

Cheese Aging Chemistry

Flavor and Texture Changes Over Time

Queso Diego - April 21st, 2020

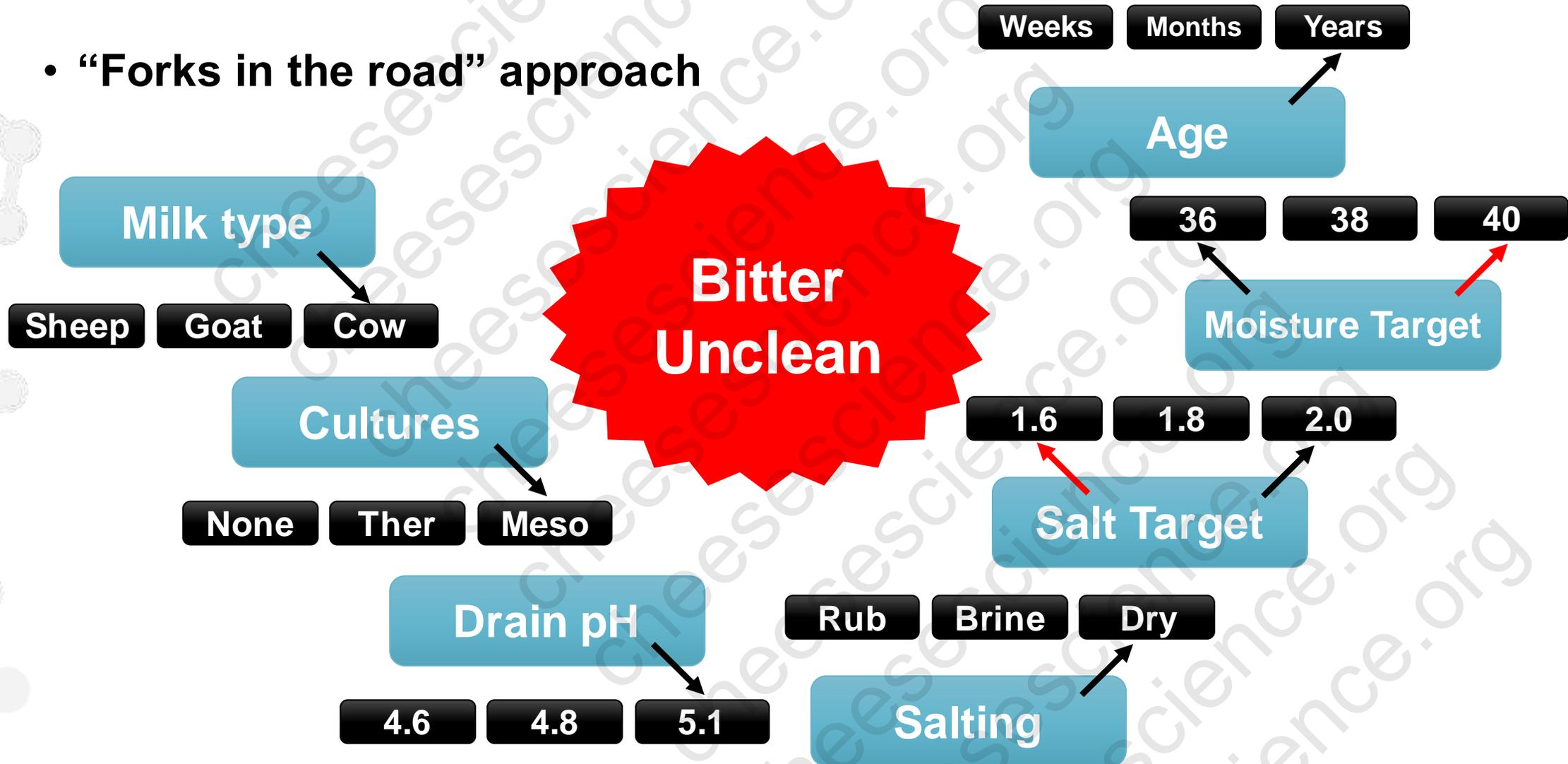
Basic Steps of Cheesemaking



**or some other treatment*

Manufacturing Technology

- “Forks in the road” approach



The Life of a Cheese

Different chemistry depending on age



Infancy

Day 0



Adolescence

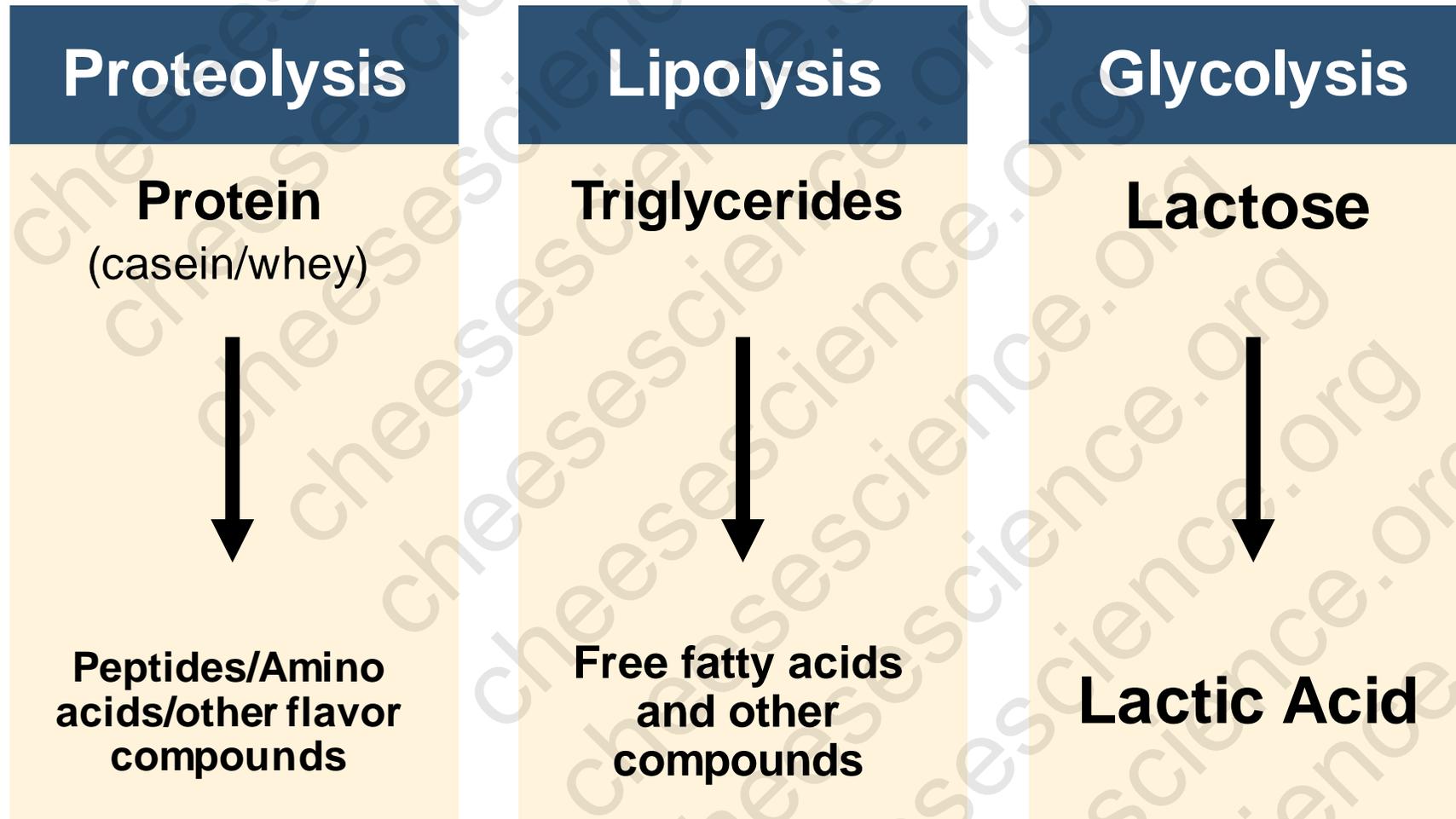
Day 1-7



Maturity

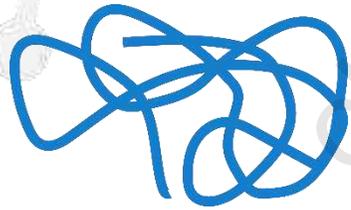
Weeks - ∞

Reactions in Cheese



Flavor Creation in Cheese

Proteolytic Flavors



Large intact protein

Too bulky to interact with taste/olfactory receptors

Protease

Peptide fragments

Small enough to interact

BITTER

Protease

Free amino acids & more flavor...

