4. Life cycles

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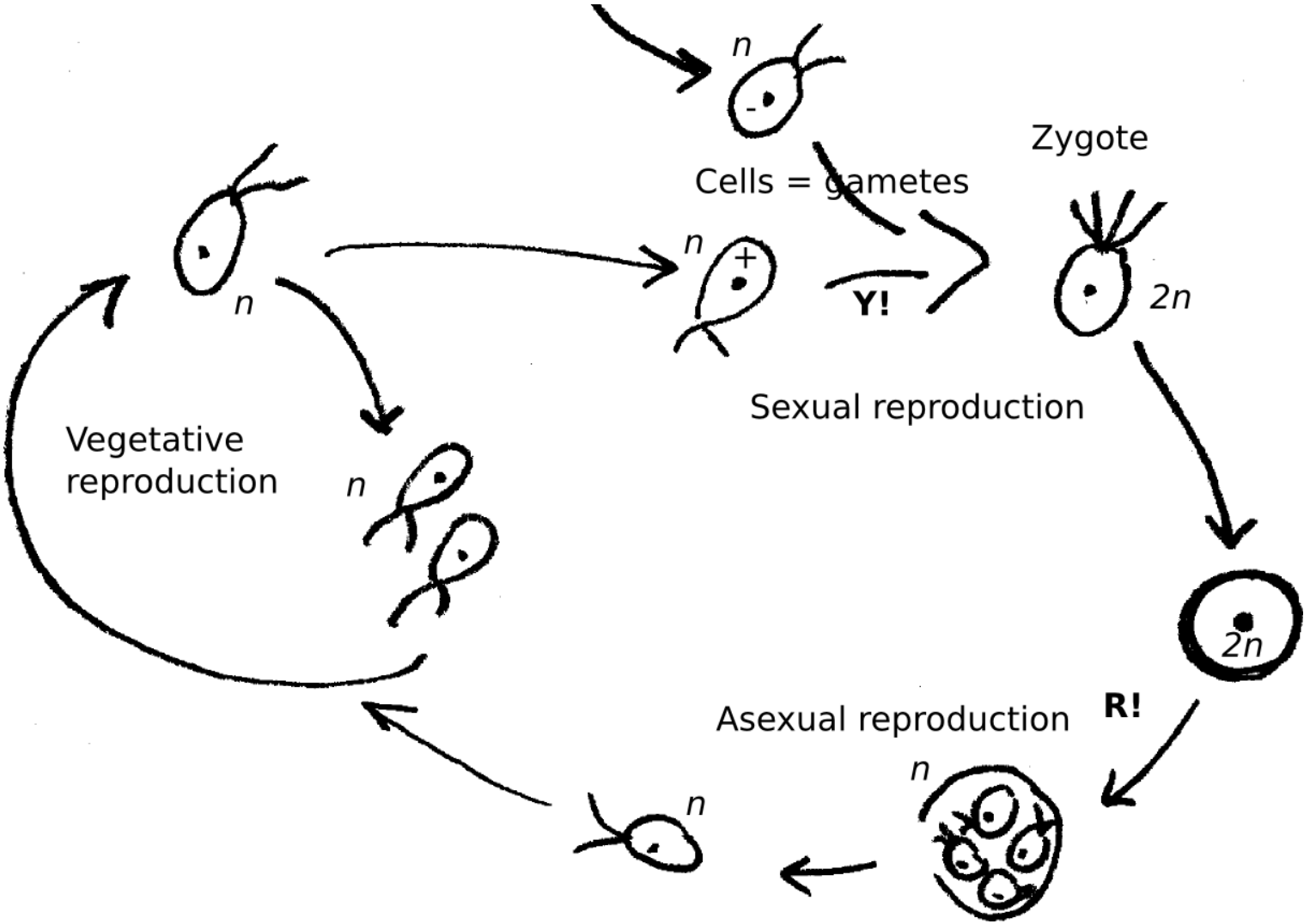
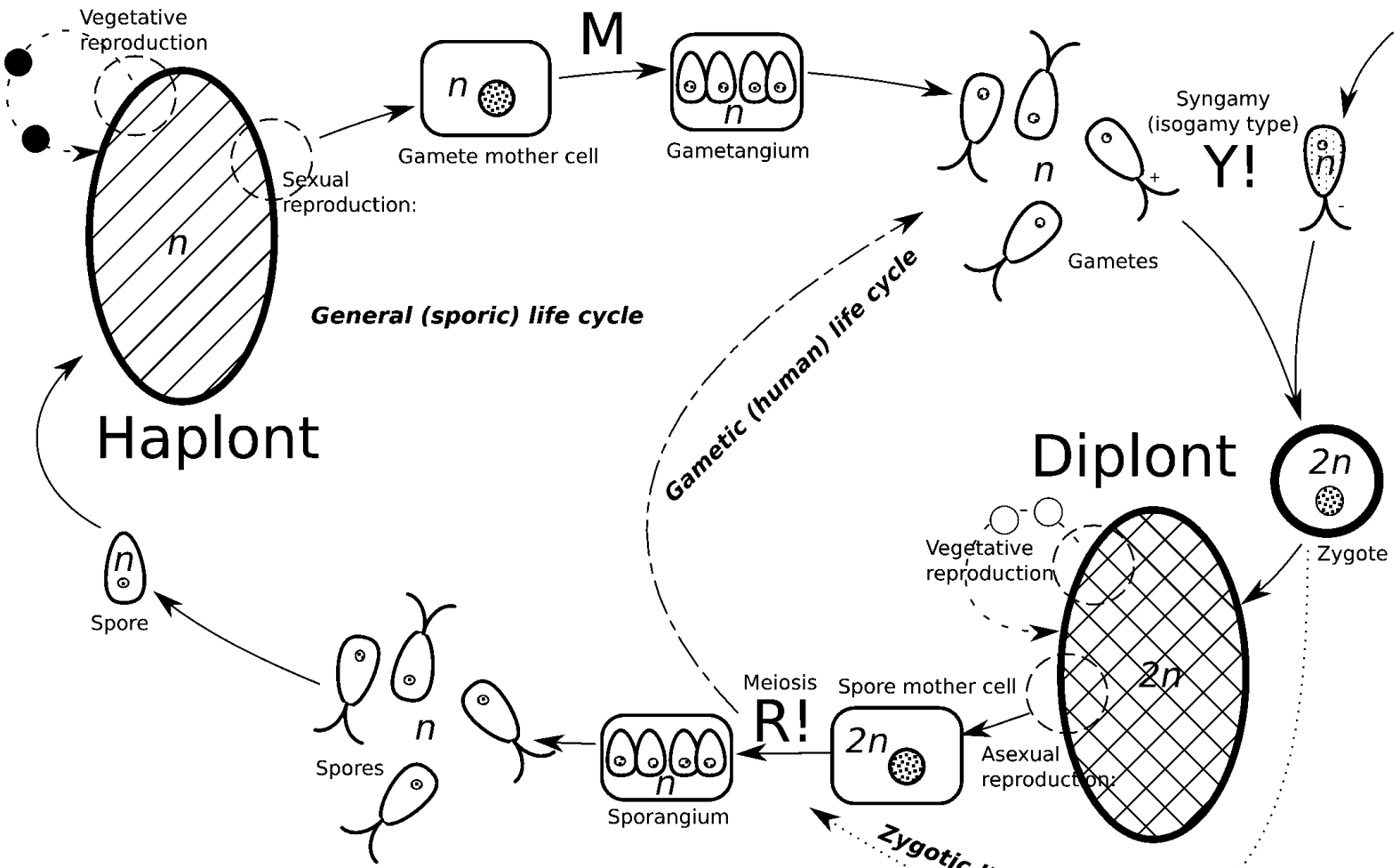
Outline

