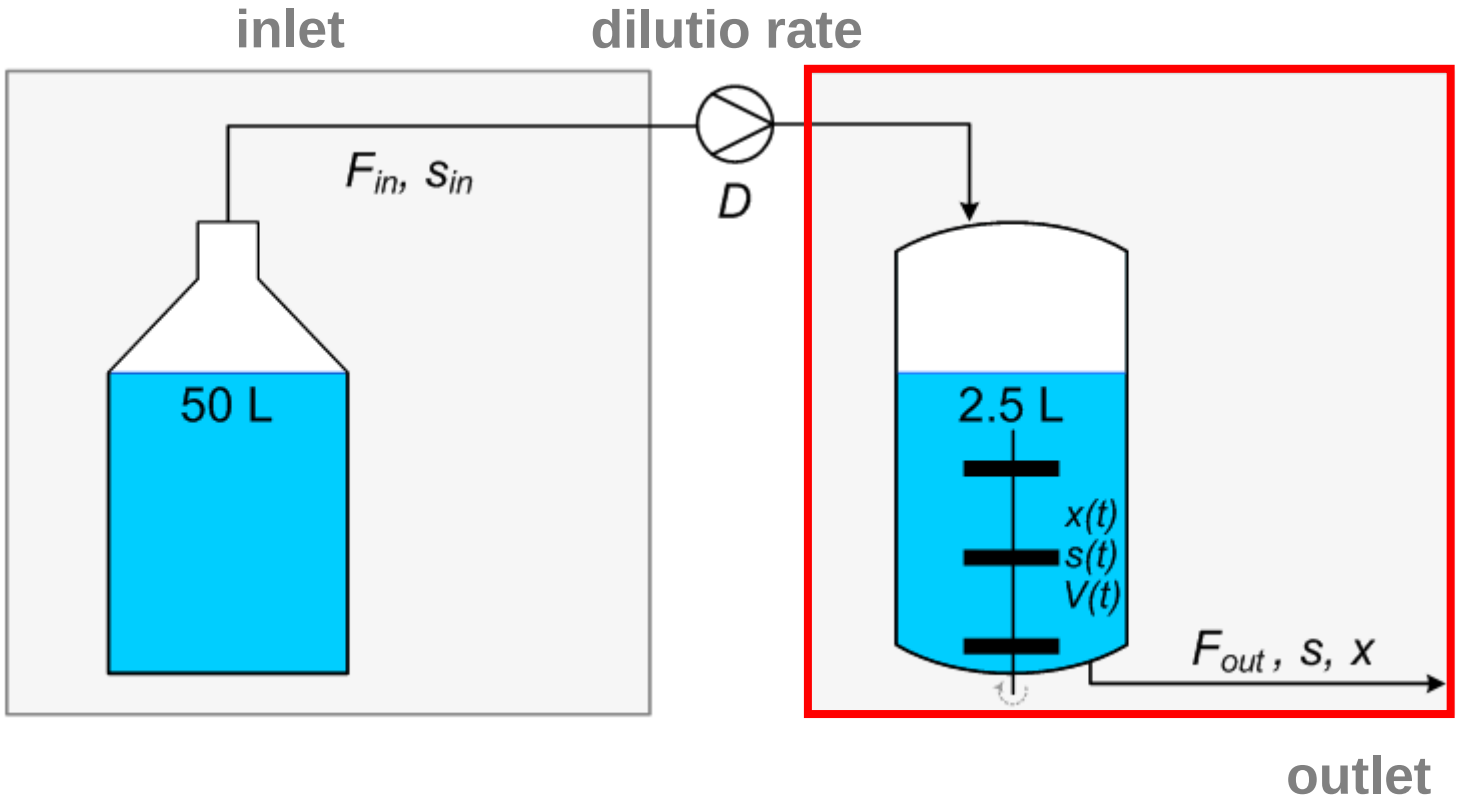
3

simulation

- **culture modes**
- **mass balance equation (= modelling)**
- **what-if analyses (= simulation)**

continuous culture – CSTR

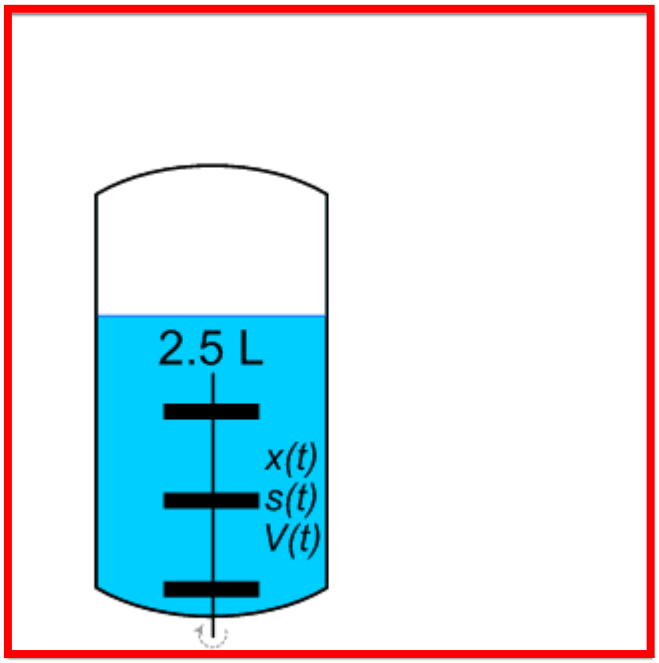


mass change = inlet – outlet + reaction

$$\frac{d}{dt}(c_i \cdot V) = F_{in}(t) \cdot c_{i,in}(t) - F_{out}(t) \cdot c_{i,out}(t) + r_i(t) \cdot V(t)$$

