



Multiscale Model of Human Pathogen Growth on Fresh Produce

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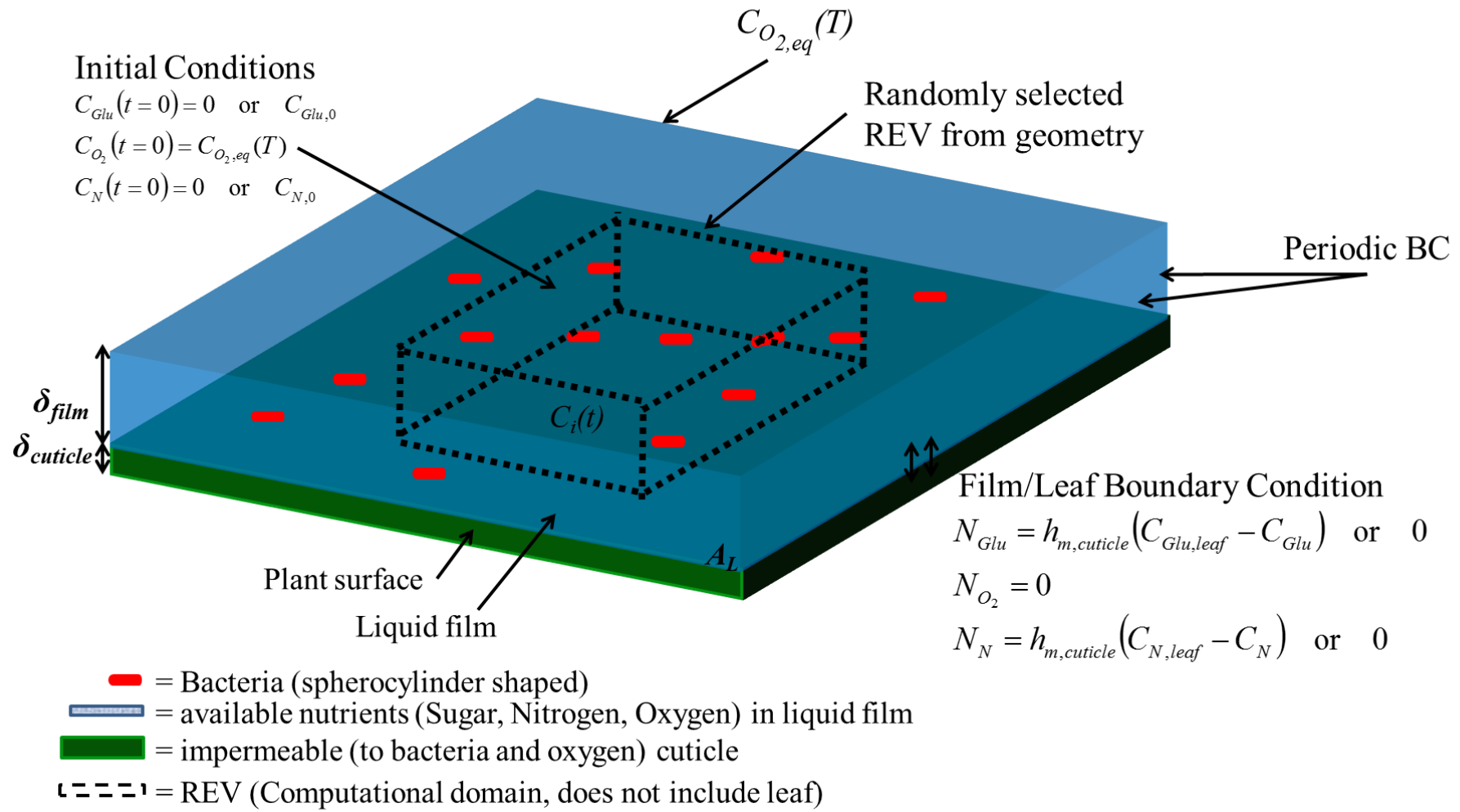
COMSOL
CONFERENCE
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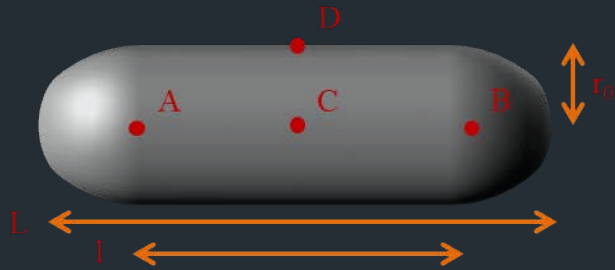


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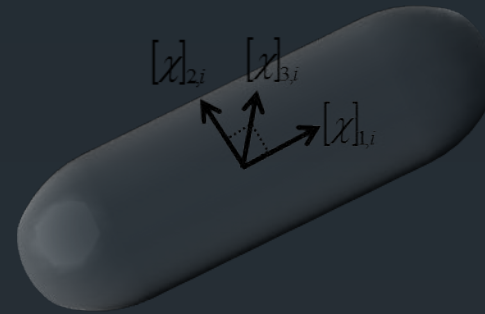
Problem Formulation/Schematic



