Appendix 1. – Listing of characters and character states coded for analyses.

CROWN (CR)

CR1 Symmetry
0: pentameral/subpentameral about the oral-aboral axis
1: poor bilateral symmetry
2: perfect bilateral symmetry
3: irregular
4: three-fold symmetry
5: tetragonal/triagonal

CR2 Crown attitude on column
0: erect
1: pendent
2: recumbent

CALYX (CA)

CA1 Calyx/aboral cup height (height/width)
0: very high: > 2.0
1: high: 2.0 to >1.25
2: medium: <1.25 to >0.75
3: low: <0.75 to >0.50
4: flat: < 0.50- >0.25
5: very flat: <0.25

CA2 Calyx/aboral cup profile
0: straight sides
1: convex sides -- widest at top of calyx/aboral cup
2: convex sides -- widest below top of calyx/aboral cup
3: concave sides
4: laterally compressed (Calceocrinidae)
5: adanally-abanally compressed (Calceocrinidae)
6: bilateral and subcylindrical (Calceocrinidae)
7: bilateral and vase shaped (Calceocrinidae)
CA3 Basic calyx plating
0: basically arranged in alternating circlets
1: basal circket and radial circket articulated on a fulcral ridge (Calceocrinidae)
2: irregular plating (as in protocrinoids)

CA4 Calyx plate suturing (degree to which calyx plates are attached to one another)
0: poor (easily crushed during compaction)
1: good (not easily crushed during compaction, but not ankylosed)
2: cemented (ankylosed)

CA5 Calyx plate thickness measured on radial plate
0: thin (<25% height or width)
1: thick (>25% height or width)

CA6 Calyx plate cross-sectional shape
0: flat
1: convex
2: nodose
3: spinose
4: concave

CA7 Sutures commonly distinct (visibility) on calyx and tegmen
0: absent
1: present

CA8 Calyx plate sculpturing (see Bohaty and Ausich)
0: smooth
1: finely nodose
2: coarsely nodose
3: finely granulose
4: coarsely granulose
5: coarse irregular nodes and pitting
6: finely pitted
7: coarsely pitted
8: with ridges
9: with stellate ridges
10: spine
11: movable, articulated spines
12: concave
CA9  Sculpturing at base of calyx
    0: ridge absent
    1: nodose
    2: broken ridge/coalesced nodes
    3: continuous ridge
    4: variable in a species

CA10 Shape of circllet(s) at base of calyx
    0: upright (visible in lateral view)
    1: flat
    2: concave

CA11 Calyx lobation at the position along which arms become free
    0: absent
    1: present

CA12 Short ray lobes built with fixed brachials
    0: absent
    1: present

CA13 Ligament pit on articulation between radial and basal circllets (for calceocrinids)
    0: divided
    1: undivided

CA14 Calyx plate addition
    0: in circllets
    1: insertion of plates around primary circllet plates
    2: both
    3: insertion of plates exclusively in interarea
    4: insert plate in circllets and in columns beneath basals (Acrocrinidae)
    5, both (as in Habrotecrinus)

CA15 Consistent plating pattern (presumably under genetic control)
    0: absent
    1: present

CA16 "Gap" plate(s) in lowest calyx circllet
    0: absent
    1: present

CA17 Calyx sutures
    0: surface flush between adjacent plates
    1: impressed in a groove
INFRABASAL CIRCLET (IC)

IC1  Infrabasal circlet
    0: absent
    1: absent in adults
    2: present in adults

IC2  Relative height of the infrabasal circlet
    0: covered by column cicatrix
    1: entirely in basal concavity
    2: partially in basal concavity
    3: along flat base of calyx (neither in basal concavity nor visible in side view)
    4: plates wrap around from calyx base to side view of calyx
    5: all plates in vertical wall of calyx
    6: partially in basal concavity and wraps around to be visible in side view

IC3  Number of infrabasal plates
    0: none
    1: one
    2: two
    3: three
    4: four
    5: five
    6: six

IC4  Infrabasal plate dimensions
    0: W>H
    1: H~W
    2: H>W

BASAL CIRCLET (BC)

BC1  Relative height of basal circlet
    0: covered by column cicatrix
    1: entirely in basal concavity
    2: partially in basal concavity
    3: along flat base of calyx (neither in basal concavity nor visible in side view)
    4: plates wrap around from calyx base to side view of calyx
    5: all plates in vertical wall of calyx
    6: internal rosette
7: partially in basal concavity and wraps around to be visible in side view
8: plates partially covered by infrabasals (as in *Homalocrinus*)
9: plates completely covered by infrabasals (as in *Homalocrinus*)

BC2 Number of basal plates
0: none
1: one
2: two
3: three
4: four
5: five

BC3 Basal plate dimensions
0: W>H
1: H~W
2: H>W

BC4 Basal plate, relative sizes
0: plates of equal size
1: subequal
2: unequal

BC5 All basals part of distal margin articulated to radial circlet (for calceocrinids)
0: no
1: yes

