Basic approach to design and optimize a PDO fermentation process

Technology for biobased products

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Design approach

- Process reaction based on black box model (week 3)

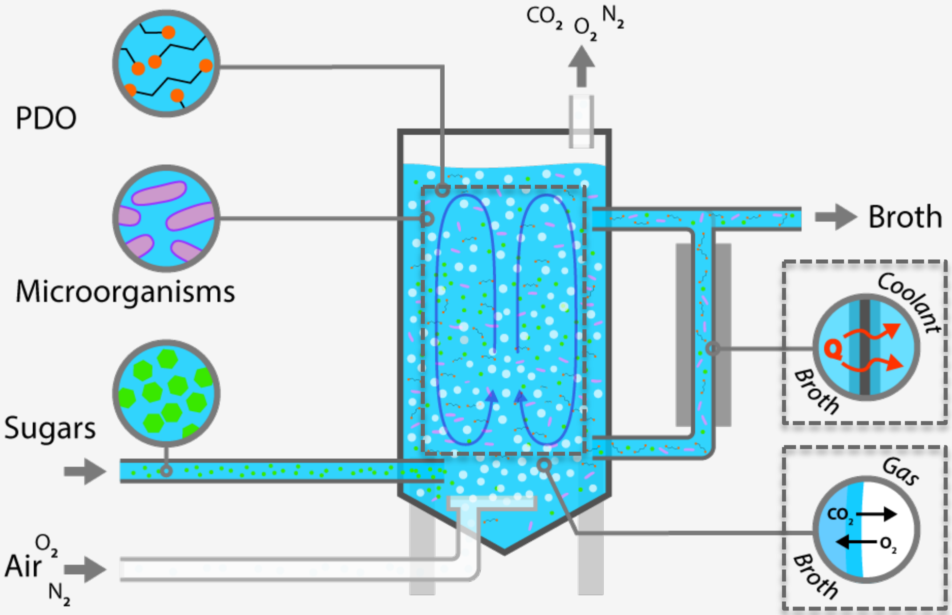
- Bioreactor type and mode of operation
  - STR, BC or ALR
  - Batch, continuous or fed-batch

- Reactor volume is determined by rate-limiting transport step

Large-scale design: Comparison of the transport phenomena

What is the rate-limiting transport step?

- Oxygen transfer
  - →minimize c_o gradients
- CO_2 removal
  - →minimize CO_2 inhibition
- Heat removal
  - → minimize T shocks
- Mixing
  - →minimize c_s gradients



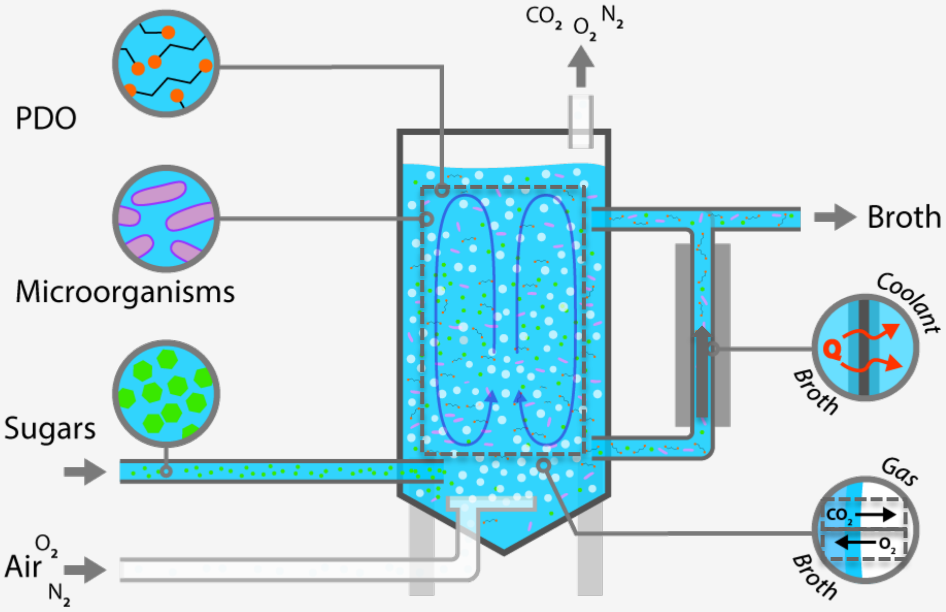
Defining what is most likely limiting factor