Problem Formulation/Schematic

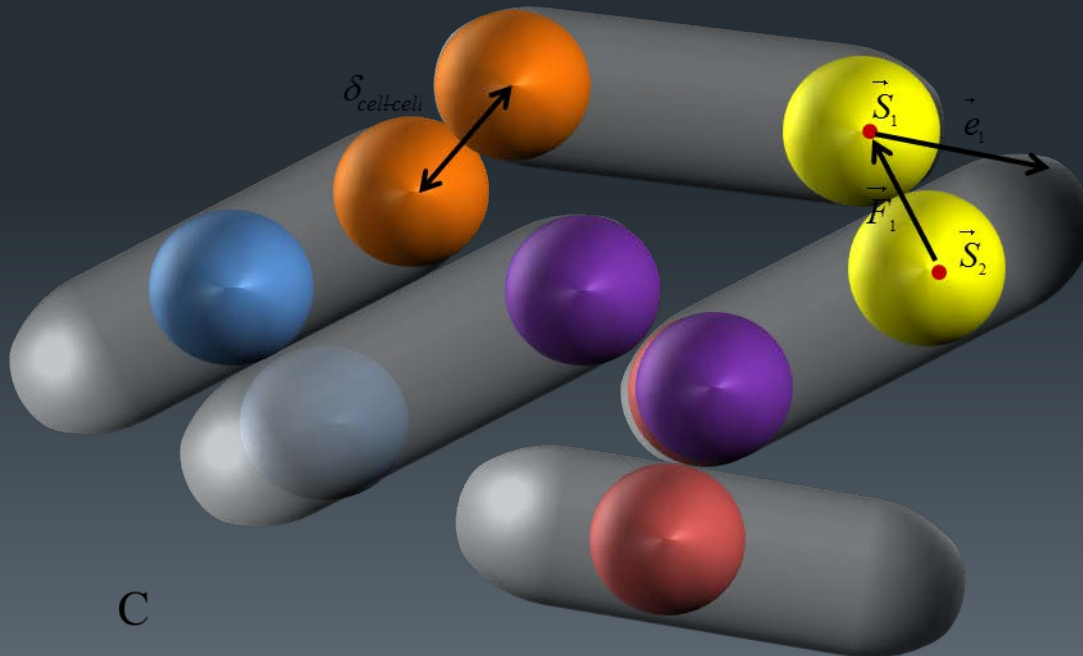


A

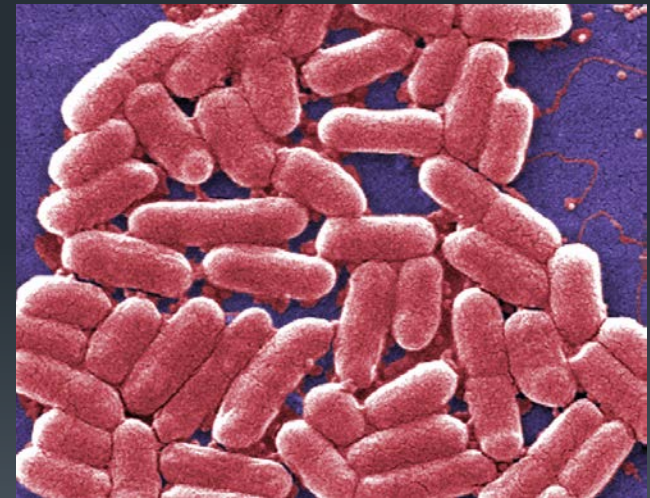


B

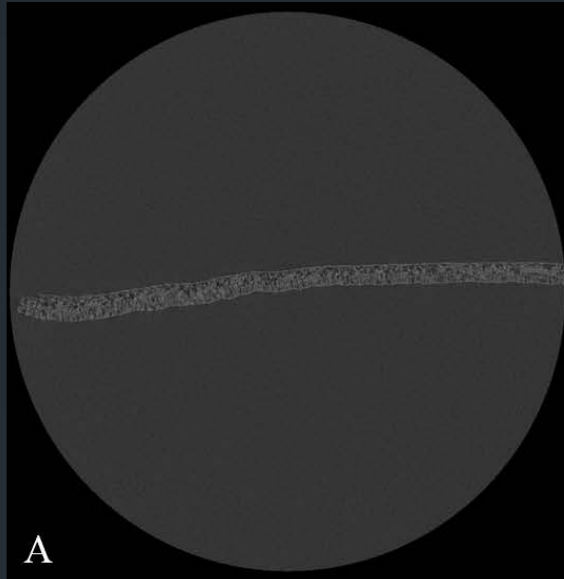
E. coli



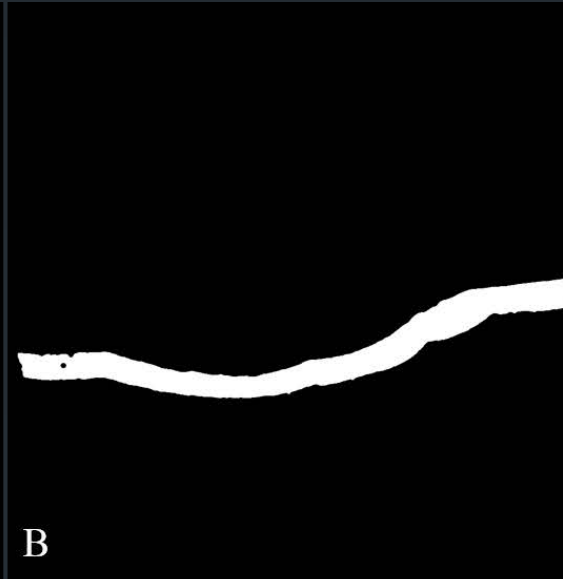
C



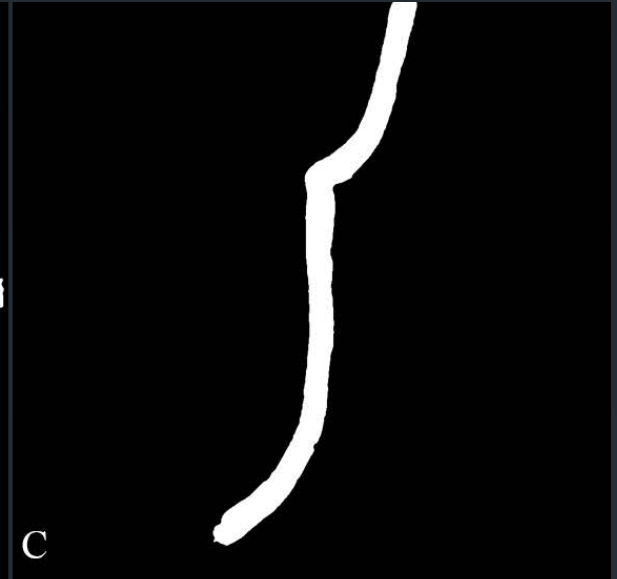
Geometry Acquisition from μ CT



