

Concepts of Biology: BIOL 111

Study guide for Exam 2

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Lectures 7–14

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Outline

1 Questions and answers

1.1 Exam 2

Results of Exam 2: statistic summary

Summary:

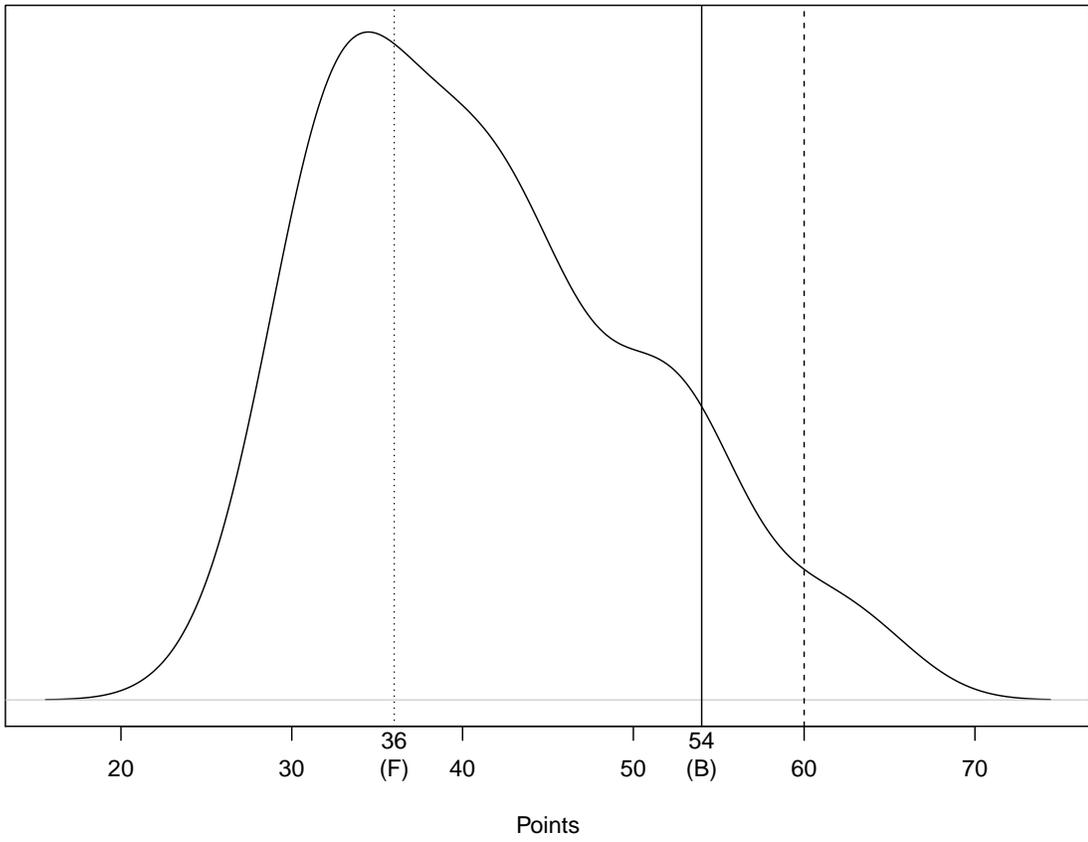
Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	NA's
25.00	34.00	40.00	41.34	47.75	65.00	9

Grades:

F	D	C	B	max
36	42	48	54	60

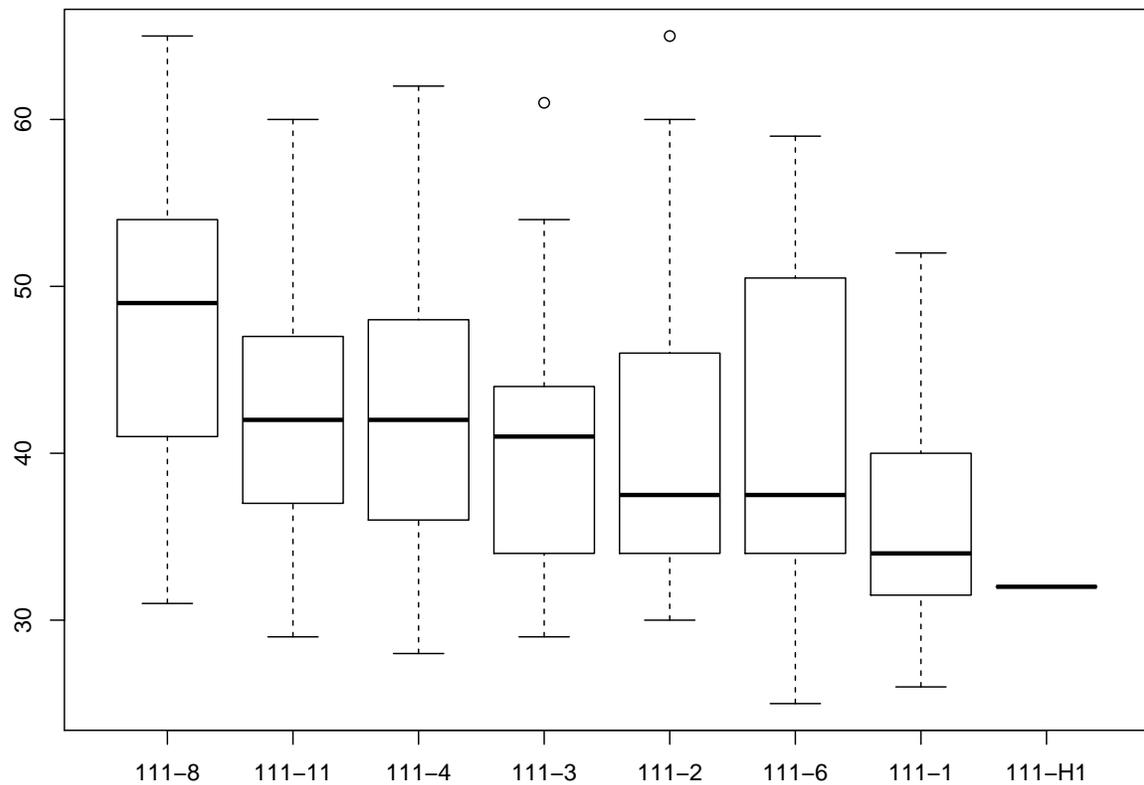
Results of Exam 2: the curve

Density estimation for Exam 2 (Biol 111)



Results of Exam 2: sections

Competition between Biol 111 sections (Exam 2)



Results of Exam 2: three questions

- What is ATP?
 - A. Universal source of energy in the cell
 - B. Molecule which is similar to nucleotides
 - C. **Both of above**
- Cell wall:
 - A. **Defends the cell mechanically**
 - B. Is a barrier for water
 - C. Both of above
- Since DNA is two complimentary chains, duplication of each chain:
 - A. Makes two exact copies
 - B. Makes two “mirror” copies
 - C. **Makes one exact and one “mirror” copy**

2 Where we are?

2.1 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

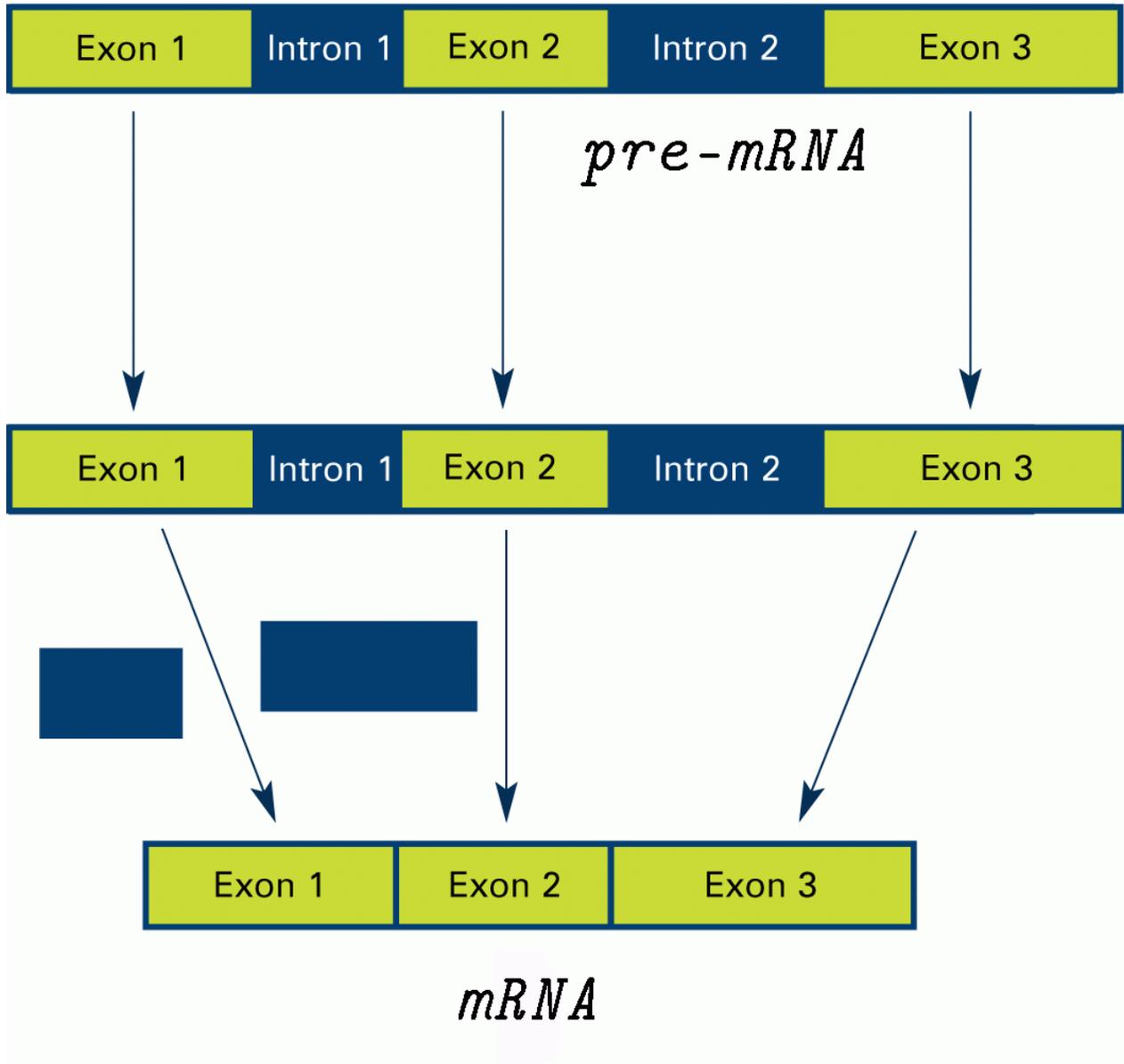
Nuclear envelope

- 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 and exons



Only archebacteria and eukaryotes have introns

Linear DNA

- Circular molecules of DNA are harder to keep, difficult to enlarge and slower to duplicate
- Eukaryotes change 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**

2.2 Precambrian life

Precambrian life

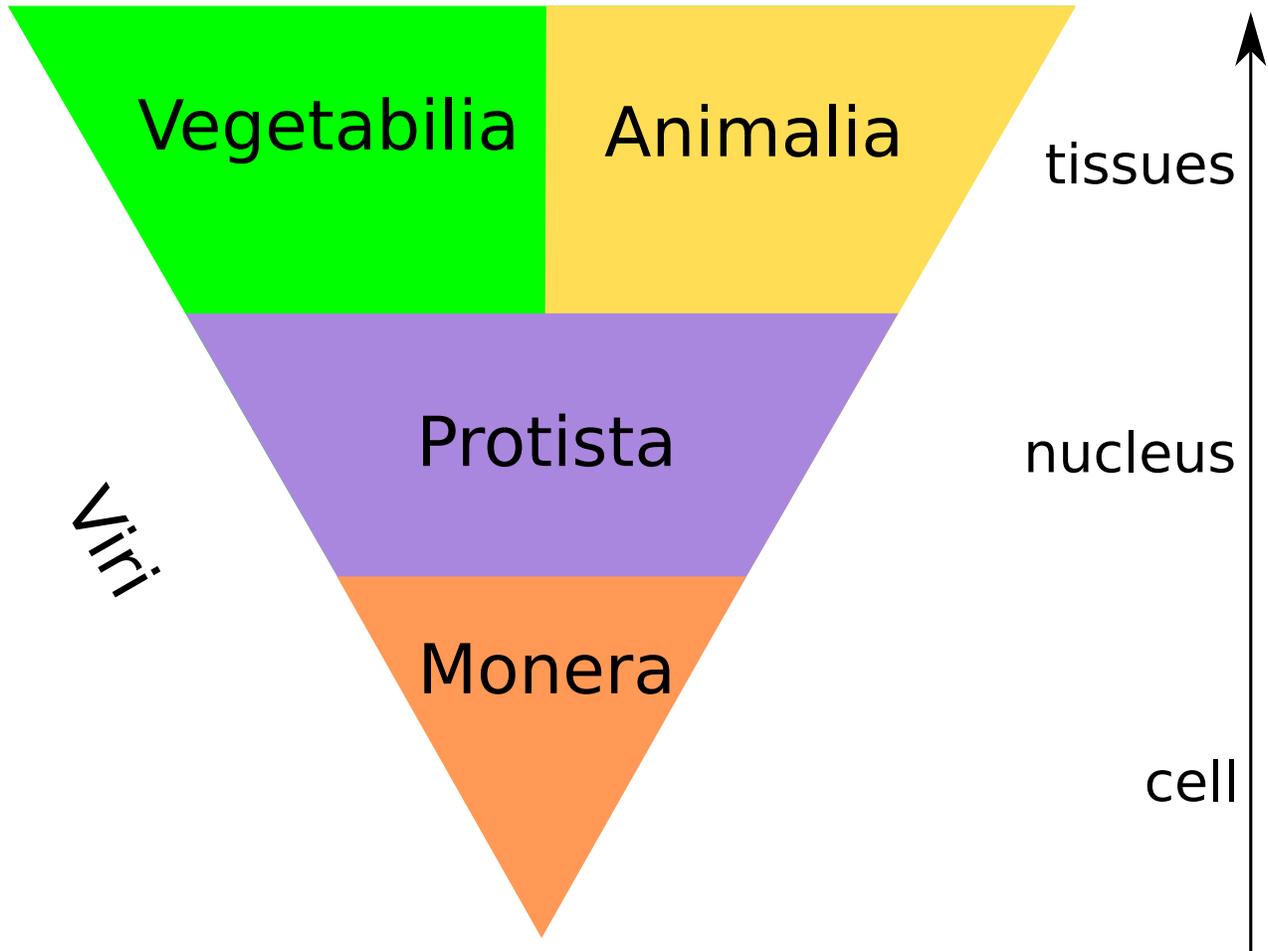
- In Cryogenian, Marinoan glaciation covered the whole Earth
- In Ediacarian, multicellular and then multi-tissued eukaryotes appeared

