Palaeontology

Lecture 3

Palaeoecology
Taphonomy

Setting a new species

- Description of all morphological features
  Comparisons with other similar species
  Recognize the unique characters that distinguish them from other species
  The description is based on species-type which, after publication, is kept in museum collections
  The species-type refers to the characteristic sample on which the introduction of the new species was based
  Types must be accessible for study
  Usually the best preserved sample is selected as the reference, the Holotype
  Samples that may offer extra information are called Paratypes

Types

- Holotype (original)
  Paratype (complementary)
  Lectotype (later)
  Neotype (replacement)

  Detailed description, comparison with other similar / related taxa, definition of geological age, geographic location / expansion

Types

- On these the creation and naming of taxonomic groups is based on.
  e.g. Type Genus is the specific genus on which the corresponding family name was based.
  In contrast, Genotype is the characteristic species from which the name of the genus was based and bears its basic characteristics
  Priority to the names of the types, the older ones are selected
  The rest are considered as synonyms

Naming Criteria

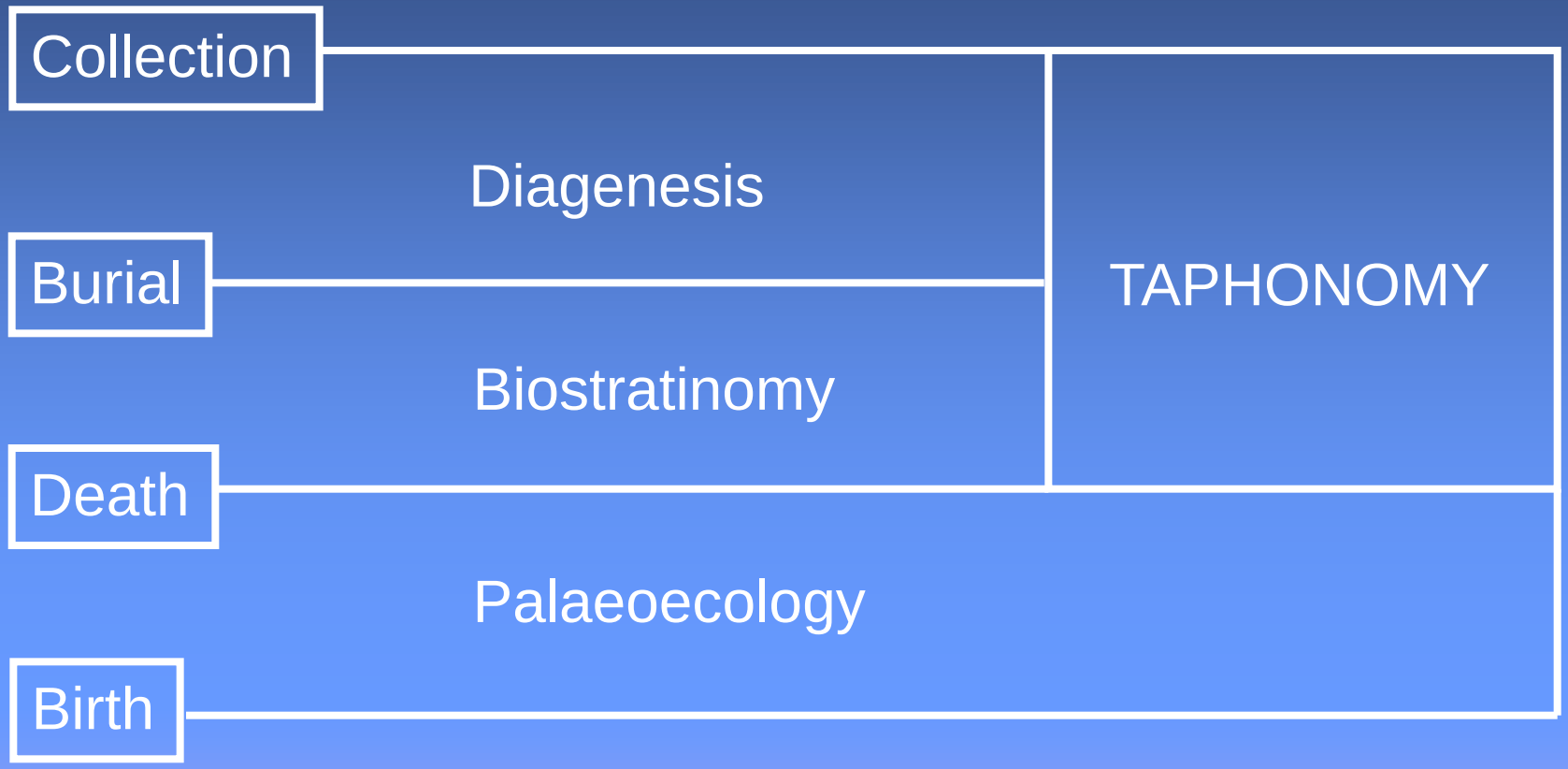
Uniqueness
Universality
Stability

Species names

1. Descriptive (*Deinotherium giganteum*)
2. Geographical (*Lutrogale cretensis*)
3. Geological (*Globorotalia miocenica*)
4. Patronomy or Mythological (*Mene psarianosi*)
5. Mixed

We also have valid, invalid and legalized names

Palaeoecology
Taphonomy


Collection
Diagenesis
Burial
TAPHONOMY
Biostratinomy
Death
Palaeoecology
Birth

Palaeoecology

- The study of the old organisms and the environment in which they lived, as well as their interactions.
- Need to discern if the environment that the remains of an organism were found is the environment that it lived or the environment that was buried and fossilized
- Identify their ecological adjustments

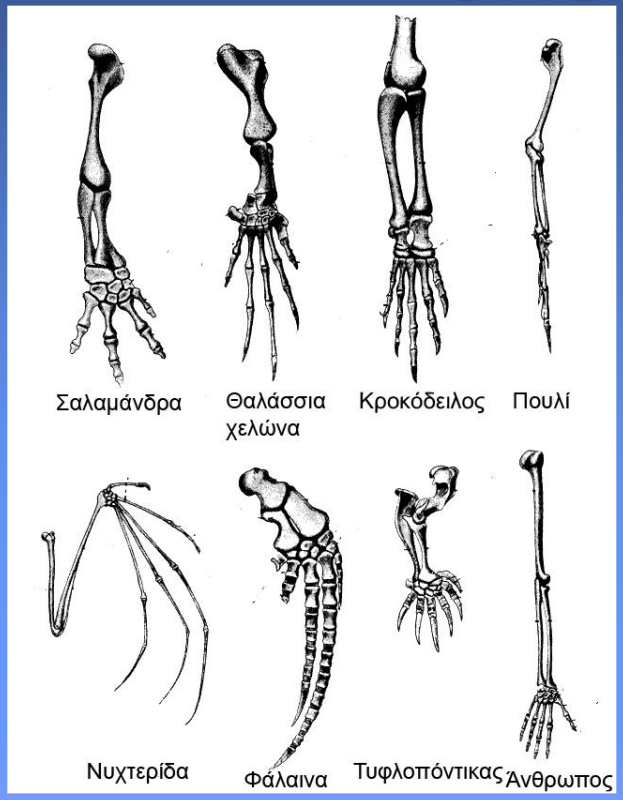
ecological adjustments

- Each organism is adapted to live in an environment with specific physical, chemical and biological parameters
- Each group of organisms lives in such a particular environment, the niche
  All the organisms living in a particular environment, this environment and the relationships between the organisms are the ecosystem
  Population: a group of individuals of the same species who can freely exchange genetic material.
  The place where a group of organisms lives is its biotope
  To study the old ones first we need to research the modern ones

Principles of Palaeoecology

- Adaptation to the environment
- Adaptation to Lifestyle (homologous and analogous characters)
- Ecological restrictions
- Dependence on other organisms (competition, diet, cohabitation, parasitism)
- Taphonomical Restrictions

homologous and analogous characters



homologous = common characters being the result of common ancestry eg. Upper limbs

Analogous = similar characters being phylogenetically independent eg. Wings of different taxa as adjustment to the same way of life.

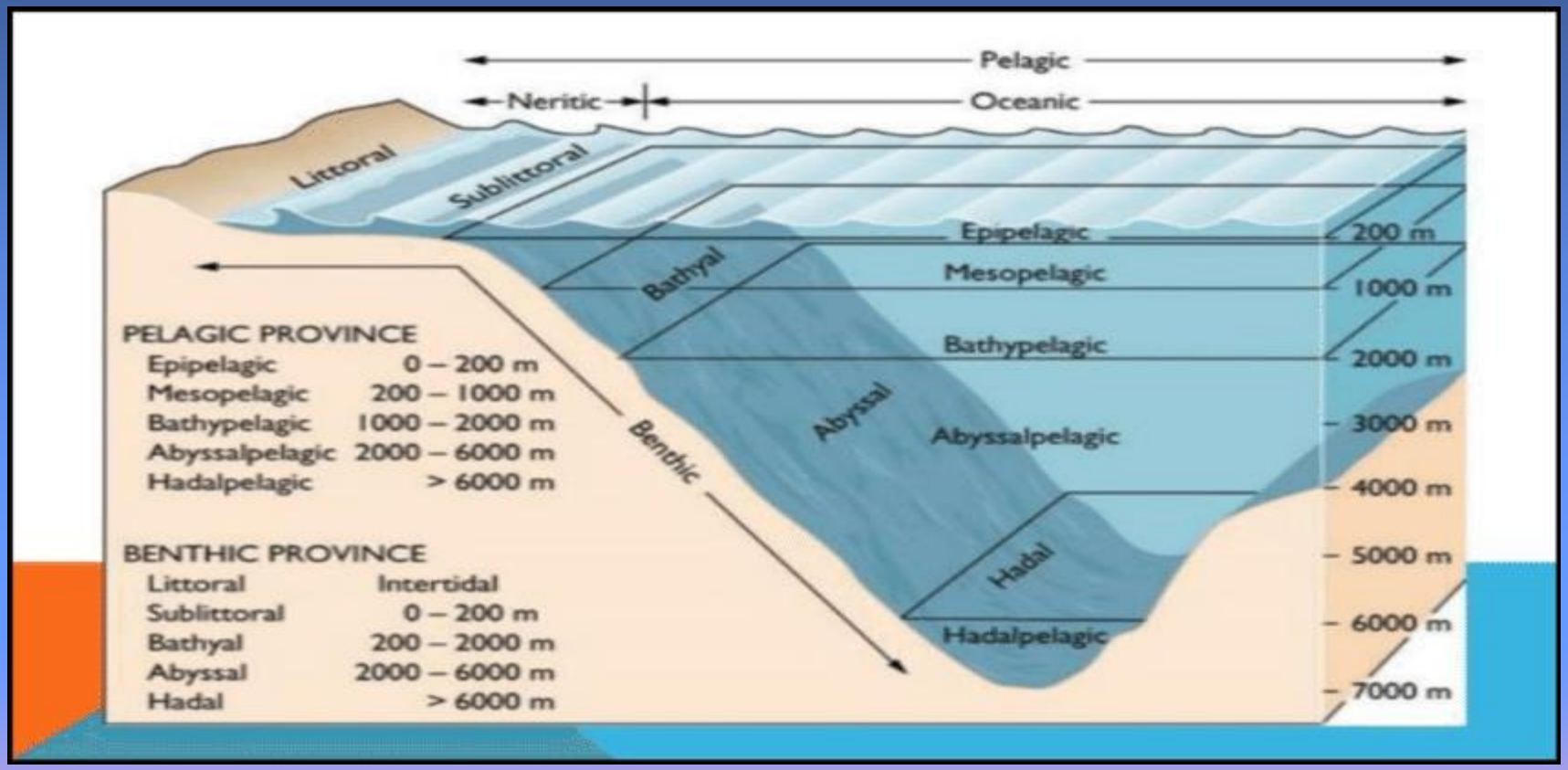
Relationships between species

- interspecific competition,
  diet,
  cohabitation,
  tolerance,
  parasitism,
  abundance

Environments

1. Continental
Terrestrial, lacustrine, Caves, Rivers, Aeolian, alluvial, marshy, glacier, brackish
2. Marine
Lagoonal, coastal, supertidal, tidal, shelf, deep-sea, hadal
They are also distinguished in coastal or photic or neritic areas (0-200 meters) and in ocean or pelagic or aphotic areas