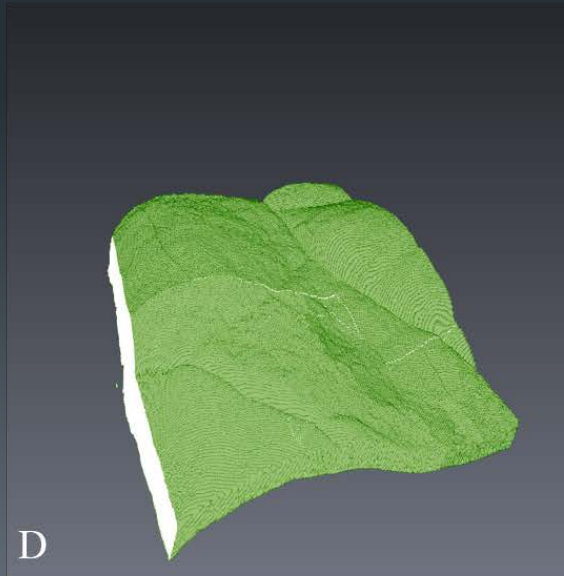
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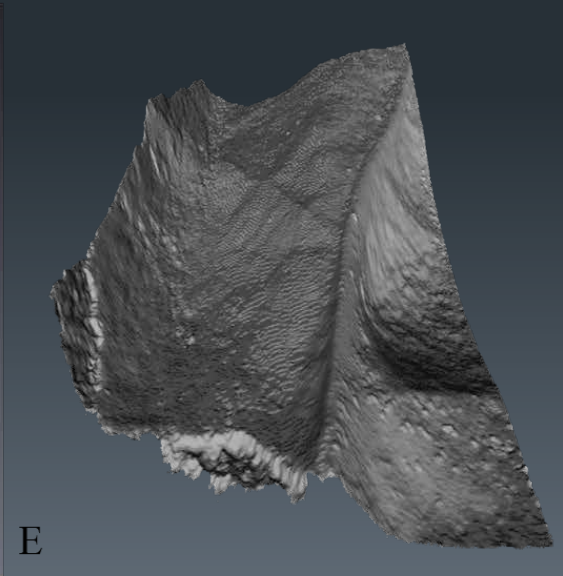
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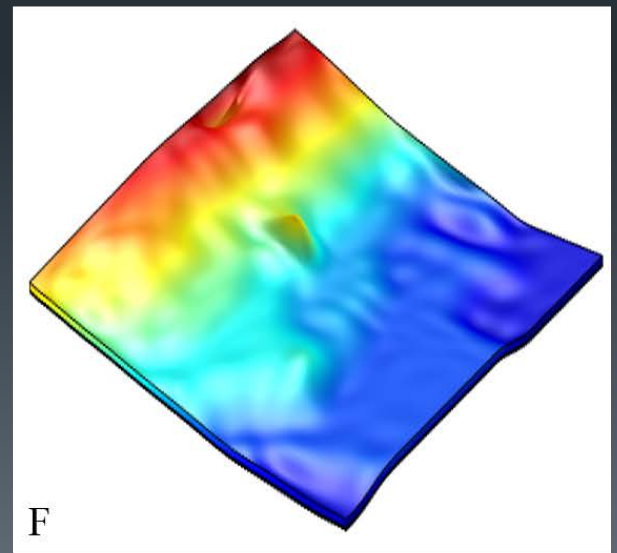
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D

