These bugs consume simple carbohydrates and produce lactic acid, alcohol, and carbon dioxide gas, along with hundreds of minor compounds. They were already present on the cabbage; Leo and I did nothing except discourage the growth of competing organisms with salt and a bit of temperature control so that our welcome guests could flourish.

There will, of course, be a veritable menagerie of other bacteria that we might not welcome: various species of Klebsiella and Enterobacter, some of which can add off-flavors, and various species of Acetobacter and Pediococcus, both of which can produce harmless, but quite unpalatable, slime. As its name implies, Acetobacter produces acetic acid and is employed to advantage in vinegar production. Acetic acid has a prominent and characteristic flavor that might make good vinegar but is most unwelcome in sauerkraut or kimchi. The soft, round taste of lactic acid is what we are after. We can only hope that our inevitable freeloaders are harmless, or sensitive to the salt we added and the acid that our preferred critters generate.

Cabbage and salt: this is basic sauerkraut; this is basic kimchi. They are not different versions of each other; they are each other. Brining cabbage with salt to select for lactic-fermentative bacteria is the essence; everything else is a matter of taste. Thus we can say that kimchi is sauerkraut in the Korean style, and that sauerkraut is kimchi in the German style. Call it what you will: sauerkraut, kimchi, choucroute, suan cai, kiszona kapusta, tsukemono, sirkrüt, zuurkool, or liberty cabbage. The only differences among them are entirely cosmetic, such as the variety of cabbage used, the way it is cut, and the exogenous flavorings added. The process is the same; the bugs are the same; the chemistry is the same.

“Will the good germs help our blood cells kill the bad germs?” I tell Leo that he has just asked a very good question. We humans have been brining vegetables to encourage lacto-fermentation for millennia, and young Leo has already absorbed the belief that these foods fight disease. He is hardly alone: rare is the German grandmother not convinced that a slug of sauerkraut juice is a virtual tonic. Equally rare is the Korean grandmother with the merest doubt about the salutary powers of kimchi. They have that in common with Aristotle, another true believer. We have passed this folk wisdom down through at least two hundred years. But we know it is only an old wives’ tale: these bugs and those cells must interact in some as-yet-ununderstood way if the good germs are to do any good. We have learned that certain microorganisms can help us do that.
generations: there is evidence, nearly five thousand years old, of brining in ancient Mesopotamia. And it certainly caught on: today, there is hardly a society on Earth that does not brine vegetables.

Millennia ago, our ancestors discovered that people who eat fermented vegetables benefit from it. It is a fact that brining preserves the vitamin C present in cabbage better than any other means of preparation, from raw to cooked. Both oxygen and heat destroy vitamin C, whereas brining causes cabbage to express liquid that displaces air while the bacteria act as oxygen scavengers. Not only does brining preserve the cabbage’s nutrients, bacteria synthesize many additional compounds during fermentation. Many of these are thought to be salutary, and perhaps with good reason. We know that European sailors ate sauerkraut and found it an effective means of averting scurvy. It is almost certain that the terms Kraut and Limey originated from national differences in scurvy prevention at sea. From ancient times, preserved vegetables were a means of providing adequate vitamin C during months when the foods containing it could not be had fresh. People who ate brined vegetables out of season would have been healthier than those who did not, for that reason alone. And that alone would be sufficient to guarantee sauerkraut’s reputation as a tonic.

Above: Kimchi (fermented cabbage with red pepper, garlic, turnip, and salt).