Simple life cycle (unicellular protist)

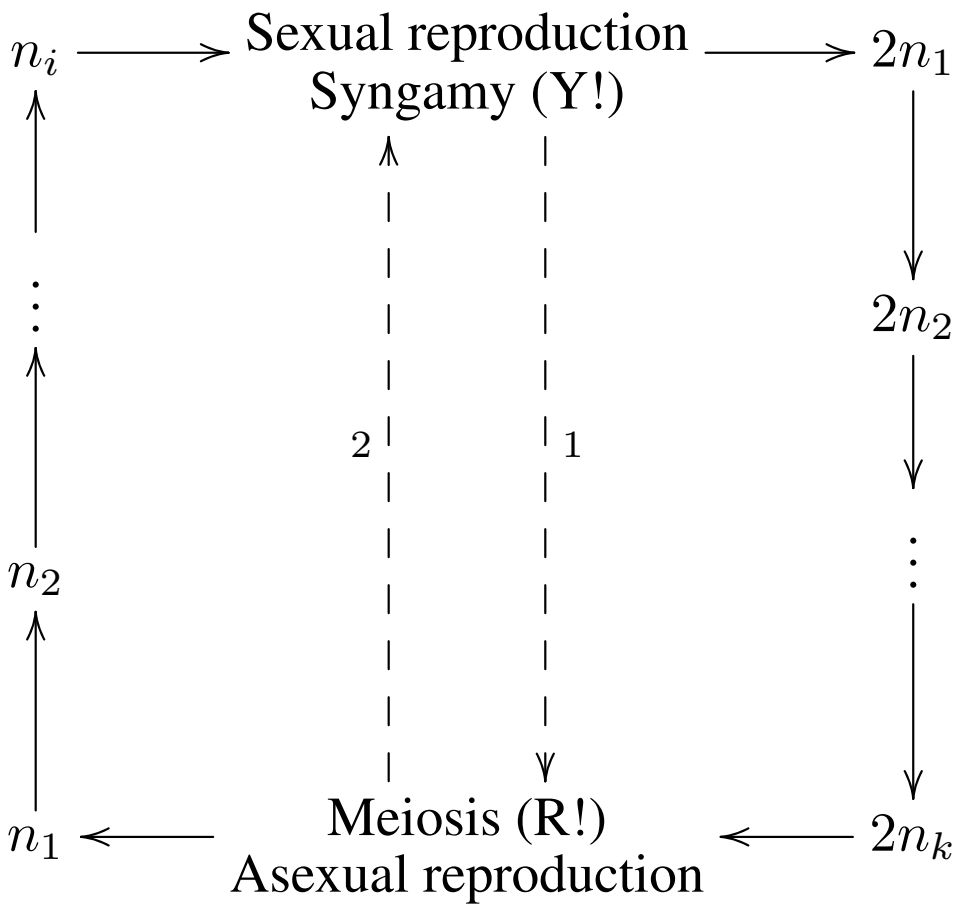


General life cycle



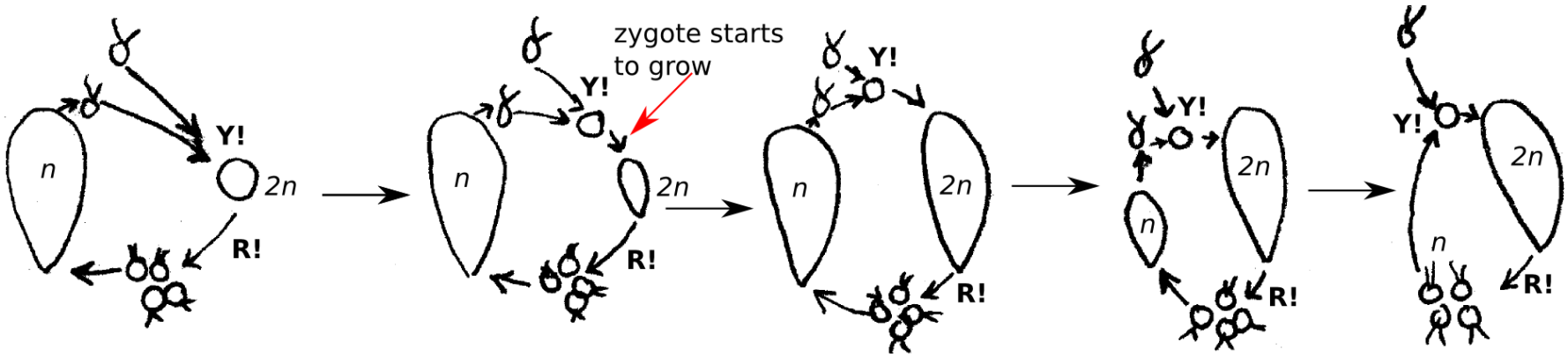
Eukaryote life cycles

Even more general life cycle



1 — zygotic cycle (Y!→R!);
2 — gametic cycle (R!→Y!).

