Concepts of Biology: BIOL 111
Study guide for Exam 4

Alexey Shipunov

Lectures 24–30

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Outline

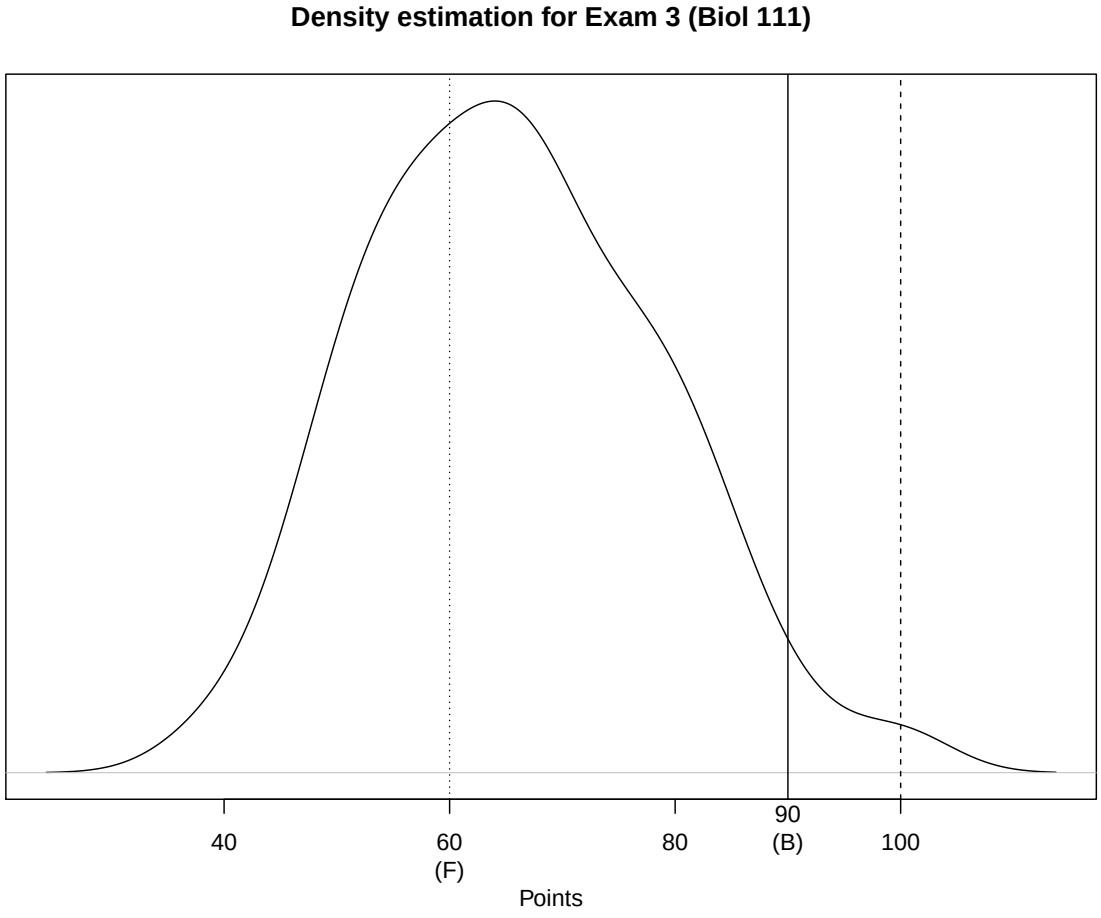
1 Questions and answers

1.1 Exam 3

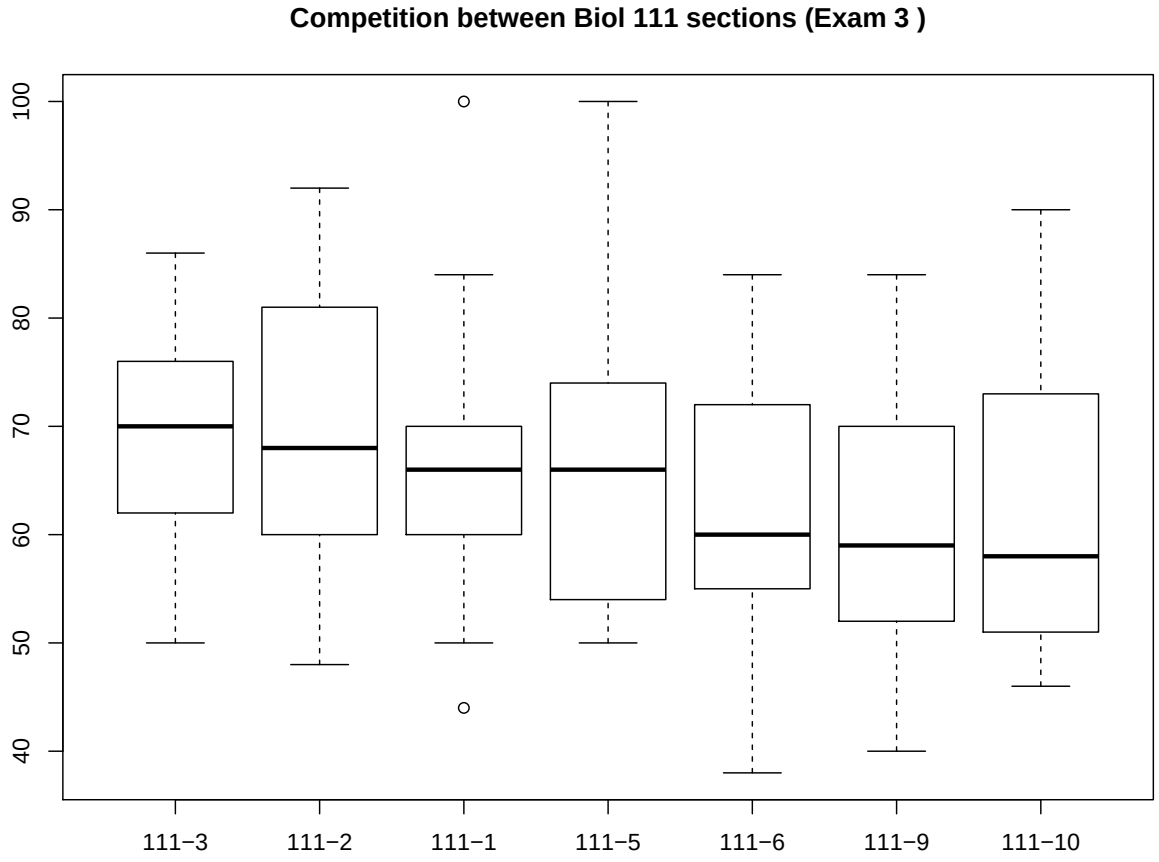
Results of Exam 3: statistic summary

```
Summary:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
   38.0    56.0    65.0    65.8    76.0   100.0      14
Grades:
   F    D    C    B  max
< 60 < 70 < 80 < 90  100
```

