Extracting information from biological data

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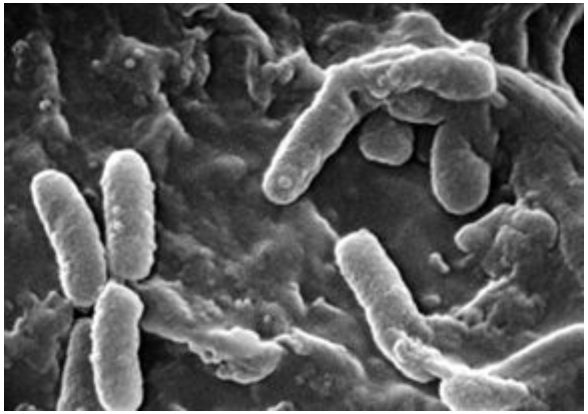
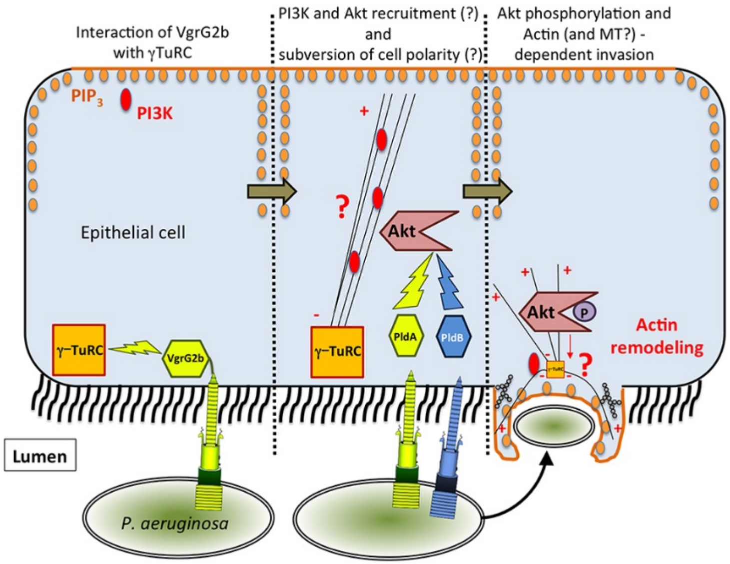
TIC Santé 2A
2019