PDO Case, transport terms determined in previous units:

- Required $T_{N,0}$ = 193 mol/(m^3·h)

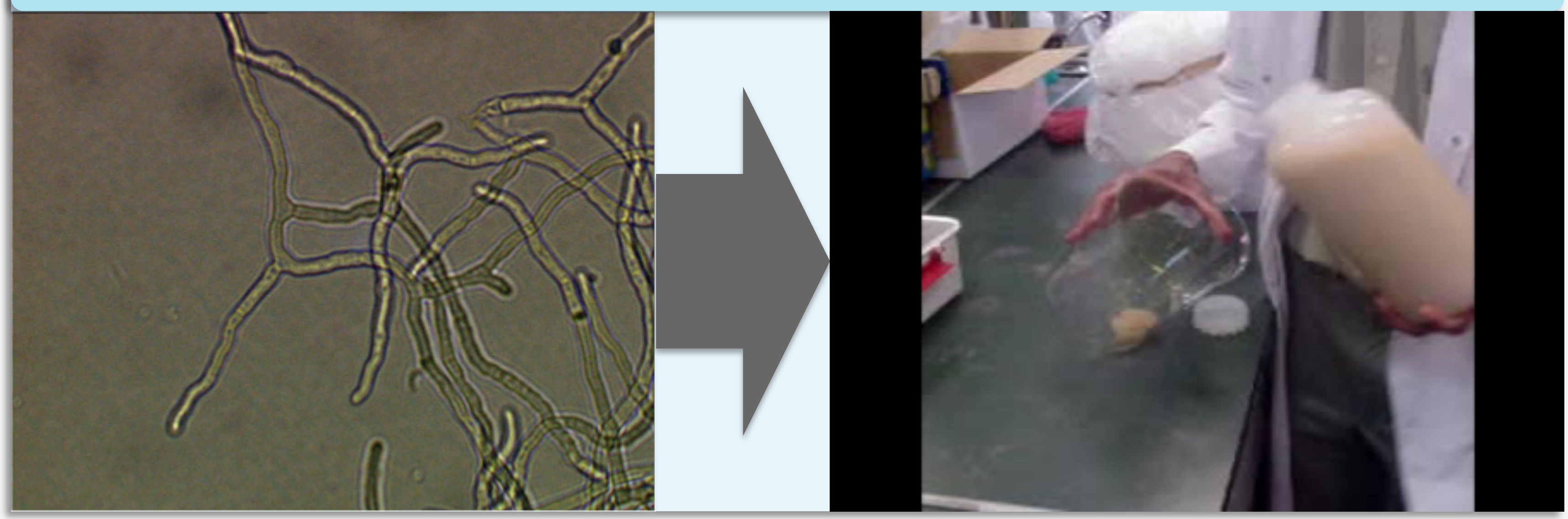
  Actual $T_{N,0}$ = 135 mol/(m^3·h)

