Concepts of Biology: BIOL 111
Study guide for Exam 2

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Lectures 8–16

Contents

Outline

1 Where we are?

2 Questions and answers

2.1 Exam 2

Results of Exam 2: statistic summary

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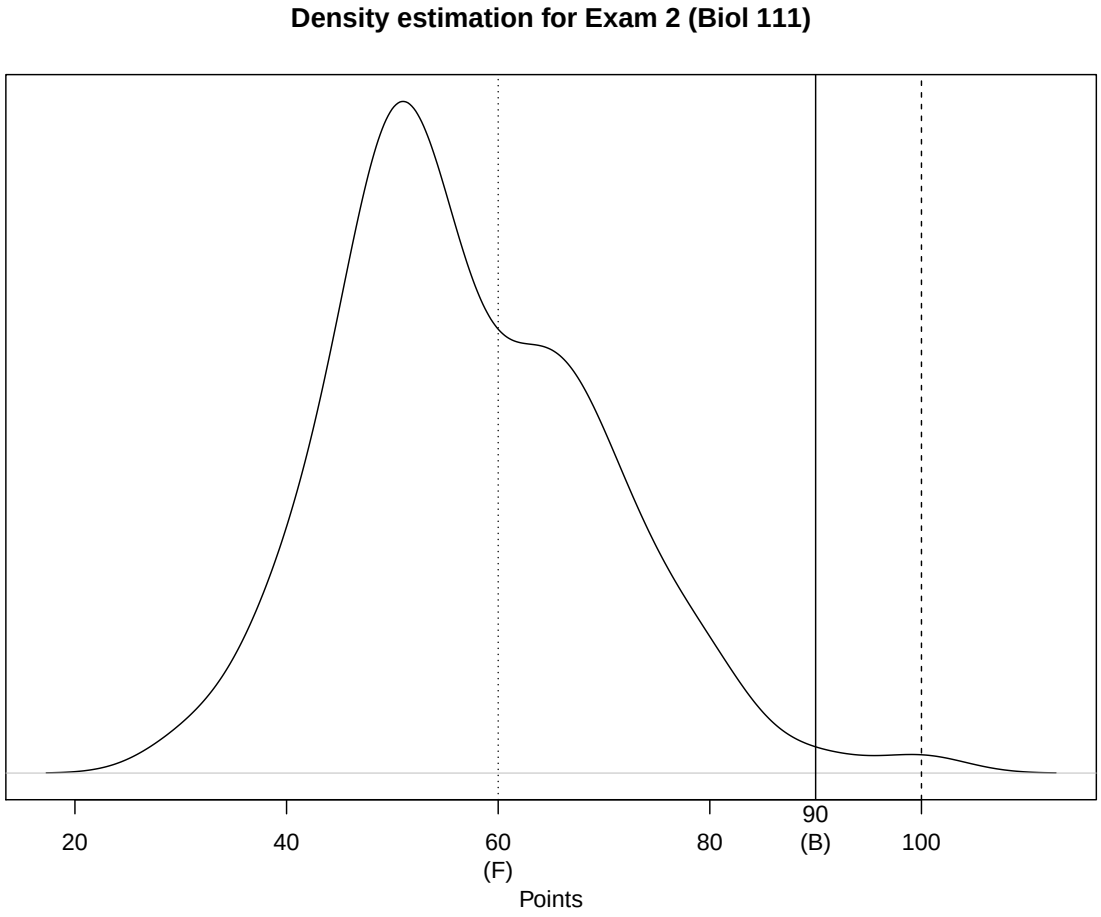
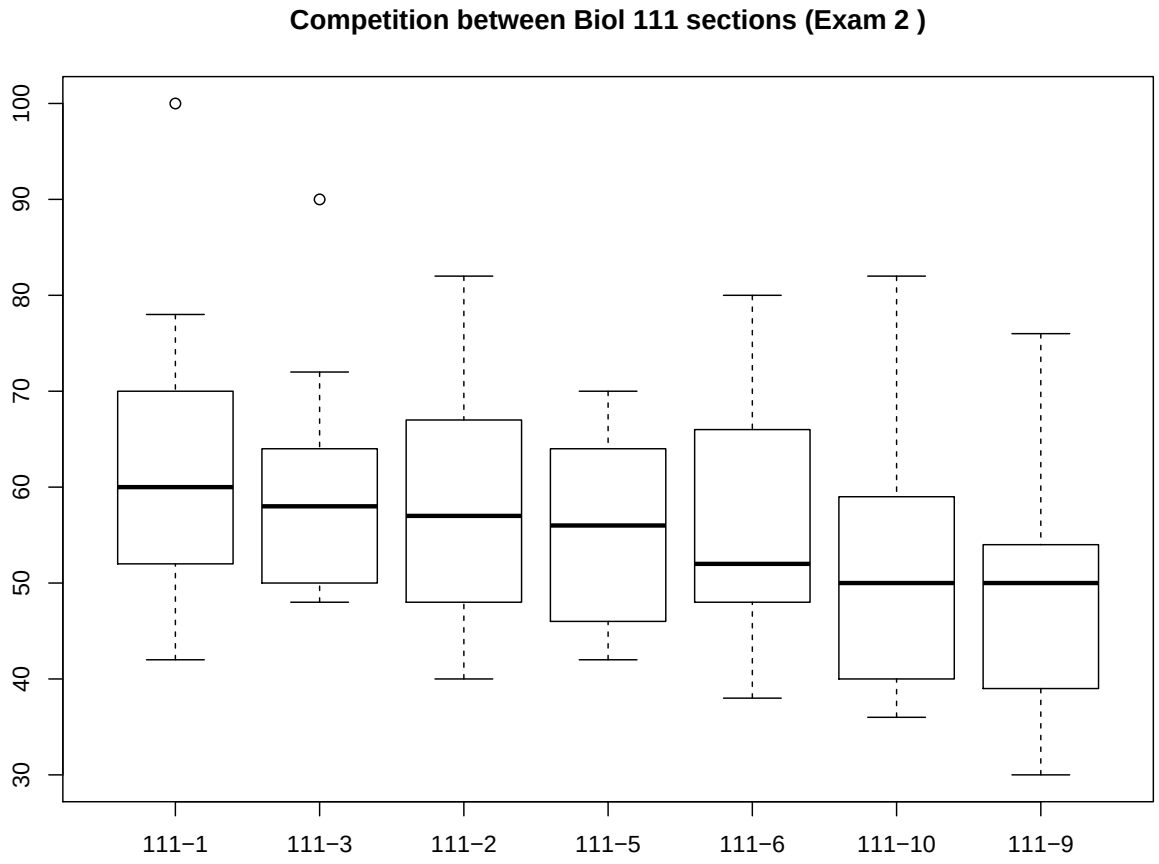
Summary:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
  30.00   50.00   54.00   57.24   66.00  100.00      13
Grades:
   F    D    C    B  max
< 60 < 70 < 80 < 90  100
```

Results of Exam 2: the curve



Results of Exam 2: sections



Results of Exam 2: two questions

4. To make lipids from carbohydrates, plants need:

   A. **To recombine atoms in molecule**
   B. To add phosphorous
   C. To add phosphorous and nitrogen

45. What is the horizontal transfer of DNA?

   A. Transfer of DNA from mother to daughter cells
   B. **Transfer of DNA between cells of different species**
   C. Transfer of DNA between cells of one tissue

3 Where we are?

3.1 Nucleus, introns and telomerase

The logic of acquiring nucleus

- In bacterial mat, many bacterial groups coexist

- Due to the evolution, they become more and more dissimilar
- However, **horizontal transfer** of DNA continued
- To prevent the transfer of alien genes, some cells "decided" to separate DNA with membranes

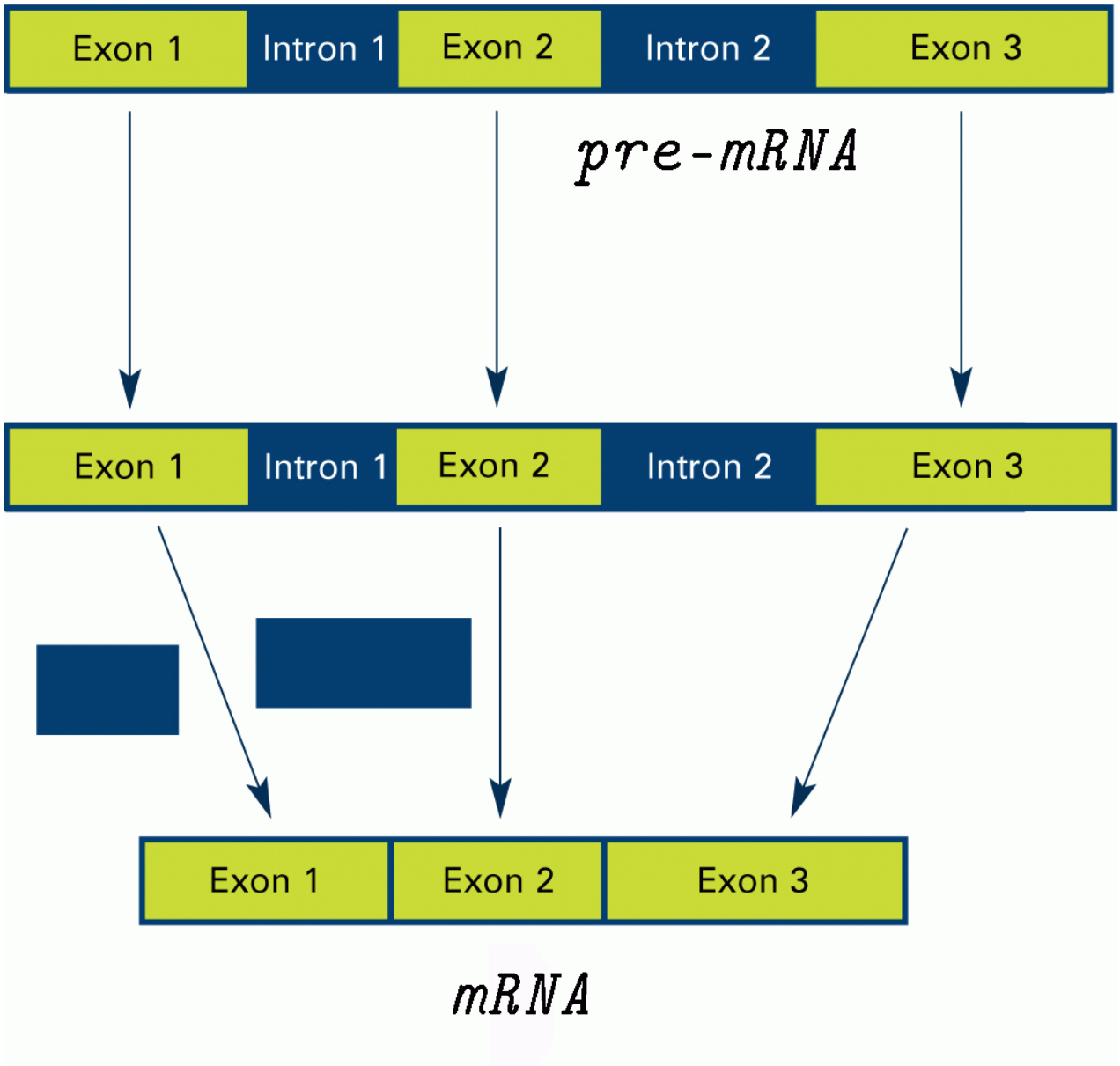
Nuclear envelope

- There are many ways to create nucleus-like structures. For example, it could be guarded with one membrane but then pores will be impossible
- Eukaryote ancestors created the *nuclear envelope from ER*

Introns

- Creating a nucleus run the cascade of consequences. First of all, cell now may keep much more DNA
- Some of this DNA may now contain insertions—**introns** which are removed before mRNA go through the nuclear pore
- Introns increase the variability of DNA and allow to make many variants of proteins

Introns ans exons



Only archebacteria and eukaryotes have introns

Linear DNA

- Big circular (as opposed to small circles) molecules of DNA are harder to keep, difficult to enlarge and slower to duplicate
- Eukaryotes changed circular DNA into linear
- Every linear DNA molecule is "I-chromosome"

Telomerase and aging

- Unfortunately, replication of linear DNA has a problem: with every replication, the very end of DNA molecule *is not replicated*
- **Telomerase** adds some nonsense DNA to the telomere and thus prevent the shortening of DNA molecule

- Unfortunately, sometimes telomerase is not working well and DNA was cut... This is one of main reasons of **aging**

Summary

- Introns, linear DNA molecules and telomere/telomerase system differ eukaryotes from most prokaryotes

For Further Reading

References

[1] Introns. `http://en.wikipedia.org/wiki/Intron`

Outline