Lipolytic Flavors



No aroma

too bulky, not volatile enough

Lipase

bit.do/fattyacids

Glycerol

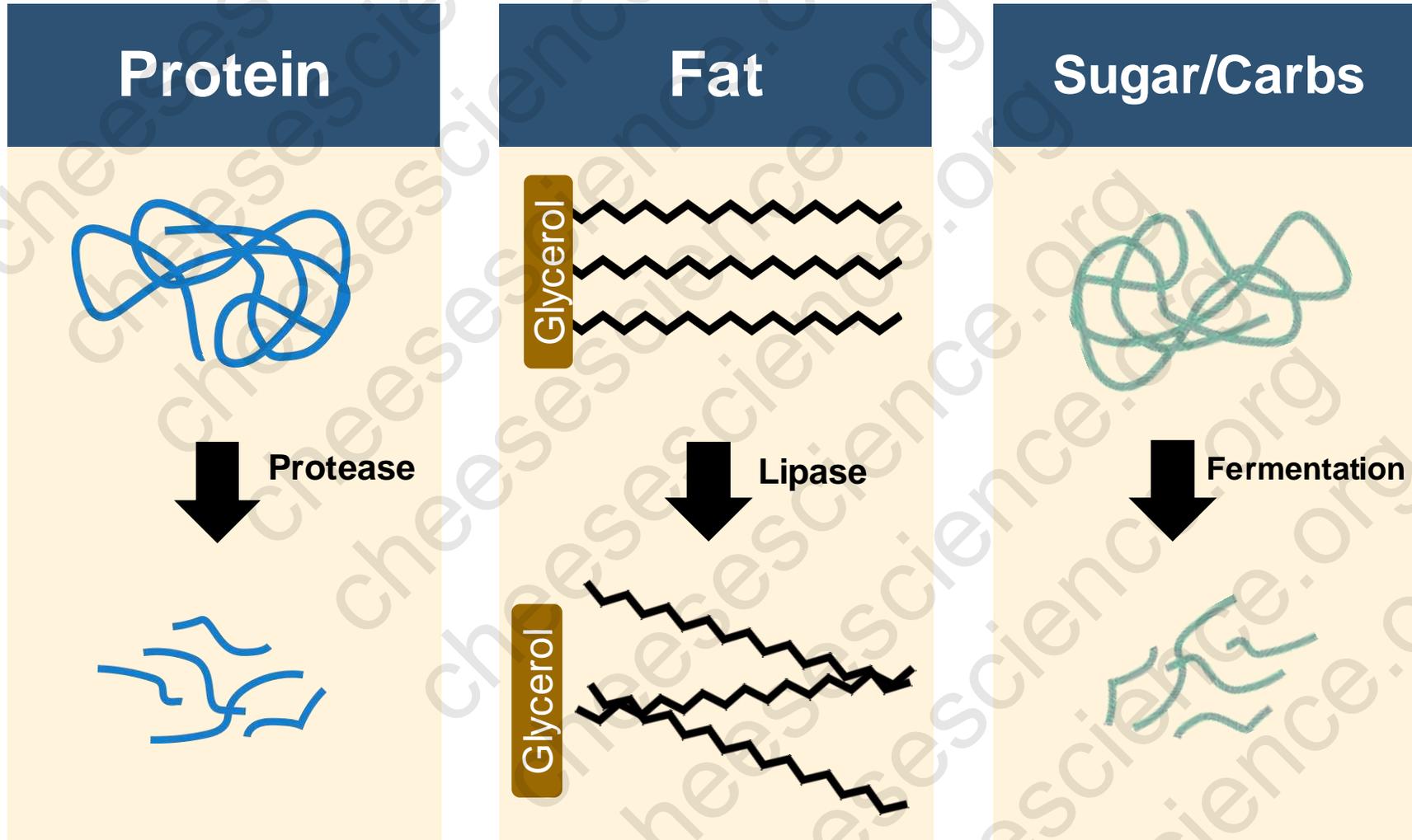


Aroma!

FFAs = volatile

Microbes (e.g. cultures) produce/contain enzymes are crucial to flavor development

Enzymes in Cheese

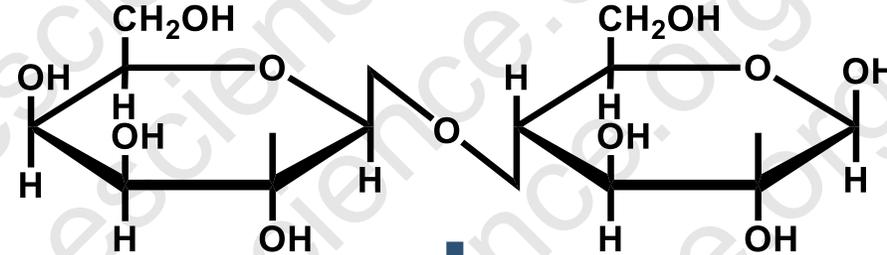


Glycolysis

Breakdown of Lactose

Acid Creation

Lactose

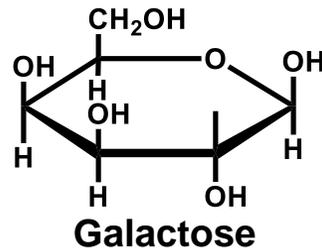


****Reminder!****

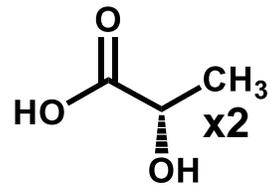
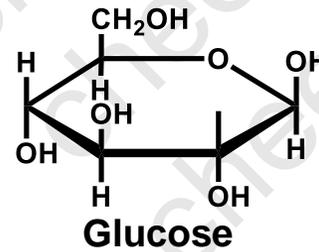
↑ Acid ~ ↓ pH

Cheesemaking

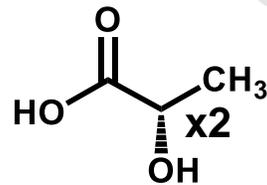
Mesophiles



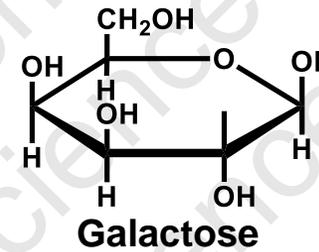
+



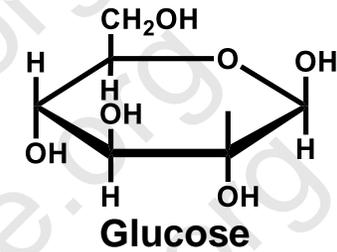
Lactic acid



Thermophiles

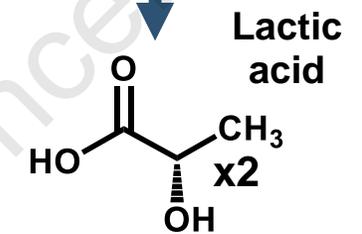


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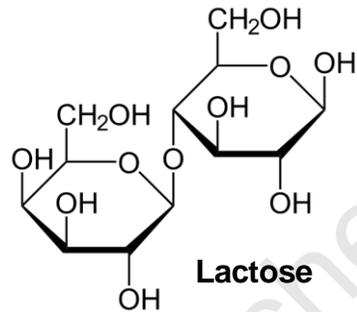


✗

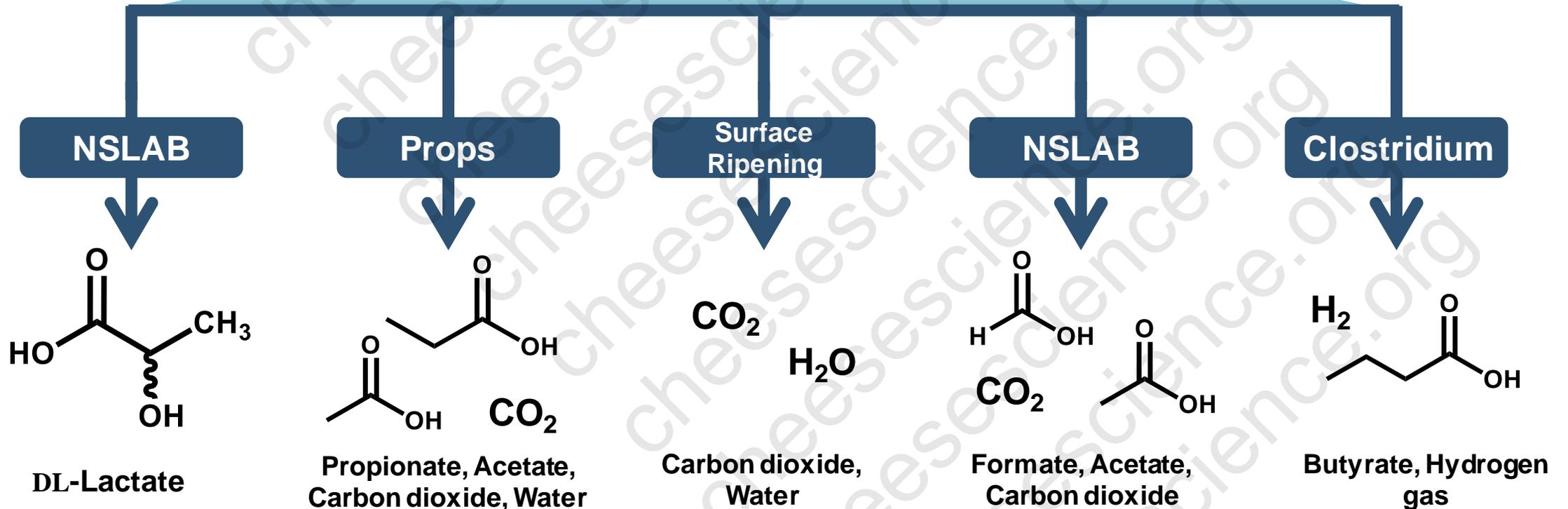
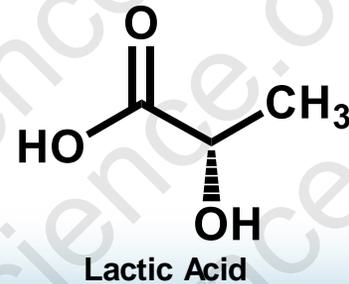
Not Used*



