ECHINODERMATA

ESTUARINE AND BRACKISH

SCIENCE ASSOCIATION

UNIVERSITY OF STIRLING

SEPTEMBER 1982

ECHINODERMS

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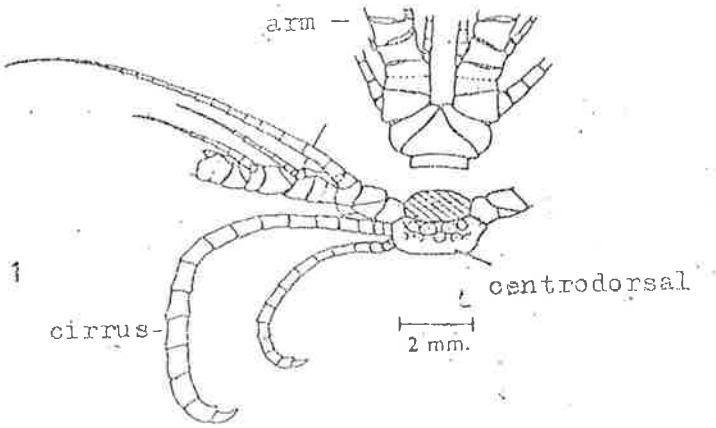
CRINOIDEA

Crinoids have five, ten or more feather-like arms attached to a small cup-shaped body. The mouth and anus are both on the upper side of the body. The lower side is, in the sea-lilies, attached to a jointed stalk. The feather-stars, on the other hand, spend a brief juvenile period attached to a stalk and then become free-living. The lower side of the body then consists of a large calcareous plate, the centrodorsal, and this bears a number of slender, jointed appendages, called cirri, with which the feather star holds on to convenient objects. In British seas there are two species of feather-star but no sea-lilies.

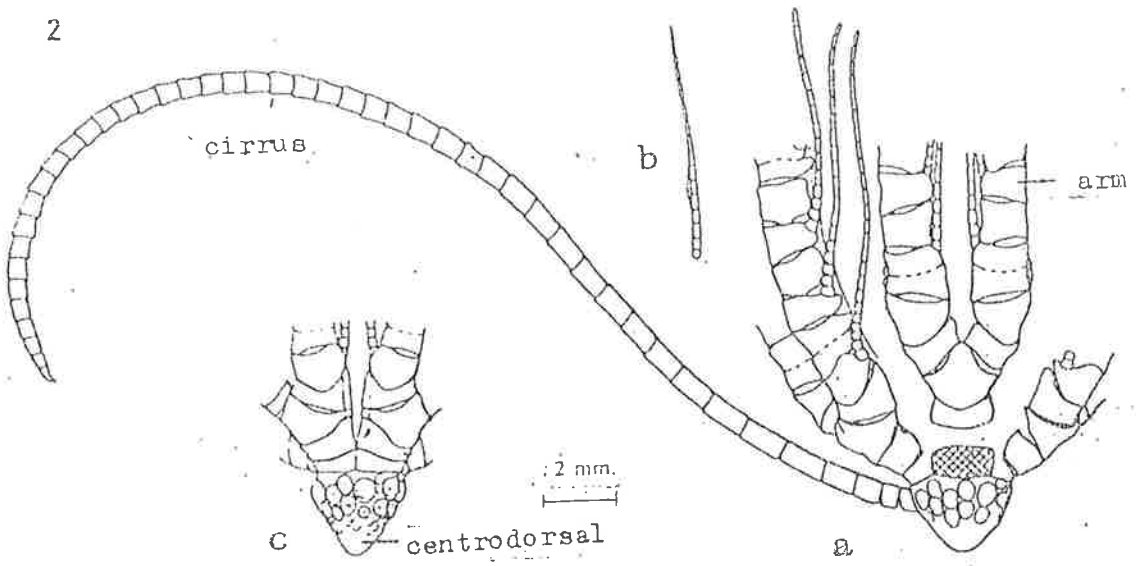
KEY

1. Cirri short, the longest having 14-17 joints; centrodorsal flattened (fig. 1) . . . Antedon bifida
   10 arms; colour red, purple, orange or yellow. Subtidal down to 200 m; southwest, west and northeast coasts.

   Cirri long, having 40-50 joints; centrodorsal conical or broadly truncated (fig. 2) . . Leptometra celtica
   10 arms. Depths of 70 to more than 200 m; west coasts of Scotland and Ireland.



Antedon bifida (Pennant)



Leptometra celtica

CLASS ASTEROIDEA

Free living seastars with a flat, star-shaped or pentagonal body, with five or more arms radiating out from a central disk (Fig. 1). The boundary between arm and disk is often not easy to define. The mouth is on the underside and the anus, if present, is on the upper surface. The distance from the mouth to the arm tip is termed R whilst the interradius measurement is termed r.

Along each arm on the ventral (under) side is the ambulacral furrow (Fig. 2) containing the tube feet, which may be pointed or have a sucking disk at their tip. The tube feet extend between the ambulacral plates which form the 'arch' of the furrow. Occasionally a supraambulacral plate is found above the ambulacral plate (e.g., in Astropecten). Lining each side of the ambulacral furrow are a series of distinct adambulacral plates which support a series of adambulacral spines which are of great taxonomic significance.

Along the margins of the arms are found the infero-marginal and superomarginal plates usually covered in fine granules or spines of varying size. In some species an actinal plate may be found between the adambulacral plate and the infero-marginal plate.

The dorsal (upper) surface is covered with a series of calcareous plates. These calcareous plates support spines which may be in groups or bundles and are called paxillae. Extending between the spines are delicate tubes, the papulae which function as gills.

In most sea stars, pedicellariae are found, the various types being found in Fig. 3. In their simplest form, they consist of 2-4 spines articulating together and in more advanced forms they consist of pincer type mechanisms.

KEY

1. Marginal plates large, usually distinct, sometimes covered by skin; tube feet in 2 series 3

   Marginal plates inconspicuous; tube feet in 2 or 4 series . 2

2. Crossed pedicellariae present (fig. 3); spines of upper side usually single; tube feet in 4 series . . . 13

   Pedicellariae rare, never of crossed type; spines of upper side usually in groups; tube feet in 2 series . 7

3. Tube feet pointed, no sucking disc 4

   Tube feet with sucking disc 6

4. Both rows of large marginal plates obvious; those of the lower row each have 4 or 5 large spines which form fringe around whole body (fig. 4) . . Astropecten irregularis
   5 fairly short arms; colour pinkish or yellowish. Max. diam. 20 cm. Shallow water to more than 200 m depth, in sand. All round British Isles.

   Only lower row of marginal plates obvious, all with spines; upper row of plates paxilliform (see above) . . . 5

5. 5 arms; lower marginal plates bear 3 (rarely 4) spines each . . . . . Luidia sarsi
   Colour reddish brown. Max. diam. 34 cm. Shallow water to more than 200 m; all round British Isles.

   7 arms; lower marginal plates have 4 or 5 spines each (fig. 5) . . . . . Luidia ciliaris
   Colour red. Max. diam. 60 cm. Shallow water to more than 200 m; south, west and northeast coasts.

6. Marginal plates large and distinct; edge of disc vertical; upper side and marginal plates bear thick spines . . . . . Hippasteria phrygiana
Disc large, arms short; colour red. Max. diam. 40 cm. Depths of 20 to more than 200 m; west north and northeast coasts, rare.

Marginal plates less distinct, partly overlapping; disc sharp-edged, with fringe of fine spines; upper surface with thick smooth skin and no spines . Porania pulvillus
Disc large, arms short; colour red or yellowish, spotted or mottled. Max. diam. 12 cm. Shallow water to more than 200 m, on sand; south, west and northeast coasts.

7. Body flattened to give sharp edge between upper and lower sides 8

No sharp limit between upper and lower sides . . 9

8. Body very thin with a crestlike thickening along each ray (fig. 6) . . . Anseropoda placenta
Shape pentagonal, colour red on upper side, yellow on lower. Max. diam. 20 cm. Shallow water to 200 m; south, west and northeast coasts.

Body not very thin; no crest along rays . Asterina gibbosa
Body starshaped, with very short arms; upper side slightly swollen; colour greenish, yellowish or brownish. Max. diam. 6 cm. On or under stones, shore and shallow water; all round British Isles.

9. Small disc, 5 long arms (rarely 6 or 7) . . . 10

Large disc, at least 7 arms, usually 9 or more . . 12

10. Spines rather coarse, single . Echinaster sepositus
Usually 5 arms, occasionally 6 or 7; colour scarlet; soft kin covers body and most spines. Max. diam. 14 cm. Shallow water to more than 200 m; Brittany.

Spines very fine, in small groups 11

11. Spines end in crown of long thorns, not covered by skin (fig. 9) . . . Henricia sanguinolenta
5 arms, colour red, tips of arms usually white. Max. diam. 20 cm. Shallow water to more than 200 m; northwest, north and northeast coasts.

Spines have rather blunt ends with irregular points (fig. 8) and are covered with thick skin . Henricia oculata
5 arms, colour red, orange or yellow. Low water to about 100 m, on coarse sand and gravel; south and west coasts, Irish Sea.

12. Marginal paxillae (see p. 2) are long, obvious and in a single row round the edge of the body . Crossaster papposus
8 to 13 arms, colour variable, disc usually purplish red, arms whitish with broad red transverse band, underside whitish. Max. diam. 38 cm. Shallow water to 100 m, on coarse sand and gravel; all round British Isles.

Marginal paxillae are small, inconspicuous and in two rows, the upper much smaller than the lower . . . . . Solaster endeca
7 to 13 arms, colour yellowish red or violet. Max. diam. 40 cm. Shallow water to more than 200 m; west, north and northeast coasts. Not in Channel.

13. Upper side has groups of granules or small spines . . . . . Stichastrella rosea
5 long tapering arms, colour orange, reddish or yellowish. Max. diam. 30 cm. Shallow water to more than 200 m; west, north and east coasts.

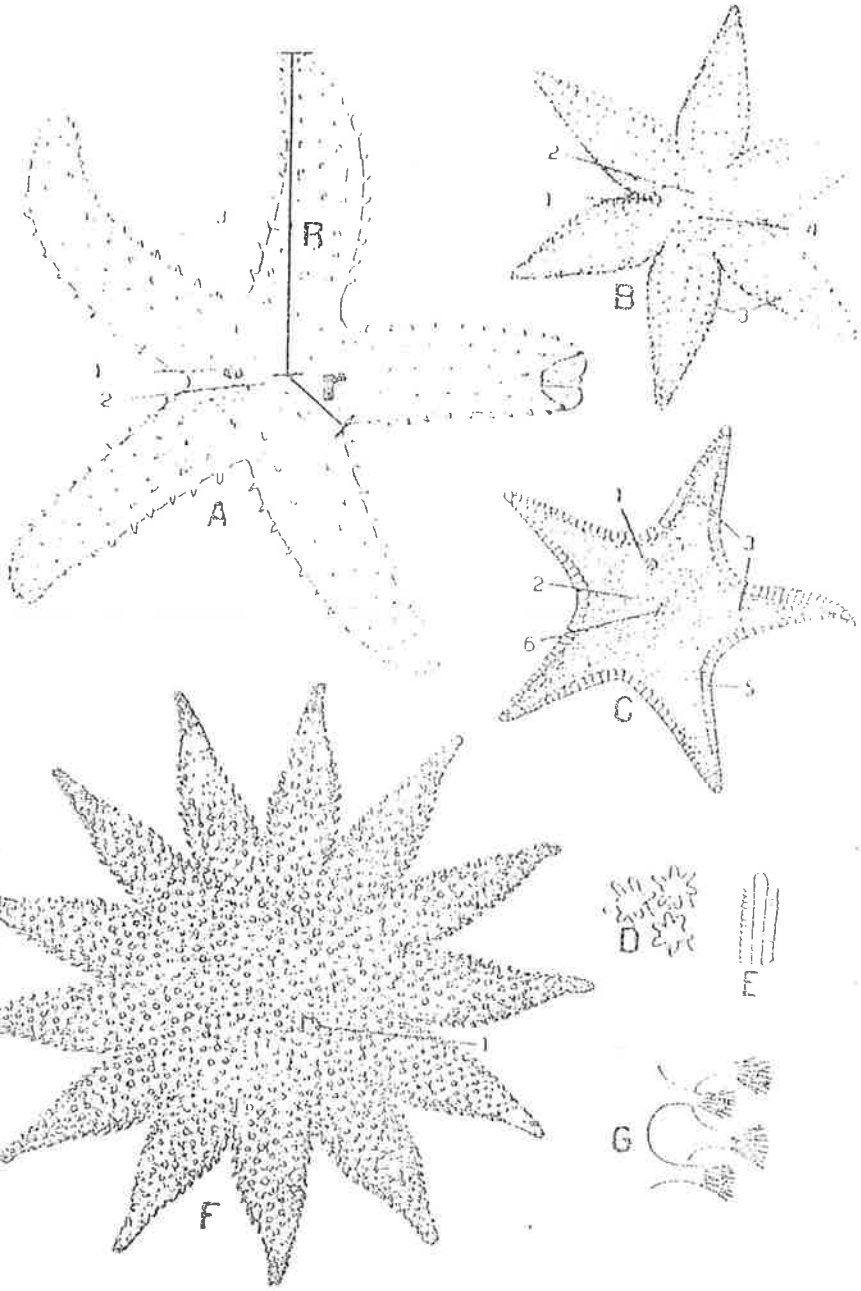
Upper side has single spines 14

14. Spines along edge of ambulacral grooves in very regular single series . . . . Marthasterias glacialis
Small disc, long tapering arms; three conspicuous series of large spines on upper side of arms, colour greenish, yellowish, orange or reddish. Max. diam. 70 cm. Shore to 200 m; southwest and west coasts.

