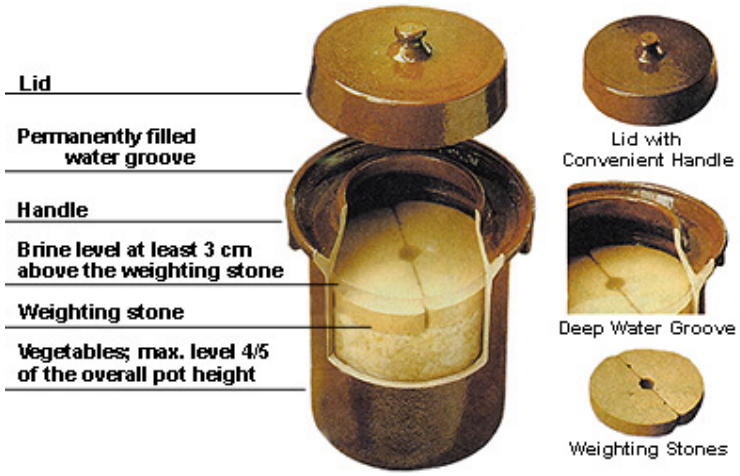
The Science of Sauerkraut Fermentation

Traditional fermenting crocks were made of pottery or clay. The cabbage was packed tightly inside the fermenting crock, with a cloth large enough to drape over the crock and cover the top of the cabbage on top. Rocks were placed on top of the cloth to weigh down the cloth-covered cabbage, keeping it submerged under the juices that are released during brining, providing a "brine seal." If any mold happened to get on the top of the brine, it wouldn't reach past the rocks and cloth, and the cabbage below would remain safe for consumption.



Many cultures have used fermentation to preserve vegetables, and they have employed similar techniques. German and Polish fermenters used a "moat" around the lid where water could be added, creating a barrier between the oxygen outside the crock and the ferment inside the crock. The small amount of oxygen left inside would be quickly pushed out with the help of carbon dioxide produced by the bacteria consuming the lactic acid. This method ensures that air only flows one way through the system – the air could be pushed out through the water, but none could make it in. Koreans use a similar method but they would bury their crock of fermenting cabbage (or other vegetables) in the ground. The ground would provide the barrier from the air in the same way that water "moat" did for the Germans and Polish. Other cultures used the stomachs of animals or other various organs that would allow for carbon dioxide to be released without allowing air inside.

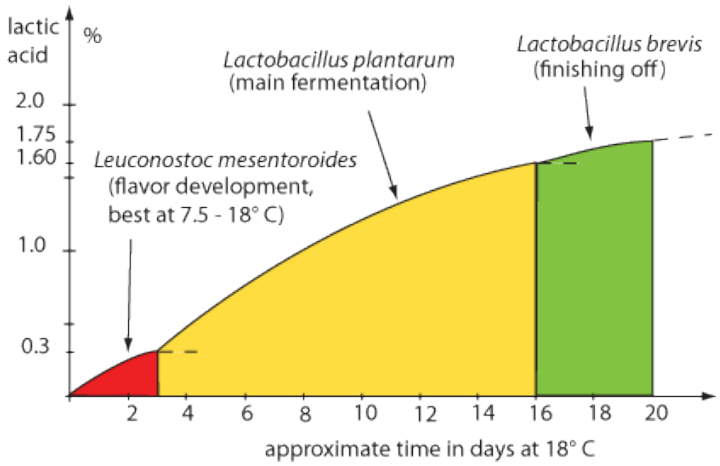
The science of cooking

Fermentation in general has been defined as "a biochemical change which is brought about by the anaerobic or partially anaerobic oxidation of carbohydrates by either micro-organisms or enzymes." In sauerkraut fermentation, this is accomplished by lactic acid-producing bacteria (LABs), primarily *Lactobacilli.* In this case, "lacto" is not referring to the lactose found in dairy, but the lactic acid that is produced in the breaking down of sugars. Lactic acid prevents the growth of harmful bacteria because this conversion process reduces the pH, creating and acidic environment that is unsuitable for the growth of unwanted bacteria. They are anaerobic organisms, meaning it is difficult for them to live in the presence of oxygen, but there are sub-groups of LABs, the microaerophiles, that require small amounts of oxygen to function. These include *Lactobacilli* and *Leuconostoc,* both of which are vital for sauerkraut fermentation. Though the crock prevents most oxygen from entering, there is a small enough amount present to allow this process to continue.

The over all process requires LABs (either naturally or by introduction via a starter cuture or whey), sugars (in the vegetables), salt, and time. The amount of time that it takes the ferment to finish is largely based on temperature; heat speeds up fermentation, cold slows it down. Additionally, taste dictates when your ferment is done – the longer you allow it to ferment, the tangier it will taste.

There are three stages of fermentation.

1. *Leuconostoc mesenteroides* produce carbon dioxide, replacing the oxygen in the jar and creating an anaerobic environment. When lactic acids reach between .25 and .3%, *Leuconostoc mesenteroides* bacteria slow down and die off. This stage lasts between one and three days, depending on temperature.



2. *Lactobacillus plantarum* and *Lactobacillus cucumeris* continue the ferment until lactic acid level of 1.5-2% is attained. High salt and low temp inhibit these bacteria, so don't over-salt your cabbage and be sure not to refrigerate yet. This stage continues for 10-30 days, depending on temperature.

3. *Lactobacillus brevis* (some sources also include *Lactobacillus pentoaceticus)* finish off the ferment. When lactic acid reaches 2-2.5%, they reach their max growth and the ferment is over. This final stage lasts under a week.

You will know your sauerkraut is ready for long-term storage or to eat when there are no more bubbles on the sides or top of your jar.

Health Benefits of Fermentation

The art and science of fermenting foods has been around for thousands of years. Even though traditional cultures may not have known the science behind fermenting, they did not have refrigeration and for them it was a practical way to increase the "shelf life" of their food supply. What traditional cultures experienced were the benefits of a food full of lactic acid bacteria which has now been discovered to be a powerful probiotic, promoting growth of healthy intestinal bacteria.

Lacto-fermentation may also increase the enzyme content of the food, making it easier for us to digest. Normal digestion of foods requires that the body produce specific enzymes, but lacto-fermented foods come with those enzymes all in one neat little package!

Additional Resources:

https://www.foodpreservationmethods.com/sauerkraut-kimchi-pickles-relishes/sauerkraut/fermentation

Katz, Sandor. 2012 The Art of Fermentation.