Modelling the CLASP Protein in *A. Thaliana* Mutants

Riley Wheadon

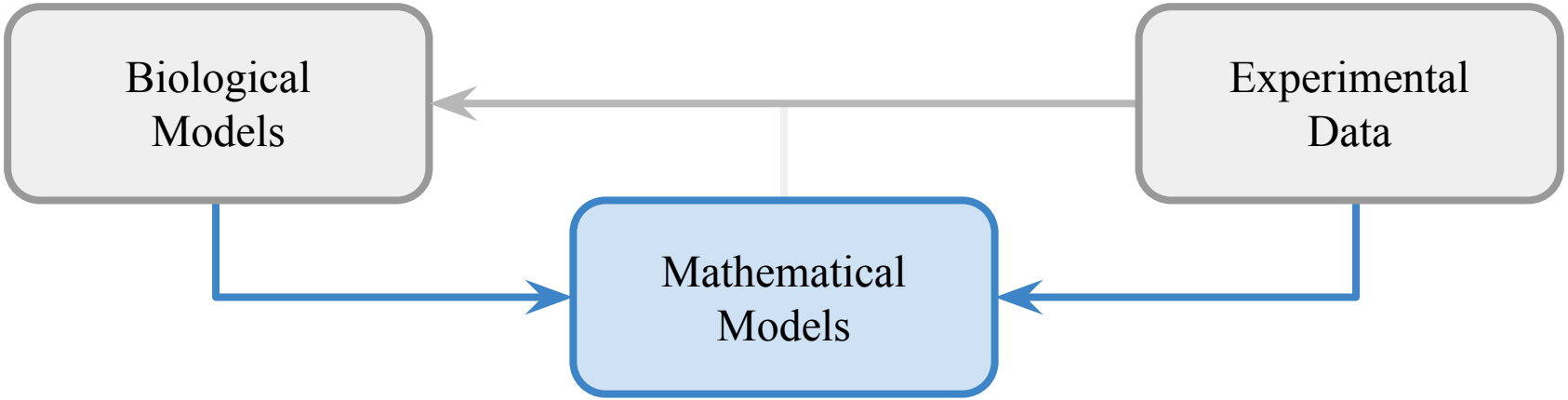
Supervised by Dr. Eric Cytrynbaum & Dr. Geoffrey Wasteneys

Why build models?

Biologists develop *implicit models* of complex systems through data and observations.

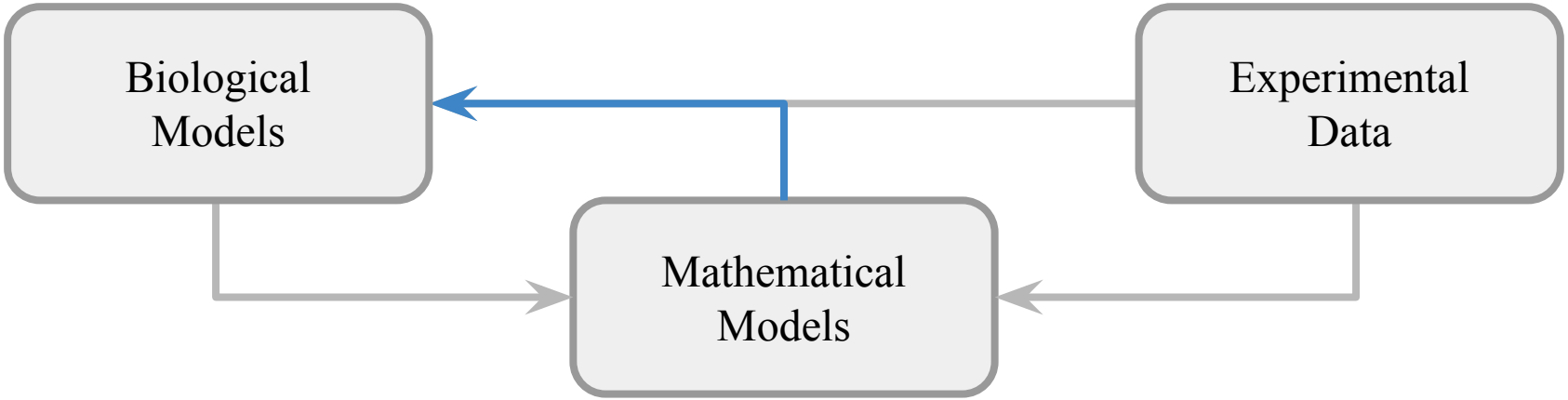
Why build models?

We can use these biological models along with the data to create *mathematical models*.



Why build models?