Marine Environments

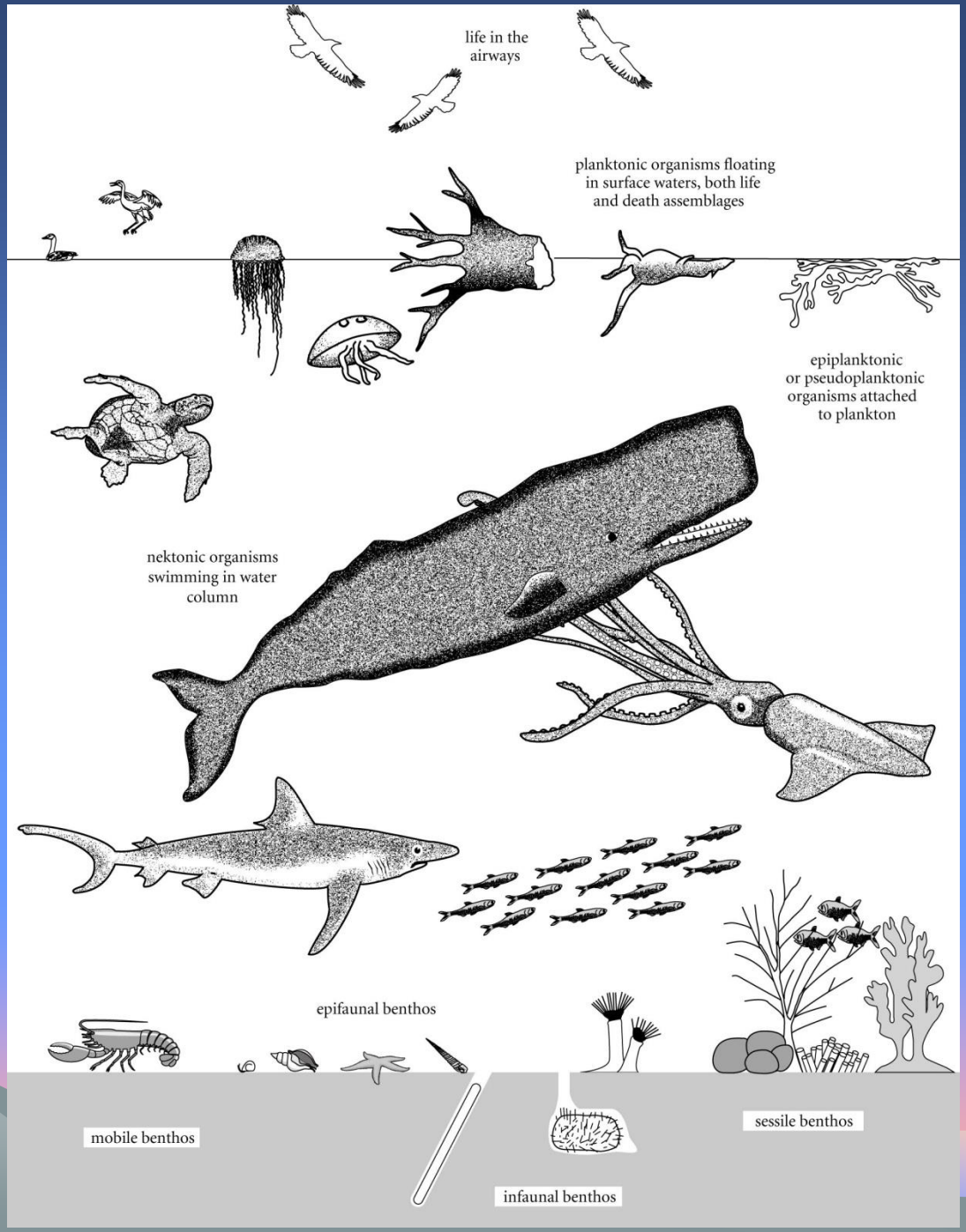


Organisms and their Environments

- Depending on their expansion
  Stenotopic
  Eurytopic
  Cosmopolitan
- Depending on the adjustments
  For salinity euryhaline, stenohaline
  For temperature, eurythermal, stenothermal

Modes of life

- Pelagic organisms
  Planktonic organisms or plankton
  Swimming organisms or nykton
- Benthic organisms or benthos
  Epifaunal
    Free
    Attached
  Endofaunal
    Penetrating
    Drilling
  Meiofauna

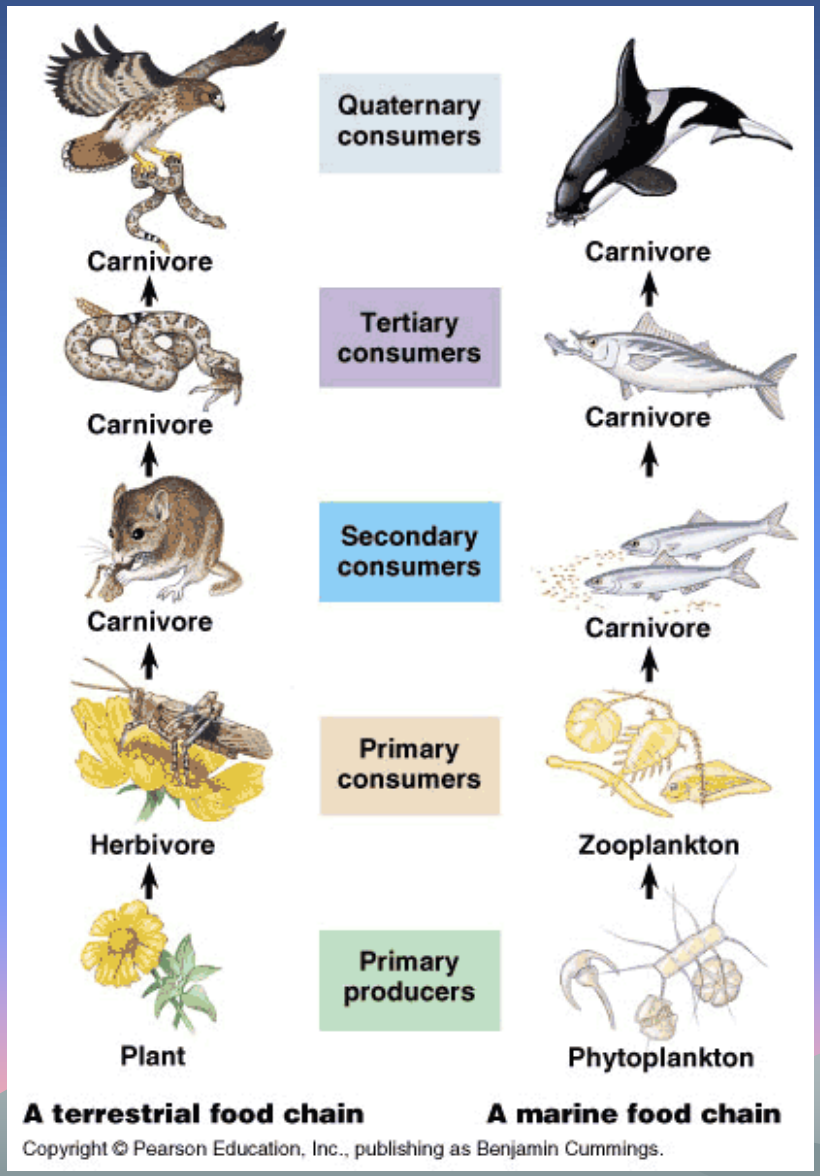

life in the airways
planktonic organisms floating in surface waters, both life and death assemblages
epiplanktonic or pseudoplanktonic organisms attached to plankton
nektonic organisms swimming in water column
epifaunal benthos
mobile benthos
sessile benthos
infaunal benthos

Modes of life

- Herbivores
  Suspension Feeders
  Detritivores
  Decomposers
  Carnivores (predators, scavengers)

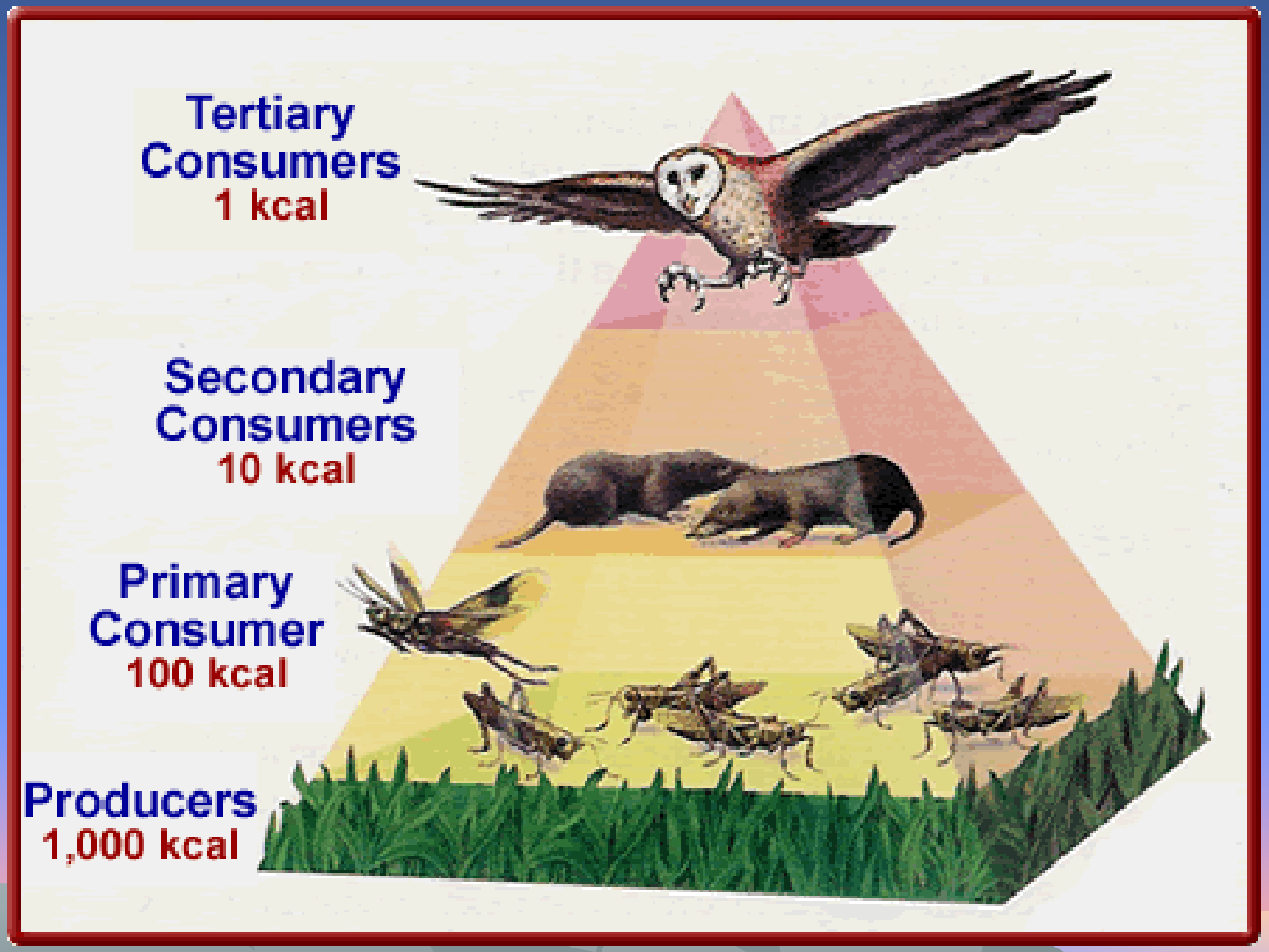
  Food chains, food networks and food pyramids

Food chains



Food networks

Food pyramid



accumulations

- Group of organisms in a layer is called accumulation
  Group of accumulations with similar species composition is called assemblage
  A group of organisms in the same environment in an area is a biocoenosis
  The proportion of taxonomic groups in a biocoenosis is its population