Source: lab Meeting of M Madec, 20/02/2019





Assessement of the invasion efficiency of *Pseudomonas Aeruginosa*

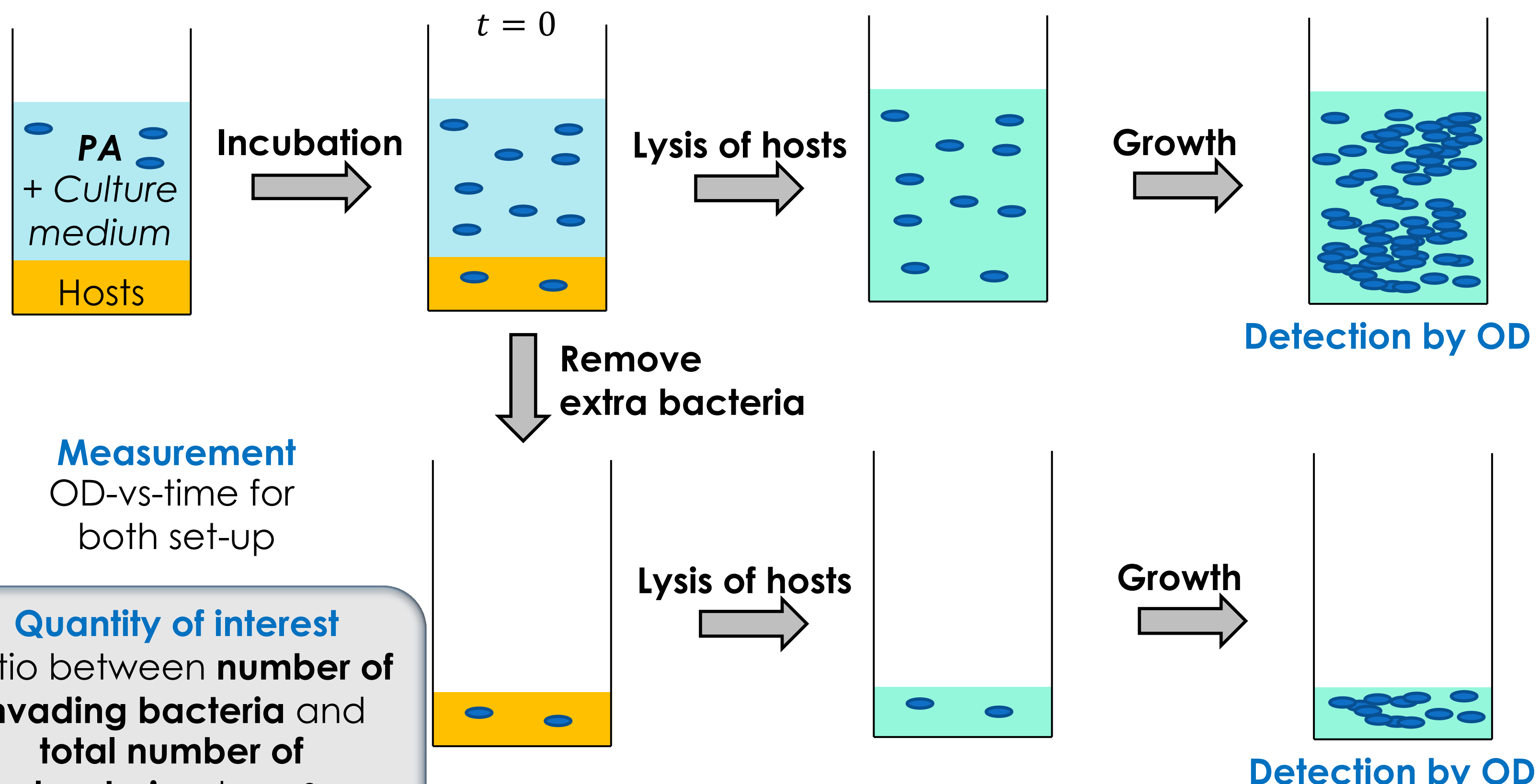
Report

- For you – trace of the work done during the two sessions
- Sent to me – maybe graded
- Group work – asking questions aloud enhances discussions, it’s always good !
- The report != a list of answers – questions are a guideline, can be answered in various order, you can and are encouraged to add your own reflexions/
- Justify everything you say – explanations/curves/data

Goal

Estimation of the invasion efficiency of *Pseudomonas Aeruginosa*

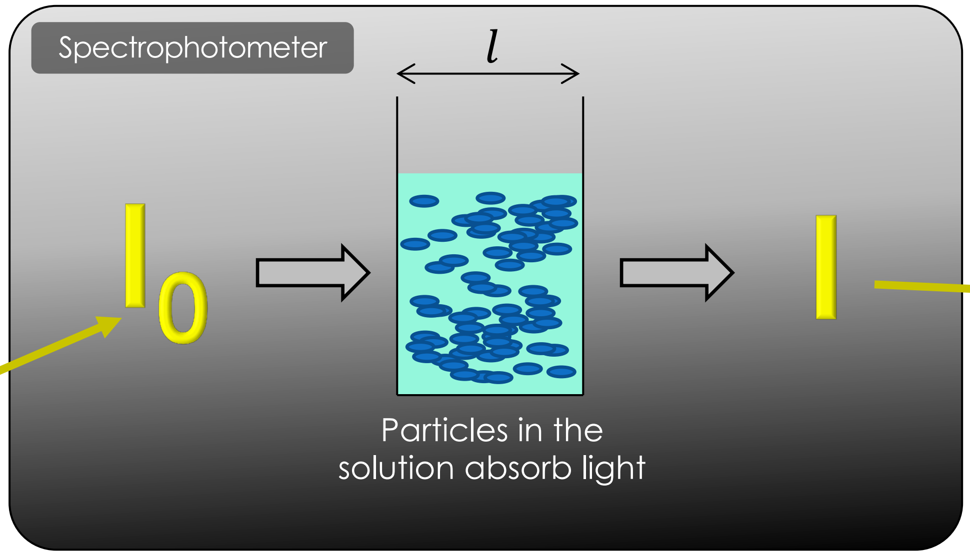
Experimental set-up



Measurement
OD-vs-time for both set-up

Quantity of interest
Ratio between **number of invading bacteria** and **total number of bacteria** at $t = 0$

