# Solutions Tasks 5-10

Manfred Zinn

# Task 5: Fed-Batch culture

In a fed-batch culture operating with intermittent addition of glucose solution, values of the following parameters are given at time t = 2 h, when the system is at quasi-steady state.

$V = 1000$ ml

$dV/dt = 200$ ml/h => F

$s_0 = 100$ g glucose/l

$\mu_{max} = 0.3\ h^{-1}$

$K_s = 0.1$ g gluscose/l

$Y_{XS} = 0.5$ g cells / g glucose

$X_0 = 30$ g (total = $x_o^t$)

a) Find $V_0$ ( the inital volume of the culture) $V = V_0 + F*t$ => $V_0 = 0.6$ L

b) Determine the concentration of growth-limiting substrate in the vessel at quasi-steady state at t = 2 h. $s=Ks*D/(\mu m-D)$ => 0.2 g $L^{-1}$

c) Determine the concentration and total amount of biomass in the vessel at t = 2 h (at quasi-steady state) $x=x_0+F*Y_{X/S}*s_0*t$ => 50 g or ($V_{2h}$=1 L) 50 g $L^{-1}$

d) If $q_p = 0.2$ g product /g cells h, $p_O = 0$, determine the concentration of product in the vessel at t = 2 h

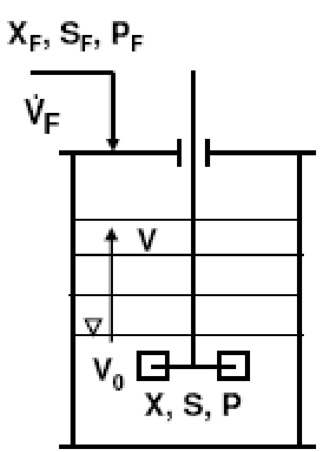
$$P = P_0\frac{V_0}{V} + q_p X_m\left(\frac{V_0}{V} + \frac{Dt}{2}\right)t$$

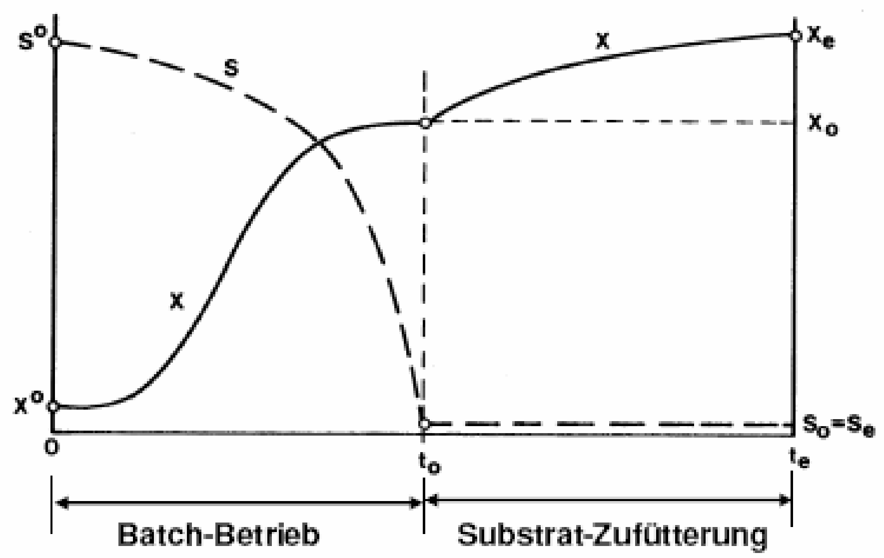
16 g /1 L = 16 g $L^{-1}$

# Task 6: Fed-Batch culture

The substrate concentration in a fed-batch should be kept constant at a relatively low value. How should the speed of dosage for a highly concentrated substrate solution be modified in order to reach this goal?

"Dans une fermentation de type Fed-Batch, la concentration en substrat se doit d'être maintenue à des valeurs constamment faible. Comment devrait varier la vitesse de dosage (feeding) d'une solution fortement concentrée durant le process pour pouvoir s'en assurer?"



Substrate should remain very low (avoidance of substrate inhibition):

$$d(V*X)/dt = \mu * X * V \rightarrow dX/dt = X * (\mu - D)$$

$$d(V*S)/dt = S*dV/dt + V*dS/dt = F*S_i - \mu*X*V/Y_{X/}$$

$$dS/dt = D*(Si - S) - \mu * X / Y_{X/S}$$

F = const.: First growth at $\mu_{max}$, later on with decreasing $\mu$.

