A Compiled Key To The Living Sea Urchins In And Around The Hawaiian Islands

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Preface

This key is based substantially upon the monumental work of Theodor Mortensen. It is a key of only the living sea urchins in the Hawaiian area known as of 1950 and does not include any extinct species. This key is divided into four sections. First, is a complete list of the urchins known from the Hawaiian area. Second, is the key itself starting on page 1 with the regular /irregular urchins catagorized into the major orders. The orders are separated by pages to ease navigating through the key, except in those orders with only a few species. For example, the orders *Lepidocentroida* and *Stirodonta* are combined on page 1 as there are only two species in each. Third, I've included a dictionary of terms to aid in deciphering the words used in the key. And fourth, a number of figures provide pictoral descriptions.

The reader is further directed towards the individual species descriptions found in Mortensen's *Monograph to the Echinoidea* and Agassiz & Clark's *Hawaiian and Other Pacific Echini* to verify the sample they wish to key. A complete description of all the species listed herein was judged beyond the scope of this report. The key includes 8 orders, 11 suborders, 20 families, 5 subfamilies, 52 genera, and 72 species, 31 of which are known to occur in depths of less than 100 feet. One species, *Aceste ovata* is known to occur in depths of greater than 12,000 feet.

There were two areas of discussion in recent years. The first was the separation of *Echinometra mathaei* and *Echinometra oblonga* into separate species. Mortensen's keys list *E. oblonga* as a variety of *E. mathaei* and not as a separate species. Kelso (1970) and Metz (1990) both agreed that these two urchins should be separate species. According to Matsuoka and Hatanaka (1991), one of the color variations of *E. mathaei* in Japan is black which would make visual differentiation of this species and *E. oblonga* very difficult. My modification to Mortensen's key using the black color to differentiate *E. mathaei* and *E. oblonga* in Hawaii was based on Kelso's study that suggested that all black colored *Echinometra* were *E. oblonga*. However, this may be in error in view of the black variety of *E. mathaei* found in Japan and should be used with due caution. Uehara and Shingaki (1984 & 1985) and Matsuoka and Hatanaka (1991) go even further to suggest that the four different color variations in *E. mathaei* in Japan may be separated into four different species. This may be an area of further study.

The second area of dicussion is the proper placement of the genera *Tripneustes* and *Pseudoboletia* into the Families *Strongylocentrotidae,* as proposed by H. L. Clark or *Toxopneustidae*, as proposed by Mortensen. Matsuoka (1985) agrees with Mortensen's assessment on the basis of genetic differentiation. It appears that such genetic work may be valuable in solving other differences in classification.

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Living Hawaiian Sea Urchin Key

Subclass *Echinoidea vera*

1. Dental apparatus present; periproct within the apical system (Subclass *Regularia* or Endocyclica) 2
   Dental apparatus present or absent; periproct outside the apical system, in the posterior interambulacrum (Subclass *Irregularia* or Exocyclica) . . . . . page 5
2. Ambulacra continuing over the peristome, there being series of plates between mouth and edge of peristome, 20 or more columns of plates 4
   Ambulacra not continuing over the peristome, only a single pair of ambulacral plates, called the buccal plates, between mouth and peristomial edge. Only 20 columns of plates 5
4. Peristome with only the ambulacral series of plates, no series of interradial plates. Primary spines usually not very large, with a cortex layer. Sphaeridia present; gills present or absent (Order *Lepidocentroida*) . . . . . see below
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   Teeth keeled 6
6. Epiphyses not joining over the teeth; foramen open (Order *Stirodonta*) . . . . . see below
   Epiphyses joining over the teeth; foramen closed (Order *Camarodonta*) . . . . . page 4

Order *Lepidocentroida*

1. Primary spines of oral side club-shaped, skin-clad, without hoof (Subfamily *Phormosominae*) . . . . . *Phormosoma bursarium*
   Primary spines of oral side terminating with a hoof, not skin-clad, not club-shaped (Subfamily *Astenosominae*) . . . . . *Sperosoma obscurum*

Order *Stirodonta*

1. One or more angular suranal plates in the apical system (Suborder *Calycina*) 2
   No angular suranal plate (Suborder *Phymosomina*) 3
3. Apical system large; 5 anal valves. Peristomial membrane scale-covered outside the buccal plates. Papillae of test not arranged in horizontal and vertical rows . . . . . *Habrocidaris argentea*
   Apical system small; 4 anal valves. Peristomial membrane naked outside the buccal plates. Papillae of test arranged in horizontal and vertical rows . . . . . *Podocidaris ornata*

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Order *Cidaroida*

1. No globiferous pedicellariae, only tridentate pedicellariae present (Group *Histocidarina*) . . . . . *Histocidaris variabilis*
   Globiferous pedicellariae present, tridentate present or absent 2
2. Opening of globiferous pedicellariae rather small, terminal, well formed, with a serrate lower lip; the stalk usually with a limb of projecting rods; small globiferous with a distinct end tooth (Group *Stylocidarina*) 4
   Opening of globiferous pedicellariae usually subterminal, usually not with a distinct lower lip; no limb on the stalk. Small globiferous pedicellariae with or without an end tooth 3
3. Pores conjugate; no grooves in the sutures of the coronal plates or on the plates (Group *Rhabdocidarina*) . . . . . *Chondrocidaris gigantea*
   Pores non-conjugate; often grooves in the sutures of the coronal plates, more rarely on the plates themselves (Group *Sterocidarina*) 10
4. Tubercles distinctly crenulate; primary spines very long, flattened, with a long collar . . . . . *Acanthocidaris hastigera*
   Tubercles non-crenulate, or only with faint traces of crenulation. Primary spines not flattened, or if so, not with a long collar 5
5. Primary spines distinctly verticillate; test green-mottled . . . . . *Plococidaris verticillata*
   Primary spines not distinctly verticillate; test not green-mottled 6
6. Pores, in adult specimens, distinctly conjugate. Collar of primary spines usually with red or purple spots or stripes . . . . . *Prionocidaris hawaiiensis*
   Pores not conjugate or at most sub-conjugate; collar of primary spines not spotted or striped with red or purple (but sometimes with brown stripes) 7
7. Pores sub-conjugate. Peristomial ambulacral pores in single series. Primary spines thick and coarse, the surface covered by a coarse reticulation formed by the anastomosing hairs . . . . . *Actinocidaris Thomasi*
   Pores non-conjugate. Peristomial ambulacral pores in single or double series 8
8. Primary spines slender, usually tapering to a rather fine point; hairs on surface of shaft usually simple, not anastomosing, sometimes totally lacking. Peristomial ambulacral pores in single series (Genus *Stylocidaris*) 9
   Primary spines slender or coarse, usually not tapering; if so, there peristomial ambulacral pores partly in double series; hairs on suface of shaft anastomosing and forming a thick spongy coat . . . . . *Eucidaris metularia*
9. Primary spines greenish-brown banded, with very small, low spinules arranged in numerous close, but distinct longitudinal series . . . . . *Stylocidaris calacantha*
   Primary spines light brownish, with numerous low, white spinules, being thus finely spotted . . . . . *Stylocidaris rufa*
10. Military spines slender, erect . . . . . *Stereocidaris leucacantha*
    Military spines broad and flat, more or less scale-like, usually appressed . . . . . *Stereocidaris hawaiiensis*