4 Where we are?

4.1 Precambrian life

Precambrian life

- In Cryogenian, Marinoan glaciation covered the whole Earth
- In Edicarian, multicellular and then multi-tissued eukaryotes appeared

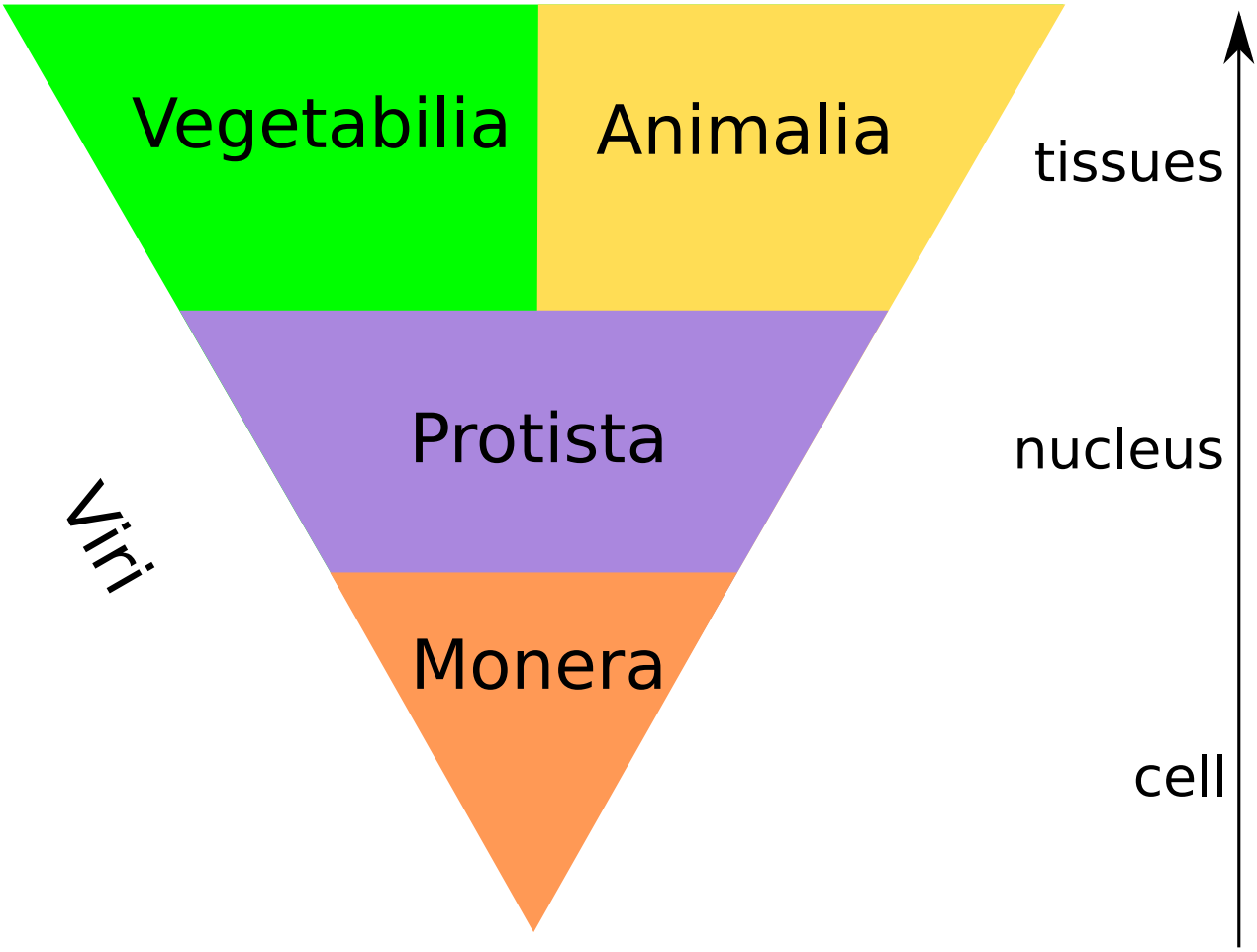
One of first multicellular alga with reproductive cells

Bangiomorpha, putative red alga from Proterozoic

5 Cells, tissues and kingdoms

5.1 Pyramid of Life

Cells, tissues, kingdoms and viruses



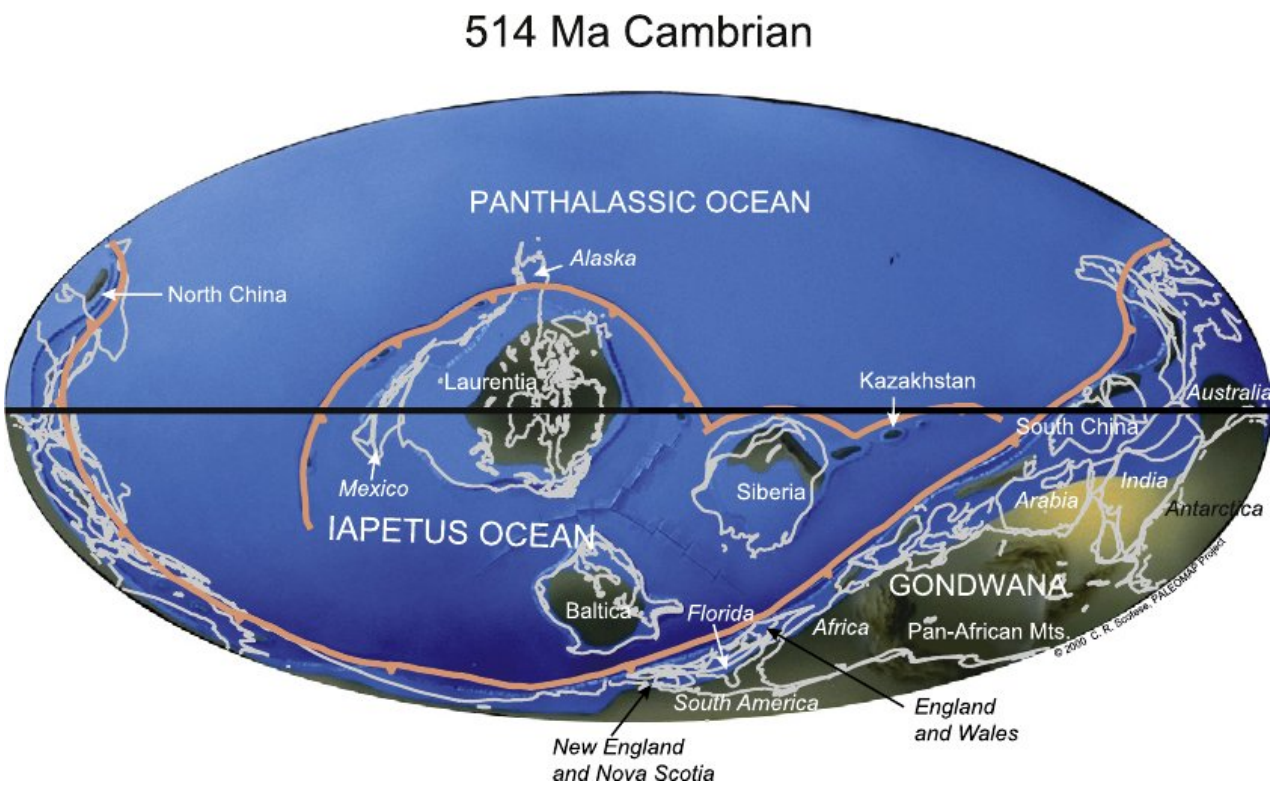
6 Cambrian period

6.1 Life in Cambrian

Timescale of Phanerozoic eon, Paleozoic era

- Phanerozoic eon
  - Paleozoic era
    - Cambrian period: 541 Mya
    - Ordovician period: 485 Mya
    - Silurian period: 443 Mya
    - Devonian period: 419 Mya