BC6 Number of basals in contact with basal concavity (for calceocrinids)
0: four
1: three
2: two
3: one

RADIAL PLATES (RC)

RC1 Radial circlet shape
0: radial
1: flat rectangular (for Calceocrinidae)
2: flat trapezoid (for Calceocrinidae)
RC2  Radial circlet interruption
    0: absent
    1: CD interray only
    2: all interrays
    3: more than one interray but less than five

RC3  Radial plates in contact laterally to basals and proximally to infrabasals (as in Cleiocrinus)
    0: no
    1: yes

RC4  Number of rays with radial plates
    0: none
    1: one (fused)
    2: two
    3: three
    4: four
    5: five

RC5  Simple radial plate dimensions
    0: W>H
    1: H=W
    2: H>W

RC6  Supraradial plate dimensions (if compound radials)
    0: W>H
    1: H=W
    2: H>W

RC7  Infraradial plate dimensions (if compound radials)
    0: W>H
    1: H=W
    2: H>W

RC8  Superradial plates much smaller than infrerradial plates (if compound radials)
    0: no
    1: yes supraradial <50% of infrerradial
RC9  Relative height of radial circlet
0: covered by column cicatrix
1: entirely in basal concavity
2: partially in basal concavity
3: along flat base of calyx (neither in basal concavity nor visible in side view)
4: plates wrap around from calyx base to side view of calyx
5: all plates in vertical wall of calyx
6: partially in basal concavity and wraps around to be visible in side view
7: plates partially covered by infrabasals (as in *Homalocrinus*)
8: above aboral cup (as in *Tetragonocrinus*)

RC10  Radial plate largest plate in calyx
0: no
1: yes

RC11  C radial plate much smaller than other radial plates
0: no
1: yes

RC12  Radial plates unequal in size
0: no
1: yes

RC13  A-ray radial plate
0: absent
1: simple with one radial facet
2: compound
3: simple without a radial facet
4: simple with multiple facets
5: compound with multiple facets

RC14  B-ray radial plate
0: absent
1: simple with one radial facet
2: compound
3: simple without a radial facet
4: simple with multiple facets
5: compound with multiple facets
RC15  C-ray radial plate  
   0: absent  
   1: simple with one radial facet  
   2: compound  
   3: simple without a radial facet  
   4: simple with multiple facets  
   5: compound with multiple facets  

RC16  D-ray radial plate  
   0: absent  
   1: simple with one radial facet  
   2: compound  
   3: simple without a radial facet  
   4: simple with multiple facets  
   5: compound with multiple facets  

RC17  E-ray radial plate  
   0: absent  
   1: simple with one radial facet  
   2: compound  
   3: simple without a radial facet  
   4: simple with multiple facets  
   5: compound with multiple facets  

RC18  E-ray inferradial-superradial sutural contact (for Calceocrinidae)  
   0: absent  
   1: long  
   2: short  
   3: narrowly separated  
   4: widely separated  

RC19  Width of E inferradial relative to total hinge length (for Calceocrinidae)  
   0: 33 %  
   1: 67 %  
   2: 100 %  

RC20  B and C inferradials fused (for Calceocrinidae)  
   0: yes  
   1: no  
   2: absent
RC21  B and C inferradials fused with A and D radials (for Calceocrinidae)
   0: absent
   1: present

RADIAL FACETS (RF)

RF1  Radial facet width and shape (5: fixed brachial above)
   0: angustary <70% width
   1: peneplenary >70%
   2: plenary (complete facet plenary)
   3: inplenary (facets touching only adaxially)
   4: explenary (facets touching only abaxially)
   5: fixed brachial above
   6: absent
   7: multiple facets

RF2  Radial facet type
   0: unifascial
   1: bifascial
   2: trifascial
   3: multifascial

RF3  Straight fulcral ridge
   0: absent
   1: weak
   2: strong

RF4  Axial nerve through radial facet
   0: absent
   1: single opening
   2: double opening
   3: triple opening

RF5  Radial facet orientation
   0: sursumate
   1: planate
   2: declivate
   3: vertical

RF6  Crenulae surrounding aboral ligamentary fossae
   0: absent
   1: present
RF7  On facet with aboral ligamentary fossae: grooves from margin to center of facet
0: absent
1: present and oriented toward midline and toward ambulacral groove
2: present and oriented toward midline and toward aboral side of plate

RF8  If plenary, …
0: explenary (facets touching only abaxially)
1: inplenary (facets touching only adaxially)

FIXED INTERRAYS AND BRACHIALS (FP)

FP1  Regular interray with fixed plates
0: absent
1: present
2: interlocking or loosely sutured (as in flexibles)