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Order *Aulodonta*

1. Primary spines with solid axis; tubercles non-crenulate (Suborder *Pedinina*) 3
   Primary spines without solid axis 2
2. Primary spines usually hollow; tubercles crenulate or noncrenulate (Suborder *Diademina*) 4
   Primary spines with axis divided into compartments separated by fenestrate transverse plates (dissepiments), connect by long thin threads Tubercles strongly crenulate (Suborder *Aspidodiademina*) 10
3. Primary spines long, slender, densely thorny, unbanded. Genital plates purplish violet . . . . . *Caenopedina hawaiiensis*
   Pimary spines short, thick, smooth not exceeding 1 1/2 horizontal height of test; Apical plates brownish rose, conspicuously sculptured in center. Secondary spines white or reddish-white . . . . . *Caenopedina pulchella*
4. Tubercles crenulate 5
   Tubercles non-crenulate . . . . . *Leptodiadema purpureum*
5. Test low, flexible 6
   Test sub-hemispherical; not flexible or if flexible; pentagonal 7
6. Pore pairs arranged in single series . . . . . *Chaetodiadema pallidum*
   Pore pairs arranged in distinct arcs of three . . . . . *Astropyga radiata*
7. Primary ambulacral tubercles consipcuous in two regular series. Ambulacral spines not different from other spines 8
   Primary ambulacral tubercles very small, not in two regular series. Aboral ambulacral spines very fine, setiform, retrorsely barbed at point (Genus *Echinothrix*) 9
8. Spines on buccal plates. Globiferous pedicellariae present . . . . . *Centrostephanus astericus*
   No spines on buccal plates. No globiferous pdeicellaria . . . . . *Diadema paucispinum*
9. Primary spines distinctly verticillate, ambulacra usually conspicuously raised aborally, naked sunken median area aborally in interambulacra, ambulacral tubercles not enlarged at ambitus, test color aborally green . . . . . *Echinothrix calamaris*
   Primary spines not verticillate but finely longitudinally ridged; ambulacra not raised aborally, no naked median area in interambulacra, ambial ambulacral tubercles enlarged, test not green aborally . . . . . *Echinothrix diadema*
10. Primary spines greenish; test on aboral side light purplish . . . . . *Aspidodiadema hawaiiense*
    Primary spines not greenish, spines and test light violet, Primary tubercles elongate-oval; pore pairs in distinct oblique arcs of three at ambitus . . . . . *Aspidodiadema articum*

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Order *Camarodonta*

1. Test sculpted or not, if not, gill-slits deep and sharp (Suborder *Temnopleurina*) 2
   Test not sculpted, gill-slits not deep and sharp (Suborder *Echinina*) 10
2. Tubercles usually crenulate. Test usually sculptured (Family *Temnopleuridae*) 3
   Tubercles smooth. Test not sculptured (Family *Toxopneustidae*) 8
3. Angular pores or pits present; sometimes indistinct in adults (Subfamily *Temnopleurinae)* . . . . . *Temnotrema hawaiiense*
   No angular pores or pits present; elaborate scupture on test, sometimes only on apical system. Tubercles not very dense (Subfamily *Trigonocidarinae*) 4
4. Test scupture not distinct. Tubercles non-crenulate, not indented 5
   Test scupture distinct 6
5. Apical system (usually) distinctly sculptured; interambulacral midline sunken . . . . . *Prionechinus sculptus*
   Apical system not, or only slightly sculptured . . . . . *Prionechinus Agassizi*
6. Buccal membrane covered with large plates . . . . . *Trigonocidaris albidioides*
   Buccal membrane naked or with small imbedded plates 7
7. Apical system deeply sculptured; valves of globiferous pedicellaria with blade in shape of elongate closed tube . . . . . *Orechinus monolini*
   Apical system smooth or feebly sculptured; valves with short, open blade . . . . . *Lamprechinus sculptus hawaiiensis*
8. Ambulacral plates trigeminate 9
   Ambulacral plates polyporous . . . . . *Pseudoboletlia indiana*
9. Primary tubercle on each ambulacral plate . . . . . *Crytechinus verruculatus*
   Primary tubercle not regularly on every second ambulacral plate . . . . . *Tripneustes gratilla*
10. Test round, four pore pairs in upper plates . . . . . *Echinostrephus aciculatus*
    Test transversely elongate 11
11. Long axis through I.A.3-A.I; marginal primary spines not forming a lateral fringe or otherwise specially developed (Genus *Echinometra*) 13
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12. Primary spines long, thick, heavy . . . . . *Heterocentrotus mammillatus*
    Primary spines flattened forming dense mosaic . . . . . *Colobocentrotus (Podophora) atratus*
13. Spine color other than black . . . . . *Echinometra mathaei*
    Spine color black . . . . . *Echinometra oblonga*

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Subclass Irregularia

1. Ambulacra simple, not forming petals aborally or phyllodes adorally. Peristome central. Dental apparatus present or more or less reduced or completely resorbed. Test high, not broad (Order *Holectypoida*) 3
   Ambulacra petaloid aborally, test broad 2
2. Dental apparatus strongly developed, no phyllodes (Order *Clypeastroida*) 5
   Dental apparatus not present, phylloids more or less developed (Order *Spatangoida*) . . . . . page 6
3. Apical system with separate genital plates; ambial pores with peripodium rudimentary or lacking . . . . . *Micropetalon purpureum*
   Apical system compact, genital plates not separate; pores with distinct peripodium throughout ambulacrum (Genus *Echinoneus*) 4
4. Primary tubercles imperforate; glassy tubercles well developed . . . . . *Echinoneus cyclostomus*
   Primary tubercles perforate; glassy tubercles small or lacking . . . . . *Echinoneus abnormalis*
5. Plates of petals alternating primary and demi-plates. Auricles separate. Aboral military spines simply serrate, never terminating in a regular crown (Suborder *Clypeastrina*, Family *Clypeastridae*) 6
   Plates of petals all primaries. Auricles fused. Aboral military spines terminating in regular crown or glandular bag (Suborder *Laganina*) 10
6. Test without distinct margin. Internal skeleton forming newly complete inner wall, test being thus double . . . . . *Clypeaster eurypetalus*
   Test usually with distinct margin. Internal skeleton consisting of more or less isolated lamellae or pillars, not forming complete inner wall, test not double 7
7. Test very concave on oral side; marginal internal skeleton (lamellae) very reduced or lacking (Section *Rhaphidoclypus*) 8
   Test more or less flat on oral side, at least not markedly concave; marginal internal skeleton (lamellae) usually strongly developed (Section *Stolonoclypus*) . . . . . *Clypeaster leptostracon*
8. Edge of test usually markedly thickened; petaloid area somewhat depressed . . . . . *Clypeaster reticulatus*
   Edge of test not markedly thickened; petaloid area not depressed 9
9. Petals all closed; test low and thin . . . . . *Clypeaster reticulatus sundaicus*
   At least frontal petal open; test not very low and thin . . . . . *Clypeaster lytopetalus*
10. Small forms of more or less ovoid shape, rarely flattened. Petals short, more or less rudimentary (Family *Fibulariidae*) 11
    Usually medium size forms, very flattened, discoidal. Petals well developed . . . . . *Peronella strigata*
11. Periproct naked, usually covered by five radiating plates 12
    Periproct covered with spines, periproctal plates irregular . . . . . *Echinocyamus (Mortonia) australis*
12. Petals large, continuing to edge of test; pore series diverging . . . . *Echinocyamus megapetalus*
    Petals more or less developed, not reaching edge of test; pore series parallel or converging 13
13. Peristome deeply sunken . . . . . *Echinocyamus crispus*
    Peristome not deeply sunken 14
14. Aboral side of test with prominent glassy tubercles, higher than the other tubercles . . . . . *Echinocyamus scaber*
    Glassy tubercles, if present, not very prominent . . . . . *Echinocyamus incertus*

Living Hawaiian Sea Urchin Key

Order *Spatangoida*

1. Petals imperfectly developed or rudimentary (Family *Paleopneustidae*) 6
   Petals well developed 2
2. Peristome non-labiate; mouth opening central . . . . . *Acete ovata*
   Peristome labiate; mouth opening not central 3
3. Subanal fasciole present 4
   Subanal fasciole not present (Family *Schizasteridae*) . . . . . *Hypselaster maximus*
4. Inner fasciole present (Family *Loveniidae*) 8
   Inner fasciole not present 5
5. Peripetalous fasciole present (Family *Brissidae*) 10
   Peripetalous fasciole not present (Family *Spatangidae*) . . . . . *Spatangus paucituberculatus*
6. A more or less conspicuous frontal depression 7
   No frontal depression . . . . . *Pycnolampas oviformis*
7. Subanal fasciole present . . . . . *Argopatagus vitreus*
   Subanal fasciole not present . . . . . *Phrissocystis multispina*
8. Paired ambulacra not distinctly petaloid . . . . . *Pseudolovenia hirsuta*
   Paired ambulacra distinctly petaloid 9
9. Posterior end of test deeply sunken forming an anal funnel . . . . . *Lovenia hawaiiensis*
   Posterior end of test vertical, not deeply sunken, at most somewhat concave . *Lovenia grisea*
10. Large primary tubercles on aboral side (Genus *Eupatagus*) 16
    No large primary tubercles on aboral side 11
11. Subanal plastron reniform 13
    Subanal plastron cordiform, shield-shaped 12
12. Faint frontal depression . . . . . *Brissopsis luzonica*
    No frontal depression . . . . . *Brissus latecarinatus*
13. Subanal plastron more or less distinctly projecting downwards or backwards (Genus *Rhinobrissus*) 14
    Subanal plastron not projecting (Genus *Metalia*) 15
14. Vertex anterior to apical system and very marked . . . . . *Rhinobrissus hemiasteroides*
    Vertex posterior to apical system and not very marked . . . . . *Rhinobrissus placopetalus*
15. Posterior petals coalescing adapically, the posterior interambulacral without primary tubercles adapically . . . . . *Metalia sternalis*
    Posterior petals not coalesing adapically, the posterior interambulacral with primary tubercles till adapical end . . . . . *Metalia spatagus*
16. No primary tubercles in posterior interambulacra inside peripetalous fasciole . . . . . *Eupatagus Lymani*
    Few primary tubercles in posterior interambulacra inside peripetalous fasciole . . . . . *Eupatagus obscurus*