batch culture

~~inlet~~ ~~dilution rate~~



~~outlet~~

mass change = reaction

$$\frac{d}{dt}(c_i \cdot V) = r_i(t) \cdot V(t)$$

batch model

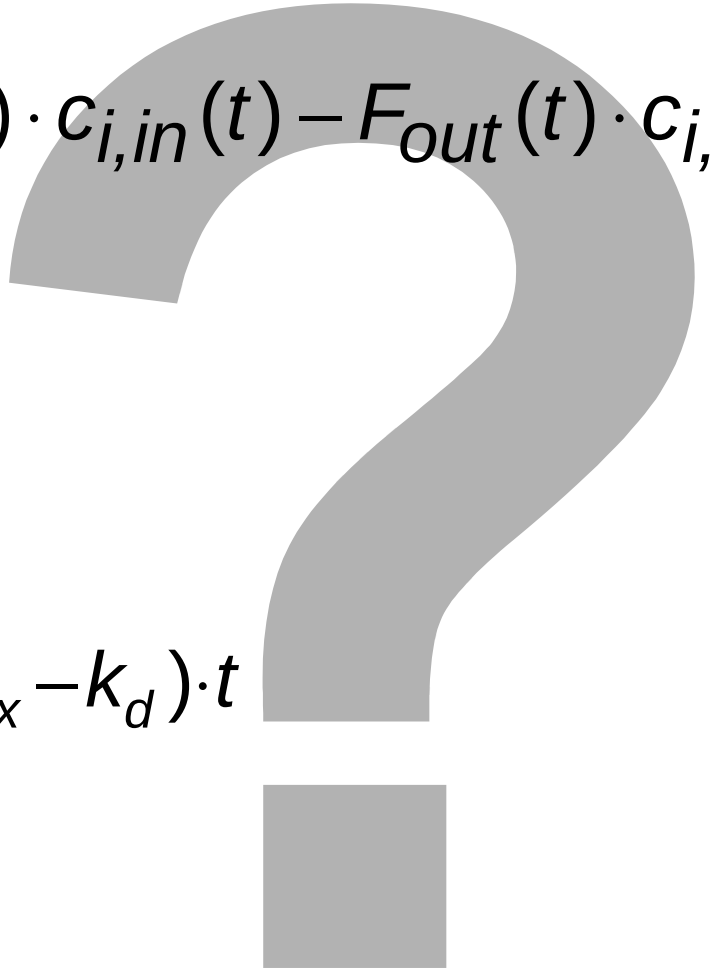
$$\frac{d}{dt}(c_i \cdot V) = F_{in}(t) \cdot c_{i,in}(t) - F_{out}(t) \cdot c_{i,out}(t) + r_i(t) \cdot V(t)$$

$$\frac{d}{dt}c_i = r_i(t)$$

$$x(t) = x_0 \cdot e^{(\mu_{max} - k_d) \cdot t}$$

$$\left[g\,L^{-1} = g\,L^{-1}\,1 \right]$$

$$t = \frac{1}{\mu_{max}} \cdot ln(\frac{x(t)}{x_0}) - t_0$$



$$\frac{d}{dt}(c_i \cdot V) = F_{in}(t) \cdot c_{i,in}(t) - F_{out}(t) \cdot c_{i,out}(t) + r_i(t) \cdot V(t)$$ **1**

?

$$\frac{d}{dt}c_i = r_i(t)$$ **2 (batch, *V*=const.)**

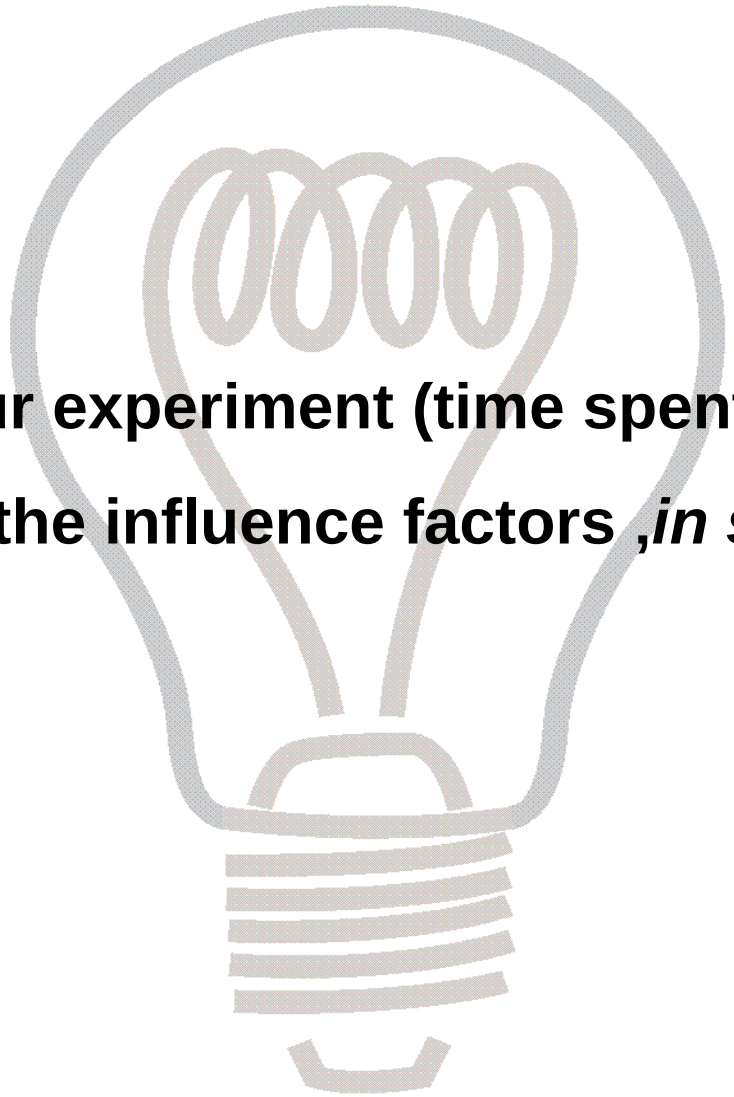
? (integration)