There is an element of mystery as well. Fermented foods occupy a privileged place in all major traditions. In earliest times the inoculated brine would have seemed to come alive, responding to forces invisible to the naked eye, and then go on to provide a conspicuous health advantage: that is, it would have seemed miraculous. Foods transformed by fermentation have long been entwined with ideas of the magical, even the sacred. Ancient Israel kept the Bread of the Presence on a gilded table, resting on plates of gold. Only priests were to eat it in the Tabernacle, shrouded by clouds of incense smoke lest they inadvertently see God—whose physical presence was presumed—and be struck dead. It should surprise no one that Israel commemorates deprivation and exile, even abandonment, with unleavened, or dead, loaves. Nor is it surprising that the Eucharist is born of the two most celebrated fermented foods in human history: bread and wine. Bread and beer figured heavily in Egypt’s religious festivals; the Greeks celebrated bread and decided that wine deserved a god of its own. Rome sent pickled vegetables along with her legions on campaign to keep them healthy in distant lands. The
Chinese developed pickling at least three thousand years ago. The earliest written references appear in the Book of Songs, which contains source material from a broad period (1122–256 B.C.), making it hard to date the practice of brining, which would certainly be older than its earliest mention. But it is worth noting that pickling appears in a literary work which would certainly be older than its earliest mention. But it is worth noting that pickling appears in a literary work that later contributed to the formation of a highly influential, secular quasi-religion: Confucianism. The Japanese believe solidly in the health benefits of miso, a fermented soybean paste, as do Koreans regarding their version of it, called toen-jang; and of course, hardly a Korean alive doubts that kimchi is essentially a form of medicine.

But is it? This much we know: if one’s regular diet lacks vitamin C, adding sauerkraut will prevent deficiency. Will it do more? Many people today believe that in the human gut, lacto-fermentive bacteria from sauerkraut and kimchi stimulate the autoimmune response, suppress pathogens, and synthesize additional nutrients from the foods we eat. Cabbage and the byproducts of lacto-fermentation also contain chemicals that are believed to fight cancer and heart disease. Indeed, there are few nutritive or therapeutic effects not attributed to sauerkraut, although none except the vitamin C boost has been proved. And a vitamin C boost is hardly a coup: today, in the developed world, it is nearly impossible to avoid consuming enough of it. An exclusive diet of junk food would likely supply more than one needs. We might see alarming rates of type-2 diabetes in children today, but, honestly, when was the last time you met anyone suffering from scurvy?

We know that several species of Lactobacillus produce bacteriocins, or toxins that kill or suppress competing bacteria. This has spawned a belief that bacteriocin-producing critters keep us healthy by killing pathogens in our gut. Many beneficial bacteria do survive in the gut, and some produce detectable amounts of bacteriocin. The two questions we still face are whether they might, ironically, kill bacteria even more beneficial to us than themselves, or whether the effect is so weak that it’s irrelevant either way. At this writing, we still don’t know.

It is true that Lactobacilli synthesize nutrients from cabbage’s simple carbohydrates. It is true also that in the gut, they and other bacteria synthesize enzymes on which our digestion depends. Without intestinal flora, we would be poorly nourished indeed. But is it desirable to select the organisms we host in our digestive systems based on the sorts of compounds they tend to produce? In other words, is this natural symbiosis something we can optimize? Or, are the critters we collect without even trying and without awareness as good for us as any others? Again, we really don’t know. The supporting research is suggestive and vague: ideal for generating enthusiasm in the press without proving anything decisively, which is just how the nutritional industry likes its research. A beloved hypothesis takes great effort to cultivate, but it can be blown by a single contrary observation. It is best, then, not to probe too deeply, especially when billions of dollars are riding on a highly profitable assumption: namely, that we can optimize nutrition.

That assumption rests on the question of whether the body actually profits from the extra nutrients with which we Westerners supplement our already over-nourishing diets. For example, we might demonstrate in a laboratory that an isothiocyanate compound called sulforaphane, present in cabbage and sauerkraut, impedes the action of some carcinogens and inhibits tumor growth. There is, however, a leap of faith between observing these chemicals’ effects in a lab and assuming that we can fight disease by consuming them. The body has a frustrating tendency not to absorb substances in concentrations greater than it is naturally inclined to do. This means that it will, at times, defiantly absorb toxins in almost limitless quantities while rejecting all but traces of some of the healthiest compounds known.