FP2  Regular interray proximal fixed plating (number of plates in first and second range)
0: none
1: one to two (1-2)
2: one to three (1-3)
3: one-one (1-1)
4: one to greater than 3 (1->3)
5: only one plate
6: multiple plates in first row

FP3  Approximate number of regular interradial plates
0: one to three (1-3)
1: four to twelve (4-12)
2: more than twelve (>12)

FP4  Regular interrays depressed
0: no
1: yes

FP5  Regular interrays with plating in biseries
0: no
1: yes
FP6  Position of distal-most interradial plates in relation to fixed brachials
   0: primibrachitaxis
   1: secundibrachitaxis
   2: tertibrachitaxis
   3: quartibrachitaxis
   4: >quintibrachitaxis

FP7  Interrays
   0: in contact with tegmen in all interrays
   1: in contact with the tegmen in CD interray
   2: not in contact with the tegmen

FP8  Fixed brachials
   0: absent
   1: present
   2: interlocking or loosely sutured (as in flexibles)

FP9  Fixed rays symmetrical
   0: absent
   1: present

FP10 Median ray ridges
   0: absent
   1: present

FP11 Fixed first primibrachial shape
   0: 4-sided
   1: 5-sided
   2: 6-sided
   3: 7-sided
   4: 8-sided
   5: 3-sided

FP12 Fixed first primibrachial dimensions
   0: W>H
   1: H~W
   2: H>W

FP13 Fixed brachials isotomously branched
   0: no
   1: yes
<table>
<thead>
<tr>
<th>FP14</th>
<th>Distal most fixed brachitaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:</td>
<td>primibrachials</td>
</tr>
<tr>
<td>1:</td>
<td>secundibrachials</td>
</tr>
<tr>
<td>2:</td>
<td>tertibrachials</td>
</tr>
<tr>
<td>3:</td>
<td>&gt; quartibrachials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FP15</th>
<th>Fixed pinnules</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:</td>
<td>absent</td>
</tr>
<tr>
<td>1:</td>
<td>present</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FP16</th>
<th>Fixed intrabrachials within a ray</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:</td>
<td>no</td>
</tr>
<tr>
<td>1:</td>
<td>yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FP17</th>
<th>Position of highest intrabrachials plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:</td>
<td>primibrachitaxis</td>
</tr>
<tr>
<td>1:</td>
<td>secundibrachitaxis</td>
</tr>
<tr>
<td>2:</td>
<td>tertibrachitaxis</td>
</tr>
<tr>
<td>3:</td>
<td>&gt; quartibrachitaxis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FP18</th>
<th>Arm trunks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:</td>
<td>absent</td>
</tr>
<tr>
<td>1:</td>
<td>present, with short trunk and few biserial arms</td>
</tr>
<tr>
<td>2:</td>
<td>present, with long trunk and many biserial arms</td>
</tr>
</tbody>
</table>

**POSTERIOR PLATING OF CLADID, DISPARID, FLEXIBLE, and ARTICULATES (PF)**

[USE NAMES AND HOMOLOGIES IN 1978 CRINOID TREATISE]

<table>
<thead>
<tr>
<th>PF1</th>
<th>Anal series articulated with C ray (for posterior of cladids, disparids, flexibles, &amp; articulates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:</td>
<td>no</td>
</tr>
<tr>
<td>1:</td>
<td>yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PF1a</th>
<th>Radial plate presence (proximal-most CD interray plate in cladids, disparids, flexibles, and articulates and in sutural contact with with infrabasal or basal circlet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 :</td>
<td>absent</td>
</tr>
<tr>
<td>1:</td>
<td>present</td>
</tr>
</tbody>
</table>
PF2  Radial plate (proximal-most CD interray plate in cladids, disparids, flexibles, and articulates and in sutural contact with with infrabasal or basal circlet)
   0: absent
   1: simple
   2: compound

PF3  Radial (or Superradial) shape (for posterior of cladids, disparids, flexibles, and articulates)
   0: pentagonal
   1: hexagonal
   2: septagonal
   3: tetragonal
   4: triangular

PF4  Radial plate proximal width (for posterior of cladids, disparids, flexibles, and articulates)
   0: full width beneath C radial plate
   1: to left and below C radial plate
   2: within radial/superradial circlet
   3: To the left and above C radial/superradial

PF5  Radial plate in contact proximally with (for posterior of cladids, disparids, flexibles, and articulates)
   0: basal plates
   1: infrabasal plates
   2: superradial
   3: radial

PF6  Anal X shape (for posterior of cladids, disparids, flexibles, and articulates)
   0: tetragonal
   1: pentagonal
   2: hexagonal
   3: heptagonal
   4: octagonal
   5: nonagonal
   6: decagonal
   7: triangular
   8: ovate
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF7</td>
<td>Right tube plate shape (for posterior of cladids, disparids, flexibles, and articulates)</td>
</tr>
<tr>
<td>0</td>
<td>tetragonal</td>
</tr>
<tr>
<td>1</td>
<td>pentagonal</td>
</tr>
<tr>
<td>2</td>
<td>hexagonal</td>
</tr>
<tr>
<td>3</td>
<td>heptagonal</td>
</tr>
<tr>
<td>4</td>
<td>octagonal</td>
</tr>
<tr>
<td>PF8</td>
<td>Anal X position</td>
</tr>
<tr>
<td>Z</td>
<td>absent</td>
</tr>
</tbody>
</table>