One of first multicellular alga with reproductive cells



Bangiomorpha, putative red alga from Proterozoic

Cells, tissues, kingdoms and viruses



Summary

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

For Further Reading

References

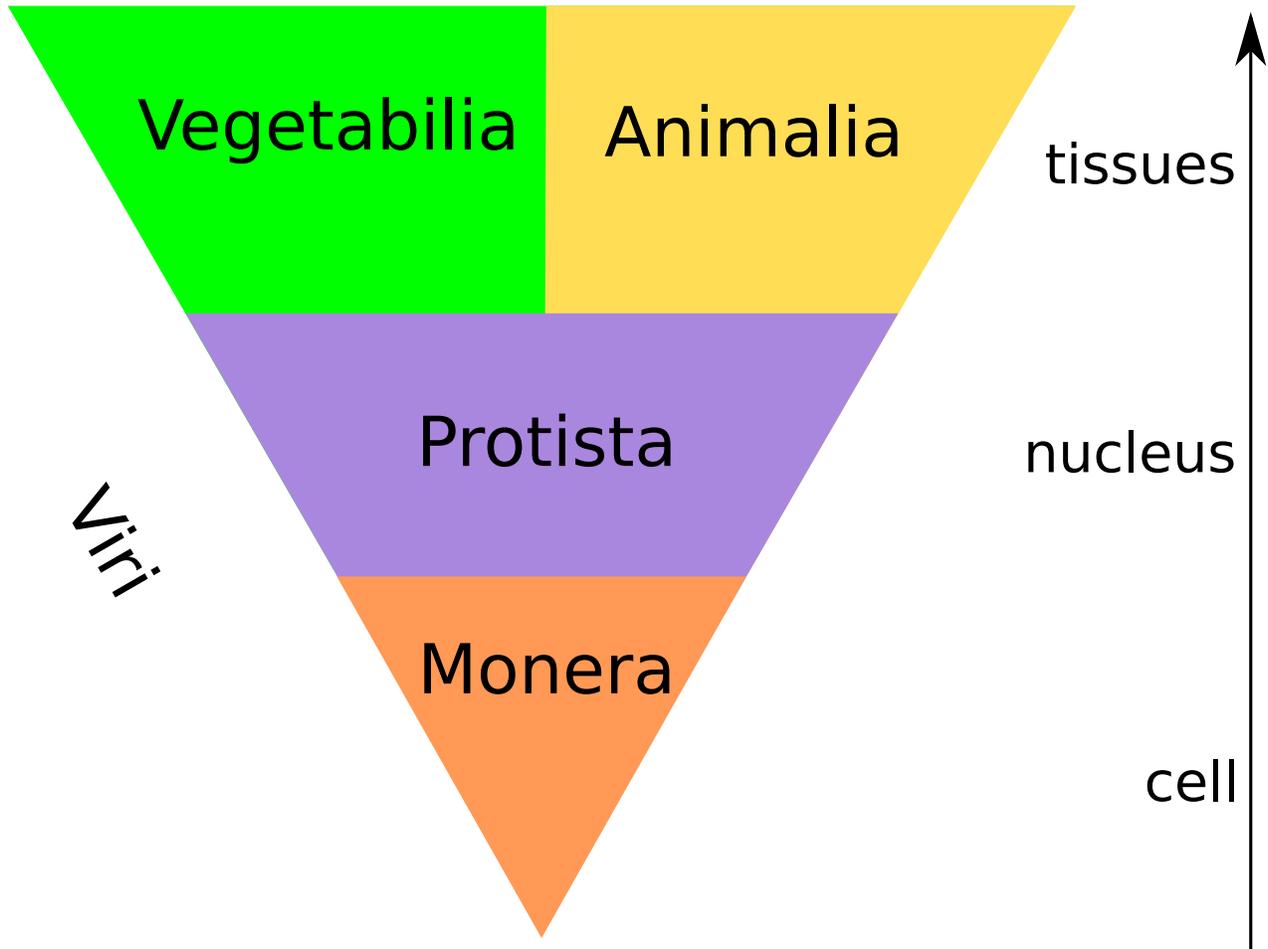
[1] Introns. <http://en.wikipedia.org/wiki/Intron>

Outline

3 Where we are?

3.1 Cells, tissues, kingdoms and viruses

Cells, tissues, kingdoms and viruses



4 Cambrian period

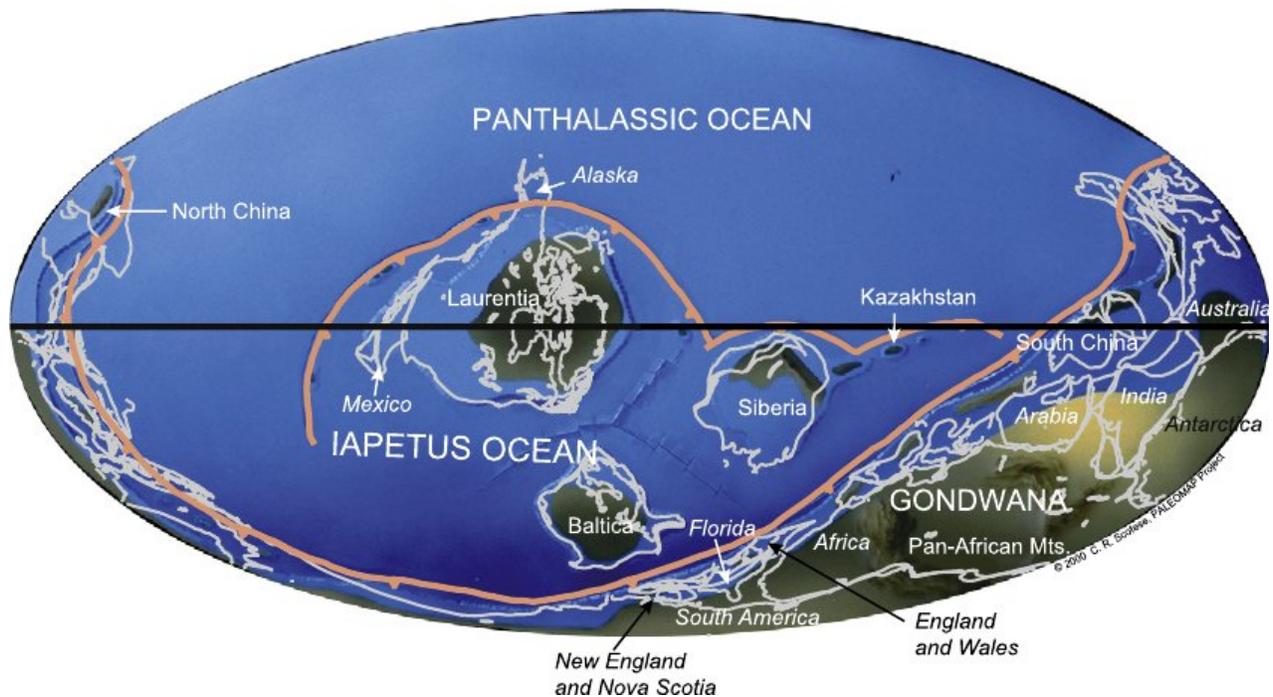
4.1 Life in Cambrian

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

514 Ma Cambrian



Cambrian climate

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

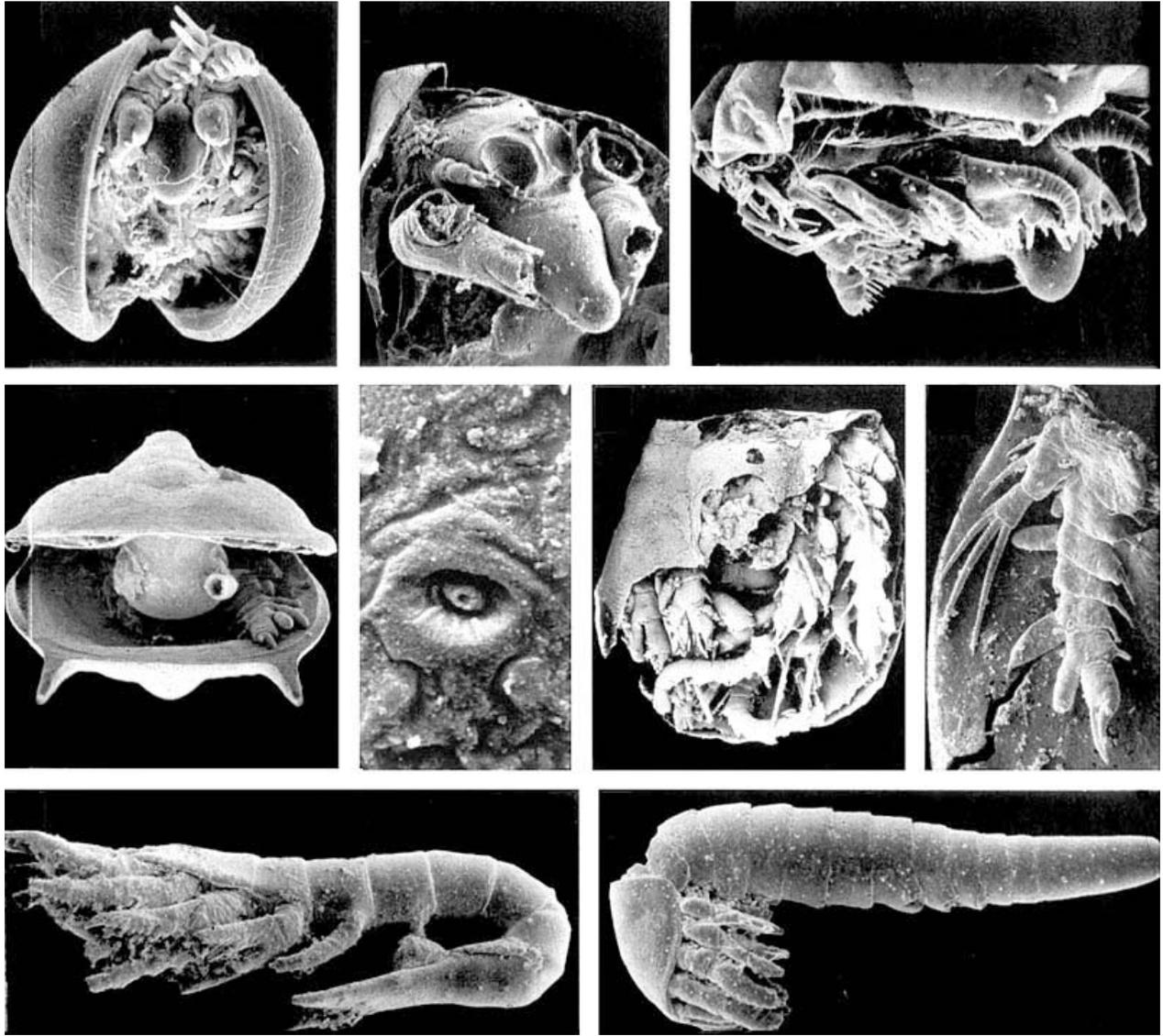
Main Cambrian biotas

- 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



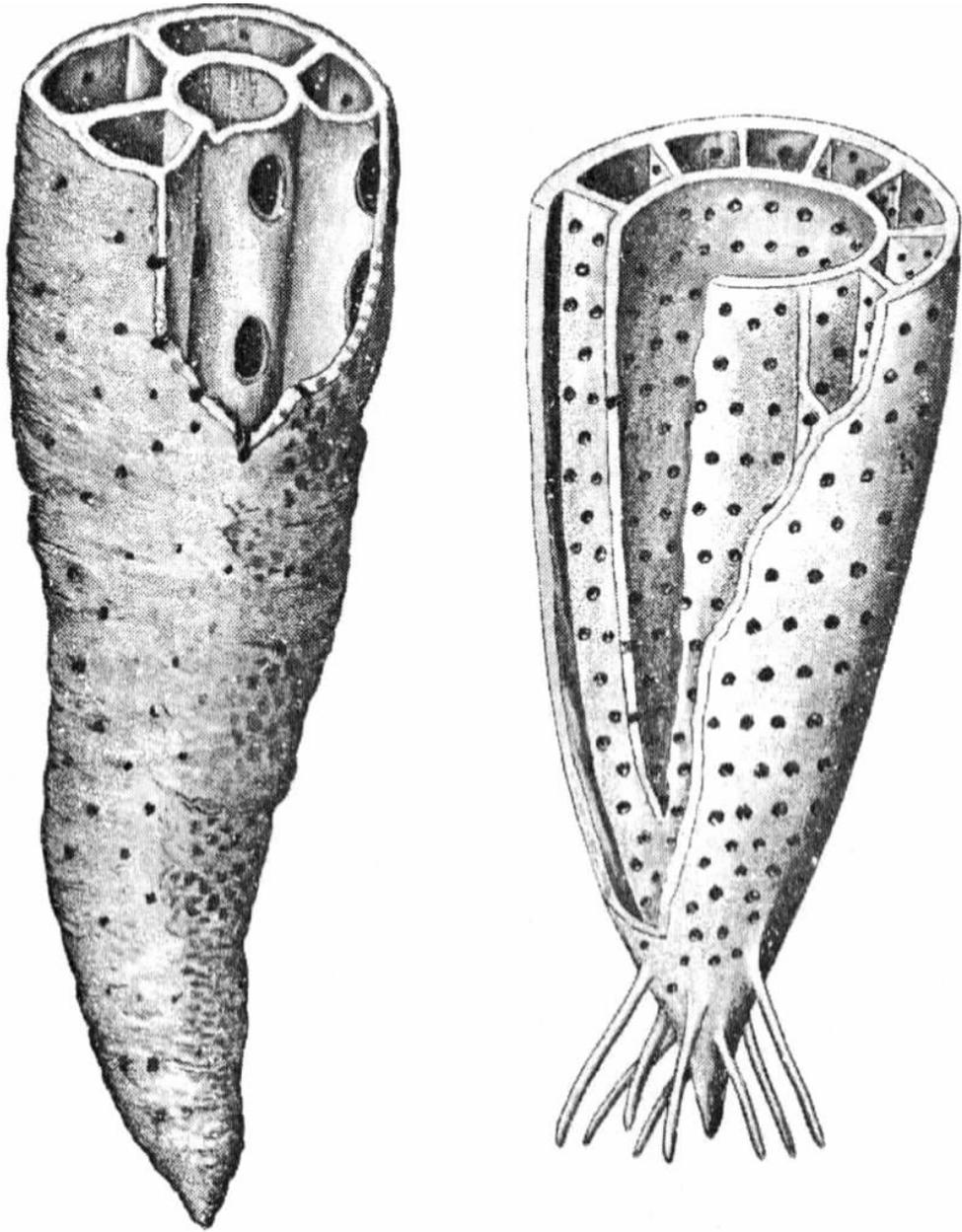
4.2 Cambrian explosion of skeletal fauna

