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Active depinning of bacterial droplets: The collective surfing of *Bacillus subtilis*

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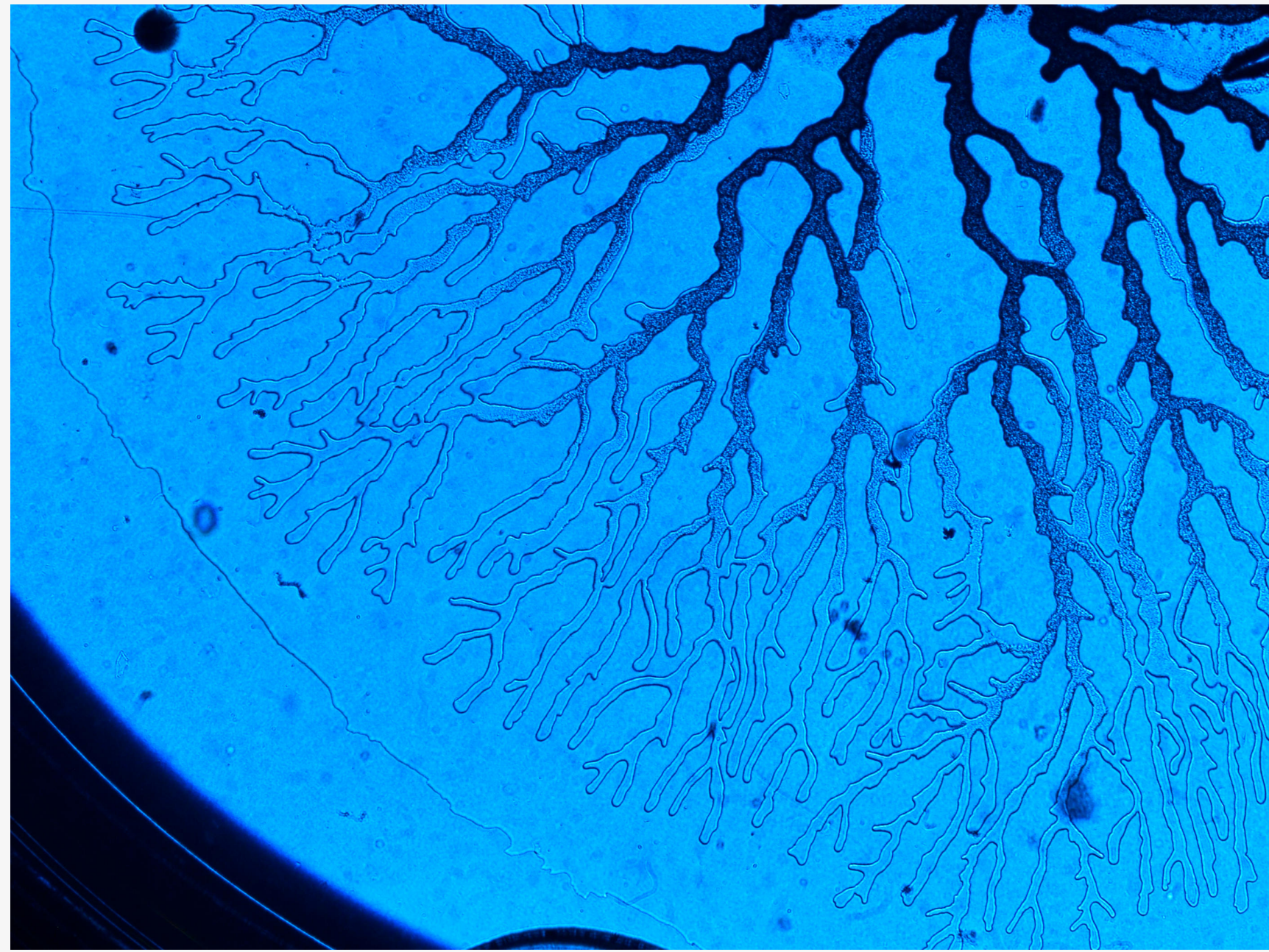
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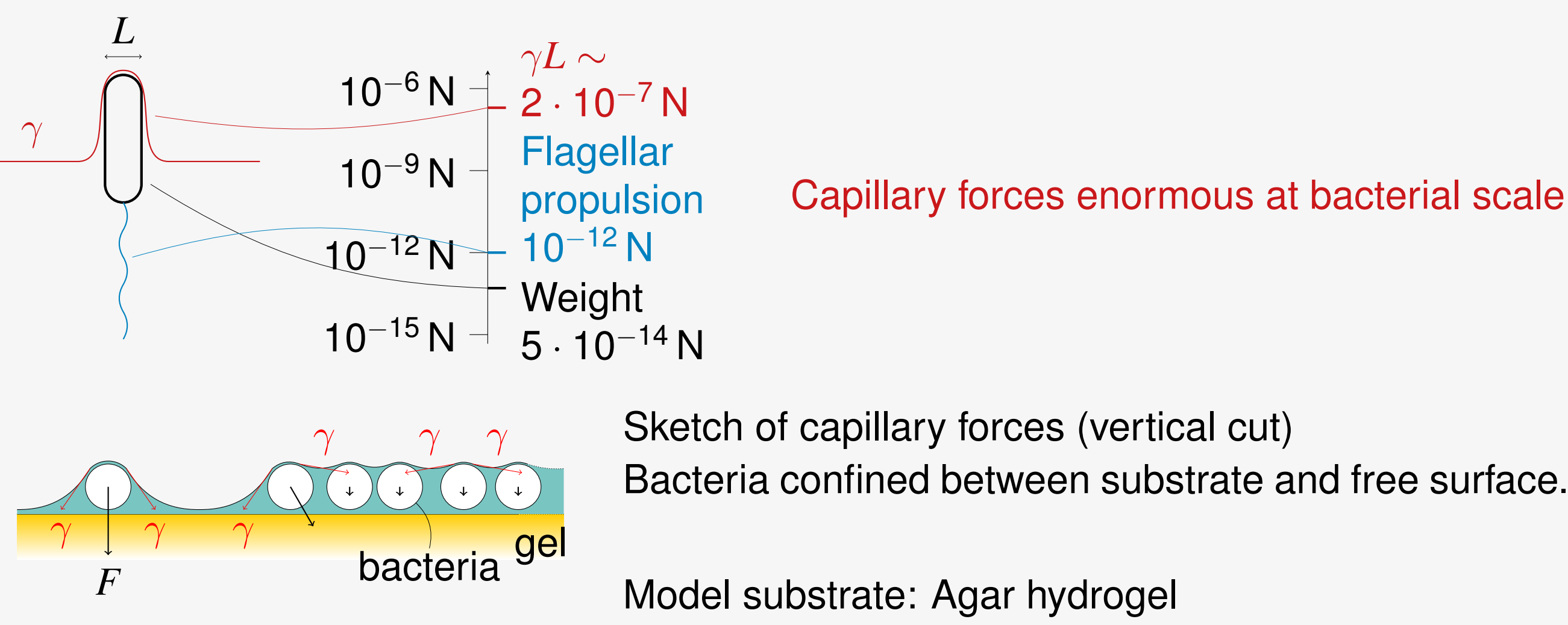
Active depinning of bacterial droplets: the collective surfing of *Bacillus subtilis*

