



Synthetic Biology in Dairy Sector

Why in news?

There has been increasing research on animal-free dairy by replicating milk proteins in genetically modified microbes by using genetic sequences from many mammals.

What is the composition of milk?

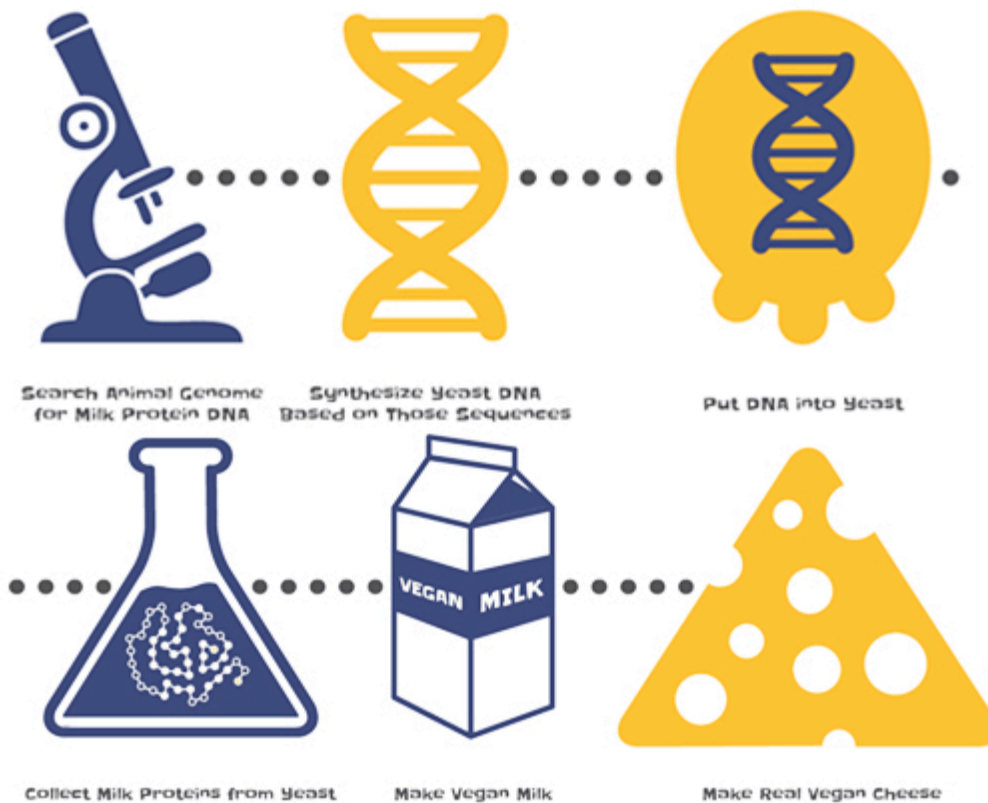
India is the world's largest dairy producer and has over 100 million dairy farmers.

- Milk is a superfood that plays critical role in our nutrition.
- On an average, 87% of cow's milk is water.
- Lactose, a simple sugar consisting of glucose and galactose sub-units, makes up 4.4%.
- Milk fats average to about 4.5% and minerals constitute less than 1%.
- Milk proteins make up 3.8% of which almost 80% is caseins and about 20% is whey proteins.
- Lactoferrin and a few other proteins are also present in minute quantities.
- When the milk turns sour due to acid-producing bacteria, or if one adds a little bit of lemon juice, it curdles and the caseins precipitate.

What is synthetic biology?

- Synthetic biology is a field of science that involves redesigning organisms for useful purposes by engineering them to have new abilities.
- Redesigning organisms can produce substances, such as medicine or fuel, or gain a new ability, such as sensing something in the environment.
- Some examples of what scientists are producing with synthetic biology are:
 - Microorganisms harnessed for bioremediation to clean pollutants from our water, soil and air.

- Rice modified to produce beta-carotene that prevents vitamin A deficiency.
- Yeast engineered to produce rose oil as an eco-friendly and sustainable substitute for real roses
- Production of animal free dairy products



What is the difference between synthetic biology and genome editing?