Beer-Lambert law of absorption



Intensity of the light stream sent on the sample

Intensity of the **transmitted** light stream

Absorbance or Optical Density (OD): $A = \log\left(\frac{I}{I_0}\right)$

Beer Lambert law: $A = \varepsilon\, l\, c$

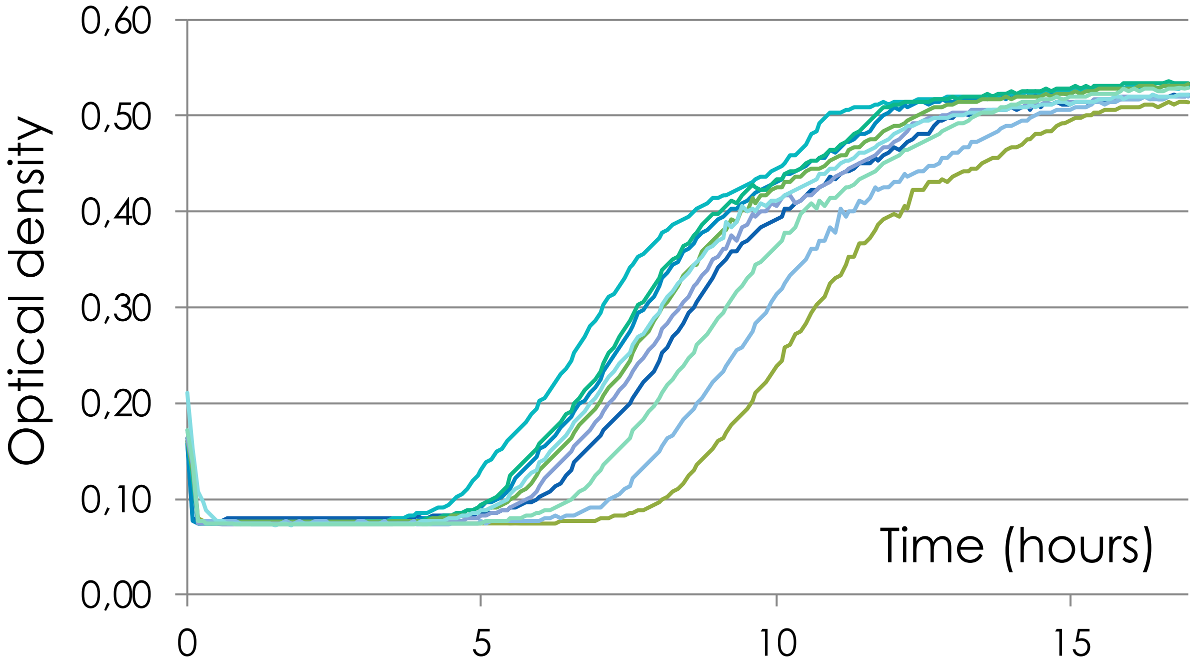
Molar attenuation coefficient ($m^3.mol^{-1}.cm^{-1}$)

Path length (cm)

Concentration of the solution ($mol.m^{-3}$)