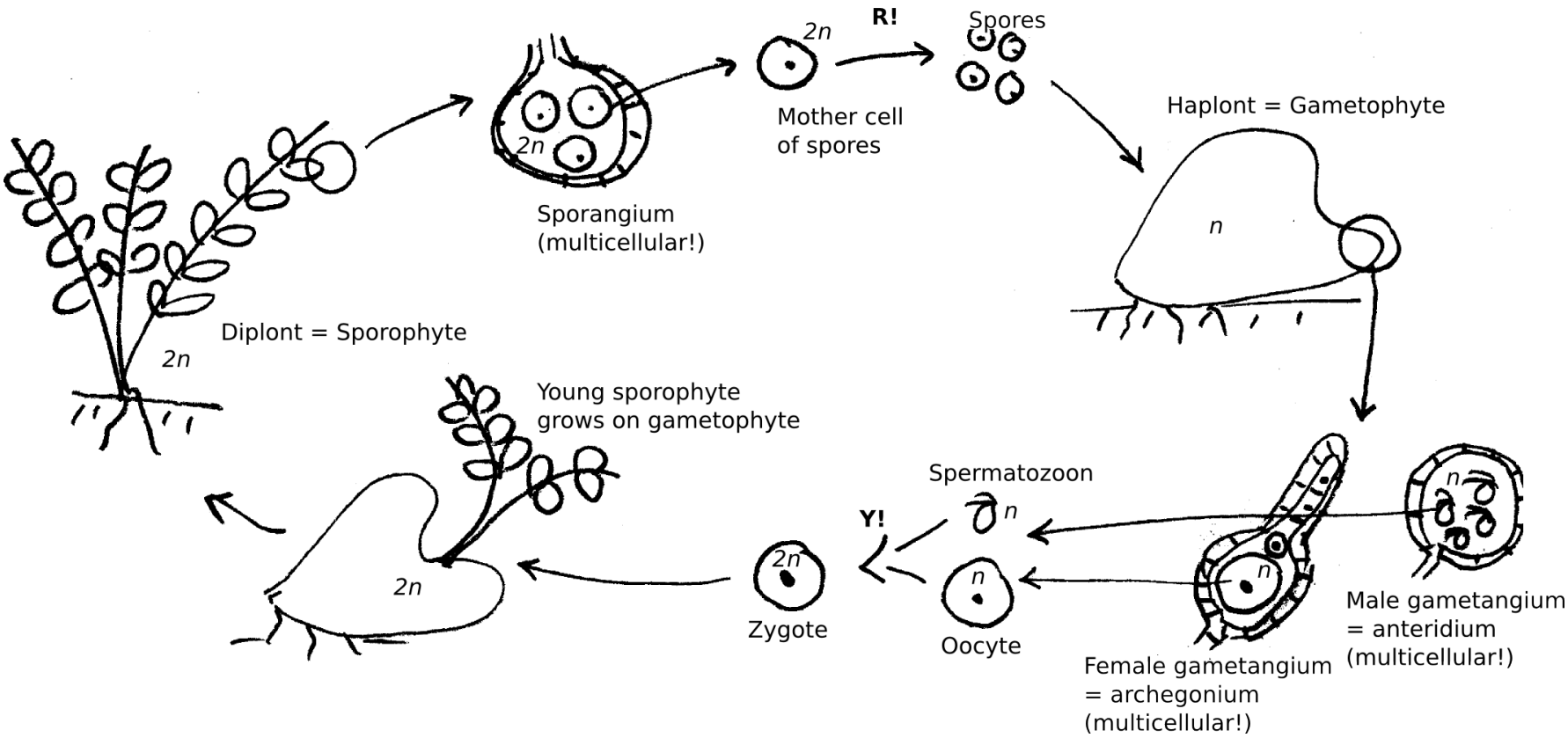
Evolution of life cycles from zygotic to gametic



