

ICHNOLOGY

STUDY OF FOSSIL TRACKS, TRAILS AND FOOTPRINTS



- **ICHTNOLOGY** - study of organism behaviour and its products: trace fossils
- **TRACE FOSSIL** - product of an organism interacting with a substrate in an environment that generates a three-dimensional physical structure (Hasiotis & Roberts, 2005).
- They are records of biological activity left in rock, that is, evidence that organisms were active there. They do not include hard parts, a.k.a. "body fossils".
- **ICHTNOFACIES** - depositional environments that ichnofossils are thought to represent

OLDEST ICHNOFOSSILS

THE OLDEST ICHNOFOSSILS ARE THOUGHT TO
BE AS OLD AS 3.5 BILLION YEARS AS
MICROTRACES IN SEA-FLOOR BASALTS.

STROMATOLITES ARE ALSO TRACE FOSSILS AND
ARE EQUALLY OLD.



Stromatolite - Eleanor Barbour Cook Museum

PRINCIPLES IN ICHNOLOGY



Chondrites von Strenberg, 1833

- ❖ Most trace fossils are largely facies dependant - very useful as indicators of depositional environment
- ❖ Long temporal ranges - they are not useful as indicators of age
- ❖ No secondary displacement or transport.
- ❖ Trace fossils are common in rocks that otherwise are unfossiliferous. (siliciclastics, shorelines)
- ❖ Non-preservation of the causative organism.
- ❖ Biogenic sedimentary structures, where preserved intact, are closely related to the environment in which they formed -they are not transported as some body fossils can be.

PRINCIPLES IN ICHNOLOGY

- ❖ Multiple architects may produce a single structure.
- ❖ The same individual can produce different structures corresponding to different behavior.
- ❖ The same individual may produce different structures corresponding with identical behavior but in different substrates.
- ❖ Identical structures may be produced by the activity of systematically different organisms where behavior is similar.
- ❖ Abundance - one animal, especially if mobile, can make many traces during its lifetime, whereas it may or may not have its body preserved in the fossil record.



Steinichnus Bromley and Asgaard, 1979

INTERACTIONS ARE VIA BEHAVIOR:

- ❖ Dwelling
- ❖ Feeding
- ❖ Crawling
- ❖ Hiding
- ❖ Resting

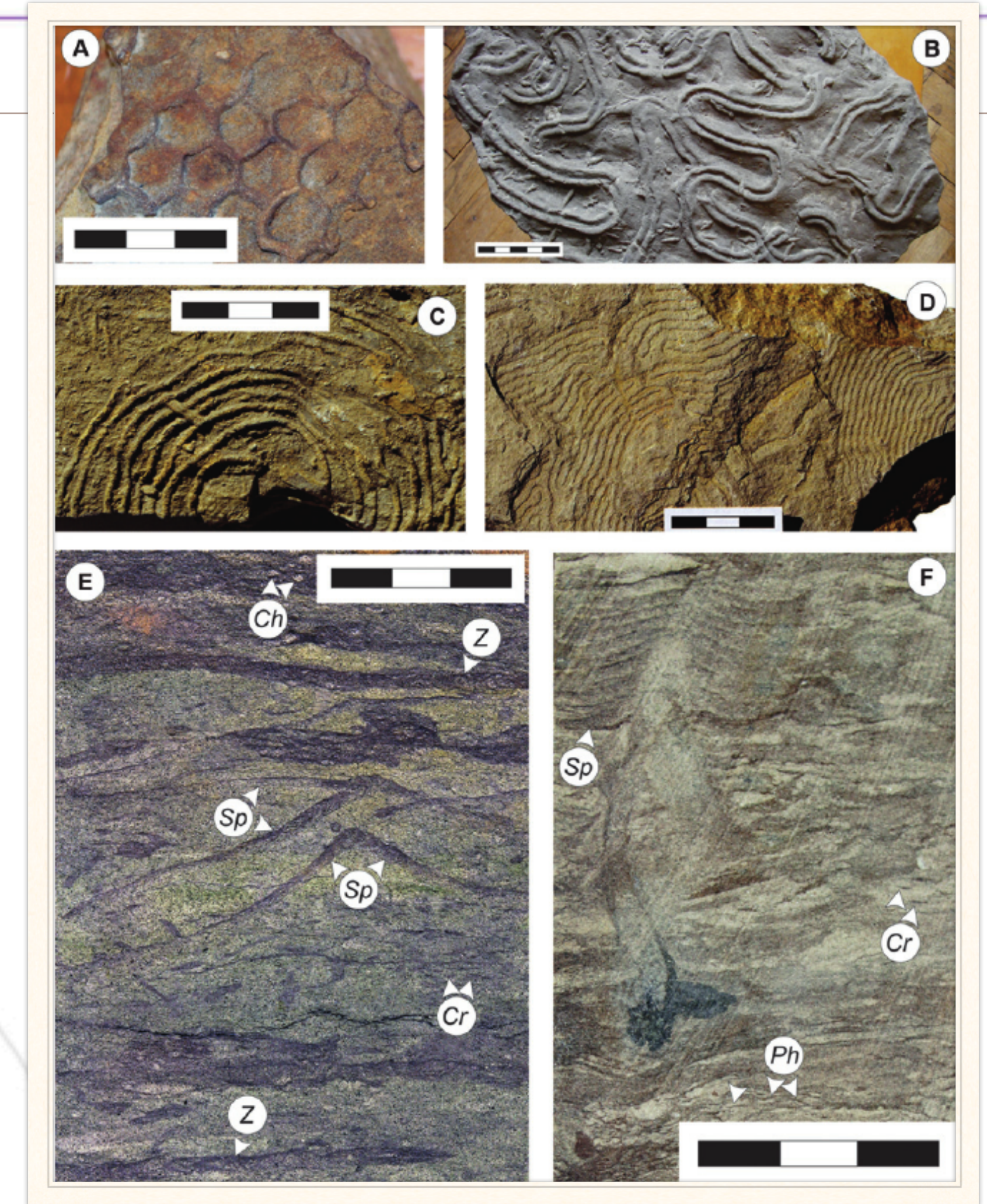


- ❖ Grazing
- ❖ Cultivating
- ❖ Reproducing
- ❖ Escaping
- ❖ Multifunctional

Male common teal producing feeding traces

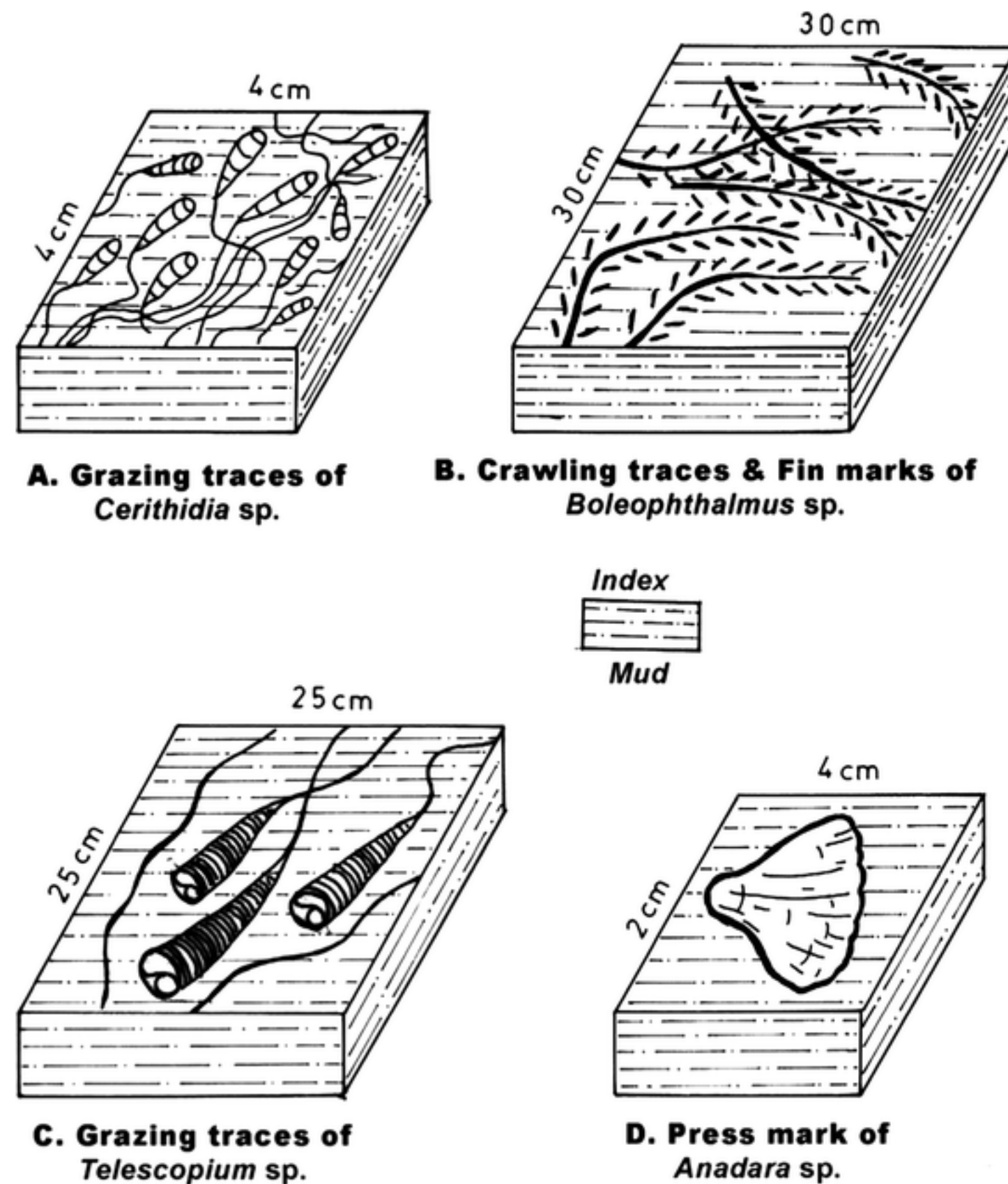
THE CONCEPTUAL FRAMEWORK OF ICHNOLOGY

- ❖ Biogenic structures represent the activity of soft-bodied organisms that are not generally preserved.
- ❖ Such organisms (include many entire phyla) are commonly the dominant component of the biomass of many environments.
- ❖ Biogenic structures are commonly enhanced by diagenesis and can be used in horizons where physical sedimentary structures have been masked.
- ❖ In many siliciclastic regimes, diagenesis dissolves most of the shelly fauna and trace fossils represent the only clue as to the original biogenic component of the unit.



MacEachern, J. & Bann, Kerrie & Gingras, Murray & Zonneveld, John-Paul & Dashtgard, Shahin & Pemberton, George. (2012). The Ichnofacies Paradigm. *Developments in Sedimentology*. 64. 103-138. 10.1016/B978-0-444-53813-0.00004-6.