Life in Cambrian



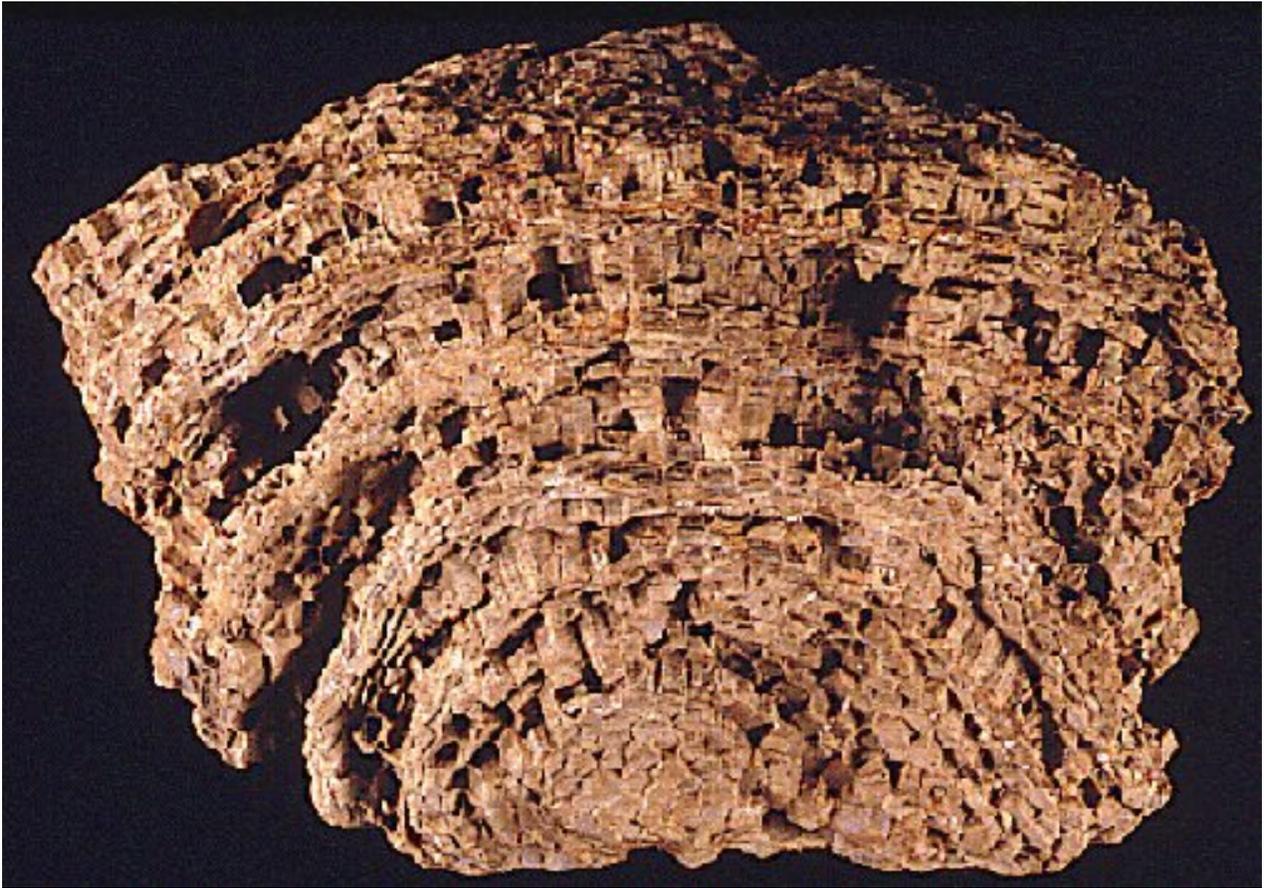
This is the picture of famous Czech artist Zdenek Burian

Archaeocyaths (most probably sponges)



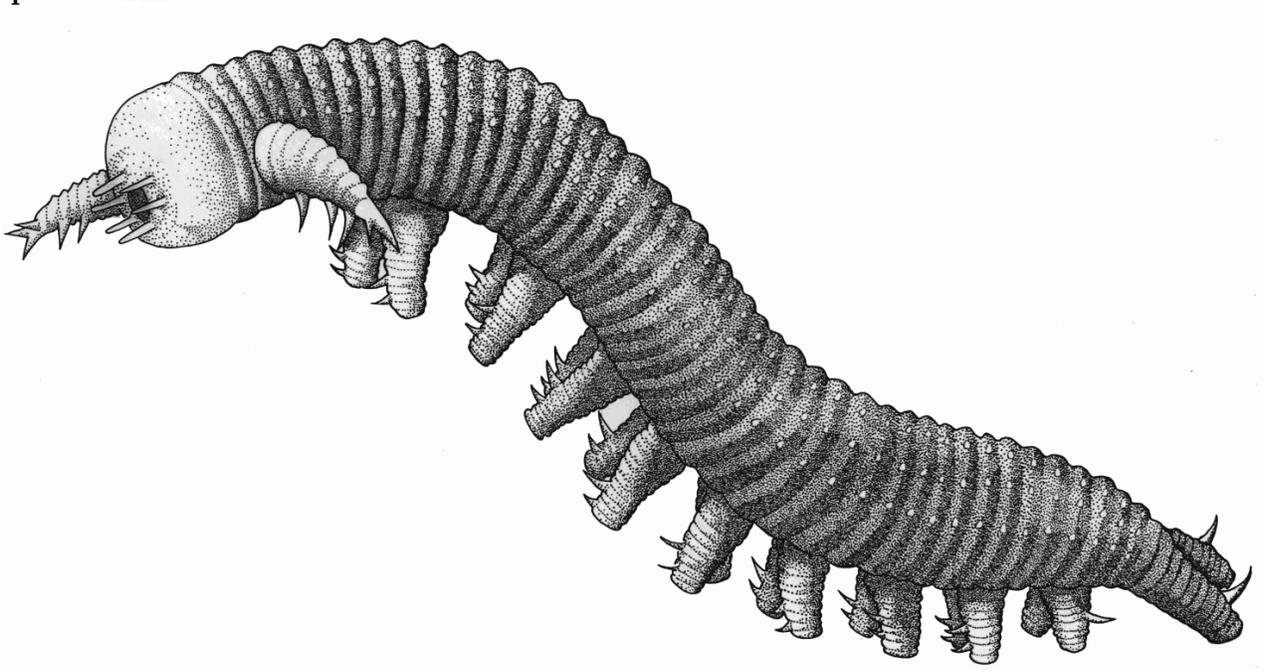
Most probably, Archaeocyaths were sponges

Cnidaria



Tabulate coral

Lobopod worms



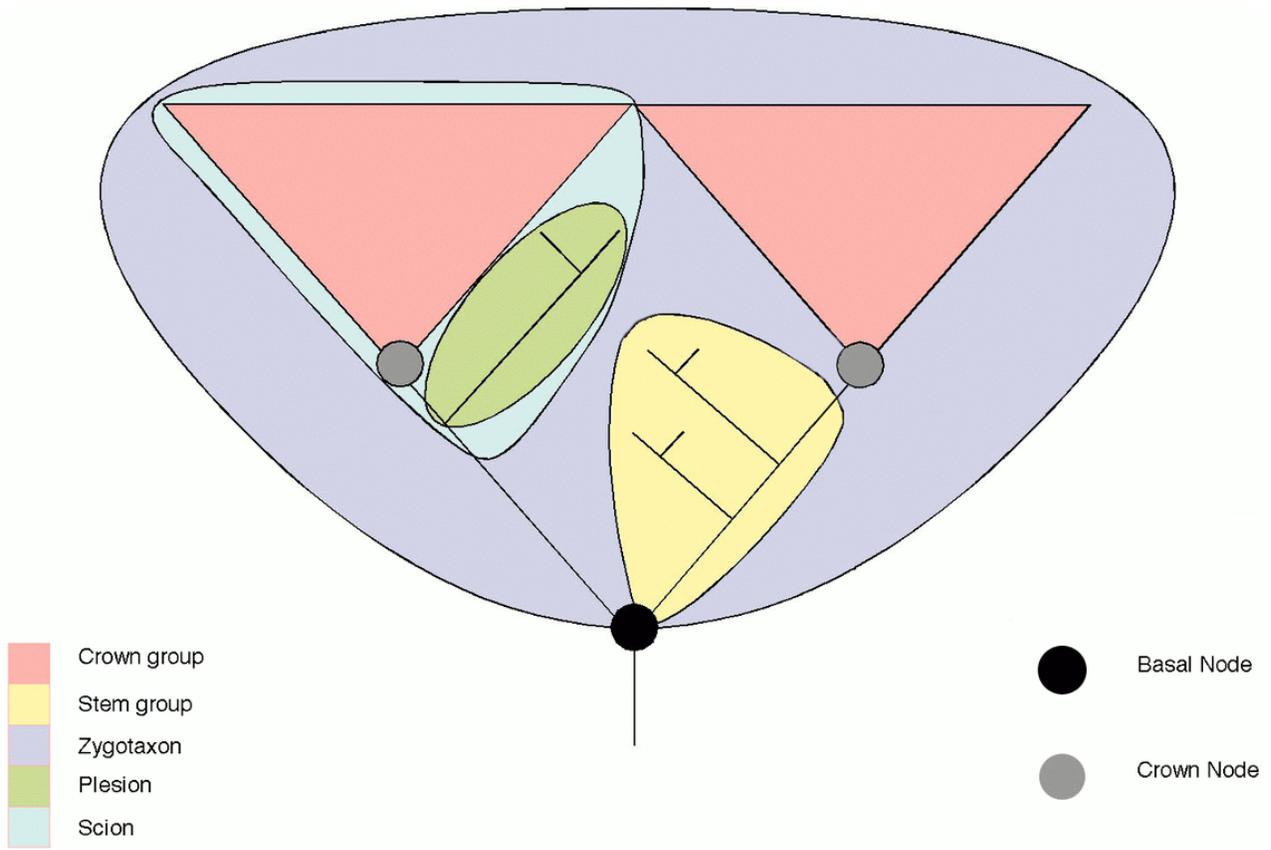
This is *Aysheaia*

Our *Hallucigenia* is also a lobopod worm!