    - Carboniferous period: 358 Mya
    - Permian period: 299–252 Mya

Cambrian map



Cambrian climate

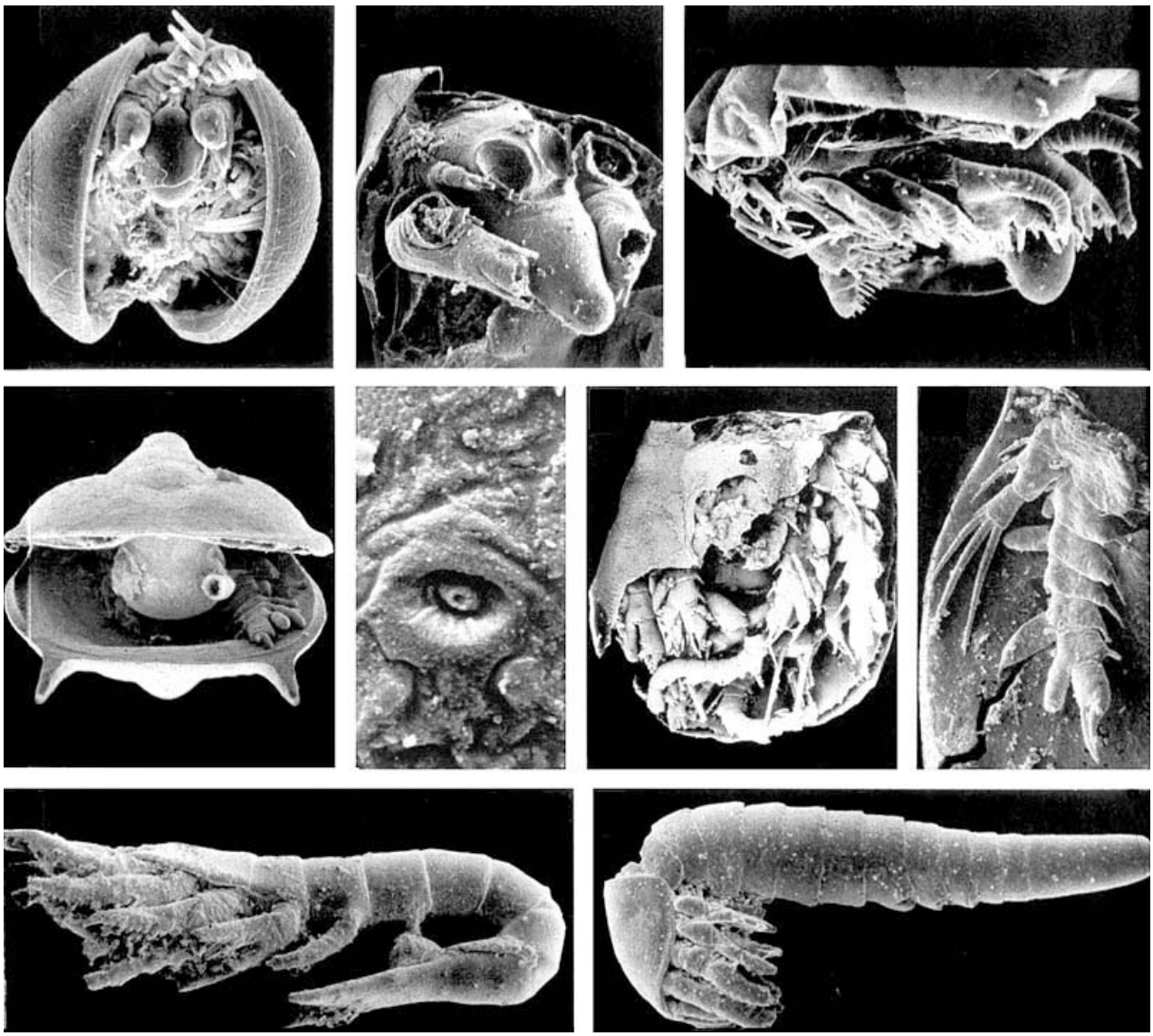
- Gradually changed from colder to warmer
- Polar ice caps were most probably present

Main Cambrian biotas

- Burgess shale (505 Mya)
- Orsten fauna (498 Mya)
- These fossils were kept in *Lagerstaettes*—exceptionally well preserves clay deposits
- This excellent preservation could be consequence of the rarity of Cambrian destroyers

Burgess shale

Orsten fauna

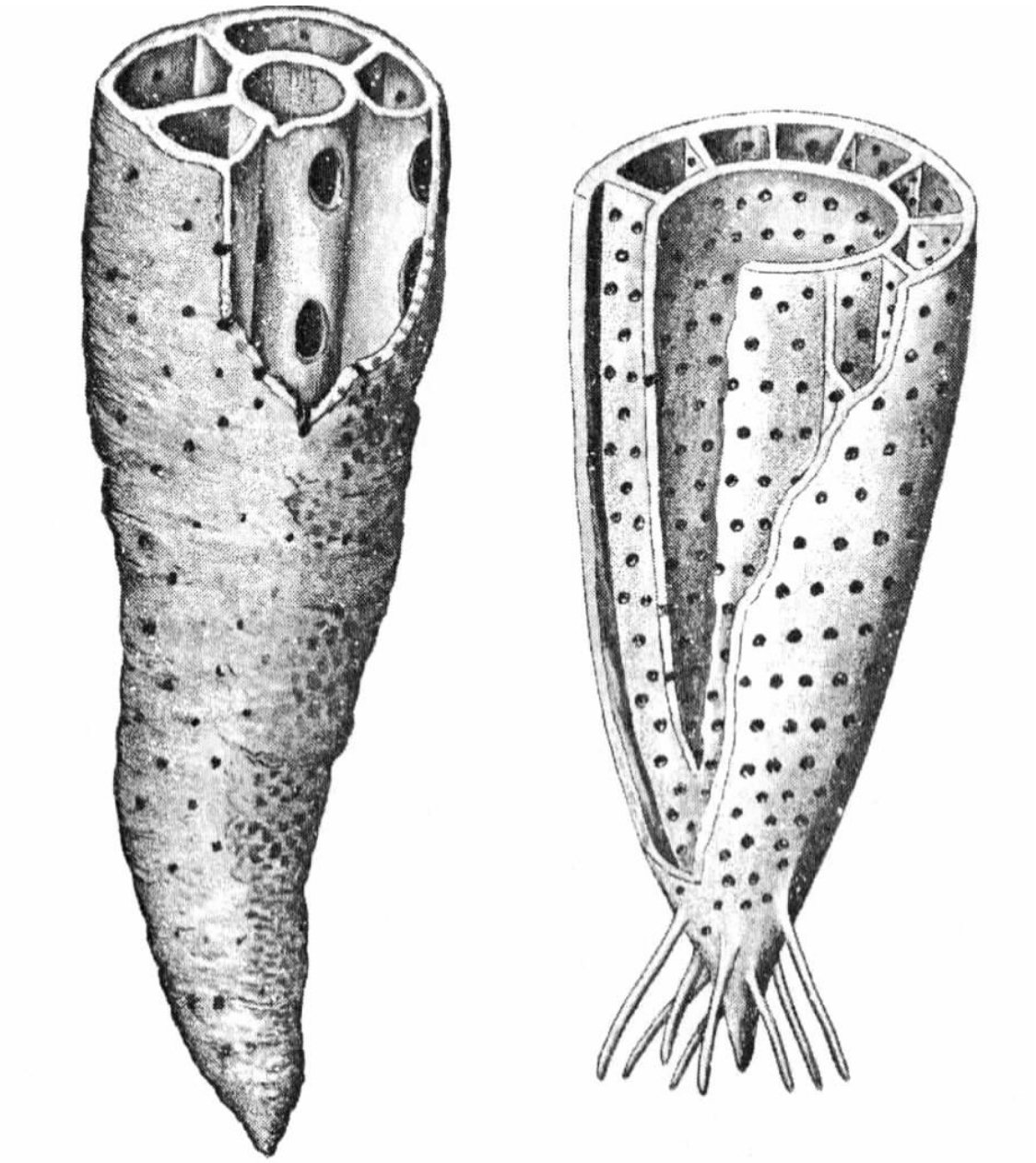


6.2 Cambrian explosion of skeletal fauna

Life in Cambrian

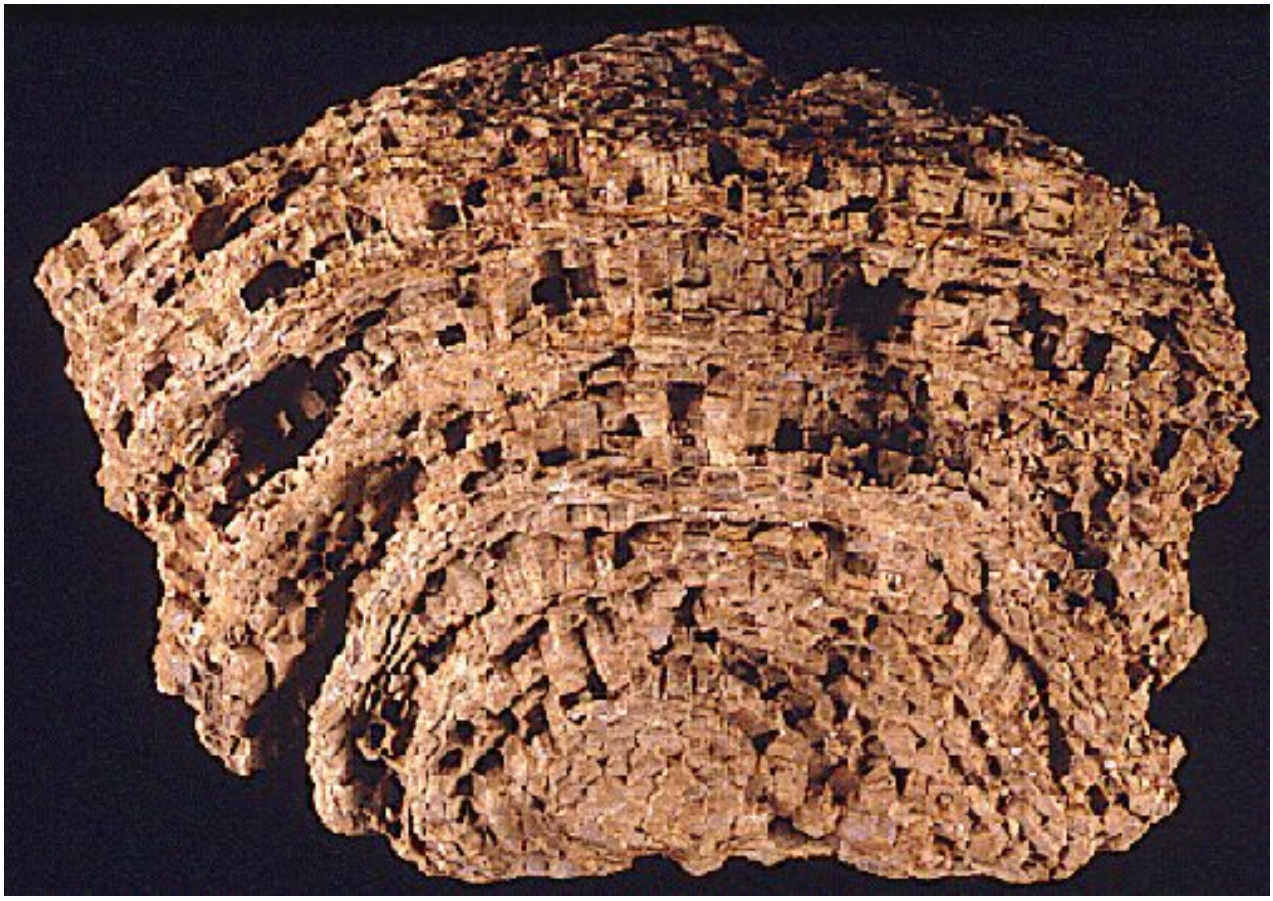
This is the picture of famous Czech artist Zdenek Burian