USDA Agricultural Research Service National Program Leader in Human Nutrition David M. Klurfeld notes that “Even if…produce has 10 or 50 percent more of certain nutrients, does that translate into a health benefit when it is eaten? To my knowledge, there has been a single study, in France, comparing the consumption of 300 grams per day of organic and conventional tomatoes. The organic fruits were significantly higher in carotenoids and vitamin C, but there were no differences at all in the blood levels of these compounds among people who ate them daily for three weeks.”1

If exotic nutrients are to offer advantages worth paying for, it is obvious that the body would first have to assimilate them. Unfortunately, increased consumption does not necessarily result in higher blood or tissue concentrations. There is no doubt that a placebo effect is in play here, if nothing else; and we shouldn’t forget that placebo offers real, measurable benefits. Of course, these benefits are not worth paying for because every manner of placebo is freely available. But the placebo effect is generally positive and quite real nevertheless.2 If eating sauerkraut makes you feel a bit healthier, it almost certainly is making you a bit healthier.

We have to ask, how much of this nutraceutical, phyto-nutritional, probiotic stuff is actually worth paying for? Because billions of dollars ride on our assumption that nutrition can indeed be optimized with foods rich in beta-thins and omega-thals, investigative studies like the one Klurfeld cites are rarely carried out, so it is hard to say, and for several
reasons. For one, such studies can become expensive and cumbersome if they are designed with good controls. We can easily imagine an ideal study to learn whether adding sauerkraut to the diet offers a mortality advantage and even discover which diseases it might prevent or retard. But we would need thousands of people willing either to eat it regularly or avoid eating it for years, if not decades. In the control group we would have to allow for other lacto-fermented foods such as pickles, cheese, yogurt, crème fraîche, and some types of beer that might duplicate sauerkraut's effects. In the study group we would have to allow for participants who mistakenly eat pasteurized or cooked sauerkraut, in which the magic critters are, unfortunately, dead. In other words, it would be practically impossible.

Furthermore, no outfit with pockets deep enough, and a willingness to reach into them for nutritional research, wants to sponsor a truly well-controlled study. It is hardly in the nutrition industry's interests to prove decisively that many of the miracle phytonutrients and probiotics it peddles are rubbish. The industry thrives on uncertainty and suggestive data. Of course, the major players are always pleased to sponsor limited research enabling them to claim truthfully that, say, "studies indicate that sulforaphane might fight cancer, and cabbage is a great source of sulforaphane." Indeed, that is precisely the language chosen by Oregon State University's Linus Pauling Institute in an article encouraging the consumption of cruciferous vegetables like cabbage. We are told first that "Isothiocyanates such as sulforaphane may help prevent cancer by promoting the elimination of potential carcinogens from the body and by enhancing the transcription of tumor suppressor proteins." We are later advised that "Cruciferous vegetables such as broccoli, cabbage, and kale are rich sources of sulfur-containing compounds called glucosinolates. Isothiocyanates are biologically active hydrolysis (breakdown) products of glucosinolates." Both are true statements; both are meaningless. A meaningful statement would be, "Adding 250 grams of cooked cabbage per day to the diet extended the lives of cancer patients by 12 percent, as demonstrated in double blind, randomized, placebo-controlled clinical trials." Such a study is, of course, impossible. It can't be blind because we can't hide from patients and doctors the fact that one is eating a substantial amount of cabbage. Nor could it be placebo controlled for the same reason: how would we come up with placebo cabbage? (Not that Big Agriculture hasn't been trying for decades, but that is a topic for another issue.) The best we could do is administer sulforaphane as an isolate. The study results would speak to sulforaphane alone; they would say nothing about cabbage, which might contain other compounds that either enhance, or obstruct, any possible therapeutic effects we observe from ingesting sulforaphane under controlled conditions.

Cabbage extract has been shown to mitigate hypercholesterolemia (high blood cholesterol) in rats. That fact alone is sufficient to persuade many people that eating cabbage will lower their blood cholesterol. Let's set aside the obvious facts that cabbage extract is not cabbage and that rats are not people; there is something more important to consider here. Even if eating cabbage does lower blood cholesterol in humans, and especially the much dreaded LDL (low-density lipoprotein) component, does this mean that anyone is going to live longer because of it? David Klurfeld spoke to the question of whether a given nutrient translates into a health advantage. What we now need to ask is, does an apparent health advantage translate into a mortality advantage? We tend to deceive ourselves about this.