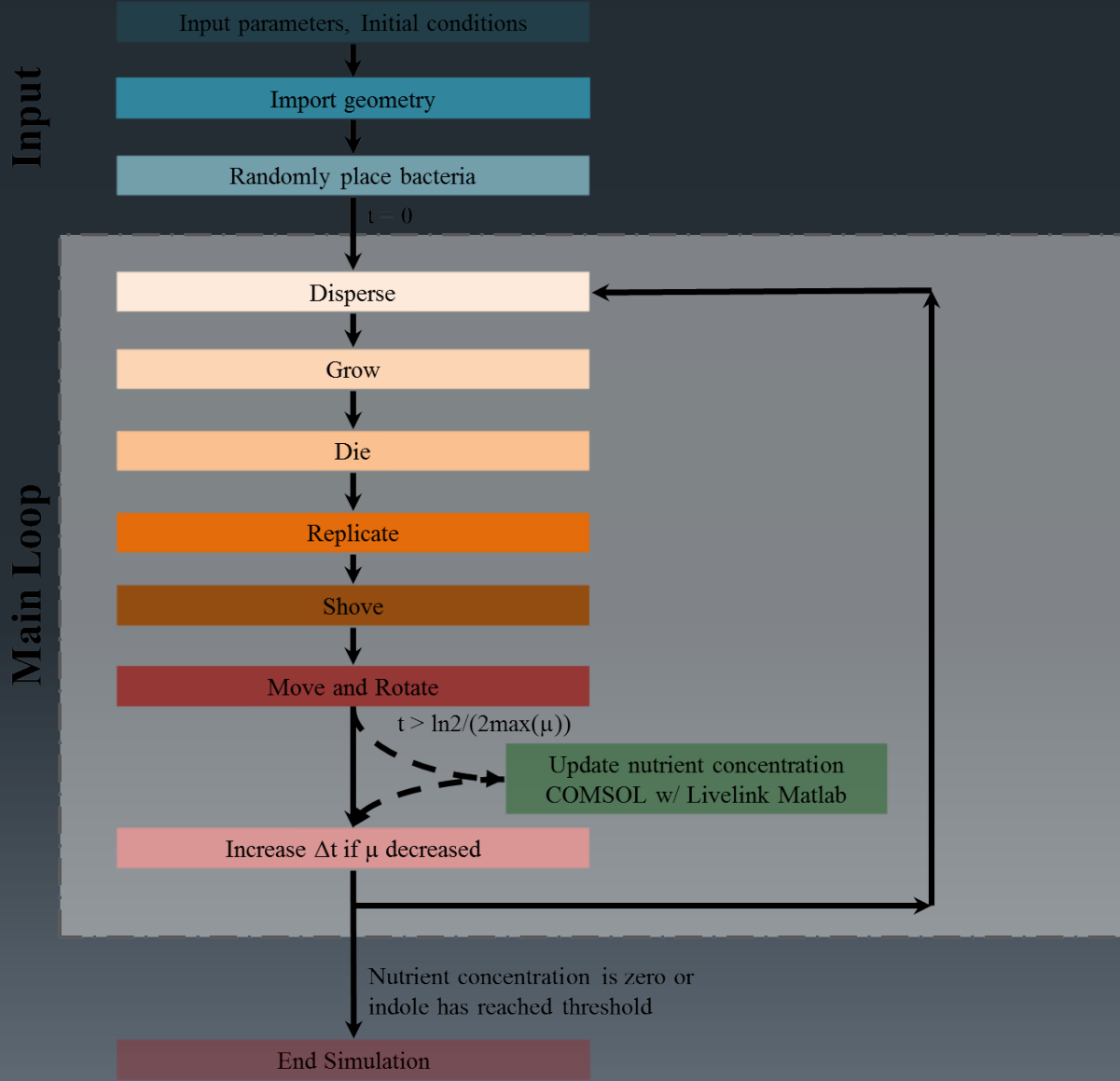


E



F

Numerical Implementation



Governing Equations

Carbon (Glucose), Nitrogen (Ammonium), Oxygen, and Chemoattractant Transport

$$\frac{\partial C_i}{\partial t} = D_{i,w}(X, T) \nabla^2 C_i + r_{i,X}$$

Nutrient Consumption

$$r_{i,X} = Y_{i/X} \mu X \quad X = \frac{\sum m^j}{V_{REV}}$$

Growth Rate

$$\mu^j = \mu_{max}^j \prod_i \phi_i \quad \phi_i = \frac{C_i}{K_i(T) + C_i} \quad \frac{dv^j}{dt} = \mu^j v^j$$

