FROM MILK TO...

CHEESE

1. **Heat Milk**
   Warm the milk to kill harmful bacteria and **denature** the milk proteins so they're ready to form curds.

2. **Add Bacteria Culture**
   Mix in good **bacteria** that eat lactose (milk sugar) and make lactic acid. The acid lowers the pH and helps curds form.

3. **Add Rennet**
   Add an **enzyme** called rennet that makes the milk thicken and form a gel-like curd.

4. **Cut the Curd and add Heat**
   Cut the curd into small pieces and gently heat it to help the whey (liquid) separate from the curds (solids).

5. **Drain, Salt, and Press**
   Drain out the whey, mix in salt, and press the curds into shape. You can eat the cheese fresh or age it for more flavor.

Look at the SCIENCE

Denature means to change the shape of a protein so it no longer works the same way. You can think of it like this: proteins are made of long chains folded into special shapes. When they are heated, mixed with acid, or shaken too much, those shapes unfold or twist. Once that happens, the protein can't do the same job it did before.

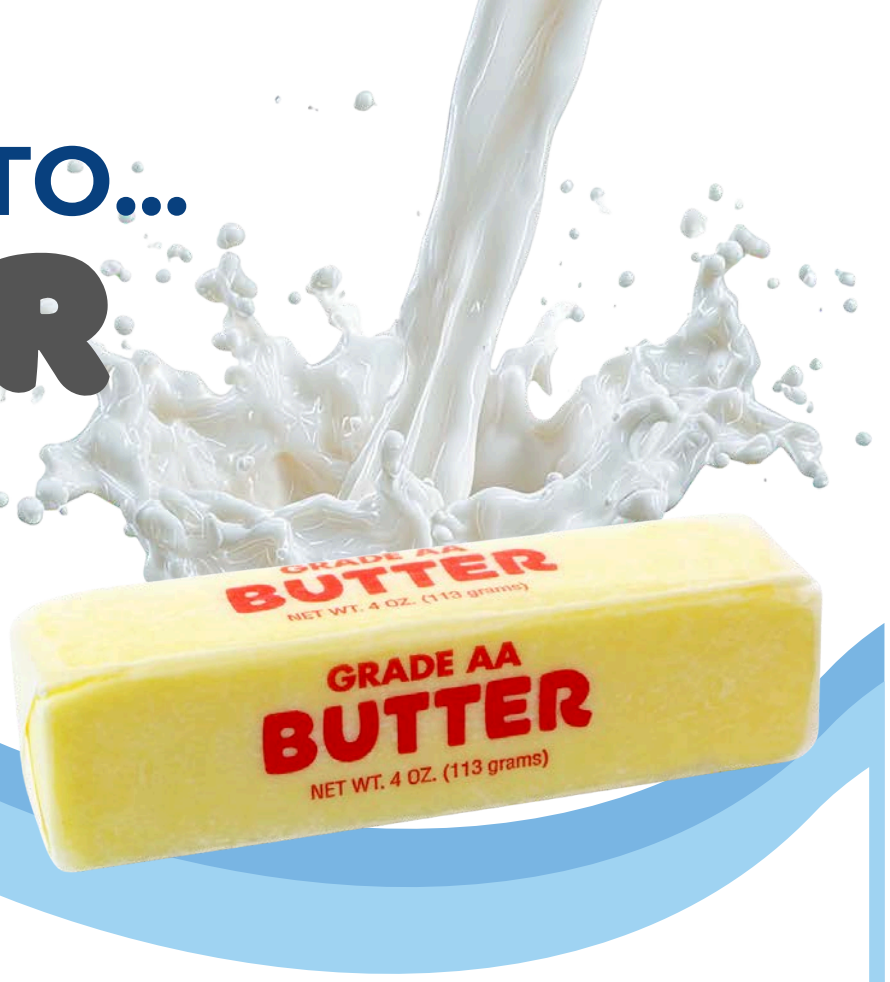
Enzymes are a special type of protein that speeds up chemical reactions in living things without being used up. You can think of enzymes as tiny "helpers" or "tools" that make reactions happen faster and easier — kind of like how scissors help you cut paper. Rennet is an enzyme that helps milk turn from a liquid into a solid curd. It works by cutting the milk protein casein into smaller pieces. When this happens, the casein molecules start to stick together, forming a gel. This gel traps fat and water, which makes the soft solid part we call the curd.

