eyelids; color deep blue, ranging to red; up to about 45 cm long; common north of Cape Cod, but taken occasionally in Woods Hole waters in summer.

PART 3. SHELLED GASTROPODS

KEY TO SHELLED GASTROPODS OF THE WOODS HOLE REGION

1. Single aspidobranch ctenidium (figs. 1 and 2) and other archaeogastropod characters, simple conical shell without internal shelf or recurved apex, "tortoise-shell" coloring . . . . . *Acmaea testudinalis*
1. Single pectinibranch ctenidium (figs. 3 and 4), shells of various forms -- coiled, conical, or reduced 3
1. No ctenidium, mantle cavity as a lung, (and other Pulmonate characters), shiny ovoid shells with no operculum, small salt marsh or high littoral snails 2

2. Squat, egg shaped, widest behind aperture, with very short conical spire, translucent brown, adult is about 15 mm long with 5-6 whorls, abundant in salt marshes . . . . . *Melampus bidentatus*
2. Top shaped, widest at aperture, with longer conical spire one-third length of shell, shiny brownish-yellow, adult is about 7.5 mm long with 7-8 whorls and incised suture, less common than *Melampus* . . . . . *Ovatella* (+*Alexia*) *myosotis*

3. Snails with an inhalent pallial siphon and an extensible proboscis bearing a narrow radula, mostly active predaceous carnivores or carrion feeders, turbinate coiled shells with a canal or rudimentary notch next to the columella to accomodate the pallial siphon, (Neogastropoda - "Whelks" and "Drills") 31
3. Snails other than above 4

4. Shells with only apex as regular turbinate spiral shell, continuing to grow as cylindrical tube which may be irregularly worm-like or minute cucumber shaped 7
4. Cap shaped conical shells with internal shelf 5
4. Snails other than above 9

5. Almost circular "limpet" shell with central cup shaped shelf internally . . . . . *Crucibulum striatum*
5. Ovate "slipper limpet" shells with posterior shelf 6

6. Robust "slipper limpet", shell opaque dirty white to tan, often with brownish blotches, shell height about one third of length, concave white shelf occupies about one half of aperture, often found in "stacks"; up to 5 cm long . . . . *Crepidula fornicata*
6. Very flat "slipper limpet", always pearly white, variably flexed white shelf occludes less than one half of aperture, never forms "stacks", often inside shells or on *Limulus*; up to 3.3 cm long . . . . . *Crepidula plana*
6. Small, relatively high "slipper limpet", apex obvious and often overhanging posterior margin of shell, oblique brown shelf occluding about one third of aperture; up to 13 mm long . . . . . *Crepidula convexa*

7. Attached tubular shell drawn out distally and irregularly twisted to resemble a large serpulid worm tube, relatively large, up to 7.6 cm long; only one species recorded near Woods Hole . . . . . *Vermicularia spirata*
7. Minute cucumber shaped molluscs with only a tiny spiral apex which may be eroded 8

8. Glossy opaque white, with about 15 longitudinal ribs, about 5 mm in length . . . . . *Caecum cooperi*
8. Translucent tan when alive, chalky white when dead, with about 20-30 circular ribs; about 2 mm in length . . . . . *Caecum pulchellum*

9. Snails with no operculum, and reduced shell which is usually enclosed within expanded pallial or pedal tissues in life, animal usually incapable of withdrawing completely within shell 10
9. Snails with normal operculum and shell, though expanded soft parts appear disproportionately large and may conceal shell almost completely; but animal is capable of total withdrawal into shell 16
9. Snails with normal operculum and shell, soft parts are readily contained within shell 22

10. Shell totally enclosed within animal 11
10. Shell may be partially or largely exposed upon retraction of animal 12
(Note: Pteropods and other pelagic gastropods with reduced shells are omitted from this key.)

11. With internal saucer shaped horny shell, extensible mantle lobes used for swimming, the only species of "sea hare" recorded in this area; up to 20 cm long . . . . . Aplysia willcoxi
11. With fragile glassy bean shaped turbinate shell within mantle, living animal characteristically exhibiting four fleshy lobes when viewed dorsally; up to 13 mm long . . . . . Philine lima

12. Shell visible externally, with a prominent spire and ornamented with fine spiral rows of dots at level of aperture, shell up to 8 mm long . . . . . Acteon punctostriatus
12. Shells not usually visible externally when animals are active, spire low or absent, thin glassy shell lacking ornamentation, "Bubble-shell" Tectibranchs 13

13. Shells with a small but elevated spire 14
13. Shells with spire depressed into pit, that is, body whorl completely encloses the rest of the shell 15

14. Stubby, fragile shell with very low spire, white with yellowish-brown staining, columella smooth; up to 3 mm shell length . . . . . Retusa obtusa
14. Moderately elongate, stronger shell with more obvious spire except when eroded; white with dark rust-brown staining; columella with strong spiral ridge; up to 6 mm shell length . . . . . Retusa canaliculata

15. Larger globose shell, fragile bluish-white; relatively large aperture; up to 13 mm shell length . . . . . Haminoea solitaria
15. Smaller elongate cylindrical shell; white with brown periostracum; relatively narrow aperture; up to 5 mm shell length . . Cylichna alba
(Note: Other species of "Bubble-shell" Tectibranchs may occur in this area.)

16. Globose shells (shaped like Helicid land snails), lacking any siphonal canal on shell, with brown horny operculum characteristically D-shaped; in living animal enormous expanded foot partially encloses shell as animal plows along on sandy substrate; proboscis extrusible but not usually visible, short retractible fleshy inhalent pallial siphon; predaceous carnivores (Naticid "Moon-shells") 17
16. Other than above, recheck alternative characters at 3 and at 9.

17. Shell umbilicus clearly open (fig. 10) 18
17. Shell umbilicus totally or nearly occluded by callus (fig. 11) 20

18. With no obvious callus 19
18. With obvious ivory white thickened callus which does encroach on the umbilicus; shell white with yellowish periostracum; up to 1 cm long . . . . . Polinices immaculatus

19. Coarse heavy shell, with no callus; brownish-gray; often with attached algal filaments; up to 12 cm shell diameter; common . . . . . Lunatia heros
19. Thin clean shell, with inconspicuous white callus on inner lip, light brown or white with three characteristic rows of squarish dark brown spots on last whorl; up to 13 mm shell diameter; less common . . . . . Lunatia triseriata

20. Shell considerably wider than high with flat spire; clean bluish-gray, with obvious purple (or more rarely brown or pink) callus almost completely occluding umbilicus; up to 7.5 cm diameter; often abundant intertidally and in shallow water . . . . . Polinices duplicatus
20. Shells slightly higher than wide with obvious spire; white with pale brown periostracum; white callus closing or nearly closing umbilicus; opercula more calcified than other Naticids above; smaller species, less common and usually subtidal 21

21. Larger globose shell; polished white flat callus always completely sealing over umbilicus; up to 3.8 cm shell height . . . Natica clausa
21. Smaller ovate shell; white callus usually leaving open chink at umbilicus; shell usually with faint bands of light brown; up to 8 mm shell height . . . . . Natica pusilla

22. Elongate turret shells (fig. 15); usually more than 5 obvious whorls; height more than 1.5 times diameter 23
22. Globose shells (fig. 14); height less than 1.5 times diameter 29