THE CONCEPTUAL FRAMEWORK OF ICHNOLOGY

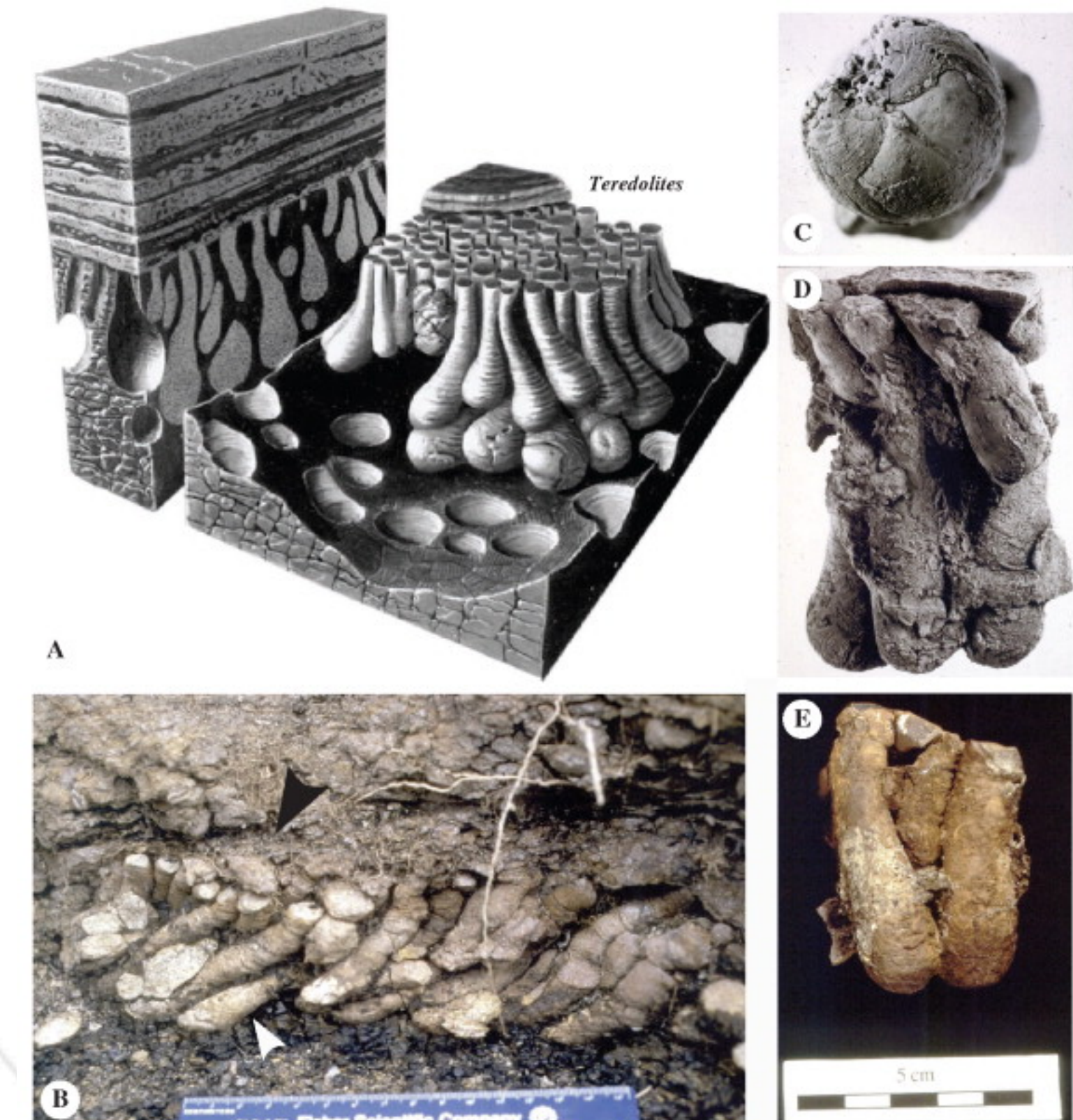


Surface bioturbation structures
on the intertidal mudflats of Sunderbans

- ❖ Biogenic structures can be used for the paleoecological reconstruction of depositional environments.
- ❖ Biogenic structures are sensitive to fluctuations in sedimentary dynamics. Bioturbation patterns are important in recognizing event beds and sedimentation patterns.
- ❖ Biogenic structures are sensitive indicators of substrate coherence. The Trypanites, Glossifungites and Teredolites ichnofacies are substrate-controlled and are emerging as important elements in the evolving concepts of sequence stratigraphy.

THE CONCEPTUAL FRAMEWORK OF ICHNOLOGY

- ❖ Biogenic structures ordinarily cannot be transported and therefore represent the original environmental position of the trace making animal. Commonly such transgressions bottom out on peats because they are difficult to erode.
- ❖ Biogenic structures are sensitive to changes in certain ecological parameters that are otherwise difficult to ascertain. Trace fossil models are emerging to recognize changes in such parameters as salinity and oxygen levels.
- ❖ An integrated approach utilizing physical, chemical, biological and ichnological lines of evidence constitutes a powerful tool for facies interpretation.