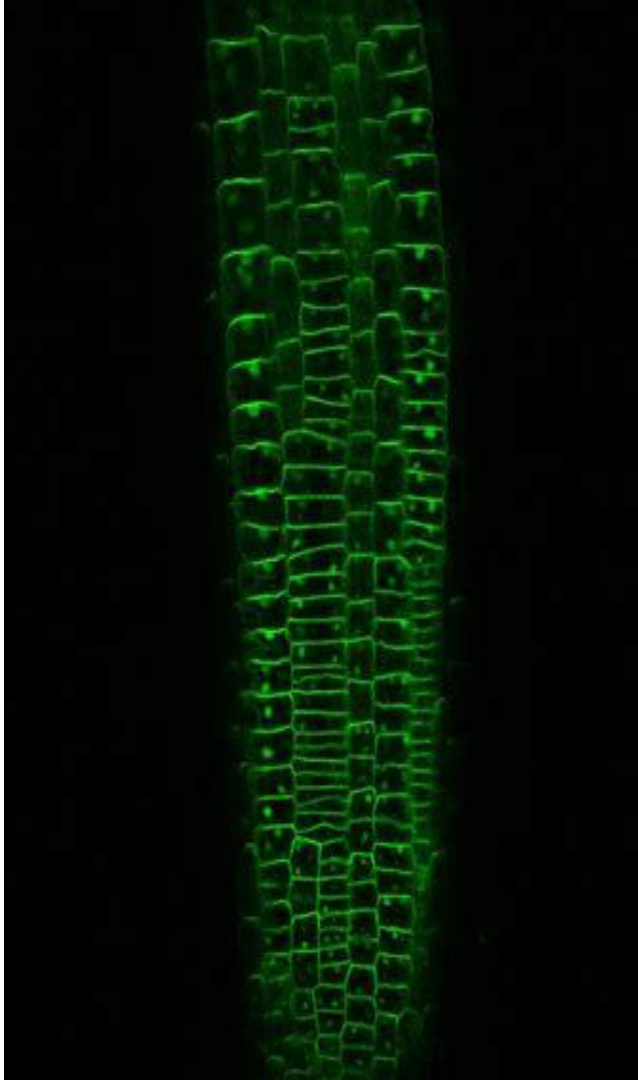
Then, we can use the mathematical models to *update* our biological models.



Zonation of the *A. Thaliana* Root

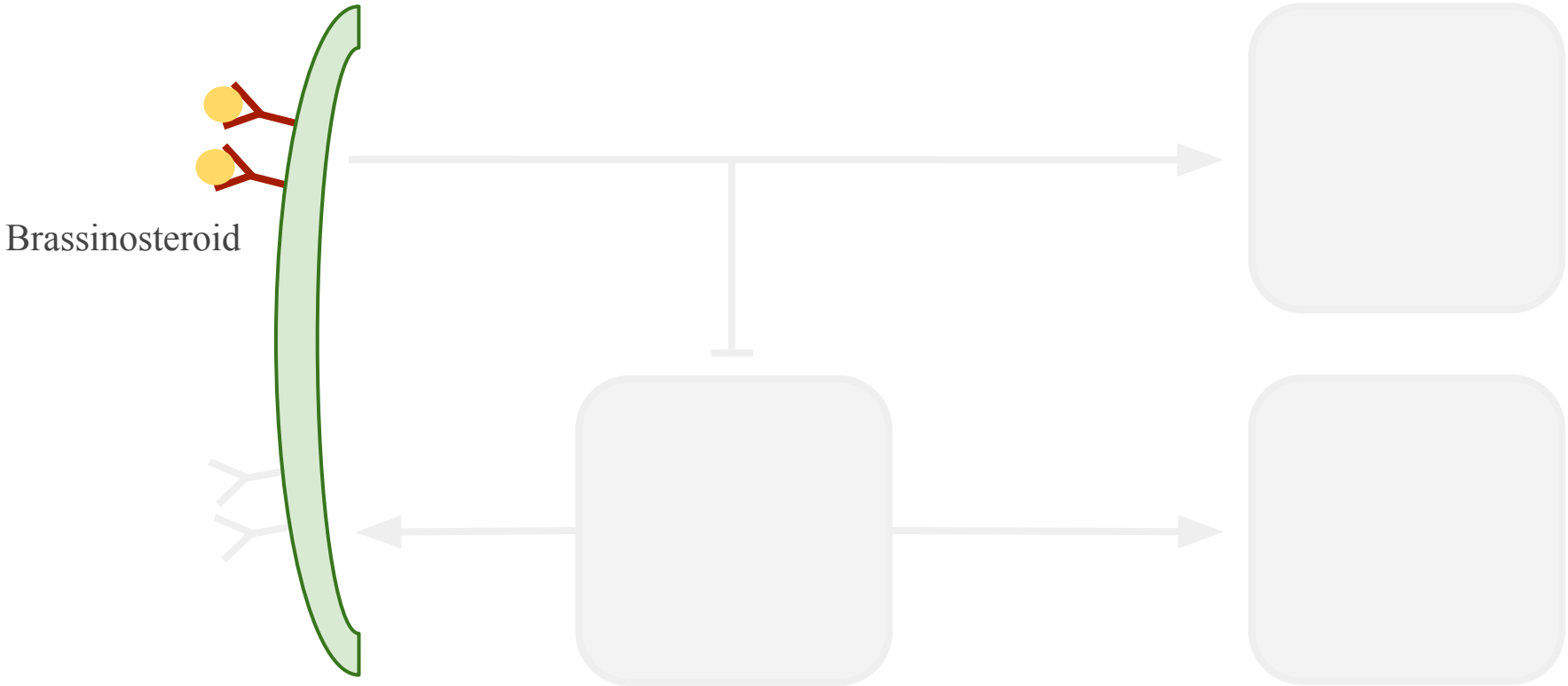
- ➔ Root cells go through three stages of development: **Division**, **Elongation**, and **Differentiation** (in this order).
- ➔ We are interested how the **CLASP** protein affects the transition from division to elongation.