Quorum Sensing

$$\frac{d[C]_{QS}}{dt} = \kappa_{QS} [C]^n$$

Governing Equations

Drift Velocity

$$\vec{v}_d = \frac{300}{\sqrt{2}} \frac{\nabla C_{Glu}}{C_{Glu}} + \frac{300}{\sqrt{2}} \frac{\nabla C_{CA}}{C_{CA}}$$

Run and Tumble

$$\vec{v}_{diffusion} = 1200 (\cos \theta, \sin \theta)$$

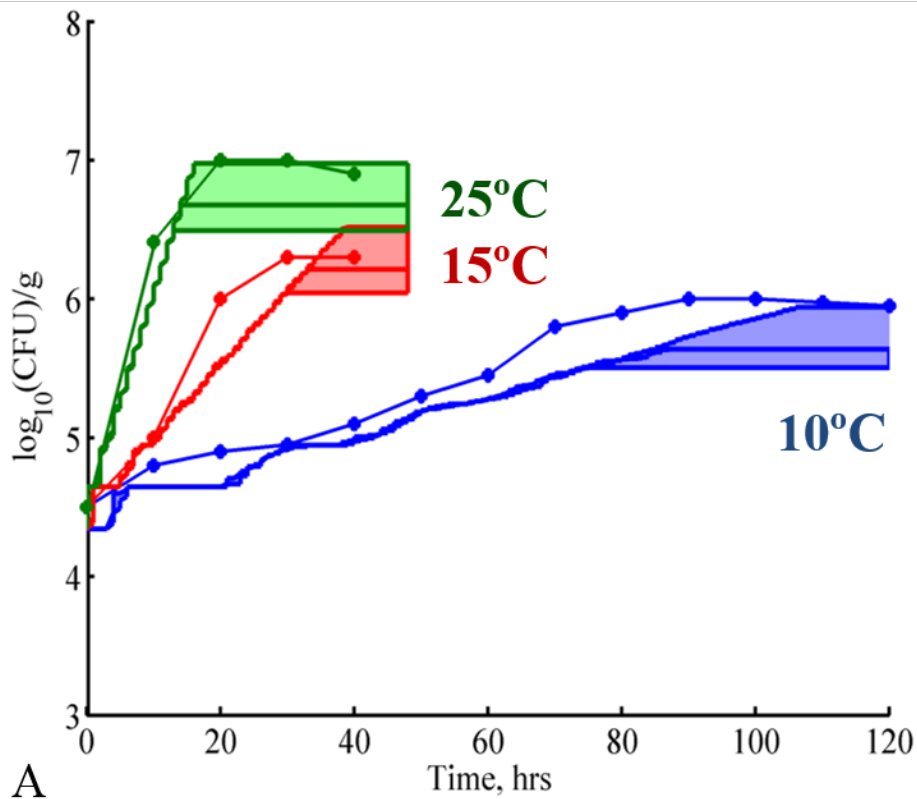
Displacement

$$\vec{d} = 1200 \frac{\vec{v}_{diffusion} + \vec{v}_{drift}}{\|\vec{v}_{diffusion} + \vec{v}_{drift}\|} \Delta t$$