Stem Arthropods



Stem and crown groups

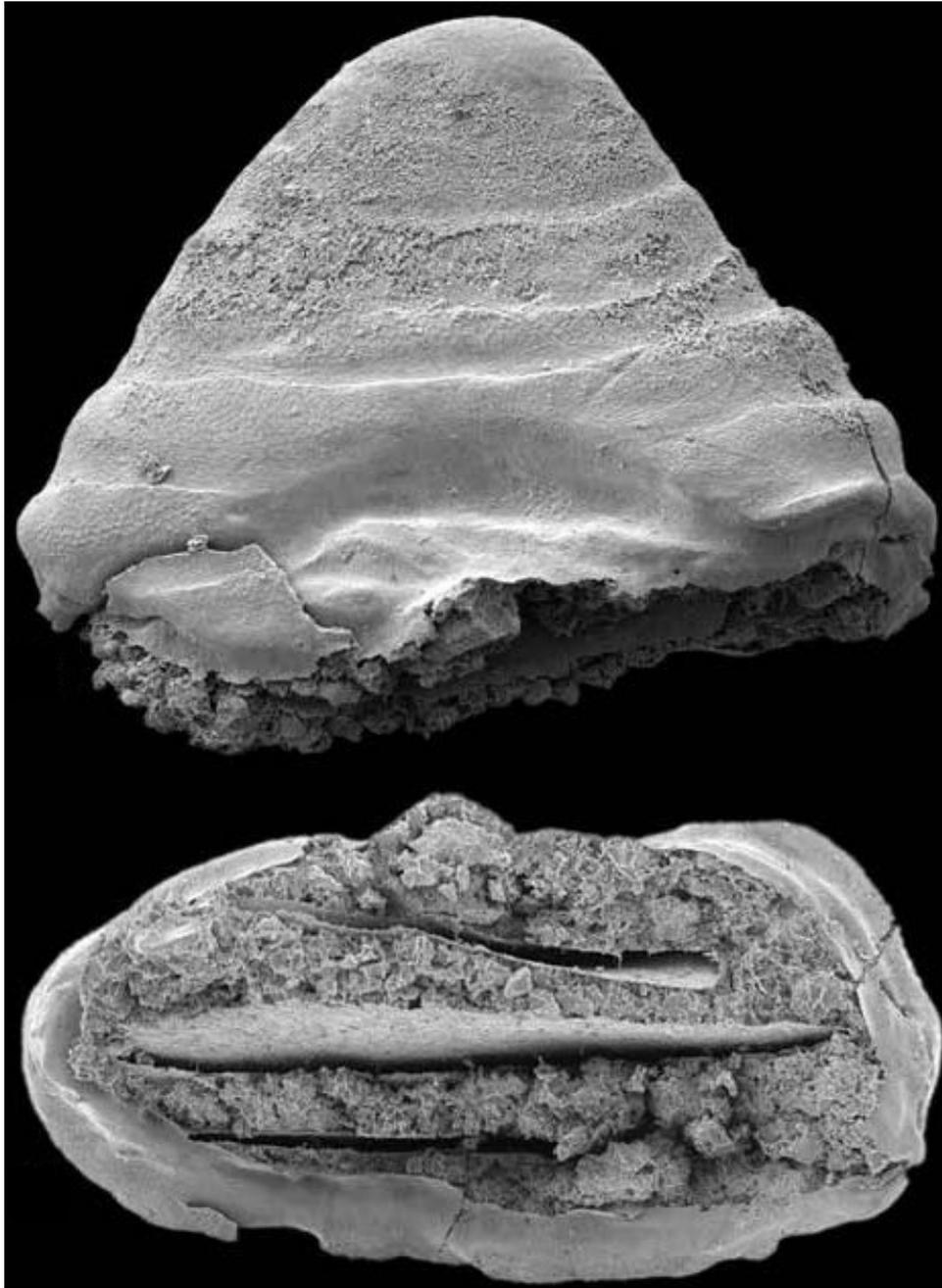


Mollusks: naked



Odontogriphus – stem naked mollusk

... and shelled

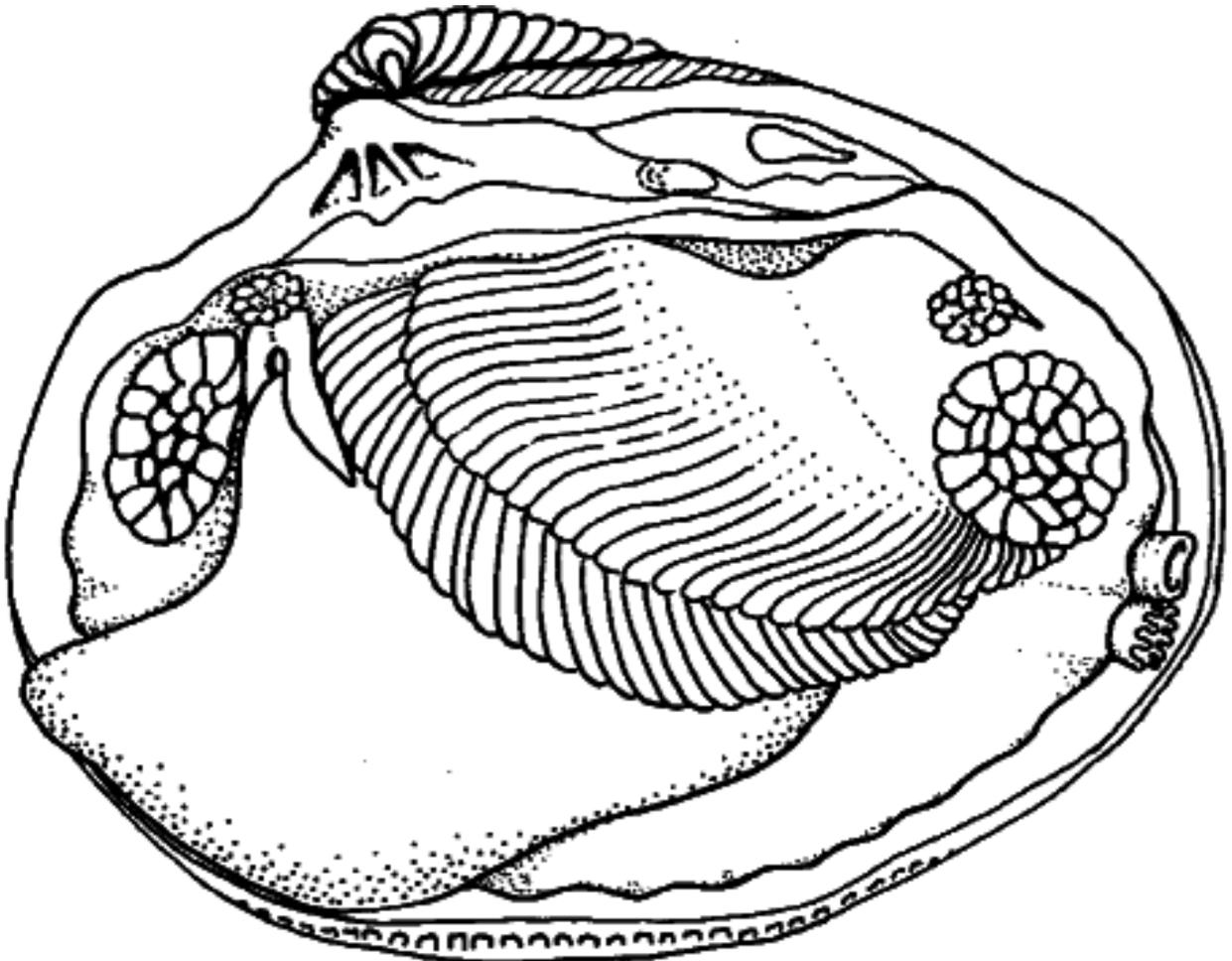
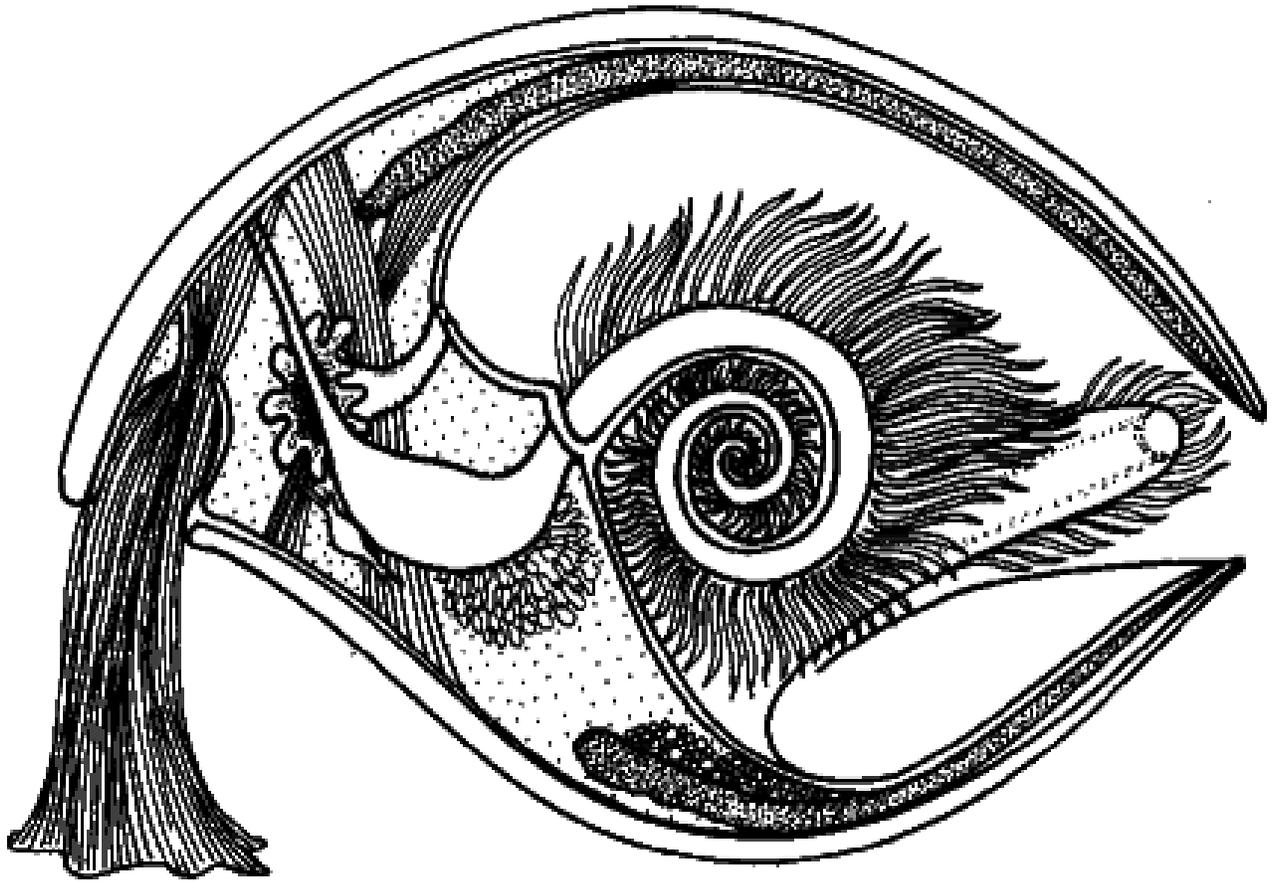


Helcionellid shell-bearing mollusk from Greenland

Brachiopods



Brachiopods are not mollusks!