23. Shells coiled dextrally 24
23. Shell coiled sinistrally; 10-12 whorls, dark brown with three spiral rows of prominent beads; up to 6 mm long . . . . . Triphora nigrocincta

24. About 11 markedly globose whorls, expanding rapidly to give a conical shell, each whorl bearing about 16 strong longitudinal ribs; circular aperture with thickened lip; up to 2.5 cm long; the only true "Wentletrap" recorded in this area . . . . . Epitonium rupicola
24. Whorls not markedly globose; whole shell awl or spindle shaped; mostly under 15 mm shell length 25

25. Without obvious shell sculpture; about 5 somewhat globose whorls separated by a clear suture; aperture ovate-circular; up to 5 mm in length 26
25. With obvious shell sculpture of various forms; more than 6 somewhat flatter whorls; aperture flattened or rectangular; up to 18 mm long 27

26. Minute; smooth yellow-brown shells with no markings apart from growth lines; up to 5 mm long (several species may occur in this area, including some in brackish waters). . . . . Hydrobia spp.
26. Minute; light yellow to brown shell with microscopic spiral sculpture of incised lines; also tiny riblets near suture; up to 2.5 mm long . . . . . Cingula aculeus

27. Shell with rounded aperture with barely perceptible siphonal notch; 6-8 whorls when adult; about 5 mm long; common species which can be abundant intertidally . . . . . Bittium alternatum
27. Shells with obvious siphonal notch at anterior of aperture; 10-15 whorls when adult; lengths 3 mm to 15 mm; rarer species, usually subtidal 28

28. Minute species; glossy brown; later whorls bearing 2-3 rows of glassy beads; 10 whorls when adult; about 3 mm long. . Cerithiopsis greeni
28. Larger species; more elongate; chocolate brown; flattish whorls each bearing 3 rows of distinct raised beads which are lighter in color; 14-15 whorls when adult; about 15 mm long . . Cerithiopsis subulata
28. Larger species; more elongate; flattish whorls each bearing 3 strong continuous squarish spiral cords; 10-12 whorls when adult; about 13 mm long (fig. 15) . . . . . Seila adamsi

29. Medium sized (up to 3 cm); coarser shells, lacking umbilicus or apertural groove; adults rarely translucent 30
29. Very small, fragile, smooth shell with groove in inner lip extending into chink-like umbilicus; color variable from pink to brown with purple or dark brown markings; up to 8 mm long . Lacuna vincta
(Note: Minute specimens suspected of being spat (juveniles) of Littorina spp. or of Lacuna are best identified by comparing them closely with the apical parts of the shells in known specimens of adults of all four species.)

30. Spire flattened; shell very smooth and shiny; color variable but commonly uniform clear yellow-orange; often banded; up to 1 cm across; in lower littoral associated with fucoid seaweeds . . . . . Littorina obtusata
30. Moderate spire, expanding more rapidly after first tiny whorls with raised spiral threads when young; usually black when young; variable but dull as adult; with planktonic larvae (thus apical shell is small and if not eroded in adult is very sharply pointed); up to 3 cm across; thecommonest and most abundant "periwinkle" at all tidal levels . . . . . Littorina littorea
30. Obvious but variable spire; shell rough with irregular raised lines; color variable but commonly greenish-yellow; viviparous (thus apical shell relatively large); up to 13 mm long; higher littoral (fig. 14). . . . . Littorina saxatilis

31. Snails with protrusible proboscis and inhalent siphon, but with unsculptured globose shells lacking any siphonal canal or notch (almost certainly naticid "moon-shells") see 16
31. Snails with protrusible proboscis and inhalent siphon, but with turreted shells usually with sculpture and with a siphonal canal or notch near the columella 32

32. Minute turreted snails less than 5 mm shell length as adult 33
32. Snails usually larger than 12 mm shell length when adult (most species much larger) 34

33. Smooth glossy shell; gray or yellow-brown with darkened marbling; narrow oval aperture; with siphonal notch; up to 5 mm shell length, common free living species on eel grass and elsewhere in littoral . . . . . Mitrella lunata
33. White glossy shells with considerable ornamentation, usually no obvious siphonal notch; up to 5 mm shell length; usually ectoparasites (often on specific invertebrates) . . . . . PYRAMIDELLIDACEA
(See note overpage)

Two species have been positively identified in this region:
Odostomia (Menestho) bisuturalis - host unknown
Odostomia (Chrysallida) seminuda - parasitic on Crepidula fornicata

34. Siphonal canal short, forming conspicuous notch in apertural lip (fig. 13) 35
34. Siphonal canal elongate, forming an obvious extension of the apertural lip (fig. 12) 39

35. Larger "whelk"; solid chalky-gray shell, with rough yellowish periostracum; low but obvious sculpture consisting of about 5 spiral cords crossed by about 12 longitudinal ribs in each whorl; flesh of living animal startling white with black blotches; up to 10 cm shell length; common offshore, rarely in littoral . . . . . Buccinum undatum
35. Smaller snails with conspicuous siphonal notch; less than 2.5 cm long 36

36. Stout "dirty" shell often eroded, dark brown or black with neither suture nor sculpture obvious; often with adherent debris or organisms; up to 2.5 cm long; often abundant on mud flats intertidally . . . . . Nassarius obsoletus
36. Clean shells with obvious sculpture 37

37. Essentially conical shell with 8-9 whorls in adult, bearing about 5 spiral rows of ranked beads giving "waffle-like" pattern; off- white in color; up to 2 cm long(fig. 13); usually living on sand . . . . . Nassarius trivittatus
37. Squat solid pear shaped shell with 4-5 whorls in adult, each bearing about 12 pronounced longitudinal folds; off-white in color; up to 13 mm long; less common in this area, living in muddy sand . . . . . Nassarius vibex
37. Slimmer spindle shaped shells, with 6-7 whorls in adult, with less complex sculpture; up to 18 mm long 38

38. With about 12 low rounded longitudinal folds on each whorl; usually dark grayish-brown; up to 13 mm long; lower littoral . Anachis avara
38. With about 24 narrow longitudinal folds on each whorl crossed by incised spiral lines; usually drab yellow in color; up to 18 mm long; lower littoral and shallow water . . . . . Anachis translirata
(Note; Specific identification of minute specimens suspected of being spat (juveniles) of Nassarius spp. or Anachis spp. is aided by comparing them with the apical parts of the shell in known - and not eroded - specimens of all five species).