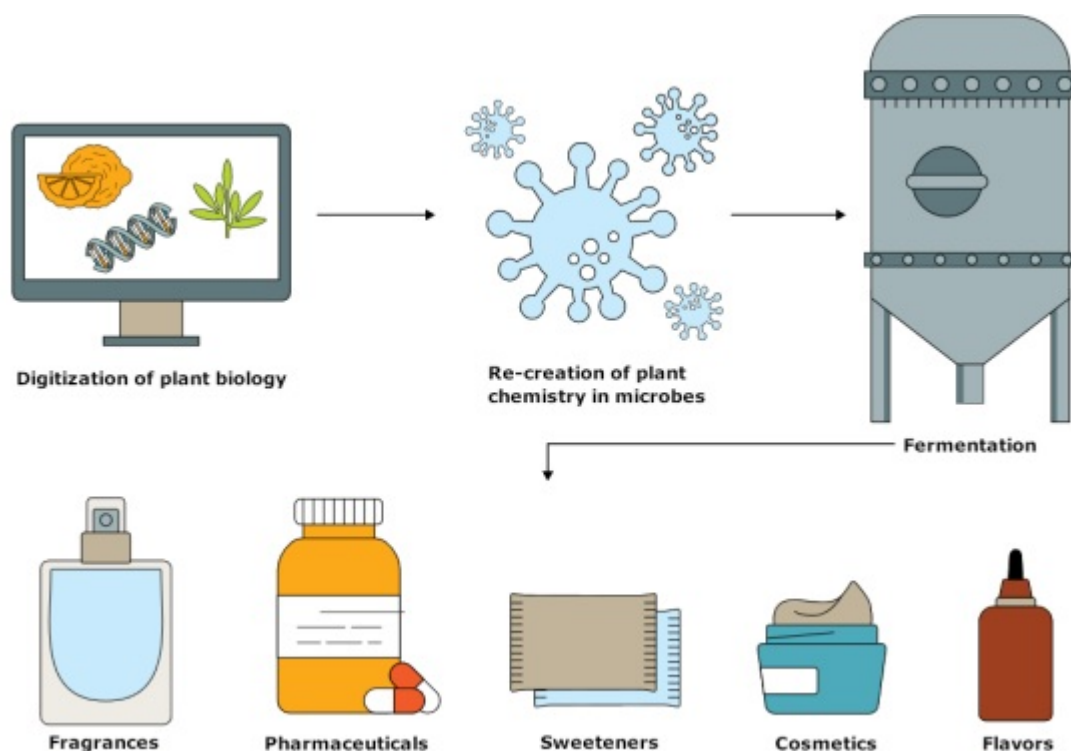
- In synthetic biology, scientists typically stitch together long stretches of DNA and insert them into an organism's genome.
- These synthesized pieces of DNA could be genes that are found in other organisms or they could be entirely novel.
- In genome editing, scientists typically use tools to make smaller changes to the organism's own DNA.
- Genome editing tools can also be used to delete or add small stretches of DNA in the genome.

What is the significance of studying mammalian lactation?

- It shows us how evolution has resulted in remarkably fine-tuned solutions to problems.
- **Study about antimicrobial protein** - For instance, the duck-billed

platypus, a mammal that lays eggs has evolved a milk pad but not teats.

- As a result, its newborn sucklings are exposed to a large load and variety of microbes.
- An unusually potent antimicrobial protein, MLP (**Monotreme Lactation Protein**) found only in platypus milk serves to protect its babies from pathogens.
- **Promote business** - Studying the mammalian lactation can aid to build sustainable businesses in the vegan milk sector.
- Amongst the most ambitious approaches are the ones trying to grow cell cultures of the mammary organs themselves to secrete human and other mammalian milks.
- Several start-ups are attempting to make “animal-free” value-added dairy products and atleast one start-up is trying to re-constitute human breast milk with critical proteins made through synthetic biology.
- **Understanding the proteins** - It helps scientists understand how **lactoferrin**, a whey protein, modulates in multiple ways thus promoting a beneficial gut microbiome among infants.
- Recently whey proteins have been produced using synthetic biology techniques by relying on re-programming a type of fungus called Trichoderma.
- The **Vechur cow** (now almost extinct), a dwarf cow, native to the Kuttanad region of Kerala yields milk containing as much lactoferrin as human breast milk.



What are the ethical and social implications of synthetic biology?

- Many of the ethical questions relevant to synthetic biology are similar to ethical discussions related to genome editing.
- Are humans crossing moral boundaries by redesigning organisms with synthetic biology techniques?
- If synthetic biology yields new treatments and cures for diseases, who in our society will have access to them?
- What are the environmental impacts of introducing modified organisms into the ecosystem?

What supports an animal-free food supply chain?

- Factory farming of animals has led to widespread antibiotic resistance because best practices in such factories required the extensive use of antibiotics.
- Pandemics also have arisen on account of the high density of animals in the factory farms.
- The vast amounts of concentrated animal waste also require careful disposal of nitrogen compounds into the environment.
- The ethical alternatives offered by synthetic biology decrease animal suffering.

References

1. <https://www.genome.gov/about-genomics/policy-issues/Synthetic-Biology>
2. <https://www.financialexpress.com/opinion/milking-synthetic-biology/2372030/>



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