A **bacterial culture** is a group of good bacteria that we purposely add to milk when making cheese. These bacteria are safe and helpful — not the kind that make you sick. They live, grow, and multiply in the milk. A bacterial culture is like a starter team of good microbes that begin the chemical changes turning milk into cheese — by using lactose and producing acid that changes the milk's structure, flavor, and safety.

Summary: Changing milk into cheese is a chemical change because enzymes and bacteria break and form new molecular bonds, creating new substances like curds and whey that cannot be reversed to milk.

FROM MILK TO...

BUTTER



1

Separation

Fresh milk contains both water and fat. The fat rises to the top and forms cream, which is used to make butter.

2

Pasteurization

The cream is heated to kill any **bacteria** that could spoil it. This process makes the cream safe to eat and helps it last.

3

Churning

The cream is rapidly mixed, breaking the **emulsion** so fat **molecules** clump together and seperate from the liquid.

4

Formation

As the fat clumps grow, they form solid butter and leave behind a liquid called buttermilk.

5

Processing

The butter is washed, sometimes salted for flavor, and then shaped or packaged. Now it’s ready to use!

Look at the SCIENCE

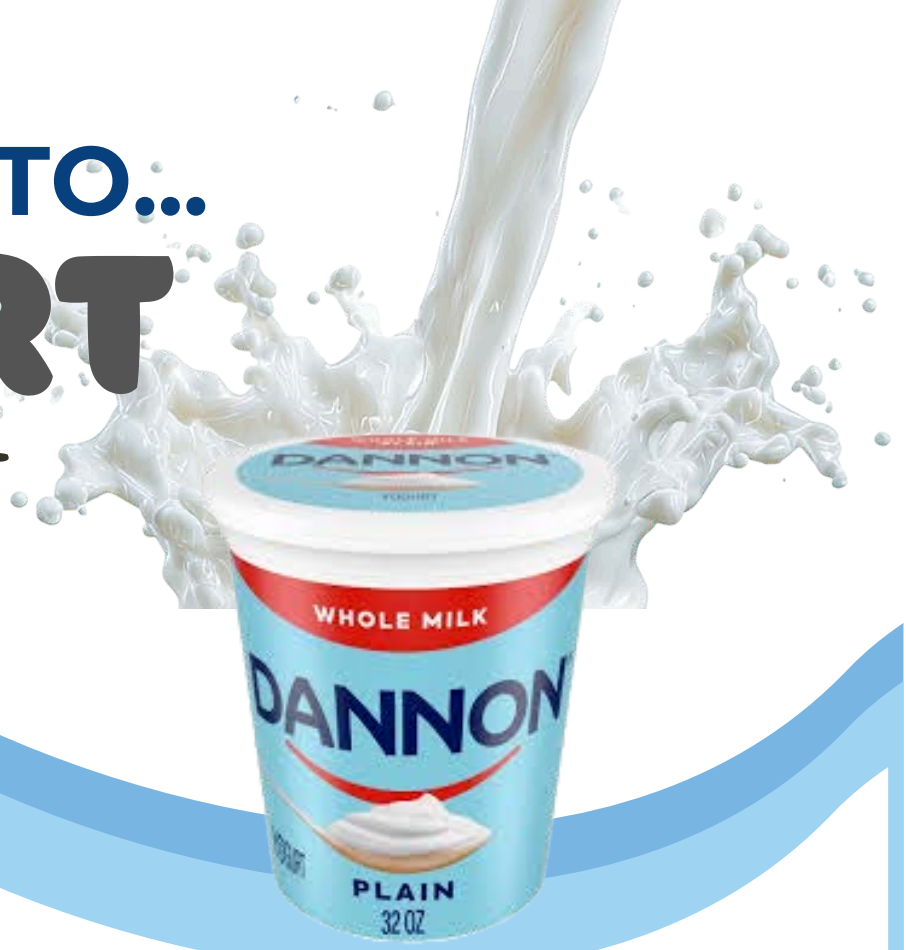
Bacteria are tiny living organisms that can only be seen with a microscope. Some bacteria are harmful, but others are helpful — especially in making foods like butter, cheese, and yogurt. In butter making, certain good bacteria can be added to the cream to help develop its flavor and texture. These bacteria change some of the milk sugars into acids, which give butter a slightly tangy taste. Before this happens, the cream is pasteurized to kill any bad bacteria so only the safe, helpful ones can grow.