- In a coenosis, organisms are characterized as:
  Dominant if> 50% of the total
  Characteristic if 25-50% of the total
  Companions if 10-25% of the total
  Random if <10% of the total

palaeoautecology

- Deals with the palaeoecology of individuals or small groups
- Methods of study

Comparison with extant
Comparison of morphology of fossil and extant
Orientation
Organic assemblages
Activity examples
Sediments
Lateral changes
Geographic dispersion
Changes in lifestyle and living habits

palaeosynecology

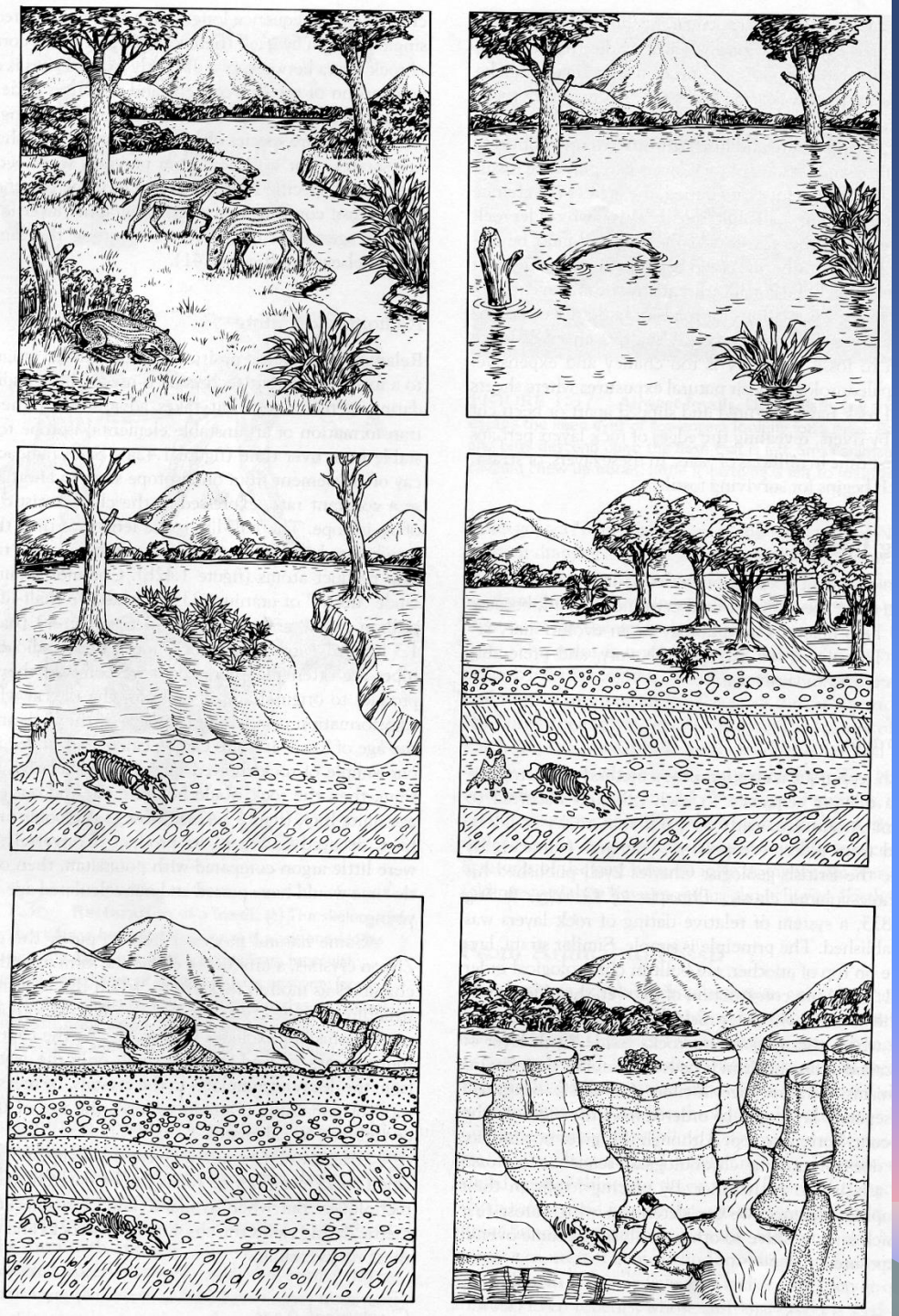
- It deals with the study of fossil coenoses and studies the relationships between the biocoenoses and their environment
- Methods of study
  Comparison with living accumulations
  Geological evidence
  Density and variety
  Relationship between species (competition, cohabitation, tolerance, parasitism)
  Lateral and vertical changes in a accumulation
  Geographical dispersion of accumulations

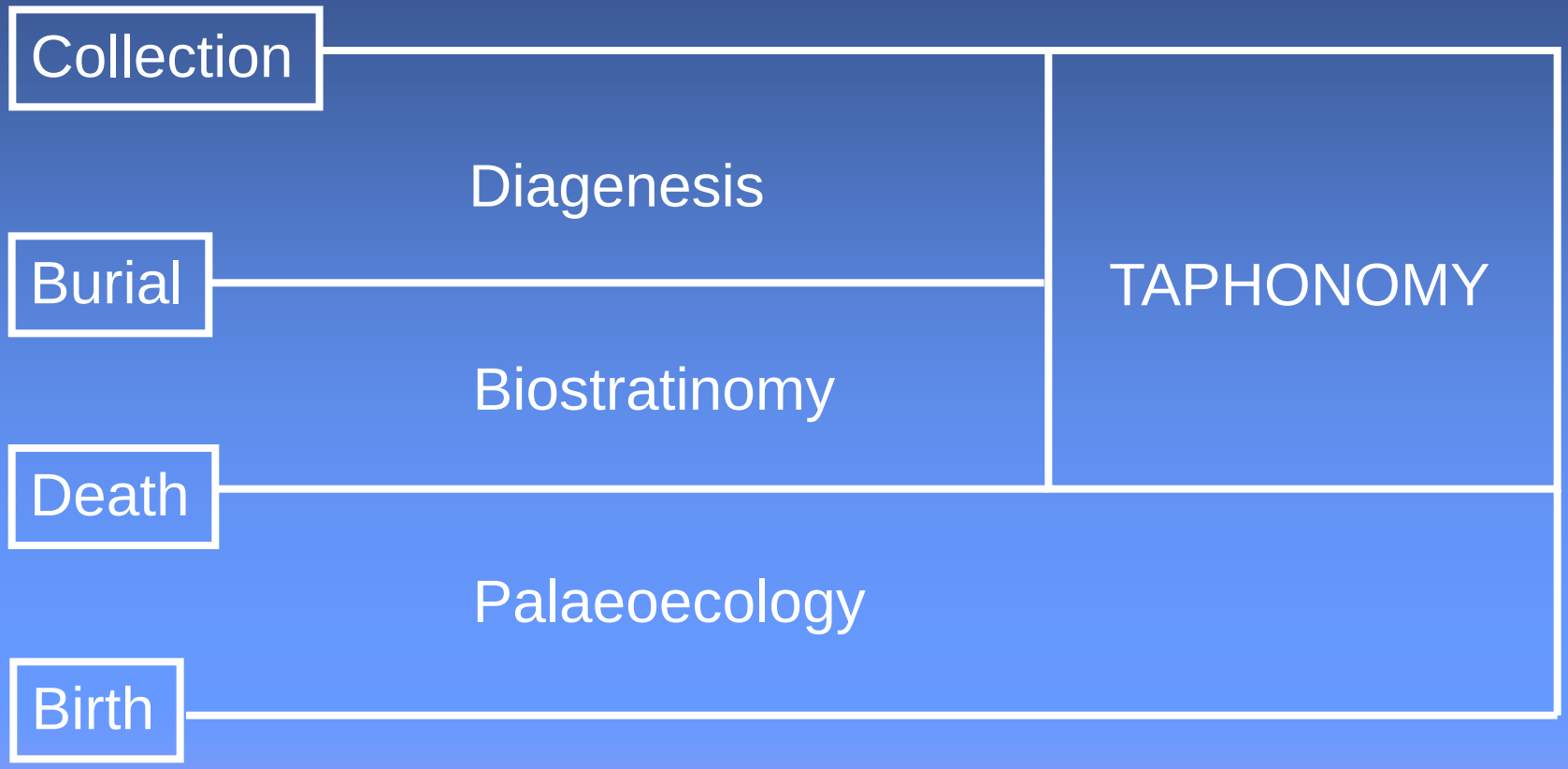
Taphonomy (Effremov, 1940)

Taphos (grave, burial) + nomos (law)

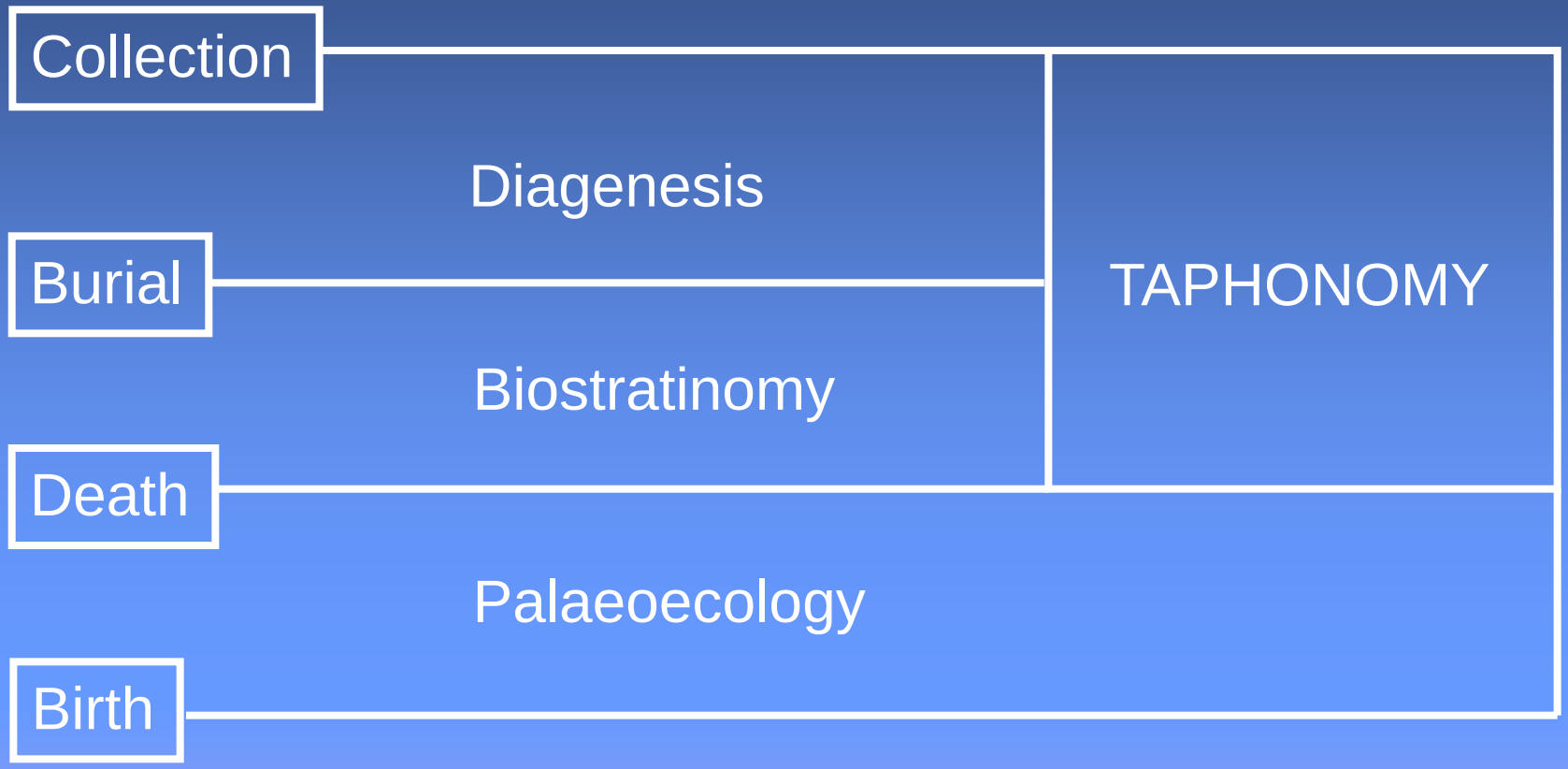
The study of all the processes that govern the transition of organic remains from the biosphere to the lithosphere.

- Relatively new branch of science
- Birth in 19th century
- The “Germans” and Weigelt (1927)
- The first workers were vertebrate palaeontologists
- Other palaeontology disciplines, archaeology, forensic science




Collection
Diagenesis
Burial
TAPHONOMY
Biostratinomy
Death
Palaeoecology
Birth

Palaeoecology is the study of past organisms and the environment in which they lived.