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

Echinoderms



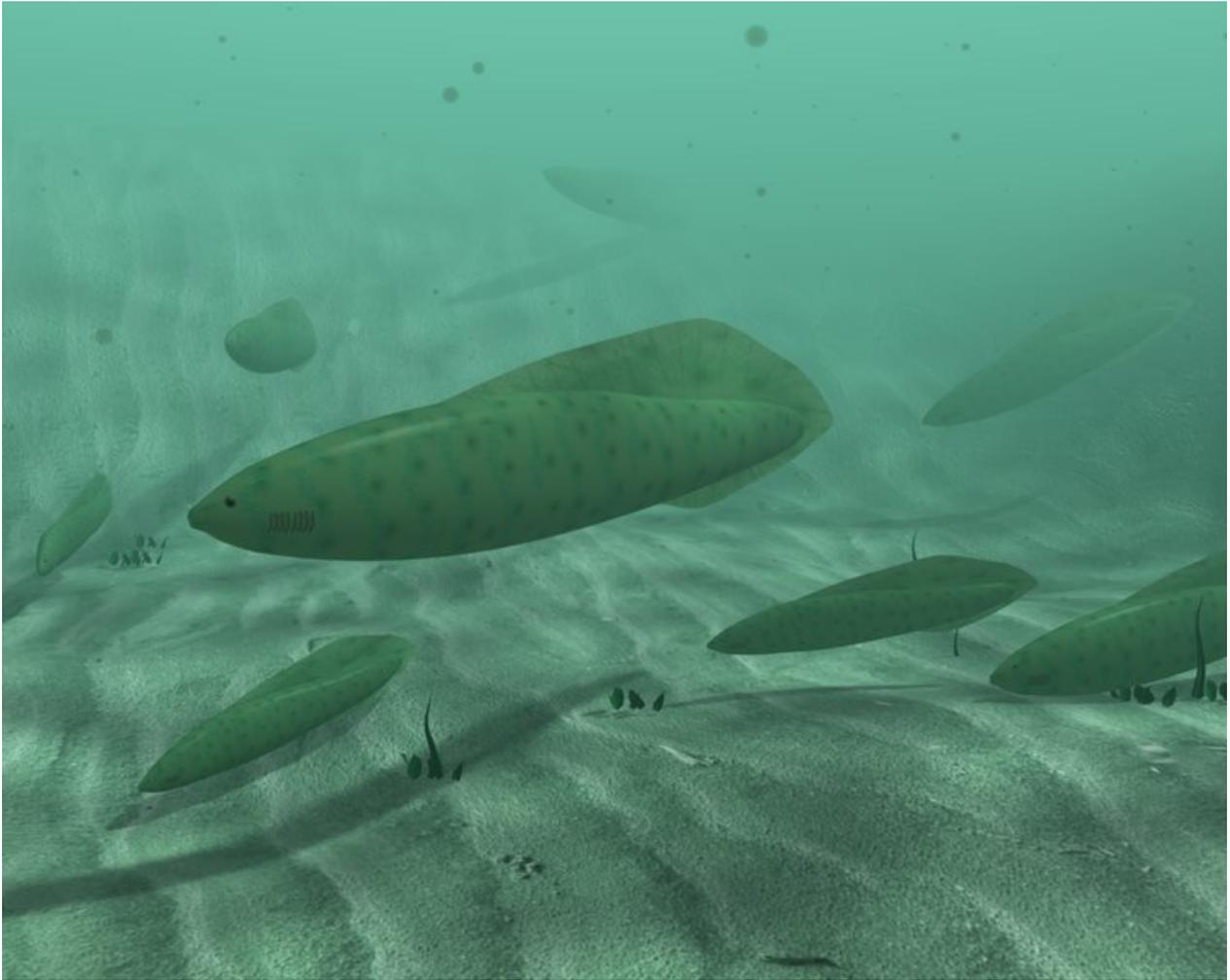
Sea lily *Gogia* from Nevada

Soft-bodied chordates



Pikaia from Burgess shale

First fish-like animals: craniate *Haikouichthys*

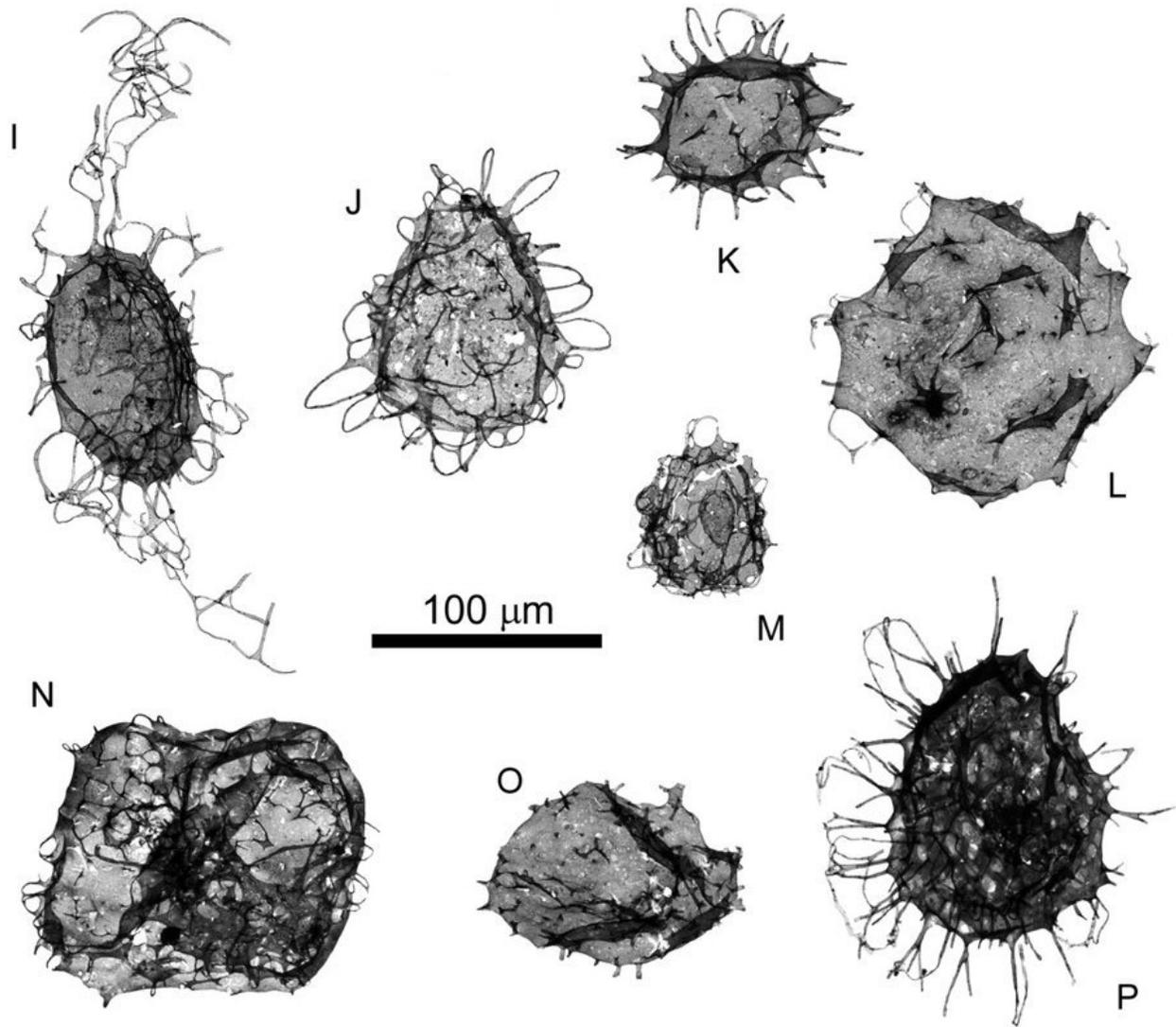


Algae



Yuknessia is a fossil green alga from Utah

Fungi



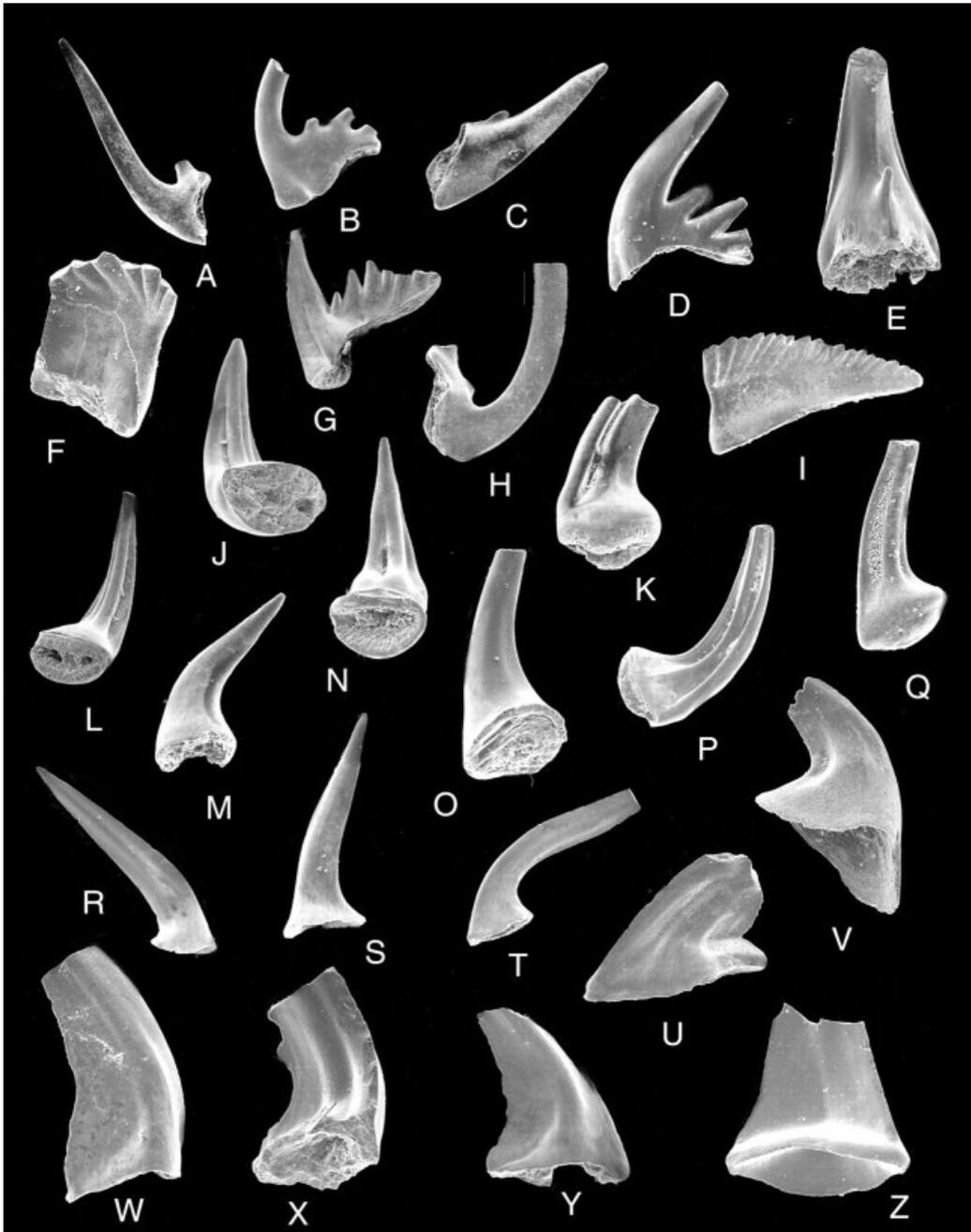
Tappania fungus was known even before Cambrian

Problematics: *Aldanophyton*



Terrestrial plant? Or alga?

Problematics: conodonts



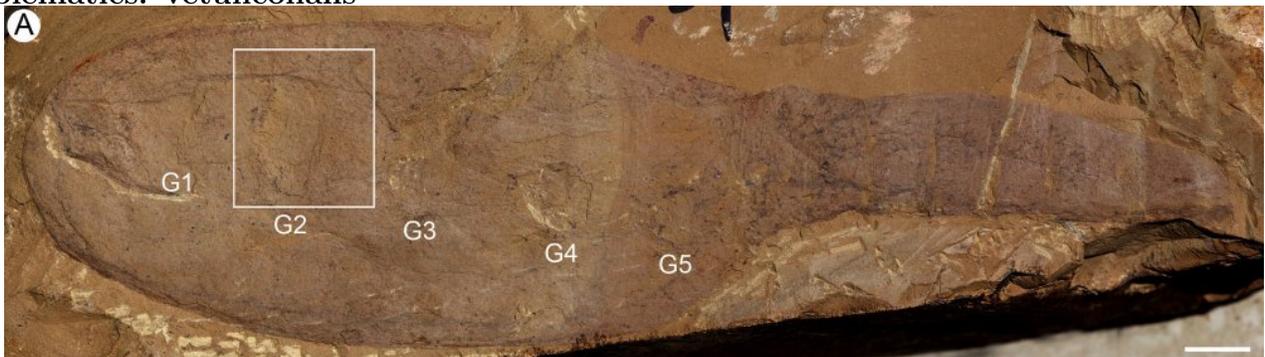
Conodonts are just teeth of unknown animal, it is still not clear what was it. Jawless fish?

Problematics: hyoliths



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

Problematics: vetulicolians



Ancestors of both echinoderms and chordates?

Summary

- Introns, linear DNA molecules and telomere/telomerase system differ eukaryotes from most prokaryotes
- Cambrian period started with massive appearance of skeletal fauna: “Cambrian explosion”

For Further Reading

References

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

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

Outline

5 Where we are?

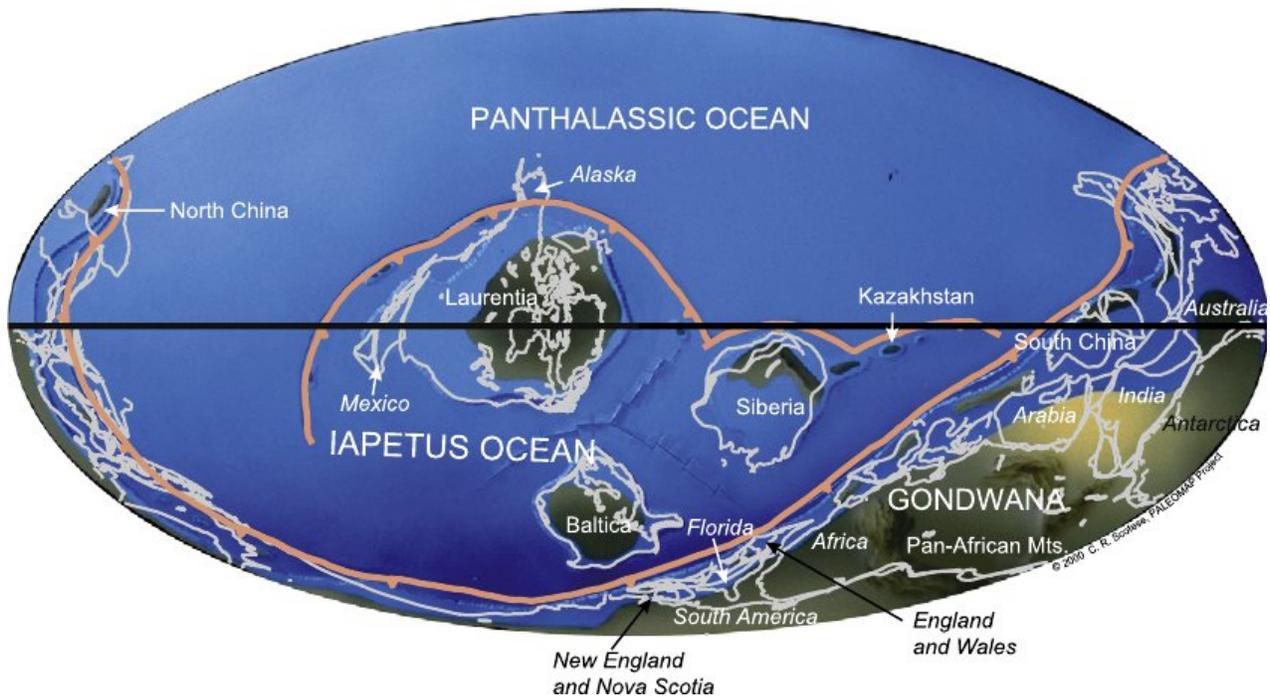
5.1 Cambrian life

Timescale of Phanerozoic eon, Paleozoic era

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

Cambrian map

514 Ma Cambrian



5.2 Cambrian explosion

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

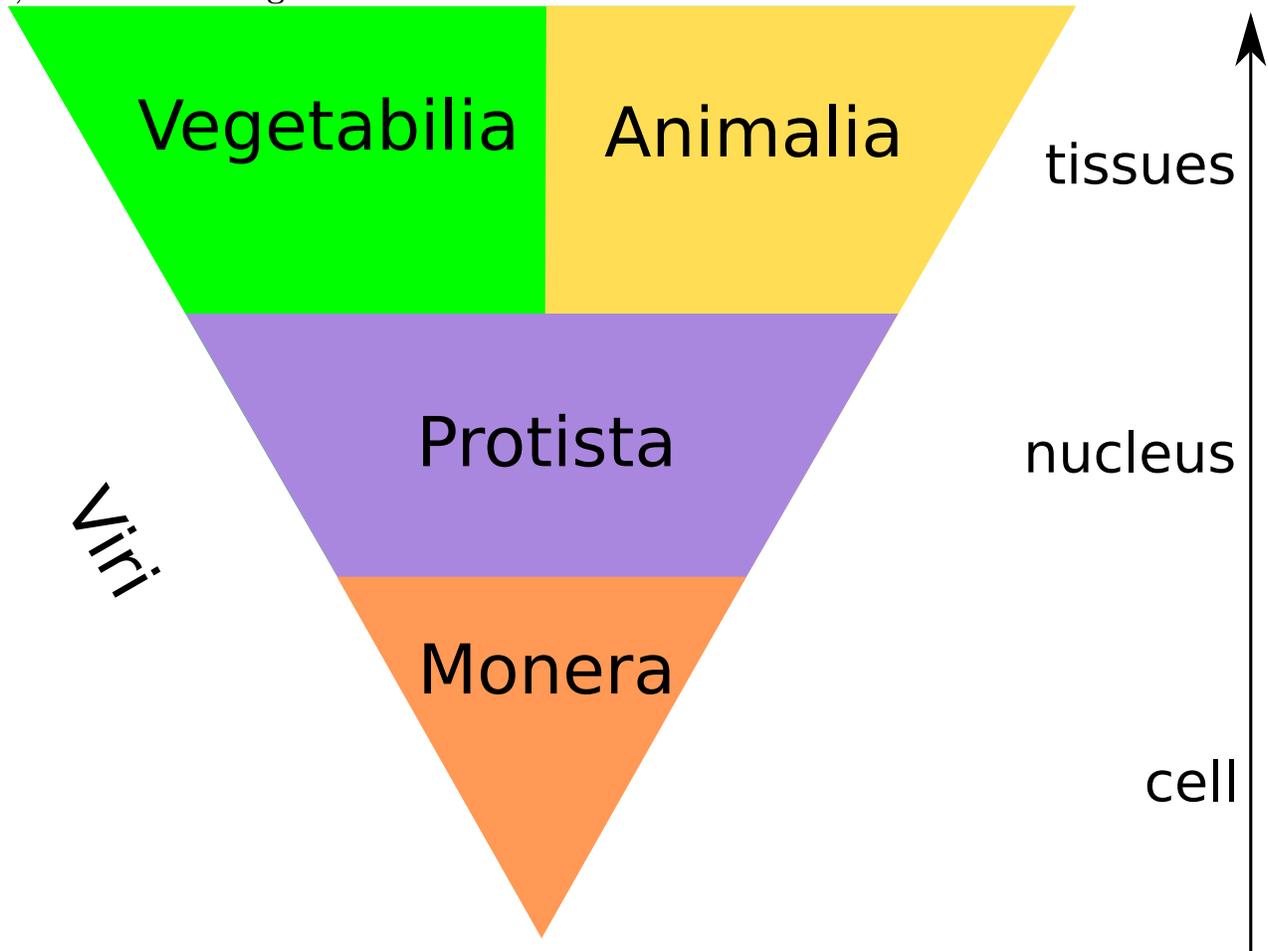
- Internal (endoskeleton): hydrostatic (worms), spicules (sponges), bones and cartilage
- External (exoskeleton): chitinous, shells, skin plates

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.