Spines in two series along edge of ambulacral grooves, at least on outer parts of arms 15

15. Upper side rather soft, with fairly large naked spaces between the spines; these spaces are occupied by several small, delicate papulae; the spines are irregularly arranged except for a fairly regular row along the midline of each arm . . . . . Asterias rubens
Usually 5 arms, sometimes more; arms broad at base, tapering to tip. Colour reddish brown, orange or violet, with paler spines. Max. diam. 54 cm. Shore to more than 200 m; very common all round British Isles.

Upper side firm, with only small naked spaces and one or two papulae between the spines; spines irregularly arranged . . . . . Leptasterias muelleri
5 arms, broad at base and tapering to tip; colour reddish or violet, arm tips whitish. Shore to more than 200 m; western Ireland, Irish Sea, west and north Scotland. Max. diam. 20 cm.



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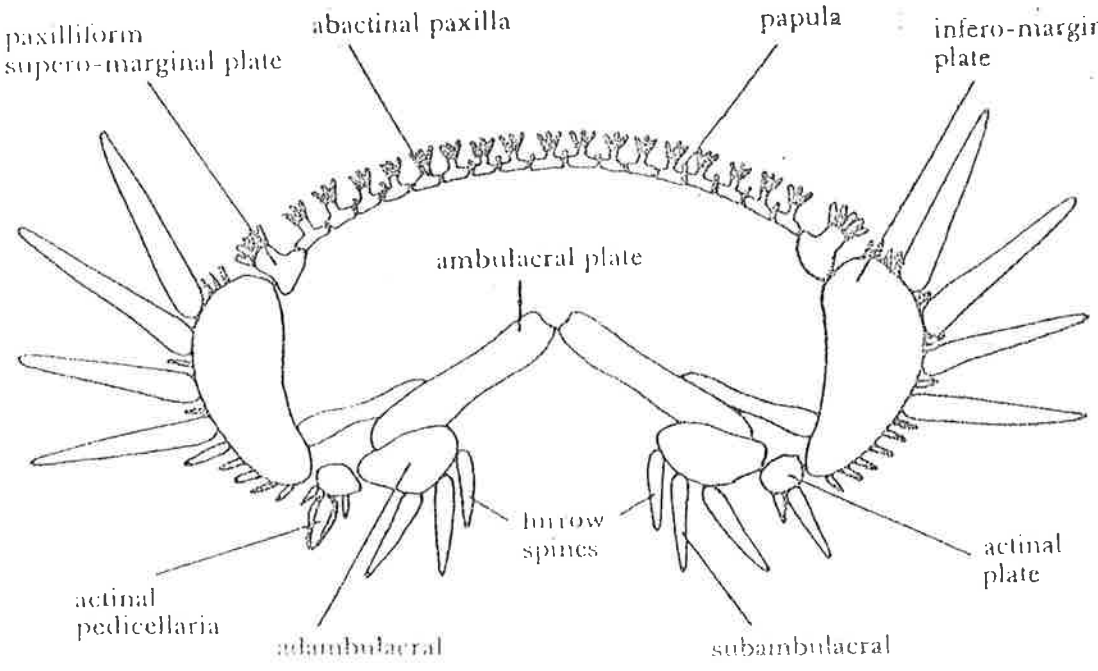

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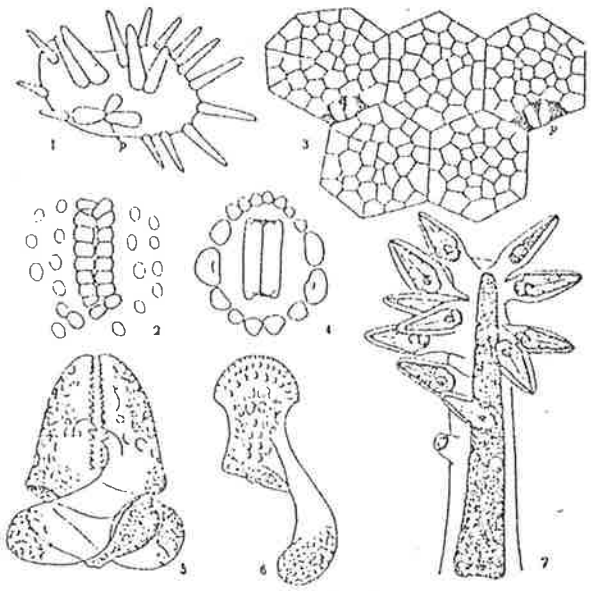
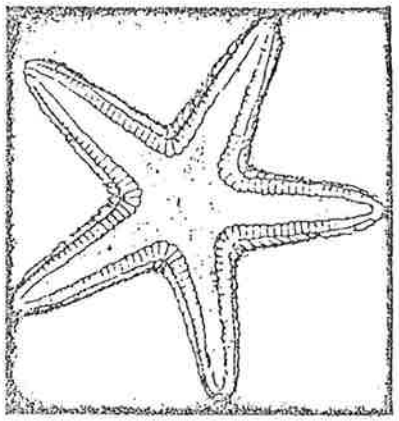


—Various sorts of pedicellariæ of Asteroids.
(From *Danmark's Fauna.*)

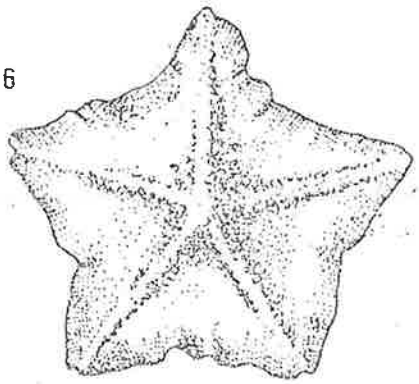
1. Simple type (*Pontaster tenuispinus*). × 13. 2. Pectinate pedicellaria (*Pseudechinaster Parelii*). × 13. 3. Paxilla-like groups of grains from the dorsal side of *Ceramaster granularis*, with two valvate pedicellariæ. × 13. 4. Bivalve pedicellaria of *Hippasteria coccinea*. × 6. 5. Crossed pedicellaria of *Asterias rubens*. × 120. 6. Valve of the same, seen from the inside. × 120. 7. Group of straight pedicellaria on an adambulacral spine of *Asterias rubens*; the small, lowermost one just beginning to form. × 10. Pedicellaria.

4



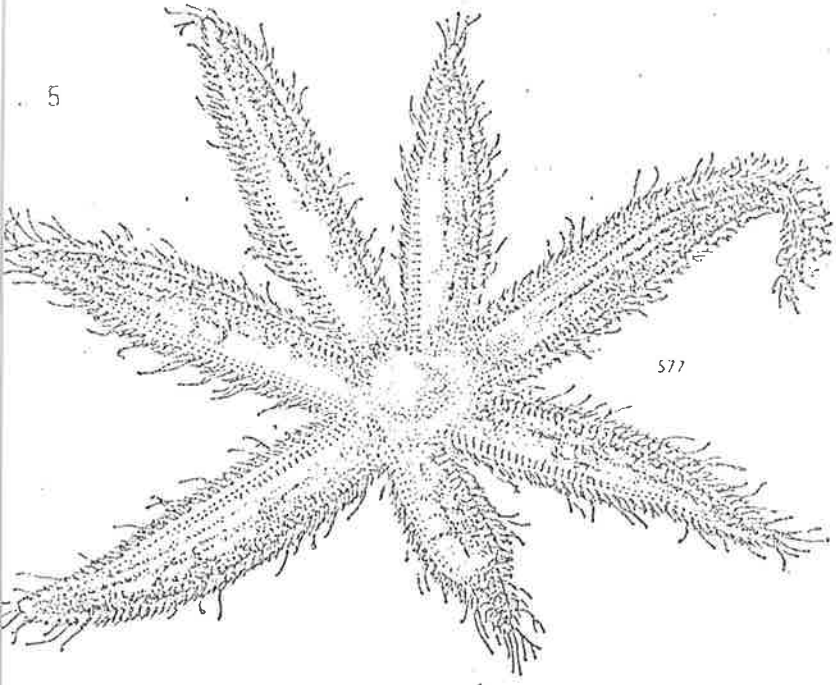
—*Astropecten irregularis*. Dorsal side.

6



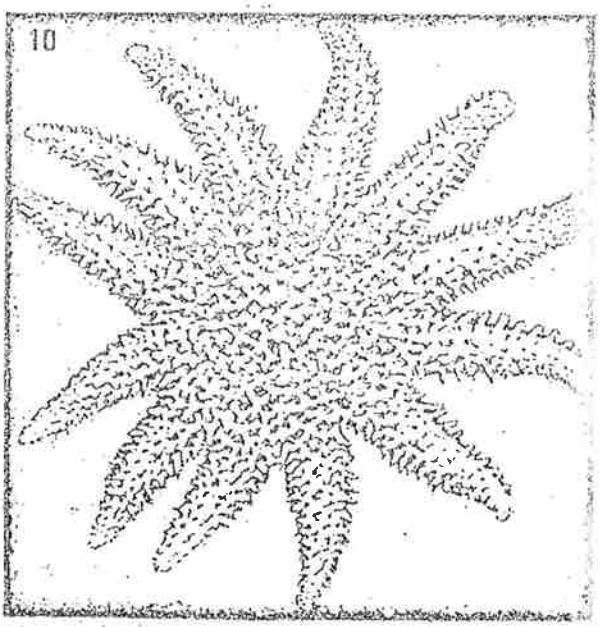
Anseropoda placenta

5



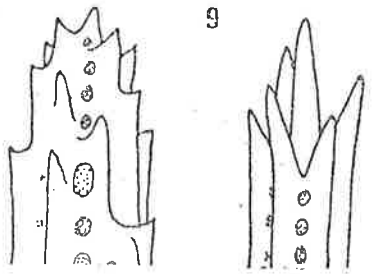
Luidia ciliaris

10



—*Solaster* (*Crossaster*) *papposus*, dorsal side.

8 9



Spine tips of

Henricia oculata

Henricia sanguinolenta

CLASS OPHIUROIDEA.

The Ophiuroids are the largest group of living echinoderms, comprising some 1800 spp. In British seas they usually occur sublittorally or in the lower intertidal as epifauna on rock or soft substrata and also as an infaunal component of soft substrates, in truly marine areas.

Morphologically the adult consists of a dorsal flattened flexible disk which on the ventral side surrounds a rigid oral frame. Attached to the oral frame and proximally covered by the dorsal flexible disk are five thin, articulate arms extending horizontally. In many species these arms break off easily, hence the common name brittlestar.

The dorsal (upper) surface of the disk has no apertures (as found in other echinoderms) but is covered above and below with overlapping scales among which the primary central, radial (and interradial) plates of the newly metamorphosed young may still be distinct usually leaving bare a pair of more or less conspicuous radial shields opposite the base of each arm. These scales may be naked (e.g., Ophiuridae, Amphiuridae), or armed with thorny stumps or spinelets (e.g., Ophiacanthidae, Ophiotrichidae) or coated with granules (e.g., Ophiocomidae). In some Ophiuridae the arm comb, a row of papillae, are found at the disk edge at the base of each arm.

The ventral (under) side of the disk contains a central mouth leading to the stomach. Food is ingested through the mouth and undigested remains are egested by the same route. The mouth is divided by five interradial jaws consisting of a pair of angled oral plates crowned by a dental plate. At the apex of the jaw are the teeth. These structures may occur as a complete vertical row (as in Ophiura) or be partially replaced by a cluster of tooth papillae covering the teeth (as in Ophiothrix). In other families single (e.g., Ophiuridae) or paired (e.g., Amphiuridae) infra dental oral papillae crown the apex of the jaw superficial to the ventral-most tooth.

Along the jaw edge, leading to the jaw angle, are found oral (or mouth) papillae (except in Ophiotrichids). The apical oral papillae arise from the oral plates.

Moving from the jaw apex to the inter radius, behind the oral plates is a superficial pair of adoral shields. These shields usually lie proximal to the oral shield which is the largest plate in each ventral interradius. One of these oral shields is modified as the madreporite. At the radial jaw angle the first plate to occur in the adult is the first ventral arm plate inclined into the oral slit and therefore nearly always integrated into the oral structure. The first tube foot (tentacle) and usually the second one arise on the side of the oral plate within the mouth slit. However, as in Ophiura, the second tube foot may or may not be superficial; it is guarded by one or more oral tentacle scales (except in the Ophiotrichidae). Lying along either side of the arms on the ventral side of the disk is a genital slit occasionally lined abradially with genital papillae.

The arms consist of a series of concealed vertebrae each bearing a pair of lateral arm plates and single superficial dorsal and ventral arm plates that outwardly form a set of four plates from an arm segment. The distal edge of the lateral plates is fringed with a series of spines varying in both number, shape and size. On each side of the ventral plate lies the tube foot pore which may or may not possess one or more tentacle scales.

KEY TO BRITISH FAMILIES

1. Arms move mainly horizontally. Articulation of arm vertebrae by pits and processes. Distinct scale covering on disk and arms. Arms simple.

2 Arms move vertically. Articulation of vertebrae by means of hour glass shaped surface. No distinct scale covering. Arms simple or branched.

6

2.	Arm spines oppressed, disk scales distinct.	*F. OPHIURAE*	p. 3.
	Arm spines erect.		3
3.	Tooth papillae present.		4
	No tooth papillae but a complete vertical row of teeth.		5
4.	Mouth papillae present.	*OPHIOCOMIDAE*	p.6.
	No mouth papillae present.	*OPHIOTRICHIDAE*	p.7.
5.	Single infra-dentral pappila on apex of jaw.	*OPHIACTIDAE*	p.8
	Pair of infra-dentral papillae on apex of jaw.	*AMPHIURIDAE*	p9.
6.	Arms branched. Hooks on outer part of arms.	*GORGONOCEPHALIDAE*	p12
	Disk large. Slender arms.	*ASTRONYCHIDAE*	p12.