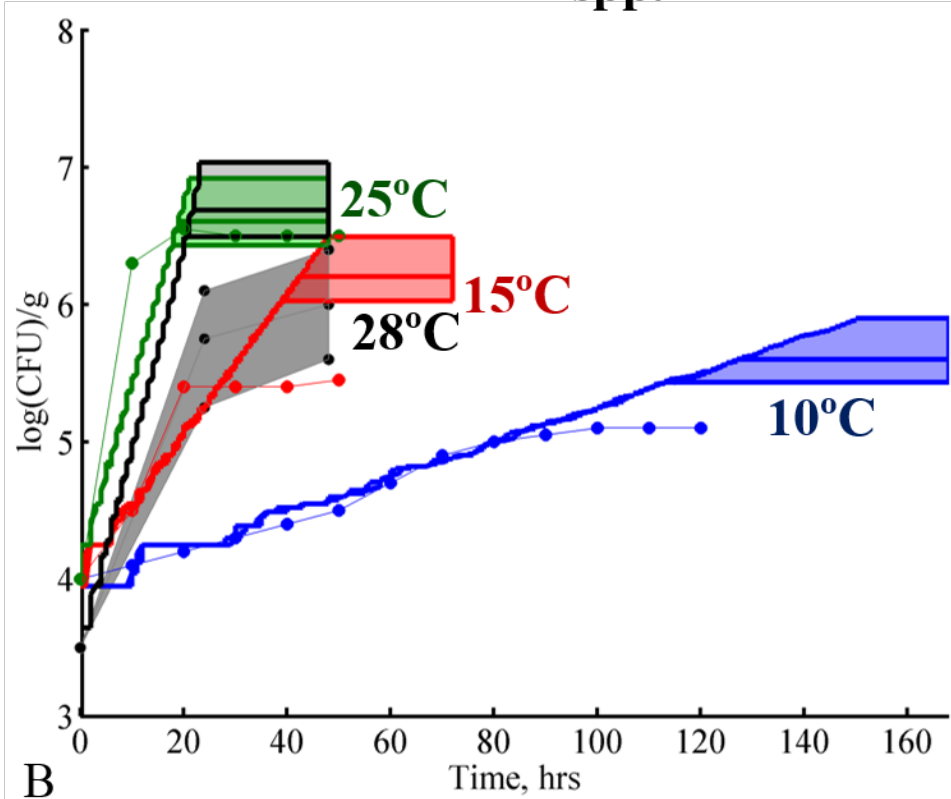
Validation



E. coli O157:H7

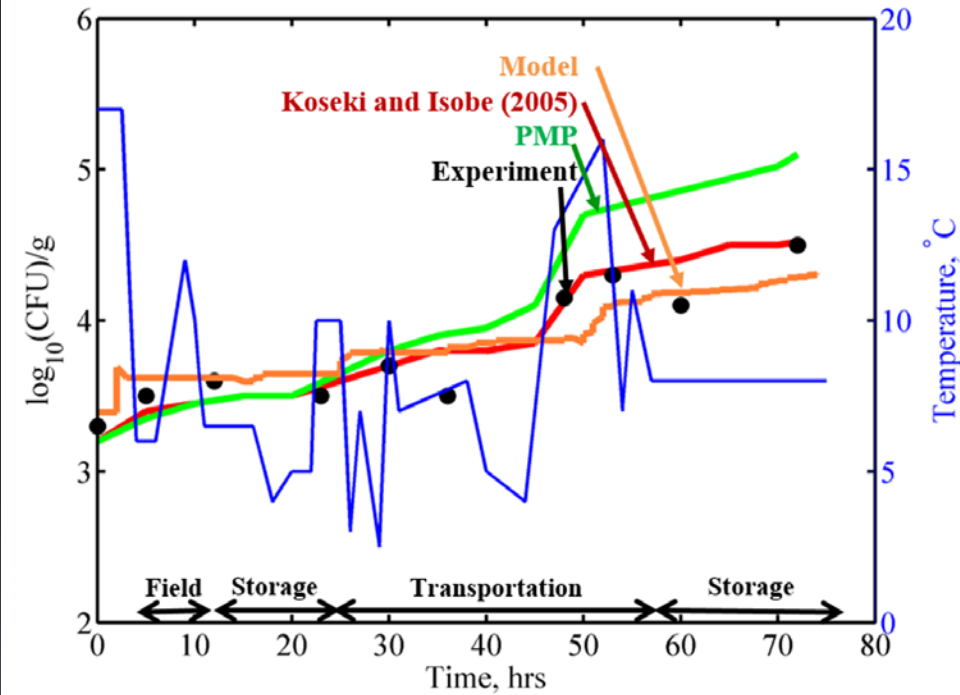


Salmonella spp.