6 Animals

6.1 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

7 Questions and answers

7.1 Where we are?

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

- Blastaea
- Phagocytella
- Gastraea

Main organ systems in animals

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

8 Animals

8.1 Basic principles of animal body construction

Generalized animal

Summary

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

For Further Reading

References

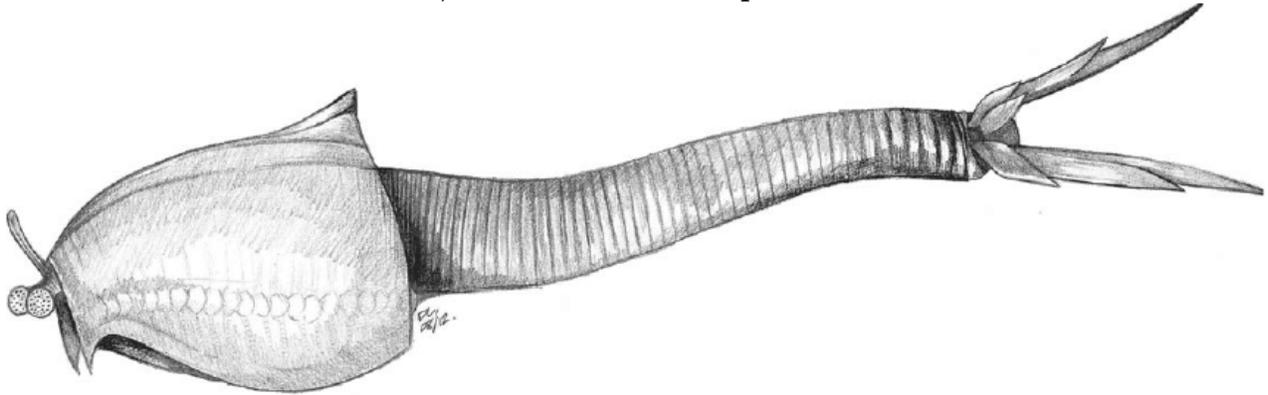
- [1] Skeleton. <http://en.wikipedia.org/wiki/Skeleton>
[2] Animal. <http://en.wikipedia.org/wiki/Animal>

Outline

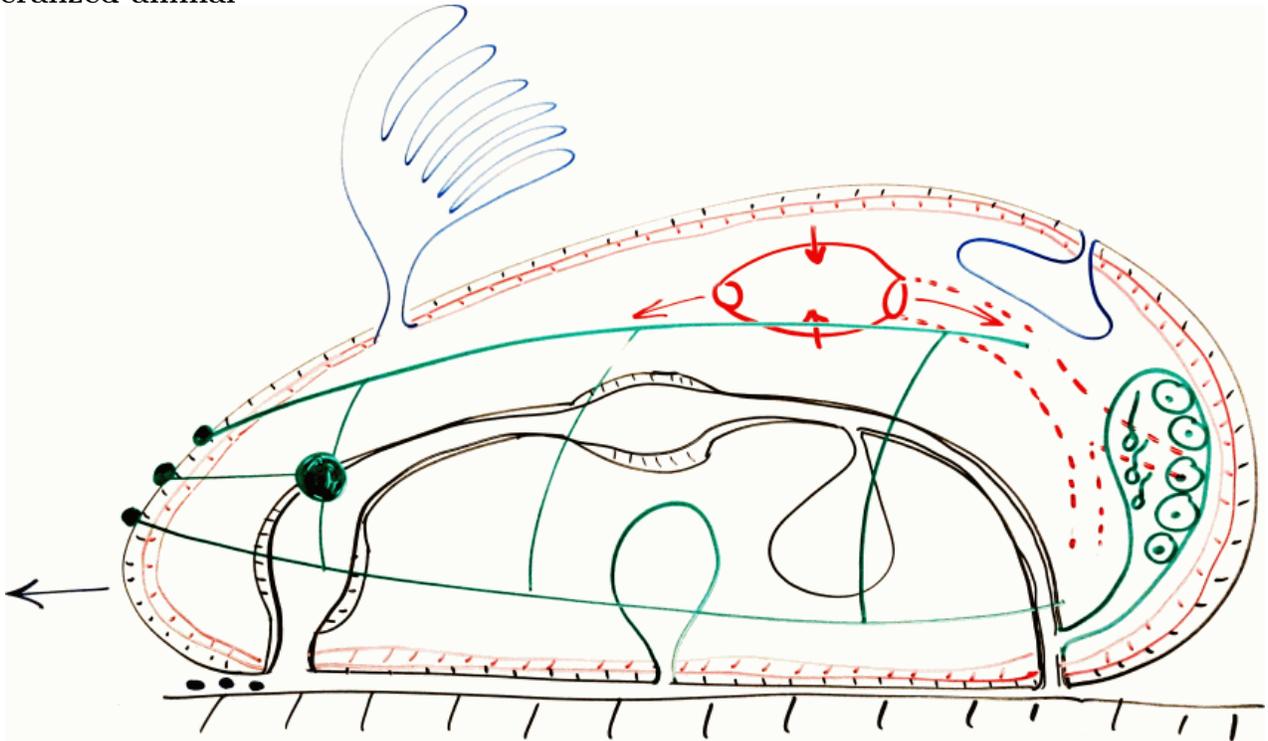
9 Questions and answers

9.1 Where we are?

Neocaris—fossil Orsten filtrator, ancestor of arthropods



Generalized animal



10 Animals

10.1 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

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

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

11 Questions and answers

11.1 Where we are?

Animal motion

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

12 Animal

12.1 Animal body

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

For Further Reading

References

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

Outline

13 Animals

13.1 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.

Four subkingdoms

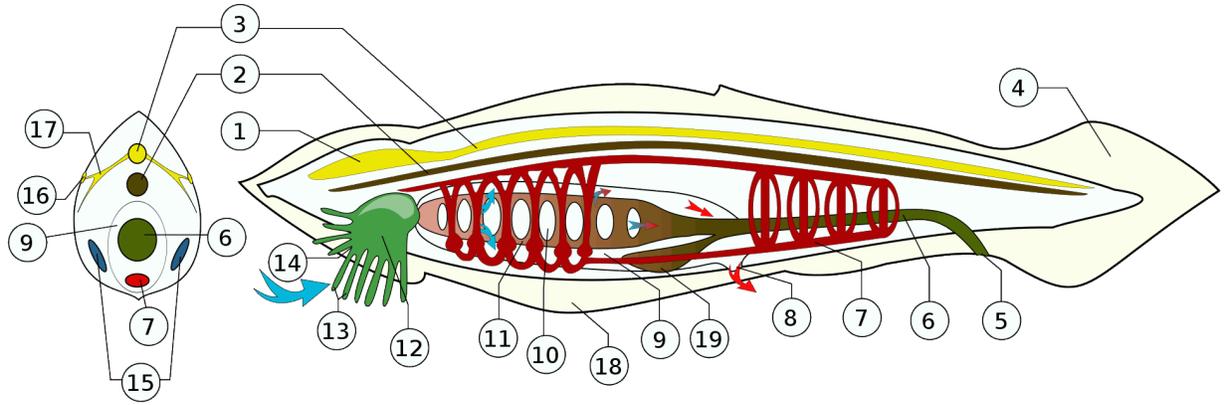
- Spongia: asymmetric filtrators
- Phagocytellozoa: asymmetric crawlers
- Cnidaria: radial stinging predators
- Bilateria: bilateral

Nine phyla

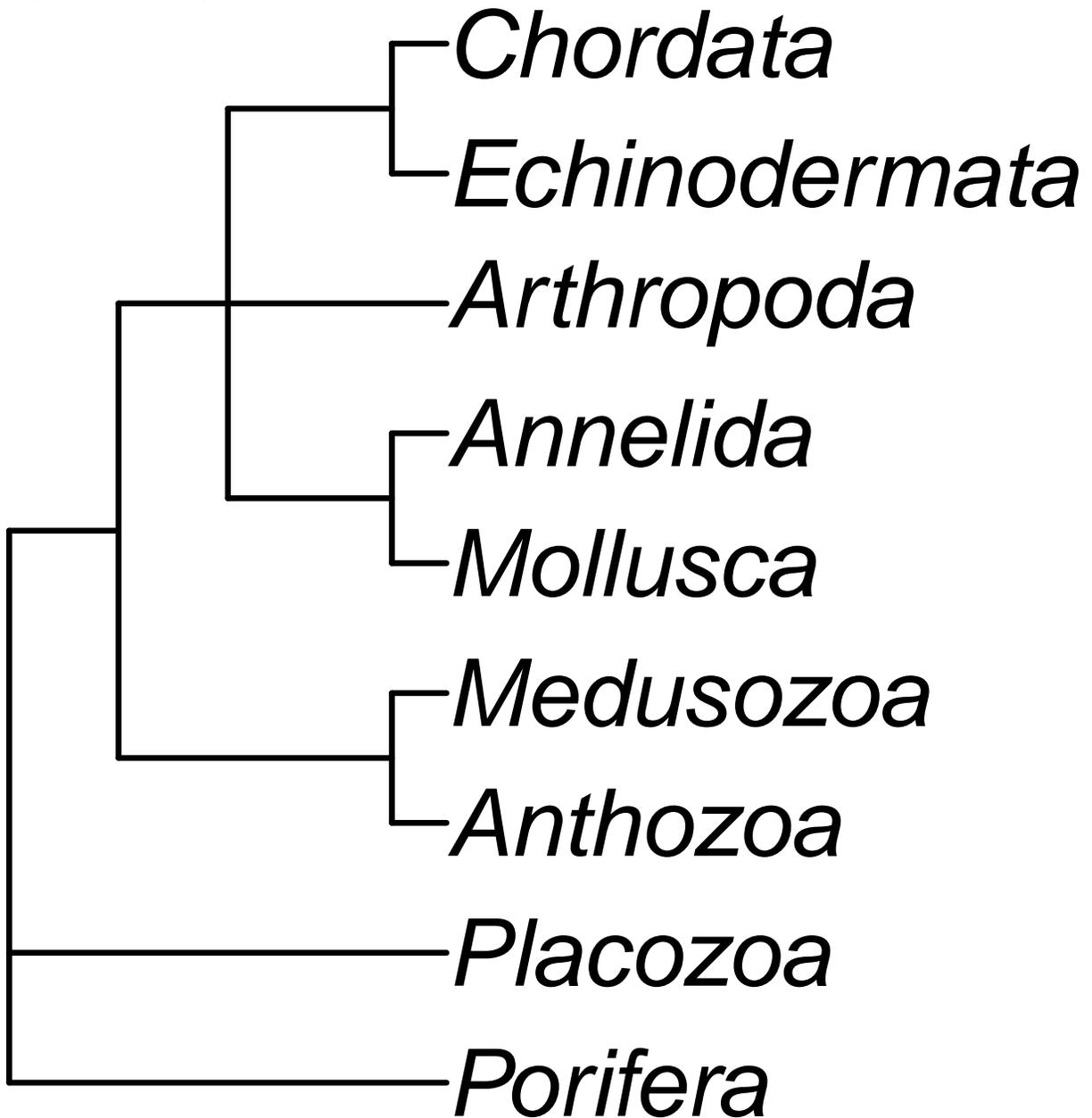
- Spongia
 - Porifera, sponges
- Phagocytellozoa
 - Placozoa, *Trichoplax*
- Cnidaria
 - Anthozoa, corals
 - Medusozoa, jellyfish
- Bilateria
 - Mollusca
 - Annelida
 - Arthropoda
 - Echinodermata
 - Chordata

Nine phyla = nine body plans

Chordate body plan



Phylogeny of nine phyla



13.2 Classes of chordates and their phylogeny

Eight classes of Chordata

Acrania:

Class 1. Leptocardii: lancelet

Vertebrata:

- Pisces:

Class 2. Chondrichthyes

Class 3. Actinopterygii

Class 4. Dipnoi

- Tetrapoda:

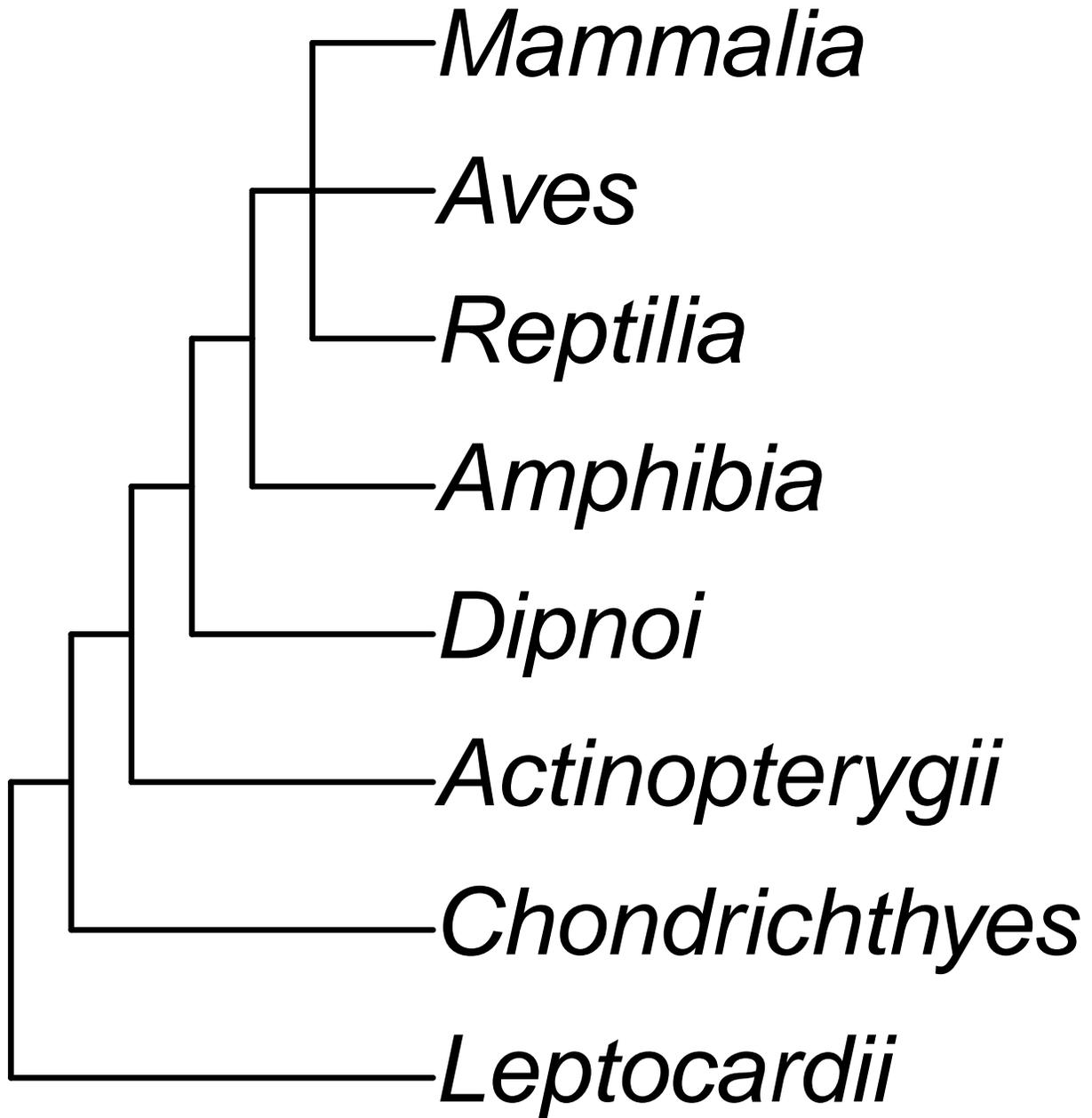
Class 5. Amphibia[.5ex] *Amniota:

Class 6. Reptilia

Class 7. Aves

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	8	9	10
Porifera										
Placozoa										
Anthozoa										
Medusozoa										
Annelida										
Mollusca										
Arthropoda										
Echinodermata										
Chordata										

Characters: 1 ...

Characters will not be necessary relevant to all members of phylum!

Summary

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

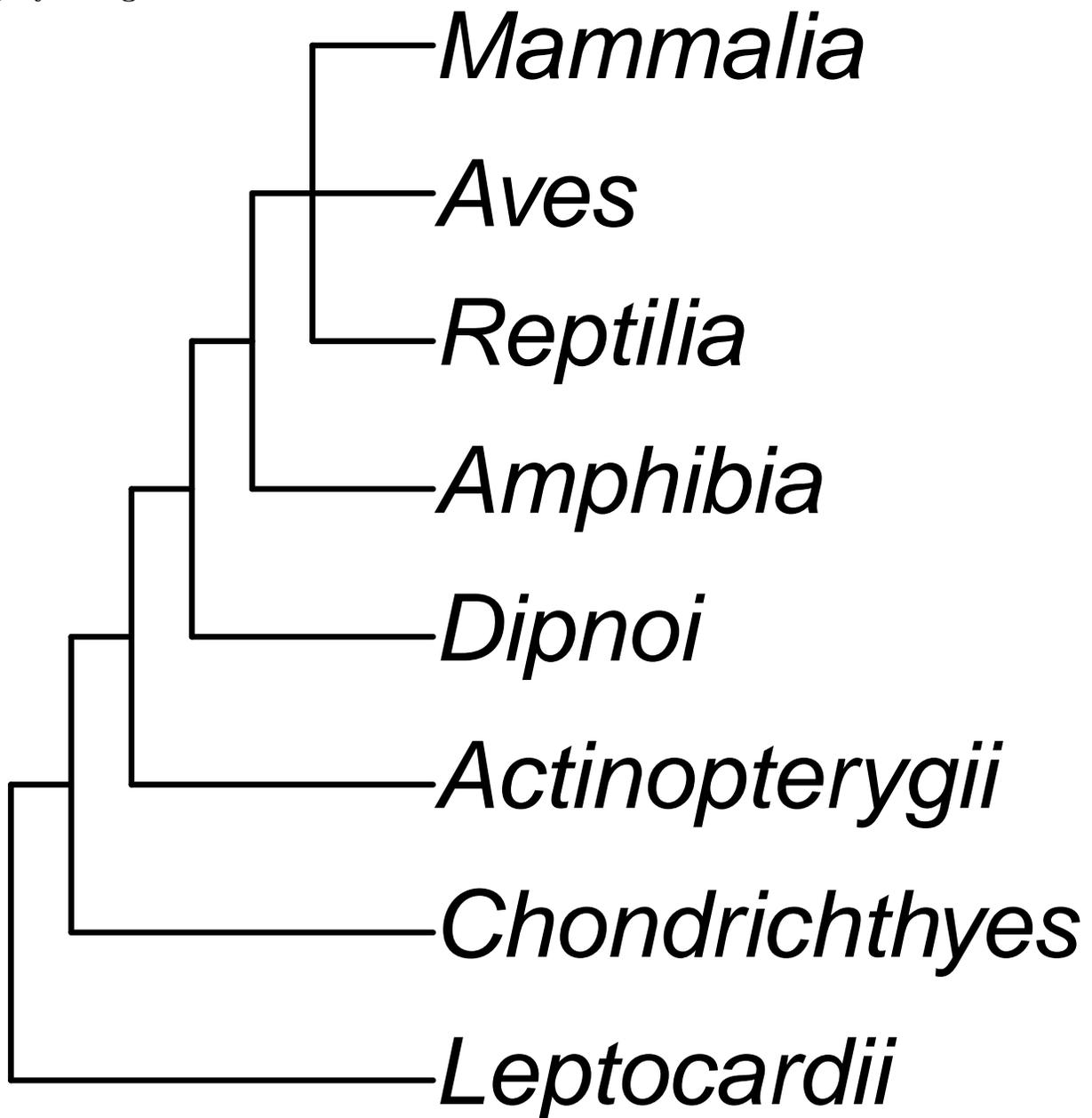
For Further Reading

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>

Outline

Phylogeny of eight classes



Timescale of Phanerozoic eon, Paleozoic era

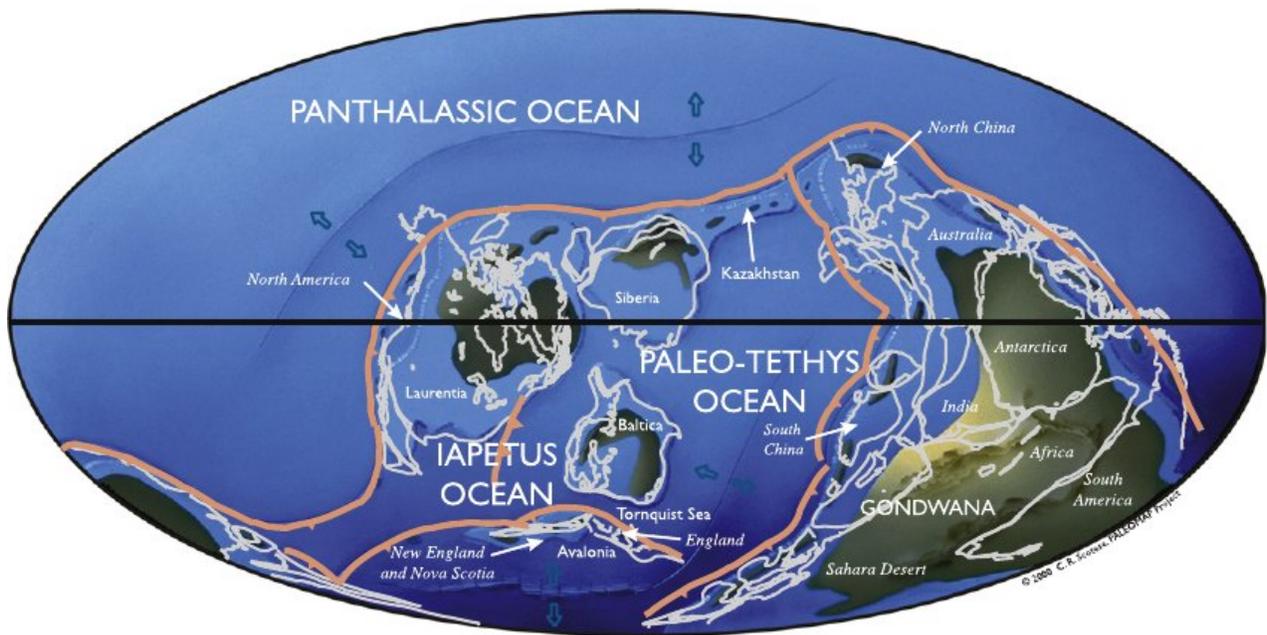
- Phanerozoic eon
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 - * Devonian period: 419 Mya
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 - * Permian period: 299–252 Mya

14 Everybody is going terrestrial

14.1 Ordovician, Silurian and Devonian: three ages of fishes

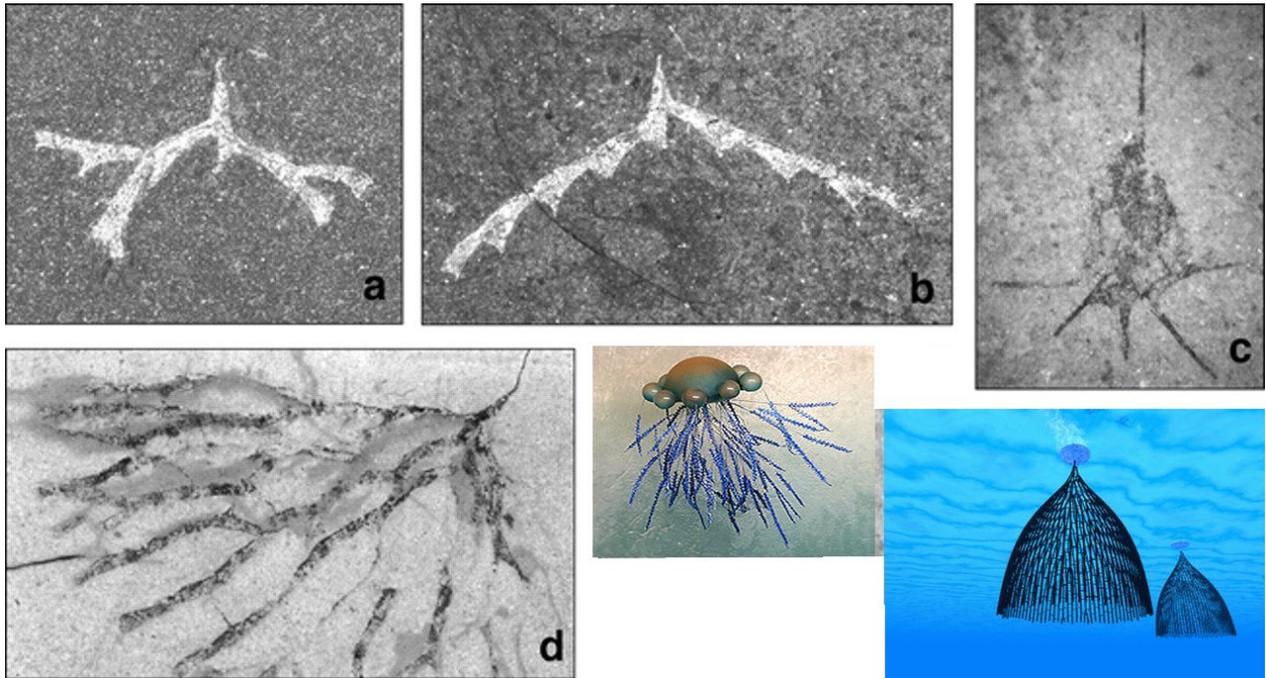
Ordovician period

458 Ma Ordovician



- Climate changed from hot to glaciated (Gondwana hits the South Pole)
- Marine fauna spread out, especially cephalopods, conodonts and graptolites
- In the end, the first great extinction: 85% of marine species extinct