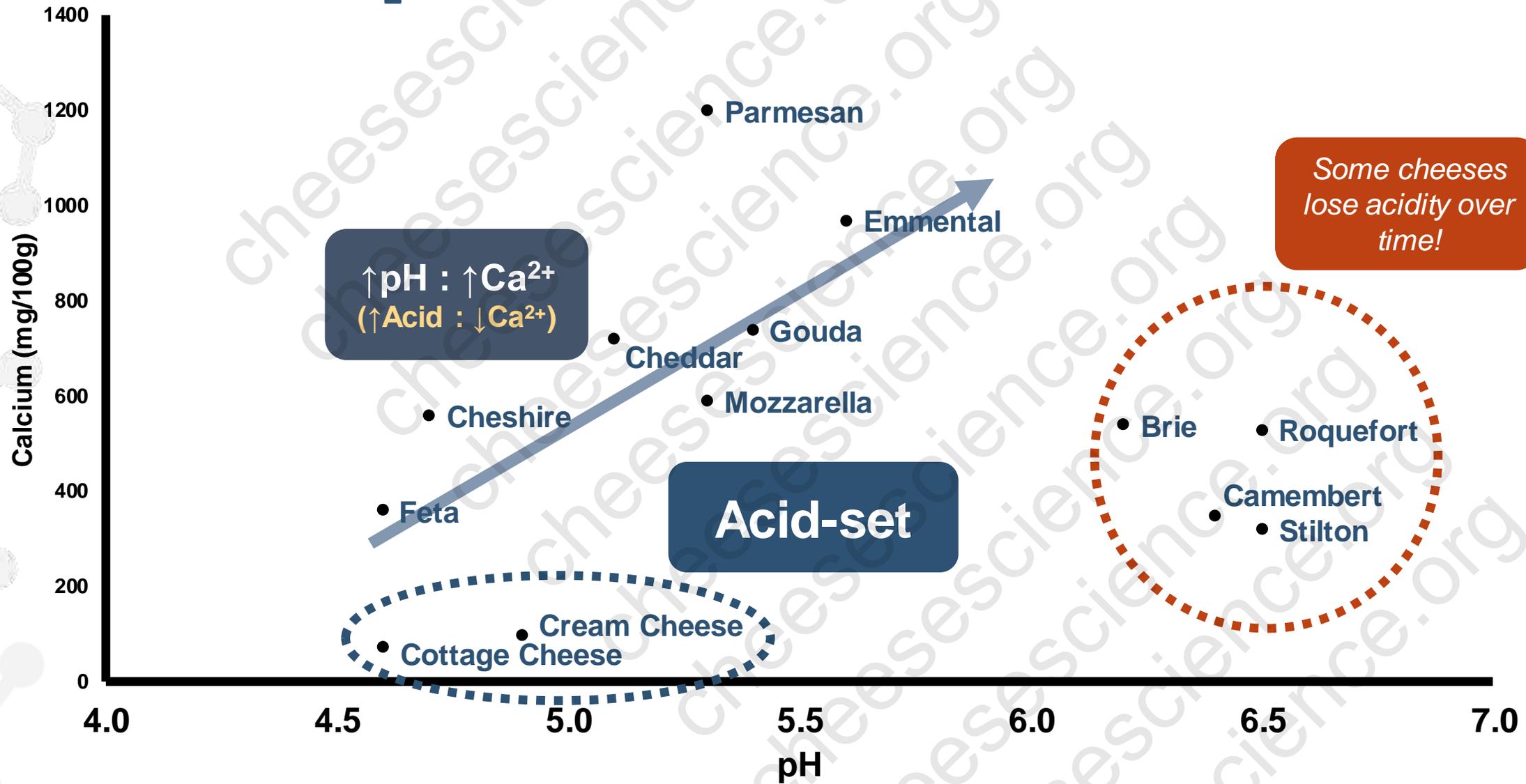
Lactic Acid Metabolization



Glycolysis
(fermentation)
via Starters

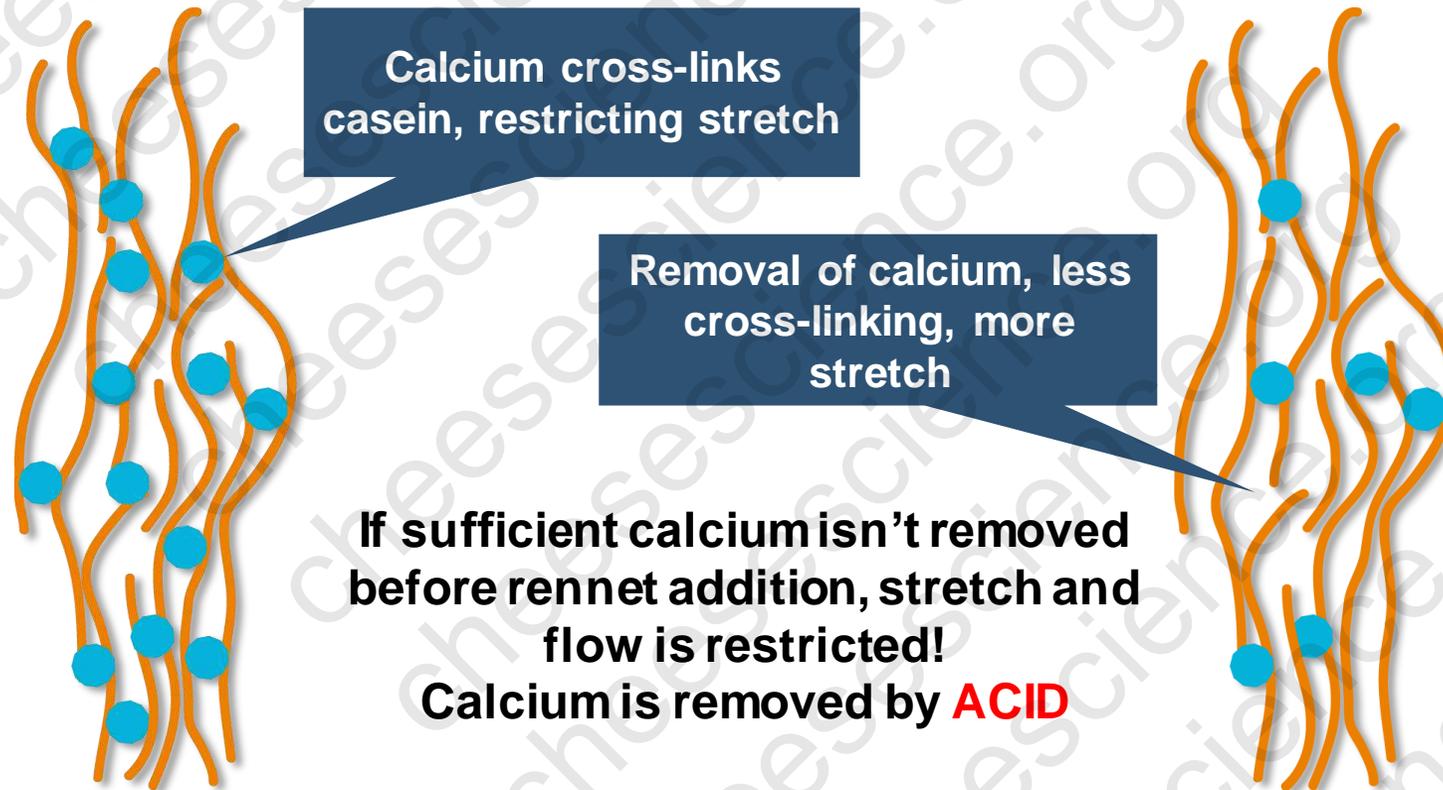


Cheese pH vs. Calcium



Calcium and Casein

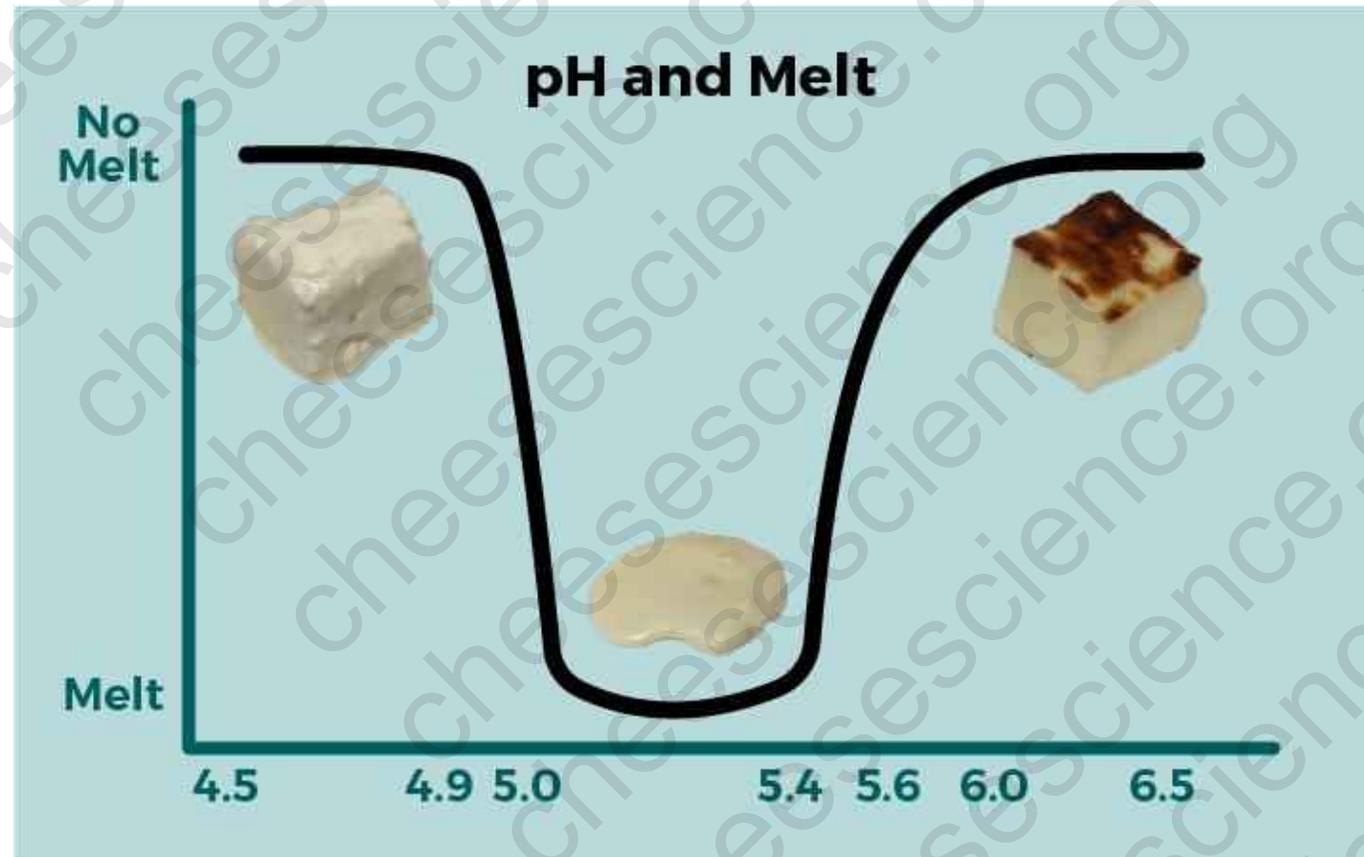
- Acid dissolves calcium from casein matrix



