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Presentation

Membrane Theory

Lehmann&Voss&Co. KG
Alsterufer 19
20354 Hamburg

Established Technology for future challenges

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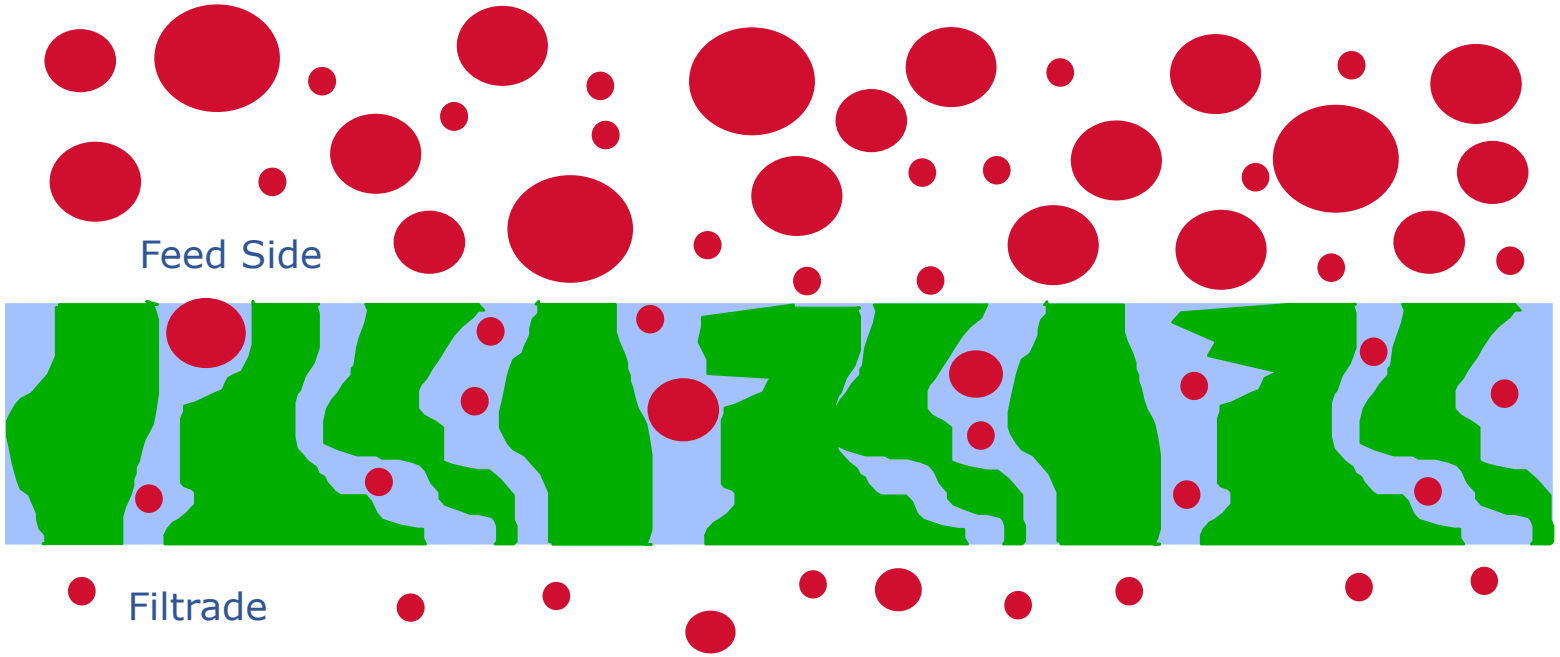
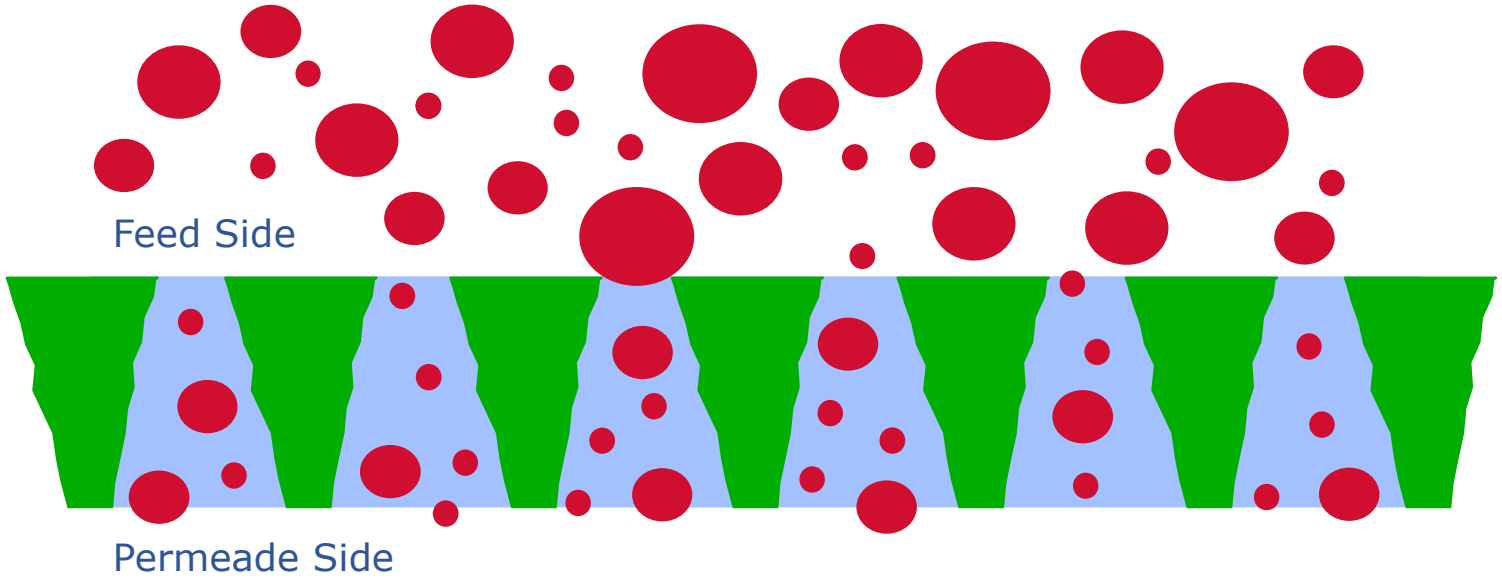
Conventional filtration



Asymmetric membrane pore technology



The asymmetric membranes have an extremely smooth surface and very short capillaries.

The pores of the membrane support structure have a “conical” profile thus eliminating blockage.

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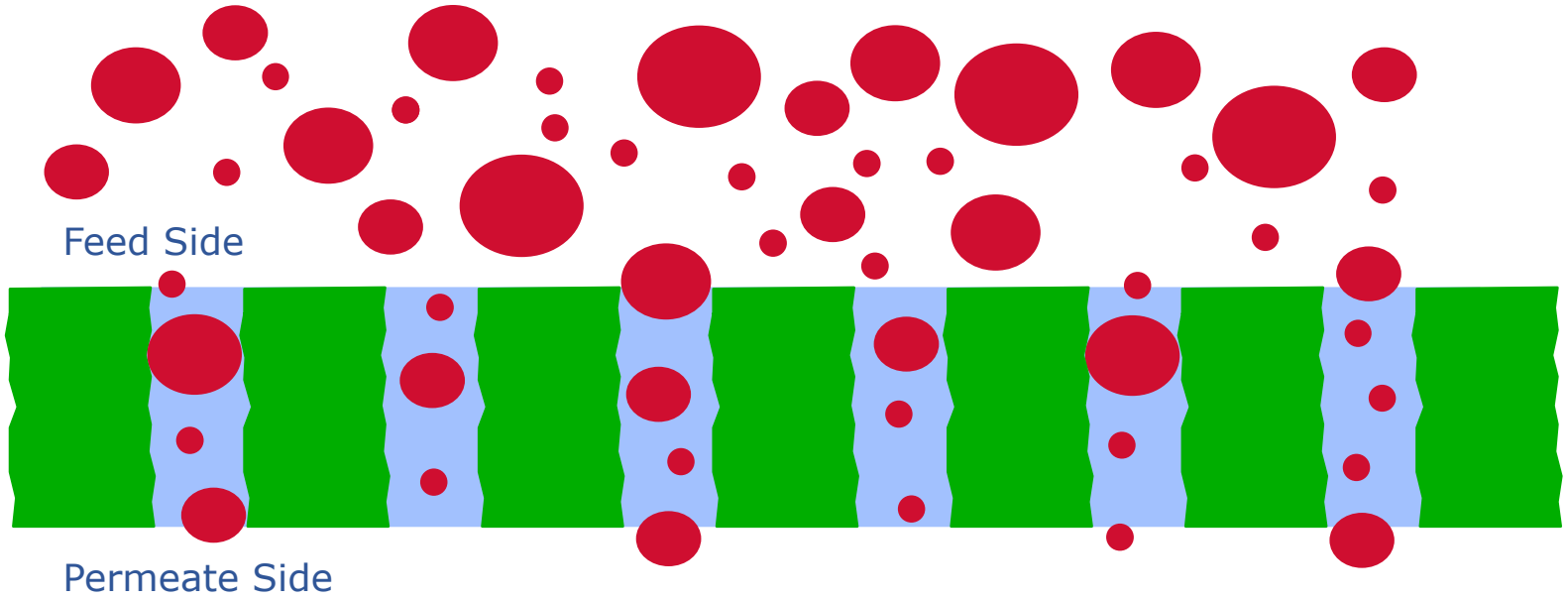
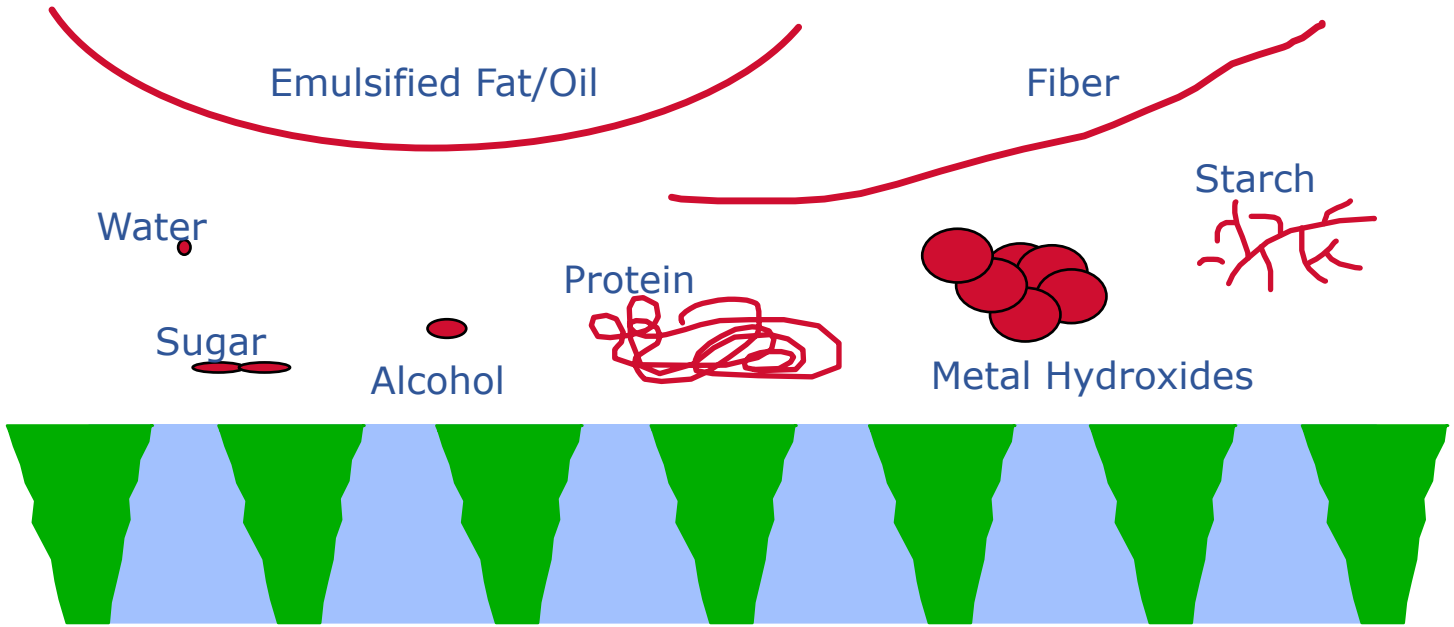
Symmetric membrane pore technology