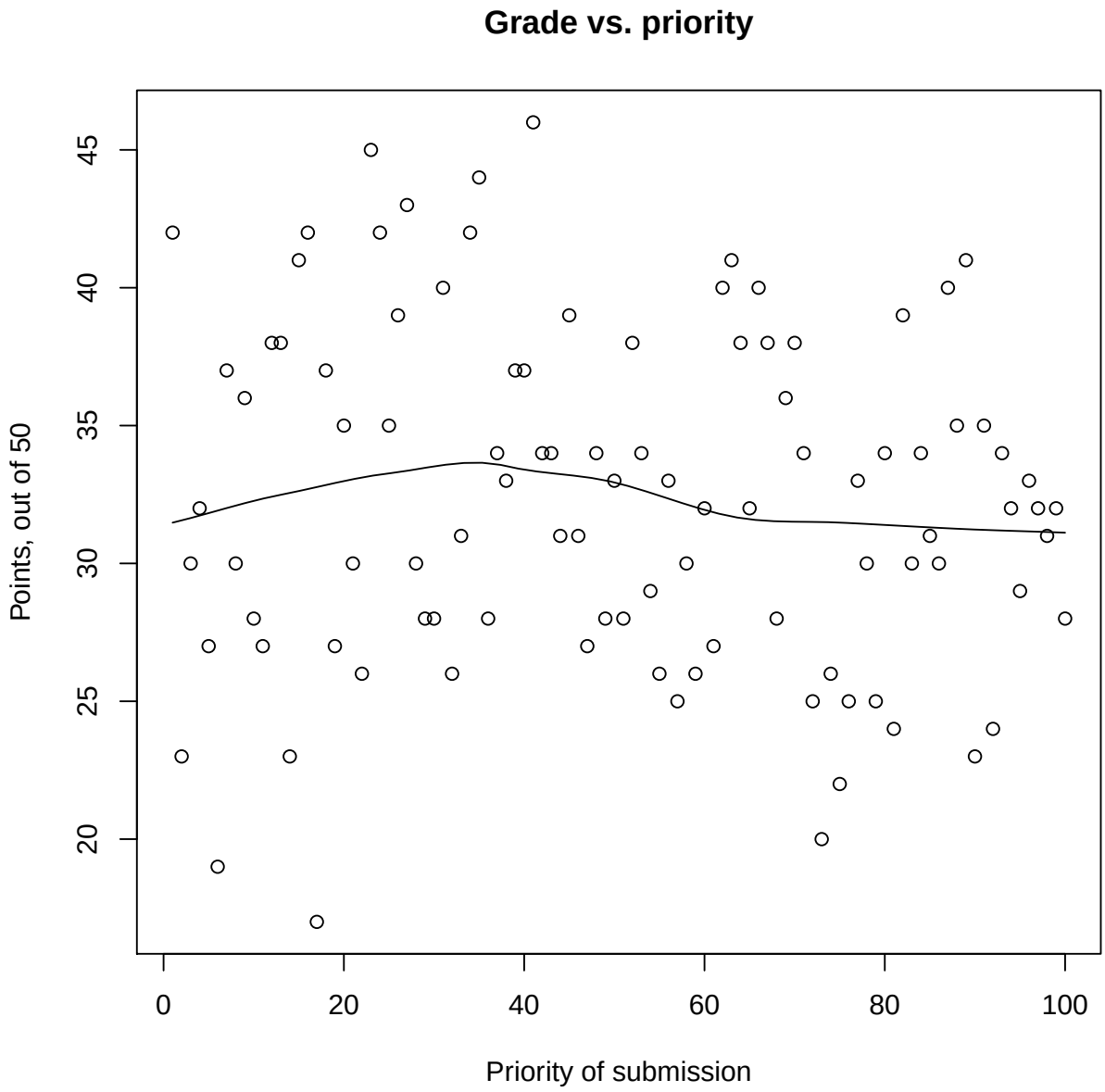
Results of Exam 3: the curve



Results of Exam 3: sections



Results of Exam 3: priority vs. points



Results of Exam 3: three questions

14. In Cambrian, Orsten and Burgess faunas were located:

    A. On Siberian continent
    B. On Gondwana continent
    C. **In the ocean**

19. Cambrian echinoderms:

    A. Sea cucumbers
    B. Sea horses
    C. **Sea lilies**