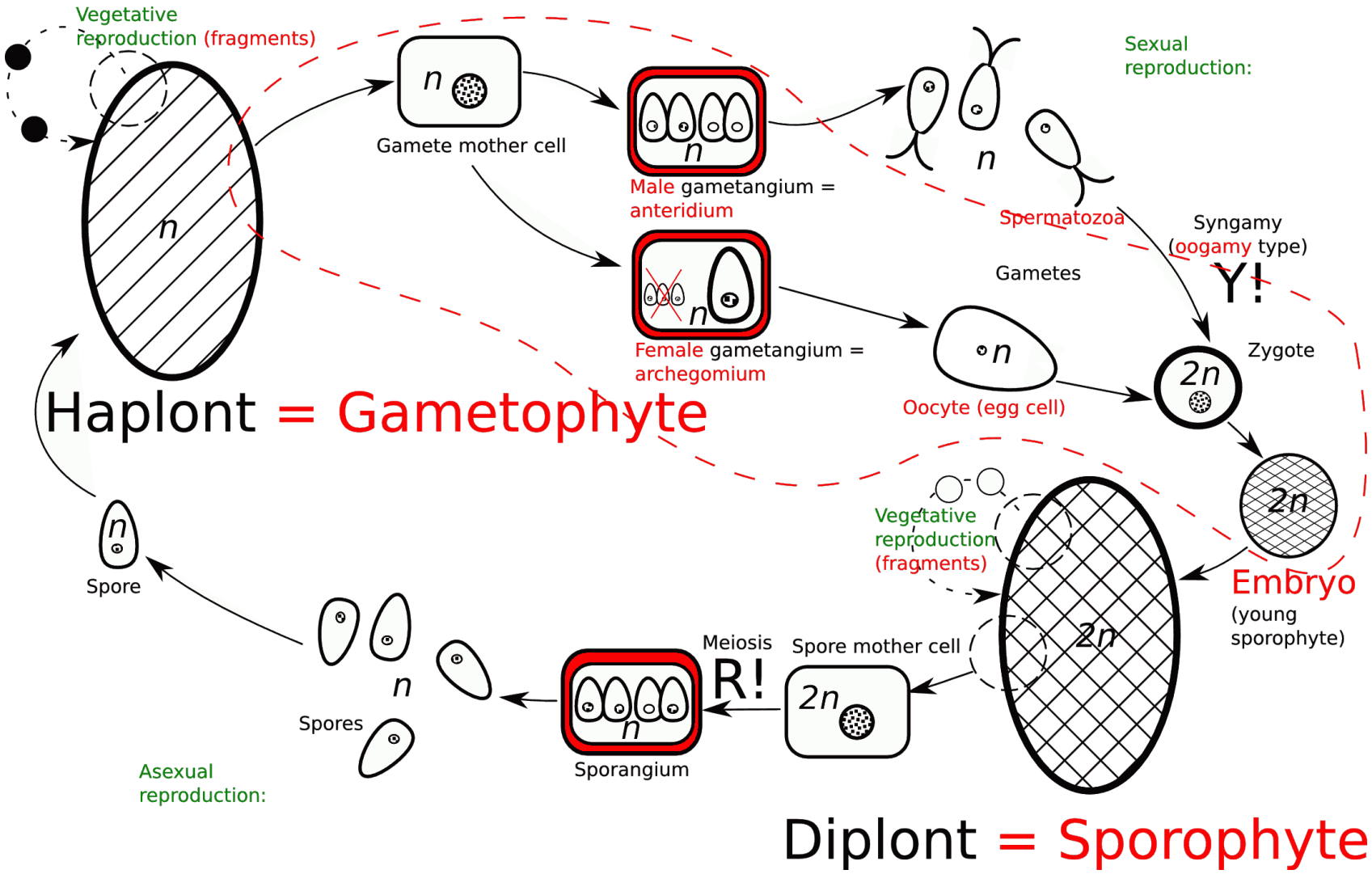
Directions of life cycle evolution

- The simplest life cycle of unicellular organism is the alternation of syngamy (cell fusion) and meiosis
- Next stage is a zygotic cycle of many algae and fungi
- When zygote starts to divide without changing genotype, sporic life cycle arises
- Initial sporic cycle was probably with haplont dominance (mosses), then with equal generations
- Advanced sporic cycle is with diplont predominance (ferns and seed plants)
- Finally, gametic cycle of animals and some algae in the final step of life cycle evolution

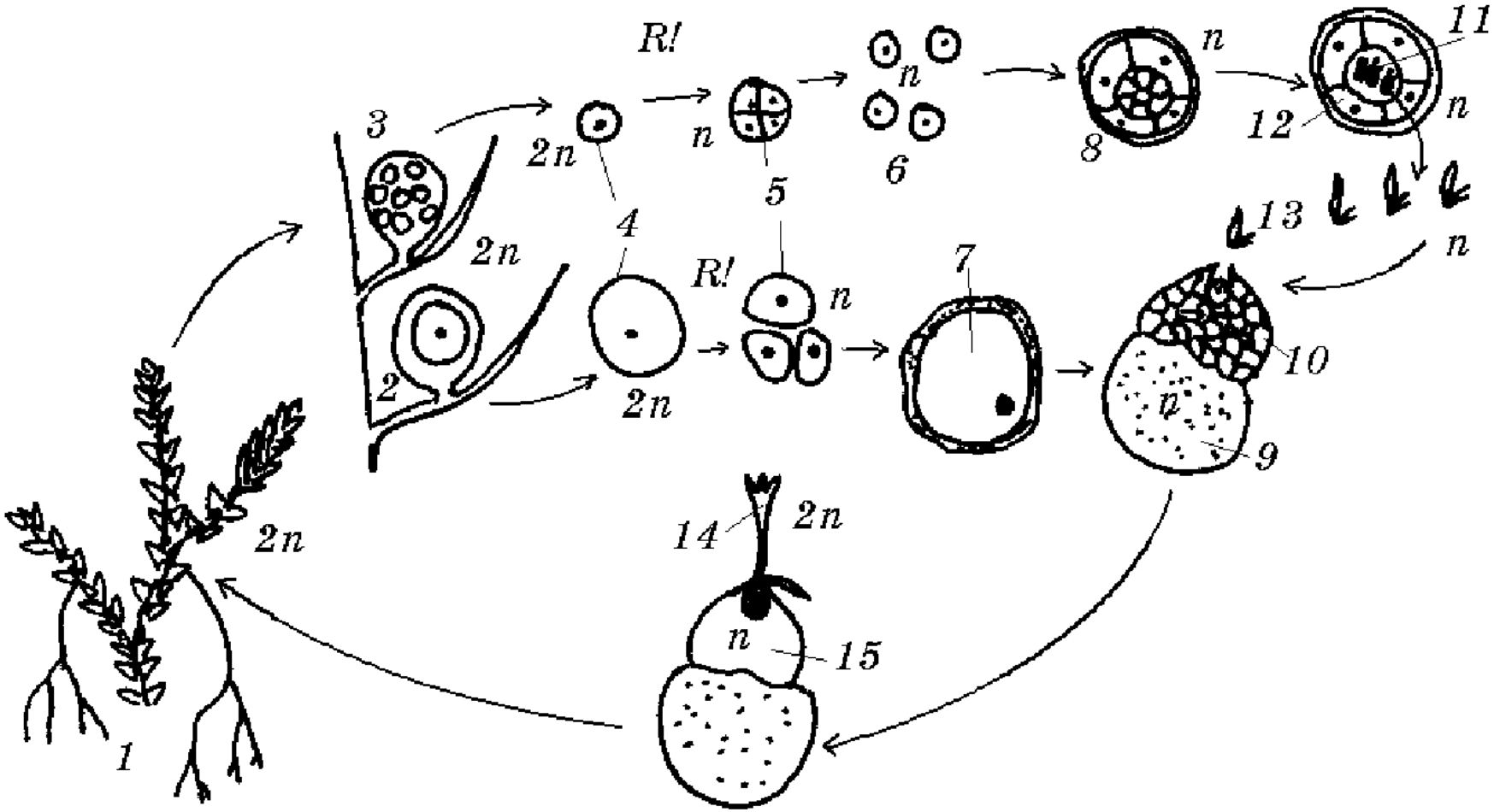
Life cycle of land plants from fern viewpoint