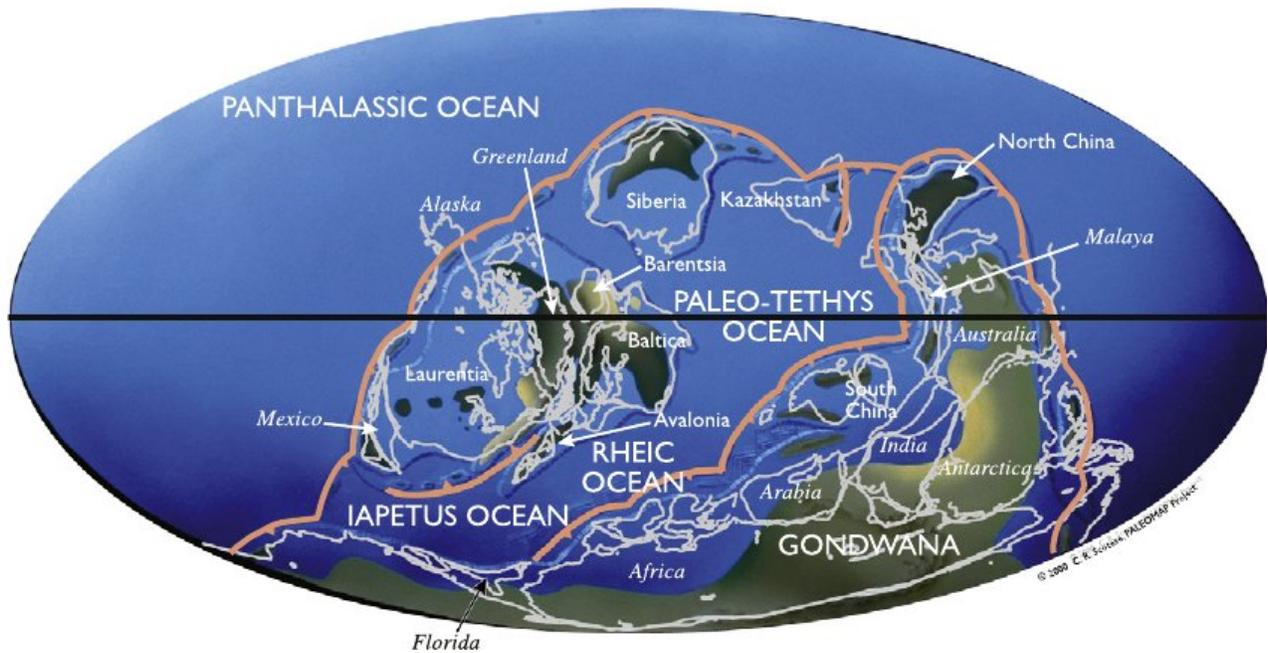
Graptolites



They were plankton colonial animals close to echinoderms and chordates

Silurian period

425 Ma Silurian



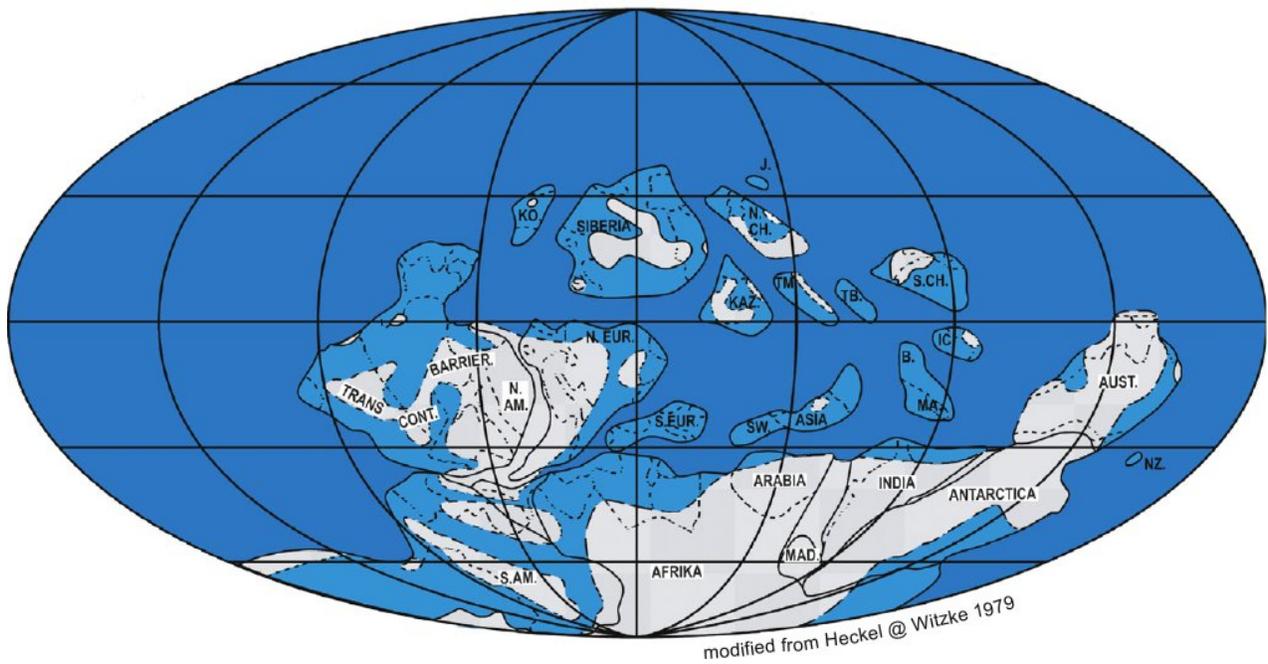
- Fluctuating climate
- Prospering of marine fauna again
- Land colonization started from plants and arthropods!
- South Pole still in the Gondwana

Silurian sea



Devonian period

Middle Devonian



- Moderate climate becoming warmer
- Exceptionally high sea level
- Greatest diversity of marine fauna in Paleozoic (especially fishes)
- Terrestrial vertebrates: tetrapods appeared!

14.2 Plants are going terrestrial

Protists, algae and plants

- Photosynthetic protists are algae
- Plants are descendants of green algae, they developed tissues in the process of land colonization

Primordial plant cell: cell wall, chloroplasts and turgor, plasmodesmata

Origin of tissues and organs of plants: first steps

Terms associated with origin of plants

- Thallus
- Epidermis
- Cuticle
- Transpiration
- Stomata, guard cells
- Compound tissues
- Ground tissue
- Supportive tissues
- Shoot system
- Absorption tissue, mycorrhiza
- Root system

Summary

- Plants are photosynthetic multi-tissued eukaryotes
- Plants developed tissues independently from animals, in the process of land colonization

For Further Reading

References

- [1] Plant cell. http://en.wikipedia.org/wiki/Plant_cell
- [2] Plant tissues. http://en.wikipedia.org/wiki/Tissue_%28biology%29#Plant_tissues

Outline

15 Where we are?

Primordial plant cell

- Cell wall: primary (cellulose) and secondary (cellulose + lignin and suberin)
- Chloroplasts with thylakoids
- Turgor: vacuole and cell wall pressures
- Plasmodesmata

16 Plants

16.1 Origin of plant tissues

Origin of tissues and organs of plants: first steps

Availability of light, temperature-gases conflict and competition pushed plants to land. Two first tissues, compound epidermis and ground tissue were response to desiccation. Epidermis could be developed in advance as adaptation to spore delivery. Next stages: supportive tissues, vascular tissues and absorption tissues.

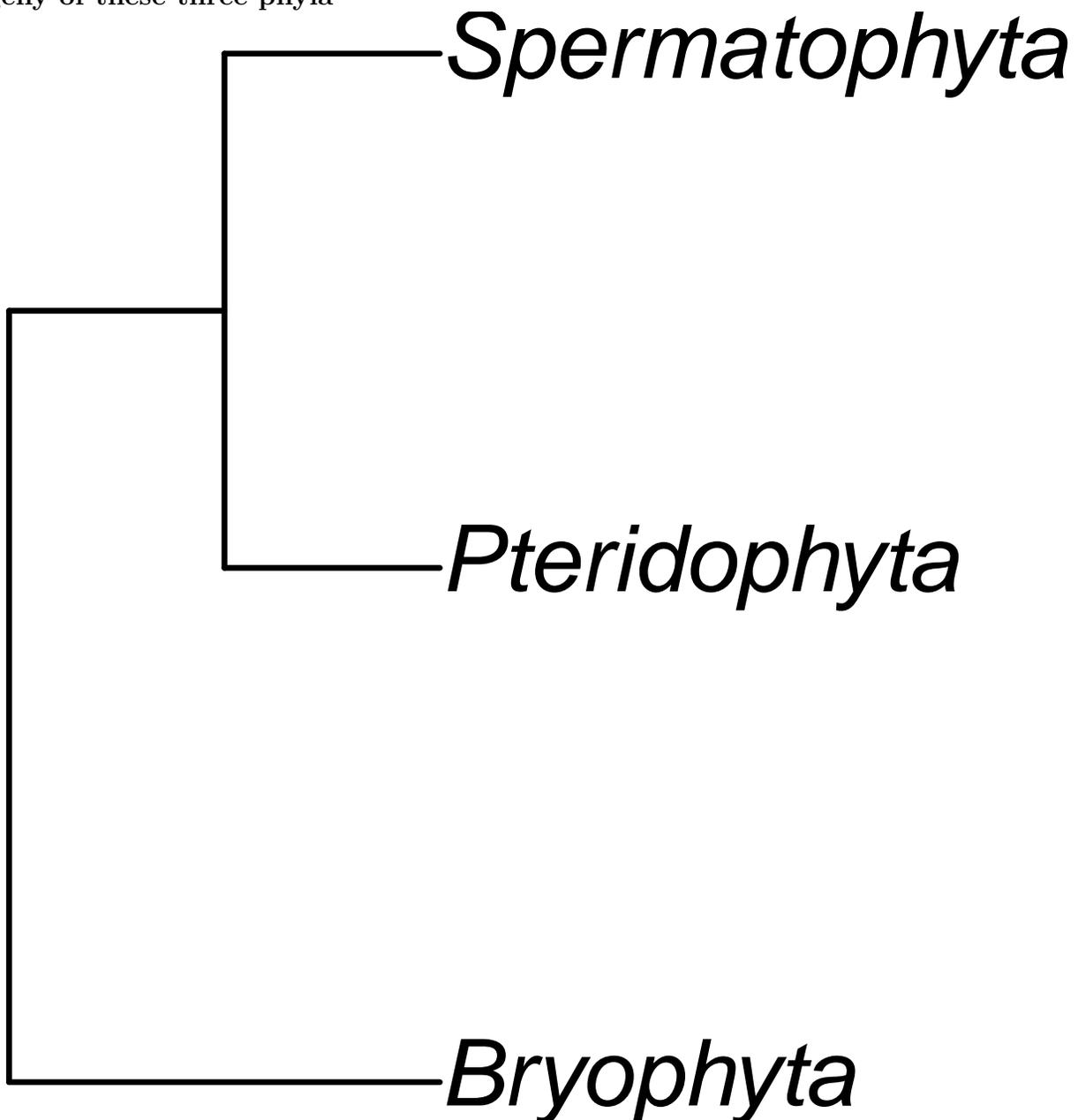
Terms associated with origin of plants

- Thallus
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- Cuticle
- Transpiration
- Stomata, guard cells
- Compound tissues
- Ground tissue
- Supportive tissues
- Shoot system
- Absorption tissue, mycorrhiza
- Root system

Three main phyla of plants

- **Bryophyta:** mosses
No roots, leaves thin or absent, withstand desiccation, **gametophyte dominance**
- **Pteridophyta:** ferns and allies (like clubmosses and horsetails)
Roots adventitious, leaves are not associate with buds, stem-like or scale-like, water-savers, **sporophyte dominance, no seeds**
- **Spermatophyta:** seed plants (including conifers and flowering plants)
Body with two poles, typical leaves associate with buds, water-savers, sporophyte dominance, **seeds**

Phylogeny of these three phyla



17 Genetics and inheritance

17.1 Meiosis

Exchange and renovation of DNA

- To sustain with the ever-changed environment, organisms must evolve
- To evolve, they need a genetic diversity: different genotypes in different organisms
- To be genetically diverse, they need a process of genetic exchange
- One of ways of exchange is a sexual process in a form of **syngamy**
- However, constant syngamy will result in constant increase of DNA amount
- Meiosis is a counterbalance to syngamy

Definition of meiosis

- Chromosome formula: $XX \longrightarrow X + X \longrightarrow I + I + I + I$
- **The goal of meiosis** is to counterbalance the syngamy
- Meiosis changes genotype of cells because: (1) chromosomes are **recombined** and (2) chromosomes exchange their genetic material

Ploidy, or chromosome set

- In diploid ($2n$) organisms, chromosomes form pairs
- Paired chromosomes (XX) are **homologous**
- In haploid (n) organisms, all chromosomes are single
- In mitosis, ploidy will be the same: $2n \longrightarrow 2n + 2n$
- In syngamy, ploidy will increase: $n + n \longrightarrow 2n$
- In meiosis, ploidy will reduce: $2n \longrightarrow n + n$

Stages of meiosis

- First division: reductive part
 - Prophase I: homologous chromosomes form pairs (**synapses**) and start to exchange DNA (**crossing-over**)
 - Metaphase I
 - Anaphase I: homologous chromosomes will go *independently* to different poles
 - Telophase I becomes Prophase II, without interphase (and typically without cytokinesis)
- Second division: equal part (similar to mitosis)

- Prophase II
- Metaphase II
- Anaphase II
- Telophase II

For Further Reading

References

- [1] Plant tissues. http://en.wikipedia.org/wiki/Tissue_%28biology%29#Plant_tissues
- [2] Plants. <http://en.wikipedia.org/wiki/Embryophyte>
- [3] [For the lab]: Mendel's laws. http://en.wikipedia.org/wiki/Mendelian_inheritance

Example questions for the exam

1. Which of the following is a name of Cambrian animal group:
 - A. Mosses
 - B. Chordates
 - C. Rangeomorphs
2. Choose the correct sequence:
 - A. Carboniferous, Cambrian, Ordovician, Devonian
 - B. Ediacarian, Ordovician, Silurian, Devonian
 - C. Cambrian, Ordovician, Silurian, Devonian
3. Radial symmetry is characteristic for:
 - A. Mollusks
 - B. Anthozoans (corals)
 - C. Arthropods

Answers

1B, 2C, 3B