$$x(t) = x_0 \cdot e^{\mu_{max} \cdot t}$$ **3**

?

$$t = \frac{1}{\mu_{max}} \cdot ln(\frac{x(t)}{x_0}) - t_0$$ **4**

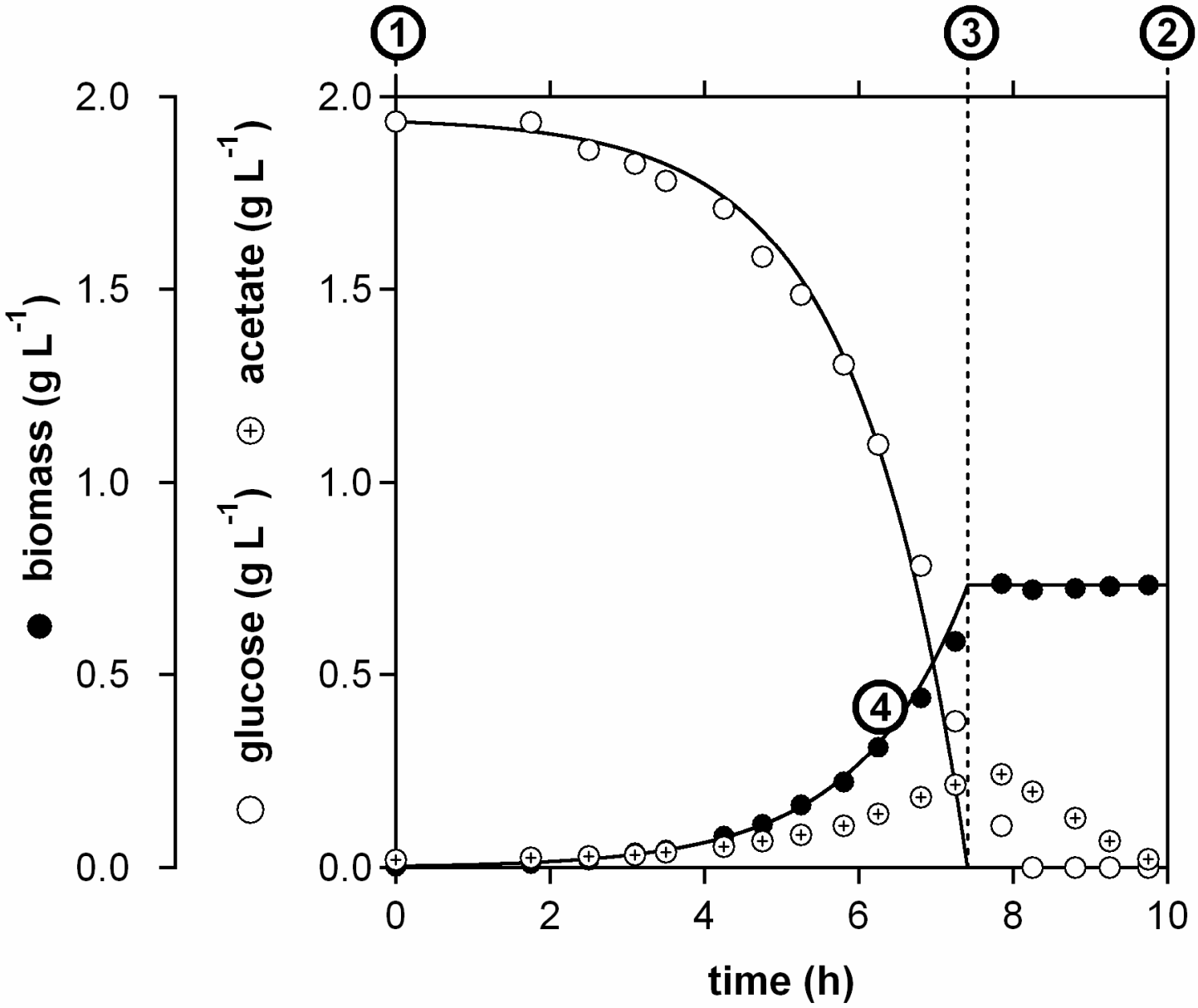
$$\left[g\,L^{-1} = g\,L^{-1}\,1 \right]$$ **5**



Plan your experiment (time spent in lab)!