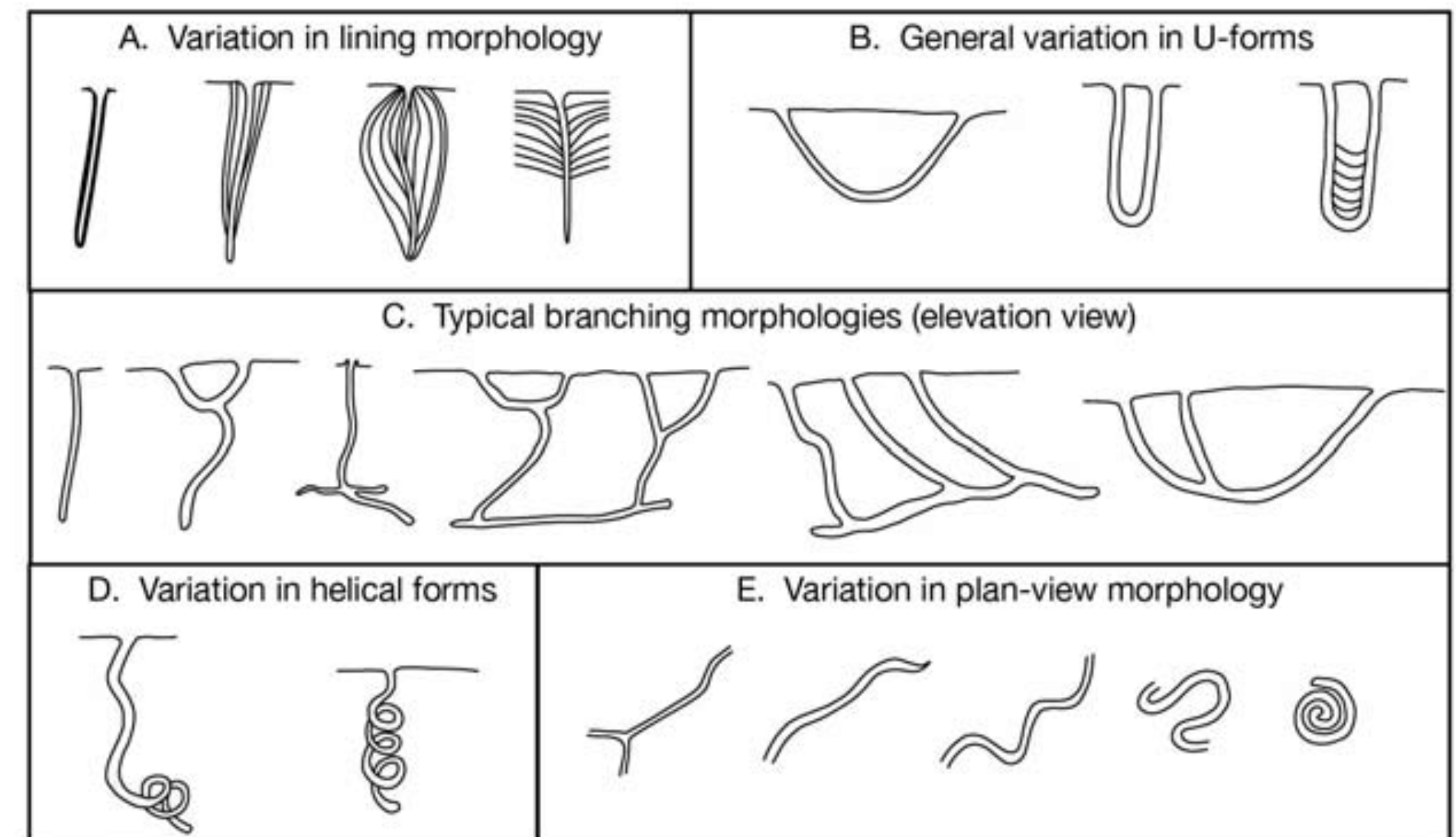
Teredolites Ichnofacies

WILLIAM MILLER, The Ichnofacies Paradigm: A Fifty-Year Retrospective, Trace Fossils, Elsevier, 2007

TRACE FOSSIL IDENTIFICATION CRITERIA:

A. BASIC MORPHOLOGY

1. BURROW WALL
2. BURROW LINING
3. BACKFILL STRUCTURE (MENISCAE)
4. SPREITE STRUCTURE
5. TUNNEL (HORIZONTAL TUBE)
6. SHAFT (VERTICAL TUBE)
7. ROOT PATTERN (TAPERING)
8. BRANCHING (Y, T, INTERSECTIONS)





TRACE FOSSIL IDENTIFICATION CRITERIA:



B. GENERAL RECOGNITION CRITERIA

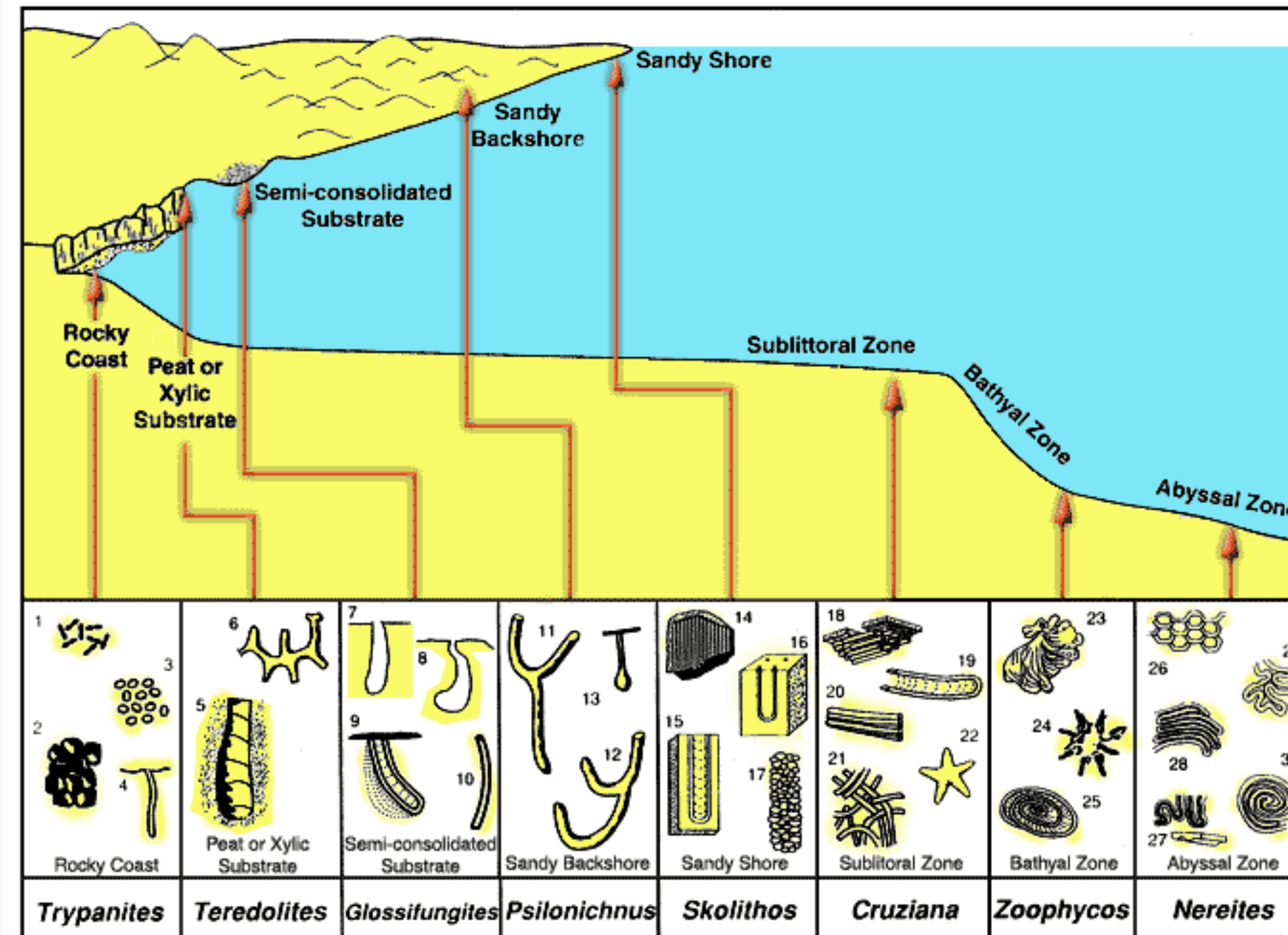
1. RESEMBLE BODY FORM OR BODY PART AN ORGANISM
2. UNIFORM DIMENSIONS OR CONTINUITY OF STRUCTURE
3. DOWNWARD TAPERING DIMENSIONS AND CIRCULAR CROSS SECTION
4. LACK OF CURRENT ALIGNMENT
5. PRESERVATION IN RELIEF
6. MORPHOLOGIC TRAITS
7. ASSOCIATION WITH BODY FOSSIL
8. PELLETS
9. DELICATE MORPHOLOGICAL FEATURES

TRACE FOSSILS CLASSIFICATION



- ❖ The preservational (stratinomic) - which treats of the origin of the fossil in the rocks.
- ❖ The behavioral (ethological) - which treats of the biological function represented in the fossil.
- ❖ The phylogenetic (taxonomic) - which is concerned with the identity of the organism that produced the fossil.