An **emulsion** is a mixture made when two liquids that usually don't mix, like oil and water, are blended together. In milk, tiny fat droplets spread evenly through the water, making it look smooth and creamy. When cream is churned to make butter, the emulsion breaks and the fat droplets join together to form solid butter.

Molecules are the tiny building blocks that make up everything around us, including milk and butter. In milk, fat molecules are mixed evenly in water, forming an emulsion that looks smooth and creamy. When the cream is churned, these fat molecules bump into each other and start to stick together, breaking the emulsion. As more molecules join, they form larger clumps, which eventually become solid butter.

Summary: Turning milk into butter is a physical change because churning only separates and gathers the fat molecules already present in the milk without creating any new substances. The chemical composition stays the same; the fat is simply rearranged to form butter while the liquid becomes buttermilk.

FROM MILK TO...
YOGURT



1. **Heating**
   The milk is first heated to kill harmful bacteria and to change the protein structure so the yogurt will be smooth instead of lumpy.

2. **Cooling**
   The hot milk is then cooled to a warm temperature that helps good bacteria grow without being destroyed by heat.

3. **Adding Culture**
   A small amount of live bacteria, called a **starter culture**, is mixed into the milk to start the yogurt-making process

4. **Fermentation**
   During fermentation, bacteria feeds on the **lactose** and make lactic acid, which thickens the milk and gives yogurt its sour flavor.

5. **Chilling**
   The yogurt is cooled to stop **fermentation** and stored in the refrigerator where it becomes firm and ready to eat

FROM MILK TO...

SOUR CREAM

1

Pasteurization

Milk is heated to kill harmful bacteria though pasteurization. This keeps the milk's proteins stable and safe to use

2

Starter Culture

After cooling, a starter culture full of helpful **microorganisms** is added. These microbes begin breaking down the milk's lactose.

3

Fermentation

During fermentation, microbes convert lactose into lactic acid, which permanently alters the milk's chemical structure.

4

Thickening

As lactic acid builds up, the milk's **pH** drops, and the **proteins** start to clot. This reaction creates a thicker, gel-like texture.

5

Cooling

The mixture is cooled so the enzymes and bacteria slow down. Once it rests, the thickened product becomes smooth sour cream.

Look at the SCIENCE

A **starter culture** is a small amount of good bacteria that is added to cream to help start the process of making yogurt. These bacteria begin to grow and change some of the milk sugars into acids, which gives the butter a richer flavor and a smoother texture. Using a starter culture also helps control the fermentation process so the butter turns out the same way each time. It's kind of like adding yeast to bread dough — it helps the transformation begin!

Lactose is the natural sugar found in milk and other dairy products. When making foods like yogurt, cheese, or butter, certain bacteria feed on the lactose during fermentation. As they break it down, they produce lactic acid, which helps thicken the milk and gives the food a tangy flavor. People who are lactose intolerant have trouble digesting this sugar because their bodies don't make enough of the enzyme needed to break it down.

Fermentation is a natural process where bacteria or yeast break down sugars, like lactose in milk, into other substances such as acids or gases. In butter and yogurt making, fermentation helps change the flavor, texture, and smell of the milk. For example, the bacteria produce lactic acid, which gives these foods their tangy taste and helps them thicken. Fermentation is one of the oldest ways people have used to make food last longer and taste better.

Summary: Changing milk into yogurt is a chemical change because bacteria convert lactose into lactic acid, creating new substances that permanently alter the milk's taste, texture, and composition.

Look at the SCIENCE

Microorganisms are tiny living things, like bacteria, that are too small to see without a microscope. When making sour cream, special helpful microorganisms are added to the milk to start the fermentation process. These microorganisms eat the lactose, which is the natural sugar in milk, and turn it into lactic acid. The lactic acid makes the milk thicken and gives sour cream its tangy taste. Without these hardworking microorganisms, the milk would never change into sour cream.

