

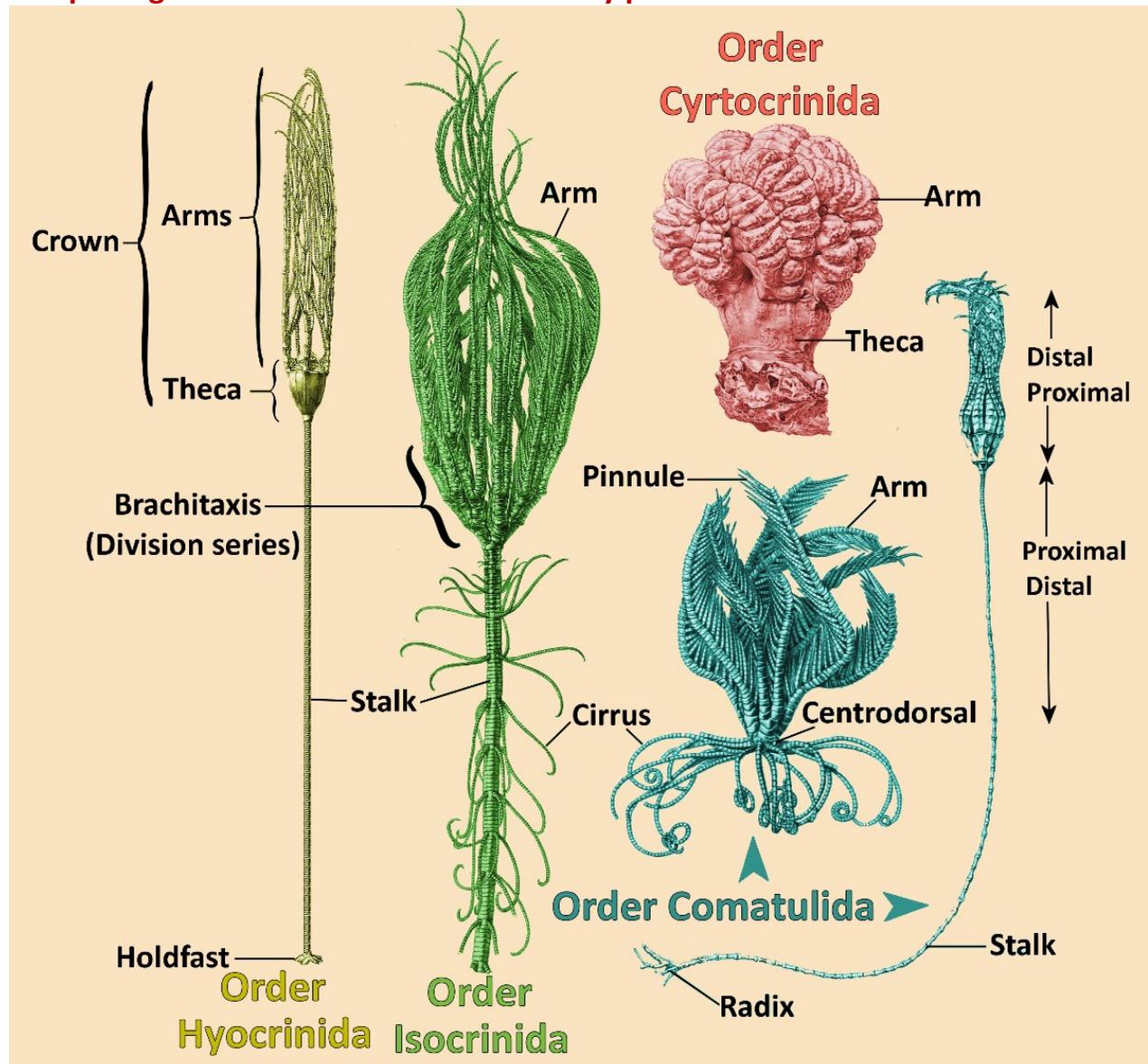
Deep-water (>250 m) Crinoidea (Sea lilies and feather stars)

A guide by Charles G. Messing



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Morphological characters – 1. General body parts



Source: Carpenter (1888).

Theca – Central crinoid body from which the arms radiate.

Arm – Branched or unbranched series of **ossicles** (skeletal pieces) arising from the theca. Often refers to the undivided portion distal to any branching.

Ray – The series of arms plus the radial ossicle of the theca from which they arise.

Brachitaxis (division series) – Branching portion of a ray arising from the theca.

Pinnule – Slender, alternating side branchlets (in all living crinoids) that give each arm a feather-like appearance; the primary food-collecting sites for suspension-feeding.

Crown – The theca plus arms; the entire crinoid except the stalk.

Stalk (column, stem) - Series of ossicles that arises from the center of the aboral surface (opposite the mouth) of the theca and supports the body above and fixes it to the substrate.

Centrodorsal – Uppermost (proximal) stalk ossicle retained on the aboral surface of feather stars following separation from the postlarval stalk; disk- dome-, star-, cone-, or cylinder-shaped.

Cirrus (pl. cirri) – unbranched, usually hook-like or prehensile anchoring appendages arising from a centrodorsal or heteromorphic stalk.

