Synder®
Filtration
Membranes That Perform.
People Who Deliver.™
Principles of Filtration for Milk,
Cheese & Dairy Products

Agenda

1. Membrane Construction
2. Filtration Principles
3. Cheesemaking
4. Milk Standardization
5. Benefits of Micro-Filtration

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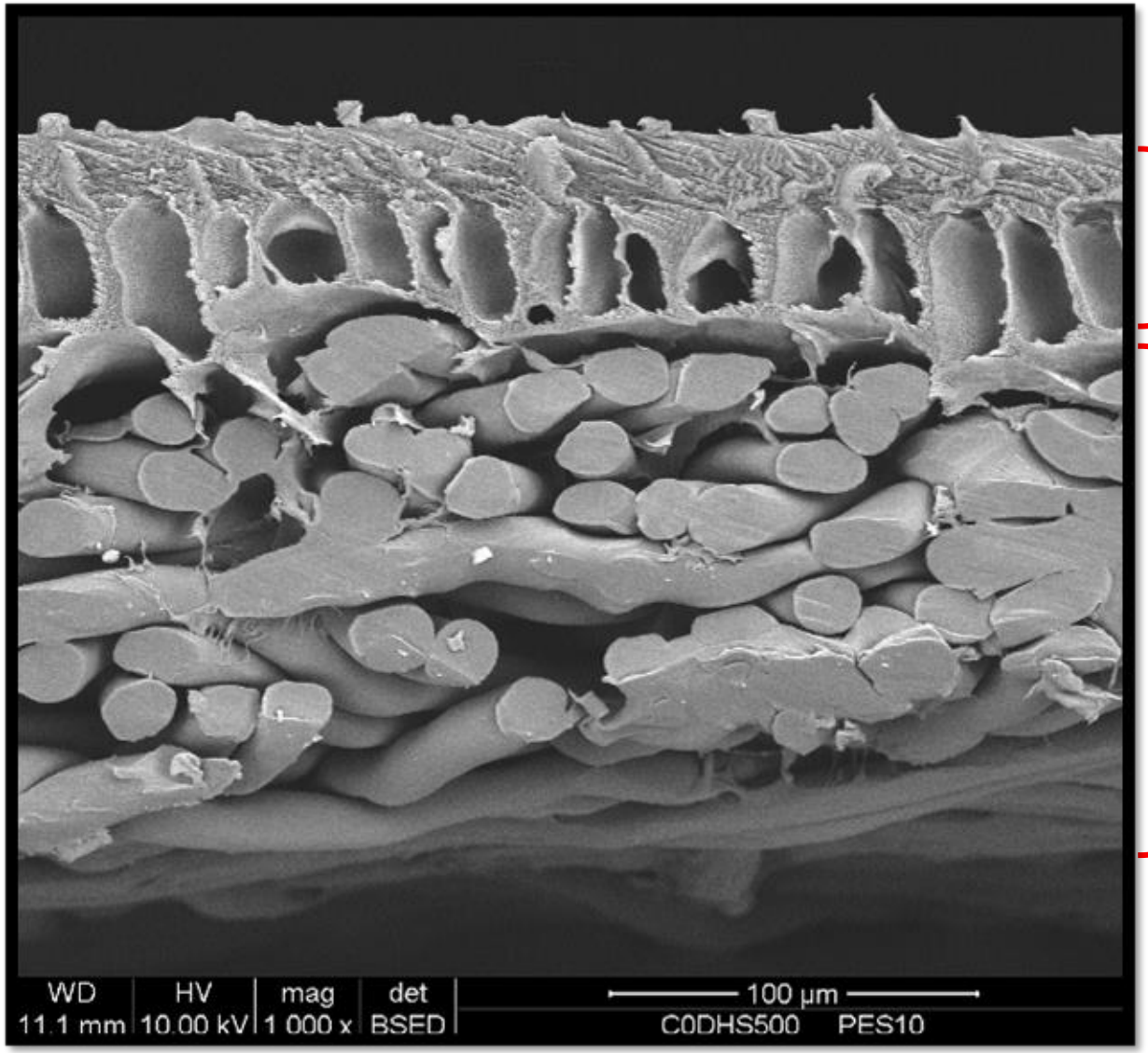
What are Polymeric Membranes?



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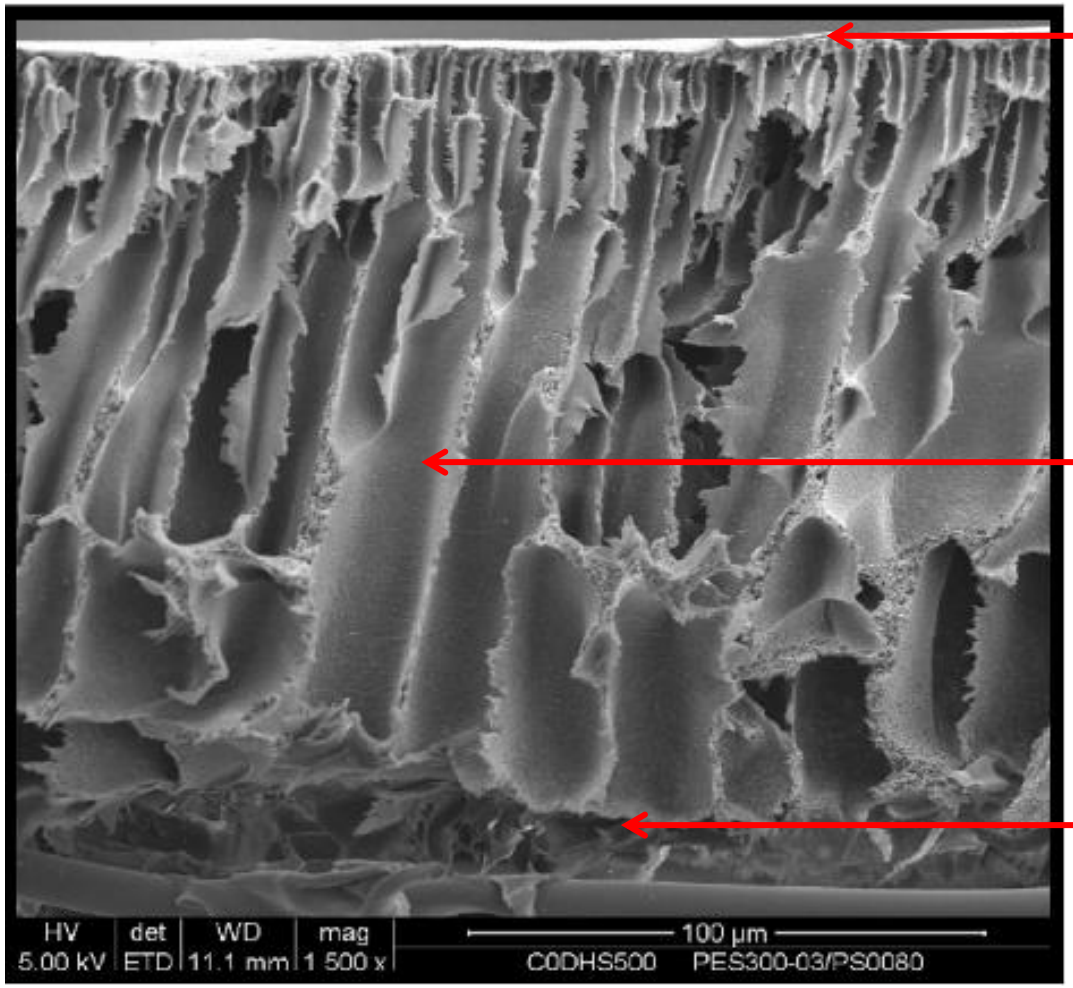
Polymeric Membranes



Surface pores control rejection

Larger macro-voids deeper into membrane provide more room for permeate transport, maximizing flux

PE or PP backing material (very porous)

Synder "LX" PES300kD
Cross Section (1500x)

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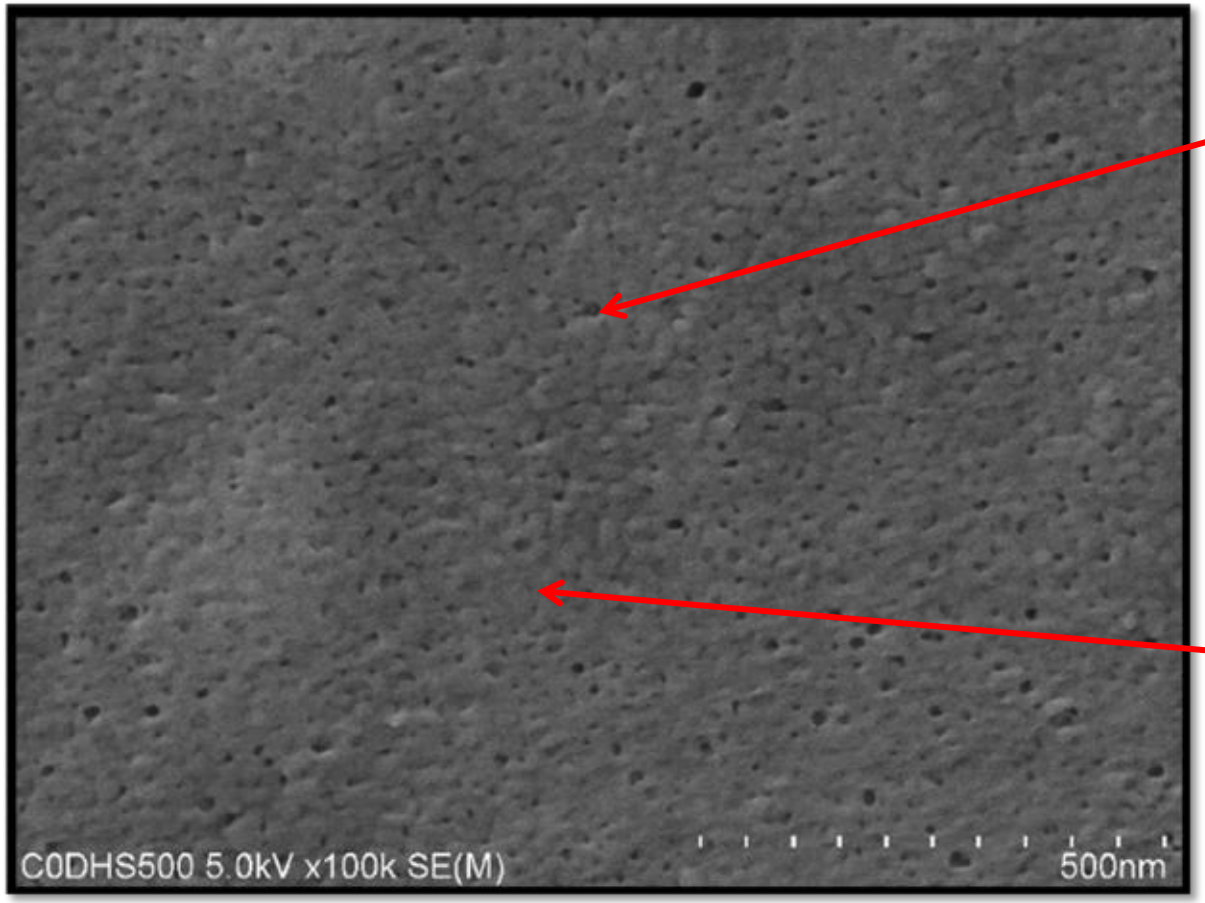
Polymeric Membranes