Context: Surface translocation of microbes



Swarming *B. subtilis*

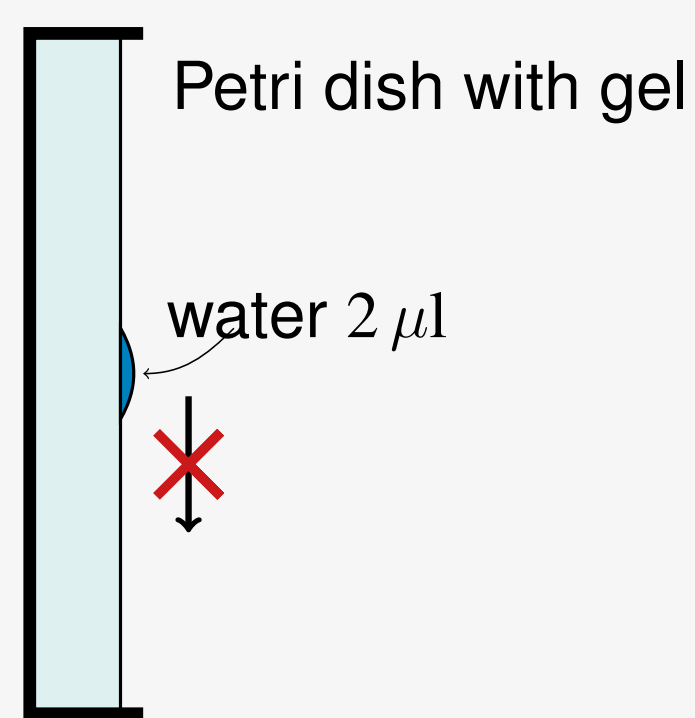
- Rich phenomenology, mechanisms unclear
- Often sharp colony boundary: no leaving colony alone
- Movement strongly constrained by interfacial forces