 = Calcium
 = Casein strand

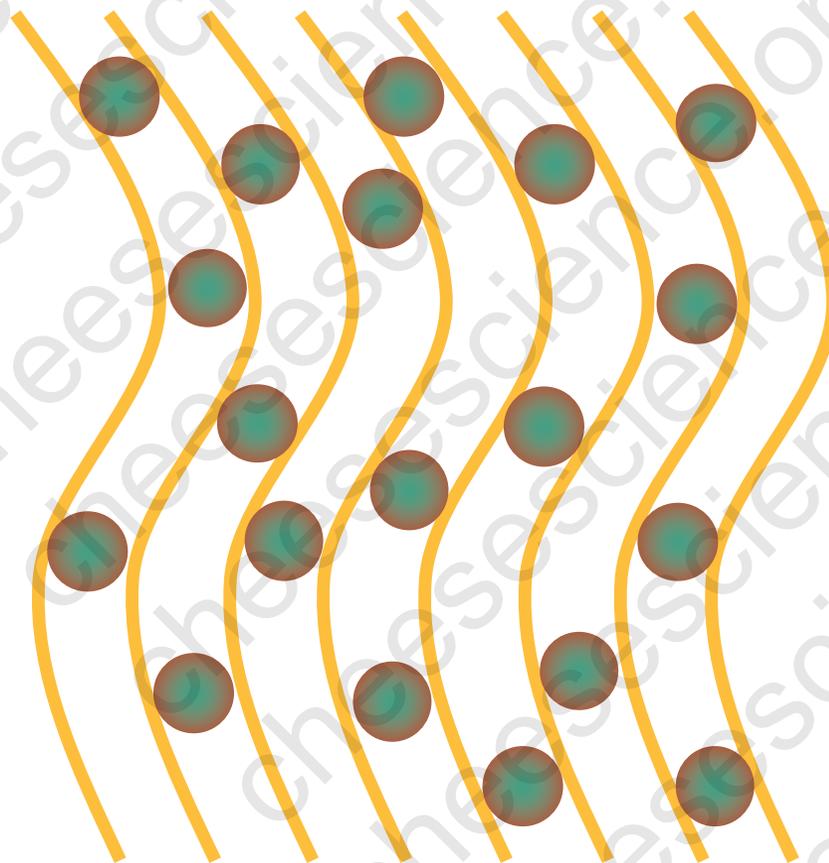
Acidity and Melt

- Acidity is the most crucial element that determines melting profile



pH and Melt

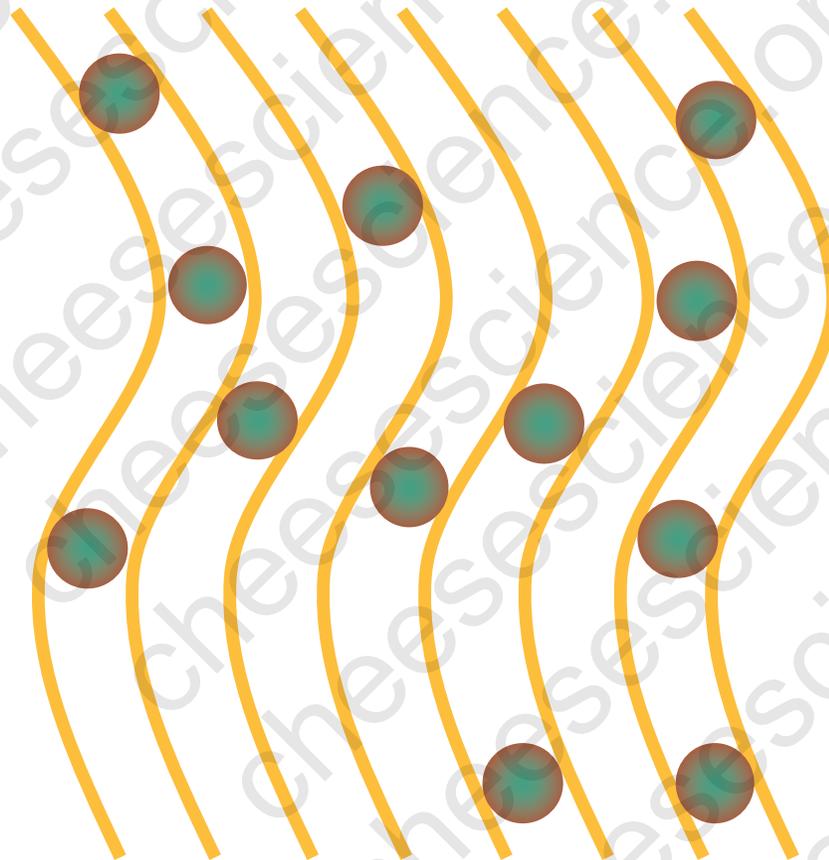
- Cheeses melt best at a moderate pH (~5.0 – 5.7)



High pH
lots of bound
calcium

pH and Melt

- Cheeses melt best at a moderate pH (~5.0 – 5.7)



Moderate pH
some bound calcium

pH and Melt

- Cheeses melt best at a moderate pH (~5.0 – 5.7)

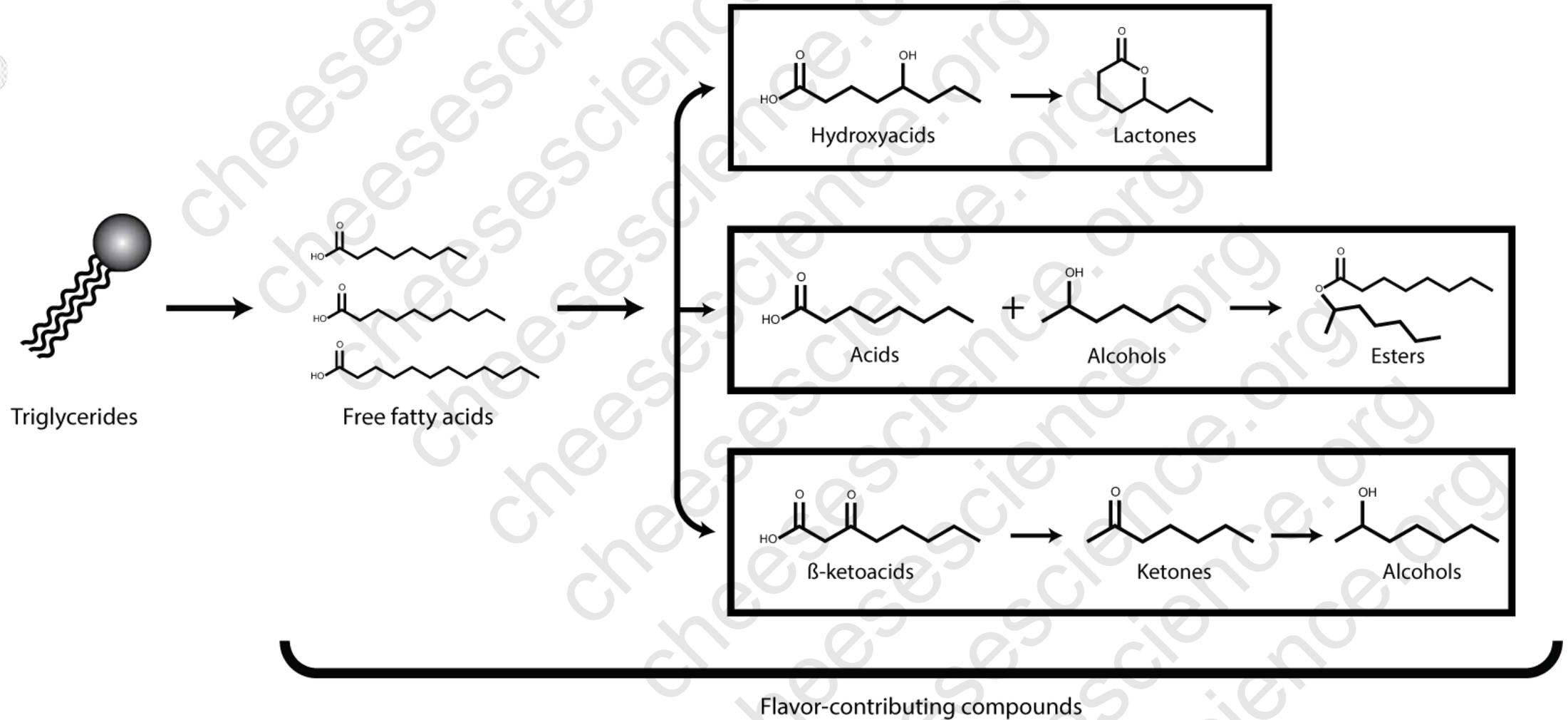


Low pH
no bound calcium,
but high protein
associations

Lipolysis

Fat Breakdown

Lipolysis



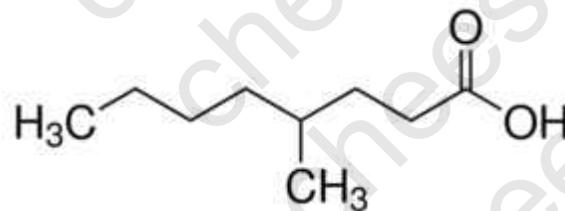
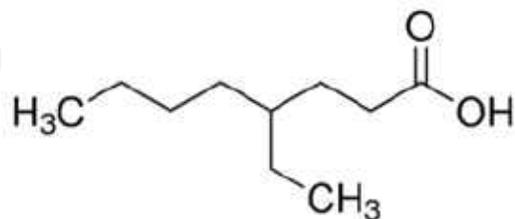
Goat and Sheep Flavor

Fatty Acid (g/100g fat)	Goat Milk	Sheep Milk	Cow Milk
Caproic acid (C6:0)	2.78	1.87	2.01
Caprylic acid (C8:0)	2.92	1.87	1.39
Capric acid (C10:0)	9.59	6.63	3.03
Lauric acid (C12:0)	4.52	3.99	3.64
Total	19.8	14.4	10.1

“Animal” flavors

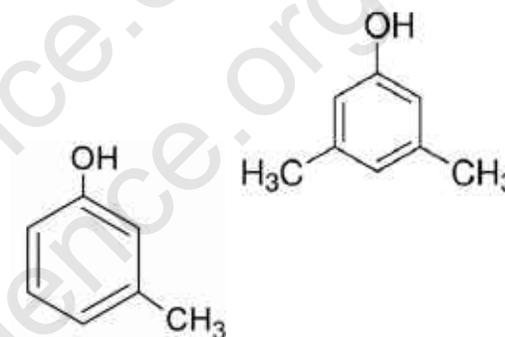
- **Branched fatty acids also play an important role**