Source: Phillip Brewer, University of Adelaide



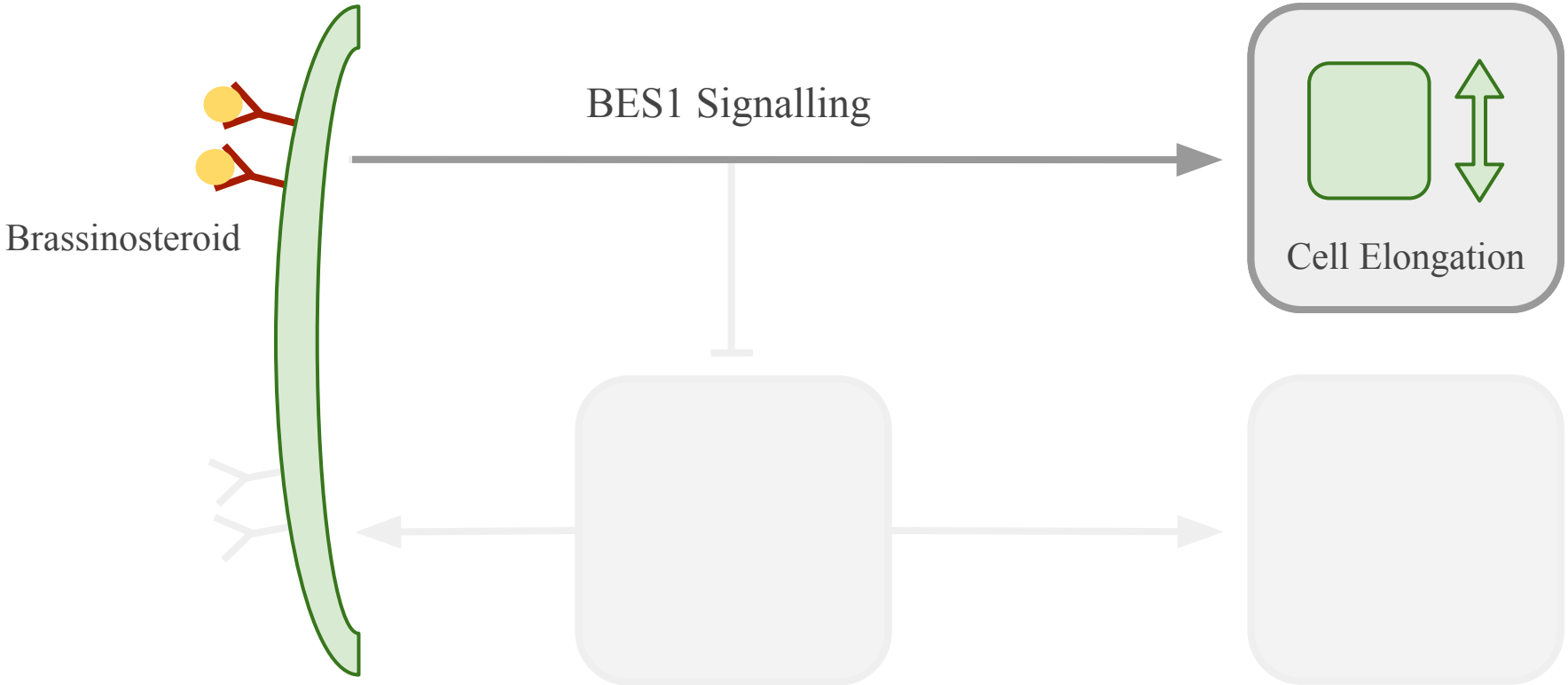
The Biological Model

Brassinosteroid molecules bind to BRI1 receptors on the cell membrane.