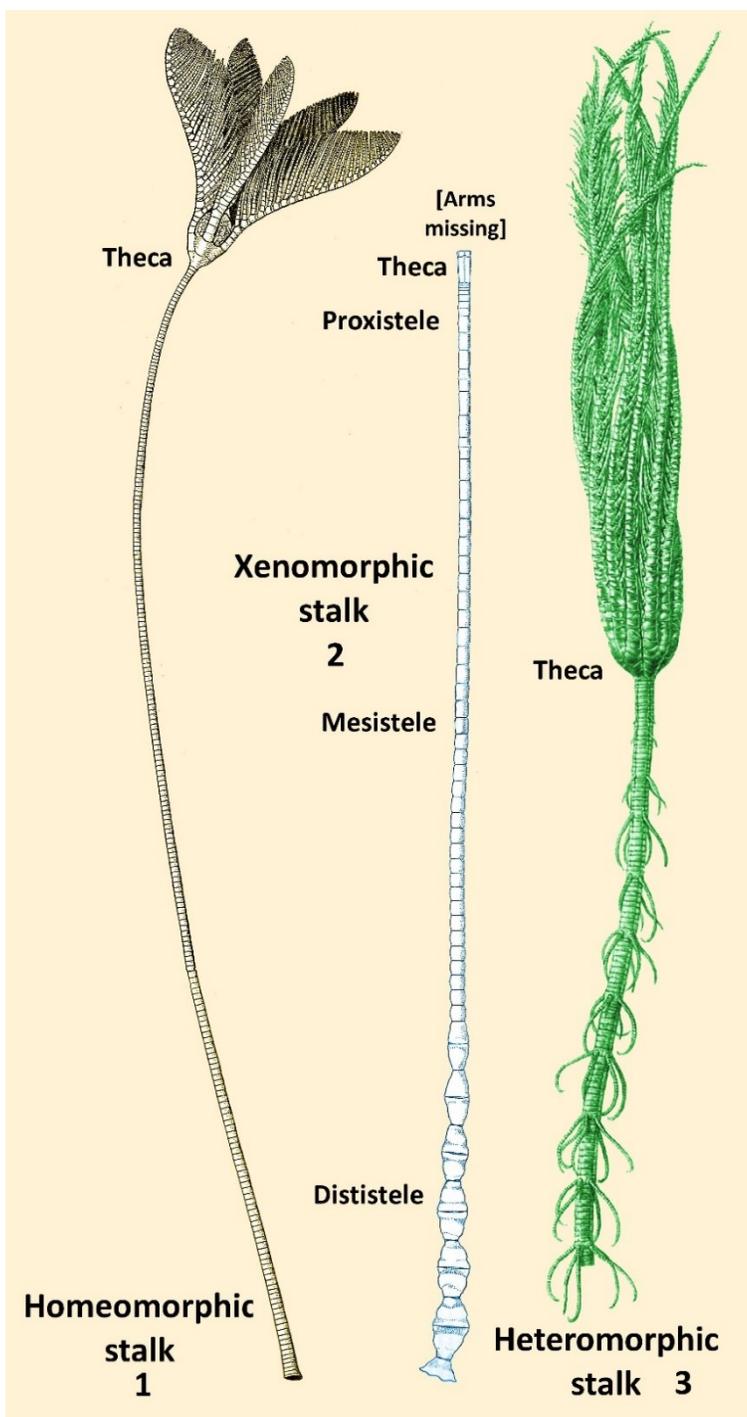
Holdfast – The distalmost element of a stalk used for anchoring to hard substrates.

Radix – Branching, rootlike distal series of stalk ossicles modified for anchoring in sediment.

Proximal – Toward the base of an arm, ray, or pinnule; toward the end of the stalk bearing the theca.

Distal - Toward the tip of an arm, ray or pinnule; toward the anchoring end of the stalk.

Morphological characters – 2. Stalked crinoids: Stalks



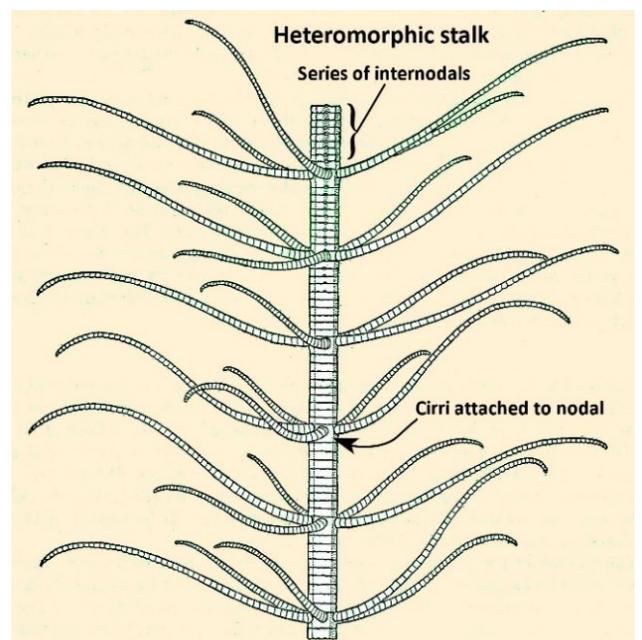
Columnals – Ossicles that compose the stalk.

Heteromorphic stalk – different kinds of columnals distributed along the stalk, or most of it (e.g., **nodals** bearing cirri alternating with series of **internodals**) (left: Carpenter, 1884; below: Clark, 1915).