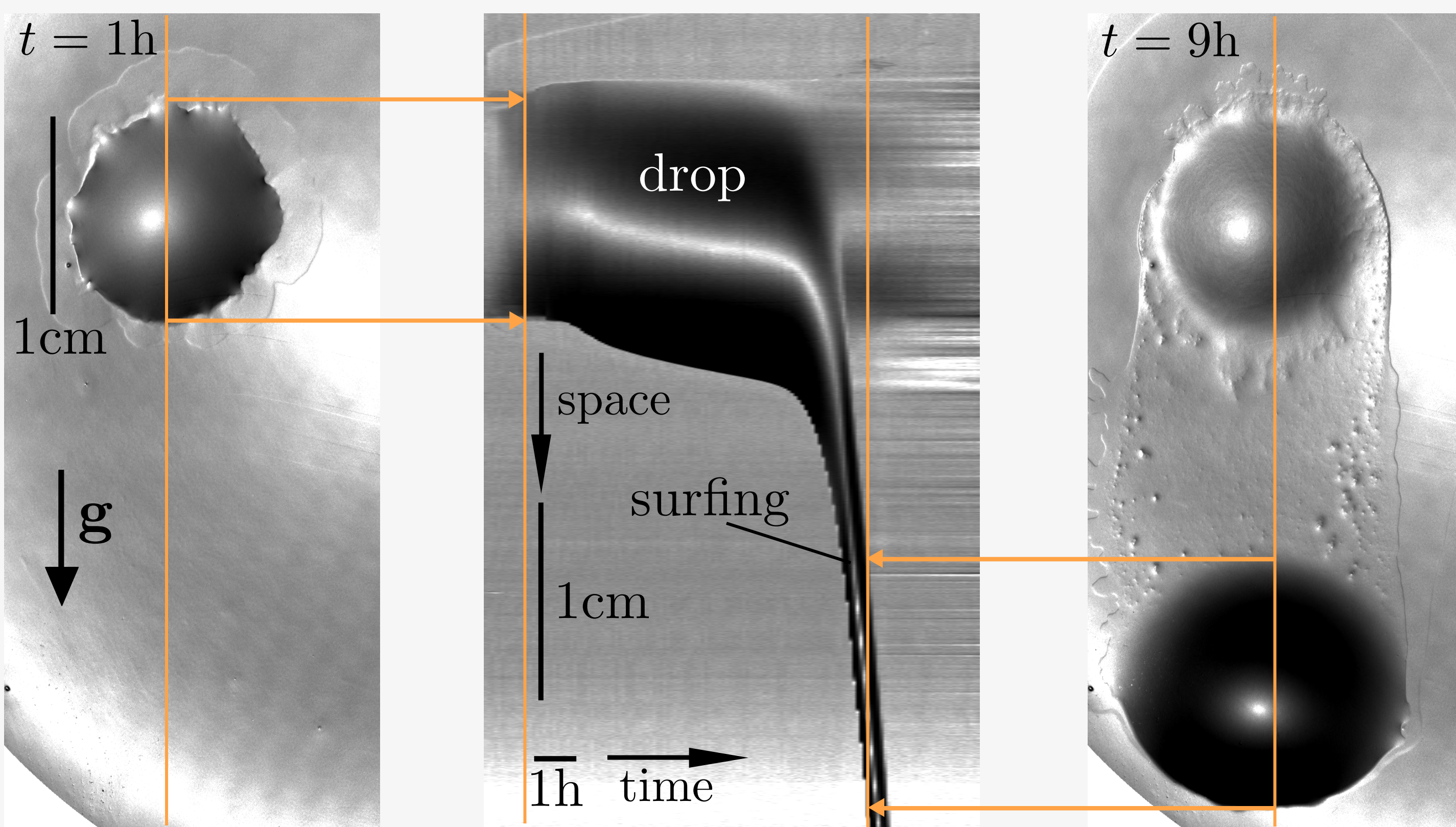
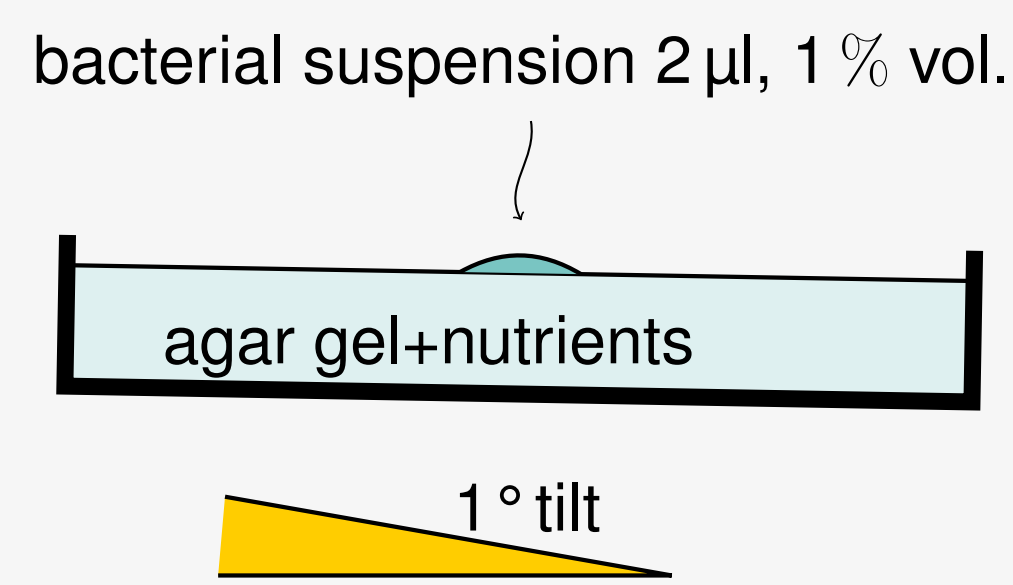
- Role of wetting and contact line depinning ?

Wetting of bacterial droplets

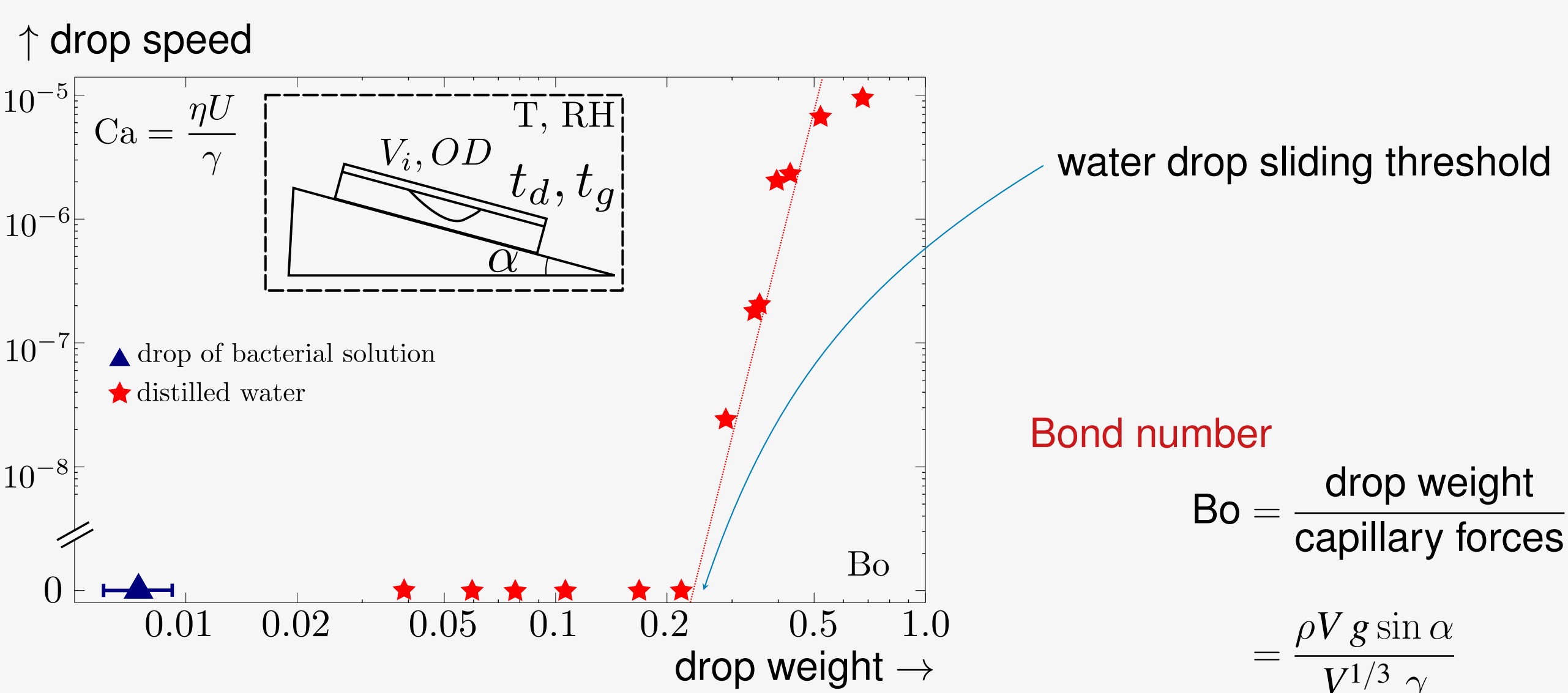
- Wetting hysteresis pins even millimetric water droplets to vertical