The pores of a symmetric membrane have a “cylindrical” profile. The capillary extends through the entire filter.

The risk of irreversable membrane plugging is high due to particle entrappment.

Relative particle size



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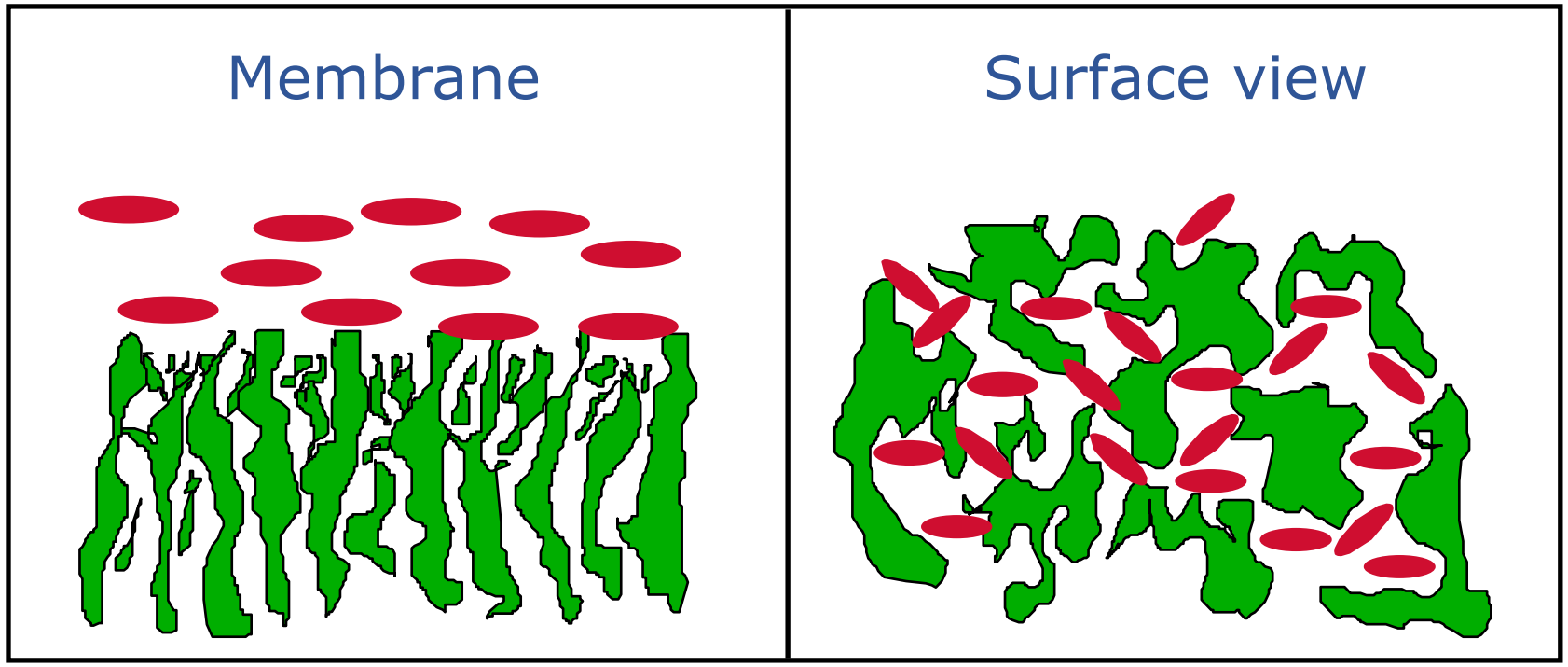
Membrane structure



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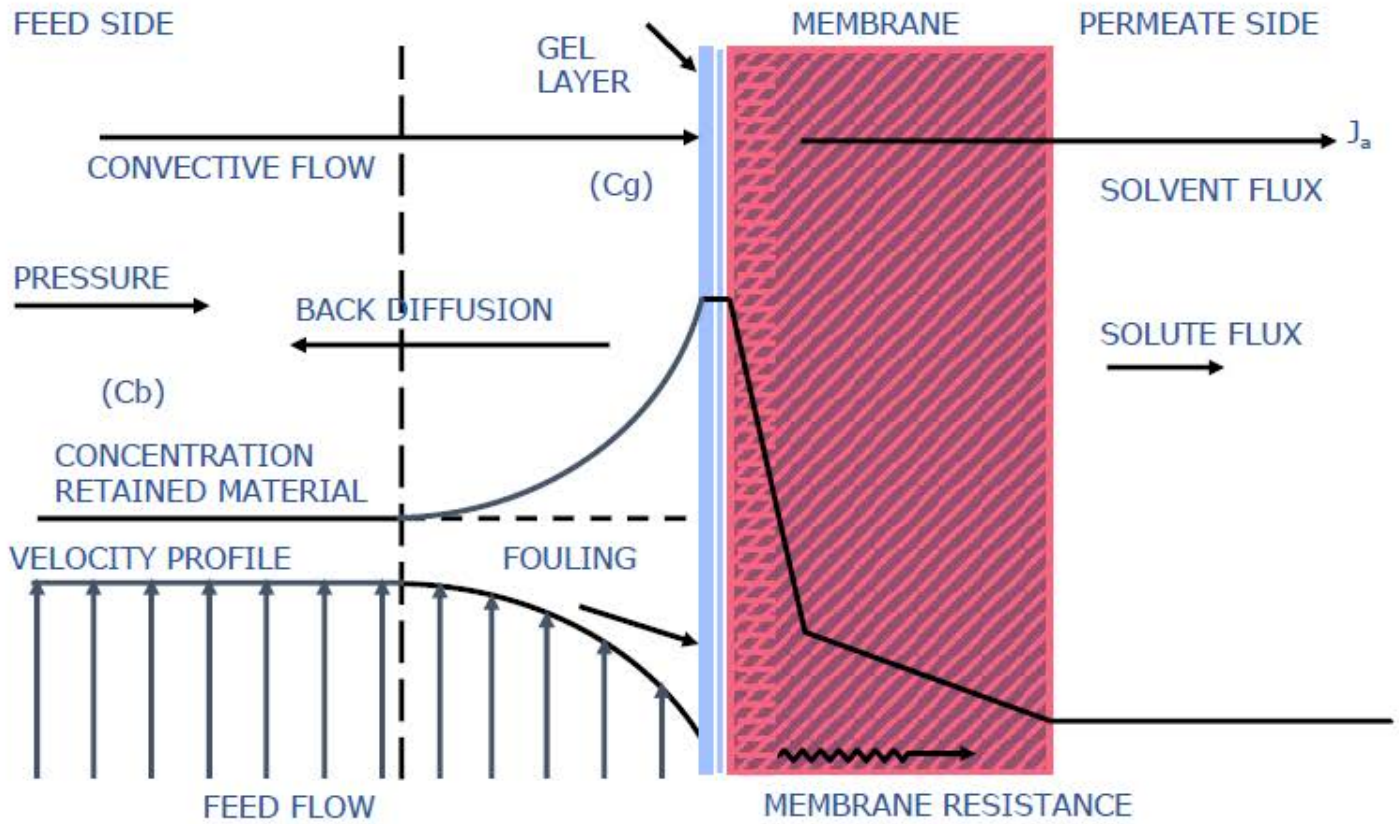
Cross Flow filtration concepts



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Membrane fouling

- Flux decline over time (constant @, P, C and T)
- Molecular Attraction of feed with membrane
- Most fouling is reversible with cleaning
- Irreversible fouling is rare

Mechanisms of fouling

- Submicron surface deposition
- Membrane/solute interaction
- Crystallization in or on the membrane
- Precipitation on the surface