Collection
Diagenesis
Burial
TAPHONOMY
Biostratinomy
Death
Palaeoecology
Birth

Taphonomic processes → pre-burial
→ post-burial

Taphonomy → biostratinomy
→ diagenesis

Biostratinomy (Weigelt, 1927)

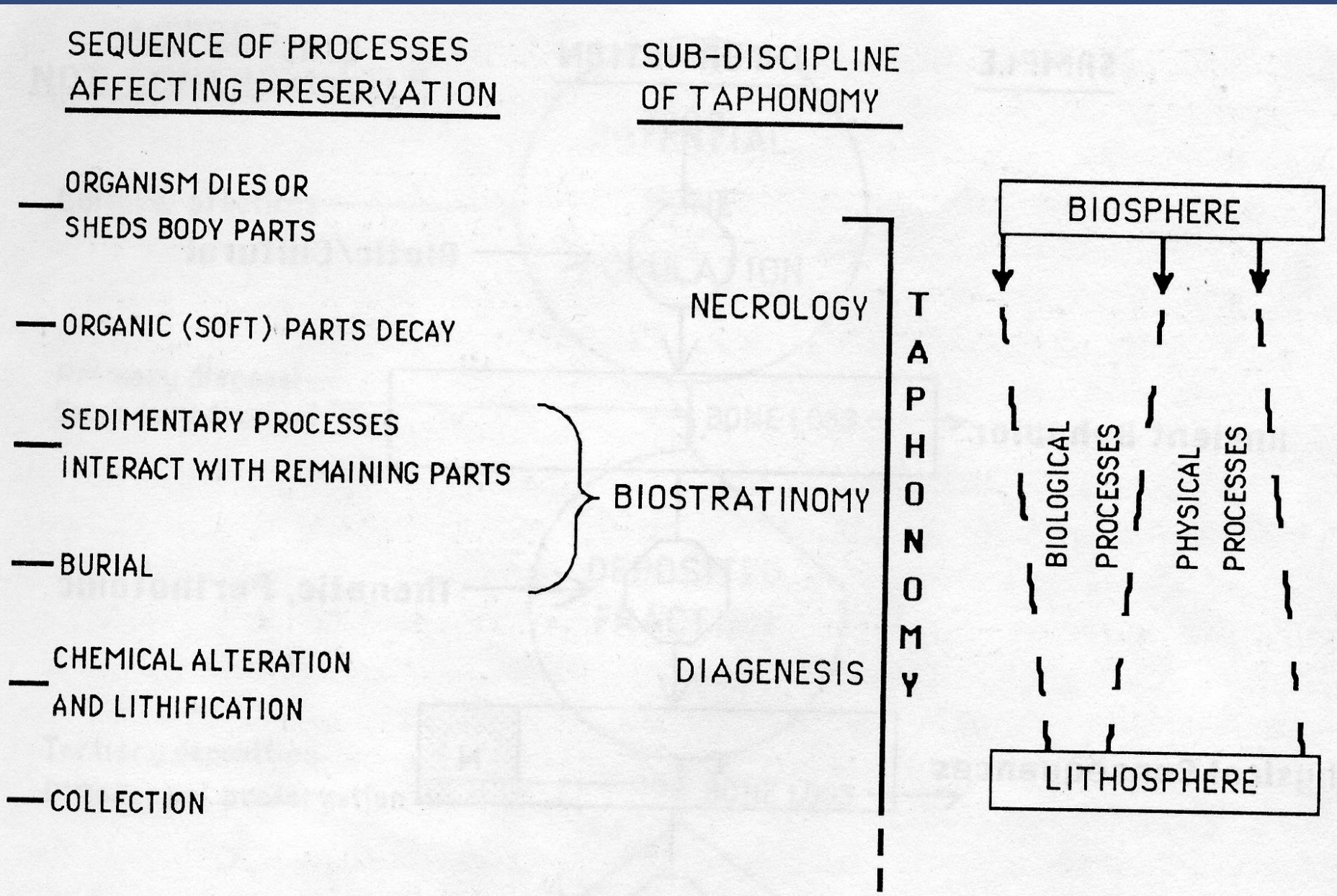
The study of the environmental factors and processes that affect organic remains between an organism's death and the final burial of the remains.

Diagenesis

- The chemical and physical changes that take place after the final burial of organic remains.

Fossilisation ⟶ a set of diagenetic processes

Taphonomic processes → physical
chemical
biological


SEQUENCE OF PROCESSES AFFECTING PRESERVATION
SUB-DISCIPLINE OF TAPHONOMY
ORGANISM DIES OR SHEDS BODY PARTS
ORGANIC (SOFT) PARTS DECAY
SEDIMENTARY PROCESSES INTERACT WITH REMAINING PARTS
BURIAL
CHEMICAL ALTERATION AND LITHIFICATION
COLLECTION
BIOSTRATINOMY
NECROLOGY
DIAGENESIS
TAPHONOMY
BIOSPHERE
BIOLOGICAL PROCESSES
PHYSICAL PROCESSES
LITHOSPHERE

Modes of death

- Volcanic activity
- Poisonous gases
- Fire
- Drowning
- Miring (mud, quicksand, oil, tar)
- Flooding
- Salinity flunctuation
- Drought
- Overpopulation (and thus malnutrition)
- Predation (hunting)
- Lack of food (starving)
- Freezing
- Falling through ice
- Injury through accident (falling) or intraspecific competition

Demography of death

- Attritional (normal) mortality.
- Selective mortality, vulnerable individuals (juveniles, old, ill), U-shaped
- Catastrophic (mass) mortality. Frequency distribution of age classes, catastrophic event, L-shaped

Attritional

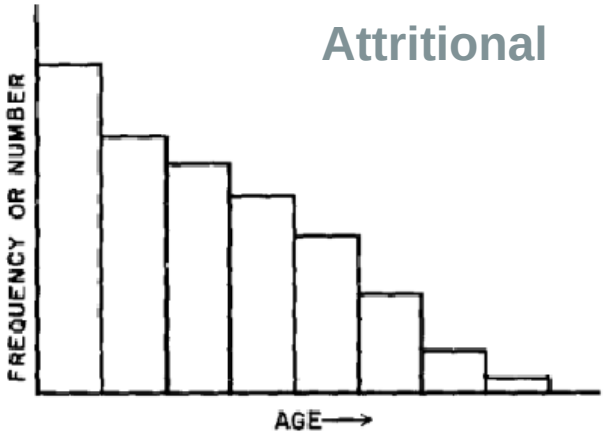


FIG. 1. Graph of age profile expected in a stable population of mammals (after Voorhies, 1969). The graph also represents a "catastrophic" sample, produced by mortality that was not selective to age.

Selective

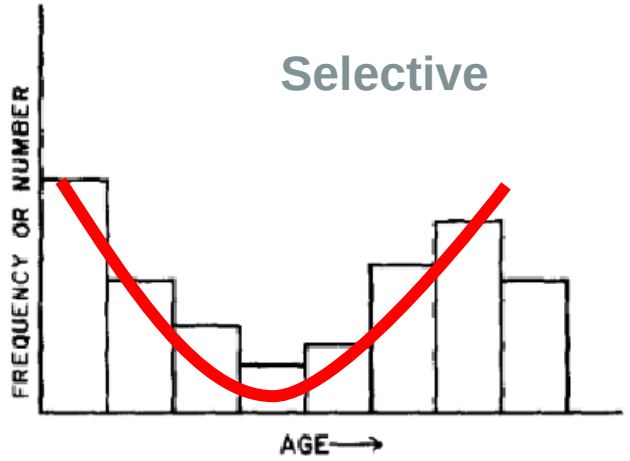


FIG. 2. Age profile expected in an "attritional" sample, produced by age-specific mortality processes that affect a stable population of mammals (after Voorhies, 1969).

Catastrophic

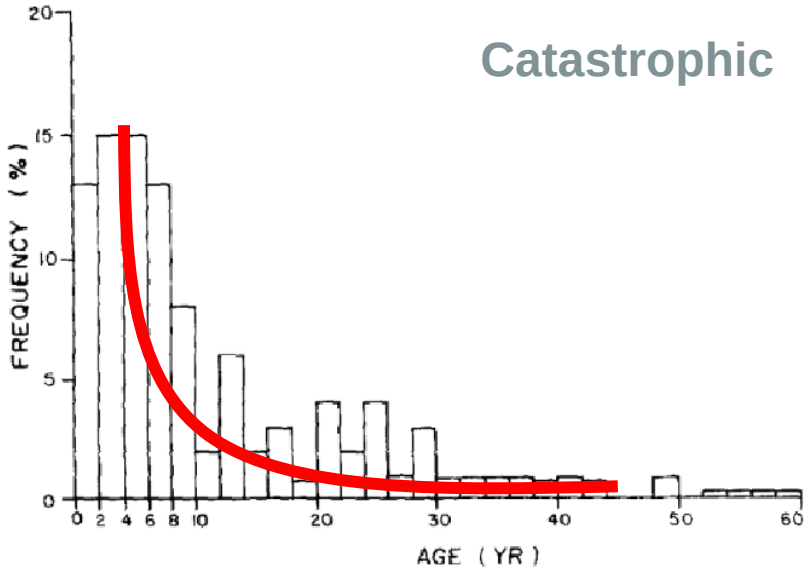
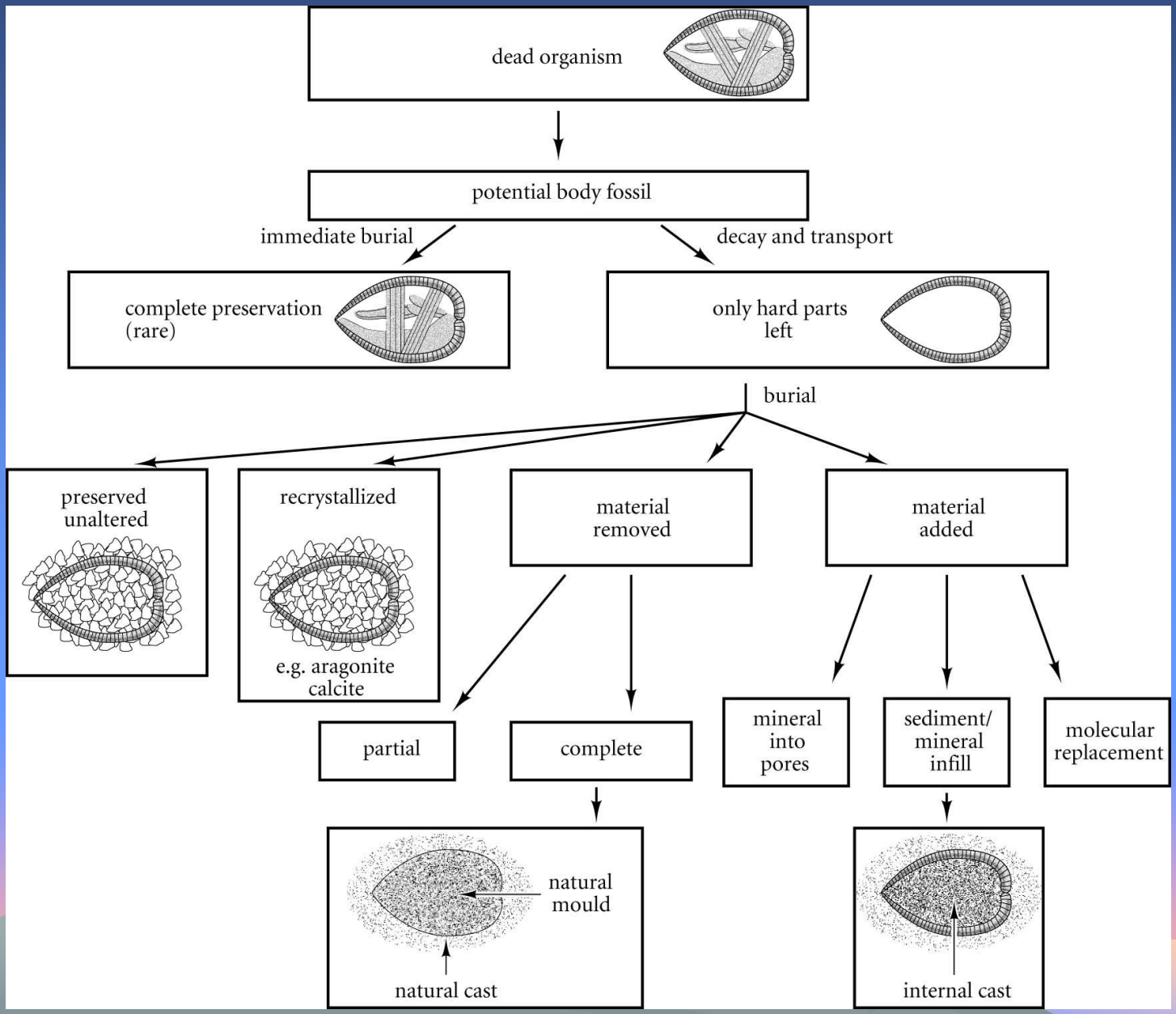
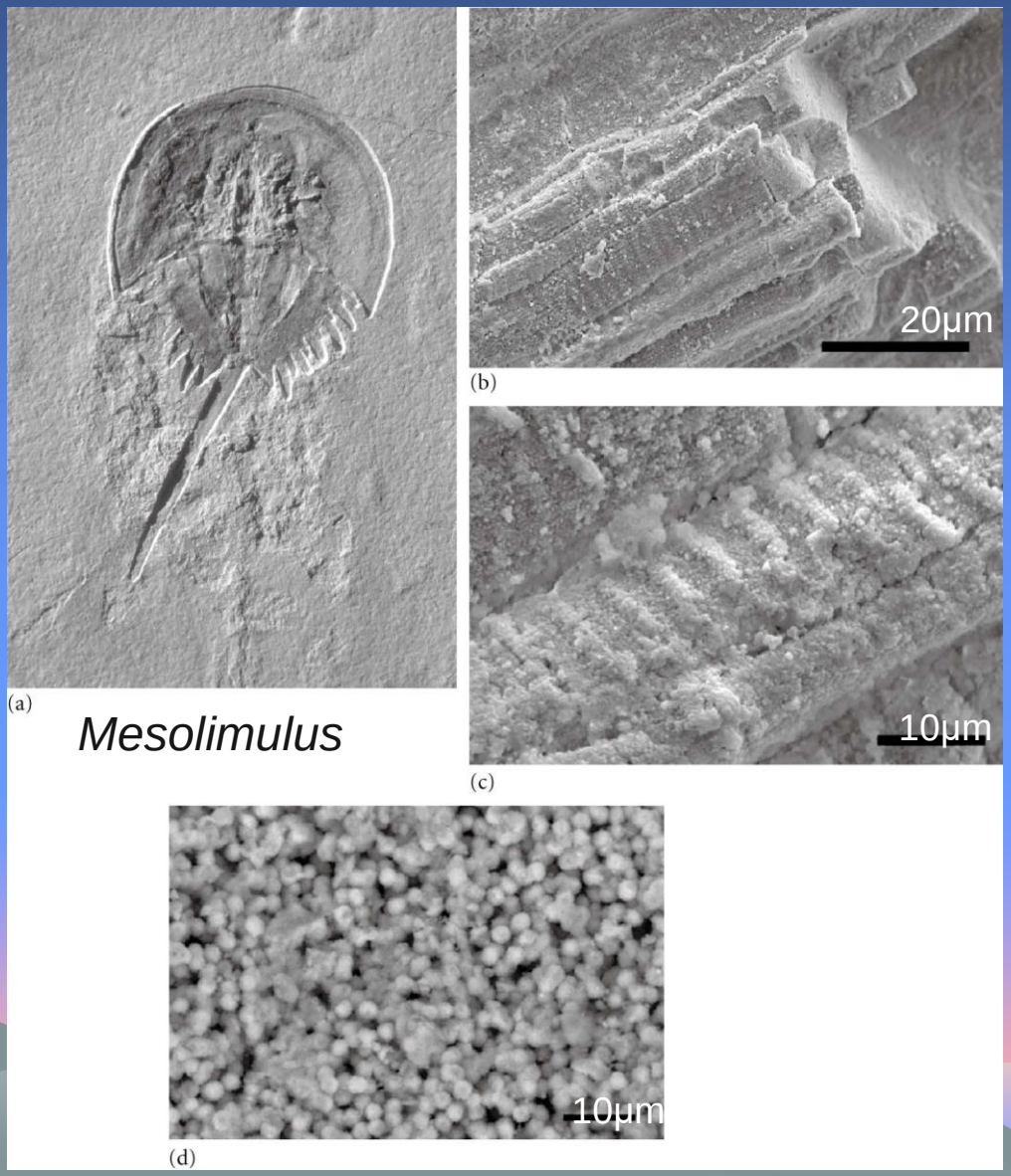