- c_C = 7.0 mol/m^3
- F_{loop}= 2.46 m^3/s
- t_{mix} = 69 s



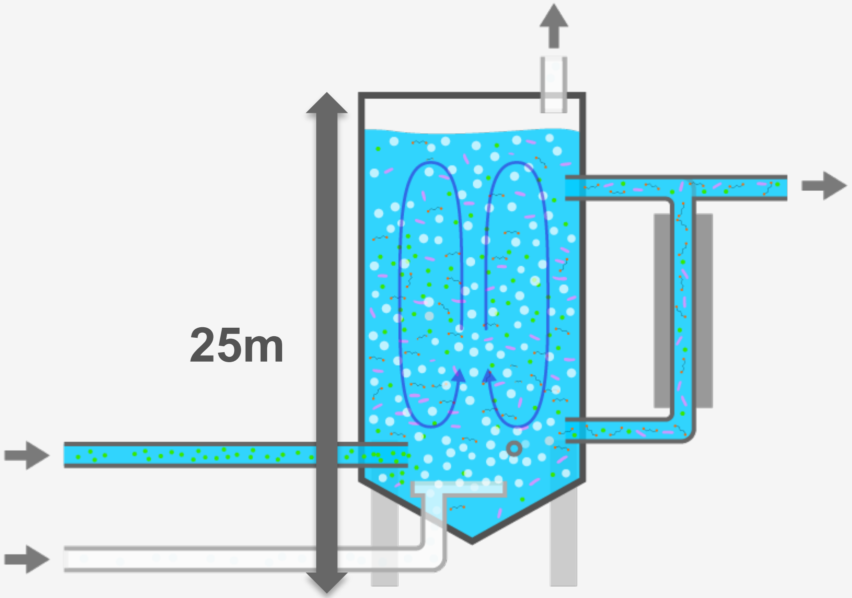
Note: this all assumes low viscosity

Always design/select non-filamentous microorganisms so that the broth viscosity stays low. If not, transport rates can be 10-100× lower

