A model for sporophyte development in the filamentous brown alga *Ectocarpus siliculosus*

Bernard Billoud[1], Aude Le Bail[2], Bénédicte Charrier[2]

(1) Université Pierre et Marie Curie - Paris 6, Atelier de BioInformatique, 12, rue Cuvier 75005 Paris, France.
(2) UMR7139, Station Biologique, CNRS, Université Pierre et Marie Curie, Place Georges Teissier, 29 682 Roscoff cedex, France.

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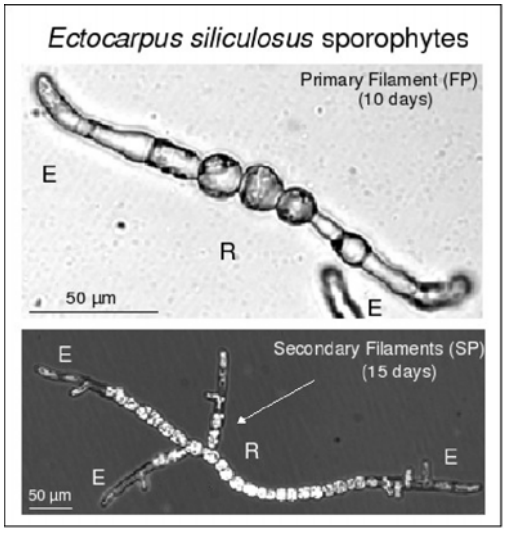
Background and biological model

Brown algae are marine multicellular plant organisms evolutionary very distant from land plants (Baldauf, 2003). *Ectocarpus siliculosus* (Dillw.) is a small brown alga, growing throughout the world in temperate areas (Müller, 1979). Its body architecture is filamentous (Ravanko, 1970). Molecular phylogeny showed that, despite its simple architecture, *Ectocarpus* belongs to the most evolved brown algae, with Laminariales ("giant kelps") and Fucales, both developing 3-D vegetative structures (parenchyma) (Draisma *et al*., 2003). Moreover, plasmodesmata differentiate, resulting in symplastic communications between adjacent cells (de Reviers, 2003) potentially involved in the establishment of integrated developmental mechanisms.



Sporophytes develop from an initial cell (spore, unfertilised gamete or zygote), which divides sequentially and uni-directionally to produce a uniseriate filament ("Primary Filament", PF) composed of two types of cells with different shapes and location: round cells (R), grouped by the centre of the PF, and elongated cells (E), found at the extremities. After a few more mitoses, changes in cell polarisation make cell division produce branches ("Secondary Filaments", SF), eventually leading to the formation of a basal and vegetative filamentous network. All basal filaments display the same general architecture. Growth is not apical, but intercalary and diffuse.

Results

Morphometric analyses carried out on the early stages of the sporophyte development (Le Bail *et al*., in prep) showed that the position of the SFs is neither precisely scheduled, nor a uniform random process. It appears to be linked with the distribution of the two kinds of cells. This distribution is for instance not canonical in ecotypes or mutants characterized by their unusual branching structure. The R/E-shaped cell pattern is also the primary target of the phytohormone auxin which leads to a change in the R/E ratio and to perturbations in the SF distribution. This pattern is thus a key feature for the subsequent branching structure development.

We studied the establishment of the R/E cell pattern as the result of two local processes: cell division and cell differentiation. Using an asynchronous cellular automaton, we modelled the development of a PF, starting from a unique, round cell, up to a 10-cell filament. The parameters (*ie* relative frequencies of division and differentiation events) were adjusted by a maximum-likelihood approach, in order to fit with the patterns actually observed during the first steps of PF growth, and their respective prevalence. This allowed us to predict which intermediary steps and transformations are the most likely to occur during the sporophyte development.

Conclusion and perspectives

Using morphometry and growth simulation, we described and quantified the cell-level processes involved in the whole individual morphology construction. Because of its growth in liquid medium, algal development might recruit different processes from land plant. These studies also aim at identifying which mechanistic process is modified in response to phytohormones and in morphological mutants.

References

Baldauf, S. L. The deep roots of eukaryotes. *Science* 13;300(5626):1703-6, 2003.

Draisma, S. G. A., Peters, A. F. and Fletcher, R.L. Evolution and taxonomy in the Phaeophyceae: effects of the molecular age on brown algal systematics. In: *Out of the Pas*t. Ed. T.A. Norton. *British Phycological Society*, pp. 87-102, 2003.

Müller, D. G. Genetic affinity of *Ectocarpus siliculosus* (Dillw.) Lyngbye from the Mediterranean, North Atlantic and Australia. *Phycologia* 18: 312-318, 1979.

Ravanko, O. Morphological, developmental and taxonomic studies in the *Ectocarpus* complex (Phaeophyceae). *Nova Hedwigia* 20:179-252, 1970.

Reviers, B. de. *Biologie et phylogénie des algues*. Tome 2. Paris : Belin, 255 p. ISBN 2-7011-3512-5, 2003.