

## Lecture 17 Fermentations

Written by punjalak  
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Biomass biological conversions are like having an aquarium. It is technically an ecosystem, so you have to consider all the angles and how things will get along. You have to keep everything alive by feeding it and making sure the conditions are correct, and most importantly you have to keep it wet. Living things don't do dry well, so biological conversions range from wet to completely submerged, like your aquarium, water is a must.

Of the biological conversions available to us, arguably fermentation is used the most for chemicals production. Fermentation is generally the act of feeding microbes in a low O<sub>2</sub> environment so that they will start producing things we want. A lot of microbes can live in O<sub>2</sub> rich or O<sub>2</sub> lean environments, but they produce very different things depending on what they are living in and when it's a low O<sub>2</sub> environment, they start using fermentation pathways. Fermentations can produce a very wide range of products from an even wider range of microbes.

It is important that you think about fermentation as a continuum because you may find that a lot of things seem to be fermentations and this can make it clearer. An easy way to think about it is apple juice. When you ferment apple juice microbes eat the easy sugar and make alcohols, acids, and tough sugars. If the microbe you used was yeast and you stop here, you have a nice hard cider. If you let it go a little longer, the microbe ecology changes and you become bacterial and acetogenic. Acetogenic bacteria are very very effective at eating everything marginally edible and will consume all the alcohols, acids, and tough sugars from the alcohol step. They combine these with CO<sub>2</sub> and they generate acetates and acids, largely acetic and propionic. So, the gist of it is if you let the hard cider ferment a little longer, you end up with apple cider vinegar. Now, while we generally stop here from a food perspective, we don't have to and the final step is methanogenesis. Methanogens hate O<sub>2</sub> and love acetic acid, it is their preferred food. So if I spike my apple cider vinegar with some aged compost and wait a few days I will make an anaerobic digester and it will start to produce methane. So think of fermentations as a continuum; easy sugar turns to hard cider, hard cider turns to vinegar, and vinegar turns to methane.

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