39. Smaller "drills" etc. under 4 cm shell length as adults (mostly about 2.5 cm long); common in littoral 40
39. Larger "whelks" all over 6 cm length as adults (may be up to 23 cm long); mostly sublittoral and offshore 43

40. Relatively thin shelled with 6-8 globose whorls in adult; gray with greenish periostracum; no obvious shell sculpture; siphonal canal of moderate length bent back from aperture; up to 2.5 cm long . . . . . Colus pygmaea
40. Stout shelled "drills" with obvious shell sculpture 41

41. With 5 angular whorls and deep suture, giving sharp "shoulders" to spire, and relatively long siphonal canal which is almost closed over; up to 2.5 cm long (fig. 12) . . . . . Eupleura caudata
41. With rounded but ornamented whorls, siphonal canal relatively short and open 42

42. Very thick polished white shell with thickened lip (rarer color variants - clear yellow, orange-brownish or striped); about 5 whorls in adult with rounded spiral ridges giving corrugated appearance; up to 3.5 cm long; less common, on exposed rocky shores . . . . . Thais (=Nucella) lapillus
42. Thick duller grayish, yellowish, or brown shell; about 6 whorls in adult, each with 9 to 12 strong longitudinal ribs crossed by spiral grooves giving knobby appearance; up to 2.5 cm long; the commonest local "drill," on all hard substrates . . . . Urosalpinx cinerea (Note: Minute specimens suspected of being spat (juveniles) of Eupleura, Thais, or Urosalpinx can best be separated by the relative lengths of their siphonal canals. Comparison with apical parts of the shells of known adults is less useful here).

43. Combined length of aperture and siphonal canal about one half shell length 44
43. Combined length of aperture and siphonal canal markedly greater than one half shell length 46

44. Heavy grayish shell with 6-7 whorls as adult, bearing up to 10 conspicuous reddish-brown spiral ridges; up to 10 cm long . . . . . Neptunea decemcostata
44. Lighter shells with simple globose whorls 45

45. Shells more elongate, sharper spired; 6-7 whorls in adult; siphonal canal straight; thin semi-glossy periostracum; up to 13 cm long . . . . . Colus stimpsoni
45. Shells less elongate, blunter spire; 5-6 whorls in adult; siphonal canal usually twisted away from aperture; hairy periostracum; up to 6.5 cm shell length . . . . . Colus pubescens

46. Suture channeled giving broad flat "shoulders" to whorls; up to 20 cm long . . . . . Busycon canaliculatum
46. Suture not deeply incised; single row of knobby tubercles on inclined "shoulders" of whorls; up to 23 cm long . . . . . Busycon carica

ANNOTATED LIST OF SHELLED GASTROPODS OF THE WOODS HOLE REGION

Acmaea testudinalis (Müller). "Tortoise-shell limpet". On hard substrata only, in the lower littoral and immediate sublittoral of exposed shores, the only true limpet in this area, and the single local gastropod species which retains the primitive feather shaped ctenidium of the rchaeogastropods.

Acteon punctostriatus (C. B. Adams). Near low water mark and offshore, preferred substrata not known.

Anachis avara (Say). Lower littoral, common in some places. Both species of Anachis are predaceous carnivores and are more abundant in the south.

Anachis translirata (Ravenel). Lower littoral, but more commonly dredged in shallow water.

Aplysia willcoxi Heilprin. "Sea Hare". Probably rare, this is the only large tectibranch which has been recorded in this area. The group is better represented on more southern Atlantic coasts.

Bittium alternatum (Say). Common and often extremely abundant on tidal flats and in shallow water offshore, on a variety of substrata but especially organic muds and eelgrass.

Buccinum undatum L. "White helk" or "Buckie". Not uncommon offshore in colder waters, rarely in littoral, on a variety of substrata.

(Note: *= Busycotypus canaliculatus; **= Busycon aruanum; Hollister, S. C., 1958. Paleont. Amer. 4: 59-125)

Busycon canaliculatum (L). "Channeled Whelk". Dredged in shallow water on sandy bottoms, more common than B. carica in this area.

Busycon carica (Gmelin). "Knobbed Whelk". Dredged in shallow water on sandy bottoms, not uncommon.

Caecum cooperi S. Smith, and

Caecum pulchellum Stimpson. Minute cucumber shaped gastropods found interstitially in sand or in dead sponges, detailed ecology unknown, inshore in warmer waters.

Cerithiopsis greeni (C. B. Adams), and

Cerithiopsis subulata (Montagu). Less common in Cape area than in warmer waters to the south, in shallow water, detailed ecology unknown.

Cinqula aculeus Gould. In shallow water; other species of the Rissoacea may be discovered in this area.

Colus pubescens (Verrill) and

Colus pygmaea (Gould) and

Colus stimpsoni (Mörch). Dredged subtidally and offshore.

Crepidula convexa Say. Littoral and offshore, the least common of the three local "slipper-limpets", occasionally on eelgrass and more commonly on a variety of shells.

Crepidula fornicata (L.). "Common Slipper-limpet". Littoral and offshore, the commonest and largest local "slipper-limpet", often found in stacks, showing characteristic sex change with size and position.

Crepidula plana Say. Littoral and offshore, never forming stacks, variably flexed to fit their substratum which may be the inside surface of a larger molluscan shell, or the exoskeleton of Limulus.

Crucibulum striatum (Say). Dredged in shallow water, with an enlarged ctenidium like the closely related Crepidula spp., probably also a filter feeder.

Cylichna alba (Brown). Low water mark and shallow water, the detailed ecology of this and other species of "Bubble-shell tectibranchs" is unknown.

Epitonium rupicola Kurtz. "Brown-banded Wentletrap". Near low water mark and further offshore, not uncommon, this is the only local species of a genus more common to the south.

Eupleura caudata (Say). "Thick-lipped Drill". Hard substrata, lower littoral and subtidal, probably more common in warmer waters. This is the least common of the three local species of "drills" which are predaceous carnivores with radula and proboscis modified for boring and an accessory boring organ in the foot.

Haminoea solitaria (Say). Low water mark and shallow water, probably the commonest "Bubble-shell tectibranch" in this area, may occur mainly in muddier inlets with eelgrass, detailed ecology and reproductive behavior unknown.

Hydrobia spp. Several species of this difficult but widespread genus may occur in this area, some in brackish waters.

Lacuna vincta (Montagu). "Chink-shell". Lower littoral and shallow water, often abundant, a cold water species.

Littorina littorea (L.). "Common Periwinkle". Typically at midlevel littoral, in this area the largest, commonest, and most abundant "periwinkle" at all tide levels, with planktonic larvae and less capacity to resist desiccation and to respire in air than L. saxatilis.

Littorina obtusata (L.). "Smooth Periwinkle". At lower levels at the littoral, usually associated with fucoid seaweeds including Ascophyllum. This periwinkle is referred to in modern European physiological literature as L. littoralis (L.) (not to be confused with the distinct species L. littorea which also occurs in Europe), and in early U. S. conchological literature as L. palliata (Say).

Littorina saxatilis (Olivi). "Rough Periwinkle". Typically high level littoral, of variable shell form and color, in this periwinkle females have a brood pouch and give birth to shelled young resembling miniature adults, the gill is reduced and the mantle cavity more lung-like, and all stages have a greater capacity to resist dessication than the other littorinids. L. rudis (Maton) is simply a synonym of L. saxatilis.

Lunatia heros (Say). "Moon-shell". Not uncommon on sand intertidally but more abundant subtidally, this is the largest of the six local species of predaceous

carnivores belonging to the Naticidae. It is less resistant than Polinices duplicata to higher temperatures and lower salinities.

Lunatia triseriata (Say). Less common and usually subtidal, this small naticid occurs, however, intertidally in Lagoon Pond, Martha's Vineyard, and elsewhere in this area.