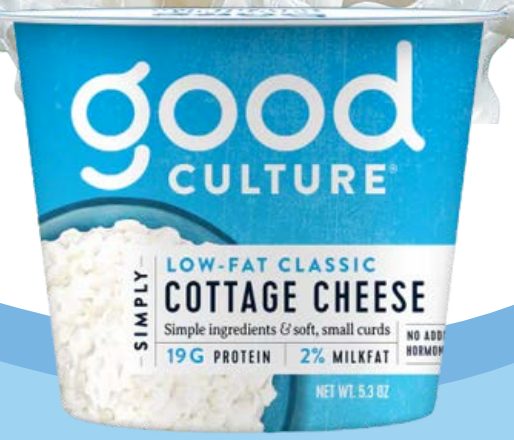
pH is a way to measure how acidic or basic something is, using a scale from 0 to 14. When milk is turning into sour cream, the pH slowly drops as helpful bacteria produce lactic acid during fermentation. A lower pH means the milk is becoming more acidic, which causes the proteins to thicken and change texture. As the pH continues to fall, the milk becomes creamy and tangy, eventually turning into sour cream. Without this change in pH, the milk would stay liquid and wouldn't become sour cream at all.

Proteins are large molecules in milk that help give it structure, and they change as the milk becomes sour cream. When helpful bacteria make lactic acid during fermentation, the acid causes the proteins to tighten and stick together. As the proteins clump, the milk becomes thicker and less watery. This thickening is what turns liquid milk into the creamy texture of sour cream. Without proteins reacting this way, the milk wouldn't thicken at all.

Summary: Changing milk into sour cream is a chemical change because lactic acid bacteria alter the milk's composition by converting lactose into lactic acid, permanently changing its taste and texture.

FROM MILK TO...

COTTAGE CHEESE



1

Pasteurization

The milk is heated during pasteurization to kill harmful bacteria and protect the milk's proteins. This makes the milk safe.

2

Starter Culture

A starter culture filled with helpful microorganisms is added to the milk. These microbes begin breaking down **lactose**.

3

Coagulation

Rennet or another enzyme is added to coagulate the milk, causing the proteins to bond together and form soft curds.

4

Cutting and Heating

The curds are cut into pieces to release whey, the liquid part of the milk. Then they are heated which helps the proteins firm up.

5

Draining and Rinsing

The whey is drained off, leaving the solid curds behind. The curds are rinsed and cooled to stop fermentation.

Look at the SCIENCE

Lactose is the natural sugar found in milk. It helps start the changes that turn milk into cottage cheese. When helpful bacteria in the starter culture break down lactose, they produce lactic acid. This lactic acid makes the milk more acidic, which causes the proteins to thicken and form curds. Without lactose for the bacteria to use, the milk wouldn't turn into cottage cheese.

Coagulate means to thicken or clump together, and it is an important step when making cottage cheese. When rennet or acids are added to the milk, they cause the milk's proteins to stick to each other. As the proteins gather, the liquid milk turns into soft solid pieces called curds. Without coagulation, the curds wouldn't form, and cottage cheese couldn't be made.

Rennet is a special enzyme that helps milk thicken during the process of making cottage cheese. When rennet is added to the milk, it causes the proteins to stick together and form curds. These curds are the solid pieces that eventually become cottage cheese. Without rennet, the milk wouldn't thicken and the curds would not form properly.

Summary: Making cottage cheese is a chemical change because enzymes curdle milk proteins, creating new substances that differ from the original milk.

FROM MILK TO...

WHIPPED CREAM

1

Separating

Milk naturally separates as the cream and fat **molecules**, being less dense, rise to the top. The skim milk remains at the bottom.

2

Cooling

The cream is chilled so the fat hardens, helping it trap air at a low temperature.

3

Agitating

A whisk adds **mechanical energy** that mixes in air bubbles and stretches the proteins.

4

Farming Foam

The fat molecules stick together and create a foam structure with a **protein** network around the air.

5

Thickening

More air becomes trapped as the fat forms clusters, making the mixture thick and fluffy. This creates the whipped cream.

Look at the SCIENCE

Molecules are the tiny particles that make up everything around us, including the cream used to make whipped cream. In cream, there are fat molecules that play a big role in the whipping process. When the cream is whipped, these fat molecules bump into each other and start sticking together, which helps trap air. This trapped air makes the cream thicker and fluffier. Without these molecules working together, whipped cream wouldn't form at all.

Mechanical energy is the energy used when you move or stir something, and it's important for making whipped cream. When you whisk or beat the cream, the mechanical energy from your hands or a mixer moves the cream around quickly. This motion helps mix in air bubbles and stretches the proteins in the cream. The energy makes the cream thicker and fluffy, turning it into the whipped cream we eat. Without mechanical energy, the cream would stay liquid.