- Bacteria depin their drop



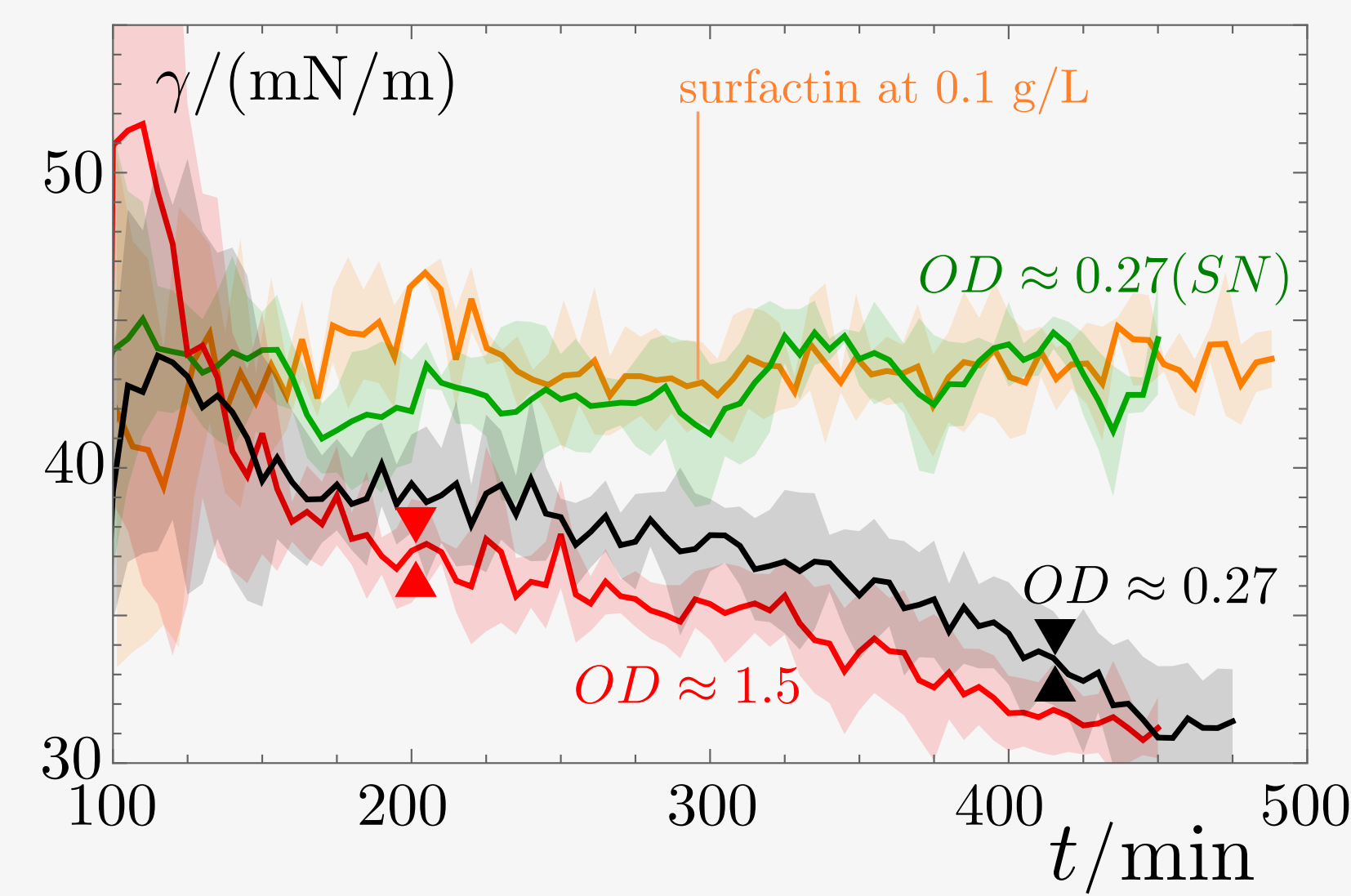
- Bacteria achieve depinning on very shallow slopes ...