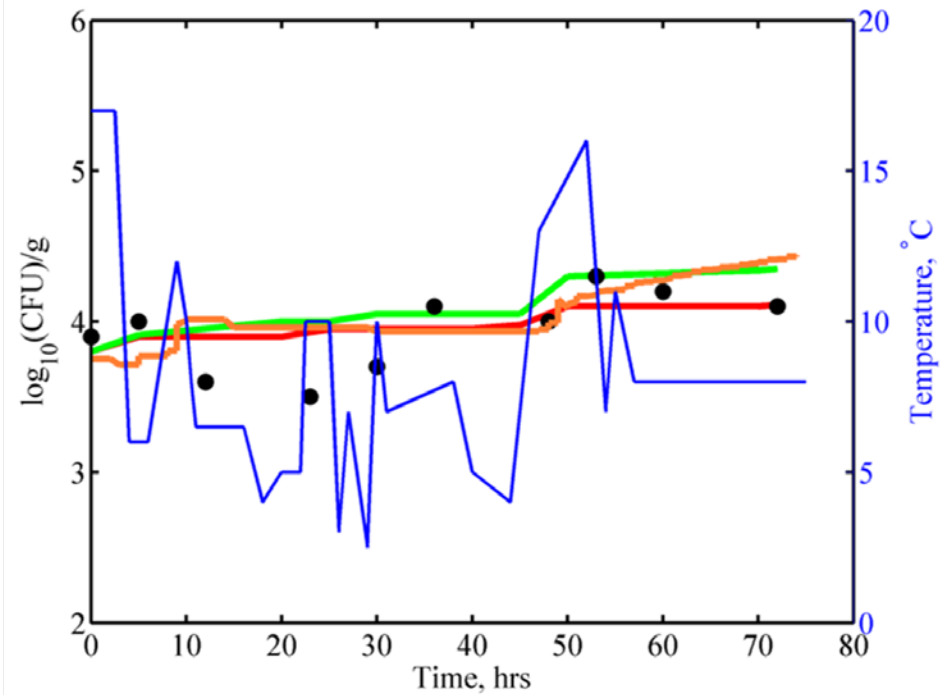


Validation

E. coli O157:H7

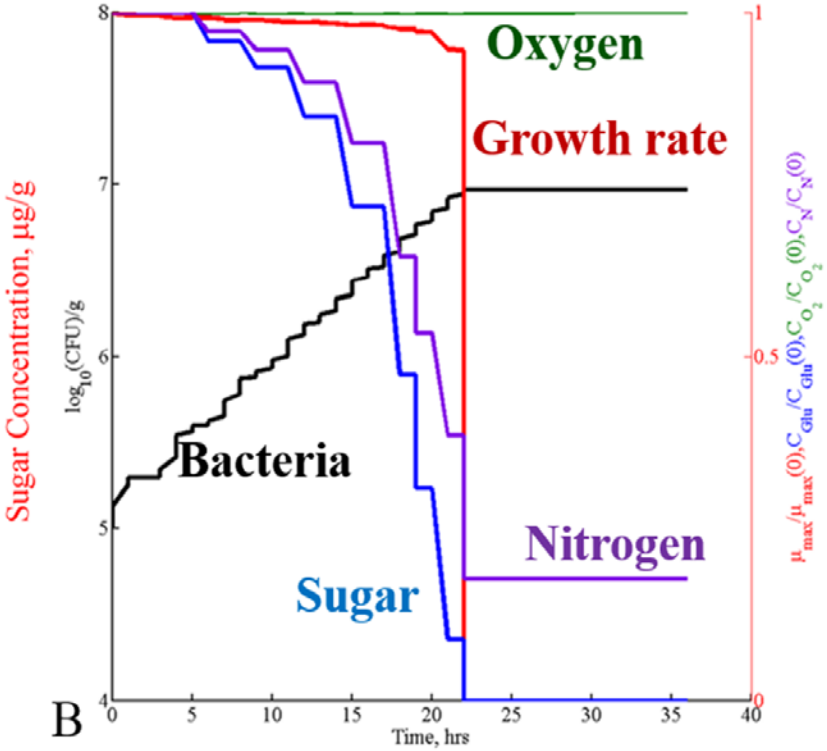
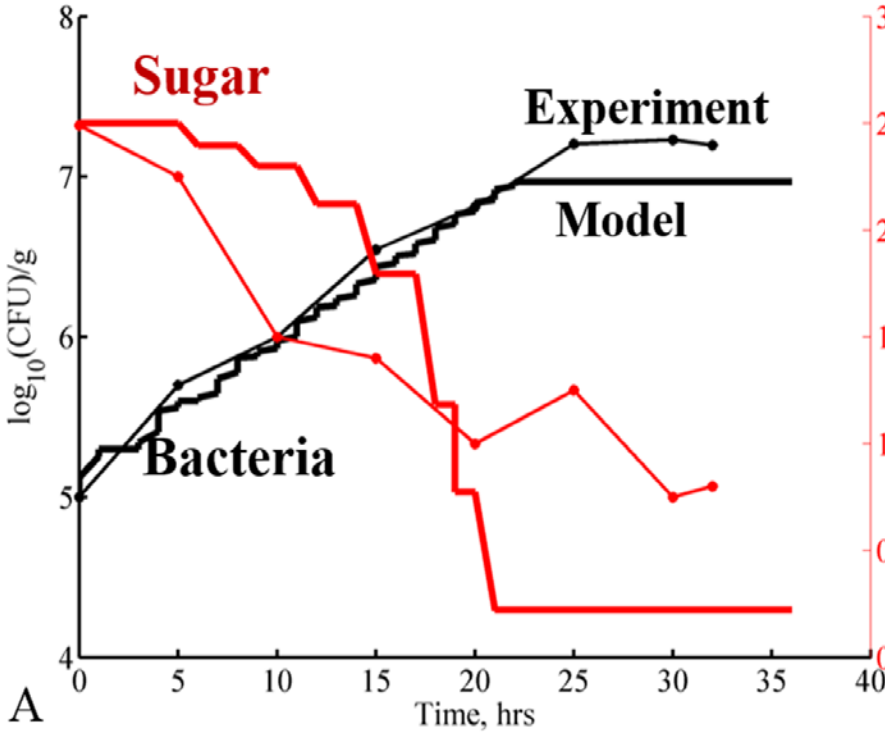


Salmonella spp.