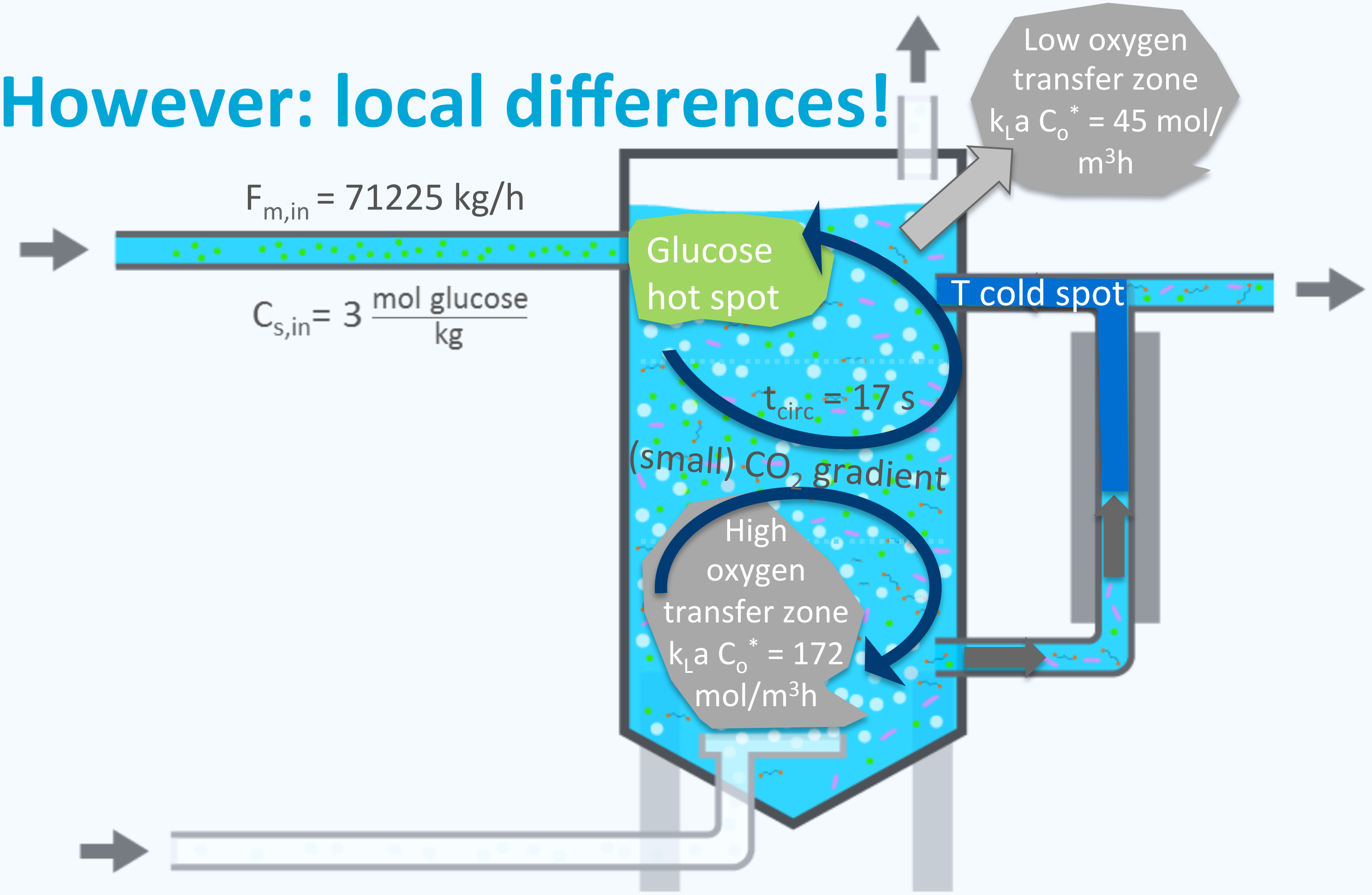


PDO performance

Economy performance indicators	
Titer kg PDO / tonne broth	228
Rate kg PDO/h / tonne broth	5.6
Yield kg PDO / kg glucose	0.33
(theoretical maximal)	(0.528)