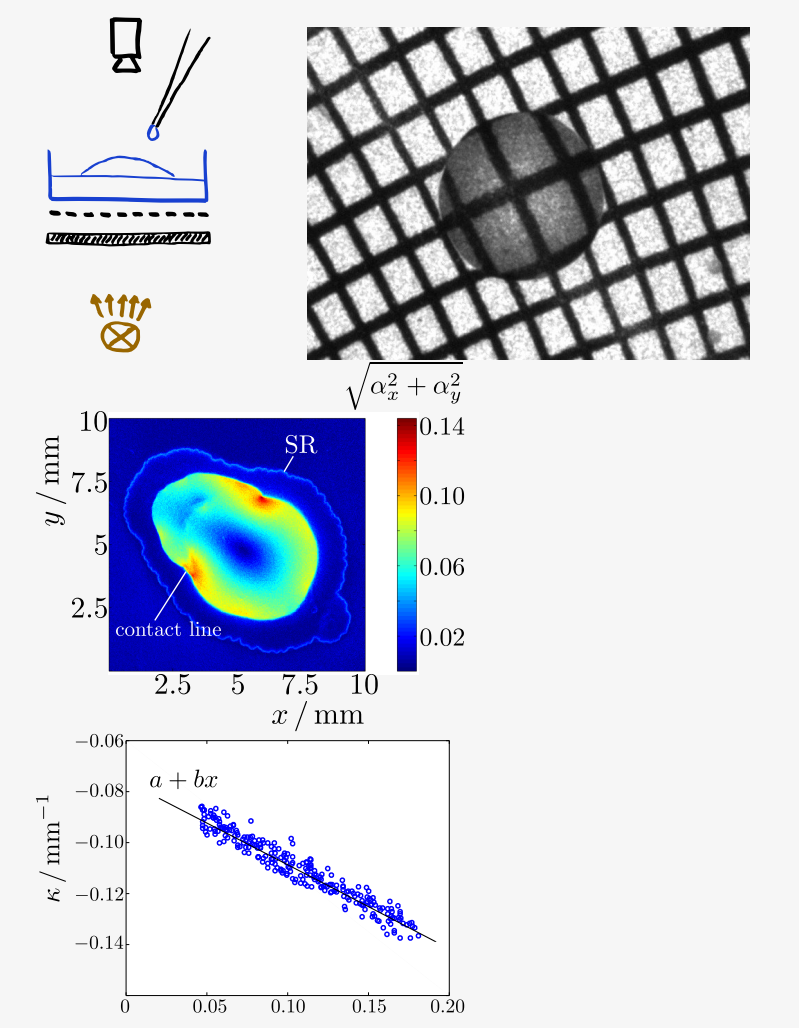
- ... initial droplet of bacterial suspension
- ... water

- ... but this colony surfing occurs only after several hours.

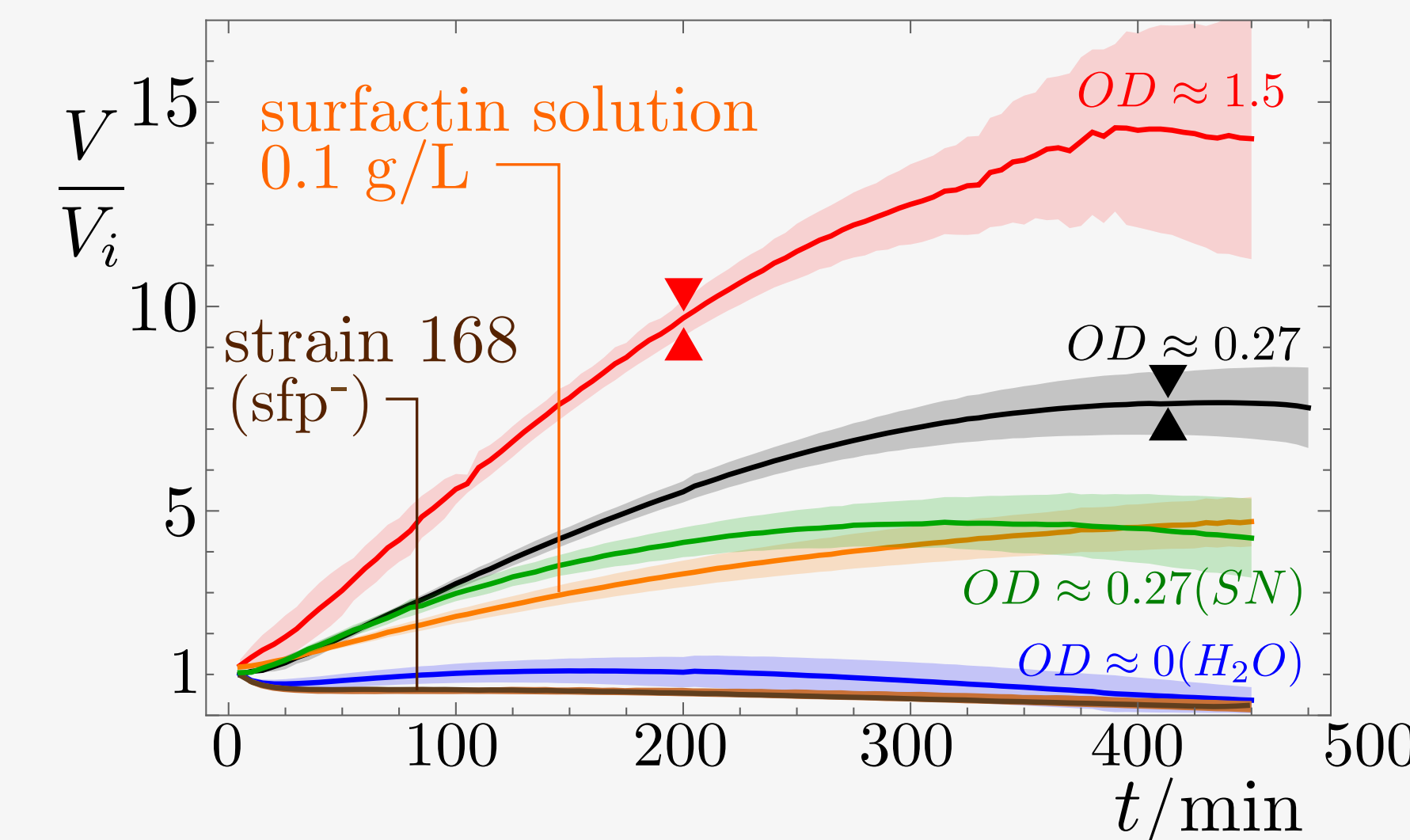
B. subtilis produces biosurfactant surfactin → reduces surface tension