CLASS OPHIUROIDEA

ORDER OPHIURIDA

1. *OPHIURAE.*

Scales on both sides of disk. Mouth papillae form a continuous series. Single vertical row of teeth. Appressed arm spines. Single or double combs at base of arm. Second tentacle pore inside or outside mouth edge.

1.	Single arm combs form a continuous series across the base of arm.	*OPHIOCTEN SERICEUM*
	Outer arm combs do not form a continuous series across the base of arm.	2
2.	Ventral plates in proximal part of arm separated by paired pores. Numerous papillae in arm combs (c.30).	*OPHIURA OPHIURA* (lacertosa)
	No pores between proximal ventral plates. 7-15 papillae in outer comb.	3

3. One or two small tentacle scales, ventral plates widely separated.

4

Three or more tentacle scales. *OPHIURA ALBIDA*

4. Only 3 mouth papillae on jaw. The outer one is very broad (operculiform). Inner arm comb meets in centre of arm. Dorsal arm plates broad and roof shaped. *OPHIURA AFFINIS*

3 or 4 small mouth papillae in jaw. Poorly developed arm combs. *OPHIURA ROBUSTA*

Ophiura ophiura (L 1758) (often called *O. texturata*).

[Mortensen 1927, p.236].

Disk up to 35mm diameter, usually about 25-30mm. Primary plate distinct. Radial shields large = 1/2 disk radius; just touching above innermost dorsal arm plate. Dorsal side of disk red/brown in life. Two layers of arm combs above each arm. Outer comb consists of about 30 fine papillae. Proximal ventral arm plates separated by a pair of pores in mid-line of arm. Mouth shields long, occupying 2/3 rds of distance from disk edge to adoral plate. 4-6 mouth papillae. Ventral side of disk pale. Common all round Britain. Mainly sublittoral on a variety of soft substrata.

Ophiura albida Forbes. 1841

[Forbes 1841, Mortensen, 1927, p.238].

Disk up to 12mm diameter. Dorsal surface red/brown in life. Primary plates not distinct. Radial shields small. Innermost dorsal arm plated heart-shaped. Outer arm of 10-12 short, stout spines. Inner comb indistinct. Dorsal and ventral arm plates with convex outer edge. 3 arm spines equidistant from each other. Spines equal to 1/2 lateral plate length. Mouth shield small approximately 1/3rd disk radius. 3-5 simple mouth papillae. Common all round Britain. Mainly sublittoral or a variety of soft substrata.

Ophiura affinis Lutken 1855

[Lutken 1858, p.45; Mortensen, 1927, p.244].

Maximum disk diameter 8.0mm. Primary plates conspicuous. Radial shields small, wholly separate, similar in size to central plate. Second tentacle pore with only two tentacle scales. Outermost mouth papillae broad. Occasionally rudimentary arm combs may meet across base of arm. Occurs on muddy sand, fine shell and gravel (Taylor, 1958).

Ophiura robusta (Ayres 1851)

[Ayres, 1851, p.134; Mortensen, 1927, p.242].

Disk diameter 10mm maximum. Scales of aboral surface uniform in size. Radial shields very small and wholly separated. Arm combs consist of stunted papillae and side of arm base. Dorsal arm plates with strongly convex outer edge. Ventral plates have shallow concavity on outer edge except first ventral plate, which has three shallow concavities on outer edge. Three arm spines, the lower two short, the upper long and stout. Short broad mouth shields and three or four mouth papillae. Found on a variety of substrata in the northern half of the British Isles.

Ophiocten sericeum (Forbes 1852)

[Forbes, 1852, p.CCXV; Mortensen, 1927, p.247].

Maximum size 18mm. Dorsal disk surface covered by fine scales which expose primary plates and widely separated radial shields. Proximal dorsal arm plates with fine papillae along outer edge. Disk edge above the arm base also carries a row of short spines. Ventral plates very short and broad. Mouth shields almost broad as long, 4-5 mouth papillae.

This species is a cold water species found in the arctic and deeper water to the west of the British Isles.

The other common members of this family viz. *Ophiura ljungmani* (Lyman),

Ophiura carnea M. Sars, *Ophiopleura aurantiaca* (Verrill), and *Ophiomusium lymani* are only found in deep water off the west coast of Ireland and Scotland.

2. *OPHIOCOMIDAE*

Disk covered with granules completely covering scales and radial shields. Erect arm spines. Well developed dorsal and ventral plates. Mouth papillae. Tooth papillae over a series of strong teeth. 2nd pair of tube feet inside mouth edge.

1. Disk granulated. Tentacle scales simple. *OPHIOCOMINA NIGRA*

   Disk not granulated. Inner tentacle scale elongated crossing that of opposite tentacle scale. 2

2. Arm spines 7 (6-8) flattened and blunt, not overlapping except for longer ventral one. Radial shield distinct, small and widely separated. Inner tentacle scales as long as arm joint. *OPHIOPSILA ARANEA*

   Arm spine very variable, 10-12. Latero-ventral spines slender cylindrical. Latero-dorsal spines flattened and overlapping. Radial shields not visible externally, wholly covered by scales. Inner tentacle scale almost twice as long as arm joint *OPHIOPSILA ANNULOSA*

Ophiocomina nigra (Abildgaard 1789)

[Mortensen, 1927, p.178].

Disk up to 25mm diameter. Colour in life black to grey occasionally red. Fine scales on dorsal disk surface completely covered by granules. Granules cover only part of ventral interradius. Mouth shields oval, 10-15 tooth papillae over single vertical row of teeth. Four long, thin mouth papillae. Two tentacles scales, outer one larger. 5-7 smooth arm spines.

Common on all south and west coasts and occasionally in the North Sea (Ursin, 1960). Occurs mainly on stones or rock. Rheophilic.

Ophiopsila aranea Forbes. 1843

[Forbes 1843 , Mortensen, 1927, p.180].

Elongated tentacle scale equal to one arm joint. Spines short and flat with first arm spine equivalent to one arm joint.

Ophiopsila annulosa M. Sars. 1857

[M. Sars 1857 , Mortensen, 1927, p.181].

Elongated tentacle scales twice arm joint length. Spines long and flat with first ventral spine longer than arm joint.

3. *OPHIOTRICHIDAE*.

Large conspicuous radial shields. Spines and thorny stumps cover remainder of dorsal surface of disk. Dorsal and ventral arm plates well developed. Well developed tooth papillae. No mouth papillae. Second pair of tube feet inside mouth edge. Thorny erect spines.

Ophiothrix fragilis (Abildgaard in) [in O.F. Muller].

[Abildgaard 1789 , Mortensen, 1927, p.176].

Up to 20mm disk diameter showing great colour variation. Large naked conspicuous radial shields; 2/3rd disk radius. Remainder of dorsal disk covered with spines of thorny stumps - also occur on ventral disk interradius. Keel on naked dorsal arm plates. One small tentacle scale. C. seven, often serrate, arm spines. Gonads expand ventral side of disk between arms.

This species show great variation and four varieties have been proposed but intermediate stages occur between these varieties (Koehler, 1924).

Very common all round Britain in lower littoral and sublittorally on

suitable hard bottoms including some sand/shell sediments. Rheophilic.

The closely related *Ophiothrix luetkeni* is found in 150+m off the west coast of Ireland.

4. *OPHIACTIDAE*.

Scales visible through spines and granules of dorsal disk surface. Mouth papillae. Single series of square teeth overlain by an infra dental papillae (absent in occasional species of *Ophiactis*). Second pair of tube feet inside mouth edge. Short, erect spines.

1. Each dorsal arm plate surrounded by small plates. *OPHIOPHOLIS ACULEATA*

Dorsal plates not surrounded by small plates. 2

2. One mouth papilla on either side of jaw. *OPHIACTIS BALLI*

Two mouth papillae on either side of jaw. *OPHIACTIS ABYSSICOLA*

Ophiopholis aculeata L 1767

[Mortensen, 1927, p.204].

Up to 20mm disk diameter (usually < 15mm). Colour in life variable, especially red and purple.

Radial shields concealed. Primary plates obvious surrounded by granules and blunt spines - continue onto ventral side. Dorsal arm plates oval, surrounded by ring of small plates. 6-7 arm spines. Ventral arm plates rectangular. Three mouth papillae. Infradental papillae small. Wedge shaped truncated vertical row of teeth.

Common round most of Britain although rarer in the south. Occurs in areas of stone and shell.

Ophiactis balli (Thompson. 1840)

[Mortensen, 1927, p.200].

Small disk c.5mm diameter of variable colour, but especially reds occur. Some colour banding of the arms is seen.

The radial shields are small, separate; the remainder of the dorsal disk surface is covered by small scales. Spines occur along disk edge and on ventral interradii. Mouth shields small. Single distal mouth papilla each side. Single series of teeth overlain by single infradental papilla. Dorsal arm plates rounded triangles and joined. Ventral arm plates rounded with obtuse inner angle. One large tentacle scale. 4-5 conical arm spines.

Found sublittorally off south and west coasts, especially in small crevices in stones and shell, and also between the membranous layers in *Chaetopterus*.

Ophiactis abyssicola (M. Sars 1861)

[M. Sars 1861 ; Mortensen, 1927, p.202].

Up to 9mm disk diameter, red in colour. Dorsal disk with coarse scales, with occasional spines. Large radial shields. Two broad distal mouth papillae on either side of jaw. Infradental papillae heart-shaped.

This species has only been recorded from depths greater than 125m to the west of Ireland.

5. *AMPHIURIDAE*

Single distal mouth papilla on each side of jaw, well separated from infradental papillae. If a second papilla occurs with the oral tube foot, it is within the oral slit. Arms long, fine and very flexible.

1. One distal mouth papilla on either side of jaw not contiguous with infradental papillae. 2

   Two outer mouth papillae on either side of jaw, contiguous with infradental papillae the outermost very broad. *AMPHIPHOLIS SQUAMATA* FIG. 19

2. Scales on ventral side and margin of dorsal side of disk

thickened and tubercule form. Radial shields with a transverse furrow. (view dry!) *ACROCNIDA BRACHIATA* Fig 20

Scales smooth. No transverse furrows on radial shield. 3

3. Underside of disk wholly covered with scales. Two tentacle scales. *AMPHIURA CHIAJEI* Fig 23

Underside of disk partly or wholly naked. No tentacle scales. 4

4. Dorsal side of disk wholly scale covered. Outer mouth papillae conical. *AMPHIURA FILIFORMIS* Fig 22

Dorsal side of disk nearly naked (scaling reduced to a patch, proximate to each pair of radial shields). Outer mouth papillae, small, scale-like. *AMPHIURA SECURIGERA* Fig. 24

Axiognathus (formerly *Amphipholis) squamata*(D. Chiaje 1828) [Mortensen, 1927, p.221].

A very small ophiuroid ca. 5mm disk diameter greyish in colour. Dorsal disk surface covered by small scales. Radial shields equal 1/3rd disk radius and are joined for almost entire length. Dorsal arm plates rounded, triangular, broader than long in proximal part of arm. Ventral plates triangular, truncated at proximal apex. 3-4 short, conical arm spines. Mouth shields rhombic broader than long. Outer mouth papillae very broad.

This species occurs commonly all round Britain in both the mid and lower littoral and sub-littoral. Found mainly in shell gravel and occasionally on sandy bottoms.

Acrocnida brachiata (Montagu 1804) [Mortensen, 1927, p.218].

Disk diameter up to 12mm with very long, thin flexible arms. Brown-grey in colour. Dorsal surface covered by fine scales with small primary plates and separate small radial shields. Ventral scales thickened and tubercular. Mouth shields diamond-shaped. Outer mouth papilla broad and scale-like. Two infradental papillae cover teeth. Dorsal arm plates rhombic. Ventral arm plates truncated pentagonal with marked median longitudinal keel in proximal part of arm with a lateral small keel on either side. Two large tentacle scales in proximal part of arm. Up to 12 arm spines.

Lives littorally and sub-littorally in fine sand (Ursin, 1960) buried in the sediment with only the distal parts of the arms protruding. Common where substrate is suitable, e.g. Salcombe Estuary, Devon (littoral) (M.B.A., 1957) and on western edge of Dogger Bank (sublittoral)(Ursin, 1960).

Amphiura chiajei Forbes. 1843

[Forbes 1843 ; Mortensen, 1927, p.212].

Disk diameter up to 11mm with long, fine arms. Disk covered with fine scales on both dorsal and ventral sides. Primary plates distinct. Radial shields separate or just contiguous distally. Outer mouth papillae broad and flat. Ventral arm plates slightly sculptured. Mouth shields rhombic. 4-6 arm spines. Two large tentacle scales.

A. chiajei is a deposit feeder (Buchanan, 1967) living especially in muddy substrata (Thorson, 1957).

Madsen (1971) suggests that *Acrocnida* is only a subgenus of *Amphiura* and that *Acrocnida brachiata* and *Amphiura chiajei* are very closely related with only the thicker ventral scales and more pronounced sculpturing on the ventral arm plates distinguishing *Acrocnida brachiata* from *Amphiura chiajei*.

Amphiura filiformis (O.F. Muller. 1776)

[Mortensen, 1927, p.214].

Disk, red-grey in colour up to 10mm with long, fine arms. Disk covered with fine scales not extending to the ventral interradius. Radial shields usually separate, but may join at base. Mouth shields rounded pentagons. Outer mouth papillae conical, spine-like. Dorsal arm plates oval. Ventral arm plates square with convex outer edge with a small median keel. 5-7 arm spines, the second from bottom blunt. No tentacle scales.