Results

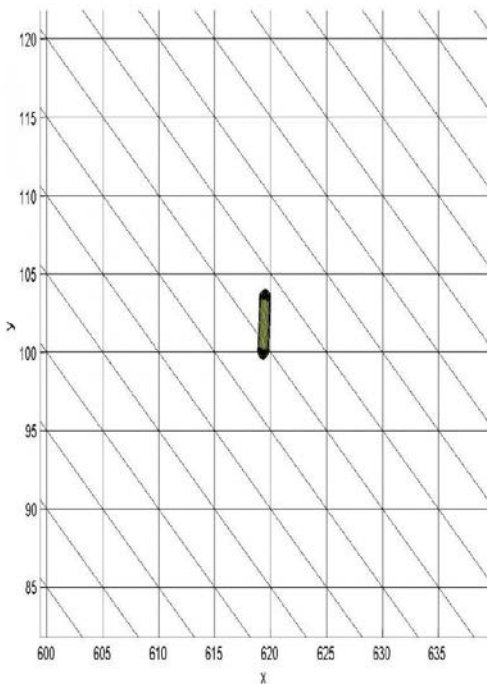
Pseudomonas fluorescens



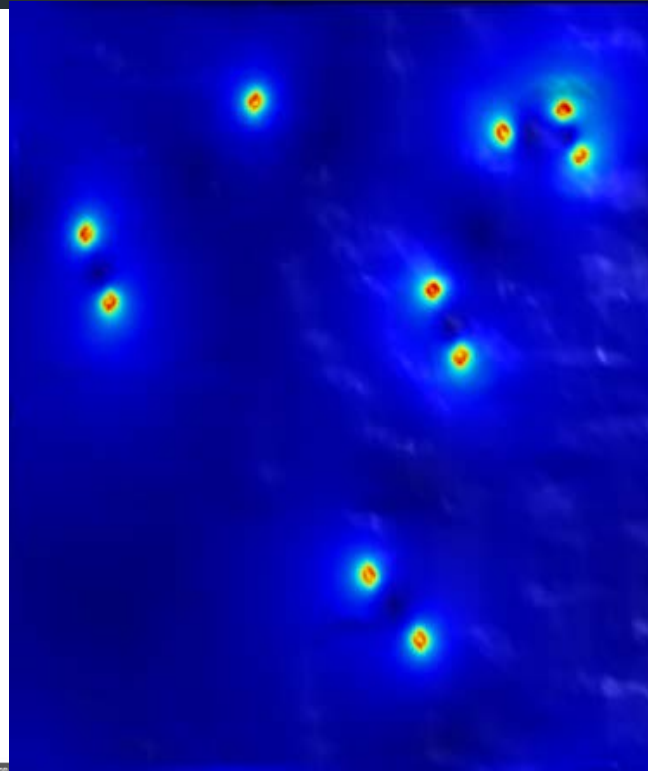
Results, contd.



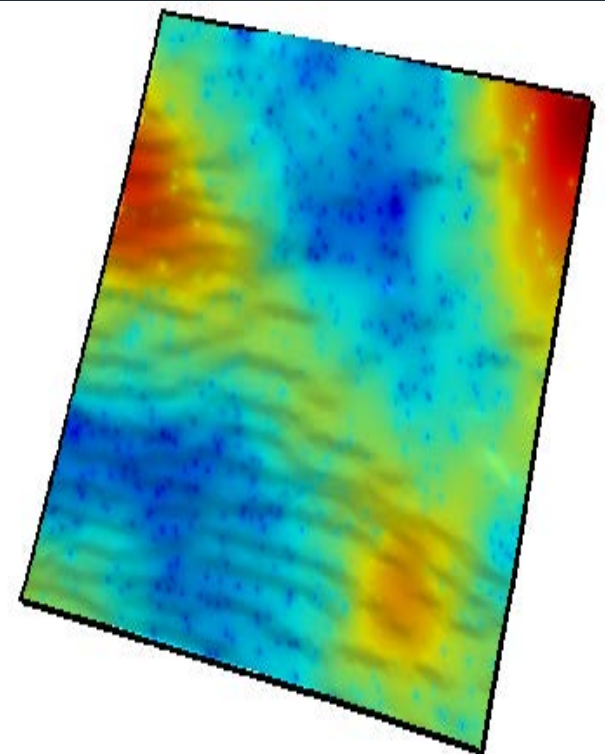
Growth



Gradients



Dispersion



Conclusions/Challenges



- Geometry has limited effect on colony morphology
- Through a mechanistic model, most food safety growth models can be reduced to a single individual based model instead of needing a database
- Internalization and dispersion is only understandable through an IbM that incorporates nutrient and chemoattractant concentration fields

References

- 1. Solomon, Ethan B., Hoan-Jen Pang, and Karl R. Matthews. "Persistence of Escherichia coli O157: H7 on lettuce plants following spray irrigation with contaminated water." *Journal of food protection* 66.12 (2003): 2198-2202.
- 2. Koseki, Shigenobu, and Seiichiro Isobe. "Prediction of pathogen growth on iceberg lettuce under real temperature history during distribution from farm to table." *International Journal of Food Microbiology* 104.3 (2005): 239-248.
- 3. Brandl, M. T., and R. Amundson. "Leaf age as a risk factor in contamination of lettuce with Escherichia coli O157: H7 and Salmonella enterica." *Applied and environmental microbiology* 74.8 (2008): 2298-2306.
- 4. Mercier, Julien, and S. E. Lindow. "Role of leaf surface sugars in colonization of plants by bacterial epiphytes." *Applied and Environmental Microbiology* 66.1 (2000): 369-374.

Questions?