Definitions of Terms

Abactinal system - apical system
Abactinal - aboral
Aboral - the side opposite the mouth
Acetabulum - cavity in the proximal end of primary spine; where mamelon articulates
Actinal - oral
Actinosome - peristome
Adoral - near the mouth
Ambitus - outer edge or margin, outline of test viewed from apical pole
Ambulacra - the plates of the test where the pore pairs and tubercles occur
Ambulacral plates (compound) - see compound plates
Ambulacrum (anterior) - in spatangoids, a narrow band of even width bearing on each side a single row of podia that is generally not altered into a petaloid ambulacra
Ambulacrum (petaloid) - one of five ambulacra that form the petal on irregular urchins
Ambulacrum (posterior) - opposite the anterior; sometimes towards the anus
Ampulla - an internal reservoir, usually a bag of skin, on ring canal of water vascular system
Anastomosing - a joining or union of parts
Annulus - see milled ring
Anterior - ventral, facing outwards from the axis; previous or before
Anterior ambulacrum - see ambulacrum
Anus - the terminal end of the digestive tract
Apical spines - primary or secondary spines on the apical side
Apical system - the tip of the aboral side, surrounds the anus in regular Echinoids
Apophyses - internal bony structures on test (oral side) to which the lantern muscles attach in Cidarids
Appressed - lying flat or pressed closely against
Areole - a clear area encircling the boss of the primary or secondary tubercles; for muscle attachment
Areole (confluent) - the margins of the areoles merge into each other
Auricles - same as apophyses; in Echinoids other than Cidarids; connected radially
Basal terrace - a circular impression (indistict) at the base of the boss, tissue connects boss to spine
Base - the proximal end of the primary spine that is closest to the test below the milled ring
Bifid - forked
Bourrelets - in Cassiduloida, conspicuous prominences formed by the meeting of the single interambualcral plates with the peristome between the phyllodes.
Boss - base of primary or secondary tubercles
Buccal plate - only one pair of ambulacral plates on peristome in each radius in regular Echinoids
Buccal tube feet (podia) - innermost tubefeet on the peristome
Calcareous plate of peristome - see peristomal plates

Definitions of Terms

Central core - an irregular calcareous meshwork found in the center of the primary spine shaft
Collar (collerette) - the area of the primary spine immediately above the milled ring; has no cortex
Compound plate - ambulacral plates composed of two or more primary plates
Compound plate (diademoid) - having three full-sized primary plates
Compound plate (arbacioid) - having a median primary plate with a demiplate to either side
Compound plate (echinoid) - having two primary plates with a demiplate between their outer ends
Confluent - see areole
Conjugate - two pores united by a furrow or depression
Cordiform - heart shaped
Corona - test except for apical and peristomal plates
Coronal plates - plates on the corona
Cortex - the outer most layer of the spine
Crenulate - impressions along the edge of the parapet
Demiplates - plates that do not reach from the outer to the inner edge of the compound plate
Dental apparatus (lantern) - the chewing bony parts of the mouth; epiphyses, pyramid, tooth, etc.
Dermal gill - a gill on the dermal surface
Dicyclic apex - see ocular plate exsert
Diploporous - the pore pairs on the peristome are displaced and not in straight series
Distal - end furthest from the organism's midline
Endocyclic - having an apical system with double circle of plates surrounding anus; regular urchins
End tooth - a usually sharp fang-like calcarious projection at the end of pedicellaria
Epiphyses - a stout bar firmly fused to alveolus of each jaw and articulating with rotulae
Ethmophract - a condition in which the apical system has ocular and genital plates encircling the madreporite
Ethmolytic - a madreporite that has moved from the center of the genital plates to an outer position
Exocyclic - periproct lies outside the apical system; irregular urchins
Exsert - see ocular plates exsert
Excavate - to make or be hollow
Excurvate - to curve outwards from center
Fasciole - a cilliated band that sweeps water over surrounding parts; usually in irregular urchins
Fasciole (internal) - a fasciole that encloses the aboral apex and much of the anterior ambulacrum
Fasciole (lateral) - a fasciole that runs from the peripetalous fasciole backward toward the posterior

Definitions of Terms

Fasciole (peripetalous) - a fasciole surrounding the petals
Fasciole (subanal) - a fasciole near the anus
Foramen (open) - an incomplete opening or hole formed by the epiphyses of the lantern that do not unite above the teeth
Foramen (closed) - a completely formed hole contrary to above
Gemmiform pedicellariae - see pedicellariae globiferous
Genital pore - a pore usually on the outer edge of the genial plate, gametes released through pore
Genital plate - system of plates surrounding the periproct usually with genital pore
Glandular pedicellariae - see pedicellariae globiferous
Hoof - a hard covering on the terminal end of the oral primary spines in Subfamily *Astenosominae*
Horizontal Diameter (h.d.) - midline ambulacrum to midline of opposite ambulacrum at the ambitus
Imbricating - having parts overlapping each other like roof tiles
Imperforate - not having pores
Internal fasciole - see fasciole (internal)
Insert - see ocular plates insert
Interambulacra - the plates of the test between the ambulacra
Interporiferous zone - the area on the ambulacral plate between the two pairs of pores; between the pore zones
Keel - part of pyramid that resembles the ridge on the keel of a boat
Labiate - lip-like or having lip-like parts
Labrum - a lip-like projection of the posterior interambulacrum in some irregular urchins
Lantern - see dental apparatus
Madreporite - a flat perforated plate at end of interambulacra area or between two such areas
Mamelon - topmost knob of primary or secondary tubercle
Marginal fringe - primary spines along the outermost margin of the test that are sometimes flattened
Marginal tubercle - tubercles along the margin of the test
Marginal series - the columns of spines or tubercles along the margin of the test
Median area of the interambulacra - space between the two series of areoles
Military tubercle - tubercles of military spines
Military spine - very small spines
Milled ring - a raised ring-like usually striated structure near base of primary spine; no cortex
Monocyclic apex - see ocular plate insert
Mouth - the opening of the digestive system
Neck - the portion of the primary spine between the collar/shaft and having a smooth cortex layer
Neuropore - located next to pore pair, nerves for tube feet
Ocular plate - plates at end of ambulacral areas alternating w/ genital plates in apical system

Definitions of Terms

Ocular plate (exsert) - ocular plates not in contact with the periproct
Ocular plate (insert) - ocular plates in contact with the periproct thus separating the genital plates
Oligoporous - plates bearing two or three pore pairs
Oral - towards the mouth
Oral primaries - primary spines on the oral side
Ostracum - see cortex
Papilla - nipple-like projections
Parapet - if present, distinct area between boss and mamelon. Also may be called platform.
Pedicellariae - minute pincher-like structures studding the surface of some echinoderms
Pedicellariae (dactylous) - variant of golobiferous; only in Echinothuriidae;
Pedicellariae (globiferous) - poison gland lies free usually on outside of valve on back
Pedicellariae (globiferous) - poison gland lies inside of valve in special chamber (Cidarids only)
Pedicellariae (globiferous - large) - (Cidarids only) large maybe same size as small
Pedicellariae (globiferous - small) -(Cidarids only) size no easily distinguished
Pedicellariae (ophiocephalous) - mostly on peristome; short, inward curved jaws with blunt tips
Pedicellariae (tridentate) - long, slender valves; no poison gland
Pedicellariae (triphyllous) - three narrow jaws; usually serrated, meeting only at tips
Perforate - a mamelon that has a pit or pore hole for attachment of ligament to spine base
Periproct - the area surrounding the anus in regular echinoids
Periproctal plate - plates making up the periproct
Peristome - region surrounding the mouth
Petal - expanded part of ambulacral areas of certain Echinoidea
Phyllode - a petal-like shape in some irregular urchins created when the oral ends of the ambulacra surrounding the peristome alternate with the interambulacra
Plastron - a bony shield; on the oral side, the area bracketed by the two posterior ambulacra extending from the labrum in front to the periproct behind
Platform - see parapet
Podia (buccal) - see buccal tube feet
Podia (papillate) - aboral podia lacking terminal disks; taper to rounded end; in regular urchins
Podia (penicillate) - greatly altered podia of phyllodes; same as buccal podia of regular urchins
Podia (subanal) - large podia enclosed by subanal fasciole
Podia (branchial) - simple or lobed podia of petaloids
Podia (suckered) - podia with terminal disks or suckers
Polyporous - plates bearing more than three pore pairs