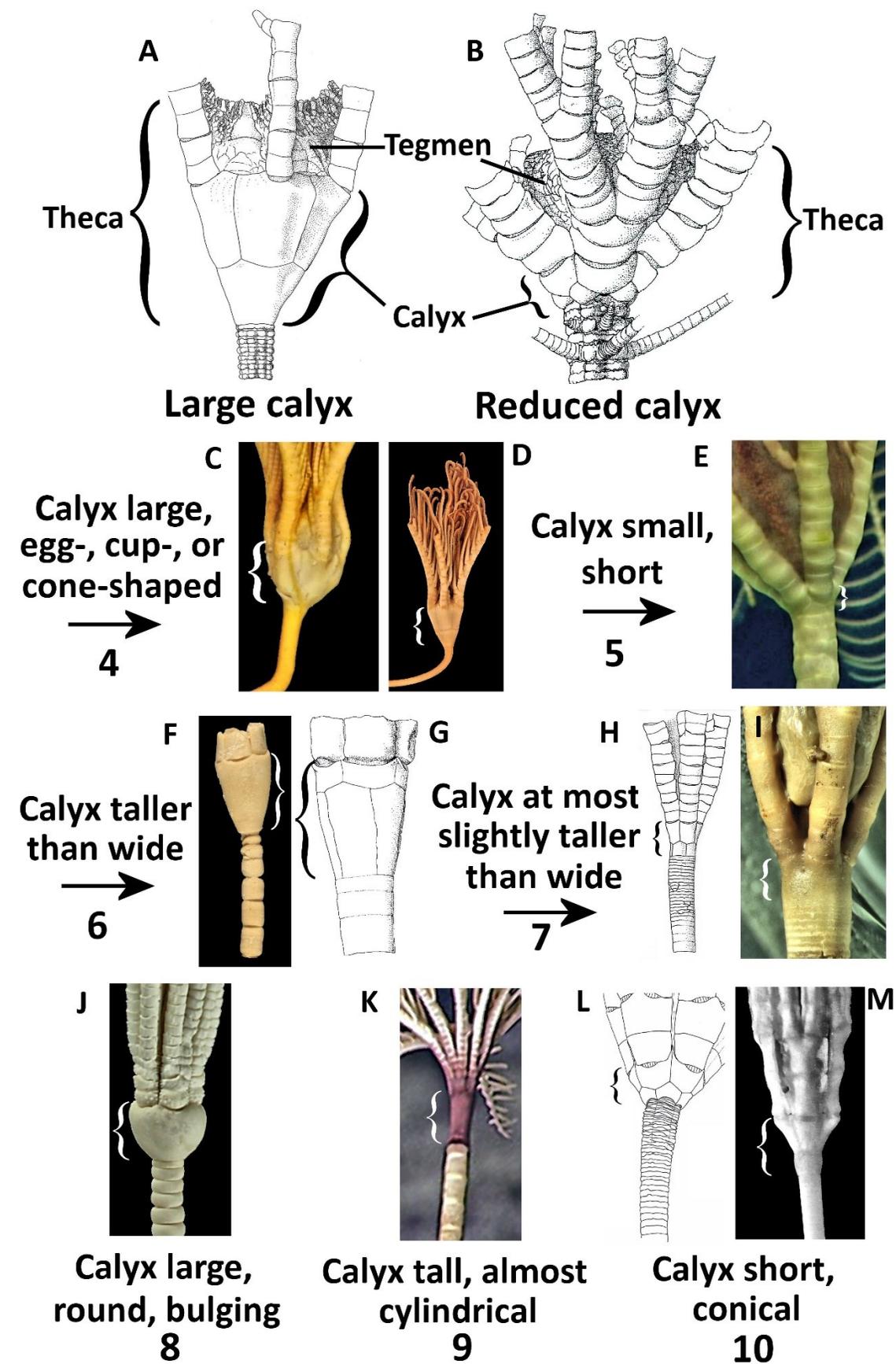
Homeomorphic stalk – similar columnals that may change gradually along the length of the stalk (modified from Clark, 1915).

Xenomorphic stalk – proximal, middle, and distal sections of the stalk (also called proxistele, mesistele and dististele, respectively) each consist of different kinds of columnals (modified from Clark, 1915).

Numbers refer to keys below.



Morphological characters – 3. Stalked crinoids: Theca



Theca – Central crinoid body from which the arms radiate—composed of calyx, visceral mass, and overlying tegmen.

Calyx – Circlets of one or two (rarely three) skeletal plates that enclose, support, or lie below the central visceral mass.

Tegmen - Overlying, sometimes calcified membrane that bears mouth, anus.

Numbers refer to keys below.

Sources: A, B, G: Roux et al. (2002); C ©Stefano Schiaparelli University of Genoa/ IPY-CAML TAN0802, CC BY 4.0; E, K: NOAA; F: Muséum national d'Histoire naturelle, Paris; H: Messing (2007); I: CG Messing; J: Station marin de Concarneau; L: Mironov & Pawson (2010); M: Roux & Messing (2017).

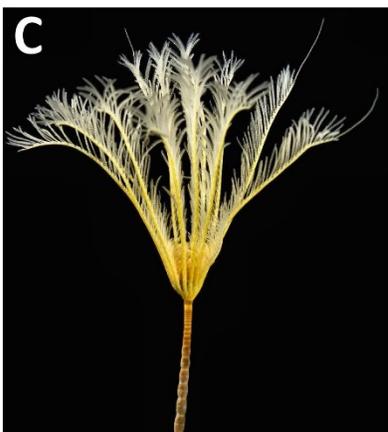
Morphological characters – 4. Stalked crinoids: Arms and pinnules



A
 Long pinnules - 4



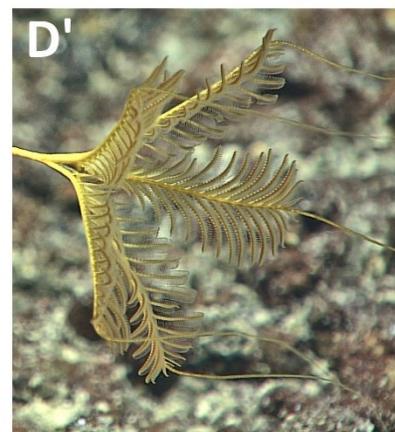
B
 Five undivided arms
 Short pinnules - 5