Archaeocyaths (most probably sponges)



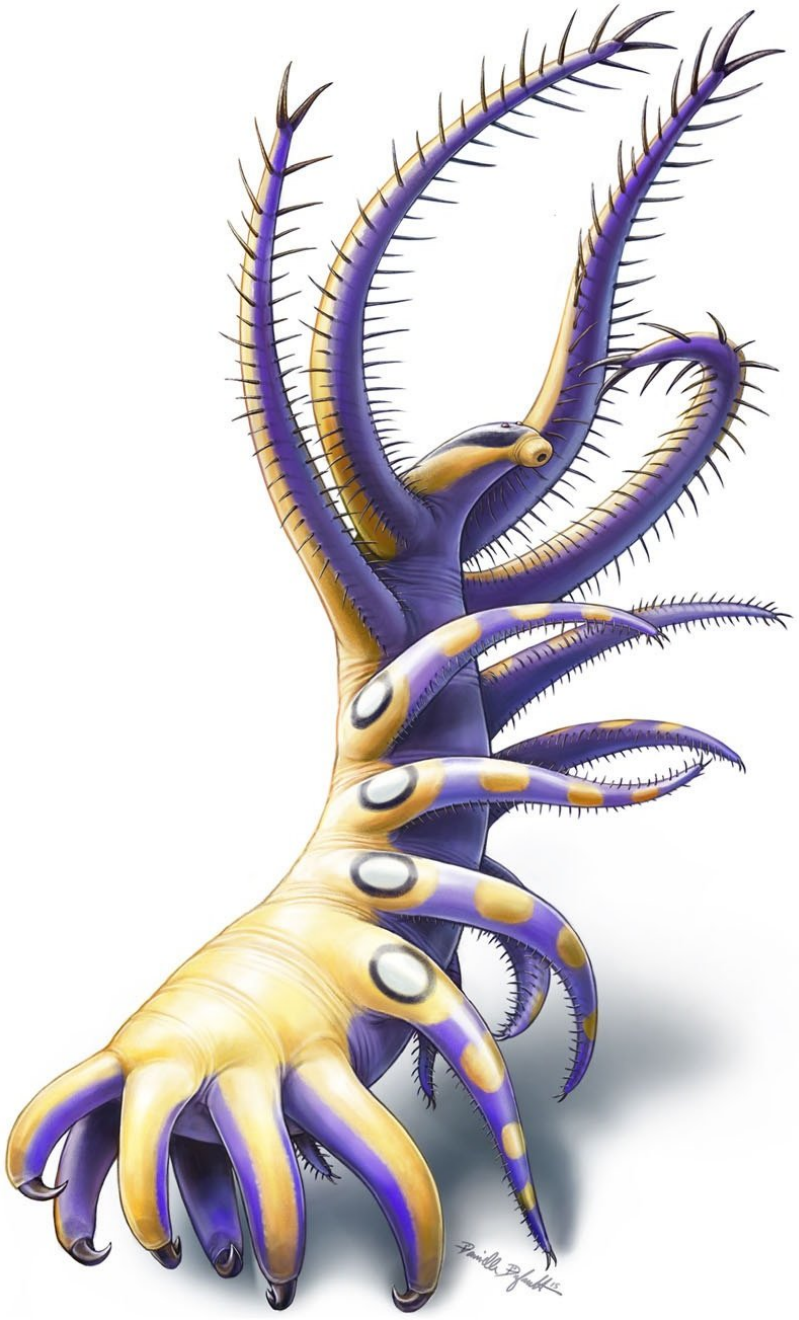
Most probably, Archaeocyaths were sponges

Cnidaria



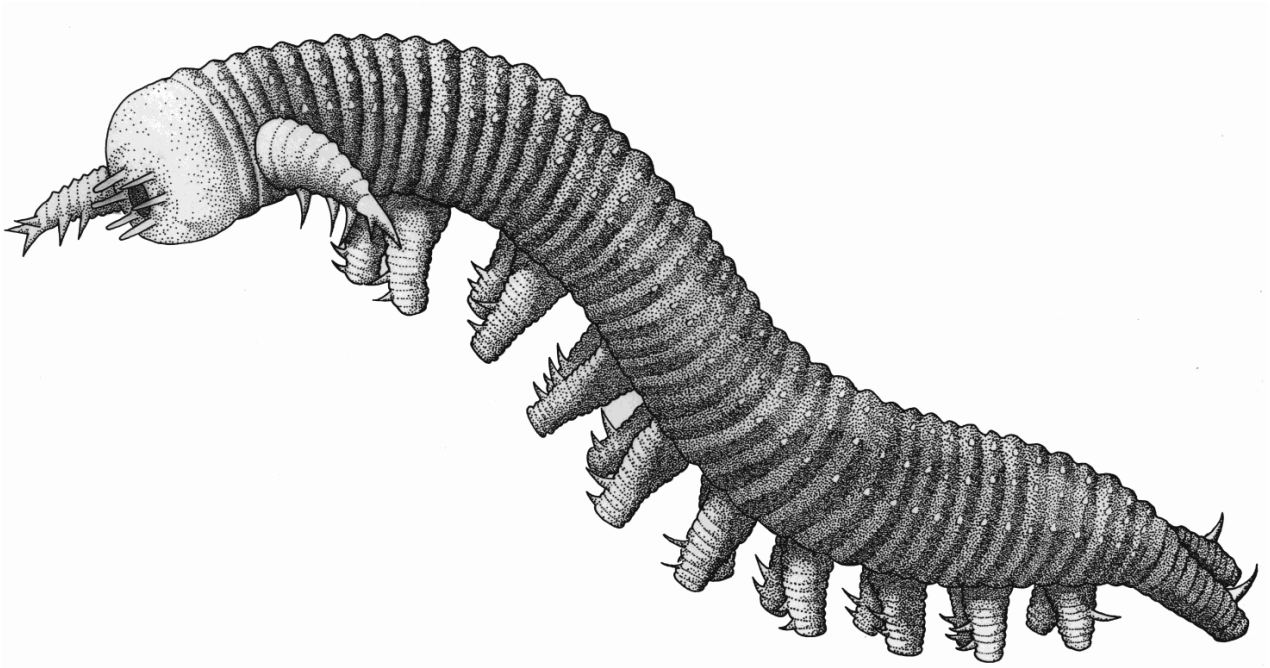
Tabulate coral

Lobopod worms: *Ovatiovermis*



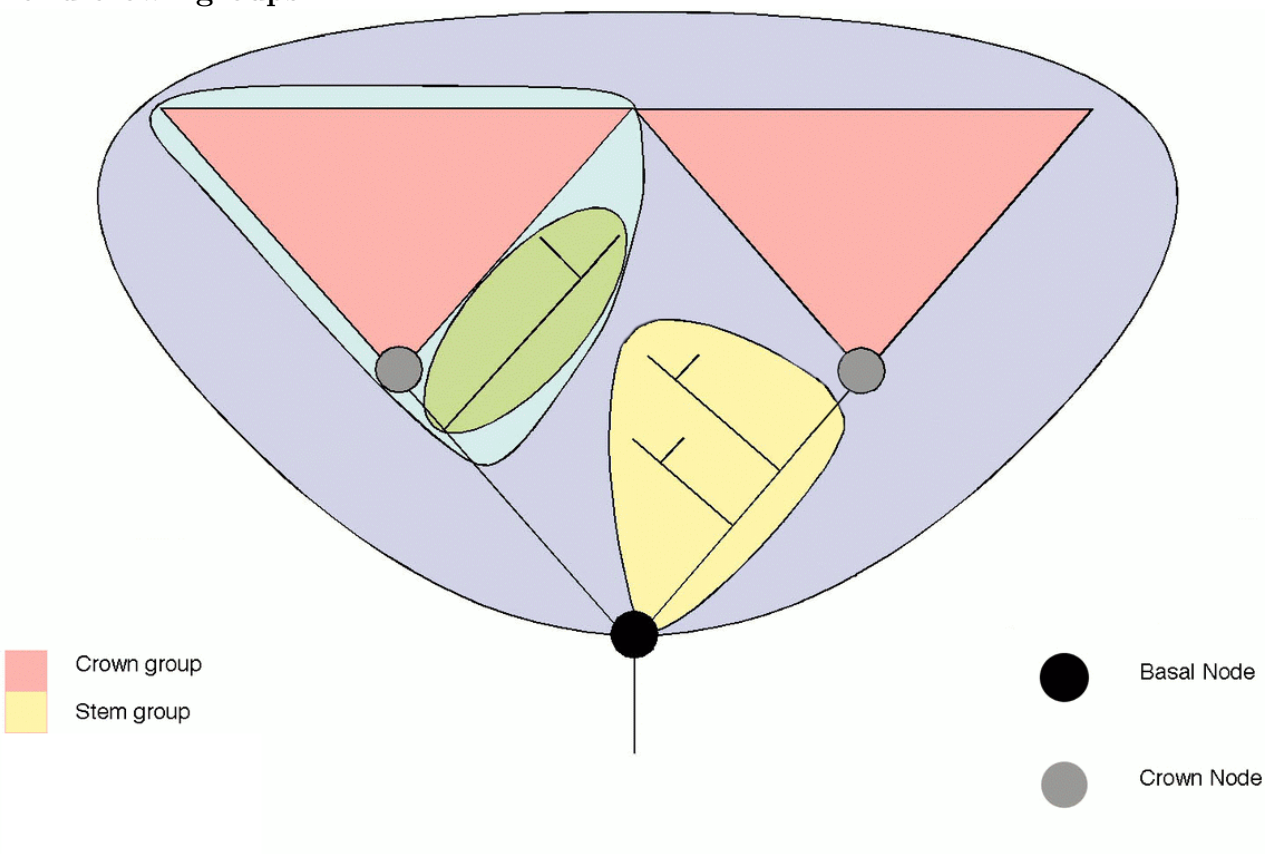
Lobopod worms: *Hallucigenia*

Lobopod worms: *Aysheaia*



Stem Arthropods

Stem and crown groups

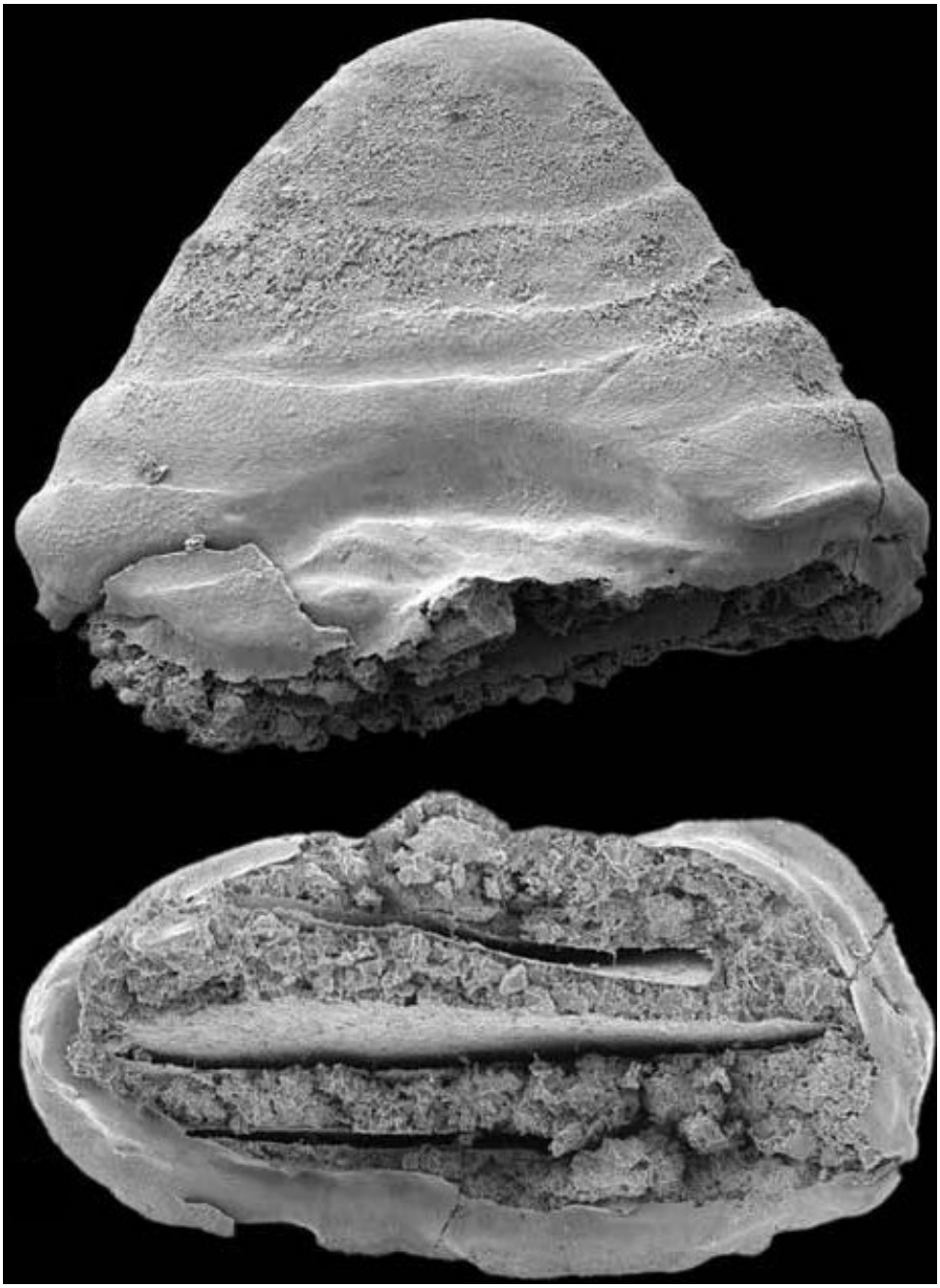


Stem group has no immediate sisters among living organisms.

Mollusks: naked

Odontogriphus – stem naked mollusk

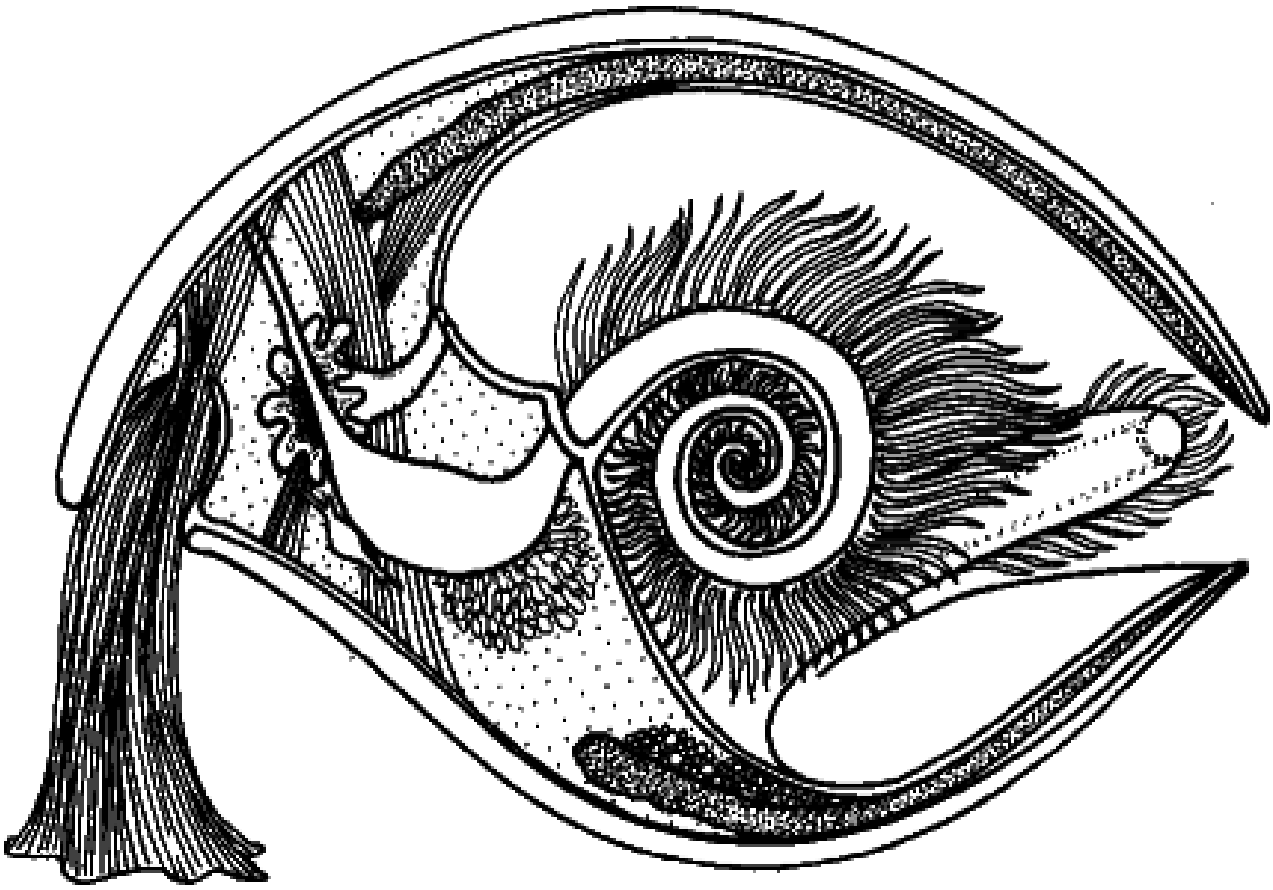
... and shelled

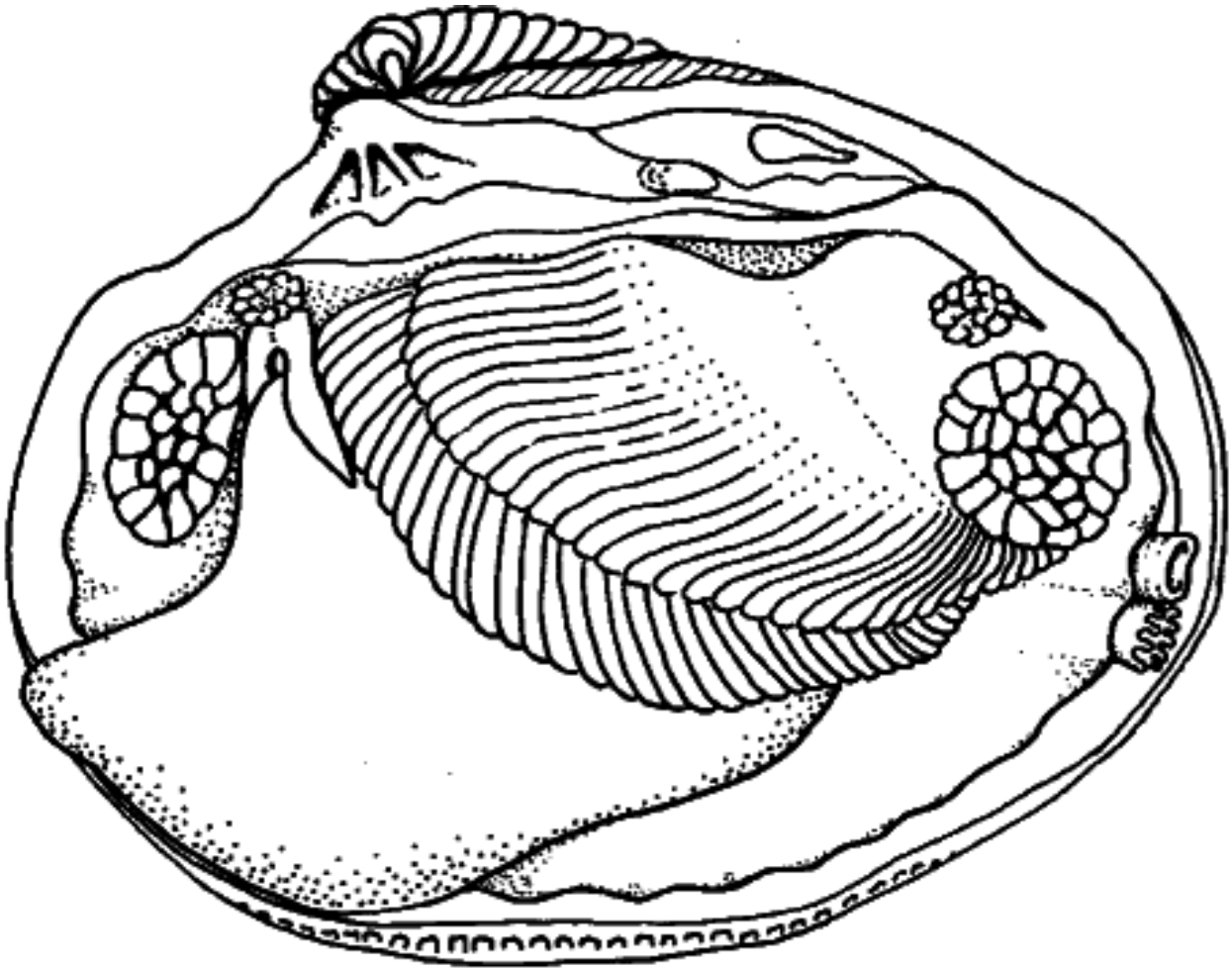


Helcionellid shell-bearing mollusk from Greenland

Brachiopods

Brachiopods are not mollusks!



