Energy consuming and energy producing products

Technology for Biobased Products

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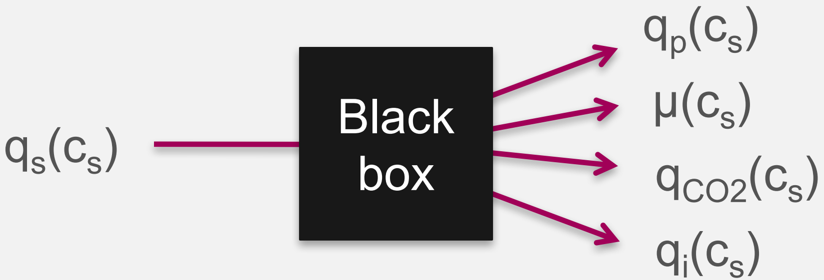
Pseudo steady state flux coupling

Substrate limitation → $q_s(c_s)$ (constant T, pH, pressure)



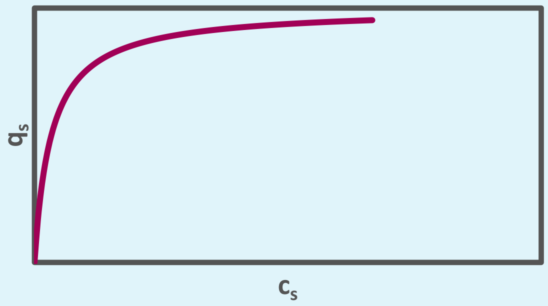
Product consumes energy = **aerobic**

Product produces energy = **anaerobic**

Substrate uptake

Energy consuming and energy producing product

Hyperbolic function of q_s

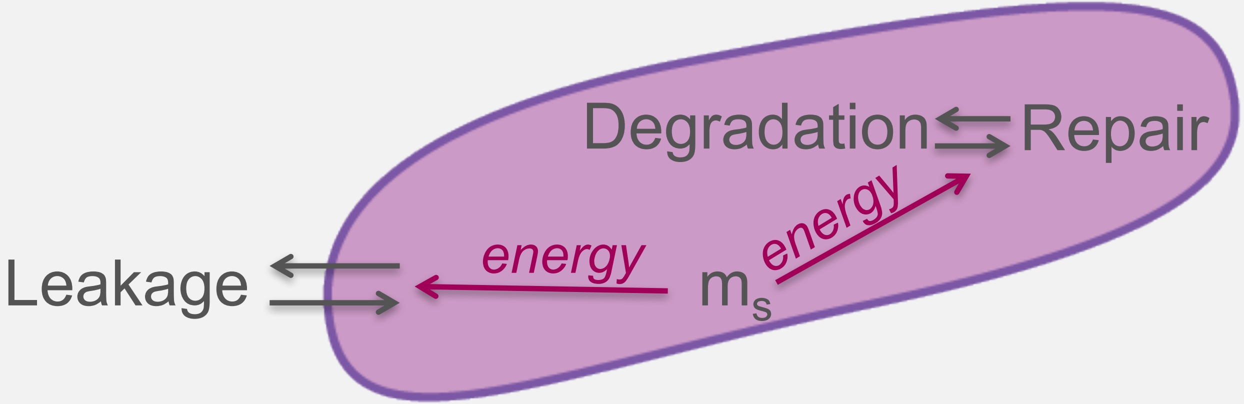


$$q_s = q_{s,\max} * \frac{c_s}{K_s + c_s}$$

Parameters $q_{s,max}$ and K_s

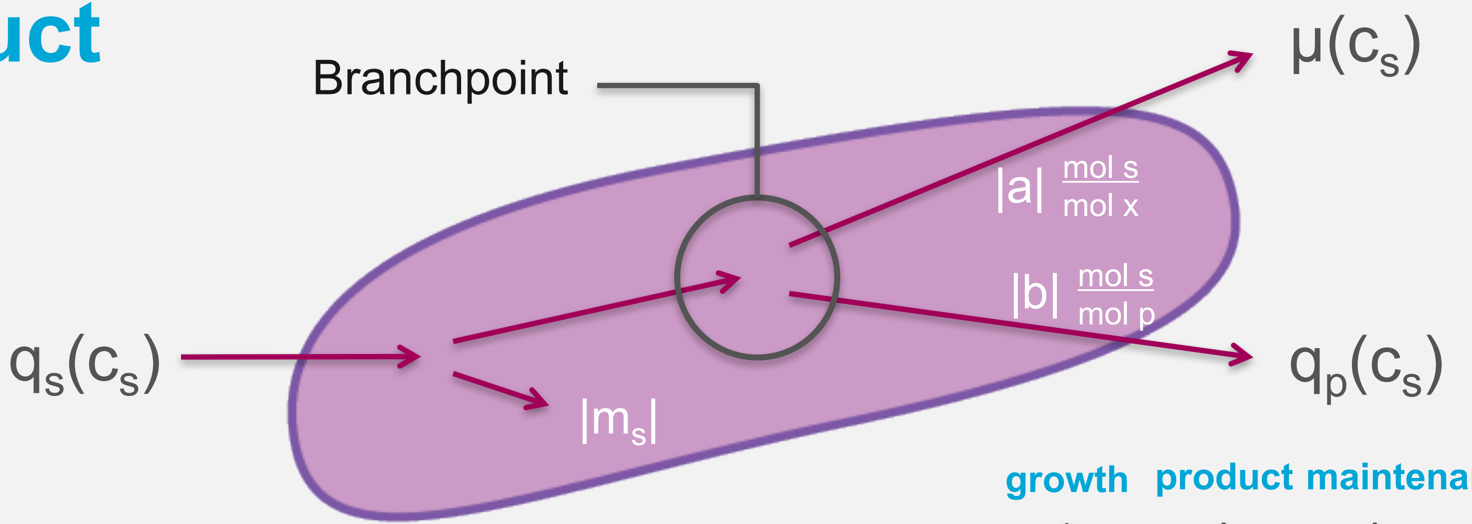
- Assumed to be constant
- Need to be determined
- Depends on organism, substrate, T and pH

