

# Modeling of the Shoot Apical Meristem Structure Regulation Based on CLV1, CLV2, CLV3 and WUS Interactions

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## Extended abstract

**Introduction.** The group of cells at the growing tip of the shoot, referred to as the shoot apical meristem (SAM), is of importance. The SAM contains stem cells that continuously divide, ultimately giving rise to all the cells of the plant. Although the cells of the SAM are undifferentiated, they are distinguishable with respect to the expression of certain genes, and, on this basis, the SAM is divided into compartments that are specifically positioned relative to each other in space through the entire life of the plant. The cells, that are located around the vertical axis of the meristem in the radius of 2-4 cells at the uppermost layers 3-4 synthesize a diffusible protein called CLV3, belong to the central zone (CZ). The cells that express the *WUS* gene are located at the lower layer of the CZ cells. These cells are referred to the organizing center (OC), that is about 2-3 cells thick in the vertical direction. There is a protein complex CLV1/CLV2 can be detected around the organizing center. The CLV1/CLV2 is suspected to be a membrane receptor, so the complex is not diffusible. When the CLV3 + CLV1/CLV2 association occurs on surface of a cell, the *WUS* expression is inhibited in the cell. This mechanism of *WUS* synthesis repression was proposed in some papers. *WUS*, as is hypothesized in turn, can activate CLV1/CLV2 synthesis.

It is thought that the constancy of the SAM structure is required for the maintenance of the pool of the stem cells.

**The model.** A 2D model of the mechanism that provide the constancy of the SAM structure, based on above interactions between CLV1/CLV2, CLV3 and *WUS*, was built. The interactions in the basis of the mechanism are shown in Figure 1.

The suppositions were formalized as the model (1)-(4).

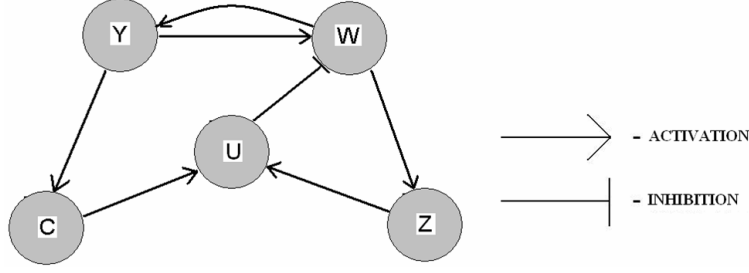


Figure 1: The interactions between the players in the model. The Y, C, W, Z, U in the scheme and the model represent a hypothesized Y, and CLV3, WUS-dependent protein, CLV1/CLV2 membrane receptor and complex CLV3 + CLV1/CLV2.

$$\frac{\partial y_i}{\partial t} = D_Y \Delta_i y - d_Y y_i + \frac{1}{\tau_Y} I_i^Y g(h_Y + T_{YW} \cdot w_i), \quad (1)$$

$$\frac{\partial c_i}{\partial t} = D_C \cdot \Delta_i c - d_C \cdot c_i - \alpha \cdot c_i \cdot z_i + \frac{1}{\tau_C} I_i^C g(h_C + T_{CY} \cdot y_i), \quad (2)$$

$$\frac{\partial z_i}{\partial t} = -d_Z z_i - \alpha c_i z_i + \frac{1}{\tau_Z} g(h_Z + T_{ZW} w_i), \quad (3)$$

$$\frac{\partial w_i}{\partial t} = D_W \cdot \Delta_i w - d_W w_i + \frac{1}{\tau_W} g(h_W + T_{WY} y_i - T_{WU} c_i z_i). \quad (4)$$

Here functions  $I_i^Y$ ,  $I_i^C$  are equal to 1 where Y or C synthesis is allowed, and are equal 0 otherwise.

In addition, the C synthesis is confined to L1 and L2 layers. Further, we postulate a threshold regulation for C synthesis. As a consequence, we obtain perfectly determined area where W synthesis can occur under threshold mechanism of regulation from Y and C.

Sets of parameters was found that supply a biologically plausible solution for the model (Fig. 2). With a one set of parameters the model solution gives the restriction of *WUS*

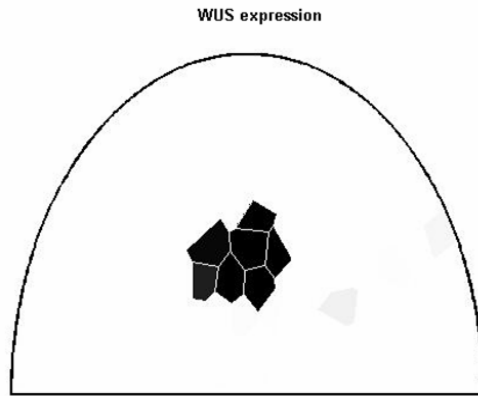


Figure 2: WUS expression marks location of the organizing center.

expression by CLV3+CLV1/CLV2 complex formation. With other parameters this complex

determinates upper boundary of the OC, while the threshold concentration of the Y sets the OC lower boundary.