STRATONOMIC CLASSIFICATION

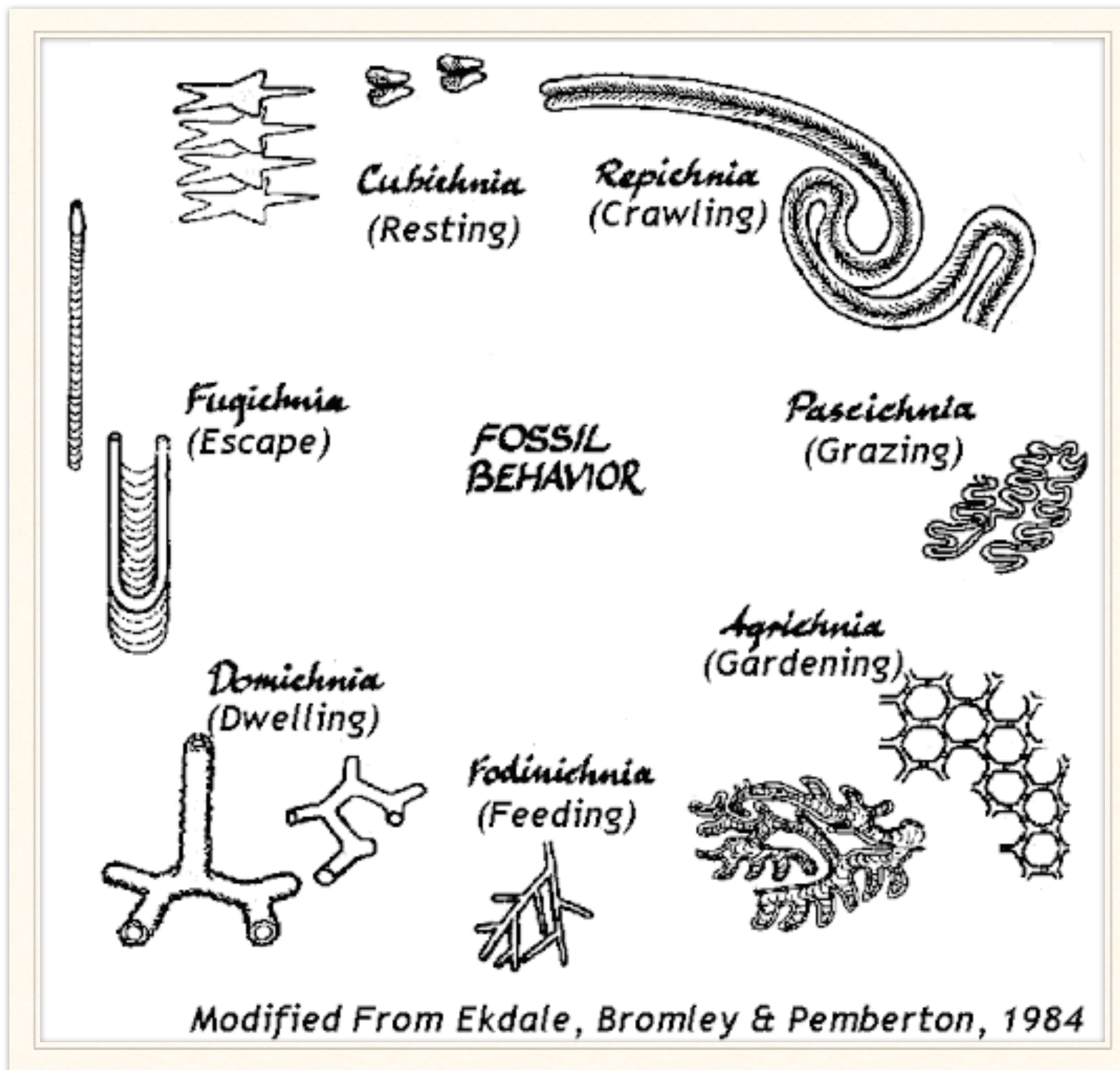


after Seilacher image from <http://research.eas.ualberta.ca/ichnology/>

Distribution of Common Marine Ichnofacies

Typical trace fossils include: 1) *Caulostrepsis*; 2) *Entobia*; 3) echinoid borings; 4) *Trypanites*; 5) *Teredolites*; 6) *Thalassinoides*; 7, 8) *Gastrochaenolites* or related genera; 9) *Diplocraterion* (*Glossifungites*); 10) *Skolithos*; 11, 12) *Ptilonichnus*; 13) *Macanopsis*; 14) *Skolithos*; 15) *Diplocraterion*; 16) *Arenicolites*; 17) *Ophiomorpha*; 18) *Phycodes*; 19) *Rhizocorallium*; 20) *Teichichnus*; 21) *Planolites*; 22) *Asteriacites*; 23) *Zoophycos*; 24) *Lorenzina*; 25) *Zoophycos*; 26) *Paleodictyon*; 27) *Taphrhelminthopsis*; 28) *Helminthoida*; 29) *Cosmorhaphis*; 30) *Spirorhaphis*.