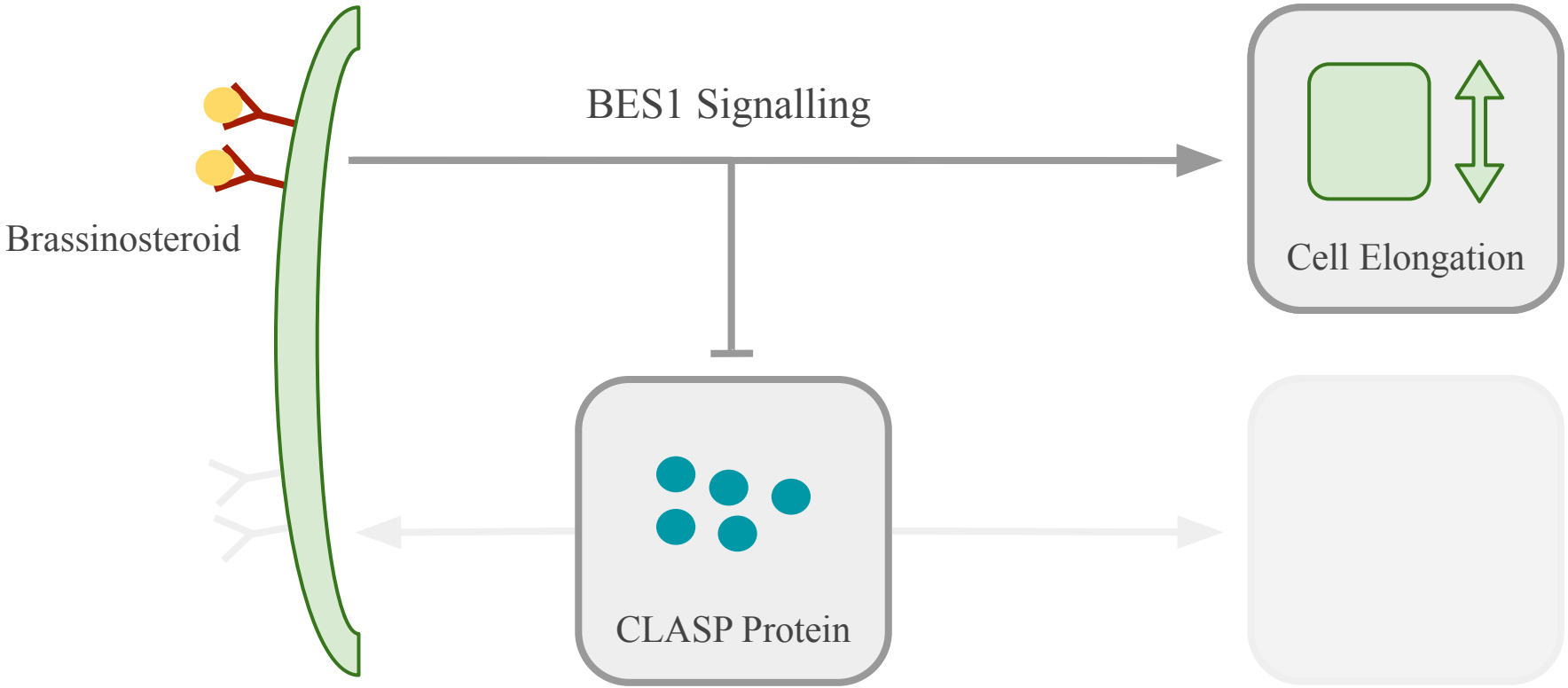
The Biological Model

Bound BRI1 receptors activate BES1 signalling, promoting cell elongation.



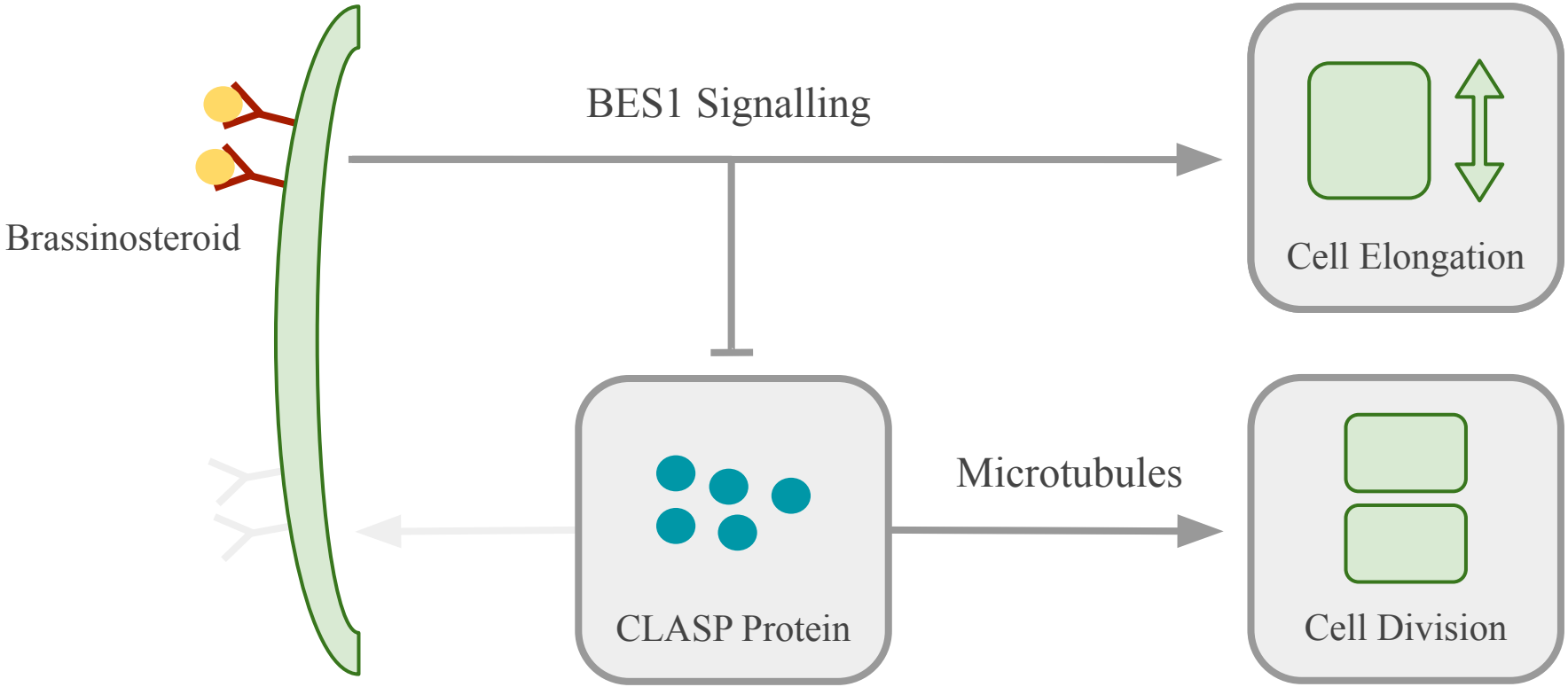
The Biological Model

BES1 signalling also inhibits production of the CLASP protein.