Uniform pore structure and a high degree of porosity

Smooth surface desirable for reduction of fouling tendency

Synder "LX" PES300kD
Cross Section (100,000x)

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Polymeric Membranes

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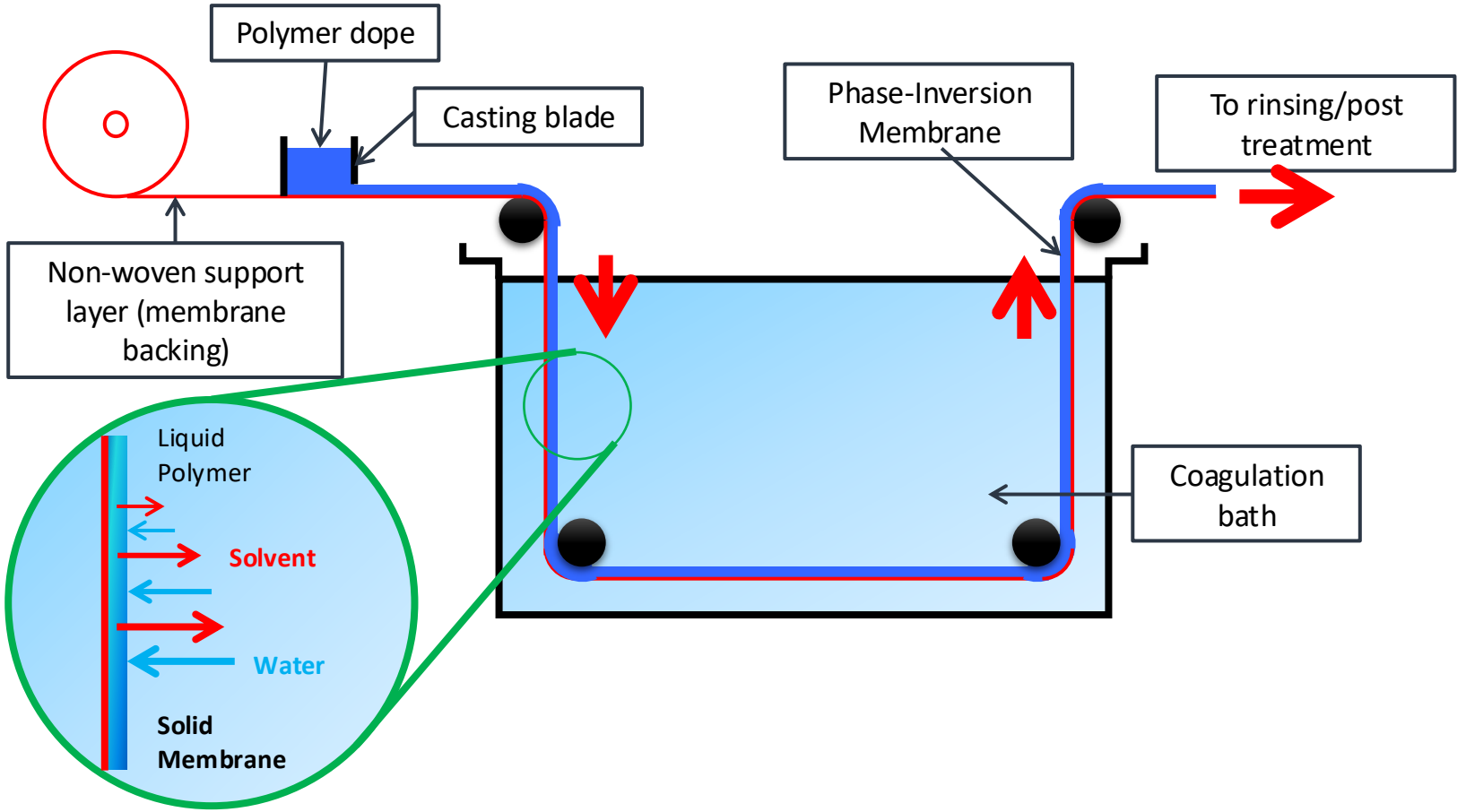
Polymeric Membranes



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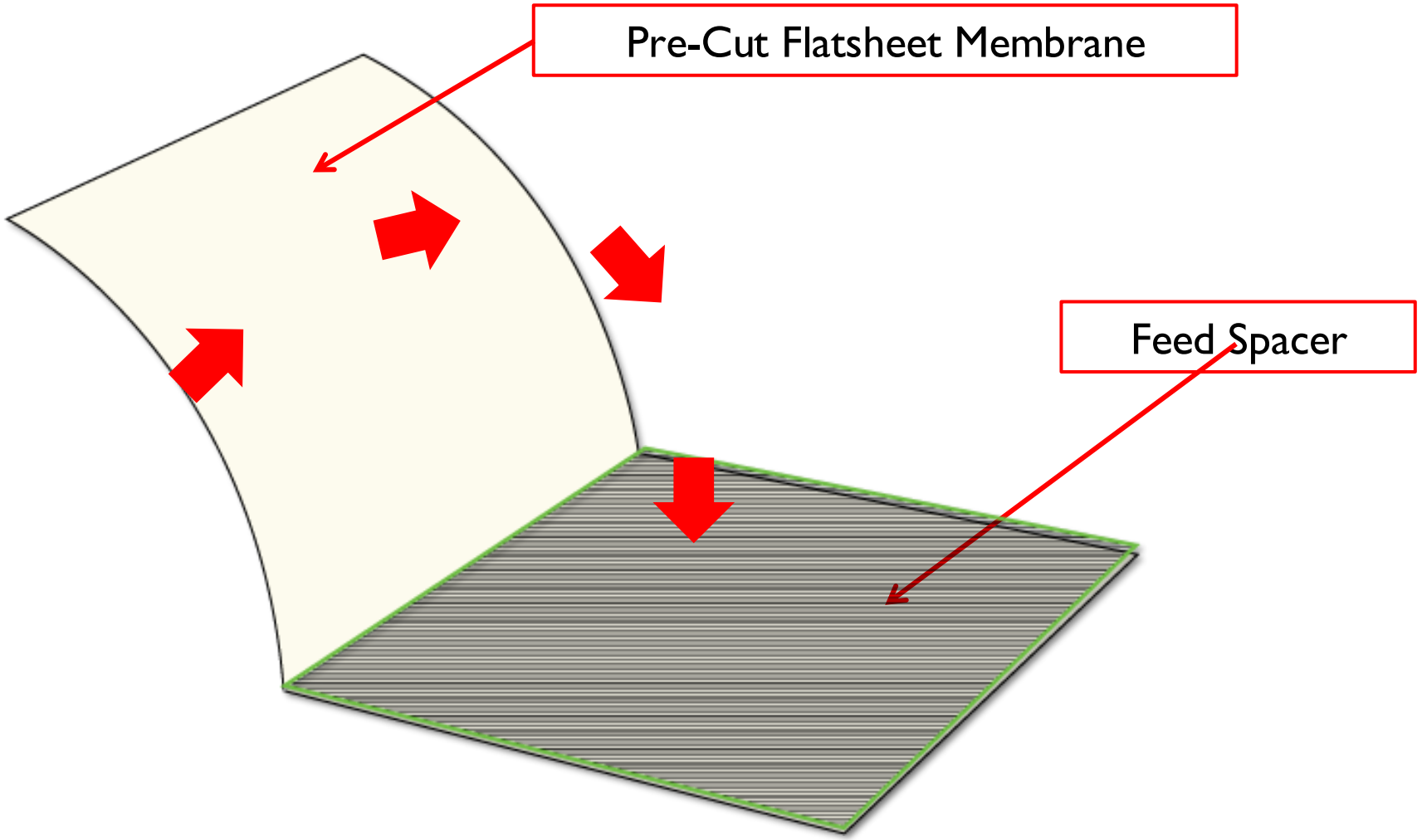
Spiral Membranes



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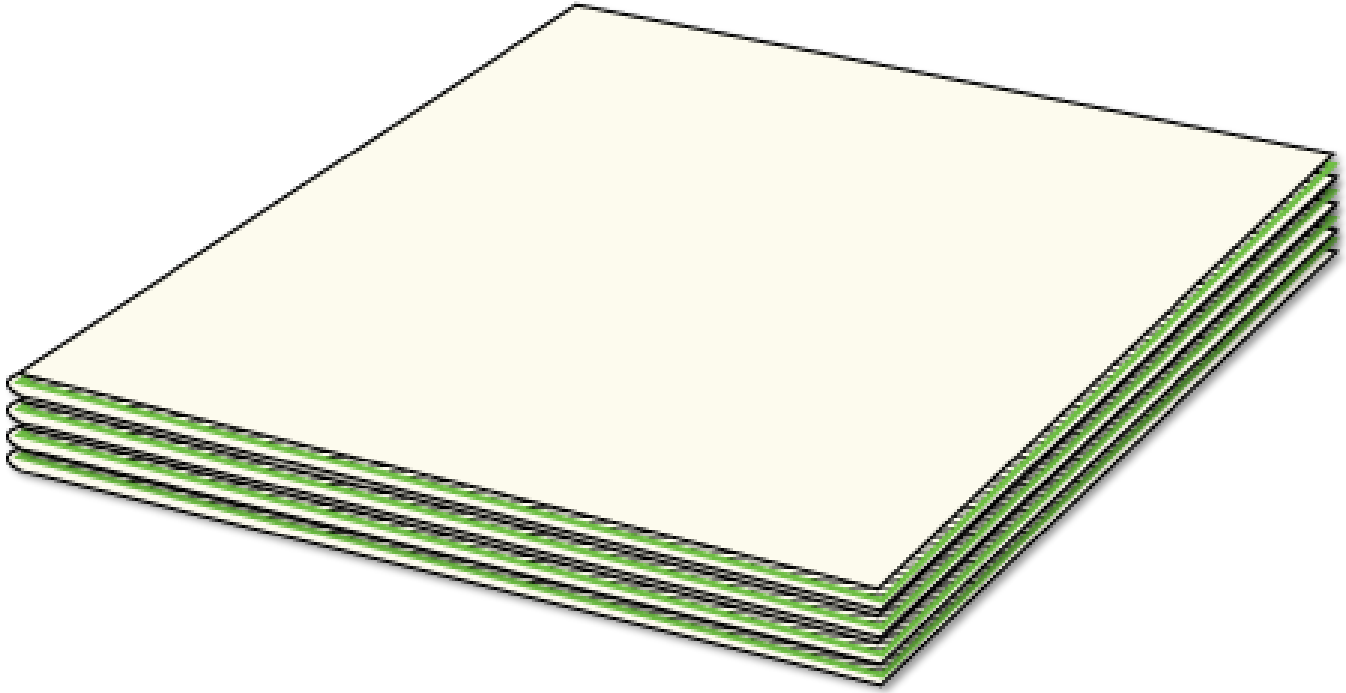
Spiral Membranes



