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The Fungus Among Us

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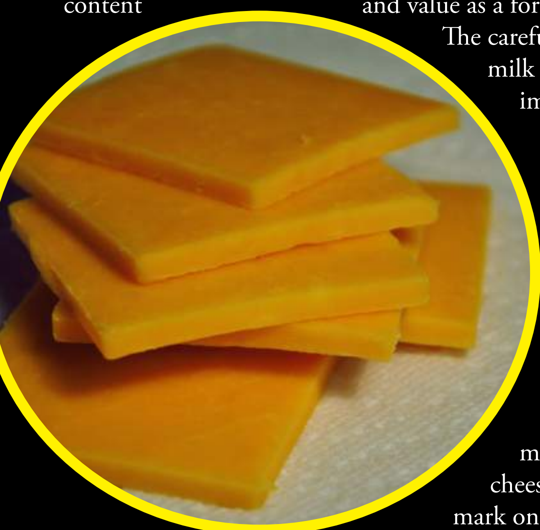
Imagine you pour yourself a cup of milk before bed and set it down on your desk as you burrow under the covers with your laptop streaming endless episodes of Bob's Burgers. Lulled to sleep, you wake up the next morning in a rush to get to class and promptly get swept away in a tide of endless tasks and assignments until suddenly days have passed and the weekend has arrived. That's when you remember: the milk. The milk that's been sitting on your desk for a week. You gingerly pick up the cup and peer inside only to be smacked in the face with the scent of sour, spoiled, spongy… something.

Fortunately for you, the process of making cheese has been around since approximately 2300 B.C., and years of troubleshooting have resulted in a commercial product far more appetizing than your leftover milk. Although cheese is now a mass-market commodity eaten mostly for its flavor, it was prized for centuries due to its rich caloric content and value as a form of milk preservation. The careful transformation of milk into cheese was an important task to ensure survival in times when fresh milk was not available and culling an animal was not a sustainable venture. While the process of cheese-making was not understood on a microbial level until much more recently, millennia of intentional cheese-making has left its mark on the genetic codes of the microorganisms that cause the fermentation reactions within milk.



Although genes are generally thought to be passed down through sexual or asexual reproduction, Horizontal Gene Transfer (HGT) can also occur, in which sections of DNA from one organism are transferred over to another independent organism and inserted into its genetic code. Recently, researchers at the Laboratoire d'Ecologie, Systématique et Evolution at the University of Paris identified an 80kb (80,000 nucleotides) long horizontally transferred region (HGR) of DNA in four different species of fungi commonly used in industrial cheese making. In addition to over 30 other genes, this HGR, called *CheesTer*, codes for several macromolecules that enable the reactions that turn milk into cheese and prevent the formation of inedible mold. *CheesTer* retards contaminant mold formation through the creation of a lactic acid based rind and also seems to make these HGT sharing fungal species grow at a far greater rate in a dairy environment than most other microbes. This means that HGT not only codes for things that contribute to the tastes and forms that we like in cheese, but also helps desired fungi outcompete ones that would cause spoilage to occur.

The value of *CheesTer* can be seen in the cross species transfer of the code for lactose permease, a symporter that draws lactose into cells for metabolism during the first few days of cheese maturation. This is used differently amongst cheese types; for example, in Emmental, the lactose transporter is what helps holes to form! The lactose drawn in by the symporter is broken down into lactic acid, which is then broken down by another bacteria into several products, among which is the gaseous CO2 that bubbles up in inside the pressed curd and causes the formation of eyes. The breakdown of lactose in Swiss, Roquefort, Camembert, and many other cheese types also aids in the formation of a rind that keeps out other microbes that would compete with beneficial bacteria and fungi for dominance in the cheese.

In a non-sterile environment, you could potentially end up with a mass of inedible mold, but years of cohabitation and horizontal gene transfers in dairy environments have given beneficial fungi and bacteria the home field advantage when it comes to thriving in milk and creating delicious cheeses. Yum!

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