Life cycle of land plants: differences from general



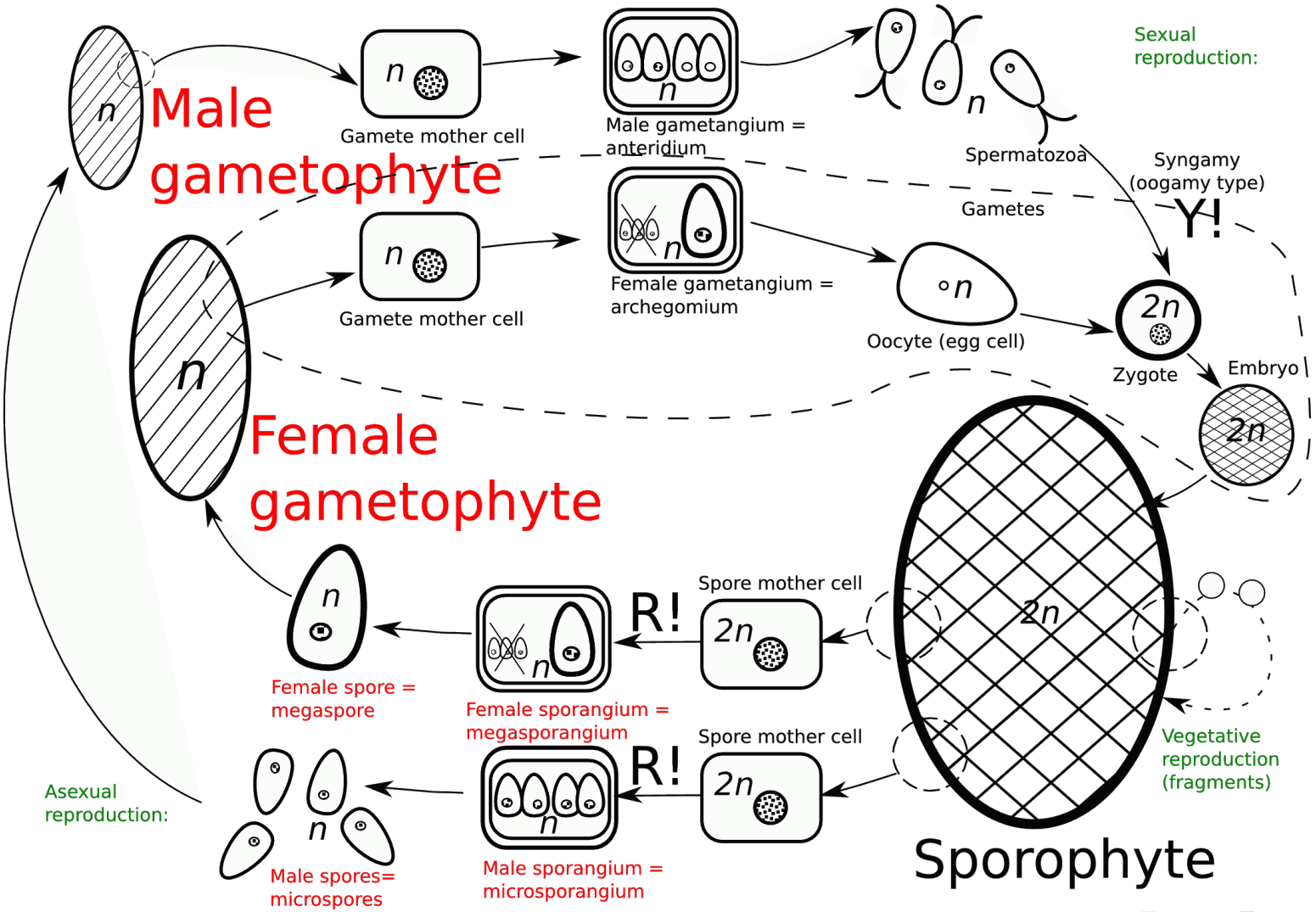
Heterosporic cycle from *Selaginella* viewpoint



Heterosporic cycle from *Selaginella* viewpoint: labels

1 Sporophyte; 2 female sporangium; 3 male sporangium; 4 mother cells of male and female spores; 5 spores after meiosis; 6 male spores; 7 female spore; 8 male gametophyte; 9 female gametophyte; 10 archegonium (female sexual organ); 11 sperms; 12 anteridium (male sexual organ); 13 sperms in outer space; 14 young sporophyte (note it is located on female gametophyte as a “parazite”); 15 female gametophyte

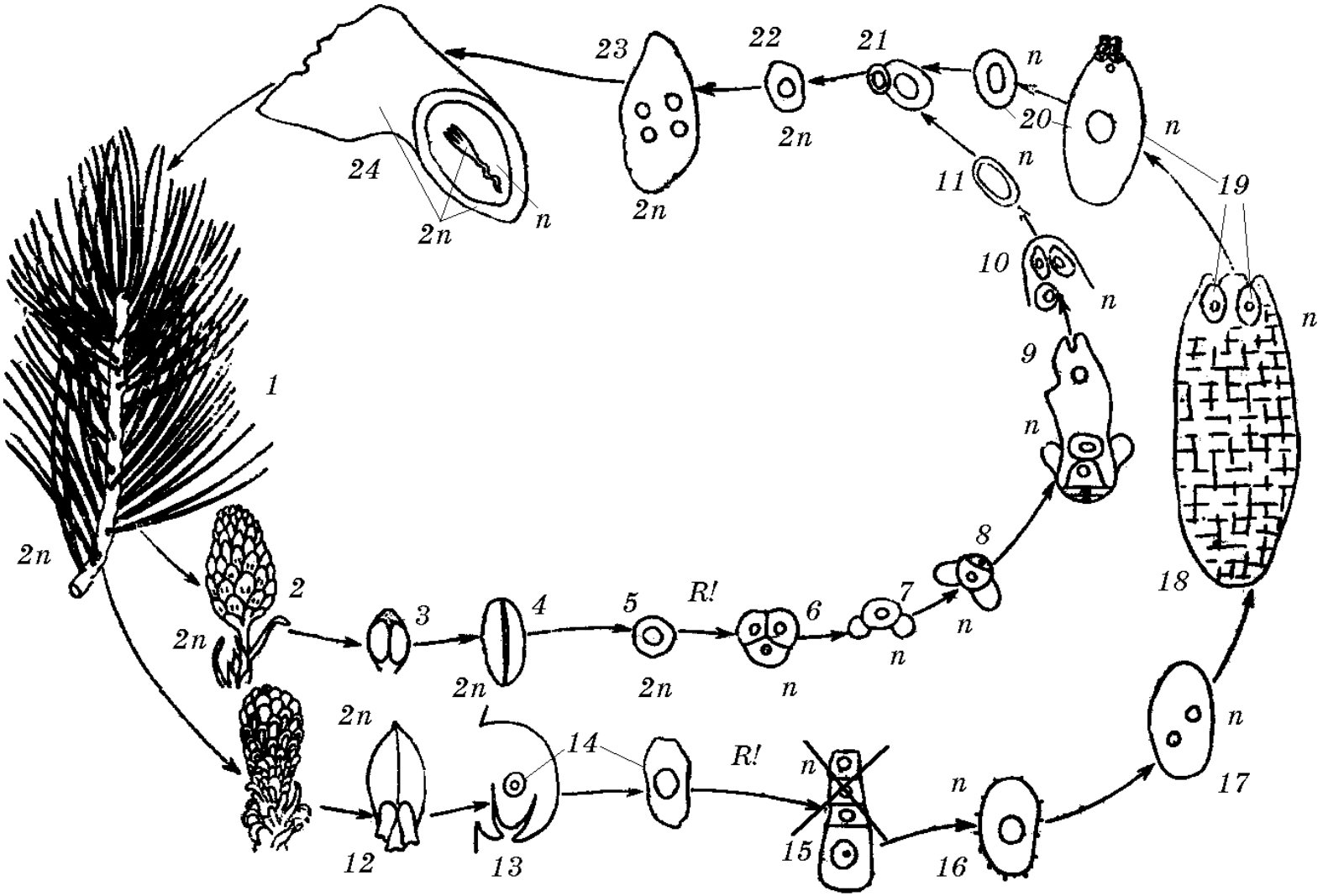
Heterosporic cycle: differences from generalized land plants cycle