Common sublittorally all round the coast in suitable muddy sand substrates This species is a suspension feeder (Buchanan, 1967).

Amphiura securigera Duben and Koren. 1846

[Duben and Koren, 1846, ; Mortensen, 1927, p.217].

Maximum disk diameter 5mm. Disk almost wholly naked. Scales proximate to radial shield pairs. Triangular mouth shields. Radial shields long, narrow, parallel and contiguous in their whole length. Second arm spine from below is axe-shaped.

ORDER PHRYNOPHIURIDA

1. *GORGONOCEPHALIDAE.*

Gorgonocephalus caputmedusae L 1758

[Mortensen 1927 p162]

Disk diameter up to 90mm. Disk covered with numerous short stumpy conical spines. Radial shields rib-like prominent. Repeatedly branching arms covered with fine grains but for segmental rings of minute hooklets. Disk appears to overly first arm fork.

Usually found in water deeper than 100m.

ASTERONYCHIDAE

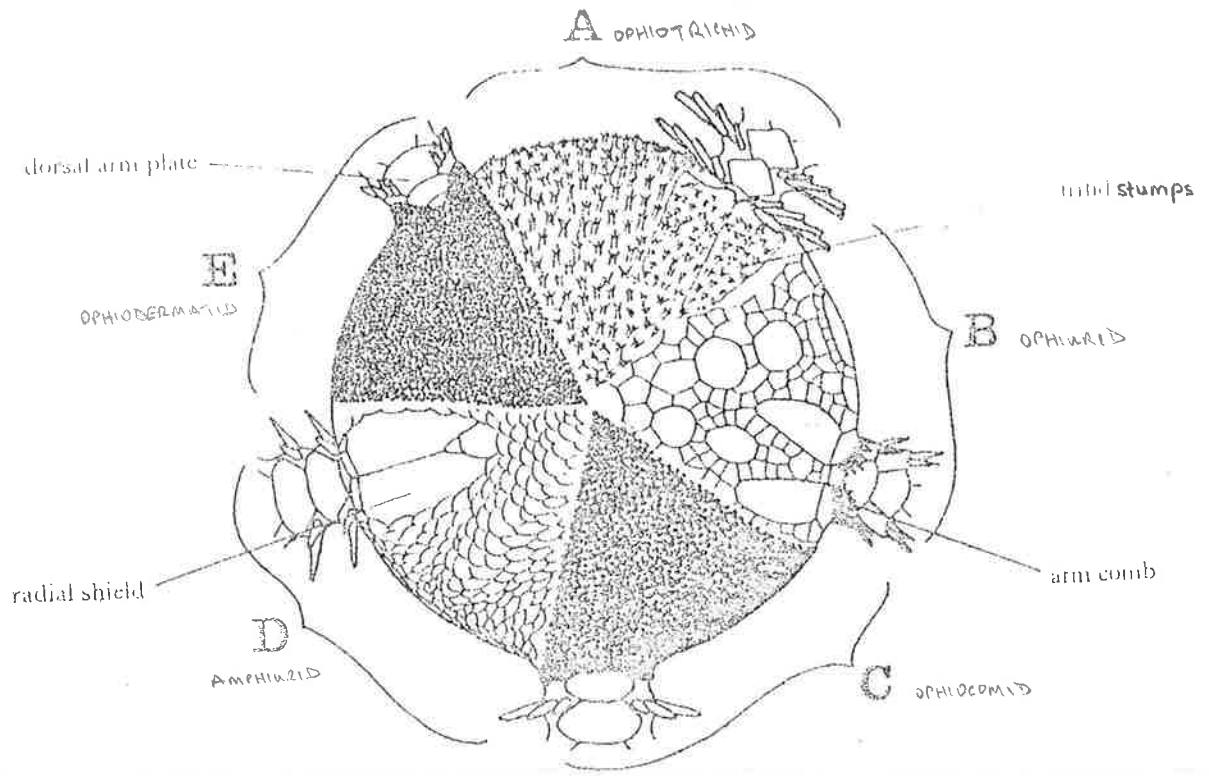
Asteronyx loveni Muller and Troschel. 1842

[Mortensen 1927 p158]

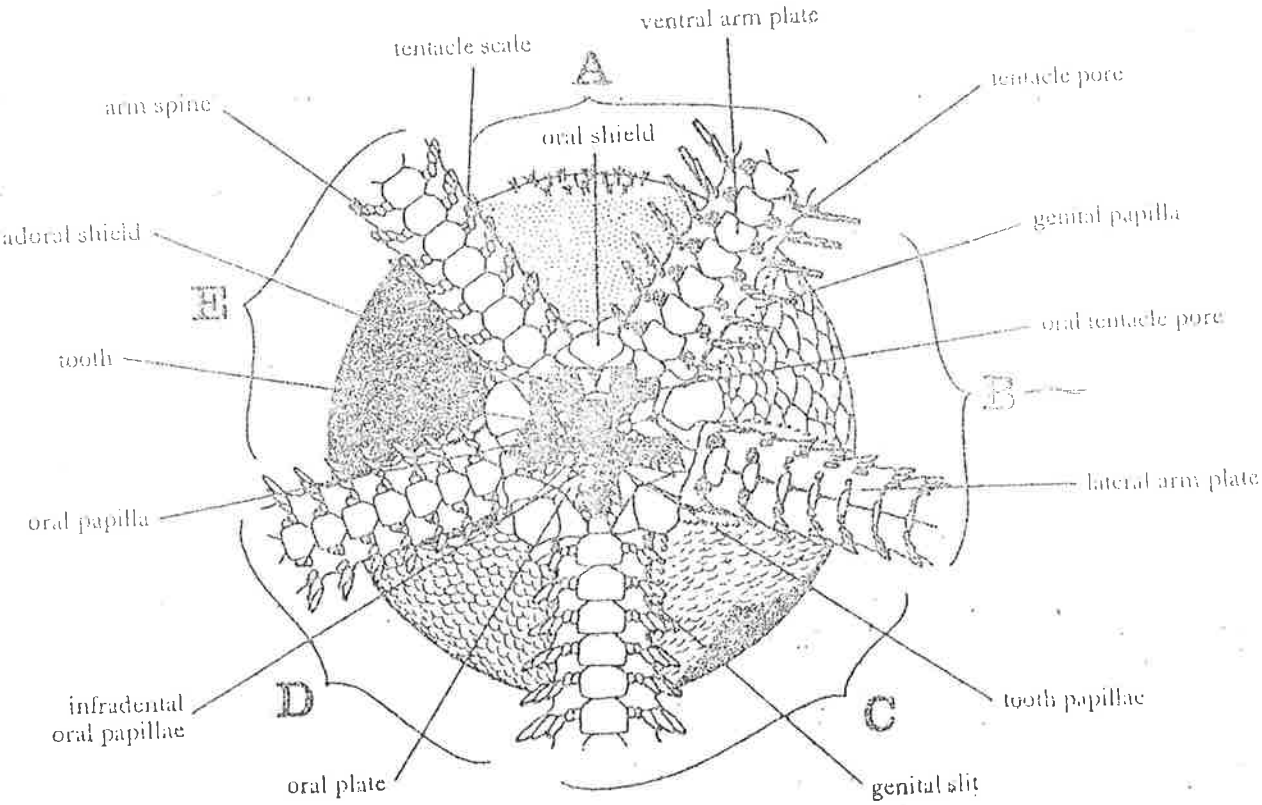
Maximum disk diameter 35mm. Dorsal surface with a few scattered small plates (just visible in dried specimens) and long narrow rib-like

radial shields. Disk covered with thick skin. Arms very long, undivided. No dorsal arm plates. Ventral plates covered in thick skin. Arm spines ventral club shaped.

Usually found only below 100m depth, often commensal on pennatulids (Ursin, 1960).



a.

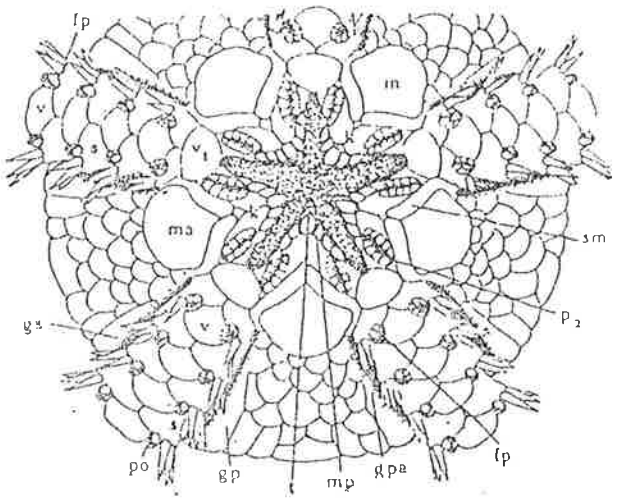


b.

Introductory figures of ophiuroids: a. dorsal and b. ventral composites of examples of fiv families: A Ophiotrichid, B Ophiurid, C Ophioconid, D Amphiurid and E Ophiodermatid.

FROM
CLARK + ROWE (1970)

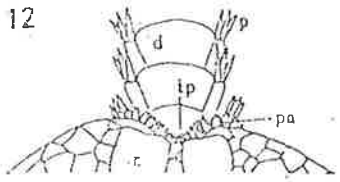
11



A Brittle-star (*Ophiura robusta*) from the oral side

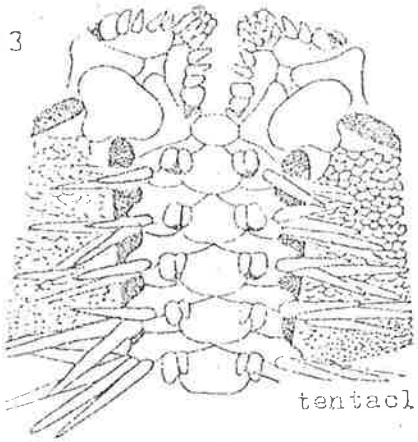
d, Dorsal plate; fp, Foot papillæ or tentacle scales; gp, Genital plate; gpa, Genital papillæ; gs, Genital or bursal slit; ip, Inner comb of papillæ; k, Jaw; m, Mouth shield; ma, Madreporite; mp, Mouth papillæ; p, Arm spines; pa, Outer comb of papillæ; po, Pore of tube-foot; p_2, Second foot pore; r, Radial shield; s, Side or lateral plate; sm, Adoral shield; t, Teeth; v, Ventral plate; v_1, First ventral plate.

12



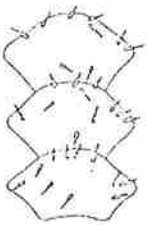
part of dorsal side of disk and arm of *Ophiura affinis*

13



—*Ophiocomina nigra*; part of oral side.

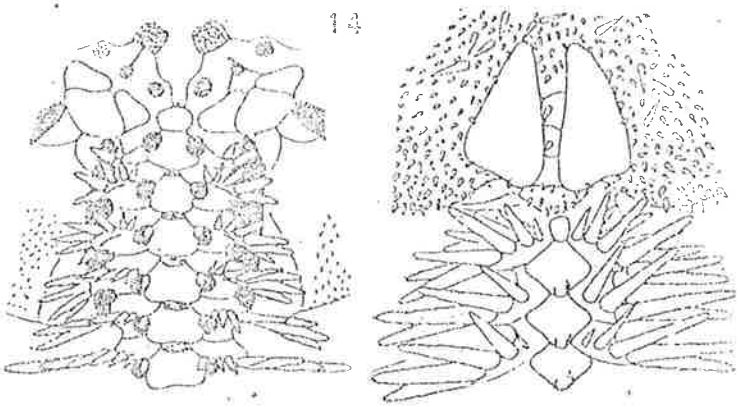
15



—Dorsal plates of *Ophiothrix Lütkeni*. × 6. (From *Danmark's Fauna*.)

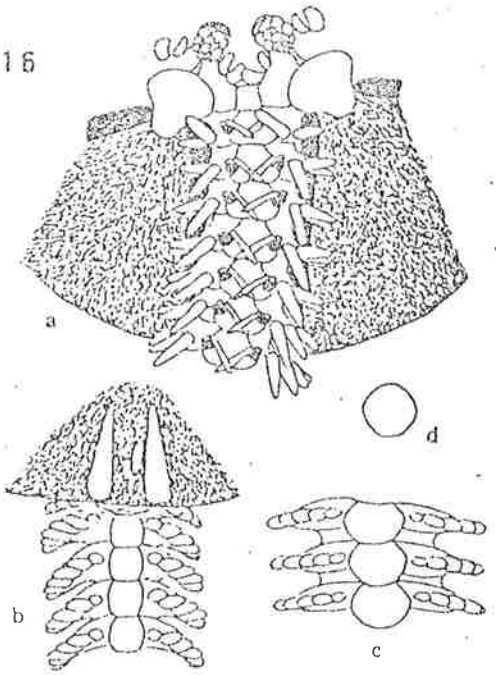
tentacle scale

14



—*Ophiothrix fragilis*; part of oral and dorsal side. × 8.

16



—*Ophiopsila aranea*; part of oral side (*a*), of dorsal side, with ...al part of arm (*b*), and of dorsal side of arm, from the middle (*c*); ...th shield of younger specimen (*d*). × 8.