22. Jet motion is characteristic for:

A. Some arthropods

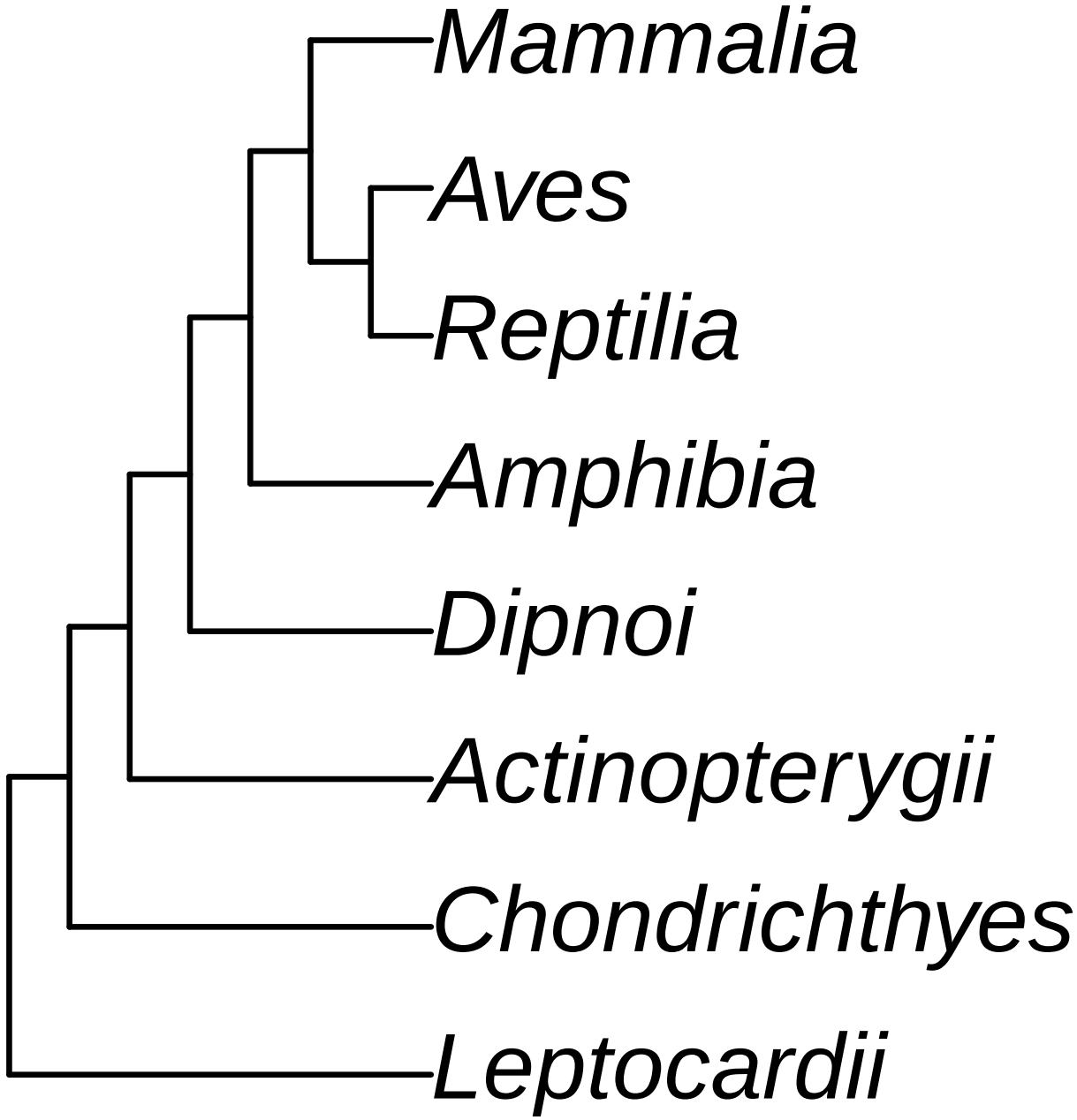
B. Some chordates

C. **Some mollusks**

2 Where we are

2.1 Animals

Phylogeny of eight classes



Timescale of Phanerozoic eon, Paleozoic era

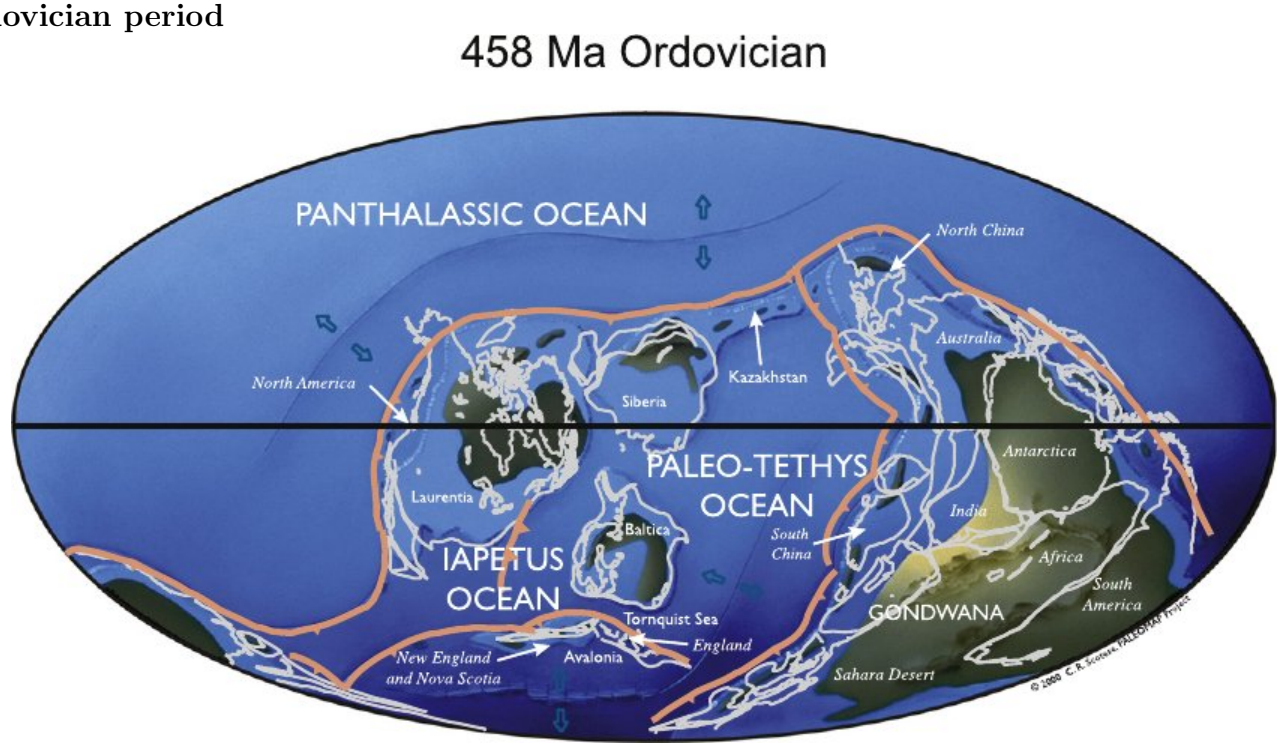
- Phanerozoic eon
  - Paleozoic era

* 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

