Mammals can produce milk.

Man has used Milk for an evolutionary advantage:

- Gives newborns the unique advantage of a perfectly formulated food after birth
- 1st several months after birth, babies are helpless because their brains are not fully developed. Need proper nutrition for this to happen.

Why Cow/Goat/Sheep, etc.?

- Based on availability
- Around 30 Million years ago, the climate became very arid – ecologically, this favors plants that can grow quickly and generate seeds to survive dry periods. Lots of grass and other plant life that humans cannot digest.
- Ruminating animals thrived because they are able to digest the cellulose.
    - Chewing, swallow, regurgitate
    - 4 stomachs
    - First stomach (called the rumen) has trillions of bacteria that can break down cellulose → energy for production of milk.

Milk is synonymous with wholesome, fundamental nutrition.

- Why? Because it is ACTUALLY designed to be food.
- It is composed of essential nutrients including sugar, fat, protein, and vitamins (A, B, D, E, K and Ca^{2+})

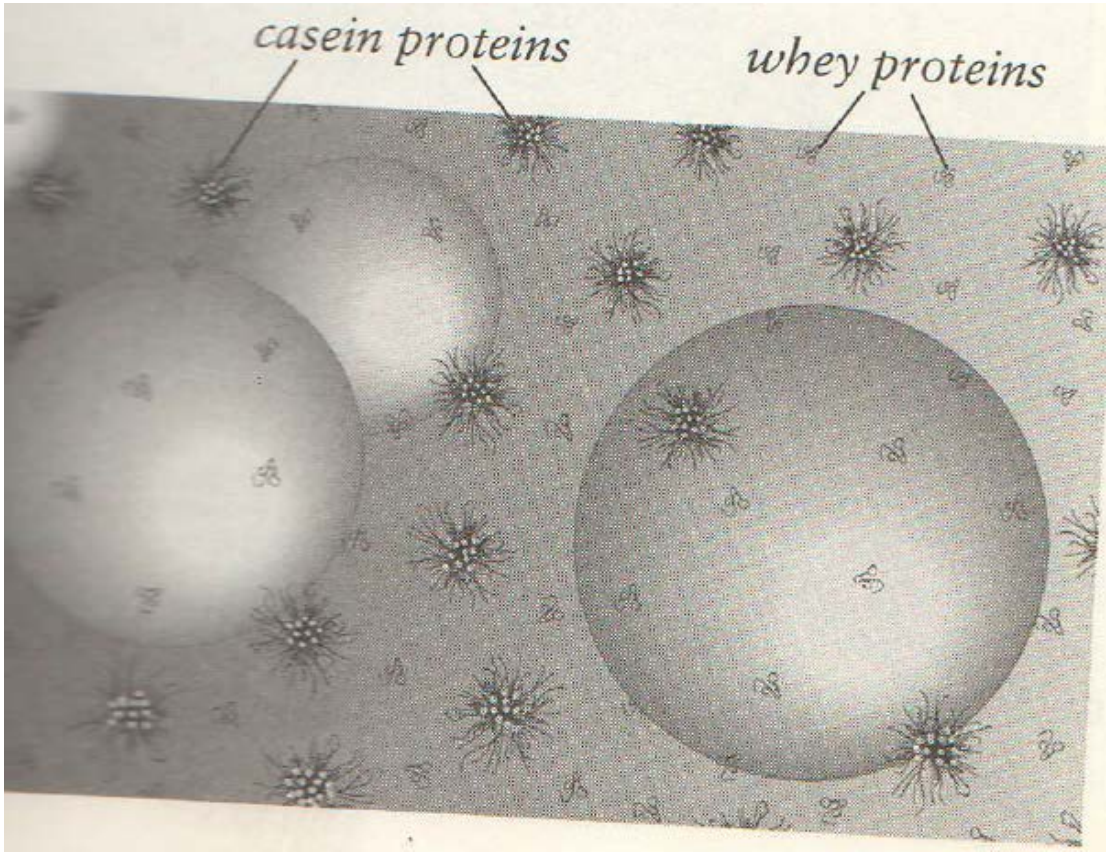
The Compositions of Various Milks

The figures in the following table are the percent of the milk's weight accounted for by its major components.