Study the influence factors ‚*in silico*‘!

state variables – batch culture



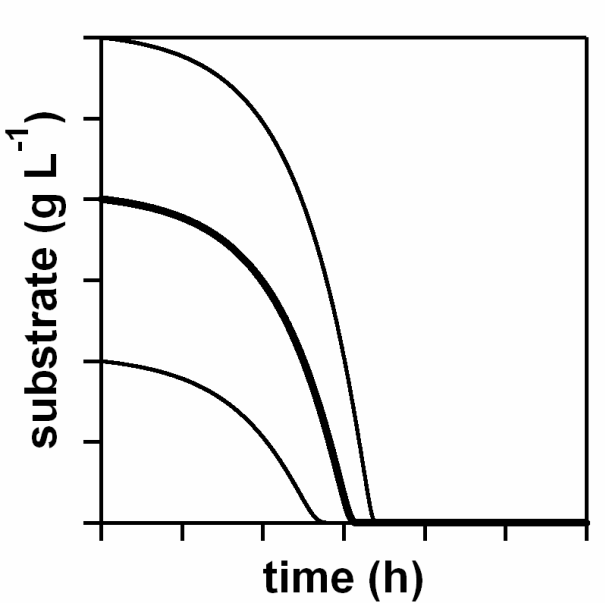
1 initial values

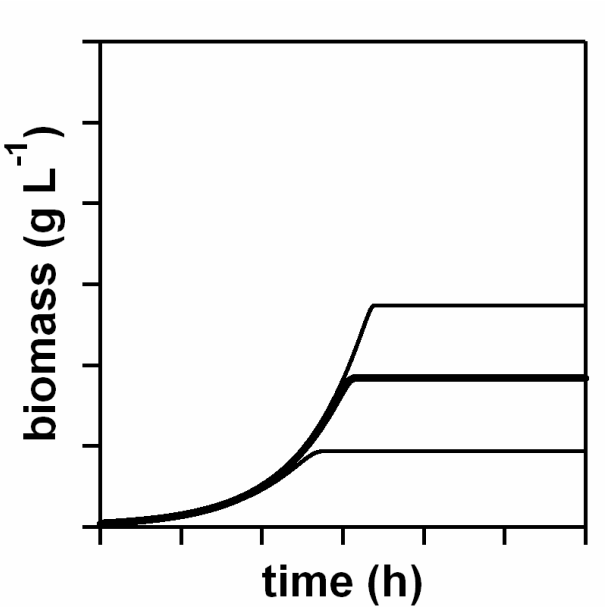
2 yield

3 duration

4 kinetics

mathematical model – batch culture





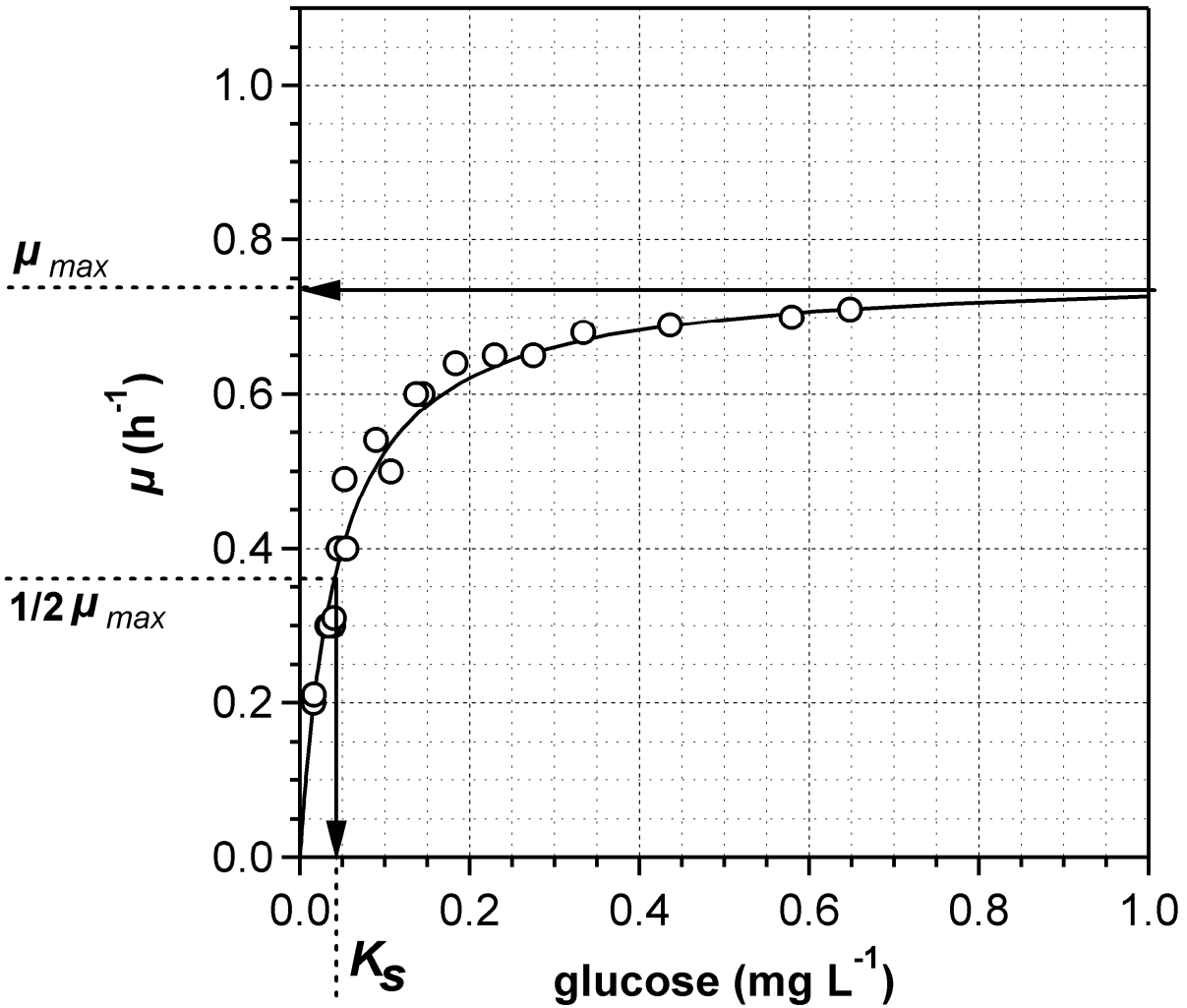
$$\frac{d}{dt}x = \mu(t)\cdot x(t) \qquad \frac{d}{dt}s = -\frac{1}{Y_{x/s}}\cdot \mu(t)\cdot x(t)$$