3 Everyone is going terrestrial

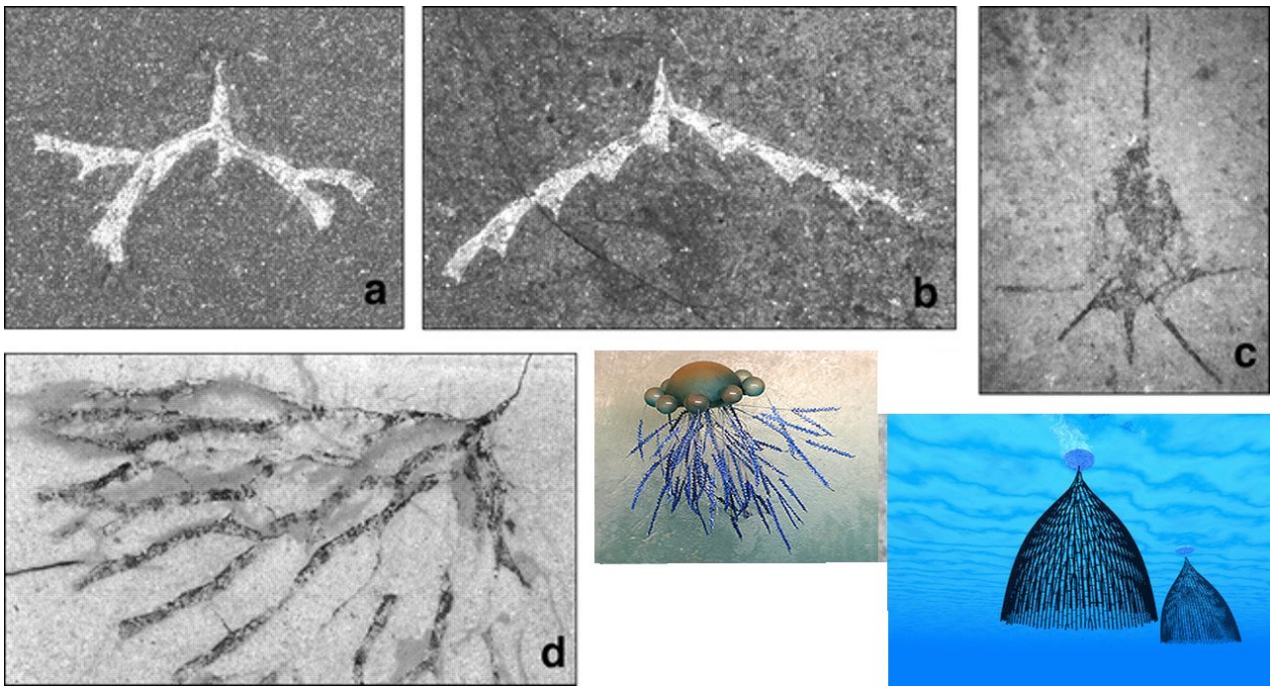
3.1 Ordovician, Silurian and Devonian: three ages of fishes

Ordovician period



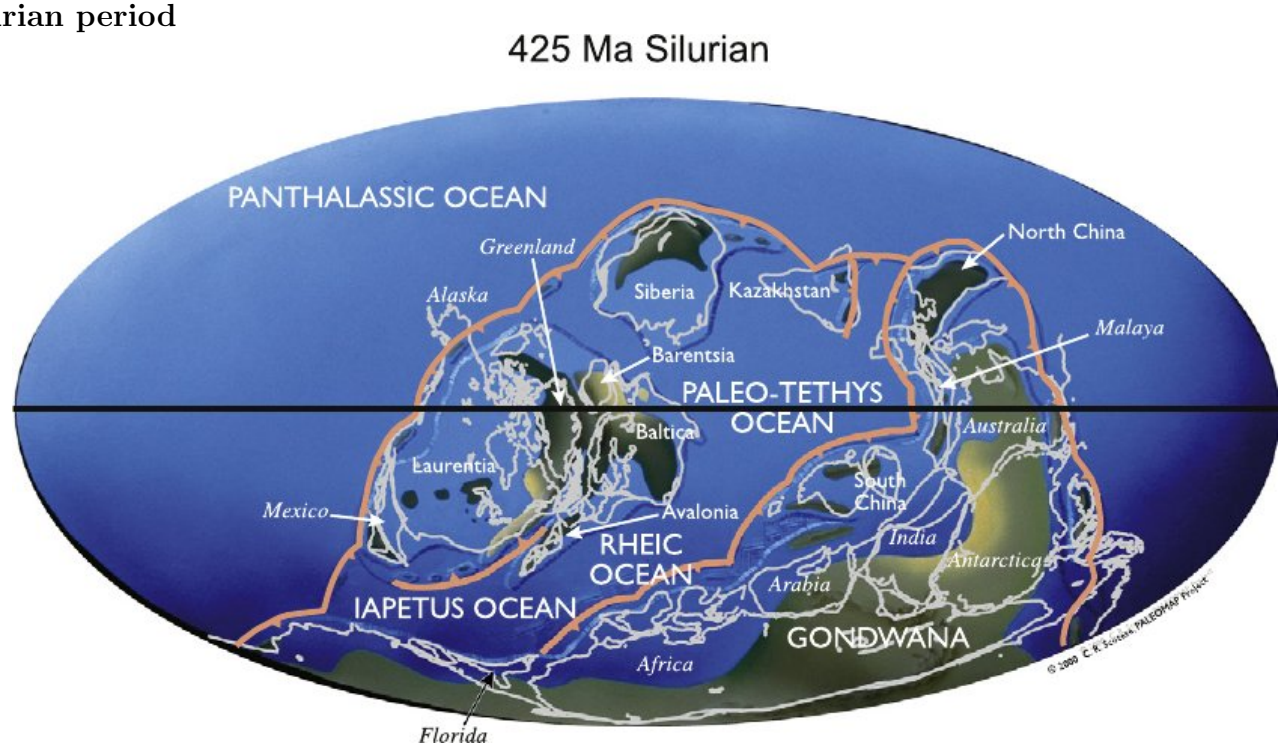
- Climate changed from hot to glaciated (Gondwana hits the South Pole)
- Marine fauna spread out, especially cephalopods, conodonts and graptolites
- In the end, the first great extinction: 85% of marine species extinct