Origin of seed

- **Seed is the result of enforced control of sporophyte over gametophyte**
- **Dinosaur problem:** without control on the *r*-strategic gametophyte, *K*-strategic tree sporophyte cannot guarantee its reproduction
- Growing of gametophytes, syngamy (fertilization) and growing of daughter sporophyte—everything happens **right on mother sporophyte**
- Seed is a **chimeric organ** with three layers: (1) mother sporophyte tissue (integument + nucellus), (2) female gametophyte tissue (endosperm) and (3) daughter sporophyte (embryo)
- Biggest disadvantages of having seed are: (a) low probability of fertilization (pollination needed) and (b) overall slowness of cycle

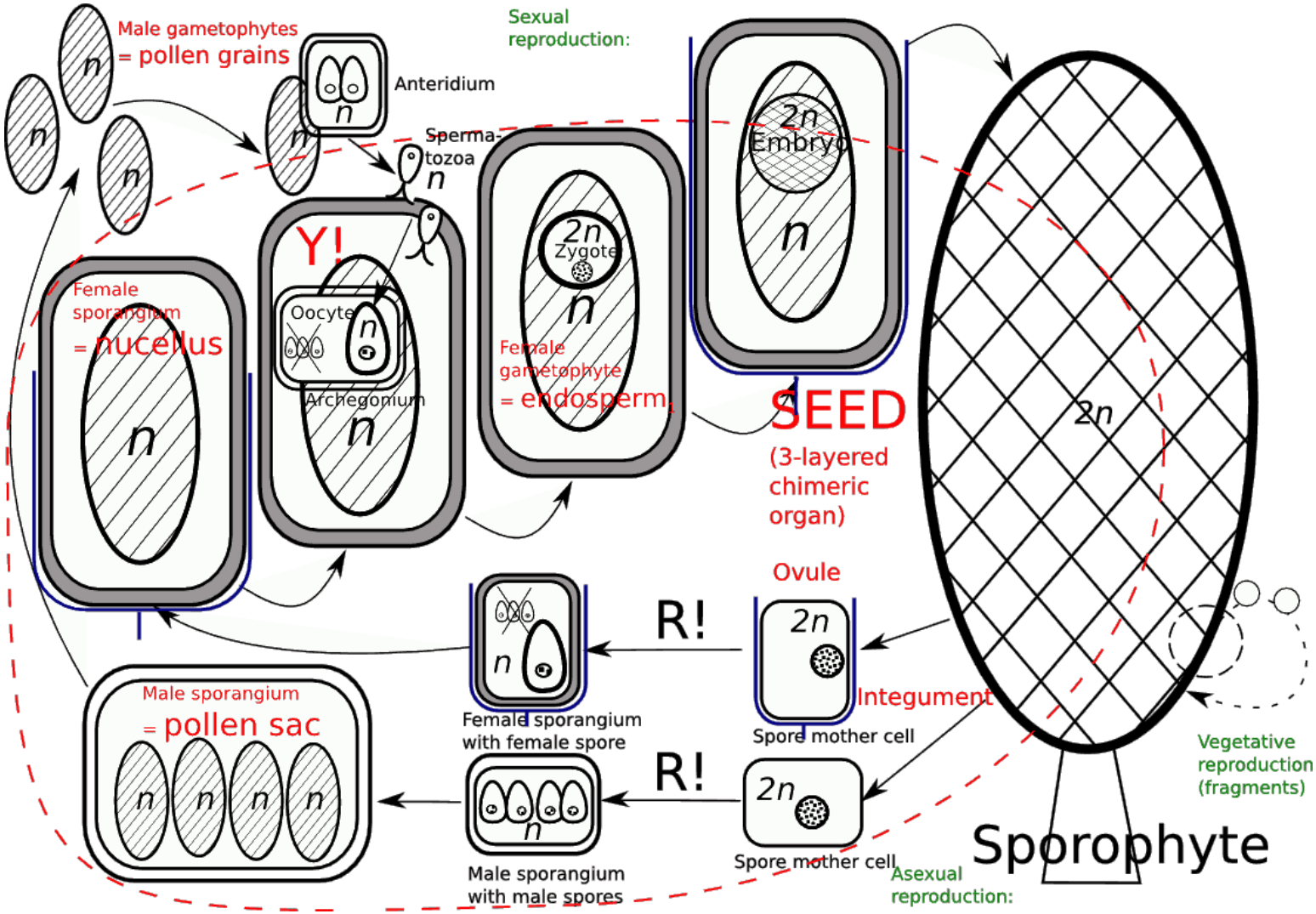
Life cycle of seed plants from the pine tree viewpoint



Life cycle of seed plants from the pine tree viewpoint: labels

1 Sporophyte; 2 male cone; 3 sporophyll (leaf bearing sporangia); 4 male sporangium (anther); 5 mother cell of male spores; 6 male spores after meiosis; 7 male spore with two floating sacs; 8 male gametophyte (pollen) with two floating sacs; 9 pollen tube; 10 tip of pollen tube with two spermatia (immotile sperms) and nucleus of tube cell; 11 spermation; 12 female sporophyll; 13 ovule (female sporangium); 14 mother cell of female spores; 15 female spore after meiosis; 16 female spore; 17 young endosperm$_1$ (female gametophyte); 18 mature endosperm$_1$ (female gametophyte); 19 archegonia (female sexual organs); 20 egg cell inside archegonium; 21 fertilization; 22 zygote; 23 young embryo; 24 seed = seed coat ($2n$) + endosperm$_1$ (n) + embryo ($2n$)