Growth curves

Example of growth curve



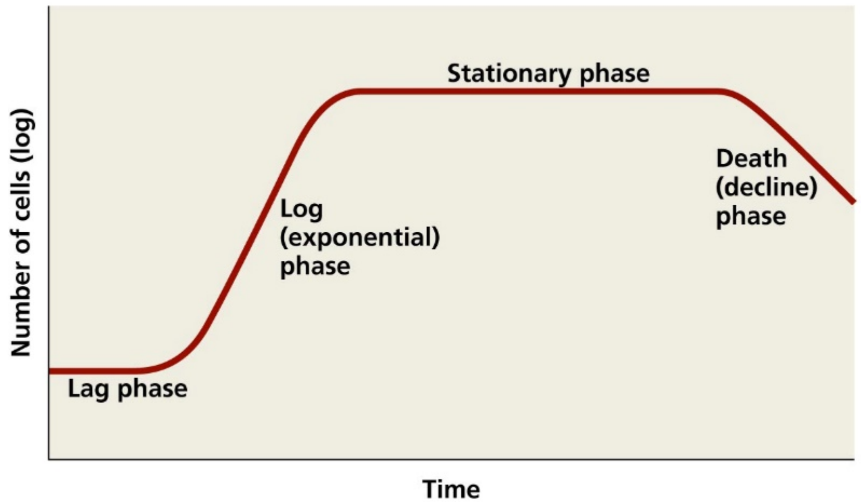
Different initial concentrations of bacteria.

What can we notice ?

Modeling of population growth

Population growth model

Observed behaviour



Associated model

$$\frac{dn}{dt} = \alpha(t) \cdot \mu(n) \cdot n$$

n the population (number of bacteria)

α the lag term (adjustment)

μ the growth rate

Non-autonomous model

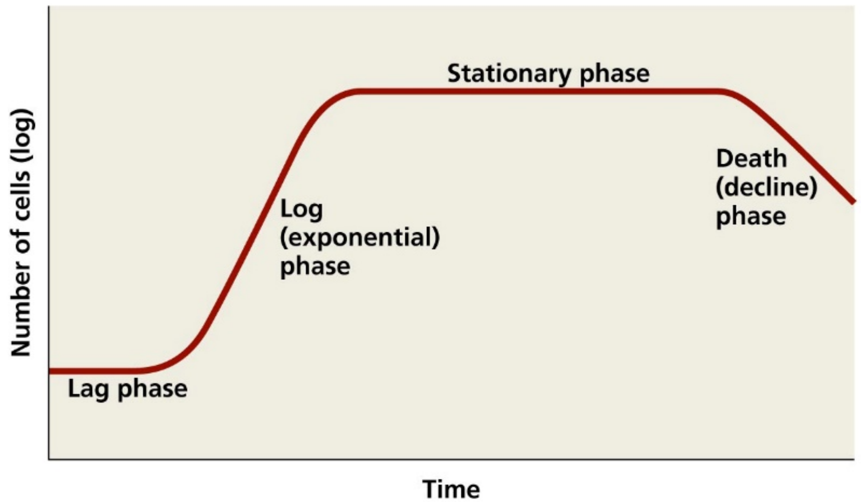
- Dynamic is not only population-dependent
- Time-varying parameters

J. Baranyi et al., Food Microbiology, 10 (1993)

Modeling of population growth

Population growth model

Observed behaviour



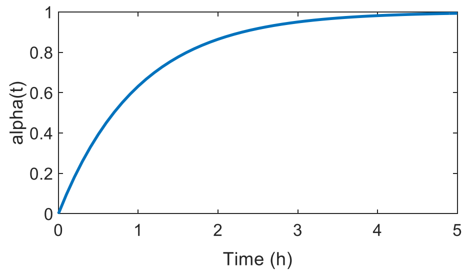
Associated model

$$\frac{dn}{dt} = \alpha(t) \cdot \mu(n) \cdot n$$

Lag term

What approximation can be used?