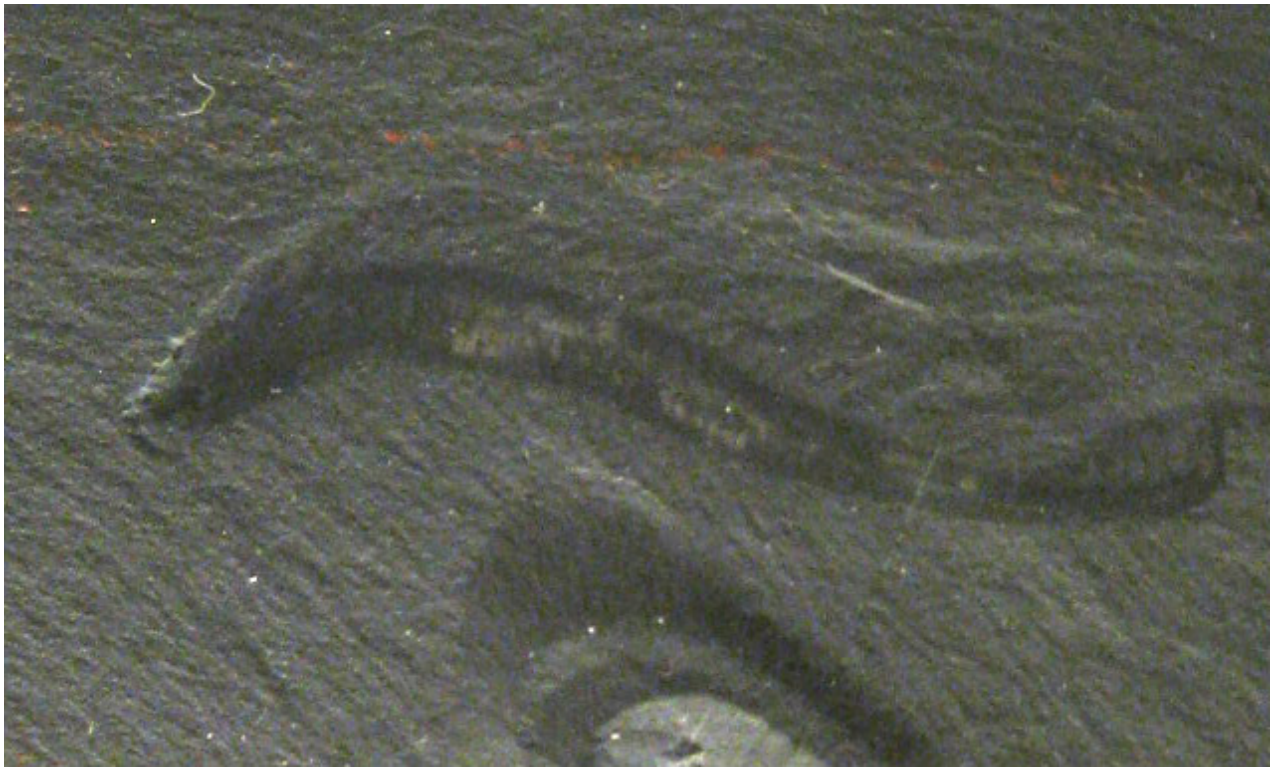


Brachiopoda (left) are completely different internally from bivalve mollusks (right)

Echinoderms

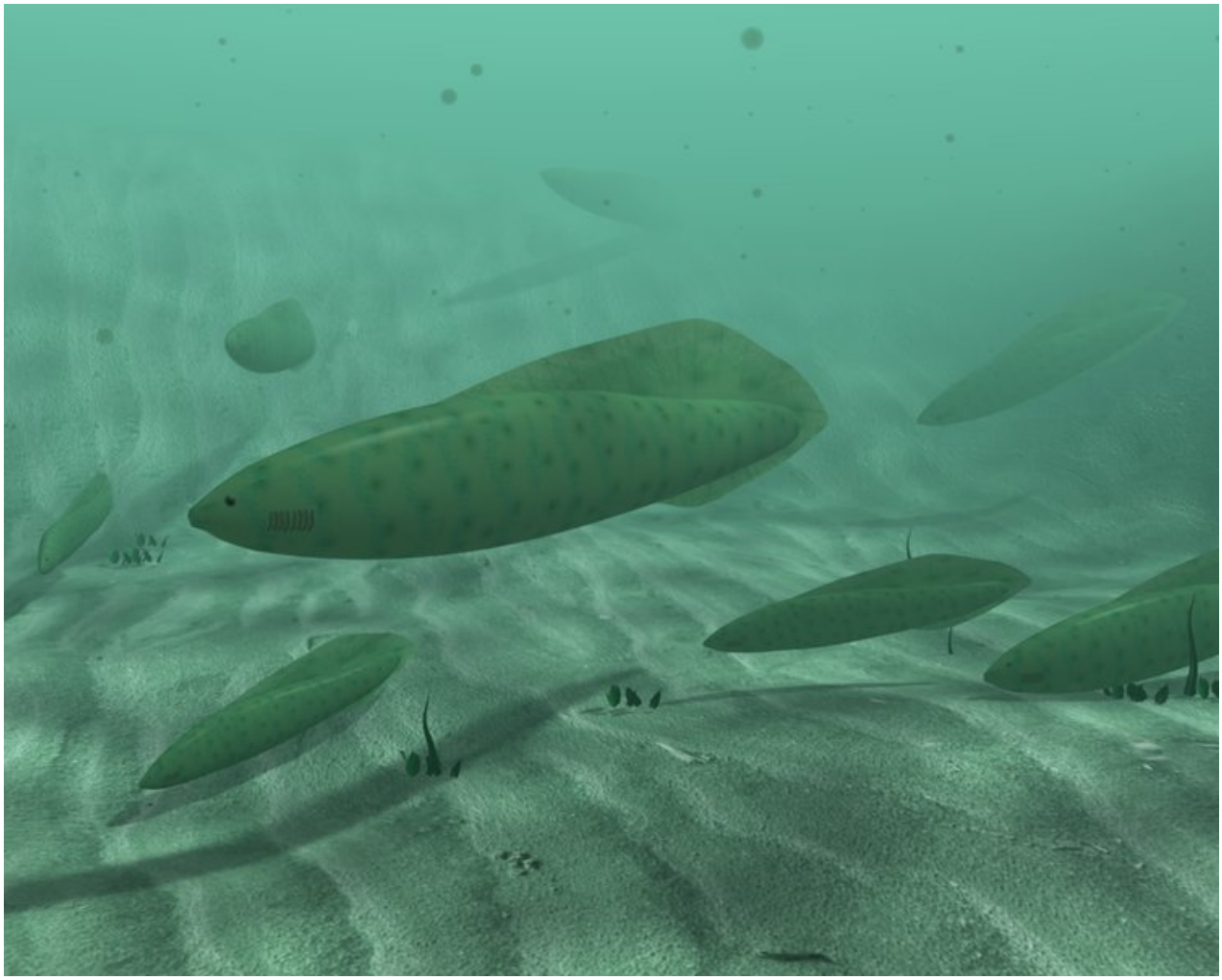
Sea lily *Gogia* from Nevada

Soft-bodied chordates



Pikaia from Burgess shale

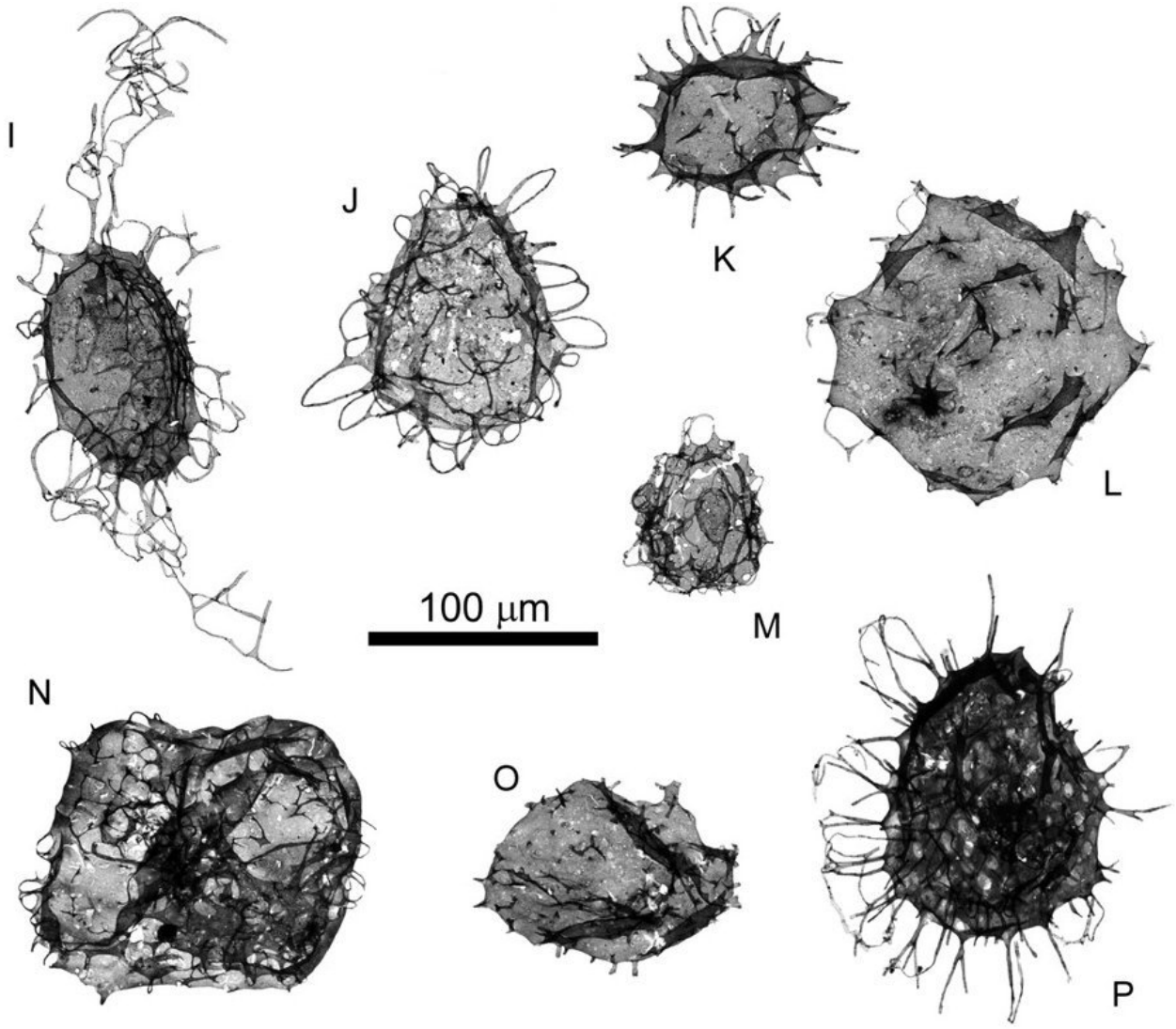
First fish-like animals: craniate *Haikouichthys*



Algae

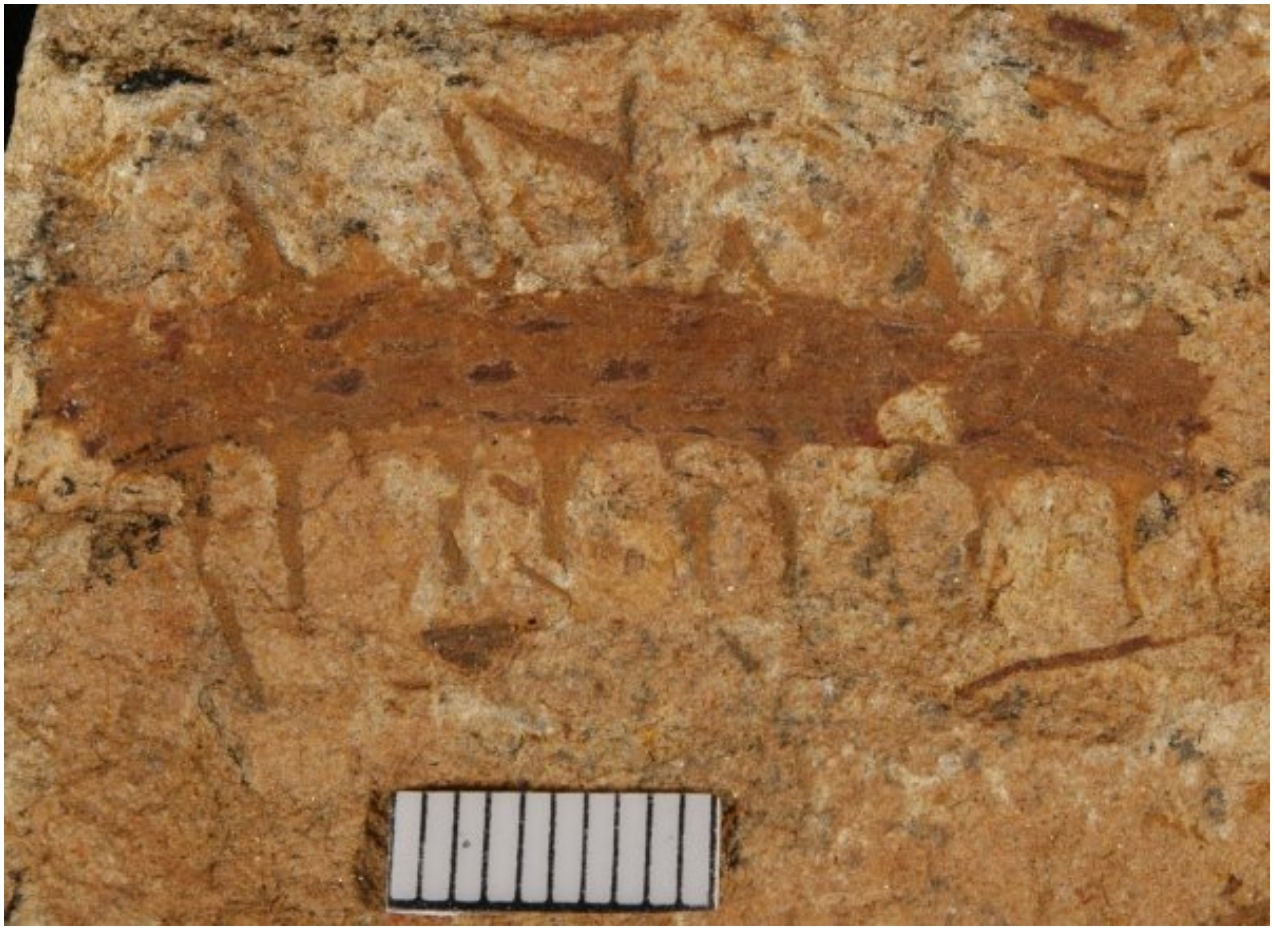
Yuknessia is a fossil green alga from Utah

Fungi



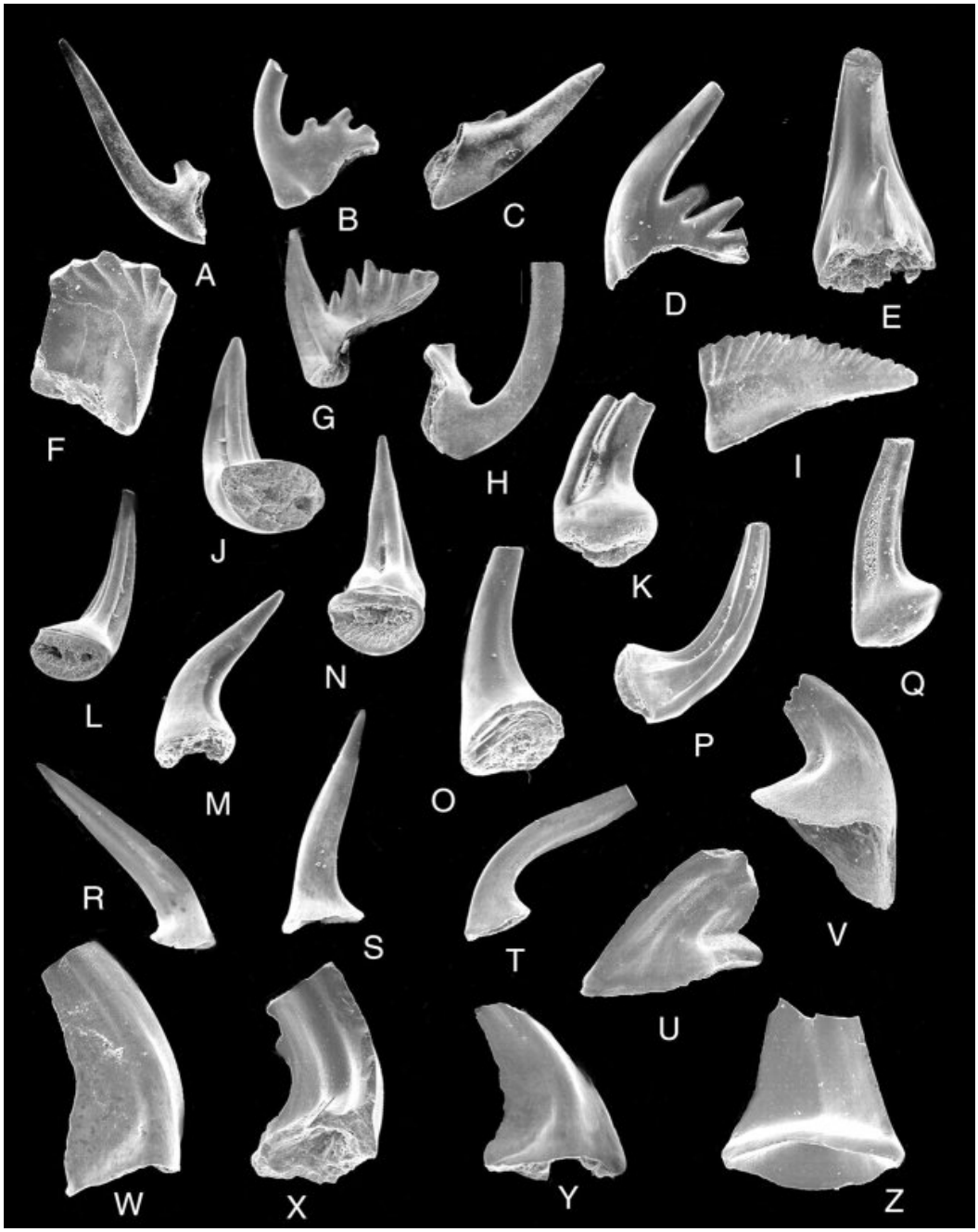
Tappania fungus was known even before Cambrian

Problematics: *Aldanophyton*



Terrestrial plant? Or alga?