differential eqs.

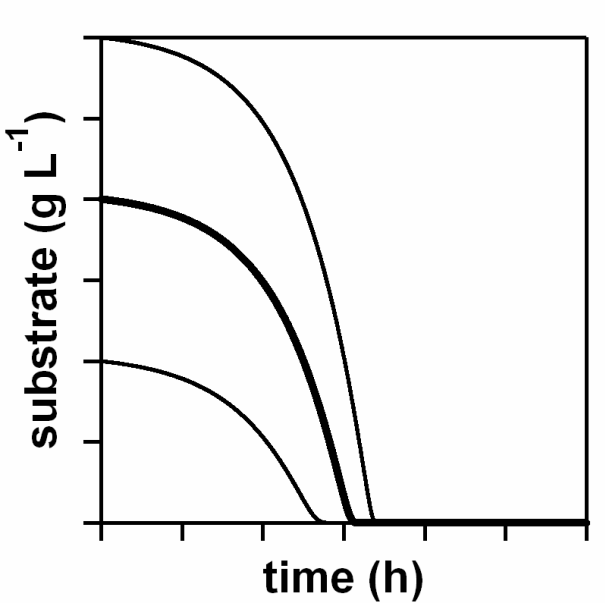
$$\mu(s,t) = \mu_{max}\cdot\frac{s(t)}{s(t)+K_s}$$

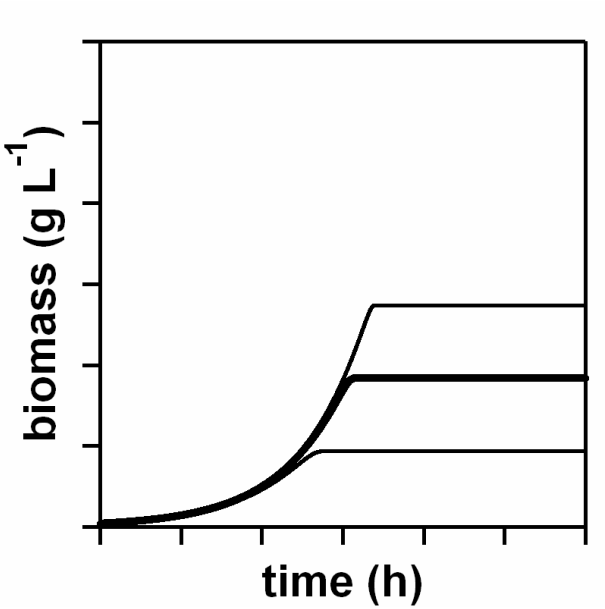
Monod kinetics

$\mu=f(s)$ or $\mu=f(q_s)$ – Monod equation



algebraic equations – batch culture





$$\frac{d}{dt}s = -\frac{1}{Y_{x/s}} \cdot \mu(t) \cdot x(t) \qquad \frac{d}{dt}x = \mu(t) \cdot x(t)$$

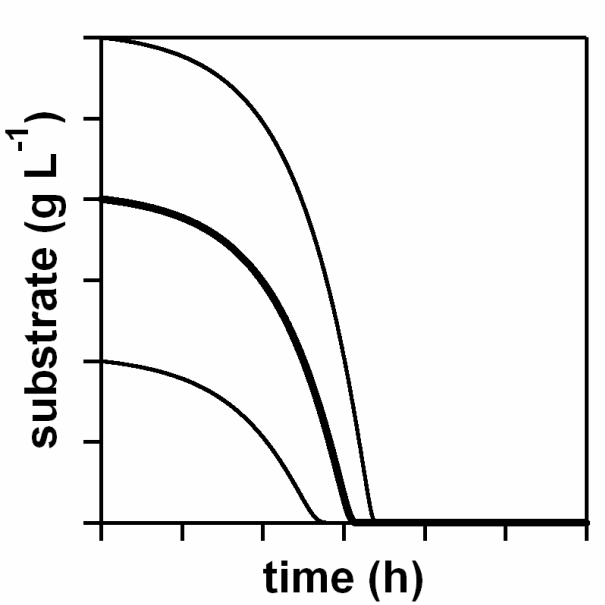
differential eqs.