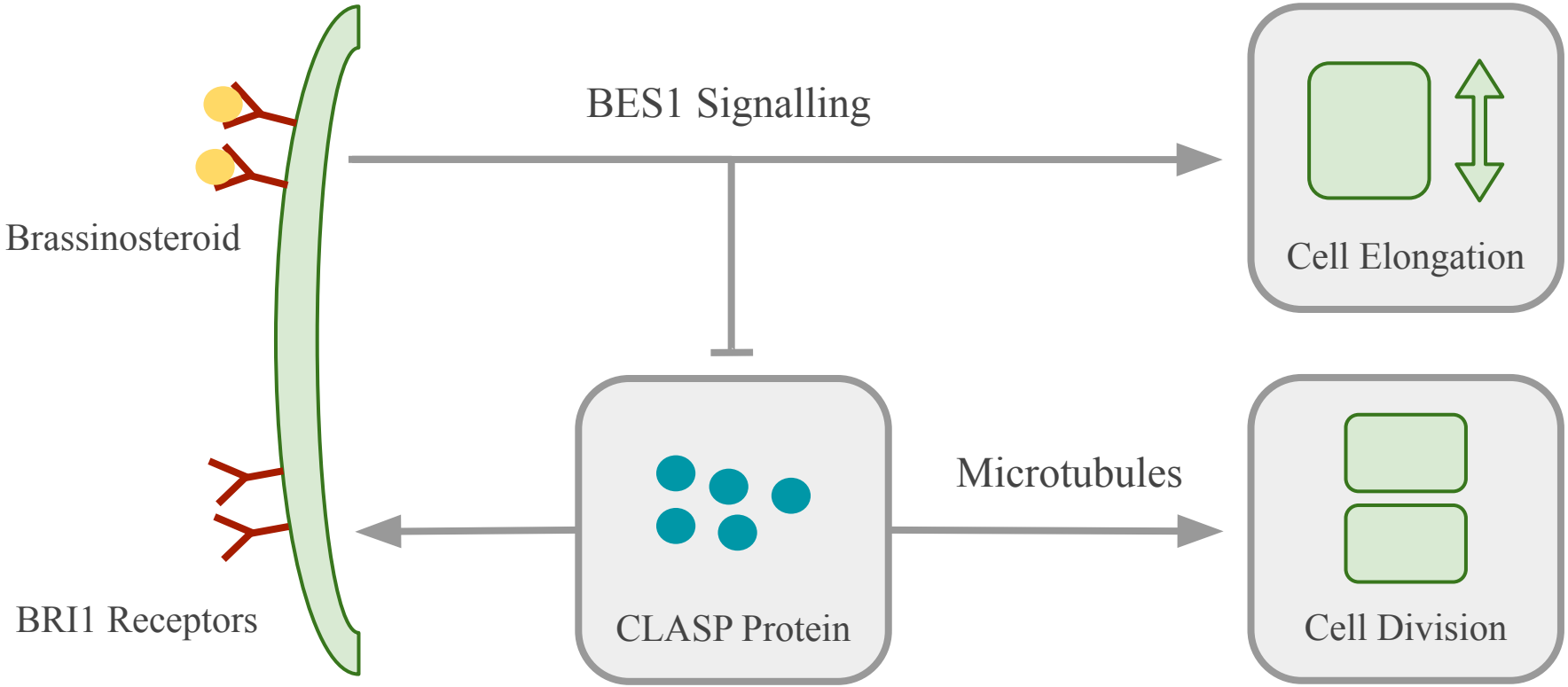
The Biological Model

The CLASP protein promotes cell division by influencing microtubule arrangement.