C
 Up to 17 undivided
 arms - 11



D
 Arms divided
 repeatedly to
 near tips - 12



D'
 Arms with
 terminal filament - 7



E
 Arms divided at
 least once, after
 several ossicles
 13

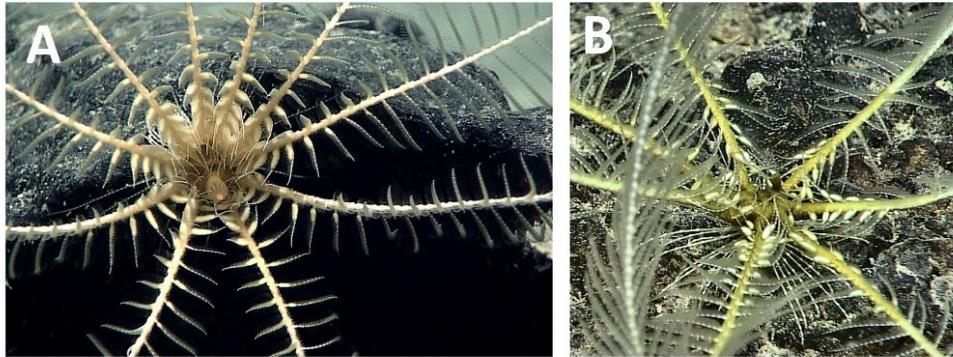


F **G** **H**
 10 arms only, divided just above
 base (at 2nd ossicle) - 14

Sources: A, B, D, D', F, H: NOAA; C: CG Messing/NSF. E: © CG Messing; G: From Mironov & Pawson (2010).

Numbers refer to keys below.

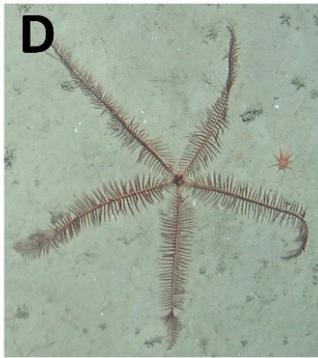
Morphological characters – 5. Feather stars: Rays, arms, and pinnules



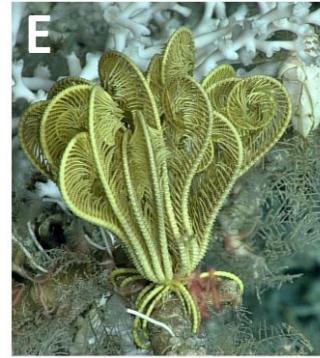
7-10 undivided rays - 15



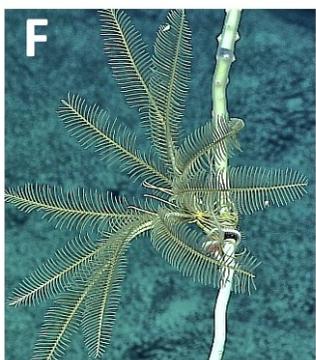
10 rays divided once; 20 arms - 16



**5 undivided rays
17**



**More than 10 arms
19**



5 rays divided once; 10 arms; most deep-sea feather stars - 18



Proximal pinnules present - 20



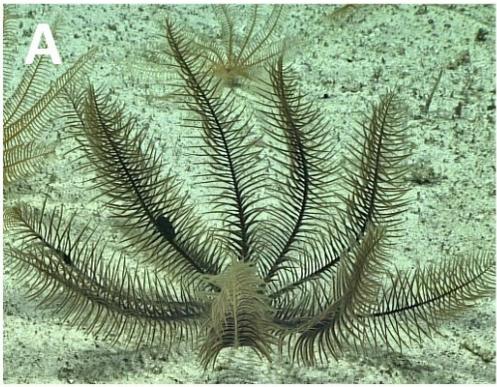
Proximal pinnules absent - 21

**Arms end in long filament; very long cirri
20**

Sources: A, B, E, F, H, I: NOAA. C: © norb.homesdns.org. G: ©Mark Woomb (https://www.argyllhopespot.scot/explore/species/northern-feather-star/)

Numbers refer to keys below.

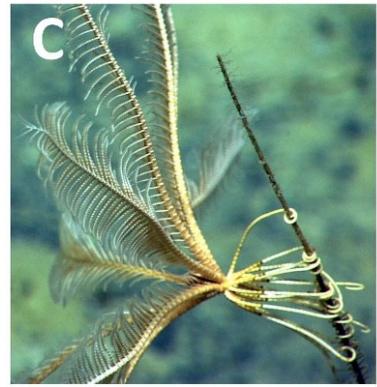
Morphological characters – 6. Feather stars: Arms, cirri, and pinnules



Pinnules arranged in 4 directions (tetrads) - 22



Few oral pinnules stiff - 23



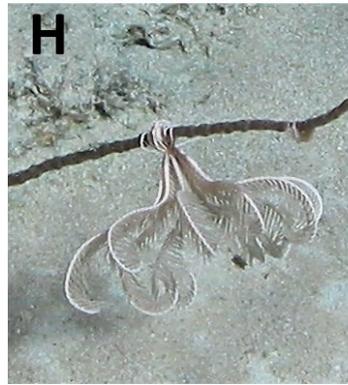
Cirri 20-50% of arm length; distally coiled - 24



Calyx hidden 25



Cirri <20% of arm length, gently curved; arm bases form funnel/cup-like array - 26



Cirri ~15-50% of arm length, slender to delicate, usually distally hooked, may coil around perch in small taxa - 27

