Learning about the process and organism: Batch

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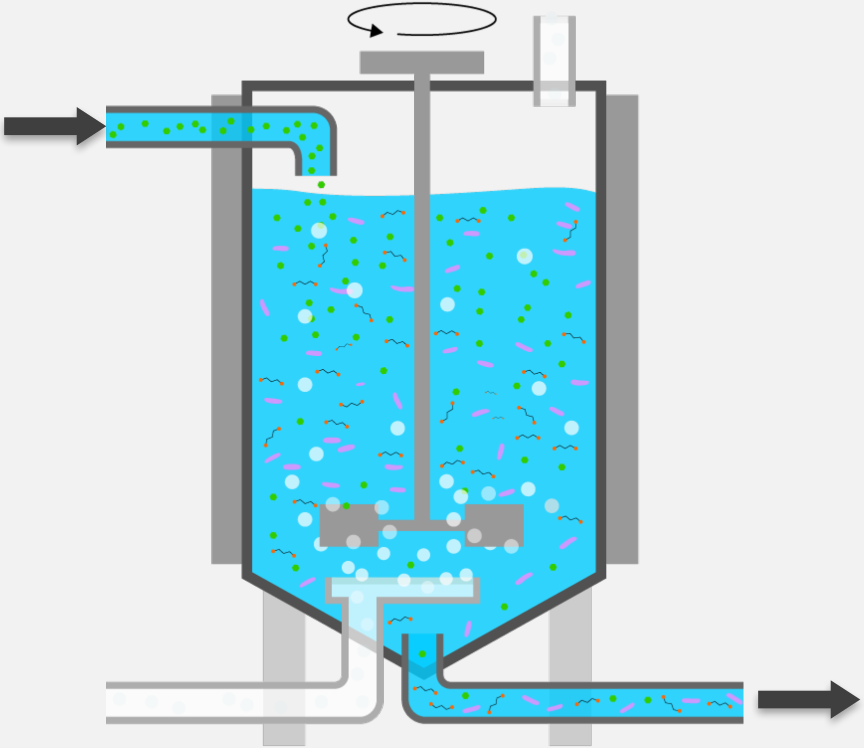
Chemostat