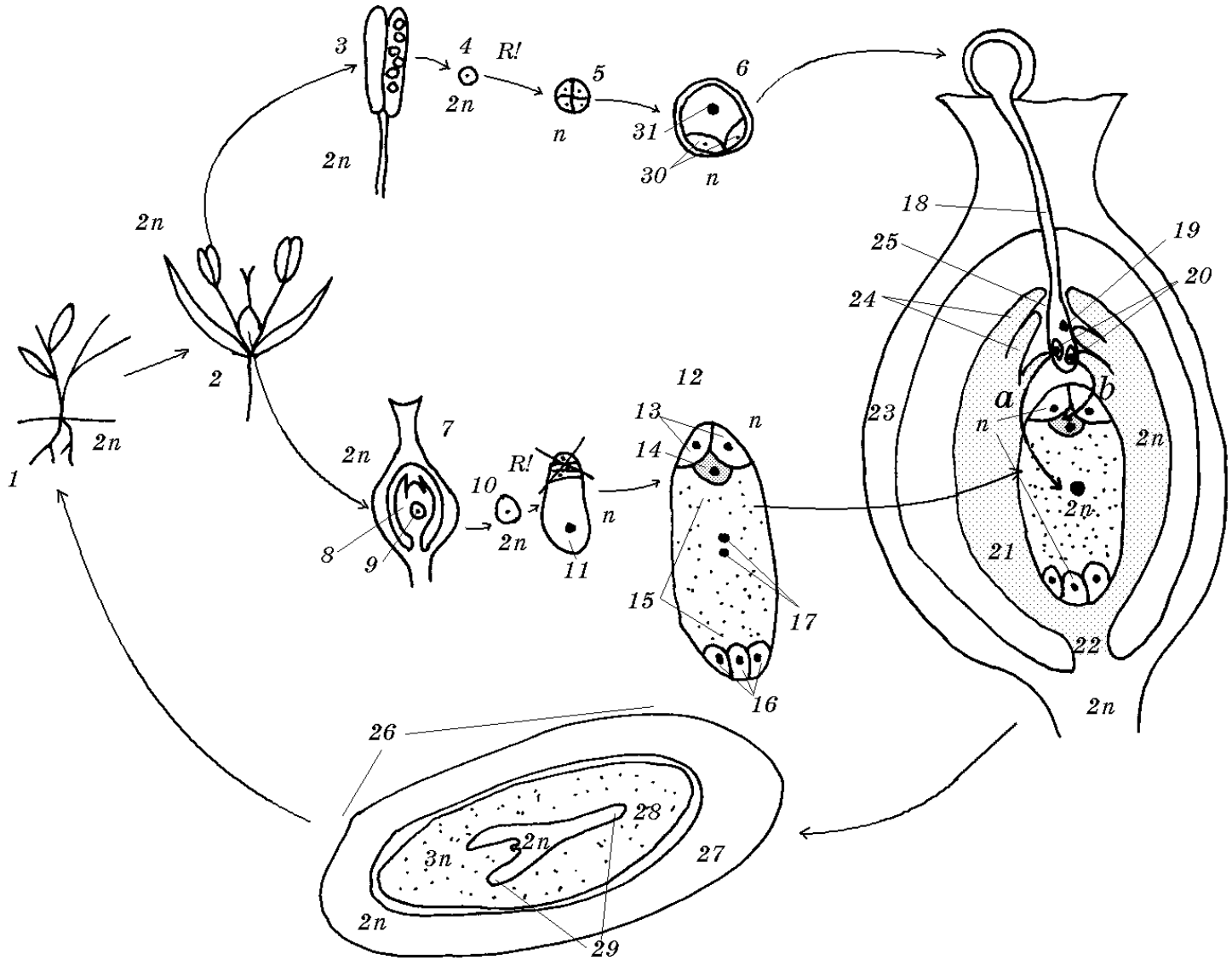
Life cycle of seed plants: differences from heterosporic



Life cycle of angiospems: differences

- Reduction of gametophyte: 3-celled pollen and 7-celled embryo sac
- No archegonia and anteridia
- Spermatia (immotile sperm cells), pollen tube
- Double fertilization:
  1. Sperm_1 (n) + Egg cell (n) = Zygote ($2n$) $\rightarrow$ Embryo (young sporophyte)
  2. Sperm_2 (n) + Central cell ($2n$) = Mother cell of endosperm_2 ($3n$)
- New endosperm_2 (literally, it is a second embryo; in other seed plants, endosperm_1 is a female gametophyte)
- Cupule (pistil) and fruit
- In general, **angiosperms have accelerated life cycle** needed for fast-growing herbs