Milk	Fat	Protein	Lactose	Minerals	Water
Human	4.0	1.1	6.8	0.2	88
Cow	3.7	3.4	4.8	0.7	87
Holstein/Friesian	3.6	3.4	4.9	0.7	87
Brown Swiss	4.0	3.6	4.7	0.7	87
Jersey	5.2	3.9	4.9	0.7	85
Zebu	4.7	3.3	4.9	0.7	86
Buffalo	6.9	3.8	5.1	0.8	83
Yak	6.5	5.8	4.6	0.8	82
Goat	4.0	3.4	4.5	0.8	88
Sheep	7.5	6.0	4.8	1.0	80
Camel	2.9	3.9	5.4	0.8	87
Reindeer	17	11	2.8	1.5	68
Horse	1.2	2.0	6.3	0.3	90
Fin whale	42	12	1.3	1.4	43

Overall structure of milk:

- Fat Globules
- Proteins: Casein (curd) and Whey
    - Caseins outweigh whey by ~ 4 times
    - Distinguished by their reaction to acids
    - Casein proteins clump together in acid (this is the origin of making cheese, yogurt, etc.)
    - Whey influences the casein curd and stabilized milk foam
- "space" is filled with water, sugar (lots of lactose) and minerals



Milk fat is important!

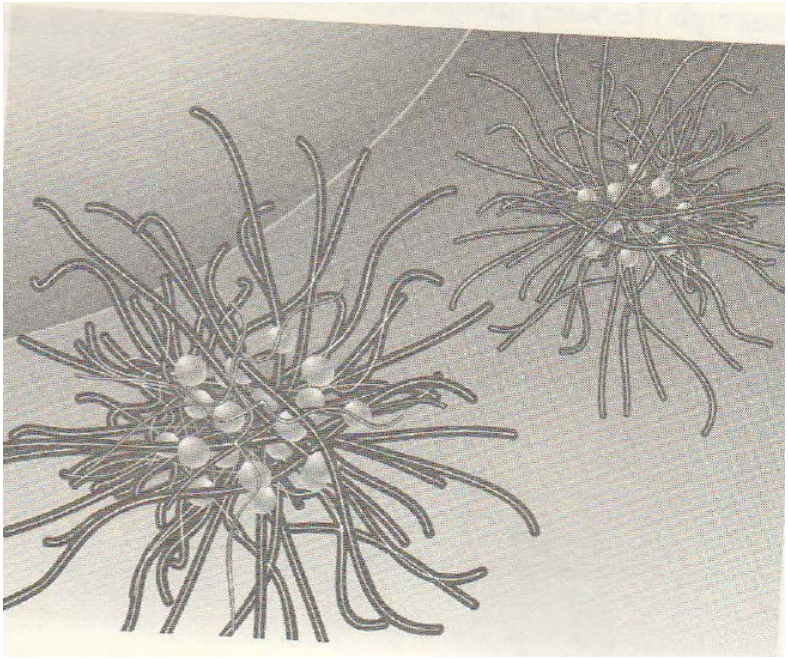
- Milk globules carry the fat soluble vitamins (A, D, E, K).
- The higher the fat content, the more cream or butter can be made!

- Fat is packaged into globules.
- The outside of globules is made up of phospholipids (remember these are glycerol backbone with 2 fatty acids and a phosphate) and proteins.
    - Serves as an emulsifier – a molecule that helps fat dissolve in water
    - Separates fat droplets and prevents them from pooling together
    - Protects them from fat digesting enzymes that are present in the milk (remember the lipases from your homework)
    - Milk spoiling happens because these droplets begin to break up and the fats get broken down by the lipases