Moving grid profilometry



Drop volume increases prior to depinning



- slow volume decrease for water
- the more bacteria ($OD \approx 1.5 > OD \approx 0.27$), the faster volume increases
- supernatant (SN = bacteria removed) behaves the same initially
- surfactant deficient strain 168 ⇒ no volume increase, as for water
- pure surfactant solution ⇒ volume increase

Bacterial droplets harness 3 distinct effects to unpin

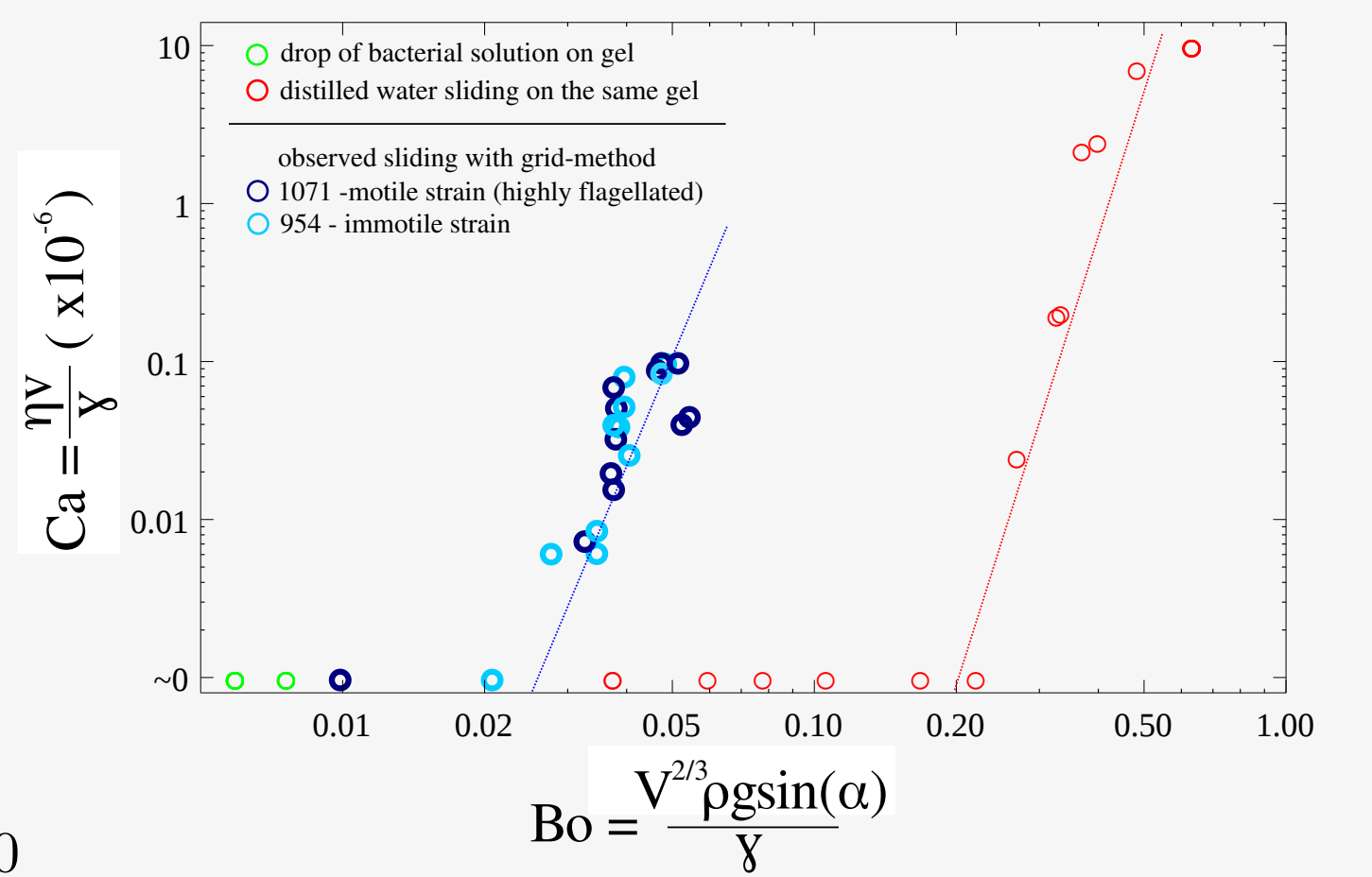
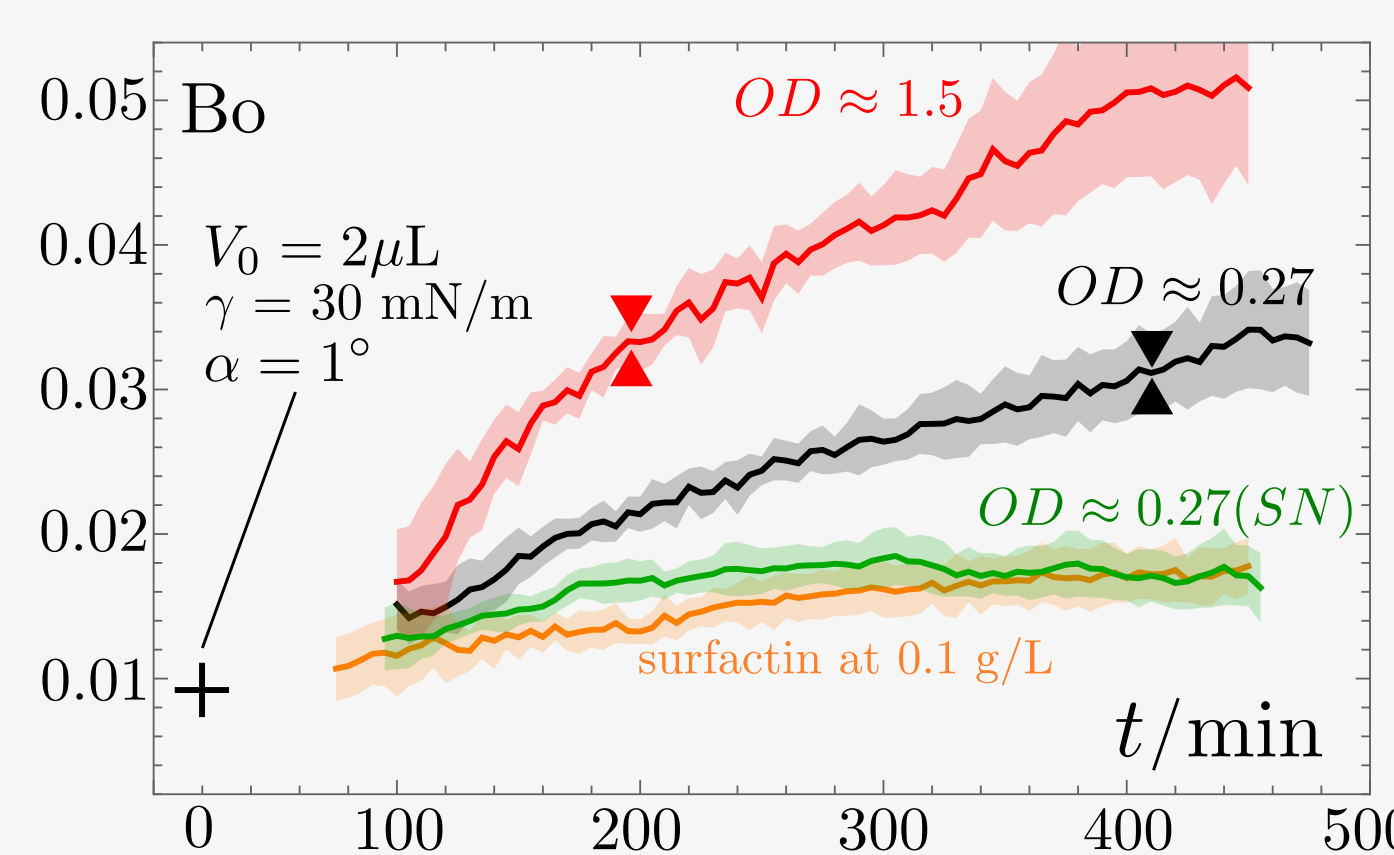
drop depinning condition:

$$\text{Weight} > \text{Contact line pinning force}$$

$$\rho V g \sin \alpha > \text{cst.} \cdot V^{1/3} \gamma (\cos \theta_r - \cos \theta_a)$$

$$\text{Volume} \nearrow, \text{Surface tension} \searrow \Rightarrow Bo = \rho V^{2/3} g \sin \alpha / \gamma \text{ increases,}$$

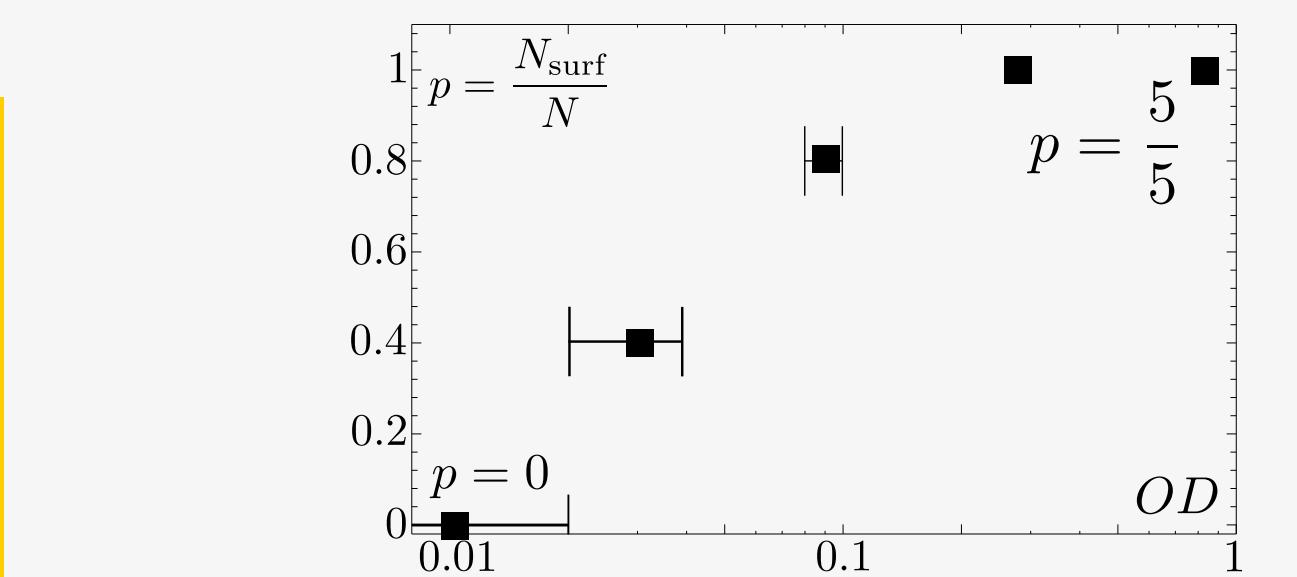
$$\text{Wetting hysteresis} \searrow \Rightarrow \text{critical Bond from 0.2 down to } \sim 0.03$$



Control experiments

- How many bacteria are needed ?

