Predicting stochastic bacterial population behavior via Bayesian statistical modeling

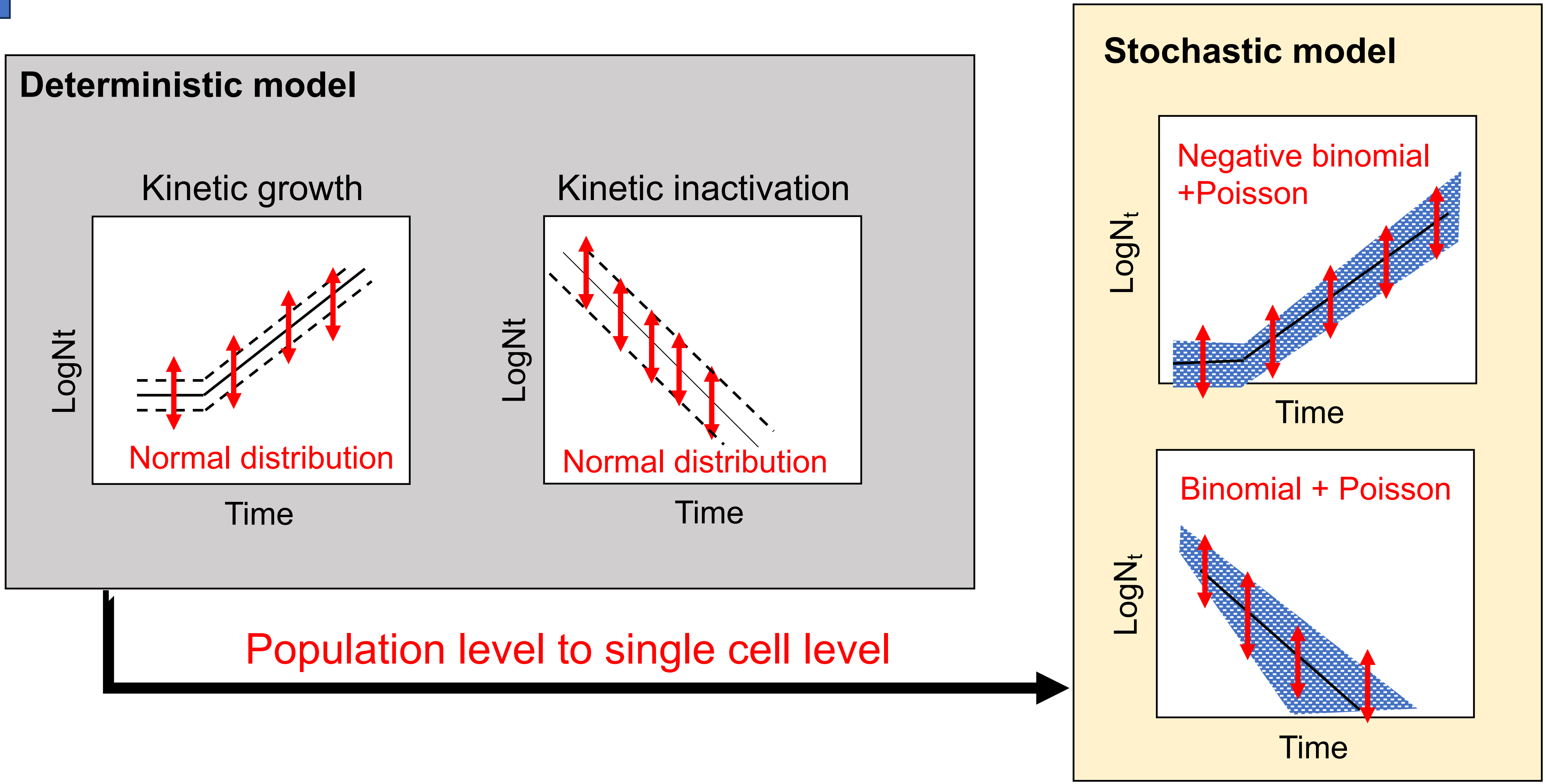
Topic

・Predictive microbiology

・Population growth and inactivation behavior

・Stochastic modeling

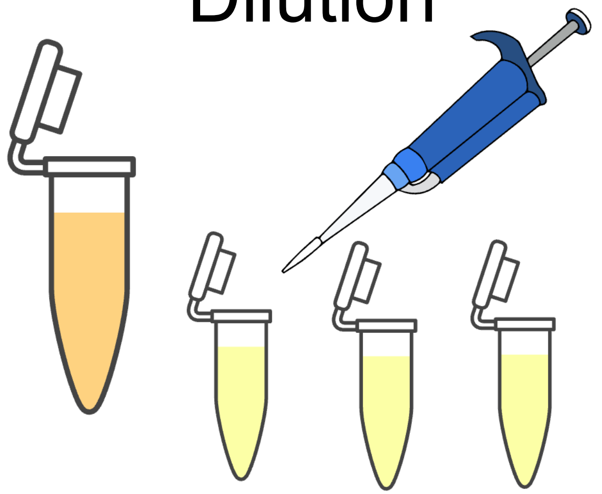
Objective: Modeling for growth and inactivation



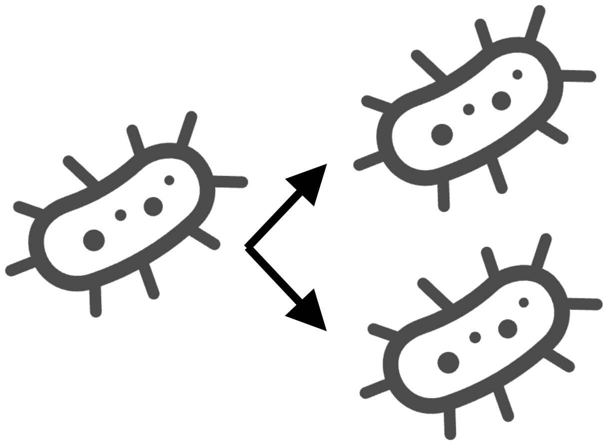
Sources of stochastic process

Assumption: Each process is independent.