Melampus bidentatus (Say) (= M. lineatus (Say)). Usually living around the high water mark of spring tides, and abundant in the high levels of Cape Cod salt marshes, Melampus is a pulmonate belonging to the family Ellobiidae and thus probably related to the gastropod stock which gave rise to most land snails and to the freshwater pulmonates like Lymnaea.

Mitrella lunata (Say). Near low water mark and in shallow water on a variety of substrata, often extremely abundant, this minute snail is closely related to Anachis spp. and is a predaceous carnivore using its extensible rasping and sucking proboscis to prey on various small sessile invertebrates such as Botryllus.

Nassarius obsoletus (Say). "Common Mud Snail". In shallow water subtidally, intertidally on mud flats, and even in estuarine conditions, this is often an extremely abundant species congregating in packed masses which can temporarily cover acres. Embryologists have tended to refer to this snail as Ilyanassa obsoleta (using its subgeneric name), and certain older books place it in the genus Nassa.

Nassarius trivittatus (Say). Intertidally and in shallow water, usually on clean sand in sheltered localities, this species is common but less abundant than N. obsoletus.

Nassarius vibex (Say). Occurs on sand and mud flats intertidally, less common in this area than the other two Nassarius spp.

Natica clausa Broderip and Sowerby. Dredged subtidally and offshore in the Cape Cod area, intertidal on some more northern shores.

Natica pusilla Say. Dredged subtidally and offshore.

Neptunea decemcostata (Say). Dredged offshore, shells occasionally washed up.

Odostomia (Menestho) bisuturalis (Say). Identified here, see below.

Odostomia (Chrysallida) seminuda (Say). Identified here, and found by the writers to live as an ectoparasite on Crepidula fornicata.
(Note: Other species of the PYRAMIDELLIDACEA will probably be found in this area: they are usually ectoparasites and often highly specific as regards their host invertebrates.)

Ovatella (=Alexia) myosotis (Draparnaud). Living around the high water mark of spring tides (for example, in crevices of wharfs and docks, and under the "trash line" of high salt marshes), this minute pulmonate snail is related to Melampus.

Philine lima Brown. Not common in this area, dredged in colder waters.

Polinices duplicatus (Say). "Shark Eye" or "Moon-shell". Most abundant intertidally on sand, this is the commonest of the local species of the Naticidae. Unlike Lunatia heros, it survives lowered salinity and high temperatures, and is thus able to colonize estuarine and high littoral habitats. All naticid snails are predaceous carnivores using the radula in the extensible proboscis to drill through the shells of other molluscs.

Polinices immaculatus (Totten). Less common naticid, subtidal in this area, occuring more frequently to the south.

Pteropods (and other pelagic gastropods with reduced shells) are omitted from this list.

Retusa canaliculata (Say). Sand and mud flats intertidally and in shallow water, this minute species plows along the surface like a tiny naticid and is probably the commonest shelled tectibranch in this area.

Retusa obtusa (Montagu). Not uncommon in habitats similar to those of R. canaliculata.

Seila adamsi (H. C. Lea). Not uncommon around low water mark and subtidally; like the related Cerithiopsis spp., this small "turret-shell" is less common in the Cape area than in warmer water to the south.

Plate 18

MOLLUSCA (1)

Figures 1-8: Mantle cavity and ctenidium in representative molluscs. Figures 1-9 by Stephen C. Brown; 10-15 by Ruth L. von Arx.

Fig. 1. The aspidobranch ctenidium as in the limpet, Acmaea testudinalis.

2. Face view of ctenidial leaflets in Acmaea.

3. The pectinibranch ctenidium as in Littorina littorea.

4. Face view of ctenidial leaflet in Littorina.

5. The protobranch ctenidium, associated with large labial palps and palp proboscides, as in Nucula.

6. Face view of ctenidial leaflets in Nucula.

7. The true lamellibranch ctenidium, as in Mytilus.

8. Face view of ctenidial filaments in Mytilus.

9. Sectional view of the shell of Buccinum undatum, showing whorls surrounding central columella from apical whorl at top to largest "body" whorl with prominent siphonal notch.

10. The naticid "Moon-shell", Lunatia heros, showing the shell umbilicus clearly open.

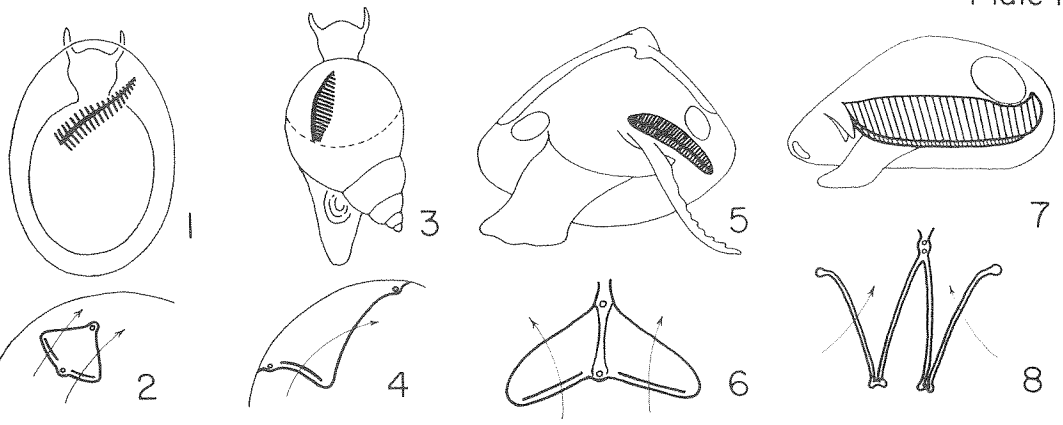
11. The naticid "Moon-shell", Polinices duplicatus, showing the obvious pigmented callus nearly occluding the umbilicus.