Proteins are special molecules in cream that help give whipped cream its structure. When the cream is whipped, the proteins stretch and form a network around the air bubbles. This network holds the air in place and keeps the cream thick and fluffy. Without proteins, the cream would not be able to trap air and would stay runny.

Summary: Changing milk into whipped cream is a physical change because the milk is just being whipped to trap air and change its texture, but its chemical makeup stays the same. No new substance is formed.

FROM MILK TO...
SWEETENED CONDENSED MILK

1. **Pasteurization**
   Milk is heated to kill harmful bacteria through pasteruization. This keeps the proteins and sugar in the milk safe.

2. **Adding Sugar**
   Sugar is mixed into the milk, increasing **solute** concentration and making a syrupy solution.

3. **Evaporation**
   The milk and sugar mixture is heated to remove water through **evaporation**. This concentrates the lactose and proteins in milk.

4. **Thickening**
   As water evaporates, the proteins and sugar interact to thicken the milk. This creates a smooth, **viscous** texture.

5. **Cooling**
   The thickened mixture is cooled, and then canned or stored.

Look at the SCIENCE

A **solute** is a substance that gets dissolved in a liquid to make a solution. In sweetened condensed milk, sugar is the solute that is mixed into the milk. When the sugar dissolves, it spreads evenly throughout the milk, making it sweet and helping it thicken. The solute also helps slow down the growth of microorganisms, which keeps the milk safe to eat longer. Without the sugar acting as a solute, the milk wouldn't become sweetened condensed milk.

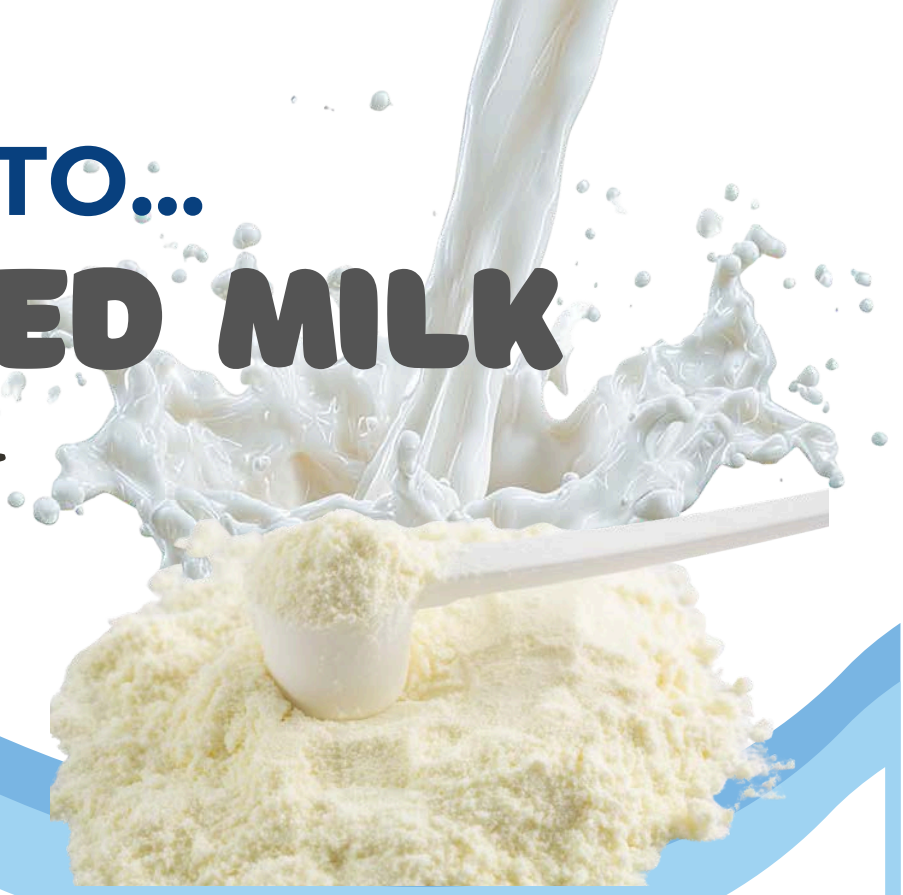
Evaporation is when liquid water turns into vapor and leaves the mixture. In sweetened condensed milk, the milk is heated so that some of the water evaporates, which makes the milk thicker. As the water leaves, the proteins and sugars become more concentrated, giving the milk a rich, creamy texture. Without evaporation, the milk would stay thin and runny instead of becoming sweetened condensed milk.