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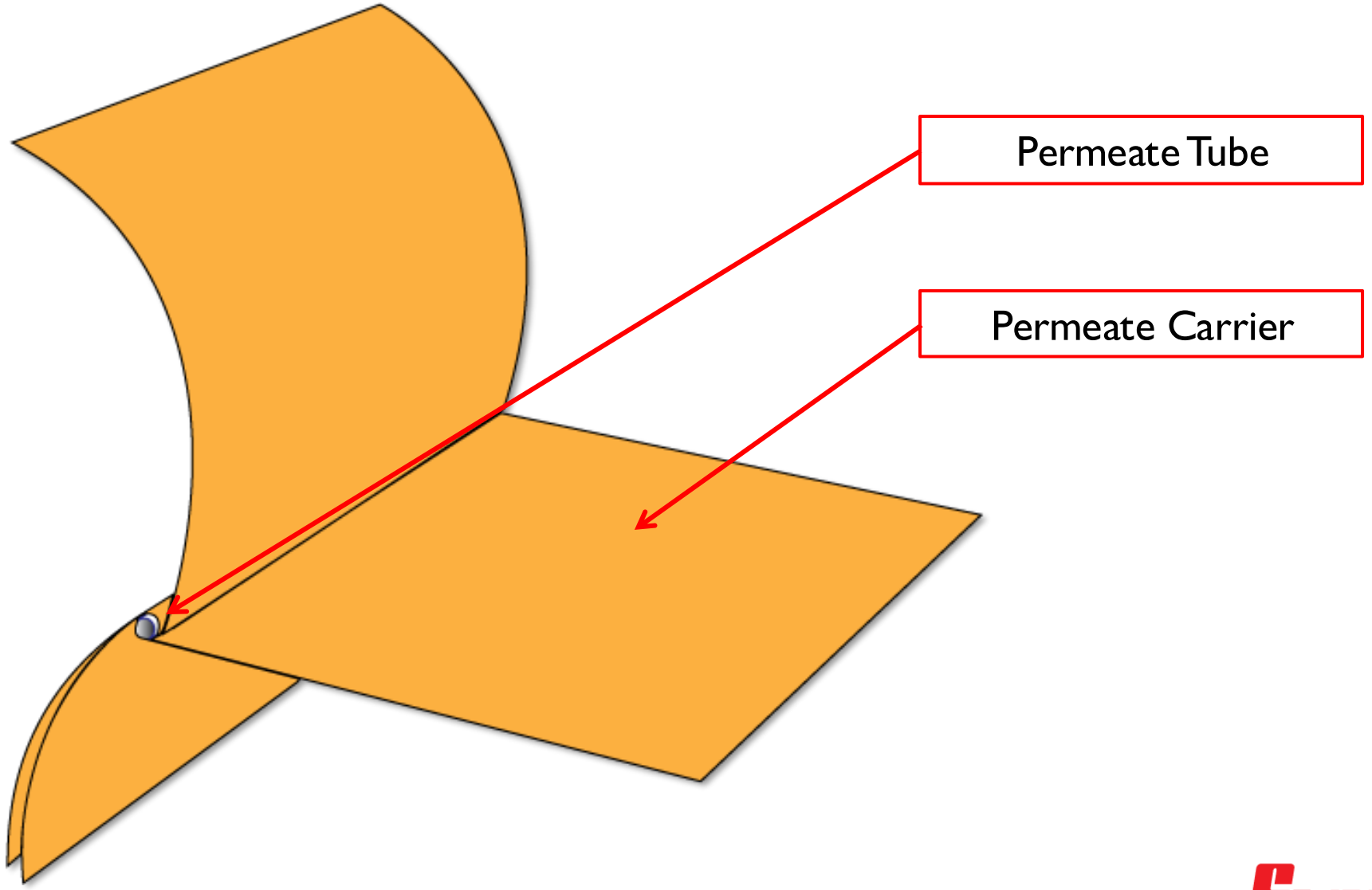
Spiral Membranes



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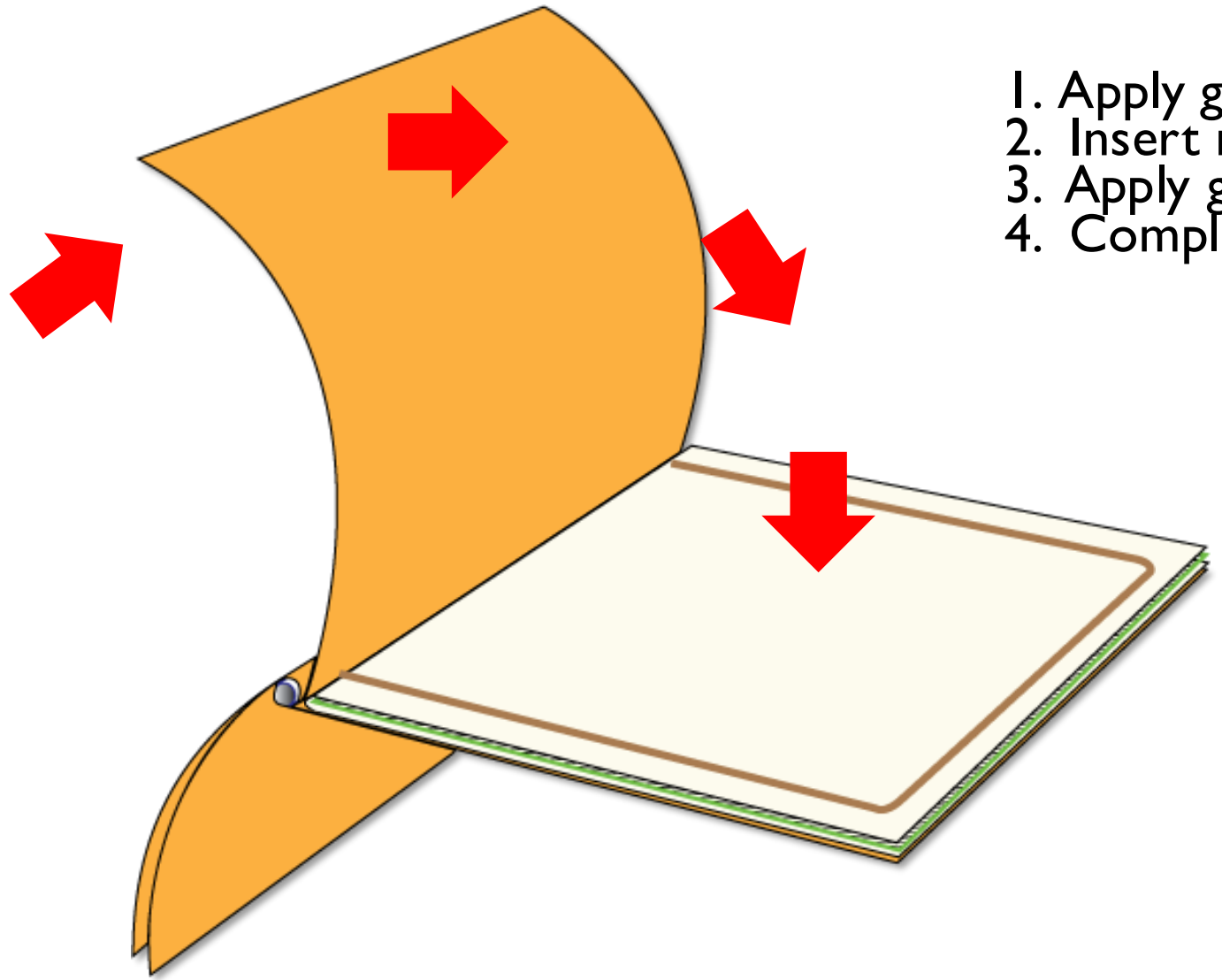
Spiral Membranes