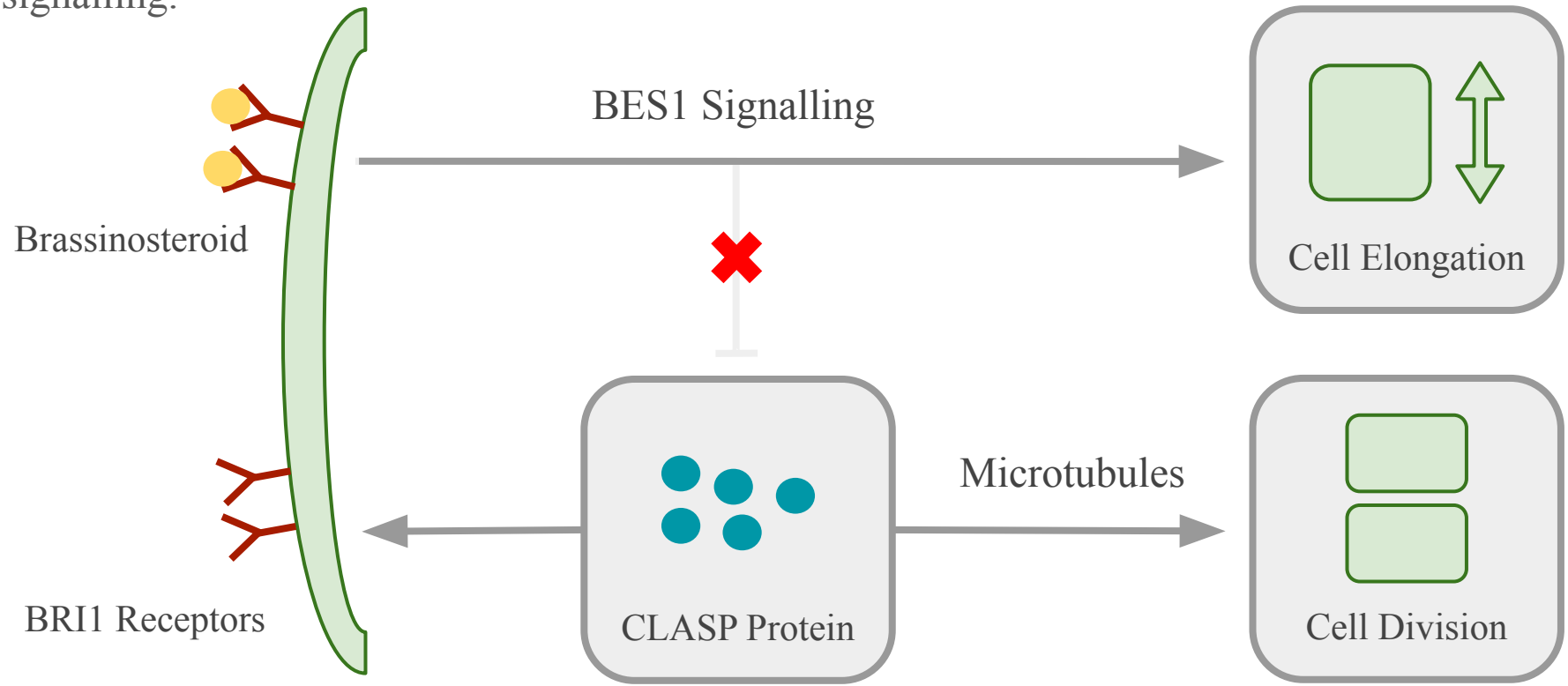
The Biological Model

The CLASP protein also promotes the production of BRI1 receptors.



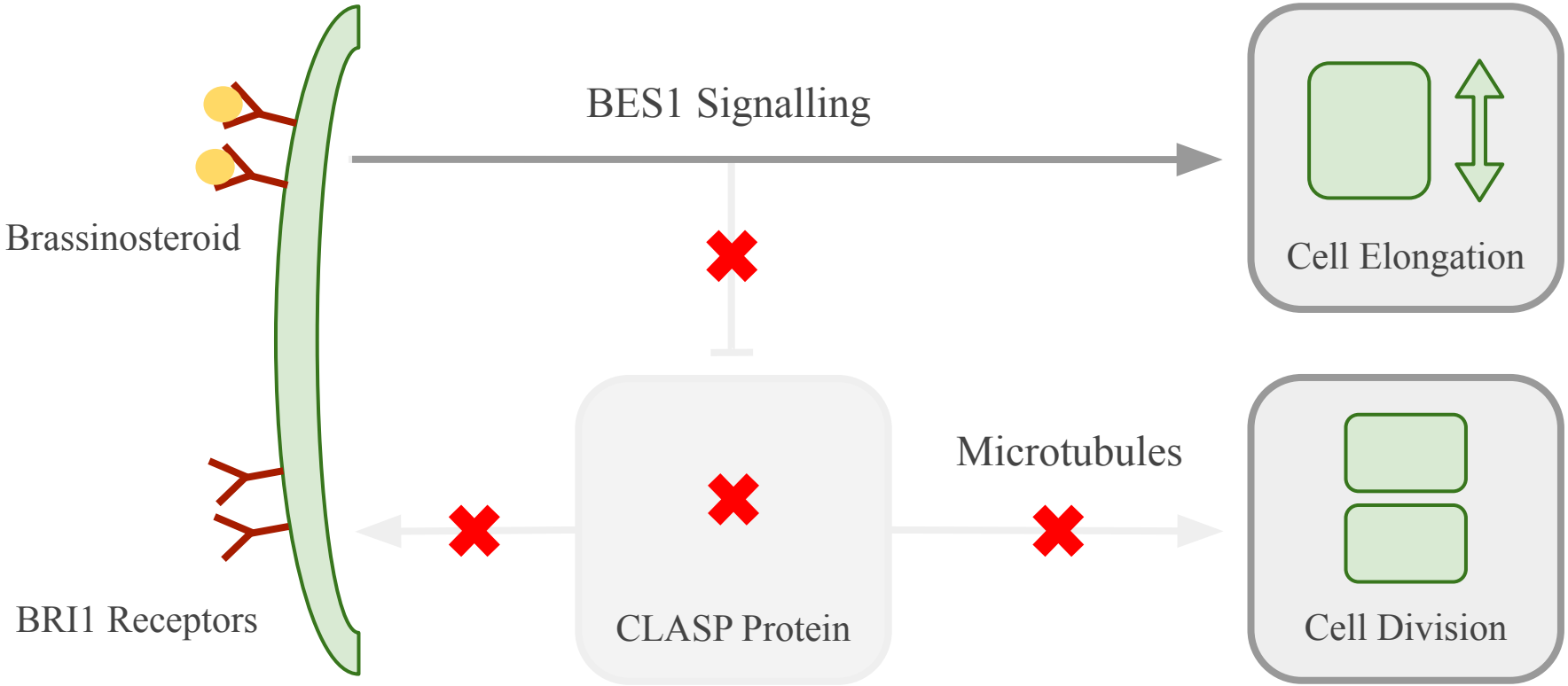
The BRIN-CLASP Mutant

The BRIN-CLASP mutant has CLASP promoters which are insensitive to BES1 signalling.