Problematics: conodonts

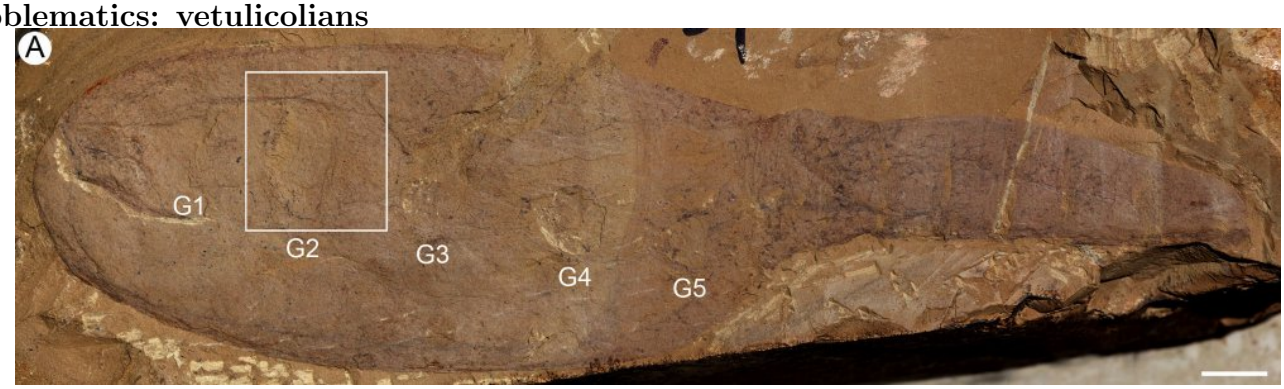


Conodonts are just teeth of unknown animal, it is still not clear what was it. Jawless fish?

Problematics: hyoliths

Haplophrentis, mollusk? Or separate branch on the tree of life?

Problematics: vetulicolians



Ancestors of both echinoderms and chordates?

Recently found *Saccorhytus*

Another possible ancestor of echinoderms and chordates?

Summary

- Cambrian period started with massive appearance of skeletal fauna: "Cambrian explosion"

For Further Reading

References

[1] Cambrian explosion. `http://en.wikipedia.org/wiki/Cambrian_explosion`

Outline