Substrate for maintenance energy



Energy consuming product	Energy producing product
Aerobic m_s = 0.005 (mol glucose/h)/mol x	Anaerobic m_s = 0.05 (mol glucose/h)/mol x

Black box model energy consuming product



Herbert-Pirt substrate distribution relation

growth / product / maintenance

$$q_s = a*\mu + b*q_p + m_s$$

Kinetic coupling of q_p and μ

$$q_p(\mu) = non\text{-}linear$$

Aerobic black box PDO model

Glucose uptake rate

$$-q_s = 0.20\, c_s / (0.5 + c_s)$$

Herbert-Pirt substrate distribution

growth product maintenance

$$-q_s = \underbrace{0.25\, \mu}_{\text{growth}} + \underbrace{0.8\, q_p}_{\text{product}} + \underbrace{0.005}_{\text{maintenance}}$$

Non-linear $q_p(\mu)$ relation

$$q_p = 0.05\, \mu / (0.03 + \mu)$$

3 equations

4 variables

= 1 free variable which can be μ or c_s

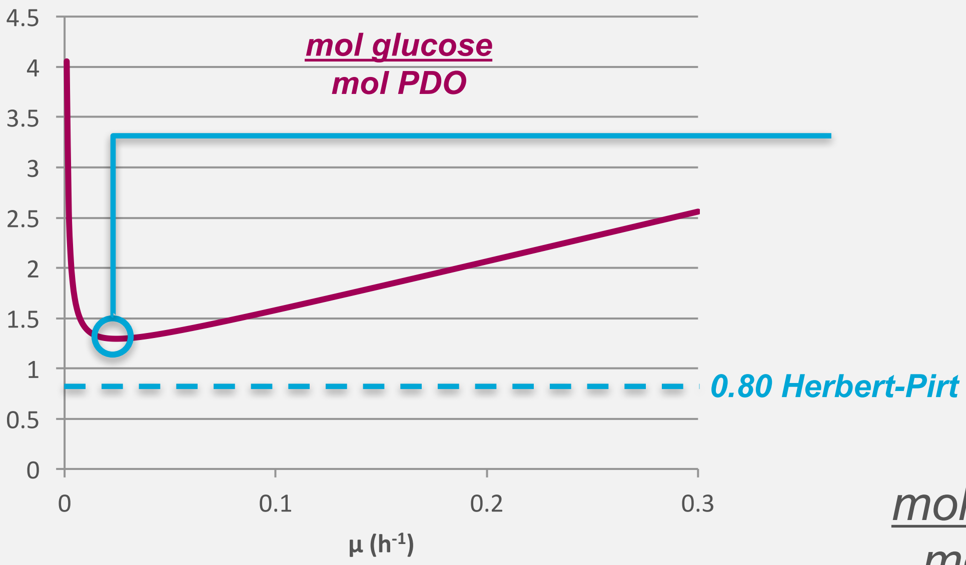
Economics aerobic PDO production

$$\frac{\text{mol glucose}}{\text{mol PDO}} = \frac{q_s}{q_p} = \frac{0.25\,\mu + 0.8\,q_p + 0.005}{0.05\,\mu/(0.03+\mu)}$$

$$|q_s/q_p| = \frac{0.25\,\mu}{0.05\,\mu/(0.03+\mu)} + 0.8 + \frac{0.005}{0.05\,\mu/(0.03+\mu)}$$

$$|q_s/q_p| = \frac{\text{mol glucose}}{\text{mol PDO}} = 1.05 + 5\mu + 0.003/\mu$$