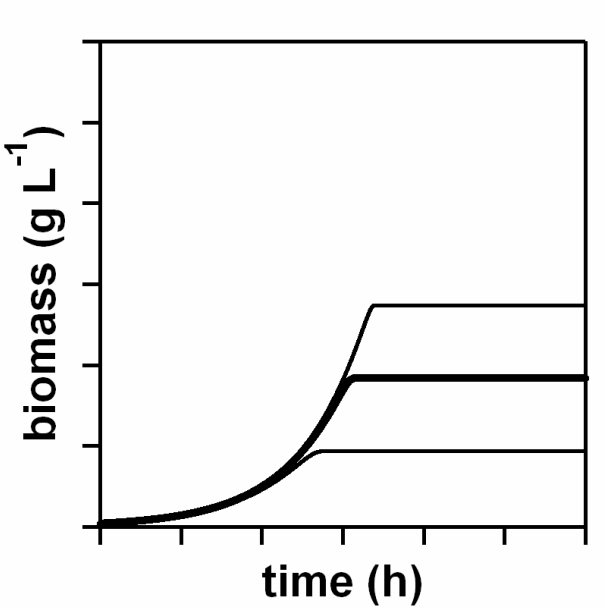
for K_s << s(t)

$$s(t) = s_0 - \frac{x_0 \cdot e^{\mu max \cdot t} - x_0}{Y_{x/s}} \qquad x(t) = x_0 \cdot e^{\mu max \cdot t}$$

analytical solution

system of (dependent) differential equation – batch culture





$$\frac{d}{dt}s = -\frac{1}{Y_{x/s}} \cdot \mu(t) \cdot x(t)$$

$$\frac{d}{dt}x = \mu(t) \cdot x(t)$$

differential eqs.

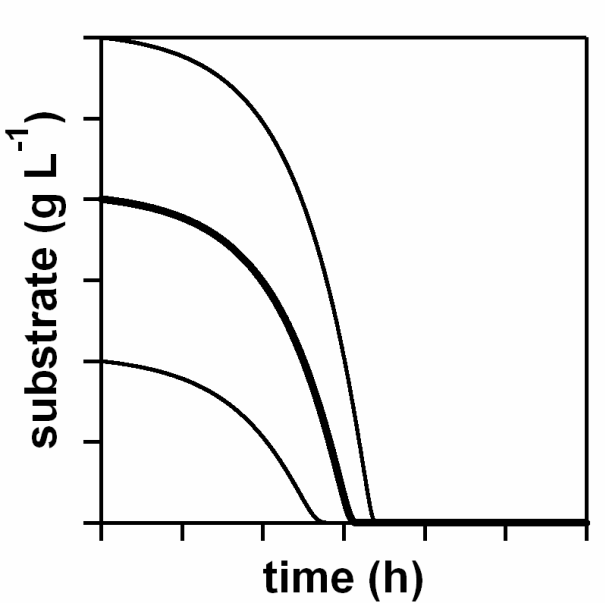
for K_s >= s(t)

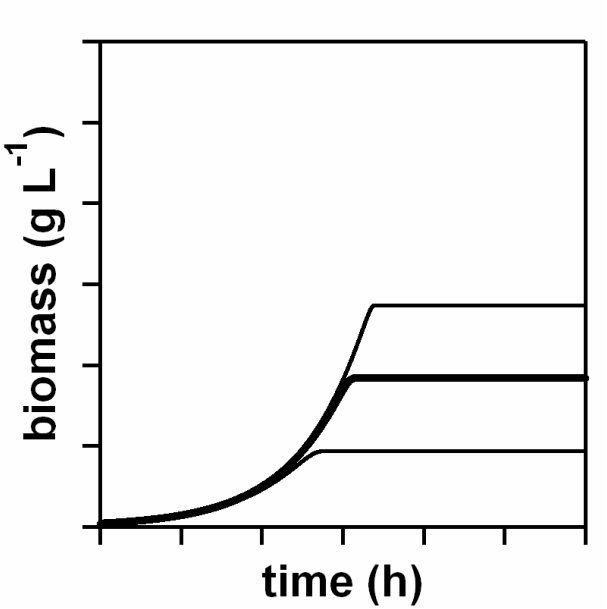
s(t) = ?

x(t) = ?