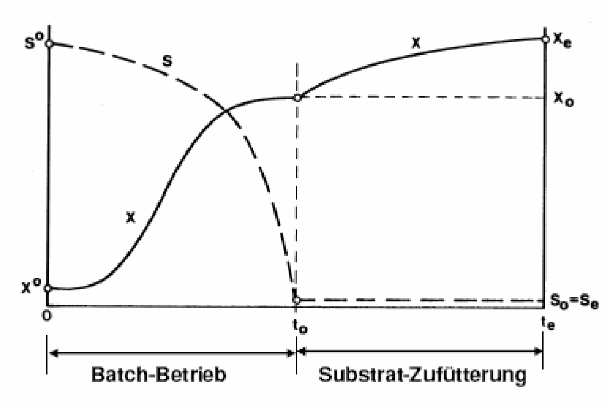
S = const. (dS/dt = 0): Addition of substrate is exponential.

$$F_t = \mu*V_o*X_o*e^{\mu*t} / [Y_{X/S} * (S_i - S)]$$

The feed should be exponential in order to have a constant s!

# Tasks 7a & b: Fed-batch culture

a) Analyse the dynamics of the fed-batch culture with respect to x and s, when the feed rate is kept constant.




Because of cell maintenance the biomass cannot increase linearly with the feed. The substrate concentration in the culture will decrease because of decreased $\mu$.

b) In a fed-batch culture, the following problem requires a solution: how can you compute the feed rate of substrate in order to keep the value of $\mu$ constant ($\mu$ can be respresented by a function of substrate concentration).

$$F_t = \mu * V_o * X_o * e^{\mu * t} / [Y_{X/S} * (S_i - S)]$$

# Task 8: Steady state relationship between dilution rate and substrate concentration

The growth of a strain of *Lactococcus lactis* on a medium containing glucose as the growth limiting nutrient is characterized by the following parameters:

$\mu_m = 0.6\ h^{-1}$

$K_s = 0.03\ g\ L^{-1}$

$Yx/s = 0.3\ g\ g^{-1}$

Calculate the steady state [glucose] at the following dilution rates.

| | |
|---|---|
| $D = 0.1\ h^{-1}$ | $s = 0.006\ g\ L^{-1}$ |
| $D = 0.2\ h^{-1}$ | $s = 0.015\ g\ L^{-1}$ |
| $D = 0.3\ h^{-1}$ | $s = 0.030\ g\ L^{-1}$ |
| $D = 0.4\ h^{-1}$ | $s = 0.060\ g\ L^{-1}$ |
| $D = 0.5\ h^{-1}$ | $s = 0.150\ g\ L^{-1}$ |

# Task 9: Steady state relationship between dilution rate and biomass concentration

The growth of a strain of *Lactococcus lactis* on a medium containing glucose as the growth limiting nutrient is characterized by the following parameters:

$\mu_m = 0.6\ h^{-1}$
$K_s = 0.03\ g\ L^{-1}$
$Y_{x/s} = 0.3\ g\ g^{-1}$

Calculate the steady state [biomass] at the following dilution rates. The feed contains 1 g $L^{-1}$ of glucose:

| | |
|---|---|
| $D = 0.1\ h^{-1}$ | $x = 0.298\ g\ L^{-1}$ |
| $D = 0.2\ h^{-1}$ | $x = 0.295\ g\ L^{-1}$ |
| $D = 0.3\ h^{-1}$ | $x = 0.291\ g\ L^{-1}$ |
| $D = 0.4\ h^{-1}$ | $x = 0.282\ g\ L^{-1}$ |
| $D = 0.5\ h^{-1}$ | $x = 0.255\ g\ L^{-1}$ |

# Task 10: Steady state relationship between dilution rate and product concentration

The growth of a strain of *Lactococcus lactis* on a medium containing glucose as the growth limiting nutrient is characterized by the following parameters:

$\mu_m = 0.6\ h^{-1}$

$K_s = 0.03\ g\ L^{-1}$

$Y_{x/s} = 0.3\ g\ g^{-1}$

Lactate (P) is produced in a growth associated manner and the yield coefficient for lactate formation is:

$Y_{p/s} = 0.8\ g\ g^{-1}$

Calculate the steady state lactate concentration at the following dilution rates.

The feed contains 1 g $L^{-1}$ of glucose:

| | |
|---|---|
| $D = 0.1\ h^{-1}$ | $P = 0.080\ g\ L^{-1}$ |
| $D = 0.2\ h^{-1}$ | $P = 0.158\ g\ L^{-1}$ |
| $D = 0.3\ h^{-1}$ | $P = 0.233\ g\ L^{-1}$ |
| $D = 0.4\ h^{-1}$ | $P = 0.301\ g\ L^{-1}$ |
| $D = 0.5\ h^{-1}$ | $P = 0.340\ g\ L^{-1}$ |