**ABOVE AND TO LEFT OF RADIANAL**
- **0**: above to left of radianal, lateral to D radial plate to left and right tube plate on upper right shoulder
- **1**: above to left of radianal and on upper right shoulder of D radial plate
- **A**: above to the left of radianal, lateral to C radial plate but not in contact with D radial plate
- **B**: above to left of radianal and adjacent to both C radial (or superradial) and D radial (or superradial)

**DIRECTLY ABOVE RADIANAL**
- **2**: directly above radianal and lateral to D radial plate and right tube plate on upper right shoulder
- **3**: directly above radianal and on upper right shoulder D radial plate
- **C**: directly above radianal, lateral to C radial plate but not in contact with D radial plate
- **D**: directly above radianal and adjacent to both C radial (or superradial) and D radial (or superradial)

**DIRECTLY ABOVE RADIAL (OR SUPERRADIAL) PLATE**
- **4**: directly above C radial plate (or superradial plate)

**ABOVE AND TO LEFT OF RADIAL (SUPERRADIAL) PLATE**
- **6**: sutured above and to left of C radial plate (superradial plate) and on shoulder of D radial plate (superradial plate)
- **E**: sutured above and to left of C radial plate (superradial plate) and not in contact with D radial plate (superradial plate)
- **M**: suture above to left of C inferradial and laterally between C superradial and D radial plate

**ABOVE PRIMIBRACHIAL**
- **5**: sutured above and to left of first primibrachial
- **7**: above and left of radianal and lateral to D radial plate
DIRECTLY ABOVE CD BASAL PLATE AND RADIANAL ABSENT
8: directly above CD basal (radianal absent) and adjacent to C and D radials
9: directly above CD basal (radianal absent) and on shoulders of C and D radials
F: directly above CD basal (radianal absent) and above aboral cup
G: directly above CD basal (radianal absent) and adjacent to C radial plate but not D radial plate
L: D but not C

DIRECTLY ABOVE CD BASAL AND RADIANAL PRESENT
H: directly above CD basal and separated from radianal plate
K: directly above CD Basal and radial plate lateral to right

ABOVE AND TO LEFT OF CD BASAL
I: Anal X and radianal plate adjacent between C and D radial plates

CALCEOCRINIDS
J: directly above fused B and C superradials (subanal)

ACOLOCRINUS
K. Sits on top of cup wall at juncture between C and D inferradials and superradials"

PF9 Right tube plate position
Z: absent

ABOVE AND TO RIGHT OF ANAL X
0: above to right of anal X and lateral to C radial plate (superradial)
1: above to right of anal X and lateral to D radial plate (superradial)
7: above and to right of anal X and resting on upper shoulder of C and or D radial (superradial)
8: presumed right tube plate (plate to right and above anal X) and not in contact with either C or D radial (superradial) plate (in or out of cup)

DIRECTLY ABOVE ANAL X (RADIANAL ABSENT)
2: directly above anal X and lateral to C radial plate
3: directly above anal X and not lateral to C radial plate (above aboral cup)
9: directly above anal X and lateral to C and D radial plates;

ABOVE RADIANAL
4: above and to right of radianal, above and to right of anal X, and in contact with C radial plate
5: above and to right of radianal, above and to right of anal X, and not in contact with C radial plate
6: above (and to right of) radianal, above and to right of anal X, and lateral to the anal X and in contact with C radial

ADJACENT TO ANAL X
A: laterally between anal X and C radial plate;

ADJACENT TO ANAL X AND ABOVE ABORAL CUP
B: above radianal, above cup, directly adjacent to anal X

POSTERIOR PLATING OF CAMERATES (PC)

PC1  CD interray proximal plating (for posterior of camerates: P=primanal)
   0: P-2
   1: P-3
   2: P-> 4
   3: P-1
   4: P (only)
   5: multiple plates

PC2  Number of extra plates in CD interray (for posterior of camerates)
   0: none
   1: one or two (1 or 2)
   2: three or four (3 or 4)
   3: four
   4: five or more (>5)

PC3  CD interray width in comparison with regular interrays (for posterior of camerates)
   0: same
   1: wider than
   2: very much wider than high

PC4  CD interray (for posterior of camerates)
   0: in contact with tegmen
   1: not in contact with tegmen

PC5  Anitaxis plating (for posterior of camerates)
   0: absent
   1: present

PC6  Anitaxial ridge (for posterior of camerates)
   0: absent
   1: present
### PERISTOMIAL REGION OF TEGMEN