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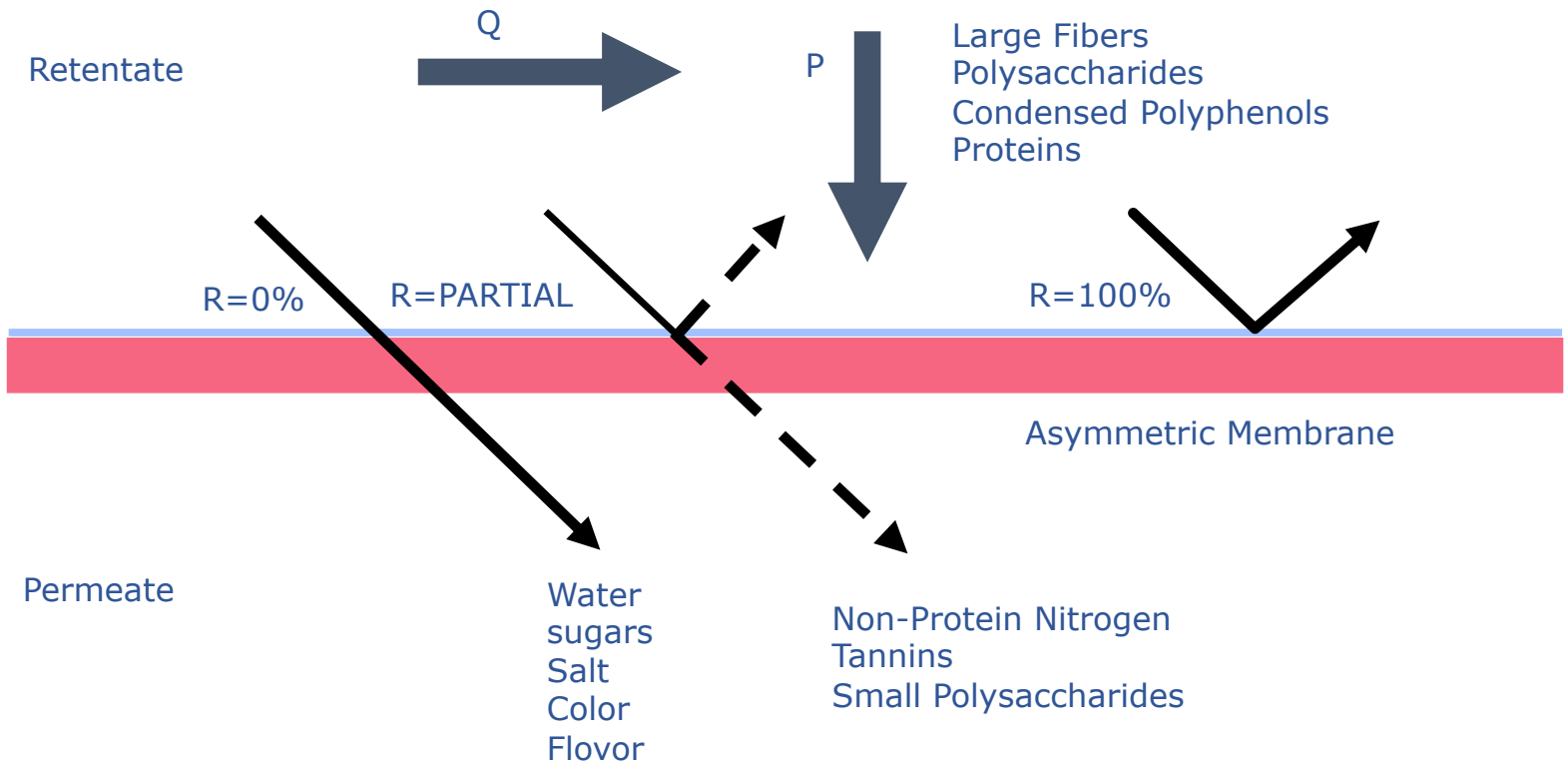
Selective membrane retention



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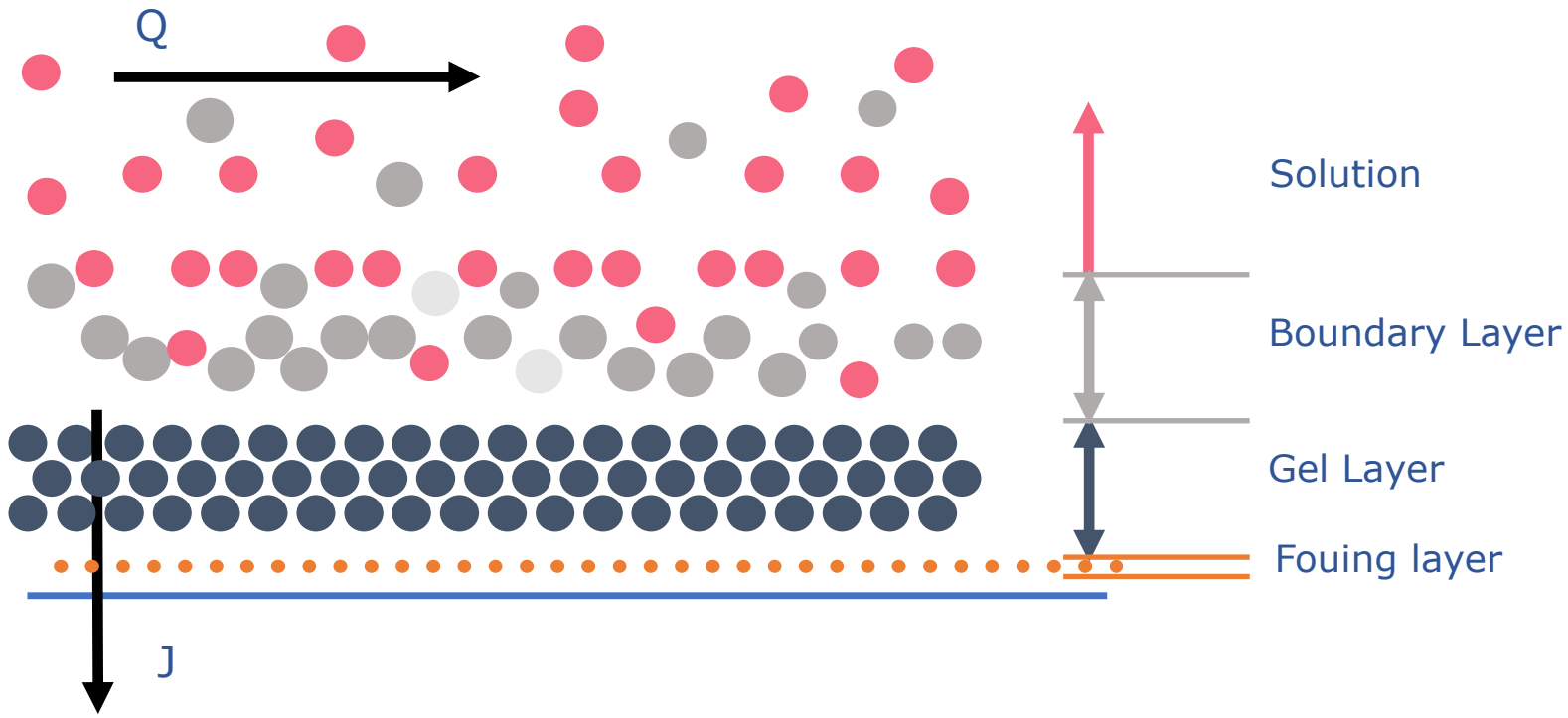
Membrane hydrodynamic limitations



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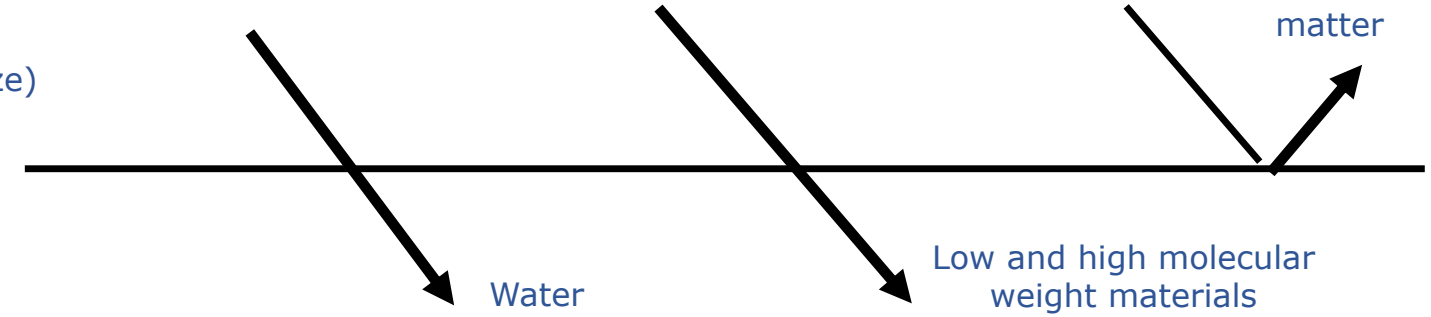
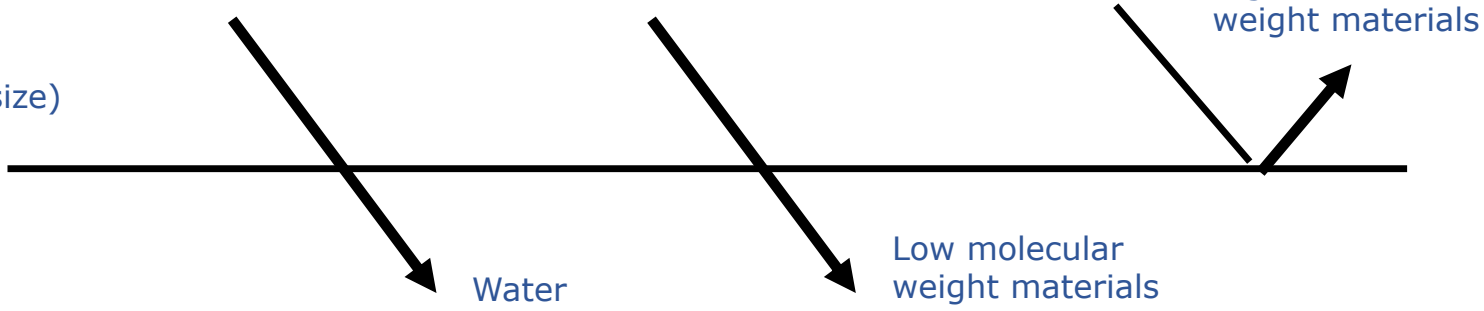
Microfiltration
(separates on particle size)

1 to 7 bar



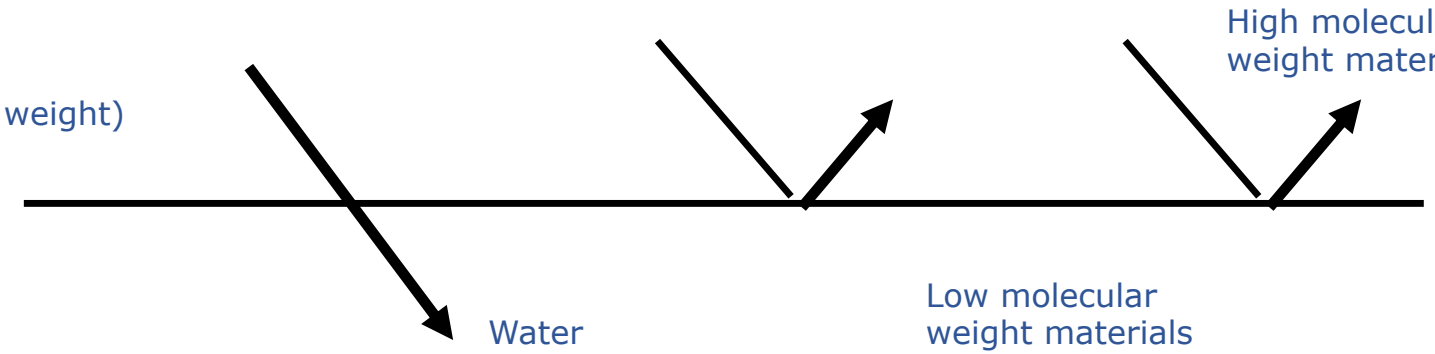
Ultrafiltration
(separates on molecular size)