Economics aerobic PDO production



$$\mu_{opt} = 0.0245 \frac{\text{mol x / h}}{\text{mol x in fermenter}}$$

$$q_{p,opt} = 0.0227 \frac{\text{mol PDO / h}}{\text{mol x in fermenter}}$$

$$q_{s,opt} = 0.0294 \frac{\text{mol glucose / h}}{\text{mol x in fermenter}}$$

$$\frac{\text{mol glucose}}{\text{mol PDO}} = |q_s/q_p| = \frac{0.0294}{0.0227} = \underline{1.29}$$

$$|q_s/q_p| = \frac{\text{mol glucose}}{\text{mol PDO}} = 1.05 + 5\mu + 0.003/\mu$$

Economics aerobic PDO production

$$-q_{s,opt} = 0.25\,\mu_{,opt} + 0.8\,q_{p,opt} + 0.005$$

$\mu_{opt} = 0.0245$

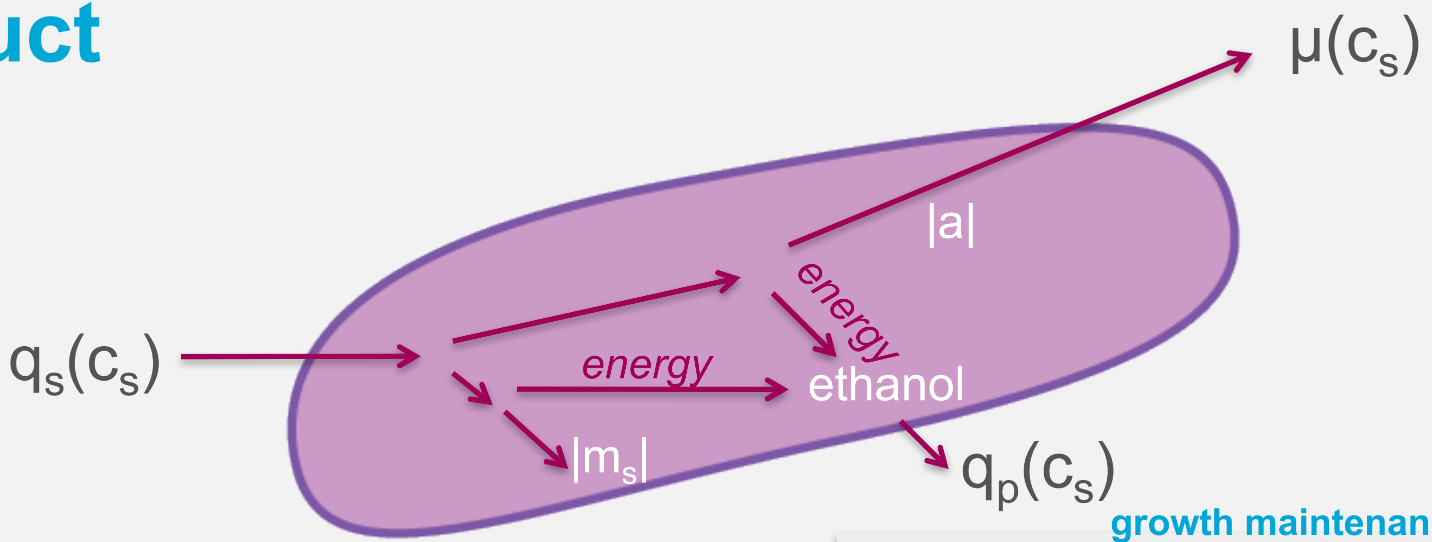
$q_{p,opt} = 0.0227$

$q_{s,opt} = 0.0294$

$$-q_{s,opt} = 0.25 * 0.0245 + 0.8 * 0.0227 + 0.005$$

$$-q_{s,opt} = \underbrace{0.0062}_{\text{growth} = 21\%} + \underbrace{0.0182}_{\text{product} = 62\%} + \underbrace{0.005}_{\text{maintenance} = 17\%}$$

Anaerobic BB model energy producing product



Herbert-Pirt substrate distribution relation

$$q_s = \underbrace{a^*\mu}_{\text{growth}} + \underbrace{m_s}_{\text{maintenance}}$$

Stoichiometric (energy) coupling of q_p and μ

$$q_p = a_p{}^*\mu + m_p = linear$$

Summary black box model

Energy consuming product

Aerobic

$$q_s = q_{s,\max} * \frac{c_s}{K_s + c_s}$$

$q_s = a*\mu + b* q_p + m_s$

$q_p (\mu)$ is non linear

Kinetic coupling q_p and μ

Energy producing product

Anaerobic

$$q_s = q_{s,\max} * \frac{c_s}{K_s + c_s}$$

$q_s = a*\mu + m_s$

$q_p = a_p*\mu + m_p$ which is linear

Stoichiometric (energy) coupling q_p and μ

See you in the next unit!