FIG. 4. Age profile of Hwange elephants culled in 1983 (n = 1951 animals).

But what happens after the organisms die and until we discover their fossil remains?


dead organism
potential body fossil
immediate burial
decay and transport
complete preservation (rare)
only hard parts left
burial
preserved unaltered
recrystallized
e.g. aragonite calcite
material removed
material added
partial
complete
mineral into pores
sediment/ mineral infill
molecular replacement
natural mould
natural cast
internal cast

Exceptional preservation



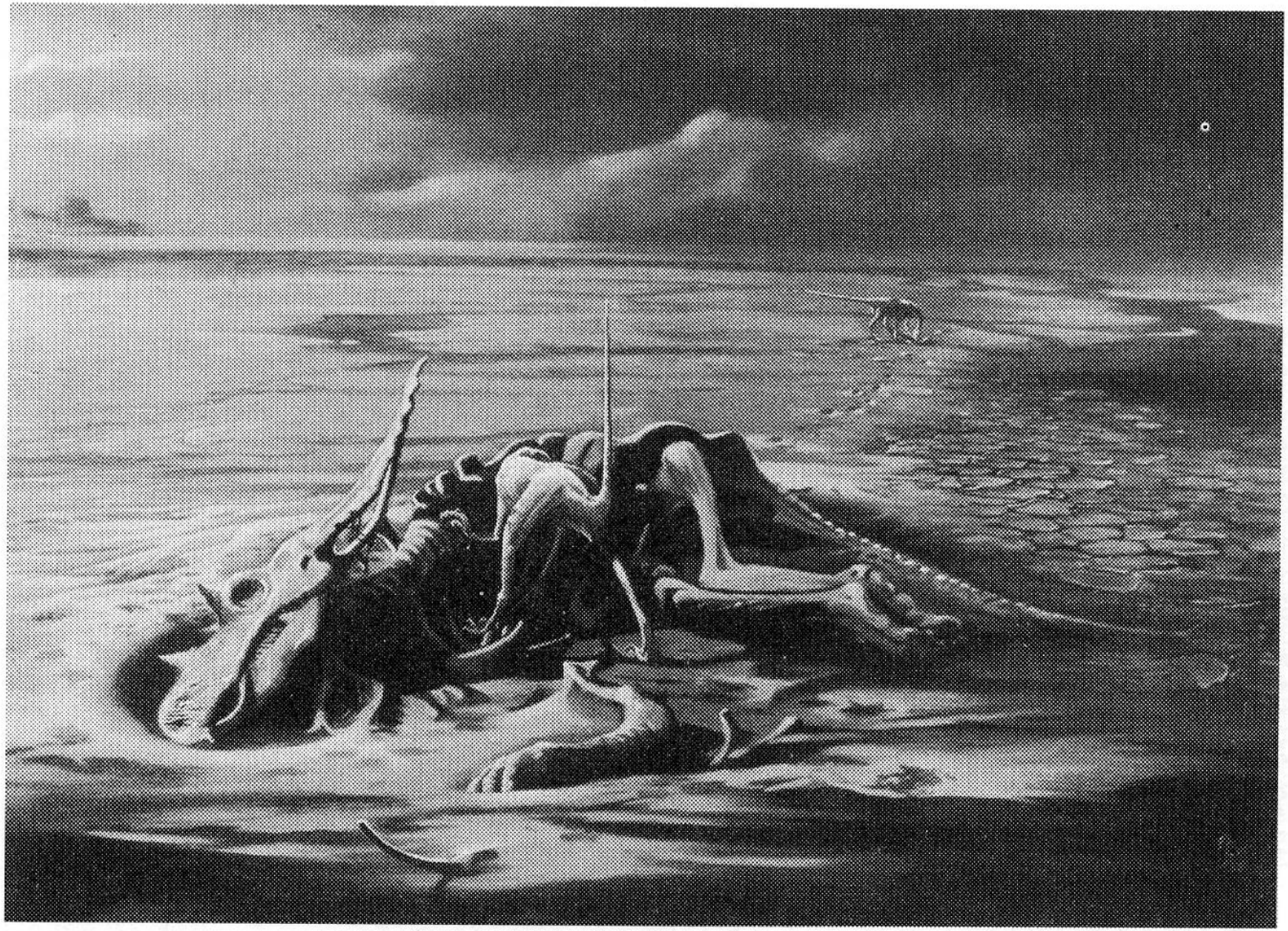
Muscle fibber

Decaying Muscle fibber

Microorganisms on a Muscle fibber

Soft tissue decay

- Scavenging by large vertebrates
- Scavenging by insects
- Decay by microorganisms (bacteria, fungi, algae etc.)



Soft tissue decay

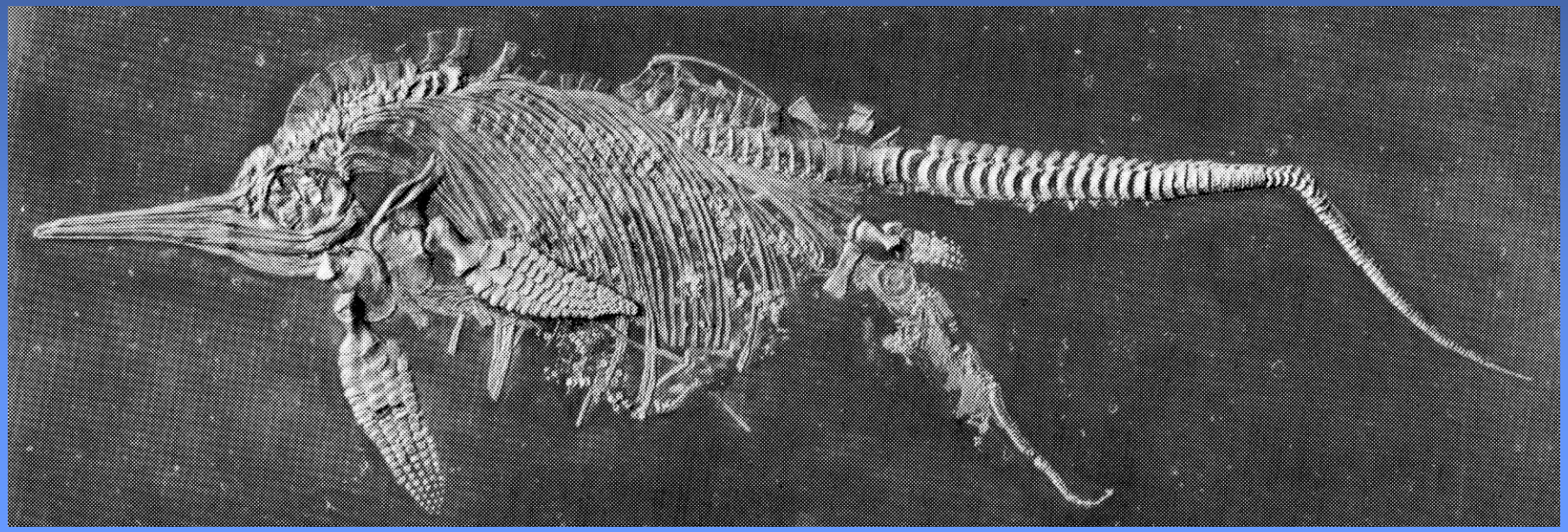
Forensic literature

- Scavenging
- Decay (aerobic breakdown of protein)
- Autolysis (breakdown of protein by enzymes contain within the organism)
- Putrefaction (anaerobic, bacterial breakdown of protein)