- 4-methyloctanoic acid
- 4-ethyloctanoic acid



- **Phenolic compounds important for sheep milk**

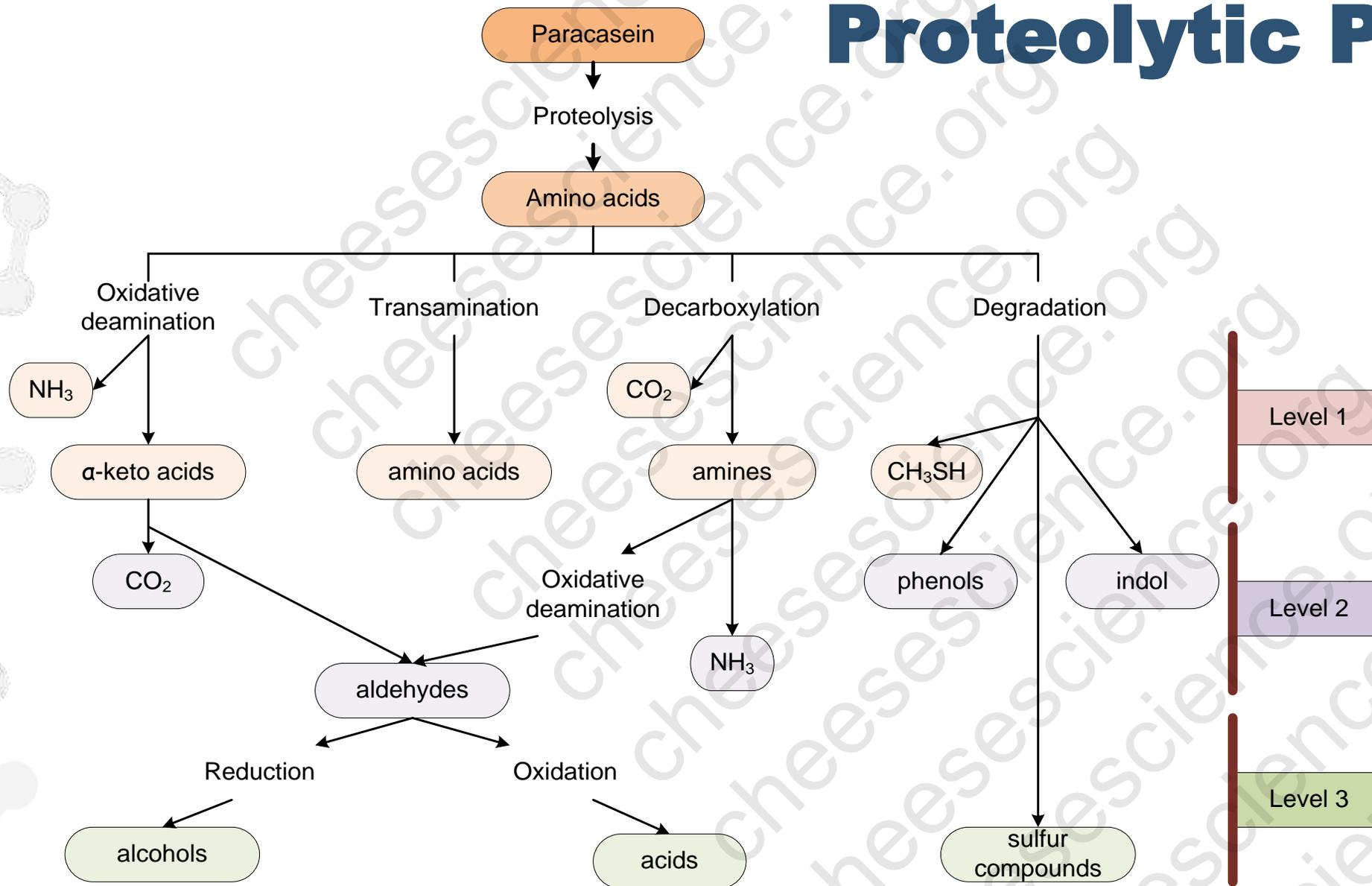
- Cresol
- Dimethylphenols
- Diethylphenols