Definitions of Terms

Pore Zone - the area on the ambulacral plate encompassing the pore pair
Pore Pair - two holes in the ambulacral plate to which the tube feet attach
Posterior - dorsal, behind the axis
Primary ambulacral tubercle - see marginal tubercle
Primary plates - ambulacral plates in one piece from outer to inner edge; one pore pair per plate
Primary series - see marginal series
Primary spines - the largest spines on the test
Primary tubercle - the area on the test where the primary spines attach
Proximal - end nearest the midline of the organism
Pyramid - the largest bones (5) of the lantern
Radial Plate - see ocular plate
Radiole - see primary spine
Reniform - shaped like a kidney
Reticulate - like network or meshwork; forming a network
Retrorsely - turned or directed backwards
Ridge - aboral side of pores, separates lower from upper part of primary plate
Scrobicule - outermost part of areole, where spine muscles attach to tubercle
Scrobicular tubercles - secondary tubercles set around the edge of the areole in Cidarids
Scrobicular spines - secondary spines found at the base of the primary spines in Cidarids
Sculptured - impressions or raised markings or the patterns of such markings on the surface of the test
Secondary tubercles - the usually smaller tubercles of secondary spines
Secondary spines - usually smaller than primaries; lacking central core and cortex
Series (single) - arranged in one column
Series (double) - arranged in two columns
Setiform - bristle shaped, very finely or closely set
Shaft - the main portion of the primary spine distal from the neck
Sinuate - having a winding, wavy, indented margin
Sphaeridia - minute, glassy, hard, rounded bodies on ambulacral; probably balancing organs
Spinulose - covered with small spines
Steward's Organ - five large bush-shaped growths arranged in pentagon from upper side of lantern
Subanal fasciole - see Fasciole (subanal)
Subconjugate - intermediary between conjugate and not conjugate
Subhemispherical - nearly half sphere in shape
Subterminal opening - the cup-like chamber formed by calcareous bone in some pedicellaria; usually located near or below the end of the pediciellaria
Subvertical - nearly but not quite vertical
Suranal - above anus or anal region
Suture - a line of junction between two parts that are immovably connected
Terminal plate - see ocular plate

Definitions of Terms

Tertiary spine - very small spines; see military spine
Test - the shell of Echinoderms
Tooth - largest of the bonys in the dental apparatus if present; usually five in number
Tridactyle - see pedicellariae tridentate
Trifoliate - see pedicellariae triphyllous
Trigeminate - arrangement of pairs of pores in three rows in ambulacra
Tube feet - fleshy tube-like organs, some with suckers distally; connected to water vascular system
Tuberculate - having or resembling tubercles
Valve - the calcareous skeleton of the jaws of pedicellariae
Vertex - highest point on test
Vertical Diameter (v.d.) - height of corona from oral to aboral end of ambulacrum
Verticillate - arranged in or forming a whorl or whorls; a turn or convolution of a spiral
Wall - space between the pore pairs

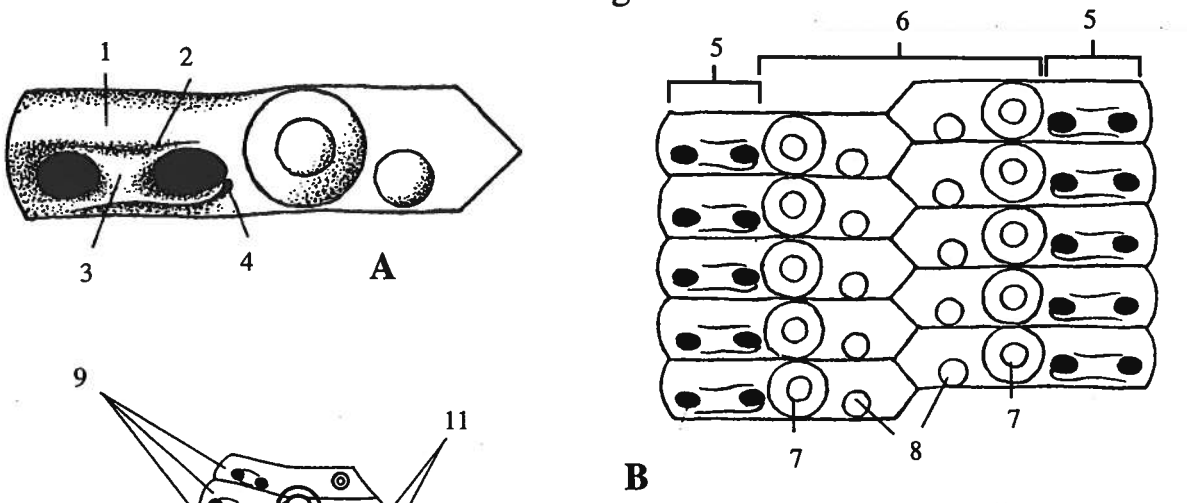
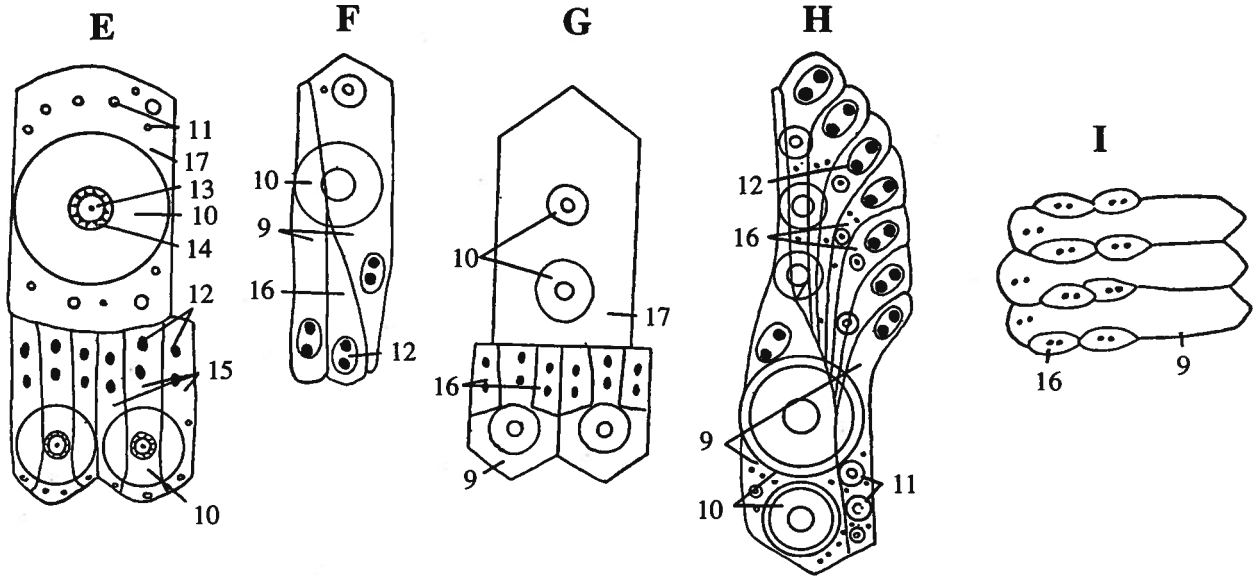


Figure 1. Regular Urchin Test Morphology. A. ambulacral plate of a Cidarid. B. part of ambulacrum of a Cidarid. C. compound oligoporous plates of *Echinus elegans*. D. compound polyporous plates of *Echinometra mathaei* (A-D, *after Mortensen*) E. plates of *Diadema*, showing diadematoid arrangement. F. ambulacral plate of *Echinus*, showing echinoid arrangement. G. ambulacral and interambulacral plates of *Arbacia*, showing arbacioid arrangement, note lack of secondary tubules. H. polyporous ambulacral plate of *Strongylocentrotus* (E-H, *after Hyman*, 1955). I. echinothuriid ambulacral plates (*after Mortensen, Monogr.*) 1. ridge; 2. furrow; 3. wall; 4. neuropore; 5. pore zone; 6. interporiferous zone; 7. marginal tubercle; 8. inner tubercle; 9. primary plates; 10. primary tubercles; 11. secondary tubercles; 12. pore pair; 13. perforate mamelon; 14. crenulations; 15. three primary plates of ambulacrum; 16. demiplate; 17. interambulacra.