12. Eupleura caudata, showing the elongate siphonal canal forming an obvious extension of the apertural lip.

13. Nassarius trivittatus, showing the short siphonal canal forming a prominent notch in the apertural lip.

14. Littorina saxatilis, showing a typical "globose" shell with height less than 1.5 times diameter.

15. Seila adamsi, showing a typical elongate "turret-shell" with height more than 1.5 times diameter.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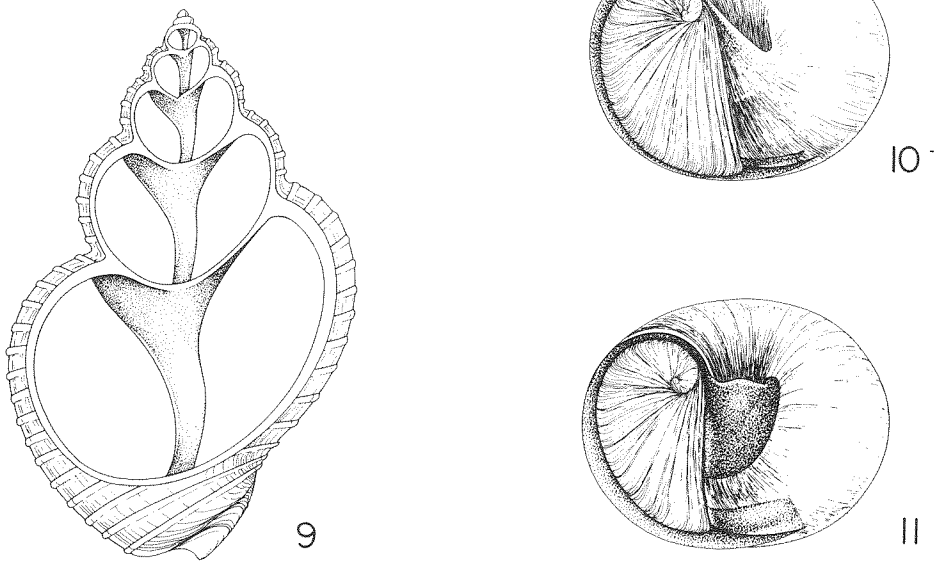
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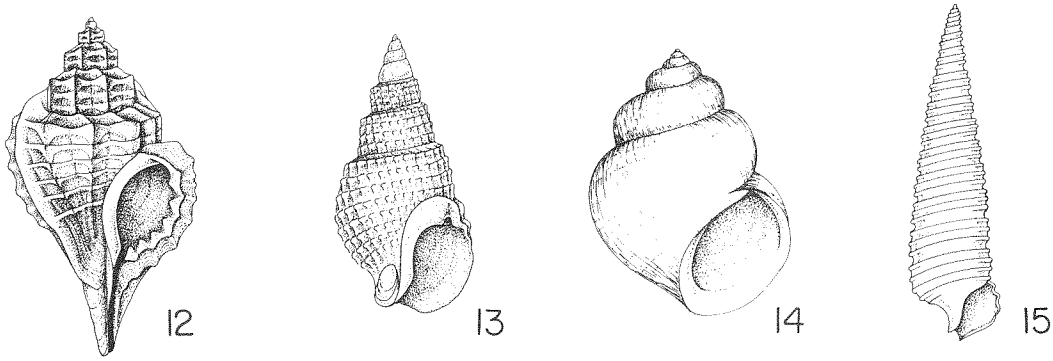
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Plate 19

MOLLUSCA (2)

Figures 16-20 and 25-29 by Mrs. R. von Arx; 21-24 by W. Russell Hunter; 30-31 by Bruce Shearer.

Fig. 16. Modiolus demissus, shell valve showing the heteromyarian condition of the adductor muscles, and a long external ligament.

17. Anadara transversa, shell valve showing dimyarian condition of the adductor muscles, and taxodont dentition in the hinge line.

18. Aequipecten irradians, shell valve showing monomyarian condition. of adductor muscle, and internal triangular ligament or "resilium"

19. Thyasira gouldi, dorsal view of shell valves with characteristic prominent radial folds running posteriorly from anterior umbones.

20. Macoma tenta, dorsal view of shell valves with characteristic posterior twist.

21-24 (following). Siphonal types, and natural posture in substrate, of various bivalves.

21. Mya arenaria, a sedentary deep burrowing bivalve with massive fused siphons.

22. Tellina agilis, a deposit feeding bivalve with separate extensible siphons.

23. Mercenaria mercenaria, an active shallow burrowing bivalve with short fringed siphons and a relatively massive foot.

24. Ensis directus, a typical razor clam with short fringed siphons and massive powerful foot emerging terminally like a "mushroom" anchor.

25. Bankia gouldi, a typical "Shipworm" bivalve; the elongate body bears reduced valves anteriorly and calcareous pallets at the siphonal openings.

26. Bankia gouldi, plume like compound pallet.

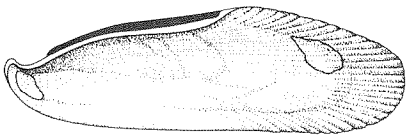
27. Teredo navalis, simple paddle shaped pallet.

28. Mercenaria mercenaria, anterior view of shell showing obvious deeply incised lunules below umbones.

29. Pitar morrhuana, anterior view of shell showing large but indistinct lunules below umbones.

30. Loligo pealei, showing characteristic lateral fins more than half the length of the trunk and large eyes without eyelids.

31. Ilex illacebrosus, showing characteristic short lateral fins and eyes with eyelids.



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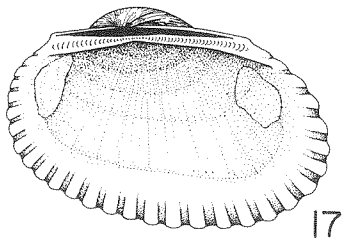

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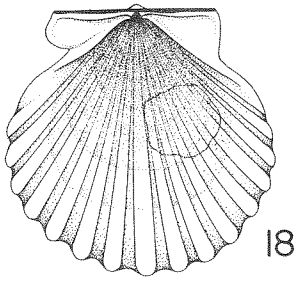

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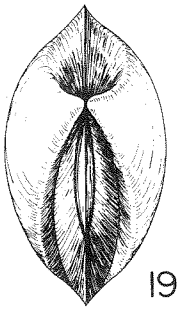

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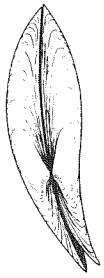

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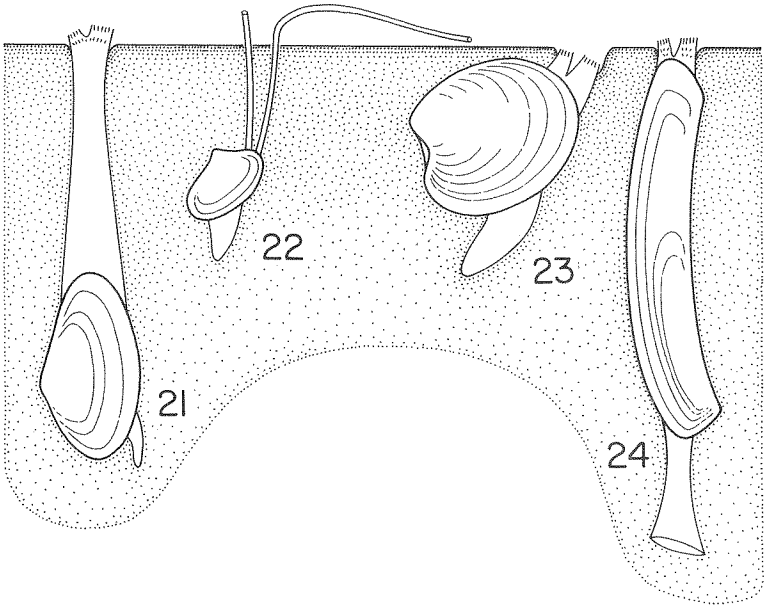

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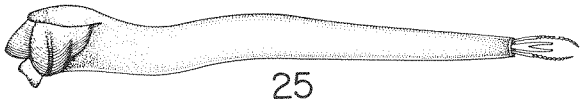

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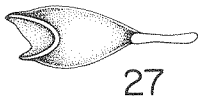

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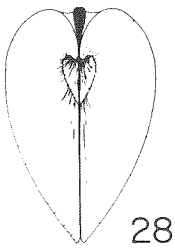

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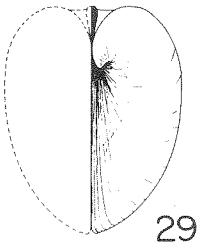

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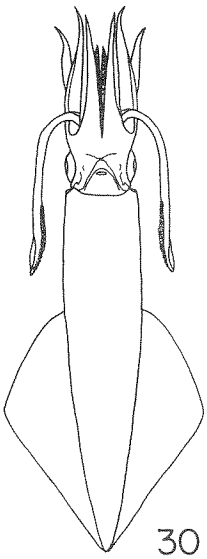

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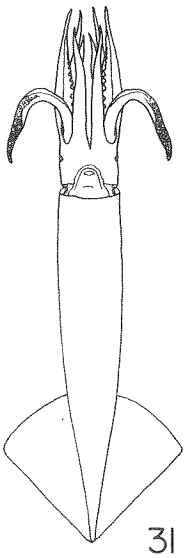

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Thais (=Nucella) lapillus (L.). "Dogwinkle". Hard substrata, lower littoral and subtidal, common only in the Cape area on certain beaches exposed to wave action. This is another carnivorous "drill", feeding on barnacles as well as molluscs.