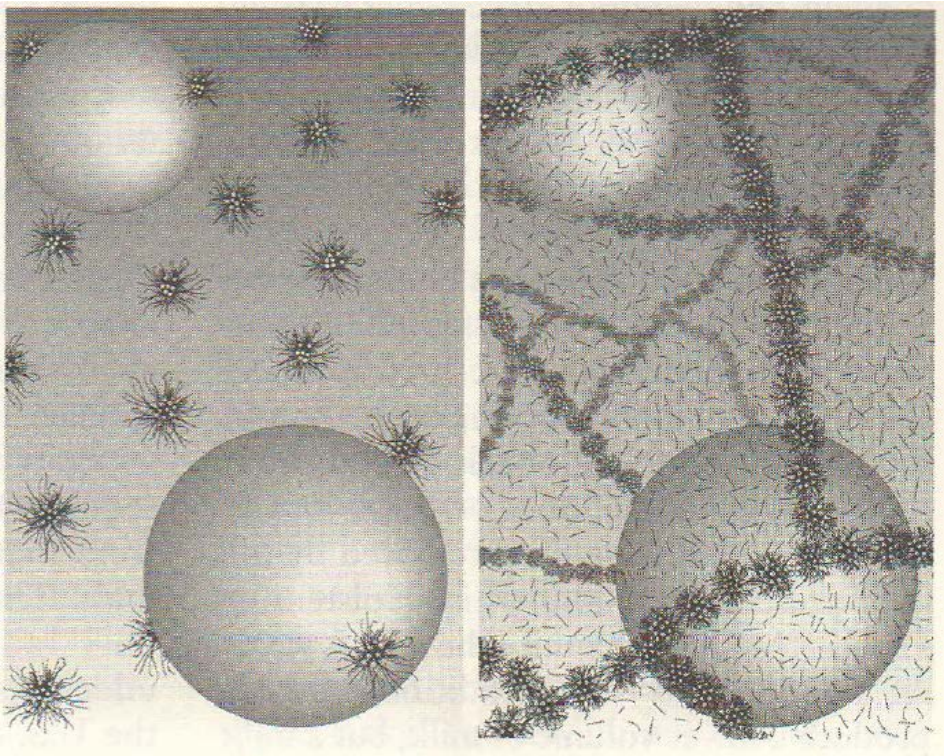
- Creaming – process where fresh milk is allowed to rest at cool temperatures for a few hours
    - Fat globules rise to the top and form a fat-rich layer (fat is less dense than water) = cream
    - 19th century – centrifuges made this process much more efficient.

Caseins (the curd):

- Composed of 4 different kinds of protein
- Lots of negatively charged amino acids
- Clump together in micelles
    - Each micelle contains a few thousand individual proteins
    - These micelles make up ~10% of the volume of milk
    - A lot of the calcium in milk is associated with the casein micelles (calcium phosphate serves as a glue holding the proteins together because it stabilizes the bulk of negative charges)
- Kappa casein is one important member of the protein family
    - It is the "capping" protein
    - Prevents the micelle from growing out of control.



- Disrupting the structure of casein (i.e. making cheese):
    - Adding acid (or through natural souring of milk → fatty acids are released)
        - This is how yogurt or sour cream is made.
        - Normal pH of milk ~ 6.5
        - pH 5.5:
            - kappa casein gets neutralized (because it binds to a H^+ ion).
            - Calcium "glue" also dissolves
            - Casein proteins scatter because negative charges repel each other
        - pH 4.7
            - rest of the caseins get neutralized
            - no longer repel each other
            - clumping begins
    - Adding chymosin (digestive enzyme) or renin
        - Proteases (hydrolyzed peptide bonds)
        - Clip off kappa casein
        - The "haircut" allows casein to clump together (no souring smell or taste)



Whey proteins

- What is left over after the casein is removed.
- Defensive proteins
- Transport nutrients and enzymes
- Most abundant is lactoglobulin.
    - Denatures (unfolds) at 172-178°C. Sulfur atoms react with H^+ to form H_2S
    - This is the source of some of the terrible smell and taste of sour milk.
- When heated, whey proteins bind to kappa casein – this prevents coagulation.
- Coagulation can be forced by acidifying in conditions where most of the casein has been removed.
    - This is how ricotta is made