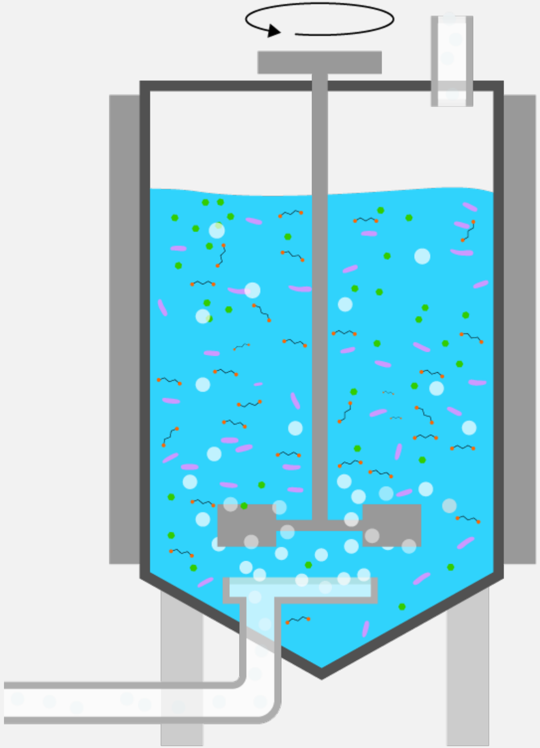
Control over μ, q_s and q_p



Volume: constant

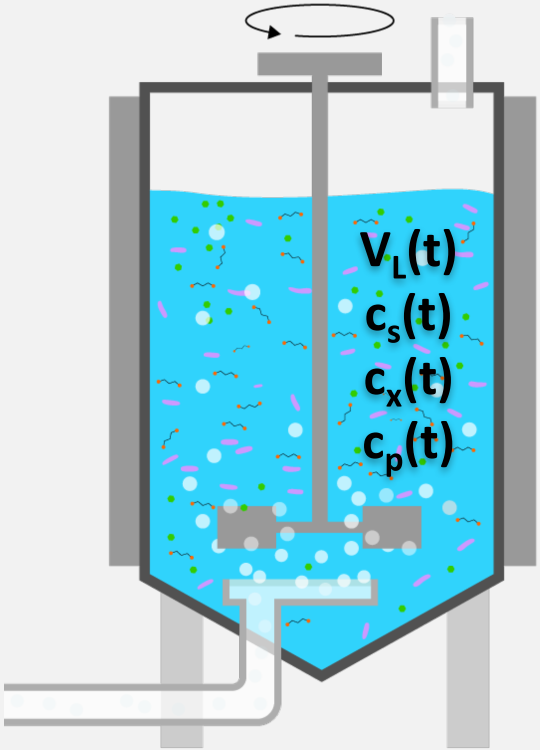
Batch

μ, q_s and q_p?



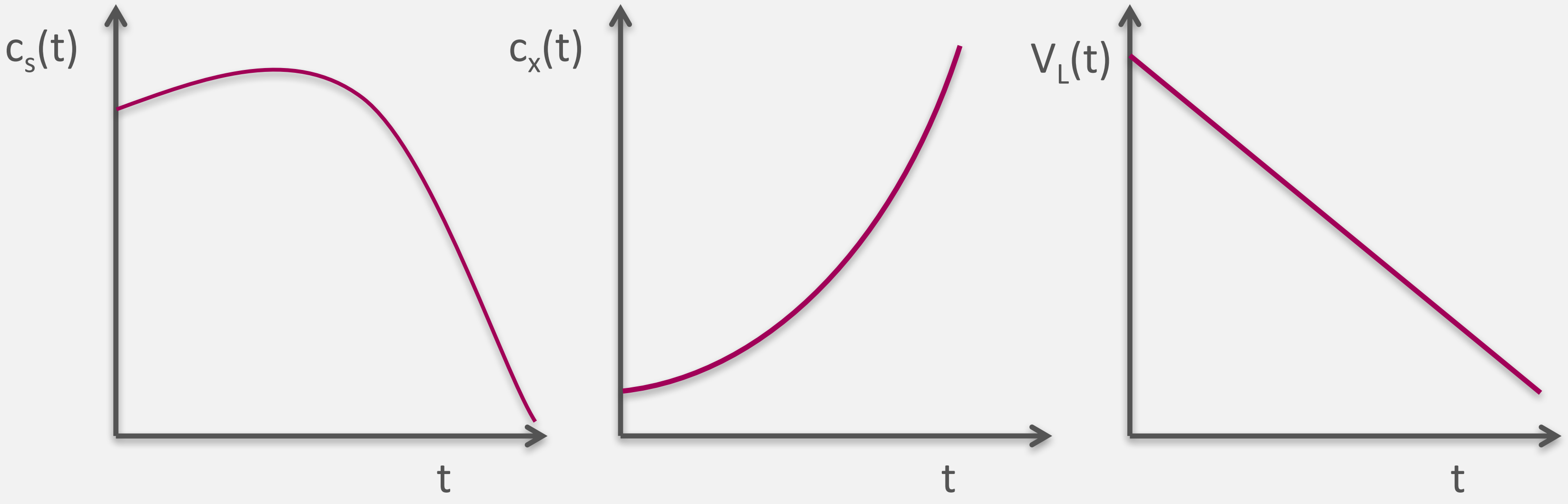
Volume: not constant

Broth balances in batch



All time dependent

Batch volume changes in time



Volume change: water evaporation, pH-titrant addition

Broth balances in batch

Biomass:

$$\frac{d(V_L(t)c_x(t))}{dt} = \mu(t)V_L(t)\,c_x(t)$$

Accumulation	Conversion

Substrate:

$$\frac{d(V_L(t)c_s(t))}{dt} = q_s(t)V_L(t)\,c_x(t)$$

Accumulation	Conversion

NO STEADY STATE
TIME DEPENDENT CONCENTRATIONS

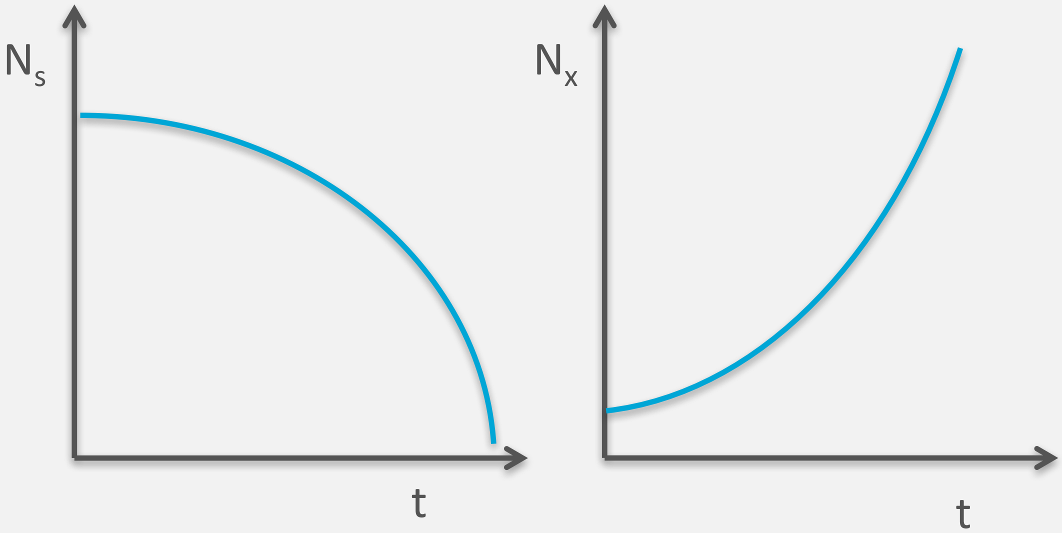
$$N_x(t) = V_L(t)\,c_x(t)$$

$$\frac{dN_x(t)}{dt} = \mu(t)N_x(t)$$

$$N_s(t) = V_L(t)\,c_s(t)$$

$$\frac{dN_s(t)}{dt} = q_s(t)N(t)$$

In batch we look at amounts N_i



Obtaining µ from a batch experiment: Set up the biomass balance

Biomass balance:

$$\frac{dN_x(t)}{dt} = \mu(t) N_x(t)$$

3 variables

($N_x(t)$, t, μ (t))

UNSOLVABLE

$$\mu(t) = \mu_{max}$$

$$\frac{dN_{x(t)}}{dt} = \mu_{max} N_x(t)$$

2 variables *($N_x(t)$, t)*

1 parameter *(μ_{max})*

SOLVABLE

Obtaining μ from a batch experiment: Solve the biomass balance

$$\frac{dN_{x(t)}}{dt} = \mu_{max} N_x(t)$$

$$\frac{1}{N_x(t)} dN_{x(t)} = \mu_{max}\, dt$$

Separating variables

$$\int_{N_x(0)}^{N_x(t)} \frac{1}{N_x(t)} dN_{x(t)} = \mu_{max} \int_{t_0}^{t} dt$$

Setting integral and initial values

INTEGRATION

$$ln \frac{N_x(t)}{N_x(0)} = \mu_{max} t$$

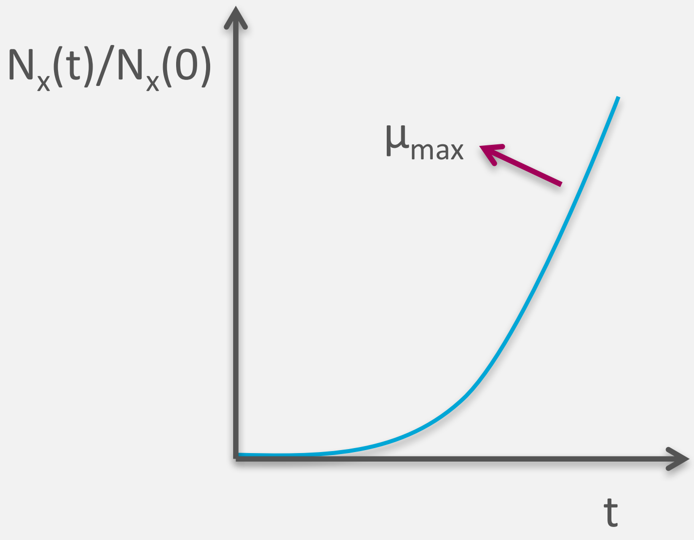
Log-linear

or:

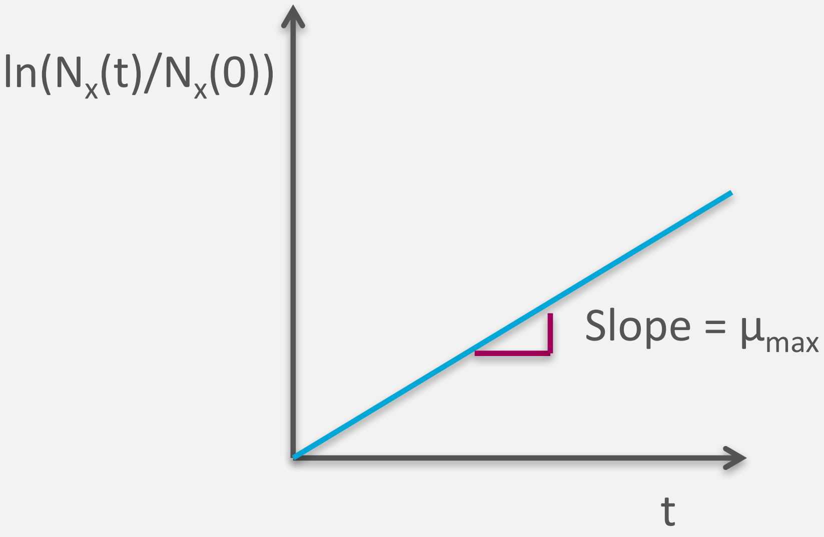
$$N_x(t) = N_x(0) e^{\mu_{max} t}$$

Exponential

Obtaining μ_{max}: Non-lineair data fitting to $N_x(t)$



Exponential relation



Log-linear growth relation

Obtaining $q_{s,max}$: solving the substrate balance

Substrate balance:

$$\frac{dN_{s(t)}}{dt} = q_{s,max} N_x(t)$$

Biomass balance:

$$\frac{dN_{s(t)}}{dt} = \mu_{max} N_x(t)$$

COMBINE

$$\frac{dN_{s(t)}}{dt} = \frac{q_{s,max}}{\mu_{max}} \frac{dN_{x(t)}}{dt}$$

$$\int_{N_s(0)}^{N_s(t)} dN_{s(t)} = \frac{q_{s,max}}{\mu_{max}} \int_{N_x(0)}^{N_x(t)} dN_{x(t)}$$

Setting integral and initial values

INTEGRATION

$$\left(N_{s(t)} - N_{s(0)}\right) = \frac{q_{s,max}}{\mu_{max}} \left(N_{x(t)} - N_{x(0)}\right)$$

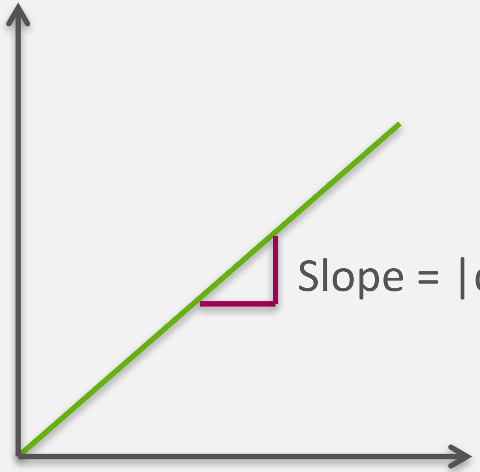
Consumed substrate

Produced biomass

Obtaining $q_{s,max}/\mu_{max}$: linear data fitting

mol s consumed

$|(N_s(t) - N_s(0))|$



Slope = $|q_{s,max}/\mu_{max}|$

$\rightarrow |q_{s,max}| = \text{Slope} * \mu_{max}$

mol x produced

$(N_x(t) - N_x(0))$

Wrap up:
Learning about the process and organism: Batch

We have learned about the batch that:

- Batch broth volume seldom constant in time
- Balances show: use amounts, not concentrations
- Biomass balance
  - Biomass growth is exponential in time
  - Allows to calculate μ_{max}
- $q_{s,max}$ and $q_{p,batch}$ found through combi-balances
- Combi-balances show that linear plots of consumed s or produced p against produced x should be made

See you in the next unit!