Proteolysis

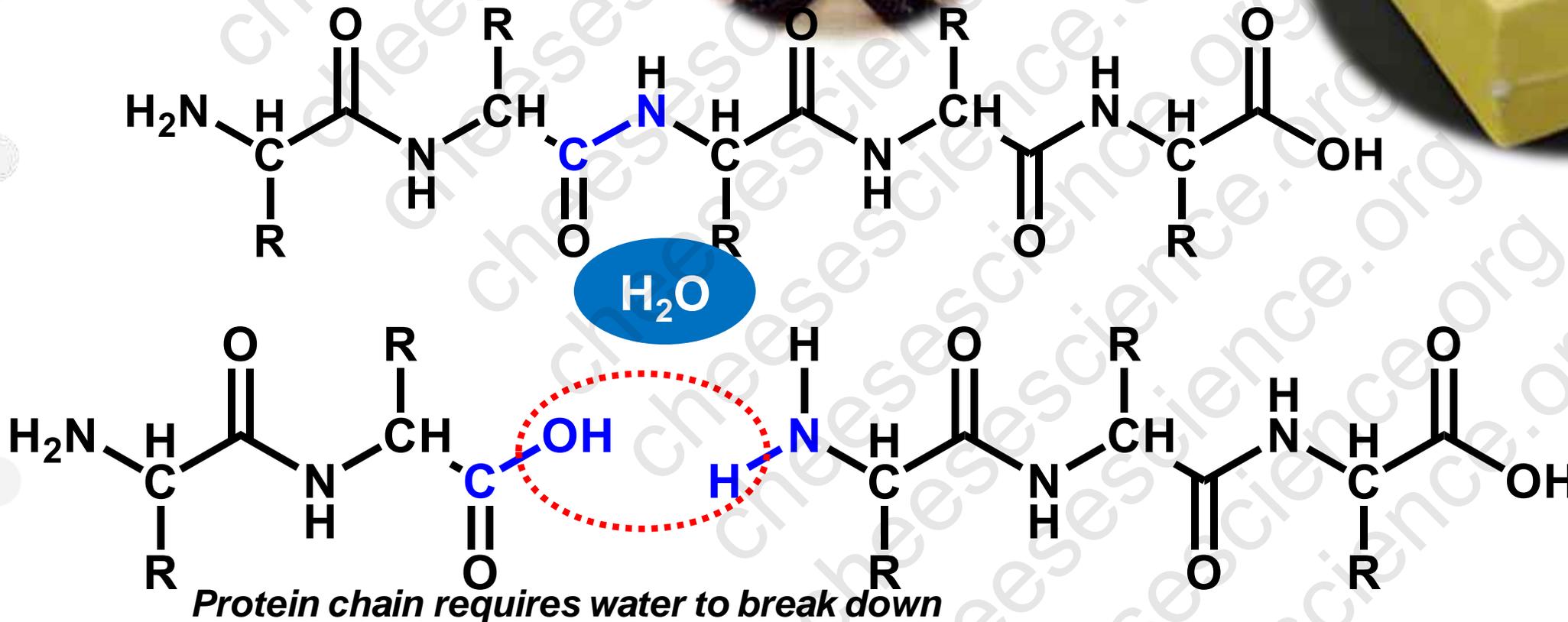
Protein Breakdown

Proteolytic Products

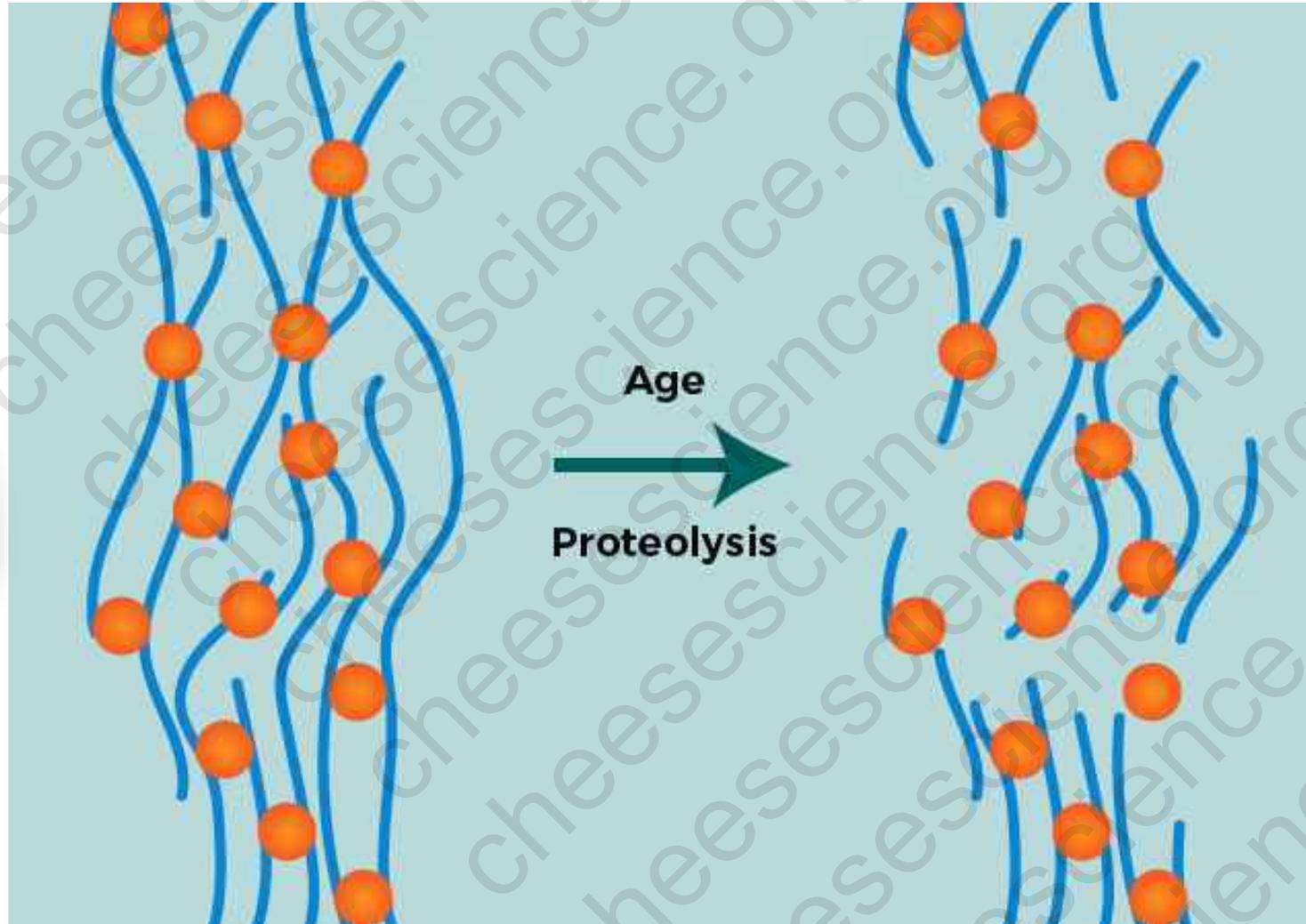


Proteolysis and Texture

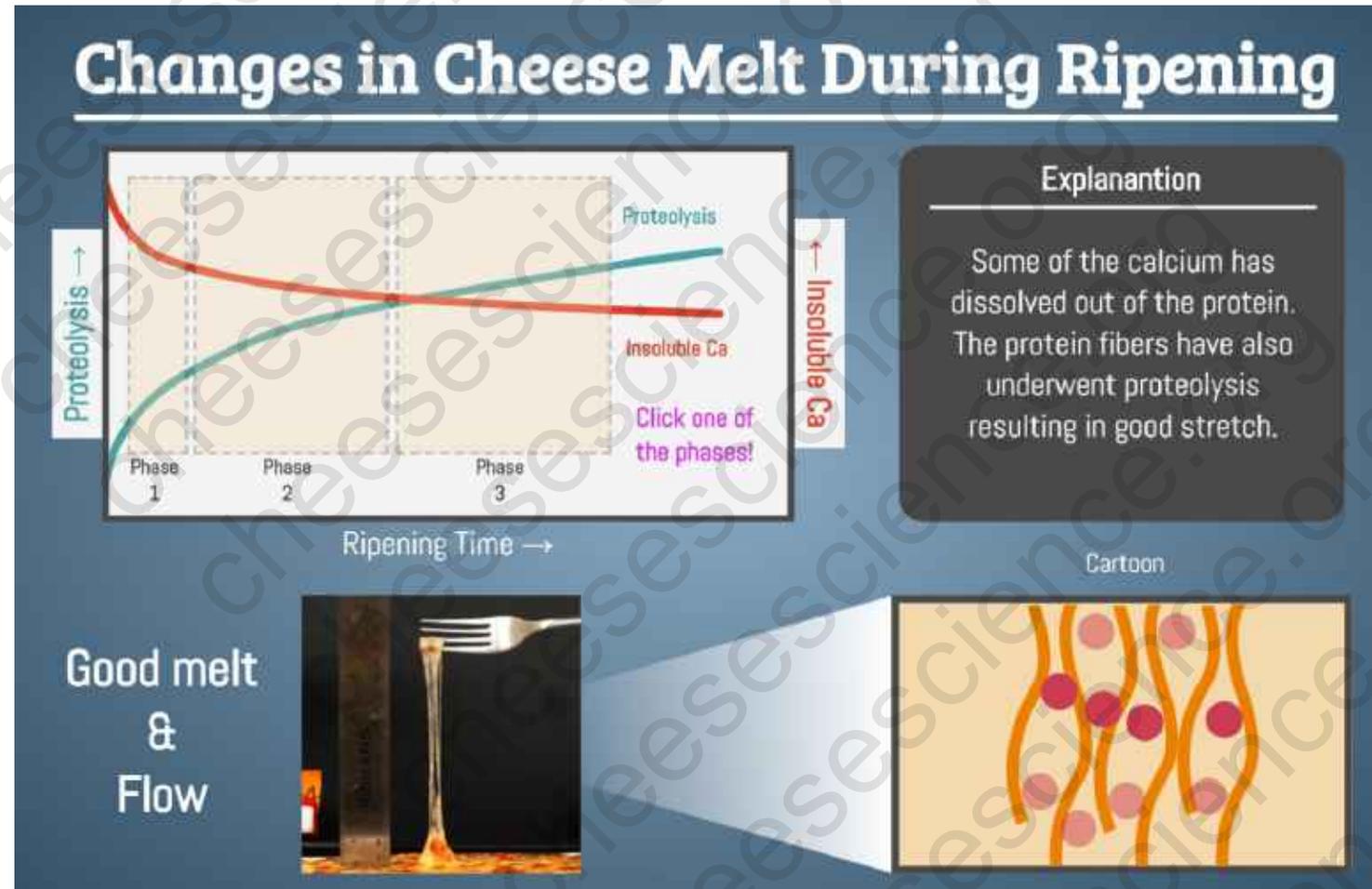
- Broken-down texture
 - Crumbly, more dry(?)



Proteolysis & Mold



Putting in all together



bit.do/cheese_melting

Affinage

The Art of Aging Cheese

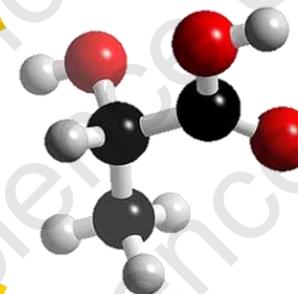
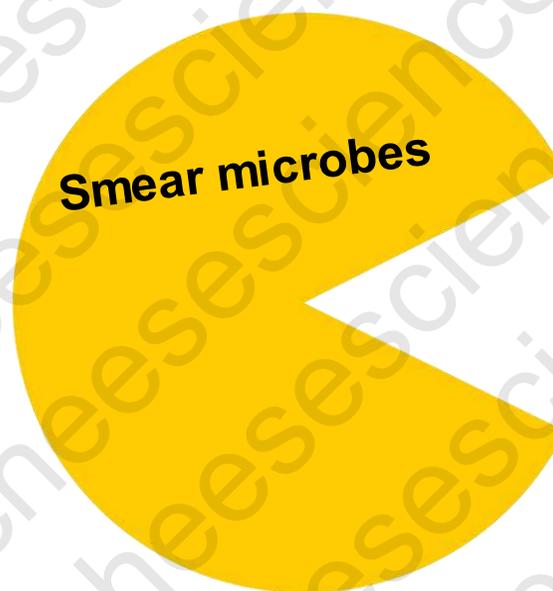
cheesescience.org 🌐

Affinage and Microbes

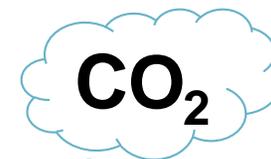
- **Microflora (bacteria, molds, yeasts)**
- **Enzymes produced**
 - Proteases
 - Lipases
- **Ripening environment**
 - Carbon dioxide
 - Ammonia
- **Lactate metabolized***
 - pH rises
- **Flavors galore**



©INRA MIMA2



Lactic acid



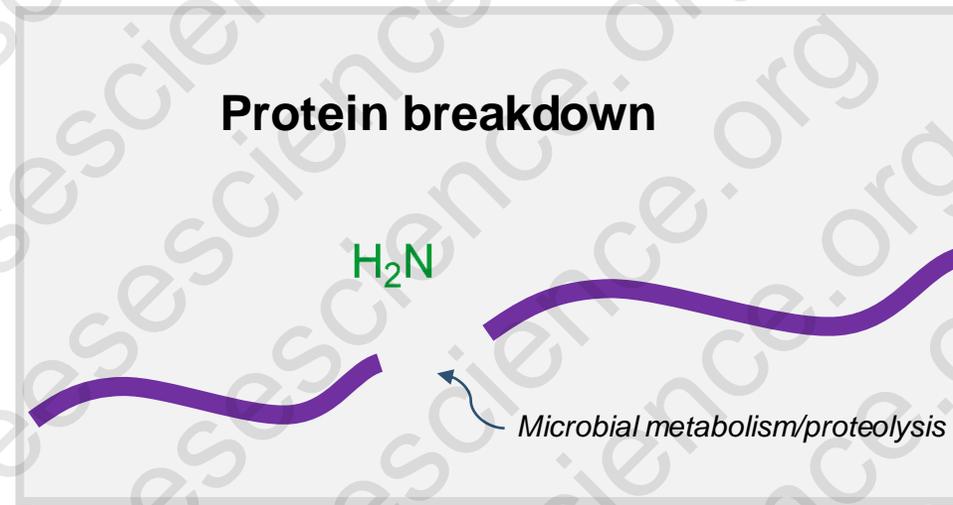
*Mold ripened, smear ripened cheeses

Affinage and Microbes

- Microflora (bacteria, molds, yeasts)
- Enzymes produced
 - Proteases
 - Lipases
- Ripening environment
 - Carbon dioxide
 - Ammonia
- Lactate metabolized*
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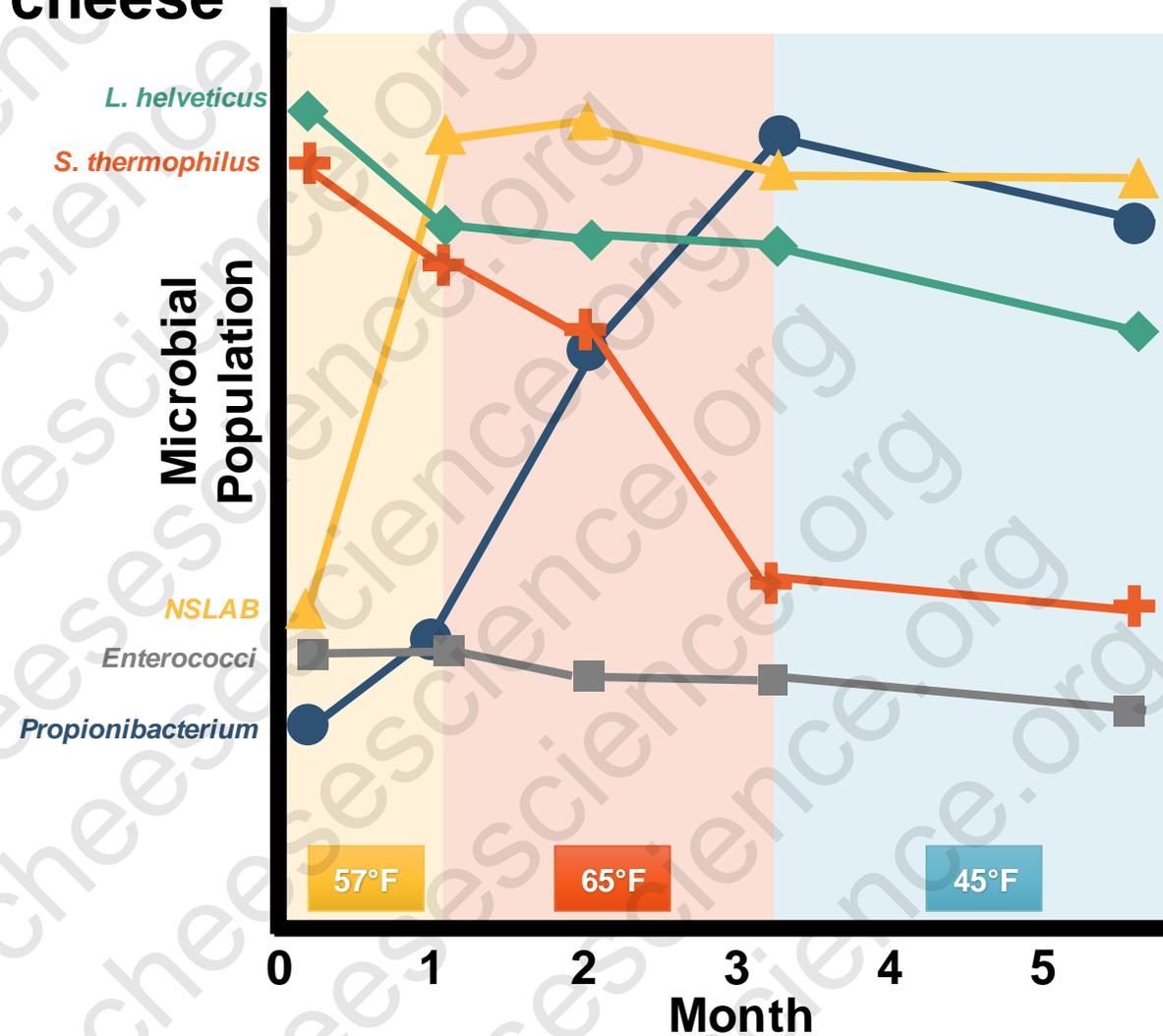
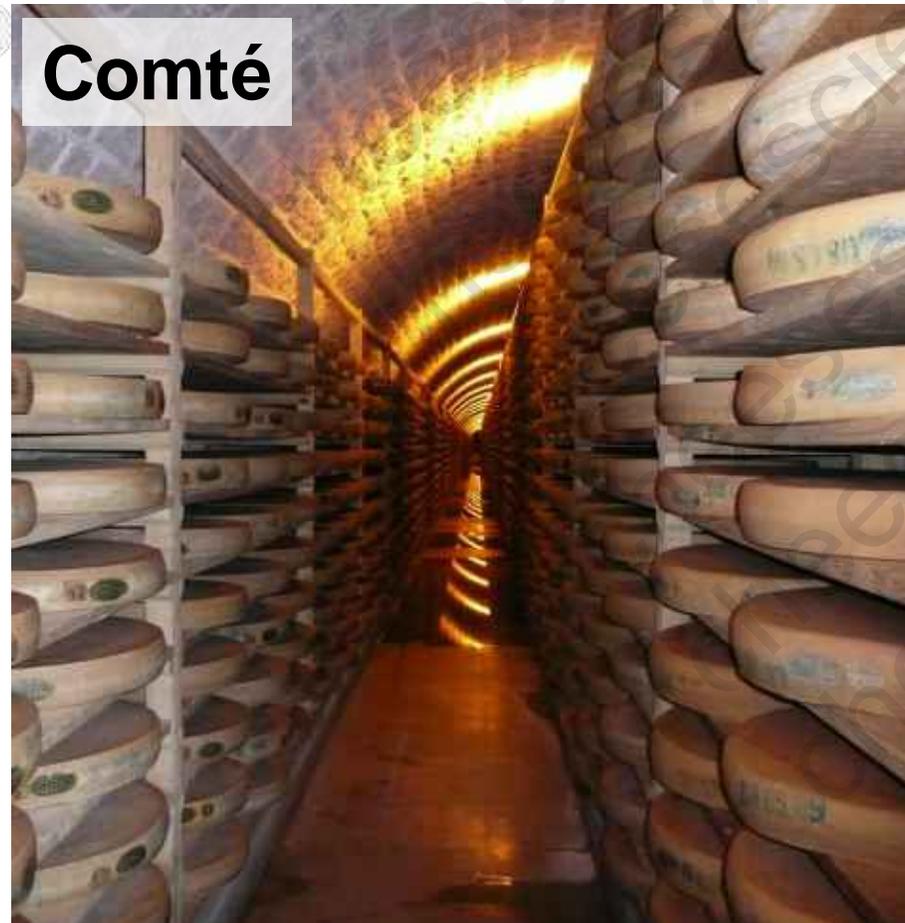
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*Mold ripened, smear ripened cheeses