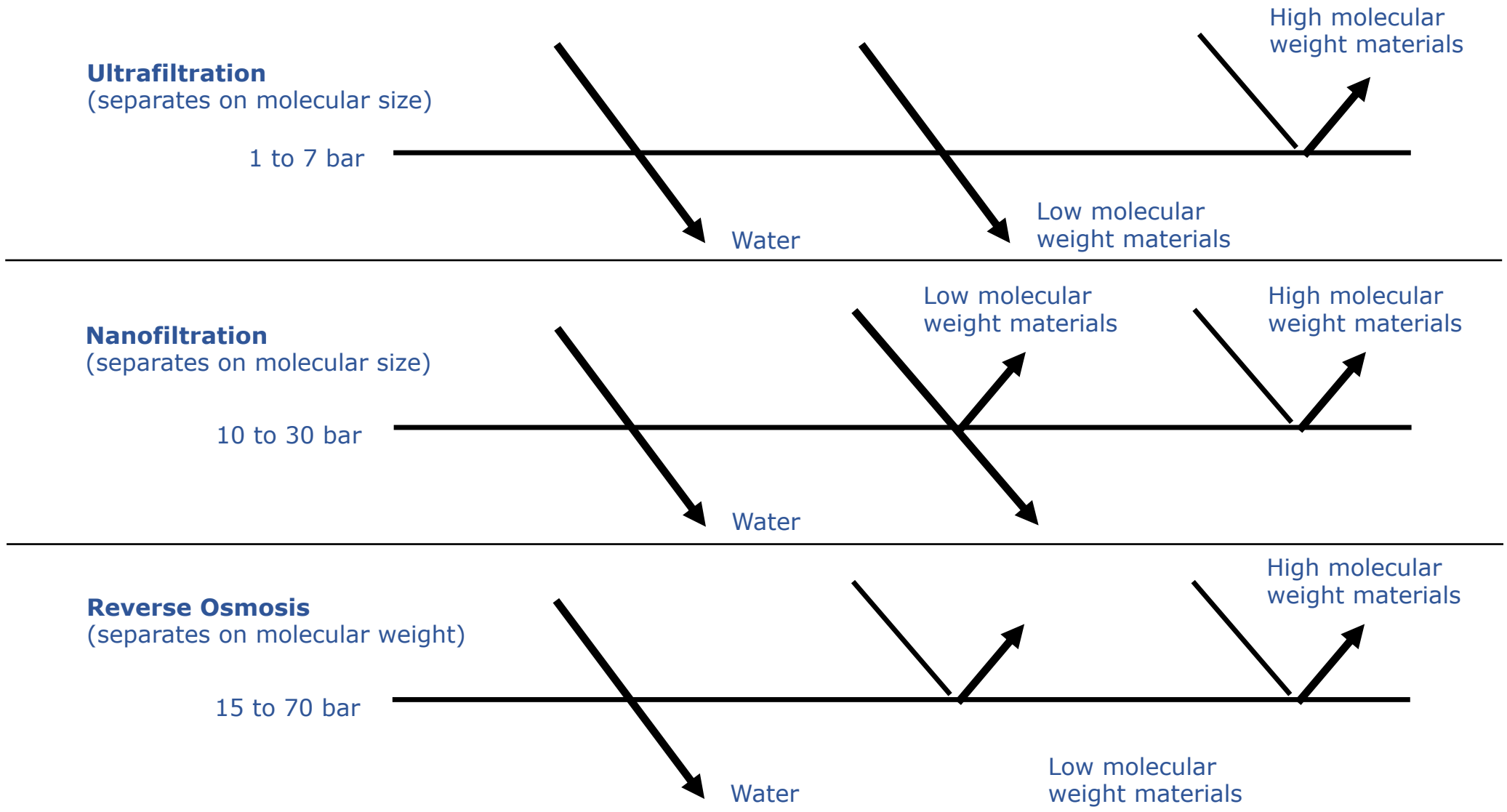
1 to 7 bar



Reverse Osmosis
(separates on molecular weight)

15 to 70 bar




Ultrafiltration
(separates on molecular size)
1 to 7 bar
Water
Low molecular weight materials
High molecular weight materials
Nanofiltration
(separates on molecular size)
10 to 30 bar
Water
Low molecular weight materials
High molecular weight materials
Reverse Osmosis
(separates on molecular weight)
15 to 70 bar
Water
Low molecular weight materials
High molecular weight materials

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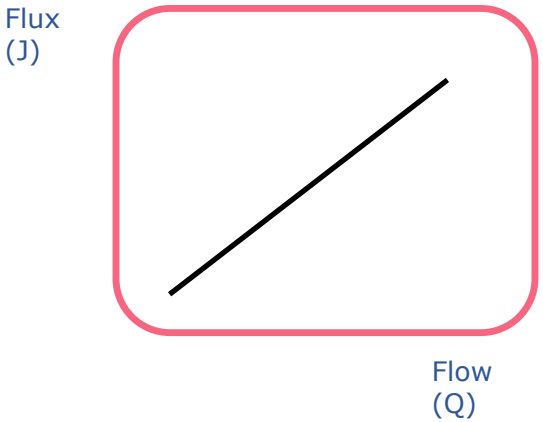
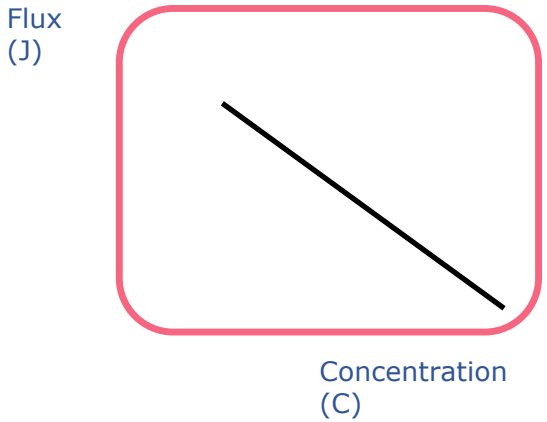
Ultrafiltration process parameters