Viscous means thick and sticky, like syrup, instead of runny like water. When making sweetened condensed milk, heating the milk and sugar causes the proteins and sugar to come together, making the mixture viscous. This thick texture helps the milk hold its shape and feel creamy. Without becoming viscous, the sweetened condensed milk would stay too thin to use in desserts.

Summary: Turning milk into sweetened condensed milk is a physical change because water is removed and sugar is added, but the milk's chemical structure stays the same. No new substance is created—just a thicker, sweeter version of milk.

FROM MILK TO...

POWDERED MILK



1. **Pasteurization**
   Milk is heated to kill harmful bacteria and protect the milk's proteins, making the milk safe for processing

2. **Concentration**
   Some water is removed from the milk using **evaporation**, which makes the milk thicker and easier to dry.

3. **Homogenization**
   The milk is blended through **homogenization**. This prevents the fat from seperating and creates a smooth solution.

4. **Drying**
   The concentrated milk is sprayed or heated to remove almost all remaining water. This process locks in the nutrients and lactose.

5. **Cooling**
   The powdered milk is cooled to stop **enzymes**. It is then packaged into containers to keep it safe and shelf-stable.

Look at the SCIENCE

Evaporation is when liquid water turns into vapor and leaves a mixture. In sweetened condensed milk, the milk is heated so that some of the water evaporates, making the milk thicker and creamier. As the water leaves, the sugars and proteins become more concentrated, giving the condensed milk its rich texture. Without evaporation, the milk would stay too runny and wouldn't become sweetened condensed milk.

Homogenization is the process of breaking up fat molecules in milk so they are evenly spread throughout the liquid. In sweetened condensed milk, this helps prevent the fat from separating and keeps the milk smooth and creamy. It also makes the proteins and sugars mix more evenly, which improves the texture and consistency. Without homogenization, the milk could become lumpy or separate while being stored.

Enzymes are special proteins that help speed up chemical reactions in food. In sweetened condensed milk, enzymes naturally present in the milk can cause tiny changes in the proteins and sugars if the milk isn't heated or stored properly. Heating and cooling the milk slows down these enzymes, which helps keep the milk smooth and prevents it from spoiling. Without controlling enzyme activity, the sweetened condensed milk might change texture or taste over time.

Summary: Turning milk into powdered milk is a physical change because the water is removed by drying, but the milk's chemical composition stays the same. It's still milk—just in a dry form.

FROM MILK TO...
ICE CREAM

1

Pasteurization

The milk is first heated to kill harmful **bacteria** and protect the **milk proteins**. This keeps milk safe for making ice cream.

2

Mixing

Sugar, cream, and flavoring are added to this milk, creating a solution with sugars, fat molecules and proteins. This is a base.

3

Blending

The milk, cream, and sugar are blended so the **fat molecules** and proteins mix evenly. This keeps the ice cream smooth.

4

Churning

The mixture is cooled and churned, which traps air bubbles and prevents large ice crystals. This gives it the creamy, soft texture.

5

Freezing

The ice cream is placed in a freezer to harden. This creates the cold, creamy texture that can be scooped and eaten.

Look at the 

Bacteria are tiny living organisms that are too small to see without a microscope. In milk, some bacteria can be harmful and make the milk spoil. During ice cream making, the milk is pasteurized to kill these harmful bacteria so the milk stays safe. This ensures that the proteins and fats in the milk can be used to make smooth, creamy ice cream without causing illness.