1. Apply glue line
2. Insert membrane "leaf"
3. Apply glue line
4. Complete

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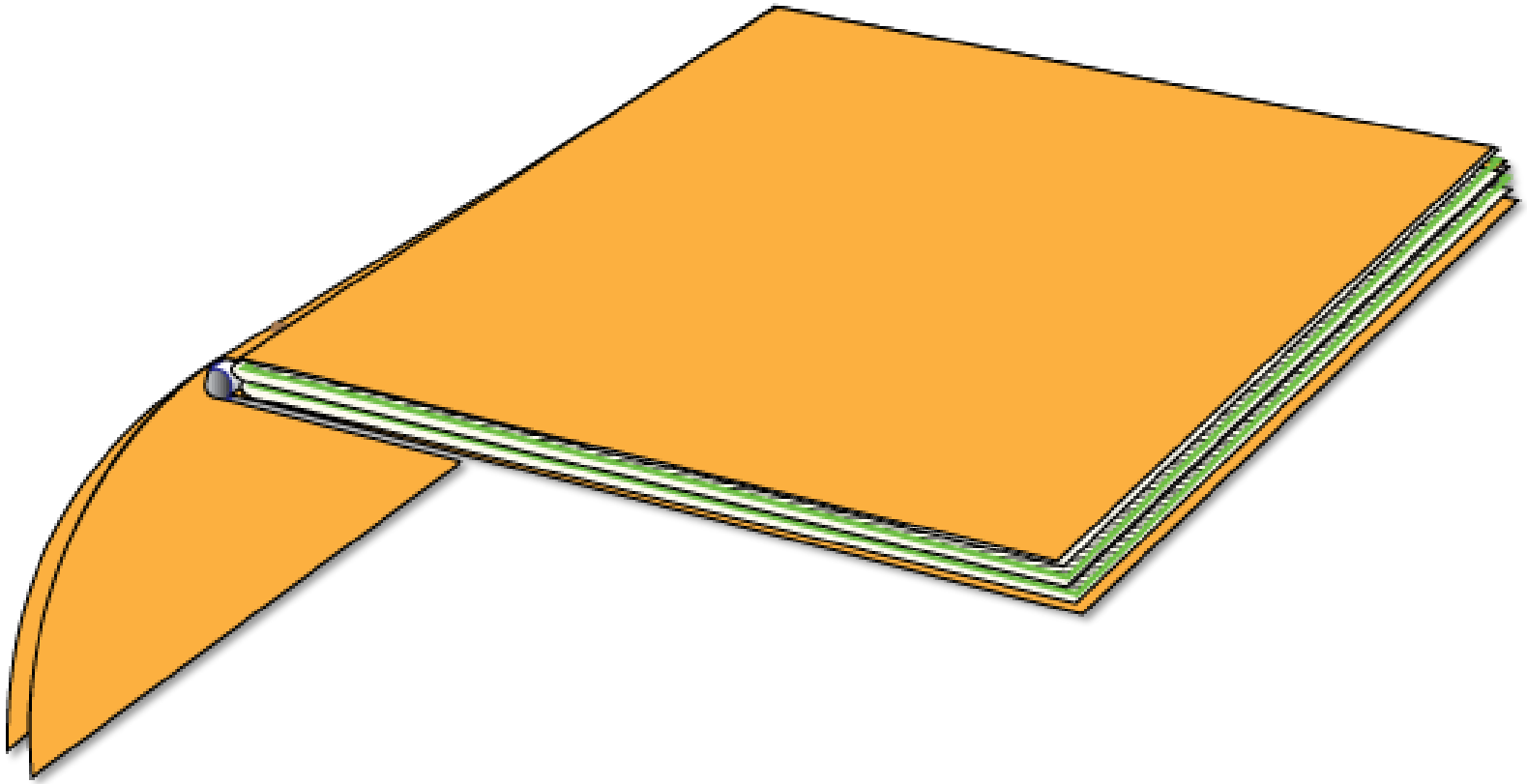
Spiral Membranes



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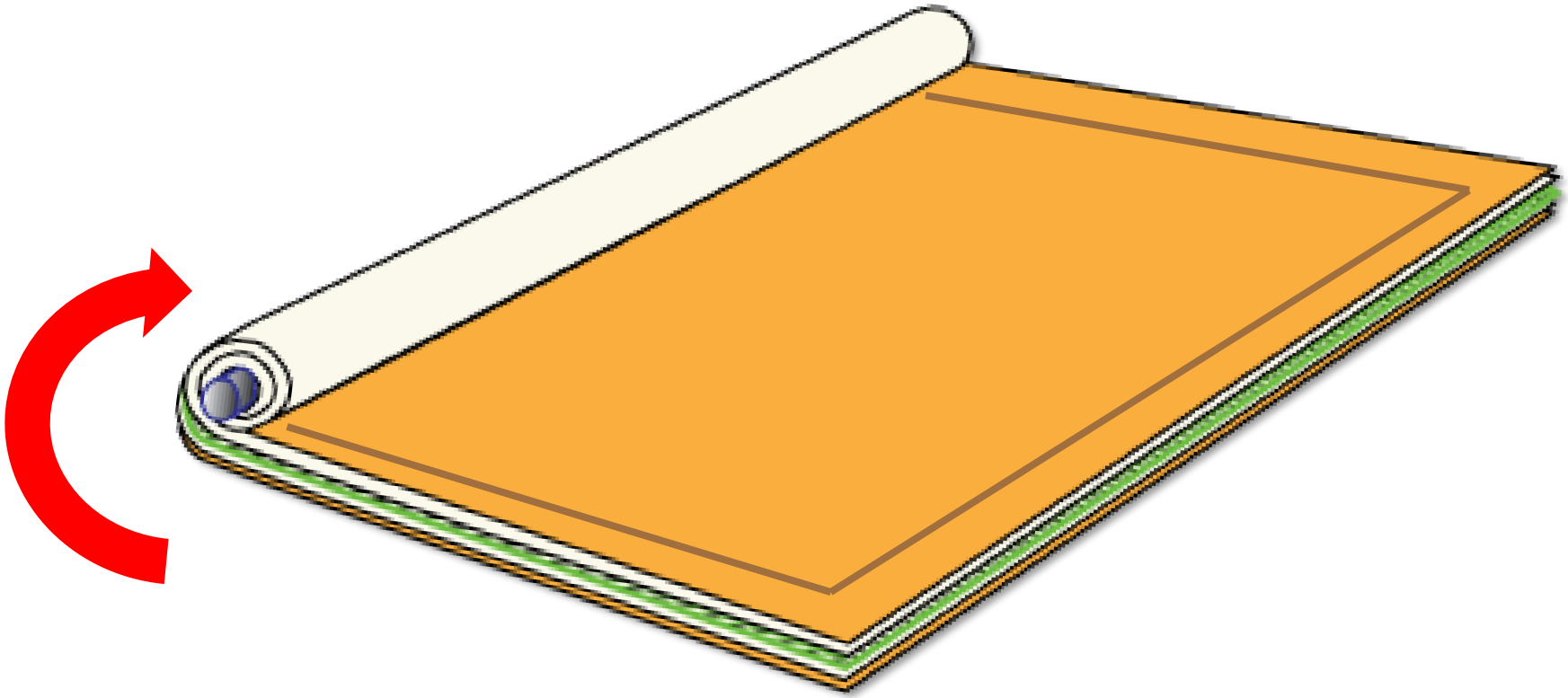
Spiral Membranes