no analytical solution

system of (dependent) differential equation – batch culture





$$\frac{d}{dt}s = -\frac{1}{Y_{x/s}} \cdot \mu(t) \cdot x(t)$$

$$\frac{d}{dt}x = \mu(t) \cdot x(t)$$

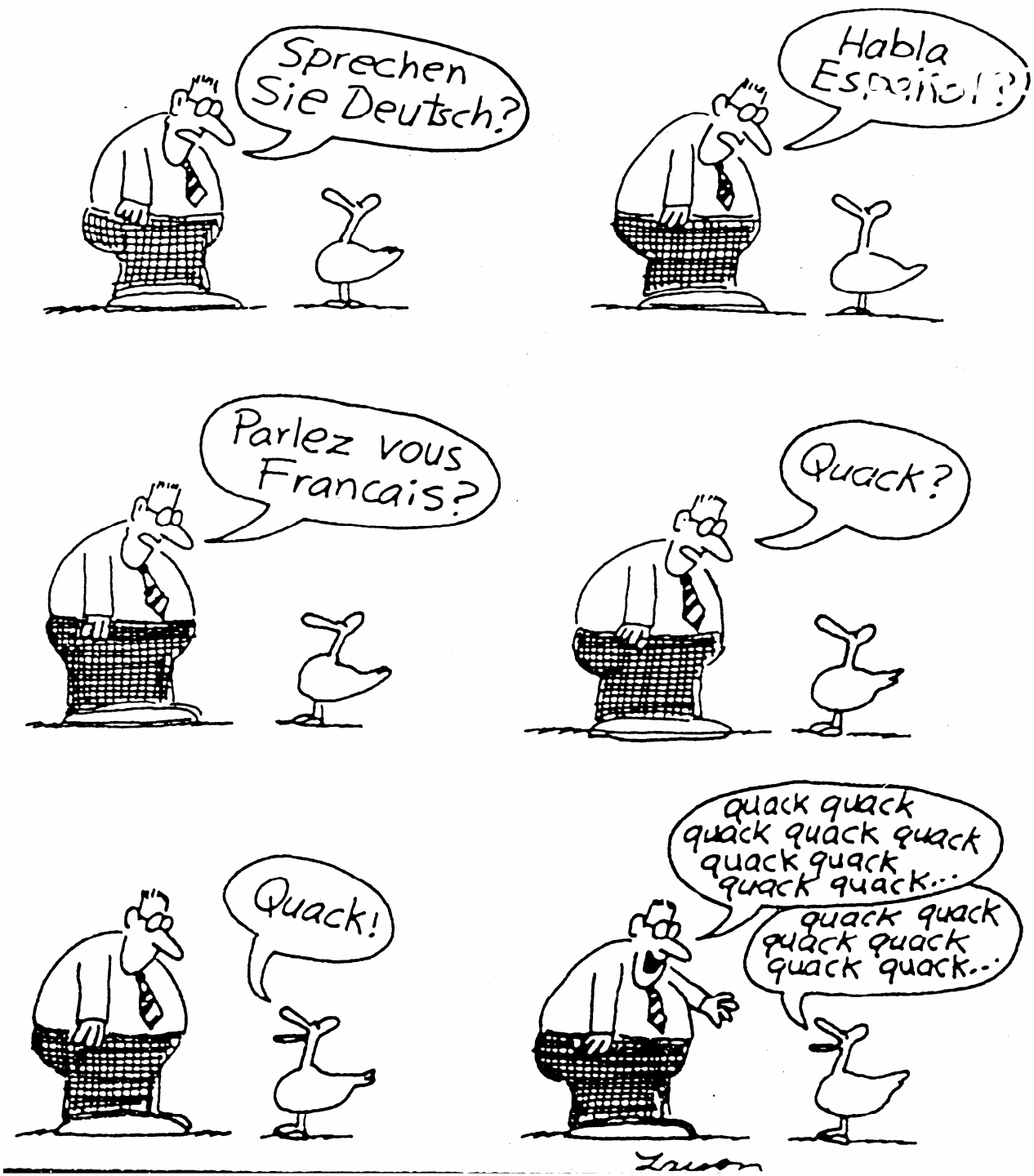
differential eqs.

for K_s >= s(t)

***s(t)* = numerical solution**

***x(t)* = numerical solution**

simulation


Sprechen Sie Deutsch?
Habla Español?
Parlez vous Francais?
Quack?
Quack!
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Exercise

Stichwörter GO

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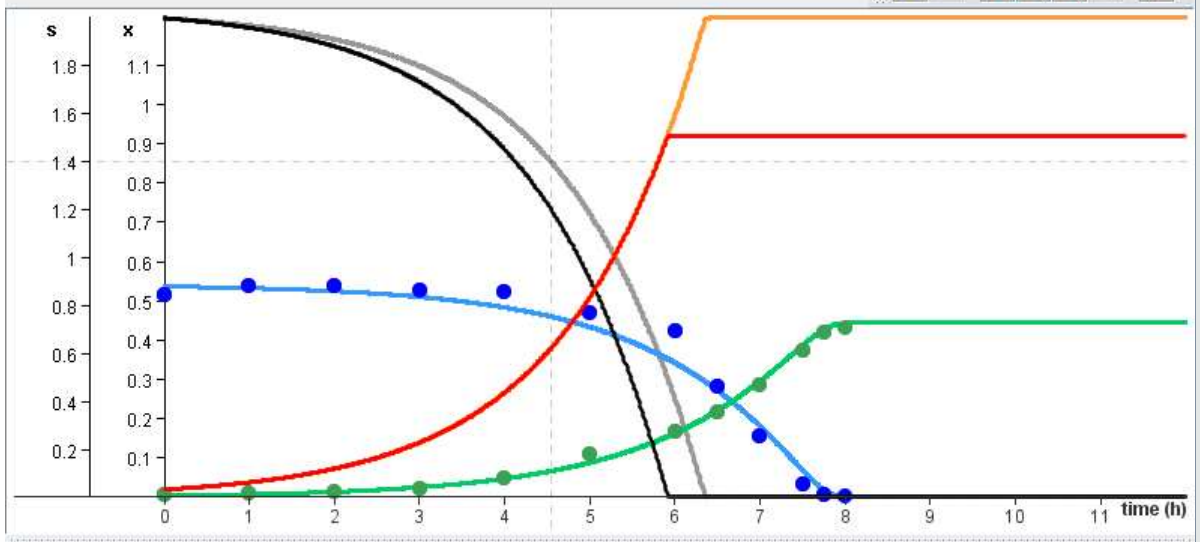
Course_ETHZ/UZH
Download - Course Materials