$$\alpha(t) = 1 - exp\left(-\frac{t}{\tau}\right)$$



J. Baranyi et al., Food Microbiology, 10 (1993)

Modeling of population growth

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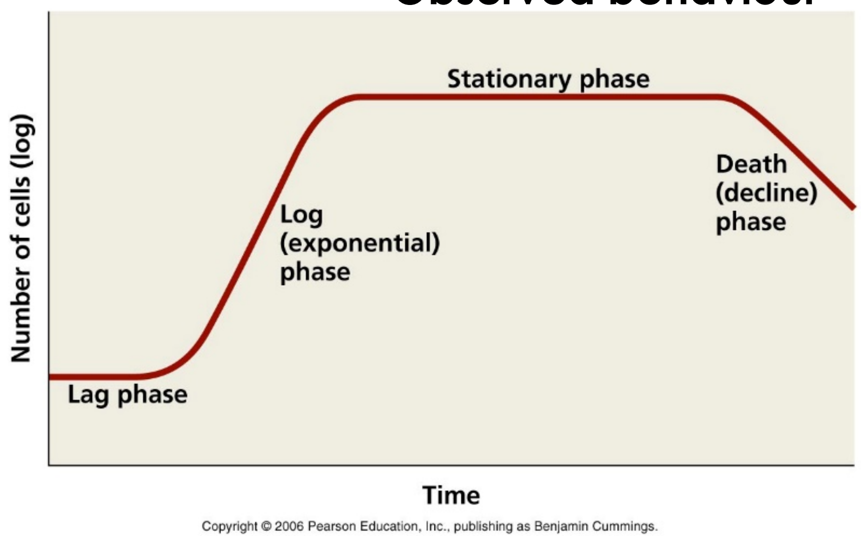


Associated model

$$\frac{dn}{dt} = \alpha(t) \cdot \mu(n) \cdot n$$

Lag term

Variable growth rate

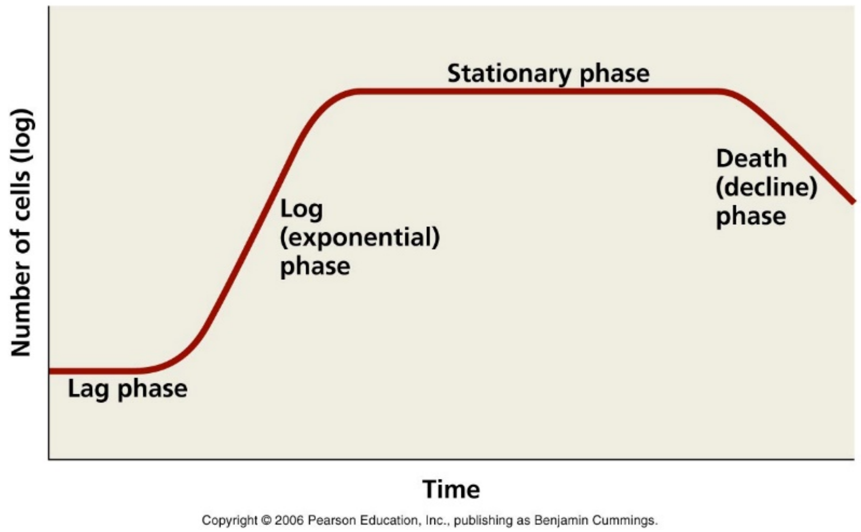
What do we expect from the model of $\mu(n)$?