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Module Types

Dead end filtration

Flow is perpendicular to the membrane surface

Particles larger build up as a cake layer on the membrane surface

Cross flow filtration

- Flow is parallel the membrane surface

- Shearing effect on the surface of the membrane

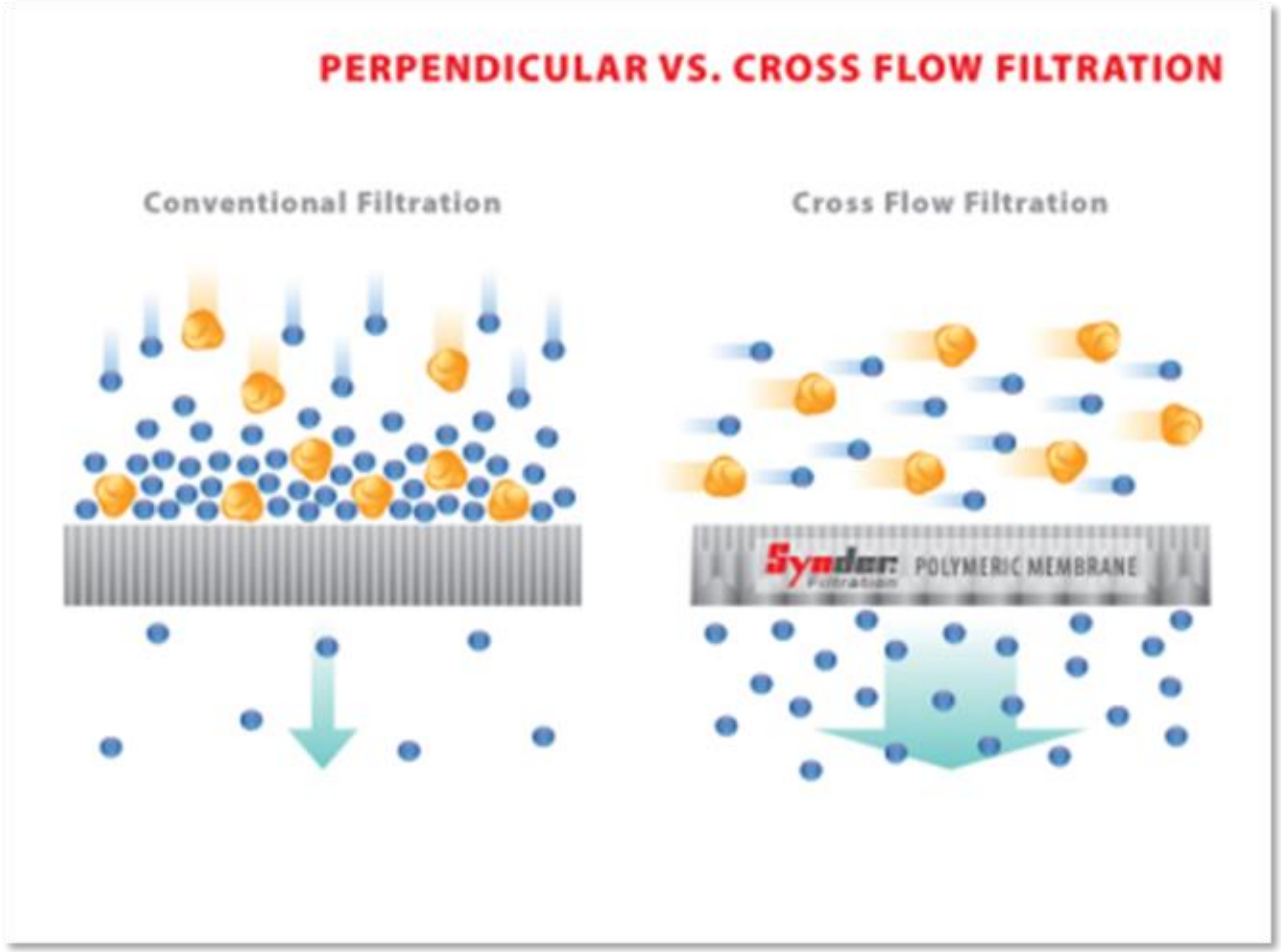
reduced fouling

Advantages of cross flow filtration

Reduced fouling on membrane surface

- Increased operating time between CIPs

- Increased element lifespan



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Dairy Applications

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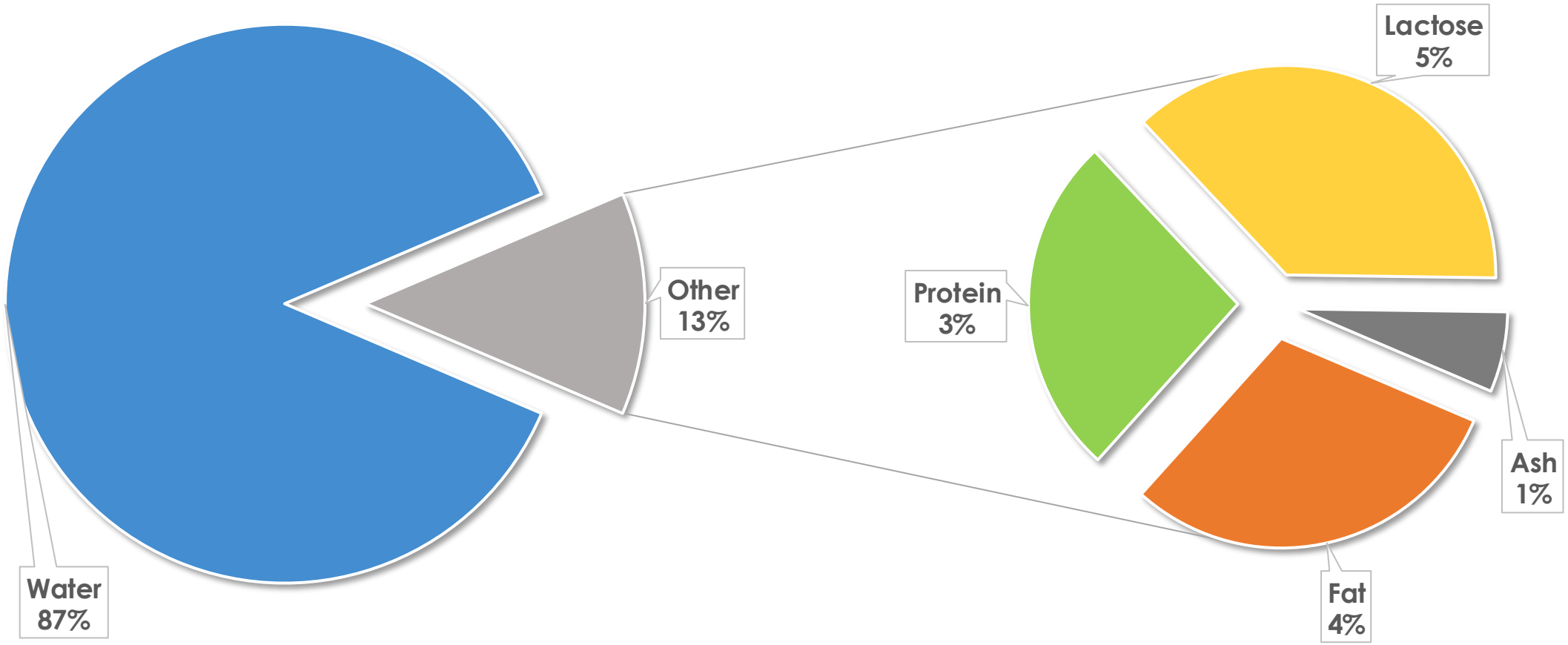
Milk Composition



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Membranes in Dairy

- Used for a variety of different processes and ingredients
- RO, NF, UF, and MF membranes all used to some degree
- Reduces processing cost and increases yield for value added products

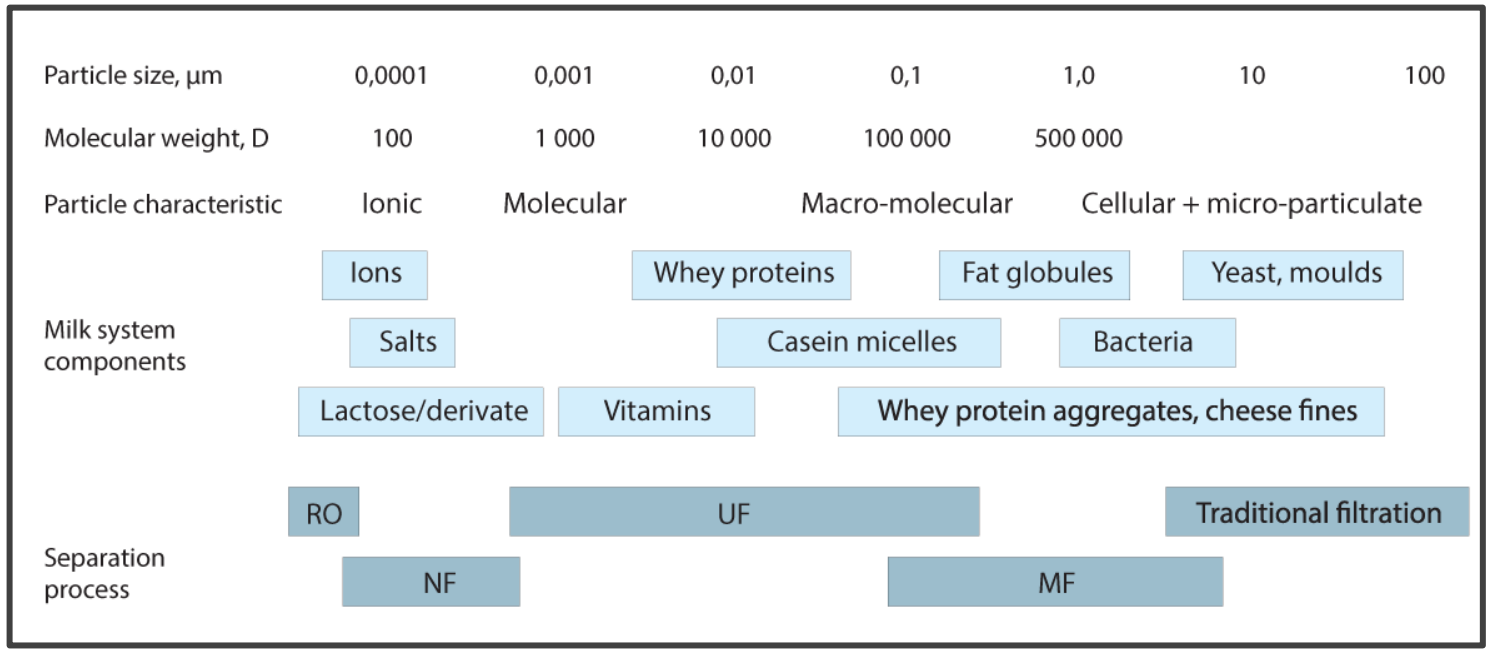

Fig 6.4.1 Spectrum of application of membrane separation processes in the dairy industry. From *Tetra-pak Dairy Processing Handbook*

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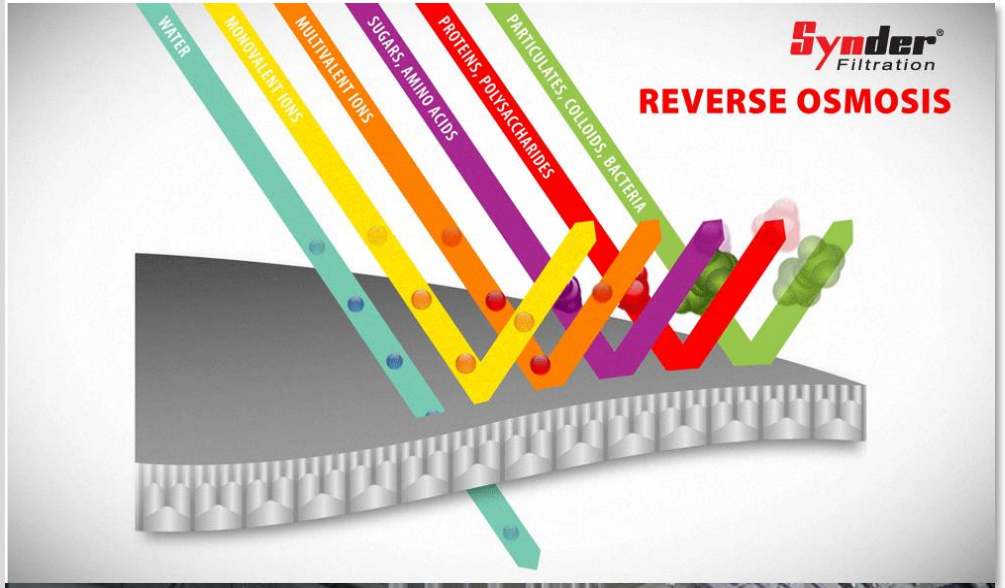
Dairy Applications

- Typical Operating Pressures: 200-500 PSI
- High pressure process for concentration/water recovery

Common Uses in Dairy:

- Concentration
  - WPC/WPI
  - MPC
  - Milk powders
- Permeate Polishing
- Volume Reduction
- Product Recovery After CIP
- Wastewater Treatment



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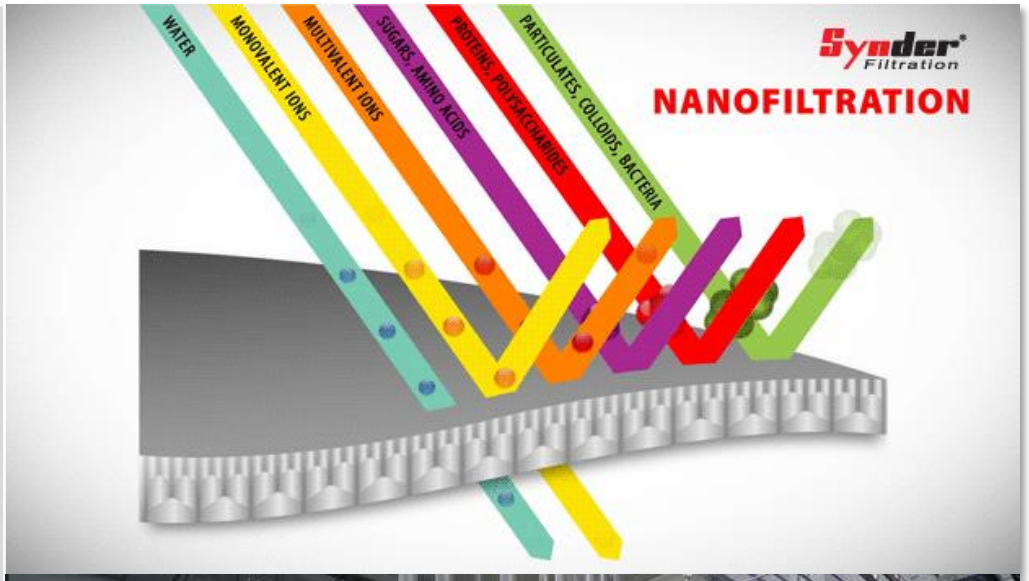
Dairy Applications