Microbial Ecology

- Changes over time for every cheese



Case Study: Cheddar

Let's go through it!

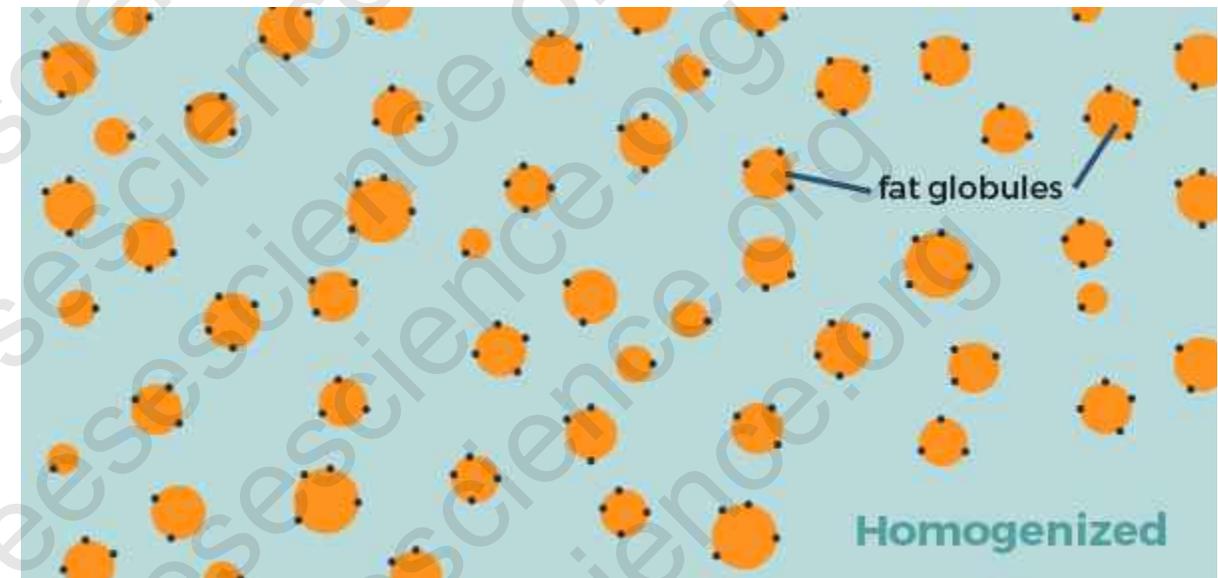
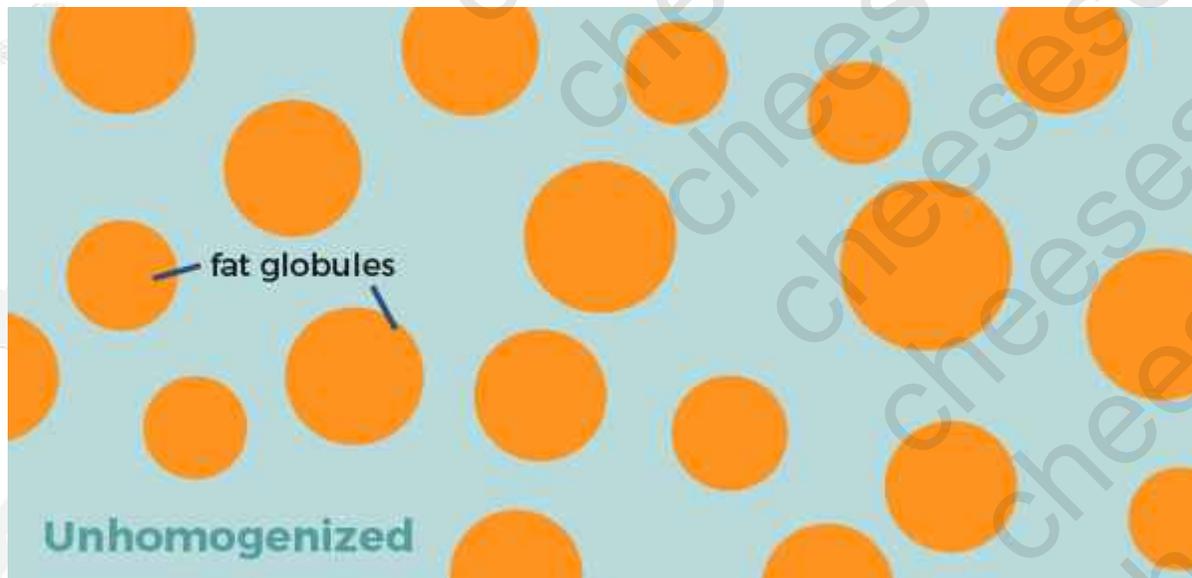
Milk

- **Whole milk**
- **Not often homogenized**
 - Expose triglycerides to lipase activity (rancid flavor)