J. Baranyi et al., Food Microbiology, 10 (1993)

Modeling of population growth

Population growth model

Observed behaviour



Associated model

$$\frac{dn}{dt} = \alpha(t) \cdot \mu(n) \cdot n$$

Lag term

Variable growth rate

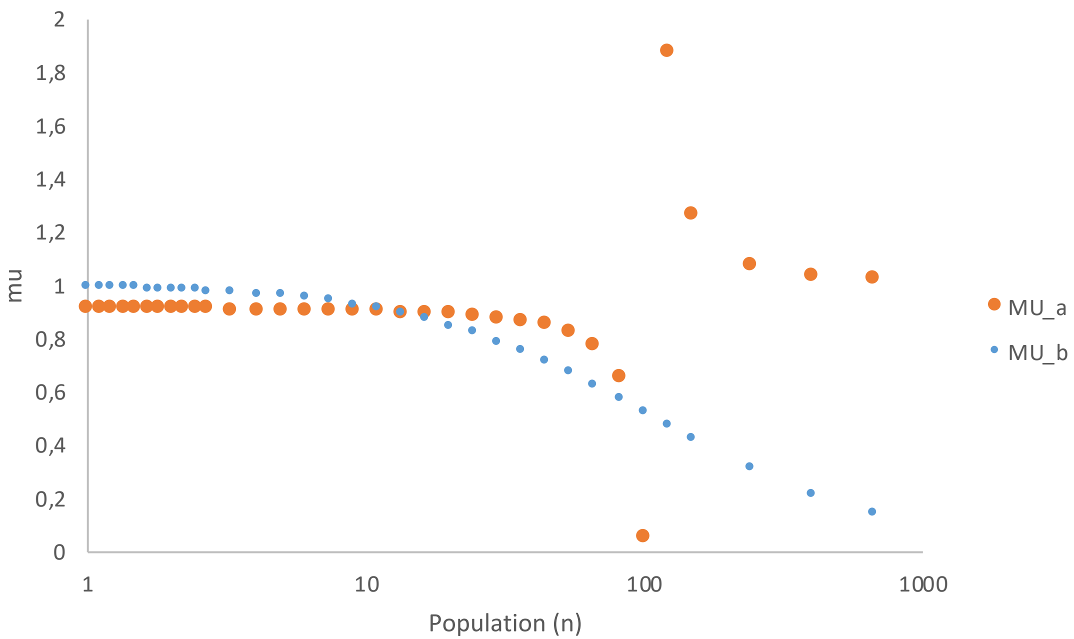
Limited by the initial stock S_0 of nutriment

$$\mu(n) = \mu_{max} \frac{S_0 - n}{S_k + S_0 - n}$$

J. Baranyi et al., Food Microbiology, 10 (1993)

Modeling of population growth

Growth rate



$$\mu_a(n) = \mu_{max} \frac{S_0 - n}{S_k + S_0 - n}$$

$$\mu_b(n) = \mu_{max} \frac{S_k'}{S_k' + n}$$

$$\mu_c(n) = \mu_{max}\ ?$$

μ_{max}	S_k	S_0	S_k'
1	10	100	110

What approximation for μ ?

Analytic solution

Approximations used

$$\frac{dn}{dt} = \alpha(t) \cdot \mu(n) \cdot n$$

$$\alpha(t) = \begin{cases} 0 \text{ before } t_{lag} \\ 1 \text{ after } t_{lag} \end{cases} \qquad \mu(n) = \mu_{max}$$

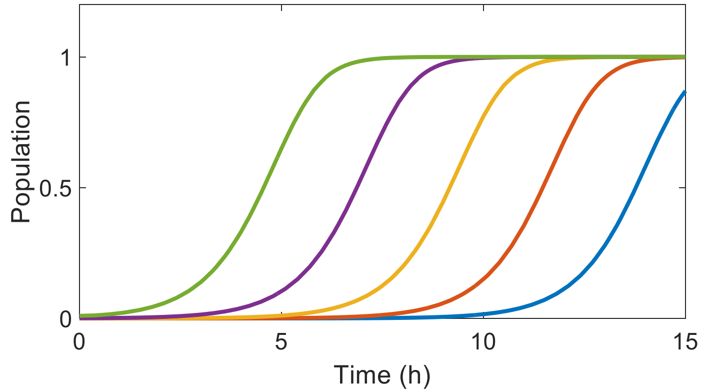
Analytic solution of the differential equation:

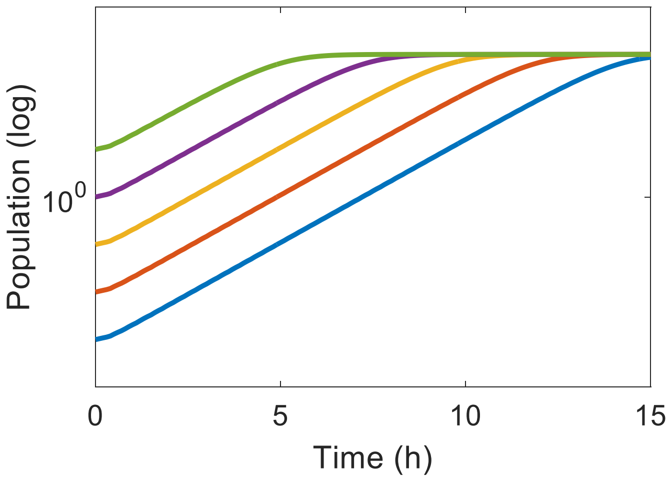
$$n(t) = n_0 \cdot e^{\mu \cdot t}$$

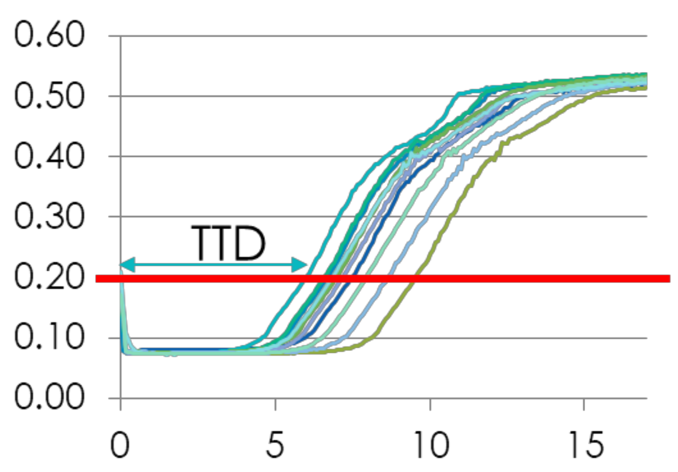
$$\log n(t) = \log n_0 + \mu \cdot t$$

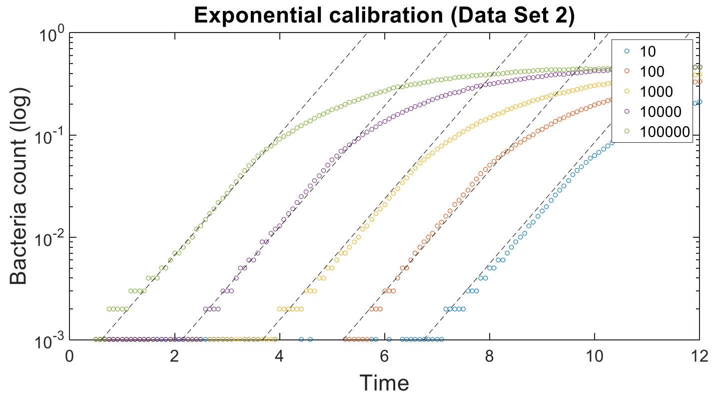
Interesting manipulation to the equation?

What parameter varies between these curves?