- Typical Operating Pressures: 150-300 PSI
- High pressure process for salt/mineral removal
- Usually for high solids end of the process when concentrating

Common Uses in Dairy:

- Demineralization
  - Skim Milk
  - Sweet Whey
  - Acid Whey
- Concentration
  - WPC/WPI
- Desalination
  - UF Permeate



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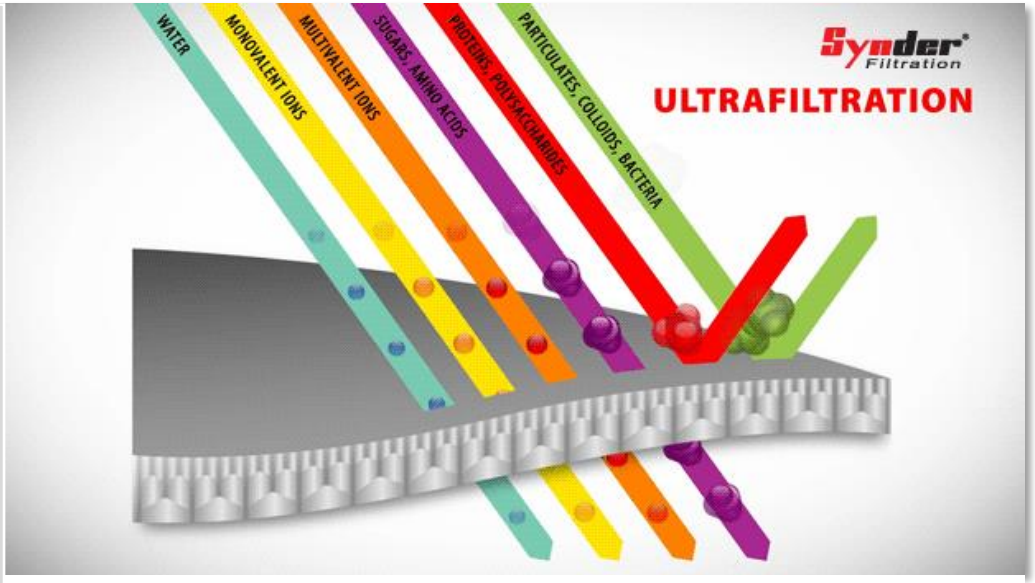
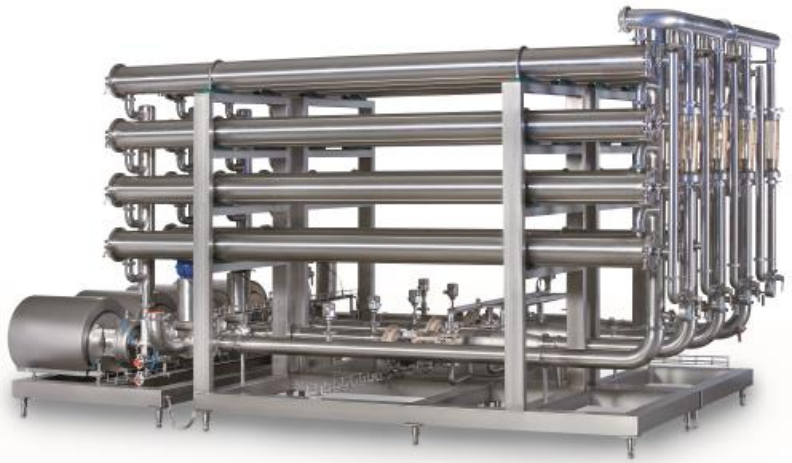
Dairy Applications

- Typical Operating Pressures: 20-70 PSI
- Simple and robust process for removing lactose, minerals, and salts
- Water is commonly introduced here (Diafiltration)

Common Uses in Dairy:

- Concentration/Isolation of Protein
  - WPC/WPI
  - MPC
- Lactose Free/Reduced Milk
- Milk Standardization for cheese make
- Cheese Brine Clarification





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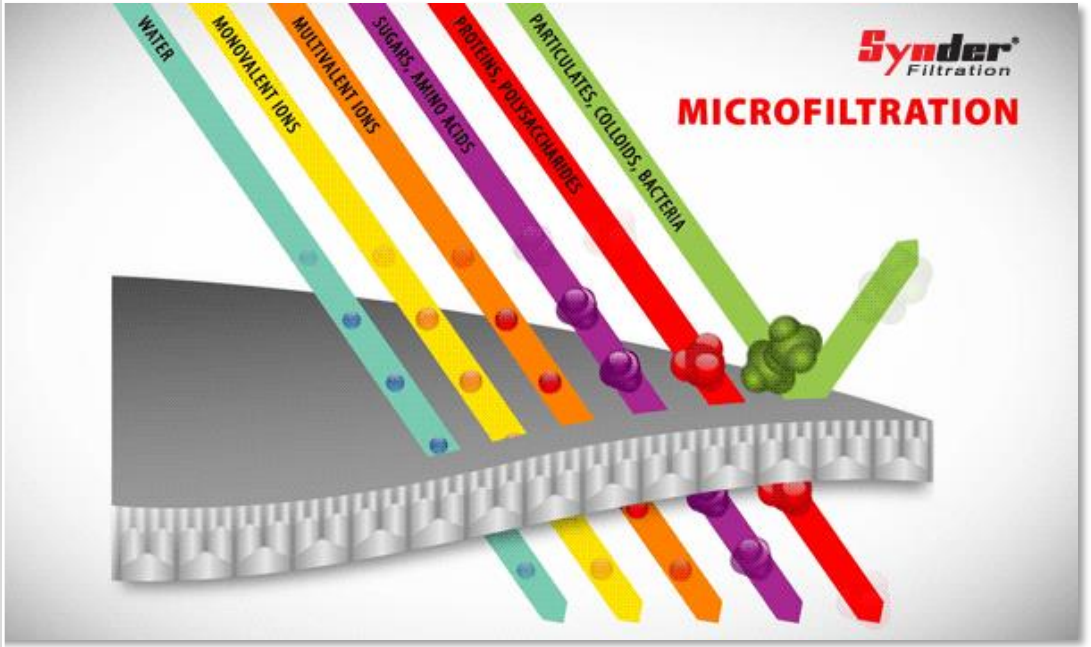
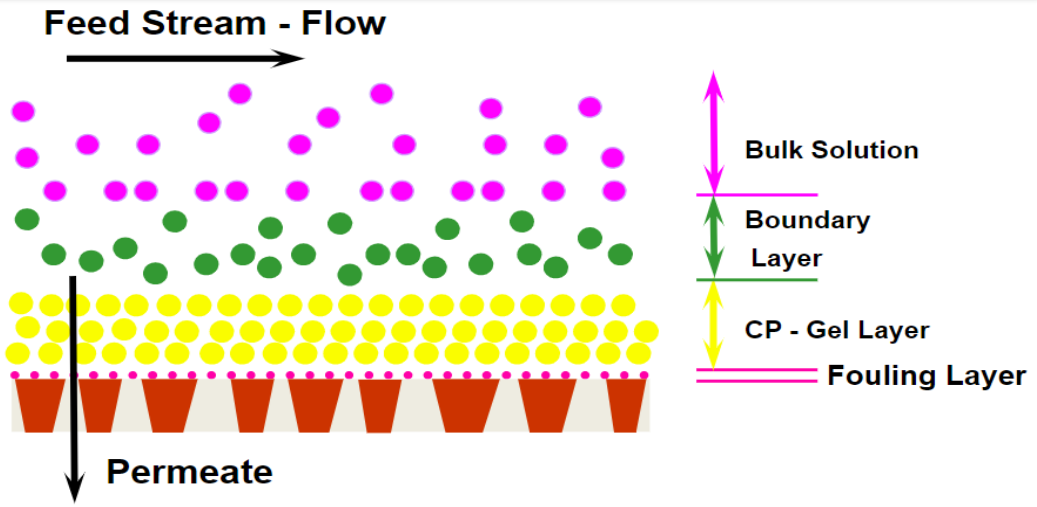
Dairy Applications

- Typical Operating Pressures: 10-15 PSI
- Very pressure and flow Sensitive
- Relies on additional resistance from protein/fat gel layer to perform
- Requires careful operation to perform its separation effectively
- Usually highly automated

Common Uses in Dairy:

- Fractionation of Casein and Whey
- Removal of Fats
  - WPI
- Cheese Milk Standardization
- Cheese Brine Clarification
- Cold Sterilization of Milk





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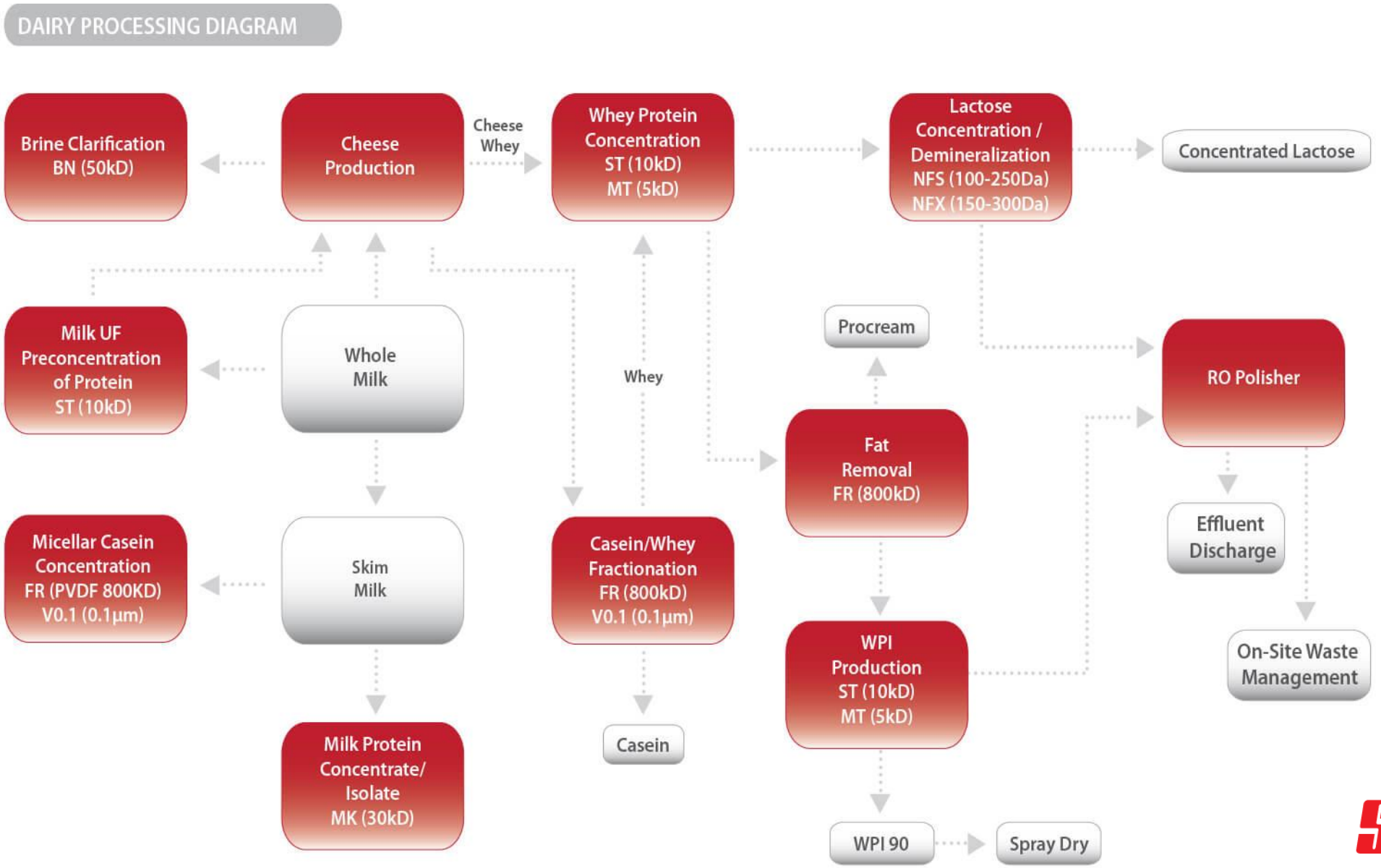
Dairy Processing