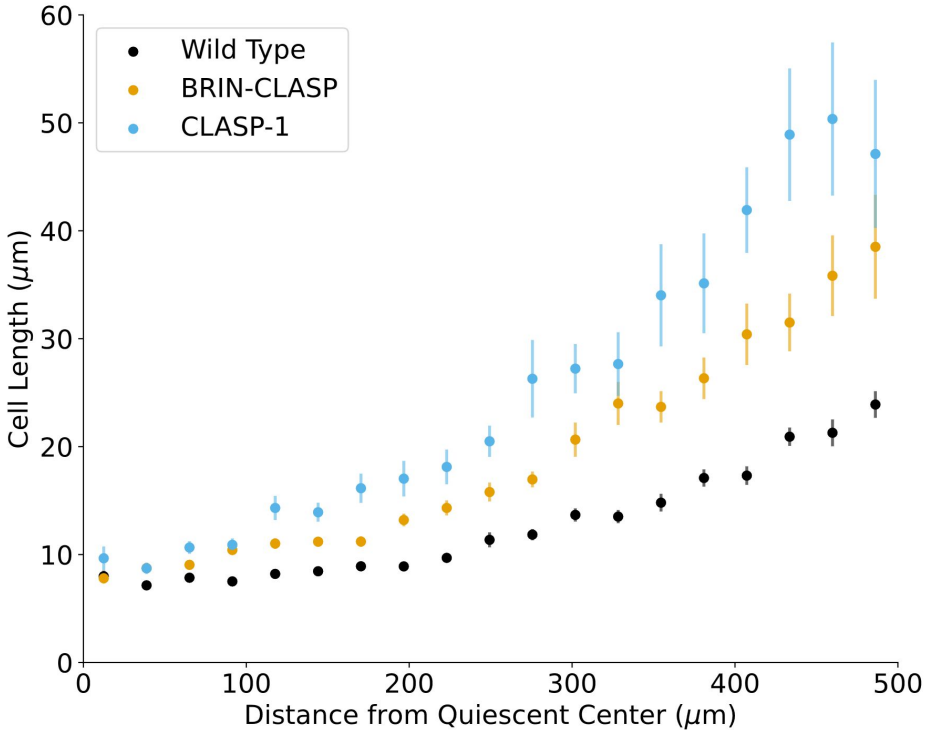
The CLASP-1 Mutant

The CLASP-1 mutant has no CLASP protein.



The Data

- ➔ We plot average cell size as a function of the cell location.
- ➔ The **CLASP-1** mutant has the largest cells, followed by the **BRIN-CLASP** mutant and then the wild type.



The Mathematical Model

We used a system of **time-dependent ODEs** to model protein levels and cell state.

$$0 = \frac{dC}{dt} = (c_0 - c_1 R_B) - c_2 C$$

$$0 = \frac{dR_T}{dt} = (r_0 + r_1 C) - r_2 R_T$$

$$0 = \frac{dR_B}{dt} = k_{\text{on}}(R_T - R_B)B_{\text{free}} - k_{\text{off}} R_B$$

Hormone and Protein Levels

$$\frac{dD}{dt} = (1 + \delta_0 C)\left(1 - \frac{L^n}{\delta_1^n + L^n}\right)$$

$$\frac{dL}{dt} = (\gamma_0 + \gamma_1 R_B)\, L$$

Division and Elongation

The Mathematical Model

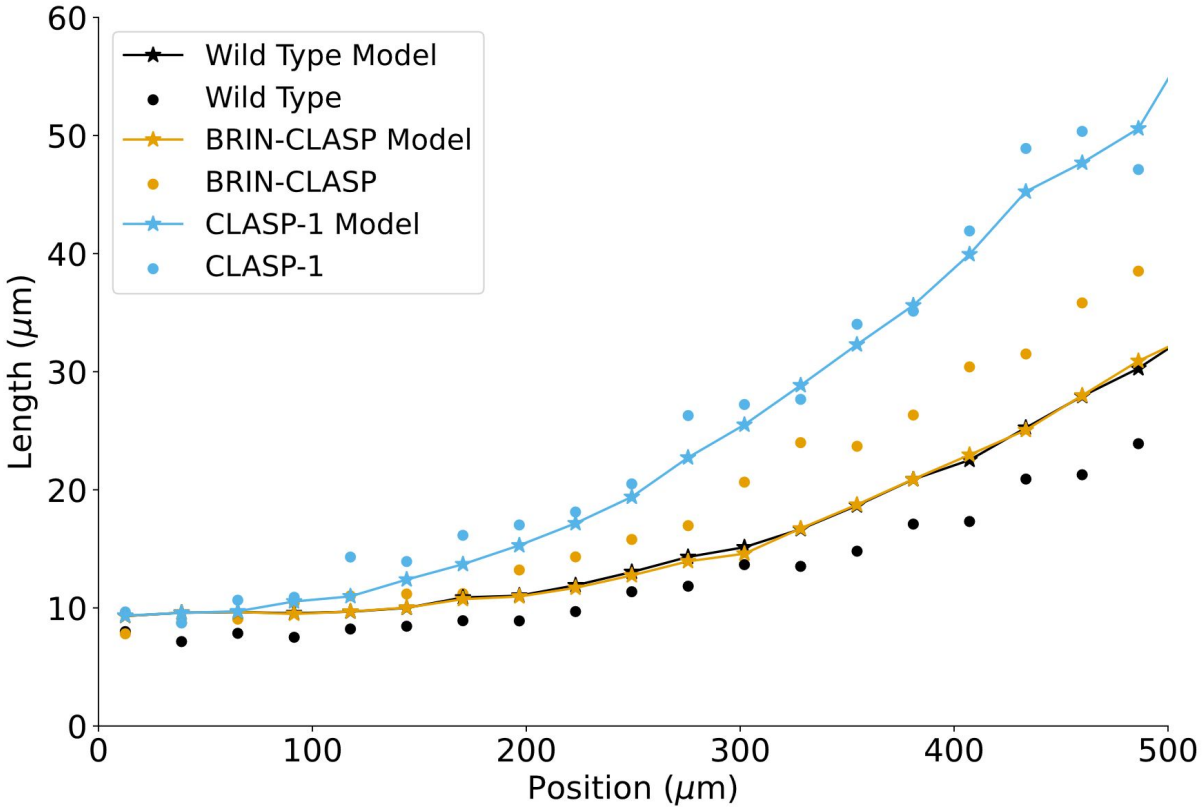
$$\frac{dD}{dt} = (1 + \delta_0 C)\left(1 - \frac{L^n}{\delta_1^n + L^n}\right)$$