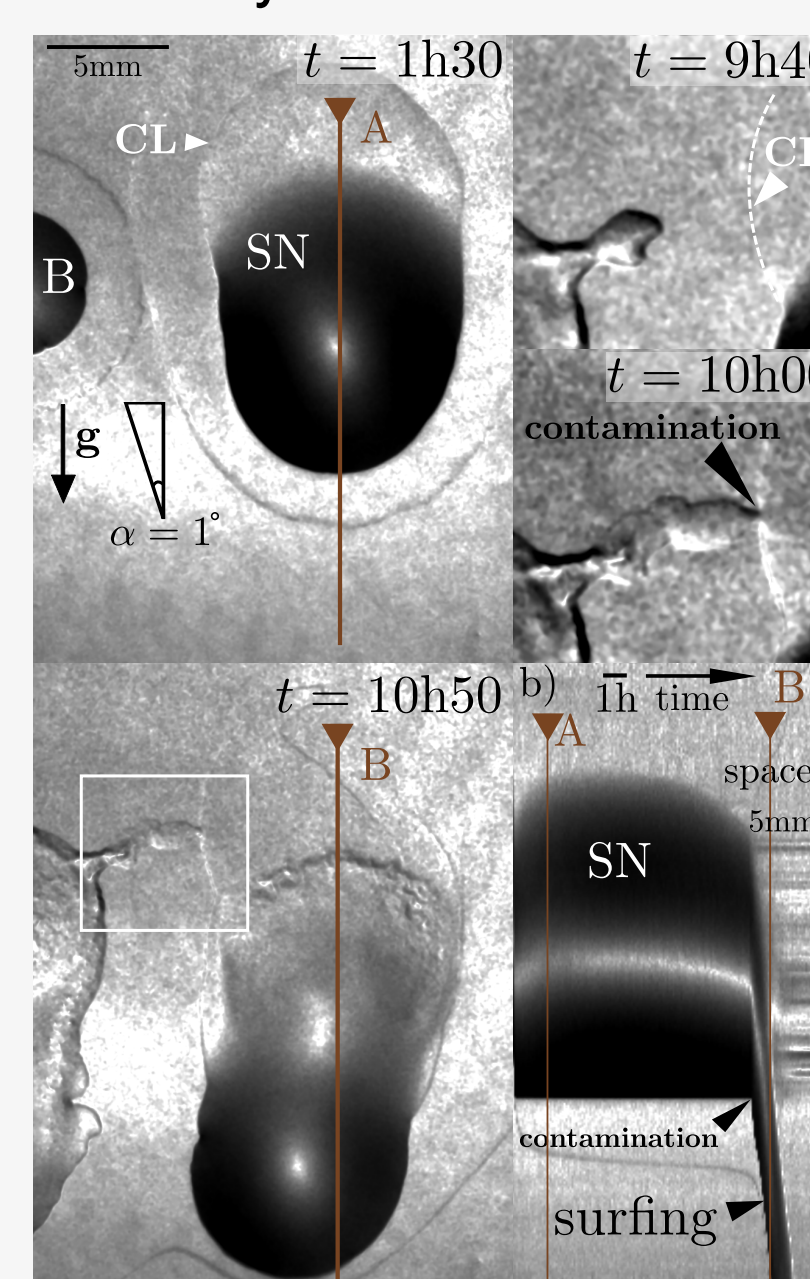
Fraction of colony surfing events ($N = 5$) for different bacterial concentrations (OD) in the deposited drop.



- $OD \leq 0.02$ no surfing (out of five exp.)
- $OD \geq 0.27$ surfing always occurs

- Are bacteria really needed ?

- Centrifuge & filter, keep supernatant (SN)
- Put droplets of bacterial suspension and of SN side-by-side

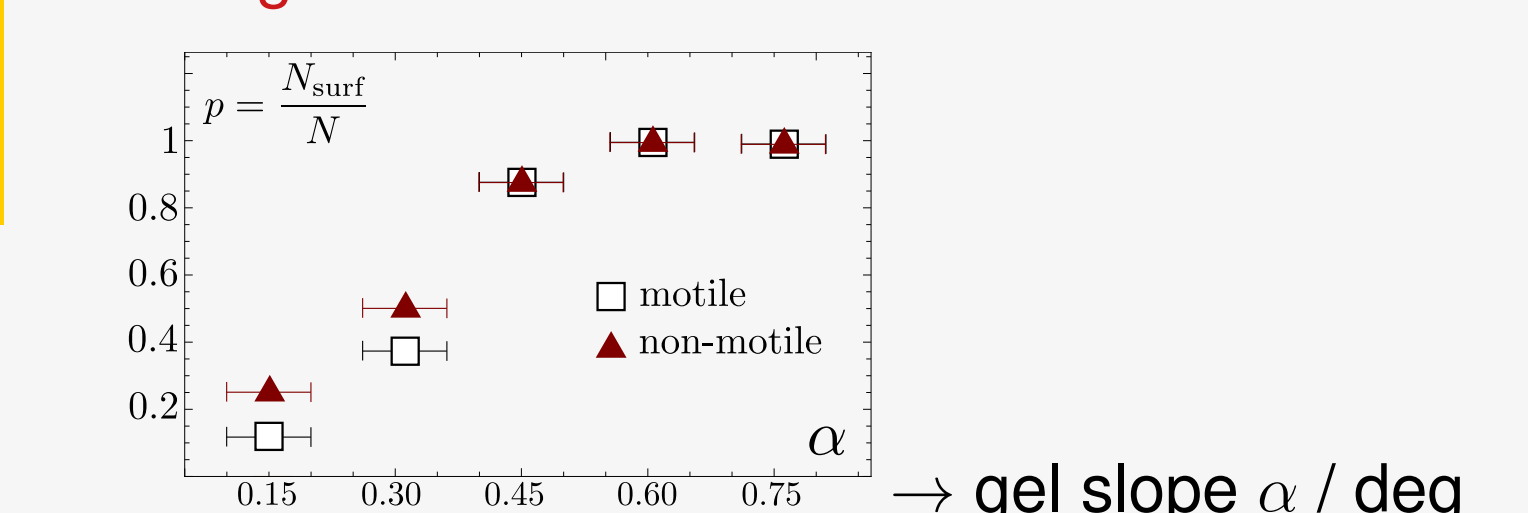


⇒ Contamination triggers drop sliding

- Do propelling forces contribute to depinning ?

Pressure from active swimmers could help depin contact line

↪ Compare with surfing probability for non-flagellated mutant



⇒ Colony surfing independent of individual motility