Graptolites



They were plankton colonial animals close to echinoderms and chordates

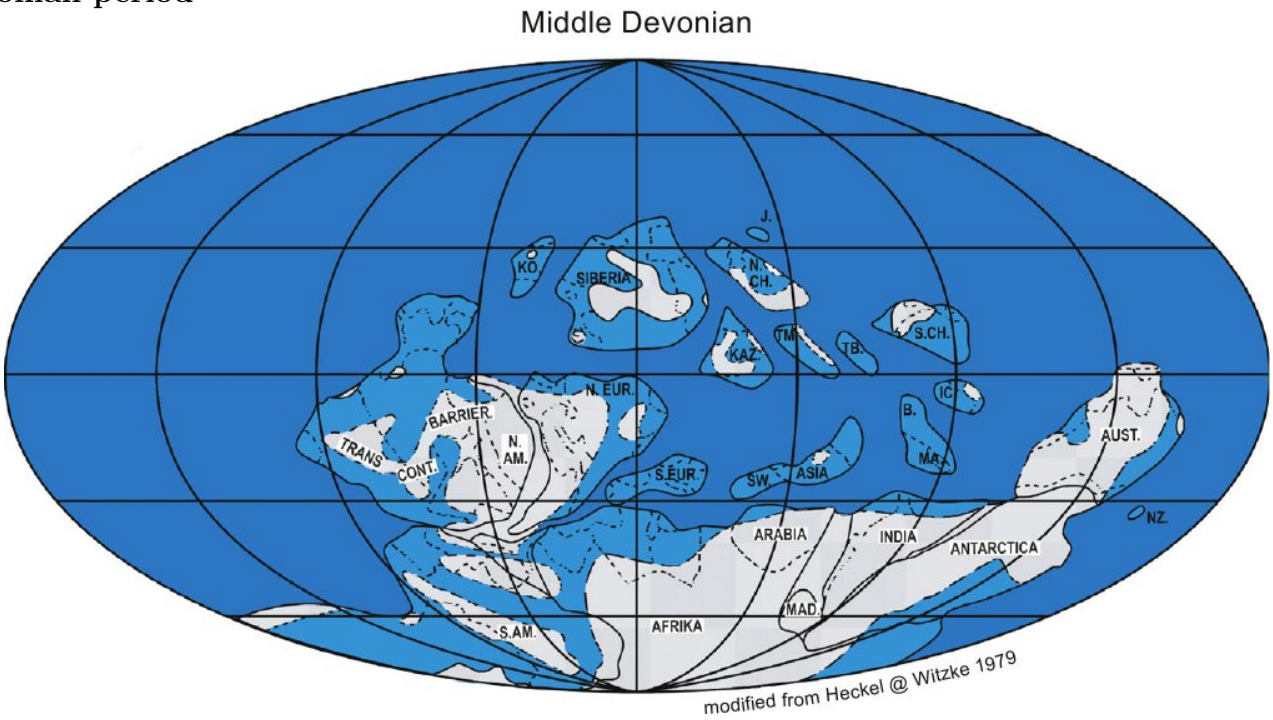
Silurian period



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

Silurian sea

Devonian period



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

3.2 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, vacuole and turgor, plasmodesmata

Origin of tissues and organs of plants: first steps

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

4 Where we are

4.1 Plants

Primordial plant cell

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

5 Plants

5.1 Origin of plant tissues

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

Three main phyla of plants

- **Bryophyta**: mosses

  No roots, leaves thin or absent, withstand desiccation, **gametophyte dominance**

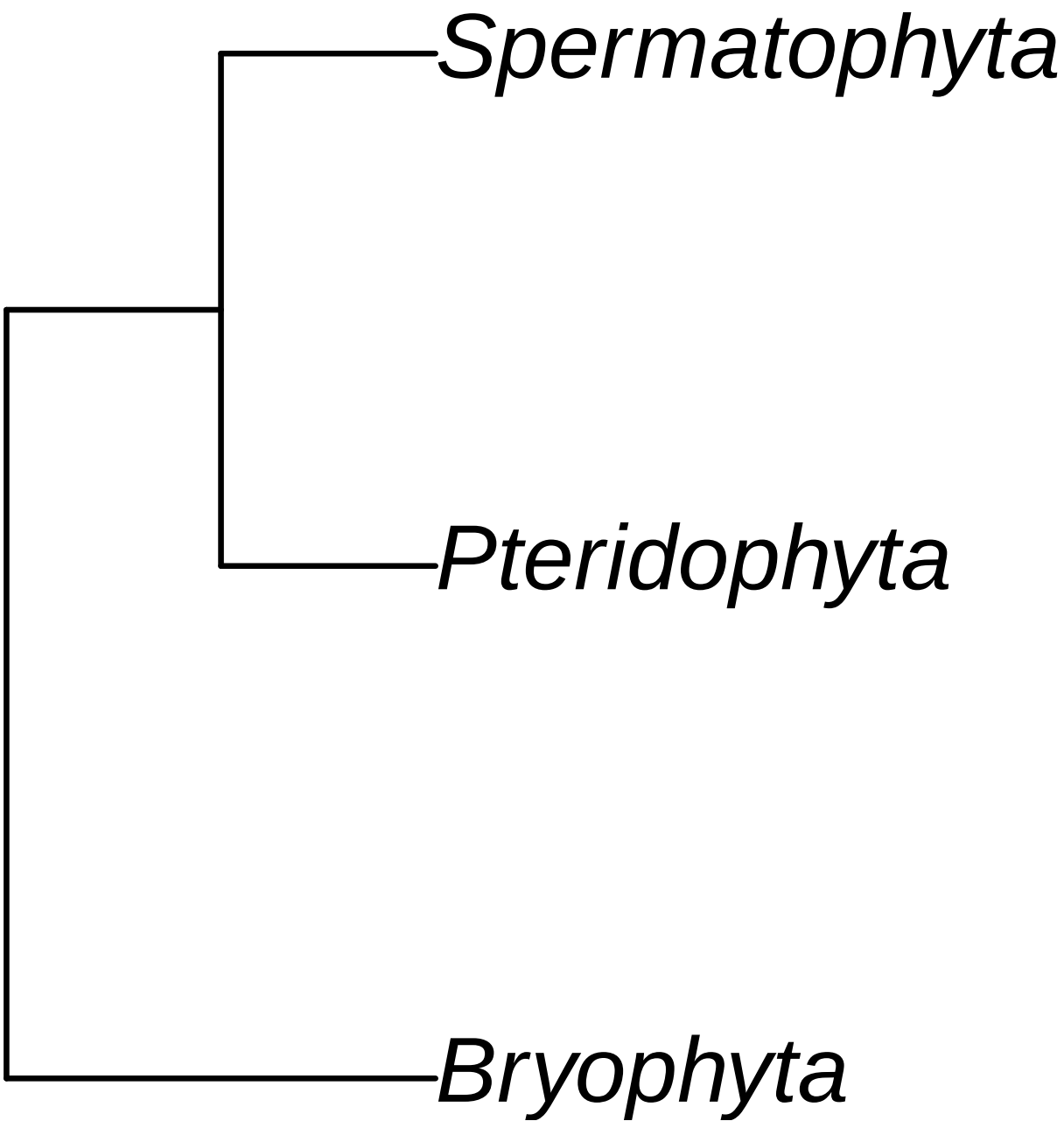
- **Pteridophyta**: ferns and allies (like clubmosses and horsetails)

  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



6 Genetics and inheritance

6.1 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

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] [From the lab]: Mendel's laws. http://en.wikipedia.org/wiki/Mendelian_inheritance

Outline

7 Where we are

7.1 Plants

Origin of tissues and organs of plants: first steps

- (a) Availability of light, (b) temperature-gases conflict and (c) ecological interactions "pushed" plants to land.
- Two first tissues, (1) isolating/ventilating compound epidermis and (2) photosynthetic/storage ground tissue were response to desiccation.
- Epidermis could be developed in advance as adaptation to spore delivery.
- Next stages: (3) supportive tissues to solve "Manhattan problem", (4) vascular tissues to transport water and sugars, (5) branching and (6) absorption tissues (or mycorrhiza) for water uptake.