Triphora nigrocincta (C. B. Adams). Around low water mark on seaweeds, not uncommon, this is the only local gastropod species with a sinistrally coiled shell.

Urosalpinx cinerea (Say). "Oyster-drill". Hard substrata, lower littoral and subtidal, often abundant, this is the commonest of the three local species of drills but, besides using radula, proboscis, and pedal accessory boring organ to bore through the shells of other molluscs, this predaceous carnivore also feeds extensively on barnacles, using muscular action by the proboscis to force apart the plates of the barnacle test without actual boring.

Vermicularia spirata (Philippi). Probably living in shallow water, detailed ecology unknown. "Worm-shells" of this type are rare in this area. Tucker Abbott (1954) records this species only for "Southeast Florida and the West Indies", but shells have been found in the Cape Cod area on several occasions and living specimens found once in 1961 and twice in 1963.

PART 4. CLASS BIVALVIA

KEY TO BIVALVED MOLLUSCS OF THE WOODS HOLE REGION

1. Without lamellar gills, ctenidia resembling those of aspidobranch gastropods (figs. 5 and 6) . . . . . Order Protobranchia 2
1. With lamellar gills clearly modified for filter feeding (figs. 7 and 8) 4

2. Protobranchiates feeding by palp proboscides, without lamellar gills, with taxodont dentition (fig. 5) 3
2. Modified protobranchiate with reduced palps, hinge of elongate shell without dentition, with lustrous yellow-brown periostracum, radially marked and extending beyond shell margins. . . . . Solemya velum

3. Obliquely ovate globose shell, usually greenish-gray . . . . . Nucula proxima
3. Asymmetric elongate shell, narrowing posteriorly, usually greenish-brown . . . . . Yoldia limatula

4. With lamellar gills, but retaining taxodont dentition (fig. 17) 5
4. With lamellar gills, with other than taxodont dentition 6

5. Rhomboidal shell (up to 3.8 cm); 30-50 ribs; gray-brown periostracum usually worn, longer stouter ligament clearly distinct, left valve overlapping right valve . . . . . Anadara transversa
5. Ovate shell (up to 5.9 cm); 26-35 ribs; hairy black-brown periostracum persistant; narrow ligament less distinct . . . . . Anadara ovalis

6. Monomyarian condition of adductor muscle (fig. 18) 7
6. Markedly heteromyarian condition of adductor muscles (fig. 16) 12
6. Dimyarian condition (or nearly so) of adductor muscles (fig. 17) 19

7. Swimming monomyarian bivalves (Scallops) 10
7. Attached monomyarian bivalves (Oysters and Jingle shells) 8

8. Lower bivalve with hole through which passes calcified byssus 9
8. No such hole, lower valve directly cemented to hard substrata (Eastern oyster) . . . . . Crassostrea virginica

9. Upper valve translucent and smooth, up to 5.1 cm . . . . . Anomia simplex
9. Upper valve drably opaque and rough with small prickles . . . Anomia aculeata

10. Both valves with strong radial sculpture 11
10. Rough, dirty-white, pink or yellowish valves without strong radial sculpture; up to 20 cm diameter . . . . . Placopecten magellanicus

11. Approximately equal "wings" (or "ears") at hinge; 17-20 regular ribs forming strong radial corrugations; up to 7.6 cm diameter (fig. 18) . . . . . Aequipecten irradians
11. Markedly unequal "wings", about 50 irregular cord-like ribs; up to 10.2 cm diameter . . . . . Chlamys islandica

12. "Shipworms" boring in timber, worm-like bodies (fig. 25) bearing reduced valves anteriorly and pallets posteriorly 18
12. Wedge shaped shells, markedly narrow anteriorly with well developed, usually dark periostracum, byssal attachment, lacking siphons (Mussels) 13
12. Markedly elongate shells, active burrowers in sand, with well developed foot and short or medium length separate siphons 16

13. Umbo near but not at anterior tip of each valve (fig. 16) 14
13. Umbo at anterior tip of each valve, no shell sculpture, blue-black with shiny periostracum; common in littoral, often abundant . . . . . Mytilus edulis

14. With radial shell sculpture and thin periostracum 15
14. Without radial shell sculpture, with thick hairy periostracum; usually dark brown; up to 15 cm, less common species; lower littoral and subtidally . . . . . Modiolus modiolus

15. Hinge without teeth; strong radial ribs which bifurcate usually covering entire shell; up to 10 cm long; salt marshes and upper littoral, often abundant (fig. 16) . . . . . Modiolus demissus
15. Hinge finely dentate, ribs on anterior and posterior thirds of shell only; up to 6.4 cm long; rarer species; subtidal in this area . . . . . Musculus (=Modiolaria) niger

16. Umbo nearly central, siphons separate and moderately long; powerful foot emerging ventrally 17
16. Umbo at anterior end of dorsal margin; very elongate shell curving dorsally; short siphons; powerful foot emerging terminally; "razor" shape; up to 25 cm long (fig. 24) . . . . . Ensis directus
16. Umbo towards anterior end; elongate ovate shell; short siphons; with strong internal rib running ventrally from umbo; up to 6.4 cm long . . . . . Siliqua costata

17. Dull greenish-yellow periostracum often eroded around umbones; thick opaque shell gaping at ends; up to 10 cm long . . . . . Tagelus plebeius
17. Shiny thin periostracum with radial markings; often pale purple, fragile shell; up to 3.8 cm long . . . . . Tagelus divisus

18. Pallets as simple paddle shaped blades (fig. 27) . . . . . Teredo navalis
18. Pallets each plume-like of many cones (fig. 26) . . . . . probably Bankia gouldi (but check other Bankia spp.)