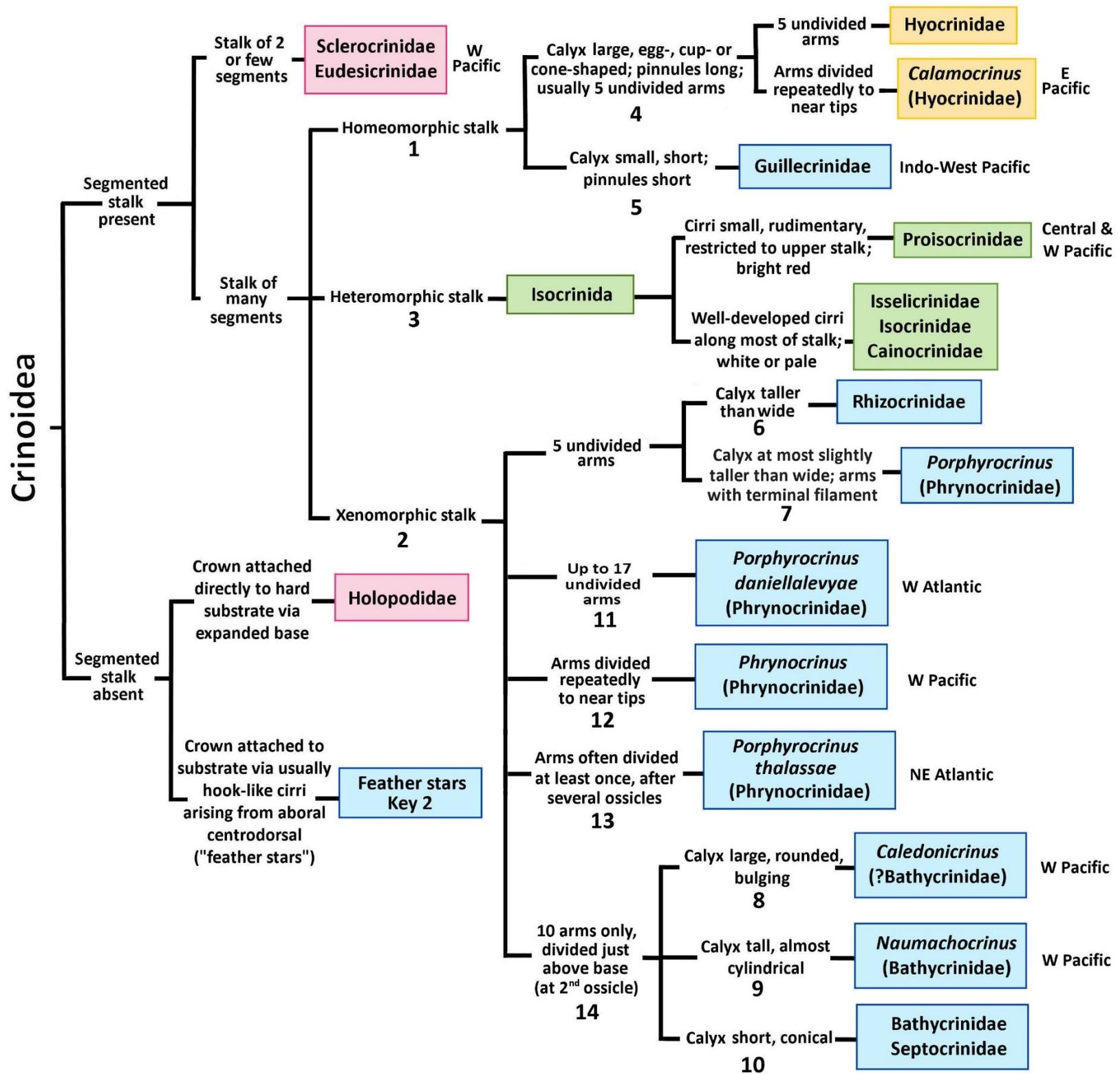


Arms spread almost horizontally from bases - 28

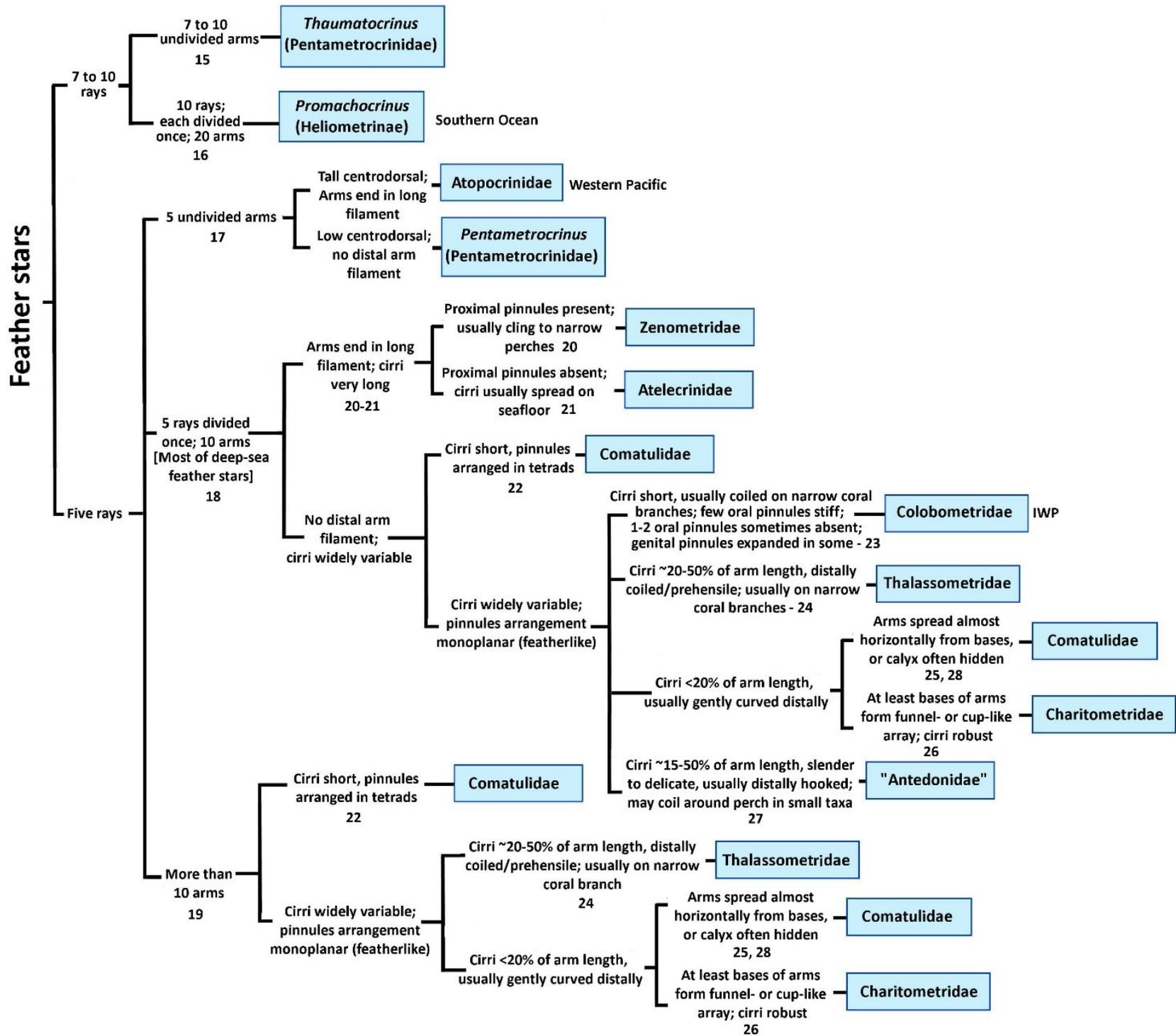
Sources: A, C, F, G: NOAA. B: ©Thierry Mulochau. D: © John K Reed/HBOI at FAU. E, I: © T.K. Baumiller/C.G. Messing.