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Figures

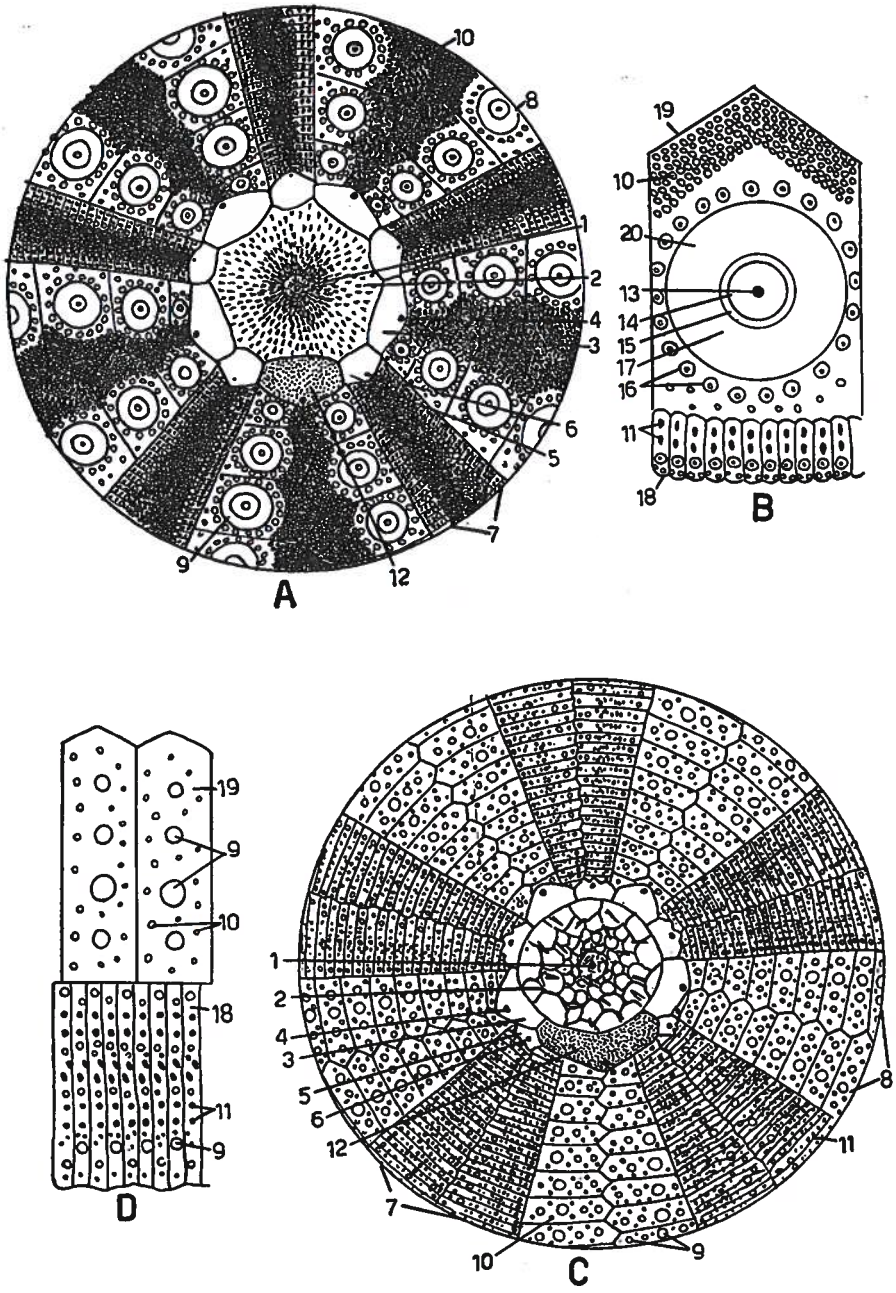


Figure 2. Regular Urchin Test Morphology (cont.). A. aboral side of the test of a cidaroid *Eucidaris tribuloides*. B. ambulacral and interambulacral plates of A. C. aboral side of the test of *Tripneustes ventricosus*. D. ambulacral and interambulacral plates of C (A-D, *after Hyman*, 1955). 1. anus; 2. periproct; 3. genital plate; 4. gonopore; 5. terminal plate; 6. pore for terminal podium; 7. ambulacrum; 8. interambulacrum; 9. tubercle of primary spine; 10. tubercles of secondary spines; 11. porepairs; 12. madreporite; 13. perforation; 14. mamelon; 15. ledge at base of mamelon; 16. scrobicular tubercles; 17. boss; 18. ambulacral plates;19. interambulacral plate; 20. areole.

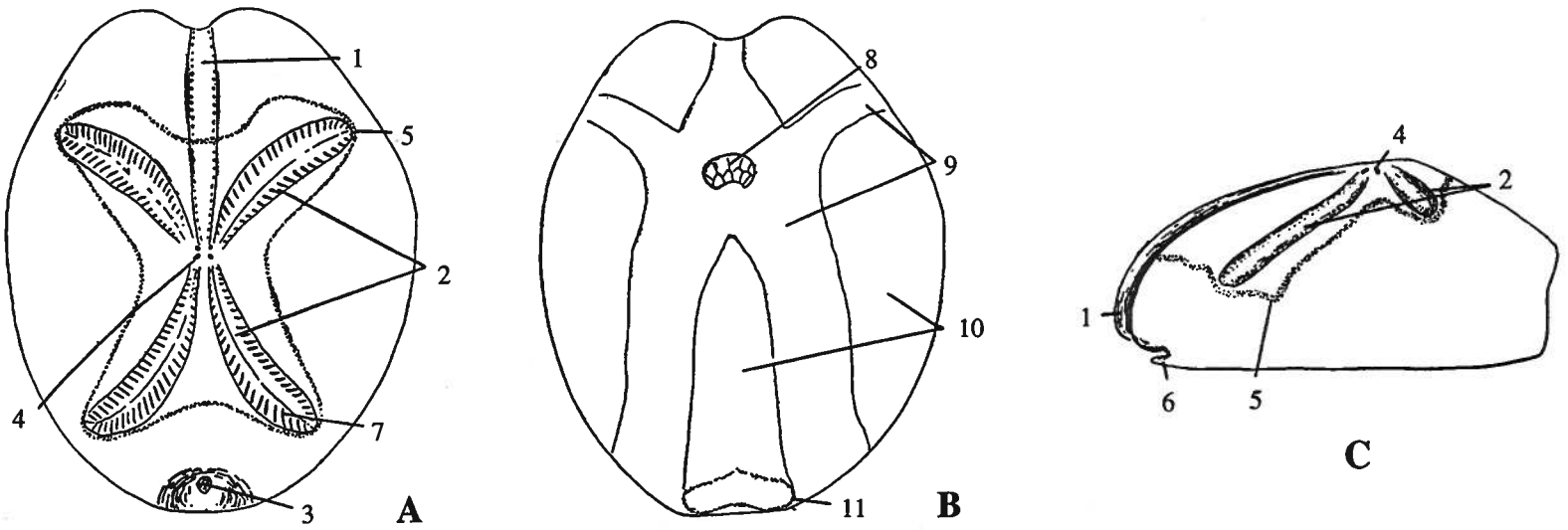
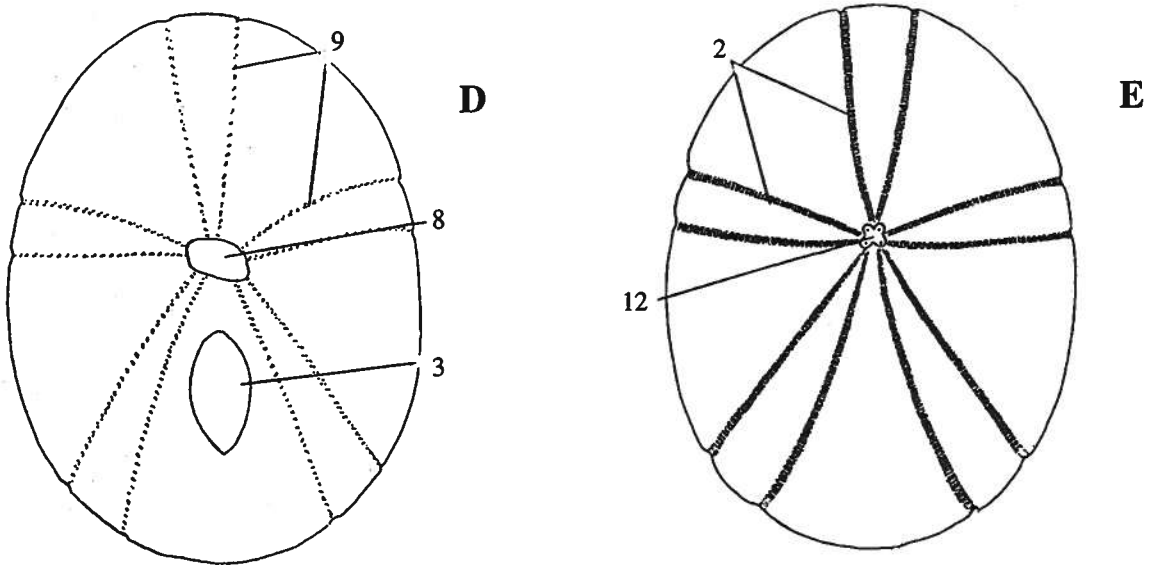