Here is how we go off the rails: we observe that people with low levels of LDL tend to be healthy, while people with high levels tend to be unhealthy. There is no doubt about that: LDL is without question a marker of relative health. So we test our blood and perhaps learn, much to our horror, that our cholesterol levels are in a range associated with poor health and early death. Now we know something we didn't before—so far so good. Next comes the almost inescapable blunder: we assume that if we take some nutrient or drug that will lower our LDL level—suddenly making this health marker in our blood resemble that of a healthy person—we will make ourselves healthier. That is a very seductive mistake. The only thing we can say with confidence is this: we have just changed a bio-marker; our blood looks more like the blood of a healthy person than it did before. The only way to prove that we actually enhanced our own health would be through mortality studies, but these are few and far between when it comes to cholesterol. That is because there are hundreds of billions of dollars to be made each year selling foods, nutritional supplements, and drugs that will change this blood marker. No one earning those dollars wants to find out that you or I won't live a day longer because we did change it.

Five-thousand years' worth of folk wisdom packs a massive rhetorical wallop that sets us up to deceive ourselves, and most nutritional study data is conveniently packaged to help us do just that. For example, agribusiness and nutrition-industry flacks might sell the press on two facts we have already covered: sulforaphane might fight cancer, and cabbage and sauerkraut contain sulforaphane. They wouldn't dare link eating cabbage or sauerkraut directly to cancer...
And so, every couple of weeks, Leo and I make a batch of sauerkraut together. It always excites him. On this occasion we go Korean style, with Napa cabbage, garlic, scallions, fish sauce, and sweet paprika in place of the hotter gochu garu, or flaked red pepper, which is too intense for him. When I finally get around to answering his question, he shows mild disappointment. He is used to getting answers like this from me: I tell him, "No one really knows, Son; but sauerkraut sure tastes good, and it certainly can't do us any harm." Then he grins and bounces on his toes again as he watches the smelly red goo bubbling away and the bits of cabbage drifting about as if on their own. He knows that in a day or two, those good germs will start fighting the bad germs in his body.

Recipes

There are two basic approaches to making sauerkraut, which we might call the German and Korean methods. The chief difference is in the way salt is used.

Above: A bowl of freshly made sauerkraut.

Photograph by Lehner © 2011, istockphoto.com

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Five thousand years of folk wisdom is a force to be reckoned with: we believe in pickled vegetables. And yet, this old, guiding wisdom might be based on nothing more than a vitamin C boost that gave our ancestors a marked health and survival advantage, and means almost nothing in today’s world where ascorbic acid, cheap and plentiful, is added to so much of what we eat and drink. Our ancient cultural memory, lately enriched by the ubiquitous arts of mass advertising and vast heaps of quasi-scientific data, could easily cloud our understanding with magical thinking—or not. While most of our beliefs about brined vegetables have not been proved, and indeed might never be proved, it is hard to imagine that they would have lasted five millennia if vitamin C was the whole story.
measured amount of salt is added. Koreans rarely measure salt, but prefer to rinse the cabbage before brining and again after. Another difference is fermentation temperature and time: the German method uses a slow fermentation of several weeks at a low temperature (68–72°F). Koreans often ferment their sauerkraut at room temperature for only one to three days. There are advantages to both methods.

**German method**

The cabbage is shredded finely and added to a suitable container, two pounds or so at a time. Part of the salt is distributed through each layer while sprigs of fresh dill and slices of peeled, fresh horseradish are laid on top. Then the process is repeated. Tradition holds that the dill and horseradish inhibit undesirable microorganisms, but they are both good for flavor. Usually, the cabbage will express enough liquid to remain submerged. If it does not, you can add a bit of plain brine. The cabbage is then covered and weighted, and left to ferment.

**Basic ingredients:**
- 10 lb. of dense head cabbage, loose outer leaves removed
- 6 tablespoons of non-iodized fine salt, or 8 tablespoons of non-iodized coarse salt
- 1½ lb. of fresh horseradish, peeled and sliced
- Approximately 1 pint of plain brine (2 tablespoons non-iodized salt dissolved in one quart of boiled, cooled water), more as needed
- 1 lb. of fresh dill sprigs, washed
- Caraway seeds, whole
- Juniper berries, whole
- Garlic cloves, peeled and cracked
- Black peppercorns, coarsely cracked