Terms associated with origin of plants and their tissues

- *Thallus*: primary, pancake-like plant body (like in contemporary liverworts)
- *Epidermis* as a compound tissue which consists of (a) epidermal cells covered with cuticle, and (b) stomata
- *Stomata* are transpiration openings surrounded with *guard cells*
- Ground tissue
- Supportive tissues
- Shoot system is a result of branching
- Vascular tissues
- Absorption tissue, *mycorrhiza* (interaction with soil fungi) and 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)

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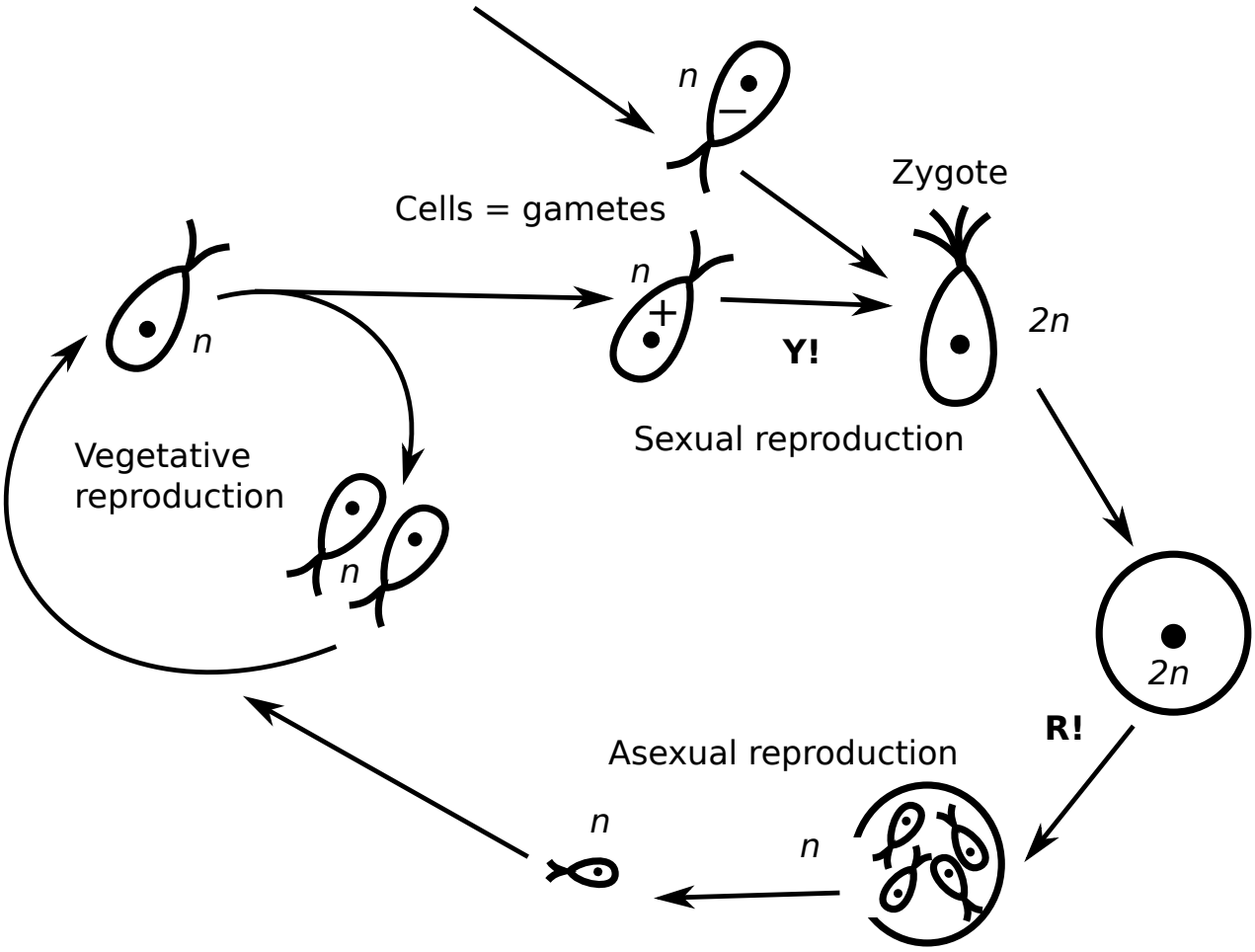
8 Genetics and inheritance

8.1 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 recombination, 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

Life cycle of unicellular organism



Terms associated with 1-cell life cycle

- mitosis, **meiosis** (R!), **syngamy** (Y!)
- result of syngamy: **zygote**
- participant of syngamy: **gamete**
- smaller gamete: **male**, bigger gamete: **female**
- movable male gamete: **spermatozoon** (**sperm**), motionless female gamete: **oocyte** (**egg cell**)
- results of meiosis: **spores**
- **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: $2n \longrightarrow n + n$

Definition of meiosis

- **The goal of meiosis** is to counterbalance the syngamy
- Since DNA is *already duplicated*, meiosis goes in two stages: XX $\longrightarrow$ X + X $\longrightarrow$ I + I + I + I
- Meiosis changes genotype of cells because: (1) chromosomes are **recombined** and (2) chromosomes exchange their genetic material

Stages of meiosis

- First division: reductive part
  - Prophase I: homologous chromosomes form pairs (**synapses**) and start to exchange DNA (**crossing-over**)[1]
  - 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

9 Genetics and inheritance

9.1 Gregor Mendel

Pea

- Self-pollinated: to cross, one needs to pollinate it artificially
- Contrasting characters (flower color, seed coat color, seed coat surface, plant height, pod wall color etc.)
- Pure lines: always produce the same characters

First and second generations

- First: all the same
- Second: 3/4 like one parent and 1/4 like another parent

[1] See later.