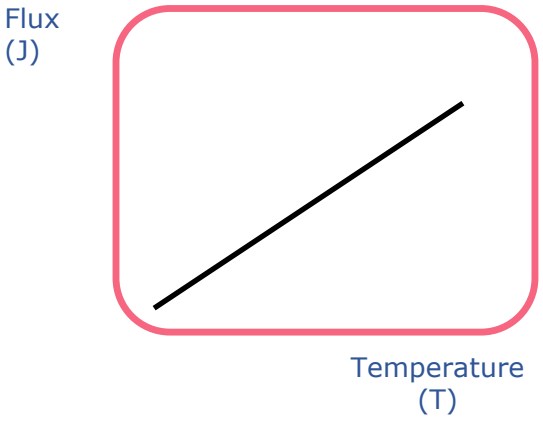
Flux versus Flow



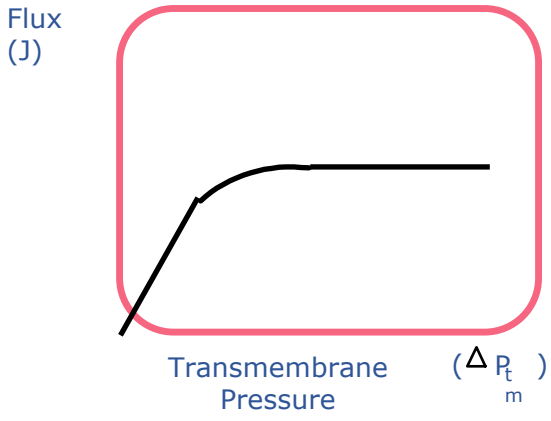
Flux versus Concentration



Flux versus Temperature



Flux versus Pressure



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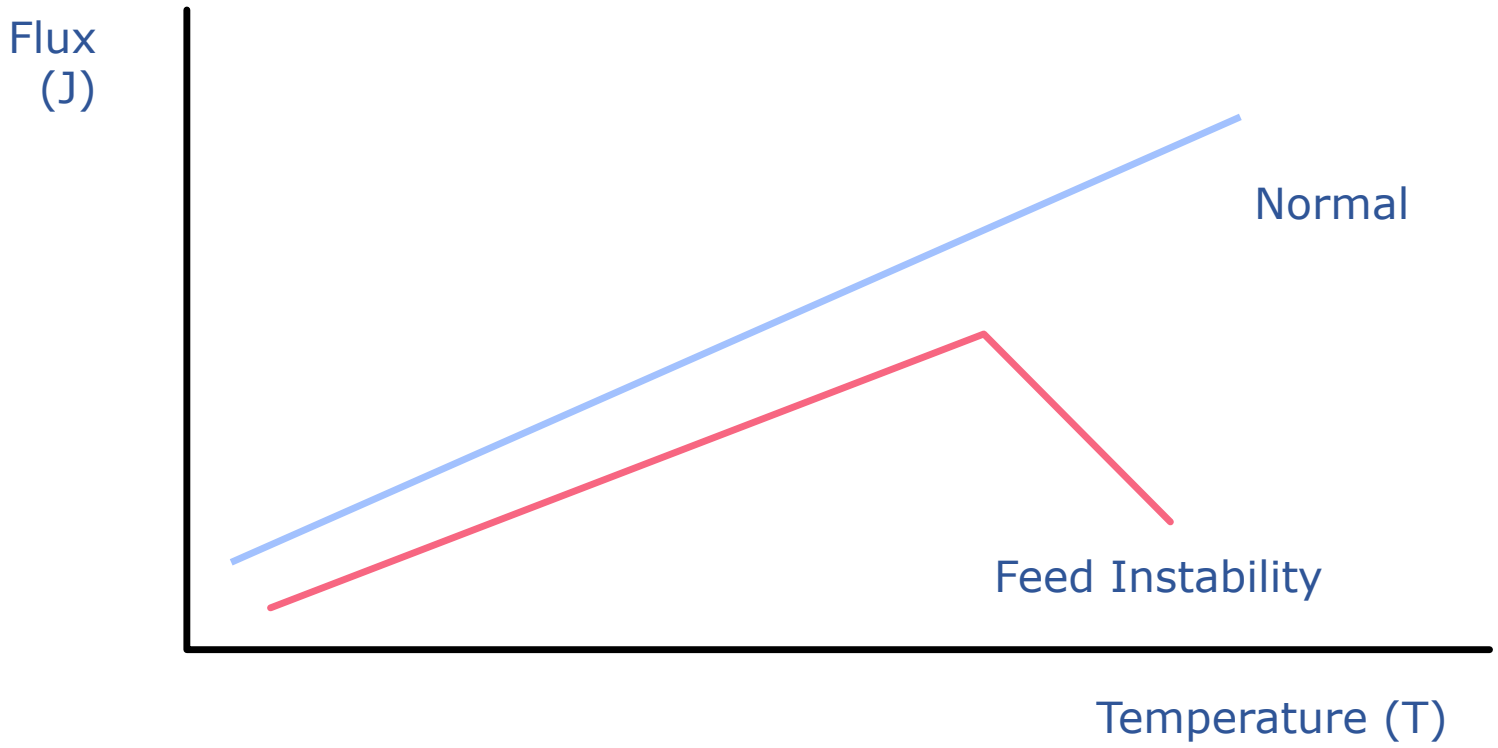
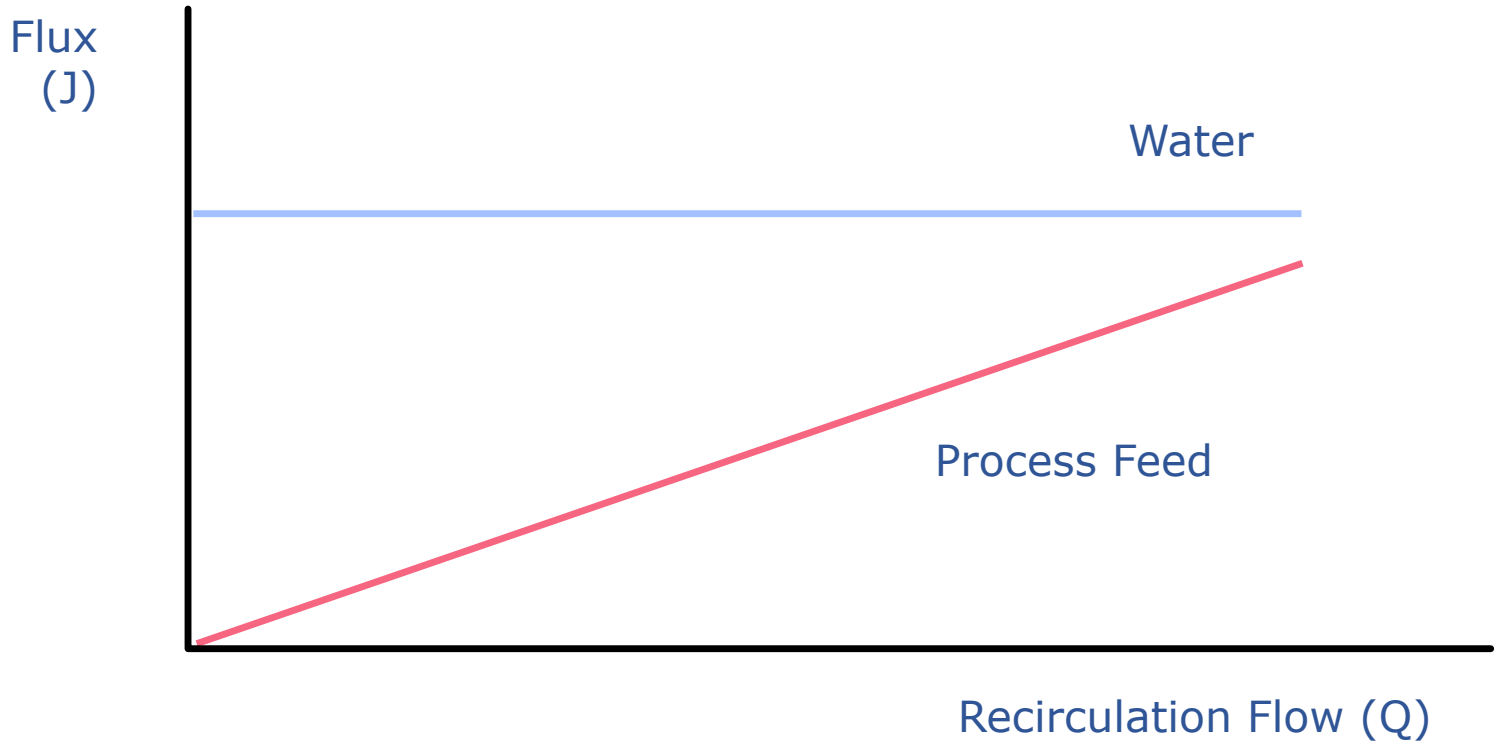
Effect of temperature on flux



Effect of flow on flux



Conditions: Constant Pressure and Concentration

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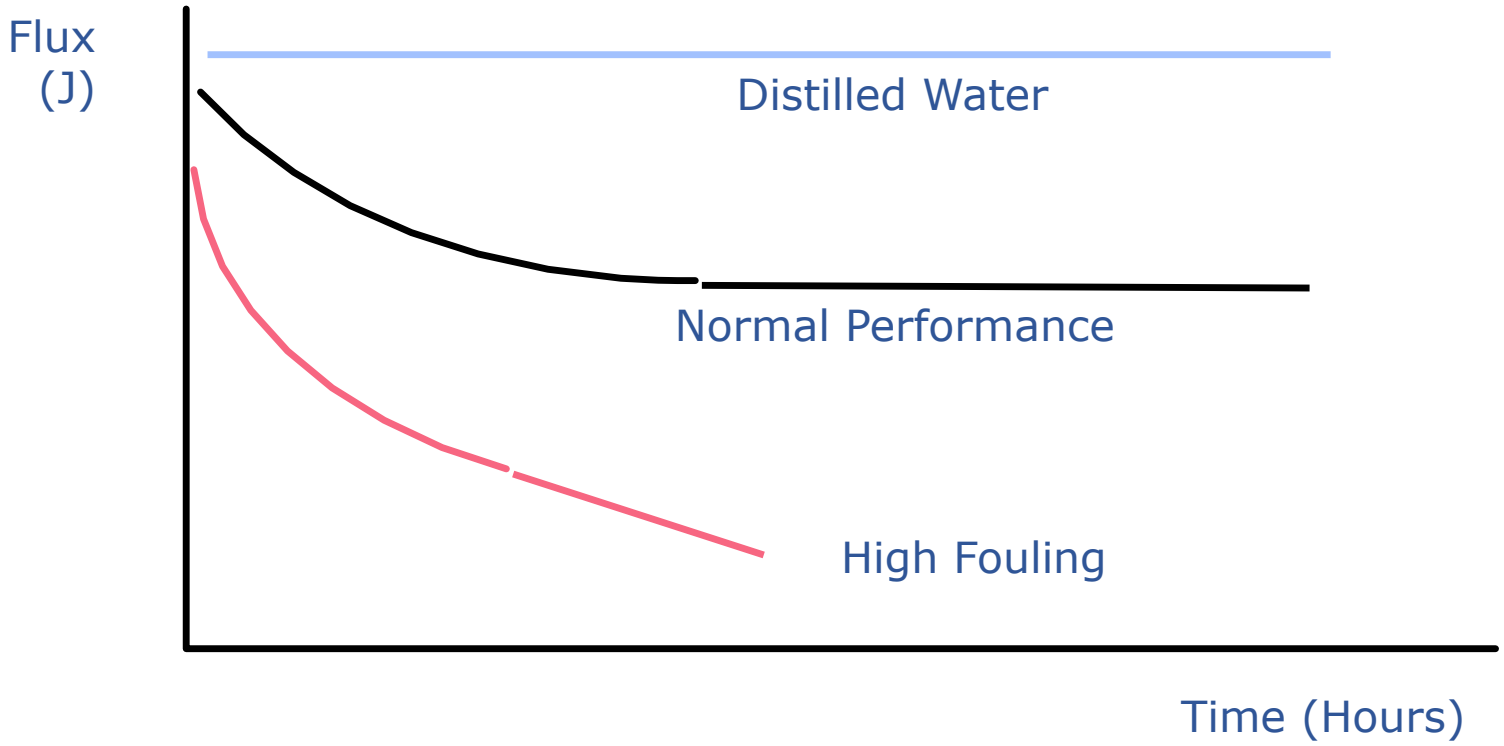
Effect of time on flux on various streams



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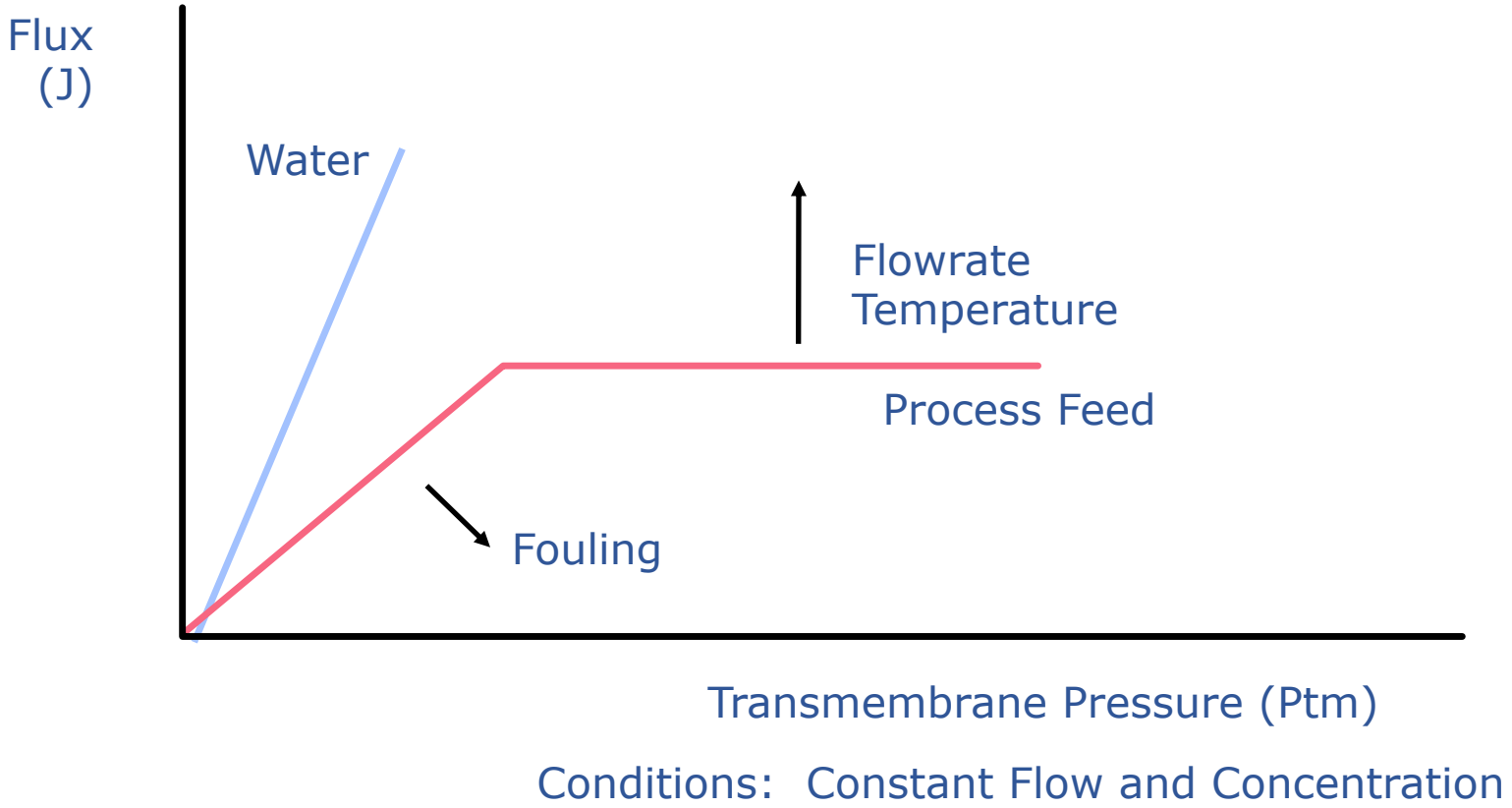
Effect of pressure on flux



