

Products from Biotechnology

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Producing beer requires a process called fermentation, which converts sugars into alcohol and carbon dioxide. Beer is a biotechnology product, because humans exploit an organism (yeast) to perform the fermentation step.

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Brewer's yeast is a microorganism. It is a unicellular eukaryote belonging to the kingdom, Fungi. It is just one example of a cell capable of fermentation. Your own (human) cells are capable of fermentation also, but human cells use a different process of fermentation. Yeast cells are used for their fermenting abilities in a variety of biotechnological processes, including not only brewing, but the production of wine, liquor, and bread, as well.

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Though winemaking starts out similarly to brewing, using yeast that produce both alcohol and carbon dioxide, for most wines the carbon dioxide is removed.

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Liquors are higher in alcohol content than beers and wines, because making liquor involves two steps. Fermentation (which is a biotechnology) produces the alcohol, and distillation (which is not a biotechnology) concentrates the alcohol by removing other parts of the liquid.

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Distillation is a basic separation technique used in chemistry and in the production of liquor. Distillation separates the different parts of a liquid mixture based on the fact that different components have different boiling points. By carefully heating a liquid mixture, the component with the lowest boiling point will evaporate (turn into gas) and leave the mixture before the other components. By collecting and cooling the gas, that component can then be condensed (turned back into liquid), leaving the rest of the mixture behind.

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Fermentation is an anaerobic process, which means that it does not require oxygen. Fermentation is coupled to another set of reactions called glycolysis. Glycolysis is the splitting of a glucose molecule for the purpose of producing an energy-carrying molecule called adenosine triphosphate (ATP). Glycolysis cannot occur unless a different energy-carrying molecule, called NAD^+ is present. NAD^+ receives electrons and protons from the sugar, which turns NAD^+ into $\text{NADH} + \text{H}^+$. NADH cannot receive any more electrons and protons from sugar. NADH therefore needs to be converted back into NAD^+ , so it can receive more electrons and protons from another glucose molecule, allowing glycolysis to continue. Fermentation is the process that converts NADH back into NAD^+ . As a byproduct of the style of fermentation that occurs in yeast cells, carbon dioxide and ethanol (a kind of alcohol) are also produced. This style of fermentation is called alcohol fermentation. We exploit yeast fermentation for the alcohol and carbon dioxide.

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There are many different styles of fermentation that occur, depending on the kind of cell undergoing fermentation. There are only two styles that most people care about. We care about one of these (alcohol fermentation), because we use it to produce alcoholic beverages and bread. We care about another style (lactic acid fermentation), because that's the style that our own cells are capable of, and because bacteria that undergo this style of fermentation are used in the cheese making process. When a human cell is deprived of oxygen, it switches from aerobic respiration to lactic acid fermentation, which allows glycolysis to continue. Lactic acid fermentation occurs for the same reason that alcohol fermentation occurs: to convert NADH back into NAD⁺. However, in lactic acid fermentation, no carbon dioxide is produced, and the final product is lactic acid instead of ethanol.

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Making bread requires yeast just as brewing does, and therefore both alcohol and carbon dioxide are produced when dough rises. The carbon dioxide gas is what causes the dough to rise. But the finished bread does not contain alcohol, because alcohol is volatile (it evaporates easily), so it leaves the dough as gas when the dough is baked.

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Bacteria that undergo lactic acid fermentation are used in the production of dairy products like sour cream, yogurt, and cheese. The acidic environment that fermentation produces helps to preserve the food, and it also causes the milk to curdle, which is the first step in making sour cream, yogurt, or cheese. For some cheeses, other organisms (like fungi) are used for various ripening and flavoring purposes. These cheeses are therefore biotechnology products for multiple reasons.