17

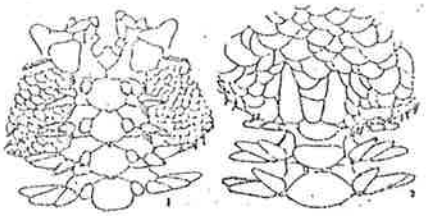
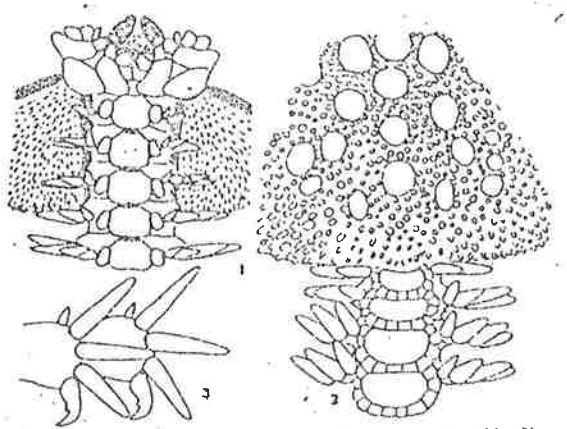


FIG. 112.—*Ophiactis Balli*. 1. Oral side. 2. Dorsal side. × 8. (From *Danmark's Fauna*.)

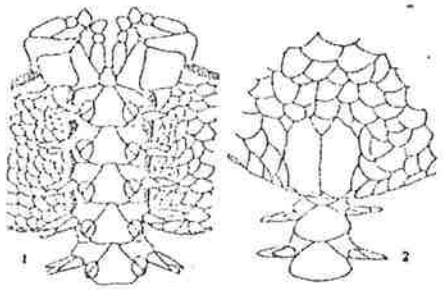
18



—*Ophiopholis aculeata*. (From *Danmark's Fauna*.)

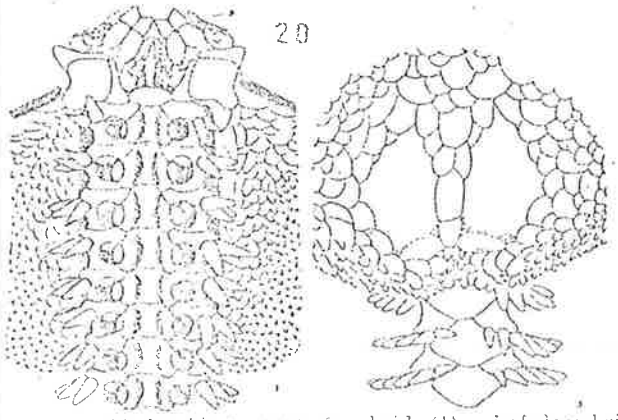
1. Part of oral side. 2. Of dorsal side. 3. Two arm joints from distal part of arm, ... view, showing the lower arm spine transformed into a hook. 1 and 2. × 4. 3. ×

19



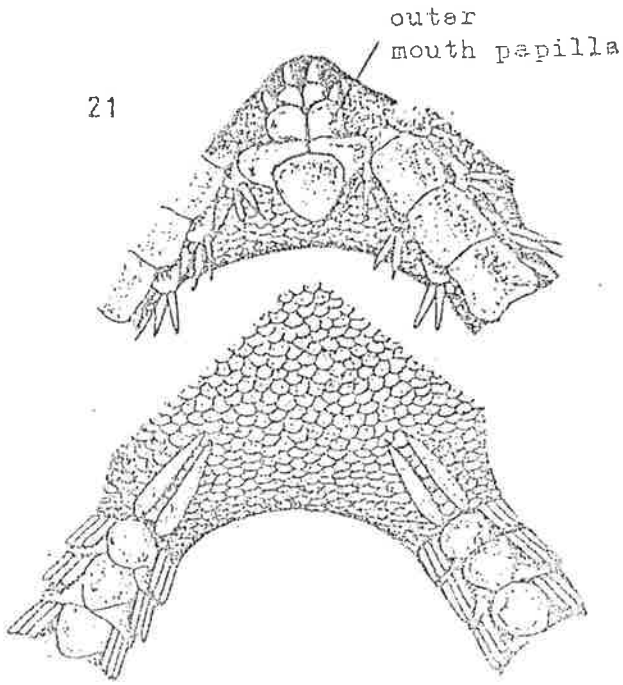
—*Amphipholis squamata*; part of oral side (1) and of dors side (2). ×12. (From *Danmark's Fauna.*)

20



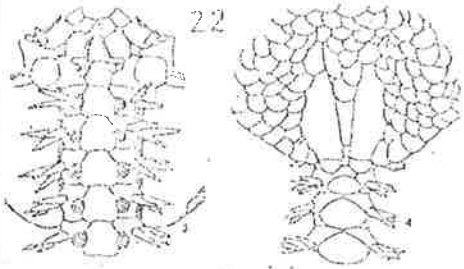
—*Acrocnida brachiata*; part of oral side (1) and of dorsal side (2).

21



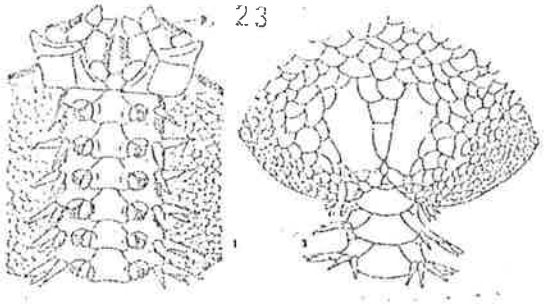
—*Paramphiura punctata*; part of oral and dorsal side. (After Koehler, *Notes échinologiques.*)

22



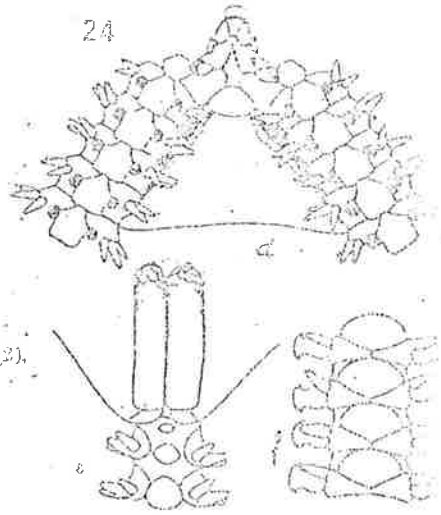
Amphiura filiformis; part of oral side (3) and dorsal side (4);

23



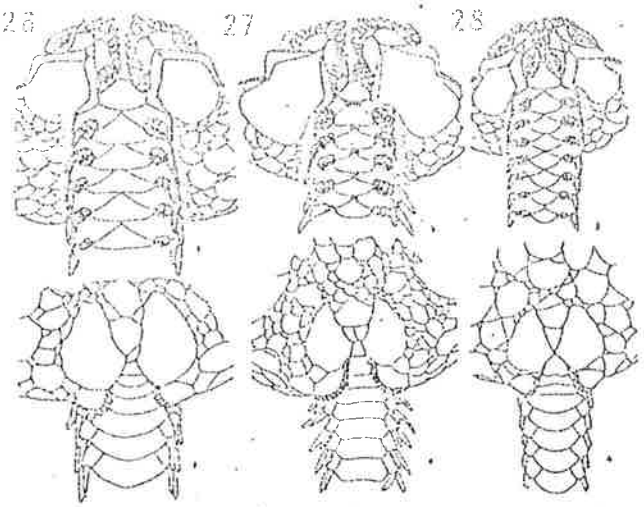
Amphiura Chiajei; part of oral side (1) and dorsal side (2).

24



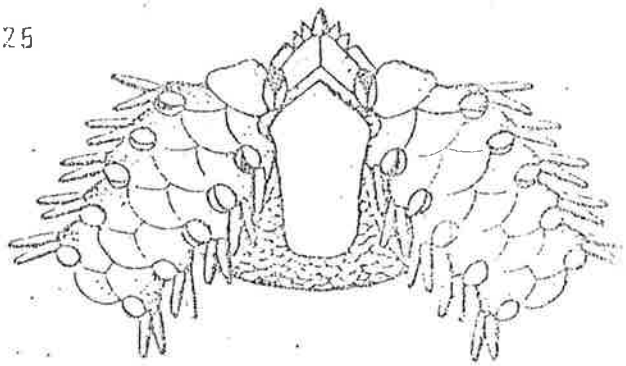
Amphiura securigera
part of oral side,
part of dorsal side,
dorsal side of part o
arm, f.

26 27 28



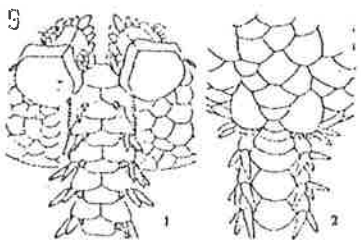
—1-2. *Ophiura Sarsi.* 3-4. *O. texturata.* 5-6. *O. albida.* The upper figures represent part of the oral side, the lower figures of the dorsal side. × 4. (From *Danmark's Fauna.*)

25



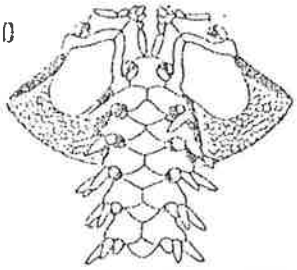
—*Ophiocten scutatum*; part of oral side. ×10. (From Koehler, *Monaco*, xii.)

29



—1-2. *Ophiura robusta.*

30



—*Ophiura affinis*; part of oral side. × 8.

HOLOTHUROIDEA - SEA CUCUMBERS

Holothurians are rather soft, sausage-shaped animals. The mouth is at one end of the body, surrounded by retractable tentacles, and the anus is at the other end (Fig. C, D). In some species the body is flattened and the underside on which the animal walks is termed ventral; the upper side is termed dorsal. There are basically five longitudinal rows of tube feet, but various modifications of this pattern exist; some species have no tube feet. If living animals are kept in cool sea-water they may extend their tentacles, and it is sometimes possible to narcotise and fix specimens with their tentacles extended. Preserved holothurians often need to be dissected to discover the tentacles. In one group the part of the body immediately behind the tentacles, called the introvert (Fig. 52), is more flexible than the rest and can be pulled inside the body by special retractor muscles, carrying the tentacles well out of sight. The skin, in most species, contains small calcareous deposits (spicules) whose shape is important for identification of species. To investigate them, mount a small piece of skin on a slide, in a drop of 50% glycerine and examine with a low power objective (e.g. x 10). Gentle pressure on the cover slip may help to make the spicules more visible. A second preparation may be made, using a drop of commercial bleach to dissolve the tissue and leave the spicules, which can then be rinsed in a drop of water and mounted in glycerine or a more permanent medium. Formalin-containing fixatives tend to dissolve the spicules, so it is best to preserve holothurians in alcohol.

1. Tube feet present; tentacles peltate (Fig. A) or dendritic (Fig. B) 2

   No tube feet; tentacles pinnate or digitate . . . Fam. SYNAPTIDAE . 22

2. Tentacles peltate; no retractor muscles or introvert, though tentacles may be hidden in fold of skin 3

   Tentacles dendritic; retractor muscles and introvert present, tentacles can be withdrawn into body 6

3. No tentacle ampullae . . . . Fam. SYNALLACTIDAE .
   (up to 20 tentacles; spicules tables) Mesothuria intestinalis

   Tentacle ampullae present (Fig. D) 4

4. Gonads arranged in 2 tufts, one each side of dorsal mesentery Fam. STICHOPODIDAE 5

   Gonads in a single tuft, on left side of dorsal mesentery (Fig. C) . . . . Fam. HOLOTHURIIDAE
   (20 tentacles; few spicules with 4 holes (Fig. 53) . . . Holothuria forskali - Edmonds, Baker

5. Body cylindrical with scattered large papillae; spicules tables, rods & stars; live animal red (occ. white) . . . . . Stichopus tremulus

   Body flattened, with fringe of large papillae; spicules tables (Fig. 55), rods & a few stars; live animal brown . . . Stichopus regalis

6. Body with flat lower sole . . . Fam. PSOLIDAE . . 7

   Body cylindrical 9

7. Body high, sole small; tube feet along centre line of sole . . . . Psolus phantapus

   Body flattened, broad oval shape; centre line of sole without tube feet 8

8. Spicules in sole are small delicate plates with holes (Fig. 68) . . . . . Psolus squamatus

Spicules in sole are small cups and larger tuberculate bodies (Fig. 67) . . . . . Young Psolus phantapus

9. 10 tentacles . . . . . Fam. CUCUMARIIDAE . 10

10 large and 5 or 10 small tentacles Fam. PHYLLOPHORIDAE . 20

10. Tube feet in 5 fairly distinct rows 11

Tube feet scattered all over body 17

11. Body thick; skin leathery, almost without spicules; young specimens have plates with holes (Fig. 56) . . . . . Cucumaria frondosa

Body not thick; skin rough, many spicules . . . 12

12. Body narrow, with thinner posterior end; spicules small cups and smooth plates with holes . . Leptopentacta elongata

Body not elongated 13

13. Spicules smooth plates, sometimes also small stars . . 14

Spicules tuberculate plates, with small cups or stars . 15

14. Spicules large plates, with many holes, closely packed (Fig. 56) Panningia hyndmani

Spicules small plates, with 4 main holes; outer layer of star-shaped spicules (Fig. 61) . Pawsonia saxicola

15. Spicules tuberculate plates with 4 holes; outer layer of cup-shaped spicules (Fig. 61) . Aslia lefevrei

Spicules tuberculate plates with 4 or more holes; outer layer of irregular star-shaped spicules 16