Conditions: Constant Flow and Concentration

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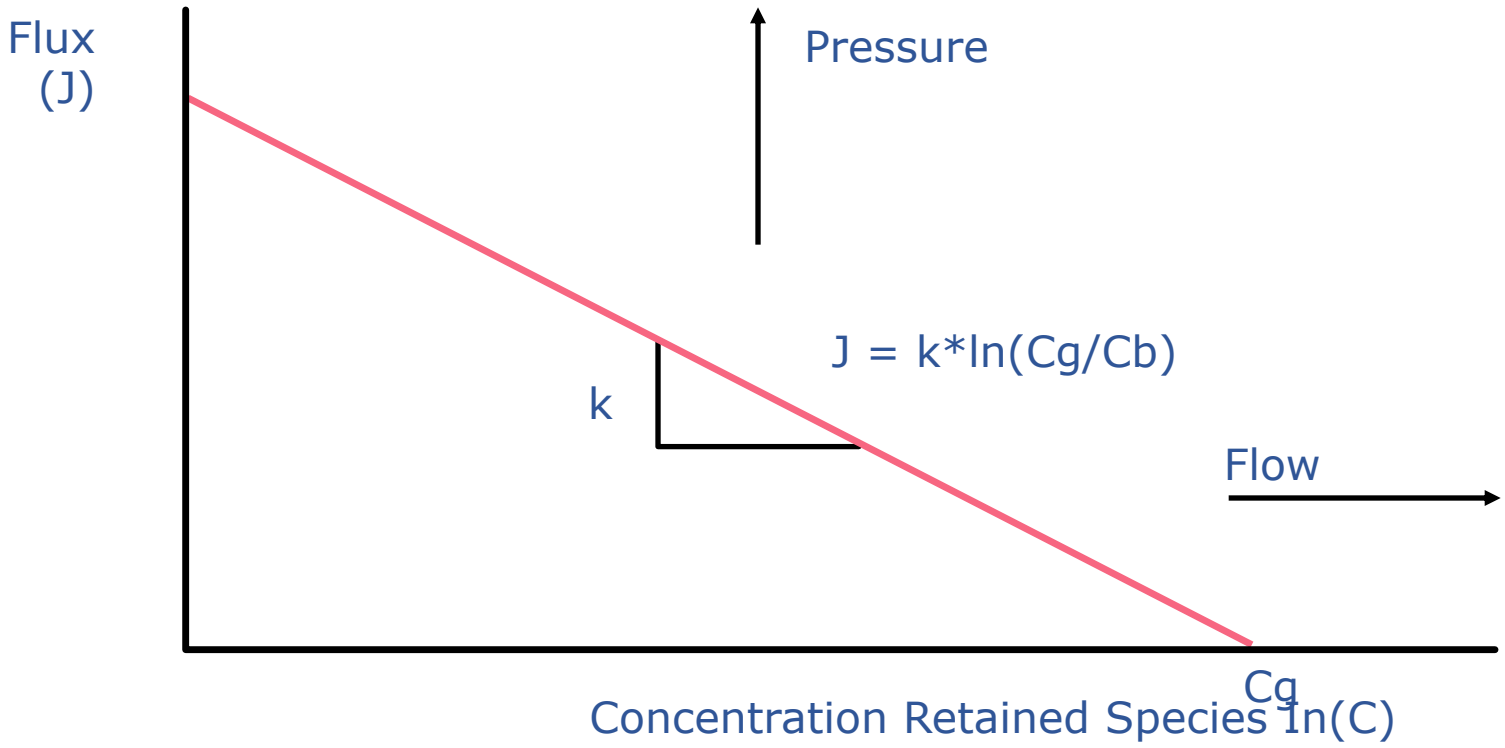
Effect of concentration on flux



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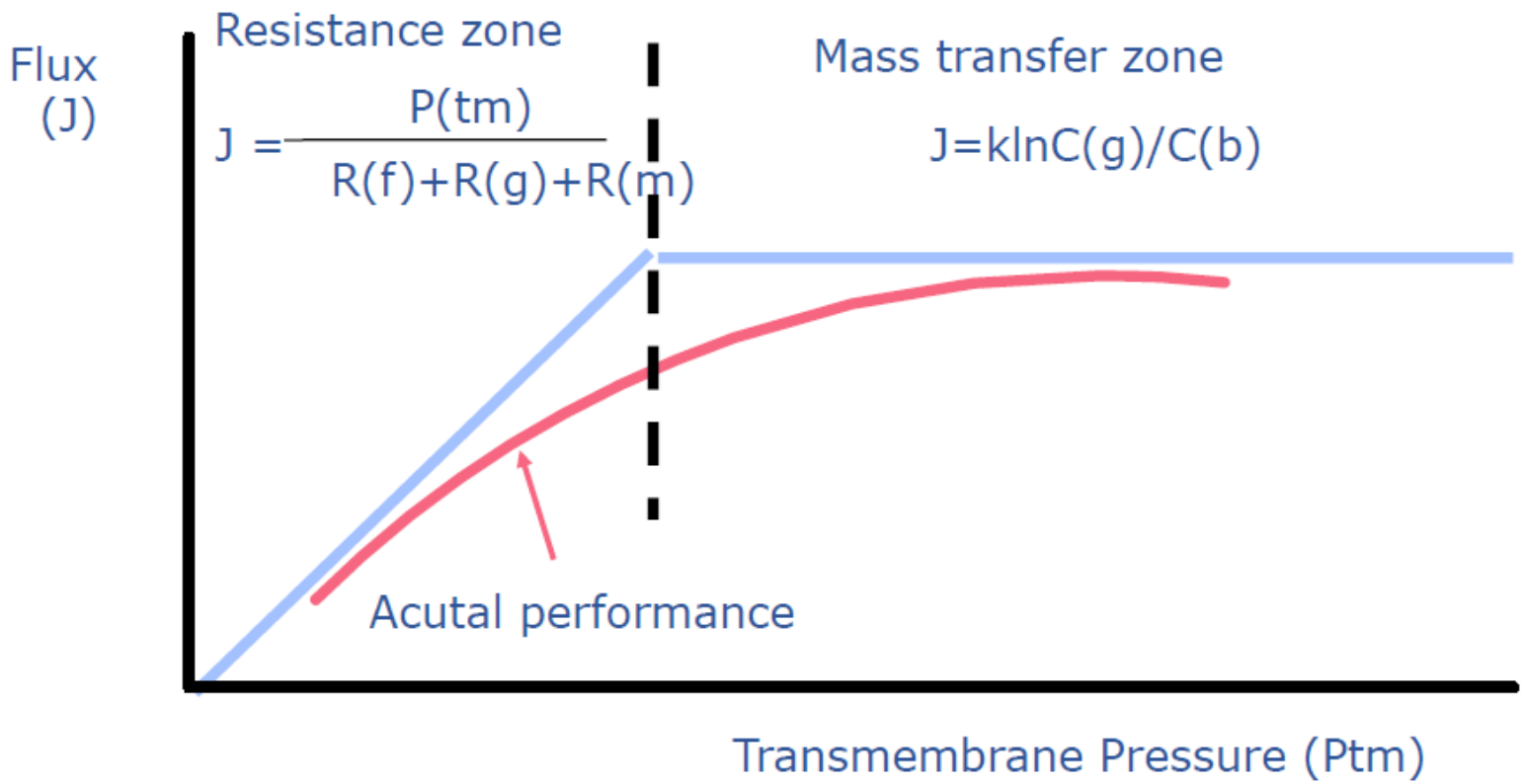
Restitance and mass transfer models of flux