Exposed skeletal remains

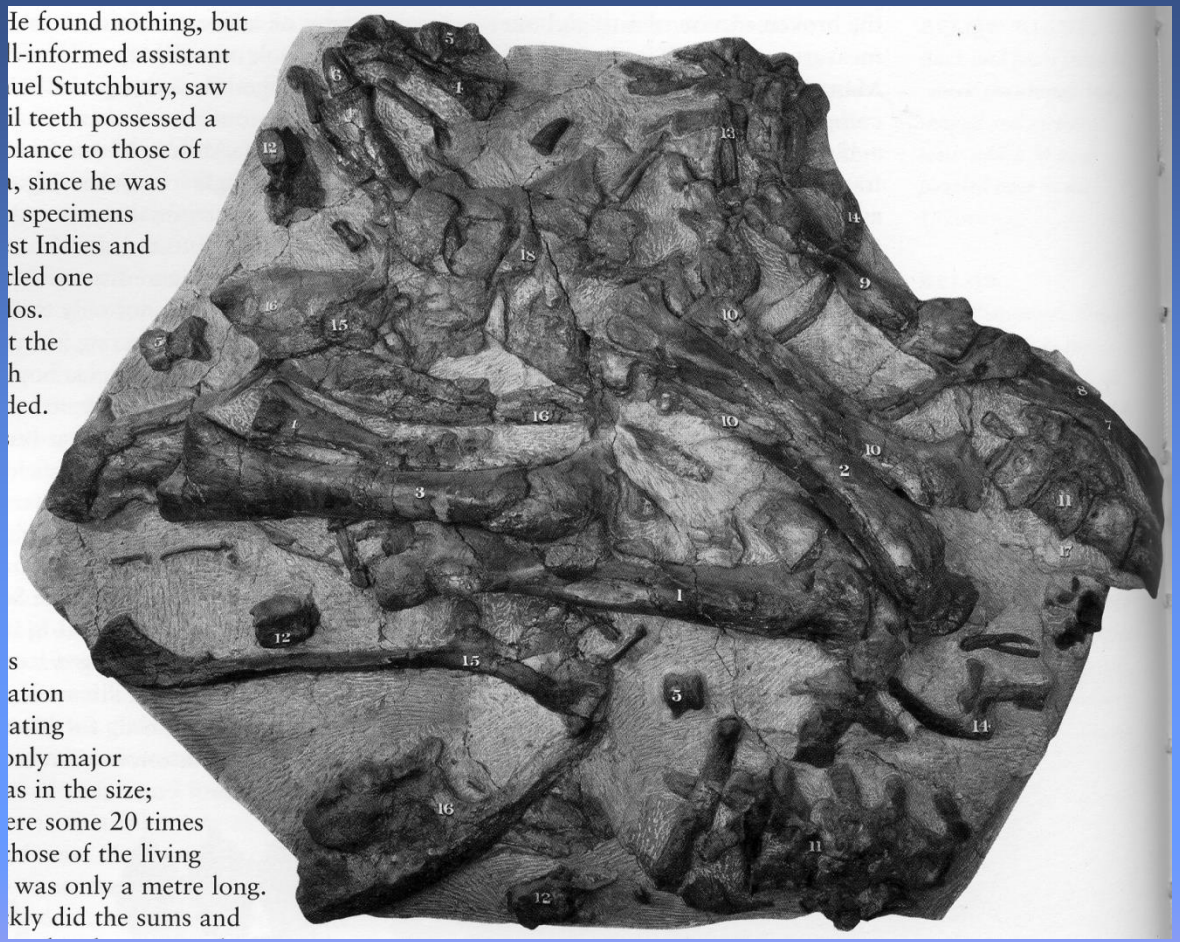
- Disarticulation
- Scattering
- Dispersal
- Transportation
- Accumulation
- Burial

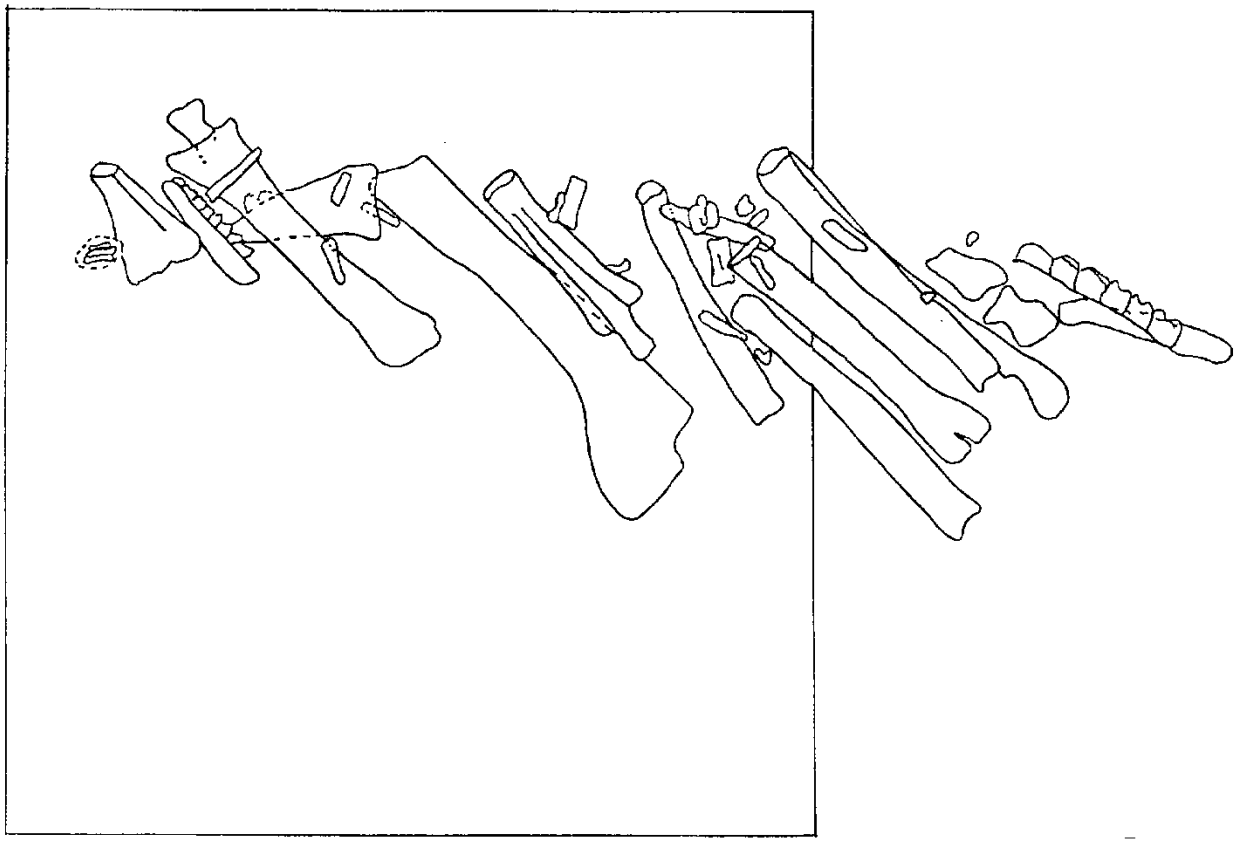
Factors: shape of fossils, fluvial channels or currents, orientation of bones



He found nothing, but
ll-informed assistant
uel Stutchbury, saw
il teeth possessed a
blance to those of
, since he was
n specimens
st Indies and
tled one
los.
t the
h
ded.

s
ation
ating
only major
as in the size;
ere some 20 times
those of the living
was only a metre long.
kly did the sums and