When using round head cabbage, look for large heads surrounded by loose green leaves. Discard the outer leaves and rinse the solid inner head in running water to remove any contaminants on the surface. Core and cut the cabbage into manageable pieces, and then shred it with a knife or mandolin. Place one quarter of the cabbage into a very clean vessel, then sprinkle on one quarter of the salt plus any of the optional flavorings you like. Mix the salt through and then compress the cabbage firmly with your hands. Lay slices of horseradish and sprigs of dill on top, and repeat. It is good to have six inches or more of headspace when you are done. Within an hour or so, the cabbage will have expressed enough liquid to keep it submerged. It is essential that the cabbage remain submerged in liquid; if there is too little, add plain brine until the sauerkraut is covered by about two inches.

The cabbage must be covered and weighted. A large, food-grade plastic bag, such as one designed for roasting turkeys or large joints of meat, works well. Fill one with approximately two quarts of water, tie the opening securely, and lay it on top. This will form an adequate cover and provide enough weight. Leave the sauerkraut to ferment for approximately three weeks at a fairly low temperature of 68–72°F. Check it every few days and skim off any mold that might appear on the surface. German-style sauerkraut is rarely eaten before three weeks of fermentation. The bulk of it is often left to continue fermenting until it is all used, but it can be refrigerated when the flavor (in your estimation) peaks. Refrigeration will stop fermentation, or at least slow it considerably.

My personal preference is for horseradish, dill, and a little caraway seed.

**Korean method**

In Korea, Napa is typically used to produce pickled cabbage (*baechu kimchi*). It is either cross-cut into bite-sized pieces (*mat baechu kimchi*) or quartered lengthwise for a more attractive presentation (*poggi baechu kimchi*). Round head cabbage makes perfectly good Korean-style sauerkraut when chopped, but it will not be as crunchy as Napa, and it will be sweeter. In any case, the cabbage is first cut, then rinsed and drained. Salt is added liberally, without measuring. If one makes *poggi kimchi*, the salt is sprinkled between the interleaved ribs of each quarter. It is not necessary to measure it because the cabbage will be rinsed again. While it is willing, one periodically takes a bit of cabbage and rinses it, then tastes it. When it retains a pleasant saltiness after rinsing, it is ready to be flavored, then stored for fermentation. I suspect that the Korean method strips the cabbage of most of its microorganisms. It is likely that exogenous ingredients, especially dried red pepper flakes, contribute most of the lacto-fermentative bugs, so in this recipe, the pepper flakes are considered essential. Good-quality sweet paprika can be substituted by those who dislike hot peppers. In Korea, red pepper flakes are usually bought at a local outdoor market where small samples can be evaluated and compared. Normally, a quite mild hot red pepper with a strong and familiar pimento/bell-pepper flavor is sought. At your local Asian grocery, “Korean” pepper flakes will come packaged, most often from China. Chinese ingredients vary wildly in terms of safety, quality, and consistency. Look for dried red pepper flakes of Korean origin, vacuum packed. That is no guarantee of good quality, but it is a sensible choice. In time, you will find a brand that suits you, both in flavor and in terms of the lacto-fermentive critters it supplies.

**Basic ingredients:**
- 10 lb. of Napa cabbage, cross-cut into bite-sized pieces or quartered lengthwise
- Approximately ½ cup of non-iodized salt
- Approximately ½ cup of dried, red pepper flakes (gochu ganu)
Approximately 1 pint of plain brine (2 tablespoons non-iodized salt dissolved in one quart of boiled, cooled water), more as needed

**Optional ingredients:**
- Scallions, sliced or chopped
- Leeks, sliced or chopped
- Garlic, peeled and finely sliced or grated
- Ginger, peeled and finely sliced or grated
- Asian pears, peeled, cored, and sliced thin
- Apples, peeled, cored, and sliced thin
- Daikon radish, peeled and shredded or diced
- Perilla leaves (shiso [Japan])
- Fermented fish sauce (nuoc mâm [Vietnam] or nam pla [Thailand])
- Salted shrimp (saeujeot)
- Raw squid tubes, cleaned and chopped
- Raw oysters, shucked and chopped, with brine
- Leeks, sliced or chopped
- Ginger, peeled and finely sliced or grated
- Garlic, peeled and finely sliced or grated
- Asian pears, peeled, cored, and sliced thin
- Apples, peeled, cored, and sliced thin
- Daikon radish, peeled and shredded or diced
- Perilla leaves (shiso [Japan])
- Fermented fish sauce (nuoc mâm [Vietnam] or nam pla [Thailand])
- Salted shrimp (saeujeot)
- Raw squid tubes, cleaned and chopped