The division rate, expressed as a derivative.

CLASP increases the division rate.

When cells become sufficiently long, they stop dividing.

Initial Results



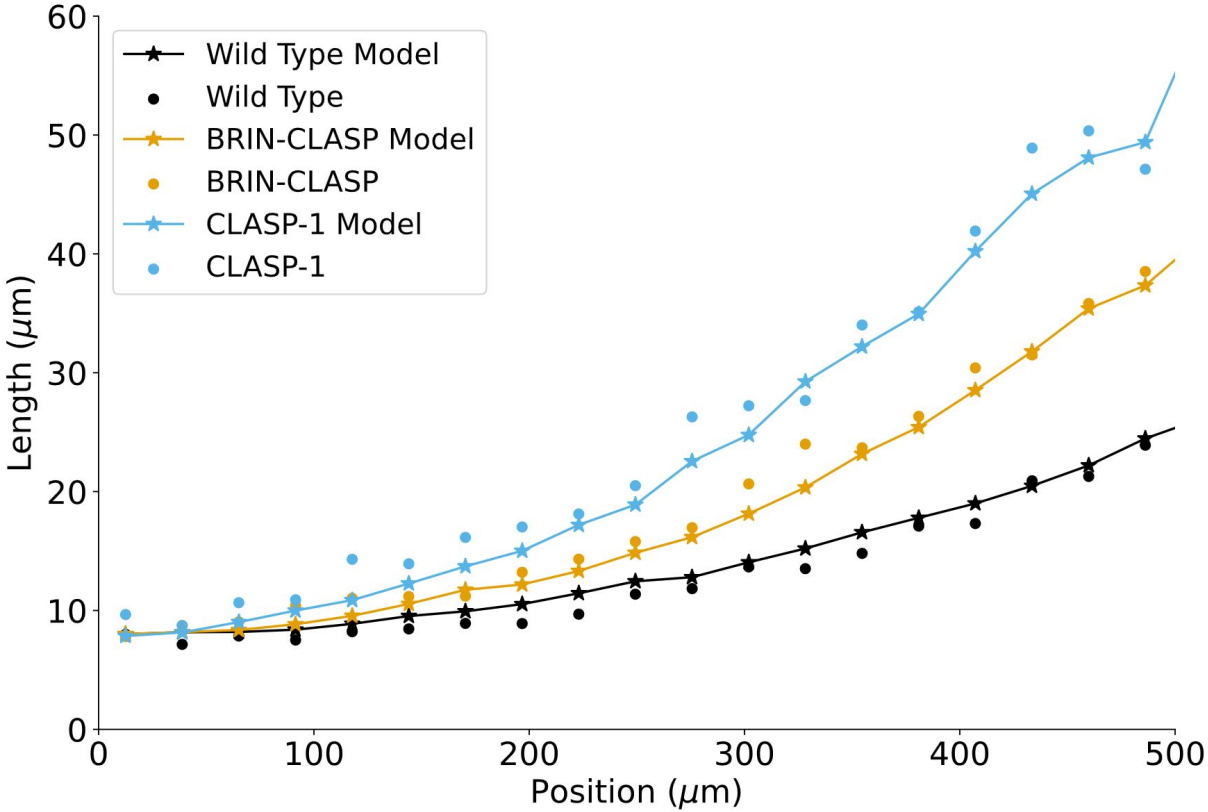
Updating the Model

The nuances of microtubule arrangement mean that the CLASP protein could be inhibiting cell division at **both** high **and** low concentrations.

$$\frac{dD}{dt} = (\sigma_0 + \sigma_1 C - C^2)\left(1 - \frac{L^n}{\delta_1^n + L^n}\right)$$

CLASP must be “just right” to maximize the division rate.

Updated Results



Why does this matter?

- ➔ The CLASP protein has shown to be sensitive to **drought**, **heat**, and **cold** (Halat et al., 2020).
- ➔ Therefore, our research into how the CLASP protein affects root development helps lay the theoretical groundwork for advances in **sustainable agriculture**.

Thanks for listening!