16. Tube feet scarce, in 5 zig-zag rows (spicules Fig. 63) . Ocnus lactea

Tube feet in 5 double rows (spicules Fig. 60) . . . Ocnus planci

17. Body wall spicules are smooth plates with holes (Fig 59) . *Pseudothyone raphanus*

Spicules, if present, are small tables 18

18. Spicules (Fig. 62) numerous in body wall . . . . . *Thyone fusus*

Spicules either absent or in very short "tail" region only 19

19. Spicules in tail region and in introvert . . . . . *Thyone inermis*

No spicules . . . . . *Thyone roscovita*

20. Tube feet in 5 fairly distinct rows; numerous spicules, tables with 4-column spire (Fig. 64) . *Neopentadactyla mixta*

Tube feet scattered all over body 21

21. 15 tentacles, 10 large and 5 very small; body wall thin; tube feet large; spicules tables, scarce in older animals . . *Thyonidium pellucidum*

20 tentacles, 5 pairs large and 5 pairs small; body wall thick; tube feet thin, very numerous; no spicules in body wall, tables in introvert (Fig. 66) *Duasmodactyla commune*

22. No spicules; 10 simple tentacles . *Rhabdomolgus ruber*

Spicules anchor-shaped with attached anchor plate . . 23

23. Anchor plate has narrow "handle" (Fig. 69, 71) . . . 24

Anchor plate does not have handle (Fig 74) . . . 26

24. 11 tentacles, each with terminal digit and 1 pair of lateral digits (spicules Fig. 69) . . *Labidoplax buski*

12 tentacles, each with 2 pairs lateral digits, no terminal digit 25

25. Anchor plate symmetrical, with 6 main holes (like Fig. 69) . . *Labidoplax media*

Anchor plate thin, irregular shape, many holes (Fig. 71) *Labidoplax digitata*

26. 10 tentacles 27

12 tentacles (rarely 10 - 13) 28

27. Tentacles simple . . *Leptosynapta minuta*

Tentacles pinnate, 2 to 4 pairs lateral digits . . . *Leptosynapta decaria*

28. Anchor plates have serrated edge (Fig. 73) . . . . *Leptosynapta gallieni*

Anchor plates have smooth edge 29

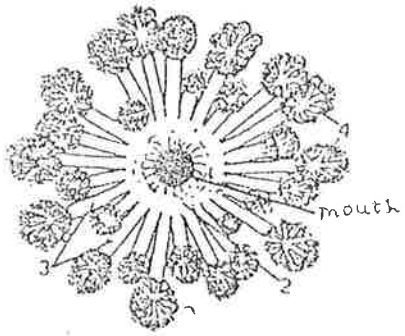
29. Spicules in longitudinal muscles are rods, dumbells and spheres; tentacles have 3 - 7 pairs pinnules *Leptosynapta inhaerens*

Spicules in longitudinal muscles are C-shaped or O-shaped . 30

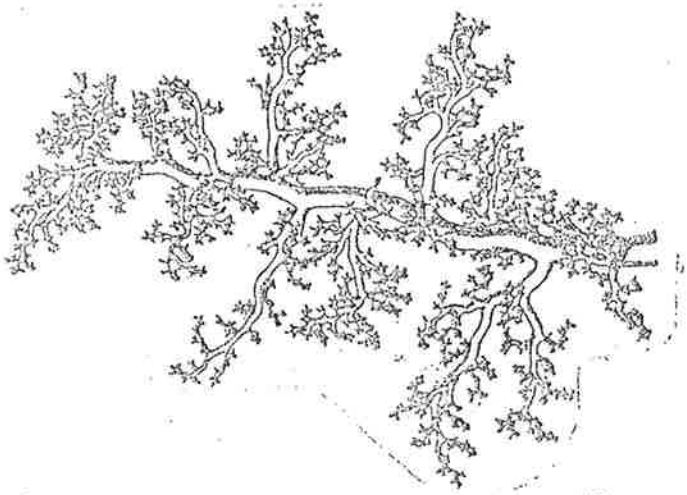
30. Spicules in tentacles are rods with holes in the knobbed ends; 5 - 7 pairs of tentacle pinnules . *Leptosynapta cruenta*

Spicules in tentacles are C-shaped, O-shaped and rods without holes; 7 - 11 pairs of pinnules . *Leptosynapta bergensis*

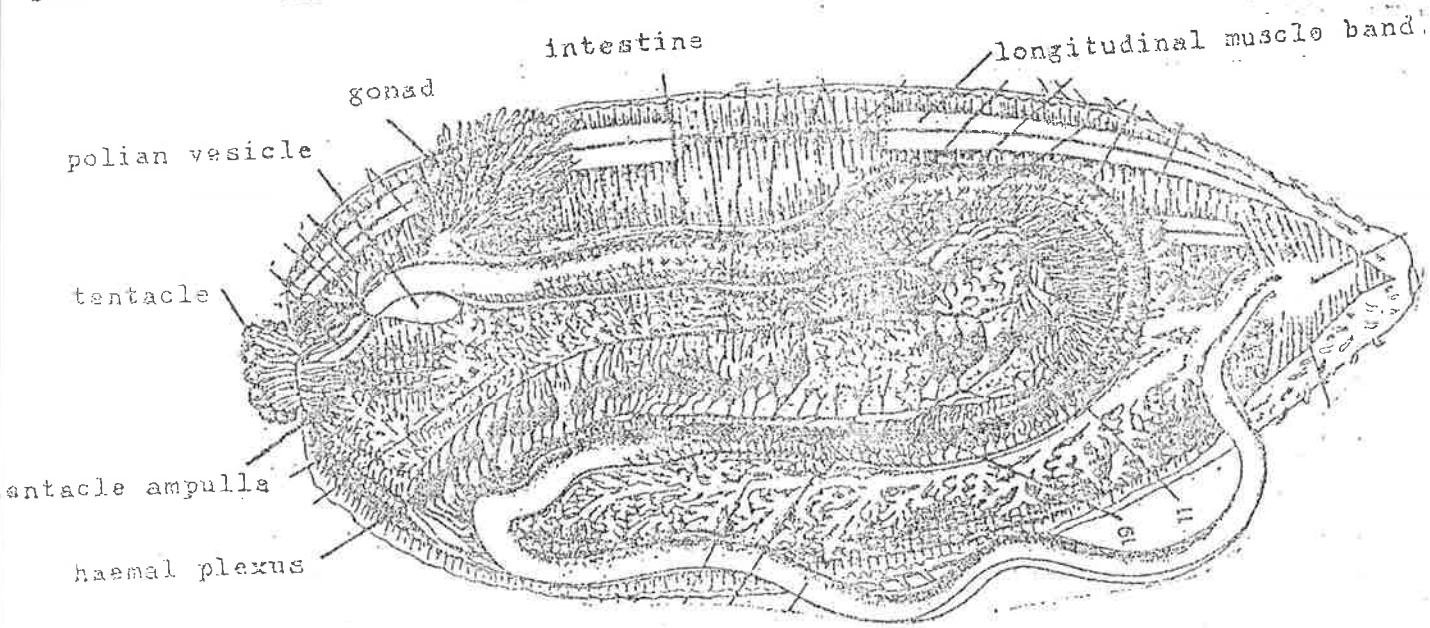
A PELTATE TENTACLES



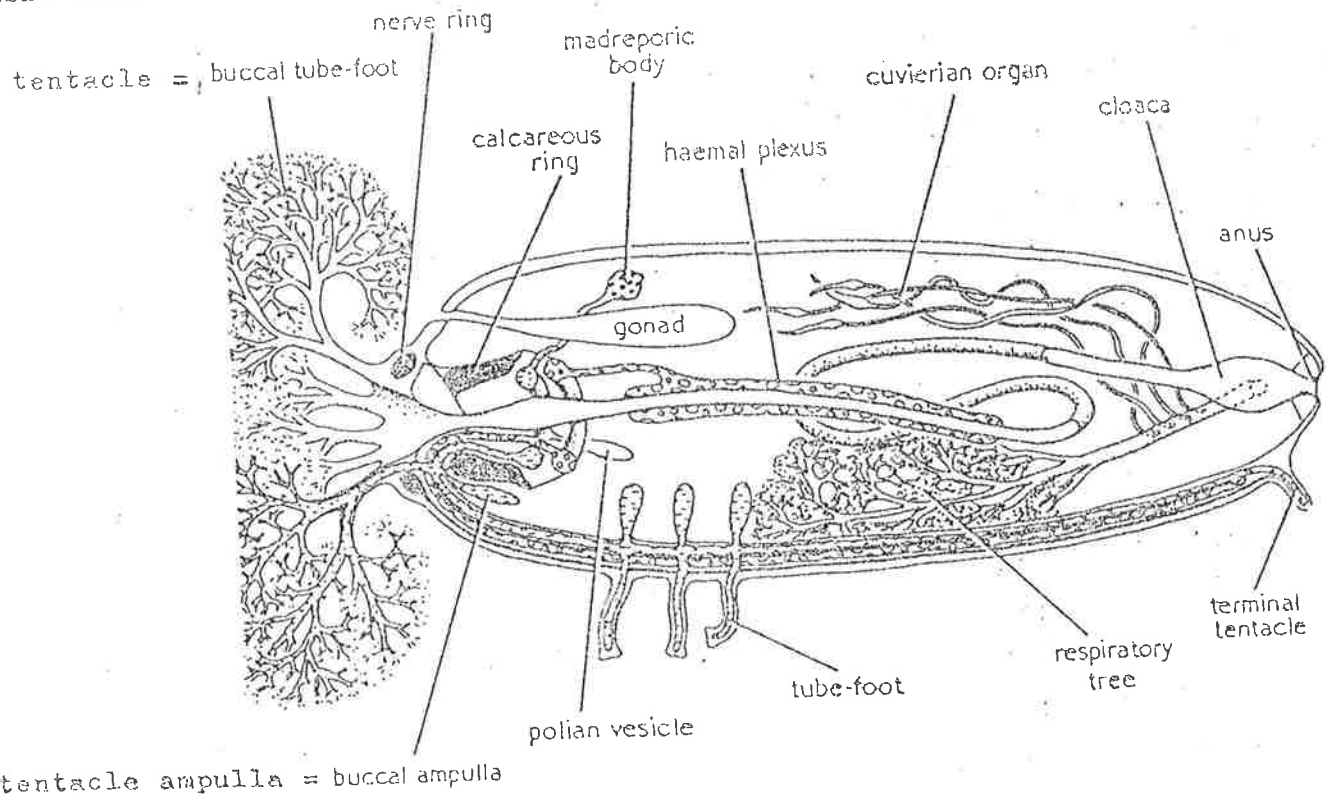
B EXTENDED DENDRITIC TENTACLE



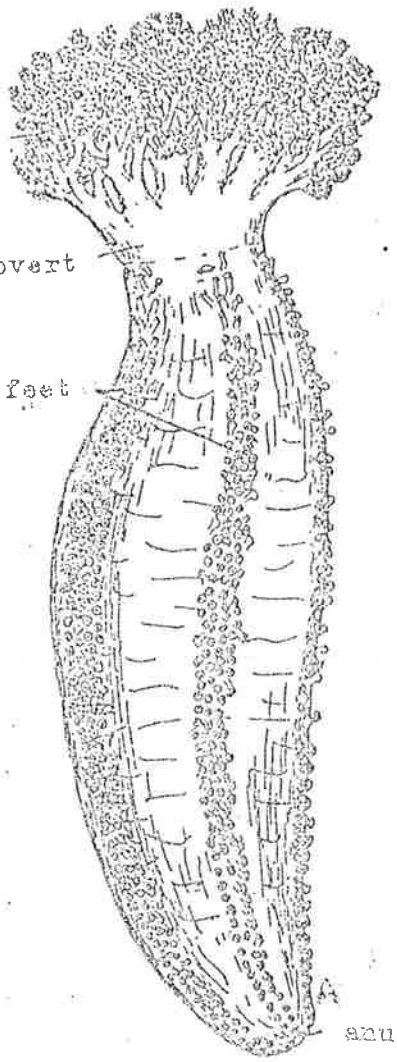
DISSECTION OF HOLOTHURIA (Ludwig)



D BASIC ANATOMY OF A HOLOTHURIAN (Nichols)

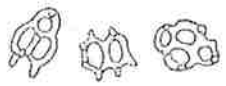


52



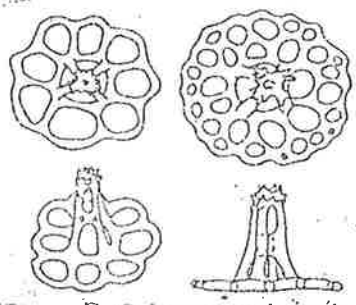
Anatomy of Cucumaria.

53



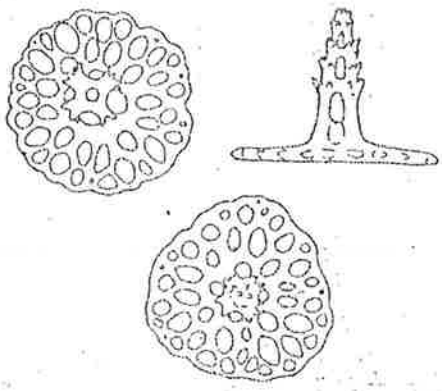
—Deposits of *Holothuria Forskali*. ×450. (After Boll, *Catalogue Brit. Echinod.*)

54



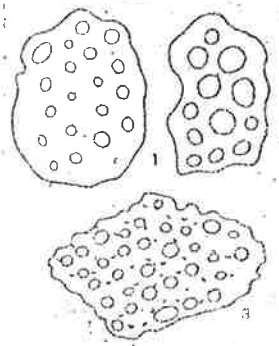
—Calcareous deposits (tables) of *Mesothuria intestinalis*, seen from above and in side view. ×145. (From *Danmark's Fauna.*)

55



—Tables of *Stichopus regalis*, from above and inside view.