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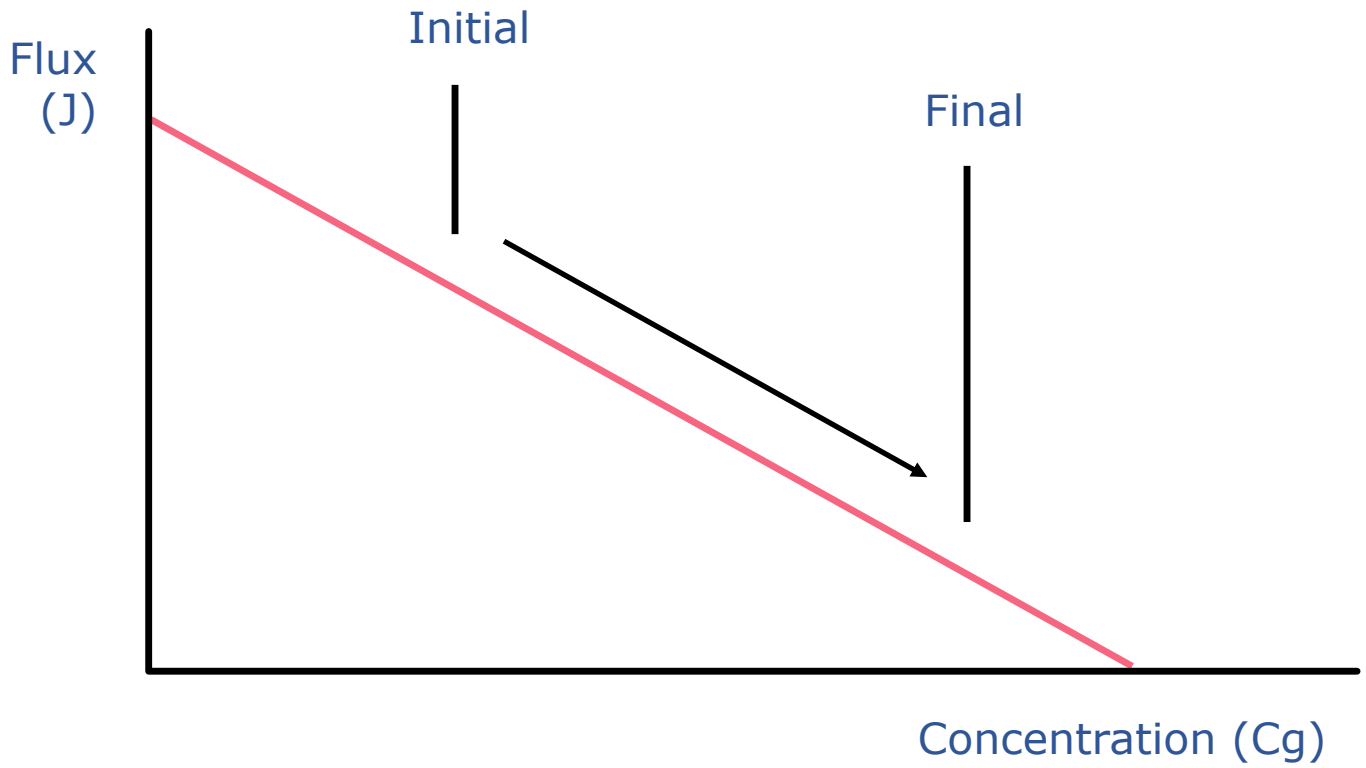
Cross Flow membrane filtration batch processing



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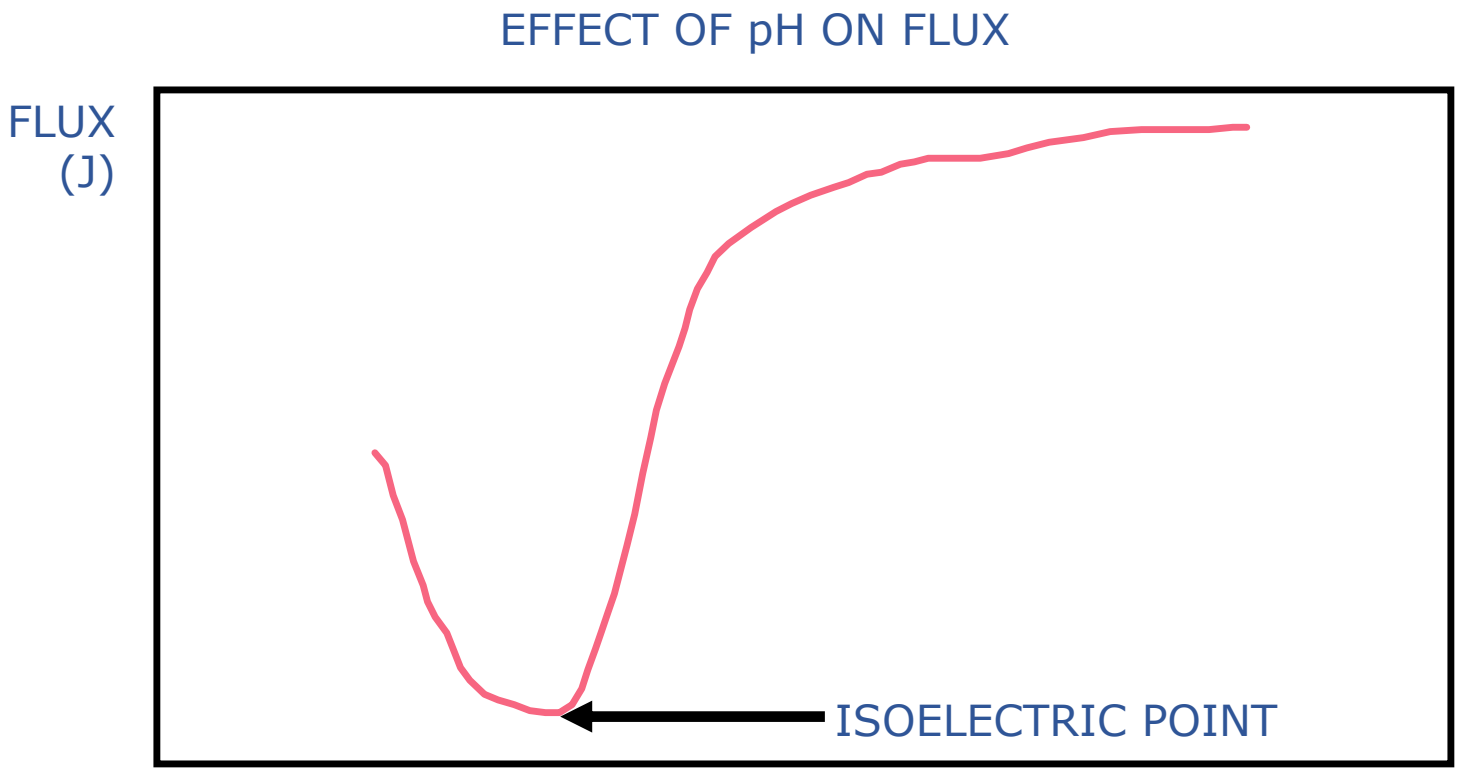
CROSS-FLOW MEMBRANE FILTRATION



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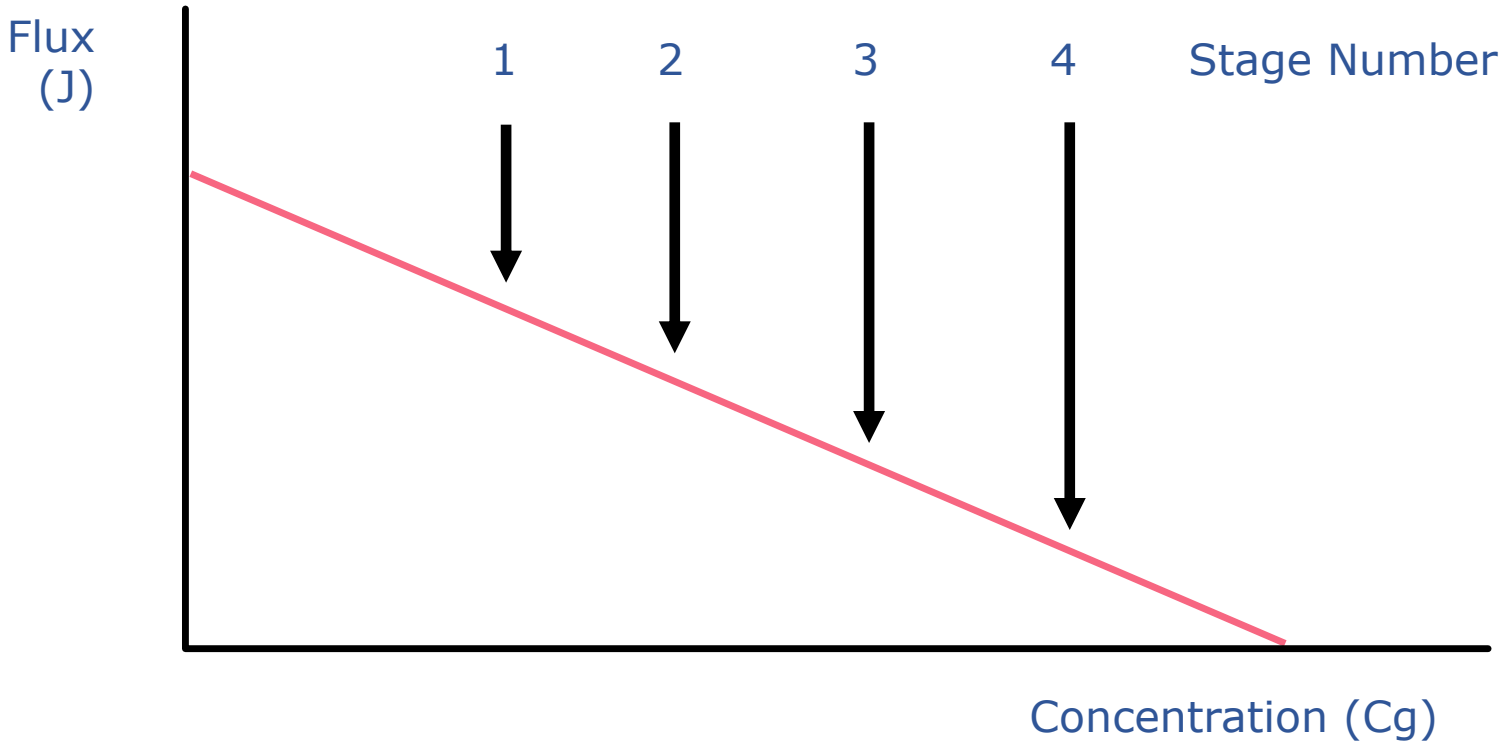
Stages in series continuous processing



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Cross Flow membrane filtration controling factors

- Transmembrane pressure
- Fluid flow across the membrane
- Viscosity
- Temperature
- Concnetration of retained particles
- Pretreatment conditions
- Fouling characteristics of the feed
- Microbiological activity in the feed
- Plant operator

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UF operating precautions

1. Do not let membranes dry out.
2. Do not use silicone based deformers.
3. Do not dead head the modules.
4. Do not over-concentrate during batchdown.
5. Do not exceed maximum temperature specification.
6. Be aware that increasing pH and temperature decreases membrane life.
7. Avoid water hammer.
8. Minimize the time the system sits idle with process fluids on the membrane.
9. Do not allow the modules to freeze after startup.
10. Operate the system in accordance with the guideline.