Theory and explanation

- Two different factors (variants of one character): *two variants (**alleles**) of one **gene***
- Factors are paired in plant but separated in gametes: *meiosis*
- One factor is dominant: *one variant is working DNA, the other is not*

Genes and characters

- Genotype and phenotype
- Homozygous and heterozygous plants
- 3/4 and 1/4 is the result of **combining probabilities**

Summary

- Plant body and its tissues is the result of adaptation for the life on land
- The life cycle is the sequence of events between two syngamies
- Gender is the result of division of labor between two gametes: female gametes invest in resources whereas male invest in numbers
- Mendelian (classic) genetics is based on (1) segregation, (2) dominance and (3) independent assortment

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`

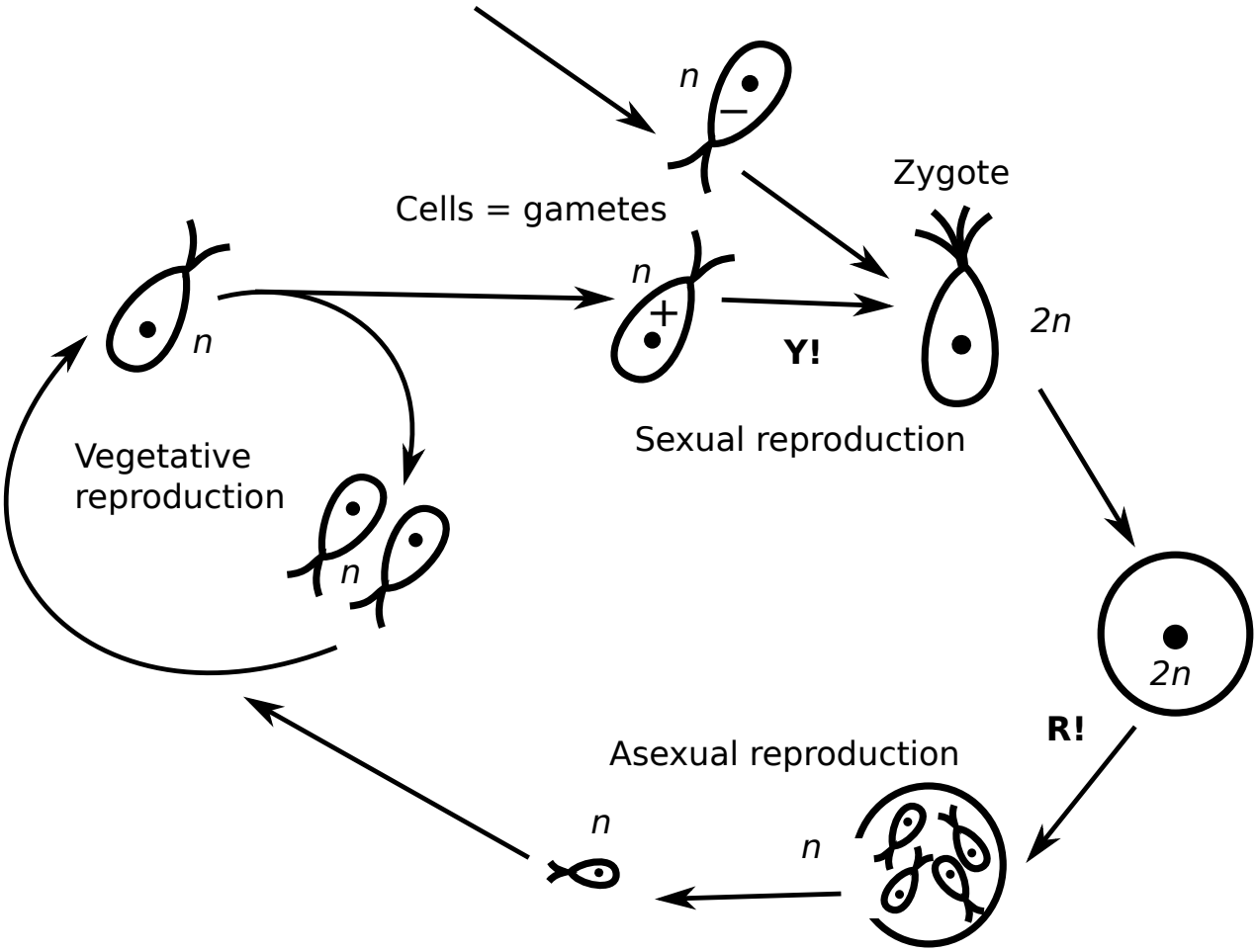
[3] [From the lab]: Mendel's laws. `http://en.wikipedia.org/wiki/Mendelian_inheritance`

Outline

10 Where we are

10.1 Inheritance

Life cycle of unicellular organism



The goal of meiosis (R!) is to counterbalance the syngamy (Y!)

Mendel's peas: one character, 1st and 2nd generations

- Parents: pure lines
- First: all the same
- Second: 3/4 like one parent and 1/4 like another parent

Check also the "Genetics and Inheritance" lab materials.

11 Genetics and inheritance

11.1 Mendel, peas and life cycle

Mendel's peas: 2 characters, 1st and 2nd generations: theory and explanation

- 1st generation all the same: genes are paired (*diploid*); there are two variants (*alleles*) of each gene, one is working (*dominant*), another (*recessive*) is not; in 1st generation they mixed (*heterozygous*) and only dominant effects are visible in *phenotype*; recessive are visible only if they doubled (*homozygous*)
- Second generation: 9/16 like one parent, 1/16 like another parent, and two groups (3/16 and 3/16) with *new combinations* of characters—**recombinants**: when genes separate in haploid gametes, they *recombine freely*, so after fertilization, they mix in 16 new combinations (*genotypes*) which make 4 phenotypes

- *Genes recombine freely* because genes from different chromosomes separate between gametes independently in the *anaphase I of meiosis*

Gregor Mendel discovered genes, chromosomes and meiosis "on paper", not knowing cell division and without microscope!

Anaphase I and recombinants

Imagine that parent is fully heterozygous, like in Mendel's first generation. It has red flowers (Rr) and long stems (Ll), the whole genotype is then "RrLl".

There are **two possibilities** in the anaphase I:

A. Either "R-chromosome" and "L-chromosome" come to one pole (consequently, "l-chromosome" and "r-chromosome" to other pole)

B. Or "R-chromosome" + "l-chromosome" come one way, and "r-chromosome" + "L-chromosome" another way

Each variant has 1/2 (50%) probability, like in throwing a coin.
Four gamete types are possible:

A. RL

B. rl

C. Rl

D. rL

Four gametes give 16 combinations (**check it yourself** with Punnett square). As R and L are dominant, only 4 phenotypes appear (again, **check it yourself**), and 2 of them are **recombinants**, phenotypes unlike parents.