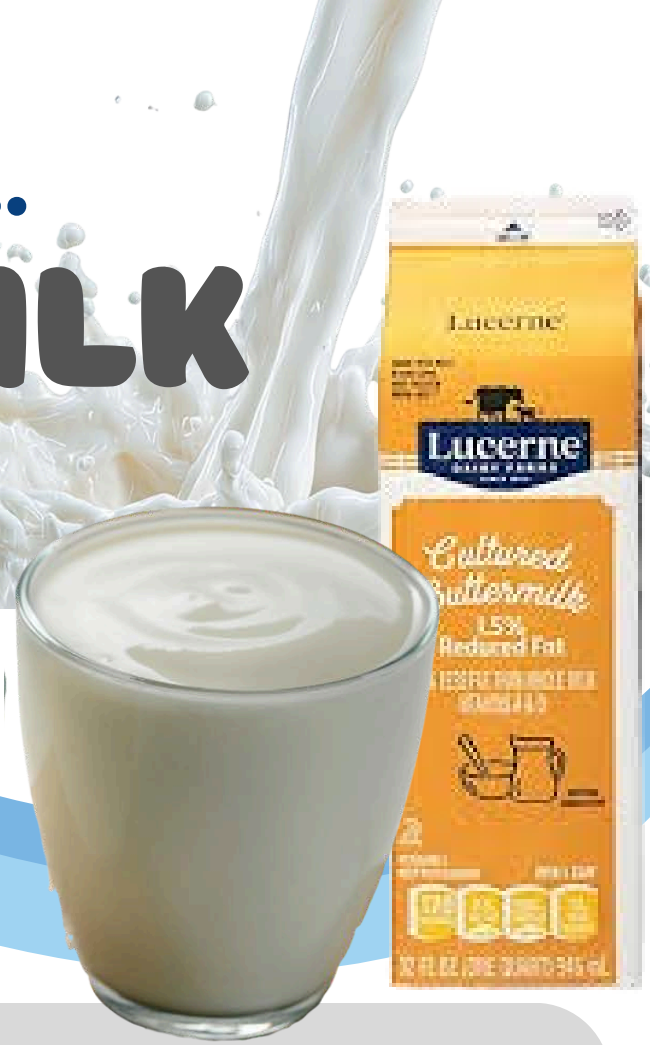
Milk proteins are molecules in milk that help give ice cream its structure and texture. When milk, cream, and sugar are mixed and frozen, the proteins interact with fat molecules and water to help trap air bubbles. This makes the ice cream smooth, creamy, and scoopable. Without the proteins, the ice cream would be icy and wouldn't hold its shape well.

Fat molecules are tiny particles of fat found in milk and cream that give ice cream its rich and creamy texture. When ice cream is churned, the fat molecules clump together and help trap air bubbles, which makes the ice cream light and fluffy. They also interact with proteins and sugars to create a smooth, creamy consistency. Without fat molecules, ice cream would be icy and not as creamy.

Summary: Turning milk into ice cream is a physical change because the milk mixture is frozen and churned to change its texture and state, but its chemical makeup stays the same. No new substance is formed—just a solid, creamy version of milk.

FROM MILK TO...

BUTTERMILK



1

Pasteurization

Milk is heated to kill harmful **bacteria** and protect the milk's proteins. This makes milk safe for fermentation.

2

Cooling

The milk is cooled to the right temperature so that helpful **microorganisms** can grow. This ensures it ferments correctly.

3

Adding Culture

A starter culture of good bacteria is added to the milk. These microbes feed on the lactose and start producing **lactic acid**.

4

Fermentation

The milk is left to ferment, allowing lactic acid to build up. The acid causes the proteins to thicken and the milk to develop a tangy taste.

5

Cooling

Once thickened, the buttermilk is cooled. It is then packaged for storage and ready to drink or use.

Look at the SCIENCE

Bacteria are tiny living organisms that are too small to see without a microscope. In buttermilk, helpful bacteria are added to the milk to start fermentation. These bacteria eat the milk's lactose and produce lactic acid, which makes the milk thicken and taste tangy. Without these bacteria, the milk would stay liquid and would not turn into buttermilk.

Microorganisms are tiny living things, like bacteria, that are too small to see without a microscope. When making buttermilk, special helpful microorganisms are added to the milk to start fermentation. These microorganisms eat the milk's lactose and produce lactic acid, which thickens the milk and gives it a tangy flavor. Without these microorganisms, the milk would stay liquid and would not become buttermilk.

Lactic acid is a chemical that is produced when helpful bacteria break down lactose, the natural sugar in milk. In buttermilk, the lactic acid makes the milk more acidic, which causes the proteins to thicken and the milk to develop a tangy flavor. It also helps preserve the milk by slowing the growth of harmful microorganisms. Without lactic acid, the milk would stay thin and wouldn't taste like buttermilk.

Summary: Turning milk into buttermilk is a chemical change because bacteria ferment the milk sugars into lactic acid, creating a new substance with a sour taste and different properties.