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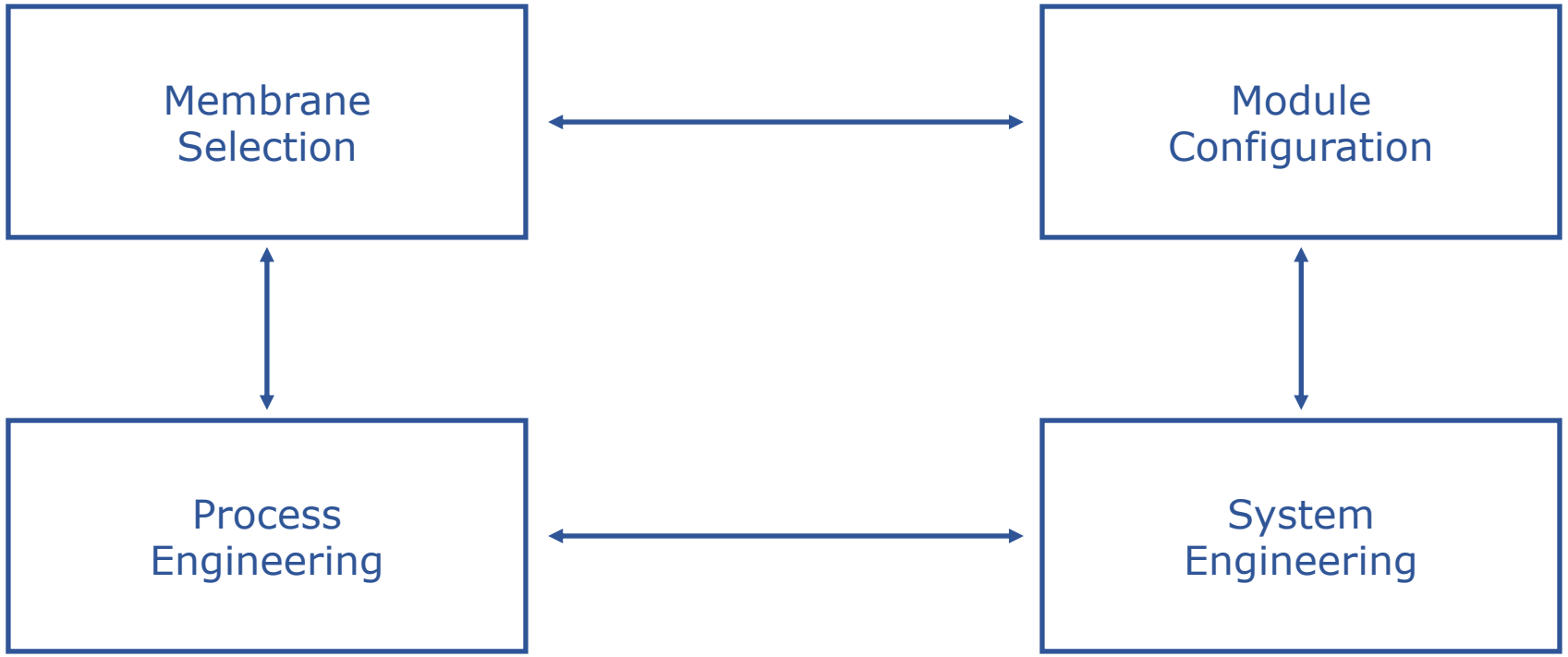
Components for a successful membrane filtration



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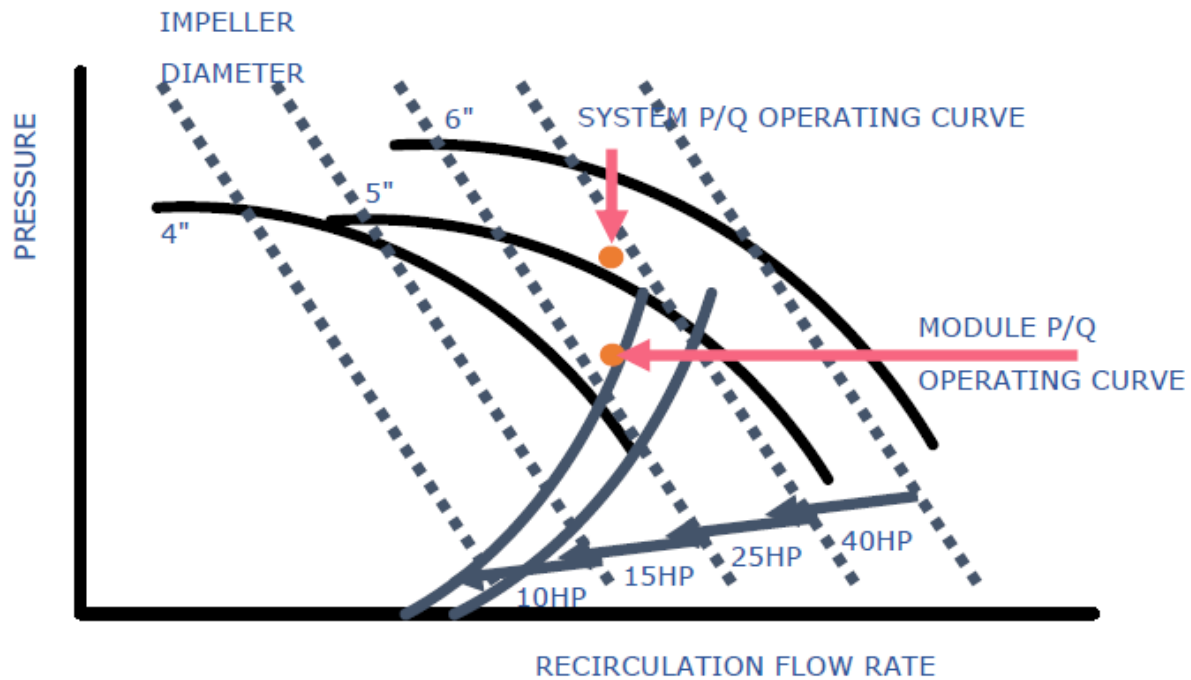
Ultrafiltration systems design – Recirculation pump selection



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Cross Flow Filtration concept importants formulars

$$\text{FLUX (J)} = \frac{\text{PERMEATE FLOW}}{\text{MEMBRANE AREA}} = \text{"LMH"}$$

$$\text{TRANSMEMBRANE PRESSURE} \qquad P_{avg.} = \frac{P_{in}+P_{out}}{2}$$

$$\text{CONVERSION (\%)} = \frac{V_f - V_r}{V_f} = \frac{V_p}{V_f} = 1 - \frac{1}{CF}$$

$$\text{\% RETENTION} = \left(1 - \frac{[\text{PERMEATE}]}{[\text{RETENTATE}]}\right) \times 100$$

RETENTION VON 0 TO 100%

PRESSURE DROP

$P_{delta} = P_{in} - P_{out}$

RELATION dP TO Q

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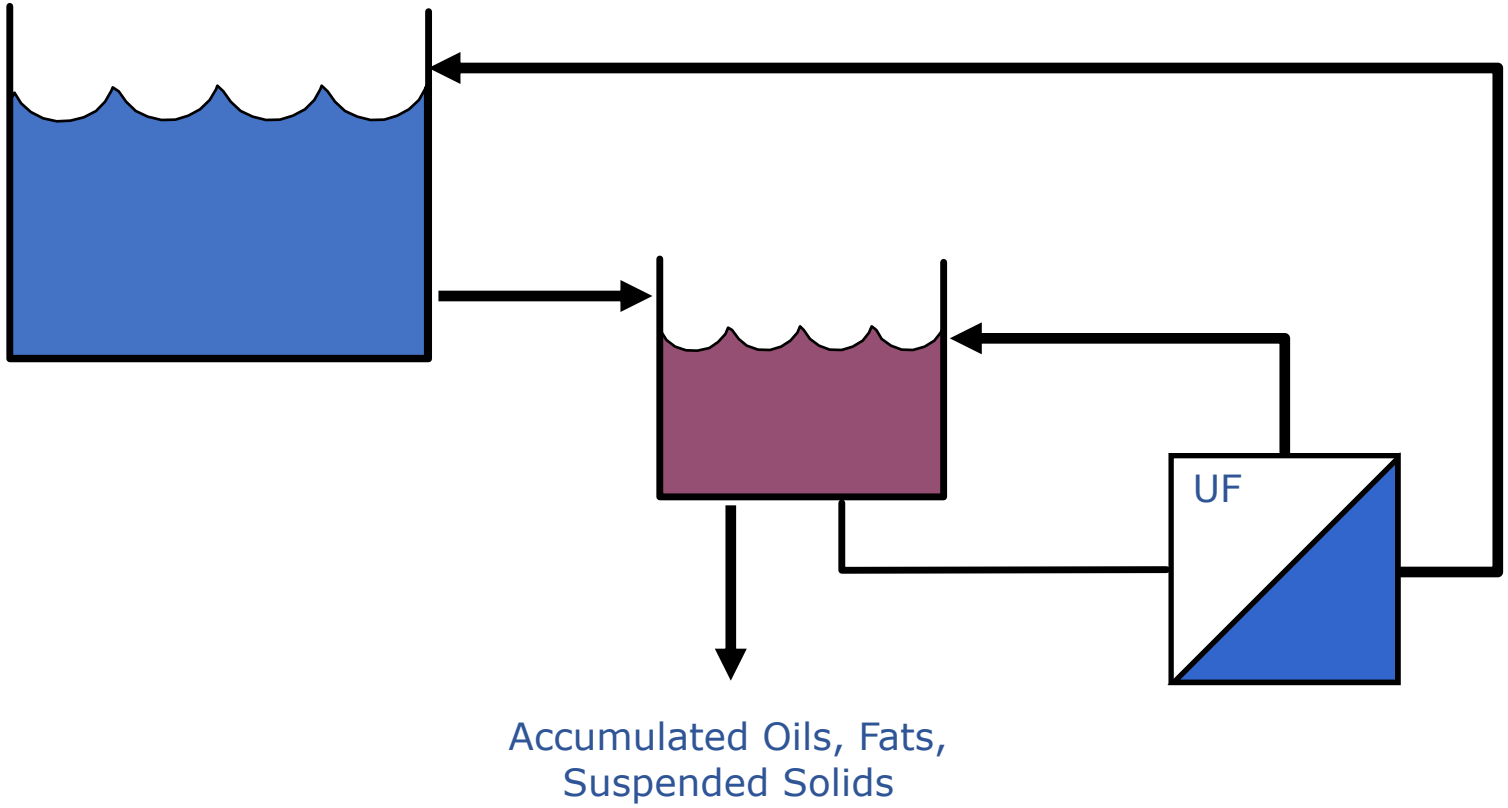
Pilot data collection important parameters

1. Define flux concentration of retained species
   - assess flux over complete range of concentration
   - collect concentration and permeate samples
2. Define effect of flow and pressure on flux
   - assess standard operating conditions
   - perform flow and pressure excursions
3. Assess flux cecline over time.
   - run at constante concentrating by recycling permeate
   - factor out effects of fouling
4. Continuous pilots
   - run multiples stages if possible
   - run at constant x to study fouling
5. Establish reproducibility of process runs.
6. Establish cleanability of the modules.

Kindney operations

KIDNEY OPERATIONS



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The consequence of experience of

a successful business model.

Established Technology for future challenges