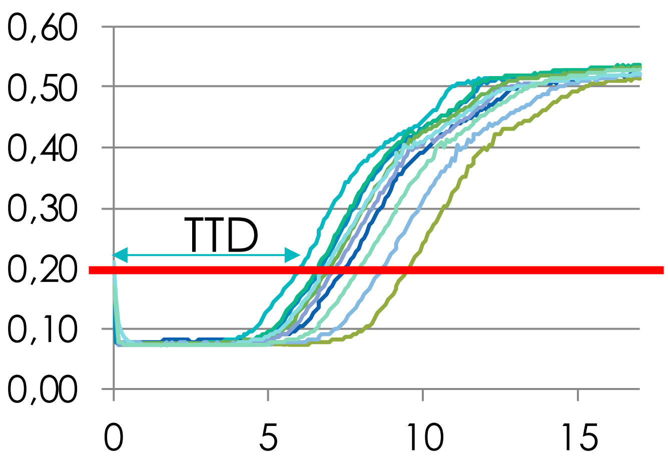


Methods to find the ratio of interest

TTD method and linear study

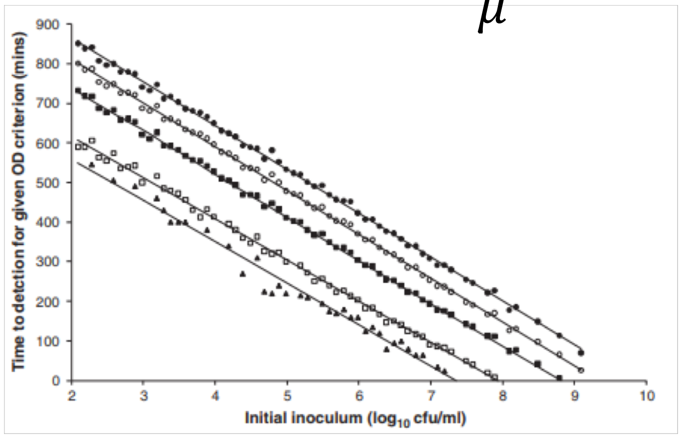
First method: TTD

Time-to-detect (TTD)
Time required for a growing population to reach a given OD



Linear regression
For low OD, TTD is assumed to be proportional to the log of the initial population:

$$TTD = TTD_1 - \frac{logN_0}{\mu}$$

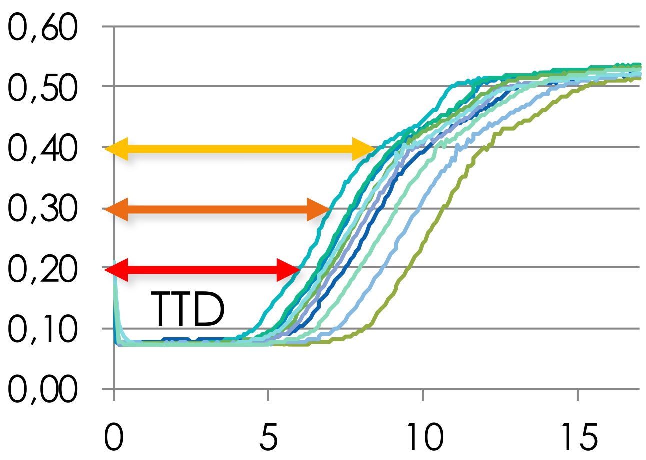


Multiple TTD
TTD estimated for multiple ODs
→ Multiple estimation of N_0
→ Error reduction by averaging

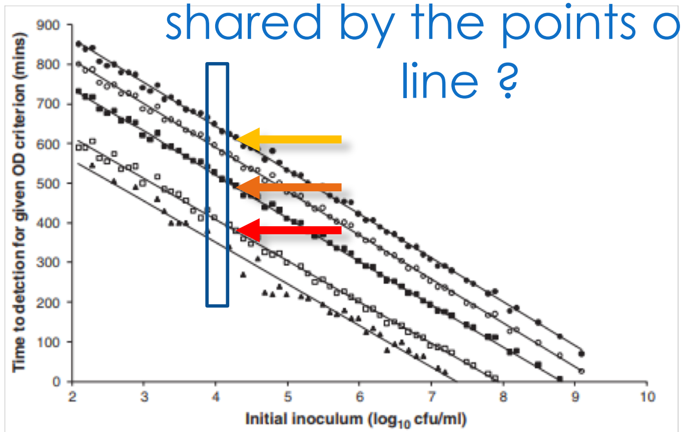
I. Mytilinaios et al., International Journal of Food Microbiology, 154 (2012)

First method: TTD

Time-to-detect (TTD)
Time required for a growing population to reach a given OD



Where are the different points of a same growth curve ?
What characteristic is shared by the points on a line ?



I. Mytilinaios et al., International Journal of Food Microbiology, 154 (2012)

Manipulating experimental data

- Import the rawData.mat
- Calibration:
  - SerieNb = number of the dilution serie (4 series)
  - Dilution: log of the initial number of bacteria (7 corresponds to $n_0 = 10^7$)
- Measurement
  - MOI: factor related to the expected number of bacteria
  - Type: 0 → infecting bacteria, 1 → total bacteria

Manipulating experimental data

- Plot the data for one serie of dilutions.
- Chose a curve to study. Does the data need to be "cleaned" ?
- Use matlab fit function with the model of your chosing (feel free to try different model). Check the parameters given by matlab.
- Apply the TTD method.
  - Compute a function that finds the time (TTD) at which the OD overpasses the OD threshold (use a linear interpolation between the neighboring points)
  - Extract TTD for different OD threshold, for different n_0
  - Find the n_0 of the curve.
- Enhance your set up (use replicates…)