FROM OLM AND IL MAP SYSTEMS
TO INDETERMINATE AND DETERMINATE GROWTH
IN PLANT MORPHOGENESIS

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ABSTRACT. Double wall map OLM systems (dwMOL systems) are used to simulate the
development of botanical organisms. Dw maps grow by half-wall segment substitution and
by insertion of new double structured walls. This insertion of division walls is in-
vestigated exhaustively by specification of all possible sets of segment productions.
(1) The case of segment parity between complementary half-walls : maps are characte-
rized by synchronous divisions of all regions (or cells). Such systems are able, e.g.,
to simulate the inception of leaves at the top of plant shoots. (2) There is no segment
parity in every wall : we assume some "stretching" by interaction between half-walls
and recover the parity. It results in a finite alphabet and maps with non dividing but
still growing cells. The construction of this alphabet and the corresponding production
set is realized via an IL system which generates "oppositely running double strings".
Derivations of this system become production rules for a dwMOL system. Such map sys-
tems simulate growing plant-bodies with cells which become mitotically inactive but
continue to elongate, just as in real organisms.

Key words: Map OLM systems, double-wall maps, theoretical biology, morphogenesis,
plant growth, aging.

INTRODUCTION

Plant growth occurs in tissues called meristems, localized for example at the apex
of a plant axis. The activity in meristems consists in cell divisions and cell enlarg-
ment. When cell divisions stop, growth continues by cell elongation. Meristems give
ininitely rise to appendices such as leaves, stipples, branches, which are arranged in
a regular spatio-temporal pattern. Some lateral appendices have limited growth, others
have not. Old fundamental botanical questions such as : "Why has the apex an unlimit-
ed growth? How can the apex give rise to protuberances? Why have protuberances mostly
limited growth?" are still waiting for an answer. We are looking for an explanation of
these regularities and pattern inception in meristems, an explanation through an unique
underlying system.

DOUBLE WALL MAP OLM SYSTEMS

We describe 2-dimensional cell layers by "maps". A map is a finite set of non-inter-
secting regions which lie on a plane [1]. Regions are separated by frontiers. Accord-
ingly, a map has bounded regions (r) which can be considered as cells and an unbounded
region (e) which corresponds to the environment of the layer. Frontiers represent cell
walls (Fig. 1a). A map describes the topological relationships between the cells of a
cell layer. This kind of maps were generated by different developmental systems and models applied to botanical problems [2,3,4,5,6,7].

In order to attribute to each region its own frontier, we introduced double structured walls [8,...,16]. A cell wall (w) separating two contiguous cells consists consequently of two half-walls (hw) (Fig.1b). Each half-wall may be composed of one or several segments separated by virtual nodes. In this framework, a cell is described by a circular sequence of hw-segments which are labelled clockwise by a serial numbering assumed to start at the youngest cell wall. Corners are not considered explicitly.

After a cell division, each of the two daughter cells has to appear with its characteristic labelled circular segment sequence. To perform this, a cell division is real-

Fig. 1 : (a) Single wall map. (b) Piece of a double wall map.

Fig. 2 : A map derivation representing a cell division. (a) Daughter cells with identic division wall insertion. (b) Daughter cells with different division wall insertion. For more detail, cf. [14]. In the sequel, slash-indices will be omitted.

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