Peas and life cycle

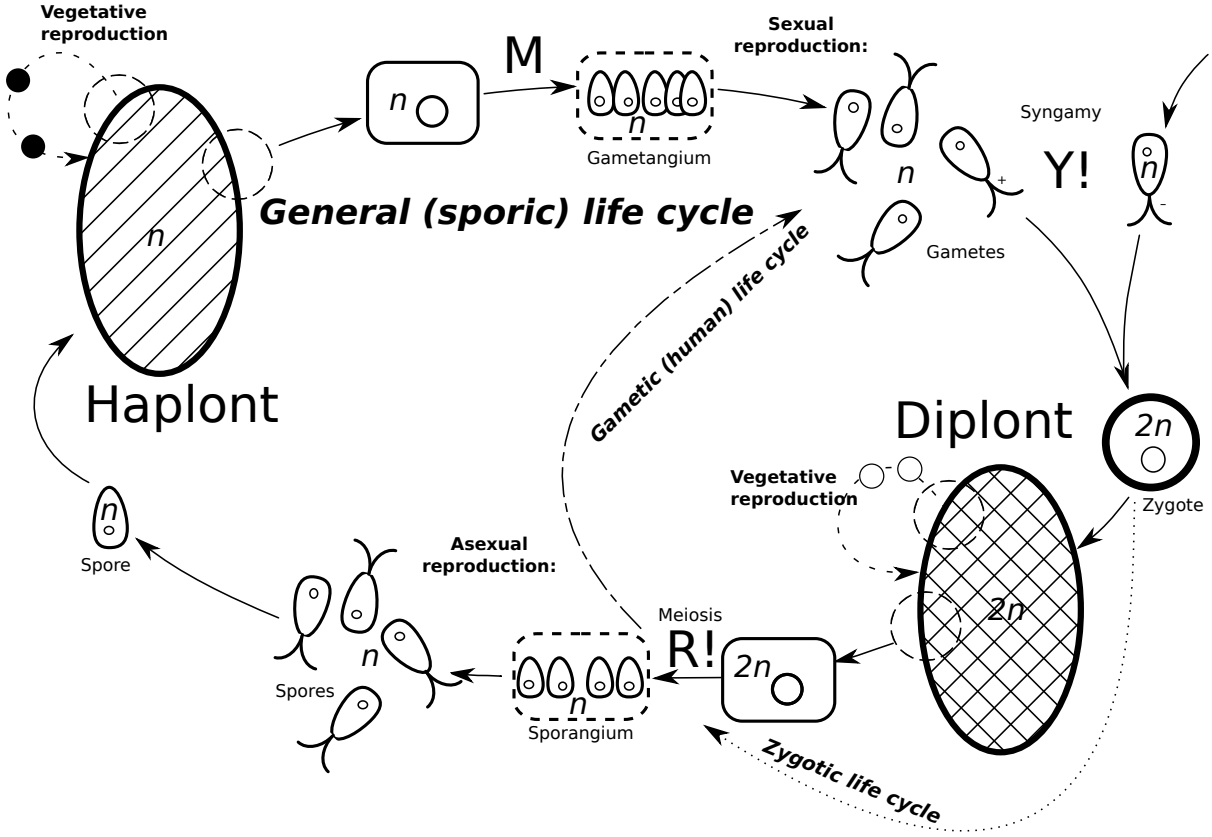
- Mendel "saw" genes mixed, segregated and then immediately mixed/recombined again
- In life cycle above, they are segregated, then mixed/recombined and immediately segregated again

This is because for multicellular organism, diploid condition is better. Since not all genes are strictly dominant, then:

- Diploids are broader adapted, due to two variants of gene
- If one copy breaks (mutation), the other still works

There are other pluses as well.

Life cycle of multicellular organism



Terms associated with multicellular life cycles

- mitosis, meiosis (R!), syngamy (Y!)
- vegetative reproduction (cloning), sexual reproduction and asexual reproduction
- result of syngamy: zygote; participant of syngamy: gamete
- smaller gamete: male, bigger gamete: female; movable male gamete: spermatozoon (sperm), motionless female gamete: oocyte (egg cell)
- result of meiosis: spores
- **haplont** (plants: **gametophyte**) and **diplont** (plants: **sporophyte**)
- **sporic** life cycle (like in plants), **gametic** life cycle (like in animals) and **sporic** (only protists)
- sporic: **gametophyte dominance** (mosses) and **sporophyte dominance** (ferns and seed plants)

12 Inheritance

12.1 Genes and chromosomes

Thomas Hunt Morgan and fruit fly

- Grey with normal wings × black with reduced wings: in first generation, all same (gray normal) but in second generation only two groups: 3/4 gray normal and 1/4 black reduced!

- BUT if you count thousands of fruit flies, few recombinants may be found
- WHY?

Linkage and crossing-over

- If genes are located in the same chromosome, they are **linked** and will not be inherited independently
- However, linkage could be broken in **crossing-over** (it runs in prophase I of meiosis)

Sex and chromosomes

- One gender has the pair where chromosomes are non-equal
- Deviating chromosome is sex chromosome, it contains small number of genes
- Two variants are possible: XY (mammals, fruit fly, ginkgo tree) and ZW (birds, butterflies)
- In both cases, sexes are always 1:1
- The gender where chromosomes are equal often has the second chromosome inactivated (i.e., Barr body in human female cells)
- The gender where chromosomes are non-equal is more susceptible to mutations because all mutations in main chromosome will be manifested (it has no counterpart)

Summary

- Plant body and its tissues is the result of adaptation for the life on land
- The life cycle is the sequence of events between two syngamies
- Gender is the result of division of labor between two gametes: female gametes invest in resources whereas male invest in numbers
- Mendelian (classic) genetics is based on segregation, dominance and independent assortment

For Further Reading

References

[1] Mendelian inheritance. `https://en.wikipedia.org/wiki/Mendelian_inheritance`

[2] Punnett square. `https://en.wikipedia.org/wiki/Punnett_square`

[3] Linkage. `https://en.wikipedia.org/wiki/Genetic_linkage`

[4] Sex chromosomes. `https://en.wikipedia.org/wiki/Sex_chromosome`

13 Movies

- BBC: Life on Earth, `https://en.wikipedia.org/wiki/Life_on_Earth_(TV_series)`. Episode 3. The First Forests.
- BBC: Walking with Monsters, `https://en.wikipedia.org/wiki/Walking_with_Monsters`. Episodes 1–3.