Numbers refer to keys below.

ARTIFICIAL KEYS TO DEEP-SEA CRINOIDS – 1. Stalked crinoids



ARTIFICIAL KEYS TO DEEP-SEA CRINOIDS – 2. Feather stars



Order HYOCRINIDA (Family Hyocrinidae)

- Stalk: Homeomorphic – composed of similar columnals that may change gradually along the length.
- Attach to hard substrates via disk-shaped, stellate, or irregular holdfast.
- Theca cup-, egg-, or funnel-shaped; wider at upper end.
- Five undivided arms (except in tropical eastern Pacific *Calamocrinus*); arm bases much narrower than theca.
- Longest pinnules may reach about half arm length.
- Global distribution; depths chiefly >1,000 m (as shallow as ~200 m in Southern Ocean)
- 29 species; stalk length to ~50 cm.

Unidentified Hyocrinidae



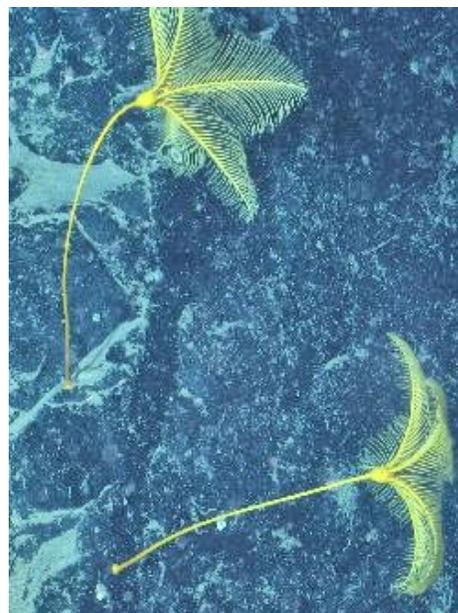
Anachalypsicrinus nefertiti



Ptilocrinus amezianeae



Anachalypsicrinus Nefertiti

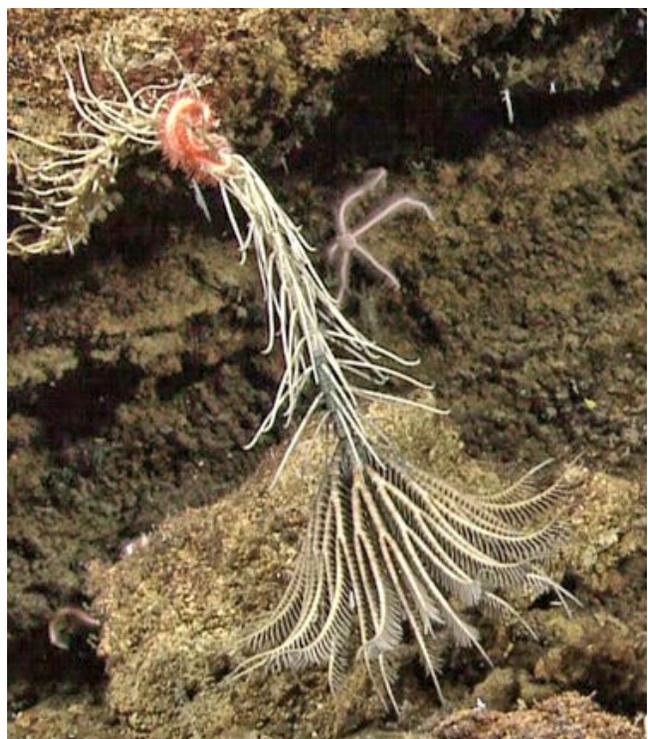
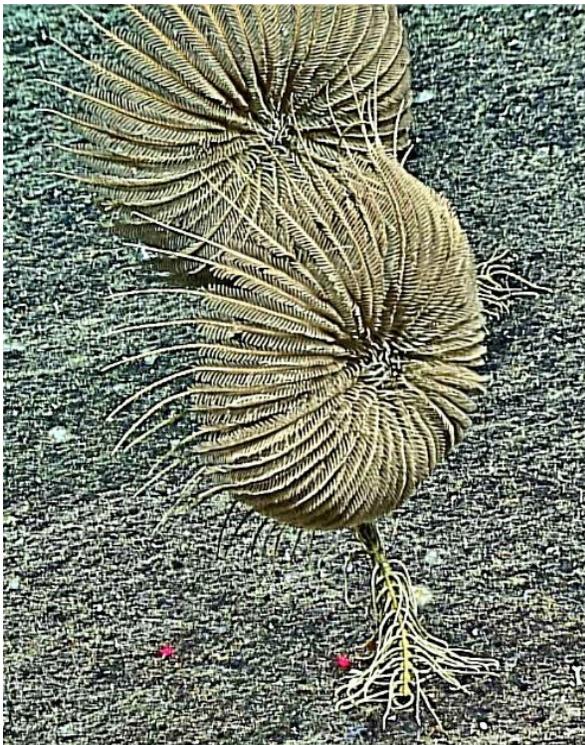