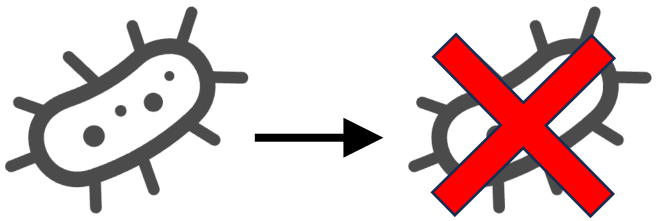
Dilution



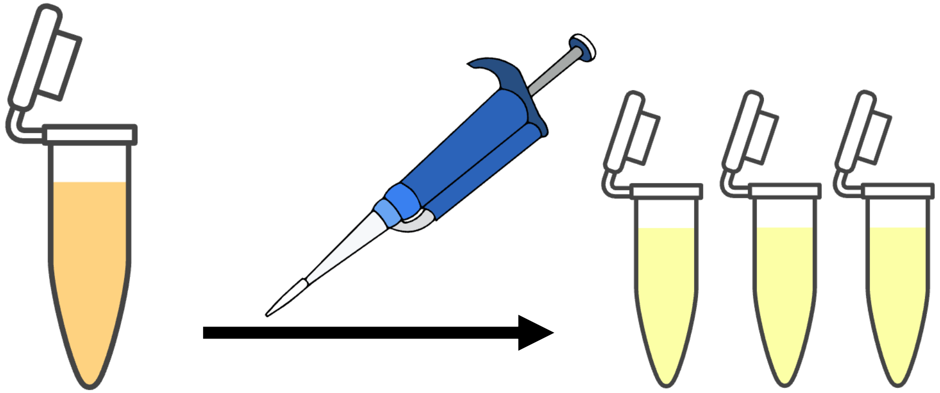
Single cell division



Single cell death



Sources of stochastic process: Dilution



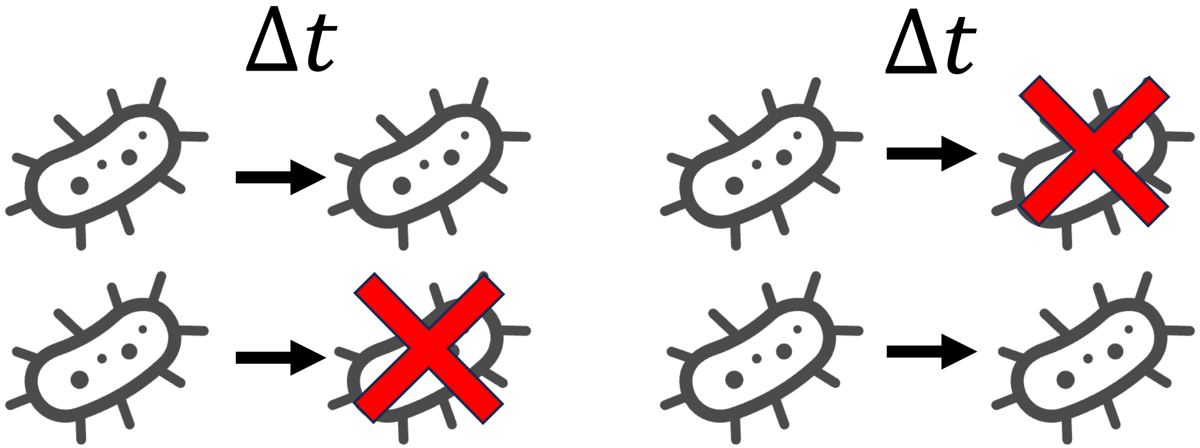
Number of bacteria follows Poisson distribution

$$N_0 \sim Poisson(E(N_0))$$

Assumption:

- ◯ Bacteria are randomly distributed in the sample.
- ◯ A small portion is obtained from a sufficiently large sample.
- ◯ Each sampling procedure is independent of other procedures.

Sources of stochastic process: Single cell death



Number of survivor follows binomial distribution

$$N_t \sim Binomial\left(N_0, \frac{E(N_t)}{N_0}\right)$$

Assumption:

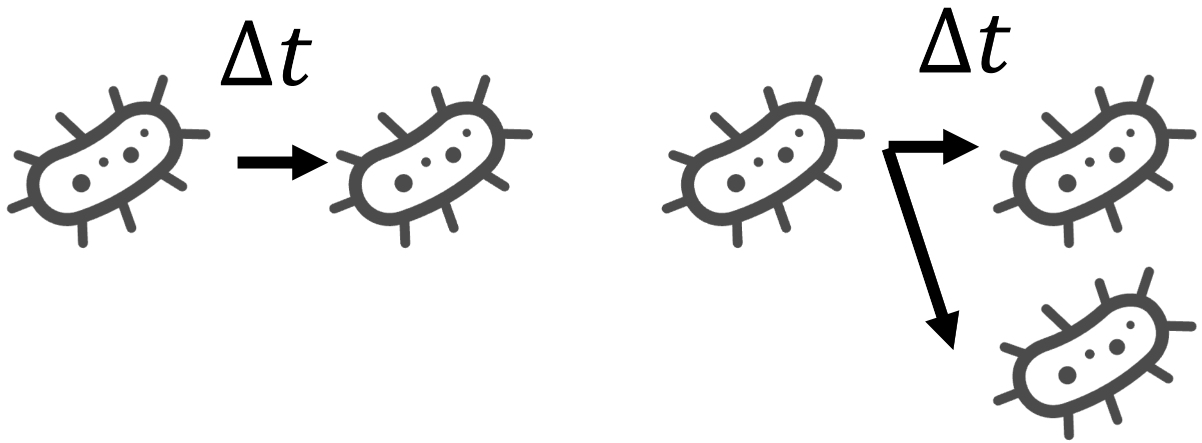
○ Cell inactivation is independent from other events.

○ Bacteria have the same inactivation rate, k, which is constant over time.

○ Bacteria do not grow during the stochastic bacterial inactivation process.

○ The cell state is either survive or death at time t.

Sources of stochastic process: Single cell growth



Number of division follows Negative binomial distribution

$$\boldsymbol{N_t \sim N_0 + Negbin(N_0, e^{-\mu t})}$$

Assumption:

○ Cell division event is independent from other events.

○ Cell division starts after the lag phase which is estimated by the kinetics.

○ Single cell growth rate, μ, is the same and remains constant over time.

Stochastic growth or inactivation model