7 Where we are?

7.1 Cambrian life

Timescale of Phanerozoic eon, Paleozoic era

- Phanerozoic eon
  - Paleozoic era
    - Cambrian period: 541 Mya
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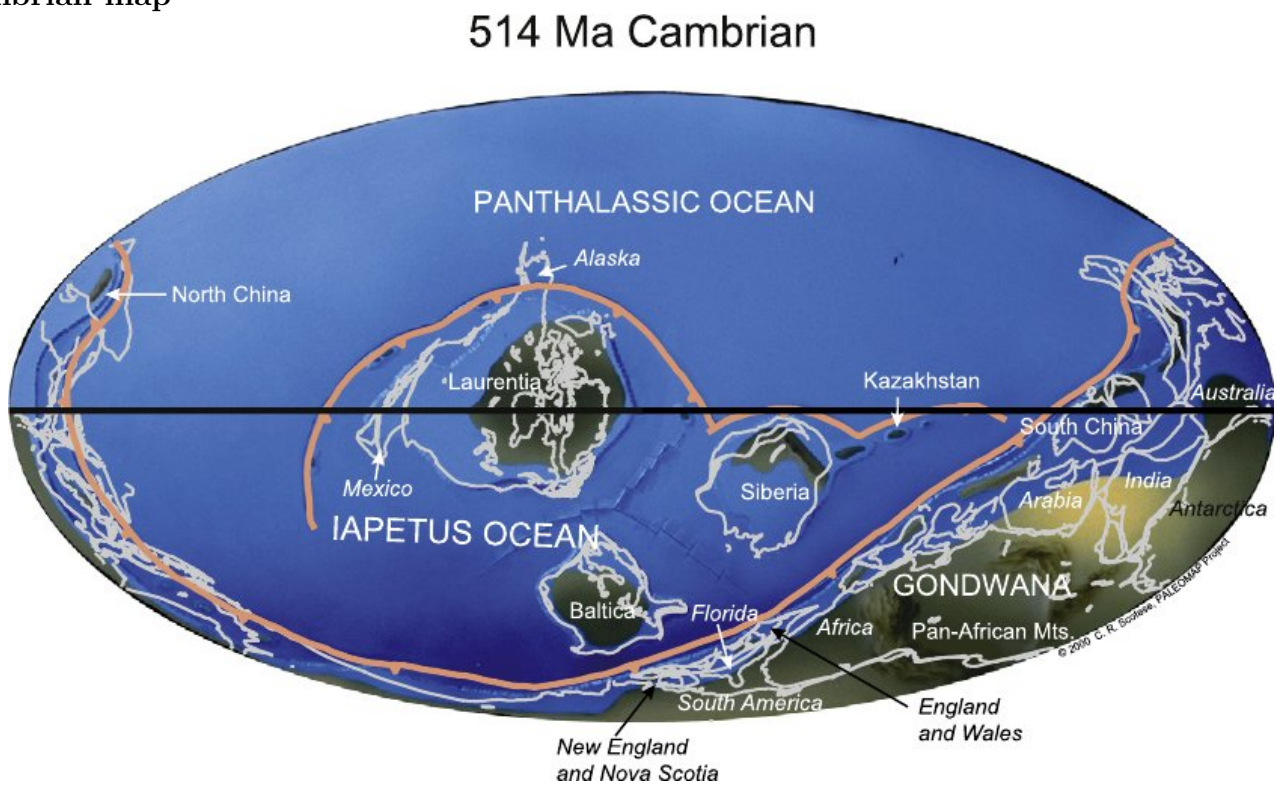
Cambrian map



8 Cambrian explosion

8.1 Sudden diversity of animals

Animal phyla in Cambrian

- Porifera
- Cnidaria
- Mollusca

- Brachiopoda
- Arthropoda (including Lobopoda)
- Echinodermata
- Chordata

Theories of Cambrian explosion

- Pellet revolution
- Acquiring the ability of making hard tissues
- Absolute predator

Evolutionary cascade resulted in skeletal revolution

- Muddy water: all dust and microscopic feces is slowly subsiding down
- Plankton arthropods appeared, they are making pellets from dust and excretions
- Water became more transparent, oxygen is not spending for dust oxidation
- More photosynthesis, more oxygen, more organic on bottom
- Animals became more active
- Big predators appeared
- Animals acquire skeleton and other defensive structures

Skeleton

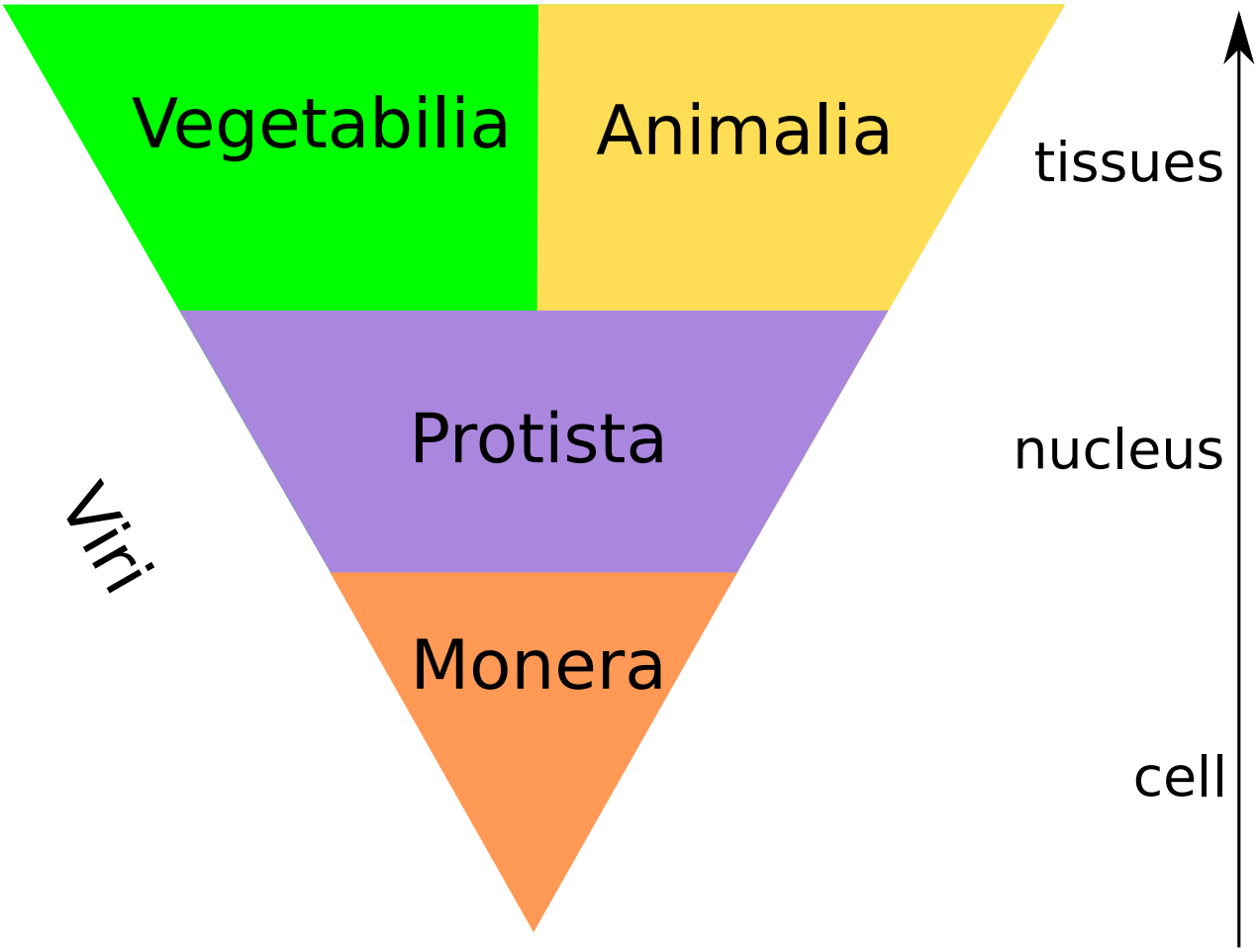
- Internal (endoskeleton): hydrostatic (worms), spicules (sponges), bones and cartilage
- External (exoskeleton): chitinous, shells, skin plates

Since volume grows faster with size than surface, animals with exoskeleton will suffer from the big size more than animals with endoskeleton. This is why arthropods do not reach size of chordates.

9 Animals

9.1 Origin of animals

Cells, tissues and kingdoms



Origin of animals

- Blastaea: not the animal yet. *Volvox*, *Proterospongia*.
- Phagocytella. Two tissues: kinoblast and phagocytoblast. *Trichoplax*.
- Gastraea. Three tissues: ectoderm, entoderm and mesoderm. Closed gut.

Summary

- The main driving force of animal evolution was feeding on bigger and bigger pray.

For Further Reading

References

[1] Skeleton. `http://en.wikipedia.org/wiki/Skeleton`

[2] Animal. `http://en.wikipedia.org/wiki/Animal`

Outline

10 Where we are?

10.1 Origin of animals

Basic principles which drive animal evolution

- Prey and predator interactions
- Surface and volume
- Ecological pyramid

Stages of animal evolution

- Blastaea
- Phagocytella
- Gastraea
- Skeleton and all diversity of living animal phyla, including 7 phyla we study

11 Animals

11.1 Basic principles of animal body construction

Main organ systems in animals

- In higher animals, tissues are members of organs, and organs—of organ systems
- Every organ system is responsible for the particular aspect of animal life:
  - locomotion and support;
  - feeding, excretion and osmoregulation;
  - circulation and gas exchange;
  - signaling and reception;
  - reproduction.

Generalized animal

Summary

- The structure of animal body follows few basic principles of construction

For Further Reading

References

[1] Skeleton. http://en.wikipedia.org/wiki/Skeleton

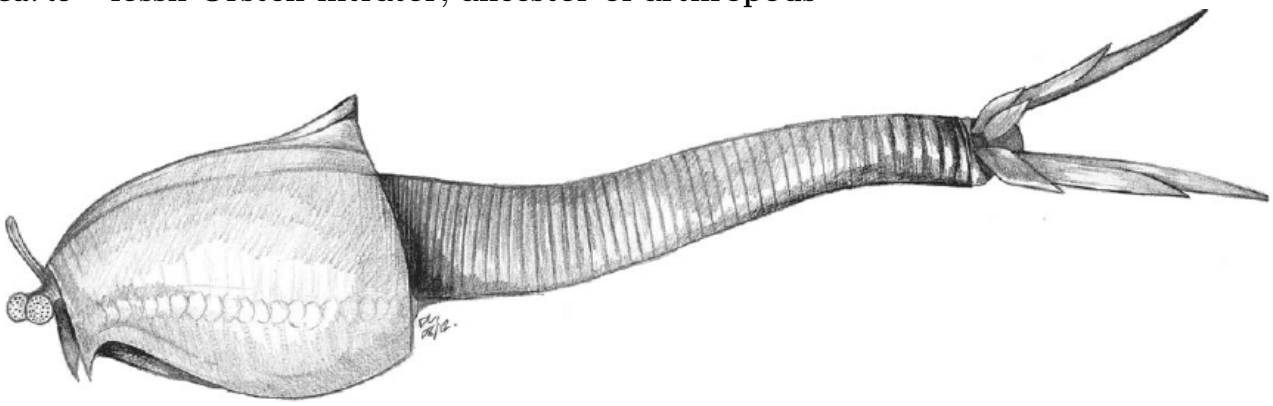
[2] Animal. http://en.wikipedia.org/wiki/Animal

Outline

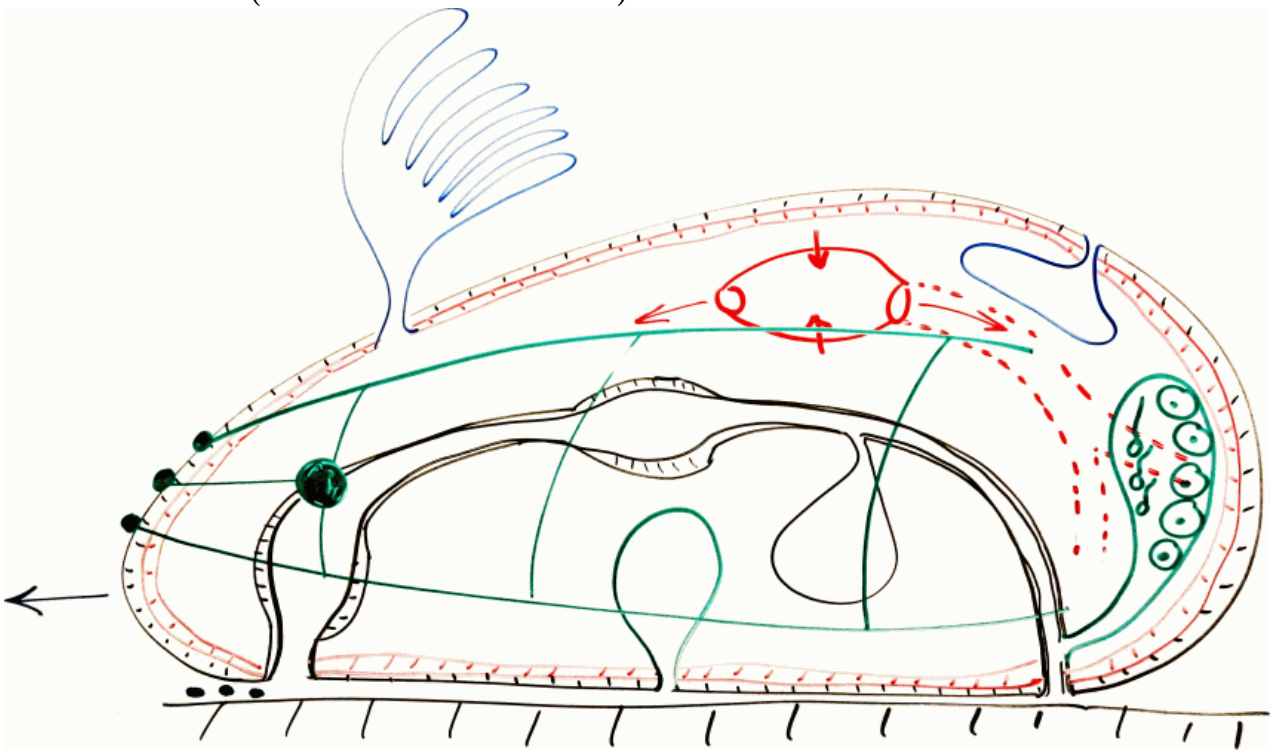
12 Where we are?

12.1 Origin of animals

***Neocaris*—fossil Orsten filtrator, ancestor of arthropods**



Generalized animal (another variant: worm)



13 Animals

13.1 Basic principles of animal body construction

Symmetry

- Absent
- Radial
- Bilateral
- Secondary radial

Body parts

- Cup-shaped whole body
- Vermicular body
- Segmented body
- Body with appendages
- Head and tail

Locomotion

- Peristaltic motion: crawling without appendages (vermicular motion)
- Bending motion (nematode worms)
- Swimming with appendages
- Crawling with appendages
- Walking with appendages
- Walking with water-vascular system
- Jet motion

Summary

- Basic organ systems of animals are responsible for
  - locomotion and support;
  - feeding, excretion and osmoregulation;
  - circulation and gas exchange;
  - signaling and reception;
  - reproduction.

For Further Reading

References

[1] Animal. http://en.wikipedia.org/wiki/Animal

Outline

14 Where we are?

14.1 Basic principles of animal body construction

Animal motion

Peristaltic: earthwotm Bending: nematode Swimming upside down: horseshoe crab Swimming: horseshoe crab Walking: crab Swimming: ray Water-vascular: starfish Jet: jellyfish Jet: squid

15 Animal

15.1 Animal body

Skin

- One- or multi-layered epithelium
- Basal membrane with collagen
- Skin-muscular bag

Muscle system

- Muscle layer
- Separate muscles
- Water-vascular system

Body cavity

- Mesoderm, no cavity
- Primary cavity
- Secondary cavity (coelom)

Digestion

- Closed or open gut
- Pharynx
- Jaws and teeth
- Stomach, esophagus etc.