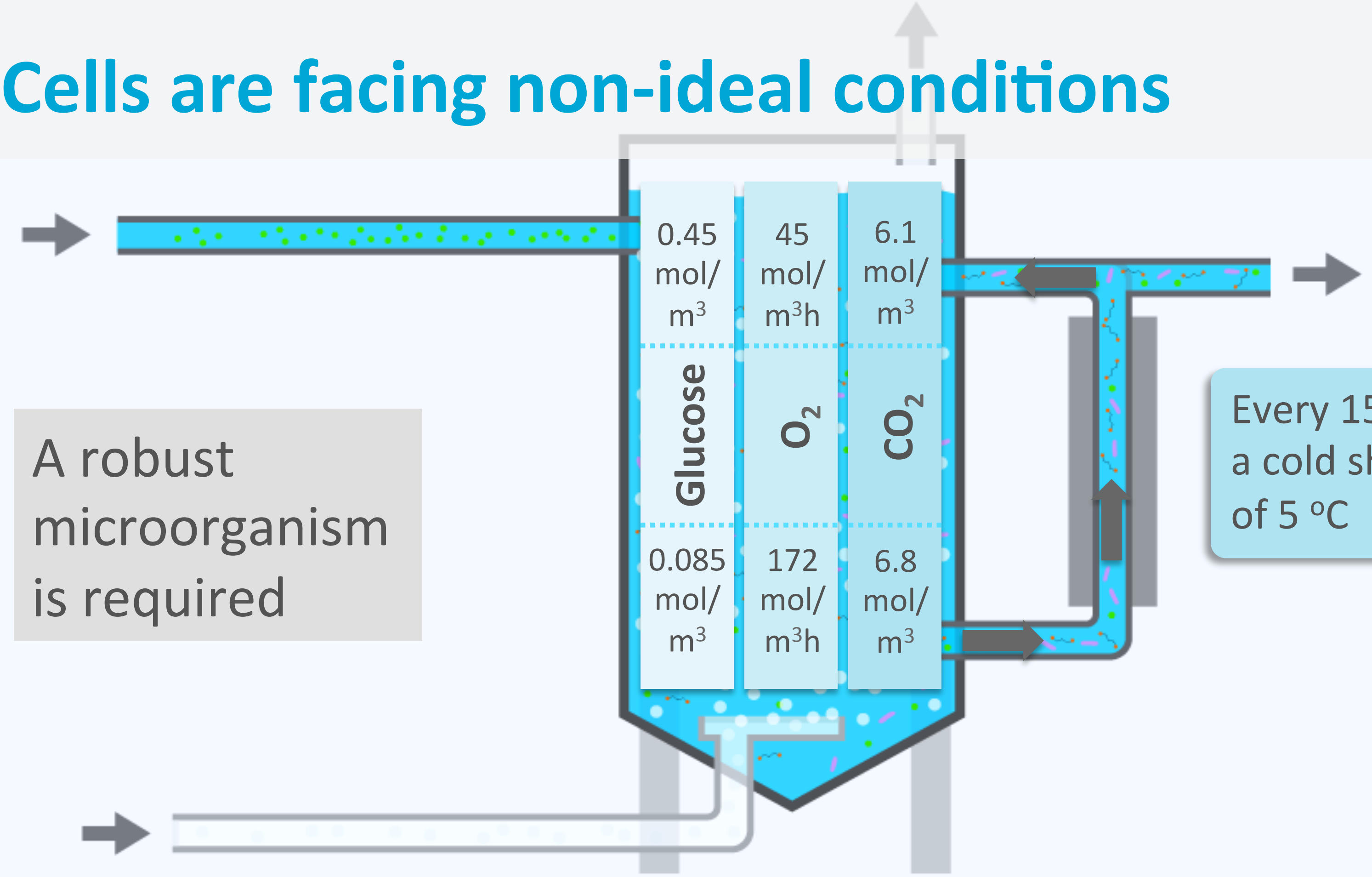


However: local differences!