Sources: Unidentified hyocrinid, E Pacific: Jason II. *Anachalypsicrinus nefertiti*, NE Atlantic: (top right) Plymouth University; (bottom right) IFREMER. *Ptilocrinus amezianeae*, Southern Ocean: NIWA New Zealand.

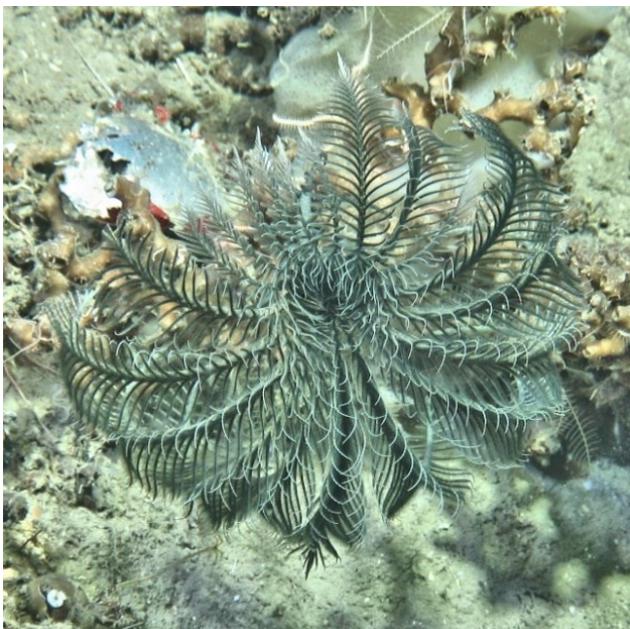
Order ISOCRINIDA

- Stalk: Heteromorphic – composed of two kinds of columnals distributed along most or the entire column: cirrus-bearing nodals separated by internodals lacking cirri. Recurved arms may obscure short stalk in some species. Pacific *Proisocrinus ruberrimus* is unique in having only rudimentary cirri, all restricted to the upper stalk, but still has nodals without cirri along the rest of the stalk.
- Cling to hard substrates with cirri along a prostrate distal portion of the stalk or with just the terminal whorl of cirri. They can lie down, release their anchoring cirri and crawl with their arms.
- Theca reduced to circlets of 2-3 small plates at stalk apex.
- Each of 5 rays divided at least once to produce 10 or more (usually 20-50) arms.
- Tropical W Atlantic (5 species), NE Atlantic (1), Indian (1), W Pacific (14); depths ~100 - >2,000 m; stalk length to ~90 cm.

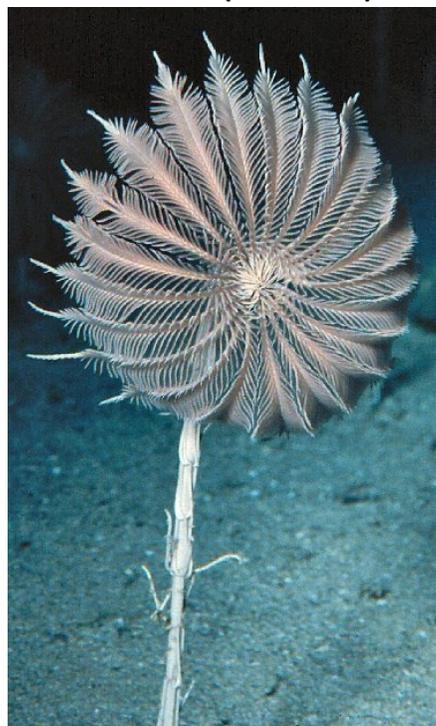
Isselocrinidae (Metacrininae, either *Saracrinus* or *Metacrinus*)



Isselocrinidae (Diplocrininae, *Endoxocrinus* (*Diplocrinus*) *wyvillethomsoni*)



Isocrinidae (*Neocrinus*)



Sources: Metacrininae, Tropical Western Pacific: NOAA. *Endoxocrinus* (*Diplocrinus*) *wyvillethomsoni*, NE Atlantic: Plymouth Univ. *Neocrinus*: C. G. Messing/NSF.

Order ISOCRINIDA – Regional examples

NORTHEASTERN ATLANTIC

Endoxocrinus (Diplocrinus) wyvillethomsoni

Note anchoring via terminal whorl of cirri

From Conan *et al.* (1981)



TROPICAL WESTERN ATLANTIC

Neocrinus decorus (tall)

Endoxocrinus parrae (lower left)

Credit: C. G. Messing / NSF



WESTERN PACIFIC

Metacrininae – either *Saracrinus* or *Metacrinus*

Credit: NOAA/W. Embley



WESTERN AND CENTRAL PACIFIC

Proisocrinus ruberrimus

Note rudimentary cirri near top of stalk

Credit: NOAA



Order CYRTOCRINIDA

- Stalk: Composed of two or (possibly) a few ossicles OR theca attached directly to substrate via expanded, sometimes stump-like, base.
- Rays at least weakly asymmetric, arising obliquely from theca.
- Arms 10 to ~20, reduced in *Cyathidium*; they curl over and protect oral surface when disturbed.
- Cemented to hard substrates via holdfast or base of theca.
- Tropical western Atlantic and Pacific, and NE Atlantic; depths ~140-1,140 m.
- 8 species; <10 cm tall; *Cyathidium* to ~2 cm across.