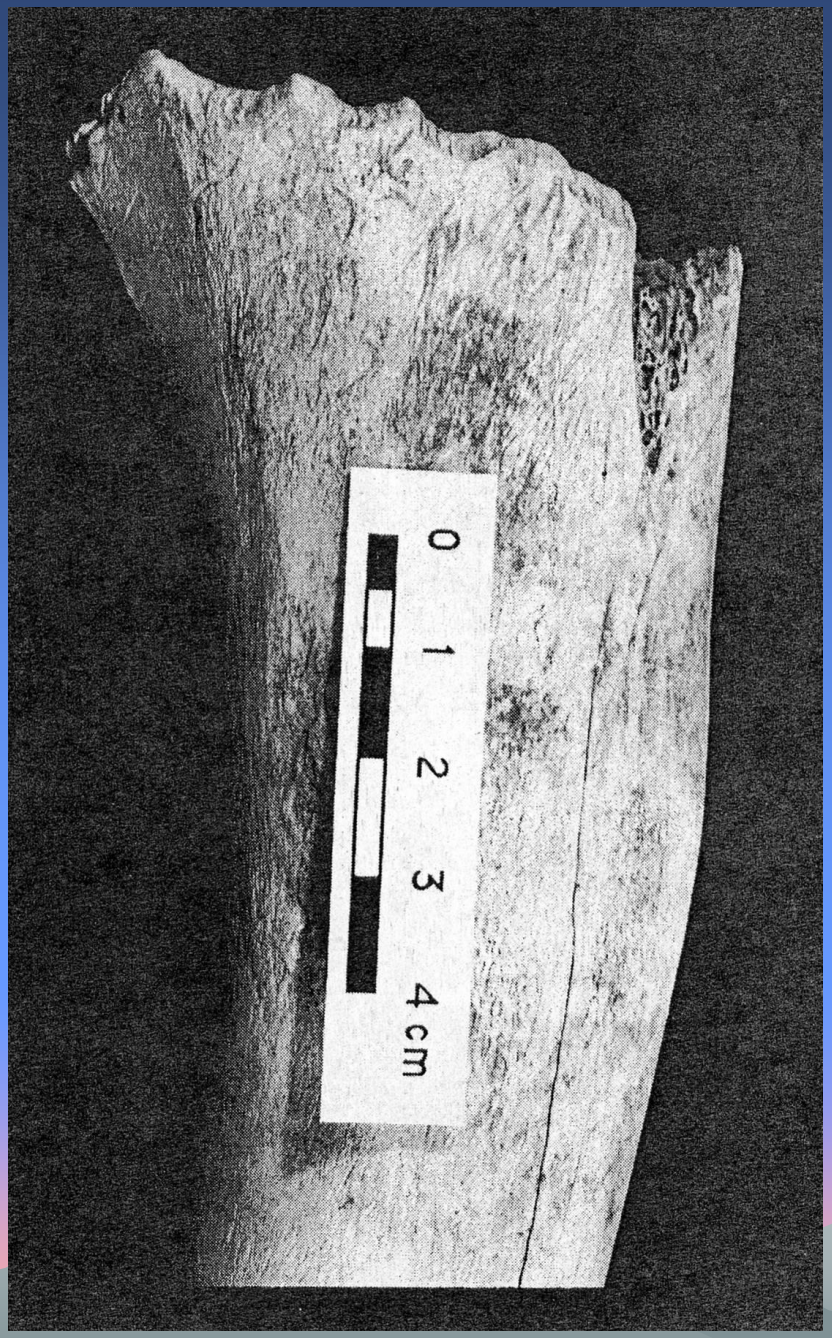


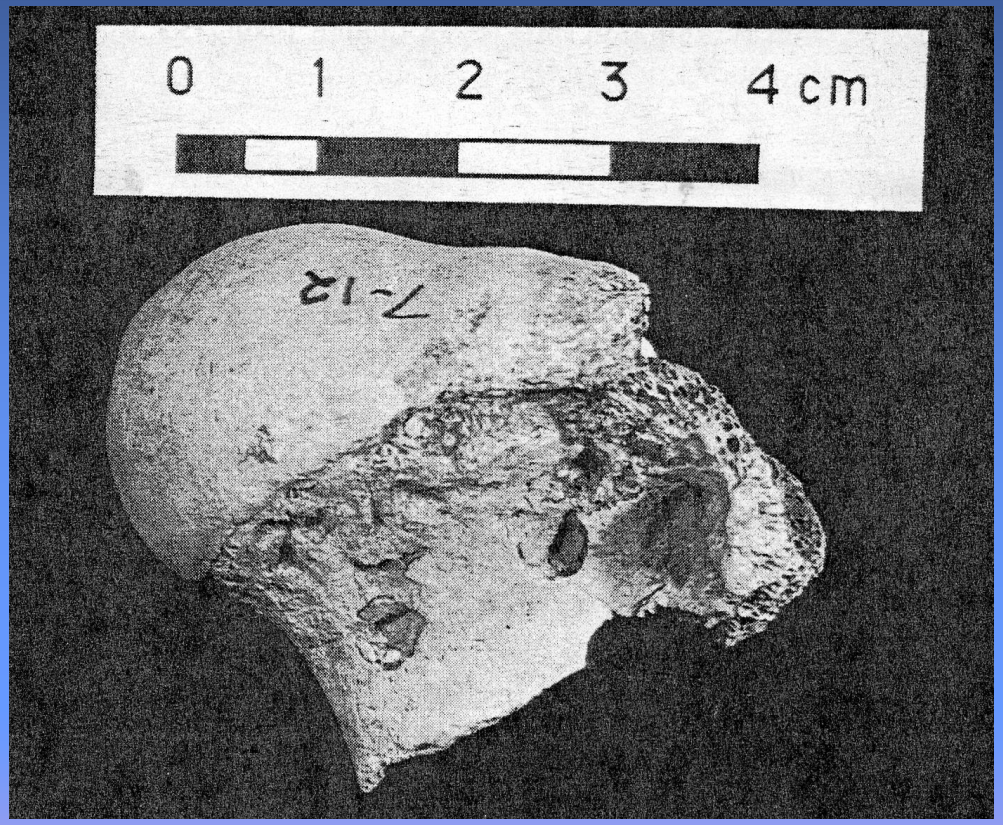
N

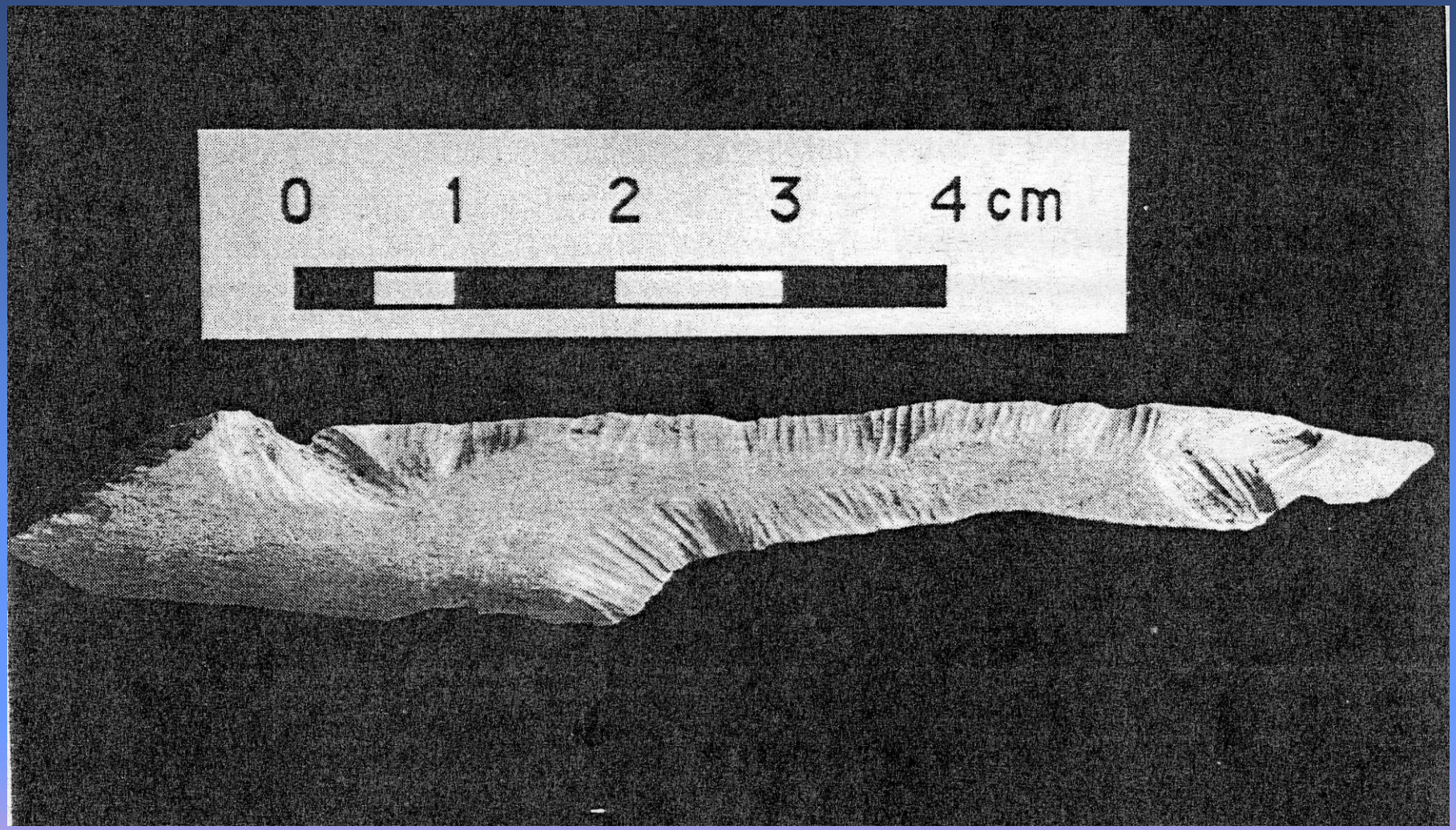
Destructive preburial processes

- Scavenging
- Abrasion
- Weathering
- Rodent gnawing
- Digestive corrosion
- Percussion marks
- Fracturing
- Trampling
- Burning

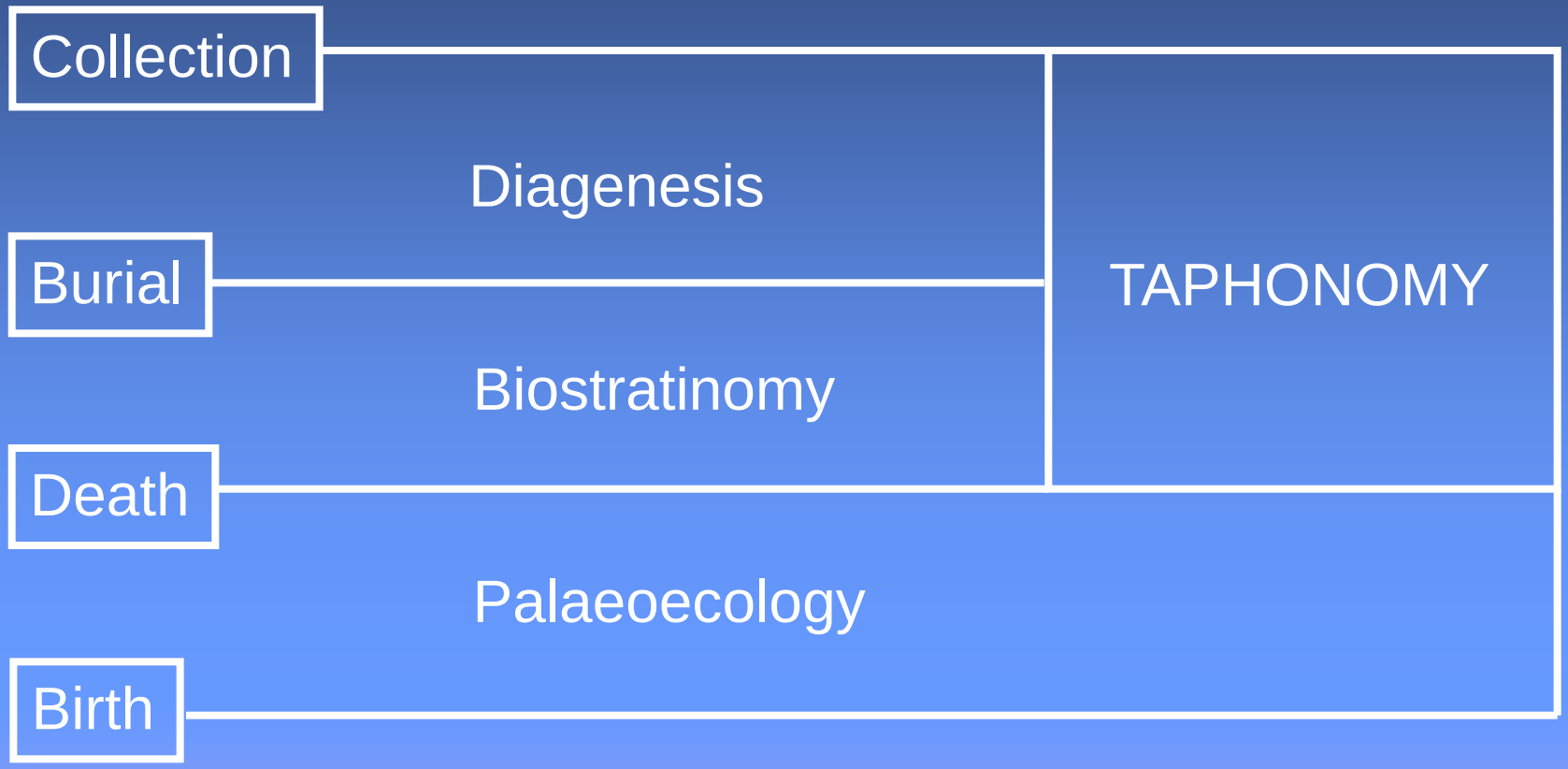
Scavenging - Gnawing






0 1 2 3 4 cm

Weathering


Collection
Diagenesis
Burial
TAPHONOMY
Biostratinomy
Death
Palaeoecology
Birth

Diagenesis

The chemical and physical changes occurring after the final burial of the remains of organisms

- Fossilisation=A series of diagenetic processes

Post burial processes

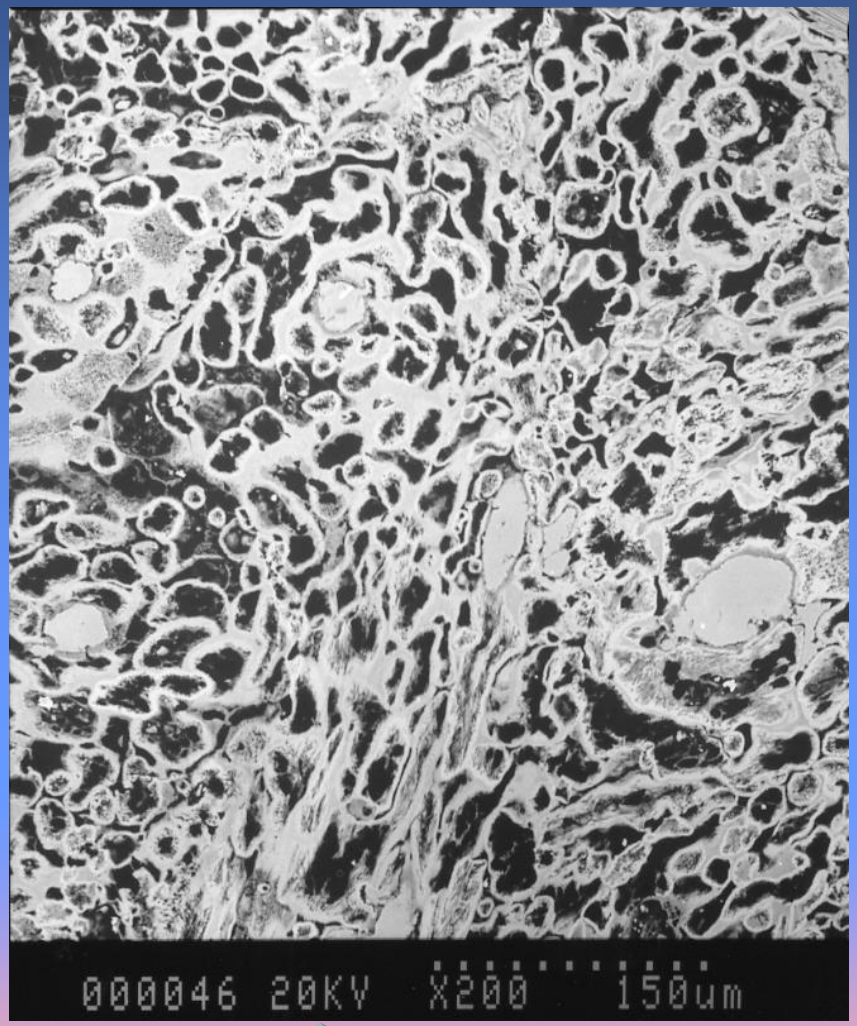
- Sedimentation
- Mineralization
- Permineralisation
- Leaching
- Enrichment
- Deformation
- Compaction
- Bioerosion (microorganisms)
- Dissolution
- Reworking
- Root etching