Chop or slice the cabbage, rinse it thoroughly in clean water, and drain it. Place it in a very clean mixing bowl. Add salt liberally (you can’t use too much) and mix well. If you are making *poggi* kimchi, sprinkle the salt between each rib. Let it wilt; while that is going on, periodically remove a sample, rinse it, and taste it. When the cabbage tastes pleasantly salty after rinsing, it’s done. This normally takes one to three hours. Rinse the entire batch and drain it again. Add the pepper flake and whatever additional flavorings you like (taking care to distribute them between the ribs if you are making *poggi* kimchi), and pack the sauerkraut into a very clean vessel, adding enough simple brine to ensure that it is just covered in liquid. Cover with plastic film laid directly on the surface to keep out air. Koreans often ferment sauerkraut at room temperature (76–80°F) for only 24 to 72 hours, until it just starts to become sour, and then keep it refrigerated. It is best when eaten fresh, within two weeks of being made.

My personal preference is for red pepper flakes, scallions, sliced apple, and a little salted shrimp.

**Advantages**

**German:** 1. All of the liquid expressed by the cabbage is eaten fresh, within two weeks of being made. 2. By altering the exogenous ingredients and their sources or brands over time, one may find that the cabbage can be inoculated repeatedly with an especially flavorful assortment of critters. There is a hit-or-miss element in relying strictly on the cabbage, which is subject to conditions that the retail consumer cannot control. 3. If one uses length-quartered Napa heads, it will be difficult to distribute a measured amount of salt evenly between each of the ribs. Salting with abandon and then rinsing is far easier.

**Choice of cabbage**

Round head cabbages tend to be sweet while Napa tends not to be. Napa retains more crunch after brining, although the leafy outer fringe will become soft and somewhat slimy. Still, the main part of the rib is more fibrous and stays crunchy so long as the cabbage is not shredded.

**Suitable containers**

Glazed ceramic, glass, and stainless steel vessels are appropriate. Aluminum, iron, and most plastic containers are not, although food-grade plastic pails are acceptable.

**Sanitation**

Everything that touches the cabbage must be spotlessly clean: knives, the fermentation vessel, your hands, and so on. Otherwise, molds and wild yeasts might be introduced, and they can easily ruin a batch. Napa cabbage packaged in plastic and kept refrigerated is a poor choice: this is an invitation to mold. Try to buy it loose, not refrigerated, and as fresh as possible. The Korean method, where the cabbage is rinsed after brining, is likely an adaptation to the problem of moldy Napa. Round head cabbages with a good covering of outer leaves are safer for beginners using the German method, as they are rarely refrigerated or packaged, and removing the outer leaves removes most of the mold and other contaminants. Beginners using Napa cabbage should use the Korean method.

**Insurance**

Lacto-fermentive starter cultures intended for pickling vegetables can be bought at many health food stores. They are not cheap, but they will add a layer of insurance for beginners. I would recommend using them in one’s first few batches.
Making sauerkraut is easy, but laborious, and it therefore makes little sense to do it in a small way. Nevertheless, I recommend relatively small, 10-pound batches for beginners as insurance against wasting too much food if something goes wrong. Once you develop some expertise, you will likely prefer to make 20-pound or larger batches. You can always invite friends to share the labor and divide the spoils whenever you make bulk amounts.

NOTES
1. E-mail interview with author, May 2008.
2. I say generally positive. Patients on placebo in clinical trials experience not only medical effects but side effects as well, some of them significant.
5. An important eight-year metastudy called ALLHAT followed patients taking statins, a class of cholesterol-lowering drug. The statin group showed a nonsignificant decrease in heart attacks and strokes, and no reduction in deaths. See http://allhat.sph.uth.tmc.edu.