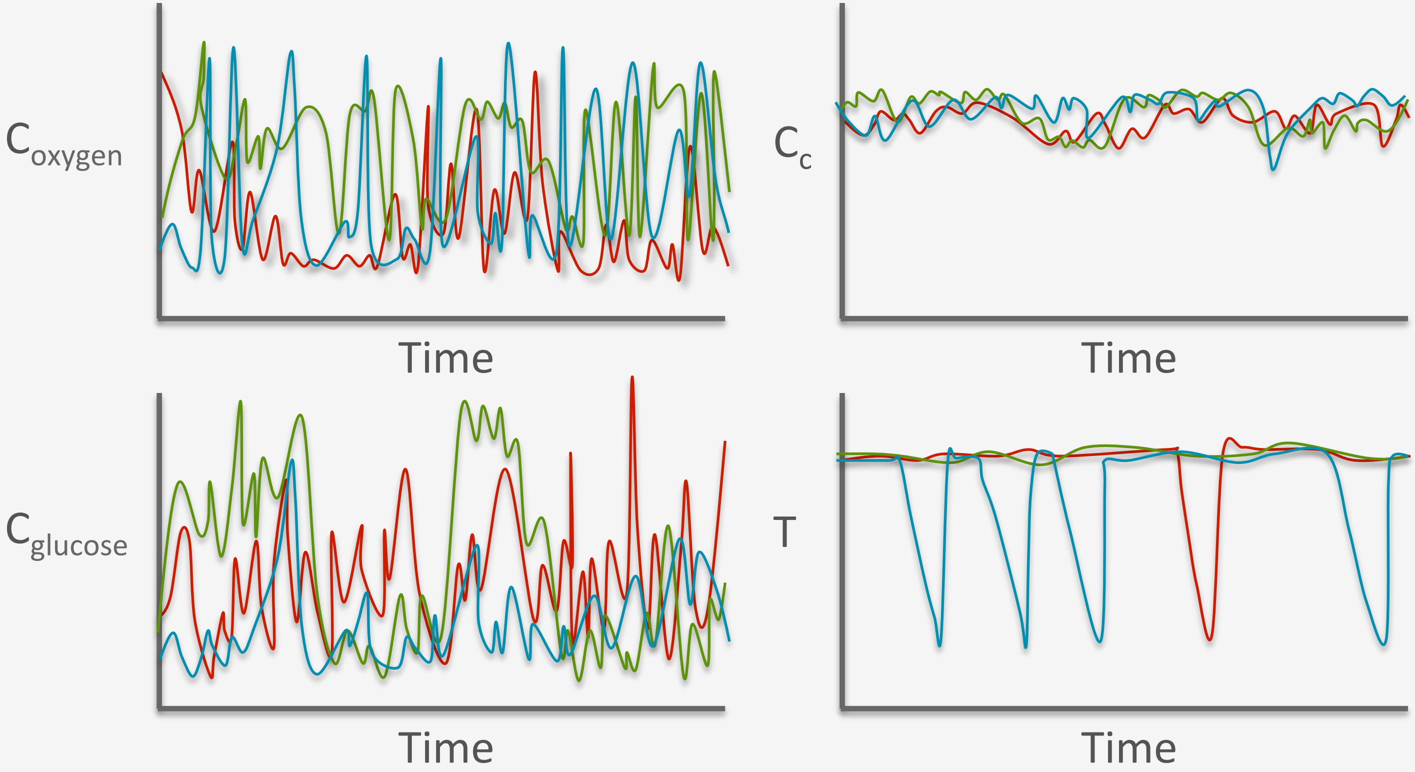
Cells are facing non-ideal conditions

A robust microorganism is required

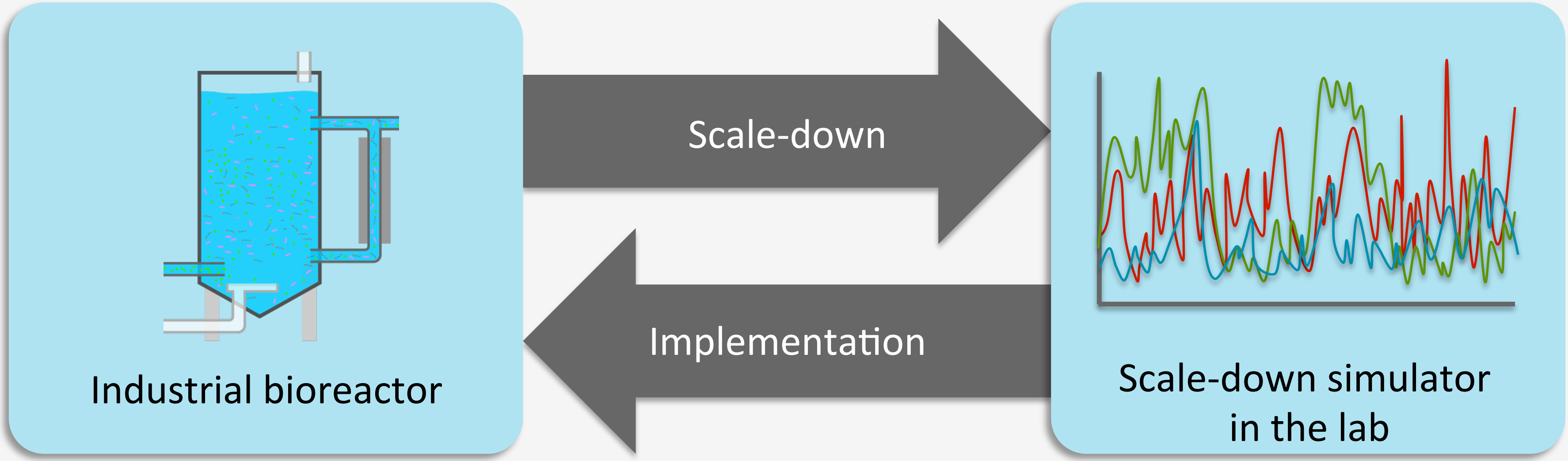


Every 15 min a cold shock of 5 °C

Simulation of cell life-lines of 3 individual cells



Is the microorganism robust enough?
→ Scale-down, not scale-up



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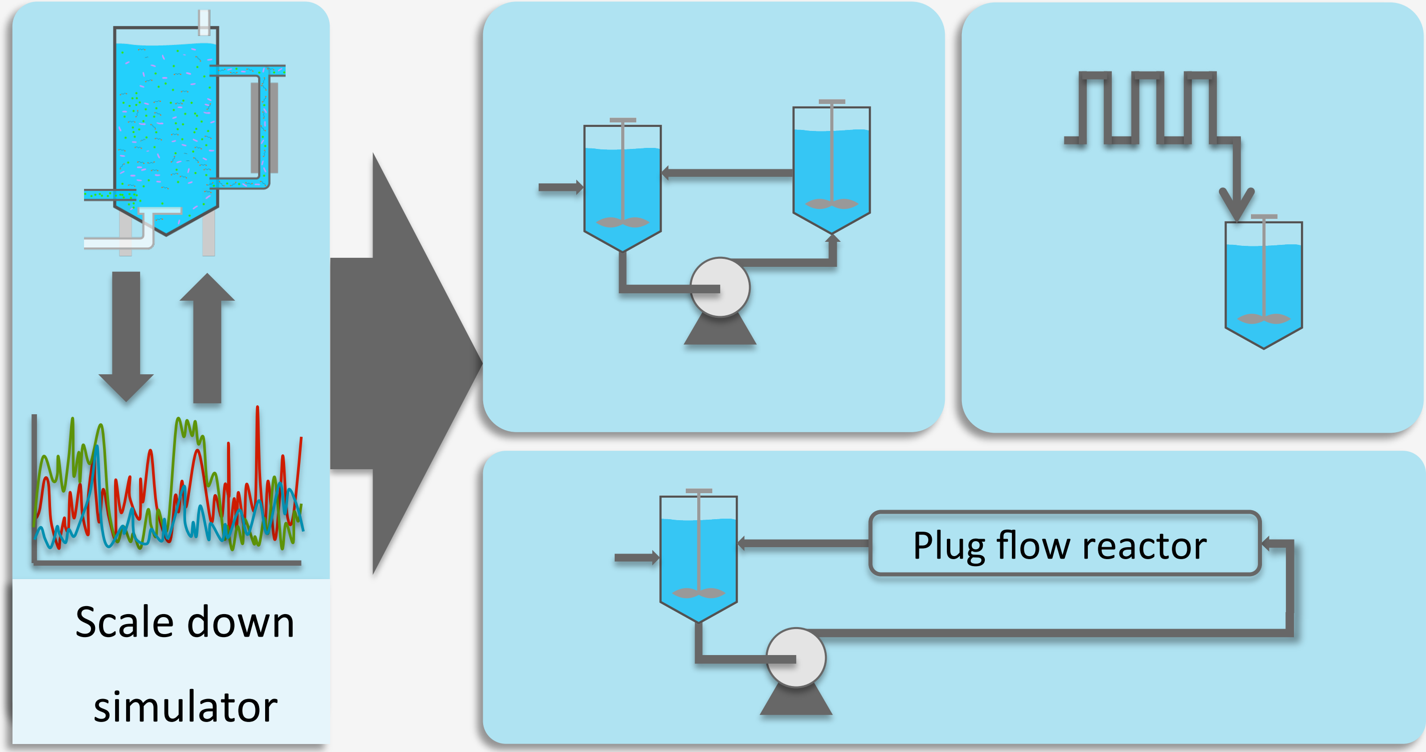

General ways to improve the process:

Micro-organism
- Selection of robust microorganisms
- Metabolic Engineering

Physiology
- Use black box model to better control critical process parameters

Reactor engineering
- Hardware adjustments

Conclusion

Integral design requires quantification and comparison of:

O_2 transfer, CO_2 transfer, Heat transfer, Mixing to determine

1. the transport bottleneck
2. the full scale environment of the microorganism

Best rational optimization method:

Scale-down rather than scale-up

See you in the next unit!