19. Deep burrowing or boring bivalves with massive fused siphons (fig. 21) 20
19. Deposit feeding bivalves with separate extensible siphons (fig. 22) 23
19. Otherwise, usually with short fringed siphons (fig. 23) 29

20. Stout rasping spines externally on anterior of valves, reduced periostracum, borers in peat, clay, or stone 21
20. Thin valves with irregular growth rings but no sculpture; thick periostracum on ventral margin and siphons; up to 15 cm shell length; burrowing in muddy sand . . . . . Mya arenaria

21. Elongate shell, umbones nearer anterior, entire shell sculptured with spines; large siphons 22
21. Squat shell; up to 5 cm length; umbones nearer midline; sculpture limited to anterior; shell gaping widely at both ends; disproportionately large siphons . . . . . Zirfaea crispata

22. Shell tapering posteriorly, with only slight gape; up to 21 cm long . . . . . Cyrtopleura (=Barnea) costata
22. Shell truncate posteriorly, gaping widely at both ends; up to 5 cm in length . . . . . Cyrtopleura (=Barnea) truncata

23. Ligament internal, triangular 24
23. Ligament external 25

24. Symmetrical ovate shell; pearly white; up to 3.8 cm length . . . . . Periploma (=Cochlodesma) leanum
24. Asymmetrical, shell tapering posteriorly, chalky white; up to 2 cm in length . . . . . Cumingia tellinoides

25. Shells markedly elongate 28
25. Shells sub-circular or ovate 26

26. Duller white shells, often with slight posterior twist (fig. 20), and pallial sinus more extensive in right valve 27
26. Glossy white opalescent shell with pallial sinuses similar in both valves; up to 13 mm in length . . . . . Tellina agilis

27. Variable dull white shell, never elongate; up to 3.8 cm length . . . . . Macoma balthica
27. White, fragile shell moderately elongate-ovate; with slight but obvious posterior twist; up to 2 cm length . . . . . Macoma tenta

28. Shell sculptured with rasping spines; reduced periostracum; dull white borer in peat or clay; shell proportions somewhat variable . . . . . Petricola pholadiformis
28. Shells not sculptured; well developed periostracum 17

29. Subglobular shells 30
29. Elongate ovate shell, tapering and becoming compressed posteriorly; periostracum with fine radial lines, often with adherent sand grains; up to 2 cm shell length . . . . . Lyonsia hyalina
29. Entire shell compressed; with umbones near anterior corner of nearly rectangular valves; somewhat saddle shaped; up to 3.4 cm across . . . . . Pandora gouldiana

30. Shells with concentric sculpture 31
30. Shell with strong radial sculpture . . . . . Cardita borealis
30. Shells with no sculpture apart from irregular growth rings 34

31. Ligament external 32
31. Ligament internal, triangular; up to 10 mm across . . . . . Crassinella (=Gouldia) mactracea

32. With lunules anterior to umbones (fig. 28) . . . . . young Mercenaria (=Venus) mercenaria
32. Without such lunules 33

33. Ovate with strong concentric sculpture; up to 5 cm across . . . . . Astarte borealis
33. Trigonal with low concentric sculpture; up to 2.5 cm across . . . . . Astarte castanea

34. Ligament external 39
34. Ligament internal, triangular 36
34. Ligament in groove but partly external; characteristic small shells with 2 prominent radial folds (fig. 19) running posteriorly from umbones which are anterior 35

35. Oblong valves, translucent-white; up to 13 mm long . . . Thyasira trisinuata
35. Rounded valves, yellowish periostracum; up to 6.4 mm long . . Thyasira gouldi

36. Mantle almost completely fused; short siphons surrounded by common circlet of tentacles; posterior of right valve slightly overlapping left; up to 6.4 mm long . . . . . Corbula contracta
36. Ventral margins of mantle apparently fused, but without tissue union; fourth pallial opening ventral to inhalent siphon with associated groove for waste disposal (mactrid clams) 37

37. Mactrid clams less than 18 mm shell length 38
37. Mactrid clam more than 18 mm shell length; strong, ovate; smooth shell covered by shiny thin yellowish-brown periostracum; spoon shaped chondrophore in left valve; up to 18 cm shell length . . . . . Spisula solidissima

38. Rather globose shell with proportionately small chondrophore; no denticles on hinge teeth; each valve with a single low radial rib near posterior . . . . . Mulinia lateralis
38. Slimmer shells, with disproportionately large chondrophore; tiny saw-tooth denticles on anterior and lateral hinge teeth . . . . . young of Spisula solidissima

39. Shells under 5 mm shell length 40
39. Shells over 5 mm shell length 42

40. Look out for spat of larger bivalves!
a) If heteromyarian with wedge shaped shell, specimen is likely to be a juvenile mussel. Go back to 13
b) If moderately elongate with fused siphons, specimen is likely to be a juvenile of Mya arenaria; see 20
c) If round or ovate with separate extensible siphons, specimen is likely to be a juvenile deposit feeder like a tellinid clam. Go back to 23
d) If bearing prominent concentric sculpture and lunules anterior to umbones, specimen is likely to be juvenile of Mercenaria; see. . . . . 32 and 43
40. Shells under 5 mm shell length, seemingly adult and not in above categories 41

41. Minute globose shiny shell, with umbones near mid-line and fine concentric lines; white, often with blue or purple patches (very common and often abundant) . . . . . Gemma gemma
41. Minute ovate shell with posterior umbones and shiny nut-brown periostracum (rare and probably commensal) . . . . . Mysella (=Rochefortia) planulata

(See note overpage)

(But other minute leptonacean clams may also belong here, check Aligena elevata and Montacuta spp.)

42. Globular smooth "cockle" with variable brown patterning on white exterior of shell; interior always translucent yellow; actively moving through sandy substrates by large very extensible foot; up to 2.5 mm diameter . . . . . Laevicardium mortoni
42. Slimmer but still globose clams without above shell coloring; may be up to 15 cm in diameter 43

43. Shell valves with marked, deeply incised lunules anterior to umbones (fig. 28); shell may retain traces of juvenile concentric sculpture, internal free margin of shells crenulated and usually purple; up to 15 cm diameter, "Quahog" . . . . . Mercenaria (=Venus) mercenaria
43. Shell valves without such lunules and with shiny dark brown or black periostracum showing many fine incised growth lines; no crenulation on valve margin; up to 13 cm diameter . . . . . Arctica (=Cyprina) islandica
43. Shell valves with large but shallow lunules; dull chalky white; without crenulation on ventral margin of valves; up to 5 cm diameter (fig. 29) . . . . . Pitar morrhuana

ANNOTATED LIST OF BIVALVES OF THE WOODS HOLE REGION

Aequipecten irradians (Lamarck). "Bay Scallop". The commonest scallop of the area, in most larger harbors and lagoons on flats exposed at lowest tides, also subtidal in shallow water.

Anadara ovalis (Bruguière). "Blood Ark". Formerly known as Arca campechiensis Gmelin, fairly common low water mark to subtidal.

Anadara transversa (Say). "Transverse Ark". Smallest of our"Ark-shells", fairly common in mud, low water mark to subtidal.

Anomia aculeata Gmelin. "Prickly Jingle". Less common, attached to rocks or empty shells, near low water mark.

Anomia simplex Orbigny. "Common Jingle" or "Mermaid's Toenail". More common, attached to logs, docks and boats as well as to rocks; near low water mark.

Arctica (=Cyprina) islandica (L.)."Black Quahog". Dredged in muddy sand, common in certain areas.

Astarte borealis Schumacher and

Astarte castanea (Say). Dredged in shallow water locally, may occur intertidally on exposed sand beaches north of the Cape.

Bankia gouldi Bartsch. A common and very destructive "Shipworm" on the southern Atlantic coast, transported to this area in drifting wood.