CFR 133.113 Cheddar

$\leq 39\%$ moisture

$\geq 50\%$ FDB

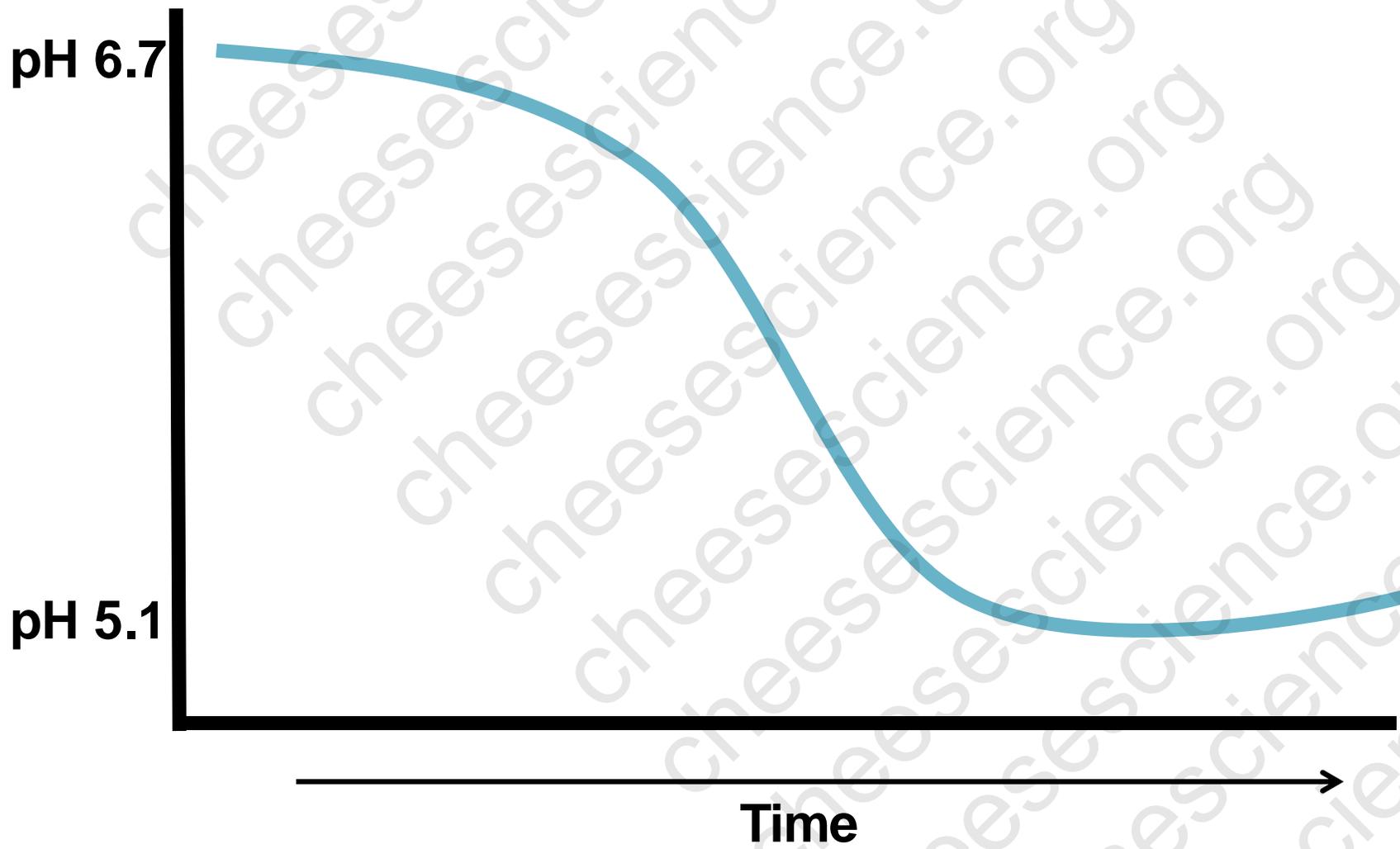


Cheddar Cultures

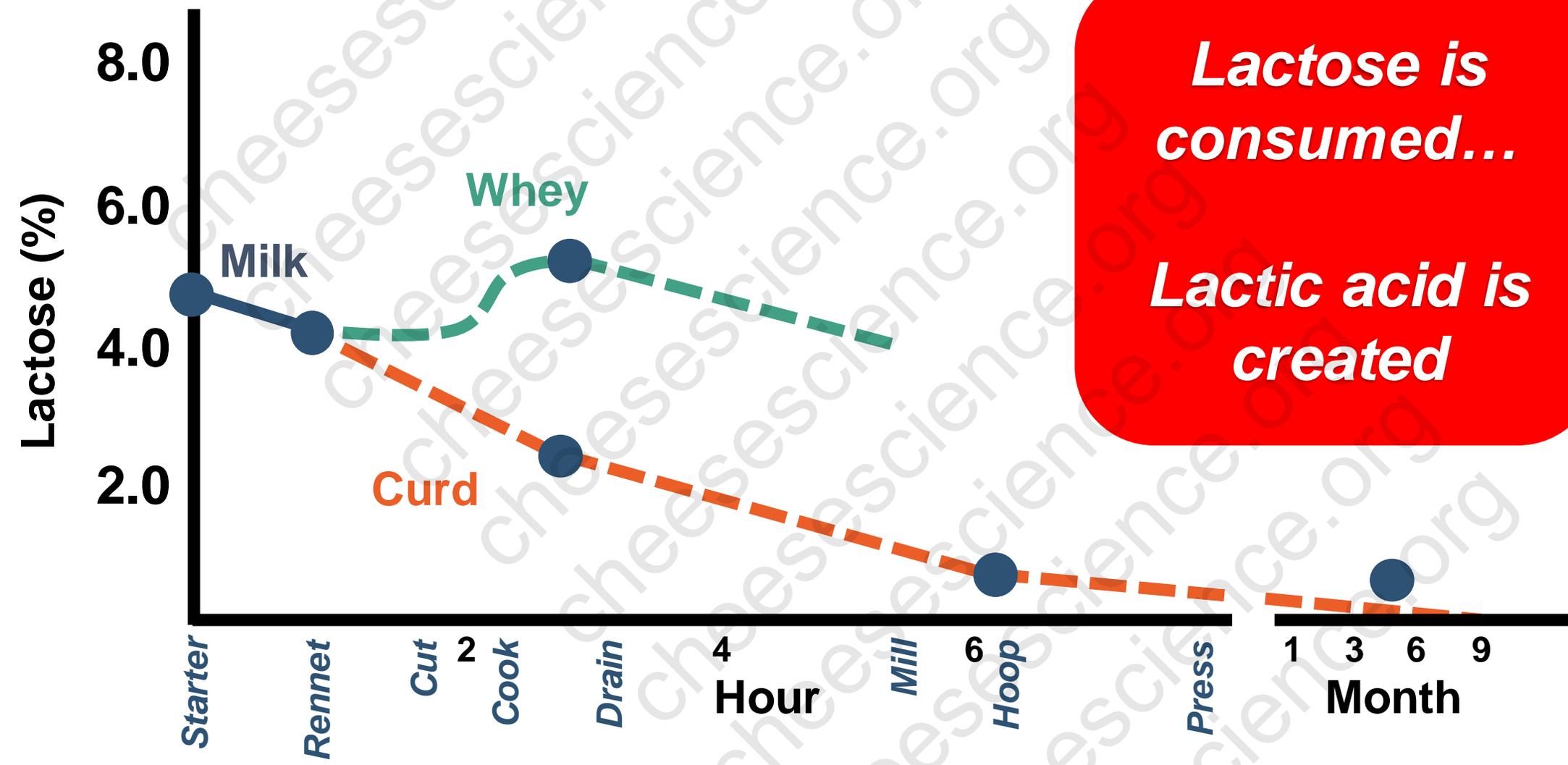
- A blend is usually used

Bacteria	Growth in 4% salt	Growth at 104°F	Flavor potential	Phage robustness
<i>L. lactis</i> subsp. <i>cremoris</i>	—	—	+++	+
<i>L. lactis</i> subsp. <i>lactis</i>	+	+	++	++
<i>S. thermophilus</i>	—	+	+	+++

pH over time



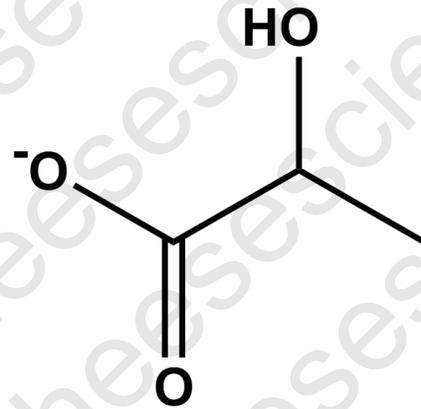
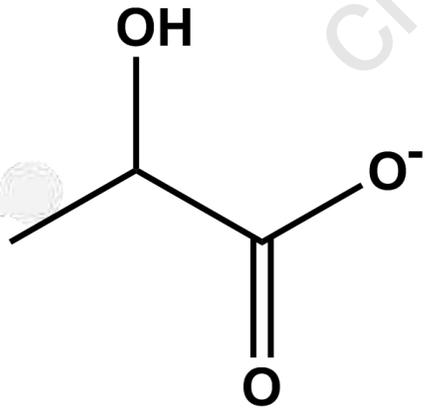
Lactose Over Time



Lactose is consumed...
Lactic acid is created

Lactic Acid

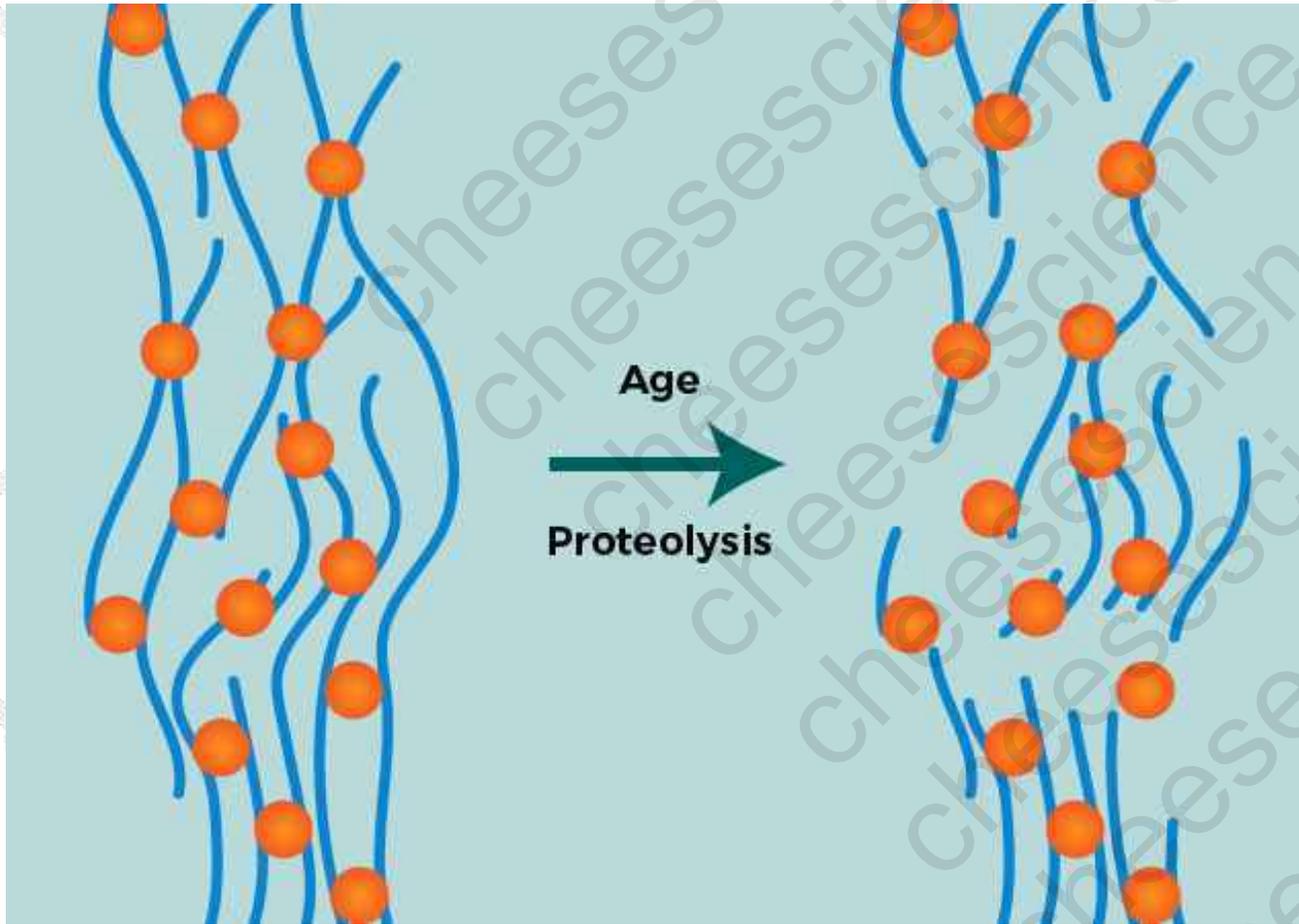
go.uvm.edu/crystals



**Calcium
Lactate**



Proteolysis



Common flavor attributes

- Acid
- Salt
- Meaty/Umami
- Sulfur
- Bitter

Common texture attributes

- Smooth
- Waxy
- Crumbly

Cheese Aging Chemistry
Flavor and Texture Changes Over Time

Thank you!