<table>
<thead>
<tr>
<th>PR1</th>
<th>Overall rigidity of plating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>tessellate plating</td>
</tr>
<tr>
<td>1</td>
<td>imbricated</td>
</tr>
<tr>
<td>2</td>
<td>plates in a flexible integument</td>
</tr>
<tr>
<td>3</td>
<td>unplated (not due to lack of preservation)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR2</th>
<th>Tegmen plate arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>radial pattern visible</td>
</tr>
<tr>
<td>1</td>
<td>plates homogenous, usually numerous, lacking obvious radial pattern</td>
</tr>
<tr>
<td>2</td>
<td>irregular plates and plating</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR3</th>
<th>True Orals (interradial) form a mouth ring below peristomial cover plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>absent</td>
</tr>
<tr>
<td>1</td>
<td>present, not covered by ambulacral plates</td>
</tr>
<tr>
<td>2</td>
<td>present, covered by ambulacral plates, except Oral 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR4</th>
<th>Oral 1 visible on tegmen surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>absent</td>
</tr>
<tr>
<td>1</td>
<td>present</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR5</th>
<th>Respiratory structures on modified oral plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>absent</td>
</tr>
<tr>
<td>1</td>
<td>present</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR6</th>
<th>Ambulacral cover plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>absent (but not from lack of preservation)</td>
</tr>
<tr>
<td>1</td>
<td>present at arm bases and extend to peristome region</td>
</tr>
<tr>
<td>2</td>
<td>present at arm bases but do not extend to peristome region</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR7</th>
<th>Ambulacral cover plates function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>not tightly sutured, may have opened</td>
</tr>
<tr>
<td>1</td>
<td>fixed, differentiated from other tegmen plates and radiating from peristomial cover plates</td>
</tr>
<tr>
<td>2</td>
<td>fixed, undifferentiated from other tegmen plates</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PR8</th>
<th>Ambulacra branch on tegmen</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>absent</td>
</tr>
<tr>
<td>1</td>
<td>present, axillary ambulacral cover plates swollen</td>
</tr>
<tr>
<td>2</td>
<td>present, axillary ambulacral cover plates not swollen</td>
</tr>
<tr>
<td>3</td>
<td>present, cover plates absent</td>
</tr>
</tbody>
</table>
PR9  Peristome
   0: covered by peristomial cover plates (as in hybocrinids and cladids)
   1: covered by true oral plates
   2: open (for articulates – others?)

PR10 Peristomial cover plates
   0: absent
   1: differentiated, similar in size to ambulacral cover plates
   2: differentiated, significantly larger than ambulacral cover plates
   3: undifferentiated from other tegmen plates

PR11 Peristomial cover plates function
   0: not tightly sutured, may have opened
   1: tightly sutured, fixed

PR12 Interambulacrals (plates between ambulacra that are not true orals, or thecal plates)
   0: none (as in hybocrinids; dichocrinids)
   1: few in each interray (some cladids)
   2: numerous in each interray (flexibles)

PR13 Hydropore
   0: absent
   1: present on oral

PR14 Goniopore
   0: absent
   1: present

PR15 Madreporite
   0: absent
   1: present

PR16 Ambulacra arrangement symmetry
   0: 2-1-2
   1: pseudo five fold
   2: three-fold
   3: four-fold
CLADID, DISPARID, FLEXIBLE, ARTICULATE TEGMEN (TF)

TF1  Anus position in CD interray
  0: tegmen top, subcentral
  1: tegmen top, eccentric
  2: tegmen side
  3: calyx side
  4: elevated on anal sac (on top)
  5: elevated on anal sac (~mid-height)
  6: elevated to base of anal sac

TF2  Erect anal structure (for posterior of cladids, disparids, flexibles, & articulates)
  0: absent
  1: anal sac
  2: anal papilla (small unplated structure on at least many articulates)

TF3  Anal sac plating
  0: in vertical columns of aligned rows
  1: in vertical columns of offset rows
  2: irregular

TF4  Dominant column supporting sac
  0: absent
  1: present

TF5  Anal sac plate sculpturing
  0: smooth
  1: radiating ridges
  2: nodose
  3: vertical grooves and ridges
  4: spinose
  5: finely pustulose

TF6  Anal sac plate cross section
  0: flat
  1: plicated
  2: convex
  3: nodose
  4: spinose
TF7 Anal sac shape (for posterior of cladids, disparids, flexibles, & articulates)
0: cylindrical
1: tapering distally
2: expanded distally, club-shaped
3: folded over
4: bulbous (e.g., Coeliocrinus)
5: spiral (e.g., Streptocrinus)

TF8 Anal sac “respiratory openings” (for posterior of cladids, disparids, flexibles, & articulates)
0: absent
1: sutural pores
2: slits