Barnea, see Cyrtopleura.

Cardita borealis (Conrad). Dredged in shallow water and on the continental shelf, probably common in some places. This species is listed in most of the textbooks as Venericardia borealis, but Venericardia is apparently a Tertiary genus not surviving today.

Cerastoderma pinnulatum (Conrad). Not in key. Dredged subtidally.

Chlamys islandica Müller. "Iceland Scallop". Common in shallow water and on the continental shelf.

Corbula contracta Say. Dredged in shallow water.

Crassinella (=Gouldia) mactracea Lindsley. Dredged from current swept sand and shell bottom in shallow water.

Crassostrea virginica (Gmelin). "Eastern Oyster". This is the commercially important oyster of the Atlantic seaboard; greatly variable in size and shape; around and below low water mark in estuarine as well as marine conditions, attached to any hard substrata including empty shells, with free swimming larvae, unlike Ostrea spp.

Cumingia tellinoides Conrad. In muds, usually associated with eelgrass, a deposit-feeding bivalve, which, however, does not belong to the family Tellinidae but to the Semelidae, illustrating convergence in functional morphology.

Cyrtodaria siliqua (Spengler). Dredged subtidally. Not in key.

Cyrtopleura (=Barnea) costata (L.). "Angel Wing". Around low water mark in sandy mud, may also be found boring in peat or clay.

Cyrtopleura (=Barnea) truncata (Say). "Truncated Borer". Borers in peat or clay on the Cape, and in softer rocks (e.g. shales) outside of this area.

Ensis directus (Conrad). "Common Razor Clam". Rapid vertical burrower in sand, very common in some areas (including Barnstable).

Gemma gemma (Totten). Very common and particularly abundant on tidal flats.

Hiatella gallicana (Lamarck) and possibly also

Hiatella arctica (L.). Non-boring specimens belonging to this genus have been dredged subtidally and a living specimen of H. gallicana was found in 1963 in shallow water at the Sandwich end of the Cape Cod Canal. Not in key.

Laevicardium mortoni (Conrad). In muddy sand, occasionally with eelgrass, in more sheltered shallow waters.

Lyonsia hyalina (Conrad). Rare at low water mark, more commonly dredged.

Macoma balthica (L.). Common in organic muds, a deposit feeder.

Macoma tenta (Say). In muddy sand, a deposit feeder.

Mercenaria (=Venus) mercenaria (L.). "Quahog" or "Little-neck Clam" or "Hard-shelled Clam". The most important commercial clam, very common, locally abundant.

Modiolus demissus (Dillwyn). "Ribbed Mussel". Salt marshes and upper littoral, often abundant. The nomenclature, and even the systematic position, of this mussel have been obscure. Its shell lacks teeth next to the ligament, and it is certainly erroneous to place it in the genus Brachidontes, the shells of which always have tooth-like crenulations just behind the ligament. Care must be taken to distinguish M. demissus from Brachidontes recurvus Rafinesque ("Hooked Mussel"), common on more southern Atlantic shores, but which may extend into this area. Note that Mytilus (or Modiolus) plicatulus is simply a synonym for M. demissus and that both Volsella and Arcuatula have been suggested as generic names for this species. Volsella has been rejected, but recently Soot-Ryen (1955) has suggested Arcuatula demissa as the best name after setting up several diagnostic characters (including the radial sculpture) to separate Arcuatula from the more characteristic species of the genus Modiolus.

Modiolus modiolus (L.). "Horse Mussel". Cooler waters, usually below low water mark, reaching greatest size subtidally.

Mulinia lateralis (Say). A dwarf mactrid clam, related to Spisula, usually found in shallow water in mud or clay, but occasionally in the same habitat as Spisula in surf stirred sand.

Musculus (=Modiolaria) niger (Gray). A rarer mussel, near low water mark and subtidally, more actively moving than most mussels.

Mya arenaria L. "Soft-shelled Clam" or "Long-neck Clam". The important commercial clam of mud flats, but occurring commonly in a wide variety of substrata (gravel, sand, mud or peat) at all tidal levels and in shallow water. Burrows are probably permanent and adult Mya completely sedentary organisms.

Mysella (=Rochefortia) planulata (Stimpson). A minute leptonacean clam which is probably commensal. This is the only species of this group positively identified recently, but Aligena elevata and Montacuta spp. may occur. Mysella planulata has previously been placed in the genera Kellia and Rochefortia.

Mytilus edulis L. "Common Mussel". Common, often abundant in extensive, packed colonies forming "blankets", between tidemarks, and on the masonry and pilings of docks and other structures.

Nucula proxima (Say). In mud subtidally (several other Nucula spp. may occur in this area). Deposit feeding using palp proboscides, this is probably the most primitive genus of living bivalves.

Pandora gouldiana (Dall). Rare, lower intertidal and shallow water.

Periploma (=Cochlodesma) leanum (Conrad). Rare, dredged.

Petricola pholadiformis Lamarck. "False Angel Wing". The commonest borer in peat and clay in this area. This species, as is clearly revealed by the separate extensible siphons, is a modified deposit feeder derived from a stock like

the Tellinidae, which shows secondary convergence in structure and habit with the Pholadidae, e.g. Cyrtopleura spp. and Zirfaea spp.

Phacoides (Lucinoma) filosus Stimpson. Subtidally, dredged in Vineyard Sound. Not in key.

Pitar morrhuana (Linsley). Dredged.

Placopecten magellanicus (Gmelin). "Deep-sea Scallop". Common subtidally and on the Continental Shelf.

Siliqua costata (Say). On shallow water and sand flats, another vertically burrowing razor clam, belonging to the Solenidae.

Solemya velum Say. Not uncommon on intertidal mud flats and mud subtidally, a specialized representative of the Protobranchia.

Spisula solidissima (Dillwyn). "Surf Clam" or "Hen Clam". In surf stirred clean sand, common below low water mark on exposed ocean beaches, young specimens occur in the littoral. Called Mactra solidissima in much experimental literature.

Tagelus divisus (Spengler) and

Tagelus plebeius (Solander) (=T. gibbus (Spengler)). In muddy sand, on intertidal flats and in shallow water, these are deposit feeding bivalves related to the Tellinidae (note the separate extensible siphons). Tagelus spp. have secondarily assumed structure and habits like those of the true razor clams.

Tellina agilis Stimpson (=T. tenera Say). In fine or muddy sand, on intertidal flats and in shallow water, the only local representative of this important world wide genus of deposit feeding bivalves with separate, very extensible siphons.

Teredo navalis L. "Shipworm". A common and destructive wood borer of world wide distribution, transported to this area in drifting wood from more southern parts of the Atlantic coast.

Thyasira gouldi (Philippi) and

Thyasira trisinuata (Orbigny). Dredged.

Yoldia limatula (Say). Dredged in shallow water just below low water mark, occasionally found intertidally (two other species, Yoldia sapotilla (Gould) and Yoldia thraciaeformis Storer, may occur in this area. This is one of the three local genera of Protobranchia, deposit feeding by means of palp proboscides.

Zirfaea crispata (L.). "Piddock". Borer in peat or clay on the Cape, and in softer rocks (e.g. shales) outside this area; more common in colder waters.

Venericardia, see Cardita.