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Membranes in Dairy

- Fat/Bacteria/Particulate Removal → **FR** (800kDa); **V0.1** (0.1µm); **V0.2** (0.2µm)
- Casein/Whey Fractionation → **FR** (800kDa); **V0.1** (0.1µm)
- Milk Standardization for Cheesemaking → **FR** (800kDa)

MF

- Cheese Brine Clarification → **BN** (50kDa)
- Milk Protein Concentrate/Isolate → **MK** (30kDa)
- WPC Low Protein Content → **ST** (10kDa); **MT** (5kDa)

UF

- WPC High/ WPI Production → **NFX** (150-300Da)
- Milk Concentration → **NFX** (150-300Da)
- Lactose Concentration/Demineralization → **NFS** (100-250Da); **NFX**(150-300Da)

NF

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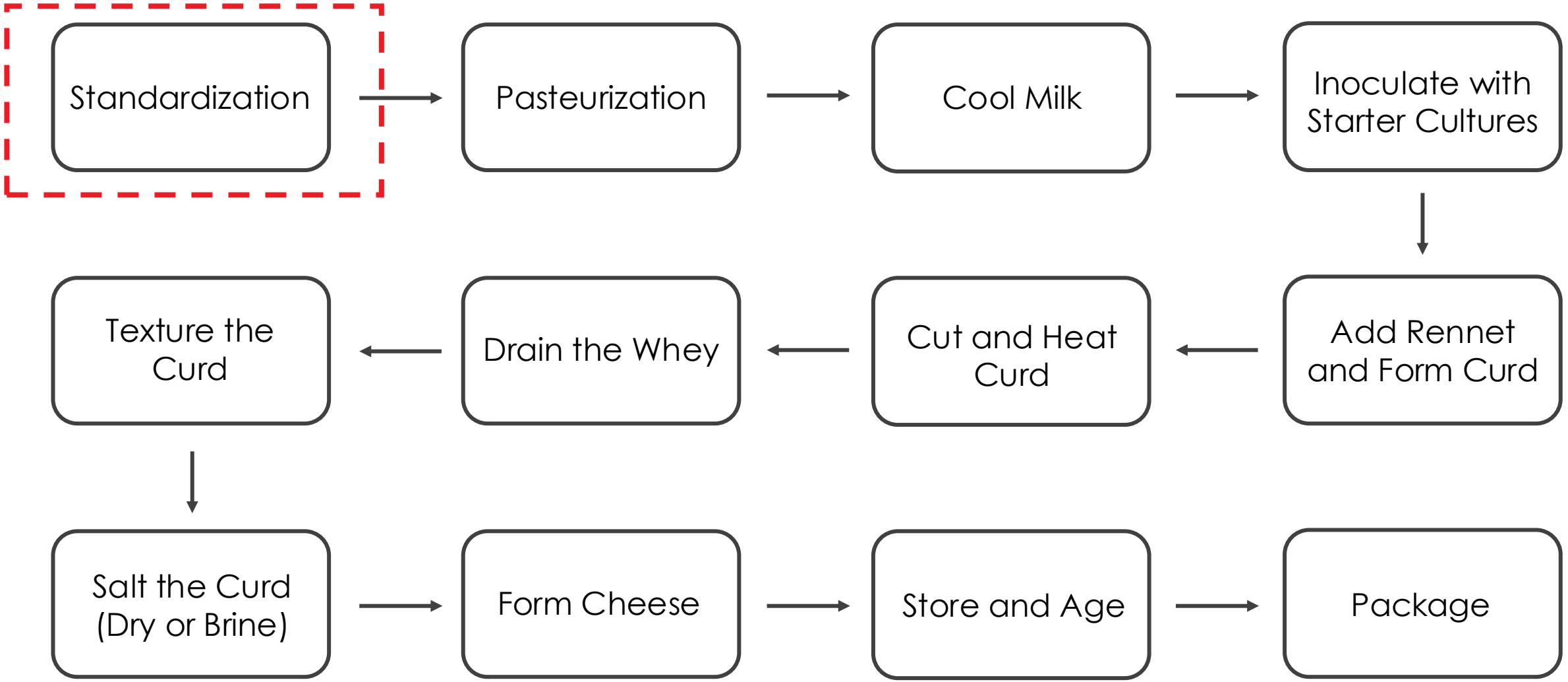
Cheesemaking Overview



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What is Milk Standardization?

- Milk composition is moderated to control relative percentages of **fat** and **protein**
- Most important step in ensuring **consistency** and **quality** of cheese
- Used to maximize **efficiency** and **yield** of process cheese

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What is Milk Standardization?

Milk Standardization is the practice of adjusting the Protein to Fat Ratio (PF) of cheese milk
Usually by either adding protein or reducing fat

Nonfat Dry Milk (NFDM) is added to increase protein content relative to fat

Cream is separated and then added back into Skim at a known concentration

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What is Milk Standardization?

Another metric in standardization is the Casein Number (CN); this compares the concentration of the two different proteins in milk: Casein and Whey Protein

- Makes up ~80% of protein in milk by weight
- Class of proteins which self-associate to form large, insoluble micelles
- Closely associated with sensory properties of milk

- Make up ~20% of protein in milk by weight
- Also called milk-serum protein
- Small, water soluble
- Byproduct of Cheesemaking
- High Nutritional Value

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What is Milk Standardization?

A third metric to consider is Fat in Dry Matter (FDM):
Ratio of **Cheese Fat %W_{DB}** to **%Ratio of Cheese Fat to Total Solids**

$$\frac{Weight\ of\ Water}{Weight\ of\ Cheese\ Fat} * 100$$

$$\frac{Weight\ of\ Cheese\ Fat}{Weight\ of Total\ Solids} * 100$$

PF, **CN**, and **FDM** are the three main metrics by which standardization approach is determined.

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Different Approaches

Change Protein Concentration → Add NFDM

Add Skim Milk

Change Fat Concentration → Add Cream

Remove Cream

Microfiltration
FR (PVDF 800kDa) → Concentrate Casein & Remove Whey, Lactose, Minerals, Etc.

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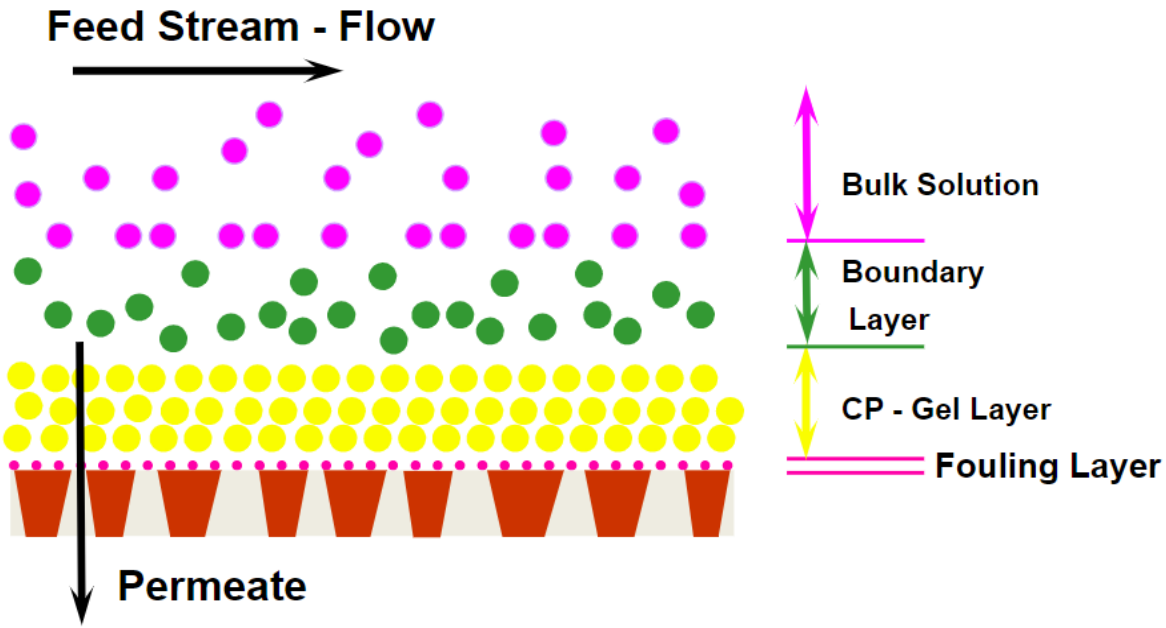
Microfiltration

- Typically Operates Between 10-15 PSI
- Very Pressure and Flow Sensitive
- Relies on Gel Layer Formation from Protein/Fat to Perform Optimally
- Usually Highly Automated



Common Uses in Dairy:

- **Fractionation of Casein and Whey**
- **Removal of Fats**
- **Cold Sterilization**
- **Cheese Brine Clarification**
- **Cheese Milk Standardization**

FR (800kDa); **V0.1** (0.1µm); **V0.2** (0.2µm)

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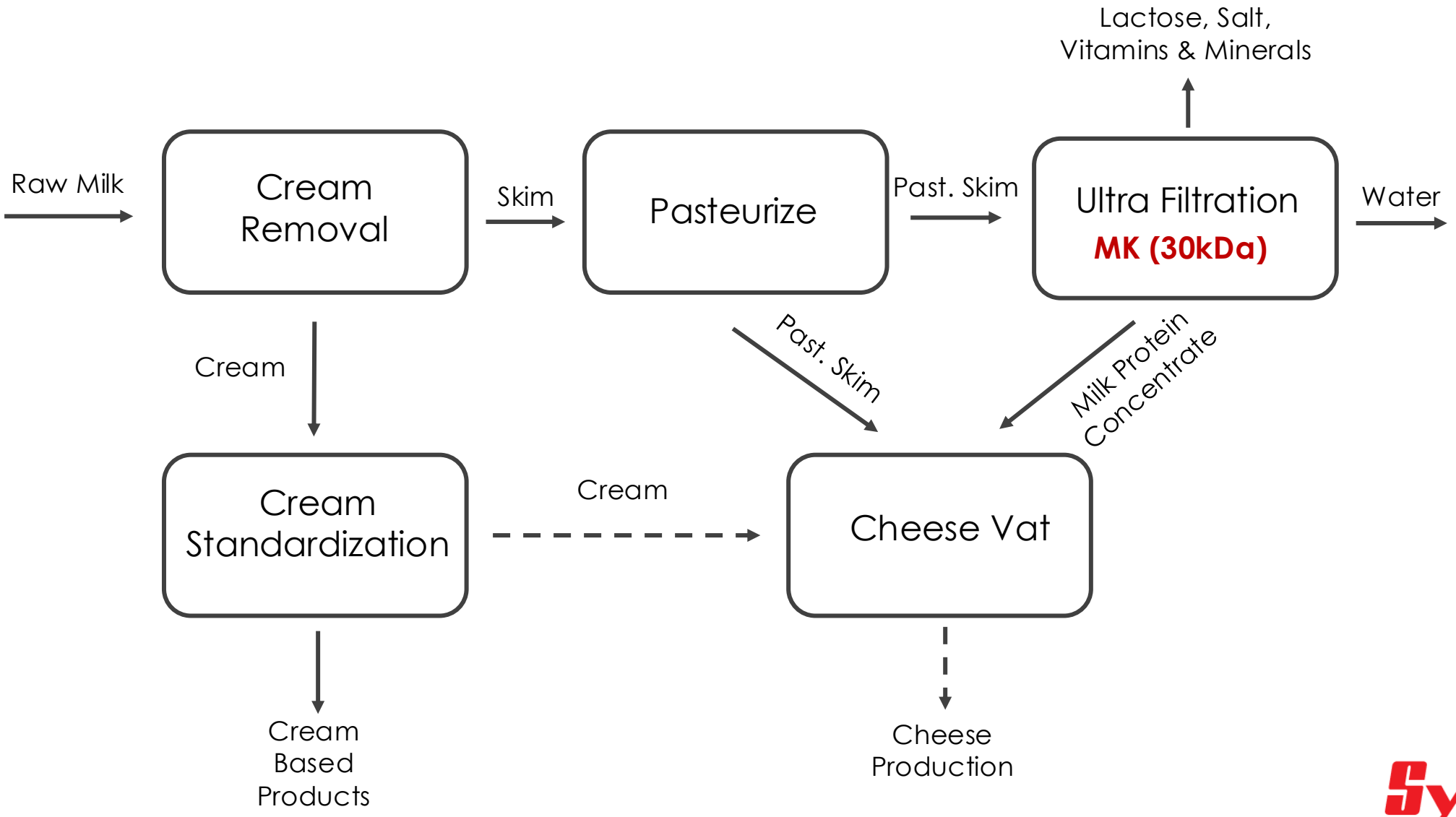
UF Standardization PFD



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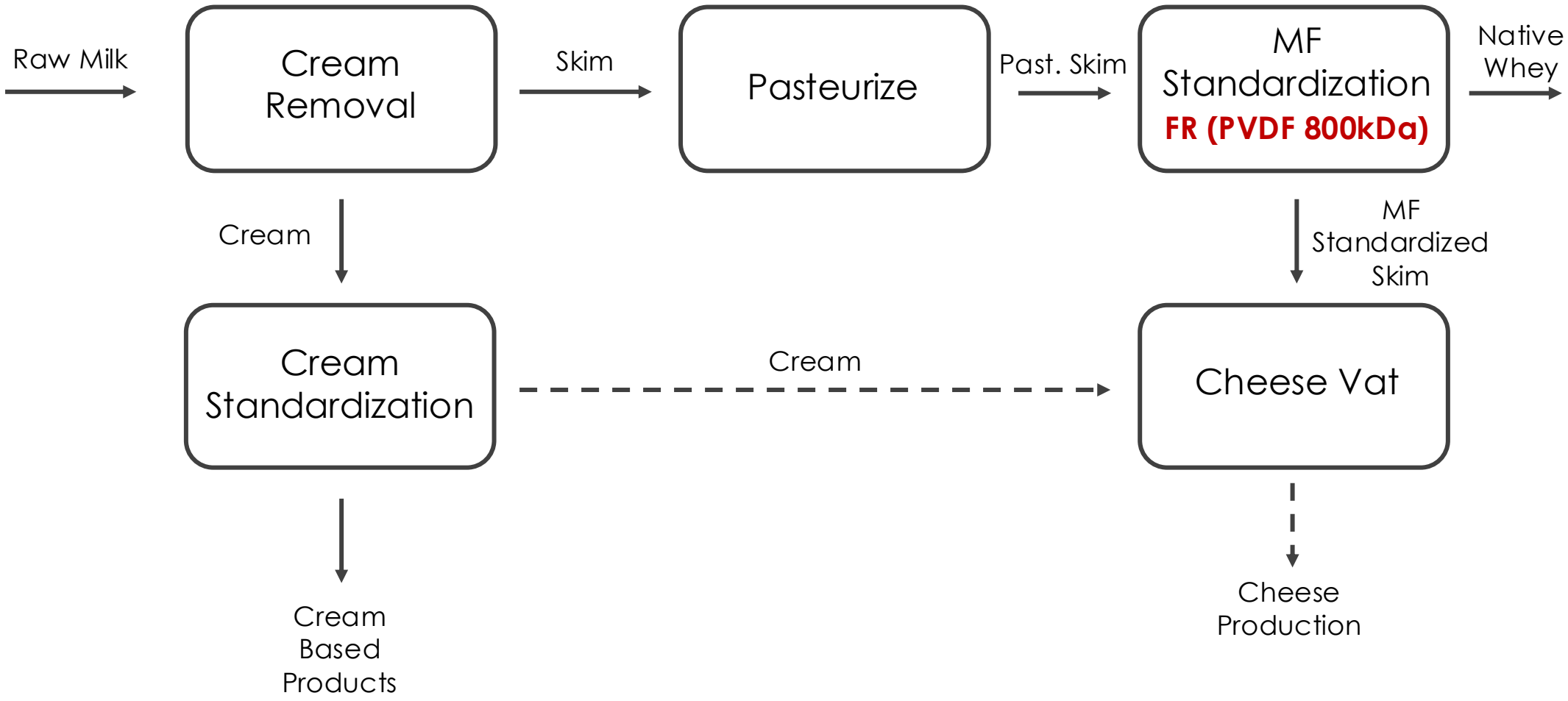
MF Standardization PFD



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Benefits of Microfiltration in Standardization

Consistency

Precisely control casein levels as cheese milk enters production

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Benefits of Microfiltration in Standardization

Quality

Reduce off flavors and bitter notes introduced by whey trapped in curd

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Benefits of Microfiltration in Standardization

Yield

Limit the necessary processing volume by increasing casein concentration before entering vat

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Benefits of Microfiltration in Standardization

Sustainability

Limits the number of steps needed to standardize milk, limiting errors and inconsistencies

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Why the Difference?

Per FDA & CFSAN August 2017

Ultrafiltered Milk in the Production of Standardized Cheese and Related Cheese Products: Guidance for Industry

Our regulations specify the standards of identity for cheeses and related cheese products in part 133 (21 CFR part 133). The general provisions within part 133, in part, define "milk" and "nonfat milk" that may be used in the manufacture of cheeses and related cheese products. The definitions for "milk" and "nonfat milk" in § 133.3(a) and (b), respectively, list different forms of milk and nonfat milk, including concentrated, reconstituted, and dried forms, that may be used in the making of cheeses and related cheese products. Fluid or dried filtered forms of milk obtained through mechanical filtration of milk or nonfat milk are not included within these definitions. Therefore, while current regulations permit the use of concentrated, reconstituted, and dried forms of milk and nonfat milk as basic dairy ingredients (i.e., the only difference in these ingredients is the amount of water), they do not provide for the use of fluid or dried filtered milk or fluid or dried filtered nonfat milk as basic dairy ingredients in standardized cheeses and related cheese products.

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What About UF Milk in Cheese?

Per FDA & CFSAN August 2017

Ultrafiltered Milk in the Production of Standardized Cheese and Related Cheese Products: Guidance for Industry

Mechanical filtration technologies available for milk processing include ultrafiltration. For purposes of this guidance, we consider filtration to be a process whereby milk is passed over a series of semipermeable membranes with varying pore sizes. The portion of milk that passes through the membranes is referred to as the "permeate," and the portion that does not pass through the membranes is referred to as the "retentate." Ultrafiltration retains macromolecules and particles larger than about 0.001–0.02 micrometers. In dairy processing, ultrafiltration is typically used to retain all protein components of milk, including casein and whey proteins, while some of the lactose, minerals, and water soluble vitamins present in milk are lost along with water.

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So What?

FDA U.S. FOOD & DRUG ADMINISTRATION

CENTER FOR FOOD SAFETY AND APPLIED NUTRITION

CODE OF FEDERAL REGULATIONS

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Summary

- Membrane Construction Basics
- Principles of filtration
- Standardization aims to control the fat and protein concentration in milk
- Microfiltration is growing in popularity
- Microfiltration for Standardization is allowed in EU and elsewhere, not yet in US

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Filtration
Membranes That Perform.
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Thank You!