ETHOLOGICAL CLASSIFICATION

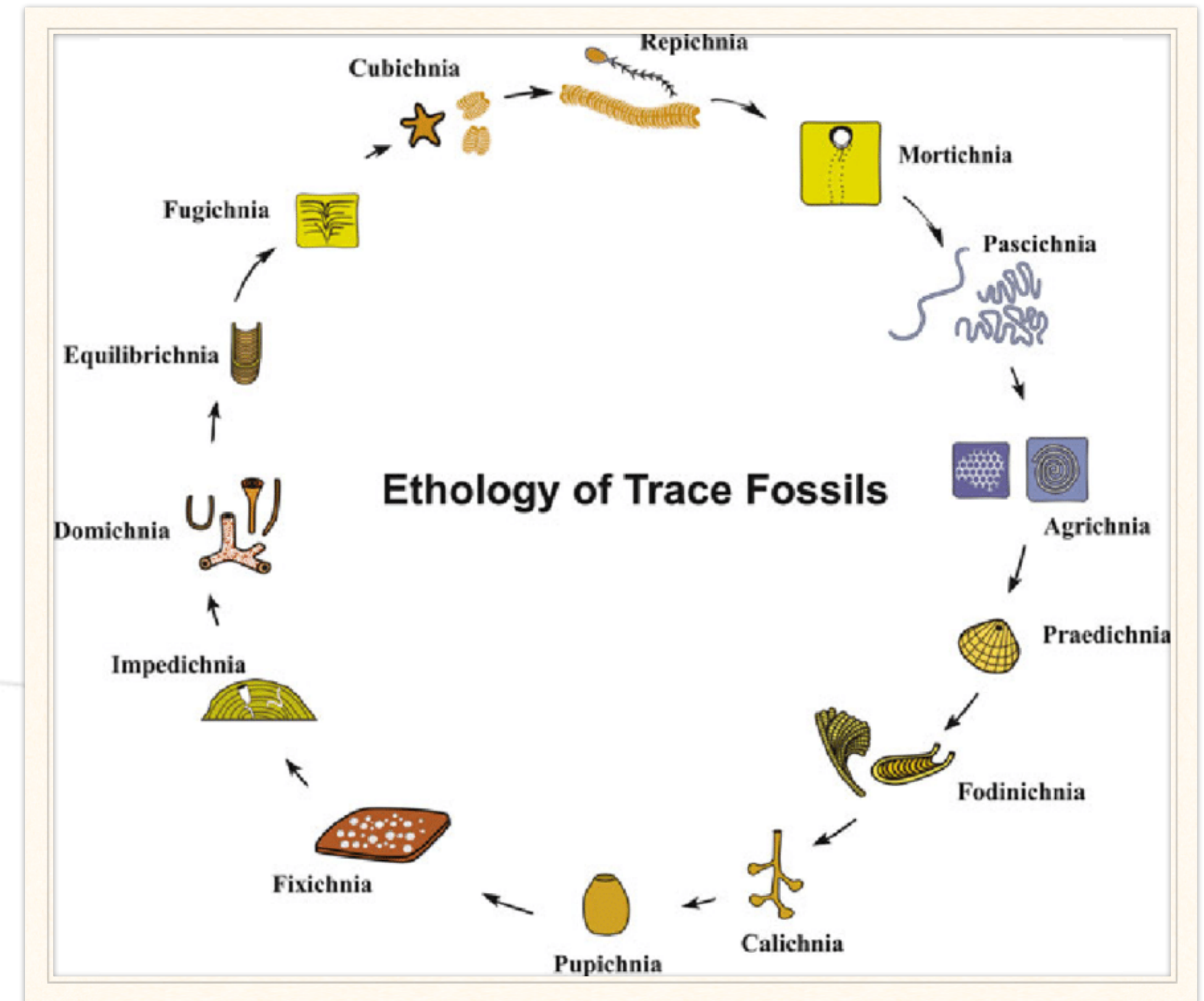


- ❖ Repichnia = Locomotion Traces
- ❖ Cubichnia = Resting Traces
- ❖ Domichnia = Dwelling Traces
- ❖ Pascichnia = Grazing Traces
- ❖ Fodinichnia = Feeding Burrows



ETHOLOGICAL CLASSIFICATION

- ❖ Agrichnia - Traps and Gardening Traces
- ❖ Praedichnia - Predation Traces
- ❖ Equilibrichnia - Equilibrium Traces
- ❖ Fugichnia - Escape Traces
- ❖ Aedificichnia - Edifices Built Above the Substrate
- ❖ Calichnia - Structures Made for Breeding Purposes



TAXONOMIC CLASSIFICATION

❖ PRESERVATIONAL CLASSIFICATION

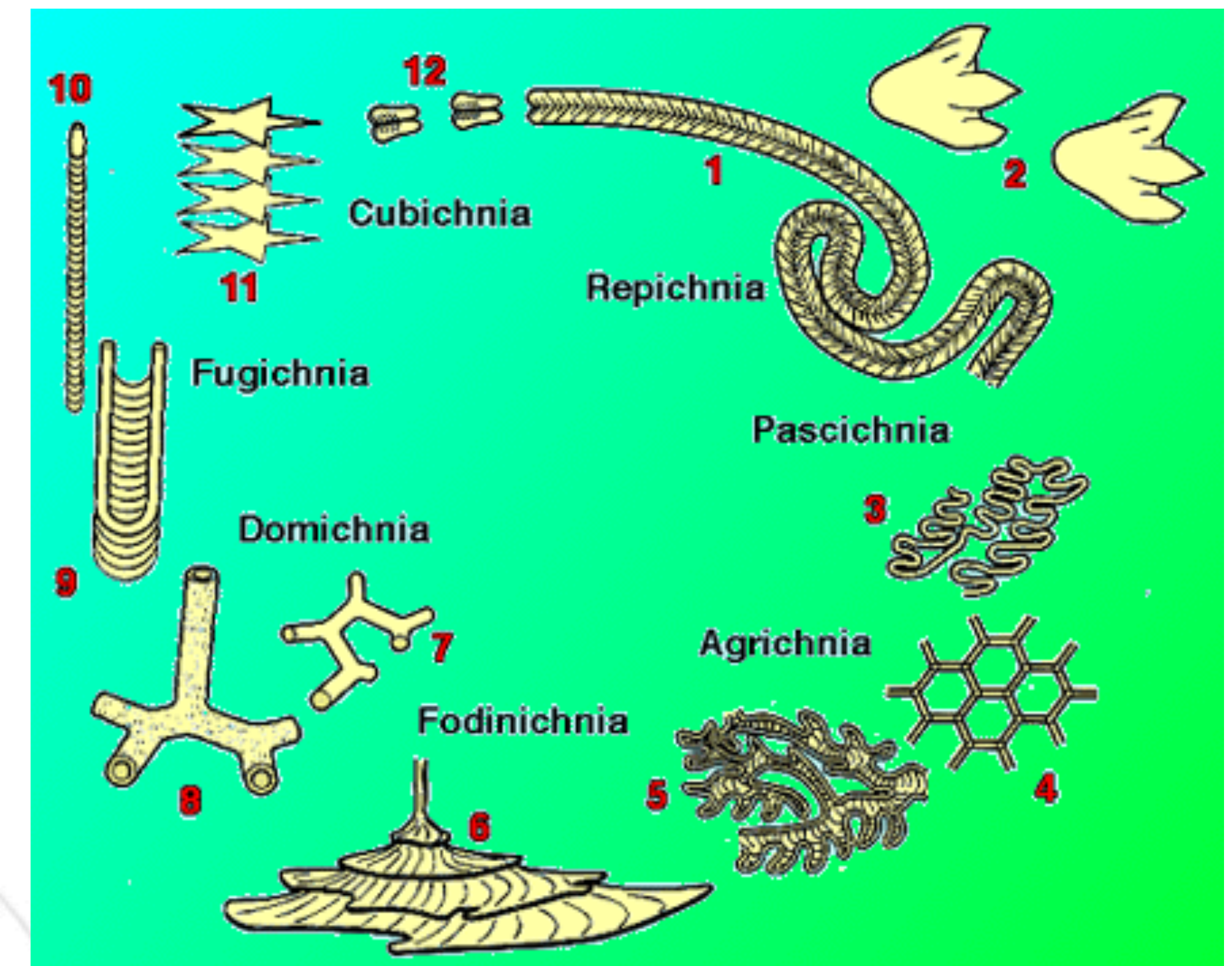
- Seilacher's and Martinsson's classification