Figure 3. Irregular Urchin Test Morphology. A. *Brissopsis pacifica*, Panamic region, aboral view. B. same as A, oral view. C. *Brisaster latifrons*, side view; D. *Echinoneus cyclostomus*, oral view of test. E. same as D, aboral view. (A-E, *after Hyman*. 1955). 1. anterior ambulacrum; 2. petaloids; 3. periproct; 4. gonopores; 5. peripetalous fasciole; 6. labrum; 7. conjugated pore pairs; 8. peristome; 9. ambulacra; 10. interambulacra; 11 subanal fasciole; 12. apical center.



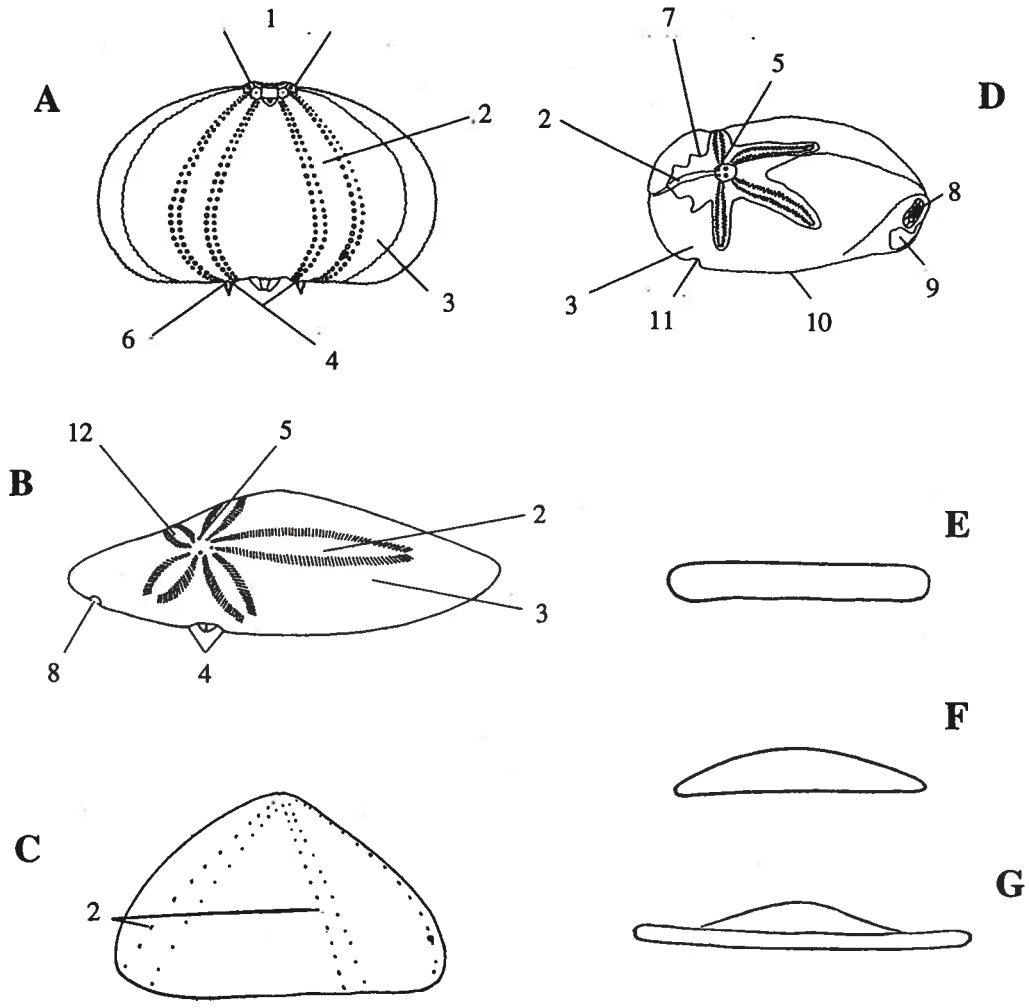


Figure 4. Test Profiles. Profiles of A. *Tripneustes gratilla* (regular urchin). B. *Brissus latecarinatus* (heart urchin). C. ovoid form of *Urechinus loveni*. D. *Clypeaster* (cake urchin). E. thick-edged, discoid form of *Echinarachnius parma* F. thin-edged, discoid form of *Laganum laganum*. G. thick-edged, discoid form with elevated center of *Peronella*. (A, B, D, *after Hiatt*, 1954; C, E, F, G, *after Hyman*, 1955). 1. apical system; 2. ambulacrum; 3. interambulacrum; 4. peristome; 5. genital pore; 6. dermal gill; 7. inner fasciole; 8. anus; 9. subanal fasciole;10. plastron; 11. mouth; 12. petal.