TF9 Anal sac spines at summit (for posterior of cladids, disparids, flexibles, & articulates)
0: absent
1: single spine on top of anal sac
2: multiple spines at summit of anal sac
3: "umbrella" of spines form roof of anal sac (composed only of spine plates)
4: "umbrella" of spines form roof of anal sac composed of both spine plates and extra plates

TF10 Arrangement of spinose plates if form roof over anal sac
0: spine plates continuous around periphery
1: spine plates separated by one or more non-spine plate around periphery

TF11 Anal sac spine shape
0: taper abaxially
1: expand abaxially

TF12 Anal sac spine cross section
0: circular
1: flattened oral-aborally
2: flattened laterally

TF13 Anal sac height
0: shorter than aboral cup height
1: higher than aboral cup approximately mid-arm length
2: approximately height of arms
3: higher than arms
CAMERATE TEGMEN (TC)

TC1  Tegmen height (height/width)
   0: very high: > 2.0
   1: high: 2.0 to >1.25
   2: medium: <1.25 to >0.75
   3: low: <0.75 to >0.50
   4: flat: < 0.50

TC2  Tegmen shape profile
   0: straight sides
   1: convex sides -- widest at base if tegmen
   2: convex sides -- widest above top of tegmen
   3: concave sides

TC3  Tegmen height in relation to calyx
   0: lower than calyx
   1: tegmen approximately as high as calyx
   2: higher than calyx

TC4  Rigidly plated tegmen
   0: no
   1: yes

TC5  Tegmen plate sculpturing, including anal tube
   0: smooth
   1: finely nodose
   2: coarsely nodose
   3: finely granulose
   4: coarsely granulose
   5: coarse irregular nodes and pitting
   6: finely pitted
   7: coarsely pitted
   8: with ridges
   9: with stellate ridges
   10: spine
   11: movable, articulated spines
   12: concave

TC6  Proximal brachials fixed into side of tegmen
   0: absent
   1: present
TC7  Approximate number of tegmen plates
   0: basically five
   1: ten
   2: 11—50
   3: >50

TC8  Tegmen plates gradational in size from abaxial margin to center
   0: absent
   1: present

TC9  Tegmen spines
   0: absent
   1: cylindrical
   2: spatulate

TC10 Anus position
   0: tegmen top, central
   1: tegmen top, subcentral
   2: tegmen top, eccentric
   3: tegmen side
   4: calyx side
   5: from terminus of anal tube
   6: mid-height of anal tube
   7: base of anal tube

TC11 Anal tube (for camerates)
   0: absent
   1: present
   2: very short raised cluster of plates

TC12 Anal tube plating (for camerates)
   0: in vertical columns of aligned rows
   1: in vertical columns of offset rows
   2: irregular

TC13 Anal tube shape (for camerates)
   0: conical
   1: cylindrical
   2: recumbent
TC14  Anal tube height (for camerates)
   0: shorter than tegmen radius
   1: higher than tegmen radius but shorter than height of arms
   2: higher than height of arms

TC15  Anal tube spines (for camerates)
   0: absent
   1: present

TC16  Tubular tegmen extensions (Gilbertsocrinus)
   0: absent
   1: present

FREE ARMS (FA)

FA1  Arm openings into the calyx
   0: none
   1: three
   2: four
   3: five
   4: ten
   5: eleven to twenty
   6: > 20
   7: 6-9

FA2  Appendage type
   0: true arms
   1: uniserial armlets (as in Acolocrinus)
   2: raised ambulacra but not arms

FA3  Arm habit
   0: erect
   1: pendant
   2: fixed into wall of calyx
   3: recumbent

FA4  Ambulacral floor plates in at least proximal free arms
   0: absent
   1: present
FA5  Proximal free arms projection
0: upward
1: outward and upward
2: outward
3: outward and downward
4: laterally

FA6  Maximum number of primibrachials (in B-E rays) [CODE whether fixed or free]
1: one
2: two
3: three
4: four
5: five
6: >five

FA7  Distal free arms are expanded or spatulate
0: absent
1: present

FA8  First primibrachial dimensions (NA if fixed brachials)
0: W>H
1: H=W
2: H>W

FA9  First primibrachial shape (NA for fixed brachials)
0: tetragonal (straight sided)
1: hexagonal
2: pentagonal (axillary) straight sided
3: pentagonal (axillary) concave sided
4: trapezoid
5: triangular
6: tetragonal (concave sided)

FA10 Free arm branching in secundibrachials and above (and lateral arms in Calceocrinidae; if fixed brachials only for free portion of arms)
NA: if atomous arms (5 arms or things like Catillocrinids)
0: none
1: isomtomous
2: poorly isomtomous
3: asymmetrical heterotomous
4: bilateral heterotomy
5: endotomous
6: exotomous
7: parapinnules
8: pinnate (in Calceocrinidae)
9: fused mesh (*Crotalocrinites*)
10: biendotomous
11: arm trunk (uniserial or uniserial to biserial) with bilateral heterotomous biserial arms
12: arm trunk (uniserial or uniserial to biserial) with exotomous biserial arms not fused abaxially
13: arm trunk (uniserial or uniserial to biserial) with exotomous biserial arms fused abaxially
14: arm trunk (multiserial) with bilateral heterotomous biserial arms