56



—Calcareous deposits of *Cucumaria Hyndmani* (1) and *Cuc. frondosa*, young (2). 1, ×50; 2, ×60. (From *Danmark's Fauna.*)

57

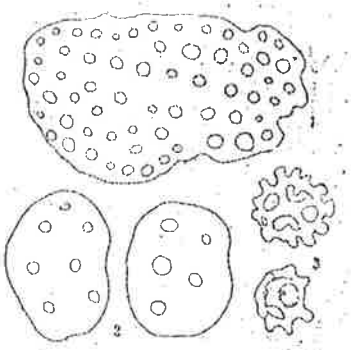
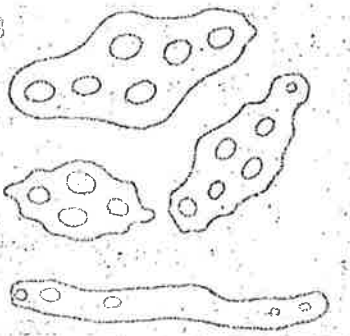


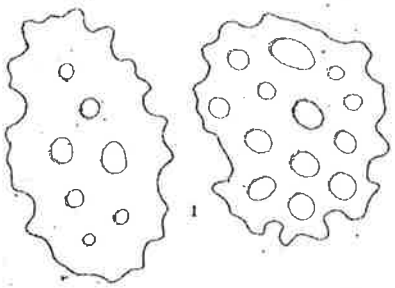
Fig. 238.—Calcareous deposits of *Cucumaria elongata*: 1, ×50; 2-3, ×145. (From *Danmark's Fauna.*)

58



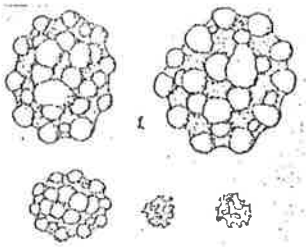
—Deposits of *Cucumaria varicola* from the skin and the tube-feet (the lowermost figure). ×130.

59



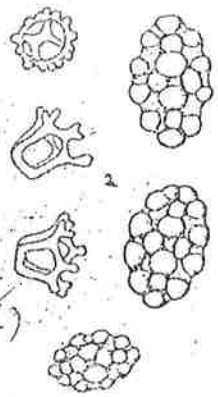
—Calcareous deposits of *Thyone raphanus* (1).

60



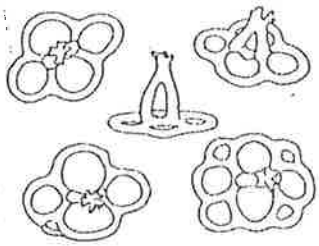
—Deposits of *Cucumaria Planci* (1).

61



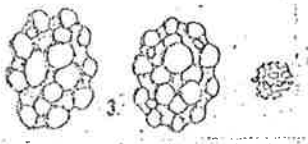
C. lefevrei (2)

62



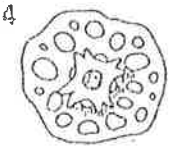
—Calcareous deposits of *Thyone fusus*. ×200.

63



Cuc. lactea (3). ×190.

64



Deposits of Neopentadactyla mixta

65

Deposits from body wall of *Thyonidium pellucidum*. × 145. (From *Danmark's Fauna*.)
1. From above. 2. Half side view. 3. Side view.

66

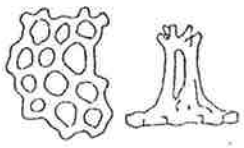
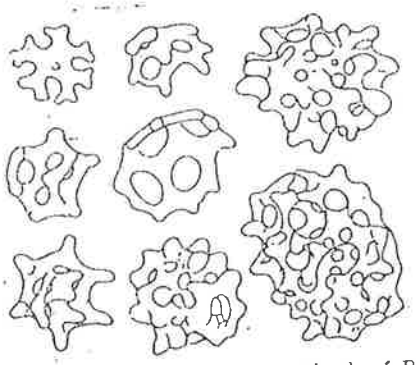


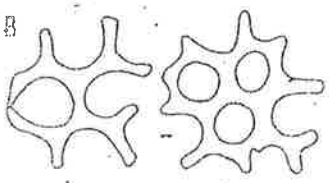
Fig. 250. — Deposits from introvert of *Thyonidium commune*. × 250.

67



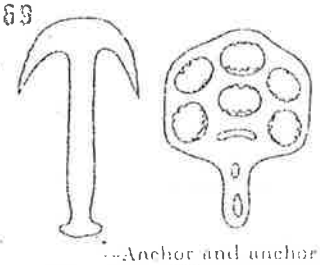
Calcareous deposits from the ventral sole of *Psolus phantapus* × 145. (From *Danmark's Fauna*.)

68



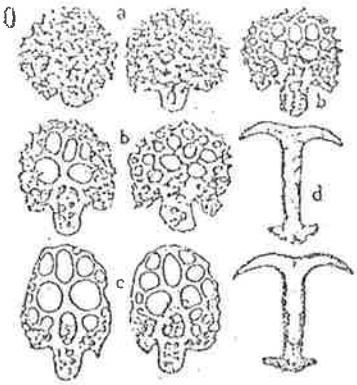
—Deposits from the ventral sole of *Psolus squamatus*

69



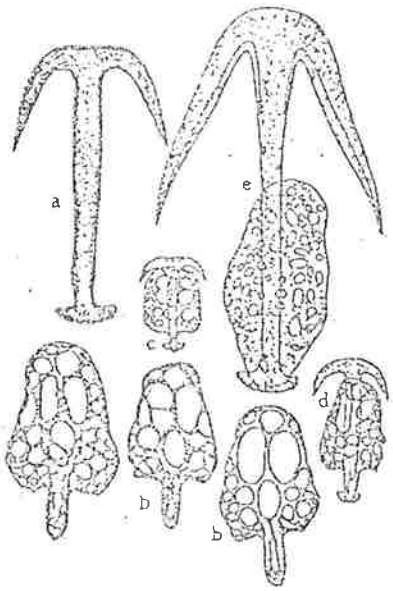
—Anchor and anchor plate of *Labidoplax Buski*. × 200. (From *Danmark's Fauna*.)

70



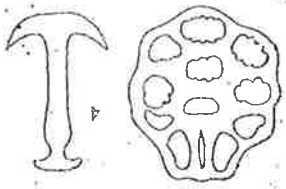
—Anchor plates (*a-c*) and anchors (*d*) of *Labidoplax Thomsoni*.

71



—Deposits of *Labidoplax digitata*. × 70. (After Koehler, *Échinodermes, Faune de France*.)

72



Leptosynapta minuta

73

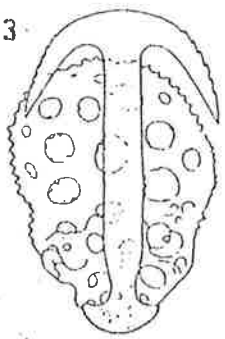
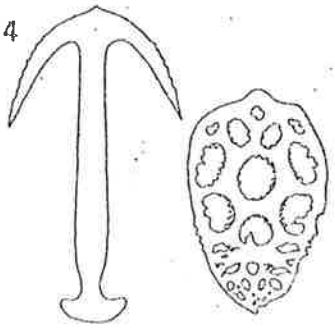
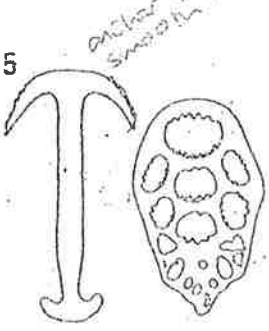


Fig. 263.—Anchor and anchor plate of *Leptosynapta Galliennii*. × 155.

74

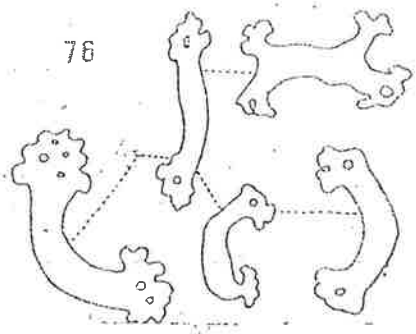


75



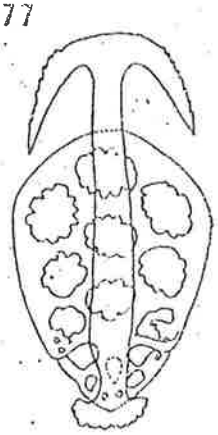
Leptosynapta bergensis Leptosynapta inhaerens

76



Spicules from tentacles of Leptosynapta cruenta

77



Anchor and anchor pla
of Leptosynapta crue

ECHINOIDEA - SEA URCHINS

Echinoids are globular, egg-shaped or flattened, without arms. The skeleton, or test forms a complete covering and is composed of flat calcareous plates with knobs or tubercles, to which spines are attached. The mouth is on the underside and the anus is either on the upper side (in regular urchins) or near one end of the egg-shaped test (in irregular urchins). The plates of the test are in ten double series (Fig. 31). Five double series are perforated by small pores connected to the soft tube feet (Fig. C). The perforated plates are termed the ambulacral plates and the intermediate series are termed interambulacral. On both series of plates large primary tubercles carry primary spines and small secondary tubercles carry secondary spines (Fig. 37). In regular urchins there is a circular soft-skinned area around the mouth, termed the peristome, which bears a variable number of small calcareous plates. The test at the edge of the peristome is notched by gill clefts (see Fig. C). The peristome is not obvious in irregular urchins because it is covered with closely fitting plates. The spines are typically conical, but in heart-urchins they are variously flattened and ornamented. In addition, heart urchins often have small, dark, clubshaped spines arranged in narrow bands termed fascioles (Fig. 47). Among the spines are delicate pincer-like organs termed pedicellariae. These have flexible stalks and heads composed of three calcareous valves. Those with large globular heads, the globiferous pedicellariae, are valuable in the identification of regular urchins. They can be mounted in a drop of 50% glycerine and examined with a low power objective (x 10).

1. Body round, anal opening close to centre of upper side . 2

   Body oval, anal opening posterior or underneath . . . 11

2. Ambulacral and interambulacral plates extend to cover the peristome (Fig. A) . . Fam. CIDARIDAE

   Cidaris cidaris

   Only small scale-like plates on peristome 3

3. Test is incised by deep gill clefts; stalks of globiferous pedicellariae bear mucus glands, valves lack lateral teeth (Fig. 32) . . Fam. TOXOPNEUSTIDAE

   Sphaerechinus granularis (Channel Is.)

   Gill clefts slight (Fig. 31); no glands on stalks of pedicellariae 4

4. Valves of globiferous pedicellariae have no lateral teeth (Fig. 35); spicules in tube feet have branched ends (Fig. 42) . . Fam. STRONGYLOCENTROTIDAE . 5

   Valves of globiferous pedicellariae have lateral teeth (Fig. 33, 34); spicules in tube feet are C-shaped Fam. ECHINIDAE . . 6

5. Globiferous pedicellariae have ovoid head and thick muscular neck; 5 (occ. 6) pore pairs in each ambulacral plate (Fig. 37) . . Strongylocentrotus droebachiensis

   Globiferous pedicellariae have globular head and short neck; 6 (occ. 7 or 8) pore pairs in each ambulacral plate . . . Strongylocentrotus pallidus (pop. N. Scotland, Shetland etc.)

6. 5 or 6 pore pairs in each ambulacral plate . . . Paracentrotus lividus (single tube feet per pair)

   3 pore pairs (Fig. 39) 7

7. Peristome packed with small thick plates (Fig. B); valves of globiferous pedicellariae have rows of lateral teeth (Fig. 34) . . *Psammechinus miliaris*

Peristome smooth, with a few thin plates; valves of globiferous pedicellariae have one or two lateral teeth each side (Fig. 36) 8

8. Every ambulacral plate has a primary tubercle (Fig. 38) . . *Echinus elegans*

Alternate ambulacral plates lack primary tubercles (Fig. 39) . 9

9. Test white, globular; spines short and slender . . . . *Echinus tenuispinus*

Test at least partly coloured 10

10. Test globular; uniformly red or purplish; primary and secondary spines of equal size, forming a uniform coat of short spines; plates on peristome carry small spines and pedicellariae . . *Echinus esculentus*

Test slightly conical; striped brown and white; primary spines longer than secondary spines; plates on peristome carry only pedicellariae . . . *Echinus acutus*

11. Mouth and anus both on underside; very small species (Fig. 43) . . *Echinocyamus pusillus*

Mouth anterior, anus posterior (Fig. 49) 12

12. One fasciole, below the anal region Fam. SPATANGIDAE

Two fascioles, one subanal and one on upper surface (Fig. 48) .13

13. Upper fasciole encircles tips of all five ambulacral petals (Fig. 47) . . Fam. BRISSIDAE *Brissopsis lyrifera*

Upper fasciole surrounds only the anterior ambulacral petal (Fig. 48) . . Fam. LOVENIIDAE . 14

14. Anterior ambulacrum forms a deep furrow (Fig. 48) . . . *Echinocardium cordatum*

Anterior ambulacrum is flush with test (Fig. 49) . . 15

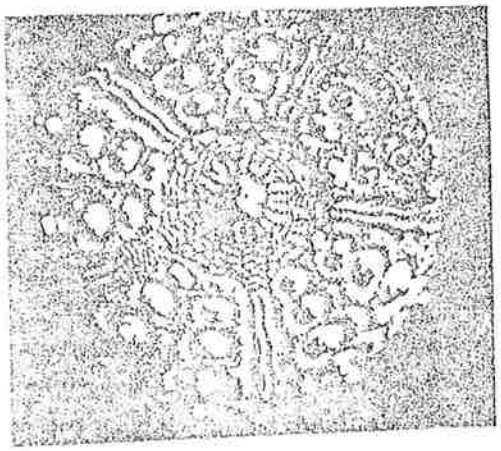
15. Labrum (plate behind mouth) is large (Fig. 51); on upper side large tubercles carrying long spines are mixed with small tubercles and spines . . *Echinocardium flavescens*