Holopodidae (*Holopus*)



Holopodidae (*Cyathidium*)



Sclerocrinidae (*Neogymnocrinus*)



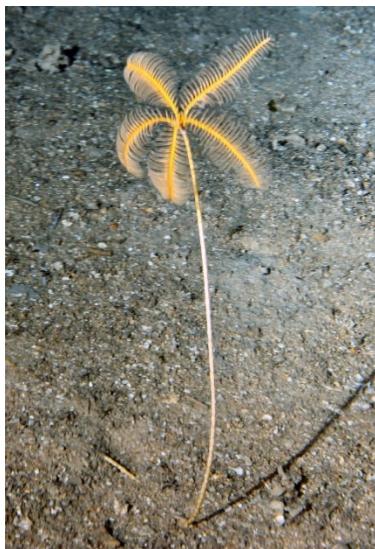
Sources: *Holopus*, Caribbean Sea: © C.G. Messing / T.K. Baumiller. *Cyathidium foresti*, Azores, NE Atlantic, from Max Wisshak, from Wisshak et al. (2009), fig. 2D (cropped). *Neogymnocrinus richeri*, New Caledonia, KANADEEP II Exped, IFREMER.

Order COMATULIDA (includes both feather stars and stalked forms)

- Stalk either xenomorphic or lost following a postlarval stage.
- Most stalk columnals joined by **synarthry** (fulcral ridge on opposite ends of a columnal orient at different angles, so that successive articulations point in different directions).
- **Feather stars** – Retain only centrodorsal bearing cirri; arm length usually <25 cm.
- Rays divided once in most deep-sea species to produce 10 arms, or divided repeatedly; undivided in a few species.
- 46 stalked species; stalks to at least 30 cm; ~556 feather star species (deep and shallow).

STALKED FORMS

Rhizocrinidae (*Democrinus*)



Bathycrinidae (*Bathycrinus*)



Bathycrinidae (*Naumachocrinus*)

with hydroids on stalk



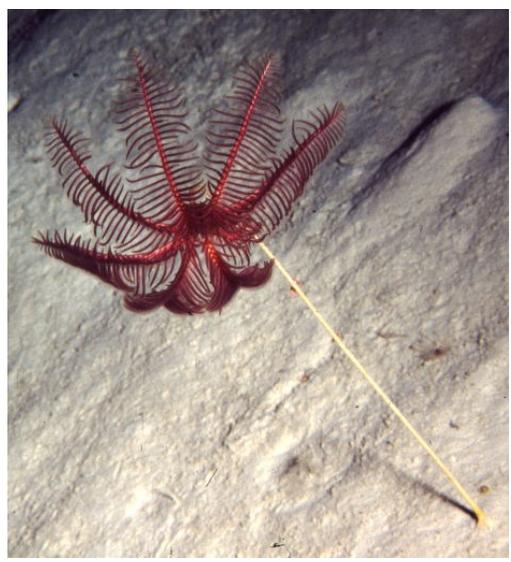
Phrynocrinidae
(*Phrynocrinus*)



Phrynocrinidae with well-developed stalk synarthries



Septocrinidae (*Rouxicrinus*)



Phrynocrinidae (*Porphyrocrinus*)



Guillecrinidae (*Guillecrinus*)



Sources: Rhizocrinidae, Caribbean Sea: ©CG Messing/TK Baumiller. Septocrinidae, Caribbean Sea: Smithsonian Institution/Harbor Branch Oceanographic Institute. All others, W & Central Pacific: NOAA.

Order COMATULIDA

FEATHER STARS

Pentametrocrinidae (*Thaumatoocrinus*)



Pentametrocrinidae (*Pentametrocrinus*)



Atopocrinidae (*Atopocrinus*)



Atelecrinidae (*Paratelecrinus*)



Zenometridae (*Sarametra*)



Colobometridae (*Decametra*)



Thalassometridae (*Thalassometra*)



Thalassometridae (*Koehlermetra*)



Order COMATULIDA

FEATHER STARS – continued

Charitometridae (*Crinometra*)



Comatulidae (*Neocomatella*)



“Antedonidae” (polyphyletic) – including Heliometrinae

Leptometra celtica



Heliometra glacialis



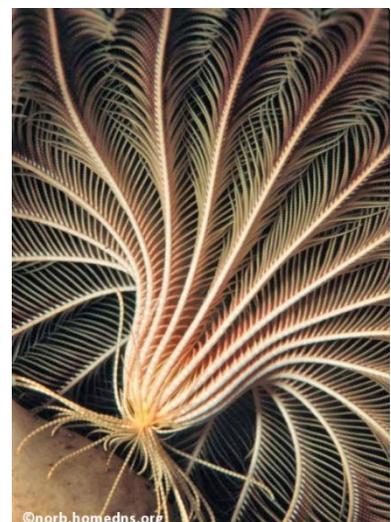
Trichometra



Bathymetra



Promachocrinus



Sources: Colobometridae, W Indian Ocean: ©Thierry Mulochau. *Koehlermetra*, *Leptometra*, *Heliometra*, all NE Atlantic: Plymouth University. *Trichometra*, Bahamas: C.G. Messing/ NSF. *Crinometra*, *Neocomatella*, Caribbean Sea: ©T.K. Baumiller/C.G. Messing. Atopocrinidae, Indonesia: NOAA. *Promachocrinus*, Southern Ocean: © norb.homedns.org. All others, Western & Central Pacific: NOAA.

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