Deformation

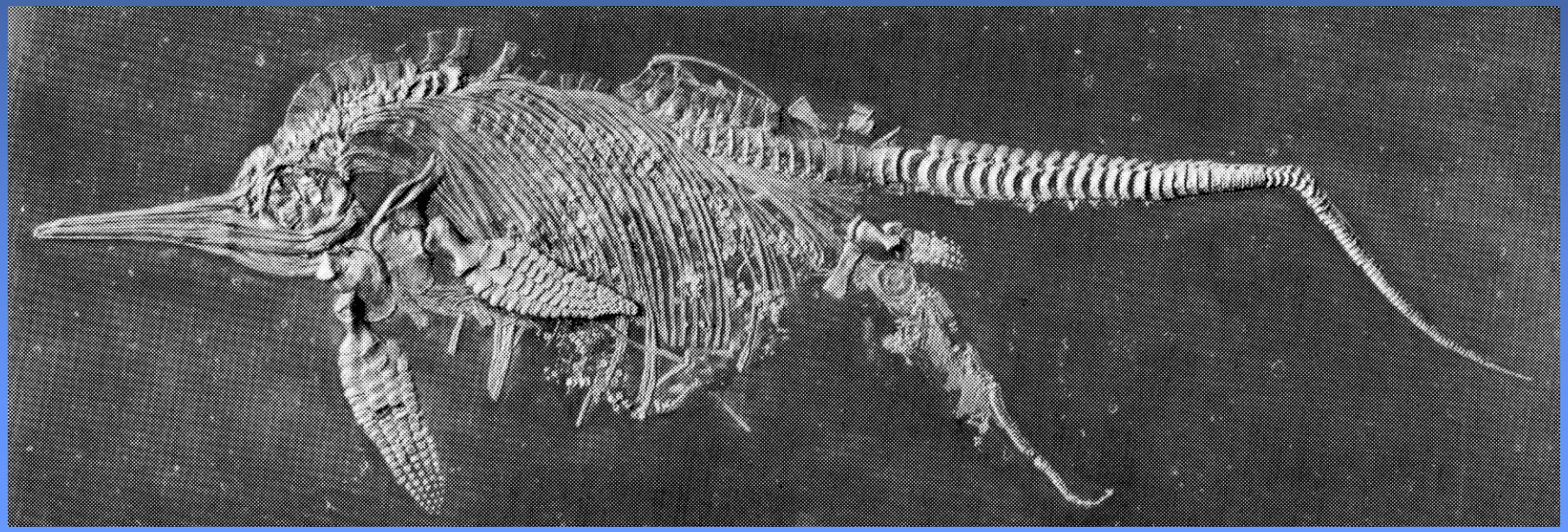
(b)

(c)

Bioerosion



Dissolution



Preferable factors for fossilisation

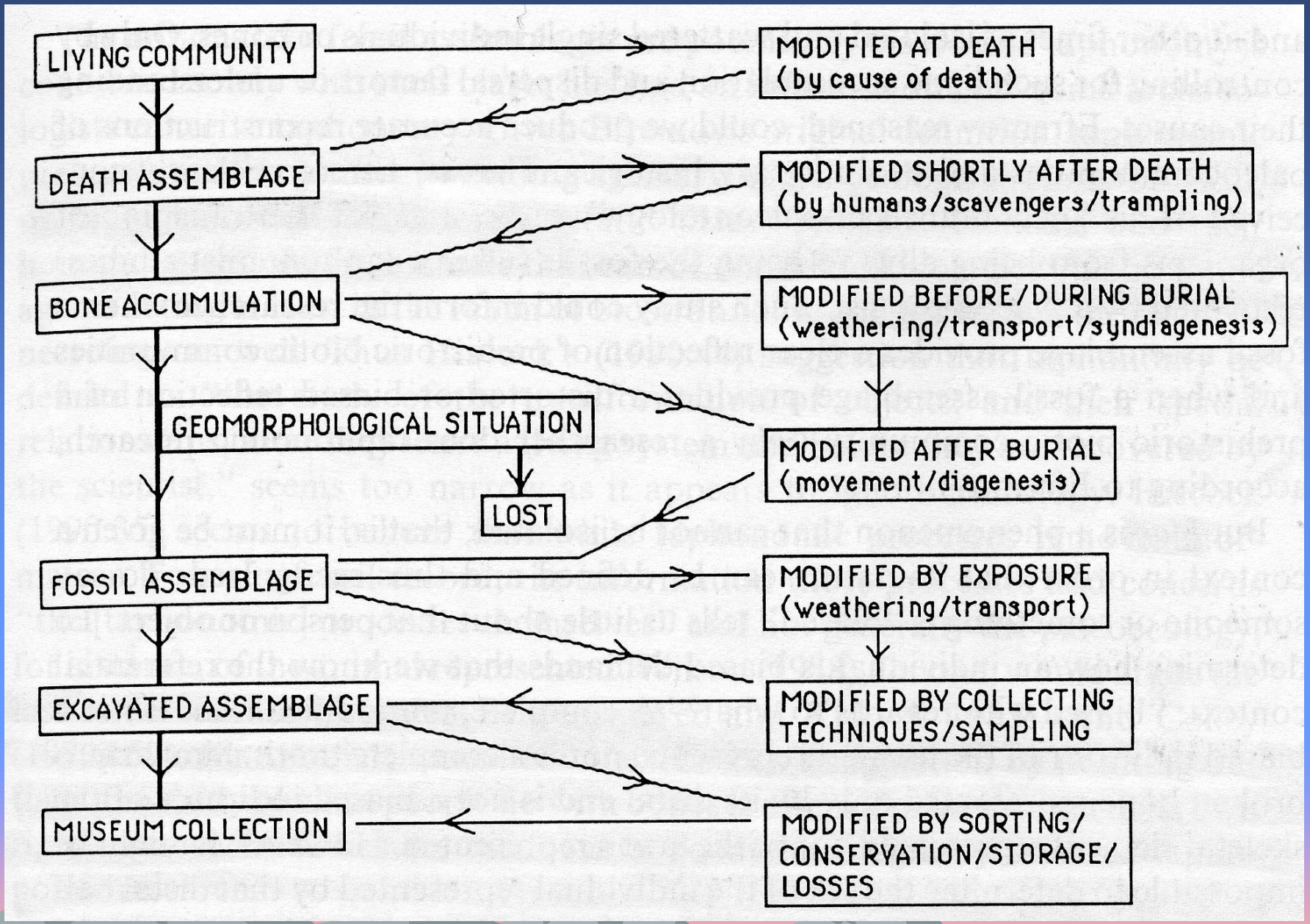
- Abundance of organisms
- Minimal physical disturbance
- Fast burial
- Avoid contact with oxygen and water
- Small size
- Structure and composition of the original skeleton
- Nature and grain size of the surrounding sediments
- Chemical conditions in the burial sediment
- Diagenetic processes

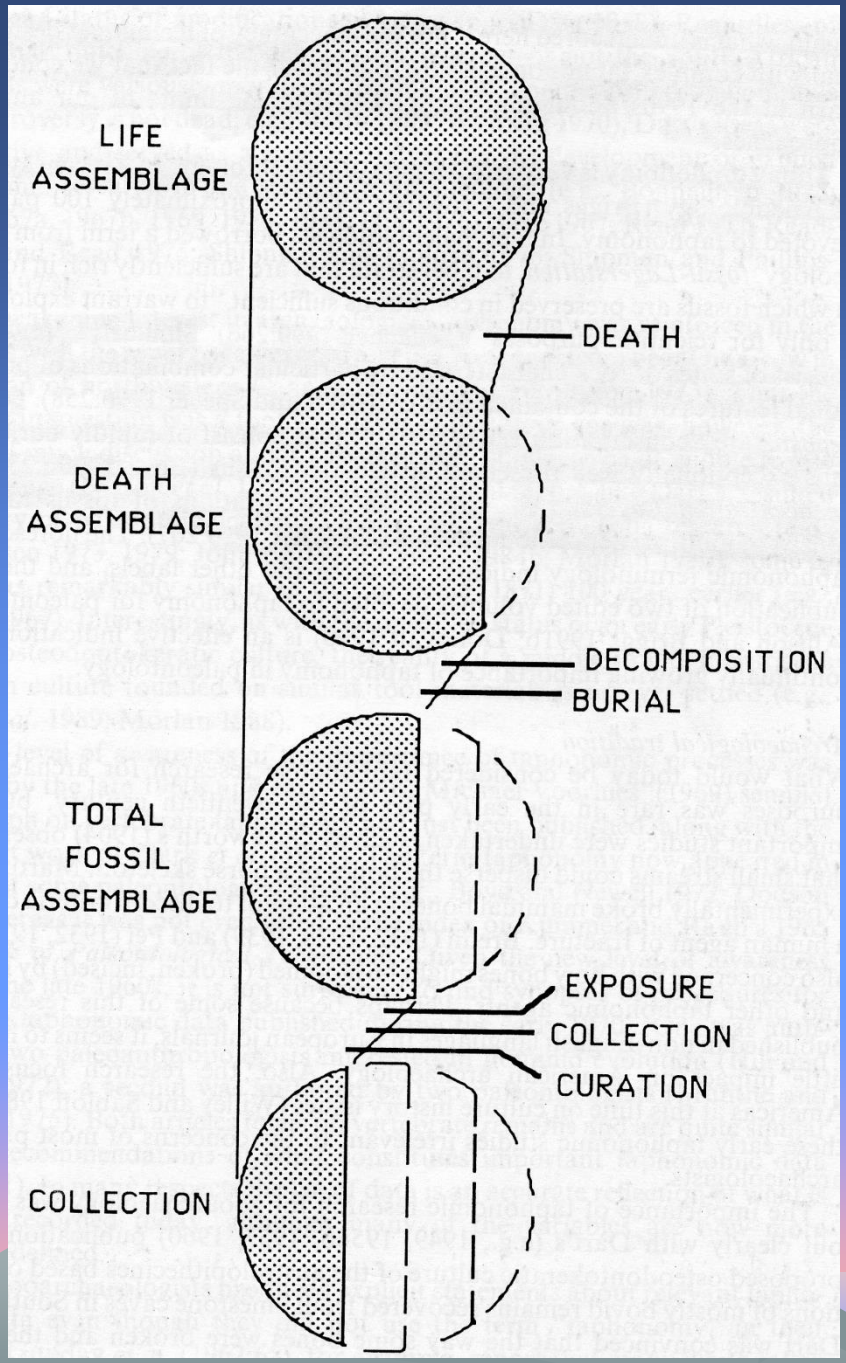
Fossil record

- It is defined as the total number of fossils that have entered or are potentially present in the sedimentary rocks. A partial list of life on earth that records the history of life.
- By “completeness” we describe how complete we would expect the record to be in a region or in general the global record.
- The record is never complete. Why;

Incompleteness of fossil record

- The fossil record is incomplete
- Partial catalogue of past life
- Soft bodied animals underrepresented
- Selective fossilisation
- Vagaries of fossilisation processes, thus always gaps in the fossil record
- It can be improved but never completed


LIVING COMMUNITY
MODIFIED AT DEATH
(by cause of death)
DEATH ASSEMBLAGE
MODIFIED SHORTLY AFTER DEATH
(by humans/scavengers/trampling)
BONE ACCUMULATION
MODIFIED BEFORE/DURING BURIAL
(weathering/transport/syndiagenesis)
GEOMORPHOLOGICAL SITUATION
LOST
MODIFIED AFTER BURIAL
(movement/diagenesis)
FOSSIL ASSEMBLAGE
MODIFIED BY EXPOSURE
(weathering/transport)
EXCAVATED ASSEMBLAGE
MODIFIED BY COLLECTING
TECHNIQUES/SAMPLING
MUSEUM COLLECTION
MODIFIED BY SORTING/
CONSERVATION/STORAGE/
LOSSES


LIFE
ASSEMBLAGE
DEATH
DEATH
ASSEMBLAGE
DECOMPOSITION
BURIAL
TOTAL
FOSSIL
ASSEMBLAGE
EXPOSURE
COLLECTION
CURATION
COLLECTION

Taphonomic assemblages

- biocoenosis: living assemblage
- thanatocoenosis: assemblage after death and decay
- taphocoenosis: fossil assemblage that is preserved
- life assemblages = autochthonous thanatocoenoses
- death assemblage = allochthonous taphocoenoses
- time-averaging assemblage: is accumulation of mixture of successive populations

- Most assemblages are made up from transported remains
- Biased assemblages, certain skeletal elements or individuals more susceptible to destruction (size, age of animal, type of skeletal element)
- They can provide a good representation of living community