**FA11** Ramule type (if heterotomous type branching)
0: simple
1: armlets

**FA12** Maximum number of secundibrachials [CODE whether fixed or free]
NA: if atomous arms (5 arms or things like Catillocrinids)
0: one
1: two
2: three
3: four
4: five
5: 6 or more

**FA13** Pinnulation
0: apinnulate
1: pinnules [definition in 1978 Treatise]
2: hyperpinnulation

**FA14** Mature free arm brachials (terminology following Webster and Maples, 2008)
0: rectilinear uniserial
1: weakly cuneate uniserial
2: moderately cuneate uniserial
3: strongly cuneate uniserial
4: wedge biserial
5: round biserial
6: flat chisel biserial

**FA15** Patelloid process
0: no
1: yes
FA16  First pinnule conspicuously larger than others
0: no
1: yes

FA17  E-ray branching pattern (for Calceocrinidae only)
0: atomous
1: isomomous
2: heterotomous
3: pinnulate [use Fig. 72 in 1978 Treatise (more detail coming)]

FA18  Main axil series with non-axillary plates (for Calceocrinidae)
0: no
1: yes

FA19  Main axil series branching (for Calceocrinidae)
0: isomomous
1: heterotomous

FA20  Robust beta ramules (for Calceocrinidae)
0: no
1: yes

FA21  Transition from proximal free brachials to mature free brachials
0: none
1: uniserial to biserial
2: one type of uniserial to another
3: one type of biserial to another

FA22  Number of primibrachials in A ray [CODE whether fixed or free]
0: same as other rays
1: atomous
2: first branching higher than other rays
3: first branching lower than other rays

FA23  Branching pattern in A ray same as in other rays [CODE whether fixed or free]
0: no
1: yes
FA24 Free arm branching on primaxil only [NA if fixed arms]
   NA: if fixed or atomous arms (5 arms or things like Catillocrinids)
   1: isotomous
   2: poorly isotomous
   3: asymmetrical heterotomous
   4: bilateral heterotomy
   5: endotomous
   6: exotomous
   7: parapinnules
   8: pinnate (in Calceocrinidae)

FA25 Primaxil spinose or nodose [if in free arms]
   0: absent
   1: spinose
   2: nodose

FA26 Primaxil spine length
   0: less than width of primaxil
   1: greater than width of primaxil

FA27 Primaxil spine shape
   0: taper abaxially
   1: expand abaxially

FA28 Primaxil spine cross section
   0: circular
   1: flattened oral-aborally
   2: flattened laterally

FA29 Secundaxil and higher axillaries spinose or nodose [if in free arms]
   0: absent
   1: spinose
   2: nodose

FA30 Secundaxil and higher axillaries spine length
   0: less than width of primaxil
   1: greater than width of primaxil

FA31 Secundaxil and higher axillary spine shape
   0: taper abaxially
   1: expand abaxially
FA32  Secundaxil and higher axillary spine cross section
  0: circular
  1: flattened oral-aborally
  2: flattened laterally

FA33  Maximum number of "in line" bifurcations above radial plate [including any portion of ray fixed]
  0: none (if 5 atomous arms or things like Catillocrinids)
  1: one
  2: two
  3: three
  4: four
  5: five
  6: six
  7: > seven

FA34  A ramule in position of first pinnule
  0: absent
  1: present and unbranched
  2: present and branched

FA35  Axillary arm plates with pinnules
  0: absent
  1: present

FA36  Proximal free arms with gaping sutures
  0: absent
  1: present

FA37  Laterally interlocking brachials in free arms
  0: absent
  1: between arms within individual ray
  2: between arms of adjacent rays

COLUMN (CO)

CO1  Column
  0: absent
  1: present
CO2  Column attitude
   0: erect
   1: recumbent
   2: planispiral coil
   3: hanging (*Schyphocrinites*)

CO3  Proximal columnals cemented into calyx (as in *Apiocrinites*)
   0: absent
   1: present

CO4  Proxistele (proximal column) construction
   0: holomeric
   1: pentameric
   2: tetrameric
   3: trimeric
   4: bimeric
   5: hexameric

CO5  Mesistele (middle column) construction
   0: holomeric
   1: pentameric
   2: tetrameric
   3: trimeric
   4: bimeric
   5: hexameric

CO6  Dististele (column in holdfast sector) construction
   0: holomeric
   1: pentameric
   2: tetrameric
   3: trimeric
   4: bimeric
   5: hexameric