- Digestion glands: liver etc.

Blood system

- Open and closed
- Heart
- Hemoglobin and hemocyanin

Respiration

- Gills
- Lungs
- Tracheas

Osmoregulation

- Nephridia
- Kidneys

Nervous system

- Diffuse neurons
- Trunks and circles
- Ganglia
- Brain

Reproduction and development

- External and internal fertilization
- Direct development or development with metamorphosis

Summary

- Basic organ systems of animals are responsible for
  - locomotion and support;
  - feeding, excretion and osmoregulation;
  - circulation and gas exchange;
  - signaling and reception;
  - reproduction.

For Further Reading

References

[1] Animal. `http://en.wikipedia.org/wiki/Animal`

Outline

16 Animals

16.1 Animal phyla and their phylogeny

Where we are?

- Basic organ systems of animals are responsible for
  - locomotion and support;
  - feeding, excretion and osmoregulation;
  - circulation and gas exchange;
  - signaling and reception;
  - reproduction.

Three subkingdoms

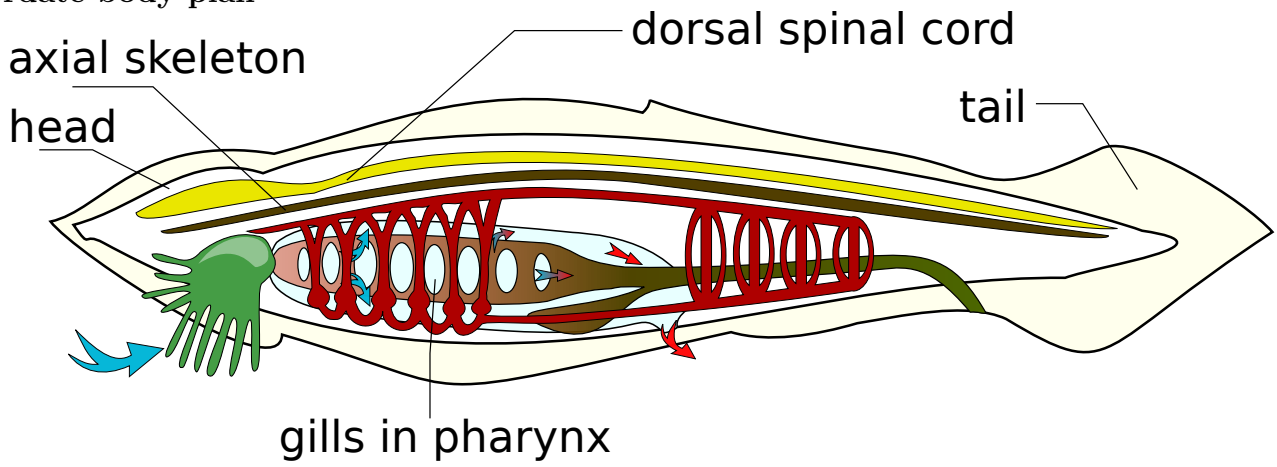
- Spongia: asymmetric filtrators
- Cnidaria: radial stinging predators
- Bilateria: bilateral

Ten phyla

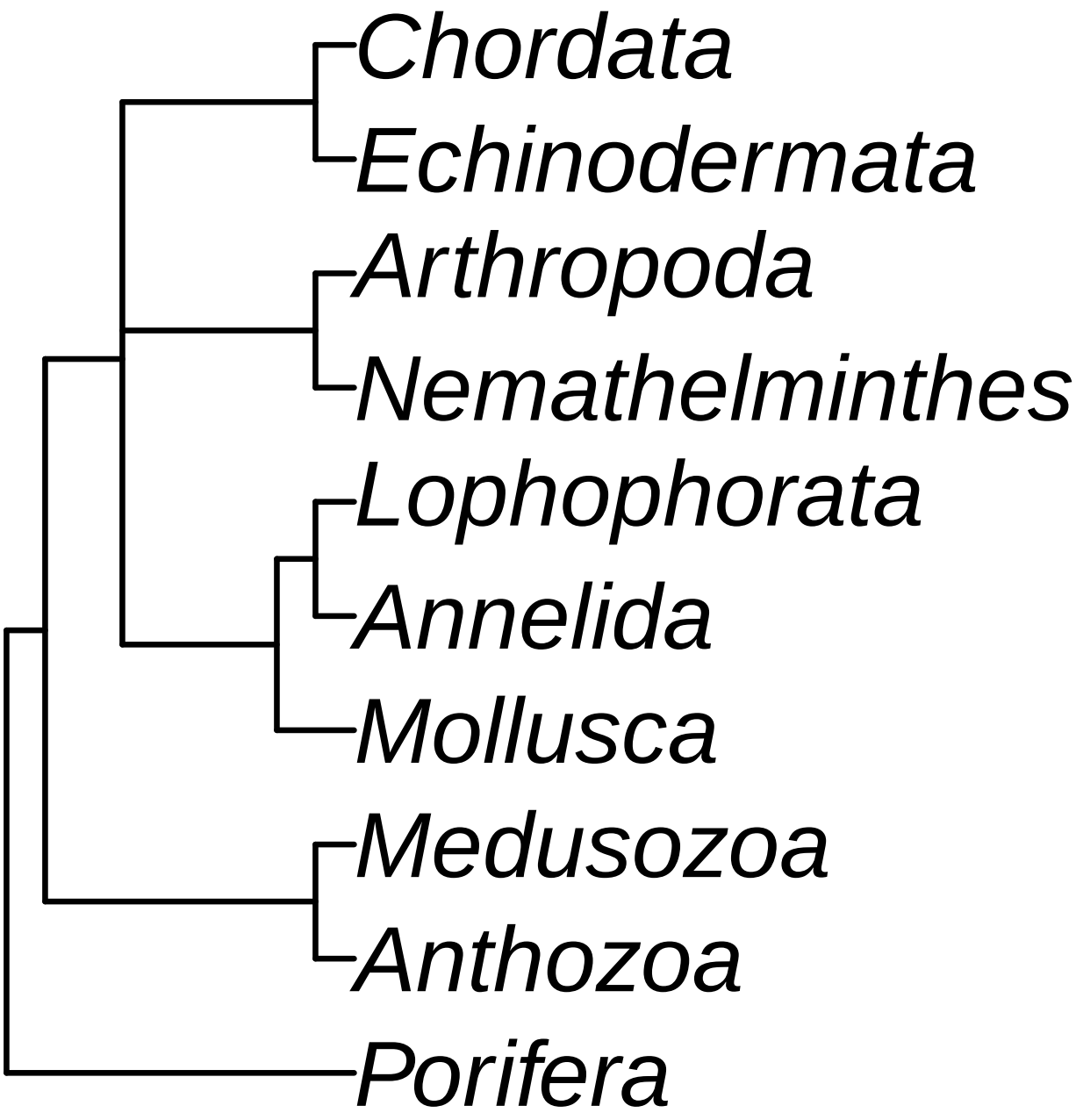
- Spongia
  - Porifera
- Cnidaria
  - Anthozoa: sitting, colonial, with skeleton
  - Medusozoa: swimming, [solitary], soft
- Bilateria
  - Mollusca: shell, body straight
  - Annelida: segmented worms
  - Lophophorata: [shell], body curved
  - Nemathelminthes: worms with cuticle and primary cavity
  - Arthropoda: segmented body and appendages
  - Echinodermata: small-plate exoskeleton, secondary radial, water-vascular
  - Chordata: head and tail, gills in pharynx, axial skeleton

Ten phyla = ten body plans

Chordate body plan



Phylogeny of nine phyla



16.2 Classes of chordates and their phylogeny

Eight classes of Chordata

Acrania:

Class 1. Leptocardii: lancelet with no eyes and jaws

Vertebrata:

- Pisces:

Class 2. Chondrichthyes: cartilaginous

Class 3. Actinopterygii: boned, rayed fins, [gills]

Class 4. Dipnoi: boned, thick, leg-like fins, [gills and lungs]

- Tetrapoda:

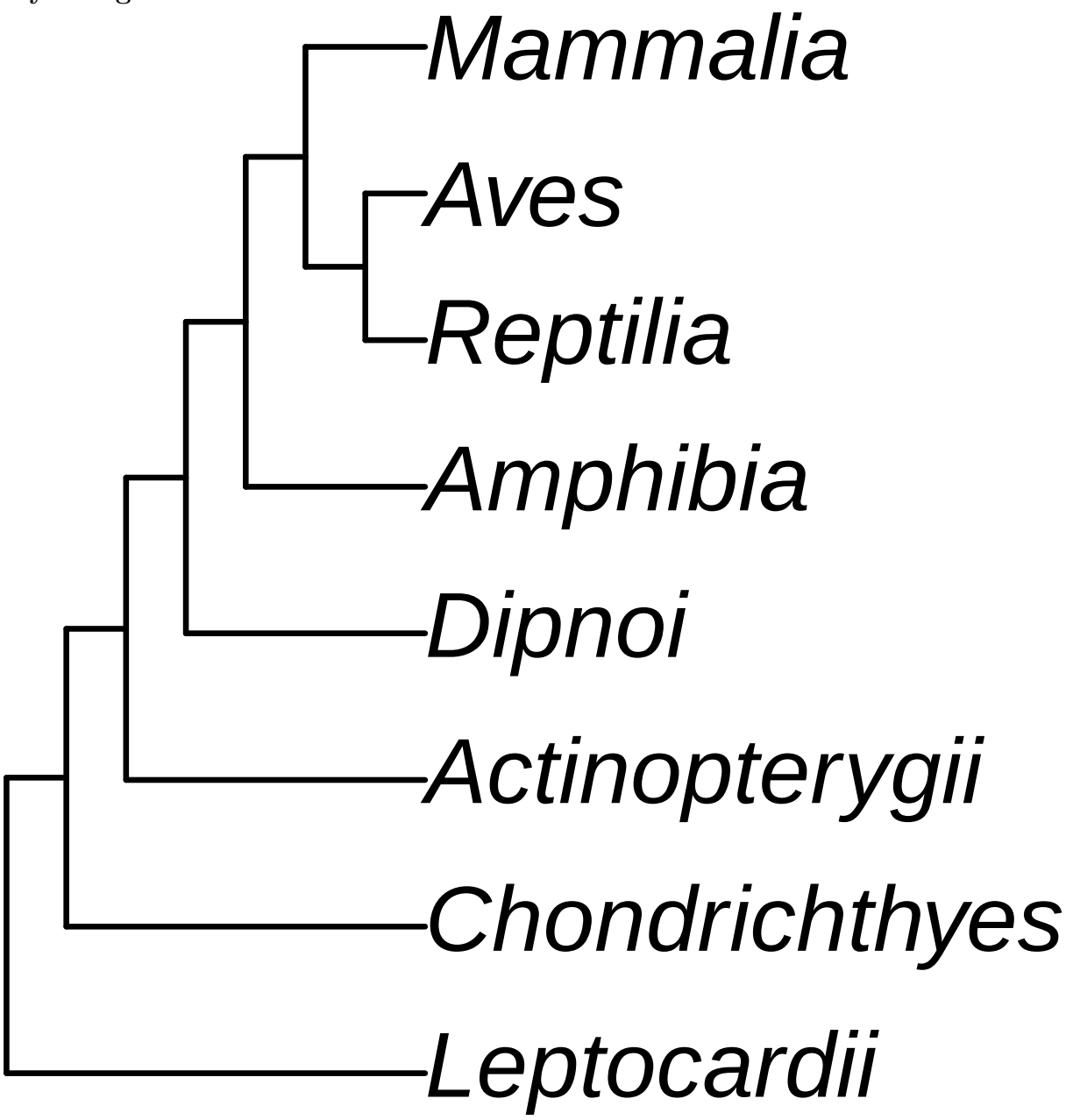
Class 5. Amphibia: metamorphosis[.5ex] *Amniota:

Class 6. Reptilia

Class 7. Aves: feathers, bipedal

Class 8. Mammalia

Phylogeny of eight classes



Optional homework: in preparation for the 3rd test, fill this table:

	1	2	3	4	5	6	7
Porifera							
Anthozoa							
Medusozoa							
Annelida							
Lophophorata							
Mollusca							
Nemathelminthes							
Arthropoda							
Echinodermata							
Chordata							

Characters: 1 ...; 2 ...
*Characters should not be necessary relevant to **all** members of phylum!*

Make the same table for 8 chordate classes

Summary

- Classes of vertebrates differ mostly in overall optimization of their body functions and in adaptations to the specific environment

For Further Reading

References

[1] Animal phyla. `http://en.wikipedia.org/wiki/Phylum#Animal_phyla`

[2] Vertebrates. `http://en.wikipedia.org/wiki/Vertebrate`

[3] Fishes. `http://en.wikipedia.org/wiki/Fish`