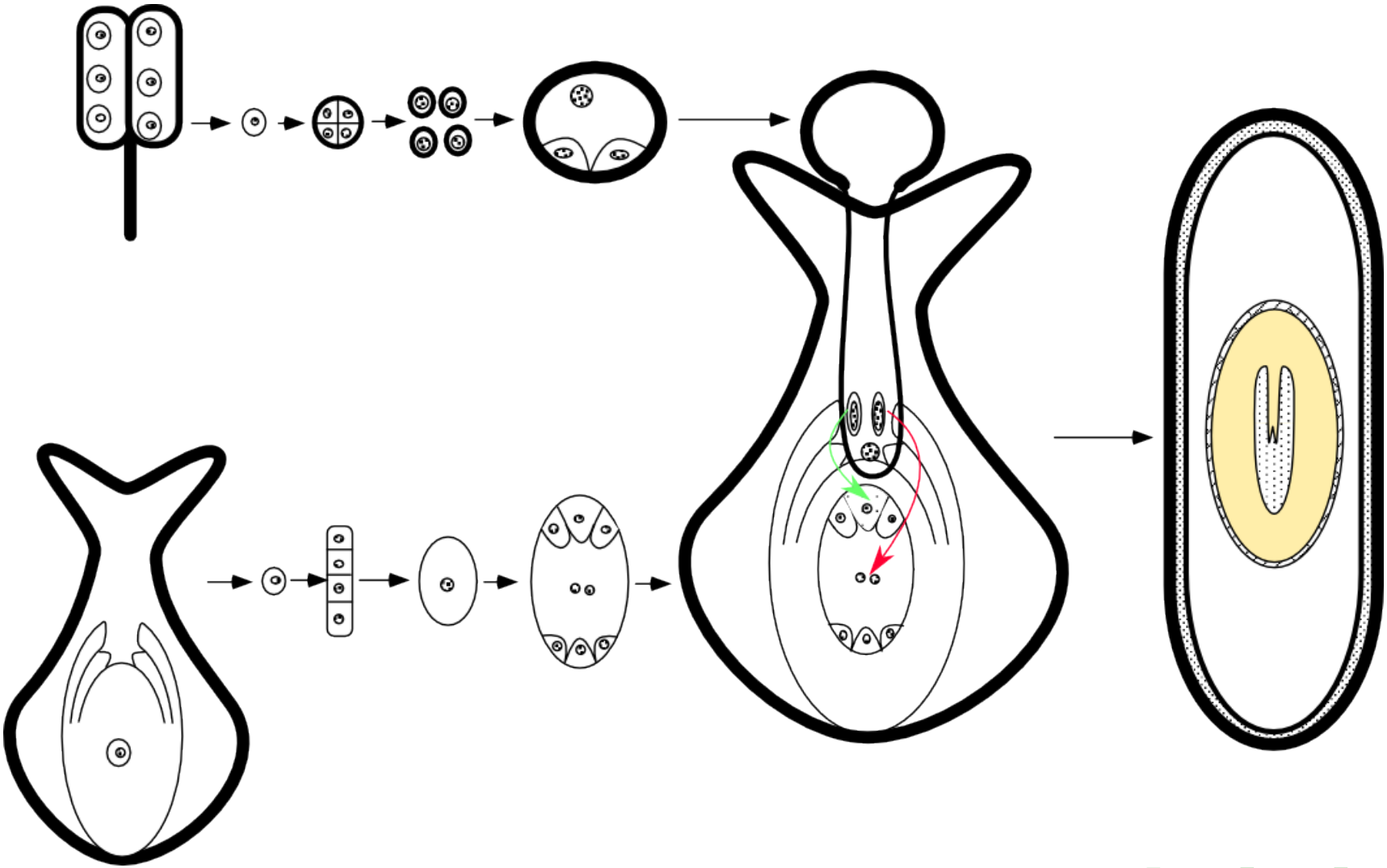
Life cycle of angiosperms



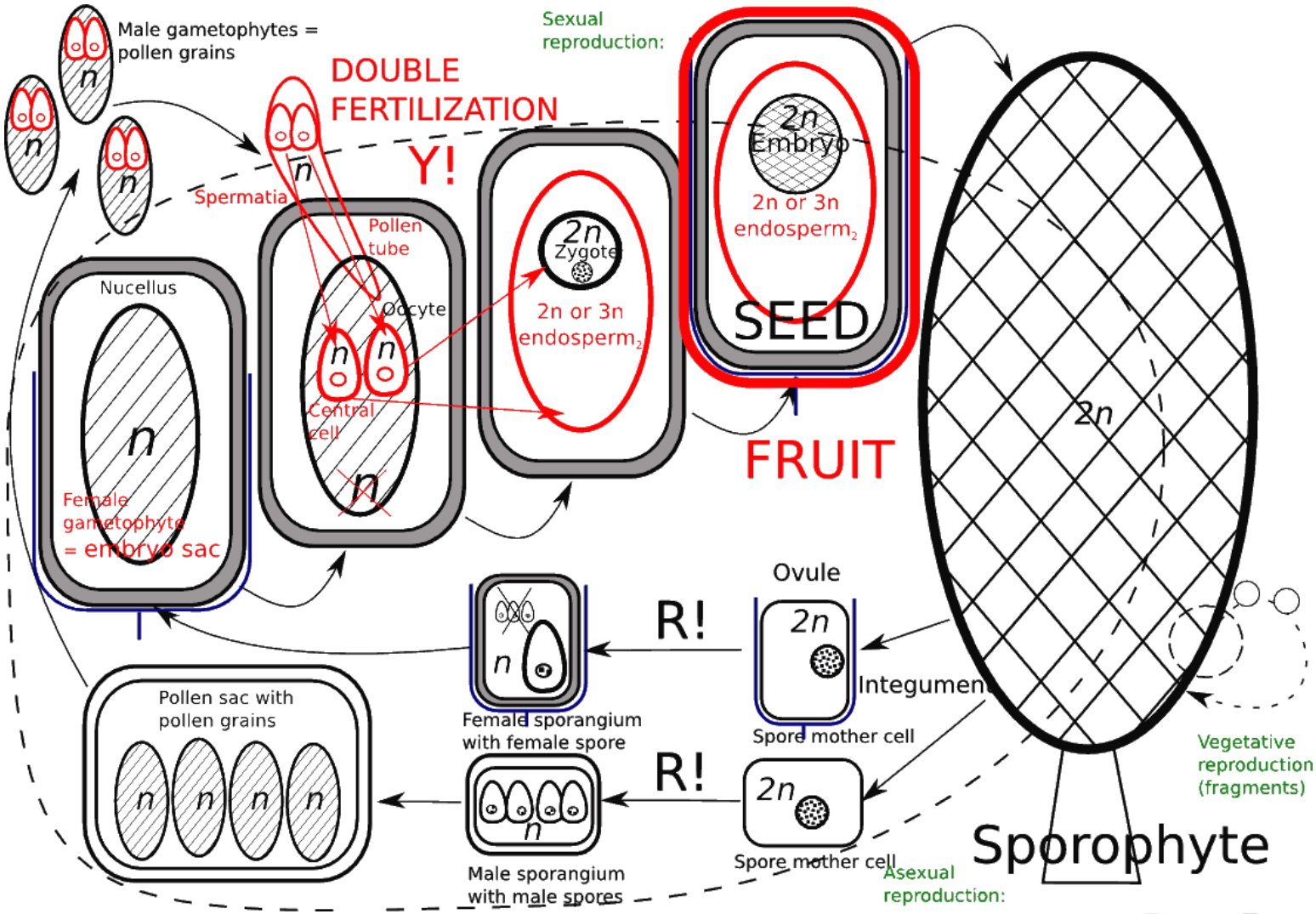
Life cycle of angiosperms: labels

1 sporophyte; 2 flower; 3 anther (male sporangium); 4 mother cell of male spores; 5 meiosis; 6 pollen (male gametophyte); 7 pistil; 8 ovule (female sporangium); 9 mother cell of female spores; 10 mother cell of female spores; 11 female spore; 12 embryo sac (female gametophyte); 13 synergides; 14 egg cell; 15 central cell; 16 antipodes; 17 central nuclei; 18 pollen tube; 19 tube cell; 20 sperms; 21 nucellus (wall of female sporangium); 22 chalasa (receptacle of the ovule); 23 pistil wall; 24 integuments (ovule entrance lobes); 25 micropyle (ovule entrance); 26 fruit; 27 pericarp (fruit flesh, from pistil wall); 28 endosperm$_2$; 29 embryo (young sporophyte)

Life cycle of angiosperms: relations between structures



Life cycle of angiosperms: differences from more primitive seed plants



Life cycle of angiosperms: sources of optimization

- Reduction of everything, especially of haploid stages
- Signal role of second embryo (source of endosperm$_2$)
- Well-developed pollination

Summary

- *Sporophyte* is a diplont of plants; *gametophyte* is a haplont
- Land plants have: (1) multicellular sporangia and gametangia, (2) vegetative reproduction via fragments, (3) oogamy and also (4) embryo—young sporophyte growing on gametophyte
- Mosses have sporic cycle with gametophyte predominance whereas ferns and seed plants—with sporophyte predominance
- Heterosporic plants have two kinds of spores: female (megaspores) and male (microspores)
- Seed plants have compact life cycle where almost all stages happen on mother sporophyte
- Angiosperms accelerated seed plant life cycle using (a) reduction, (b) signaling second embryo and (c) sophisticated pollination