❖ LINNAEAN CLASSIFICATION

- Ichnotaxa = Ichnogenus + Ichnospecies

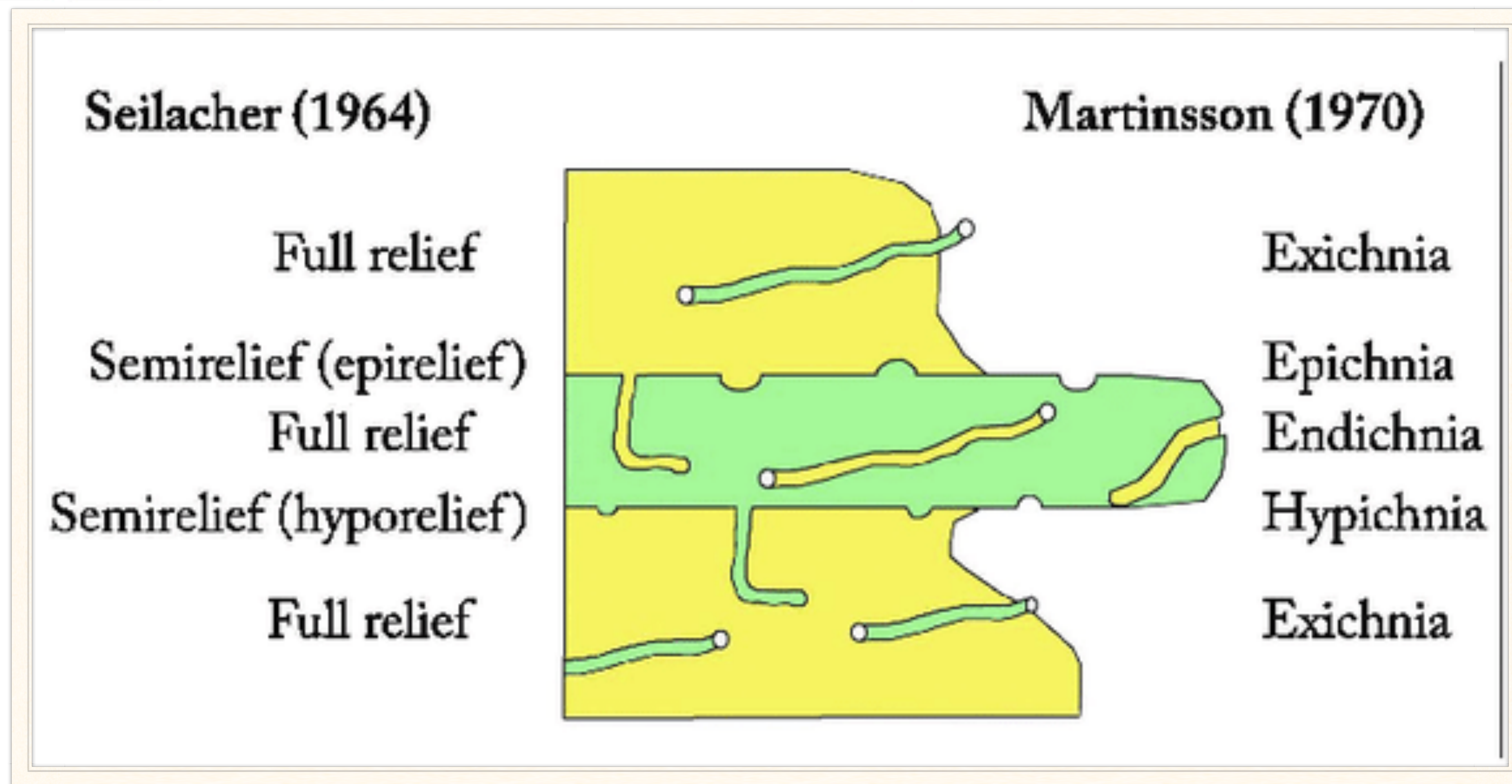
❖ PALEOENVIRONMENTAL CLASSIFICATION

- trace fossil associations ("ichnofacies")



Linnean classification

PRESERVATIONAL TERMS BASED ON SEILACHER'S AND MARTINSSON'S CLASSIFICATION





THE IMPORTANCE OF ICHNOLOGY

- ❖ Long time range - similar taxa occur in present day environments as they did early in Phanerozoic, a useful concept for palaeoecological interpretations, although the long time range restricts the value of trace fossils in biostratigraphy.
- ❖ Narrow facies range - certain traces are found in close association with certain substrate (facies type).
- ❖ No reworking - traces themselves are a part of the fabric of a sedimentary rock, so that they are destroyed by erosion, rather than released and reworked as the body fossils.



THE IMPORTANCE OF ICHNOLOGY

- ❖ Occurrence in nonfossiliferous rocks - is usually of a great help for palaeoecological and stratigraphical studies in hostile, poorly populated environments.
- ❖ Creation by soft-bodied taxa - trace fossils could give the only information about organisms which are not otherwise found within the sedimentary record, by demonstrating their presence or function through the interaction with the sediment.
- ❖ Eg - the existence of soft-body metazoans prior to evolution of hard body parts in Precambrian.

ICHTHOLOGY AND FORENSIC ODONTOLOGY



- PASCICHNIA = GRAZING TRACES

CHALLENGES IN ICHNOLOGY

- ❖ Different organisms may produce a single structure, and the same individual or species can produce different structures corresponding to different behaviour -it can be very difficult to know what made the trace
- ❖ The same individual may produce different structures corresponding with identical behaviour but in different substrates -interpreting environments from trace fossils can be difficult
- ❖ Identical structures may be produced by the activity of systematically different trace-making organisms where behaviour is similar (and similar ichnofossils can be formed by organisms from different periods that have similar behaviours)



THANK YOU

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