Labrum small (Fig. 50; on upper side all spines equal in size . . *Echinocardium pennatifidum*

16. Subanal fasciole oblong (Fig. 46); conspicuous long sharp spines among smaller spines of upper side . . . . *Spatangus purpureus*

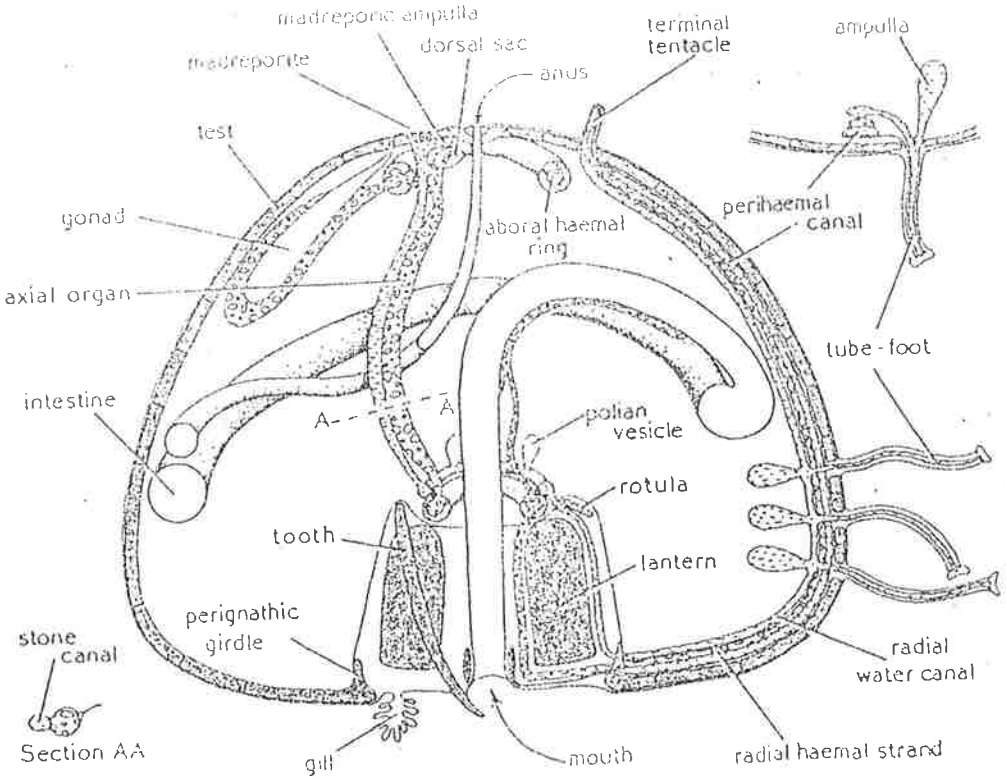
Subanal fasciole heart-shaped (Fig. 45); large spines less obvious . . *Spatangus raschi*

A ORAL SIDE OF CIDARIS CIDARIS

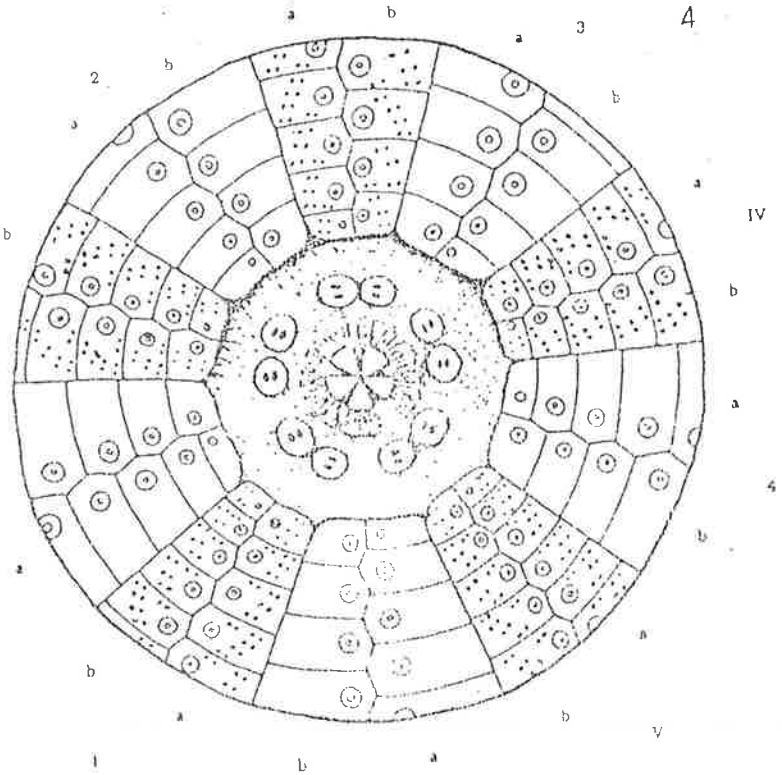


B ORAL SIDE OF PSAMMECHINUS MILIARIS

C BASIC ANATOMY OF AN ECHINOID (Nichols)



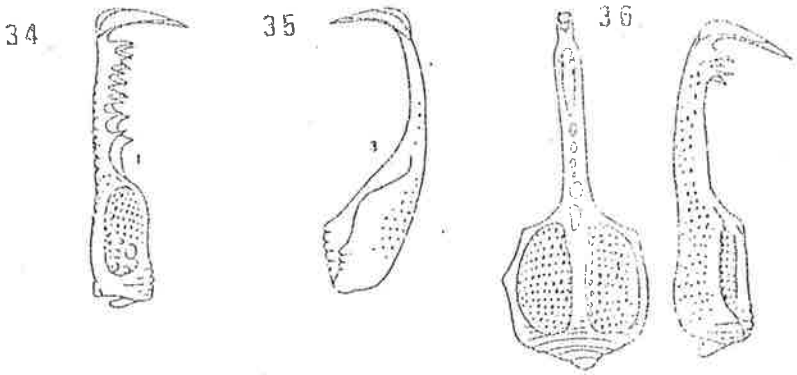
31

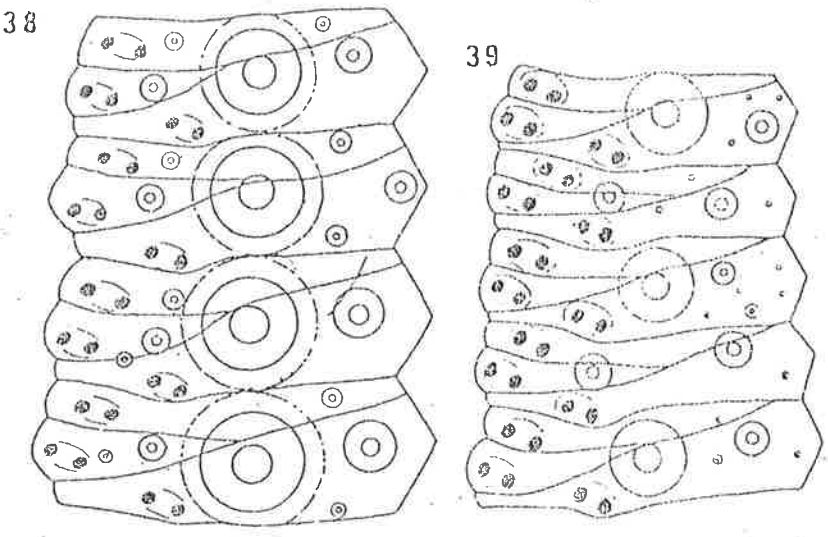


Structural pattern of the test of a regular sea urchin seen from the ventral (oral) side: I – V = ambulacral rows; 1 – 5 = interambulacral rows. In the center is the mouth, surrounded by five triangular teeth; around these is the perignathic girdle (crosshatched) of the thickened oral membrane; the oral membrane (peristome) is shaded, and on it are five pairs of pore-bearing oral or buccal plates, each plate corresponding to one oral podium; at the margins of the peristome are 10 small notches projecting into the test: these are the gill cuts

Isolated valves of globiferous pedicellariae

P. miliaris S. droebachiensis E. elegans



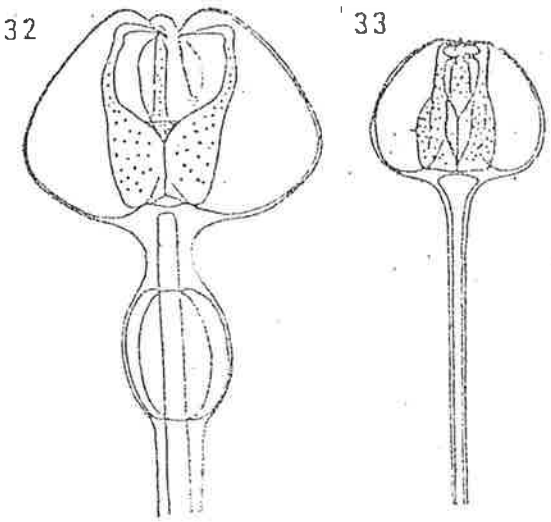


a.

Ambulacra of *Echinus elegans*. Echinus esculentus

Globiferous pedicellariae of

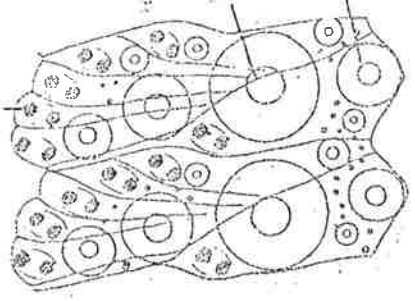
Sphaerechinus granularis Paracentrotus lividus



Spicule from tube foot of S. droebachiensis

secondary tubercle

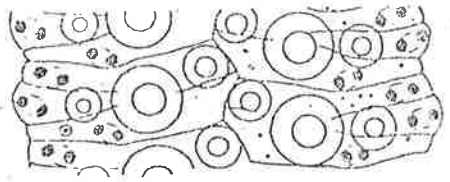
primary tubercle



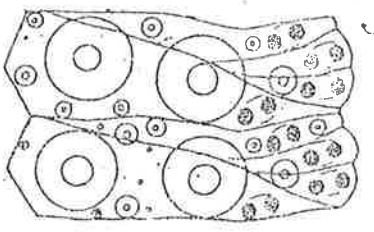
pore

a.

Part of ambulacrum of *Strongylocentrotus droba*

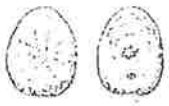


Psammechinus miliaris;



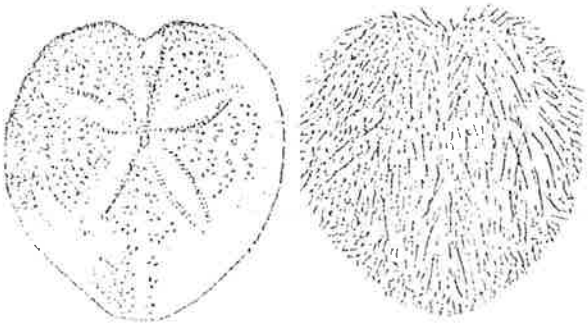
Sphærechinus granularis,

43



Echinocyamus pusillus

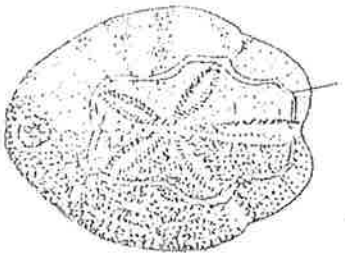
44



Spatangus purpureus

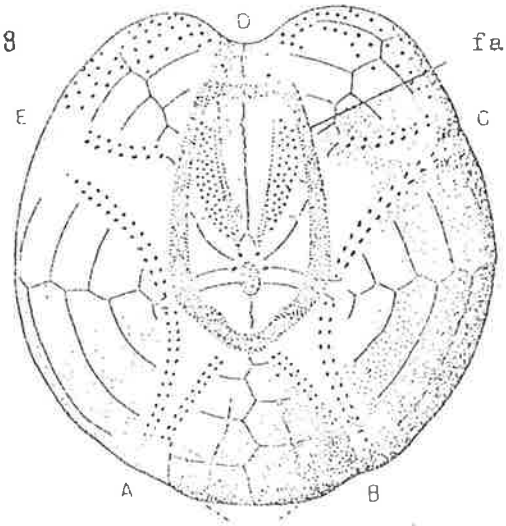
Subanal fasciole of *Spatangus Raschi* (upper figure) and *Sp. purpureus* (lower figure). Slightly enlarged.

47



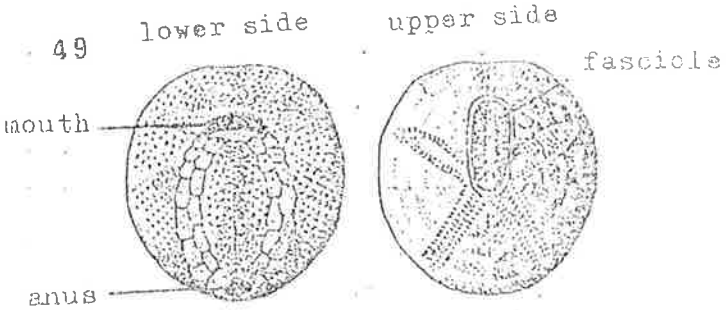
Brissopsis lyrifera

48



Echinocardium cordatum

49



Echinocardium pennatifidum

50

51

Echinocardium flavescens