BiotechSIM

File Data Scenario View Run ?

substrate conc. (s) = 1.403 g/L, time = 4.536 h, What-if , #1



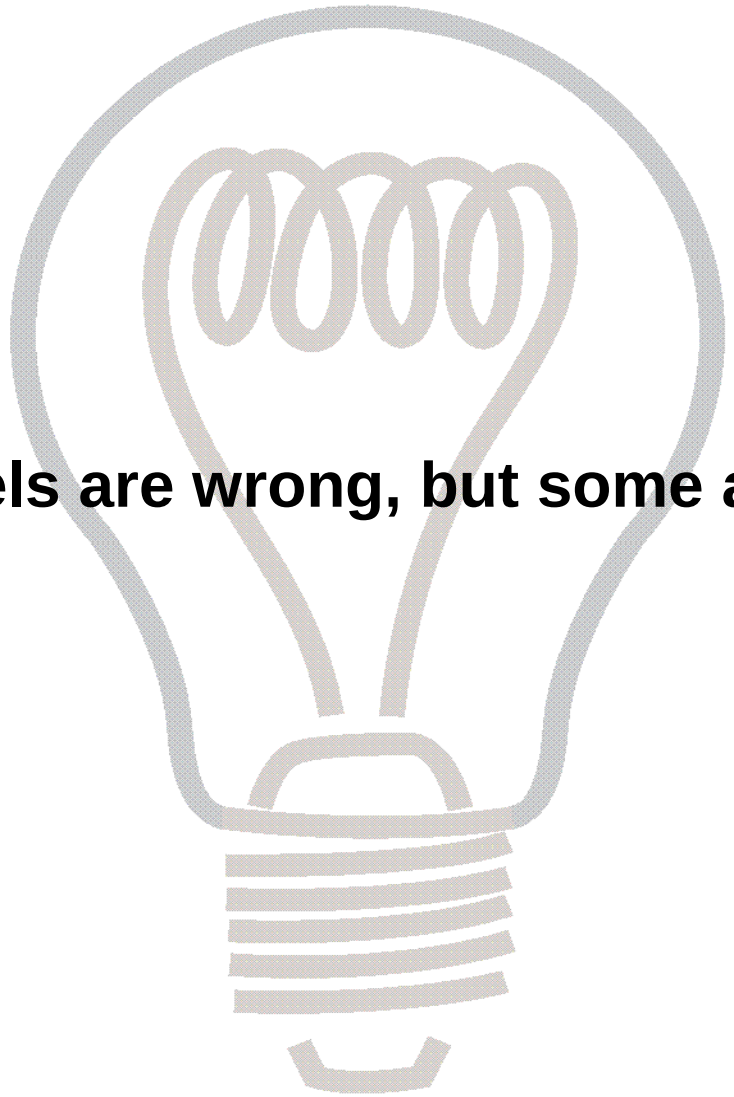
Cultivation Systems

Continuous Culture | Fedbatch | Batch

Scenario	Model	s_0	x_0	V_0	K_s	k_d	μ_{max}	m_s	$q_{s,max}$	$Y_{x/s}$	μ	μ_{max}'	r_s
What-if	ms kd	2	0.02	2.5	0.004	0	0.65	0	-	0.6	graph	-	gra
Adjust to exp. data	ms kd	0.88	0.004	2.5	0.04	0	0.65	0	-	0.5	graph	-	gra
manual data	unknown_	import	import	-	-	-	-	-	-	-	-	-	
generic scenario #1	ms kd	2	0.02	2.5	0.004	0	0.65	0	-	0.45	graph	-	gra
generic scenario #2	qs	2	0.02	2.5	0.004	0	-	0	1.444	0.45	graph	0.65	gra
batch	**ms kd**	**2**	**0.02**	**2.5**	**0.004**	**0**	**0.65**	**0**	**-**	**0.45**	**graph**	**-**	**gra**
cell's death	ms kd	2	0.02	2.5	0.004	0.05	0.65	0	-	0.45	graph	-	gra

added value of e-learning


HELP
1 | 2 | 3 | 4 | 5 | 6 | 7
Requirements
Stichwörter
GO
Browser
Das Internetangebot von BiotechLAB unterstützt die folgenden Browser:
Internet Explorer 4 - 7
Mozilla Firefox 1.x, 2.0.0.x
Netscape 6 + 7
Opera 6.x
Hardware
Java
Folgende Javaversion ist für den Betrieb von biotechlab.net nötig:
JRE (Java Plug-in) 6 oder höher, am besten Sie installieren die aktuellste Version
-> Download Java Runtime Environment (JRE) 6
Hinweise zur Java Installation
Trial version (02.05.07)
Trial version (18.09.07)
Trial version (26.09.07)
Trial version (02.10.07)



„All models are wrong, but some are useful.“

G.E.P. Box

model predictive control – mathematical models