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/

SHANKAR IAS PARLIAMENT
Information is Empowering