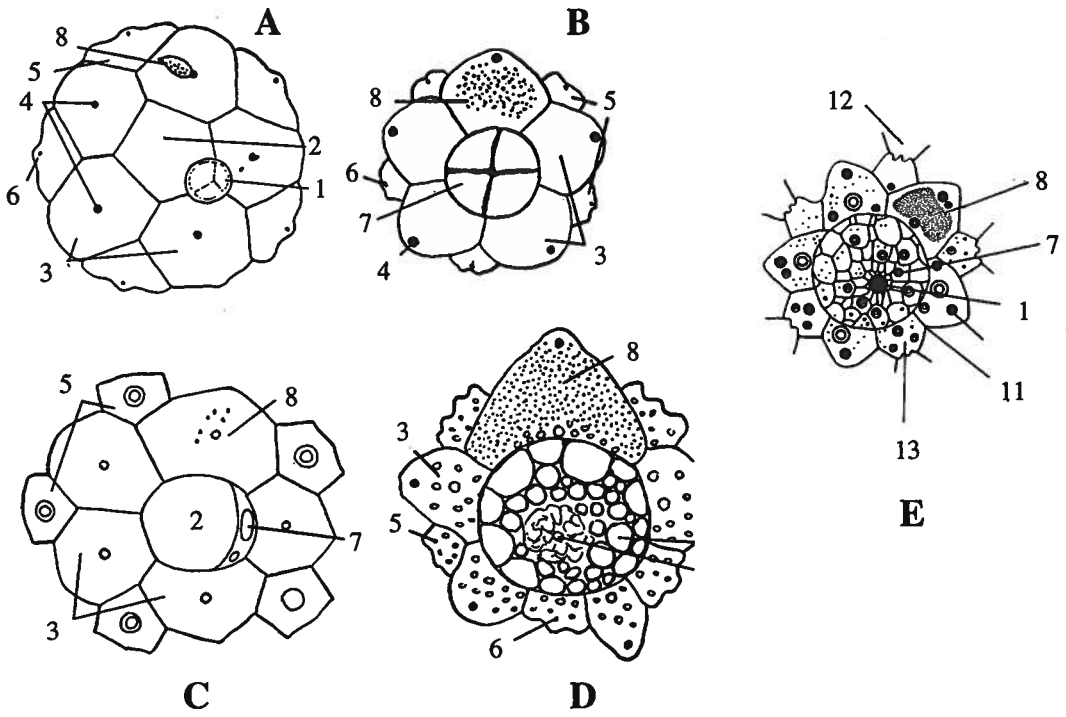
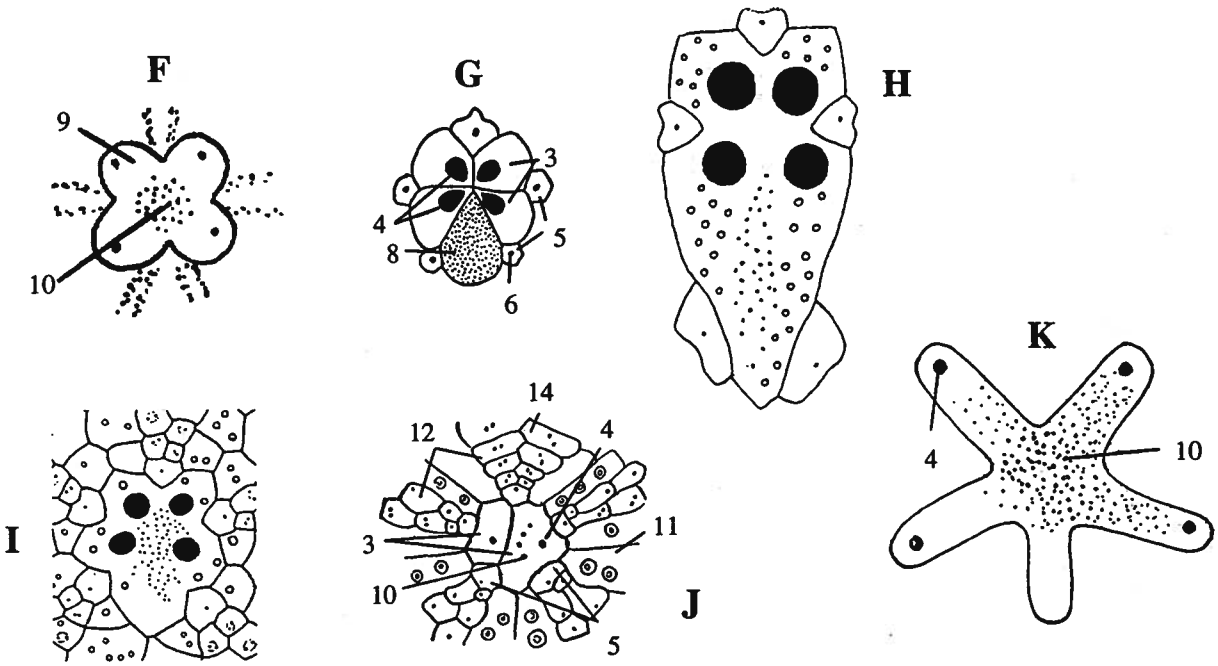


Figure 5. Periprocts and Apical Systems of A. *Salenia*. B. *Arbacia*. C. young *Strongylocentrotus*. D. same as C in adult. Apical systems of E.*Tripneustes gratilla*. F. *Echinoneus cyclostomus*. G. spatangoid *Plagiobrissus grandis*. H. *Rhinobrissus hemiasteroides*. I. *Argopatagus vitreus*. J. *Aceste*. K. *Peronella*. (A, C, *after Loven*, 1874 in *Hyman*; J, *after Loven*, 1883 in *Hyman*; B, D, F, G, K, *after Hyman*, 1955; E, H, I, *after Mortensen*, *Monogr*). 1. anus; 2. central plate of periproct; 3. genital plates; 4. gonopore; 5. terminal plates; 6. pore for terminal podium; 7. plates of periproct; 8. madreporite; 9. fused genital plates; 10. madreporic pores. 11. interambulacrum; 12. ambulacrum; 13. ocular plate; 14. anterior ambulacrum.



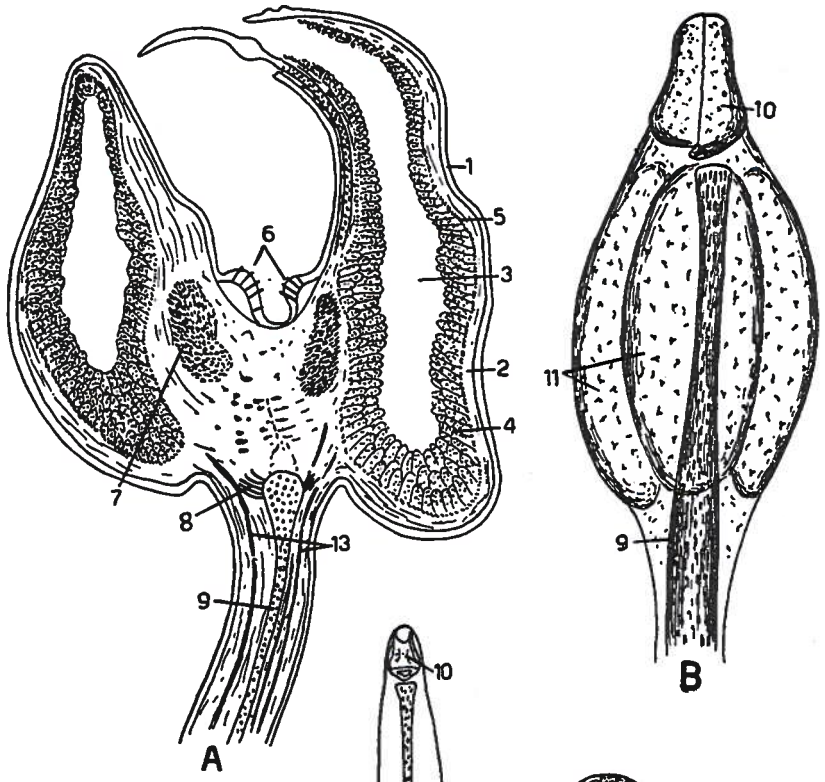


Figure 6. Pedicellariae. A. longitudinal section of a globiferous pedicellaria of *Sphaerechinus* (*after Hamann*, 1887 *in Hyman*). B. ophiocephalous pedicellaria of diadematid *Astropyga* with poison glands on stalk. C. claviform pedicellaria of diadematid *Centrostephanus*. (*after Hyman*. 1955) D. ophiocephalous pedicellaria of aspidodiadematid *Plesiodiadema*, stage of degeneration to claviform condition. (B-D, *after Mortensen, Monogr.*). E. claviform pedicellaria of *Colobocentrotus* (*after Agassiz*, 1908 *in Hyman*). 1. epidermis; 2. dermis; 3. poison sac; 4. glandular lining of poison sac; 5. muscles sheath of poison sac; 6. sensory hillock; 7. adductor muscle; 8. flexor muscle; 9. skeletal rod of stalk; 10. head of ohiocephalous pedicellaria; 11. poison glands of stalk; 12. gland aperture; 13. nerves; 14. pigment cells. 15. glands of head; 16. jaws; 17. valve or endoskeletal piece of jaws.