CO7  Proxistele (proximal column) heteromorphic
   0: absent
   1: present

CO8  Mesistele (middle column)
   0: absent
   1: present
CO9  Dististele (column in holdfast sector) heteromorphic
   0: absent
   1: present

CO10  Columnal shape in proxistele columnals
   0: circular
   1: pentalobate
   2: pentagonal
   3: tetralobate
   4: tetragonal
   5: elliptical
   6: bilateral for planispiral coiling
   7: decagonal

CO11  Columnal shape in mesistele columnals
   0: circular
   1: pentalobate
   2: pentagonal
   3: tetralobate
   4: tetragonal
   5: elliptical
   6: bilateral for planispiral coiling
   7: decagonal

CO12  Columnal shape in dististele columnals (in holdfast region)
   0: circular
   1: pentalobate
   2: pentagonal
   3: tetralobate
   4: tetragonal
   5: elliptical
   6: bilateral for planispiral coiling
   7: decagonal

CO13  Latus profile in proxistele
   0: planar vertical
   1: planar non-vertical (wider at base or top)
   2: convex
   3: concave
CO14 Latus profile in mesistele
   0: planar vertical
   1: planar non-vertical (wider at base or top)
   2: convex
   3: concave

CO15 Latus profile in dististele
   0: planar vertical
   1: planar non-vertical (wider at base or top)
   2: convex
   3: concave

CO16 Columnal height:width in proxistele
   0: discoidal (H:W < 0.5)
   1: elongate (H:W > 0.5)

CO17 Columnal height:width in mesistele
   0: discoidal (H:W < 0.5)
   1: elongate (H:W > 0.5)

CO18 Columnal height:width in dististele
   0: discoidal (H:W < 0.5)
   1: elongate (H:W > 0.5)

CO19 Lumen shape in proxistele columnals
   0: circular
   1: pentalobate
   2: pentagonal
   3: pentastellate
   4: tetralobate
   5: tetragonal
   6: trilobate
   7: trigonal
   8: crescentic
CO20 Lumen shape in mesistele columnals
0: circular
1: pentalobate
2: pentagonal
3: pentastellate
4: tetralobate
5: tetragonal
6: trilobate
7: trigonal
8: crescentic

CO21 Lumen shape in dististele columnals (in holdfast region)
0: circular
1: pentalobate
2: pentagonal
3: pentastellate
4: tetralobate
5: tetragonal
6: trilobate
7: trigonal
8: crescentic

CO22 Columnal articulation type
0: symplexy, radial
1: symplexy in petals (perpendicular to sides)
2: synostosis
3: synarthrial
4: smooth

CO23 Areola
0: absent
1: present

CO24 Jugula
0: flat sided
1: constricted

CO25 Branching on column proxistele
0: absent
1: rhizoids
2: cirri
CO26 Branching on column mesistele
   0: absent
   1: rhizoids
   2: cirri

CO27 Pattern of rhizoid/cirri
   0: radial
   1: asymmetrical/bilateral (myelodactylids)

CO28 Holdfast
   0: absent
   1: terminal rhizoids
   2: runner rhizoids
   3: terminal cirri
   4: runner cirri
   5: cemented
   6: lobolith
   7: coil
   8: plated (lichenocrinus-type)
   9: slightly expanded many plated
  10: grapnel

CO29 Generating columnal between proxistele and mesistele
   0: absent
   1: present

RESPIRATORY STRUCTURES

RS1 Pore rhomb structures on calyx
   0: absent
   1: present

RS2 Pores at plate sutures
   0: absent
   1: present

LINTEL CIRCLET (LC)

LC1 Lintel circlet visible in lateral view (if used)
   0: absent
   1: present
<table>
<thead>
<tr>
<th>LC2</th>
<th>Relative height of the lintel circket</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>covered by column cicatrix</td>
</tr>
<tr>
<td>1</td>
<td>entirely in basal concavity</td>
</tr>
<tr>
<td>2</td>
<td>partially in basal concavity</td>
</tr>
<tr>
<td>3</td>
<td>along flat base of calyx (neither in basal concavity nor visible in side view)</td>
</tr>
<tr>
<td>4</td>
<td>plates wrap around from calyx base to side view of calyx</td>
</tr>
<tr>
<td>5</td>
<td>all plates in vertical wall of calyx</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LC3</th>
<th>Number of lintel plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>none</td>
</tr>
<tr>
<td>1</td>
<td>one</td>
</tr>
<tr>
<td>2</td>
<td>two</td>
</tr>
<tr>
<td>3</td>
<td>three</td>
</tr>
<tr>
<td>4</td>
<td>four</td>
</tr>
<tr>
<td>5</td>
<td>five</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LC4</th>
<th>Lintel plate dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>W&gt;H</td>
</tr>
<tr>
<td>1</td>
<td>H= W</td>
</tr>
<tr>
<td>2</td>
<td>H&gt;W</td>
</tr>
</tbody>
</table>