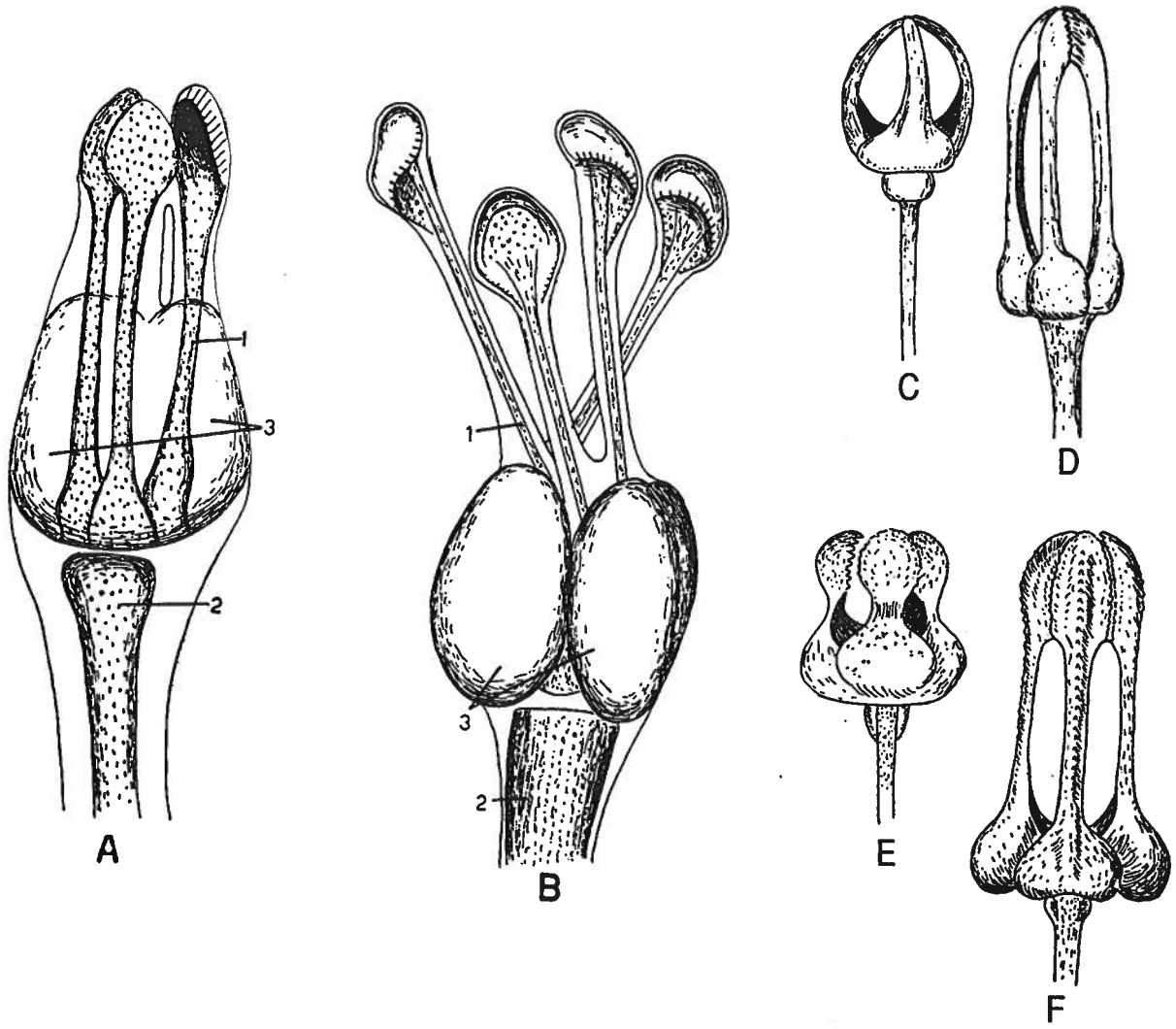


Figure 7. Pedicellariae (cont.). A. dactylous pedicellaria of *Araeosoma thetidis*. B. more advanced type of dactylous pedicellaria of *Araeosoma violaceum*. (A,B, *after Mortensen, Monogr.*) C. rostrate pedicellaria. D. tridentate pedicellaria of *Meoma*. (C,D, *after Boone, 1933* in *Hyman.*) E. ophiocephalous pedicellaria of *Clypeaster rosaceus*. F. tridentate pedicellaria of *Clypeaster rosaceus*. 1. valve; 2. skeletal rod; 3. poison sac

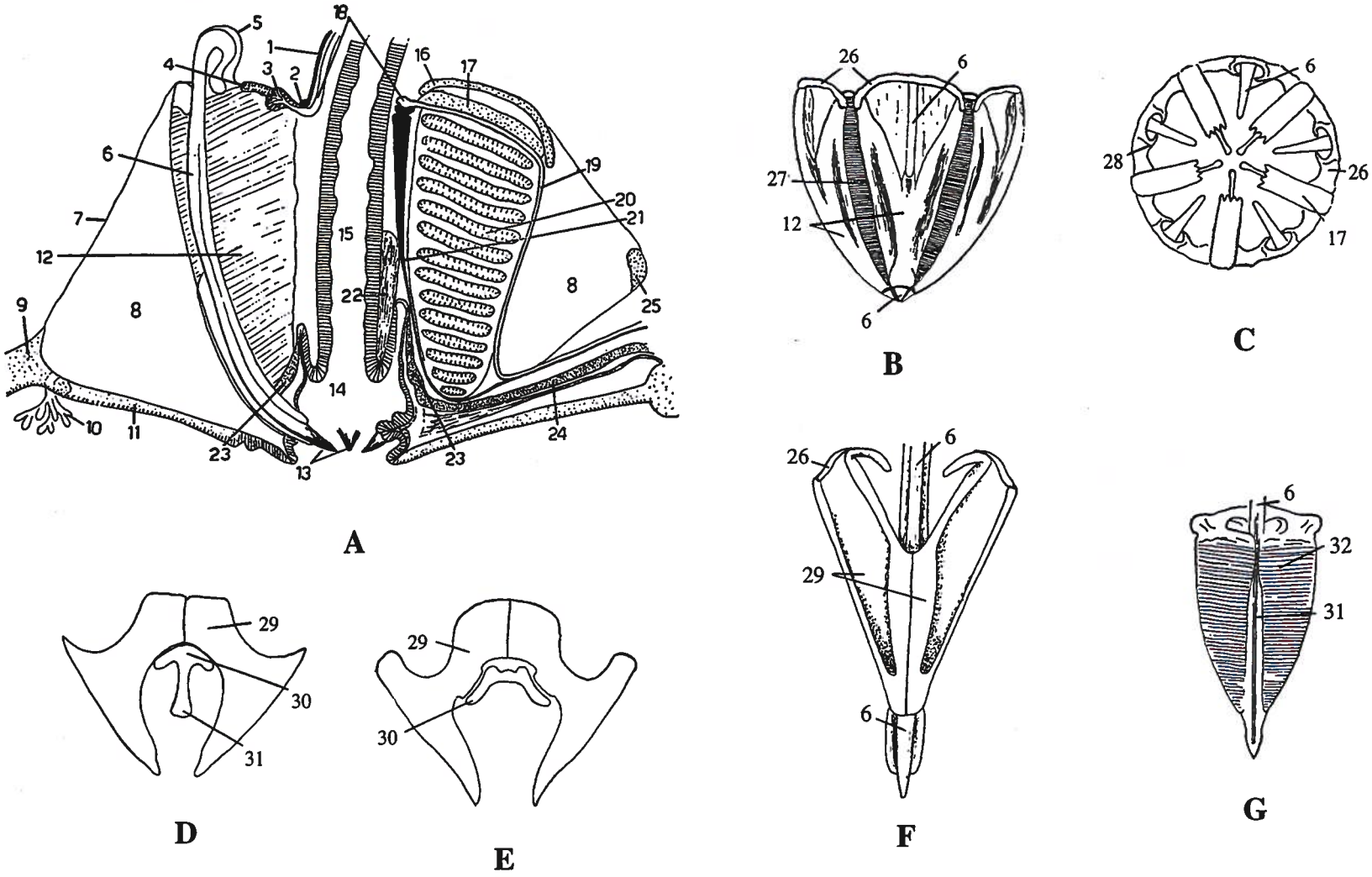


Figure 10. Lantern. A. vertical section through the lantern and peripharyngeal cavity of *Paracentrotus lividus*. B. side view of closed foramen in lantern of *Tripneustes ventricosus*, cleaned (A,B, *after Cuenot*, 1891 in *Hyman*). C. top of lantern of B, with compasses removed to show rotules (*after Hyman*, 1955). D. cross section through a pyramid, aulodont type. E. cross section through a pyramid, camarodont type. (D,E, *after Loven*, 1892 in *Hyman*). F. open foramen of diadematid pyramid showing small, separated epiphyses (*after Mortensen, Monogr.*). G. pyramid of *Tripneustes ventricosus* seen from the inside (*after Hyman*, 1955). 1. haemal channel to axial gland; 2. haemal ring; 3. spongy body; 4. compass muscle; 5. dental sac; 6. tooth; 7. coelomic membrane enclosing peripharngeal cavity; 8. peripharyngeal cavity; 9. edge of test; 10. gill; 11. peristomial membrane; 12. pyramid; 13. free ends of teeth; 14. buccal cavity; 15. pharynx; 16. compass; 17. rotule; 18. water ring; 19. radial water canal; 20. comminator muscle; 21. radial haemal sinus; 22. connective tissue support of pharynx; 23. nerve ring; 24. radial nerve; 25. piece of auricle; 26. epiphyses; 27. comminator muscles; 28. projections of epiphyses to hold tooth; 29. half pyramid; 30. section of tooth; 31. keel of tooth; 32. ridges for attachment of comminator muscles.

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ERRATA SHEET

Throughout this document, the term "military" spines are used. This should be "miliary" spines instead.